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SPN 906 Relative Speed; Front Axle, Right Wheel

The speed of the front axle, right wheel relative to the front axle speed, SPN 904.

Data Length: 1 byte
Resolution: 1/16 km/h per bit, -7.8125 km/h offset
Data Range: -7.8125 to 7.8125 km/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65215

SPN 907 Relative Speed; Rear Axle #1, Left Wheel

The speed of the rear axle #1, left wheel relative to the front axle speed, SPN 904.

Data Length: 1 byte
Resolution: 1/16 km/h per bit, -7.8125 km/h offset
Data Range: -7.8125 to 7.8125 km/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65215

SPN 908 Relative Speed; Rear Axle #1, Right Wheel

The speed of the rear axle #1, right wheel relative to the front axle speed, SPN 904.

Data Length: 1 byte
Resolution: 1/16 km/h per bit, -7.8125 km/h offset
Data Range: -7.8125 to 7.8125 km/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65215

SPN 909 Relative Speed; Rear Axle #2, Left Wheel

The speed of the rear axle #2, left wheel relative to the front axle speed, SPN 904.

Data Length: 1 byte
Resolution: 1/16 km/h per bit, -7.8125 km/h offset
Data Range: -7.8125 to 7.8125 km/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65215

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SPN 910 Relative Speed; Rear Axle #2, Right Wheel

The speed of the rear axle #2, right wheel relative to the front axle speed, SPN 904.

Data Length: 1 byte
Resolution: 1/16 km/h per bit, -7.8125 km/h offset
Data Range: -7.8125 to 7.8125 km/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65215

SPN 911 (R) Service Component Identification

Identification of component needing service. See Table SPN911_A.

Data Length: 1 byte
Resolution: 1 ID/bit, 0 offset
Data Range: 0 to 250 ID Operational Range: same as data range
Type: Measured
Supporting information: See Appendix D - SPN 911
PGN 65216

SPN 912 Service Component Identification

Identification of component needing service. See Table SPN911_A.

Data Length: 1 byte
Resolution: 1 ID/bit, 0 offset
Data Range: 0 to 250 ID Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65216

SPN 913 Service Component Identification

Identification of component needing service. See Table SPN911_A.

Data Length: 1 byte
Resolution: 1 ID/bit, 0 offset
Data Range: 0 to 250 ID Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65216

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SPN 914 Service Distance

The distance which can be traveled by the vehicle before the next service inspection is required. A negative distance is transmitted if the service inspection has been passed. The component that requires service is identified by the service component identification (see SPN 911-913, 1379, and 1584).

Data Length: 2 bytes
Resolution: 5 km/bit, -160,635 km offset
Data Range: -160,635 to 160,640 km Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65216

SPN 915 Service Delay/Calendar Time Based

The time in weeks until the next vehicle service inspection is required. A negative value is transmitted if the service inspection has been passed. The component that requires service is identified by the service component identification (see SPN 911-913, 1379, and 1584).

Data Length: 1 byte
Resolution: 1 week/bit, -125 weeks offset
Data Range: -125 to 125 weeks Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65216

SPN 916 Service Delay/Operational Time Based

The time in vehicle operational time until the next vehicle service inspection is required. A negative value is transmitted if the service inspection has been passed. The component that requires service is identified by the service component identification (see SPN 911-913, 1379, and 1584).

Data Length: 2 bytes
Resolution: 1 hr/bit, -32,127 hr offset
Data Range: -32,127 to 32,128 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65216

SPN 917 High Resolution Total Vehicle Distance

Accumulated distance traveled by the vehicle during its operation.

NOTE - See SPN 245 for alternate resolution.

Data Length: 4 bytes
Resolution: 5 m/bit, 0 offset
Data Range: 0 to 21,055,406 km Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65217

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SPN 918 High Resolution Trip Distance

Distance traveled during all or part of a journey.

NOTE - See SPN 244 for alternate resolution.

Data Length: 4 bytes
Resolution: 5 m/bit, 0 offset
Data Range: 0 to 21,055,406 km Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65217

SPN 927 Location

To identify to which of several similar devices (such as tires or fuel tanks) the information applies.

The low order 4 bits represent a position number, counting left to right when facing in the direction of normal vehicle travel (forward).

The high order 4 bits represent a position number, counting front to back on the vehicle.

The value 0xFF indicates not available.

It is recommended that output devices add 1 to the position number (range 1 to 15, not 0 to 14) for use by drivers and service technicians.

Examples: Tire pressure for location 0x00 would be left front tire.

Tire pressure for location 0x23 would be right outside rear rear on a 3-axle tractor with dual axle per side (3rd axle, 4th tire).

Data Length: 8 bits
Resolution: 256 states/8 bit, 0 offset
Data Range: 0 to 255 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61446

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SPN 928 Axle Location

To identify to which of several similar devices (such as tires or fuel tanks) the information applies.

The low order 4 bits represent a position number, counting left to right when facing in the direction of normal vehicle travel (forward).

The high order 4 bits represent a position number, counting front to back on the vehicle.

The value 0xFF indicates not available.

It is recommended that output devices add 1 to the position number (range 1 to 15, not 0 to 14) for use by drivers and service technicians.

Examples: Tire pressure for location 0x00 would be left front tire.

Tire pressure for location 0x23 would be right outside rear rear on a 3-axle tractor with dual axle per side (3rd axle, 4th tire).

Data Length: 8 bits
Resolution: 256 states/8 bit, 0 offset
Data Range: 0 to 255 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65258

SPN 929 (R) Tire Location

Identifies which tire is associated with the parametric data in this PGN.

The low order 4 bits represent a position number, counting left to right when facing in the direction of normal vehicle travel (forward).

The high order 4 bits represent a position number, counting front to back on the vehicle.

The value 0xFF indicates not available.

It is recommended that output devices add 1 to the position number (range 1 to 15, not 0 to 14) for use by drivers and service technicians.

Examples: Tire pressure for location 0x00 would be left front tire.

Tire pressure for location 0x23 would be right outside rear rear on a 3-axle tractor with dual axle per side (3rd axle, 4th tire).

Data Length: 8 bits
Resolution: 256 states/8 bit, 0 offset
Data Range: 0 to 255 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65268

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SPN 930 Drive Axle Location

To identify to which of several similar devices (such as tires or fuel tanks) the information applies.

The low order 4 bits represent a position number, counting left to right when facing in the direction of normal vehicle travel (forward).

The high order 4 bits represent a position number, counting front to back on the vehicle.

The value 0xFF indicates not available.

It is recommended that output devices add 1 to the position number (range 1 to 15, not 0 to 14) for use by drivers and service technicians.

Examples: Tire pressure for location 0x00 would be left front tire.

Tire pressure for location 0x23 would be right outside rear rear on a 3-axle tractor with dual axle per side (3rd axle, 4th tire).

Data Length: 8 bits
Resolution: 256 states/8 bit, 0 offset
Data Range: 0 to 255 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65273

SPN 957 Number of Forward Gear Ratios

Number of forward gear ratios in the transmission, provided as part of the configuration.

Data Length: 1 byte
Resolution: 1 gear value/bit, 0 offset
Data Range: 0 to 250 Operational Range: 0 to 125 gear ratios
Type: Measured
Supporting information:
PGN 65250

SPN 958 Number of Reverse Gear Ratios

Number of reverse gear ratios in the transmission, provided as part of the transmission configuration.

Data Length: 1 byte
Resolution: 1 gear value/bit, 0 offset
Data Range: 0 to 250 Operational Range: 0 to 125 gear ratios
Type: Measured
Supporting information:
PGN 65250

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SPN 959 Seconds

Part of a parameter used to represent time.

Data Length: 1 byte
Resolution: 0.25 s/bit, 0 offset
Data Range: 0 to 62.5 s Operational Range: 0 to 59.75 sec
Type: Measured
Supporting information:
PGN 65254

SPN 960 Minutes

Part of a parameter used to represent time.

Data Length: 1 byte
Resolution: 1 min/bit, 0 offset
Data Range: 0 to 250 mins Operational Range: 0 to 59 min
Type: Measured
Supporting information:
PGN 65254

SPN 961 Hours

Part of a parameter used to represent time.

Data Length: 1 byte
Resolution: 1 hr/bit, 0 offset
Data Range: 0 to 250 hr Operational Range: 0 to 23 hr
Type: Measured
Supporting information:
PGN 65254

SPN 962 Day

Part of a parameter used to represent a calendar date.

NOTE - A value of 0 for the date is null. The values 1, 2, 3, and 4 are used to identify the first day of the month; 5, 6, 7, and 8 identify the second day of the month; etc.

Data Length: 1 byte
Resolution: 0.25 days/bit, 0 offset
Data Range: 0 to 62.5 days Operational Range: 0.25 to 31.75 day
Type: Measured
Supporting information:
PGN 65254

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SPN 963 Month

Part of a parameter used to represent a calendar date.

NOTE - A value of 0 for the month is null. The value 1 identifies January; 2 identifies February; etc.

Data Length: 1 byte
Resolution: 1 month/bit, 0 offset
Data Range: 0 to 250 months Operational Range: 1 to 12 month
Type: Measured
Supporting information:
PGN 65254

SPN 964 Year

Part of a parameter used to represent a calendar date.

NOTE - A value of 0 for the year identifies the year 1985; a value of 1 identifies 1986; etc.

Data Length: 1 byte
Resolution: 1 year/bit, 1985 years offset
Data Range: 1985 to 2235 years Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65254

SPN 965 Number of Software Identification Fields

Number of software identification designators represented in the software identification parameter group.

Data Length: 1 byte
Resolution: 1 step/bit, 0 offset
Data Range: 0 to 250 steps Operational Range: 0 to 125
Type: Measured
Supporting information:
PGN 65242

SPN 966 Engine Test Mode Switch

Switch signal which indicates the position of the engine test mode switch.

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65265

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SPN 967 (R) Engine Idle Decrement Switch

Switch signal which indicates the position of the idle decrement switch.

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65265

SPN 968 (R) Engine Idle Increment Switch

Switch signal which indicates the position of the idle increment switch.

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65265

SPN 969 Remote Accelerator Enable Switch

Switch signal which indicates that the remote accelerator has been enabled and controls the engine.

00 - Off
01 - On
10 - Error
11 - Not available

NOTE—The accelerator interlock switch (see SPN 972) must be disabled in order for the remote accelerator to perform engine control.

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61441

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SPN 970 (R) Engine Auxiliary Engine Shutdown Switch

Switch signal which requests that all engine fueling stop.

00 - Off
01 - On
10 - Error
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61441

SPN 971 Engine Derate Switch

Switch signal used to activate the torque limiting feature of the engine. The specific nature of torque limiting should be verified with the manufacturer.

00 - Off
01 - On
10 - Error
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61441

SPN 972 Accelerator Interlock Switch

Switch signal used to disable the accelerator and remote accelerator inputs, causing the engine to return to idle.

00 - Off
01 - On
10 - Error
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61441

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SPN 973 Engine Retarder Selection

The position of the operator controlled selector, expressed as a percentage and determined by the ratio of the current position of the selector to its maximum possible position. Zero percent means no braking torque is requested by the operator from the engine while 100% means maximum braking.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61441

SPN 974 (R) Remote Accelerator Pedal Position

The ratio of actual position of the remote analog engine speed/torque request input device (such as an accelerator pedal or throttle lever) to the maximum position of the input device.

For example, in on-highway vehicles this could be an accelerator control device that is external to the drivers cab or an accelerator that is controlled by a hand lever from the operators seat.

The Remote Accelerator Enable Switch is SPN 969. This parameter enables the remote accelerator operation.

NOTE—See SPNs 28, 29, and 91 for additional accelerator position parameters. If only one accelerator position exists on a vehicle, SPN 91 shall be used

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61443

SPN 975 Estimated Percent Fan Speed

Estimated fan speed as a ratio of the fan drive (current speed) to the fully engaged fan drive (maximum fan speed). A two state fan (off/on) will use 0% and 100% respectively. A three state fan (off/intermediate/on) will use 0%, 50% and 100% respectively. A variable speed fan will use 0% to 100%. Multiple fan systems will use 0 to 100% to indicate the percent cooling capacity being provided.

Note that the intermediate fan speed of a three state fan will vary with different fan drives, therefore 50% is being used to indicate that the intermediate speed is required from the fan drive.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 65213

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SPN 976 (R) PTO State

This parameter is used to indicate the current state or mode of operation by the power takeoff (PTO) device. It needs to be ensured that each achieved state information be set up to be conveyed in at least one datalink message before a transition to another state is allowed. The Suspect Parameter Number for this parameter is 976.

Data Length: 5 bits

Resolution: 32 states/5 bit, 0 offset

Data Range: 0 to 31 Operational Range: same as data range

Type: Status

Supporting information: See Appendix D - SPN 976

PGN 65265

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SPN 977 Fan Drive State

This parameter is used to indicate the current state or mode of operation by the fan drive.

0000 Fan off
0001 Engine system–General
0010 Excessive engine air temperature
0011 Excessive engine oil temperature
0100 Excessive engine coolant temperature
0101 Excessive transmission oil temperature
0110 Excessive hydraulic oil temperature
0111 Default Operation
1000 Not defined
1001 Manual control
1010 Transmission retarder
1011 A/C system
1100 Timer
1101 Engine brake
1110 Other
1111 Not available

Fan off 0000b —Used to indicate that the fan clutch is disengaged and the fan is inactive

Engine system–General 0001b —Used to indicate that the fan is active due to an engine system not otherwise defined.

Excessive engine air temperature 0010b —Used to indicate that the fan is active due to high air temperature.

Excessive engine oil temperature 0011b —Used to indicate that the fan is active due to high oil temperature.

Excessive engine coolant temperature 0100b —Used to indicate that the fan is active due to high coolant temperature.

Manual control 1001b —Used to indicate that the fan is active as requested by the operator.

Transmission retarder 1010b —Used to indicate that the fan is active as required by the transmission retarder.

A/C system 1011b —Used to indicate that the fan is active as required by the air conditioning system.

Timer 1100b —Used to indicate that the fan is active as required by a timing function.

Engine brake 1101b —Used to indicate that the fan is active as required to assist engine braking.

Excessive transmission oil temperature - 0101b - Used to indicate fan is active due to excessive transmission oil temperature.

Excessive hydraulic oil temperature - 0110b - Used to indicate fan is active due to excessive hydraulic oil temperature.

Default Operation - 0111b - Used to indicate fan is active due to a error condition resulting in default operation

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65213

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SPN 978 (R) Engine Remote PTO Variable Speed Control Switch

Switch signal which indicates that the remote PTO toggle switch is in the enabled (ON) position. If the toggle switch is enabled and other conditions are satisfied then the remote PTO control feature is activated and the PTO will control at a variable speed.

00 - Off
01 - On
10 - Error

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65264

SPN 979 (R) Engine Remote PTO Preprogrammed Speed Control Switch

Switch signal which indicates that the remote PTO toggle switch is in the enabled (ON) position. If the toggle switch is enabled and other conditions are satisfied then the remote PTO control feature is activated and the PTO will control at the preprogrammed speed.

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65264

SPN 980 (R) Engine PTO Enable Switch

Switch signal which indicates that the PTO toggle switch is in the enabled (ON) position and therefore it is possible to manage the PTO control function.

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65264

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SPN 981 (R) Engine PTO Accelerate Switch

Switch signal of the PTO control activator which indicates that the activator is in the position "accelerate".

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65264

SPN 982 (R) Engine PTO Resume Switch

Switch signal of the PTO control activator which indicates that the activator is in the position "resume".

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65264

SPN 983 (R) Engine PTO Coast/Decelerate Switch

Switch signal of the PTO control activator which indicates that the activator is in the position "coast/decelerate".

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65264

SPN 984 (R) Engine PTO Set Switch

Switch signal of the PTO control activator which indicates that the activator is in the position "set".

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65264

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SPN 985 A/C High Pressure Fan Switch

Switch signal which indicates that the pressure in the coolant circuit of an air conditioning system is high and the fan may be engaged.

00 - Pressure normal
01 - Pressure high, fan may be engaged

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65252

SPN 986 Requested Percent Fan Speed

Fan speed as a ratio of the actual fan drive (current speed) to the fully engaged fan drive (maximum fan speed). A two state fan (off/on) will use 0% and 100% respectively. A three state fan (off/intermediate/on) will use 0%, 50% and 100% respectively. A variable speed fan will use 0% to 100%. Multiple fan systems will use 0 to 100% to indicate the percent cooling capacity being provided. Feedback to this request is provided using the estimated fan speed (see SPN 975).

Note that the intermediate fan speed of a three state fan will vary with different fan drives, therefore 50% is being used to indicate that the intermediate speed is required from the fan drive.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 57344

SPN 988 Trip Group 1

Command signal used to reset the PGNs and parameters as defined in Table SPN988_A.

00 Take no action
01 Reset
11 Not applicable

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information: See Appendix D - SPN 988
PGN 56832

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SPN 989 Trip Group 2 - Proprietary

Command signal used to reset proprietary parameters associated with a trip but not defined within this document.

00 Take no action
01 Reset
11 Not applicable

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 56832

SPN 990 Total Compression Brake Distance

Total distance over which the compression brakes have been active for the life of the engine.

Data Length: 4 bytes
Resolution: 0.125 km/bit, 0 offset
Data Range: 0 to 526,385,151.9 km Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65212

SPN 991 Trip Compression Brake Distance

Total distance over which the compression brakes have been active since the last trip reset.

Data Length: 4 bytes
Resolution: 0.125 km/bit, 0 offset
Data Range: 0 to 526,385,151.9 km Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65212

SPN 992 Trip Service Brake Distance

Total distance over which the service brakes have been active since the last trip reset.

Data Length: 4 bytes
Resolution: 0.125 km/bit, 0 offset
Data Range: 0 to 526,385,151.9 km Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65212

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SPN 993 Trip Service Brake Applications

Total number of times the service brakes have been activated since the last trip reset. Brake applications of less than 0.5 s are not counted and lengthy brake applications (longer than 0.5 s) are counted as a single event.

NOTE - Definition and resolution shall stay the same if brakes are applied by only the tractor, only the trailer or both.

Data Length: 4 bytes
Resolution: 1 brake appl/bit, 0 offset
Data Range: 0 to 4,227,858,431 appl Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65212

SPN 994 Trip Fan On Time

Total time the fan has been on (due to an automatic trigger or manual trigger) since the last trip reset. The fan could be requested to be on by the engine system, a manual switch, and/or the A/C system. Whichever system requests the fan activation first shall have the time accumulated against it. The sum total of these three values shall equal the trip fan on time.

NOTE—If the fan has been requested to be on by a component that is not one of the defined categories, this time shall be

Data Length: 4 bytes
Resolution: 0.05 hr/bit, 0 offset
Data Range: 0 to 210,554,060.75 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65211

SPN 995 Trip Fan On Time Due to the Engine System

Total time the fan has been on due to engine triggers (i.e., excluding time on due to an operator manual switch or A/C system) since the last trip reset. For the time to be accumulated against the engine system, it is necessary that it be the first to request the fan activation or it be the only system requesting fan activation.

Data Length: 4 bytes
Resolution: 0.05 hr/bit, 0 offset
Data Range: 0 to 210,554,060.75 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65211

SPN 996 Trip Fan On Time Due to a Manual Switch

Total time the fan has been on due to manual activation by the operator (i.e., excluding time on due to automatic triggers) since the last trip reset. For the time to be accumulated against the manual switch, it is necessary that it be the first to request the fan activation or it be the only system requesting fan activation.

Data Length: 4 bytes
Resolution: 0.05 hr/bit, 0 offset
Data Range: 0 to 210,554,060.75 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65211

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SPN 997 Trip Fan On Time Due to the A/C System

Total time the fan has been on due to the A/C system since the last trip reset. For the time to be accumulated against the A/C system, it is necessary that it be the first to request the fan activation or it be the only system requesting fan

Data Length: 4 bytes
Resolution: 0.05 hr/bit, 0 offset
Data Range: 0 to 210,554,060.75 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65211

SPN 998 Trip Distance on VSL

Total distance accumulated while the engine torque mode is road speed governing since the last trip reset.

Data Length: 4 bytes
Resolution: 0.125 km/bit, 0 offset
Data Range: 0 to 526,385,151.9 km Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65210

SPN 999 Trip Gear Down Distance

Total distance accumulated while the vehicle has operated in the gear which is one gear down from top gear and exceeds a calibrated minimum time (typically the time to shift the transmission) since the last trip reset.

Data Length: 4 bytes
Resolution: 0.125 km/bit, 0 offset
Data Range: 0 to 526,385,151.9 km Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65210

SPN 1000 Trip Distance in Top Gear

Total distance accumulated while the vehicle has operated in top gear for a calibrated minimum time since the last trip reset.

Data Length: 4 bytes
Resolution: 0.125 km/bit, 0 offset
Data Range: 0 to 526,385,151.9 km Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65210

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SPN 1001 Trip Drive Fuel Used

Total fuel consumed while the engine speed is greater than zero, vehicle speed is greater than or equal to 2 km/h, and neither the PTO or the remote PTO is controlling the engine power output, since the last trip reset.

NOTE—This parameter is intended for liquid fueled engines. See SPN 1007 for alternate resolution.

Data Length: 4 bytes
Resolution: 0.5 L/bit, 0 offset
Data Range: 0 to 2,105,540,607.5 L Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65209

SPN 1002 Trip PTO Moving Fuel Used

Total fuel consumed while the PTO or remote PTO is in the hold state, the engine speed is greater than zero, and vehicle speed is greater than or equal to 2 km/h, since the last trip reset.

NOTE—This parameter is intended for liquid fueled engines. See SPN 1008 for alternate resolution.

Data Length: 4 bytes
Resolution: 0.5 L/bit, 0 offset
Data Range: 0 to 2,105,540,607.5 L Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65209

SPN 1003 Trip PTO Non-moving Fuel Used

Total fuel consumed while the PTO or remote PTO is in the hold state, the engine speed is greater than zero, and vehicle speed is less than 2 km/h, since the last trip reset.

NOTE—This parameter is intended for liquid fueled engines. See SPN 1009 for alternate resolution.

Data Length: 4 bytes
Resolution: 0.5 L/bit, 0 offset
Data Range: 0 to 2,105,540,607.5 L Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65209

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SPN 1004 Trip Vehicle Idle Fuel Used

Total fuel consumed while neither the PTO or remote PTO is in the hold state, the engine speed is greater than zero, and vehicle speed is less than 2 km/h, since the last trip reset.

In marine applications, this parameter is defined as the total fuel consumed while the engine speed is greater than zero, and less than or equal to 50 RPM greater than low idle, since the last trip reset.

NOTE—This parameter is intended for liquid fueled engines. See SPN 1010 for alternate resolution.

Data Length: 4 bytes
Resolution: 0.5 L/bit, 0 offset
Data Range: 0 to 2,105,540,607.5 L Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65209

SPN 1005 Trip Cruise Fuel Used

Total fuel consumed while the engine is in the cruise hold state since the last trip reset. If both cruise control and VSL (vehicle speed limiter) are commanding the same amount of fuel, the cruise control is deemed the active torque mode and fuel will be accumulated in "trip cruise fuel used" parameter. If fuel commanded due to the accelerator pedal position is larger than fuel commanded by cruise control (e.g., accelerator override torque mode), the cruise control is not deemed the active torque mode and fuel will not be accumulated in the "trip cruise fuel used" parameter.

NOTE—This parameter is intended for liquid fueled engines. See SPN 1011 for alternate resolution.

Data Length: 4 bytes
Resolution: 0.5 L/bit, 0 offset
Data Range: 0 to 2,105,540,607.5 L Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65209

SPN 1006 Trip Drive Fuel Economy

Trip drive fuel economy is equal to the distance traveled by vehicle in the drive state (engine speed greater than zero, vehicle speed greater than or equal to 2 km/h, and neither the PTO or remote PTO is controlling engine power output) divided by trip drive fuel used (SPN 1001), since the last trip reset.

NOTE—This parameter is intended for liquid fueled engines. See SPN 1012 for alternate resolution.

Data Length: 2 bytes
Resolution: 1/512 km/L per bit, 0 offset
Data Range: 0 to 125.5 km/L Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65209

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SPN 1007 Trip Drive Fuel Used (Gaseous)

Total fuel consumed while the engine speed is greater than zero, vehicle speed is greater than or equal to 2 km/h, and neither the PTO or the remote PTO is controlling the engine power output, since the last trip reset.

NOTE—This parameter is intended for gaseous fueled engines. See SPN 1001 for alternate resolution.

Data Length: 4 bytes
Resolution: 0.5 kg/bit, 0 offset
Data Range: 0 to 2,105,540,607.5 kg Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65208

SPN 1008 Trip PTO Moving Fuel Used (Gaseous)

Total fuel consumed while the PTO or remote PTO is in the hold state, the engine speed is greater than zero, and vehicle speed is greater than or equal to 2 km/h, since the last trip reset.

NOTE—This parameter is intended for gaseous fueled engines. See SPN 1002 for alternate resolution.

Data Length: 4 bytes
Resolution: 0.5 kg/bit, 0 offset
Data Range: 0 to 2,105,540,607.5 kg Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65208

SPN 1009 Trip PTO Non-moving Fuel Used (Gaseous)

Total fuel consumed while the PTO or remote PTO is in the hold state, the engine speed is greater than zero, and vehicle speed is less than to 2 km/h, since the last trip reset.

NOTE—This parameter is intended for gaseous fueled engines. See SPN 1003 for alternate resolution.

Data Length: 4 bytes
Resolution: 0.5 kg/bit, 0 offset
Data Range: 0 to 2,105,540,607.5 kg Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65208

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SPN 1010 Trip Vehicle Idle Fuel Used (Gaseous)

Total fuel consumed while neither the PTO or remote PTO is active, the engine speed is greater than zero, and vehicle speed is less than to 2 km/h, since the last trip reset.

NOTE—This parameter is intended for gaseous fueled engines. See SPN 1004 for alternate resolution. Trip vehicle idle fuel while in fast idle (vehicle speed less than 2 km/h with engine speed greater than 700 rpm) shall be accumulated in the trip vehicle idle fuel category. All other fuel usage scenarios that do not fall directly in the categories defined shall be accumulated in trip drive fuel used.

Data Length: 4 bytes
Resolution: 0.5 kg/bit, 0 offset
Data Range: 0 to 2,105,540,607.5 kg Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65208

SPN 1011 Trip Cruise Fuel Used (Gaseous)

Total fuel consumed while the engine is in the cruise hold state since the last trip reset. If both cruise control and VSL (vehicle speed limiter) are commanding the same amount of fuel, the cruise control is deemed the active torque mode and fuel will be accumulated in "trip cruise fuel used" parameter. If fuel commanded due to the accelerator pedal position is larger than fuel commanded by cruise control (e.g., accelerator override torque mode), the cruise control is not deemed the active torque mode and fuel will not be accumulated in the "trip cruise fuel used" parameter.

NOTE—This parameter is intended for gaseous fueled engines. See SPN 1005 for alternate resolution.

Data Length: 4 bytes
Resolution: 0.5 kg/bit, 0 offset
Data Range: 0 to 2,105,540,607.5 kg Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65208

SPN 1012 Trip Drive Fuel Economy (Gaseous)

Trip drive fuel economy is equal to the distance traveled by vehicle in the drive state (engine speed greater than zero, vehicle speed greater than or equal to 2 km/h, and neither the PTO or remote PTO is controlling engine power output) divided by trip drive fuel used (SPN 1007), since the last trip reset.

NOTE—This parameter is intended for gaseous fueled engines. See SPN 1006 for alternate resolution.

Data Length: 2 bytes
Resolution: 1/512 km/kg per bit, 0 offset
Data Range: 0 to 125.5 km/kg Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65208

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SPN 1013 Trip Maximum Engine Speed

Maximum engine speed achieved since the last trip reset.

Data Length: 2 bytes
Resolution: 0.125 rpm/bit, 0 offset
Data Range: 0 to 8,031.875 rpm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65207

SPN 1014 Trip Average Engine Speed

Average speed of the engine since the last trip reset.

NOTE—Excludes ignition-on time without the engine speed above zero. Includes idle, PTO (moving and non-moving), and drive operation.

Data Length: 2 bytes
Resolution: 0.125 rpm/bit, 0 offset
Data Range: 0 to 8,031.875 rpm Operational Range: same as data range
Type: Measured
Supporting information: See Appendix D - SPN 1014
PGN 65207

SPN 1015 Trip Drive Average Load Factor

Average engine load factor while engine speed is greater than zero, vehicle speed is greater than or equal to 2 km/h, and both the PTO (moving/non-moving) and remote PTO are not in the hold state, since the last trip reset. Engine operation during cruise control operation is included.

In marine applications, this parameter is defined as the average engine load factor while engine speed is greater than zero, since last trip reset.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65207

SPN 1016 Total Drive Average Load Factor

Average engine load factor while engine speed is greater than zero, vehicle speed is greater than or equal to 2 km/h, and both the PTO (moving/non-moving) and remote PTO are not in the hold state, over the life of the engine. Engine operation during cruise control operation is included.

In marine applications, this parameter is defined as the average engine load factor while engine speed is greater than zero.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65207

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SPN 1017 Total Engine Cruise Time

Total time that the engine has operated in the cruise hold state, excluding time in accelerator override, over the life of the

Data Length: 4 bytes
Resolution: 0.05 hr/bit, 0 offset
Data Range: 0 to 210,554,060.75 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65207

SPN 1018 Trip Maximum Vehicle Speed

Maximum vehicle speed achieved while the engine speed is greater than zero and the accelerator pedal position (APS) is at a value greater than 0%, since the last trip reset.

Data Length: 2 bytes
Resolution: 1/256 km/h per bit, 0 offset
Data Range: 0 to 250.996 km/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65206

SPN 1019 Trip Cruise Distance

Total distance that the engine has operated in the cruise hold state, excluding time in accelerator override, since the last trip reset.

Data Length: 4 bytes
Resolution: 0.125 km/bit, 0 offset
Data Range: 0 to 526,385,151.9 km Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65206

SPN 1020 Trip Number of Hot Shutdowns

Total number of hot shutdowns since the last trip reset. A hot shutdown is based on operation at high load or high engine speed or for long operating periods without allowing the engine to cool sufficiently.

Data Length: 2 bytes
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 64,255 counts Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65205

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SPN 1021 Trip Number of Idle Shutdowns

Total number of times the engine has been shutdown due to idling too long (at normal idle or fast idle) since the last trip

Data Length: 2 bytes
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 64,255 counts Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65205

SPN 1022 Trip Number of Idle Shutdown Overrides

Total number of times an operator disables idle shutdown to prevent an engine shutdown, since the last trip reset.

Data Length: 2 bytes
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 64,255 counts Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65205

SPN 1023 Trip Sudden Decelerations

Total number of decelerations whenever the vehicle deceleration is more than XYZ km/h/sec (where XYZ is a calibratible threshold), since the last trip reset. A lengthy deceleration shall be counted as one sudden deceleration.

Data Length: 2 bytes
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 64,255 counts Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65205

SPN 1024 Trip Time in VSL

Total time accumulated when the engine has operated on the vehicle speed limiter (VSL) while not in the cruise hold state, since the last trip reset. The engine torque mode is equal to road speed governor during this operation.

Data Length: 4 bytes
Resolution: 0.05 hr/bit, 0 offset
Data Range: 0 to 210,554,060.75 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65204

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SPN 1025 Trip Time in Top Gear

Total time accumulated when the vehicle has operated in top gear for a calibrated minimum time, since the last trip reset.

Data Length: 4 bytes
Resolution: 0.05 hr/bit, 0 offset
Data Range: 0 to 210,554,060.75 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65204

SPN 1026 Trip Time in Gear Down

Total time accumulated when the vehicle has operated in one gear down from the top gear for a calibrated minimum time, since the last trip reset.

Data Length: 4 bytes
Resolution: 0.05 hr/bit, 0 offset
Data Range: 0 to 210,554,060.75 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65204

SPN 1027 Trip Time in Derate by Engine

Total time accumulated when the engine final fueling has been derated due to an engine protection algorithm, since the last

Data Length: 4 bytes
Resolution: 0.05 hr/bit, 0 offset
Data Range: 0 to 210,554,060.75 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65204

SPN 1028 Total Engine PTO Fuel Used

Total fuel used while the PTO or remote PTO is in the hold state and engine speed is above zero, over the life of the engine.

Data Length: 4 bytes
Resolution: 0.5 L/bit, 0 offset
Data Range: 0 to 2,105,540,607.5 L Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65203

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SPN 1029 Trip Average Fuel Rate

Average fuel rate, equal to trip fuel divided by trip time while the engine speed is above zero, since the last trip reset. This includes idle, PTO (both moving and non-moving) and drive operation but excludes ignition-on time while the engine speed is at zero rpm.

NOTE—This parameter is intended for liquid fueled engines. See SPN 1031 for alternate resolution.

Data Length: 2 bytes
Resolution: 0.05 L/h per bit, 0 offset
Data Range: 0 to 3,212.75 L/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65203

SPN 1030 Total Engine PTO Fuel Used (Gaseous)

Total fuel used while the PTO or remote PTO is in the hold state and engine speed is above zero, over the life of the engine.

Data Length: 4 bytes
Resolution: 0.5 kg/bit, 0 offset
Data Range: 0 to 2,105,540,607.5 kg Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65202

SPN 1031 Trip Average Fuel Rate (Gaseous)

Average fuel rate, equal to trip fuel divided by trip time while the engine speed is above zero, since the last trip reset. This includes idle, PTO (both moving and non-moving) and drive operation but excludes ignition-on time while the engine speed is at zero rpm.

NOTE—This parameter is intended for gaseous fueled engines. See SPN 1029 for alternate resolution.

Data Length: 2 bytes
Resolution: 0.05 kg/h per bit, 0 offset
Data Range: 0 to 3212.75 kg/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65202

SPN 1032 Total ECU Distance

Total distance accumulated over the life of the ECU. When the ECU is replaced this value shall be reset.

Data Length: 4 bytes
Resolution: 0.125 km/bit, 0 offset
Data Range: 0 to 526,385,151.9 km Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65201

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SPN 1033 Total ECU Run Time

Total time accumulated over the life of the ECU, from ignition switch ON to ignition switch OFF. When the ECU is replaced this value shall be reset.

Data Length: 4 bytes
Resolution: 0.05 hr/bit, 0 offset
Data Range: 0 to 210,554,060.75 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65201

SPN 1034 Trip Cruise Time

Total time accumulated while the engine is in the cruise hold state, excluding time in accelerator override, since the last trip
Data Length: 4 bytes
Resolution: 0.05 hr/bit, 0 offset
Data Range: 0 to 210,554,060.75 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65200

SPN 1035 Trip PTO Time

Total time accumulated while the engine is in the PTO or remote PTO hold state since the last trip reset.
Data Length: 4 bytes
Resolution: 0.05 hr/bit, 0 offset
Data Range: 0 to 210,554,060.75 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65200

SPN 1036 Trip Engine Running Time

Total time accumulated while the engine speed is greater than zero since the last trip reset. Note that time with the ignition switch on but engine speed at zero is not included.

Data Length: 4 bytes
Resolution: 0.05 hr/bit, 0 offset
Data Range: 0 to 210,554,060.75 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65200

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SPN 1037 Trip Idle Time

Total time accumulated while the engine speed is greater than zero, both the PTO and remote PTO is inactive, and the vehicle speed is less than 2 km/h, since the last trip reset.

In marine applications, this parameter is defined as the total time accumulated while the engine speed is greater than zero, and less than or equal to 50 RPM greater than low idle, since the last trip reset.

Data Length: 4 bytes
Resolution: 0.05 hr/bit, 0 offset
Data Range: 0 to 210,554,060.75 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65200

SPN 1038 Trip Air Compressor On Time

Total time that the air compressor is on and compressing air since the last trip reset.

Data Length: 4 bytes
Resolution: 0.05 hr/bit, 0 offset
Data Range: 0 to 210,554,060.75 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65200

SPN 1039 Trip Fuel (Gaseous)

Total fuel consumed (trip drive fuel + trip PTO moving fuel + trip PTO non-moving fuel + trip idle fuel) since the last trip

Data Length: 4 bytes
Resolution: 0.5 kg/bit, 0 offset
Data Range: 0 to 2,105,540,607.5 kg Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65199

SPN 1040 Total Fuel Used (Gaseous)

Total fuel consumed (trip drive fuel + trip PTO moving fuel + trip PTO non-moving fuel + trip idle fuel) over the life of the

Data Length: 4 bytes
Resolution: 0.5 kg/bit, 0 offset
Data Range: 0 to 2,105,540,607.5 kg Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65199

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SPN 1081 (R) Engine Wait to Start Lamp

Lamp signal which indicates that the engine is too cold to start and the operator should wait until the signal becomes inactive (turns off).

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65252

SPN 1082 Engine Coolant Load Increase

Status of an event, external to the engine, that may increase the nominal temperature of the engine coolant liquid.

00 No coolant load increase
01 Coolant load increase possible

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61440

SPN 1083 Auxiliary I/O Channel #1

Auxiliary channel of data (16 bit) read by the ECU. This data is in A/D counts and is manufacturer specific. It may be configured uniquely per application.

Data Length: 2 bytes
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 64,255 counts Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65241

SPN 1084 Auxiliary I/O Channel #2

Auxiliary channel of data (16 bit) read by the ECU. This data is in A/D counts and is manufacturer specific. It may be configured uniquely per application.

Data Length: 2 bytes
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 64,255 counts Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65241

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SPN 1085 Intended Retarder Percent Torque

Braking torque of retarder that the retarder is currently trying to achieve. This value takes into account all static limitations, but not the limitations due to the dynamic behavior of the retarder. This value, if unchanged over a certain time, can and will be reached by the actual retarder - percent torque (See SPN 520).

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: -125 to 0%
Type: Status
Supporting information: See Appendix D - SPN 1085
PGN 61440

SPN 1086 Parking and/or Trailer Air Pressure

The pneumatic pressure in the circuit or reservoir for the parking brake and/or the trailer supply.

Data Length: 1 byte
Resolution: 8 kPa/bit, 0 offset
Data Range: 0 to 2,000 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65198

SPN 1087 Service Brake Air Pressure Circuit #1

The pneumatic pressure in the service brake circuit or reservoir #1.

Data Length: 1 byte
Resolution: 8 kPa/bit, 0 offset
Data Range: 0 to 2,000 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65198

SPN 1088 Service Brake Air Pressure Circuit #2

The pneumatic pressure in the service brake circuit or reservoir #2.

Data Length: 1 byte
Resolution: 8 kPa/bit, 0 offset
Data Range: 0 to 2,000 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65198

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SPN 1089 Auxiliary Equipment Supply Pressure

The pneumatic pressure in the auxiliary circuit.

Data Length: 1 byte
Resolution: 8 kPa/bit, 0 offset
Data Range: 0 to 2,000 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65198

SPN 1090 Air Suspension Supply Pressure

The pneumatic pressure in the circuit for the electronically controlled air suspension system.

Data Length: 1 byte
Resolution: 8 kPa/bit, 0 offset
Data Range: 0 to 2,000 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65198

SPN 1091 Brake Application Pressure High Range, Front Axle, Left Wheel

The brake application pressure for the left wheel on the front axle.

Data Length: 1 byte
Resolution: 5 kPa/bit, 0 offset
Data Range: 0 to 1,250 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65197

SPN 1092 Brake Application Pressure High Range, Front Axle, Right Wheel

The brake application pressure for the right wheel on the front axle.

Data Length: 1 byte
Resolution: 5 kPa/bit, 0 offset
Data Range: 0 to 1,250 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65197

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SPN 1093 Brake Application Pressure High Range, Rear Axle #1, Left Wheel

The brake application pressure for the left wheel on the rear axle #1.

Data Length: 1 byte
Resolution: 5 kPa/bit, 0 offset
Data Range: 0 to 1,250 kPa
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65197

SPN 1094 Brake Application Pressure High Range, Rear Axle #1, Right Wheel

The brake application pressure for the right wheel on the rear axle #1.

Data Length: 1 byte
Resolution: 5 kPa/bit, 0 offset
Data Range: 0 to 1,250 kPa
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65197

SPN 1095 Brake Application Pressure High Range, Rear Axle #2, Left Wheel

The brake application pressure for the left wheel on the rear axle #2.

Data Length: 1 byte
Resolution: 5 kPa/bit, 0 offset
Data Range: 0 to 1,250 kPa
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65197

SPN 1096 Brake Application Pressure High Range, Rear Axle #2, Right Wheel

The brake application pressure for the right wheel on the rear axle #2.

Data Length: 1 byte
Resolution: 5 kPa/bit, 0 offset
Data Range: 0 to 1,250 kPa
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65197

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SPN 1097 Brake Application Pressure High Range, Rear Axle #3, Left Wheel

The brake application pressure for the left wheel on the rear axle #3.

Data Length: 1 byte
Resolution: 5 kPa/bit, 0 offset
Data Range: 0 to 1,250 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65197

SPN 1098 Brake Application Pressure High Range, Rear Axle #3, Right Wheel

The brake application pressure for the right wheel on the rear axle #3.

Data Length: 1 byte
Resolution: 5 kPa/bit, 0 offset
Data Range: 0 to 1,250 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65197

SPN 1099 Brake Lining Remaining, Front Axle, Left Wheel

The percentage of brake lining which can still be measured for the left wheel on the front axle. 100% represents new brake linings, 0% represents totally worn brake linings.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65196

SPN 1100 Brake Lining Remaining, Front Axle, Right Wheel

The percentage of brake lining which can still be measured for the right wheel on the front axle. 100% represents new brake linings, 0% represents totally worn brake linings.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65196

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SPN 1101 Brake Lining Remaining, Rear Axle #1, Left Wheel

The percentage of brake lining which can still be measured for the left wheel on the rear axle #1. 100% represents new brake linings, 0% represents totally worn brake linings.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65196

SPN 1102 Brake Lining Remaining, Rear Axle #1, Right Wheel

The percentage of brake lining which can still be measured for the right wheel on the rear axle #1. 100% represents new brake linings, 0% represents totally worn brake linings.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65196

SPN 1103 Brake Lining Remaining, Rear Axle #2, Left Wheel

The percentage of brake lining which can still be measured for the left wheel on the rear axle #2. 100% represents new brake linings, 0% represents totally worn brake linings.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65196

SPN 1104 Brake Lining Remaining, Rear Axle #2, Right Wheel

The percentage of brake lining which can still be measured for the right wheel on the rear axle #2. 100% represents new brake linings, 0% represents totally worn brake linings.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65196

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SPN 1105 Brake Lining Remaining, Rear Axle #3, Left Wheel

The percentage of brake lining which can still be measured for the left wheel on the rear axle #3. 100% represents new brake linings, 0% represents totally worn brake linings.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65196

SPN 1106 Brake Lining Remaining, Rear Axle #3, Right Wheel

The percentage of brake lining which can still be measured for the right wheel on the rear axle #3. 100% represents new brake linings, 0% represents totally worn brake linings.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65196

SPN 1107 Engine Protection System Timer State

Status signal which indicates the current mode of the engine protection system timer system. See Figure SPN1107_A.

00 - Inactive
01 - Active

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information: See Appendix D - SPN 1107
PGN 65252

SPN 1108 Engine Protection System Timer Override

Status signal which indicates the status of the override feature of the engine protection system timer. See Figure SPN1107_A.

00 – Inactive
01 – Active

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65252

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SPN 1109 Engine Protection System Approaching Shutdown

Status signal which indicates that engine shutdown is imminent. This engine protection signal can be a result of different systems failing, i.e., engine overheating. See Figure SPN1107_A.

00 - Not approaching
01 - Approaching

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65252

SPN 1110 Engine Protection System has Shutdown Engine

Status signal which indicates whether or not the engine protection system has shutdown the engine. See Figure SPN1107_A.

00 – No
01 – Yes

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65252

SPN 1111 Engine Protection System Configuration

Parameter which indicates the configuration of the engine shutdown system.

00 - Disabled in calibration
01 - Enabled in calibration

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65252

SPN 1113 Recommended Gear

The transmission calculates this gear continuously. In dangerous situations this gear may be selected to gain back vehicle control.

Data Length: 1 byte
Resolution: 1 gear value/bit, -125 offset
Data Range: -125 to 125 Operational Range: -125 to +125, negative values are reverse gears, positive values are forward gears, zero is neutral. 251 (0xFB) is park.
Type: Status
Supporting information:
PGN 65195

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SPN 1114 Lowest Possible Gear

The transmission calculates this gear continuously. Together with the highest possible gear (see SPN 1115), it enables a management computer to know the exact range of available gears.

Data Length: 1 byte
Resolution: 1 gear value/bit, -125 offset
Data Range: -125 to 125 Operational Range: -125 to +125, negative values are reverse gears, positive values are forward gears, zero is neutral. 251 (0xFB) is park.
Type: Status
Supporting information:
PGN 65195

SPN 1115 Highest Possible Gear

The transmission calculates this gear continuously. Together with the lowest possible gear (see SPN 1114), it enables a management computer to know the exact range of available gears.

Data Length: 1 byte
Resolution: 1 gear value/bit, -125 offset
Data Range: -125 to 125 Operational Range: -125 to +125, negative values are reverse gears, positive values are forward gears, zero is neutral. 251 (0xFB) is park.
Type: Status
Supporting information:
PGN 65195

SPN 1116 (R) Engine Gaseous Fuel Correction Factor

A correction to a predefined gaseous fuel energy (expressed in energy per unit volume) represented as a percentage. The actual fuel energy used to control the engine is the product of the gaseous fuel correction factor and the energy of the gas.

Data Length: 1 byte
Resolution: 1 %/bit, 0 offset
Data Range: 0 to 250 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65194

SPN 1117 (R) Engine Desired Rated Exhaust Oxygen

The desired amount of oxygen in the exhaust at rated conditions represented as a percentage by volume with respect to the total volume of exhaust gases leaving the engine.

Data Length: 2 bytes
Resolution: 0.0025 %/bit, 0 offset
Data Range: 0 to 160.6375 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65193

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SPN 1118 (R) Engine Desired Exhaust Oxygen

The desired amount of oxygen in the exhaust represented as a percentage by volume with respect to the total volume of exhaust gases leaving the engine.

Data Length: 2 bytes
Resolution: 0.0025 %/bit, 0 offset
Data Range: 0 to 160.6375 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65193

SPN 1119 (R) Engine Actual Exhaust Oxygen

The actual amount of oxygen in the exhaust represented as a percentage by volume with respect to the total volume of exhaust gases leaving the engine.

Data Length: 2 bytes
Resolution: 0.0025 %/bit, 0 offset
Data Range: 0 to 160.6375 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65193

SPN 1120 Articulation Angle

Angle of deflection of an articulated transit vehicle. A right turn is indicated with a positive angle and a left turn is indicated with a negative angle.

Data Length: 1 byte
Resolution: 1 deg/bit, -125 deg offset
Data Range: -125 to 125 deg Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65192

SPN 1121 EBS Brake Switch

Switch signal which indicates that the brake pedal is being pressed. The EBS brake switch is independent of the brake light switch and has no provisions for external connections.

00 - Brake pedal is not being pressed
01 - Brake pedal is being pressed
10 - Error
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61441

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SPN 1122 (R) Alternator Bearing 1 Temperature

Temperature of the bearing inside the alternator. Bearing 1 is the left or rear bearing.

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65191

SPN 1123 (R) Alternator Bearing 2 Temperature

Temperature of the bearing inside the alternator. Bearing 2 is the right or front bearing.

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65191

SPN 1124 (R) Alternator Winding 1 Temperature

Temperature of the windings inside the alternator.

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65191

SPN 1125 (R) Alternator Winding 2 Temperature

Temperature of the windings inside the alternator.

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65191

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SPN 1126 (R) Alternator Winding 3 Temperature

Temperature of the windings inside the alternator.

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65191

SPN 1127 (R) Engine Turbocharger 1 Boost Pressure

Gage pressure of air measured downstream of the compressor discharge side of the turbocharger. See also SPN 102 for alternate range and resolution. If there is only one boost pressure to report and the range and resolution in SPN 102 is adequate, then it should be used.

Data Length: 2 bytes
Resolution: 0.125 kPa/bit, 0 offset
Data Range: 0 to +8031.875 kPa (0 to Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65190

SPN 1128 (R) Engine Turbocharger 2 Boost Pressure

Gage pressure of air measured downstream of the compressor discharge side of the turbocharger. See also SPN 102 for alternate range and resolution. If there is only one boost pressure to report and the range and resolution in SPN 102 is adequate, then it should be used.

Data Length: 2 bytes
Resolution: 0.125 kPa/bit, 0 offset
Data Range: 0 to +8031.875 kPa (0 to Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65190

SPN 1129 (R) Engine Turbocharger 3 Boost Pressure

Gage pressure of air measured downstream of the compressor discharge side of the turbocharger. See also SPN 102 for alternate range and resolution. If there is only one boost pressure to report and the range and resolution in SPN 102 is adequate, then it should be used.

Data Length: 2 bytes
Resolution: 0.125 kPa/bit, 0 offset
Data Range: 0 to +8031.875 kPa (0 to Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65190

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SPN 1130 (R) Engine Turbocharger 4 Boost Pressure

Gage pressure of air measured downstream of the compressor discharge side of the turbocharger. See also SPN 102 for alternate range and resolution. If there is only one boost pressure to report and the range and resolution in SPN 102 is adequate, then it should be used.

Data Length: 2 bytes
Resolution: 0.125 kPa/bit, 0 offset
Data Range: 0 to +8031.875 kPa (0 to Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65190

SPN 1131 (R) Engine Intake Manifold 2 Temperature

Temperature of pre-combustion air found in intake manifold of engine air supply system.

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65189

SPN 1132 (R) Engine Intake Manifold 3 Temperature

Temperature of pre-combustion air found in intake manifold of engine air supply system.

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65189

SPN 1133 (R) Engine Intake Manifold 4 Temperature

Temperature of pre-combustion air found in intake manifold of engine air supply system.

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65189

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SPN 1134 Engine Intercooler Thermostat Opening

The current position of the thermostat used to regulate the temperature of the engine intercooler. A value of 0% represents the thermostat being completely closed and 100% represents the thermostat being completely open.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65262

SPN 1135 Engine Oil Temperature 2

Temperature of the engine lubricant.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65188

SPN 1136 Engine ECU Temperature

Temperature of the engine electronic control unit.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65188

SPN 1137 (R) Engine Exhaust Gas Port 1 Temperature

Temperature at the cylinder exhaust port of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65187

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SPN 1138 (R) Engine Exhaust Gas Port 2 Temperature

Temperature at the cylinder exhaust port of the engine.
Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65187

SPN 1139 (R) Engine Exhaust Gas Port 3 Temperature

Temperature at the cylinder exhaust port of the engine.
Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65187

SPN 1140 (R) Engine Exhaust Gas Port 4 Temperature

Temperature at the cylinder exhaust port of the engine.
Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65187

SPN 1141 (R) Engine Exhaust Gas Port 5 Temperature

Temperature at the cylinder exhaust port of the engine.
Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65186

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SPN 1142 (R) Engine Exhaust Gas Port 6 Temperature

Temperature at the cylinder exhaust port of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65186

SPN 1143 (R) Engine Exhaust Gas Port 7 Temperature

Temperature at the cylinder exhaust port of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65186

SPN 1144 (R) Engine Exhaust Gas Port 8 Temperature

Temperature at the cylinder exhaust port of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65186

SPN 1145 (R) Engine Exhaust Gas Port 9 Temperature

Temperature at the cylinder exhaust port of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65185

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SPN 1146 (R) Engine Exhaust Gas Port 10 Temperature

Temperature at the cylinder exhaust port of the engine.
Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65185

SPN 1147 (R) Engine Exhaust Gas Port 11 Temperature

Temperature at the cylinder exhaust port of the engine.
Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65185

SPN 1148 (R) Engine Exhaust Gas Port 12 Temperature

Temperature at the cylinder exhaust port of the engine.
Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65185

SPN 1149 (R) Engine Exhaust Gas Port 13 Temperature

Temperature at the cylinder exhaust port of the engine.
Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65184

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SPN 1150 (R) Engine Exhaust Gas Port 14 Temperature

Temperature at the cylinder exhaust port of the engine.
Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65184

SPN 1151 (R) Engine Exhaust Gas Port 15 Temperature

Temperature at the cylinder exhaust port of the engine.
Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65184

SPN 1152 (R) Engine Exhaust Gas Port 16 Temperature

Temperature at the cylinder exhaust port of the engine.
Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65184

SPN 1153 (R) Engine Exhaust Gas Port 17 Temperature

Temperature at the cylinder exhaust port of the engine.
Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65183

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SPN 1154 (R) Engine Exhaust Gas Port 18 Temperature

Temperature at the cylinder exhaust port of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65183

SPN 1155 (R) Engine Exhaust Gas Port 19 Temperature

Temperature at the cylinder exhaust port of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65183

SPN 1156 (R) Engine Exhaust Gas Port 20 Temperature

Temperature at the cylinder exhaust port of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65183

SPN 1157 (R) Engine Main Bearing 1 Temperature

Temperature of the main bearing which supports the crankshaft of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65182

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SPN 1158 (R) Engine Main Bearing 2 Temperature

Temperature of the main bearing which supports the crankshaft of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65182

SPN 1159 (R) Engine Main Bearing 3 Temperature

Temperature of the main bearing which supports the crankshaft of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65182

SPN 1160 (R) Engine Main Bearing 4 Temperature

Temperature of the main bearing which supports the crankshaft of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65182

SPN 1161 (R) Engine Main Bearing 5 Temperature

Temperature of the main bearing which supports the crankshaft of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65181

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SPN 1162 (R) Engine Main Bearing 6 Temperature

Temperature of the main bearing which supports the crankshaft of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65181

SPN 1163 (R) Engine Main Bearing 7 Temperature

Temperature of the main bearing which supports the crankshaft of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65181

SPN 1164 (R) Engine Main Bearing 8 Temperature

Temperature of the main bearing which supports the crankshaft of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65181

SPN 1165 (R) Engine Main Bearing 9 Temperature

Temperature of the main bearing which supports the crankshaft of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65180

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SPN 1166 (R) Engine Main Bearing 10 Temperature

Temperature of the main bearing which supports the crankshaft of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65180

SPN 1167 (R) Engine Main Bearing 11 Temperature

Temperature of the main bearing which supports the crankshaft of the engine.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65180

SPN 1168 (R) Engine Turbocharger Lube Oil Pressure 2

Gage pressure of oil in turbocharger lubrication system.

Data Length: 1 byte
Resolution: 4 kPa/bit, 0 offset
Data Range: 0 to 1000 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65179

SPN 1169 (R) Engine Turbocharger 2 Speed

Rotational velocity of rotor in the turbocharger.

Data Length: 2 bytes
Resolution: 4 rpm/bit, 0 offset
Data Range: 0 to 257,020 rpm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65179

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SPN 1170 (R) Engine Turbocharger 3 Speed

Rotational velocity of rotor in the turbocharger.

Data Length: 2 bytes
Resolution: 4 rpm/bit, 0 offset
Data Range: 0 to 257,020 rpm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65179

SPN 1171 (R) Engine Turbocharger 4 Speed

Rotational velocity of rotor in the turbocharger.

Data Length: 2 bytes
Resolution: 4 rpm/bit, 0 offset
Data Range: 0 to 257,020 rpm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65179

SPN 1172 (R) Engine Turbocharger 1 Compressor Inlet Temperature

Temperature of the air entering the compressor side of the turbocharger.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65178

SPN 1173 (R) Engine Turbocharger 2 Compressor Inlet Temperature

Temperature of the air entering the compressor side of the turbocharger.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65178

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SPN 1174 (R) Engine Turbocharger 3 Compressor Inlet Temperature

Temperature of the air entering the compressor side of the turbocharger.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65178

SPN 1175 (R) Engine Turbocharger 4 Compressor Inlet Temperature

Temperature of the air entering the compressor side of the turbocharger.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65178

SPN 1176 (R) Engine Turbocharger 1 Compressor Inlet Pressure

Gage pressure of the air entering the compressor side of the turbocharger.

Data Length: 2 bytes
Resolution: 1/128 kPa/bit, -250 kPa offset
Data Range: -250 kPa TO 251.99 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65177

SPN 1177 (R) Engine Turbocharger 2 Compressor Inlet Pressure

Gage pressure of the air entering the compressor side of the turbocharger.

Data Length: 2 bytes
Resolution: 1/128 kPa/bit, -250 kPa offset
Data Range: -250 kPa TO 251.99 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65177

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SPN 1178 (R) Engine Turbocharger 3 Compressor Inlet Pressure

Gage pressure of the air entering the compressor side of the turbocharger.

Data Length: 2 bytes
Resolution: 1/128 kPa/bit, -250 kPa offset
Data Range: -250 kPa TO 251.99 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65177

SPN 1179 (R) Engine Turbocharger 4 Compressor Inlet Pressure

Gage pressure of the air entering the compressor side of the turbocharger.

Data Length: 2 bytes
Resolution: 1/128 kPa/bit, -250 kPa offset
Data Range: -250 kPa TO 251.99 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65177

SPN 1180 (R) Engine Turbocharger 1 Turbine Inlet Temperature

Temperature of the combustion by-products entering the turbine side of the turbocharger.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65176

SPN 1181 (R) Engine Turbocharger 2 Turbine Inlet Temperature

Temperature of the combustion by-products entering the turbine side of the turbocharger.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65176

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SPN 1182 (R) Engine Turbocharger 3 Turbine Inlet Temperature

Temperature of the combustion by-products entering the turbine side of the turbocharger.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65176

SPN 1183 (R) Engine Turbocharger 4 Turbine Inlet Temperature

Temperature of the combustion by-products entering the turbine side of the turbocharger.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65176

SPN 1184 (R) Engine Turbocharger 1 Turbine Outlet Temperature

Temperature of the combustion by-products exiting the turbine side of the turbocharger.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65175

SPN 1185 (R) Engine Turbocharger 2 Turbine Outlet Temperature

Temperature of the combustion by-products exiting the turbine side of the turbocharger.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65175

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SPN 1186 (R) Engine Turbocharger 3 Turbine Outlet Temperature

Temperature of the combustion by-products exiting the turbine side of the turbocharger.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65175

SPN 1187 (R) Engine Turbocharger 4 Turbine Outlet Temperature

Temperature of the combustion by-products exiting the turbine side of the turbocharger.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65175

SPN 1188 (R) Engine Turbocharger 1 Wastegate Drive

Position of the wastegate drive. A value of 0% represents fully closed and a value of 100% represents fully open.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65174

SPN 1189 (R) Engine Turbocharger 2 Wastegate Drive

Position of the wastegate drive. A value of 0% represents fully closed and a value of 100% represents fully open.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65174

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SPN 1190 (R) Engine Turbocharger 3 Wastegate Drive

Position of the wastegate drive. A value of 0% represents fully closed and a value of 100% represents fully open.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 %
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65174

SPN 1191 (R) Engine Turbocharger 4 Wastegate Drive

Position of the wastegate drive. A value of 0% represents fully closed and a value of 100% represents fully open.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 %
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65174

SPN 1192 (R) Engine Turbocharger Wastegate Actuator Control Air Pressure

Gage pressure of the air used to control the actuator which opens and closes the wastegate valve.

Data Length: 1 byte
Resolution: 4 kPa/bit, 0 offset
Data Range: 0 to 1000 kPa
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65174

SPN 1193 Engine Operation Time Since Rebuild

The time in engine operation since the last engine rebuild.

Data Length: 4 bytes
Resolution: 1 s/bit, 0 offset
Data Range: 0 to 4,211,081,215 s
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65173

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SPN 1194 Anti-theft Encryption Seed Present Indicator

Indicates the presence of the encryption seed random number.

00 - Random number is not present
01 - Random number is present

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 56320

SPN 1195 Anti-theft Password Valid Indicator

Indicates the presence of a validated password.

00 - Password is not a validated password
01 - Password is a validated password

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 56320

SPN 1196 Anti-theft Component Status States

Indicates whether or not the component can be started.

00 Unlocked
01 Locked
10 Blocked
11 Not defined

00b - Unlocked = This state indicates that the component can be started without the end user being required to enter a password.

01b - Locked = This state indicates that the component can NOT be started (i.e., Unlocked) without the end user being required to enter a password.

10b - Blocked = This state indicates that a Lock or Unlock command cannot be executed because some other algorithm or command of higher priority is commanding differently.

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 56320

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SPN 1197 Anti-theft Modify Password States

This parameter is used to indicate whether a password request was successfully performed, or if the request could not be perform due to system constraints or if the request was not a valid request.

00 Ok
01 Full_of_Passwords
10 Empty_of_Passwords
11 Not_valid

00b - Ok = This state indicates that the request was successfully performed.

01b - Full_Of_Passwords = This state indicates that the component can NOT store any additional passwords in its memory.

10b - Empty_Of_Passwords = This state indicates that the component would be empty of passwords (an unacceptable condition) if the password under which the end user is logged in, is deleted. Thus the delete password command is not successfully executed.

Note that if the Delete_Password command is sent to a component that does not currently have a password the Empty_Of_Passwords state indicator shall be used.

11b - Not_Valid = This state indicates that the request is not a valid one.

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 56320

SPN 1198 Anti-theft Random Number

A seven byte random numeric code provided by the component in response to an anti-theft request. This parameter is sent as a numeric value utilizing the full range of 0 to 0xFFFFFFFFFFFFFF. The most significant byte is sent first, not following the rules of Table 1.

Data Length: 7 bytes
Resolution: ASCII, 0 offset
Data Range: 0 to 255 per byte Operational Range: same as data range
Type: Status
Supporting information:
PGN 56320

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SPN 1199 Anti-theft Encryption Indicator States

This parameter is used to indicate if a random number seed is being requested, or if an encrypted password is being provided to the component.

00 Encryption_Seed_Request
01 Encrypted_Code_Present
10 Not defined
11 Not_Available

00b - Encryption_Seed_Request = This state represents a request to the component to provide a random number seed.

01b - Encrypted_Code_Present = This state is used to indicate that an encrypted password is being provided to the component.

11b - Not_Available = This state is used to indicate that a random number is NOT being requested nor is an encrypted password being provided to the component.

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 56576

SPN 1200 Anti-theft Desired Exit Mode States

This parameter is used to specify the desired triggers that are to be used by the component in deciding when to transition to the Locked state.

00 Lock_Upon_Operator_Request
01 Lock_When_Key_Off
10 Not defined
11 Not_Available

00b - Lock_Upon_Operator_Request—This state is used to indicate that the end user would have to manually enter a password to Lock the engine.

01b - Lock_When_Keyoff—This state is used to indicate that the component would automatically transition to the Locked state when the end user turns off the engine (i.e. without the end user being required to manually enter the password).

11b - Not_Available—This state is indicates that the option is not selectable or changeable by the operator via using current tool.

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 56576

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SPN 1201 Anti-theft Command States

This parameter is used to identify the specific requests being sent to the component.

000 Add_Password
001 Delete_Password
010 Change_Password
011 Lock_or_Unlock
100 Check_Status
101 Login
110-111 Not defined

000b - Add_Password—This state represents a request to the component to add a password to the list of passwords that the component has stored as valid codes. This command will not be performed if the component has already stored, the maximum number of passwords that it is capable of storing. The Login command must precede this command.

001b - Delete_Password—This state represents a request to the component to delete the password (the same one used when the end-user logged in). See SPN 1197 for limitations.

010b - Change_Password—This state represents a request to the component to change the password (the same one that the end-user logged in with) to a different password, which is to be specified by the end user. The Login command must precede this command.

011b - Lock_Or_Unlock—This state represents a request to the component to change from the Locked state to the Unlocked state or from the Unlocked state to the Locked state.

100b - Check_Status—This state represents a request to check to see if the component is in the Locked or Unlocked state.

101b - Login—This state represents a request to validate the end user, before performing commands such as Add_Password and Change_Password.

Data Length:	3 bits		
Resolution:	8 states/3 bit, 0 offset		
Data Range:	0 to 7	Operational Range:	same as data range
Type:	Status		
Supporting information:			
PGN	56576		

SPN 1202 Anti-theft Password Representation

This parameter is the seven byte numeric code (i.e., 'encrypted password' or 'key') that is generated based on the encryption algorithm, the password supplied by the end user, and the random number seed given by the component. This parameter is sent as a numeric value utilizing the full range of 0 to 0xFFFFFFFFFFFFFF. The most significant byte is sent first, not following the rules of Table 1.

Data Length:	7 bytes		
Resolution:	ASCII, 0 offset		
Data Range:	0 to 255 per byte	Operational Range:	same as data range
Type:	Status		
Supporting information:			
PGN	56576		

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SPN 1203 Engine Auxiliary Coolant Pressure

Gage pressure of coolant found in the intercooler which is located after the turbocharger.

Data Length: 1 byte
Resolution: 4 kPa/bit, 0 offset
Data Range: 0 to 1000 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65172

SPN 1204 Electrical Load

Electrical power delivered by the engine to the electrical system connected to the generator.

Data Length: 2 bytes
Resolution: 0.5 kW/bit, 0 offset
Data Range: 0 to 32,127.5 kW Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65171

SPN 1205 Safety Wire Status

Status signal which indicates that the safety wire has been activated. When the safety wire is activated, the engine will not operate. This is used for maintenance purposes.

00 - Safety wire has not been activated
01 - Safety wire has been activated

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65171

SPN 1206 Turning Gear Engaged

Status signal which indicates that the turning gear is engaged. The turning gear is used to turn the flywheel/crankshaft, for maintenance purposes, while the engine is not running.

00 - Turning gear is not engaged
01 - Turning gear is engaged

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65171

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SPN 1207 Engine ECU Temperature (OBSOLETE use SPN 1136)

Temperature of the engine electronic control unit.

(21, 1207 are not to be used - obsolete)

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN

SPN 1208 (R) Engine Pre-filter Oil Pressure

Gage pressure of the engine oil before the oil reaches the oil filter.

Data Length: 1 byte
Resolution: 4 kPa/bit, 0 offset
Data Range: 0 to 1000 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65170

SPN 1209 (R) Engine Exhaust Gas Pressure

Gage pressure of the exhaust gasses as measured at the turbine inlet of the turbocharger.

Data Length: 2 bytes
Resolution: 1/128 kPa/bit, -250 kPa offset
Data Range: -250 kPa TO 251.99 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65170

SPN 1210 (R) Engine Fuel Rack Position

Measured position of the engine fuel rack. A value of 0% rack represents no fueling and a value of 100% rack represents maximum fueling.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65170

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SPN 1211 Engine Build Hours Reset

Command signal used to reset the engine rebuild hours.

00 Do not reset
01 Reset
11 Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 56832

SPN 1212 Engine Auxiliary Coolant Temperature

Temperature of coolant found in the intercooler which is located after the turbocharger.

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65172

SPN 1237 Engine Shutdown Override Switch

Switch signal which indicates the position of the engine shutdown override switch. This switch function allows the operator to override an impending engine shutdown.

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65265

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SPN 1238 Traction Control Override Switch

Switch signal which indicates the position of the traction control override switch. The traction control override signal disables the automatic traction control function allowing the wheels to spin.

00- off
01- on
10 - Error
11 - Not available or not installed

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61441

SPN 1239 (R) Engine Fuel Leakage 1

Status signal which indicates fuel leakage in the fuel rail of the engine. The location can be either before or after the fuel pump.

00 - no leakage detected
01 – leakage detected

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65169

SPN 1240 (R) Engine Fuel Leakage 2

Status signal which indicates fuel leakage in the fuel rail of the engine. The location can be either before or after the fuel pump.

00 - no leakage detected
01 – leakage detected

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65169

SPN 1241 (R) Engine Mass Flow (Gaseous)

Mass flow of natural gas to the engine.

Data Length: 2 bytes
Resolution: 0.05 kg/h per bit, 0 offset
Data Range: 0 to 3212.75 kg/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65170

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SPN 1242 Instantaneous Estimated Brake Power

Estimate of the power developed by the engine.

Data Length: 2 bytes
Resolution: 0.5 kW/bit, 0 offset
Data Range: 0 to 32,127.5 kW Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65170

SPN 1243 ABS Fully Operational

Signal which indicates whether an ABS system is fully operational or whether its functionality is reduced by a defect or by an intended action (e.g., by activation of an ABS-off-road switch or during special diagnostic procedures). There are cases where the signal is necessary to fulfill legal regulations for special applications (e.g., switching off integrated retarders).

00 - Not Fully Operational
01 - Fully Operational
10 - Reserved
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61441

SPN 1246 (R) Number of Engine Torque History Records

Number of torque history records contained in the engine torque history PGN. A value of 0 is broadcast if no torque history records are stored in the ECU.

Data Length: 1 byte
Resolution: 1 record/bit, 0 offset
Data Range: 0 to 250 records Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65168

SPN 1247 Engine Power

Advertised engine power capability. Advertised power is what a customer will find on a sales sheet for an engine with a certain calibration.

Data Length: 2 bytes
Resolution: 0.5 kW/bit, 0 offset
Data Range: 0 to 32,127.5 kW Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65168

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SPN 1248 (R) Engine Peak Torque 1

Maximum torque output of the current ECU calibration when the engine operates on torque curve 1. For calibrations that support two torque curves, this parameter shall be assigned the value of the lower curve. For calibrations that support only one curve, this parameter should be used.

Data Length: 2 bytes
Resolution: 1 Nm/bit, 0 offset
Data Range: 0 to 64,255 Nm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65168

SPN 1249 (R) Engine Peak Torque 2

Maximum torque output of the current ECU calibration when the engine operates on torque curve 2. For calibrations that support two torque curves, this parameter shall be assigned the value of the higher curve. For calibrations that support only one curve, this parameter should to set to "not available".

Data Length: 2 bytes
Resolution: 1 Nm/bit, 0 offset
Data Range: 0 to 64,255 Nm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65168

SPN 1250 Calibration Record Start Month

Calendar month timestamp when an ECU record was established.

NOTE - A value of 0 for the month is null. The value 1 identifies January; 2 identifies February; etc.

Data Length: 1 byte
Resolution: 1 month/bit, 0 offset
Data Range: 0 to 250 months Operational Range: 1 to 12 month
Type: Measured
Supporting information:
PGN 65168

SPN 1251 Calibration Record Start Day

Calendar day timestamp when an ECU record was established.

NOTE - A value of 0 for the date is null. The values 1, 2, 3, and 4 are used to identify the first day of the month; 5, 6, 7, and 8 identify the second day of the month; etc.

Data Length: 1 byte
Resolution: 0.25 days/bit, 0 offset
Data Range: 0 to 62.5 days Operational Range: 0.25 to 31.75 day
Type: Measured
Supporting information:
PGN 65168

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SPN 1252 Calibration Record Start Year

Calendar year timestamp when an ECU record was established.

NOTE - A value of 0 for the year identifies the year 1985; a value of 1 identifies 1986; etc.

Data Length: 1 byte
Resolution: 1 year/bit, 1985 years offset
Data Range: 1985 to 2235 years Operational Range: 1985 to 2235 year
Type: Measured
Supporting information:
PGN 65168

SPN 1253 Calibration Record Duration Time

Duration in hours for which the engine operated in the conditions captured in the current record.

Data Length: 4 bytes
Resolution: 0.05 hr/bit, 0 offset
Data Range: 0 to 210,554,060.75 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65168

SPN 1254 Torque Limiting Feature Status

Status of an ECU feature which limits the torque output of the engine.

00 - Disabled
01 - Enabled

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65168

SPN 1255 Transmission Gear Ratio 1

Gear ratio value stored in the ECU that is used to define a range of transmission gears for which a limit is applied to the engine output torque. Transmission gear ratio 1 should be the numerically highest transmission gear ratio breakpoint that defines ratio ranges for torque limits.

Data Length: 2 bytes
Resolution: 0.01/bit, 0 offset
Data Range: 0 to 642.55 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65168

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SPN 1256 Engine Torque Limit 1, Transmission

Limit applied to the engine output torque during vehicle operation in transmission gear ratios numerically greater than transmission gear ratio 1 (see SPN 1255).

Data Length: 2 bytes
Resolution: 1 Nm/bit, 0 offset
Data Range: 0 to 64,255 Nm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65168

SPN 1257 Transmission Gear Ratio 2

Gear ratio value stored in the ECU that is used to define a range of transmission gears for which a limit is applied to the engine output torque. Transmission gear ratio 2 should be the numerically highest transmission gear ratio breakpoint less than transmission gear ratio 1 (see SPN 1255) that defines ratio ranges for torque limits.

Data Length: 2 bytes
Resolution: 0.01/bit, 0 offset
Data Range: 0 to 642.55 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65168

SPN 1258 Engine Torque Limit 2, Transmission

Limit applied to the engine output torque during vehicle operation in transmission gear ratios numerically less than or equal to transmission gear ratio 1 (see SPN 1255) and numerically greater than transmission gear ratio 2 (see.SPN 1257). For example, with transmission gear ratio 1 equal to 12.0:1 and transmission gear ratio 2 equal to 5.0:1, vehicle operation in a transmission gear with a ratio of 6.0:1 will result in the application of engine torque limit 2, transmission.

Data Length: 2 bytes
Resolution: 1 Nm/bit, 0 offset
Data Range: 0 to 64,255 Nm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65168

SPN 1259 Transmission Gear Ratio 3

Gear ratio value stored in the ECU that is used to define a range of transmission gears for which a limit is applied to the engine output torque. Transmission gear ratio 3 should be the numerically highest transmission gear ratio breakpoint less than transmission gear ratio 2 (see SPN 1257) that defines ratio ranges for torque limits.

Data Length: 2 bytes
Resolution: 0.01/bit, 0 offset
Data Range: 0 to 642.55 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65168

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SPN 1260 Engine Torque Limit 3, Transmission

Limit applied to the engine output torque during vehicle operation in transmission gear ratios numerically less than or equal to transmission gear ratio 2 (see SPN 1257) and numerically greater than transmission gear ratio 3 (see.SPN 1259). For example, with transmission gear ratio 2 equal to 5.0:1 and transmission gear ratio 3 equal to 2.0:1, vehicle operation in a transmission gear with a ratio of 3.0:1 will result in the application of engine torque limit 3, transmission.

Data Length: 2 bytes
Resolution: 1 Nm/bit, 0 offset
Data Range: 0 to 64,255 Nm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65168

SPN 1261 Engine Torque Limit 4, Transmission

Limit applied to the engine output torque during vehicle operation in transmission gear ratios numerically less than or equal to transmission gear ratio 3 (see SPN 1259).

Data Length: 2 bytes
Resolution: 1 Nm/bit, 0 offset
Data Range: 0 to 64,255 Nm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65168

SPN 1262 Engine Torque Limit 5, Switch

Limit applied to the engine output torque based on activation of an ECU switch input.

Data Length: 2 bytes
Resolution: 1 Nm/bit, 0 offset
Data Range: 0 to 64,255 Nm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65168

SPN 1263 Engine Torque Limit 6, Axle Input

Limit applied to the engine output torque based on the maximum allowable axle input torque. Axle input torque is calculated as the current engine torque output multiplied by the transmission gear ratio.

Data Length: 2 bytes
Resolution: 2 Nm/bit, 0 offset
Data Range: 0 to 128,510 Nm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65168

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SPN 1264 (R) Engine Extended Crankcase Blow-by Pressure - duplicate (see SPN 22)

Differential crankcase blow-by pressure as measured through a tube with a venturi.

(1264 not to be used – obsolete)

Data Length: 1 byte
Resolution: 0.05 kPa/bit, 0 offset
Data Range: 0 to 12.5 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN

SPN 1320 (R) Engine External Shutdown Air Supply Pressure

Pressure of the air used to shut off the fuel supply to the engine.

Data Length: 2 bytes
Resolution: 0.5 kPa/bit, 0 offset
Data Range: 0 to 32,127.5 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65167

SPN 1349 (R) Engine Injector Metering Rail 2 Pressure

The gage pressure of fuel in the metering rail #2 as delivered from the supply pump to the injector metering inlet. See Figure SPN1381_A for fuel system related parameters. Although the figure does not show rail #2 it does show the relationship of rail pressure to other signals.

Data Length: 2 bytes
Resolution: 1/256 MPa/bit, 0 offset
Data Range: 0 to 251 Mpa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65243

SPN 1350 Time Since Last Service

The vehicle operation time since the last service was performed. The type of service information is identified by the service component identification number.

Data Length: 2 bytes
Resolution: 1 hr/bit, -32,127 hr offset
Data Range: -32,127 to 32,128 hr Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65166

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SPN 1376 Battery 2 Potential (Voltage) (duplicate - see also SPN 444)

The voltage for isolated battery #2.

Data Length: 2 bytes
Resolution: 0.05 V/bit, 0 offset
Data Range: 0 to 3212.75 V Operational Range: same as data range
Type: Measured
Supporting information:
PGN

SPN 1377 (R) Engine Synchronization Switch

This is the On/Off operation of the Multiple Unit Synchronization functionality. When it is enabled (i.e. On) the master engine will synchronize one or more slave engines to operate at the same speed. This switch position indicates whether this feature is disabled (off) or enabled (on).

00 Functionality is disabled (off)
01 Functionality is enabled (on)
10 Error
11 Not available or Unused

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64971

SPN 1379 Service Component Identification

Identification of component needing service. See Table SPN911_A.

Data Length: 1 byte
Resolution: 1 ID/bit, 0 offset
Data Range: 0 to 250 ID Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65166

SPN 1380 Engine Oil Level Remote Reservoir

Ratio of current volume of engine oil in a remote reservoir to the maximum required volume. If a single switch (on/off) is used, 20% and 100% respectively will be used where 100% means no oil needs to be added and 20% means oil needs to be added. If two switches are used, 20%, 50%, and 100% will be used where 20% indicates the oil is critically low, 50% indicates the oil level is low, and 100% means no oil needs to be added. For continuous sensors, the actual measured

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65130

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SPN 1381 (R) Engine Fuel Supply Pump Inlet Pressure

Absolute pressure of fuel at the fuel supply pump inlet. See Figures SPN16_A & SPN16_B

Data Length: 1 byte
Resolution: 2 kPa/bit, 0 offset
Data Range: 0 to 500 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65130

SPN 1382 (R) Engine Fuel Filter (suction side) Differential Pressure

Differential pressure measured across the fuel filter located between the fuel tank and the supply pump. See Figures SPN16_A and SPN16_B.

Data Length: 1 byte
Resolution: 2 kPa/bit, 0 offset
Data Range: 0 to 500 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65130

SPN 1385 Auxiliary Temperature #1 (duplicate see also SPN 441)

Temperature measured by auxiliary temperature sensor #1 or #2. Not to be used in place of existing SPNs.

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN

SPN 1386 Auxiliary Temperature #2 (duplicate see also SPN 442)

Temperature measured by auxiliary temperature sensor #1 or #2. Not to be used in place of existing SPNs.

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN

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SPN 1387 Auxiliary Pressure #1

Pressure measured by auxiliary pressure sensor #1. Not to be used in place of existing SPNs.

Data Length: 1 byte
Resolution: 16 kPa/bit, 0 offset
Data Range: 0 to 4000 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65164

SPN 1388 Auxiliary Pressure #2

Pressure measured by auxiliary pressure sensor #2. Not to be used in place of existing SPNs.

Data Length: 1 byte
Resolution: 16 kPa/bit, 0 offset
Data Range: 0 to 4000 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65164

SPN 1389 (R) Engine Fuel Specific Gravity

This parameter conveys the specific gravity of the gaseous fuel being used by the engine. The specific gravity of the fuel can then be used to compute the density of the fuel.

Data Length: 2 bytes
Resolution: 0.0001/bit, 0 offset
Data Range: 0 to 6.4255 Operational Range: 0 to 2.0000
Type: Status
Supporting information:
PGN 65202

SPN 1390 (R) Engine Fuel Valve Inlet Absolute Pressure

The absolute pressure at the inlet of the gaseous fuel valve.

Data Length: 2 bytes
Resolution: 0.1 kPa/bit, 0 offset
Data Range: 0 to 6,425.5 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65163

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SPN 1391 (R) Engine Fuel Valve Differential Pressure

The differential pressure between the inlet and the outlet of a gaseous fuel valve.

Data Length: 2 bytes
Resolution: 0.1 kPa/bit, 0 offset
Data Range: 0 to 6,425.5 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65163

SPN 1392 (R) Engine Air to Fuel Differential Pressure

The differential pressure between the gaseous fuel and the air intake manifold.

Data Length: 2 bytes
Resolution: 0.1 kPa/bit, 0 offset
Data Range: 0 to 6,425.5 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65163

SPN 1393 (R) Engine Cylinder #1 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65160

SPN 1394 (R) Engine Cylinder #2 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65160

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SPN 1395 (R) Engine Cylinder #3 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65160

SPN 1396 (R) Engine Cylinder #4 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65160

SPN 1397 (R) Engine Cylinder #5 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65160

SPN 1398 (R) Engine Cylinder #6 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65160

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SPN 1399 (R) Engine Cylinder #7 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65160

SPN 1400 (R) Engine Cylinder #8 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65160

SPN 1401 (R) Engine Cylinder #9 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65161

SPN 1402 (R) Engine Cylinder #10 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65161

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SPN 1403 (R) Engine Cylinder #11 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65161

SPN 1404 (R) Engine Cylinder #12 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65161

SPN 1405 (R) Engine Cylinder #13 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65161

SPN 1406 (R) Engine Cylinder #14 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65161

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SPN 1407 (R) Engine Cylinder #15 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65161

SPN 1408 (R) Engine Cylinder #16 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65161

SPN 1409 (R) Engine Cylinder #17 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65162

SPN 1410 (R) Engine Cylinder #18 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65162

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SPN 1411 (R) Engine Cylinder #19 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65162

SPN 1412 (R) Engine Cylinder #20 Ignition Transformer Secondary Output

This parameter indicates the relative intensity of the secondary output voltage of the ignition transformer.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65162

SPN 1413 (R) Engine Cylinder #1 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65154

SPN 1414 (R) Engine Cylinder #2 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65154

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SPN 1415 (R) Engine Cylinder #3 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65154

SPN 1416 (R) Engine Cylinder #4 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65154

SPN 1417 (R) Engine Cylinder #5 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65155

SPN 1418 (R) Engine Cylinder #6 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65155

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SPN 1419 (R) Engine Cylinder #7 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65155

SPN 1420 (R) Engine Cylinder #8 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65155

SPN 1421 (R) Engine Cylinder #9 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65156

SPN 1422 (R) Engine Cylinder #10 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65156

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SPN 1423 (R) Engine Cylinder #11 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg
Operational Range: same as data range
Type: Status
Supporting information:
PGN 65156

SPN 1424 (R) Engine Cylinder #12 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg
Operational Range: same as data range
Type: Status
Supporting information:
PGN 65156

SPN 1425 (R) Engine Cylinder #13 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg
Operational Range: same as data range
Type: Status
Supporting information:
PGN 65157

SPN 1426 (R) Engine Cylinder #14 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg
Operational Range: same as data range
Type: Status
Supporting information:
PGN 65157

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SPN 1427 (R) Engine Cylinder #15 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65157

SPN 1428 (R) Engine Cylinder #16 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65157

SPN 1429 (R) Engine Cylinder #17 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65158

SPN 1430 (R) Engine Cylinder #18 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65158

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SPN 1431 (R) Engine Cylinder #19 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65158

SPN 1432 (R) Engine Cylinder #20 Ignition Timing

The ignition timing of the cylinder.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65158

SPN 1433 (R) Engine Desired Ignition Timing #1

A programmable timing value specific to the engine's application. Factors affecting this value include both fuel type and the nature of the load being driven.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65159

SPN 1434 (R) Engine Desired Ignition Timing #2

A programmable timing value specific to the engine's application. Factors affecting this value include both fuel type and the nature of the load being driven.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65159

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SPN 1435 (R) Engine Desired Ignition Timing #3

A programmable timing value specific to the engine's application. Factors affecting this value include both fuel type and the nature of the load being driven.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65159

SPN 1436 (R) Engine Actual Ignition Timing

The actual ignition timing at the current engine conditions. This parameter may or may not be equal to one of the desired timing parameters (see SPNs 1433-1435), depending on the status of the engine.

Data Length: 2 bytes
Resolution: 1/128 deg/bit, -200 deg offset
Data Range: -200 to 301.99 deg Operational Range: same as data range
Type: Status
Supporting information:
PGN 65159

SPN 1437 (R) Road Speed Limit Status

Status (active or not active) of the system used to limit maximum vehicle velocity.

00 - Active
01 - Not Active

NOTE - While somewhat inconsistent with other J1939 status parameters, the states defining 00 = active and 01 = inactive for Road Speed Limit Status are NOT typographical errors, and should be implemented as stated.

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61443

SPN 1438 ABS/EBS Amber Warning Signal (Powered Vehicle)

This parameter commands the ABS/EBS amber/yellow optical warning signal

00 Off
01 On
10 Reserved
11 Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61441

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SPN 1439 EBS Red Warning Signal

This parameter commands the EBS red optical warning signal

00 Off
01 On
10 Reserved
11 Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61441

SPN 1440 (R) Engine Fuel Flow Rate 1

The rate at which the fuel is flowing through a fuel valve.

Data Length: 2 bytes
Resolution: 0.1 m^3/h per bit, 0 offset
Data Range: 0 to 6425.5 m^3/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65153

SPN 1441 (R) Engine Fuel Flow Rate 2

The rate at which the fuel is flowing through a fuel valve.

Data Length: 2 bytes
Resolution: 0.1 m^3/h per bit, 0 offset
Data Range: 0 to 6425.5 m^3/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65153

SPN 1442 (R) Engine Fuel Valve 1 Position

The position of a gaseous fuel valve that is metering the fuel flow to the engine. 0% indicates no fuel flow through valve and 100% means maximum fuel flow through valve.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65153

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SPN 1443 (R) Engine Fuel Valve 2 Position

The position of a gaseous fuel valve that is metering the fuel flow to the engine. 0% indicates no fuel flow through valve and 100% means maximum fuel flow through valve.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65153

SPN 1444 (R) Engine Cylinder #1 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65147

SPN 1445 (R) Engine Cylinder #2 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65147

SPN 1446 (R) Engine Cylinder #3 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65147

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SPN 1447 (R) Engine Cylinder #4 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65147

SPN 1448 (R) Engine Cylinder #5 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65148

SPN 1449 (R) Engine Cylinder #6 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65148

SPN 1450 (R) Engine Cylinder #7 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65148

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SPN 1451 (R) Engine Cylinder #8 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65148

SPN 1452 (R) Engine Cylinder #9 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65149

SPN 1453 (R) Engine Cylinder #10 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65149

SPN 1454 (R) Engine Cylinder #11 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65149

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SPN 1455 (R) Engine Cylinder #12 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65149

SPN 1456 (R) Engine Cylinder #13 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65150

SPN 1457 (R) Engine Cylinder #14 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65150

SPN 1458 (R) Engine Cylinder #15 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65150

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SPN 1459 (R) Engine Cylinder #16 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65150

SPN 1460 (R) Engine Cylinder #17 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65151

SPN 1461 (R) Engine Cylinder #18 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65151

SPN 1462 (R) Engine Cylinder #19 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65151

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SPN 1463 (R) Engine Cylinder #20 Combustion Time

The amount of time from when the ignition of the fuel is initiated to when the fuel is completely ignited (i.e., the flame front has propagated across the cylinder).

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65151

SPN 1464 (R) Engine Desired Combustion Time

The desired combustion time based upon engine load and speed lookup maps.

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65152

SPN 1465 (R) Engine Average Combustion Time

The average combustion time of all cylinders of an engine.

Data Length: 2 bytes
Resolution: 0.01 ms/bit, 0 offset
Data Range: 0 to 642.55 ms Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65152

SPN 1466 Steer Channel Mode

Indicates the functional mode of steer channel of the tire pressure control system.

0000 Maintain
0001 Inflate
0010 Deflate
0011 Confirm
0100 Inflate Wait – System will inflate when conditions allow
0101 Deflate Wait – System will deflate when conditions allow
0110 Pressure Check
0111-1101 Reserved
1110 Error Condition
1111 Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65144

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SPN 1467 Trailer/tag Channel Mode

Indicates the functional mode of trailer/tag channel of the tire pressure control system.

0000 Maintain
0001 Inflate
0010 Deflate
0011 Confirm
0100 Inflate Wait – System will inflate when conditions allow
0101 Deflate Wait – System will deflate when conditions allow
0110 Pressure Check
0111-1101 Reserved
1110 Error Condition
1111 Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65144

SPN 1468 Drive Channel Mode

Indicates the functional mode of trailer/tag channel of the tire pressure control system.

0000 Maintain
0001 Inflate
0010 Deflate
0011 Confirm
0100 Inflate Wait – System will inflate when conditions allow
0101 Deflate Wait – System will deflate when conditions allow
0110 Pressure Check
0111-1101 Reserved
1110 Error Condition
1111 Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65144

SPN 1469 PCU Drive Solenoid Status

Current state of the drive solenoid used to implement a tire pressure control system in its pneumatic control unit (PCU).

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65144

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SPN 1470 PCU Steer Solenoid Status

Current state of the steer solenoid used to implement a tire pressure control system in its pneumatic control unit (PCU).

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65144

SPN 1471 Tire Pressure Supply Switch Status

Current state of an open/closed type switch used to determine if adequate pressure exists for system implementation.

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65144

SPN 1472 PCU Deflate Solenoid Status

Current state of the deflate solenoid used to implement a tire pressure control system in its pneumatic control unit (PCU).

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65144

SPN 1473 PCU Control Solenoid Status

Current state of the control solenoid used to implement a tire pressure control system in its pneumatic control unit (PCU).

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65144

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SPN 1474 PCU Supply Solenoid Status

Current state of the supply solenoid used to implement a tire pressure control system in its pneumatic control unit (PCU).

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65144

SPN 1475 PCU Trailer, Tag or Push Solenoid Status

Current state of the trailer, tag, or push solenoid used to implement a tire pressure control system in its pneumatic control unit (PCU).

00 - Off
01 - On

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65144

SPN 1480 Source Address of Controlling Device for Retarder Control

The source address of the SAE J1939 device currently controlling the retarder. It is used to expand the torque mode parameter (see SPN 899) in cases where control is in response to an ECU that is not listed in Table SPN899_A. Its value may be the source address of the ECU transmitting the message (which means that no external SAE J1939 message is providing the active command) or the source address of the SAE J1939 ECU that is currently providing the active command in a TSC1 (see PGN 0) or similar message. Note that if this parameter value is the same as the source address of the device transmitting it, the control may be due to a message on a non-SAE J1939 data link such as SAE J1922 or a

Data Length: 1 byte
Resolution: 1 source address/bit, 0 offset
Data Range: 0 to 255 Operational Range: 0 to 253
Type: Status
Supporting information:
PGN 61440

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SPN 1481 Source Address of Controlling Device for Brake Control

The source address of the SAE J1939 device currently controlling the brake system. Its value may be the source address of the ECU transmitting the message (which means that no external SAE J1939 message is providing the active command) or the source address of the SAE J1939 ECU that is currently providing the active command in a TSC1 (see PGN 0) or similar message. Note that if this parameter value is the same as the source address of the device transmitting it, the control may be due to a message on a non-SAE J1939 data link such as SAE J1922 or a proprietary link.

Data Length: 1 byte
Resolution: 1 source address/bit, 0 offset
Data Range: 0 to 255 Operational Range: 0 to 253
Type: Status
Supporting information:
PGN 61441

SPN 1482 Source Address of Controlling Device for Transmission Control

The source address of the SAE J1939 device currently controlling the transmission. Its value may be the source address of the ECU transmitting the message (which means that no external SAE J1939 message is providing the active command) or the source address of the SAE J1939 ECU that is currently providing the active command in a TSC1 (see PGN 0) or similar message. Note that if this parameter value is the same as the source address of the device transmitting it, the control may be due to a message on a non-SAE J1939 data link such as SAE J1922 or a proprietary link.

Data Length: 1 byte
Resolution: 1 source address/bit, 0 offset
Data Range: 0 to 255 Operational Range: 0 to 253
Type: Status
Supporting information:
PGN 61442

SPN 1483 Source Address of Controlling Device for Engine Control

The source address of the SAE J1939 device currently controlling the engine. It is used to expand the torque mode parameter (see SPN 899) in cases where control is in response to an ECU that is not listed in Table SPN899_A. Its value may be the source address of the ECU transmitting the message (which means that no external SAE J1939 message is providing the active command) or the source address of the SAE J1939 ECU that is currently providing the active command in a TSC1 (see PGN 0) or similar message. Note that if this parameter value is the same as the source address of the device transmitting it, the control may be due to a message on a non-J1939 data link such as SAE J1922 or a

Data Length: 1 byte
Resolution: 1 source address/bit, 0 offset
Data Range: 0 to 255 Operational Range: 0 to 253
Type: Status
Supporting information:
PGN 61444

SPN 1487 Illumination Brightness Percent

Commanded backlight brightness level for all cab displays
Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 53248

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SPN 1573 LED Display Data #1

Informs display devices how to display the current vertical position.

00000010 High Coarse LED on
00000100 High Fine LED on
00001000 On-grade LED on
00010000 Low Fine LED on
00100000 Low Coarse LED on
All other values Reserved

Data Length:	8 bits		
Resolution:	256 states/8 bit, 0 offset		
Data Range:	0 to 255	Operational Range:	same as data range
Type:	Status		
Supporting information:			
PGN	65142		

SPN 1574 Laser Strike Vertical Deviation

The calculated distance from the laser strike position to the current land leveling system reference point.

Data Length:	2 bytes		
Resolution:	0.1 mm/bit, -3,200 mm offset		
Data Range:	-3,200 to 3,225.5 mm	Operational Range:	-3200 to +3200 mm, negative values are below grade, positive values are above grade, zero is on grade, 0xFE03 indicates that the sensor can not sense the laser
Type:	Measured		
Supporting information:			
PGN	65141		

SPN 1575 Modify Set Point

Used to control and coordinate the set point for the leveling system.

Operating Range: -3200 to +3200 mm, negative values are below current position, positive values are above current position, zero is no change.
Parameter specific parameter:
0xFE01 indicates Stop modifying the set point
0xFE03 indicates Raise the current set point by 5 mm
0xFE11 indicates Lower the current set point by 5 mm
0xFE13 indicates Search for laser or target
0xFE15 indicates go to the Park position
0xFE17 indicates go to the Bench position

Data Length:	2 bytes		
Resolution:	0.1 mm/bit, -3,200 mm offset		
Data Range:	-3,200 to 3,225.5 mm	Operational Range:	same as data range
Type:	Measured		
Supporting information:			
PGN	65140		

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SPN 1576 Mast Position

Used to monitor the position of the sensor attached to the land leveling mast.

Data Length: 2 bytes
Resolution: 0.1 mm/bit, -3,200 mm offset
Data Range: -3,200 to 3,225.5 mm
Operational Range: -3200 to +3200 mm, negative values are below current position, positive values are above current position, zero is no change.
Type: Measured
Supporting information:
PGN 65139

SPN 1577 Blade Duration and Direction

Used to indicate the duration and direction that the land leveling system blade moves.

Data Length: 2 bytes
Resolution: 0.1 sec/bit, -3,276.8 sec offset
Data Range: -3276.8 to 3148.7 sec
Operational Range: -3276.8 to 3276.8 sec, negative values indicate move the blade up, positive values idicate move the blade down, zero indicates no change
Type: Status
Supporting information:
PGN 65138

SPN 1578 Blade Control Mode

Allows the user to select the type of blade control for the land leveling system.

00000000 Manual mode
00000001 Automatic mode
00000010 Inactive automatic mode
All other values Reserved

Data Length: 8 bits
Resolution: 256 states/8 bit, 0 offset
Data Range: 0 to 255
Operational Range: same as data range
Type: Status
Supporting information:
PGN 65138

SPN 1579 Laser Tracer Target Deviation

The calculated distance for the laser target to the current laser tracer reference point.

Parameter specific parameter: 0xFE03 indicates that the sensor can not sense the laser

Data Length: 2 bytes
Resolution: 0.1 mm/bit, -3,200 mm offset
Data Range: -3,200 to 3,225.5 mm
Operational Range: –3200 to +3200 mm, negative values are below setpoint, positive values are above setpoint, zero is on grade.
Type: Measured
Supporting information:
PGN 65137

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SPN 1580 Laser Tracer Vertical Distance

The elevation of the laser tracer sensor in a laser leveling system.

Data Length: 2 bytes
Resolution: 0.1 mm/bit, 0 offset
Data Range: 0 to 6,425.5 mm Operational Range: 0 to 6400 mm
Type: Measured
Supporting information:
PGN 65137

SPN 1581 Laser Tracer Horizontal Deviation

The calculated percent deviation between the target distance and the center of the laser tracer.

Data Length: 1 byte
Resolution: 1 %/bit, 0 offset
Data Range: 0 to 250 % Operational Range: 0 to 200%, 0 to 99% indicates target is left of center, 101 to 200% indicates target is right of center, 100% indicates target is centered, 0xFF indicates previous pass mode and thus no horizontal deviation
Type: Measured
Supporting information:
PGN 65137

SPN 1582 LED Display Data #2

Informs display devices how to display the current position of the laser tracer.

00000001 On-grade "A" LED on
00000010 On-grade "B" LED on
00000100 On-grade "C" LED on
00001000 Up LED on
00010000 Down LED on
00100000 Left LED on
01000000 Right LED on
All other values Reserved

Data Length: 8 bits
Resolution: 256 states/8 bit, 0 offset
Data Range: 0 to 255 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65137

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SPN 1583 Laser Tracer Information

Provides the status of the laser tracer to the operator.

00000001 Laser power is on
00000010 Laser is ready
00000100 Valid target (1 = yes)
00001000 Previous pass (1 = yes)
00010000 Stringline (1 = yes)
00100000 Curb (1 = yes)
All other values Reserved

Data Length: 8 bits
Resolution: 256 states/8 bit, 0 offset
Data Range: 0 to 255 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65137

SPN 1584 Service Component Identification

Identification of component needing service. See Table SPN911_A.

Data Length: 1 byte
Resolution: 1 ID/bit, 0 offset
Data Range: 0 to 250 ID Operational Range: same as data range
Type: Measured
Supporting information:
PGN 56832

SPN 1585 Powered Vehicle Weight

Total mass imposed by the tires of the powered vehicle on the road surface. Does not include the trailer.

Data Length: 2 bytes
Resolution: 10 kg/bit, 0 offset
Data Range: 0 to 642,550 kg Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65136

SPN 1586 Speed of forward vehicle

Absolute velocity of the preceding vehicle situated within 250 m in the same lane and moving in the same direction.

Data Length: 1 byte
Resolution: 1 km/h per bit, 0 offset
Data Range: 0 to 250 km/h Operational Range: 0xFF = no vehicle detected
Type: Measured
Supporting information:
PGN 65135

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SPN 1587 Distance to forward vehicle

Distance to the preceding vehicle situated within 250 m in the same lane and moving in the same direction.

Data Length: 1 byte
Resolution: 1 m/bit, 0 offset
Data Range: 0 to 250 m Operational Range: 0xFF = no vehicle detected
Type: Measured
Supporting information:
PGN 65135

SPN 1588 Adaptive Cruise Control Set Speed

Value of the desired (chosen) velocity of the adaptive cruise control system.

Data Length: 1 byte
Resolution: 1 km/h per bit, 0 offset
Data Range: 0 to 250 km/h Operational Range: 0 to 120 km/h
Type: Status
Supporting information:
PGN 65135

SPN 1589 Adaptive cruise control set distance mode

Selected distance mode for adaptive cruise control.

000 ACC Distance mode #1 (largest distance)
001 ACC Distance mode #2
010 ACC Distance mode #3
011 ACC Distance mode #4
100 ACC Distance mode #5 (shortest distance)
101 Conventional cruise control mode
110 Error condition
111 Not available/not valid

Data Length: 3 bits
Resolution: 8 states/3 bit, 0 offset
Data Range: 0 to 7 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65135

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SPN 1590 Adaptive Cruise Control Mode

This parameter is used to indicate the current state, or mode, of operation by the Adaptive Cruise Control (ACC) device. The states characterize independent system states (e.g., it is not possible to express distance control active and overtake mode simultaneously). ACC must not switch itself off while active because the driver expects it to work. So if an error occurs, the ACC must signal that to the driver so that the driver knows that he has to switch off the ACC.

000 Off (Standby, enabled, ready for activation)
001 Speed control active
010 Distance control active
011 Overtake mode
100 Hold mode
101 Finish mode
110 Disabled or error condition
111 Not available/not valid

000b - Off—Used to indicate the ACC is enabled in calibration or configuration and there are no faults that would prevent the system from operating.
001b - Speed Control Active—Used to indicate that ACC is on but not currently sending control messages. In other words, there is no target ahead and regular vehicle cruise control is controlling the vehicle speed to the driver's set speed.
010b - Distance Control Active—Used to indicate that ACC is on and actively sending control messages to maintain the appropriate following interval.
011b - Overtake Mode—Used to indicate that ACC is on but temporarily disabled because the driver is manually overriding cruise control by using either the accelerator pedal or the cruise control "accel" switch.
100b - Hold Mode—Used to indicate that the ACC has lost the previous target vehicle and is in HOLD mode. In this mode, the ACC shall limit the speed to the speed held when the target was lost. For example, if the driver activates the typical cruise buttons (Resume/Inc/Dec) the HOLD mode shall be exited and normal cruise functionality resumed. If a new target is detected, the Distance Control Active mode (010b) is again entered, unless existing conditions prohibit this.
101b - Finish Mode—Used to indicate that ACC is on with no target ahead, and ACC is currently sending control messages to return to the driver's set speed. This occurs when the target the ACC system was tracking moves out of the way so ACC returns the vehicle to the driver's set speed.
110b - Disabled or Error Condition—Used to indicate that ACC is in an error state and can not operate.

Data Length:	3 bits		
Resolution:	8 states/3 bit, 0 offset		
Data Range:	0 to 7	Operational Range:	same as data range
Type:	Status		
Supporting information:			
PGN	65135		

SPN 1591 Road curvature

Estimated value of the current road curvature for use by the adaptive cruise control system. Positive values are used for left curves. Curvature is the inverse of the radius and is zero for straight roads.

Data Length:	2 bytes		
Resolution:	1/128 1/km per bit, -250 1/km offset		
Data Range:	-250 to 251.992 1/km	Operational Range:	same as data range
Type:	Status		
Supporting information:			
PGN	65135		

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SPN 1592 Front Axle, Left Wheel Speed

High resolution measurement of the speed of the left wheel on the front axle.

Data Length: 2 bytes
Resolution: 1/256 km/h per bit, 0 offset
Data Range: 0 to 250.996 km/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65134

SPN 1593 Front axle, right wheel speed

High resolution measurement of the speed of the right wheel on the front axle.

Data Length: 2 bytes
Resolution: 1/256 km/h per bit, 0 offset
Data Range: 0 to 250.996 km/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65134

SPN 1594 Rear axle, left wheel speed

High resolution measurement of the speed of the left wheel on the rear axle.

Data Length: 2 bytes
Resolution: 1/256 km/h per bit, 0 offset
Data Range: 0 to 250.996 km/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65134

SPN 1595 Rear axle, right wheel speed

High resolution measurement of the speed of the right wheel on the rear axle.

Data Length: 2 bytes
Resolution: 1/256 km/h per bit, 0 offset
Data Range: 0 to 250.996 km/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65134

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SPN 1601 Local minute offset

Local offset in minutes from a reference time.

Data Length: 1 byte
Resolution: 1 min/bit, -125 mins offset
Data Range: -125 to 125 mins Operational Range: -59 to +59 min
Type: Measured
Supporting information:
PGN 65254

SPN 1602 (R) Local hour offset

Local offset in hours from a reference time

Data Length: 1 byte
Resolution: 1 hr/bit, -125 hr offset
Data Range: -125 to 125 hr Operational Range: -23 to +23 h
Type: Measured
Supporting information:
PGN 65254

SPN 1603 Adjust seconds

Part of the parameter used to set the time.

Data Length: 1 byte
Resolution: 0.25 s/bit, 0 offset
Data Range: 0 to 62.5 s Operational Range: 0 to 59.75 s
Type: Measured
Supporting information:
PGN 54528

SPN 1604 Adjust minutes

Part of the parameter used to set the time.

Data Length: 1 byte
Resolution: 1 min/bit, 0 offset
Data Range: 0 to 250 mins Operational Range: 0 to 59 min
Type: Measured
Supporting information:
PGN 54528

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SPN 1605 Adjust hours

Part of the parameter used to set the time.

Data Length: 1 byte
Resolution: 1 hr/bit, 0 offset
Data Range: 0 to 250 hr Operational Range: 0 to 23 h
Type: Measured
Supporting information:
PGN 54528

SPN 1606 Adjust month

Part of a parameter used to set a calendar date.

NOTE - A value of 0 for the month is null. The value 1 identifies January; 2 identifies February; etc.

Data Length: 1 byte
Resolution: 1 month/bit, 0 offset
Data Range: 0 to 250 months Operational Range: 1 to 12 month
Type: Measured
Supporting information:
PGN 54528

SPN 1607 Adjust day

Part of a parameter used to set a calendar date.

NOTE - A value of 0 for the date is null. The values 1, 2, 3, and 4 are used to identify the first day of the month; 5, 6, 7, and 8 identify the second day of the month; etc.

Data Length: 1 byte
Resolution: 0.25 days/bit, 0 offset
Data Range: 0 to 62.5 days Operational Range: 0.25 to 31.75 day
Type: Measured
Supporting information:
PGN 54528

SPN 1608 Adjust year

Part of a parameter used to set a calendar date.

NOTE - A value of 0 for the year identifies the year 1985; a value of 1 identifies 1986; etc.

Data Length: 1 byte
Resolution: 1 year/bit, 1985 years offset
Data Range: 1985 to 2235 years Operational Range: 1985 to 2235 year
Type: Measured
Supporting information:
PGN 54528

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SPN 1609 Adjust local minute offset

Used to set the local offset in minutes from a reference time.

Data Length: 1 byte
Resolution: 1 min/bit, -125 mins offset
Data Range: -125 to 125 mins Operational Range: -59 to +59 min
Type: Measured
Supporting information:
PGN 54528

SPN 1610 Adjust local hour offset

Used to set the local offset in hours from a reference time

Data Length: 1 byte
Resolution: 1 hr/bit, -125 hr offset
Data Range: -125 to 125 hr Operational Range: -24 to +23 h
Type: Measured
Supporting information:
PGN 54528

SPN 1611 Drive recognize

Indicates whether motion of the vehicle is detected or not.

00 Vehicle motion not detected
01 Vehicle motion detected

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65132

SPN 1612 Driver 1 working state

State of work of the driver.

000 Rest - sleeping
001 Driver available – short break
010 Work – loading, unloading, working in an office
011 Drive – behind wheel
100-101 Reserved
110 Error
111 Not available

Data Length: 3 bits
Resolution: 8 states/3 bit, 0 offset
Data Range: 0 to 7 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65132

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SPN 1613 Driver 2 working state

State of work of the driver.

000 Rest - sleeping
001 Driver available – short break
010 Work – loading, unloading, working in an office
011 Drive – behind wheel
100-101 Reserved
110 Error
111 Not available

Data Length: 3 bits
Resolution: 8 states/3 bit, 0 offset
Data Range: 0 to 7 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65132

SPN 1614 Overspeed

Indicates whether the vehicle is exceeding the legal speed limit set in the tachograph.

00 No overspeed
01 Overspeed

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65132

SPN 1615 Driver card, driver 1

Indicates the presence of a driver card

00 - Driver card not present
01 - Driver card present

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65132

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SPN 1616 Driver card, driver 2

Indicates the presence of a driver card

00 - Driver card not present
01 - Driver card present

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65132

SPN 1617 Driver 1 Time Related States

Indicates if the driver approaches or exceeds working time limits (or other limits).

0000 Normal/No limits reached
0001 Limit #1 – 15 min before 4 ½ h
0010 Limit #2 – 4 ½ h reached
0011 Limit #3 – 15 min before 9 h
0100 Limit #4 – 9 h reached
0101 Limit #5 – 15 min before 16 h (not having 8h rest during the last 24h)
0110 Limit #6 – 16 h reached
0111-1100 Reserved
1101 Other
1110 Error
1111 Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65132

SPN 1618 Driver 2 Time Related States

Indicates if the driver approaches or exceeds working time limits (or other limits).

0000 Normal/No limits reached
0001 Limit #1 – 15 min before 4 ½ h
0010 Limit #2 – 4 ½ h reached
0011 Limit #3 – 15 min before 9 h
0100 Limit #4 – 9 h reached
0101 Limit #5 – 15 min before 16 h (not having 8h rest during the last 24h)
0110 Limit #6 – 16 h reached
0111-1100 Reserved
1101 Other
1110 Error
1111 Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65132

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SPN 1619 Direction indicator

Indicates the direction of the vehicle.

00 - Forward
01 - Reverse

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65132

SPN 1620 Tachograph performance

Indicates the tachograph performance; including electronic or mechanical analysis, instrument analysis, speed sensor analysis, mass storage analysis, and printer analysis.

00 - Normal performance
01 - Performance analysis

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65132

SPN 1621 Handling information

Indicates that handling information is present. Information could include "no printer paper", "no driver card", etc.

00 - No handling information
01 - Handling information

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65132

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SPN 1622 System event

Indicates that a tachograph event has occurred. This may include power supply interruption, interruption of the speed sensor, incorrect data on the driver card, driving without a driver card, illegal removal of a driver card, insertion of a driver card during driving, and time adjustment.

00 - No tachograph event
01 - Tachograph event

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65132

SPN 1623 Tachograph output shaft speed

Calculated speed of the transmission output shaft.
Data Length: 2 bytes
Resolution: 0.125 rpm/bit, 0 offset
Data Range: 0 to 8,031.875 rpm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65132

SPN 1624 Tachograph vehicle speed

Speed of the vehicle registered by the tachograph.
Data Length: 2 bytes
Resolution: 1/256 km/h per bit, 0 offset
Data Range: 0 to 250.996 km/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65132

SPN 1625 Driver 1 identification

Used to obtain the driver identity.
Data Length: Variable ("*" delimited)
Resolution: ASCII, 0 offset
Data Range: 0 to 255 per byte Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65131

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SPN 1626 Driver 2 identification

Used to obtain the driver identity.

Data Length: Variable ("*" delimited)
Resolution: ASCII, 0 offset
Data Range: 0 to 255 per byte Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65131

SPN 1632 (R) Engine Torque Limit Feature

Torque limit rating described in the current record.

000 Reserved
001 Highest torque rating
010 First torque rating
011 Previous torque rating (rating prior to the current rating)
100 Current torque rating
101-110 Reserved
111 Not available

Data Length: 3 bits
Resolution: 8 states/3 bit, 0 offset
Data Range: 0 to 7 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65168

SPN 1633 Cruise Control Pause Switch

Switch signal which indicates the position of the Cruise Control Pause Switch used on Remote Cruise Control applications. The Cruise Control Pause Switch signal temporarily disables the Cruise Control function.

00 - Off
01 - On
10 - Error Indicator
11 -Take No Action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65265

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SPN 1636 (R) Engine Intake Manifold 1 Air Temperature (High Resolution)

Temperature of pre-combustion air found in intake manifold of engine air supply system. The higher resolution is required for control purposes.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65129

SPN 1637 Engine Coolant Temperature (High Resolution)

Temperature of liquid found in engine cooling system. The higher resolution is required for control purposes.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65129

SPN 1638 Hydraulic Temperature

Temperature of hydraulic fluid.

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65128

SPN 1639 Fan Speed

The speed of the fan associated with engine coolant system.

Data Length: 2 bytes
Resolution: 0.125 rpm/bit, 0 offset
Data Range: 0 to 8,031.875 rpm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65213

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SPN 1653 Vehicle Limiting Speed Governor Enable Switch

Switch signal which enables the Vehicle Limiting Speed Governor (VLSG) such that the vehicle speed may be either increased or decreased when the engine is off idle.

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 57344

SPN 1654 Vehicle Limiting Speed Governor Increment Switch

Switch signal which increases the Vehicle Limiting Speed Governor (VLSG).

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 57344

SPN 1655 Vehicle Limiting Speed Governor Decrement Switch

Switch signal which decreases the Vehicle Limiting Speed Governor (VLSG).

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 57344

SPN 1656 Engine Automatic Start Enable Switch

Switch signal which enables the idle management system to be enabled. When this system is enabled with the engine in an idle mode and safe operating conditions existing, then the engine may be started or stopped automatically.

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 57344

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SPN 1665 (R) Engine Turbocharger Oil Level Switch

Switch signal which indicates the presence of oil at the turbocharger

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65245

SPN 1666 Automatic Gear Shifting Enable Switch

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 57344

SPN 1667 Retarder Requesting Brake Light

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61440

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SPN 1675 Engine Starter Mode

There are several phases in a starting action and different reasons why a start cannot take place.

0000 start not requested
0001 starter active, gear not engaged
0010 starter active, gear engaged
0011 start finished; starter not active after having been actively engaged (after 50ms mode goes to 0000)
0100 starter inhibited due to engine already running
0101 starter inhibited due to engine not ready for start (preheating)
0110 starter inhibited due to driveline engaged or other transmission inhibit
0111 starter inhibited due to active immobilizer
1000 starter inhibited due to starter over-temp
1001-1011 Reserved
1100 starter inhibited - reason unknown
1101 error (legacy implementation only, use 1110)
1110 error
1111 not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61444

SPN 1676 Auxilary Heater Water Pump Status

Parameter indicating whether the auxilary heater water pump is running

00 Water Pump is not running
01 Water Pump is running
10 Reserved
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65133

SPN 1677 Auxiliary Heater Mode

State of the auxiliary heater

0000 Heater not active
0001 Off due to ADR per European Regulations for Transport of hazardous materials
0010 Economy mode
0011 Normal mode
0100-1101 Not defined
1110 Error
1111 Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65133

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SPN 1678 Cab Ventilation

Indicates whether the cab is being ventilated or not.

00 Cab not ventilated
01 Cab is ventilated
10 Reserved
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3
Operational Range: same as data range
Type: Status
Supporting information:
PGN 65133

SPN 1679 Engine Heating Zone

Parameter indicating whether the engine zone is being heated.

00 Engine heating zone off
01 Engine heating zone on
10 Reserved
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3
Operational Range: same as data range
Type: Status
Supporting information:
PGN 65133

SPN 1680 Cab Heating Zone

Parameter indicating whether the cab zone is being heated.

00 Cab heating zone off
01 Cab heating zone on
10 Reserved
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3
Operational Range: same as data range
Type: Status
Supporting information:
PGN 65133

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SPN 1681 Battery Main Switch Hold State

Parameter indicating whether the battery main switch is held due to an external request or not. The state battery main switch held indicates that the battery main switch is about to switch off.

00 Battery main switch not held
01 Battery main switch held
10 Reserved
11 Don't care/take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3
Type: Measured
Operational Range: same as data range
Supporting information:
PGN 65126

SPN 1682 Battery Main Switch Hold Request

Request to hold the battery main switch.

00 Release Battery Main Switch
01 Hold Battery Main Switch
10 undefined
11 Don't care/take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3
Type: Status
Operational Range: same as data range
Supporting information:
PGN 57344

SPN 1683 Auxiliary Heater Mode Request

Request to activate the auxiliary heater.

0000 De-activate auxiliary heater
0001 Off due to ADR per European Regulations for Transport of hazardous materials
0010 Economy mode
0011 Normal mode
0100-1101 Not defined
1110 Reserved
1111 Don't care/take no action

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15
Type: Status
Operational Range: same as data range
Supporting information:
PGN 57344

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SPN 1684 Auxiliary Heater Coolant Pump Request

Indicates whether to activate the auxiliary heater coolant water pump.

00 Deactivate water pump
01 Activate water pump
10 Reserved
11 Don't care/take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 57344

SPN 1685 Request Engine Zone Heating

Request to activate engine zone heating.

00 Do not heat engine zone
01 Heat engine zone
10 Reserved
11 Don't care/take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 57344

SPN 1686 Request Cab Zone Heating

Request to activate cab zone heating.

00 Do not cab engine zone
01 Heat cab zone
10 Reserved
11 Don't care/take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 57344

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SPN 1687 Auxiliary Heater Output Coolant Temperature

Temperature of the auxiliary heater output coolant (I.e. water in a water heater system.)

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65133

SPN 1688 Auxiliary Heater Input Air Temperature

Temperature of the input air in an auxiliary heater system.

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65133

SPN 1689 Auxiliary Heater Output Power Percent

Current auxiliary heater output power, relative to the auxiliary heater maximum output power.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 %
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65133

SPN 1690 Auxiliary Heater Maximum Output Power

The maximum output power of the auxiliary heater.

Data Length: 2 bytes
Resolution: 2 W/bit, 0 offset
Data Range: 0 to 128,510 W
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65127

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SPN 1691 Cab Interior Temperature Command

Parameter used to command a certain cab interior temperature.

Note: See SPN 1662 and SPN 170.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Status
Supporting information:
PGN 57344

SPN 1692 (R) Engine Desired Absolute Intake Manifold Pressure (Turbo Boost Limit)

The desired absolute intake manifold pressure of the engine.

Data Length: 2 bytes
Resolution: 0.1 kPa/bit, 0 offset
Data Range: 0 to 6,425.5 kPa Operational Range: same as data range
Type: Status
Supporting information:
PGN 65194

SPN 1693 (R) Engine Turbocharger Wastegate Valve Position

The position of the turbocharger wastegate valve (not the electronic wastegate control valve).

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65194

SPN 1694 (R) Engine Gas Mass Flow Sensor Fueling Correction

The amount of fuel the Gas Mass Flow Sensor is sensing should be added or subtracted compared to the maximum amount of fuel the control system allows the sensor to add or subtract.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65194

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SPN 1695 (R) Engine Exhaust Gas Oxygen Sensor Fueling Correction

The amount of fueling change required by the system based on the measured Exhaust Oxygen value compared to the maximum fueling change permitted by the system, expressed as percentages.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 65193

SPN 1696 (R) Engine Exhaust Gas Oxygen Sensor Closed Loop Operation

Indicates whether the engine is using the Exhaust Gas Oxygen sensor to control the air/fuel ratio.

00 Command to disable function
01 Command to enable function
10 Reserved
11 Don't Care/take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65193

SPN 1697 CTI Wheel End Electrical Fault

Indicates the status of electrical fault on CTI wheel interface.

00 Ok (No Fault)
01 Not Defined
10 Error
11 Not Supported

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65268

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SPN 1698 CTI Tire Status

Indicates the status of the tire.

00 Ok (no fault)
01 Tire leak detected
10 Error
11 Not Supported

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65268

SPN 1699 CTI Wheel Sensor Status

Indicates whether the wheel is being monitored by the CTI controller.

00 Off / isolated from CTI Pressure Controller
01 On (tire is polled)
10 Not Defined
11 Not Supported

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65268

SPN 1700 Lane Departure Imminent, Left Side

Indicates departure imminent on left side of lane.

00 Not imminent
01 Imminent
10 Reserved
11 Not used

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61447

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SPN 1701 Lane Departure Imminent, Right Side

Indicates departure imminent on right side of lane.

00 Not imminent
01 Imminent
10 Reserved
11 Not Used

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61447

SPN 1702 Lane Departure Indication Enable Status

Indicates whether lane departure indication is active.

00 Lane Departure indication disabled
01 Lane Departure Indication enabled
10 Reserved
11 Not Used

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65115

SPN 1710 Lane Tracking Status Left Side

Indicates whether the left side is tracking lane.

00 Not Tracking Left side
01 Tracking Left side
10 Reserved
11 Don't care/Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65115

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SPN 1711 Lane Tracking Status Right Side

Indicates whether right side is tracking lane.

00 Not Tracking Right side
01 Tracking Right side
10 Reserved
11 Don't Care/take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65115

SPN 1712 (R) Engine Extended Range Requested Speed Control Range Upper Limit (Engine configuration)

The maximum engine speed regardless of load that the engine will allow when operating in a speed control/limit mode, excluding any maximum momentary engine override speed, if supported.

When the limit is higher that 2500 RPM the 'Requested Speed Control Range Upper Limit (Engine Configuration)' parameter (see SPN 536) will be transmitted with a value of 2500 RPM.

Data Length: 2 bytes
Resolution: 0.125 rpm/bit, 0 offset
Data Range: 0 to 8,031.875 rpm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65251

SPN 1713 Hydraulic Oil Filter Restriction Switch

This switch indicates whether hydraulic oil filter is clogged.

00 No restriction
01 Restriction exists on oil fitler
10 Error
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65128

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SPN 1714 Operator Seat Direction Switch

Senses whether the operator seat is in the forward driving position

00 Operator seat not facing forward
01 Operator seat is facing forward
10 Error
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 57344

SPN 1715 Drivers Demand Retarder - Percent Torque

The Drivers demand retarder – percent torque is the maximum torque selected by the driver when one or more modes are selected by the driver, such as hand lever, switch, constant torque, constant velocity, etc.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: -125% to 0%
Type: Status
Supporting information:
PGN 61440

SPN 1716 Retarder Selection, non-engine

The "Retarder Selection, non-engine" is the position of the driver's selector for retarders that are not part of the engine system, expressed as percent and determined by the ratio of current position to the maximum possible position. The physical device may be a lever, rotary dial, combination of switches, or other device that the driver can use to select the type or amount of retardation needed.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61440

SPN 1717 Actual Maximum Available Retarder - Percent Torque

This is the maximum amount of torque that the retarder can immediately deliver. It is the same as the maximum torque shown in the Retarder's Configuration message, but allows for a much faster rate of change than could be communicated by reissuing the configuration message.
Application Note: The purpose for this parameter is to allow a "Master" retarder controller to more accurately allocate the vehicle's retarder requirements among multiple retarders. Its value should be the same as the value in the Configuration message at the time that message is assembled for broadcast, but may vary between those broadcasts.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: -125 % to 0
Type: Measured
Supporting information:
PGN 61440

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SPN 1718 Damper Stiffness Request Front Axle

Demand value for the shock absorber control at the front axle.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 53760

SPN 1719 Damper Stiffness Request Rear Axle

Demand value for the shock absorber control at the rear axle.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 53760

SPN 1720 Damper Stiffness Request Lift / Tag Axle

Demand value for the shock absorber control at the lift or tag axle

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 53760

SPN 1721 Relative Level Front Axle Left

Information of the height at the left side of the front axle referred to normal level 1. For explanations of normal level 1 see SPN 1734 - Nominal Level Front Axle.

Data Length: 2 bytes
Resolution: 0.1 mm/bit, -3,200 mm offset
Data Range: -3,200 to 3,225.5 mm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65113

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SPN 1722 Relative Level Front Axle Right

Information of the height at the right side of the front axle referred to normal level 1. For explanations of normal level 1 see SPN 1734 - Nominal Level Front Axle.

Data Length: 2 bytes
Resolution: 0.1 mm/bit, -3,200 mm offset
Data Range: -3,200 to 3,225.5 mm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65113

SPN 1723 Relative Level Rear Axle Right

Information of the height at the left side of the rear axle referred to normal level 1. For explanations of normal level 1 see parameter SPN 1734 - Nominal Level Front Axle.

Data Length: 2 bytes
Resolution: 0.1 mm/bit, -3,200 mm offset
Data Range: -3,200 to 3,225.5 mm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65113

SPN 1724 Relative Level Rear Axle Left

Information of the height at the left side of the rear axle referred to normal level 1. For explanations of normal level 1 see parameter SPN 1734 - Nominal Level Front Axle.

Data Length: 2 bytes
Resolution: 0.1 mm/bit, -3,200 mm offset
Data Range: -3,200 to 3,225.5 mm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65113

SPN 1725 Bellow Pressure Front Axle Left

Information of the pressure of the air suspension bellow at the left side of the front axle

Data Length: 2 bytes
Resolution: 0.1 kPa/bit, 0 offset
Data Range: 0 to 6,425.5 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65112

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SPN 1726 Bellow Pressure Front Axle Right

Information of the pressure of the air suspension bellow at the right side of the front axle

Data Length: 2 bytes
Resolution: 0.1 kPa/bit, 0 offset
Data Range: 0 to 6,425.5 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65112

SPN 1727 Bellow Pressure Rear Axle Left

Information of the pressure of the air suspension bellow at the left side of the rear axle

Data Length: 2 bytes
Resolution: 0.1 kPa/bit, 0 offset
Data Range: 0 to 6,425.5 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65112

SPN 1728 Bellow Pressure Rear Axle Right

Information of the pressure of the air suspension bellow at the right side of the rear axle

Data Length: 2 bytes
Resolution: 0.1 kPa/bit, 0 offset
Data Range: 0 to 6,425.5 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65112

SPN 1729 Damper Stiffness Front Axle

Damper stiffness information of the shock absorber control at the front axle

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 65111

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SPN 1730 Damper Stiffness Rear Axle

Damper stiffness information of the shock absorber control at the rear axle

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 65111

SPN 1731 Damper Stiffness Lift / Tag Axle

Damper stiffness information of the shock absorber control at the lift of tag axle

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 65111

SPN 1732 Level Preset Front Axle Left

Set value for nominal level 'preset level' at the left side of the front axle. This value is referred to 'Normal level 1'. For explanations of normal level 1 see parameter SPN 1734 - Nominal Level Front Axle.

Data Length: 2 bytes
Resolution: 0.1 mm/bit, -3,200 mm offset
Data Range: -3,200 to 3,225.5 mm Operational Range: same as data range
Type: Status
Supporting information:
PGN 53504

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SPN 1733 Nominal Level Rear Axle

Signal which indicates the nominal (desired) height of the rear axle to be controlled by the suspension system.

For further explanations see SPN 1734 - Nominal Level Front Axle.

0000 Level not specified,(i.e. the nominal level is none of the specified levels, no error condition)
0001 "Normal Level 1,(i.e. the level prescribed for normal driving, given by design)
0010 "Normal Level 2,(i.e. a level permitted for driving, for example to lower the vehicle in case of high speed)
0011 "Normal Level 3,(i.e. a level permitted for driving, for example to lift the vehicle in case of offroad)
0100 "Preset Level,(i.e. a level to be defined externally via CAN)
0101 "Customer Level,(i.e. a level to be defined by customer via parameter setting)
0110 "Upper Level,(i.e. the highest level to be controlled)
0111 "Lower Level,(i.e. the lowest level to be controlled)
1000-1101 Not defined
1110 Error
1111 Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65114

SPN 1734 Nominal Level Front Axle

Signal which indicates the nominal (desired) height of the front axle to be controlled by the suspension system.

These heights are discrete levels. They are the upper level, lower level, normal level 1, normal level 2, normal level 3, customer level, and preset level. Refer to Figure SPN1734_A.

· Upper Level is the highest mechanically available height of the vehicle.
· Lower Level is the lowest mechanically available height of the vehicle.

Normal Levels 1, 2 and 3 are heights normally used during driving.
· Normal Level 1 is most often used and is given by design.
· Normal Level 2 may be chosen, for example, to be lower than Normal Level 1 for the purpose of reducing fuel consumption while driving on highways.
· Normal Level 3 may be chosen above Normal Level 1 for driving off road.

The preset level has to be set by means of ASC 6 (PGN: 53504).

0000 Level not specified,(i.e. the nominal level is none of the specified levels, no error condition)
0001 "Normal Level 1,(i.e. the level prescribed for normal driving, given by design)
0010 "Normal Level 2,(i.e. a level permitted for driving, for example to lower the vehicle in case of high speed)
0011 "Normal Level 3,(i.e. a level permitted for driving, for example to lift the vehicle in case of offroad)
0100 "Preset Level,(i.e. a level to be defined externally via CAN)
0101 "Customer Level,(i.e. a level to be defined by customer via parameter setting)
0110 "Upper Level,(i.e. the highest level to be controlled)
0111 "Lower Level,(i.e. the lowest level to be controlled)
1000-1101 Not defined
1110 Error
1111 Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information: See Appendix D - SPN 1734
PGN 65114

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SPN 1735 Level Preset Rear Axle Right

Set value for nominal level 'preset level' at the right side of the rear axle. This value is referred to 'Normal level 1'. For explanations of normal level 1 see SPN 1734 - Nominal Level Front Axle.

Data Length: 2 bytes
Resolution: 0.1 mm/bit, -3,200 mm offset
Data Range: -3,200 to 3,225.5 mm Operational Range: same as data range
Type: Status
Supporting information:
PGN 53504

SPN 1736 Above Nominal Level Rear Axle

Signal which indicates whether the actual height of the rear axle is above the nominal (desired) level of the rear axle. For explanations of nominal level see parameter SPN 1734 - Nominal Level Front Axle.

00 Not above
01 Above
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65114

SPN 1737 Above Nominal Level Front Axle

Signal which indicates whether the actual height of the front axle is above the nominal (desired) level of the front axle. For explanations of nominal level see SPN 1734 - Nominal Level Front Axle.

00 Not above
01 Above
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65114

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SPN 1738 Below Nominal Level Front Axle

Signal which indicates whether the actual height of the front axle is below the nominal (desired) level for the front axle. For explanations of nominal level see parameter SPN 1734 - Nominal Level Front Axle.

00 Not below
01 Below
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65114

SPN 1739 Lifting Control Mode Front Axle

Signal which indicates the actual lifting level change at the front axle

00 Lifting not active
01 Lifting active
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65114

SPN 1740 Lowering Control Mode Front Axle

Signal which indicates the actual lowering level change at the front axle

00 Lowering not active
01 Lowering active
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65114

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SPN 1741 (R) Level Control Mode

Signal which indicates the actual control mode of the air suspension system

0000 Normal operation; i.e. the system performs a ""pure"" control of the vehicle height
0001 Traction help (load transfer); i.e. the driven axle is loaded to a maximum value given by legislation or design
0010 Load fixing; i.e. the driven axlen is loaded to a value defined by the driver
0011 Pressure ratio 1; i.e. the ratio between the pressures at the driven axle and at the third axle is controlled, so that the ratio equals a fixed value 1
0100 Pressure ratio 2; i.e. the ratio between the pressures at the driven axle and at the third axle is controlled, so that the ratio equals a fixed value 2
0101 Optimum traction 1; i.e. the pressure at the driven axle is controlled at a fixed value 1
0110 Optimum traction 2; i.e. the pressure at the driven axle is controlled at a fixed value 2
0111 Traction help - load reduce; (i.e. the driven axle load is reduced to normal load condition)
1000 Exhausting bellow function; i.e. the bellows are exhausted totally
1001-1101 Not defined
1110 Error
1111 Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65114

SPN 1742 Kneeling Information

Signal which indicates the actual level change in case of kneeling function

0000 Not active,(i.e. the kneeling function is not active")
0001Lowering active,(i.e. the vehicle is lowered due to a kneeling request)
0010 Kneeling level reached,(i.e. the vehicle is at the fixed kneeling level)
0011 Lifting active,(i.e. the vehicle is lifted due to a recover request)
0100 Kneeling aborted,(i.e. in case of manual actuation the request was dropped before the kneeling level was reached)
0101-1101 Not defined
1110 Error
1111 Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65114

SPN 1743 Lift Axle 1 Position

Signal which indicates the position / load condition of lift axle / tag axle #1. Numbering of lift/tag axles starts at front axle.

00 Lift axle position down / tag axle laden
01 Lift axle position up / tag axle unladen
10 Error

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65114

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SPN 1744 Door Release

Signal which indicates that the doors may be opened. [Please note: doors instead of door!]
In case a kneeling request is active the ASC indicates during lowering the vehicle „doors shall not be opened" as a security information until the kneeling level is reached. Then "doors may be opened" is sent.

00 Doors may not be opened
01 Doors may be opened
10 Error
11 Not available

Data Length:	2 bits		
Resolution:	4 states/2 bit, 0 offset		
Data Range:	0 to 3	Operational Range:	same as data range
Type:	Status		
Supporting information:			
PGN	65114		

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SPN 1745 Vehicle Motion Inhibit

Signal which indicates whether vehicle motion is inhibited.

00 Vehicle may be moved
01 Vehicle motion is inhibited
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65114

SPN 1746 Security Device

The signal which indicates the status of the security device. An example of a security device is a curbstone feeler installed beneath the doors of a bus. If the security device becomes active during kneeling the kneeling process (lowering) is stopped and the vehicle lifts back to the starting level.

00 Not active
01 Active
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65114

SPN 1747 Kneeling Control Mode Request

Command signal to select the kneeling functionality

00 Automatically actuated
01 Manually actuated
10 Reserved
11 Don't care/take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 53760

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SPN 1748 Kneeling Request Right Side

Command signal to activate the kneeling functionality on the right side of the vehicle

00 No kneeling request
01 Kneeling request
10 Reserved
11 Don't care/take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 53760

SPN 1749 Kneeling Request Left Side

Command signal to activate the kneeling functionality on the left side of the vehicle

00 No kneeling request
01 Kneeling request
10 Reserved
11 Don't care/take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 53760

SPN 1750 Nominal Level Request Rear Axle

Command signal to activate a level of the rear axle programmed and/or memorised in the ECU. For explanations of nominal level see SPN 1734 - Nominal Level Front Axle.

0000 No level request
0001 Normal Level 1,(i.e. the level prescribed for normal driving, given by design)
0010 Normal Level 2,(i.e. a level permitted for driving, for example to lower the vehicle in case of high speed)
0011 Normal Level 3,(i.e. a level permitted for driving, for example to lift the vehicle in case of offroad)
0100 Preset Level,(i.e. a level to be defined externally via CAN)
0101 Customer Level,(i.e. a level to be defined by customer via parameter setting)
0110 Upper Level,(i.e. the highest level to be controlled)
0111 Lower Level,(i.e. the lowest level to be controlled)
1000 Stop level change,(i.e. the level change in process shall be stopped immediately)
1001-1101 Not defined
1110 Reserved
1111 Don't care/take no action

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 53760

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SPN 1751 Nominal Level Request Front Axle

Command signal to activate a level of the front axle programmed and/or memorised in the ECU For explanations of nominal level see SPN 1734 - Nominal Level Front Axle.

0000 No level request
0001 Normal Level 1,(i.e. the level prescribed for normal driving, given by design)
0010 Normal Level 2,(i.e. a level permitted for driving, for example to lower the vehicle in case of high speed)
0011 Normal Level 3,(i.e. a level permitted for driving, for example to lift the vehicle in case of offroad)
0100 Preset Level,(i.e. a level to be defined externally via CAN)
0101 Customer Level,(i.e. a level to be defined by customer via parameter setting)
0110 Upper Level,(i.e. the highest level to be controlled)
0111 Lower Level,(i.e. the lowest level to be controlled)
1000 Stop level change,(i.e. the level change in process shall be stopped immediately)
1001-1101 Not defined
1110 Reserved
1111 Don't care/take no action

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 53760

SPN 1752 Lift Axle 1 Position Command

Signal to command the position/load condition of lift/tag axle #1. Numbering of lift/tag axles starts at front axle.

00 Lift axle position down / tag axle laden
01 Lift axle position up / tag axle unladen
10 Reserved
11 Don't care/take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 53760

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SPN 1753 (R) Level Control Mode Request

Command signal to activate a level control mode

0000 Normal operation; i.e. the system performs a ""pure"" control of the vehicle height
0001 Traction help (load transfer); i.e. the driven axle is loaded to a maximum value given by legislation or design
0010 Load fixing; i.e. the driven axlen is loaded to a value defined by the driver
0011 Pressure ratio 1; i.e. the ratio between the pressures at the driven axle and at the third axle is controlled, so that the ratio equals a fixed value 1
0100 Pressure ratio 2; i.e. the ratio between the pressures at the driven axle and at the third axle is controlled, so that the ratio equals a fixed value 2
0101 Optimum traction 1; i.e. the pressure at the driven axle is controlled at a fixed value 1
0110 Optimum traction 2; i.e. the pressure at the driven axle is controlled at a fixed value 2
0111 Traction help - load reduce; (i.e. reduce axle load of driven axle to normal load condition)
1000 Exhaust bellows
1001 -1101 Not defined
1110 Reserved
1111 Don't care/take no action

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 53760

SPN 1754 Below Nominal Level Rear Axle

Signal which indicates whether the actual height of the rear axle is below the nominal (desired) level for the rear axle. For explanations of nominal level see SPN 1734 - Nominal Level Front Axle.

00 Not below
01 Below
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65114

SPN 1755 Lowering Control Mode Rear Axle

Signal which indicates the actual lowering level change at the rear axle

00 Lowering not active
01 Lowering active
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65114

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SPN 1756 Lifting Control Mode Rear Axle

Signal which indicates the actual lifting level change at the rear axle

00 Lifting not active
01 Lifting active
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65114

SPN 1757 Level Preset Front Axle Right

Set value for nominal level 'preset level' at the right side of the front axle. This value is referred to 'Normal level 1'. For explanations of normal level 1 see SPN 1734 - Nominal Level Front Axle.

Data Length: 2 bytes
Resolution: 0.1 mm/bit, -3,200 mm offset
Data Range: -3,200 to 3,225.5 mm Operational Range: same as data range
Type: Status
Supporting information:
PGN 53504

SPN 1758 Level Preset Rear Axle Left

Set value for nominal level 'preset level' at the left side of the rear axle. This value is referred to 'Normal level 1'. For explanations of normal level 1 see SPN 1734 - Nominal Level Front Axle.

Data Length: 2 bytes
Resolution: 0.1 mm/bit, -3,200 mm offset
Data Range: -3,200 to 3,225.5 mm Operational Range: same as data range
Type: Status
Supporting information:
PGN 53504

SPN 1759 Blade Height Set Point - High Resolution

High resolution for the laser guided blade set point. The high resolution required for more accurate control and 'accurate' unit conversions.

Negative values are below grade, positive values are above grade, zero is on grade.

Data Length: 4 bytes
Resolution: 100 mm/bit, -209.7152 m offset
Data Range: -209.7152 m to 211.3929215 Operational Range: -209.7152m to 209.7152m
Type: Measured
Supporting information:
PGN 65140

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SPN 1760 Gross Combination Vehicle Weight

The total weight of the truck and all attached trailers.

Data Length: 2 bytes
Resolution: 10 kg/bit, 0 offset
Data Range: 0 to 642,550 kg Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65136

SPN 1761 Catalyst Tank Level

A special catalyst uses chemical substance to reach legal requirement for NOX emissions. This parameter indicates the level within that catalyst tank.

0 % = Empty
100% = Full

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65110

SPN 1762 Hydraulic Pressure

Hydraulic pressure measured at the output of the hydraulic pump.

Data Length: 2 bytes
Resolution: 2 kPa/bit, 0 offset
Data Range: 0 to 128,510 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61448

SPN 1763 (R) Engine Hydraulic Pressure Governor Mode Indicator

Mode for governor operation is hydraulic pressure control.

00 Disabled
01 Enabled
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61448

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SPN 1764 (R) Engine Hydraulic Pressure Governor Switch

Switch that sets the mode of hydraulic governor

00 Pressure Mode Inactive
01 Pressure Mode Active
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61448

SPN 1765 (R) Engine Requested Fuel Valve 1 Position

The requested position of a gaseous fuel valve 1 that is metering the fuel flow to the engine.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 65153

SPN 1766 (R) Engine Requested Fuel Valve 2 Position

The requested position of a gaseous fuel valve 2 that is metering the fuel flow to the engine, as requested by the Engine Control Unit.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 65153

SPN 1767 Specific Heat Ratio

The specific heat ratio of the fuel.

Data Length: 2 bytes
Resolution: 0.001/bit, 0 offset
Data Range: 0 to 64.255 Operational Range: 0 to 2.0000
Type: Status
Supporting information:
PGN 65109

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SPN 1768 (R) Engine Low Limit Threshhold for Maximum RPM from Engine

Minimum allowable value for maximum continuous RPM from engine

Data Length: 1 byte
Resolution: 32 rpm/bit, 0 offset
Data Range: 0 to 8,000 rpm Operational Range: same as data range
Type: Status
Supporting information:
PGN 65108

SPN 1769 (R) Engine High Limit Threshhold for Minimum Continuous Engine RPM

Maximum allowable value for minimum continuous RPM from engine

Data Length: 1 byte
Resolution: 32 rpm/bit, 0 offset
Data Range: 0 to 8,000 rpm Operational Range: same as data range
Type: Status
Supporting information:
PGN 65108

SPN 1770 (R) Engine Low Limit Threshold for Maximum Torque from Engine

Minimum allowable value for maximum continuous torque. From engine

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 65108

SPN 1771 (R) Engine High Limit Threshhold for Minimum Continuous Torque from Engine

Maximum allowable value for minimum continuous torque. From engine

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 65108

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SPN 1772 (R) Engine Maximum Continuous RPM

Applied limit for maximum continuous engine RPM

Data Length: 1 byte
Resolution: 32 rpm/bit, 0 offset
Data Range: 0 to 8,000 rpm Operational Range: same as data range
Type: Status
Supporting information:
PGN 65108

SPN 1773 (R) Engine Minimum Continuous RPM

Applied limit for minimum continuous engine RPM

Data Length: 1 byte
Resolution: 32 rpm/bit, 0 offset
Data Range: 0 to 8,000 rpm Operational Range: same as data range
Type: Status
Supporting information:
PGN 65108

SPN 1774 (R) Engine Maximum Continuous Torque

Applied limit for maximum continuous engine torque.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 65108

SPN 1775 (R) Engine Minimum Continuous Torque

Applied limit for minimum continuous engine torque

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 65108

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SPN 1776 ***Low Limit Threshhold for Maximum RPM from Retarder***

Minimum allowable value for maximum continuous retarder speed

Data Length: 1 byte
Resolution: 32 rpm/bit, 0 offset
Data Range: 0 to 8,000 rpm
Operational Range: same as data range
Type: Status
Supporting information:
PGN 65107

SPN 1777 ***High Limit Threshhold for Minimum Continuous RPM from Retarder***

Maximum allowable value for minimum continuous retarder speed

Data Length: 1 byte
Resolution: 32 rpm/bit, 0 offset
Data Range: 0 to 8,000 rpm
Operational Range: same as data range
Type: Status
Supporting information:
PGN 65107

SPN 1778 ***Low Limit Threshhold for Maximum Torque from Retarder***

Minimum allowable value for maximum continuous retarder torque.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 %
Operational Range: same as data range
Type: Status
Supporting information:
PGN 65107

SPN 1779 ***High Limit Threshhold for Minimum Continuous Torque from Retarder***

Maximum allowable value for minimum continuous retarder torque.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 %
Operational Range: same as data range
Type: Status
Supporting information:
PGN 65107

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SPN 1780 Maximum Continuous Retarder Speed

Applied limit for maximum continuous retarder RPM

Data Length: 1 byte
Resolution: 32 rpm/bit, 0 offset
Data Range: 0 to 8,000 rpm Operational Range: same as data range
Type: Status
Supporting information:
PGN 65107

SPN 1781 Minimum Continuous Retarder Speed

Applied limit for minimum continuous retarder RPM

Data Length: 1 byte
Resolution: 32 rpm/bit, 0 offset
Data Range: 0 to 8,000 rpm Operational Range: same as data range
Type: Status
Supporting information:
PGN 65107

SPN 1782 Maximum Continuous Retarder Torque

Applied limit for maximum continuous retarder torque.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 65107

SPN 1783 Minimum Continuous Retarder Torque

Applied limit for minimum continuous retarder torque

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 65107

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SPN 1784 (R) Engine Speed Limit Request - Minimum Continuous

Requested minimum continuous engine speed
Data Length: 1 byte
Resolution: 32 rpm/bit, 0 offset
Data Range: 0 to 8,000 rpm Operational Range: same as data range
Type: Status
Supporting information:
PGN 52992

SPN 1785 (R) Engine Speed Limit Request - Maximum Continuous

Requested maximum continuous engine speed
Data Length: 1 byte
Resolution: 32 rpm/bit, 0 offset
Data Range: 0 to 8,000 rpm Operational Range: same as data range
Type: Status
Supporting information:
PGN 52992

SPN 1786 (R) Engine Torque Limit Request - Minimum Continuous

Requested minimum continuous engine torque (operating range: 0 to 125%)
Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: 0 to 125%
Type: Status
Supporting information:
PGN 52992

SPN 1787 (R) Engine Torque Limit Request - Maximum Continuous

Requested maximum continuous engine torque (operating range: 0 to 125%)
Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: 0 to 125%
Type: Status
Supporting information:
PGN 52992

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SPN 1788 Minimum Continuous Retarder Speed Limit Request

Requested minimum continuous retarder speed
Data Length: 1 byte
Resolution: 32 rpm/bit, 0 offset
Data Range: 0 to 8,000 rpm Operational Range: same as data range
Type: Status
Supporting information:
PGN 52992

SPN 1789 Maximum Continuous Retarder Speed Limit Request

Requested maximum continuous retarder speed
Data Length: 1 byte
Resolution: 32 rpm/bit, 0 offset
Data Range: 0 to 8,000 rpm Operational Range: same as data range
Type: Status
Supporting information:
PGN 52992

SPN 1790 Minimum Continuous Retarder Torque Limit Request

Requested minimum continuous retarder torque (operating range: -125 to 0%)
Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: -125 to 0%
Type: Status
Supporting information:
PGN 52992

SPN 1791 Maximum Continuous Retarder Torque Limit Request

Requested maximum continuous retarder torque (operating range: -125 to 0%)
Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: -125 to 0%
Type: Status
Supporting information:
PGN 52992

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SPN 1792 Tractor-Mounted Trailer ABS Warning Signal

This parameter commands the tractor-mounted trailer ABS optical warning signal.

00 Off
01 On
10 Reserved
11 Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61441

SPN 1793 ATC/ASR Information Signal

This parameter commands the ATC/ASR driver information signal, for example a dash lamp.

00 Off
01 On
10 Reserved
11 Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61441

SPN 1794 Engine Moment of Inertia

Moment of inertia for the engine, including items driven full-time by the engine such as fuel, oil and cooling pumps. The inertia from the following items are not included: flywheel, alternator, compressor, fan, and other engine-driven accessories.

Data Length: 2 bytes
Resolution: 0.004 kg-m^2/bit, 0 offset
Data Range: 0 to 257.02 kg-m^2 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65251

SPN 1795 Alternator Current (High Range/Resolution)

This parameter indicates the amount of electrical current output from the alternator of the main vehicle. Alternator Current (SPN 115) has a lower range and resolution.

Data Length: 2 bytes
Resolution: 0.05 A/bit, -1600 A offset
Data Range: -1600 to 1612.75 A Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65106

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SPN 1796 ACC Distance Alert Signal

Signal to indicate to the operator that the ACC system is not able to maintain the distance to the target. Example: Target stopping rapidly. This signal may be used to activate warning sounds or indicators.

00 ACC DAS Not Active
01 ACC DAS Active
10 Reserved
11 Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65135

SPN 1797 ACC System Shutoff Warning

Signal to warn the driver of system deactivation due to non-driver actions. Example: Attempting to control vehicle speed below or above limits of ACC. This signal may be used to activate warning sounds or indicators.

00 ACC SSOW Not Active
01 ACC SSOW Active
10 Reserved
11 Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65135

SPN 1798 ACC Target Detected

Signal to indicate to the driver that the ACC system has detected a target.

00 No targets detected
01 Target detected
10 Reserved
11 Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65135

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SPN 1799 Requested ACC Distance Mode

The Requested Distance Control Mode to the ACC system from the operators interface.

The ACC Set Distance Mode (SPN 1589) indicates the selected Distance Control Mode for the ACC system. This parameter is the driver requested setting for this.

000 Requested ACC Distance Mode #1 (largest distance)
001 Requested ACC Distance Mode #2
010 Requested ACC Distance Mode #3
011 Requested ACC Distance Mode #4
100 Requested ACC Distance Mode #5 (shortest distance)
101 not defined
110 error condition
111 not available

Data Length: 3 bits
Resolution: 8 states/3 bit, 0 offset
Data Range: 0 to 7 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65105

SPN 1800 Battery 1 Temperature

Temperature of the battery 1. The relation to physical location is determined by the equipment manufacturer.

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65104

SPN 1801 Battery 2 Temperature

Temperature of the battery 2. The relation to physical location is determined by the equipment manufacturer.

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65104

SPN 1802 (R) Engine Intake Manifold 5 Temperature

Temperature of pre-combustion air found in intake manifold number 5 of engine air supply system.

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65189

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SPN 1803 (R) Engine Intake Manifold 6 Temperature

Temperature of pre-combustion air found in intake manifold number 6 of engine air supply system.

Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65189

SPN 1804 (R) Engine Start Enable Device 2

Devices that assist an engine in starting, e.g. intake heaters, ether, or an alternate/secondary starting aid. May be of the same type or different than Start Enable Device 1 (SPN 626). Parameter indicating whether the start enable device 2 is ON or OFF.

00 - start enable OFF
01 - start enable ON
10 - reserved

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64966

SPN 1805 LED Display Mode Control

This parameter informs the system what the selected Display mode will be.

0000 - Center On-Grade Display Mode 1 (5 CHANNEL)
0001 - Offset On-Grade Display Mode
0010 - Center On-Grade Display Mode 2 (7 CHANNEL)
0011 - 1110 Reserved
1111 - Not Available or Not Applicable

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65142

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SPN 1806 LED Display Deadband Control

This parameter informs the system what the selected Display deadband will be.

0000 +/- 4.5 mm (0.015 feet, 0.18 inches)
0001 +/- 12 mm (0.040 feet, 0.45 inches)
0010 +/- 24 mm (0.080 feet, 0.96 inches)
0011 +/- 5 mm (0.017 feet, 0.2 inches)
0100 +/- 1 mm (0.003 feet, 0.04 inches)
0101 - 1110 Reserved
1111 Not Available or Not applicable

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65142

SPN 1807 Steering Wheel Angle

The main operator's steering wheel angle (on the steering column, not the actual wheel angle). The vehicle being steered to the left results in a positive steering wheel angle.

Data Length: 2 bytes
Resolution: 1/1024 rad per bit, -31.374 rad offset
Data Range: -31.374 to +31.374 rad Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61449

SPN 1808 Yaw Rate

Indicates the rotation about the vertical axis. A positive yaw rate signal results when the vehicle turns counter-clockwise.

Data Length: 2 bytes
Resolution: 1/8192 rad/s per bit, -3.92 rad/s offset
Data Range: -3.92 to +3.92 rad/s Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61449

SPN 1809 Lateral Acceleration

Indicates a lateral acceleration of the vehicle. A positive lateral acceleration signal results when the vehicle is accelerated to the left.

Data Length: 2 bytes
Resolution: 1/2048 m/s² per bit, -15.687 m/s² offset
Data Range: -15.687 to +15.687 m/s² Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61449

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SPN 1810 Longitudinal Acceleration

Indicates the longitudinal acceleration of the vehicle. A positive longitudinal acceleration signal results when the vehicle speed increases, regardless of driving the vehicle forward or backward.

Data Length: 1 byte
Resolution: 0.1 m/s² per bit, -12.5 m/s² offset
Data Range: -12.5 to +12.5 m/s² Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61449

SPN 1811 Steering Wheel Turn Counter

Indicates number of steering wheel turns, absolute position or relative position at ignition on. Positive values indicate left

Data Length: 6 bits
Resolution: 1 turn/bit, -32 turns offset
Data Range: -32 to 29 turns Operational Range: -10 to +10 Turns
Type: Measured
Supporting information:
PGN 61449

SPN 1812 Steering Wheel Angle Sensor Type

Indicates whether the steering wheel angle sensor is capable of absolute measuring of the number of steering wheel turns or not (relative measuring to position at ignition on).

00 Relative measuring principle
01 Absolute measuring principle
10 Reserved
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61449

SPN 1813 VDC Information Signal

This parameter commands the VDC information signal, for example a dash lamp.

00 Off
01 On
10 Reserved
11 Don't care/Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65103

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SPN 1814 VDC Fully Operational

Signal that indicates whether VDC is fully operational or whether its functionality is reduced by a permanent or temporary (e.g. low voltage) defect, by intended action (e.g. disabled by a switch or during special diagnostic procedures), not configured or not yet fully initialized (e.g. missing initialization or configuration message). VDC contains ROP and YC.

00 Not fully operational
01 Fully operational
10 Reserved
11 Don't care/Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65103

SPN 1815 VDC brake light request

Indicates whether VDC requests to turn the vehicle brake lights on

00 Turn brake light not on
01 Turn brake light on
10 Reserved
11 Don't care/Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65103

SPN 1816 ROP Engine Control active

State Signal which indicates that the Roll Over Prevention (ROP) has commanded engine control to be active. Within the physical limits, ROP attempts to prevent rolling over of the vehicle. Active means that ROP actually tries to control the engine. This state signal is independent of other control commands to the engine which may have higher priority.

00 ROP engine control passive but installed
01 ROP engine control active
10 Reserved
11 Don't care/Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65103

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SPN 1817 YC Engine Control active

State Signal which indicates that the Yaw Control (YC) has commanded engine control to be active. Within the physical limits, YC attempts to prevent yawing of the vehicle. Active means that YC actually tries to control the engine. This state signal is independent of other control commands to the engine which may have higher priority.

00 YC engine control passive but installed
01 YC engine control active
10 Reserved
11 Don't care/Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65103

SPN 1818 ROP Brake Control active

State signal which indicates that Roll over Prevention (ROP) has activated brake control. Active means that ROP actually controls wheel brake pressure at one or more wheels of the vehicle or vehicle combination. Within the physical limits, ROP attempts to prevent rolling over of the vehicle.

00 ROP brake control passive but installed
01 ROP brake control active
10 Reserved
11 Don't care/Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65103

SPN 1819 YC Brake Control active

State signal which indicates that Yaw Control (YC) has activated brake control. Active means that YC actually controls wheel brake pressure at one or more wheels of the vehicle or vehicle combination. Within the physical limits, YC attempts to prevent yawing of the vehicle.

00 YC brake control passive but installed
01 YC brake control active
10 Reserved
11 Don't care/Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65103

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SPN 1820 Ramp / Wheel Chair Lift Position

Signal which indicates the actual position of the ramp / wheel chair lift.

00 Inside bus
01 Outside bus
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65102

SPN 1821 Position of doors

Signal which indicates the actual position of the doors.

0000 At least 1 door is open
0001 Closing last door
0010 All doors closed
0011-1101 Not defined
1110 Error
1111 Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65102

SPN 1822 Lift Axle 2 Position

Signal which indicates the position / load condition of lift axle / tag axle #2. Numbering of lift/tag axles starts at front axle.

00 Lift axle position down / tag axle laden
01 Lift axle position up / tag axle unladen
10 Error

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65114

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SPN 1823 Rear Axle in Bumper Range

Signal which indicates that the vehicle height at the rear axle (SPNs 1723 and 1724) is within the bumper range.

00 Actual level out of bumper range
01 Actual level within bumper range
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65114

SPN 1824 Front Axle in Bumper Range

Signal which indicates that the vehicle height at the front axle (SPNs 1721 and 1722) is within the bumper range.

00 Actual level out of bumper range
01 Actual level within bumper range
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65114

SPN 1825 Suspension Remote control 2

Signal which indicates that the suspension system is controlled by remote control #2. Remote control is an external unit to operate the suspension system.

00 Not active
01 Active
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65114

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SPN 1826 Suspension Remote Control 1

Signal which indicates that the suspension system is controlled by remote control #1. Remote control is an external unit to operate the suspension system.

00 Not active
01 Active
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65114

SPN 1827 (R) Suspension Control Refusal Information

Signal which indicates that the air suspension control cannot perform a request due to the operating conditions. It also provides a reason for the refusal.

0000 Actual request not refused
0001 Axle load limit reached (load transfer)
0010 Would exceed axle load limit (tag axle)
0011 Bogie differential not locked
0100 Above speed limit
0101 Below speed limit
0110 General reject; i.e. no specified reason applies
0111 - 1101 Not defined
1110 Error
1111 Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65114

SPN 1828 Lift Axle 2 Position Command

Signal to command the position / load condition of lift / tag axle #2. Numbering of lift/tag axles starts at front axle.

00 Lift axle position down / tag axle laden
01 Lift axle position up / tag axle unladen
10 Reserved
11 Don't care/take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 53760

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SPN 1829 Kneeling Command - Rear Axle

Command signal to activate the kneeling functionality at the rear axle of the vehicle.

00 Deactivate kneeling
01 Activate kneeling
10 Reserved
11 Don't care/take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 53760

SPN 1830 Kneeling Command - Front Axle

Command signal to activate the kneeling functionality at the front axle of the vehicle

00 Deactivate kneeling
01 Activate kneeling
10 Reserved
11 Don't care/take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 53760

SPN 1831 Electronic Shock Absorber Control Mode - Lift/Tag Axle

Signal which indicates the current mode of operation of the electronic shock absorber control at the lift/tag axle.

00 Normal operation dampers passive
01 Normal operation dampers active
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65111

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SPN 1832 Electronic Shock Absorber Control Mode - Rear Axle

Signal which indicates the current mode of operation of the electronic shock absorber control at the rear axle.

00 Normal operation dampers passive
01 Normal operation dampers active
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65111

SPN 1833 Electronic Shock Absorber Control Mode - Front Axle

Signal which indicates the current mode of operation of the electronic shock absorber control at the front axle.

00 Normal operation dampers passive
01 Normal operation dampers active
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65111

SPN 1834 (R) Engine Total Average Fuel Rate

Average fuel rate, equal to total fuel used divided by total engine hours, over the life of the engine

Data Length: 2 bytes
Resolution: 0.05 L/h per bit, 0 offset
Data Range: 0 to 3,212.75 L/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65101

SPN 1835 (R) Engine Total Average Fuel Economy

Average fuel economy, equal to total vehicle distance divided by total fuel used, over the life of the engine

Data Length: 2 bytes
Resolution: 1/512 km/L per bit, 0 offset
Data Range: 0 to 125.5 km/L Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65101

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SPN 1836 Trailer ABS Status

State signal which indicates that ABS in the trailer is actively controlling the brakes. A message is sent to the tractor from the trailer (i.e. by PLC). The receiving device in the tractor transfers this information to the J1939 network. At the beginning of power on the message is sent by the trailer to indicate if this status information is supported. Timeout of the trailer ABS active can be done by monitoring of the Trailer warning light information.

00 Trailer ABS Status Information Available But Not Active
01 Trailer ABS Active
10 Reserved
11 Trailer ABS Status Information Not Available or Parameter Not Supported

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61441

SPN 1837 Convoy Driving Lamp Select

Black Out Convoy Driving Lamp Selection

00 Off
01 On
10 Reserved
11 Not Supported

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65100

SPN 1838 Convoy Lamp Select

Black Out Convoy Lamp Selection

00 Off
01 On
10 Reserved
11 Not Supported

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65100

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SPN 1839 Front Black Out Marker Lamp Select

Front Black Out Marker Lamp Selection

00 Off
01 On
10 Reserved
11 Not Supported

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65100

SPN 1840 Rear Black Out Marker Select

Rear Black Out Marker Selection

00 Off
01 On
10 Reserved
11 Not Supported

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65100

SPN 1841 Black Out Brake/Stop Lamp Select

Black Out Brake/Stop Lamp Selection

00 Off
01 On
10 Reserved
11 Not Supported

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65100

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SPN 1842 Black Out Work Lamp Select

Black Out Work Lamp Selection

00 Off
01 On
10 Reserved
11 Not Supported

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65100

SPN 1843 Night Vision Illuminator Select

Night Vision Illuminator Selection

00 Off
01 On
10 Reserved
11 Not Supported

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65100

SPN 1844 Operators Black Out Intensity Selection

Operators Selection of lamp intensity in black out mode. This parameter provides the operators selected illumination intensity as a percentage of available full scale. This parameter would be typically used as a dash or instrument cluster

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Status
Supporting information:
PGN 65100

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SPN 1845 Transmission Torque Limit

Parameter provided to the engine from the transmission as a torque limit to be invoked by the engine in the event that J1939 communication with the transmission is lost.

The intention is to protect transmissions that use a continuous torque limit during torque converter mode or operation in specific lower gears, where stall or drivetrain torque may reach levels higher than the gearbox capacity. If communication is lost during torque limited operation, unrestricted engine torque output could harm the transmission.

It is recommended that engines use reception of the ETC#1 message as a transmission "heartbeat". In the event that the ETC#1 message is not received in a time period of 5 times its' broadcast rate (5 x 10 ms = 50 ms), the engine should invoke a torque limit holding the engine to less than or equal to the value of the Transmission Torque Limit parameter. The engine may release the limit when transmission-to-engine communication is re-established.

A value of 0xFF00 to 0xFFFF indicates that no transmission torque limit is desired.

It is expected that the engine will record this torque value in non-volatile memory and will include this in the engine configuration PGN as parameter Engine Default Torque Limit (SPN 1846)

If the engine observes change in this parameter value on power-up, the engine should record the new value.

Data Length:	2 bytes		
Resolution:	1 Nm/bit, 0 offset		
Data Range:	0 to 64,255 Nm	Operational Range:	same as data range
Type:	Measured		
Supporting information:			
PGN	65099		

SPN 1846 (R) Engine Default Torque Limit

Companion parameter to Transmission Torque Limit (SPN 1845). This "echo" parameter provides confirmation to the transmission that the engine has received and will invoke the requested Transmission Torque Limit in the event that J1939 communication is lost between the two devices.

If the engine supports this protection logic, the Engine Default Torque Limit parameter should be set equal to the Transmission Torque Limit parameter as received in the Transmission Configuration message (PGN 65250). Otherwise, a Engine Default Torque Limit value of FF00 to FFFF indicates that no engine default torque limit has been received or set.

The intention is to protect transmissions that use a continuous torque limit during torque converter mode or operation in specific lower gears, where stall or drivetrain torque may reach levels higher than the gearbox capacity. If communication is lost during torque limited operation, unrestricted engine torque output could harm the transmission.

It is recommended that engines use reception of the ETC#1 message as a transmission "heartbeat". In the event that the ETC#1 message is not received in a time period of 5 times its' broadcast rate (5 x 10 ms = 50 ms), the engine should invoke a torque limit holding the engine to less than or equal to the value of the Transmission Torque Limit parameter. The engine may release the limit when engine-to-transmission communication is re-established.

Data Length:	2 bytes		
Resolution:	1 Nm/bit, 0 offset		
Data Range:	0 to 64,255 Nm	Operational Range:	same as data range
Type:	Measured		
Supporting information:			
PGN	65251		

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SPN 1849 Transmission Requested Range Display Flash State

State signal indicating a transmission request for the display of the Transmission Requested Range parameter (SPN 162) to flash or not to flash. The 'Transmission Requested Range Display Flash State' indicator can be utilized by (but not limited to) the shift console, instrument cluster, or cab display. Definition of the cause of this state is at the discretion of the transmission manufacturer. The flash period shall be 700 ms @ 50% duty cycle.

Transmission manufacturers may want to flash the Transmission Requested Range display depending on certain events. It could be because a gear could not be attained, or because fluid is low, etc. Indicator should be on for 350 ms and off for 350 ms.

Transmissions supporting both this parameter and the Transmission Requested Range Display Blank State should treat the active states of these parameters as mutually exclusive; both parameters should not indicate "active" at the same time.

00 Inactive; Transmission Requested Range display should not be flashing
01 Active; Transmission Requested Range display should be flashing
10 Reserved
11 Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65098

SPN 1850 Transmission Requested Range Display Blank State

State signal indicating a transmission request for the display of the Transmission Requested Range parameter (SPN162) to be blanked or not blanked. The 'Transmission Requested Range Display Blank State' indicator can be utilized by (but not limited to) the shift console, instrument cluster, or cab display. Definition of the cause of this state is at the discretion of the transmission manufacturer

Transmission manufacturers may want to blank the Transmission Requested Range display depending on certain events. Typically it is an indication of a shift selector problem.

Transmissions supporting both this parameter and the Transmission Requested Range Display Flash State should treat the active states of these parameters as mutually exclusive; both parameters should not indicate "active" at the same time.

00 Inactive; Transmission Requested Range display should not be blanked
01 Active; Transmission Requested Range display should be blanked
10 Reserved
11 Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65098

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SPN 1851 (R) Transmission Shift Inhibit Indicator

State signal indicating a transmission request for the Shift Inhibit Indicator to be active or inactive. The shift inhibit indicator can be of lamp or text form, located on (but not limited to) the shift console, instrument cluster, or cab display. Definition of the cause of the 'range inhibit' state is at the discretion of the transmission manufacturer.

Transmission manufacturers may want to indicate that they currently cannot make a requested shift. This could be due to inappropriate vehicle speed or other restrictions.

00 Inactive; shift is not inhibited
01 Active; shift is inhibited
10 Reserved
11 Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65098

SPN 1852 Transmission Mode 1

Indicates whether transmission mode 1 is enabled. Modes are manufacturer specific and are not necessarily mutually exclusive. See also 2536.

00 Disable
01 Enable
10 Reserved
11 Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 256

SPN 1853 Transmission Mode 2

Indicates whether transmission mode 2 is enabled. Modes are manufacturer specific and are not necessarily mutually exclusive. See also SPN 2537.

00 Disable
01 Enable
10 Reserved
11 Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 256

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SPN 1854 Transmission Mode 3

Indicates whether transmission mode 3 is enabled. Modes are manufacturer specific and are not necessarily mutually exclusive. See also SPN 2538.

00 Disable
01 Enable
10 Reserved
11 Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 256

SPN 1855 Transmission Mode 4

Indicates whether transmission mode 4 is enabled. Modes are manufacturer specific and are not necessarily mutually exclusive. See also SPN 2539.

00 Disable
01 Enable
10 Reserved
11 Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 256

SPN 1856 Seat Belt Switch

State of switch used to determine if Seat Belt is buckled

00 NOT Buckled
01 OK - Seat Belt is buckled
10 Error - Switch state cannot be determined
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 57344

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SPN 1857 Winch Oil Pressure Switch

State of switch used to determine if Winch Oil Pressure is above desired minimum

00 NOT OK- Oil pressure is too low
01 OK - Oil pressure is above minimum
10 Error - Switch state cannot be determined
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65128

SPN 2347 High Beam Head Light Command

Command to activate or de-activate the tractor high beam head light lamps.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2348 High Beam Head Light Data

This parameter provides measured data from the tractor high beam head light lamps.

00 De-activate
01 Activate
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

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SPN 2349 Low Beam Head Light Command

Command to activate or de-activate the tractor low beam head light lamps.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2350 Low Beam Head Light Data

This parameter provides measured data from the tractor low beam head light lamps.

00 De-activate
01 Activate
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2351 Alternate Beam Head Light Command

Command to activate or de-activate the tractor alternate head lights (only low beam is available on alternate head lights). The alternate position lights are intended for use with loader and snow plows that tend to block the primary head lights.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

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SPN 2352 Alternate Beam Head Light Data

This parameter provides measured data from the tractor alternate beam head light lamps.

00 De-activate
01 Activate
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2353 Tractor Front Low Mounted Work Lights Command

Command to activate or de-activate the tractor front low mounted work lights.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2354 Tractor Front Low Mounted Work Lights

This parameter provides measured data from the tractor front low mounted work lights.

00 De-activate
01 Activate
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

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SPN 2355 Tractor Front High Mounted Work Lights Command

Command to activate or de-activate the tractor front high mounted work lights.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2356 Tractor Front High Mounted Work Lights

This parameter provides measured data from the tractor front high mounted work lights.

00 De-activate
01 Activate
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2357 Tractor Underside Mounted Work Lights Command

Command to activate or de-activate the tractor underside mounted work lights.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

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SPN 2358 Tractor Underside Mounted Work Lights

This parameter provides measured data from the tractor underside mounted work lights.

00 De-activate
01 Activate
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2359 Tractor Rear Low Mounted Work Lights Command

Command to activate or de-activate the tractor rear low mounted work lights.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2360 Tractor Rear Low Mounted Work Lights

This parameter provides measured data from the tractor rear low mounted work lights.

00 De-activate
01 Activate
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

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SPN 2361 Tractor Rear High Mounted Work Lights Command

Command to activate or de-activate the tractor rear high mounted work lights.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2362 Tractor Rear High Mounted Work Lights

This parameter provides measured data from the tractor rear high mounted work lights.

00 De-activated
01 Activated
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2363 Tractor Side Low Mounted Work Lights Command

Command to activate or de-activate the tractor side low mounted work lights.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

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SPN 2364 Tractor Side Low Mounted Work Lights

This parameter provides measured data from the tractor side low mounted work lights.

00 De-activated
01 Activated
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2365 Tractor Side High Mounted Work Lights Command

Command to activate or de-activate the tractor side high mounted work lights.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2366 Tractor Side High Mounted Work Lights

This parameter provides measured data from the tractor side high mounted work lights.

00 De-activated
01 Activated
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

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SPN 2367 Left Turn Signal Lights Command

Command to activate or de-activate left turn signal lights on the tractor and all connected implements

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2368 Left Turn Signal Lights

This parameter provides measured data from the tractor and attached implement left turn signal lights.

00 De-activated
01 Activated
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2369 Right Turn Signal Lights Command

Command to activate or de-activate right turn signal lights on the tractor and all connected implements

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

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SPN 2370 Right Turn Signal Lights

This parameter provides measured data from the tractor and attached implement right turn signal lights.

00 De-activated
01 Activated
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2371 Left Stop Light Command

Command to activate or de-activate the tractor and implement left stop lights

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2372 Left Stop Light

This parameter provides measured data from the tractor and attached implement left stop lights.

00 De-activated
01 Activated
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

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SPN 2373 Right Stop Light Command

Command to activate or de-activate the tractor and implement right stop light

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2374 Right Stop Light

This parameter provides measured data from the tractor and attached implement right stop lights.

00 De-activated
01 Activated
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2375 Center Stop Light Command

Command to activate or de-activate the tractor and implement center stop light

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

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SPN 2376 Center Stop Light

This parameter provides measured data from the tractor and attached implement center stop lights.

00 De-activated
01 Activated
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2377 Tractor Marker Light Command

Command to activate or de-activate tractor and implement front position lights, rear red tail lights, side amber running lights, license plate lights and instrument and switch back lights.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2378 Tractor Marker Light

This parameter provides measured data from the tractor and attached implement marker lights, including front position lights, rear tail lights, side running lights, license plate lights and instruments and switch back lights.

00 De-activated
01 Activated
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

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SPN 2379 Implement Marker Light Command

Command to activate or de-activate implement front position lights, rear red tail lights, side amber running lights, license plate lights and instrument and switch back lights.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2380 Implement Marker Light

This parameter provides measured data from an attached implement marker lights, including front position lights, rear tail lights, side running lights, license plate lights and instruments and switch back lights.

00 De-activated
01 Activated
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2381 Tractor Clearance Light Command

Command to activate or de-activate the tractor high mounted clearance and center ID lights

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

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SPN 2382 Tractor Clearance Light

This parameter provides measured data from the tractor high mounted clearance and center ID lights.

00 De-activated
01 Activated
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2383 Implement Clearance Light Command

Command to activate or de-activate the implement high mounted clearance and lights.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2384 Implement Clearance Light

This parameter provides measured data from an attached implement high mounted clearance lights.

00 De-activated
01 Activated
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

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SPN 2385 Rotating Beacon Light Command

Command to activate or de-activate slow moving vehicle indicator lights on tractor and/or implements. Activation of the slow moving vehicle lights implies that the controller should manipulate the lighting as appropriate to provide the slow moving vehicle lighting function.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2386 Rotating Beacon Light

This parameter provides measured data from the beacon light on tractor or attached implements.

00 De-activated
01 Activated
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2387 Tractor Front Fog Lights Command

Command to activate or de-activate tractor front fog lights.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

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SPN 2388 ***Tractor Front Fog Lights***

This parameter provides measured data from the tractor front fog lights.

00 De-activated
01 Activated
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2389 ***Rear Fog Light Command***

Command to activate or de-activate tractor or implement rear fog lights.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2390 ***Rear Fog Lights***

This parameter provides measured data from the tractor and/or implement rear fog lights.

00 De-activated
01 Activated
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

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SPN 2391 Back Up Light and Alarm Horn Command

Command to activate or de-activate the back up lights and/ or associated alarm if required

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2392 Back Up Light and Alarm Horn

This parameter provides measured data from the back up lights and/ or associated alarm.

00 De-activated
01 Activated
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2393 Lighting Data Request Command

Command to provide a response of the light state

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

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SPN 2394 Implement Rear Work Light

This parameter provides measured data from the implement rear work lamps.

00 De-activate
01 Activate
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2395 Implement OEM Option 1 Light Command

Command to activate or de-activate an implement OEM option 1 light. This is provided to meet special needs on implements, such as tank inspection or filling lights.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2396 Implement OEM Option 1 Light

This parameter provides measured data from the implement OEM option 1 light.

00 De-activate
01 Activate
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

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SPN 2397 Implement OEM Option 2 Light Command

Command to activate or de-activate an implement OEM option 2 light. This is provided to meet special needs on implements, such as tank inspection or filling lights.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2398 Implement OEM Option 2 Light

This parameter provides measured data from the implement OEM option 2 light.

00 De-activate
01 Activate
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2399 Implement Left Forward Work Light Command

Command to activate or de-activate the forward facing work lights toward the left end of the implement.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

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SPN 2400 Implement Left Forward Work Light

This parameter provides measured data from the forward facing work lights toward the left end of the implement.

00 De-activate
01 Activate
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2401 Implement Right Forward Work Light Command

Command to activate or de-activate the forward facing work lights toward the right end of the implement.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2402 Implement Right Forward Work Light

This parameter provides measured data from the forward facing work lights toward the right end of the implement.

00 De-activate
01 Activate
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

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SPN 2403 Running Light Command

Command to activate or de-activate the tractor or powered vehicle running lights. Usually only used for on road vehicles.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2404 Running Light

This parameter provides measured data from the vehicle's running lights.

00 De-activate
01 Activate
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2405 Implement Rear Work Light Command

Command to activate or de-activate implement rear work lights. (This is also the same as Reversing Lights for truck applications.)

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

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SPN 2406 Implement Right Facing Work Light Command

Command to activate or de-activate work lights mounted on an implement to illuminate beyond right end of the implement.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

SPN 2407 Implement Right Facing Work Light

This parameter provides measured data from the work lights mounted on an implement to illuminate beyond right end of the implement.

00 De-activate
01 Activate
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2432 Engine Demand – Percent Torque

The requested torque output of the engine by all dynamic internal inputs, including smoke control, noise control and low and high speed governing.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: -125% to +125%
Type: Measured
Supporting information: See Appendix D - SPN 2432
PGN 61444

SPN 2433 (R) Engine Exhaust Exhaust Gas Temperature - Right Manifold

Temperature of combustion byproducts within the right engine exhaust manifold. Single manifold engines should use exhaust temperature (SPN 173).

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65031

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SPN 2434 (R) Engine Exhaust Exhaust Gas Temperature - Left Manifold

Temperature of combustion byproducts within the left engine exhaust manifold. Single manifold engines should use exhaust temperature (SPN 173).

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65031

SPN 2435 Sea Water Pump Outlet Pressure

Gauge pressure of liquid found at outlet of sea water pump in sea water cooling system.

Data Length: 1 byte
Resolution: 2 kPa/bit, 0 offset
Data Range: 0 to 500 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65172

SPN 2536 Transmission Mode 1 Indicator

This state signal is the transmission's indication that it is operating under transmission mode 1 (SPN 1852) as commanded via the TC1 message (PGN 256). The definition of the transmission mode is left to the discretion of the transmission manufacturer.

00 Transmission Mode 1 not active
01 Transmission Mode 1 Active
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65098

SPN 2537 Transmission Mode 2 Indicator

This state signal is the transmission's indication that it is operating under transmission mode 2 (SPN 1853) as commanded via the TC1 message (PGN 256). The definition of the transmission mode is left to the discretion of the transmission manufacturer.

00 Transmission Mode 2 not active
01 Transmission Mode 2 Active
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65098

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SPN 2538 Transmission Mode 3 Indicator

This state signal is the transmission's indication that it is operating under transmission mode 3 (SPN 1854) as commanded via the TC1 message (PGN 256). The definition of the transmission mode is left to the discretion of the transmission manufacturer.

00 Transmission Mode 3 not active
01 Transmission Mode 3 Active
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65098

SPN 2539 Transmission Mode 4 Indicator

This state signal is the transmission's indication that it is operating under transmission mode 4 (SPN 1855) as commanded via the TC1 message (PGN 256). The definition of the transmission mode is left to the discretion of the transmission manufacturer.

00 Transmission Mode 4 not active
01 Transmission Mode 4 Active
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65098

SPN 2576 Laser Receiver Type

Identifies which type of Laser Receiver transmitted the message.

0 = Reserved
1 = Linear Laser Receiver
2 = 1 Meter Survey Receiver
3 = 2 Meter Survey Receiver
4 = 2.5 Meter Survey Receiver
5-250 = Reserved

Data Length: 1 byte
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 250 Operational Range: 1-4
Type: Status
Supporting information:
PGN 65141

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SPN 2577 Display Deadbands

Sets Display Deadbands mode.

0000 - Narrow = +/- 4.5mm
0001 - Standard = +/- 12mm
0010 - Wide = +/- 24mm
0011 - 1110 Reserved
1111 Not Available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65142

SPN 2578 LED Pattern Control

Sets LED Pattern control mode on laser leveling systems.

0000 - 5 Channel
0001 - Offset
0010 - 7 Channel
0011 - 1110 Reserved
1111 Not Available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65142

SPN 2579 Net Battery Current (High Range/Resolution)

Net flow of electrical current into/out-of the battery or batteries. This parameter is the high range and resolution of SPN 114 - Net Battery Current.

Data Length: 2 bytes
Resolution: 0.05 A/bit, -1600 A offset
Data Range: -1600 to 1612.75 A Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65106

SPN 2580 Hydraulic Brake Pressure Circuit 1

Gage hydraulic pressure in circuit 1 of the hydraulic brake system

Data Length: 1 byte
Resolution: 100 kPa/bit, 0 offset
Data Range: 0 to 25 MPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64998

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SPN 2581 Hydraulic Brake Pressure Circuit 2

Gage hydraulic pressure in circuit 2 of the hydraulic brake system

Data Length: 1 byte
Resolution: 100 kPa/bit, 0 offset
Data Range: 0 to 25 MPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64998

SPN 2582 Hydraulic Brake Pressure Supply State Circuit 1

Signal which indicates whether the hydraulic brake pressure supply of circuit 1 is reliable; that is, able to support continued braking.

00 Supply is not reliable
01 Supply is reliable
10 Error indicator
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64998

SPN 2583 Hydraulic Brake Pressure Supply State Circuit 2

Signal which indicates whether the hydraulic brake pressure supply of circuit 2 is reliable; that is, able to support continued braking.

00 Supply is not reliable
01 Supply is reliable
10 Error indicator
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64998

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SPN 2584 Hydraulic Brake Pressure Warning State Circuit 1

Signal which indicates whether the hydraulic brake pressure of circuit 1 is below the warning level

00 Pressure level sufficient
01 Pressure level below warning level
10 Error indicator
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64998

SPN 2585 Hydraulic Brake Pressure Warning State Circuit 2

Signal which indicates whether the hydraulic brake pressure of circuit 2 is below the warning level

00 Pressure level sufficient
01 Pressure level below warning level
10 Error indicator
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64998

SPN 2586 Tire Air Leakage Rate

The pressure loss rate of a tire.
Data Length: 2 bytes
Resolution: 0.1 Pa/s per bit, 0 offset
Data Range: 0 Pa/s to 6425.5 Pa/s Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65268

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SPN 2587 Tire Pressure Threshold Detection

Signal indicating the pressure level of the tire. The levels defined represent different pressure conditions of the tire:

000 Extreme over pressure - The tire pressure is at a level where the safety of the vehicle may be jeopardised.
001 Over pressure - The tire pressure is higher than the pressure defined by the vehicle or tire manufacturer.
010 No warning pressure - The tire pressure is within the thresholds defined by the vehicle or tire manufacturer.
011 Under pressure - The tire pressure is lower than the pressure defined by the vehicle or tire manufacturer.
100 Extreme under pressure - The tire pressure is at a level where the safety of the vehicle may be jeopardised.
101 Not defined
110 Error indicator
111 Not available

Data Length: 3 bits
Resolution: 8 states/3 bit, 0 offset
Data Range: 0 to 7 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65268

SPN 2588 Maximum Vehicle Speed Limit 1

The lowest Maximum Vehicle Speed Limit. This value is the similar to SPN 74. However, SPN 74 was not specifically defined to convey the applied vehicle speed limit or what was possible to be applied. This new SPN is the lowest vehicle speed limit that is possible. Additionally, the lowest vehicle speed limit shall be applied when the J1939 network is no longer providing input regarding the Selected Maximum Vehicle Speed Limit. Exceptions to this exist when the device performing the maximum vehicle speed limiting function has methods of selecting the thresholds separately from the Selected Maximum Vehicle Speed Limit parameter.

Data Length: 1 byte
Resolution: 1 km/h per bit, 0 offset
Data Range: 0 to 250 km/h Operational Range: same as data range
Type: Status
Supporting information:
PGN 64997

SPN 2589 Maximum Vehicle Speed Limit 2

The highest of the two lowest vehicle speed limits
Data Length: 1 byte
Resolution: 1 km/h per bit, 0 offset
Data Range: 0 to 250 km/h Operational Range: same as data range
Type: Status
Supporting information:
PGN 64997

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SPN 2590 Maximum Vehicle Speed Limit 3

The highest of the three lowest vehicle speed limits

Data Length: 1 byte
Resolution: 1 km/h per bit, 0 offset
Data Range: 0 to 250 km/h Operational Range: same as data range
Type: Status
Supporting information:
PGN 64997

SPN 2591 Maximum Vehicle Speed Limit 4

The highest of the four lowest vehicle speed limits

Data Length: 1 byte
Resolution: 1 km/h per bit, 0 offset
Data Range: 0 to 250 km/h Operational Range: same as data range
Type: Status
Supporting information:
PGN 64997

SPN 2592 Maximum Vehicle Speed Limit 5

The highest of the five lowest vehicle speed limits

Data Length: 1 byte
Resolution: 1 km/h per bit, 0 offset
Data Range: 0 to 250 km/h Operational Range: same as data range
Type: Status
Supporting information:
PGN 64997

SPN 2593 Maximum Vehicle Speed Limit 6

The highest of the six lowest vehicle speed limits

Data Length: 1 byte
Resolution: 1 km/h per bit, 0 offset
Data Range: 0 to 250 km/h Operational Range: same as data range
Type: Status
Supporting information:
PGN 64997

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SPN 2594 Maximum Vehicle Speed Limit 7

The highest of the seven lowest vehicle speed limits

Data Length: 1 byte
Resolution: 1 km/h per bit, 0 offset
Data Range: 0 to 250 km/h
Operational Range: same as data range
Type: Status
Supporting information:
PGN 64997

SPN 2595 Applied Vehicle Speed Limit

The vehicle speed limit in effect.

Data Length: 1 byte
Resolution: 1 km/h per bit, 0 offset
Data Range: 0 to 250 km/h
Operational Range: same as data range
Type: Status
Supporting information:
PGN 64997

SPN 2596 Selected Maximum Vehicle Speed Limit

User selected maximum vehicle speed, must equal one of the maximum vehicle speeds #1-#7 from PGN 64997 - maximum vehicle speed limit status . If different maximum vehicle speed requests are present from different devices, the lowest requested value should be used.

Data Length: 1 byte
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 250
Operational Range: 1 through 7 are allowed. 8 through 250 are not allowed.
Type: Status
Supporting information:
PGN 57344

SPN 2597 Implement Left Facing Work Light Command

Command to activate or de-activate work lights mounted on an implement to illuminate beyond left end of the implement.

00 De-activate
01 Activate
10 Reserved
11 Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3
Operational Range: same as data range
Type: Status
Supporting information:
PGN 65089

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SPN 2598 Implement Left Facing Work Light

This parameter provides measured data from the work lights mounted on an implement to illuminate beyond left end of the implement.

00 De-activate
01 Activate
10 Fault Detected
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65088

SPN 2599 Fire Apparatus Pump Engagement

The measured status of the pump used to provide water in fire fighting apparatus for distribution of water through water cannons or fire hoses.

00 Pump not engaged
01 Pump engaged
10 Error
11 Not available or not installed

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61448

SPN 2600 Payload Percentage

The current payload of the equipment, reported as a percentage of the equipment's rated payload limit.

Data Length: 1 byte
Resolution: 1 %/bit, 0 offset
Data Range: 0 to 250 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64996

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SPN 2601 Travel Velocity Control Position

The position of the travel velocity control component reported as a percentage of the control's full displacement in each direction respectively. Positive position values indicate forward travel direction; negative position values indicate reverse, or backward, travel direction; and zero (0) percent position indicates the control device is in the neutral position. Higher percent for a particular travel direction indicates a higher desired travel speed in that direction.

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64995

SPN 2602 Hydraulic Oil Level

This parameter indicates the level of the hydraulic fluid in tank as a ratio of current volume to total tank volume. This parameter is intended for reporting the hydraulic fluid level in the system tank or reservoir. This hydraulic fluid is for the entire hydraulics system of a piece of equipment.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65128

SPN 2603 Pneumatic Supply Pressure Request

Command signal to influence the pneumatic pressure in the main reservoir. This parameter is the setpoint for the parameter SPN 46.

Data Length: 1 byte
Resolution: 8 kPa/bit, 0 offset
Data Range: 0 to 2,000 kPa Operational Range: same as data range
Type: Status
Supporting information:
PGN 64994

SPN 2604 Parking and/or Trailer Air Pressure Request

Command signal to influence the pneumatic pressure in the circuit or reservoir for the parking brake and/or the trailer supply. This parameter is the setpoint for the parameter SPN 1086.

Data Length: 1 byte
Resolution: 8 kPa/bit, 0 offset
Data Range: 0 to 2,000 kPa Operational Range: same as data range
Type: Status
Supporting information:
PGN 64994

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SPN 2605 Service Brake Air Pressure Request, Circuit #1

Command signal to influence the pneumatic pressure in the service brake circuit or reservoir #1. This parameter is the setpoint for the parameter SPN 1087.

Data Length: 1 byte
Resolution: 8 kPa/bit, 0 offset
Data Range: 0 to 2,000 kPa Operational Range: same as data range
Type: Status
Supporting information:
PGN 64994

SPN 2606 Service Brake Air Pressure Request, Circuit #2

Command signal to influence the pneumatic pressure in the service brake circuit or reservoir #2. This parameter is the setpoint for the parameter SPN 1088.

Data Length: 1 byte
Resolution: 8 kPa/bit, 0 offset
Data Range: 0 to 2,000 kPa Operational Range: same as data range
Type: Status
Supporting information:
PGN 64994

SPN 2607 Auxiliary Equipment Supply Pressure Request

Command signal to influence the pneumatic pressure in the auxiliary circuit. This parameter is the setpoint for the parameter SPN 1089.

Data Length: 1 byte
Resolution: 8 kPa/bit, 0 offset
Data Range: 0 to 2,000 kPa Operational Range: same as data range
Type: Status
Supporting information:
PGN 64994

SPN 2608 Air Suspension Supply Pressure Request

Command signal to influence the pneumatic pressure in the circuit for the electronically controlled air suspension system. This parameter is the setpoint for the parameter SPN 1090.

Data Length: 1 byte
Resolution: 8 kPa/bit, 0 offset
Data Range: 0 to 2,000 kPa Operational Range: same as data range
Type: Status
Supporting information:
PGN 64994

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SPN 2609 Cab A/C Refrigerant Compressor Outlet Pressure

This is the gage pressure at the compressor outlet in the cab air conditioning system.

Data Length: 1 byte
Resolution: 16 kPa/bit, 0 offset
Data Range: 0 to 4000 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64993

SPN 2610 Solar Intensity Percent

This is the solar radiation (power density) falling on the vehicle in percent of the maximum sensor value (SPN 2611). Currently this is in the infra-red spectrum.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64992

SPN 2611 Solar Sensor Maximum

This is the maximum value which can be reported by the sensor for the solar intensity. (This is a configuration parameter)

Data Length: 1 byte
Resolution: 0.4 mW/cm^2 per bit, 0 offset
Data Range: 0 to 100 mW/cm^2 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64992

SPN 2612 Front Wheel Drive Actuator Status

Feedback on the front wheel drive actuator.

00 Front Wheel Drive Actuator not engaged
01 Front Wheel Drive Actuator engaged
10 Error
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64991

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SPN 2613 Drive Axle Lube Pressure

The drive axle lubricant pressure with location determined by Drive Axle Location (SPN 930).

Data Length: 1 byte
Resolution: 4 kPa/bit, 0 offset
Data Range: 0 to 1000 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65273

SPN 2614 Steering Axle Lube Pressure

The steering axle lubricant pressure.

Data Length: 1 byte
Resolution: 4 kPa/bit, 0 offset
Data Range: 0 to 1000 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65273

SPN 2615 (R) Engine Throttle Synchronization Mode Status

The status of the Throttle Synchronization Mode. Throttle Synchronization Mode is used to indicate which throttle, if any, is currently being used for the sychronized throttle.

0000 Not Synchronized
0001 Synchronized Center
0010 Synchronized Port
0011 Synchronized Starboard
0100 Synchronized Master
0101-1110 Reserved
1111 Take no action

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64988

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SPN 2616 Trolling Mode Status

The status of the Trolling Mode. Trolling mode limits the top speed. Full range travel of the throttle level spans from low idle engine speed to maximum trolling speed.

00 Trolling mode is OFF.
01 Trolling mode is ACTIVE.
10 Reserved
11 Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64988

SPN 2617 Slow Vessel Mode Status

The status of the Slow Vessel Mode. Slow Vessel Mode puts the engine in a lower-than-normal low idle speed during docking or other slow vessel operations.

00 Slow vessel mode is OFF.
01 Slow vessel mode is ACTIVE.
10 Reserved
11 Take no action

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64988

SPN 2629 (R) Engine Turbocharger 1 Compressor Outlet Temperature

Temperature of the air exiting the turbocharger 1 compressor outlet
Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64979

SPN 2659 (R) Engine Exhaust Gas Recirculation (EGR) Mass Flow Rate

Flow rate of gas through the EGR system. Flow rate of the exhaust gas being recirculated into the combustion air.
Data Length: 2 bytes
Resolution: 0.05 kg/h per bit, 0 offset
Data Range: 0 to 3212.75 kg/h Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61450

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SPN 2660 Joystick 1 X-Axis Position

The position of the joystick in the relative motion of travel from the neutral position. Position value of 0 is Neutral and position value 1000 (100%) is the end of linear zone. Value of 1022 indicates an error has occurred.

Data Length: 10 bits
Resolution: 0.1 %/bit, 0 offset
Data Range: 0 to 102 % Operational Range: 0.0 to 100.0%
Type: Measured
Supporting information:
PGN 64982

SPN 2661 Joystick 1 Y-Axis Position

The position of the joystick in the relative motion of travel from the neutral position. Position value of 0 is Neutral and position value 1000 (100%) is the end of linear zone. Value of 1022 indicates an error has occurred.

Data Length: 10 bits
Resolution: 0.1 %/bit, 0 offset
Data Range: 0 to 102 % Operational Range: 0.0 to 100.0%
Type: Measured
Supporting information:
PGN 64982

SPN 2662 Joystick 1 Grip X-Axis Position

The position of the joystick grip in the relative motion of travel from the neutral position. Position value of 0 is Neutral and position value 1000 (100%) is the end of linear zone. Value of 1022 indicates an error has occurred.

Data Length: 10 bits
Resolution: 0.1 %/bit, 0 offset
Data Range: 0 to 102 % Operational Range: 0.0 to 100.0%
Type: Measured
Supporting information:
PGN 64983

SPN 2663 Joystick 1 Grip Y-Axis Position

The position of the joystick grip in the relative motion of travel from the neutral position. Position value of 0 is Neutral and position value 1000 (100%) is the end of linear zone. Value of 1022 indicates an error has occurred.

Data Length: 10 bits
Resolution: 0.1 %/bit, 0 offset
Data Range: 0 to 102 % Operational Range: 0.0 to 100.0%
Type: Measured
Supporting information:
PGN 64983

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SPN 2664 Joystick 1 Theta-Axis Position

The position of the joystick in the relative motion of travel from the neutral position. Position value of 0 is Neutral and position value 1000 (100%) is the end of linear zone. Value of 1022 indicates an error has occurred.

Data Length: 10 bits
Resolution: 0.1 %/bit, 0 offset
Data Range: 0 to 102 %
Operational Range: 0.0 to 100.0%
Type: Measured
Supporting information:
PGN 64983

SPN 2665 Joystick 1 X-Axis Lever Right Positive Position Status

Reports when the current joystick position is on the positive travel side (forward, right, clockwise, up) relative to the neutral position for that axis of travel.

00 Not on Positive side of Neutral
01 On positive side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

SPN 2666 Joystick 1 Y-Axis Lever Forward Positive Position Status

Reports when the current joystick position is on the positive travel side (forward, right, clockwise, up) relative to the neutral position for that axis of travel.

00 Not on Positive side of Neutral
01 On positive side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

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SPN 2667 Joystick 1 Grip X-Axis Lever Right Positive Position Status

Reports when the current joystick grip position is on the positive travel side (forward, right, clockwise, up) relative to the neutral position for that axis of travel.

00 Not on Positive side of Neutral
01 On positive side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64983

SPN 2668 Joystick 1 Grip Y-Axis Lever Forward Positive Position Status

Reports when the current joystick grip position is on the positive travel side (forward, right, clockwise, up) relative to the neutral position for that axis of travel.

00 Not on Positive side of Neutral
01 On positive side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64983

SPN 2669 Joystick 1 Theta-Axis Clockwise Positive Position Status

Reports when the current joystick position is on the positive travel side (forward, right, clockwise, up) relative to the neutral position for that axis of travel.

00 Not on Positive side of Neutral
01 On positive side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64983

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SPN 2670 Joystick 1 X-Axis Lever Left Negative Position Status

Reports when the current joystick position is on the negative travel side (back, left, counterclockwise, down) relative to the neutral position for that axis of travel.

00 Not on negative side of Neutral
01 On negative side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

SPN 2671 Joystick 1 Y-Axis Lever Back Negative Position Status

Reports when the current joystick position is on the negative travel side (back, left, counterclockwise, down) relative to the neutral position for that axis of travel.

00 Not on negative side of Neutral
01 On negative side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

SPN 2672 Joystick 1 Grip X-Axis Lever Left Negative Position Status

Reports when the current joystick grip position is on the negative travel side (back, left, counterclockwise, down) relative to the neutral position for that axis of travel.

00 Not on negative side of Neutral
01 On negative side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64983

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SPN 2673 Joystick 1 Grip Y-Axis Lever Back Negative Position Status

Reports when the current joystick grip position is on the negative travel side (back, left, counterclockwise, down) relative to the neutral position for that axis of travel.

00 Not on negative side of Neutral
01 On negative side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64983

SPN 2674 Joystick 1 Theta-Axis Counter Clockwise Negative Position Status

Reports when the current joystick position is on the negative travel side (back, left, counterclockwise, down) relative to the neutral position for that axis of travel.

00 Not on negative side of Neutral
01 On negative side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64983

SPN 2675 Joystick 1 X-Axis Neutral Position Status

Reports when the current joystick position is in the neutral position for that axis of travel. The neutral position measurement must be determined from some mechanism other than the axis position measurement device.

00 Not in Neutral Position
01 In Neutral Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

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SPN 2676 Joystick 1 Y-Axis Neutral Position Status

Reports when the current joystick position is in the neutral position for that axis of travel. The neutral position measurement must be determined from some mechanism other than the axis position measurement device.

00 Not in Neutral Position
01 In Neutral Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

SPN 2677 Joystick 1 Grip X-Axis Neutral Position Status

Reports when the current joystick grip position is in the neutral position for that axis of travel. The neutral position measurement must be determined from some mechanism other than the axis position measurement device.

00 Not in Neutral Position
01 In Neutral Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64983

SPN 2678 Joystick 1 Grip Y-Axis Neutral Position Status

Reports when the current joystick grip position is in the neutral position for that axis of travel. The neutral position measurement must be determined from some mechanism other than the axis position measurement device.

00 Not in Neutral Position
01 In Neutral Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64983

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SPN 2679 Joystick 1 Theta-Axis Neutral Position Status

Reports when the current joystick position is in the neutral position for that axis of travel. The neutral position measurement must be determined from some mechanism other than the axis position measurement device.

00 Not in Neutral Position
01 In Neutral Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64983

SPN 2680 Joystick 1 X-Axis Detent Position Status

Reports when the current joystick position is in the detent position for that axis of travel.

00 Not in the Detent Position
01 In the Detent Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

SPN 2681 Joystick 1 Y-Axis Detent Position Status

Reports when the current joystick position is in the detent position for that axis of travel.

00 Not in the Detent Position
01 In the Detent Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

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SPN 2682 Joystick 1 Grip X-Axis Detent Position Status

Reports when the current joystick grip position is in the detent position for that axis of travel.

00 Not in the Detent Position
01 In the Detent Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3
Type: Measured
Operational Range: same as data range
Supporting information:
PGN 64983

SPN 2683 Joystick 1 Grip Y-Axis Detent Position Status

Reports when the current joystick grip position is in the detent position for that axis of travel.

00 Not in the Detent Position
01 In the Detent Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3
Type: Measured
Operational Range: same as data range
Supporting information:
PGN 64983

SPN 2684 Joystick 1 Theta-Axis Detent Position Status

Reports when the current joystick position is in the detent position for that axis of travel.

00 Not in the Detent Position
01 In the Detent Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3
Type: Measured
Operational Range: same as data range
Supporting information:
PGN 64983

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SPN 2685 Joystick 1 Button 1 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

SPN 2686 Joystick 1 Button 2 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

SPN 2687 Joystick 1 Button 3 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

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SPN 2688 Joystick 1 Button 4 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

SPN 2689 Joystick 1 Button 5 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

SPN 2690 Joystick 1 Button 6 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

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SPN 2691 Joystick 1 Button 7 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

SPN 2692 Joystick 1 Button 8 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

SPN 2693 Joystick 1 Button 9 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

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SPN 2694 Joystick 1 Button 10 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

SPN 2695 Joystick 1 Button 11 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

SPN 2696 Joystick 1 Button 12 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64982

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SPN 2697 Joystick 2 X-Axis Position

The position of the joystick in the relative motion of travel from the neutral position. Position value of 0 is Neutral and position value 1000 (100%) is the end of linear zone. Value of 1022 indicates an error has occurred.

Data Length: 10 bits
Resolution: 0.1 %/bit, 0 offset
Data Range: 0 to 102 % Operational Range: 0.0 to 100.0%
Type: Measured
Supporting information:
PGN 64984

SPN 2698 Joystick 2 Y-Axis Position

The position of the joystick in the relative motion of travel from the neutral position. Position value of 0 is Neutral and position value 1000 (100%) is the end of linear zone. Value of 1022 indicates an error has occurred.

Data Length: 10 bits
Resolution: 0.1 %/bit, 0 offset
Data Range: 0 to 102 % Operational Range: 0.0 to 100.0%
Type: Measured
Supporting information:
PGN 64984

SPN 2699 Joystick 2 Grip X-Axis Position

The position of the joystick grip in the relative motion of travel from the neutral position. Position value of 0 is Neutral and position value 1000 (100%) is the end of linear zone. Value of 1022 indicates an error has occurred.

Data Length: 10 bits
Resolution: 0.1 %/bit, 0 offset
Data Range: 0 to 102 % Operational Range: 0.0 to 100.0%
Type: Measured
Supporting information:
PGN 64985

SPN 2700 Joystick 2 Grip Y-Axis Position

The position of the joystick grip in the relative motion of travel from the neutral position. Position value of 0 is Neutral and position value 1000 (100%) is the end of linear zone. Value of 1022 indicates an error has occurred.

Data Length: 10 bits
Resolution: 0.1 %/bit, 0 offset
Data Range: 0 to 102 % Operational Range: 0.0 to 100.0%
Type: Measured
Supporting information:
PGN 64985

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SPN 2701 Joystick 2 Theta-Axis Position

The position of the joystick in the relative motion of travel from the neutral position. Position value of 0 is Neutral and position value 1000 (100%) is the end of linear zone. Value of 1022 indicates an error has occurred.

Data Length: 10 bits
Resolution: 0.1 %/bit, 0 offset
Data Range: 0 to 102 % Operational Range: 0.0 to 100.0%
Type: Measured
Supporting information:
PGN 64985

SPN 2702 Joystick 2 X-Axis Lever Right Positive Position Status

Reports when the current joystick position is on the positive travel side (forward, right, clockwise, up) relative to the neutral position for that axis of travel.

00 Not on Positive side of Neutral
01 On positive side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

SPN 2703 Joystick 2 Y-Axis Lever Forward Positive Position Status

Reports when the current joystick position is on the positive travel side (forward, right, clockwise, up) relative to the neutral position for that axis of travel.

00 Not on Positive side of Neutral
01 On positive side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

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SPN 2704 Joystick 2 Grip X-Axis Lever Right Positive Position Status

Reports when the current joystick grip position is on the positive travel side (forward, right, clockwise, up) relative to the neutral position for that axis of travel.

00 Not on Positive side of Neutral
01 On positive side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64985

SPN 2705 Joystick 2 Grip Y-Axis Lever Forward Positive Position Status

Reports when the current joystick grip position is on the positive travel side (forward, right, clockwise, up) relative to the neutral position for that axis of travel.

00 Not on Positive side of Neutral
01 On positive side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64985

SPN 2706 Joystick 2 Theta-Axis Clockwise Positive Position Status

Reports when the current joystick position is on the positive travel side (forward, right, clockwise, up) relative to the neutral position for that axis of travel.

00 Not on Positive side of Neutral
01 On positive side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64985

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SPN 2707 Joystick 2 X-Axis Lever Left Negative Position Status

Reports when the current joystick position is on the negative travel side (back, left, counterclockwise, down) relative to the neutral position for that axis of travel.

00 Not on negative side of Neutral
01 On negative side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

SPN 2708 Joystick 2 Y-Axis Lever Back Negative Position Status

Reports when the current joystick position is on the negative travel side (back, left, counterclockwise, down) relative to the neutral position for that axis of travel.

00 Not on negative side of Neutral
01 On negative side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

SPN 2709 Joystick 2 Grip X-Axis Lever Left Negative Position Status

Reports when the current joystick grip position is on the negative travel side (back, left, counterclockwise, down) relative to the neutral position for that axis of travel.

00 Not on negative side of Neutral
01 On negative side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64985

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SPN 2710 Joystick 2 Grip Y-Axis Lever Back Negative Position Status

Reports when the current joystick grip position is on the negative travel side (back, left, counterclockwise, down) relative to the neutral position for that axis of travel.

00 Not on negative side of Neutral
01 On negative side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64985

SPN 2711 Joystick 2 Theta-Axis Counter Clockwise Negative Position Status

Reports when the current joystick position is on the negative travel side (back, left, counterclockwise, down) relative to the neutral position for that axis of travel.

00 Not on negative side of Neutral
01 On negative side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64985

SPN 2712 Joystick 2 X-Axis Neutral Position Status

Reports when the current joystick position is in the neutral position for that axis of travel. The neutral position measurement must be determined from some mechanism other than the axis position measurement device.

00 Not in Neutral Position
01 In Neutral Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

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SPN 2713 Joystick 2 Y-Axis Neutral Position Status

Reports when the current joystick position is in the neutral position for that axis of travel. The neutral position measurement must be determined from some mechanism other than the axis position measurement device.

00 Not in Neutral Position
01 In Neutral Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

SPN 2714 Joystick 2 Grip X-Axis Neutral Position Status

Reports when the current joystick grip position is in the neutral position for that axis of travel. The neutral position measurement must be determined from some mechanism other than the axis position measurement device.

00 Not on negative side of Neutral
01 On negative side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64985

SPN 2715 Joystick 2 Grip Y-Axis Neutral Position Status

Reports when the current joystick grip position is in the neutral position for that axis of travel. The neutral position measurement must be determined from some mechanism other than the axis position measurement device.

00 Not in Neutral Position
01 In Neutral Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64985

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SPN 2716 Joystick 2 Theta-Axis Neutral Position Status

Reports when the current joystick position is in the neutral position for that axis of travel. The neutral position measurement must be determined from some mechanism other than the axis position measurement device.

00 Not in Neutral Position
01 In Neutral Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64985

SPN 2717 Joystick 2 X-Axis Detent Position Status

Reports when the current joystick position is in the detent position for that axis of travel.

00 Not in the Detent Position
01 In the Detent Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

SPN 2718 Joystick 2 Y-Axis Detent Position Status

Reports when the current joystick position is in the detent position for that axis of travel.

00 Not in the Detent Position
01 In the Detent Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

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SPN 2719 Joystick 2 Grip X-Axis Detent Position Status

Reports when the current joystick grip position is in the detent position for that axis of travel.

00 Not in the Detent Position
01 In the Detent Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64985

SPN 2720 Joystick 2 Grip Y-Axis Detent Position Status

Reports when the current joystick grip position is in the detent position for that axis of travel.

00 Not in the Detent Position
01 In the Detent Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64985

SPN 2721 Joystick 2 Theta-Axis Detent Position Status

Reports when the current joystick position is in the detent position for that axis of travel.

00 Not in the Detent Position
01 In the Detent Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64985

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SPN 2722 Joystick 2 Button 1 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

SPN 2723 Joystick 2 Button 2 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

SPN 2724 Joystick 2 Button 3 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

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SPN 2725 Joystick 2 Button 4 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

SPN 2726 Joystick 2 Button 5 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

SPN 2727 Joystick 2 Button 6 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

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SPN 2728 Joystick 2 Button 7 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

SPN 2729 Joystick 2 Button 8 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

SPN 2730 Joystick 2 Button 9 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

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SPN 2731 Joystick 2 Button 10 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

SPN 2732 Joystick 2 Button 11 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

SPN 2733 Joystick 2 Button 12 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64984

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SPN 2734 Joystick 3 X-Axis Position

The position of the joystick in the relative motion of travel from the neutral position. Position value of 0 is Neutral and position value 1000 (100%) is the end of linear zone. Value of 1022 indicates an error has occurred.

Data Length: 10 bits
Resolution: 0.1 %/bit, 0 offset
Data Range: 0 to 102 % Operational Range: 0.0 to 100.0%
Type: Measured
Supporting information:
PGN 64986

SPN 2735 Joystick 3 Y-Axis Position

The position of the joystick in the relative motion of travel from the neutral position. Position value of 0 is Neutral and position value 1000 (100%) is the end of linear zone. Value of 1022 indicates an error has occurred.

Data Length: 10 bits
Resolution: 0.1 %/bit, 0 offset
Data Range: 0 to 102 % Operational Range: 0.0 to 100.0%
Type: Measured
Supporting information:
PGN 64986

SPN 2736 Joystick 3 Grip X-Axis Position

The position of the joystick grip in the relative motion of travel from the neutral position. Position value of 0 is Neutral and position value 1000 (100%) is the end of linear zone. Value of 1022 indicates an error has occurred.

Data Length: 10 bits
Resolution: 0.1 %/bit, 0 offset
Data Range: 0 to 102 % Operational Range: 0.0 to 100.0%
Type: Measured
Supporting information:
PGN 64987

SPN 2737 Joystick 3 Grip Y-Axis Position

The position of the joystick grip in the relative motion of travel from the neutral position. Position value of 0 is Neutral and position value 1000 (100%) is the end of linear zone. Value of 1022 indicates an error has occurred.

Data Length: 10 bits
Resolution: 0.1 %/bit, 0 offset
Data Range: 0 to 102 % Operational Range: 0.0 to 100.0%
Type: Measured
Supporting information:
PGN 64987

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SPN 2738 Joystick 3 Theta-Axis Position

The position of the joystick in the relative motion of travel from the neutral position. Position value of 0 is Neutral and position value 1000 (100%) is the end of linear zone. Value of 1022 indicates an error has occurred.

Data Length: 10 bits
Resolution: 0.1 %/bit, 0 offset
Data Range: 0 to 102 % Operational Range: 0.0 to 100.0%
Type: Measured
Supporting information:
PGN 64987

SPN 2739 Joystick 3 X-Axis Lever Right Positive Position Status

Reports when the current joystick position is on the positive travel side (forward, right, clockwise, up) relative to the neutral position for that axis of travel.

00 Not on Positive side of Neutral
01 On positive side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

SPN 2740 Joystick 3 Y-Axis Lever Forward Positive Position Status

Reports when the current joystick position is on the positive travel side (forward, right, clockwise, up) relative to the neutral position for that axis of travel.

00 Not on Positive side of Neutral
01 On positive side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

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SPN 2741 Joystick 3 Grip X-Axis Lever Right Positive Position Status

Reports when the current joystick grip position is on the positive travel side (forward, right, clockwise, up) relative to the neutral position for that axis of travel.

00 Not on Positive side of Neutral
01 On positive side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64987

SPN 2742 Joystick 3 Grip Y-Axis Lever Forward Positive Position Status

Reports when the current joystick grip position is on the positive travel side (forward, right, clockwise, up) relative to the neutral position for that axis of travel.

00 Not on Positive side of Neutral
01 On positive side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64987

SPN 2743 Joystick 3 Theta-Axis Clockwise Positive Position Status

Reports when the current joystick position is on the positive travel side (forward, right, clockwise, up) relative to the neutral position for that axis of travel.

00 Not on Positive side of Neutral
01 On positive side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64987

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SPN 2744 Joystick 3 X-Axis Lever Left Negative Position Status

Reports when the current joystick position is on the negative travel side (back, left, counterclockwise, down) relative to the neutral position for that axis of travel.

00 Not on negative side of Neutral
01 On negative side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

SPN 2745 Joystick 3 Y-Axis Lever Back Negative Position Status

Reports when the current joystick position is on the negative travel side (back, left, counterclockwise, down) relative to the neutral position for that axis of travel.

00 Not on negative side of Neutral
01 On negative side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

SPN 2746 Joystick 3 Grip X-Axis Lever Left Negative Position Status

Reports when the current joystick grip position is on the negative travel side (back, left, counterclockwise, down) relative to the neutral position for that axis of travel.

00 Not on negative side of Neutral
01 On negative side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64987

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SPN 2747 Joystick 3 Grip Y-Axis Lever Back Negative Position Status

Reports when the current joystick grip position is on the negative travel side (back, left, counterclockwise, down) relative to the neutral position for that axis of travel.

00 Not on negative side of Neutral
01 On negative side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64987

SPN 2748 Joystick 3 Theta-Axis Counter Clockwise Negative Position Status

Reports when the current joystick position is on the negative travel side (back, left, counterclockwise, down) relative to the neutral position for that axis of travel.

00 Not on negative side of Neutral
01 On negative side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64987

SPN 2749 Joystick 3 X-Axis Neutral Position Status

Reports when the current joystick position is in the neutral position for that axis of travel. The neutral position measurement must be determined from some mechanism other than the axis position measurement device.

00 Not in Neutral Position
01 In Neutral Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

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SPN 2750 Joystick 3 Y-Axis Neutral Position Status

Reports when the current joystick position is in the neutral position for that axis of travel. The neutral position measurement must be determined from some mechanism other than the axis position measurement device.

00 Not in Neutral Position
01 In Neutral Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

SPN 2751 Joystick 3 Grip X-Axis Neutral Position Status

Reports when the current joystick grip position is in the neutral position for that axis of travel. The neutral position measurement must be determined from some mechanism other than the axis position measurement device.

00 Not on negative side of Neutral
01 On negative side of Neutral
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64987

SPN 2752 Joystick 3 Grip Y-Axis Neutral Position Status

Reports when the current joystick grip position is in the neutral position for that axis of travel. The neutral position measurement must be determined from some mechanism other than the axis position measurement device.

00 Not in Neutral Position
01 In Neutral Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64987

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SPN 2753 Joystick 3 Theta-Axis Neutral Position Status

Reports when the current joystick position is in the neutral position for that axis of travel. The neutral position measurement must be determined from some mechanism other than the axis position measurement device.

00 Not in Neutral Position
01 In Neutral Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64987

SPN 2754 Joystick 3 X-Axis Detent Position Status

Reports when the current joystick position is in the detent position for that axis of travel.

00 Not in the Detent Position
01 In the Detent Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

SPN 2755 Joystick 3 Y-Axis Detent Position Status

Reports when the current joystick position is in the detent position for that axis of travel.

00 Not in the Detent Position
01 In the Detent Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

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SPN 2756 Joystick 3 Grip X-Axis Detent Position Status

Reports when the current joystick grip position is in the detent position for that axis of travel.

00 Not in the Detent Position
01 In the Detent Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64987

SPN 2757 Joystick 3 Grip Y-Axis Detent Position Status

Reports when the current joystick grip position is in the detent position for that axis of travel.

00 Not in the Detent Position
01 In the Detent Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64987

SPN 2758 Joystick 3 Theta-Axis Detent Position Status

Reports when the current joystick position is in the detent position for that axis of travel.

00 Not in the Detent Position
01 In the Detent Position
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64987

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SPN 2759 Joystick 3 Button 1 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

SPN 2760 Joystick 3 Button 2 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

SPN 2761 Joystick 3 Button 3 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

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SPN 2762 Joystick 3 Button 4 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

SPN 2763 Joystick 3 Button 5 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

SPN 2764 Joystick 3 Button 6 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

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SPN 2765 Joystick 3 Button 7 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

SPN 2766 Joystick 3 Button 8 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

SPN 2767 Joystick 3 Button 9 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

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SPN 2768 Joystick 3 Button 10 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

SPN 2769 Joystick 3 Button 11 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

SPN 2770 Joystick 3 Button 12 Pressed Status

Reports when the joystick button has been pressed.

00 Button not pressed
01 Button pressed
10 Error Indicator
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64986

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SPN 2789 (R) Engine Turbocharger 1 Calculated Turbine Inlet Temperature

Calculated value of turbine inlet temperature based on engine operating conditions, such as intake manifold temperature, charge fuel ratio, injection timing, and engine speed. Use SPN 1180 for actual measured inlet temperature.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Status
Supporting information:
PGN 64981

SPN 2790 (R) Engine Turbocharger 1 Calculated Turbine Outlet Temperature

Calculated value of turbocharger compressor outlet air temperature. Temperature of air exiting the turbocharger compressor and before entering charge air cooler. The estimate is based on turbo speed and measured turbocharger compressor inlet temperature. Use SPN 1184 for actual measured outlet temperature.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Status
Supporting information:
PGN 64981

SPN 2791 (R) Engine Exhaust Gas Recirculation (EGR) Valve Control

Desired percentage of maximum Exhaust Gas Recirculation (EGR) valve opening. 0% means valve is closed. 100% means maximum valve opening (full gas flow).

Data Length: 2 bytes
Resolution: 0.0025 %/bit, 0 offset
Data Range: 0 to 160.6375 % Operational Range: 0 to 100%
Type: Status
Supporting information:
PGN 64981

SPN 2792 (R) Engine Variable Geometry Turbocharger (VGT) Air Control Shutoff Valve

Isolates vehicle brake air from the Variable Geometry Turbocharger (VGT) system when engine is not running. This valve prevents vehicle air from bleeding off through the VGT Control Valve when engine is not in use. Primary vehicle air system from air tanks feed the VGT Air Control Shutoff Valve, which in turn provides air to the VGT Control Valve when the keyswitch is 'ON'. The VGT Control Valve delivers air to the VGT actuator to adjust turbocharger geometry.

00 VGT Air Control Shutoff Valve is Off
01 VGT Air Control Shutoff Valve is On
10 Reserved
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64981

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SPN 2793 Laser Strike Data Latency

Time from laser strike to CAN message transmission. This parameter will be reported by survey receiver type devices only. Byte 3 (SPN 2576) of PGN 65141 identifies the type of Laser Receiver.

Data Length: 2 bytes
Resolution: 51.2 us/bit, 0 offset
Data Range: 0 to 3.289856 s
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65141

SPN 2794 Absolute Laser Strike Position

Laser Strike location on the survey type laser receiver.

Data Length: 2 bytes
Resolution: 0.1 mm/bit, 0 offset
Data Range: 0 to 6,425.5 mm
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65141

SPN 2795 (R) Engine Variable Geometry Turbocharger (VGT) 1 Actuator Position

Sensor that measures the position of the variable geometry turbocharger actuator. A position of 0% indicates the actuator is in the position creating the smallest geometry turbocharger. A position of 100% represents the largest geometry

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 %
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64981

SPN 2796 Transfer Case Selector Switch

Operator switch to select the condition of the transfer case. The possible states are 2 wheel drive, 4 wheel drive and neutral .

000 2 wheel
001 4 wheel
010 Neutral
011 - 101 Reserved for SAE assignment
110 Error indicator
111 Not available

Data Length: 3 bits
Resolution: 8 states/3 bit, 0 offset
Data Range: 0 to 7
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64980

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SPN 2799 (R) Engine Turbocharger 2 Compressor Outlet Temperature

Temperature of the air exiting the turbocharger 2 compressor outlet

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64979

SPN 2800 (R) Engine Turbocharger 3 Compressor Outlet Temperature

Temperature of the air exiting the turbocharger 3 compressor outlet

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64979

SPN 2801 (R) Engine Turbocharger 4 Compressor Outlet Temperature

Temperature of the air exiting the turbocharger 4 compressor outlet

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64979

SPN 2802 Data Memory Usage

The used storage capacity of the data buffer memory internal to an ECU, such as a data logger.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64978

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SPN 2803 Keep-Alive Battery Consumption

The capacity consumed from the direct battery connection since the key was last turned off. This value is maintained and does not accumulate while the key switch is on. The value is reset to 0 when the key switch is turned to the off position.

Data Length: 2 bytes
Resolution: 1 mAhr/bit, 0 mAhr offset
Data Range: 0 to 64255mAhr (64.255Ahr) Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64978

SPN 2804 FMS-standard Diagnostics Supported

Status signal which indicates if the FMS Vehicle Interface (FMS Gateway) supports the handling of diagnostic messages from the vehicle network onto the FMS network.

The FMS gateway does NOT support the re-broadcast of diagnostics messages present on the vehicle network.

If this 'FMS-standard Diagnostics Supported' feature is supported by the FMS Gateway, the FMS Gateway will support the requests for diagnostics information (from the FMS device) onto the vehicle network and pass the responses onto the FMS network.

Note: This feature of the FMS Gateway is independent of the 'FMS-standard Requests Supported'. The FMS Gateway may support diagnostics without supporting the 'FMS-standard Requests Supported' function, or visa-versa.

00 Diagnostics Is Not Supported
01 Diagnostics Is Supported
10 Reserved
11 Don't care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64977

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SPN 2805 FMS-standard Requests Supported

Status signal which indicates if the FMS Vehicle Interface (FMS Gateway) will respond to requests from the FMS device for the PGNs listed in the FMS Interface Specification.

This mode is to support FMS gateway devices that only operate in a 'Request' mode.

The FMS PGNs may also be broadcast periodically in this mode.

The FMS Gateway will NOT support the requests for information not included in the FMS Interface Specification onto the vehicle network."

00 On request mode is not supported
01 On request mode is supported
10 Reserved
11 Don't care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64977

SPN 2806 FMS-standard SW-version supported.

Information that identifies which issue level of the FMS-standard document the software included in the FMS gateway supports. Four bytes, representing xx.yy type revision level identification.

Information to be ASCII equivalent of the numeric revision level of the FMS document, 00.01 to 99.99. The first released version will be 01.00.

Note: the first 2 bytes contain the high order number of the spec, the second 2 bytes contain the lower order number of the spec. For example, FMS-standard version 02.06 would have 0 in the first byte, 2 in the second byte, 0 in the third byte and 6 in the fourth byte.

Data Length: 4 bytes
Resolution: ASCII, 0 offset
Data Range: 0 to 255 per byte Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64977

SPN 2809 (R) Engine Air Filter 2 Differential Pressure

Change in engine air system pressure, measured across the second air filter, due to the filter and any accumulation of solid foreign matter on or in the filter.

This is for monitoring the air filter on the inlet to the second turbocharger. Filter numbering follows the guidelines noted in section Naming Convention For Engine Parameters.

Data Length: 1 byte
Resolution: 0.05 kPa/bit, 0 offset
Data Range: 0 to 12.5 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64976

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SPN 2810 (R) Engine Air Filter 3 Differential Pressure

Change in engine air system pressure, measured across the third air filter, due to the filter and any accumulation of solid foreign matter on or in the filter.

This is for monitoring the air filter on the inlet to the third turbocharger. Filter numbering follows the guidelines noted in section Naming Convention For Engine Parameters.

Data Length: 1 byte
Resolution: 0.05 kPa/bit, 0 offset
Data Range: 0 to 12.5 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64976

SPN 2811 (R) Engine Air Filter 4 Differential Pressure

Change in engine air system pressure, measured across the fourth air filter, due to the filter and any accumulation of solid foreign matter on or in the filter.

This is for monitoring the air filter on the inlet to the fourth turbocharger. Filter numbering follows the guidelines noted in section Naming Convention For Engine Parameters.

Data Length: 1 byte
Resolution: 0.05 kPa/bit, 0 offset
Data Range: 0 to 12.5 kPa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64976

SPN 2812 (R) Engine Overspeed Test

The engine overspeed test signal as measured by the reporting ECM. Engine Overspeed Test is a mechanism to simulate engine overspeed situations, while operating the engine within the engine's safe operating range.

State signal which indicates when the overspeed test input to the ECM is being driven.

00 Engine Overspeed Test Not Active
01 Engine Overspeed Test Active
10 Reserved
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65252

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SPN 2813 (R) Engine Air Shutoff Command Status

State signal which indicates when the Air Shutoff driver output is being driven. Disabled means controller wants air flowing to the engine. Status of the airflow shutoff as being commanded by the ECU.

00 Air Shutoff Disabled, not attempting to shutoff engine air supply
01 Air Shutoff Enabled, attempting to shutoff engine air supply
10 Reserved
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65252

SPN 2814 (R) Engine Alarm Output Command Status

State signal which indicates when the Alarm driver output is being driven. Not active means the Controller has no alarm level conditions.

00 Engine Alarm Output Command Not Active
01 Engine Alarm Output Command Active
10 Reserved
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65252

SPN 2815 (R) Engine Alarm Acknowledge

The Engine Alarm Acknowledge Input signal as measured by the reporting ECM. The Engine Alarm Acknowledge is a mechanism for external acknowledgement of the SPN 2814, Engine Alarm Output Command.

00 Engine Alarm Acknowledge Not Active
01 Engine Alarm Acknowledge Active
10 Error
11 Not Available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65252

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SPN 2863 (R) Front Operator Wiper Switch

State of operation selected by operator switch for the Wiper in front of the operator position. This parameter, 'Front Operator Wiper Switch' should be used for the control information if either of the other wiper switch parameters is 'Not Available' and the associated wiper still needs to be controlled.

0 Off
1 Low
2 Medium
3 High
4 Delayed 1 (used for the first delay choice when the wiper switch position controls the delay)
5 Delayed 2 (used for the second delay choice when the wiper switch position controls the delay)
6 Mist (position where external sensor controls wiper rate)
7 Reserved
8 Reserved
9 Reserved
10 Reserved
11 Reserved
12 Reserved
13 Reserved
14 Reserved
15 Not available (do not change)

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64973

SPN 2864 (R) Front Non-operator Wiper Switch

State of operation selected by operator switch for the front wiper not in front of the operator position. The parameter, 'Front Operator Washer Switch' should be used for the control information if this parameter is 'Not Available' and the associated washer still needs to be controlled.

0 Off
1 Low
2 Medium
3 High
4 Delayed 1 (used for the first delay choice when the wiper switch position controls the delay)
5 Delayed 2 (used for the second delay choice when the wiper switch position controls the delay)
6 Mist (position where external sensor controls wiper rate)
7 Reserved
8 Reserved
9 Reserved
10 Reserved
11 Reserved
12 Reserved
13 Reserved
14 Reserved
15 Not available (do not change)

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64973

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SPN 2865 (R) Rear Wiper Switch

State of operation selected by operator switch for the rear wiper. The parameter, 'Front Operator Washer Switch' should be used for the control information if this parameter is 'Not Available' and the associated washer still needs to be controlled.

0 Off
1 Low
2 Medium
3 High
4 Delayed 1 (used for the first delay choice when the wiper switch position controls the delay)
5 Delayed 2 (used for the second delay choice when the wiper switch position controls the delay)
6 Mist (position where external sensor controls wiper rate)
7 Reserved
8 Reserved
9 Reserved
10 Reserved
11 Reserved
12 Reserved
13 Reserved
14 Reserved
15 Not available (do not change)

Data Length:	4 bits		
Resolution:	16 states/4 bit, 0 offset		
Data Range:	0 to 15	Operational Range:	same as data range
Type:	Measured		
Supporting information:			
PGN	64973		

SPN 2866 (R) Front Operator Washer Switch

State of operation selected by operator switch for the washer in front of the operator position. This parameter, 'Front Operator Washer Switch' should be used for the control information if either of the other washer switch parameters is 'Not Available' and the associated washer still needs to be controlled.

0 Off
1 Low
2 Medium
3 High
4 Reserved
5 Reserved
6 Reserved
7 Not available (do not change)

Data Length:	3 bits		
Resolution:	8 states/3 bit, 0 offset		
Data Range:	0 to 7	Operational Range:	same as data range
Type:	Measured		
Supporting information:			
PGN	64973		

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SPN 2867 (R) Front Non-operator Washer Switch

State of operation selected by operator switch for the front washer not in front of the operator position. The parameter, 'Front Operator Washer Switch' should be used for the control information if this parameter is 'Not Available' and the associated washer still needs to be controlled.

0 Off
1 Low
2 Medium
3 High
4 Reserved
5 Reserved
6 Reserved
7 Not available (do not change)

Data Length: 3 bits
Resolution: 8 states/3 bit, 0 offset
Data Range: 0 to 7 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64973

SPN 2868 (R) Rear Washer Function

State of operation selected by operator switch for the rear washer. The parameter, 'Front Operator Washer Switch' should be used for the control information if this parameter is 'Not Available' and the associated washer still needs to be controlled.

0 Off
1 Low
2 Medium
3 High
4 Reserved
5 Reserved
6 Reserved
7 Not available (do not change)

Data Length: 3 bits
Resolution: 8 states/3 bit, 0 offset
Data Range: 0 to 7 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64973

SPN 2869 (R) Front Operator Wiper Delay Control

Time between cycles of the front operator side wiper (i.e. from end of cycle 'n' to start of cycle 'n+1') as selected by the operator control (switch, etc.) in percentage of position with maximum position corresponding to maximum delay selectable. This parameter, 'Front Operator Wiper Delay Control' should be used for the delay information if either of the other delay parameters is 'Not Available' and the function needs to be provided.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64973

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SPN 2870 (R) Front Non-operator Wiper Delay Control

Time between cycles of the front non-operator side wiper (i.e. from end of cycle 'n' to start of cycle 'n+1') as selected by the operator control (switch, etc.) in percentage of position with maximum position corresponding to maximum delay selectable. The parameter, 'Front Operator Wiper Delay Control' should be used for the delay information if this parameter is 'Not Available' and the function needs to be provided.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64973

SPN 2871 (R) Rear Wiper Delay Control

Time between cycles of the rear wiper (i.e. from end of cycle 'n' to start of cycle 'n+1') as selected by the operator control (switch, etc.) in percentage of position with maximum position corresponding to maximum delay selectable. The parameter, 'Front Operator Wiper Delay Control' should be used for the delay information if this parameter is 'Not Available' and the function needs to be provided.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64973

SPN 2872 (R) Main Light Switch

A 4 bit parameter to indicate the selected position of the operator's main light switch.

0 Off - The position by which the operator selects that none of the lamps are to be on.
1 Park On - The position by which the operator selects that the park lamps are to be on.
2 Headlight On - The position by which the operator selects that the headlamps are to be on.
3 Headlight and Park On - The position by which the operator selects that Both the Headlamps and the Park lamps are to be on.
4 Reserved
5 Reserved
6 Reserved
7 Reserved
8 Delayed Off - The position by which the operator selects that a certain set of lamps are to come On and then are to be turned Off following a delay time (Operators Desired - Delayed Lamp Off Time).
9 Reserved
10 Reserved
11 Reserved
12 Reserved
13 Reserved
14 Error
15 Not available (do not change)

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64972

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SPN 2873 (R) Work Light Switch

A 4 bit parameter to indicate the selected position of the operator's work light switch. In Ag applications the work lights are often refereed to as field lights. In on-highway applications the work lights are often referred to as clearance lights and may or may not be operated by a switch separate from the main light switch.

0 Off - The position by which the operator selects that none of the work lamps are to be on.
1 Work Light Combination #1 On - The position by which the operator selects that the lamps in the combination defined as Work Light Combination #1 are to be on.
2 Work Light Combination #2 On - The position by which the operator selects that the lamps in the combination defined as Work Light Combination #2 are to be on.
3 Work Light Combination #3 On - The position by which the operator selects that the lamps in the combination defined as Work Light Combination #3 are to be on.
4 Work Light Combination #4 On - The position by which the operator selects that the lamps in the combination defined as Work Light Combination #4 are to be on.
5 Reserved
6 Reserved
7 Reserved
8 Reserved
9 Reserved
10 Reserved
11 Reserved
12 Reserved
13 Reserved
14 Error
15 Not available (do not change)

Data Length:	4 bits		
Resolution:	16 states/4 bit, 0 offset		
Data Range:	0 to 15	Operational Range:	same as data range
Type:	Measured		
Supporting information:			
PGN	64972		

SPN 2874 (R) High-Low Beam Switch

A 2 bit parameter to indicate the selected position of the operator's high/low beam select switch.

0 Low Beam Selected
1 High Beam Selected
2 Error
3 Not available (do not change)

Data Length:	2 bits		
Resolution:	4 states/2 bit, 0 offset		
Data Range:	0 to 3	Operational Range:	same as data range
Type:	Measured		
Supporting information:			
PGN	64972		

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SPN 2875 (R) Hazard Light Switch

A 2 bit parameter to indicate the selected position of the operator's hazard light switch.

0 Hazard Lamps to be Off
1 Hazard Lamps to be Flashing
2 Error
3 Not available (do not change)

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64972

SPN 2876 (R) Turn Signal Switch

A 4 bit parameter to indicate the selected position of the operator's turn signal switch.

0 No Turn being signaled
1 Left Turn to be Flashing
2 Right turn to be Flashing
3 Reserved
4 Reserved
5 Reserved
6 Reserved
7 Reserved
8 Reserved
9 Reserved
10 Reserved
11 Reserved
12 Reserved
13 Reserved
14 Error (to include both left and right selected simultaneously)
15 Not available (do not change)

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64972

SPN 2877 (R) Operators Desired - Delayed Lamp Off Time

A 16 bit parameter to be associated with Delayed Off position (1000 binary) of the Main Light Switch. This parameter indicates the time the operator wishes to have elapse following the Main Light switch being placed in Delayed Off position before the defined lights turn back off. The Operator's definition as to which lamps are to turn On (and then Off of course) when the Main Light Switch is in the Delayed Off position. The specific lamps are not identified within this message, but are to be stored by whatever device (ecu) is planning to send the lamp command message for said lamps. Said device must also provide the means for the operator to enter and/or adjust said definition.

Data Length: 2 bytes
Resolution: 1 s/bit, 0 offset
Data Range: 0 to 64,255 s Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64972

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SPN 2878 (R) Operators Desired Back-light

A 8 bit parameter to indicate the level of back lighting the operator has selected for displays. This is to be differentiated from the Illumination Brightness Percent (SPN:1487 PGN:53248 Cab Illumination Message) which is sent to the displays to tell them what level to be at. This is the operator desired level (as sensed by operator controls) for those system where the operator controls are monitored by an ecu separate from the ecu sending the command to the displays. Note each display (if appropriate) will need to have its own balance function to compensate its nominal brightness to the same level of that of all other displays. This is especially important for systems with back-lights which may change noticeable with aging. In other words it will be necessary within a vehicle to scale all of the displays down to the same level as the dimmest display (since, obviously you can not make the dimmest brighter).

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 %
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64972

SPN 2879 (R) Engine Alternate Droop Accelerator 2 Select

Same description as Engine Alternate Droop Accelerator 1 Select (SPN 2881) except that the selections may apply to Accelerator 2.

0000 – Normal Droop Setting is selected
0001 thru 1101 – One of Alternate Droop Setting 1 through 13 (in sequential order) is selected
1110 – Error condition
1111 – Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64971

SPN 2880 (R) Engine Operator Primary Intermediate Speed Select

Allows the operator to select one of 13 preprogrammed Intermediate Speed Control settings. If no speed setting is requested, the engine operates normally. The Intermediate Speed Control is widely used in the Industrial application to control the engine to an intermediate speed setting which can either replace the accelerator position control altogether, or limit the accelerator position control to a selectable speed point minimum or maximum.

0000 – indicates that the ISC functionality is not requested, engine operates normally
0001 thru 1101 – indicates that the ISC Setting 1 thru 13 (in sequential order) is selected
1110 – error condition
1111 – not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15
Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64970

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SPN 2881 (R) Engine Alternate Droop Accelerator 1 Select

In some off-highway applications it may be desirable to have multiple droop settings available across the range of engine operation. For example, in an agricultural tractor application, this functionality allows a higher engine speed during low load so as to maximize vehicle speed driven between fields on the road. Another use of the alternate droop settings would be to provide functionality for maintaining an engine speed independent of the applied load on demand. There is a normal droop setting, and up to 13 additional preprogrammed droop settings which are user selectable by switching. The selections apply to Accelerator 1.

0000 – Normal Droop Setting is selected
0001 thru 1101 – One of Alternate Droop Setting 1 through 13 (in sequential order) is selected
1110 – Error condition

Data Length:	4 bits		
Resolution:	16 states/4 bit, 0 offset		
Data Range:	0 to 15	Operational Range:	same as data range
Type:	Measured		
Supporting information:			
PGN	64971		

SPN 2882 (R) Engine Alternate Rating Select

In some off-highway applications it may be desirable to have multiple engine ratings available for selection by the operator. There is the default engine rating, which provides the maximum available power across the range of operation. There are additional engine ratings which the user can select that allow for alternate fueling across the operational range. Engine rating selection number 1 is the maximum rating. Selection number 2 is the next highest, selection 3 next highest, etc. The selection impacts the operating points in the Engine Configuration.

00 – indicates that Maximum Power Fueling is selected
01 – indicates that the Alternate Power Fueling 1 is selected
02 – indicates that the Alternate Power Fueling 2 is selected
03 – indicates that theAlternate Power Fueling 3 is selected
04 thru 253 - indicates that the Alternate Power Fueling 4 thru 253 (in sequential order) is selected.
254 – Error condition.
255 – Not available

Data Length:	8 bits		
Resolution:	256 states/8 bit, 0 offset		
Data Range:	0 to 255	Operational Range:	same as data range
Type:	Measured		
Supporting information:			
PGN	64971		

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SPN 2883 (R) Engine Alternate Low Idle Switch

Operator switch which selects between two low idle speeds, default and alternate.

The normal programmed low idle is the default low idle, and when the Alternate Low Idle switch is activated, a alternate preprogrammed low idle speed is selected. The accelerator position control operates as normal but is now bounded to a different low idle speed. This selection impacts Point 1 on the Engine Configuration.

00 Default low idle point is selected
01 Alternate low idle point is selected
10 Error
11 Not available or Unused

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64971

SPN 2884 (R) Engine Auxiliary Governor Switch

This is the On/Off operation of the Auxiliary Governor feature switch. This feature is used to allow engine speed to be controlled by an auxiliary input such as pressure or tailshaft speed. This switch position indicates whether this feature is requested or not.

00 – Auxiliary Governor is disabled
01 – Auxiliary Governor is enabled
10 – Error condition
11 – Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64971

SPN 2885 (R) Engine Alternate Droop Auxiliary Input Select

In some off-highway applications it may be desirable to have multiple droop settings available across the range of engine operation. For example, in an agricultural tractor application, this functionality allows a higher engine speed during low load so as to maximize vehicle speed driven between fields on the road. Another use of the alternate droop settings would be to provide functionality for maintaining an engine speed independent of the applied load on demand. There is a normal droop setting, and up to 13 additional preprogrammed droop settings which are user selectable by switching. The selections apply to the Alternate Droop Auxiliary Input.

0000 – Normal Droop Setting is selected
0001 thru 1101 – One of Alternate Droop Setting 1 through 13 (in sequential order) is selected
1110 – Error condition
1111 – Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64971

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SPN 2886 (R) Engine Alternate Droop Remote Accelerator Select

In some off-highway applications it may be desirable to have multiple droop settings available across the range of engine operation. For example, in an agricultural tractor application, this functionality allows a higher engine speed during low load so as to maximize vehicle speed driven between fields on the road. Another use of the alternate droop settings would be to provide functionality for maintaining an engine speed independent of the applied load on demand. There is a normal droop setting, and up to 13 additional preprogrammed droop settings which are user selectable by switching. The selections apply to the Remote Accelerator.

0000 – Normal Droop Setting is selected
0001 thru 1101 – One of Alternate Droop Setting 1 through 13 (in sequential order) is selected
1110 – Error condition
1111 – Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64971

SPN 2887 (R) Total Count of Configuration Changes Made

Total number of times changes have been made to any of the configurable parameters.

Data Length: 2 bytes
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 64,255 counts Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64969

SPN 2888 (R) Engine Alternate Rating Select State

In some off-highway applications it may be desirable to have multiple engine ratings available for selection by the operator. There is the default engine rating, which provides the maximum available power across the range of operation. There are additional engine ratings which the engine controller may use that allow for alternate fueling across the operational range. Engine rating number 1 is the maximum rating. Rating number 2 is the next highest, rating 3 next highest, etc.

00 – Control state is Maximum Power Fueling
01 – Control state is Alternate Power Fueling 1
02 – Control state is Alternate Power Fueling 2
03 – Control state is Alternate Power Fueling 3
04 thru 253 - Control state is Alternate Power Fueling 4 thru 253 (in sequential order)
254 – SAE reserved
255 – Not available

Data Length: 8 bits
Resolution: 256 states/8 bit, 0 offset
Data Range: 0 to 255 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64967

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SPN 2889 (R) Engine Alternate Droop Accelerator 1 Select State

In some off-highway applications it may be desirable to have multiple droop settings available across the range of engine operation. For example, in an agricultural tractor application, this functionality allows a higher engine speed during low load so as to maximize vehicle speed driven between fields on the road. Another use of the alternate droop settings would be to provide functionality for maintaining an engine speed independent of the applied load on demand. There is a normal droop setting, and up to 13 additional preprogrammed droop settings which are user selectable by switching. The selections may apply to Accelerator 1. This parameter indicates which state has been selected by the controlling ECM.

0000 – Control state is Normal Droop Setting
0001 thru 1101 – Control state is one of Alternate Droop Setting 1 through 13 (in sequential order)
1110 – SAE reserved
1111 – Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64967

SPN 2890 (R) Engine Multi-Unit Sync State

This feature is widely used in Industry to operate multiple engines from a single command source. A master engine will "synchronize" one or more slave engines to operate at the same speed. This feature is requested by an operator switch, this parameter indictes the state of the feature as determined by the controlling ECM.

00 Control State is Functionality disabled (off)
01 Control State is Functionality enabled (on)
10 SAE reserved
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64967

SPN 2891 (R) Engine Alternate Low Idle Select State

In many applications, it is desirable that an alternate low idle speed setting be made available via switch input. The normal programmed low idle is the default low idle, and when the Alternate Low Idle feature is activated, an alternate preprogrammed low idle speed is selected. The accelerator position control operates as normal but is now bounded to a different low idle speed. This selection impacts Point 1 on the Engine Configuration.

00 – Normal idle state
01 – Alternate idle state
10 – SAE reserved
11 – not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64967

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SPN 2892 (R) Engine Operator Primary Intermediate Speed Select State

13 preprogrammed intermediate speed control settings are availible for the contolling ECM to select. If no speed setting is requested, the engine operates normally. The Intermediate Speed Control is widely used in the Industrial application to control the engine to an intermediate speed setting which can either replace the accelerator position control altogether, or limit the accelerator position control to a selectable speed point minimum or maximum. This parameter indicates which state has been selected by the controlling ECM.

0000 – Control state is ISC functionality is not requested, engine operates normally
0001 thru 1101 – Control state is ISC Setting 1 thru 13 (in sequential order)
1110 – SAE reserved
1111 – not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64968

SPN 2893 (R) Engine Alternate Droop Accelerator 2 Select State

In some off-highway applications it may be desirable to have multiple droop settings available across the range of engine operation. For example, in an agricultural tractor application, this functionality allows a higher engine speed during low load so as to maximize vehicle speed driven between fields on the road. Another use of the alternate droop settings would be to provide functionality for maintaining an engine speed independent of the applied load on demand. There is a normal droop setting, and up to 13 additional preprogrammed droop settings which are user selectable by switching. The selections apply to Accelerator 2.

0000 – Control's state is Normal Droop Setting
0001 thru 1101 – Control's state is One of Alternate Droop Setting 1 through 13 (in sequential order)
1110 – SAE reserved

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64967

SPN 2894 (R) Engine Alternate Droop Remote Accelerator Select State

In some off-highway applications it may be desirable to have multiple droop settings available across the range of engine operation. For example, in an agricultural tractor application, this functionality allows a higher engine speed during low load so as to maximize vehicle speed driven between fields on the road. Another use of the alternate droop settings would be to provide functionality for maintaining an engine speed independent of the applied load on demand. There is a normal droop setting, and up to 13 additional preprogrammed droop settings which are user selectable by switching. The selections apply to Remote Accelerator.

0000 – Control state is Normal Droop Setting
0001 thru 1101 – Control state is One of Alternate Droop Setting 1 through 13 (in sequential order)
1110 – SAE reserved
1111 – Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64967

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SPN 2895 (R) Engine Alternate Droop Auxiliary Input Select State

In some off-highway applications it may be desirable to have multiple droop settings available across the range of engine operation. For example, in an agricultural tractor application, this functionality allows a higher engine speed during low load so as to maximize vehicle speed driven between fields on the road. Another use of the alternate droop settings would be to provide functionality for maintaining an engine speed independent of the applied load on demand. There is a normal droop setting, and up to 13 additional preprogrammed droop settings which are user selectable by switching. The selections apply to Auxiliary Input.

0000 – Control state is Normal Droop Setting
0001 thru 1101 – Control state is One of Alternate Droop Setting 1 through 13 (in sequential order)
1110 – SAE reserved

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64967

SPN 2896 (R) Engine Auxiliary Governor State

This is the Engine Auxiliary Governor feature. This feature is used to allow engine speed to be controlled by an auxiliary input such as pressure or tailshaft speed. This feature is requested by an operator switch, this parameter indicates the state of the feature as determined by the controlling ECM.

00 – Control State is Auxiliary Governor disabled
01 – Control State is Auxiliary Governor enabled
10 – SAE reserved
11 – Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64967

SPN 2897 (R) Operator PTO Memory Select Switch

Measured state of the operator PTO memory select switch. This switch selects which of the two available memory locations is to be used to store the dynamically assigned value. This speed will be set using the PTO set switch and modified using the PTO accelerate and coast/decelerate switches.

00 PTO set speed memory 1 selected
01 PTO set speed memory 2 selected
10 error
11 not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65264

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SPN 2898 (R) Engine Start Enable Device 2 Configuration

The start enable device installed for start enable device 2.

0000 - no start enable device 2 installed
0001 - glow plugs installed
0010 - fuelled start installed
0011 - ether injection installed
0100 - electric inlet air heater installed
0101 - 1110 - reserved
1111 - not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64966

SPN 2899 (R) Engine Start Enable Device 1 Configuration

The start enable device installed for start enable device 1.

0000 - no start enable device 1 installed
0001 - glow plugs installed
0010 - fuelled start installed
0011 - ether injection installed
0100 - electric inlet air heater installed
0101 - 1110 - reserved
1111 - not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64966

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SPN 2900 (R) Transmission Engine Crank Enable

State signal from the transmission indicating if the transmission's status is such that engine cranking is allowed (i.e. at a minimum, transmission is in neutral and the driveline is disengaged). As sender of this information, the transmission is responsible for correct indication immediately upon first broadcast of this parameter.

As with hard-wired neutral start implementations, those utilizing this parameter should consider the impact of the transmission or other controllers 'resetting' due to voltage drops during the engine start sequence.

The vehicle system design should also consider the impact of timing latency in the engine starting sequence. For example, the turn of an ignition key from 'off' to 'start' may happen more quickly than the transmission controller can boot up, determine its' current state of being, and begin broadcasting information over the J1939 datalink.

00 - Cranking disabled; engine cranking is prohibited by the transmission
01 - Cranking enabled; engine cranking is allowed by the transmission
10 - Error
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65098

SPN 2901 (R) ECU Part Number

The part number of the physical ECU.
Data Length: Variable - up to 200 characters ("*" delimited)
Resolution: ASCII, 0 offset
Data Range: 0 to 255 per byte Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64965

SPN 2902 (R) ECU Serial Number

The serial number of the physical ECU.
Data Length: Variable - up to 200 characters ("*" delimited)
Resolution: ASCII, 0 offset
Data Range: 0 to 255 per byte Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64965

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SPN 2903 (R) ECU Location

The location of the ECU within a network.

Data Length: Variable - up to 200 characters ("*" delimited)
Resolution: ASCII, 0 offset
Data Range: 0 to 255 per byte Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64965

SPN 2904 (R) ECU Type

The type of ECU. One example of a use of the ECU type could be for classifying ECU capabilities, such as I/O.

Data Length: Variable - up to 200 characters ("*" delimited)
Resolution: ASCII, 0 offset
Data Range: 0 to 255 per byte Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64965

SPN 2911 (R) Halt brake switch

Switch signal which indicates the position of the halt brake switch.

00 Halt brake switch passive
01 Halt brake switch active
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61441

SPN 2912 (R) Hill holder mode

Signal which indicates the current mode of the hill holder function.

000 Inactive
001 Active
010 Active, but will change to inactive in a short time. (This mode may be used to warn the driver)
011 - 101 Not defined
110 Reserved
111 Not available

Data Length: 3 bits
Resolution: 8 states/3 bit, 0 offset
Data Range: 0 to 7 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64964

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SPN 2913 (R) Halt brake mode

Signal which indicates the current mode of the halt brake function.

000 Inactive
001 Active
010 Active, but not functioning properly. (This mode may be used to warn the driver)
011 - 101 Not defined
110 Reserved
111 Not available

Data Length: 3 bits
Resolution: 8 states/3 bit, 0 offset
Data Range: 0 to 7 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64964

SPN 2914 (R) XBR EBI Mode

The XBR EBI (Endurance Brake Integration) Mode is used as an input for the brake system to prescribe the use of endurance brakes like retarders or engine brakes.

00 - No Endurance Brake Integration allowed
The demanded acceleration must be realized by the brake system by using only the foundation brakes. During an active XBR request, the brake system must not actively demand brake torque from other braking devices like retarders or engine brakes.
01 - Only Endurance Brakes allowed
The demanded acceleration must be realized by the brake system by demanding brake torque from other brake devices like retarders or engine brakes. The foundation brake itself must not be used (e.g. to reduce brake lining wear).
10 - Endurance Brake Integration allowed
The demanded acceleration may be realized by the brake system by using the foundation brakes and/or by demanding brake torque from other brake devices like retarders or engine brakes.
11 - Not defined

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 1024

SPN 2915 (R) XBR Priority

The XBR Priority is used as an input to the brake system to manage the priority of overlapping external and internal requests.

00 - Highest priority – used for emergency situations, e.g. for future Collision Avoidance System. This mode overrides any brake protection measures of the brake system.
01 - High priority – not defined
10 - Medium priority – used for ACC-Systems. This mode does not override brake protection measures of the brake
11 – Low priority – used in "override disabled" XBR Control Mode

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 1024

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SPN 2916 (R) XBR Control Mode

The XBR Control Mode is used as an input to the brake system and defines how the external acceleration demand has to be realized.

00 - Override disabled – Disable any existing control commanded by the source of this command.
01 - Acceleration control with addition mode - Add the XBR acceleration demand to the driver's acceleration demand.
10 - Acceleration control with maximum mode - Execute the XBR acceleration demand if it is higher than the driver's acceleration demand.
11 - Not defined

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 1024

SPN 2917 (R) XBR System State

This parameter indicates which external brake control is allowed.

00 - Any external brake demand will be accepted (brake system fully operational)
01 - Only external brake demand of highest XBR Priority (00) will be accepted (e.g. because the temperature limit of the brake system is exceeded)
10 - No external brake demand will be accepted (e.g. because of fault in brake system)
11 - not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64964

SPN 2918 (R) XBR Active Control Mode

This parameter indicates which XBR Control Mode is executed by the brake system.

0000 No brake demand being executed (default mode)
0001 Driver's brake demand being executed, no external brake demand
0010 Addition mode of XBR acceleration control being executed
0011 Maximum mode of XBR acceleration control being executed
0100 - 1110 Reserved for SAE assignment
1111 Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64964

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SPN 2919 (R) Foundation Brake Use

This parameter indicates if the brake system presently uses the foundation brakes.

00 Foundation brakes not in use
01 Foundation brakes in use
10 Reserved
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64964

SPN 2920 (R) External Acceleration Demand

Parameter provided to the brake system from external sources. This is the acceleration which the brake system is expected to realize. It is specified as an absolute acceleration in reference to the road. Positive values lead to increasing vehicle speed, negative values lead to decreasing vehicle speed. Note: Normally only the negative data range is used, but e.g. in case of downhill driving also positive values are possible.

Data Length: 2 bytes
Resolution: 1/2048 m/s² per bit, -15.687 m/s² offset
Data Range: -15.687 to +15.687 m/s² Operational Range: -10.0 to +10.0 m/s²
Type: Status
Supporting information:
PGN 1024

SPN 2921 (R) XBR Acceleration Limit

The brake system may temporarily or generally limit the maximum brake performance available for external systems. A temporary limit may be necessary due to high brake temperature; a general limit may be defined by the vehicle manufacturer, e.g. a value of -2.5 m/s² due to liability reasons. The actual limit is communicated to the external systems that request braking. The limit is only effective in the XBR Priorities 01 to 11. It is specified as an absolute acceleration in reference to the road.

Data Length: 1 byte
Resolution: 0.1 m/s² per bit, -12.5 m/s² offset
Data Range: -12.5 to +12.5 m/s² Operational Range: -10.0 to +10.0 m/s²
Type: Status
Supporting information:
PGN 64964

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SPN 2922 (R) Steerable Lift Axle Lowering Inhibit

A signal which indicates if lowering of lifted axle is allowed or inhibited.

00 Lowering allowed
01 Lowering inhibited
10 Reserved
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61451

SPN 2923 (R) Status of Steering Axle

A signal which indicates different states of the steering axle

0000 Axle steering not active (adhesion steering)
0001 Axle steering active
0010 Axle centered
0011 Axle centered, because of an error
0100 Axle not active because of an error (adhesion steering)
0101 Axle steering in special mode (diagnosis, calibration mode)
0110-1110 Reserved for SAE Assignment
1111 Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61451

SPN 2924 (R) Steering Type

Indicates the different types of steering systems (ref. ECE Regulation 79 paragraph 2.5)

0000 Main steering system
0001 Auxiliary steering equipment
0010-1110 Reserved for Assignment by SAE
1111 Not Available

0000 Main steering system - The steering equipment of a vehicle which is mainly responsible for determining the direction of travel.

0001 Auxiliary steering equipment - A system in which the wheels on axle(s) of vehicles of categories M and N are steered in addition to the wheels of the main steering equipment in the same or opposite direction to those of the main steering equipment and/or the steering angle of the front and/or the rear wheels may be adjusted relative to vehicle behaviour.

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61451

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SPN 2925 (R) Type of Steering Forces

Type of Steering Forces (Ref. ECE Regulation 79 paragraph 2.5)

0000	Manual steering equipment
0001	Power assisted steering equipment
0010	Full power steering equipment
0011	Self tracking steering equipment
0100-1110	Reserved for SAE assignment
1111	Not Available

0000 Manual steering equipment - The steering forces result solely from the muscular effort of the driver.
0001 Power assisted steering equipment - The steering forces result from both the muscular effort of the driver and the energy supply or supplies.
0010 Full power steering equipment - The steering forces are provided solely by one or more energy supplies.
0011 Self tracking steering equipment - A system designed to create a change of steering angle on one or more wheels only when acted upon by forces and/or moments applied through the tire to road contact.

Data Length:	4 bits		
Resolution:	16 states/4 bit, 0 offset		
Data Range:	0 to 15	Operational Range:	same as data range
Type:	Status		
Supporting information:			
PGN	61451		

SPN 2926 (R) Type of Steering Transmission

Type of Steering Transmission (Ref. ECE Regulation 79 paragraph 2.6)

0000	Purely mechanical steering transmission
0001	Purely hydraulic steering transmission
0010	Purely electric steering transmission
0011	Hybrid steering transmission
0100-1110	Reserved for SAE assignment
1111	Not available

0000 Purely mechanical steering transmission - A steering transmission in which the steering forces are transmitted entirely by mechanical means.
0001 Purely hydraulic steering transmission - A steering transmission in which the steering forces, somewhere in the transmission, are transmitted only by hydraulic means.
0010 Purely electric steering transmission - A steering transmission in which the steering forces, somewhere in the transmission, are transmitted only through electric means.
0011 Hybrid steering transmission - A steering transmission in which part of the steering forces is transmitted through one and the other part through another of the above mentioned means. However, in the case where any mechanical part of the transmission is designed only to give position feedback and is too weak to transmit the total sum of the steering forces, this system shall be considered to be purely hydraulic or purely electric steering transmission.

Data Length:	4 bits		
Resolution:	16 states/4 bit, 0 offset		
Data Range:	0 to 15	Operational Range:	same as data range
Type:	Status		
Supporting information:			
PGN	61451		

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SPN 2927 (R) Actual Inner wheel steering angle

Signal which indicates the actual inner wheel steering angle. See figure 2927A for explanation of positive and negative

Data Length: 2 bytes
Resolution: 1/256 deg/bit, -125 deg offset
Data Range: -125 to 125 deg Operational Range: same as data range
Type: Measured
Supporting information: See Appendix D - SPN 2927
PGN 61451

SPN 2928 (R) Axle Location

To identify to which of several similar devices (such as tires or fuel tanks) the information applies.

The low order 4 bits represent a position number, counting left to right when facing in the direction of normal vehicle travel (forward).

The high order 4 bits represent a position number, counting front to back on the vehicle.

The value 0xFF indicates not available.

It is recommended that output devices add 1 to the position number (range 1 to 15, not 0 to 14) for use by drivers and service technicians.

Examples: Tire pressure for location 0016 would be left front tire.

Tire pressure for location 2316 would be right outside rear rear on a 3-axle tractor with dual axle per side (3rd axle, 4th tire).

Data Length: 8 bits
Resolution: 256 states/8 bit, 0 offset
Data Range: 0 to 255 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61451

SPN 2930 (R) Hydraulic Brake System Audible Warning Command

Signal which commands an audible warning by the hydraulic braking system.

00 Audible warning off
01 Audible warning on
10 Reserved
11 Don't care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64998

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SPN 2931 (R) Hydraulic Brake Fluid Level Switch

Signal which indicates whether the hydraulic fluid level in the reservoir(s) is sufficient.

00 Fluid level is not sufficient
01 Fluid level is sufficient
10 Error indicator
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64998

SPN 2945 (R) Active Shift Console Indicator

Signal from transmission control unit indicating which shift console (primary or secondary) it currently considers as the active shift selector input.

00 Primary shift console is active
01 Secondary shift console is active
10 Reserved
11 Not available

Note: In some applications such as refuse trucks, the transmission can be operated from two positions in the vehicle. The transmission control unit will accept changes in transmission requested gear (SPN 525) from the operator only from the active shift console. The transmission control unit determines which shift console is active based on a switch input controlled by the operator and transmission system state criteria.

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65098

SPN 2948 (R) Engine Intake Valve Actuation System Oil Pressure

The gage pressure of the oil in the hydraulic system that powers the engine intake valve actuation system

Data Length: 2 bytes
Resolution: 1/256 MPa/bit, 0 offset
Data Range: 0 to 251 Mpa Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64961

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SPN 2970 (R) Accelerator Pedal 2 Low Idle Switch

Switch signal which indicates the state of the accelerator pedal 2 low idle switch. The low idle switch is defined in SAE J1843.

00 Accelerator pedal 2 not in low idle condition
01 Accelerator pedal 2 in low idle condition
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61443

SPN 2978 (R) Estimated Engine Parasitic Losses - Percent Torque

The calculated torque that indicates the estimated amount of torque loss due to engine parasitics, such as cooling fan, air compressor, air conditioning, etc. It is expressed as a percent of Engine Reference Torque.

When the data value of this parameter is equal to FB it means that all parasitic losses calculated by the engine are included in the Engine's Nominal Friction Percent Torque (SPN 514).

Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: 0 to 125%
Type: Status
Supporting information:
PGN 65247

SPN 2979 (R) Vehicle Acceleration Rate Limit Status

Status (active or not active) of the system used to limit maximum forward vehicle acceleration.

00 Limit not active
01 Limit active
10 Reserved
11 Not available

NOTE: The effects of emission control limits, such as engine exhaust smoke control, are specifically excluded; they are not considered to be part of a function to limit vehicle acceleration.

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 61443

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SPN 2983 (R) Clutch Life Remaining

Signal which indicates the actual clutch life remaining in percent. One hundred percent means the clutch is brand new and zero percent means the clutch is at the end of its life.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65195

SPN 2984 (R) Automatic traction help (load transfer)

This signal enables the traction help (load transfer) in case of an active ASR function

00 Disable automatic traction help
01 Enable automatic traction help
10 Reserved
11 Don't care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 53760

SPN 2985 (R) Transmission Shift Selector Display Mode Switch

Status of the operator's switch used to 'toggle' through multiple display modes of a shift selector display.

When a shift selector display is capable of displaying more than just range information, this switch is toggled by the operator to move through the different display modes. If the selector has only two display modes, this switch may behave as a typical SPST switch. If the selector has more than two display modes, the switch may be momentary, where each activation indicates that the selector has scrolled through to the next subsequent display mode.

00 Off
01 On
10 Error
11 Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 256

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SPN 2986 (R) Engine Intake Valve Actuation System Oil Temperature

The temperature of the oil in the hydraulic system that powers the intake valve actuation system.

Data Length: 2 bytes
Resolution: 0.03125 deg C/bit, -273 deg C offset
Data Range: -273 to 1735 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65129

SPN 3026 (R) Transmission Oil Level Measurement Status

Indicates if conditions are acceptable to obtain a valid transmission oil level measurement as conveyed in SPN 124 Transmission Oil Level or SPN 3027 Transmission Oil Level High / Low. If conditions are not acceptable, this parameter conveys to the operator what prevents conditions from being acceptable. Only one condition can be conveyed in this parameter at any given point in time. If multiple conditions exist, it is not important which condition is actually broadcast, as the driver must 'correct' each and every condition as it is presented before a valid oil level reading can be made. If multiple conditions exist that prevent a valid reading, the sender should broadcast one of those conditions until it is corrected; then the next condition can be conveyed to the operator, and so on.

0000 Conditions valid for transmission oil level measurement
0001 Conditions not valid – Settling timer still counting down
0010 Conditions not valid – Transmission in gear
0011 Conditions not valid – Transmission fluid temperature too low
0100 Conditions not valid – Transmission fluid temperature too high
0101 Conditions not valid – Vehicle moving; output shaft speed too high
0110 Conditions not valid – Vehicle not level
0111 Conditions not valid – Engine speed too low
1000 Conditions not valid – Engine speed too high
1001 Not defined
1010 Not defined
1011 Not defined
1100 Not defined
1101 Conditions not valid - Other
1110 Error
1111 Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65272

SPN 3027 (R) Transmission Oil Level High / Low

Amount of current volume of transmission sump oil compared to recommended volume. Positive values indicate overfill. Zero means the transmission fluild is filled to the recommended level.

Parameter Specific Indicator:
A value of FB hex indicates conditions are not acceptable for a valid fluid level measurement.

Data Length: 1 bytes
Resolution: 0.5 L/bit, -62.5 offset
Data Range: -62.5 to 62.5 L Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65272

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SPN 3028 (R) Transmission Oil Level Countdown Timer

Once all vehicle conditions (such as vehicle stopped, etc) are met, some transmissions may require a 'settling time' to allow the fluid level to normalize. This parameter indicates how much of the required settling time remains. When time reaches 0, a valid oil level measurement value will be broadcast in SPN 3027 Transmission Oil Level High / Low.

0000 less than 1 minute
0001 One minute
0010 Two minutes
0011 Three minutes
0100 Four minutes
0101 Five minutes
0110 Six minutes
0111 Seven minutes
1000 Eight minutes
1001 Nine minutes
1010 Ten minutes
1011 Eleven minutes
1100 Twelve minutes
1101 Thirteen minutes
1110 Error
1111 Not Available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: 0 to 13 minutes
Type: Measured
Supporting information:
PGN 65272

SPN 3030 (R) Transmission Torque Converter Ratio

Ratio of the transmissions torque converter output torque to torque converter input torque at current speed.

The ratio of 1.000 (03 E8 hex) indicates torque converter lockup.
If the ratio is less than 1 and the ratio can not be properly determined it shall be set to a value of FB00 hex.
Ratios above 1 indicate torque converter multiplication.

Data Length: 2 bytes
Resolution: 0.001/bit, 0 offset
Data Range: 0 to 64.255 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 61452

SPN 3031 (R) Catalyst Tank Temperature

Temperature of the reagent in the storage tank.
Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 deg C Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65110

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SPN 3038 (R) Flash Engine Malfunction Indicator Lamp (MIL)

This parameter provides the capability to flash the MIL

00 - Slow Flash (1 Hz, 50 % duty cycle)
01 - Fast Flash (2 Hz or faster, 50% duty cycle)
10 - Reserved
11 - Unavailable / Do Not Flash

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65226

SPN 3039 (R) Flash Engine Red Stop Lamp (RSL)

This parameter provides the capability to flash the RSL

00 - Slow Flash (1 Hz, 50 % duty cycle)
01 - Fast Flash (2 Hz or faster, 50% duty cycle)
10 - Reserved
11 - Unavailable / Do Not Flash

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65226

SPN 3040 (R) Flash Engine Amber Warning Lamp (AWL)

This parameter provides the capability to flash the AWL

00 - Slow Flash (1 Hz, 50 % duty cycle)
01 - Fast Flash (2 Hz or faster, 50% duty cycle)
10 - Reserved
11 - Unavailable / Do Not Flash

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65226

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SPN 3041 (R) Flash Engine Protect Lamp

This parameter provides the capability to flash the engine protect lamp

00 - Slow Flash (1 Hz, 50 % duty cycle)
01 - Fast Flash (2 Hz or faster, 50% duty cycle)
10 - Reserved
11 - Unavailable / Do Not Flash

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65226

SPN 3043 (R) Type of Passenger Count

Used to notify transit link devices of the type of passenger counting system used in the vehicle. Some passenger counting systems indicate real-time boarding and exiting data for other devices to accumulate. Other types of passenger counters report a current on-board total relative to a transit door status, a fare collection status, or other signal which can define the end of the boarding/exiting period and a stable underway totalized passenger count.

0 - absolute passenger count
1 - boarding passenger
2 - exiting passenger
3 - boarding passenger (second passenger stream)
4 - exiting passenger (second passenger stream)
5 to 250 - reserved for future assignment
251 to 253 - reserved
254 - error indicator
255 - not available

Data Length: 8 bits
Resolution: 256 states/8 bit, 0 offset
Data Range: 0 to 255 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64960

SPN 3044 (R) Silent Alarm Status

Used to report silent alarm push button status.

00 - Off
01 - On
10 - Error condition
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64960

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SPN 3045 (R) Vehicle Use Status

Used to indicate the proper or unauthorized use of the vehicle. The administrative control device or any device issuing the vehicle use status PID should be sensitive to the run switch status (SPN 3046) and any other locally defined criteria for authorized use (i.e., driver log-ons) before the vehicle use status PID is used to generate an unauthorized use alarm.

00 - Normal use
01 - Unauthorized use
10 - Error condition
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64960

SPN 3046 (R) Transit Run Status

Status of the run switch for the vehicle.

00 - Off
01- On
10 - Error condition
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 64960

SPN 3047 (R) Patron Count

Count of the number of passengers on a transit vehicle. If the type of passenger count (SPN 3043) is 0, the patron count indicates the number of patrons currently on vehicle after the door has closed. If the type of passenger count is 1 to 4, the patron count indicates an incremental count of passengers since the last data transmittal.

Data Length: 1 byte
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 250 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64960

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SPN 3070 (R) Number of bytes in the Milepost Identification

Number of bytes in the Milepost Identification
Data Length: 1 byte
Resolution: 1 byte/bit, 0 offset
Data Range: 0 to 250 Operational Range: 0 to 100 bytes
Type: Measured
Supporting information:
PGN 64959

SPN 3071 (R) Number of bytes in the Transit Assigned Route Identity

Number of bytes in the Transit Assigned Route Identity
Data Length: 1 byte
Resolution: 1 byte/bit, 0 offset
Data Range: 0 to 250 Operational Range: 1 to 100 bytes
Type: Measured
Supporting information:
PGN 64958

SPN 3072 (R) Number of bytes in the Transit Assigned Run Identity

Number of bytes in the Transit Assigned Run Identity
Data Length: 1 byte
Resolution: 1 byte/bit, 0 offset
Data Range: 0 to 250 Operational Range: 1 to 100 bytes
Type: Measured
Supporting information:
PGN 64958

SPN 3073 (R) Number of bytes in the Transit Assigned Block Identity

Number of bytes in the Transit Assigned Block Identity
Data Length: 1 byte
Resolution: 1 byte/bit, 0 offset
Data Range: 0 to 250 Operational Range: 1 to 100 bytes
Type: Measured
Supporting information:
PGN 64958

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SPN 3074 (R) Transit Assigned Route Identity

Identifies the transit route assigned to a specific vehicle

Data Length: Variable - up to 100 characters
Resolution: ASCII, 0 offset
Data Range: 0 to 255 per byte Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64958

SPN 3075 (R) Transit Assigned Run Identity

Identifies the transit run assigned to a specific vehicle

Data Length: Variable - up to 100 characters
Resolution: ASCII, 0 offset
Data Range: 0 to 255 per byte Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64958

SPN 3076 (R) Transit Assigned Block Identity

Identifies the transit block assigned to a specific vehicle

Data Length: Variable - up to 100 characters
Resolution: ASCII, 0 offset
Data Range: 0 to 255 per byte Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64958

SPN 3078 (R) Agency

The identity of the agency involved in this transaction

Data Length: 1 byte
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 255 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64958

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SPN 3079 (R) Intersection Preemption Request/Response

Status of the intersection signal preemption

00 - Message is a request directed to the emitter
01 - Message is a response from the emitter
10 - Error condition
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64957

SPN 3080 (R) Transit Route ID Usage

Transit route ID usage

00 - Transit route ID not used for interleaved data
01 - Transit route ID used for interleaved data (if range code not enabled)
10 - Error condition
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64957

SPN 3081 (R) Range Code Enable

Range code enable

00 - Range code not used for interleaved data
01 - Range code used for interleaved data
10 - Error condition
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64957

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SPN 3082 (R) Strobe Activation Control Status

Strobe activation control status

00 - Deactive strobe
01 - Activate strobe
10 - Error condition
11 - Not available

Note: Strobe will flash if not overridden by transit door status, strobe is working, and emitter is in the normal mode.

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64957

SPN 3083 (R) Transit Door Enable

Transit door enable

00 - Ignore transit door status
01 - Transit door status will override strobe activation
10 - Error condition
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64957

SPN 3084 (R) Priority of Response Sent by Emitter

Priority of response sent by emitter

0000 - Reserved
0001 - Low priority
0010 - Probe priority
0011 - High priority
0100 to 1000 - Reserved
1001 - Priority set by hardware to low priority
1010 - Priority set by hardware to probe priority
1011 - Priority set by hardware to high priority
1100 to 1101 - Reserved
1110 - Error condition
1111 - Not available

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64957

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SPN 3085 (R) Vehicle ID

Numerical designation of the vehicle. 65535 is used to represent the vehicle ID is not available.

Data Length: 2 bytes
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 65,535 counts Operational Range: 0 to 65,534
Type: Measured
Supporting information:
PGN 64957

SPN 3086 (R) Transmission Ready for Brake Release

This parameter indicates that enough torque / motive force is available at the transmission output shaft to release all the brakes without a risk of unintentional movement in the opposite direction.

00 - Transmission Not Ready for Brake Release
01 - Transmission Ready for Brake Release
10 - Reserved
11 - Don't Care

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65098

SPN 3087 (R) Auxiliary Level

Level measured by a sensor.

Data Length: 2 bytes
Resolution: 0.1 mm/bit, 0 offset
Data Range: 0 to 6,425.5 mm Operational Range: same as data range
Type: Measured
Supporting information:
PGN 65164

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SPN 3156 (R) Blade Control Mode Switch

This parameter indicates the blade control mode switch state the user has set for the land leveling system. The switch value directly correlates to the current switch state, regardless of the switch being used. This parameter is intended for use in systems using only one parameter to control the blade movement (i.e. elevation). Systems using two independent parameters to control blade position, i.e. one blade edge maintains a constant elevation and the other blade edge maintains a constant blade angle, should use parameters specific to that usage. Only one of the following states will be active at a time. Below are the data values defined for each switch type that may be used in this application. The purpose of the following switch information is to define what data should be reported based on what type of switch is used.

1. A toggle button with two states can be used, in which the button is either in the manual or the auto position at all times. Toggle button usage is as follows:
   Manual Position = 0010 Manual button pressed
   Auto Position = 0011 Automatic button pressed

2. The momentary rocker switch may be used, where the default is the no button pressed position. The user can press the rocker into the manual position, and when pressure is released, it will return to the no button pressed position. The user may also press the rocker into the auto position, and when pressure is released, it will return to the no button pressed position. Momentary rocker button usage is as follows:
   No Button Pressed = 0000 No button pressed
   Manual Button Pressed = 0010 Manual button pressed
   Auto Button Pressed = 0011 Automatic button pressed

3. The momentary contact button pair may be used, where the default is no buttons being pressed. The user can press the manual button, and when pressure is released, it will return to the no button pressed position. The user may press the auto button, and when pressure is released, it will return to the no button pressed position. Momentary contact buttons (button pair) usage is as follows:

   No Button Pressed = 0000 No button pressed
   Manual Button Pressed = 0010 Manual button pressed
   Auto Button Pressed = 0011 Automatic button pressed

4. The momentary contact single button may be used, where the default is no button being pressed. The user can press the button, which is the button pressed position, and when pressure is released, it will return to the no button pressed position. The controller receiving this command will keep track of what mode the blade is in, auto or manual. When the button is pressed, the "mode button pressed" state is reported and the receiving controller then changes the current mode to its opposite value (i.e. manual to automatic or vise-versa). Momentary contact button (single button) usage is as follows:

   No Button Pressed = 0000 No button pressed
   Button Pressed = 0001 Mode button pressed

Data Values and Descriptions:

0000 No button pressed
0001 Mode button pressed
0010 Manual button pressed
0011 Automatic button pressed
1110 Error Indicator
1111 Not Installed
All other values are reserved

Notes:

1. The switch state can be read in two ways. One method uses the direct analog switch input to determine the switch state, while the second method relies on a secondary control to read the analog input, then relay the information on the data link. The parameter is designed to provide the actual switch state to other controls that need the information.
2. Other systems with automated blade controls should be able to use this parameter, since it is a measured switch value.

Data Length:	4 bits		
Resolution:	16 states/4 bit, 0 offset		
Data Range:	0 to 15	Operational Range:	same as data range
Type:	Measured		

Supporting information:

PGN 61453

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SPN 3157 (R) Desired Grade Offset Switch

This parameter indicates the grade offset switch state the user has set for the land leveling system. The desired grade offset value is the vertical offset measured from a given elevation reference point to the bottom edge of the blade. This parameter is intended for use in systems using only elevation offset to control the blade movement (i.e. elevation). Systems using two independent parameters to control blade position, i.e. one edge maintains a constant elevation and the other blade edge maintains a constant angle, should use parameters specific to that usage. Only one of the following states will be active at a time. Below are the data values defined for each switch type that may be used in this application. The purpose of the following switch information is to define what data should be reported based on what type of switch is used.

1. The momentary rocker switch may be used, where the default is the no button pressed position. The user can press the rocker into the increment button pressed position, and when pressure is released, it will return to the no button pressed position. The user may also press the rocker into the decrement button pressed position, and when pressure is released, it will return to the no button pressed position. Momentary rocker button usage is as follows:

No Button Pressed = 0000 No button pressed
Increment Button Pressed = 0001 Increment button pressed
Decrement Button Pressed = 0010 Decrement button pressed

2. The momentary contact button pair may be used, where the default is the no buttons pressed position. The user can press the increment button, and when pressure is released, it will return to the no buttons pressed position. The user may press the decrement button, and when pressure is released, it will return to the no buttons pressed position. Momentary contact button (button pair) usage is as follows:

No Button Pressed = 0000 No button pressed
Increment Button Pressed = 0001 Increment button pressed
Decrement Button Pressed = 0010 Decrement button pressed

Data Values and Descriptions:
0000 No button pressed
0001 Increment button pressed
0010 Decrement button pressed
1110 Error Indicator
1111 Not installed
All other values are reserved

Notes:

1. The switch state can be read in two ways. One method uses the direct analog switch input to determine the switch state, while the second method relies on a secondary control to read the analog input, then relay the information on the data link. The parameter is designed to provide the actual switch state to other controls that need the information.
2. Other systems with automated blade controls should be able to use this parameter, since it is a measured switch value.

Data Length:	4 bits		
Resolution:	16 states/4 bit, 0 offset		
Data Range:	0 to 15	Operational Range:	same as data range
Type:	Measured		
Supporting information:			
PGN	61453		

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SPN 3158 (R) Blade Auto Mode Command

Allows other controllers to command to the primary control system what they think is the appropriate auto control mode to be engaged in, based on the information they have available to them. When in automatic mode, the blade automatically adjusts its position to the center of the blade to maintain a desired grade offset. Only one of the following states will be active at a time. Below is extended information describing each command. The purpose of this information is to define what command state should be reported based on what auto control mode command is deemed appropriate by the operational specifications of the system.

0000 Auto Allowed - Auto mode permitted as appropriate (auto button was pushed or directly returned from Suspend Auto condition)
0001 Activity Allows Auto - Auto mode permitted only if the primary control system detects operator activity. The control issuing this command does not have sufficient information/reason to absolutely allow Auto mode (state 0000) or not allow Auto mode (state 0100). The control issuing this command is permitting the primary control system to operate in auto mode only if the primary control system detects operator activity, such as direct input to the primary control system. If the primary control system does not detect operator activity, then the control issuing this command is not allowing auto mode. For example, the control issuing this command has detected no operator activity yet it acknowledges that there may be other sources of operator activity that might make auto mode permissible.
0010 Suspend Auto - Auto mode is temporarily not allowed and the control issuing this command wants the primary control system to automatically return to the previous state (Auto or Manual) when the suspend auto condition is removed.
0011 Service Mode - Auto mode is permitted only for special services such as calibrations.
0100 Auto Not Allowed - Auto mode is not allowed under any condition

Data Values and Descriptions:
0000 Auto Allowed
0001 Activity Allows Auto - must detect operator before auto allowed
0010 Suspend Auto - temporarily suspend auto mode
0011 Service Mode - auto allowed only during service modes
0100 Auto Not Allowed
1110 Error Indicator
1111 Not Supported
All other values are reserved

Note:
The control issuing this command is aware that it does not have access to all information that the primary controller of the Land Leveling System attachment has access to. Therefore, it commands the Land Leveling system to activate a auto blade mode based on the input it has access to. In some cases, like in the "Activity Allows Auto" situation, the control knows the Land Leveling system has access to an additional display (which has switches and several buttons) which may help determine if an operator is present. On the other hand, the control may also have information the primary controller of the Land Leveling System does not have access to, like the parking brake status.

Data Length:	4 bits		
Resolution:	16 states/4 bit, 0 offset		
Data Range:	0 to 15	Operational Range:	same as data range
Type:	Status		
Supporting information:			
PGN	61453		

SPN 3159 (R) Trip Number

The identity number assigned to this trip.

Data Length:	2 bytes		
Resolution:	1 count/bit, 0 offset		
Data Range:	0 to 65,535 counts	Operational Range:	same as data range
Type:	Measured		
Supporting information:			
PGN	64956		

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SPN 3160 (R) Assigned Route

The identity number assigned to this route.

Note: This is the numerical value for the route as opposed to the "Transit Assigned Route Identity" (SPN 3074) which is variable length ASCII or the "Route number" (SPN 3169) which is 12 bit numeric.

Data Length: 2 bytes
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 65,535 counts Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64956

SPN 3161 (R) Pattern Number

The agency defined pattern number for this trip
Data Length: 2 bytes
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 65,535 counts Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64956

SPN 3162 (R) Assigned Run

The agency defined run number for this trip
Data Length: 2 bytes
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 65,535 counts Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64956

SPN 3163 (R) Assigned Block

The agency defined block number for this trip
Data Length: 2 bytes
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 65,535 counts Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64956

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SPN 3164 (R) Driver's farebox security code

Security code for the farebox, numerical only.

Note: 0 = Farebox is in reporting status
1 - 65535 = security code

Data Length: 2 bytes
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 65,535 counts Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64956

SPN 3165 (R) Fare Validity

Agency defined value indicating validity of this fare
Data Length: 4 bits
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64955

SPN 3166 (R) Pass Category

Agency defined value indicating the category of the passenger associated with this fare
Data Length: 4 bits
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64955

SPN 3167 (R) Initial Fare Agency

Identifies where the initial fare is paid

Note: The definition of the agency numbering plan shall be agreed by the operating agency and the farebox manufacturer. The value of 0 is reserved, the usable range is 1 to 31.

Data Length: 5 bits
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 31 Operational Range: 1 to 31
Type: Measured
Supporting information:
PGN 64955

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SPN 3168 (R) Transfer Sold

Indicates that a transfer was sold or issued on this transaction including its type and/or restrictions. The final definitions of the transfer issued information shall be agreed by the operating agency and the farebox manufacturer.

Note: A non-zero value indicates that a transfer was sold or issued. The value of zero is reserved to indicate that no transfer has been sold or issued.

Data Length: 1 byte
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 255 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64955

SPN 3169 (R) Route Number

The route number issuing the transfer.

Data Length: 12 bits
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 4095 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64955

SPN 3170 (R) Transaction Type

Enumerated value representing the type of transaction completed

0000 = Cash
0001 = Token
0010 = Ticket
0011 = Pass
0100 = Card
0101 = Permit
0110 = Transfer
0111 = Free
1000-1011 = Reserved for assignment
1100-1111 = Agency defined

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64955

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SPN 3171 (R) Passenger Type

Enumerated value representing the type/class of passenger, as defined by the agency.

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64955

SPN 3172 (R) Type of Service

The type of service provided

000 = Local service
001 = Express service
010-111 = Agency defined

Data Length: 3 bits
Resolution: 8 states/3 bit, 0 offset
Data Range: 0 to 7 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64955

SPN 3173 (R) Transfer Type

The kind of transfer used

00000 = North
00001 = South
00010 = East
00011 = West
00100 = In
00101 = Out
00110-11111 = Agency defined

Data Length: 5 bits
Resolution: 32 states/5 bit, 0 offset
Data Range: 0 to 31 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64955

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SPN 3174 (R) Trip Direction

The general direction of travel for this trip.

0000 = North
0001 = South
0010 = East
0011 = West
0100 = In
0101 = Out
0110-1111 = Agency defined

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64956

SPN 3175 (R) Fare Presets

Fare Presets

00000000 to 00001111 = Agency defined
00010000 to 11111111 = Reserved for assignment

Data Length: 8 bits
Resolution: 256 states/8 bit, 0 offset
Data Range: 0 to 255 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64956

SPN 3176 (R) Type of Fare

Type of Fare

0000 = Cash/No detail
0001 = Token A
0010 = Token B
0011 = Ticket A
0100 = Ticket B
0101 = Pass A
0110 = Pass B
0111-1010 = Reserved for assignment
1011-1111 = Agency defined

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64955

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SPN 3177 (R) Payment Details

Payment details.

0000 = Not an upgrade
0001 = Cash
0010 = Token
0011 = Ticket
0100 = Pass
0101 = Card
0110-1010 = Reserved for assignment
1011-1111 = Agency defined

Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64955

SPN 3178 (R) Farebox Service Status

Indicates if the farebox is in or out of service.

00 = Farebox out of service
01 = Farebox in service
10 = Error Condition
11 = Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64956

SPN 3179 (R) Farebox Emergency Status

Indicates if a farebox emergency condition exists.

00 = Non-emergency condition
01 = Emergency condition
10 = Error Condition
11 = Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64954

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SPN 3180 (R) Trip Status

Trip Status

000 = Undefined
001 = Trip start
010 = Trip end
011 = Undefined
100 = Undefined
101 = Layover start
110 = Layover end
111 = Undefined

Data Length: 3 bits
Resolution: 8 states/3 bit, 0 offset
Data Range: 0 to 7 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64956

SPN 3181 (R) Farebox Alarm Identifier

Indicates the nature of the farebox alarm condition.

0000000 = Voltage dropout
0000001 = Voltage restored
0000010 = Probe started
0000011 = Probe completed
0000100 = Cashbox removed
0000101 = Cashbox restored
0000110 = Cashbox door timeout
0000111 = Cashbox opened in service, considered an alarm condition
0001000 = Insufficient fare accepted
0001001 = Coinbox 75% full
0001010 = Coinbox full
0001011 = Currency box 75% full
0001100 = Currency box less than 75% full
0001101 = Currency box full
0001110 = Card/pass box 75% full
0001111 = Card/pass box less than 75% full
0010000 = Card/pass box full
0010001 = Coin de-jam operated
0010010 = Farebox set in manual bypass
0010011 = Farebox reset to automatic mode
0010100 = Pass/transfer jam
0010101 = Pass/transfer jam cleared
0010110 = Paper currency jam
0010111 = Paper currency jam cleared
0011000 = Maintenance access in service, considered an alarm condition
0011001 = Maintenance access out of service
0011010-1100000 = Reserved - to be assigned
1100001-1111111 = Agency defined

Data Length: 7 bits
Resolution: 128 states/7 bit, 0 offset
Data Range: 0 to 127 Operational Range: same as data range
Type: Measured
Supporting information:
PGN 64954

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SPN 3188 (R) XBR Message Checksum

The XBR message checksum is used to verify the signal path from the demanding device to the brake controller on electronic brake systems. The support of this parameter is mandatory.

The 4 bit checksum is the sum of the high nibble and the low nibble of the sum of the identifier, the first 7 data bytes and the 4 bit message counter. It is calculated as follows:

Checksum = (Byte1 + Byte2 + Byte3 + Byte4 + Byte5 + Byte6 + Byte7 + message counter&0x0F + message ID low byte + message ID mid low byte + message ID mid high byte + message ID high byte)
Checksum = ((Checksum >> 4) + Checksum) & 0x0F

Note: A failure in the communication sets the XBR system state:
- to '01' for failed XBR 'priority 01, 10 or 11' messages
- to '10' for failed XBR 'priority 00' messages.

Data Length: 4 bits
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 1024

SPN 3189 (R) XBR Message Counter

The XBR message counter is to verify the signal path from the demanding device to the brake controller on electronic brake systems.. The support of this parameter is mandatory.

Note: The initial value of the 4 bit message counter for the first message during a driving cycle is arbitrary. In every following message the counter is incremented by 1 (0 follows 15).

Data Length: 4 bits
Resolution: 1 count/bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Supporting information:
PGN 1024

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SPN 3190 (R) Tire Location

Identifies which tire is associated with the parametric data in this PGN.

The low order 4 bits represent a position number, counting left to right when facing in the direction of normal vehicle travel (forward).

The high order 4 bits represent a position number, counting front to back on the vehicle.

The value 0xFF indicates not available.

It is recommended that output devices add 1 to the position number (range 1 to 15, not 0 to 14) for use by drivers and service technicians.

Examples: Tire pressure for location 0x00 would be left front tire.

Tire pressure for location 0x23 would be right outside rear rear on a 3-axle tractor with dual axle per side (3rd axle, 4th tire).

Data Length:	8 bits		
Resolution:	256 states/8 bit, 0 offset		
Data Range:	0 to 255	Operational Range:	same as data range
Type:	Measured		
Supporting information:			
PGN	64953		

SPN 3191 (R) Reference Tire Pressure

Reference value of the tire pressure as basis for the tire pressure monitoring

Data Length:	1 byte		
Resolution:	8 kPa/bit, 0 offset		
Data Range:	0 to 2,000 kPa	Operational Range:	same as data range
Type:	Status		
Supporting information:			
PGN	64953		

SPN 3192 (R) Tire Location

Identifies which tire is associated with the parametric data in this PGN.

The low order 4 bits represent a position number, counting left to right when facing in the direction of normal vehicle travel (forward).

The high order 4 bits represent a position number, counting front to back on the vehicle.

The value 0xFF indicates not available.

It is recommended that output devices add 1 to the position number (range 1 to 15, not 0 to 14) for use by drivers and service technicians.

Examples: Tire pressure for location 0x00 would be left front tire.

Tire pressure for location 0x23 would be right outside rear rear on a 3-axle tractor with dual axle per side (3rd axle, 4th tire).

Data Length:	8 bits		
Resolution:	256 states/8 bit, 0 offset		
Data Range:	0 to 255	Operational Range:	same as data range
Type:	Measured		
Supporting information:			
PGN	44544		

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SPN 3193 (R) Reference Tire Pressure Setting

Reference value of the tire pressure setting as basis for the tire pressure monitoring

Data Length: 1 byte
Resolution: 8 kPa/bit, 0 offset
Data Range: 0 to 2,000 kPa Operational Range: same as data range
Type: Status
Supporting information:
PGN 44544

SPN 3289 (R) Transmission Requested Gear Feedback

Feedback of the SPN 525 Transmission Requested Gear input as received from the shift selector, ABS or engine via PGN 256, Transmission Control #1 (TC1). Scaling, values and parameter specific indicators are identical to those listed for SPN 525 Transmission Requested Gear.

This feedback from the transmission allows shift selectors and other TC1 input devices to verify that their Transmission Requested Gear command has been properly received by the transmission. (This parameter is not intended for driver display purposes).

Data Length: 1 byte
Resolution: 1 gear value/bit, -125 offset
Data Range: -125 to 125 Operational Range: same as data range
Type: Status
Supporting information:
PGN 65098

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APPENDIX C
PGNs

PGN 0 Torque/Speed Control 1 - TSC1

NOTE - Retarder may be disabled by commanding a torque limit of 0%. Use of the limit mode allows the use of the retarder only up to the limit specified in the request. This can be used to permit retarding of up to 50%, for example, if that limit is required by some device such as an EBS, or it can disable the use of the retarder by others, as when an ABS controller detects wheel slip.

Transmission Repetition	when active; 10 ms to engine - 50 ms to retarder	
Data Length:	8	
Data Page:	0	
PDU Format:	0	
PDU Specific:	DA	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	0	(0x0)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Engine Override Control Mode	695
1.3	2 bits	Engine Requested Speed Control Conditions	696
1.5	2 bits	Override Control Mode Priority	897
2-3	2 bytes	Engine Requested Speed/Speed Limit	898
4	1 byte	Engine Requested Torque/Torque Limit	518

PGN 256 Transmission Control 1 - TC1

Transmission Repetition	when active; 50 ms to transmission and axles	
Data Length:	8	
Data Page:	0	
PDU Format:	1	
PDU Specific:	DA	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	256	(0x100)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Transmission Gear Shift Inhibit Request	681
1.3	2 bits	Torque Converter Lockup Disable Request	682
1.5	2 bits	Disengage Driveline Request	683
2	1 byte	Requested Percent Clutch Slip	684
3	1 byte	Transmission Requested Gear	525
4.1	2 bits	Disengage Differential Lock Request - Front Axle 1	685
4.3	2 bits	Disengage Differential Lock Request - Front Axle 2	686
4.5	2 bits	Disengage Differential Lock Request - Rear Axle 1	687
4.7	2 bits	Disengage Differential Lock Request - Rear Axle 2	688
5.1	2 bits	Disengage Differential Lock Request - Central	689
5.3	2 bits	Disengage Differential Lock Request - Central Front	690
5.5	2 bits	Disengage Differential Lock Request - Central Rear	691
6.1	2 bits	Transmission Mode 1	1852
6.3	2 bits	Transmission Mode 2	1853

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6.5	2 bits	Transmission Mode 3	1854
6.7	2 bits	Transmission Mode 4	1855
7.7	2 bits	Transmission Shift Selector Display Mode Switch	2985

PGN 1024 (R) External Brake Request - XBR

Used for brake control by an external device. The receiver is the brake system controlling the axle and/or wheel brakes. This system has to process the demanded acceleration. Note: This PGN shall not be used for external control of engine, engine brakes (engine retarders) or driveline retarders. Use TSC1 PGN instead.

Transmission Repetition: when active: 20 ms; else 200 ms
Data Length: 8
Data Page: 0
PDU Format: 4
PDU Specific: DA PGN Supporting Information: See Appendix D - PGN 1024
Default Priority: 3
Parameter Group Number: 1024 (0x400)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	External Acceleration Demand	2920
3.1	2 bits	XBR EBI Mode	2914
3.3	2 bits	XBR Priority	2915
3.5	2 bits	XBR Control Mode	2916
8.1	4 bits	XBR Message Counter	3189
8.5	4 bits	XBR Message Checksum	3188

PGN 44544 (R) Tire Pressure Reference Setting - TPRS

For setting the tire pressure reference values.

This message is the setpoint for the PGN 64153 Tire Pressure reference message.

Transmission Repetition: As needed
Data Length: 8
Data Page: 0
PDU Format: 174
PDU Specific: DA PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 44544 (0xAE00)

Start Position	Length	Parameter Name	SPN
1	8 bits	Tire Location	3192
2	1 byte	Reference Tire Pressure Setting	3193

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PGN 52992 ***Continuous Torque & Speed Limit Request*** ***- CTL***

Transmission Repetition	5 s		
Data Length:	8		
Data Page:	0		
PDU Format:	207		
PDU Specific:	DA	PGN Supporting Information:	See Appendix D - PGN 52992
Default Priority:	6		
Parameter Group Number:	52992	(0xCF00)	

Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Speed Limit Request - Minimum Continuous	1784
2	1 byte	Engine Speed Limit Request - Maximum Continuous	1785
3	1 byte	Engine Torque Limit Request - Minimum Continuous	1786
4	1 byte	Engine Torque Limit Request - Maximum Continuous	1787
5	1 byte	Minimum Continuous Retarder Speed Limit Request	1788
6	1 byte	Maximum Continuous Retarder Speed Limit Request	1789
7	1 byte	Minimum Continuous Retarder Torque Limit Request	1790
8	1 byte	Maximum Continuous Retarder Torque Limit Request	1791

PGN 53248 ***Cab Illumination Message*** ***- CL***

This message contains information that controls illumination devices inside the vehicle's cab.

Transmission Repetition	on change of state, but not faster that 100 ms, and every 5 s		
Data Length:	8		
Data Page:	0		
PDU Format:	208		
PDU Specific:	DA	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	53248	(0xD000)	

Start Position	Length	Parameter Name	SPN
1	1 byte	Illumination Brightness Percent	1487

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PGN 53504 Air Suspension Control 6 - ASC6

Used for suspension control

Transmission Repetition	100 ms when active	
Data Length:	8	
Data Page:	0	
PDU Format:	209	
PDU Specific:	DA	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	53504	(0xD100)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Level Preset Front Axle Left	1732
3-4	2 bytes	Level Preset Front Axle Right	1757
5-6	2 bytes	Level Preset Rear Axle Left	1758
7-8	2 bytes	Level Preset Rear Axle Right	1735

PGN 53760 (R) Air Suspension Control 2 - ASC2

Used for suspension control

Transmission Repetition	100 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	210	
PDU Specific:	DA	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	53760	(0xD200)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Automatic traction help (load transfer)	2984
1.3	2 bits	Kneeling Request Left Side	1749
1.5	2 bits	Kneeling Request Right Side	1748
1.7	2 bits	Kneeling Control Mode Request	1747
2.1	4 bits	Nominal Level Request Front Axle	1751
2.5	4 bits	Nominal Level Request Rear Axle	1750
3.1	4 bits	Level Control Mode Request	1753
3.5	2 bits	Lift Axle 1 Position Command	1752
3.7	2 bits	Lift Axle 2 Position Command	1828
4	1 byte	Damper Stiffness Request Front Axle	1718
5	1 byte	Damper Stiffness Request Rear Axle	1719
6	1 byte	Damper Stiffness Request Lift / Tag Axle	1720
7.1	2 bits	Kneeling Command - Front Axle	1830
7.3	2 bits	Kneeling Command - Rear Axle	1829

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PGN 54528 Time/Date Adjust - TDA

Transmission Repetition	As needed		
Data Length:	8		
Data Page:	0		
PDU Format:	213		
PDU Specific:	DA	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	54528	(0xD500)	

Start Position	Length	Parameter Name	SPN
1	1 byte	Adjust seconds	1603
2	1 byte	Adjust minutes	1604
3	1 byte	Adjust hours	1605
4	1 byte	Adjust month	1606
5	1 byte	Adjust day	1607
6	1 byte	Adjust year	1608
7	1 byte	Adjust local minute offset	1609
8	1 byte	Adjust local hour offset	1610

PGN 56320 Anti-theft Status - ATS

NOTE–See Figures PGN56320_A to PGN56320_F for examples of Anti-theft message transfers. Bit 1 is the right most bit in each byte.

Transmission Repetition	This message is transmitted in response to an Anti-Theft Request message. This message is also sent when the componentn has an abnormal power interuption. In this situation the Anti-Theft Status Report is sent without the Anti-Theft Request.		
Data Length:	8		
Data Page:	0		
PDU Format:	220		
PDU Specific:	DA	PGN Supporting Information:	See Appendix D - PGN 56320
Default Priority:	7		
Parameter Group Number:	56320	(0xDC00)	

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Anti-theft Encryption Seed Present Indicator	1194
1.3	2 bits	Anti-theft Password Valid Indicator	1195
1.5	2 bits	Anti-theft Component Status States	1196
1.7	2 bits	Anti-theft Modify Password States	1197
2-8	7 bytes	Anti-theft Random Number	1198

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PGN 56576 Anti-theft Request - ATR

NOTE–See Figures 20 to 25 for examples of Anti-theft message transfers. Bit 1 is the right most bit in each byte.

Transmission Repetition	Transmission of this message is interrupt driven. This message is also transmitted upon power-up of the interfacing device sending this message.	
Data Length:	8	
Data Page:	0	
PDU Format:	221	
PDU Specific:	DA	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	56576	(0xDD00)

Start Position	Length	Parameter Name	SPN
1.2	2 bits	Anti-theft Encryption Indicator States	1199
1.4	2 bits	Anti-theft Desired Exit Mode States	1200
1.6	3 bits	Anti-theft Command States	1201
2	7 bytes	Anti-theft Password Representation	1202

PGN 56832 Reset - RESET

NOTE—This message requires an Acknowledgement response (See J1939-21, PGN 59392) from the receiving node. The use of individual proprietary protocols can still be used instead of the "trip reset" PGN to maintain security.

Transmission Repetition	When needed	
Data Length:	8	
Data Page:	0	
PDU Format:	222	
PDU Specific:	DA	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	56832	(0xDE00)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Trip Group 1	988
1.3	2 bits	Trip Group 2 - Proprietary	989
2	1 byte	Service Component Identification	1584
3.1	2 bits	Engine Build Hours Reset	1211

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PGN 57344 ***Cab Message 1*** ***- CM1***

Message containing parameters originating from the vehicle cab.

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	224	
PDU Specific:	DA	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	57344	(0xE000)

Start Position	Length	Parameter Name	SPN
1	1 byte	Requested Percent Fan Speed	986
2-3	2 bytes	Cab Interior Temperature Command	1691
4.1	2 bits	Auxiliary Heater Coolant Pump Request	1684
4.3	2 bits	Battery Main Switch Hold Request	1682
4.5	2 bits	Operator Seat Direction Switch	1714
4.7	2 bits	Seat Belt Switch	1856
5.3	2 bits	Vehicle Limiting Speed Governor Decrement Switch	1655
5.5	2 bits	Vehicle Limiting Speed Governor Increment Switch	1654
5.7	2 bits	Vehicle Limiting Speed Governor Enable Switch	1653
6.5	2 bits	Automatic Gear Shifting Enable Switch	1666
6.7	2 bits	Engine Automatic Start Enable Switch	1656
7.1	4 bits	Auxiliary Heater Mode Request	1683
7.5	2 bits	Request Engine Zone Heating	1685
7.7	2 bits	Request Cab Zone Heating	1686
8	1 byte	Selected Maximum Vehicle Speed Limit	2596

PGN 61440 ***Electronic Retarder Controller 1*** ***- ERC1***

NOTE- This message will be transmitted by several types of retarding devices such as engine compression release brakes, exhaust system restriction brakes, and driveline retarders using hydraulic, electric, or mechanical friction to slow the vehicle. The source address of the message will indicate which one, and the type and location of the retarder are available in the Retarder Configuration Message (see PGN 65249) if that detail is important to the receiver.

Users should also be aware that the Shift Assist and Brake Assist switch status in the first byte of this message are to be used by other ECUs that might request retarding force from the retarder to know when such assistance is available. The state of the "switches" will NOT prevent the retarder from activating if requested, but should be honored by the requester (by not sending a request when the appropriate "switch" is not enabled) to prevent unwarranted noise.

Transmission Repetition	100 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	240	
PDU Specific:	0	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	61440	(0xF000)

Start Position	Length	Parameter Name	SPN

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1.1	4 bits	Retarder Torque Mode	900
1.5	2 bits	Retarder Enable - Brake Assist Switch	571
1.7	2 bits	Retarder Enable - Shift Assist Switch	572
2	1 byte	Actual Retarder - Percent Torque	520
3	1 byte	Intended Retarder Percent Torque	1085
4.1	2 bits	Engine Coolant Load Increase	1082
4.3	2 bits	Retarder Requesting Brake Light	1667
5	1 byte	Source Address of Controlling Device for Retarder Control	1480
6	1 byte	Drivers Demand Retarder - Percent Torque	1715
7	1 byte	Retarder Selection, non-engine	1716
8	1 byte	Actual Maximum Available Retarder - Percent Torque	1717

PGN 61441 Electronic Brake Controller 1 - EBC1

Used for brake control information

Transmission Repetition 100 ms
Data Length: 8
Data Page: 0
PDU Format: 240
PDU Specific: 1 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 61441 (0xF001)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	ASR Engine Control Active	561
1.3	2 bits	ASR Brake Control Active	562
1.5	2 bits	Anti-Lock Braking (ABS) Active	563
1.7	2 bits	EBS Brake Switch	1121
2	1 byte	Brake Pedal Position	521
3.1	2 bits	ABS Off-road Switch	575
3.3	2 bits	ASR Off-road Switch	576
3.5	2 bits	ASR "Hill Holder" Switch	577
3.7	2 bits	Traction Control Override Switch	1238
4.1	2 bits	Accelerator Interlock Switch	972
4.3	2 bits	Engine Derate Switch	971
4.5	2 bits	Engine Auxiliary Engine Shutdown Switch	970
4.7	2 bits	Remote Accelerator Enable Switch	969
5	1 byte	Engine Retarder Selection	973
6.1	2 bits	ABS Fully Operational	1243
6.3	2 bits	EBS Red Warning Signal	1439
6.5	2 bits	ABS/EBS Amber Warning Signal (Powered Vehicle)	1438
6.7	2 bits	ATC/ASR Information Signal	1793
7	1 byte	Source Address of Controlling Device for Brake Control	1481
8.3	2 bits	Halt brake switch	2911
8.5	2 bits	Trailer ABS Status	1836
8.7	2 bits	Tractor-Mounted Trailer ABS Warning Signal	1792

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PGN 61442 Electronic Transmission Controller 1 - ETC1

Transmission Repetition	10 ms		
Data Length:	8		
Data Page:	0		
PDU Format:	240		
PDU Specific:	2	PGN Supporting Information:	
Default Priority:	3		
Parameter Group Number:	61442	(0xF002)	

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Transmission Driveline Engaged	560
1.3	2 bits	Torque Converter Lockup Engaged	573
1.5	2 bits	Transmission Shift In Process	574
2-3	2 bytes	Transmission Output Shaft Speed	191
4	1 byte	Percent Clutch Slip	522
5.1	2 bits	Engine Momentary Overspeed Enable	606
5.3	2 bits	Progressive Shift Disable	607
6-7	2 bytes	Transmission Input Shaft Speed	161
8	1 byte	Source Address of Controlling Device for Transmission Control	1482

PGN 61443 (R) Electronic Engine Controller 2 - EEC2

Transmission Repetition	50 ms		
Data Length:	8		
Data Page:	0		
PDU Format:	240		
PDU Specific:	3	PGN Supporting Information:	
Default Priority:	3		
Parameter Group Number:	61443	(0xF003)	

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Accelerator Pedal 1 Low Idle Switch	558
1.3	2 bits	Accelerator Pedal Kickdown Switch	559
1.5	2 bits	Road Speed Limit Status	1437
1.7	2 bits	Accelerator Pedal 2 Low Idle Switch	2970
2	1 byte	Accelerator Pedal Position 1	91
3	1 byte	Engine Percent Load At Current Speed	92
4	1 byte	Remote Accelerator Pedal Position	974
5	1 byte	Accelerator Pedal Position 2	29
6.1	2 bits	Vehicle Acceleration Rate Limit Status	2979

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PGN 61444 ***Electronic Engine Controller 1*** ***- EEC1***

Engine related parameters

Transmission Repetition	engine speed dependent	
Data Length:	8	
Data Page:	0	
PDU Format:	240	
PDU Specific:	4	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	61444	(0xF004)

Start Position	Length	Parameter Name	SPN
1.1	4 bits	Engine Torque Mode	899
2	1 byte	Driver's Demand Engine - Percent Torque	512
3	1 byte	Actual Engine - Percent Torque	513
4-5	2 bytes	Engine Speed	190
6	1 byte	Source Address of Controlling Device for Engine Control	1483
7.1	4 bits	Engine Starter Mode	1675
8	1 byte	Engine Demand – Percent Torque	2432

PGN 61445 ***Electronic Transmission Controller 2*** ***- ETC2***

Transmission Repetition	100 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	240	
PDU Specific:	5	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	61445	(0xF005)

Start Position	Length	Parameter Name	SPN
1	1 byte	Transmission Selected Gear	524
2-3	2 bytes	Transmission Actual Gear Ratio	526
4	1 byte	Transmission Current Gear	523
5-6	2 bytes	Transmission Requested Range	162
7-8	2 bytes	Transmission Current Range	163

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PGN 61446 ***Electronic Axle Controller 1*** ***- EAC1***

NOTE - Request has to be responded to with as many messages as necessary to transmit all available information.

Transmission Repetition	500 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	240	
PDU Specific:	6	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	61446	(0xF006)

Start Position	Length	Parameter Name	SPN
1	8 bits	Location	927
2.1	2 bits	Differential Lock State - Front Axle 1	567
2.3	2 bits	Differential Lock State - Front Axle 2	568
2.5	2 bits	Differential Lock State - Rear Axle 1	569
2.7	2 bits	Differential Lock State - Rear Axle 2	570
3.1	2 bits	Differential Lock State - Central	564
3.3	2 bits	Differential Lock State - Central Front	565
3.5	2 bits	Differential Lock State - Central Rear	566

PGN 61447 ***Forward Lane Image urgent msg*** ***- FLI1***

Transmission Repetition	50 ms (only when active)	
Data Length:	8	
Data Page:	0	
PDU Format:	240	
PDU Specific:	7	PGN Supporting Information:
Default Priority:	4	
Parameter Group Number:	61447	(0xF007)

Start Position	Length	Parameter Name	SPN
1.5	2 bits	Lane Departure Imminent, Right Side	1701
1.7	2 bits	Lane Departure Imminent, Left Side	1700

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PGN 61448 ***Hydraulic Pressure Governor Info*** ***- HPG***

Information to be used for a hydraulic pressure governing control system

Transmission Repetition	50 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	240	
PDU Specific:	8	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	61448	(0xF008)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Hydraulic Pressure	1762
3.1	2 bits	Engine Hydraulic Pressure Governor Mode Indicator	1763
3.3	2 bits	Engine Hydraulic Pressure Governor Switch	1764
3.5	2 bits	Fire Apparatus Pump Engagement	2599

PGN 61449 ***Vehicle Dynamic Stability Control 2*** ***- VDC2***

Contains information which relates to the vehicle's movement.

Transmission Repetition	10 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	240	
PDU Specific:	9	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	61449	(0xF009)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Steering Wheel Angle	1807
3.1	6 bits	Steering Wheel Turn Counter	1811
3.7	2 bits	Steering Wheel Angle Sensor Type	1812
4-5	2 bytes	Yaw Rate	1808
6-7	2 bytes	Lateral Acceleration	1809
8	1 byte	Longitudinal Acceleration	1810

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PGN 61450 Engine Gas Flow Rate - EGF1

Flow rates of Air and mixed gasses into the engine cylinders.

Transmission Repetition	50 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	240	
PDU Specific:	10	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	61450	(0xF00A)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Exhaust Gas Recirculation (EGR) Mass Flow Rate	2659
3-4	2 bytes	Engine Inlet Air Mass Flow Rate	132

PGN 61451 (R) Electronic Steering Control - ESC1

PGN which indicates the actual angle and the status of a steerable axle

Transmission Repetition	20 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	240	
PDU Specific:	11	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	61451	(0xF00B)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Actual Inner wheel steering angle	2927
3	8 bits	Axle Location	2928
4.1	4 bits	Status of Steering Axle	2923
4.5	2 bits	Steerable Lift Axle Lowering Inhibit	2922
5.1	4 bits	Steering Type	2924
5.5	4 bits	Type of Steering Forces	2925
6.1	4 bits	Type of Steering Transmission	2926

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PGN 61452 (R) Electronic Transmission Controller #8 - ETC8

Electronic Transmission Controller #8

Transmission Repetition	20 ms when torque converter unlocked, 100 ms when torque converter locked	
Data Length:	8	
Data Page:	0	
PDU Format:	240	
PDU Specific:	12	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	61452	(0xF00C)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Transmission Torque Converter Ratio	3030

PGN 61453 (R) Land Leveling System Operational Information - LOI

Group of operational parameters associated with the Land Leveling System, such as switch states. This is provided to the device controlling the blade, and is usually directed at the primary land leveling controller.

Notes:
1. The parameter group is filled with SPNs sent to the Land Leveling System controller. Similar PGNs exist, 65138 for example, but (65138) is sent out by the Land Leveling System primary controller to reflect the mode the land leveling system has been put into (auto, manual). This logical decision to put the system into auto/manual mode is based in part on the input from this proposed PGN, along with other various inputs. It makes more sense to create this new PGN filled with parameters sourced from the non-primary controller, rather than use the PGN sourced by the primary controller itself. In the future, other SPNs coming from the non-primary controller can be added to the proposed PGN. There are plans to add more switch values in the future.

2. Other systems with automated blade controls should be able to use this parameter group, since it contains measured switch values.

Transmission Repetition	100 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	240	
PDU Specific:	13	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	61453	(0xF00D)

Start Position	Length	Parameter Name	SPN
1.1	4 bits	Blade Control Mode Switch	3156
1.5	4 bits	Desired Grade Offset Switch	3157
2.1	4 bits	Blade Auto Mode Command	3158

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PGN 64945 (R) After Treatment Intake Gas 2-b ***- ATI2-b***

The purpose of this PGN is to group the after treatment intake gas temperature messages for bank 2.

Transmission Repetition	500 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	177	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64945	(0xFDB1)

Start Position	Length	Parameter Name	SPN
1	2 bytes	Exhaust Gas Temperature 1 (bank 2)	3275
3	2 bytes	Particulate Trap Intake Gas Temperature (bank 2)	3276
5.1	5 bits	Exhaust Gas Temperature 1 Preliminary FMI (bank 2)	3277
6.1	5 bits	Particulate Trap Intake Gas Temperature Preliminary FMI (bank 2)	3278

PGN 64953 (R) Tire Pressure Reference Information ***- TPRI***

Information on actual tire pressure reference value for monitoring.

NOTE–Message has to repeated as necessary to transmit all available information. This method of location identification requires individual SPNs to be assigned to report failures specific to each individual component (I.e. each tire, each axle, etc.).

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	185	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64953	(0xFDB9)

Start Position	Length	Parameter Name	SPN
1	8 bits	Tire Location	3190
2	1 byte	Reference Tire Pressure	3191

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PGN 64954 (R) Farebox Status ***- TR6***

Used to report alarms of the fare collection unt.

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	186	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64954	(0xFDBA)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Farebox Emergency Status	3179
2.1	7 bits	Farebox Alarm Identifier	3181

PGN 64955 (R) Farebox Point of Sale ***- TR5***

Used to report stop level point of sale detail.

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	187	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64955	(0xFDBB)

Start Position	Length	Parameter Name	SPN
1.1	4 bits	Transaction Type	3170
1.5	4 bits	Passenger Type	3171
2.1	4 bits	Type of Fare	3176
2.5	4 bits	Payment Details	3177
3.1	4 bits	Fare Validity	3165
3.5	4 bits	Pass Category	3166
4.1	5 bits	Initial Fare Agency	3167
5.1	3 bits	Type of Service	3172
5.4	5 bits	Transfer Type	3173
6, 7.1	12 bits	Route Number	3169
8	1 byte	Transfer Sold	3168

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PGN 64956 (R) Farebox Service Detail - TR4

Used to identify service, assignments, and fare preset detail of the fare collection unit.

Transmission Repetition	On request	
Data Length:	15	
Data Page:	0	
PDU Format:	253	
PDU Specific:	188	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64956	(0xFDBC)

Start Position	Length	Parameter Name	SPN
01.1	2 bits	Farebox Service Status	3178
01.3	3 bits	Trip Status	3180
02.1	4 bits	Trip Direction	3174
03	8 bits	Fare Presets	3175
04-05	2 bytes	Trip Number	3159
06-07	2 bytes	Pattern Number	3161
08-09	2 bytes	Assigned Route	3160
10-11	2 bytes	Assigned Run	3162
12-13	2 bytes	Assigned Block	3163
14-15	2 bytes	Driver's farebox security code	3164

PGN 64957 (R) Signal Preemption - TR3

Status and configuration of the device used for intersection preemption.

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	189	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64957	(0xFDBD)

Start Position	Length	Parameter Name	SPN
1.3	2 bits	Range Code Enable	3081
1.5	2 bits	Transit Route ID Usage	3080
1.7	2 bits	Intersection Preemption Request/Response	3079
2.1	4 bits	Priority of Response Sent by Emitter	3084
2.5	2 bits	Transit Door Enable	3083
2.7	2 bits	Strobe Activation Control Status	3082
3,4	2 bytes	Vehicle ID	3085

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PGN 64958 (R) Transit Route - TR1

The current route assigned to this transit vehicle. The transit route information may be entered into different devices by different authorities (fare collection, radio log, unit control panel, etc.).

Transmission Repetition	On request		
Data Length:	variable		
Data Page:	0		
PDU Format:	253		
PDU Specific:	190	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	64958	(0xFDBE)	

Start Position	Length	Parameter Name	SPN
1	1 byte	Agency	3078
2	1 byte	Number of bytes in the Transit Assigned Route Identity	3071
3	1 byte	Number of bytes in the Transit Assigned Run Identity	3072
4	1 byte	Number of bytes in the Transit Assigned Block Identity	3073
5 to A	Variable - up to 100 characters	Transit Assigned Route Identity	3074
A+1 to B	Variable - up to 100 characters	Transit Assigned Run Identity	3075
B+1 to C	Variable - up to 100 characters	Transit Assigned Block Identity	3076

PGN 64959 (R) Transit Milepost - TR2

Identification of a transit route milepost

Transmission Repetition	On request		
Data Length:	variable		
Data Page:	0		
PDU Format:	253		
PDU Specific:	191	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	64959	(0xFDBF)	

Start Position	Length	Parameter Name	SPN
1	1 byte	Number of bytes in the Milepost Identification	3070
2 to n	Variable - up to 100 characters	Milepost Identification	509

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PGN 64960 (R) Passenger Counter - TR7

Used to notify the transit link devices of real-time boarding and exiting passengers or to indicate the total number of passengers on vehicle referenced to the last transit stop.

Also transmits information on the use status of the vehicle.

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	192	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64960	(0xFDC0)

Start Position	Length	Parameter Name	SPN
1	8 bits	Type of Passenger Count	3043
2	1 byte	Patron Count	3047
3.1	2 bits	Silent Alarm Status	3044
3.3	2 bits	Vehicle Use Status	3045
3.5	2 bits	Transit Run Status	3046

PGN 64961 (R) Engine Fluid Level/Pressure 3 - EFL/P3

Transmission Repetition	.5 sec	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	193	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64961	(0xFDC1)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Intake Valve Actuation System Oil Pressure	2948

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PGN 64964 (R) Electronic Brake Controller 5 - EBC5

Used for information on brake control.

Transmission Repetition	100 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	196	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64964	(0xFDC4)

Start Position	Length	Parameter Name	SPN
1.3	3 bits	Halt brake mode	2913
1.6	3 bits	Hill holder mode	2912
2.1	2 bits	Foundation Brake Use	2919
2.3	2 bits	XBR System State	2917
2.5	4 bits	XBR Active Control Mode	2918
3	1 byte	XBR Acceleration Limit	2921

PGN 64965 (R) ECU Identification Information - ECUID

Message for reporting identification and information about the physical ECU and its hardware, such as the ECU's part number, serial number, build date, etc. Information about the software within the ECU should be reported using the Software Identification PGN 65242 and/or DM19.

NOTE - The fields in this message are optional and separated by an ASCII "*". It is not necessary to include parametric data for all fields; however, the delimiter ("*") is always required. An ASCII "*" is required at the end of the last included field, even if there is only one ECU identification designator. Any additional ECU identification fields defined in the future will be appended at the end, each separated by an ASCII "*" as a delimiter.

Transmission Repetition	On request	
Data Length:	Variable	
Data Page:	0	
PDU Format:	253	
PDU Specific:	197	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64965	(0xFDC5)

Start Position	Length	Parameter Name	SPN
a	Variable - up to 200 characters ("*" delimited)	ECU Part Number	2901
b	Variable - up to 200 characters ("*" delimited)	ECU Serial Number	2902

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c	Variable - up to 200 characters ("*" delimited)	ECU Location	2903
d	Variable - up to 200 characters ("*" delimited)	ECU Type	2904

PGN 64966 (R) Cold Start Aids -

Cold start aid information and settings.

Transmission Repetition: As required
Data Length: 8
Data Page: 0
PDU Format: 253
PDU Specific: 198 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 64966 (0xFDC6)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Engine Start Enable Device 1	626
1.3	2 bits	Engine Start Enable Device 2	1804
2.1	4 bits	Engine Start Enable Device 1 Configuration	2899
2.5	4 bits	Engine Start Enable Device 2 Configuration	2898

PGN 64967 (R) Off-Highway Engine Control Selection States - OHCSS

Reports the states of off-highway engine control modes, as they apply to different modes of engine operation which may be used to aid particular working environments. These states provide the controls feedback for PGN 64971 which provides the operator inputs to the controller.

Transmission Repetition: 0.5 s
Data Length: 8
Data Page: 0
PDU Format: 253
PDU Specific: 199 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 64967 (0xFDC7)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Engine Auxiliary Governor State	2896
1.3	2 bits	Engine Multi-Unit Sync State	2890
1.5	2 bits	Engine Alternate Low Idle Select State	2891
2	8 bits	Engine Alternate Rating Select State	2888
3.1	4 bits	Engine Alternate Droop Accelerator 1 Select State	2889
3.5	4 bits	Engine Alternate Droop Accelerator 2 Select State	2893
4.1	4 bits	Engine Alternate Droop Remote Accelerator Select State	2894
4.5	4 bits	Engine Alternate Droop Auxiliary Input Select State	2895

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PGN 64968 (R) Operator Primary Intermediate Speed Control state - ISCS

The Operator Primary Intermediate Speed Control State is used to provide the controller feedback to indicate the controls state achieved.

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	200	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64968	(0xFDC8)

Start Position	Length	Parameter Name	SPN
1.1	4 bits	Engine Operator Primary Intermediate Speed Select State	2892

PGN 64969 (R) Electronic Control Module Information - CMI

Information relating to electronic control modules

Transmission Repetition	As required	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	201	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	64969	(0xFDC9)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Total Count of Configuration Changes Made	2887

PGN 64970 (R) Intermediate Speed Control - ISC

The Intermediate Speed Control is widely used in the Industrial application to control the engine to an intermediate speed setting which can bypass the accelerator position control. An example of this operation would be in an agricultural application where an external device is connected to an output shaft from the engine which must then be controlled to a constant speed. This is accomplished by activating a switch setting, thus eliminating the need for the operator to attempt to control this speed with the accelerator position.

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	202	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64970	(0xFDCA)

Start Position	Length	Parameter Name	SPN
1.1	4 bits	Engine Operator Primary Intermediate Speed Select	2880

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PGN 64971 (R) Off-Highway Engine Control Selection - OHECS

Allows for the selection of off-highway engine control modes, as they apply to different modes of engine operation which may be used to aid particular working environments. By offering characteristics suitable for the work in hand, the operator may select the desired mode (e.g. economy fuel ratings, droop settings, alternate idle points, multiple engine synchronization, etc.) to maximize performance under given conditions. The operator selects these inputs via hardwire switch operation, whereby an overall system control communicates the information to the engine controller.

Transmission Repetition	500 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	203	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64971	(0xFDCB)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Engine Auxiliary Governor Switch	2884
1.3	2 bits	Engine Synchronization Switch	1377
1.5	2 bits	Engine Alternate Low Idle Switch	2883
2	8 bits	Engine Alternate Rating Select	2882
3.1	4 bits	Engine Alternate Droop Accelerator 1 Select	2881
3.5	4 bits	Engine Alternate Droop Accelerator 2 Select	2879
4.1	4 bits	Engine Alternate Droop Remote Accelerator Select	2886
4.5	4 bits	Engine Alternate Droop Auxiliary Input Select	2885

PGN 64972 (R) Operators External Light Controls Message - OEL

The message containing the information about the position of the operator's external light control switch(s). Including switches for the Headlights, turn signals, hazard light, clearance lights, marker lights, etc.

Transmission Repetition	On change of switch. Maximum period of 1 second between messages. No greater than 10 messages per second for all switches.	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	204	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	64972	(0xFDCC)

Start Position	Length	Parameter Name	SPN
1.1	4 bits	Work Light Switch	2873
1.5	4 bits	Main Light Switch	2872
2.1	4 bits	Turn Signal Switch	2876
2.5	2 bits	Hazard Light Switch	2875
2.7	2 bits	High-Low Beam Switch	2874
3	1 byte	Operators Desired Back-light	2878
4-5	2 bytes	Operators Desired - Delayed Lamp Off Time	2877

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PGN 64973 (R) Operator Wiper and Washer Controls Message - OWW

Message for items related to the operators controls for the window wipers and washers on the front and rear cab windows

Transmission Repetition	200 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	205	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64973	(0xFDCD)

Start Position	Length	Parameter Name	SPN
1.1	4 bits	Front Non-operator Wiper Switch	2864
1.5	4 bits	Front Operator Wiper Switch	2863
2.5	4 bits	Rear Wiper Switch	2865
3	1 byte	Front Operator Wiper Delay Control	2869
4	1 byte	Front Non-operator Wiper Delay Control	2870
5	1 byte	Rear Wiper Delay Control	2871
6.3	3 bits	Front Non-operator Washer Switch	2867
6.6	3 bits	Front Operator Washer Switch	2866
7.6	3 bits	Rear Washer Function	2868

PGN 64976 (R) Inlet/Exhaust Conditions 2 - IC2

Inlet/Exhaust Conditions 2 is a second PGN conveying this type of engine information. Also see PGN 65270.

Transmission Repetition	0.5 s	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	208	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64976	(0xFDD0)

Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Air Filter 2 Differential Pressure	2809
2	1 byte	Engine Air Filter 3 Differential Pressure	2810
3	1 byte	Engine Air Filter 4 Differential Pressure	2811

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PGN 64977 FMS-standard Interface Identity/Capabilities - FMS

Information which specifies the capabilities of the Fleet Management System (FMS) - standard interface device. This PGN typically is sourced from the network interconnect FMS - standard interface device.

Transmission Repetition	10 s	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	209	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	64977	(0xFDD1)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	FMS-standard Diagnostics Supported	2804
1.3	2 bits	FMS-standard Requests Supported	2805
2-5	4 bytes	FMS-standard SW-version supported.	2806

PGN 64978 ECU Performance - EP

Message used to transfer ECU performance parameters.

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	210	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64978	(0xFDD2)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Keep-Alive Battery Consumption	2803
3	1 byte	Data Memory Usage	2802

PGN 64979 Turbocharger Information 6 - TCI6

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	211	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64979	(0xFDD3)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Turbocharger 1 Compressor Outlet Temperature	2629
3-4	2 bytes	Engine Turbocharger 2 Compressor Outlet Temperature	2799

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5-6	2 bytes	Engine Turbocharger 3 Compressor Outlet Temperature	2800
7-8	2 bytes	Engine Turbocharger 4 Compressor Outlet Temperature	2801

PGN 64980 Cab Message 3 - CM3

Provides information from Cab mounted operator inputs.

Transmission Repetition	On-change or every 10 s	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	212	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64980	(0xFDD4)

Start Position	Length	Parameter Name	SPN
1.1	3 bits	Transfer Case Selector Switch	2796

PGN 64981 Electronic Engine Controller 5 - EEC5

Engine related parameters

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	213	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	64981	(0xFDD5)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Turbocharger 1 Calculated Turbine Inlet Temperature	2789
3-4	2 bytes	Engine Turbocharger 1 Calculated Turbine Outlet Temperature	2790
5-6	2 bytes	Engine Exhaust Gas Recirculation (EGR) Valve Control	2791
7.1	2 bits	Engine Variable Geometry Turbocharger (VGT) Air Control Shutoff Valve	2792
8	1 byte	Engine Variable Geometry Turbocharger (VGT) 1 Actuator Position	2795

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PGN 64982 ***Basic Joystick Message 1*** ***- BJM1***

Used to transfer information about the measured status of the 1st 2 axes and up to 12 buttons of a joystick. Additional handle information is available in the Expanded Joystick Message.

10-bit position parameters are broadcast over 2 bytes. The eight most significant bits are transmitted in the second byte, with the most significant bit at bit 8. The two least significant bits are transmitted in the first byte in bit positions 7 and 8, with the most significant of the two bits at bit 8.

10-bit position SPN	Location in PGN	
Bit 10	Byte n	Bit 8
Bit 9		Bit 7
Bit 8		Bit 6
Bit 7		Bit 5
Bit 6		Bit 4
Bit 5		Bit 3
Bit 4		Bit 2
Bit 3		Bit 1
Bit 2	Byte (n-1)	Bit 8
Bit 1		Bit 7

Transmission Repetition	100 ms or on change, not to exceed 20 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	214	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	64982	(0xFDD6)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Joystick 1 X-Axis Neutral Position Status	2675
1.3	2 bits	Joystick 1 X-Axis Lever Left Negative Position Status	2670
1.5	2 bits	Joystick 1 X-Axis Lever Right Positive Position Status	2665
1.7-2	10 bits	Joystick 1 X-Axis Position	2660
3.1	2 bits	Joystick 1 Y-Axis Neutral Position Status	2676
3.3	2 bits	Joystick 1 Y-Axis Lever Back Negative Position Status	2671
3.5	2 bits	Joystick 1 Y-Axis Lever Forward Positive Position Status	2666
3.7-4	10 bits	Joystick 1 Y-Axis Position	2661
5.5	2 bits	Joystick 1 Y-Axis Detent Position Status	2681
5.7	2 bits	Joystick 1 X-Axis Detent Position Status	2680
6.1	2 bits	Joystick 1 Button 4 Pressed Status	2688
6.3	2 bits	Joystick 1 Button 3 Pressed Status	2687
6.5	2 bits	Joystick 1 Button 2 Pressed Status	2686
6.7	2 bits	Joystick 1 Button 1 Pressed Status	2685
7.1	2 bits	Joystick 1 Button 8 Pressed Status	2692
7.3	2 bits	Joystick 1 Button 7 Pressed Status	2691
7.5	2 bits	Joystick 1 Button 6 Pressed Status	2690
7.7	2 bits	Joystick 1 Button 5 Pressed Status	2689
8.1	2 bits	Joystick 1 Button 12 Pressed Status	2696
8.3	2 bits	Joystick 1 Button 11 Pressed Status	2695
8.5	2 bits	Joystick 1 Button 10 Pressed Status	2694
8.7	2 bits	Joystick 1 Button 9 Pressed Status	2693

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PGN 64983 Extended Joystick Message 1 - EJM1

Used to transfer information about the measured status of three additional axes of a joystick and switches of the joystick grip or handle. The joystick axial motion information is available in the Basic Joystick Message.

10-bit position parameters are broadcast over 2 bytes. The eight most significant bits are transmitted in the second byte, with the most significant bit at bit 8. The two least significant bits are transmitted in the first byte in bit positions 7 and 8, with the most significant of the two bits at bit 8.

10-bit position SPN	Location in PGN	
Bit 10	Byte n	Bit 8
Bit 9		Bit 7
Bit 8		Bit 6
Bit 7		Bit 5
Bit 6		Bit 4
Bit 5		Bit 3
Bit 4		Bit 2
Bit 3		Bit 1
Bit 2	Byte (n-1)	Bit 8
Bit 1		Bit 7

Note: The term Grip used here simply refers to another set of axes separate from the previously mentioned X and Y Axis.

This additional set of axes could in some cases be grip mounted sensors as opposed to the sensors mounted at the base of the handle.

Transmission Repetition	100 ms or on change, not to exceed 20 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	215	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	64983	(0xFDD7)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Joystick 1 Grip X-Axis Neutral Position Status	2677
1.3	2 bits	Joystick 1 Grip X-Axis Lever Left Negative Position Status	2672
1.5	2 bits	Joystick 1 Grip X-Axis Lever Right Positive Position Status	2667
1.7-2	10 bits	Joystick 1 Grip X-Axis Position	2662
3.1	2 bits	Joystick 1 Grip Y-Axis Neutral Position Status	2678
3.3	2 bits	Joystick 1 Grip Y-Axis Lever Back Negative Position Status	2673
3.5	2 bits	Joystick 1 Grip Y-Axis Lever Forward Positive Position Status	2668
3.7-4	10 bits	Joystick 1 Grip Y-Axis Position	2663
5.1	2 bits	Joystick 1 Theta-Axis Neutral Position Status	2679
5.3	2 bits	Joystick 1 Theta-Axis Counter Clockwise Negative Position Status	2674
5.5	2 bits	Joystick 1 Theta-Axis Clockwise Positive Position Status	2669
5.7-6	10 bits	Joystick 1 Theta-Axis Position	2664
7.3	2 bits	Joystick 1 Theta-Axis Detent Position Status	2684
7.5	2 bits	Joystick 1 Grip Y-Axis Detent Position Status	2683
7.7	2 bits	Joystick 1 Grip X-Axis Detent Position Status	2682

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PGN 64984 ***Basic Joystick Message 2*** ***- BJM2***

Used to transfer information about the measured status of the 1st 2 axes and up to 12 buttons of a joystick. Additional handle information is available in the Expanded Joystick Message.

10-bit position parameters are broadcast over 2 bytes. The eight most significant bits are transmitted in the second byte, with the most significant bit at bit 8. The two least significant bits are transmitted in the first byte in bit positions 7 and 8, with the most significant of the two bits at bit 8.

10-bit position SPN	Location in PGN	
Bit 10	Byte n	Bit 8
Bit 9		Bit 7
Bit 8		Bit 6
Bit 7		Bit 5
Bit 6		Bit 4
Bit 5		Bit 3
Bit 4		Bit 2
Bit 3		Bit 1
Bit 2	Byte (n-1)	Bit 8
Bit 1		Bit 7

Transmission Repetition	100 ms or on change, not to exceed 20 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	216	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	64984	(0xFDD8)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Joystick 2 X-Axis Neutral Position Status	2712
1.3	2 bits	Joystick 2 X-Axis Lever Left Negative Position Status	2707
1.5	2 bits	Joystick 2 X-Axis Lever Right Positive Position Status	2702
1.7-2	10 bits	Joystick 2 X-Axis Position	2697
3.1	2 bits	Joystick 2 Y-Axis Neutral Position Status	2713
3.3	2 bits	Joystick 2 Y-Axis Lever Back Negative Position Status	2708
3.5	2 bits	Joystick 2 Y-Axis Lever Forward Positive Position Status	2703
3.7-4	10 bits	Joystick 2 Y-Axis Position	2698
5.5	2 bits	Joystick 2 Y-Axis Detent Position Status	2718
5.7	2 bits	Joystick 2 X-Axis Detent Position Status	2717
6.1	2 bits	Joystick 2 Button 4 Pressed Status	2725
6.3	2 bits	Joystick 2 Button 3 Pressed Status	2724
6.5	2 bits	Joystick 2 Button 2 Pressed Status	2723
6.7	2 bits	Joystick 2 Button 1 Pressed Status	2722
7.1	2 bits	Joystick 2 Button 8 Pressed Status	2729
7.3	2 bits	Joystick 2 Button 7 Pressed Status	2728
7.5	2 bits	Joystick 2 Button 6 Pressed Status	2727
7.7	2 bits	Joystick 2 Button 5 Pressed Status	2726
8.1	2 bits	Joystick 2 Button 12 Pressed Status	2733
8.3	2 bits	Joystick 2 Button 11 Pressed Status	2732
8.5	2 bits	Joystick 2 Button 10 Pressed Status	2731
8.7	2 bits	Joystick 2 Button 9 Pressed Status	2730

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PGN 64985 Extended Joystick Message 2 - EJM2

Used to transfer information about the measured status of three additional axes of a joystick and switches of the joystick grip or handle. The joystick axial motion information is available in the Basic Joystick Message.

10-bit position parameters are broadcast over 2 bytes. The eight most significant bits are transmitted in the second byte, with the most significant bit at bit 8. The two least significant bits are transmitted in the first byte in bit positions 7 and 8, with the most significant of the two bits at bit 8.

10-bit position SPN	Location in PGN	
Bit 10	Byte n	Bit 8
Bit 9		Bit 7
Bit 8		Bit 6
Bit 7		Bit 5
Bit 6		Bit 4
Bit 5		Bit 3
Bit 4		Bit 2
Bit 3		Bit 1
Bit 2	Byte (n-1)	Bit 8
Bit 1		Bit 7

Note: The term Grip used here simply refers to another set of axes separate from the previously mentioned X and Y Axis.

This additional set of axes could in some cases be grip mounted sensors as opposed to the sensors mounted at the base of the handle.

Transmission Repetition	100 ms or on change, not to exceed 20 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	217	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	64985	(0xFDD9)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Joystick 2 Grip X-Axis Neutral Position Status	2714
1.3	2 bits	Joystick 2 Grip X-Axis Lever Left Negative Position Status	2709
1.5	2 bits	Joystick 2 Grip X-Axis Lever Right Positive Position Status	2704
1.7-2	10 bits	Joystick 2 Grip X-Axis Position	2699
3.1	2 bits	Joystick 2 Grip Y-Axis Neutral Position Status	2715
3.3	2 bits	Joystick 2 Grip Y-Axis Lever Back Negative Position Status	2710
3.5	2 bits	Joystick 2 Grip Y-Axis Lever Forward Positive Position Status	2705
3.7-4	10 bits	Joystick 2 Grip Y-Axis Position	2700
5.1	2 bits	Joystick 2 Theta-Axis Neutral Position Status	2716
5.3	2 bits	Joystick 2 Theta-Axis Counter Clockwise Negative Position Status	2711
5.5	2 bits	Joystick 2 Theta-Axis Clockwise Positive Position Status	2706
5.7-6	10 bits	Joystick 2 Theta-Axis Position	2701
7.3	2 bits	Joystick 2 Theta-Axis Detent Position Status	2721
7.5	2 bits	Joystick 2 Grip Y-Axis Detent Position Status	2720
7.7	2 bits	Joystick 2 Grip X-Axis Detent Position Status	2719

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PGN 64986 ***Basic Joystick Message 3*** ***- BJM3***

Used to transfer information about the measured status of the 1st 2 axes and up to 12 buttons of a joystick. Additional handle information is available in the Expanded Joystick Message.

10-bit position parameters are broadcast over 2 bytes. The eight most significant bits are transmitted in the second byte, with the most significant bit at bit 8. The two least significant bits are transmitted in the first byte in bit positions 7 and 8, with the most significant of the two bits at bit 8.

10-bit position SPN	Location in PGN	
Bit 10	Byte n	Bit 8
Bit 9		Bit 7
Bit 8		Bit 6
Bit 7		Bit 5
Bit 6		Bit 4
Bit 5		Bit 3
Bit 4		Bit 2
Bit 3		Bit 1
Bit 2	Byte (n-1)	Bit 8
Bit 1		Bit 7

Transmission Repetition	100 ms or on change, not to exceed 20 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	218	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	64986	(0xFDDA)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Joystick 3 X-Axis Neutral Position Status	2749
1.3	2 bits	Joystick 3 X-Axis Lever Left Negative Position Status	2744
1.5	2 bits	Joystick 3 X-Axis Lever Right Positive Position Status	2739
1.7-2	10 bits	Joystick 3 X-Axis Position	2734
3.1	2 bits	Joystick 3 Y-Axis Neutral Position Status	2750
3.3	2 bits	Joystick 3 Y-Axis Lever Back Negative Position Status	2745
3.5	2 bits	Joystick 3 Y-Axis Lever Forward Positive Position Status	2740
3.7-4	10 bits	Joystick 3 Y-Axis Position	2735
5.5	2 bits	Joystick 3 Y-Axis Detent Position Status	2755
5.7	2 bits	Joystick 3 X-Axis Detent Position Status	2754
6.1	2 bits	Joystick 3 Button 4 Pressed Status	2762
6.3	2 bits	Joystick 3 Button 3 Pressed Status	2761
6.5	2 bits	Joystick 3 Button 2 Pressed Status	2760
6.7	2 bits	Joystick 3 Button 1 Pressed Status	2759
7.1	2 bits	Joystick 3 Button 8 Pressed Status	2766
7.3	2 bits	Joystick 3 Button 7 Pressed Status	2765
7.5	2 bits	Joystick 3 Button 6 Pressed Status	2764
7.7	2 bits	Joystick 3 Button 5 Pressed Status	2763
8.1	2 bits	Joystick 3 Button 12 Pressed Status	2770
8.3	2 bits	Joystick 3 Button 11 Pressed Status	2769
8.5	2 bits	Joystick 3 Button 10 Pressed Status	2768
8.7	2 bits	Joystick 3 Button 9 Pressed Status	2767

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PGN 64987 Extended Joystick Message 3 - EJM3

Used to transfer information about the measured status of three additional axes of a joystick and switches of the joystick grip or handle. The joystick axial motion information is available in the Basic Joystick Message.

10-bit position parameters are broadcast over 2 bytes. The eight most significant bits are transmitted in the second byte, with the most significant bit at bit 8. The two least significant bits are transmitted in the first byte in bit positions 7 and 8, with the most significant of the two bits at bit 8.

10-bit position SPN	Location in PGN	
Bit 10	Byte n	Bit 8
Bit 9		Bit 7
Bit 8		Bit 6
Bit 7		Bit 5
Bit 6		Bit 4
Bit 5		Bit 3
Bit 4		Bit 2
Bit 3		Bit 1
Bit 2	Byte (n-1)	Bit 8
Bit 1		Bit 7

Note: The term Grip used here simply refers to another set of axes separate from the previously mentioned X and Y Axis.

This additional set of axes could in some cases be grip mounted sensors as opposed to the sensors mounted at the base of the handle.

Transmission Repetition	100 ms or on change, not to exceed 20 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	253	
PDU Specific:	219	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	64987	(0xFDDB)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Joystick 3 Grip X-Axis Neutral Position Status	2751
1.3	2 bits	Joystick 3 Grip X-Axis Lever Left Negative Position Status	2746
1.5	2 bits	Joystick 3 Grip X-Axis Lever Right Positive Position Status	2741
1.7-2	10 bits	Joystick 3 Grip X-Axis Position	2736
3.1	2 bits	Joystick 3 Grip Y-Axis Neutral Position Status	2752
3.3	2 bits	Joystick 3 Grip Y-Axis Lever Back Negative Position Status	2747
3.5	2 bits	Joystick 3 Grip Y-Axis Lever Forward Positive Position Status	2742
3.7-4	10 bits	Joystick 3 Grip Y-Axis Position	2737
5.1	2 bits	Joystick 3 Theta-Axis Neutral Position Status	2753
5.3	2 bits	Joystick 3 Theta-Axis Counter Clockwise Negative Position Status	2748
5.5	2 bits	Joystick 3 Theta-Axis Clockwise Positive Position Status	2743
5.7-6	10 bits	Joystick 3 Theta-Axis Position	2738
7.3	2 bits	Joystick 3 Theta-Axis Detent Position Status	2758
7.5	2 bits	Joystick 3 Grip Y-Axis Detent Position Status	2757
7.7	2 bits	Joystick 3 Grip X-Axis Detent Position Status	2756

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PGN 64988 Marine Control Information - MCI

This messages contains marine vessel control information for the engine

Transmission Repetition	1 s		
Data Length:	8		
Data Page:	0		
PDU Format:	253		
PDU Specific:	220	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	64988	(0xFDDC)	

Start Position	Length	Parameter Name	SPN
1.1	4 bits	Engine Throttle Synchronization Mode Status	2615
1.5	2 bits	Trolling Mode Status	2616
1.7	2 bits	Slow Vessel Mode Status	2617

PGN 64991 Front Wheel Drive Status - FWD

Front wheel drive ECU information

Transmission Repetition	0.5 s		
Data Length:	8		
Data Page:	0		
PDU Format:	253		
PDU Specific:	223	PGN Supporting Information:	
Default Priority:	7		
Parameter Group Number:	64991	(0xFDDF)	

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Front Wheel Drive Actuator Status	2612

PGN 64992 Ambient Conditions 2 - AMB2

This message contains measurement and configuration information about the vehicle ambient conditions.

Transmission Repetition	1 s		
Data Length:	8		
Data Page:	0		
PDU Format:	253		
PDU Specific:	224	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	64992	(0xFDE0)	

Start Position	Length	Parameter Name	SPN
1	1 byte	Solar Intensity Percent	2610
2	1 byte	Solar Sensor Maximum	2611

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PGN 64993 Cab A/C Climate System Information - CACI

This message contains measurement and condition information from cab air conditioning components.

Transmission Repetition: 1 s
Data Length: 8
Data Page: 0
PDU Format: 253
PDU Specific: 225 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 64993 (0xFDE1)

Start Position	Length	Parameter Name	SPN
1	1 byte	Cab A/C Refrigerant Compressor Outlet Pressure	2609

PGN 64994 Supply Pressure Demand - SPR

Used for controlling the supply pressure. Often used to raise the pressure of a supply pressure circuit in situations where more pneumatic energy is needed.

This message is the setpoint for the PGN 65198 message.

Transmission Repetition: 1 s, when active
Data Length: 8
Data Page: 0
PDU Format: 253
PDU Specific: 226 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 64994 (0xFDE2)

Start Position	Length	Parameter Name	SPN
1	1 byte	Pneumatic Supply Pressure Request	2603
2	1 byte	Parking and/or Trailer Air Pressure Request	2604
3	1 byte	Service Brake Air Pressure Request, Circuit #1	2605
4	1 byte	Service Brake Air Pressure Request, Circuit #2	2606
5	1 byte	Auxiliary Equipment Supply Pressure Request	2607
6	1 byte	Air Suspension Supply Pressure Request	2608

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PGN 64995 ***Equipment Operation and Control*** ***- EOAC***

Parameters related to the operation and controls for equipment

Transmission Repetition 250 mS
Data Length: 8
Data Page: 0
PDU Format: 253
PDU Specific: 227 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 64995 (0xFDE3)

Start Position	Length	Parameter Name	SPN
1	1 byte	Travel Velocity Control Position	2601

PGN 64996 ***Equipment Performance Data*** ***- EPD***

Parameters related to the performance characteristics of equipment

Transmission Repetition 500 mS
Data Length: 8
Data Page: 0
PDU Format: 253
PDU Specific: 228 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 64996 (0xFDE4)

Start Position	Length	Parameter Name	SPN
1	1 byte	Payload Percentage	2600

PGN 64997 ***Maximum Vehicle Speed Limit Status*** ***- MVS***

Reports the possible maximum vehicle speed limits, one through seven, and the applied maximum vehicle speed limit.

Transmission Repetition 1 s
Data Length: 8
Data Page: 0
PDU Format: 253
PDU Specific: 229 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 64997 (0xFDE5)

Start Position	Length	Parameter Name	SPN
1	1 byte	Maximum Vehicle Speed Limit 1	2588
2	1 byte	Maximum Vehicle Speed Limit 2	2589
3	1 byte	Maximum Vehicle Speed Limit 3	2590
4	1 byte	Maximum Vehicle Speed Limit 4	2591
5	1 byte	Maximum Vehicle Speed Limit 5	2592
6	1 byte	Maximum Vehicle Speed Limit 6	2593

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7	1 byte	Maximum Vehicle Speed Limit 7	2594
8	1 byte	Applied Vehicle Speed Limit	2595

PGN 64998 Hydraulic Braking System - HBS

Used for information on a hydraulic brake system

As an example: this PGN may be used for a two circuit hydraulic brake system with separate circuits for front and rear axle. The hydraulic energy is supplied via two independent electrically driven pumps. The energy is stored in gas filled hydraulic accumulators also separated for each circuit.

Transmission Repetition: 100 ms
Data Length: 8
Data Page: 0
PDU Format: 253
PDU Specific: 230 PGN Supporting Information:
Default Priority: 3
Parameter Group Number: 64998 (0xFDE6)

Start Position	Length	Parameter Name	SPN
1	1 byte	Hydraulic Brake Pressure Circuit 1	2580
2	1 byte	Hydraulic Brake Pressure Circuit 2	2581
3.1	2 bits	Hydraulic Brake Pressure Warning State Circuit 1	2584
3.3	2 bits	Hydraulic Brake Pressure Warning State Circuit 2	2585
3.5	2 bits	Hydraulic Brake Pressure Supply State Circuit 1	2582
3.7	2 bits	Hydraulic Brake Pressure Supply State Circuit 2	2583
4.1	2 bits	Hydraulic Brake System Audible Warning Command	2930
4.3	2 bits	Hydraulic Brake Fluid Level Switch	2931

PGN 65031 Exhaust Temperature - ET

Transmission Repetition: 0.5 s
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 7 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65031 (0xFE07)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Exhaust Exhaust Gas Temperature - Right Manifold	2433
3-4	2 bytes	Engine Exhaust Exhaust Gas Temperature - Left Manifold	2434

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PGN 65088 ***Lighting Data*** ***- LD***

This lighting message is a response to the request for lighting data in the lighting command message. Each lighting controller on the tractor and attached implements must transmit this message to the Tractor ECU when requested. The tractor will use this information to determine which lighting systems are functioning. Lighting controllers that have lamp sensing capability will also report failed light bulbs. This is a legal requirement in many areas.

See PGN 65089 for the lighting command message.

Transmission Repetition	As requested.	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	64	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65088	(0xFE40)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Running Light	2404
1.3	2 bits	Alternate Beam Head Light Data	2352
1.5	2 bits	Low Beam Head Light Data	2350
1.7	2 bits	High Beam Head Light Data	2348
2.1	2 bits	Tractor Front Fog Lights	2388
2.3	2 bits	Rotating Beacon Light	2386
2.5	2 bits	Right Turn Signal Lights	2370
2.7	2 bits	Left Turn Signal Lights	2368
3.1	2 bits	Back Up Light and Alarm Horn	2392
3.3	2 bits	Center Stop Light	2376
3.5	2 bits	Right Stop Light	2374
3.7	2 bits	Left Stop Light	2372
4.1	2 bits	Implement Clearance Light	2384
4.3	2 bits	Tractor Clearance Light	2382
4.5	2 bits	Implement Marker Light	2380
4.7	2 bits	Tractor Marker Light	2378
5.1	2 bits	Rear Fog Lights	2390
5.3	2 bits	Tractor Underside Mounted Work Lights	2358
5.5	2 bits	Tractor Rear Low Mounted Work Lights	2360
5.7	2 bits	Tractor Rear High Mounted Work Lights	2362
6.1	2 bits	Tractor Side Low Mounted Work Lights	2364
6.3	2 bits	Tractor Side High Mounted Work Lights	2366
6.5	2 bits	Tractor Front Low Mounted Work Lights	2354
6.7	2 bits	Tractor Front High Mounted Work Lights	2356
7.1	2 bits	Implement OEM Option 2 Light	2398
7.3	2 bits	Implement OEM Option 1 Light	2396
7.5	2 bits	Implement Right Facing Work Light	2407
7.7	2 bits	Implement Left Facing Work Light	2598
8.3	2 bits	Implement Right Forward Work Light	2402
8.5	2 bits	Implement Left Forward Work Light	2400
8.7	2 bits	Implement Rear Work Light	2394

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PGN 65089 Lighting Command - LC

The lighting command message has been defined as a global message from the tractor to all lighting controllers on the tractor and attached implements. Separate messages are provided for tractor and implement work and driving lights. Additional commands have been provided for 3 optional lights on implements to meet the needs of speciality equipment. Common marking and signaling messages are provided.
This message is used to control the state of all lighting functions. The lighting command message shall be sent on each change of state of a lamp. The state values indicate the lights is to be turned ON or OFF. Flashing is accomplished by sending the lighting message with the state alternately ON or OFF. A lighting command message must be sent at least once per second. It is the responsibility of the tractor designer to provide the correct combination of lamp commands to meet local legislative directives.

See PGN 65088 for the message to provide feedback for this command message.

Transmission Repetition	On change of lamp on/ off state. Maximum period of 1 second between messages. No greater than 10 messages per second for all lights.
Data Length:	8
Data Page:	0
PDU Format:	254
PDU Specific:	65 PGN Supporting Information:
Default Priority:	3
Parameter Group Number:	65089 (0xFE41)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Running Light Command	2403
1.3	2 bits	Alternate Beam Head Light Command	2351
1.5	2 bits	Low Beam Head Light Command	2349
1.7	2 bits	High Beam Head Light Command	2347
2.1	2 bits	Tractor Front Fog Lights Command	2387
2.3	2 bits	Rotating Beacon Light Command	2385
2.5	2 bits	Right Turn Signal Lights Command	2369
2.7	2 bits	Left Turn Signal Lights Command	2367
3.1	2 bits	Back Up Light and Alarm Horn Command	2391
3.3	2 bits	Center Stop Light Command	2375
3.5	2 bits	Right Stop Light Command	2373
3.7	2 bits	Left Stop Light Command	2371
4.1	2 bits	Implement Clearance Light Command	2383
4.3	2 bits	Tractor Clearance Light Command	2381
4.5	2 bits	Implement Marker Light Command	2379
4.7	2 bits	Tractor Marker Light Command	2377
5.1	2 bits	Rear Fog Light Command	2389
5.3	2 bits	Tractor Underside Mounted Work Lights Command	2357
5.5	2 bits	Tractor Rear Low Mounted Work Lights Command	2359
5.7	2 bits	Tractor Rear High Mounted Work Lights Command	2361
6.1	2 bits	Tractor Side Low Mounted Work Lights Command	2363
6.3	2 bits	Tractor Side High Mounted Work Lights Command	2365
6.5	2 bits	Tractor Front Low Mounted Work Lights Command	2353
6.7	2 bits	Tractor Front High Mounted Work Lights Command	2355
7.1	2 bits	Implement OEM Option 2 Light Command	2397
7.3	2 bits	Implement OEM Option 1 Light Command	2395

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7.5	2 bits	Implement Right Facing Work Light Command	2406
7.7	2 bits	Implement Left Facing Work Light Command	2597
8.1	2 bits	Lighting Data Request Command	2393
8.3	2 bits	Implement Right Forward Work Light Command	2401
8.5	2 bits	Implement Left Forward Work Light Command	2399
8.7	2 bits	Implement Rear Work Light Command	2405

PGN 65098 (R) Electronic Transmission Controller 7 - ETC7

Transmission status information from the transmission controller to network.

Transmission Repetition: 100 ms
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 74 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65098 (0xFE4A)

Start Position	Length	Parameter Name	SPN
1.5	2 bits	Transmission Requested Range Display Blank State	1850
1.7	2 bits	Transmission Requested Range Display Flash State	1849
2.1	2 bits	Transmission Ready for Brake Release	3086
2.3	2 bits	Active Shift Console Indicator	2945
2.5	2 bits	Transmission Engine Crank Enable	2900
2.7	2 bits	Transmission Shift Inhibit Indicator	1851
3.1	2 bits	Transmission Mode 4 Indicator	2539
3.3	2 bits	Transmission Mode 3 Indicator	2538
3.5	2 bits	Transmission Mode 2 Indicator	2537
3.7	2 bits	Transmission Mode 1 Indicator	2536
4	1 byte	Transmission Requested Gear Feedback	3289

PGN 65099 Transmission Configuration 2 - TCFG2

Contains transmission configuration information.

Transmission Repetition: On request or sender may transmit every 5 seconds until acknowlegded by reception of the engine configuration message PGN 65251 SPN 1846.
Data Length: Variable
Data Page: 0
PDU Format: 254
PDU Specific: 75 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65099 (0xFE4B)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Transmission Torque Limit	1845

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PGN 65100 Military Lighting Command - ML

The message contains parameters that control military specific lights.

Transmission Repetition: 500ms or upon state change, but not faster than 100 ms.
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 76 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65100 (0xFE4C)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Rear Black Out Marker Select	1840
1.3	2 bits	Front Black Out Marker Lamp Select	1839
1.5	2 bits	Convoy Lamp Select	1838
1.7	2 bits	Convoy Driving Lamp Select	1837
3.7	2 bits	Black Out Brake/Stop Lamp Select	1841
4.1	2 bits	Night Vision Illuminator Select	1843
4.7	2 bits	Black Out Work Lamp Select	1842
8	1 byte	Operators Black Out Intensity Selection	1844

PGN 65101 Total Averaged Information - TAVG

Averages of information accumulated over the life of the engine

Transmission Repetition: On request
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 77 PGN Supporting Information:
Default Priority: 7
Parameter Group Number: 65101 (0xFE4D)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Total Average Fuel Rate	1834
3-4	2 bytes	Engine Total Average Fuel Economy	1835

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PGN 65102 ***Door Control*** ***- DC***

Used for door information.

Transmission Repetition	100 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	78	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65102	(0xFE4E)

Start Position	Length	Parameter Name	SPN
1.1	4 bits	Position of doors	1821
1.5	2 bits	Ramp / Wheel Chair Lift Position	1820

PGN 65103 ***Vehicle Dynamic Stability Control 1*** ***- VDC1***

Contains information which relates to the VDC system status.

Transmission Repetition	100ms	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	79	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65103	(0xFE4F)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	VDC Information Signal	1813
1.3	2 bits	VDC Fully Operational	1814
1.5	2 bits	VDC brake light request	1815
2.1	2 bits	ROP Engine Control active	1816
2.3	2 bits	ROP Brake Control active	1818
2.5	2 bits	YC Engine Control active	1817
2.7	2 bits	YC Brake Control active	1819

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PGN 65104 Battery Temperature - BT1

Contains battery temperature information.

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	80	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65104	(0xFE50)

Start Position	Length	Parameter Name	SPN
1	1 byte	Battery 1 Temperature	1800
2	1 byte	Battery 2 Temperature	1801

PGN 65105 Adaptive Cruise Control, Operator Input - ACC2

The operator requested characteristics for the ACC systems operation.

Transmission Repetition	250 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	81	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65105	(0xFE51)

Start Position	Length	Parameter Name	SPN
1.6	3 bits	Requested ACC Distance Mode	1799

PGN 65106 Vehicle Electrical Power 3 - VP3

This contains high resolution/range parameters reported from the allternator or power generation components.

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	82	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65106	(0xFE52)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Alternator Current (High Range/Resolution)	1795
3-4	2 bytes	Net Battery Current (High Range/Resolution)	2579

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PGN 65107 ***Retarder Continuous Torque & Speed Limit*** ***- RTC1***

Transmission Repetition	5 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	83	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65107	(0xFE53)

Start Position	Length	Parameter Name	SPN
1	1 byte	Low Limit Threshhold for Maximum RPM from Retarder	1776
2	1 byte	High Limit Threshhold for Minimum Continuous RPM from Retarder	1777
3	1 byte	Low Limit Threshhold for Maximum Torque from Retarder	1778
4	1 byte	High Limit Threshhold for Minimum Continuous Torque from Retarder	1779
5	1 byte	Maximum Continuous Retarder Speed	1780
6	1 byte	Minimum Continuous Retarder Speed	1781
7	1 byte	Maximum Continuous Retarder Torque	1782
8	1 byte	Minimum Continuous Retarder Torque	1783

PGN 65108 ***Engine Continuous Torque & Speed Limit*** ***- ECT1***

Transmission Repetition	5 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	84	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65108	(0xFE54)

Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Low Limit Threshhold for Maximum RPM from Engine	1768
2	1 byte	Engine High Limit Threshhold for Minimum Continuous Engine RPM	1769
3	1 byte	Engine Low Limit Threshold for Maximum Torque from Engine	1770
4	1 byte	Engine High Limit Threshhold for Minimum Continuous Torque from Engine	1771
5	1 byte	Engine Maximum Continuous RPM	1772
6	1 byte	Engine Minimum Continuous RPM	1773
7	1 byte	Engine Maximum Continuous Torque	1774
8	1 byte	Engine Minimum Continuous Torque	1775

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PGN 65109 Gaseous Fuel Properties - GFD

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	85	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65109	(0xFE55)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Specific Heat Ratio	1767

PGN 65110 Tank Information 1 - TI1

Contains information on various tank levels

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	86	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65110	(0xFE56)

Start Position	Length	Parameter Name	SPN
1	1 byte	Catalyst Tank Level	1761
2	1 byte	Catalyst Tank Temperature	3031

PGN 65111 Air Suspension Control 5 - ASC5

Used for damper stiffness information

Transmission Repetition	100 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	87	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	65111	(0xFE57)

Start Position	Length	Parameter Name	SPN
1	1 byte	Damper Stiffness Front Axle	1729
2	1 byte	Damper Stiffness Rear Axle	1730
3	1 byte	Damper Stiffness Lift / Tag Axle	1731
4.1	2 bits	Electronic Shock Absorber Control Mode - Front Axle	1833
4.3	2 bits	Electronic Shock Absorber Control Mode - Rear Axle	1832
4.5	2 bits	Electronic Shock Absorber Control Mode - Lift/Tag Axle	1831

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PGN 65112 ***Air Suspension Control 4*** ***- ASC4***

Used for bellow pressure information

Transmission Repetition	100 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	88	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65112	(0xFE58)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Bellow Pressure Front Axle Left	1725
3-4	2 bytes	Bellow Pressure Front Axle Right	1726
5-6	2 bytes	Bellow Pressure Rear Axle Left	1727
7-8	2 bytes	Bellow Pressure Rear Axle Right	1728

PGN 65113 ***Air Suspension Control 3*** ***- ASC3***

Used for height information

Transmission Repetition	100 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	89	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65113	(0xFE59)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Relative Level Front Axle Left	1721
3-4	2 bytes	Relative Level Front Axle Right	1722
5-6	2 bytes	Relative Level Rear Axle Left	1724
7-8	2 bytes	Relative Level Rear Axle Right	1723

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PGN 65114 ***Air Suspension Control 1*** ***- ASC1***

Used for suspension control control information

Transmission Repetition	100 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	90	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	65114	(0xFE5A)

Start Position	Length	Parameter Name	SPN
1.1	4 bits	Nominal Level Front Axle	1734
1.5	4 bits	Nominal Level Rear Axle	1733
2.1	2 bits	Below Nominal Level Front Axle	1738
2.3	2 bits	Below Nominal Level Rear Axle	1754
2.5	2 bits	Above Nominal Level Front Axle	1737
2.7	2 bits	Above Nominal Level Rear Axle	1736
3.1	2 bits	Lowering Control Mode Front Axle	1740
3.3	2 bits	Lowering Control Mode Rear Axle	1755
3.5	2 bits	Lifting Control Mode Front Axle	1739
3.7	2 bits	Lifting Control Mode Rear Axle	1756
4.1	4 bits	Kneeling Information	1742
4.5	4 bits	Level Control Mode	1741
5.1	2 bits	Security Device	1746
5.3	2 bits	Vehicle Motion Inhibit	1745
5.5	2 bits	Door Release	1744
5.7	2 bits	Lift Axle 1 Position	1743
6.1	2 bits	Front Axle in Bumper Range	1824
6.3	2 bits	Rear Axle in Bumper Range	1823
6.7	2 bits	Lift Axle 2 Position	1822
7.1	2 bits	Suspension Remote Control 1	1826
7.3	2 bits	Suspension Remote control 2	1825
8.1	4 bits	Suspension Control Refusal Information	1827

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PGN 65115 ***Forward Lane Image*** ***- FLI2***

Transmission Repetition	100 ms		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	91	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65115	(0xFE5B)	

Start Position	Length	Parameter Name	SPN
1.3	2 bits	Lane Tracking Status Right Side	1711
1.5	2 bits	Lane Tracking Status Left Side	1710
1.7	2 bits	Lane Departure Indication Enable Status	1702

PGN 65126 ***Battery Main Switch Information*** ***- BM***

Transmission Repetition	1 s		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	102	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65126	(0xFE66)	

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Battery Main Switch Hold State	1681

PGN 65127 ***Climate Control Configuration*** ***- CCC***

Transmission Repetition	On request		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	103	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65127	(0xFE67)	

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Auxiliary Heater Maximum Output Power	1690

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PGN 65128 Vehicle Fluids - VF

Transmission Repetition: 1 s
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 104 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65128 (0xFE68)

Start Position	Length	Parameter Name	SPN
1	1 byte	Hydraulic Temperature	1638
2.1	2 bits	Hydraulic Oil Filter Restriction Switch	1713
2.3	2 bits	Winch Oil Pressure Switch	1857
3	1 byte	Hydraulic Oil Level	2602

PGN 65129 (R) Engine Temperature 3 - ET3

This parameter group is used to transit high resolution engine temperatures for control purposes.

Transmission Repetition: 1 s
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 105 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65129 (0xFE69)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Intake Manifold 1 Air Temperature (High Resolution)	1636
3-4	2 bytes	Engine Coolant Temperature (High Resolution)	1637
5-6	2 bytes	Engine Intake Valve Actuation System Oil Temperature	2986

PGN 65130 Engine Fuel/lube systems - EFS

Transmission Repetition: 0.5 s
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 106 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65130 (0xFE6A)

Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Oil Level Remote Reservoir	1380

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2	1 byte	Engine Fuel Supply Pump Inlet Pressure	1381
3	1 byte	Engine Fuel Filter (suction side) Differential Pressure	1382

PGN 65131 Driver's Identification - DI

Field:
a Driver 1 Identification
Delimiter (ASCII "*")
b Driver 2 Identification
Delimiter (ASCII "*")

NOTE - If only driver card 1 is present, only the parameter driver 1 identification and two delimiters shall be transmitted. If only driver card 2 is present, a delimiter followed by parameter driver 2 identification and the second delimiter shall be transmitted. If no driver cards are present, only the two delimiters shall be sent.

Transmission Repetition	On request	
Data Length:	Variable	
Data Page:	0	
PDU Format:	254	
PDU Specific:	107	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65131	(0xFE6B)

Start Position	Length	Parameter Name	SPN
1-2	Variable ("*" delimited)	Driver 1 identification	1625
3-4	Variable ("*" delimited)	Driver 2 identification	1626

PGN 65132 Tachograph - TCO1

Transmission Repetition	50 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	108	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	65132	(0xFE6C)

Start Position	Length	Parameter Name	SPN
1.1	3 bits	Driver 1 working state	1612
1.4	3 bits	Driver 2 working state	1613
1.7	2 bits	Drive recognize	1611
2.1	4 bits	Driver 1 Time Related States	1617
2.5	2 bits	Driver card, driver 1	1615
2.7	2 bits	Overspeed	1614
3.1	4 bits	Driver 2 Time Related States	1618
3.5	2 bits	Driver card, driver 2	1616
4.1	2 bits	System event	1622

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4.3	2 bits	Handling information	1621
4.5	2 bits	Tachograph performance	1620
4.7	2 bits	Direction indicator	1619
5-6	2 bytes	Tachograph output shaft speed	1623
7-8	2 bytes	Tachograph vehicle speed	1624

PGN 65133 Heater Information - HTR

Transmission Repetition: 1 s
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 109 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65133 (0xFE6D)

Start Position	Length	Parameter Name	SPN
1	1 byte	Auxiliary Heater Output Coolant Temperature	1687
2	1 byte	Auxiliary Heater Input Air Temperature	1688
3	1 byte	Auxiliary Heater Output Power Percent	1689
4.1	4 bits	Auxiliary Heater Mode	1677
5.1	2 bits	Auxilary Heater Water Pump Status	1676
5.3	2 bits	Cab Ventilation	1678
5.5	2 bits	Engine Heating Zone	1679
5.7	2 bits	Cab Heating Zone	1680

PGN 65134 High Resolution Wheel Speed - HRW

Transmission Repetition: 20 ms
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 110 PGN Supporting Information:
Default Priority: 2
Parameter Group Number: 65134 (0xFE6E)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Front Axle, Left Wheel Speed	1592
3-4	2 bytes	Front axle, right wheel speed	1593
5-6	2 bytes	Rear axle, left wheel speed	1594
7-8	2 bytes	Rear axle, right wheel speed	1595

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PGN 65135 Adaptive Cruise Control - ACC1

NOTE—The ACC1 message is required whenever the engine is running and ACC is powered on and not faulted. The timeout for ACC1 message will be between 2.5 times to 5 times the update rate.

The ACC1 message is intended primarily for engines and driver display units. The receiving device should identify the ACC device based on ACC function value of 32 (headway controller) or source address of 42 (headway controller).
In the event that the engine is running, the ACC is installed and the ACC1 message is not present, the engine will disable cruise control and return to non-cruise mode; also, the driver display unit will notify the driver that ACC operation is no longer available. In addition to the ACC1 timeout, engine cruise control will also be disabled if parameter "Adaptive Cruise Control State" in ACC1 is 110b (ACC disabled or in error). In some cases, it may be possible for the driver to restart cruise control (without ACC capability) during ACC/J1939 fault by performing a reset function. See Figure PGN65135_A.

It is possible that engines and driver display units may require calibration settings in order to know if the present vehicle configuration includes an ACC system or not. A calibration setting may also be needed for defining the driver reset function.

Transmission Repetition	100 ms		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	111	PGN Supporting Information:	See Appendix D - PGN 65135
Default Priority:	4		
Parameter Group Number:	65135	(0xFE6F)	

Start Position	Length	Parameter Name	SPN
1	1 byte	Speed of forward vehicle	1586
2	1 byte	Distance to forward vehicle	1587
3	1 byte	Adaptive Cruise Control Set Speed	1588
4.1	3 bits	Adaptive Cruise Control Mode	1590
4.4	3 bits	Adaptive cruise control set distance mode	1589
5-6	2 bytes	Road curvature	1591
7.1	2 bits	ACC Target Detected	1798
7.3	2 bits	ACC System Shutoff Warning	1797
7.5	2 bits	ACC Distance Alert Signal	1796

PGN 65136 Combination Vehicle Weight - CVW

Transmission Repetition	On request		
Data Length:	Variable		
Data Page:	0		
PDU Format:	254		
PDU Specific:	112	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65136	(0xFE70)	

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Powered Vehicle Weight	1585
3-4	2 bytes	Gross Combination Vehicle Weight	1760

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PGN 65137 Laser Tracer Position - LTP

Transmission Repetition	50 ms		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	113	PGN Supporting Information:	
Default Priority:	3		
Parameter Group Number:	65137	(0xFE71)	

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Laser Tracer Target Deviation	1579
3-4	2 bytes	Laser Tracer Vertical Distance	1580
5	1 byte	Laser Tracer Horizontal Deviation	1581
6	8 bits	LED Display Data #2	1582
7	8 bits	Laser Tracer Information	1583

PGN 65138 Laser Leveling System Blade Control - LBC

Transmission Repetition	50 ms		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	114	PGN Supporting Information:	
Default Priority:	3		
Parameter Group Number:	65138	(0xFE72)	

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Blade Duration and Direction	1577
3	8 bits	Blade Control Mode	1578

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PGN 65139 Laser Receiver Mast Position - LMP

Transmission Repetition	50 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	115	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	65139	(0xFE73)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Mast Position	1576

PGN 65140 Modify Leveling System Control Set Point - LSP

Transmission Repetition	50 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	116	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	65140	(0xFE74)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Modify Set Point	1575
3-6	4 bytes	Blade Height Set Point - High Resolution	1759

PGN 65141 Laser Leveling System Vertical Deviation - LVD

Transmission Repetition	50 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	117	PGN Supporting Information:
Default Priority:	3	
Parameter Group Number:	65141	(0xFE75)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Laser Strike Vertical Deviation	1574
3	1 byte	Laser Receiver Type	2576
4-5	2 bytes	Laser Strike Data Latency	2793
6-7	2 bytes	Absolute Laser Strike Position	2794

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PGN 65142 Laser Leveling System Vertical Position Display Data - LVDD

Transmission Repetition	100 ms		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	118	PGN Supporting Information:	
Default Priority:	4		
Parameter Group Number:	65142	(0xFE76)	

Start Position	Length	Parameter Name	SPN
1	8 bits	LED Display Data #1	1573
2.1	4 bits	LED Display Mode Control	1805
2.5	4 bits	LED Display Deadband Control	1806
3.1	4 bits	LED Pattern Control	2578
3.5	4 bits	Display Deadbands	2577

PGN 65143 Auxiliary Pressures - AP

Transmission Repetition	On request		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	119	PGN Supporting Information:	
Default Priority:	7		
Parameter Group Number:	65143	(0xFE77)	

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Auxiliary Vacuum Pressure Reading	136
3-4	2 bytes	Auxiliary Gage Pressure Reading 1	137
5-6	2 bytes	Auxiliary Absolute Pressure Reading	138

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PGN 65144 ***Tire Pressure Control Unit Mode and Status*** ***- TP1***

Transmission Repetition	On request		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	120	PGN Supporting Information:	
Default Priority:	7		
Parameter Group Number:	65144	(0xFE78)	

Start Position	Length	Parameter Name	SPN
1	1 byte	Tire Pressure Check Interval	39
2.1	4 bits	Steer Channel Mode	1466
3.1	4 bits	Trailer/tag Channel Mode	1467
3.5	4 bits	Drive Channel Mode	1468
4.1	2 bits	PCU Drive Solenoid Status	1469
4.3	2 bits	PCU Steer Solenoid Status	1470
4.5	2 bits	Tire Pressure Supply Switch Status	1471
5.1	2 bits	PCU Deflate Solenoid Status	1472
5.3	2 bits	PCU Control Solenoid Status	1473
5.5	2 bits	PCU Supply Solenoid Status	1474
5.7	2 bits	PCU Trailer, Tag or Push Solenoid Status	1475

PGN 65145 ***Tire Pressure Control Unit Target Pressures*** ***- TP2***

Transmission Repetition	On request		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	121	PGN Supporting Information:	
Default Priority:	7		
Parameter Group Number:	65145	(0xFE79)	

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Trailer, Tag Or Push Channel Tire Pressure Target	141
3-4	2 bytes	Drive Channel Tire Pressure Target	142
5-6	2 bytes	Steer Channel Tire Pressure Target	143

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PGN 65146 Tire Pressure Control Unit Current Pressures - TP3

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	122	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65146	(0xFE7A)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Trailer, Tag Or Push Channel Tire Pressure	144
3-4	2 bytes	Drive Channel Tire Pressure	145
5-6	2 bytes	Steer Channel Tire Pressure	146

PGN 65147 Combustion Time 1 - CT1

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	123	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65147	(0xFE7B)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Cylinder #1 Combustion Time	1444
3-4	2 bytes	Engine Cylinder #2 Combustion Time	1445
5-6	2 bytes	Engine Cylinder #3 Combustion Time	1446
7-8	2 bytes	Engine Cylinder #4 Combustion Time	1447

PGN 65148 Combustion Time 2 - CT2

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	124	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65148	(0xFE7C)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Cylinder #5 Combustion Time	1448

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3-4	2 bytes	Engine Cylinder #6 Combustion Time	1449
5-6	2 bytes	Engine Cylinder #7 Combustion Time	1450
7-8	2 bytes	Engine Cylinder #8 Combustion Time	1451

PGN 65149 Combustion Time 3 - CT3

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	125	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65149	(0xFE7D)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Cylinder #9 Combustion Time	1452
3-4	2 bytes	Engine Cylinder #10 Combustion Time	1453
5-6	2 bytes	Engine Cylinder #11 Combustion Time	1454
7-8	2 bytes	Engine Cylinder #12 Combustion Time	1455

PGN 65150 Combustion Time 4 - CT4

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	126	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65150	(0xFE7E)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Cylinder #13 Combustion Time	1456
3-4	2 bytes	Engine Cylinder #14 Combustion Time	1457
5-6	2 bytes	Engine Cylinder #15 Combustion Time	1458
7-8	2 bytes	Engine Cylinder #16 Combustion Time	1459

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PGN 65151 ***Combustion Time 5*** ***- CT5***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	127	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65151	(0xFE7F)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Cylinder #17 Combustion Time	1460
3-4	2 bytes	Engine Cylinder #18 Combustion Time	1461
5-6	2 bytes	Engine Cylinder #19 Combustion Time	1462
7-8	2 bytes	Engine Cylinder #20 Combustion Time	1463

PGN 65152 ***Combustion Time 6*** ***- CT6***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	128	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65152	(0xFE80)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Desired Combustion Time	1464
3-4	2 bytes	Engine Average Combustion Time	1465

PGN 65153 ***Fuel Information 2 (Gaseous)*** ***- GFI2***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	129	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65153	(0xFE81)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Fuel Flow Rate 1	1440
3-4	2 bytes	Engine Fuel Flow Rate 2	1441

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5	1 byte	Engine Fuel Valve 1 Position	1442
6	1 byte	Engine Fuel Valve 2 Position	1443
7	1 byte	Engine Requested Fuel Valve 1 Position	1765
8	1 byte	Engine Requested Fuel Valve 2 Position	1766

PGN 65154 ***Ignition Timing 1*** ***- IT1***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	130	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65154	(0xFE82)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Cylinder #1 Ignition Timing	1413
3-4	2 bytes	Engine Cylinder #2 Ignition Timing	1414
5-6	2 bytes	Engine Cylinder #3 Ignition Timing	1415
7-8	2 bytes	Engine Cylinder #4 Ignition Timing	1416

PGN 65155 ***Ignition Timing 2*** ***- IT2***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	131	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65155	(0xFE83)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Cylinder #5 Ignition Timing	1417
3-4	2 bytes	Engine Cylinder #6 Ignition Timing	1418
5-6	2 bytes	Engine Cylinder #7 Ignition Timing	1419
7-8	2 bytes	Engine Cylinder #8 Ignition Timing	1420

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PGN 65156 ***Ignition Timing 3*** ***- IT3***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	132	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65156	(0xFE84)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Cylinder #9 Ignition Timing	1421
3-4	2 bytes	Engine Cylinder #10 Ignition Timing	1422
5-6	2 bytes	Engine Cylinder #11 Ignition Timing	1423
7-8	2 bytes	Engine Cylinder #12 Ignition Timing	1424

PGN 65157 ***Ignition Timing 4*** ***- IT4***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	133	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65157	(0xFE85)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Cylinder #13 Ignition Timing	1425
3-4	2 bytes	Engine Cylinder #14 Ignition Timing	1426
5-6	2 bytes	Engine Cylinder #15 Ignition Timing	1427
7-8	2 bytes	Engine Cylinder #16 Ignition Timing	1428

PGN 65158 ***Ignition Timing 5*** ***- IT5***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	134	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65158	(0xFE86)

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Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Cylinder #17 Ignition Timing	1429
3-4	2 bytes	Engine Cylinder #18 Ignition Timing	1430
5-6	2 bytes	Engine Cylinder #19 Ignition Timing	1431
7-8	2 bytes	Engine Cylinder #20 Ignition Timing	1432

PGN 65159 ***Ignition Timing 6*** ***- IT6***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	135	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65159	(0xFE87)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Desired Ignition Timing #1	1433
3-4	2 bytes	Engine Desired Ignition Timing #2	1434
5-6	2 bytes	Engine Desired Ignition Timing #3	1435
7-8	2 bytes	Engine Actual Ignition Timing	1436

PGN 65160 ***Ignition Transformer Secondary Output 1*** ***- ISO1***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	136	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65160	(0xFE88)

Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Cylinder #1 Ignition Transformer Secondary Output	1393
2	1 byte	Engine Cylinder #2 Ignition Transformer Secondary Output	1394
3	1 byte	Engine Cylinder #3 Ignition Transformer Secondary Output	1395
4	1 byte	Engine Cylinder #4 Ignition Transformer Secondary Output	1396
5	1 byte	Engine Cylinder #5 Ignition Transformer Secondary Output	1397
6	1 byte	Engine Cylinder #6 Ignition Transformer Secondary Output	1398
7	1 byte	Engine Cylinder #7 Ignition Transformer Secondary Output	1399
8	1 byte	Engine Cylinder #8 Ignition Transformer Secondary Output	1400

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PGN 65161 ***Ignition Transformer Secondary Output 2*** ***- ISO2***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	137	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65161	(0xFE89)

Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Cylinder #9 Ignition Transformer Secondary Output	1401
2	1 byte	Engine Cylinder #10 Ignition Transformer Secondary Output	1402
3	1 byte	Engine Cylinder #11 Ignition Transformer Secondary Output	1403
4	1 byte	Engine Cylinder #12 Ignition Transformer Secondary Output	1404
5	1 byte	Engine Cylinder #13 Ignition Transformer Secondary Output	1405
6	1 byte	Engine Cylinder #14 Ignition Transformer Secondary Output	1406
7	1 byte	Engine Cylinder #15 Ignition Transformer Secondary Output	1407
8	1 byte	Engine Cylinder #16 Ignition Transformer Secondary Output	1408

PGN 65162 ***Ignition Transformer Secondary Output 3*** ***- ISO3***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	138	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65162	(0xFE8A)

Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Cylinder #17 Ignition Transformer Secondary Output	1409
2	1 byte	Engine Cylinder #18 Ignition Transformer Secondary Output	1410
3	1 byte	Engine Cylinder #19 Ignition Transformer Secondary Output	1411
4	1 byte	Engine Cylinder #20 Ignition Transformer Secondary Output	1412

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PGN 65163 Gaseous Fuel Pressure - GFP

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	139	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65163	(0xFE8B)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Fuel Valve Inlet Absolute Pressure	1390
3-4	2 bytes	Engine Fuel Valve Differential Pressure	1391
5-6	2 bytes	Engine Air to Fuel Differential Pressure	1392

PGN 65164 (R) Auxiliary Analog Information - AAI

Auxiliary Analog Information

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	140	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65164	(0xFE8C)

Start Position	Length	Parameter Name	SPN
1	1 byte	Auxiliary Temperature 1	441
2	1 byte	Auxiliary Temperature 2	442
3	1 byte	Auxiliary Pressure #1	1387
4	1 byte	Auxiliary Pressure #2	1388
5-6	2 bytes	Auxiliary Level	3087

PGN 65165 Vehicle Electrical Power 2 - VP2

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	141	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65165	(0xFE8D)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Battery 2 Potential (Voltage)	444

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PGN 65166 Service 2 - S2

NOTE - There are two acceptable formats for the Service PGN. Format 1 has only 8 bytes of data and reports the component most in need of service for each of the three categories. Format 2, however, uses the transport layer as necessary in order to repeat these 8 bytes of service component information until all supported service components in each category have been transmitted.

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	142	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65166	(0xFE8E)

Start Position	Length	Parameter Name	SPN
1	1 byte	Service Component Identification	1379
2-3	2 bytes	Time Since Last Service	1350

PGN 65167 Supply Pressure 2 - SP2

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	143	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65167	(0xFE8F)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine External Shutdown Air Supply Pressure	1320

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PGN 65168 ***Engine Torque History*** ***- ETH***

NOTE - The torque history PGN is variable in length and may contain up to 125 torque history records. Each torque history record MUST BE 38 bytes in length. Any unused bytes must be 0xFF.

The last six bytes of each record are not currently defined and shall be transmitted as "not available" (0xff). In the first record, these are byte positions 34-39.

Transmission Repetition	On request	
Data Length:	Variable	
Data Page:	0	
PDU Format:	254	
PDU Specific:	144	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65168	(0xFE90)

Start Position	Length	Parameter Name	SPN
01	1 byte	Number of Engine Torque History Records	1246
02-03	2 bytes	Engine Power	1247
04-05	2 bytes	Engine Peak Torque 1	1248
06-07	2 bytes	Engine Peak Torque 2	1249
08	1 byte	Calibration Record Start Month	1250
09	1 byte	Calibration Record Start Day	1251
10	1 byte	Calibration Record Start Year	1252
11-14	4 bytes	Calibration Record Duration Time	1253
15.1	2 bits	Torque Limiting Feature Status	1254
15.3	3 bits	Engine Torque Limit Feature	1632
16-17	2 bytes	Transmission Gear Ratio 1	1255
18-19	2 bytes	Engine Torque Limit 1, Transmission	1256
20-21	2 bytes	Transmission Gear Ratio 2	1257
22-23	2 bytes	Engine Torque Limit 2, Transmission	1258
24-25	2 bytes	Transmission Gear Ratio 3	1259
26-27	2 bytes	Engine Torque Limit 3, Transmission	1260
28-29	2 bytes	Engine Torque Limit 4, Transmission	1261
30-31	2 bytes	Engine Torque Limit 5, Switch	1262
32-33	2 bytes	Engine Torque Limit 6, Axle Input	1263

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PGN 65169 ***Fuel Leakage*** ***- FL***

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	145	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65169	(0xFE91)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Engine Fuel Leakage 1	1239
1.3	2 bits	Engine Fuel Leakage 2	1240

PGN 65170 ***Engine Information*** ***- EI***

Transmission Repetition	100 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	146	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65170	(0xFE92)

Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Pre-filter Oil Pressure	1208
2-3	2 bytes	Engine Exhaust Gas Pressure	1209
4	1 byte	Engine Fuel Rack Position	1210
5-6	2 bytes	Engine Mass Flow (Gaseous)	1241
7-8	2 bytes	Instantaneous Estimated Brake Power	1242

PGN 65171 ***Engine Electrical System/Module Information*** ***- EES***

Transmission Repetition	100 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	147	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65171	(0xFE93)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Electrical Load	1204

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3.1	2 bits	Safety Wire Status	1205
3.3	2 bits	Turning Gear Engaged	1206

PGN 65172 Engine Auxiliary Coolant - EAC

Transmission Repetition	0.5 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	148	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65172	(0xFE94)

Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Auxiliary Coolant Pressure	1203
2	1 byte	Engine Auxiliary Coolant Temperature	1212
3	1 byte	Sea Water Pump Outlet Pressure	2435

PGN 65173 Rebuild Information - RBI

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	149	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65173	(0xFE95)

Start Position	Length	Parameter Name	SPN
1-4	4 bytes	Engine Operation Time Since Rebuild	1193

PGN 65174 Turbocharger Wastegate - TCW

Transmission Repetition	100 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	150	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65174	(0xFE96)

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Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Turbocharger 1 Wastegate Drive	1188
2	1 byte	Engine Turbocharger 2 Wastegate Drive	1189
3	1 byte	Engine Turbocharger 3 Wastegate Drive	1190
4	1 byte	Engine Turbocharger 4 Wastegate Drive	1191
5	1 byte	Engine Turbocharger Wastegate Actuator Control Air Pressure	1192

PGN 65175 Turbocharger Information 5 - TCI5

Transmission Repetition: 1 s
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 151 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65175 (0xFE97)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Turbocharger 1 Turbine Outlet Temperature	1184
3-4	2 bytes	Engine Turbocharger 2 Turbine Outlet Temperature	1185
5-6	2 bytes	Engine Turbocharger 3 Turbine Outlet Temperature	1186
7-8	2 bytes	Engine Turbocharger 4 Turbine Outlet Temperature	1187

PGN 65176 Turbocharger Information 4 - TCI4

Transmission Repetition: 1 s
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 152 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65176 (0xFE98)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Turbocharger 1 Turbine Inlet Temperature	1180
3-4	2 bytes	Engine Turbocharger 2 Turbine Inlet Temperature	1181
5-6	2 bytes	Engine Turbocharger 3 Turbine Inlet Temperature	1182
7-8	2 bytes	Engine Turbocharger 4 Turbine Inlet Temperature	1183

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PGN 65177 ***Turbocharger Information 3*** ***- TCI3***

Transmission Repetition	1 s		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	153	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65177	(0xFE99)	

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Turbocharger 1 Compressor Inlet Pressure	1176
3-4	2 bytes	Engine Turbocharger 2 Compressor Inlet Pressure	1177
5-6	2 bytes	Engine Turbocharger 3 Compressor Inlet Pressure	1178
7-8	2 bytes	Engine Turbocharger 4 Compressor Inlet Pressure	1179

PGN 65178 ***Turbocharger Information 2*** ***- TCI2***

Transmission Repetition	1 s		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	154	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65178	(0xFE9A)	

Start Position	Length	Parameter Name	SPN
1	2 bytes	Engine Turbocharger 1 Compressor Inlet Temperature	1172
2	2 bytes	Engine Turbocharger 2 Compressor Inlet Temperature	1173
3	2 bytes	Engine Turbocharger 3 Compressor Inlet Temperature	1174
4	2 bytes	Engine Turbocharger 4 Compressor Inlet Temperature	1175

PGN 65179 ***Turbocharger Information 1*** ***- TCI1***

Transmission Repetition	1 s		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	155	PGN Supporting Information:	
Default Priority:	7		
Parameter Group Number:	65179	(0xFE9B)	

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Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Turbocharger Lube Oil Pressure 2	1168
2-3	2 bytes	Engine Turbocharger 2 Speed	1169
4-5	2 bytes	Engine Turbocharger 3 Speed	1170
6-7	2 bytes	Engine Turbocharger 4 Speed	1171

PGN 65180 Main Bearing Temperature 3 - MBT3

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	156	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65180	(0xFE9C)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Main Bearing 9 Temperature	1165
3-4	2 bytes	Engine Main Bearing 10 Temperature	1166
5-6	2 bytes	Engine Main Bearing 11 Temperature	1167

PGN 65181 Main Bearing Temperature 2 - MBT2

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	157	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65181	(0xFE9D)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Main Bearing 5 Temperature	1161
3-4	2 bytes	Engine Main Bearing 6 Temperature	1162
5-6	2 bytes	Engine Main Bearing 7 Temperature	1163
7-8	2 bytes	Engine Main Bearing 8 Temperature	1164

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PGN 65182 ***Main Bearing Temperature 1*** ***- MBT1***

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	158	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65182	(0xFE9E)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Main Bearing 1 Temperature	1157
3-4	2 bytes	Engine Main Bearing 2 Temperature	1158
5-6	2 bytes	Engine Main Bearing 3 Temperature	1159
7-8	2 bytes	Engine Main Bearing 4 Temperature	1160

PGN 65183 ***Exhaust Port Temperature 5*** ***- EPT5***

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	159	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65183	(0xFE9F)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Exhaust Gas Port 17 Temperature	1153
3-4	2 bytes	Engine Exhaust Gas Port 18 Temperature	1154
5-6	2 bytes	Engine Exhaust Gas Port 19 Temperature	1155
7-8	2 bytes	Engine Exhaust Gas Port 20 Temperature	1156

PGN 65184 ***Exhaust Port Temperature 4*** ***- EPT4***

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	160	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65184	(0xFEA0)

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Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Exhaust Gas Port 13 Temperature	1149
3-4	2 bytes	Engine Exhaust Gas Port 14 Temperature	1150
5-6	2 bytes	Engine Exhaust Gas Port 15 Temperature	1151
7-8	2 bytes	Engine Exhaust Gas Port 16 Temperature	1152

PGN 65185 Exhaust Port Temperature 3 - EPT3

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	161	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65185	(0xFEA1)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Exhaust Gas Port 9 Temperature	1145
3-4	2 bytes	Engine Exhaust Gas Port 10 Temperature	1146
5-6	2 bytes	Engine Exhaust Gas Port 11 Temperature	1147
7-8	2 bytes	Engine Exhaust Gas Port 12 Temperature	1148

PGN 65186 Exhaust Port Temperature 2 - EPT2

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	162	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65186	(0xFEA2)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Exhaust Gas Port 5 Temperature	1141
3-4	2 bytes	Engine Exhaust Gas Port 6 Temperature	1142
5-6	2 bytes	Engine Exhaust Gas Port 7 Temperature	1143
7-8	2 bytes	Engine Exhaust Gas Port 8 Temperature	1144

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PGN 65187 ***Exhaust Port Temperature 1*** ***- EPT1***

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	163	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65187	(0xFEA3)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Exhaust Gas Port 1 Temperature	1137
3-4	2 bytes	Engine Exhaust Gas Port 2 Temperature	1138
5-6	2 bytes	Engine Exhaust Gas Port 3 Temperature	1139
7-8	2 bytes	Engine Exhaust Gas Port 4 Temperature	1140

PGN 65188 ***Engine Temperature 2*** ***- ET2***

Transmission Repetition	1s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	164	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65188	(0xFEA4)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Oil Temperature 2	1135
3-4	2 bytes	Engine ECU Temperature	1136
5-6	2 bytes	Engine Exhaust Gas Recirculation Differential Pressure	411
7-8	2 bytes	Engine Exhaust Gas Recirculation Temperature	412

PGN 65189 ***Intake Manifold Information 2*** ***- IMT2***

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	165	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65189	(0xFEA5)

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Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Intake Manifold 2 Temperature	1131
2	1 byte	Engine Intake Manifold 3 Temperature	1132
3	1 byte	Engine Intake Manifold 4 Temperature	1133
4	1 byte	Engine Intake Manifold 5 Temperature	1802
5	1 byte	Engine Intake Manifold 6 Temperature	1803

PGN 65190 Intake Manifold Information 1 - IMT1

Transmission Repetition: 0.5 s
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 166 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65190 (0xFEA6)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Turbocharger 1 Boost Pressure	1127
3-4	2 bytes	Engine Turbocharger 2 Boost Pressure	1128
5-6	2 bytes	Engine Turbocharger 3 Boost Pressure	1129
7-8	2 bytes	Engine Turbocharger 4 Boost Pressure	1130

PGN 65191 Alternator Temperature - AT

Transmission Repetition: 1 s
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 167 PGN Supporting Information:
Default Priority: 7
Parameter Group Number: 65191 (0xFEA7)

Start Position	Length	Parameter Name	SPN
1	1 byte	Alternator Bearing 1 Temperature	1122
2	1 byte	Alternator Bearing 2 Temperature	1123
3	1 byte	Alternator Winding 1 Temperature	1124
4	1 byte	Alternator Winding 2 Temperature	1125
5	1 byte	Alternator Winding 3 Temperature	1126

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PGN 65192 ***Articulation Control*** ***- AC***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	168	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65192	(0xFEA8)

Start Position	Length	Parameter Name	SPN
1	1 byte	Articulation Angle	1120

PGN 65193 ***Exhaust Oxygen 1*** ***- EO1***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	169	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65193	(0xFEA9)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Desired Rated Exhaust Oxygen	1117
3-4	2 bytes	Engine Desired Exhaust Oxygen	1118
5-6	2 bytes	Engine Actual Exhaust Oxygen	1119
7	1 byte	Engine Exhaust Gas Oxygen Sensor Fueling Correction	1695
8.7	2 bits	Engine Exhaust Gas Oxygen Sensor Closed Loop Operation	1696

PGN 65194 ***Alternate Fuel 2*** ***- AF2***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	170	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65194	(0xFEAA)

Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Gaseous Fuel Correction Factor	1116
2-3	2 bytes	Engine Desired Absolute Intake Manifold Pressure (Turbo Boost Limit)	1692

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4	1 byte	Engine Turbocharger Wastegate Valve Position	1693
5	1 byte	Engine Gas Mass Flow Sensor Fueling Correction	1694

PGN 65195 Electronic Transmission Controller 6 - ETC6

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	171	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65195	(0xFEAB)

Start Position	Length	Parameter Name	SPN
1	1 byte	Recommended Gear	1113
2	1 byte	Highest Possible Gear	1115
3	1 byte	Lowest Possible Gear	1114
4	1 byte	Clutch Life Remaining	2983

PGN 65196 Wheel Brake Lining Remaining Information - EBC4

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	172	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65196	(0xFEAC)

Start Position	Length	Parameter Name	SPN
1	1 byte	Brake Lining Remaining, Front Axle, Left Wheel	1099
2	1 byte	Brake Lining Remaining, Front Axle, Right Wheel	1100
3	1 byte	Brake Lining Remaining, Rear Axle #1, Left Wheel	1101
4	1 byte	Brake Lining Remaining, Rear Axle #1, Right Wheel	1102
5	1 byte	Brake Lining Remaining, Rear Axle #2, Left Wheel	1103
6	1 byte	Brake Lining Remaining, Rear Axle #2, Right Wheel	1104
7	1 byte	Brake Lining Remaining, Rear Axle #3, Left Wheel	1105
8	1 byte	Brake Lining Remaining, Rear Axle #3, Right Wheel	1106

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PGN 65197 ***Wheel Application Pressure High Range Information*** ***- EBC3***

Transmission Repetition	100 ms		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	173	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65197	(0xFEAD)	

Start Position	Length	Parameter Name	SPN
1	1 byte	Brake Application Pressure High Range, Front Axle, Left Wheel	1091
2	1 byte	Brake Application Pressure High Range, Front Axle, Right Wheel	1092
3	1 byte	Brake Application Pressure High Range, Rear Axle #1, Left Wheel	1093
4	1 byte	Brake Application Pressure High Range, Rear Axle #1, Right Wheel	1094
5	1 byte	Brake Application Pressure High Range, Rear Axle #2, Left Wheel	1095
6	1 byte	Brake Application Pressure High Range, Rear Axle #2, Right Wheel	1096
7	1 byte	Brake Application Pressure High Range, Rear Axle #3, Left Wheel	1097
8	1 byte	Brake Application Pressure High Range, Rear Axle #3, Right Wheel	1098

PGN 65198 ***Air Supply Pressure*** ***- AIR1***

Air Supply Pressure

Transmission Repetition	1 s		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	174	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65198	(0xFEAE)	

Start Position	Length	Parameter Name	SPN
1	1 byte	Pneumatic Supply Pressure	46
2	1 byte	Parking and/or Trailer Air Pressure	1086
3	1 byte	Service Brake Air Pressure Circuit #1	1087
4	1 byte	Service Brake Air Pressure Circuit #2	1088
5	1 byte	Auxiliary Equipment Supply Pressure	1089
6	1 byte	Air Suspension Supply Pressure	1090

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PGN 65199 Fuel Consumption (Gaseous) - GFC

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	175	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65199	(0xFEAF)

Start Position	Length	Parameter Name	SPN
1-4	4 bytes	Trip Fuel (Gaseous)	1039
5-8	4 bytes	Total Fuel Used (Gaseous)	1040

PGN 65200 Trip Time Information 2 - TTI2

Transmission Repetition	On request	
Data Length:	20	
Data Page:	0	
PDU Format:	254	
PDU Specific:	176	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65200	(0xFEB0)

Start Position	Length	Parameter Name	SPN
01-04	4 bytes	Trip Cruise Time	1034
05-08	4 bytes	Trip PTO Time	1035
09-12	4 bytes	Trip Engine Running Time	1036
13-16	4 bytes	Trip Idle Time	1037
17-20	4 bytes	Trip Air Compressor On Time	1038

PGN 65201 ECU History - EH

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	177	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65201	(0xFEB1)

Start Position	Length	Parameter Name	SPN
1-4	4 bytes	Total ECU Distance	1032
5-8	4 bytes	Total ECU Run Time	1033

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PGN 65202 ***Fuel Information 1 (Gaseous)*** ***- GFI1***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	178	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65202	(0xFEB2)

Start Position	Length	Parameter Name	SPN
1-4	4 bytes	Total Engine PTO Fuel Used (Gaseous)	1030
5-6	2 bytes	Trip Average Fuel Rate (Gaseous)	1031
7-8	2 bytes	Engine Fuel Specific Gravity	1389

PGN 65203 ***Fuel Information (Liquid)*** ***- LFI***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	179	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65203	(0xFEB3)

Start Position	Length	Parameter Name	SPN
1-4	4 bytes	Total Engine PTO Fuel Used	1028
5-6	2 bytes	Trip Average Fuel Rate	1029

PGN 65204 ***Trip Time Information 1*** ***- TTI1***

Transmission Repetition	On request	
Data Length:	16	
Data Page:	0	
PDU Format:	254	
PDU Specific:	180	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65204	(0xFEB4)

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Start Position	Length	Parameter Name	SPN
01-04	4 bytes	Trip Time in VSL	1024
05-08	4 bytes	Trip Time in Top Gear	1025
09-12	4 bytes	Trip Time in Gear Down	1026
13-16	4 bytes	Trip Time in Derate by Engine	1027

PGN 65205 Trip Shutdown Information - TSI

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	181	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65205	(0xFEB5)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Trip Number of Hot Shutdowns	1020
3-4	2 bytes	Trip Number of Idle Shutdowns	1021
5-6	2 bytes	Trip Number of Idle Shutdown Overrides	1022
7-8	2 bytes	Trip Sudden Decelerations	1023

PGN 65206 Trip Vehicle Speed/Cruise Distance Information - TVI

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	182	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65206	(0xFEB6)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Trip Maximum Vehicle Speed	1018
3-6	4 bytes	Trip Cruise Distance	1019

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PGN 65207 ***Engine Speed/Load Factor Information*** ***- LF***

Transmission Repetition	On request		
Data Length:	10		
Data Page:	0		
PDU Format:	254		
PDU Specific:	183	PGN Supporting Information:	
Default Priority:	7		
Parameter Group Number:	65207	(0xFEB7)	

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Trip Maximum Engine Speed	1013
3-4	2 bytes	Trip Average Engine Speed	1014
5	1 byte	Trip Drive Average Load Factor	1015
6	1 byte	Total Drive Average Load Factor	1016
7-10	4 bytes	Total Engine Cruise Time	1017

PGN 65208 ***Trip Fuel Information (Gaseous)*** ***- GTFI***

Transmission Repetition	On request		
Data Length:	22		
Data Page:	0		
PDU Format:	254		
PDU Specific:	184	PGN Supporting Information:	
Default Priority:	7		
Parameter Group Number:	65208	(0xFEB8)	

Start Position	Length	Parameter Name	SPN
01-04	4 bytes	Trip Drive Fuel Used (Gaseous)	1007
05-08	4 bytes	Trip PTO Moving Fuel Used (Gaseous)	1008
09-12	4 bytes	Trip PTO Non-moving Fuel Used (Gaseous)	1009
13-16	4 bytes	Trip Vehicle Idle Fuel Used (Gaseous)	1010
17-20	4 bytes	Trip Cruise Fuel Used (Gaseous)	1011
21-22	2 bytes	Trip Drive Fuel Economy (Gaseous)	1012

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PGN 65209 ***Trip Fuel Information (Liquid)*** ***- LTFI***

Transmission Repetition	On request		
Data Length:	22		
Data Page:	0		
PDU Format:	254		
PDU Specific:	185	PGN Supporting Information:	
Default Priority:	7		
Parameter Group Number:	65209	(0xFEB9)	

Start Position	Length	Parameter Name	SPN
01-04	4 bytes	Trip Drive Fuel Used	1001
05-08	4 bytes	Trip PTO Moving Fuel Used	1002
09-12	4 bytes	Trip PTO Non-moving Fuel Used	1003
13-16	4 bytes	Trip Vehicle Idle Fuel Used	1004
17-20	4 bytes	Trip Cruise Fuel Used	1005
21-22	2 bytes	Trip Drive Fuel Economy	1006

PGN 65210 ***Trip Distance Information*** ***- TDI***

Transmission Repetition	On request		
Data Length:	12		
Data Page:	0		
PDU Format:	254		
PDU Specific:	186	PGN Supporting Information:	
Default Priority:	7		
Parameter Group Number:	65210	(0xFEBA)	

Start Position	Length	Parameter Name	SPN
1-4	4 bytes	Trip Distance on VSL	998
5-8	4 bytes	Trip Gear Down Distance	999
9-12	4 bytes	Trip Distance in Top Gear	1000

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PGN 65211 ***Trip Fan Information*** ***- TFI***

Transmission Repetition	On request	
Data Length:	16	
Data Page:	0	
PDU Format:	254	
PDU Specific:	187	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65211	(0xFEBB)

Start Position	Length	Parameter Name	SPN
01-04	4 bytes	Trip Fan On Time	994
05-08	4 bytes	Trip Fan On Time Due to the Engine System	995
09-12	4 bytes	Trip Fan On Time Due to a Manual Switch	996
13-16	4 bytes	Trip Fan On Time Due to the A/C System	997

PGN 65212 ***Compression/Service Brake Information*** ***- CBI***

Transmission Repetition	On request	
Data Length:	16	
Data Page:	0	
PDU Format:	254	
PDU Specific:	188	PGN Supporting Information:
Default Priority:	7	
Parameter Group Number:	65212	(0xFEBC)

Start Position	Length	Parameter Name	SPN
01-04	4 bytes	Total Compression Brake Distance	990
05-08	4 bytes	Trip Compression Brake Distance	991
09-12	4 bytes	Trip Service Brake Distance	992
13-16	4 bytes	Trip Service Brake Applications	993

PGN 65213 ***Fan Drive*** ***- FD***

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	189	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65213	(0xFEBD)

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Start Position	Length	Parameter Name	SPN
1	1 byte	Estimated Percent Fan Speed	975
2.1	4 bits	Fan Drive State	977
3-4	2 bytes	Fan Speed	1639

PGN 65214 Electronic Engine Controller 4 - EEC4

Transmission Repetition: On request
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 190 PGN Supporting Information:
Default Priority: 7
Parameter Group Number: 65214 (0xFEBE)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Rated Power	166
3-4	2 bytes	Engine Rated Speed	189

PGN 65215 Wheel Speed Information - EBC2

Transmission Repetition: 100 ms
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 191 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65215 (0xFEBF)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Front Axle Speed	904
3	1 byte	Relative Speed; Front Axle, Left Wheel	905
4	1 byte	Relative Speed; Front Axle, Right Wheel	906
5	1 byte	Relative Speed; Rear Axle #1, Left Wheel	907
6	1 byte	Relative Speed; Rear Axle #1, Right Wheel	908
7	1 byte	Relative Speed; Rear Axle #2, Left Wheel	909
8	1 byte	Relative Speed; Rear Axle #2, Right Wheel	910

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PGN 65216 ***Service Information*** ***- SERV***

Transmitted with the service component identification that has the shortest distance or nearest time until the next service inspection.

NOTE - There are two acceptable formats for the Service PGN. Format 1 has only 8 bytes of data and reports the component most in need of service for each of the three categories. Format 2, however, uses the transport layer as necessary in order to repeat these 8 bytes of service component information until all supported service components in each category have been transmitted.

Transmission Repetition	On request	
Data Length:	8 bytes or variable	
Data Page:	0	
PDU Format:	254	
PDU Specific:	192	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65216	(0xFEC0)

Start Position	Length	Parameter Name	SPN
1	1 byte	Service Component Identification	911
2-3	2 bytes	Service Distance	914
4	1 byte	Service Component Identification	912
5	1 byte	Service Delay/Calendar Time Based	915
6	1 byte	Service Component Identification	913
7-8	2 bytes	Service Delay/Operational Time Based	916

PGN 65217 ***High Resolution Vehicle Distance*** ***- VDHR***

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	193	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65217	(0xFEC1)

Start Position	Length	Parameter Name	SPN
1-4	4 bytes	High Resolution Total Vehicle Distance	917
5-8	4 bytes	High Resolution Trip Distance	918

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PGN 65218 Electronic Retarder Controller 2 - ERC2

Transmission Repetition	1 s when active; or on change of state		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	194	PGN Supporting Information:	
Default Priority:	7		
Parameter Group Number:	65218	(0xFEC2)	

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Transmission Output Retarder	748

PGN 65219 Electronic Transmission Controller 5 - ETC5

Transmission Repetition	On request		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	195	PGN Supporting Information:	
Default Priority:	7		
Parameter Group Number:	65219	(0xFEC3)	

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Transmission High Range Sense Switch	778
1.3	2 bits	Transmission Low Range Sense Switch	779
2.1	2 bits	Transmission Reverse Direction Switch	767
2.3	2 bits	Transmission Neutral Switch	604
2.5	2 bits	Transmission Forward Direction Switch	903

PGN 65221 Electronic Transmission Controller 4 - ETC4

Transmission Repetition	On request		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	197	PGN Supporting Information:	
Default Priority:	7		
Parameter Group Number:	65221	(0xFEC5)	

Start Position	Length	Parameter Name	SPN
1	1 byte	Transmission Synchronizer Clutch Value	53
2	1 byte	Transmission Synchronizer Brake Value	54

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PGN 65223 ***Electronic Transmission Controller 3*** ***- ETC3***

Transmission Repetition	On request		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	199	PGN Supporting Information:	
Default Priority:	7		
Parameter Group Number:	65223	(0xFEC7)	

Start Position	Length	Parameter Name	SPN
1	1 byte	Transmission Shift Finger Gear Position	59
2	1 byte	Transmission Shift Finger Rail Position	60
3.1	2 bits	Transmission Shift Finger Neutral Indicator	780
3.3	2 bits	Transmission Shift Finger Engagement Indicator	781
3.5	2 bits	Transmission Shift Finger Center Rail Indicator	782
4.1	2 bits	Transmission Shift Finger Rail Actuator 1	772
4.3	2 bits	Transmission Shift Finger Gear Actuator 1	773
4.5	2 bits	Transmission Shift Finger Rail Actuator 2	783
4.7	2 bits	Transmission Shift Finger Gear Actuator 2	784
5.1	2 bits	Transmission Range High Actuator	768
5.3	2 bits	Transmission Range Low Actuator	769
5.5	2 bits	Transmission Splitter Direct Actuator	770
5.7	2 bits	Transmission Splitter Indirect Actuator	771
6.1	2 bits	Transmission Clutch Actuator	788
6.3	2 bits	Transmission Lockup Clutch Actuator	740
6.5	2 bits	Transmission Defuel Actuator	786
6.7	2 bits	Transmission Inertia Brake Actuator	787

PGN 65237 ***Alternator Speed*** ***- AS***

Transmission Repetition	1 s		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	213	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65237	(0xFED5)	

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Alternator Speed	589

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PGN 65241 ***Auxiliary Input/Output Status*** ***- AUXIO***

Transmission Repetition	manufacturer defined, not faster than 100 ms	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	217	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65241	(0xFED9)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Auxiliary I/O #04	704
1.3	2 bits	Auxiliary I/O #03	703
1.5	2 bits	Auxiliary I/O #02	702
1.7	2 bits	Auxiliary I/O #01	701
2.1	2 bits	Auxiliary I/O #08	708
2.3	2 bits	Auxiliary I/O #07	707
2.5	2 bits	Auxiliary I/O #06	706
2.7	2 bits	Auxiliary I/O #05	705
3.1	2 bits	Auxiliary I/O #12	712
3.3	2 bits	Auxiliary I/O #11	711
3.5	2 bits	Auxiliary I/O #10	710
3.7	2 bits	Auxiliary I/O #09	709
4.1	2 bits	Auxiliary I/O #16	716
4.3	2 bits	Auxiliary I/O #15	715
4.5	2 bits	Auxiliary I/O #14	714
4.7	2 bits	Auxiliary I/O #13	713
5-6	2 bytes	Auxiliary I/O Channel #1	1083
7-8	2 bytes	Auxiliary I/O Channel #2	1084

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PGN 65242 ***Software Identification*** ***- SOFT***

Byte: 1 Number of software identification fields
2-n Software identification(s)
Delimiter (ASCII "*")

NOTE- The software identification field is variable in length and may contain up to 125 software identification designators. An ASCII "*" is used as a delimiter to separate multiple software identifications. Additional software identification fields may be added at the end, each separated by an ASCII "*" as a delimiter. An ASCII "*" is required at the end of the last software identification field, even if there is only one software identification designator.

Transmission Repetition	On request	
Data Length:	Variable	
Data Page:	0	
PDU Format:	254	
PDU Specific:	218	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65242	(0xFEDA)

Start Position	Length	Parameter Name	SPN
1	1 byte	Number of Software Identification Fields	965
2-N	Variable - up to 200 characters ("*" delimited)	Software Identification	234

PGN 65243 ***Engine Fluid Level/Pressure 2*** ***- EFL/P2***

Transmission Repetition	0.5 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	219	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65243	(0xFEDB)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Injection Control Pressure	164
3-4	2 bytes	Engine Injector Metering Rail 1 Pressure	157
5-6	2 bytes	Engine Injector Timing Rail 1 Pressure	156
7-8	2 bytes	Engine Injector Metering Rail 2 Pressure	1349

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PGN 65244 Idle Operation - IO

Transmission Repetition	On request		
Data Length:	Variable		
Data Page:	0		
PDU Format:	254		
PDU Specific:	220	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65244	(0xFEDC)	

Start Position	Length	Parameter Name	SPN
1-4	4 bytes	Engine Total Idle Fuel Used	236
5-8	4 bytes	Engine Total Idle Hours	235

PGN 65245 Turbocharger - TC

Transmission Repetition	1 s		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	221	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65245	(0xFEDD)	

Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Turbocharger Lube Oil Pressure 1	104
2-3	2 bytes	Engine Turbocharger 1 Speed	103
4.7	2 bits	Engine Turbocharger Oil Level Switch	1665

PGN 65246 Air Start Pressure - AIR2

Transmission Repetition	On request		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	222	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65246	(0xFEDE)	

Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Air Start Pressure	82

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PGN 65247 (R) Electronic Engine Controller 3 - EEC3

Transmission Repetition	250 msecs		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	223	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65247	(0xFEDF)	

Start Position	Length	Parameter Name	SPN
1	1 byte	Nominal Friction - Percent Torque	514
2-3	2 bytes	Engine's Desired Operating Speed	515
4	1 byte	Engine's Desired Operating Speed Asymmetry Adjustment	519
5	1 byte	Estimated Engine Parasitic Losses - Percent Torque	2978

PGN 65248 Vehicle Distance - VD

Transmission Repetition	100 ms		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	224	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65248	(0xFEE0)	

Start Position	Length	Parameter Name	SPN
1-4	4 bytes	Trip Distance	244
5-8	4 bytes	Total Vehicle Distance	245

PGN 65249 Retarder Configuration - RC

This map describes the stationary behavior of the retarder.

Transmission Repetition	On change of torque/speed points of more than 10% since last transmission, or every 5 s.		
Data Length:	19		
Data Page:	0		
PDU Format:	254		
PDU Specific:	225	PGN Supporting Information:	See Appendix D - PGN 65249
Default Priority:	6		
Parameter Group Number:	65249	(0xFEE1)	

Start Position	Length	Parameter Name	SPN
01.1	4 bits	Retarder Type	901

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01.5	4 bits	Retarder Location	902
02	1 byte	Retarder Control Method (Retarder Configuration)	557
03-04	2 bytes	Retarder Speed At Idle, Point 1 (Retarder Configuration)	546
05	1 byte	Percent Torque At Idle, Point 1 (Retarder Configuration)	551
06-07	2 bytes	Maximum Retarder Speed, Point 2 (Retarder Configuration)	548
08	1 byte	Percent Torque At Maximum Speed, Point 2 (Retarder Configuration)	552
09-10	2 bytes	Retarder Speed At Point 3 (Retarder Configuration)	549
11	1 byte	Percent Torque At Point 3 (Retarder Configuration)	553
12-13	2 bytes	Retarder Speed At Point 4 (Retarder Configuration)	550
14	1 byte	Percent Torque At Point 4 (Retarder Configuration)	554
15-16	2 bytes	Retarder Speed At Peak Torque, Point 5 (Retarder Configuration)	547
17-18	2 bytes	Reference Retarder Torque (Retarder Configuration)	556
19	1 byte	Percent Torque At Peak Torque, Point 5 (Retarder Configuration)	555

PGN 65250 (R) Transmission Configuration - TCFG

Total message length depends on total number of forward and reverse gear ratios.

NOTE: The first gear ratio transmitted in bytes 3,4 will be the highest reverse gear ratio. Additional 2-byte gear ratios will follow:

3,4 Highest reverse gear ratio
.
.
a,b Lowest reverse gear ratio
c,d Lowest forward gear ratio
.
.
e,f Highest forward gear ratio

Transmission Repetition	On request	
Data Length:	Variable	
Data Page:	0	
PDU Format:	254	
PDU Specific:	226	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65250	(0xFEE2)

Start Position	Length	Parameter Name	SPN
1	1 byte	Number of Reverse Gear Ratios	958
2	1 byte	Number of Forward Gear Ratios	957
3-4	2 bytes	Transmission Gear Ratio	581

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PGN 65251 Engine Configuration - EC

This map describes the stationary behavior of the engine and the speed dependent available indicated torque. This map should reflect the effect of changes due to barometric pressure, engine temperature, and any other stationary changes (sensor failures, etc.) which influence the engine torque curve more than 10%. This map is only valid for maximum boost pressure. At low boost pressures the torque limit may be much lower.

The engine configuration message must be sent at any time that the engine configuration map has changed by more than 10% of speed or torque (due to events other than boost pressure) since that last time the message was transmitted. As an alternative, it may be sent periodically, once every 5 s. It shall also be sent on response to a configuration request message.

The engine characteristic can be described in one of three modes. Mode 1 provides a complete curve of speed and torque points (see Figure PGN65251_A). Modes 2 and 3 provide a partial curve of speed and torque points and a separate endspeed governor characteristic. In modes 2 and 3, the receiver of the engine configuration message has to calculate the minimum of the engine torque curve and the endspeed governor characteristic to get the final available engine torque.

Mode 2 provides a high idle point where torque equals zero (point 6) and the endspeed governor gain Kp (see Figure PGN65251_B). Mode 3 provides the kick-in point of the endspeed governor (point 2) and the governor gain Kp (see Figure PGN65251_C).

The selection of the three modes can be done by setting the parameters as shown in Table PGN65251_A.

Transmission Repetition: On change of torque/speed points of more than 10% since last transmission. Alternatively , or every 5 s.
Data Length: 34
Data Page: 0
PDU Format: 254
PDU Specific: 227 PGN Supporting Information: See Appendix D - PGN 65251
Default Priority: 6
Parameter Group Number: 65251 (0xFEE3)

Start Position	Length	Parameter Name	SPN
01-02	2 bytes	Engine Speed At Idle, Point 1 (Engine Configuration)	188
03	1 byte	Engine Percent Torque At Idle, Point 1 (Engine Configuration)	539
04-05	2 bytes	Engine Speed At Point 2 (Engine Configuration)	528
06	1 byte	Engine Percent Torque At Point 2 (Engine Configuration)	540
07-08	2 bytes	Engine Speed At Point 3 (Engine Configuration)	529
09	1 byte	Engine Percent Torque At Point 3 (Engine Configuration)	541
10-11	2 bytes	Engine Speed At Point 4 (Engine Configuration)	530
12	1 byte	Engine Percent Torque At Point 4 (Engine Configuration)	542
13-14	2 bytes	Engine Speed At Point 5 (Engine Configuration)	531
15	1 byte	Engine Percent Torque At Point 5 (Engine Configuration)	543
16-17	2 bytes	Engine Speed At High Idle, Point 6 (Engine Configuration)	532
18-19	2 bytes	Engine Gain (Kp) Of The Endspeed Governor (Engine Configuration)	545
20-21	2 bytes	Engine Reference Torque (Engine Configuration)	544
22-23	2 bytes	Engine Maximum Momentary Override Speed, Point 7 (Engine Configuration)	533
24	1 byte	Engine Maximum Momentary Override Time Limit (Engine Configuration)	534
25	1 byte	Engine Requested Speed Control Range Lower Limit (Engine Configuration)	535
26	1 byte	Engine Requested Speed Control Range Upper Limit (Engine Configuration)	536
27	1 byte	Engine Requested Torque Control Range Lower Limit (Engine Configuration)	537
28	1 byte	Engine Requested Torque Control Range Upper Limit (Engine Configuration)	538
29-30	2 bytes	Engine Extended Range Requested Speed Control Range Upper Limit (Engine configuration)	1712
31-32	2 bytes	Engine Moment of Inertia	1794
33-34	2 bytes	Engine Default Torque Limit	1846

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PGN 65252 (R) Shutdown - SHUTDOW

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	228	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65252	(0xFEE4)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Engine Idle Shutdown has Shutdown Engine	593
1.3	2 bits	Engine Idle Shutdown Driver Alert Mode	594
1.5	2 bits	Engine Idle Shutdown Timer Override	592
1.7	2 bits	Engine Idle Shutdown Timer State	590
2.7	2 bits	Engine Idle Shutdown Timer Function	591
3.1	2 bits	A/C High Pressure Fan Switch	985
3.3	2 bits	Refrigerant Low Pressure Switch	875
3.5	2 bits	Refrigerant High Pressure Switch	605
4.1	2 bits	Engine Wait to Start Lamp	1081
5.1	2 bits	Engine Protection System has Shutdown Engine	1110
5.3	2 bits	Engine Protection System Approaching Shutdown	1109
5.5	2 bits	Engine Protection System Timer Override	1108
5.7	2 bits	Engine Protection System Timer State	1107
6.7	2 bits	Engine Protection System Configuration	1111
7.1	2 bits	Engine Alarm Acknowledge	2815
7.3	2 bits	Engine Alarm Output Command Status	2814
7.5	2 bits	Engine Air Shutoff Command Status	2813
7.7	2 bits	Engine Overspeed Test	2812

PGN 65253 Engine Hours, Revolutions - HOURS

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	229	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65253	(0xFEE5)

Start Position	Length	Parameter Name	SPN
1-4	4 bytes	Engine Total Hours of Operation	247
5-8	4 bytes	Engine Total Revolutions	249

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PGN 65254 ***Time/Date*** ***- TD***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	230	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65254	(0xFEE6)

Start Position	Length	Parameter Name	SPN
1	1 byte	Seconds	959
2	1 byte	Minutes	960
3	1 byte	Hours	961
4	1 byte	Month	963
5	1 byte	Day	962
6	1 byte	Year	964
7	1 byte	Local minute offset	1601
8	1 byte	Local hour offset	1602

PGN 65255 ***Vehicle Hours*** ***- VH***

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	231	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65255	(0xFEE7)

Start Position	Length	Parameter Name	SPN
1-4	4 bytes	Total Vehicle Hours	246
5-8	4 bytes	Total Power Takeoff Hours	248

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PGN 65256 Vehicle Direction/Speed - VDS

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	232	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65256	(0xFEE8)

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Compass Bearing	165
3-4	2 bytes	Navigation-Based Vehicle Speed	517
5-6	2 bytes	Pitch	583
7-8	2 bytes	Altitude	580

PGN 65257 Fuel Consumption (Liquid) - LFC

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	233	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65257	(0xFEE9)

Start Position	Length	Parameter Name	SPN
1-4	4 bytes	Engine Trip Fuel	182
5-8	4 bytes	Engine Total Fuel Used	250

PGN 65258 Vehicle Weight - VW

NOTE–Request has to be responded to with as many messages as necessary to transmit all available information.

Transmission Repetition	On request	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	234	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65258	(0xFEEA)

Start Position	Length	Parameter Name	SPN
1	8 bits	Axle Location	928
2-3	2 bytes	Axle Weight	582

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4-5	2 bytes	Trailer Weight	180
6-7	2 bytes	Cargo Weight	181

PGN 65259 Component Identification - CI

NOTE - The make, model, serial number and unit number fields in this message are optional and separated by an ASCII "*". It is not necessary to include all fields; however, the delimiter ("*") is always required.

Field:
a Make
Delimiter (ASCII "*")
b Model
Delimiter (ASCII "*")
c Serial number
Delimiter (ASCII "*")
d Unit number (Power unit)
Delimiter (ASCII "*")

Transmission Repetition	On request	
Data Length:	Variable	
Data Page:	0	
PDU Format:	254	
PDU Specific:	235	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65259	(0xFEEB)

Start Position	Length	Parameter Name	SPN
a	5 bytes	Make	586
b	Variable - up to 200 characters ("*" delimited)	Model	587
c	Variable - up to 200 characters ("*" delimited)	Serial Number	588
d	Variable - up to 200 characters ("*" delimited)	Unit Number (Power Unit)	233

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PGN 65260 Vehicle Identification - VI

Byte: 1-n Vehicle Identification Number
Delimiter (ASCII "*")

Transmission Repetition: On request
Data Length: Variable
Data Page: 0
PDU Format: 254
PDU Specific: 236 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65260 (0xFEEC)

Start Position	Length	Parameter Name	SPN
1	Variable - up to 200 characters ("*" delimited)	Vehicle Identification Number	237

PGN 65261 Cruise Control/Vehicle Speed Setup - CCSS

Transmission Repetition: On request
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 237 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65261 (0xFEED)

Start Position	Length	Parameter Name	SPN
1	1 byte	Maximum Vehicle Speed Limit	74
2	1 byte	Cruise Control High Set Limit Speed	87
3	1 byte	Cruise Control Low Set Limit Speed	88

PGN 65262 Engine Temperature 1 - ET1

Transmission Repetition: 1 s
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 238 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65262 (0xFEEE)

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Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Coolant Temperature	110
2	1 byte	Engine Fuel Temperature	174
3-4	2 bytes	Engine Oil Temperature 1	175
5-6	2 bytes	Engine Turbocharger Oil Temperature	176
7	1 byte	Engine Intercooler Temperature	52
8	1 byte	Engine Intercooler Thermostat Opening	1134

PGN 65263 Engine Fluid Level/Pressure 1 - EFL/P1

Transmission Repetition: 0.5 s
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 239 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65263 (0xFEEF)

Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Fuel Delivery Pressure	94
2	1 byte	Engine Extended Crankcase Blow-by Pressure	22
3	1 byte	Engine Oil Level	98
4	1 byte	Engine Oil Pressure	100
5-6	2 bytes	Engine Crankcase Pressure	101
7	1 byte	Engine Coolant Pressure	109
8	1 byte	Engine Coolant Level	111

PGN 65264 (R) Power Takeoff Information - PTO

Transmission Repetition: 100 ms
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 240 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65264 (0xFEF0)

Start Position	Length	Parameter Name	SPN
1	1 byte	Power Takeoff Oil Temperature	90
2-3	2 bytes	Power Takeoff Speed	186
4-5	2 bytes	Power Takeoff Set Speed	187
6.1	2 bits	Engine PTO Enable Switch	980
6.3	2 bits	Engine Remote PTO Preprogrammed Speed Control Switch	979
6.5	2 bits	Engine Remote PTO Variable Speed Control Switch	978
7.1	2 bits	Engine PTO Set Switch	984

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7.3	2 bits	Engine PTO Coast/Decelerate Switch	983
7.5	2 bits	Engine PTO Resume Switch	982
7.7	2 bits	Engine PTO Accelerate Switch	981
8.1	2 bits	Operator PTO Memory Select Switch	2897

PGN 65265 Cruise Control/Vehicle Speed - CCVS

Transmission Repetition: 100 ms
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 241 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65265 (0xFEF1)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Two Speed Axle Switch	69
1.3	2 bits	Parking Brake Switch	70
1.5	2 bits	Cruise Control Pause Switch	1633
2-3	2 bytes	Wheel-Based Vehicle Speed	84
4.1	2 bits	Cruise Control Active	595
4.3	2 bits	Cruise Control Enable Switch	596
4.5	2 bits	Brake Switch	597
4.7	2 bits	Clutch Switch	598
5.1	2 bits	Cruise Control Set Switch	599
5.3	2 bits	Cruise Control Coast (Decelerate) Switch	600
5.5	2 bits	Cruise Control Resume Switch	601
5.7	2 bits	Cruise Control Accelerate Switch	602
6	1 byte	Cruise Control Set Speed	86
7.1	5 bits	PTO State	976
7.6	3 bits	Cruise Control States	527
8.1	2 bits	Engine Idle Increment Switch	968
8.3	2 bits	Engine Idle Decrement Switch	967
8.5	2 bits	Engine Test Mode Switch	966
8.7	2 bits	Engine Shutdown Override Switch	1237

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PGN 65266 ***Fuel Economy (Liquid)*** ***- LFE***

Transmission Repetition	100 ms		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	242	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65266	(0xFEF2)	

Start Position	Length	Parameter Name	SPN
1-2	2 bytes	Engine Fuel Rate	183
3-4	2 bytes	Engine Instantaneous Fuel Economy	184
5-6	2 bytes	Engine Average Fuel Economy	185
7	1 byte	Engine Throttle Position	51

PGN 65267 ***Vehicle Position*** ***- VP***

Transmission Repetition	5 s		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	243	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65267	(0xFEF3)	

Start Position	Length	Parameter Name	SPN
1-4	4 bytes	Latitude	584
5-8	4 bytes	Longitude	585

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PGN 65268 ***Tire Condition*** ***- TIRE***

Tire Condition Message

NOTE–Message has to repeated as necessary to transmit all available information. This method of location identification requires individual SPNs to be assigned to report failures specific to each individual component (I.e. each tire, each axle, etc.).

Transmission Repetition	10 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	244	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65268	(0xFEF4)

Start Position	Length	Parameter Name	SPN
1	8 bits	Tire Location	929
2	1 byte	Tire Pressure	241
3-4	2 bytes	Tire Temperature	242
5.1	2 bits	CTI Wheel Sensor Status	1699
5.3	2 bits	CTI Tire Status	1698
5.5	2 bits	CTI Wheel End Electrical Fault	1697
6-7	2 bytes	Tire Air Leakage Rate	2586
8.6	3 bits	Tire Pressure Threshold Detection	2587

PGN 65269 ***Ambient Conditions*** ***- AMB***

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	245	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65269	(0xFEF5)

Start Position	Length	Parameter Name	SPN
1	1 byte	Barometric Pressure	108
2-3	2 bytes	Cab Interior Temperature	170
4-5	2 bytes	Ambient Air Temperature	171
6	1 byte	Engine Air Inlet Temperature	172
7-8	2 bytes	Road Surface Temperature	79

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PGN 65270 Inlet/Exhaust Conditions 1 - IC1

Transmission Repetition	0.5 s		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	246	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65270	(0xFEF6)	

Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Particulate Trap Inlet Pressure	81
2	1 byte	Engine Turbocharger Boost Pressure	102
3	1 byte	Engine Intake Manifold 1 Temperature	105
4	1 byte	Engine Air Inlet Pressure	106
5	1 byte	Engine Air Filter 1 Differential Pressure	107
6-7	2 bytes	Engine Exhaust Gas Temperature	173
8	1 byte	Engine Coolant Filter Differential Pressure	112

PGN 65271 Vehicle Electrical Power - VEP

Transmission Repetition	1 s		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	247	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65271	(0xFEF7)	

Start Position	Length	Parameter Name	SPN
1	1 byte	Net Battery Current	114
2	1 byte	Alternator Current	115
3-4	2 bytes	Alternator Potential (Voltage)	167
5-6	2 bytes	Electrical Potential (Voltage)	168
7-8	2 bytes	Battery Potential (Voltage), Switched	158

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PGN 65272 (R) Transmission Fluids - TF

Transmission Repetition: 1 s
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 248 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65272 (0xFEF8)

Start Position	Length	Parameter Name	SPN
1	1 byte	Clutch Pressure	123
2	1 byte	Transmission Oil Level	124
3	1 byte	Transmission Filter Differential Pressure	126
4	1 byte	Transmission Oil Pressure	127
5-6	2 bytes	Transmission Oil Temperature	177
7	1 bytes	Transmission Oil Level High / Low	3027
8.1	4 bits	Transmission Oil Level Countdown Timer	3028
8.5	4 bits	Transmission Oil Level Measurement Status	3026

PGN 65273 Axle Information - AI

Axle information message

NOTE–Message must be repeated as necessary to transmit all available information. This method of location identification requires individual SPNs to be assigned to report failures specific to each individual component (I.e. each tire, each axle, etc.).

Transmission Repetition: 1 s
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 249 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65273 (0xFEF9)

Start Position	Length	Parameter Name	SPN
1	1 byte	Steering Axle Temperature	75
2	8 bits	Drive Axle Location	930
3	1 byte	Drive Axle Lift Air Pressure	579
4	1 byte	Drive Axle Temperature	578
5	1 byte	Drive Axle Lube Pressure	2613
8	1 byte	Steering Axle Lube Pressure	2614

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PGN 65274 ***Brakes*** ***- B***

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	250	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65274	(0xFEFA)

Start Position	Length	Parameter Name	SPN
1	1 byte	Brake Application Pressure	116
2	1 byte	Brake Primary Pressure	117
3	1 byte	Brake Secondary Pressure	118
4.1	2 bits	Parking Brake Actuator	619

PGN 65275 ***Retarder fluids*** ***- RF***

Transmission Repetition	1 s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	251	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65275	(0xFEFB)

Start Position	Length	Parameter Name	SPN
1	1 byte	Hydraulic Retarder Pressure	119
2	1 byte	Hydraulic Retarder Oil Temperature	120

PGN 65276 ***Dash Display*** ***- DD***

Transmission Repetition	1s	
Data Length:	8	
Data Page:	0	
PDU Format:	254	
PDU Specific:	252	PGN Supporting Information:
Default Priority:	6	
Parameter Group Number:	65276	(0xFEFC)

Start Position	Length	Parameter Name	SPN
1	1 byte	Washer Fluid Level	80
2	1 byte	Fuel Level	96

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3	1 byte	Engine Fuel Filter Differential Pressure	95
4	1 byte	Engine Oil Filter Differential Pressure	99
5-6	2 bytes	Cargo Ambient Temperature	169

PGN 65277 Alternate Fuel 1 - A1

Transmission Repetition: 500 ms
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 253 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65277 (0xFEFD)

Start Position	Length	Parameter Name	SPN
1	1 byte	Engine Blower Bypass Valve Position	72
2-3	2 bytes	Engine Gas Supply Pressure	159

PGN 65278 Auxiliary Water Pump Pressure - AWPP

Transmission Repetition: 1 s
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 254 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65278 (0xFEFE)

Start Position	Length	Parameter Name	SPN
1	1 byte	Auxiliary Pump Pressure	73

PGN 65279 Water in Fuel Indicator - WFI

Transmission Repetition: 10 s
Data Length: 8
Data Page: 0
PDU Format: 254
PDU Specific: 255 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65279 (0xFEFF)

Start Position	Length	Parameter Name	SPN
1.1	2 bits	Water In Fuel Indicator	97

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APPENDIX D
SUPPORTING INFORMATION

SPN 16 – Fuel Filter (Suction Side) Differential Pressure

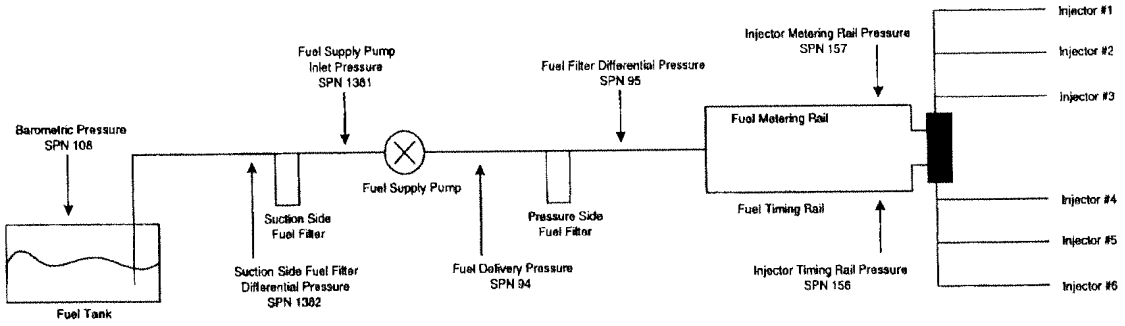


FIGURE SPN16_A—FUEL SYSTEM WITH RAILS

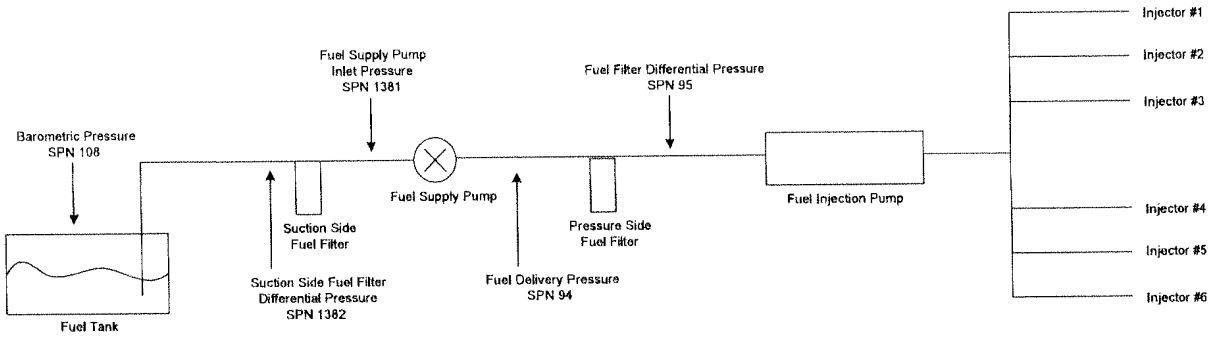


FIGURE SPN16_B—FUEL SYSTEM WITH PUMP

SPN 512 – Driver's Demand Engine – Percent Torque

Figure SPN512_A and Figure SPN512_B show two typical torque calculations in an engine controller. On the left side of the figures there are single engine controller functions. The output torque signals of these functions are connected in the manner shown. The result is the actual engine percent torque which is realized by the engine.

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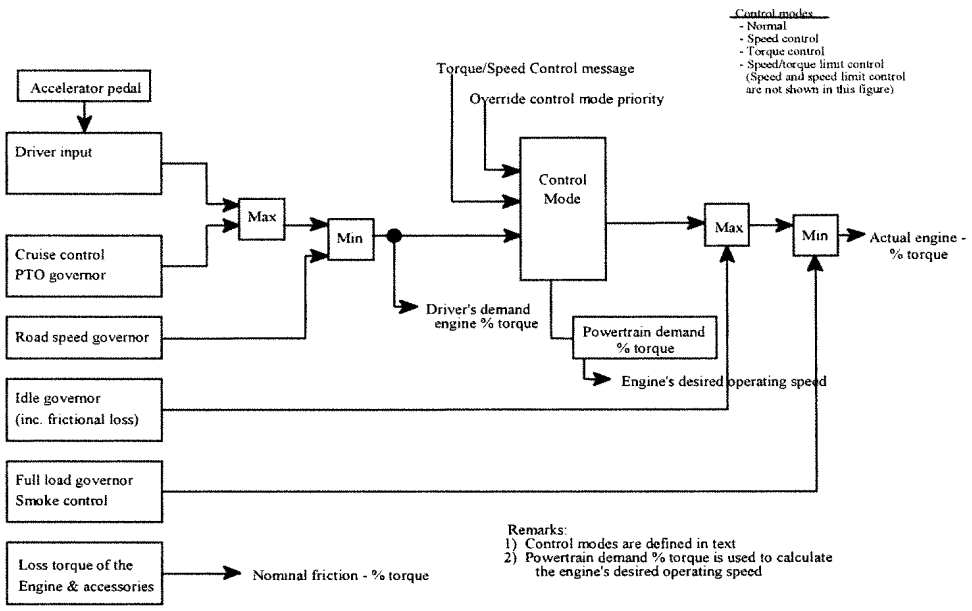


FIGURE SPN512_A —TORQUE COMMANDS AND CALCULATIONS WHEN A "MAXIMUM SELECTION FOR LOW IDLE" TECHNIQUE IS USED

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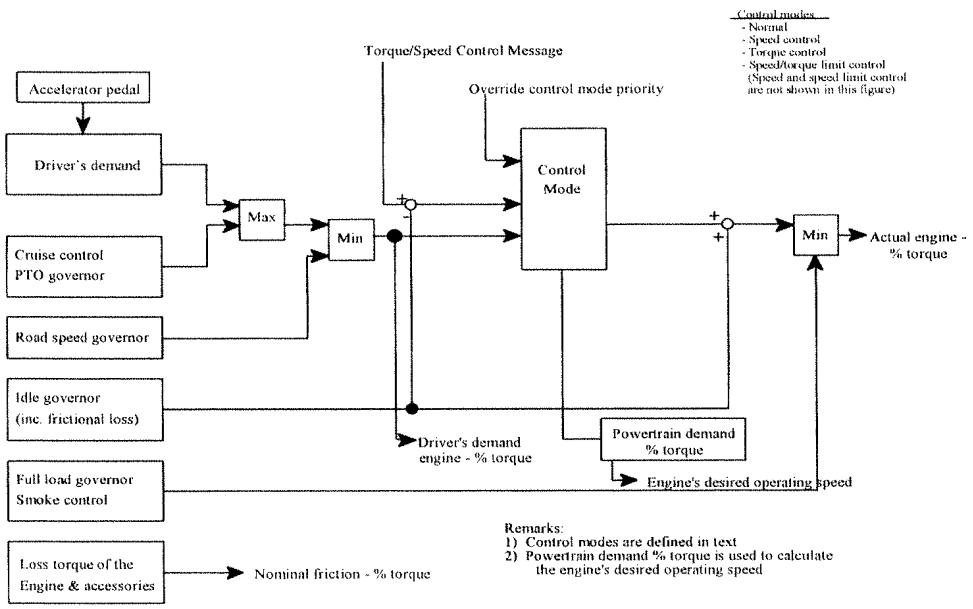


FIGURE SPN512_B —TORQUE COMMANDS AND CALCULATIONS WHEN A "SUMMATION WITH LOW IDLE" TECHNIQUE IS USED

On top of the figures, external torque commands (e.g., traction and transmission control) can control the engine. These commands can influence the engine torque by four control modes. Four engine internal signals are transmitted to the network:

a. Driver's demand engine - percent torque
b. Actual engine - percent torque
c. Nominal friction - percent torque
d. Engine's desired operating speed

The difference between Figure SPN512_A and Figure SPN512_B is the connection of the idle governor output to the torque calculation. In Figure SPN512_A there is a maximum selection, while in Figure SPN512_B a summation is used. The summation method needs a subtraction point for each external command input because the starting point of an ASR or a shift operation should be the present actual engine - percent torque value. As the actual engine - percent torque signal contains the idle governor output and the external commands are compared with the driver's demand engine - percent torque or the powertrain demand which don't contain the idle governor output, the external commands must be subtracted by the idle governor output to get the correct signals for comparison.

The advantage of the maximum selection (Figure SPN512_A) is that no other speed controller can work parallel to the idle governor. This allows for a better optimization of the different speed control loops. The advantage of the summation method (Figure SPN512_B) is that changes of the idle governor output influence the engine directly (no dead zones exist).

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SPN 518 – Engine Requested Torque/Torque Limit

When preparing to send a request to a retarder, the states of the Retarder Enable - Shift Assist Switch and the Retarder Enable - Brake Assist Switch must be checked by the requesting device to determine whether the request may be sent to the Retarder. Figure SPN518_A shows how those switches and other operator and network inputs are used to create the actual retarder operating point on a system-wide basis. The Retarder may or may not be the device reading the actual switches; even if it is, it will not accept or reject a request based on its knowledge of the switch states. Its function is to send the switch states via J1939 (in its ERC1 message) and it expects other J1939 nodes to honor those switch states by refraining from sending inappropriate commands.

Several elements affect the retarder besides the Requested Torque parameter in the TSC1 message. These elements are not looked at by the retarder itself, but are used by various other devices to determine if they may ask the retarder to be engaged. These are the Retarder Enable Shift Assist Switch, and the Retarder Enable Brake Assist Switch. The relationship between those switches and the retarder (as well as that between the operator and retarder) is described in Figure SPN518_A.

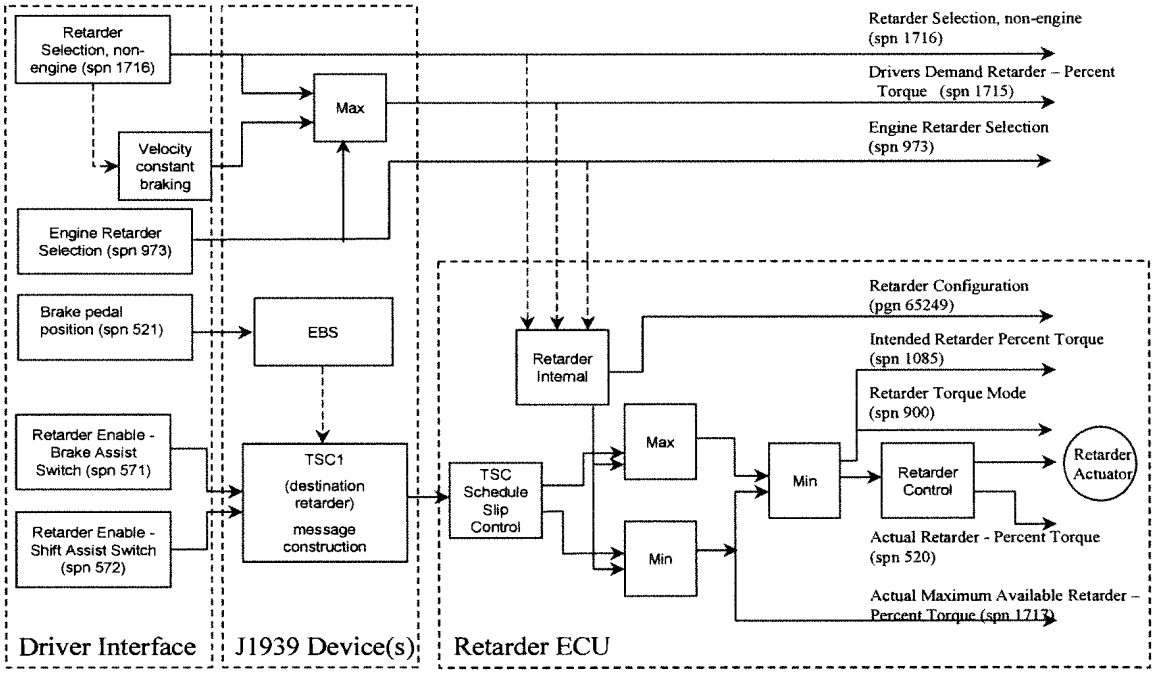


FIGURE SPN518_A—RELATIONSHIP BETWEEN OPERATOR/SWITCH INPUTS AND RETARDERS

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Tables SPN518_A and SPN518_B identify many use cases. Each row is the summary of one or more uses. One of the primary communications provided by these tables is that the retarder can be activated by the J1939 TSC1 message, although the operator input is "off."

TABLE SPN518_A—PRIMARY RETARDER – BEFORE TRANSMISSION (Compression Release Engine Retarder)

Operator Inputs				Outputs	
J1939 Inputs[1] (TSC1)	Cruise Control[2]	Accel Pedal[3]	Torque Request Via "Retarder Selection, Engine"[4]	May Retarder Provide Brake Torque?	Retarder Torque Mode (base 2)
T	Any	Any	Any	No	0000
R	Any	Any	Any	Yes	> 0001
NTR	Any	T	Any	No	0000
NTR	R	ZR	R	Yes	> 0001
NTR	R	ZR	ZR	Yes	0010
NTR	NTR	ZR	R[5]	Yes[5]	0001
NTR	NTR	ZR	ZR	No	0000
ZR	Any	Any	Any	No	0000

Key:
T = request positive Torque
R = request Retarder torque
NTR = No Torque Request
ZR = Zero torque Requested by retarder
Any = This value has no bearing whether or not the Retarder is available. The retarder will NOT be available because some other entity is requesting positive torque.

Footnotes:
1. Note that the TSC1 inputs will override Operator Torque Selection. The J1939 devices that generate the TSC1 messages will assure that the Retarder Enable Brake Assist Switch and Retarder Enable Shift Assist Switch are enabled as appropriate before commanding the Retarder to engage. See parameters SPN 571 and 572 for descriptions of these switches. Also, for the purposes of this table, it is assumed that if the TSC1, Destination Retarder message is requesting Retarder Torque, no other TSC1, Destination Engine messages are requesting engine fueling. That arbitration is beyond the scope of this section.
2. This refers to the torque requested by the cruise control, and does not refer to the cruise switches. Cruise control is defined to be on and engaged in this column. The cruise control should not request retarder torque unless the Retarder Enable - Brake Assist Switch is enabled.
3. The Accelerator Pedal is inherently incapable of requesting negative torque. It may have no particular torque demands, or it may request some engine fueling, which prevents the retarder from engaging. Consequently, the chart is complete even though no rows exist for the AP to request retarder torque.
4. The Operator Torque Request is incapable of requesting positive torque. The table is complete without the Operator Torque Request asking for positive Engine Torque
5. This description assumes no other switch (such as brake pedal depressed) is needed in order for the operator torque request to initiate retarder braking. Other implementation specific rules would apply if such a catalyst were needed.

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Table SPN518_B shows the relationship between various inputs and an after engine retarder. The biggest difference between this type of retarder and an engine brake is that the exhaust brake may be engaged while the engine is still being fueled. Also, if cruise control is communicating with the retarder, it would do so using the TSC1 message.

Consequently, columns for accelerator pedal input and cruise control input would only serve to confuse the issue of retarder availability in Table SPN518_B.

TABLE SPN518_B—PRIMARY RETARDER – AFTER ENGINE (EXHAUST BRAKE, HYDRAULIC RETARDER)

Operator Inputs		Outputs	
J1939 Inputs[1] (TSC1)	**Torque Request Via operator torque request[2]**	**May Retarder Provide Brake Torque?**	**Retarder Torque Mode (base 2)**
R	R	Yes	> 0001
R	ZR	Yes	> 0001
NTR	R[3]	Yes[3]	0001
NTR	ZR	No	0000
ZR	Any	No	0000

Key:
R = request Retarder torque - some amount of braking torque is requested of the retarder.
ZR = Zero Retarder request - Zero percent torque is requested of the retarder
NTR = No retarder Torque Request - No request is being made of the retarder one way or another.
Any = This value has no bearing whether or not the retarder is available. In fact, because of what some other entity is requesting, the retarder will NOT be available.

Footnotes:
1. Note that the TSC1 inputs will override Operator Torque Selection. The J1939 devices that generate the TSC1 messages will assure that the Retarder Enable Brake Assist Switch and Retarder Enable Shift Assist Switch are enabled before commanding the Retarder to engage. Also, for the purposes of this table, it is assumed that if the TSC1, Destination Retarder message is requesting Retarder Torque, no other TSC1, Destination Engine messages are requesting engine fueling. That arbitration is beyond the scope of this section.
2. The Operator Torque Request is incapable of requesting positive torque. The table is complete without the Operator Torque Request asking for positive Engine Torque
3. This description assumes no other switch (such as brake pedal depressed) is needed in order for the operator torque request to initiate retarder braking. Other implementation specific rules would apply if such a requirement were needed.

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SPN 519 – Desired Operating Speed Asymmetry Adjustment

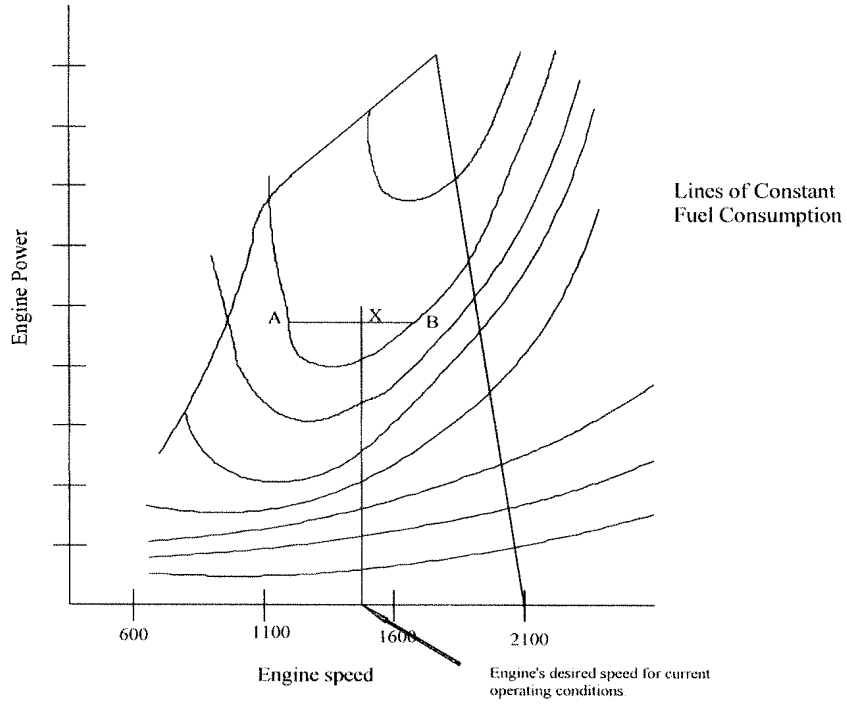


FIGURE SPN519_A—DESIRED OPERATING SPEED ASYMMETRY ADJUSTMENT

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SPN 527 – Cruise Control States

TABLE SPN527_A —CRUISE CONTROL STATES

Bit States	Cruise Control State
000	Off/Disabled
001	Hold
010	Accelerate
011	Decelerate/Coast
100	Resume
101	Set
110	Accelerator override
111	Not available

State Descriptions:
000b Off/Disabled —Used to indicate that the cruise control device is off or on standby. Note that the cruise control system switch does not necessarily have to be off to be in this mode.

001b Hold —Used to indicate that the cruise control device is active and currently maintaining a captured operating speed.

010b Accelerate —Used to indicate that the cruise control device is in the process of ramping up the operating speed.
011b Decelerate —Used to indicate that the cruise control device is in the process of ramping down, or coasting, the operating speed.

100b Resume —Used to indicate that the cruise control device is in the process of resuming the operating speed to a previously captured value.

101b Set —Used to indicate that the cruise control device is establishing the current vehicle speed as the operating speed (captured value).

110b Accelerator Override —Used to indicate that the cruise control device is active but not currently maintaining the captured operating speed.

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SPN 564 – Differential Lock Positions

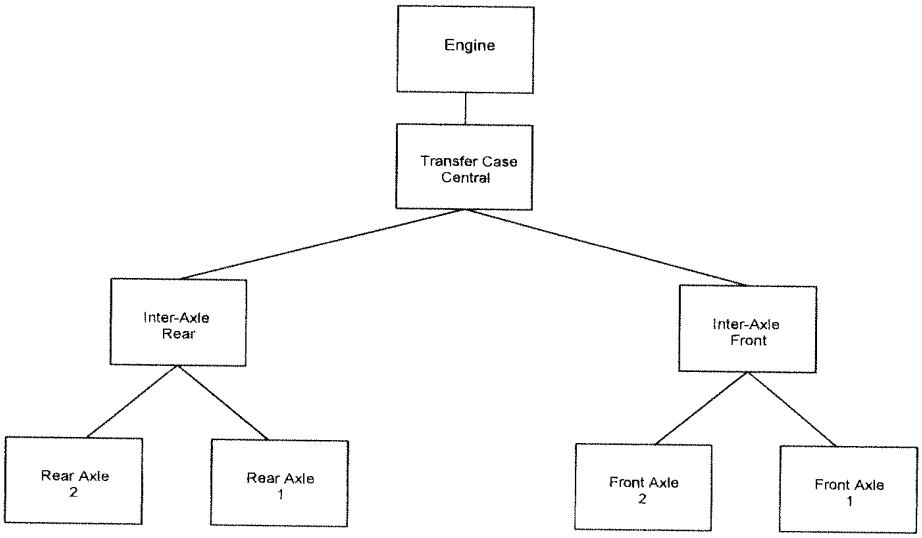


FIGURE SPN564_A—DIFFERENTIAL LOCK POSITIONS

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SPN 574 – Shift in Process

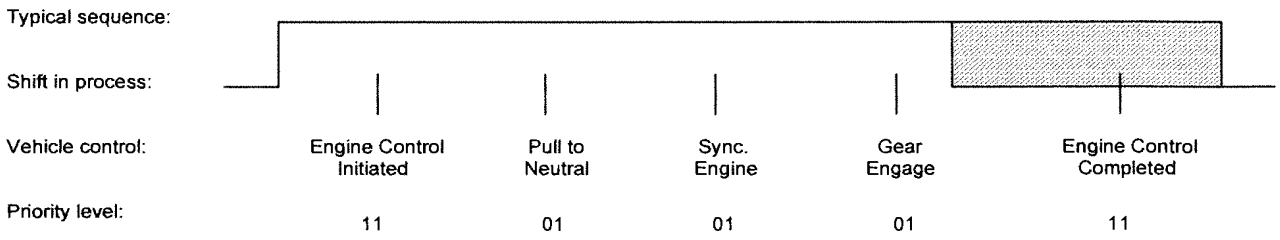


FIGURE SPN574_A —SHIFT IN PROCESS

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SPN 590 – Idle Shutdown

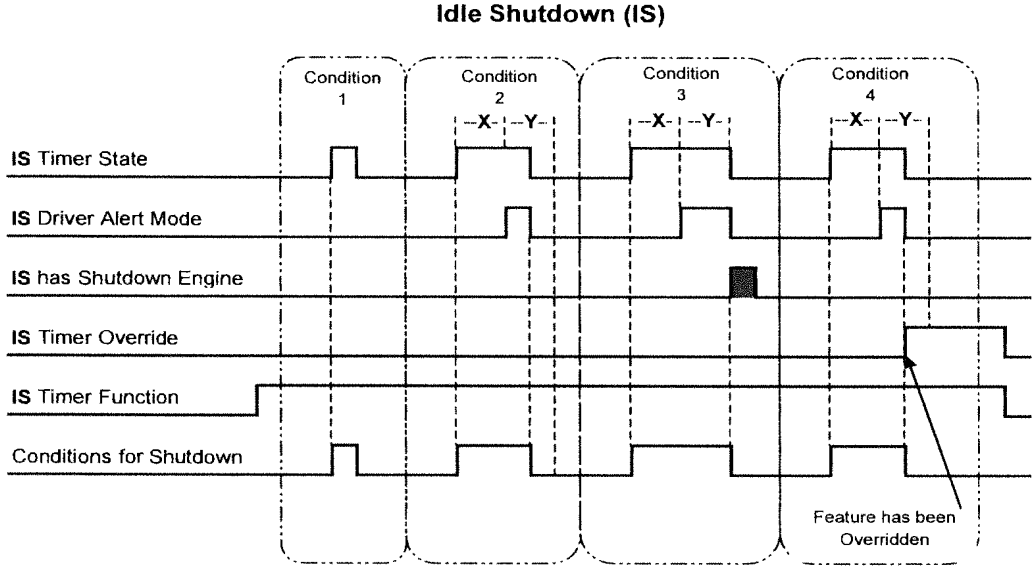


FIGURE 590_A —IDLE SHUTDOWN (IS)

Condition 1 - When the IS Timer Override is inactive, the IS Timer State will become inactive if the conditions for shutdown no longer exist before the "X" time interval has expired or IS Driver Alert Mode is activated.

Condition 2 - When the IS Timer Override is inactive, the IS Timer State will become inactive if the conditions for shutdown no longer exist before the IS Driver Alert Mode "Y" time interval has expired.

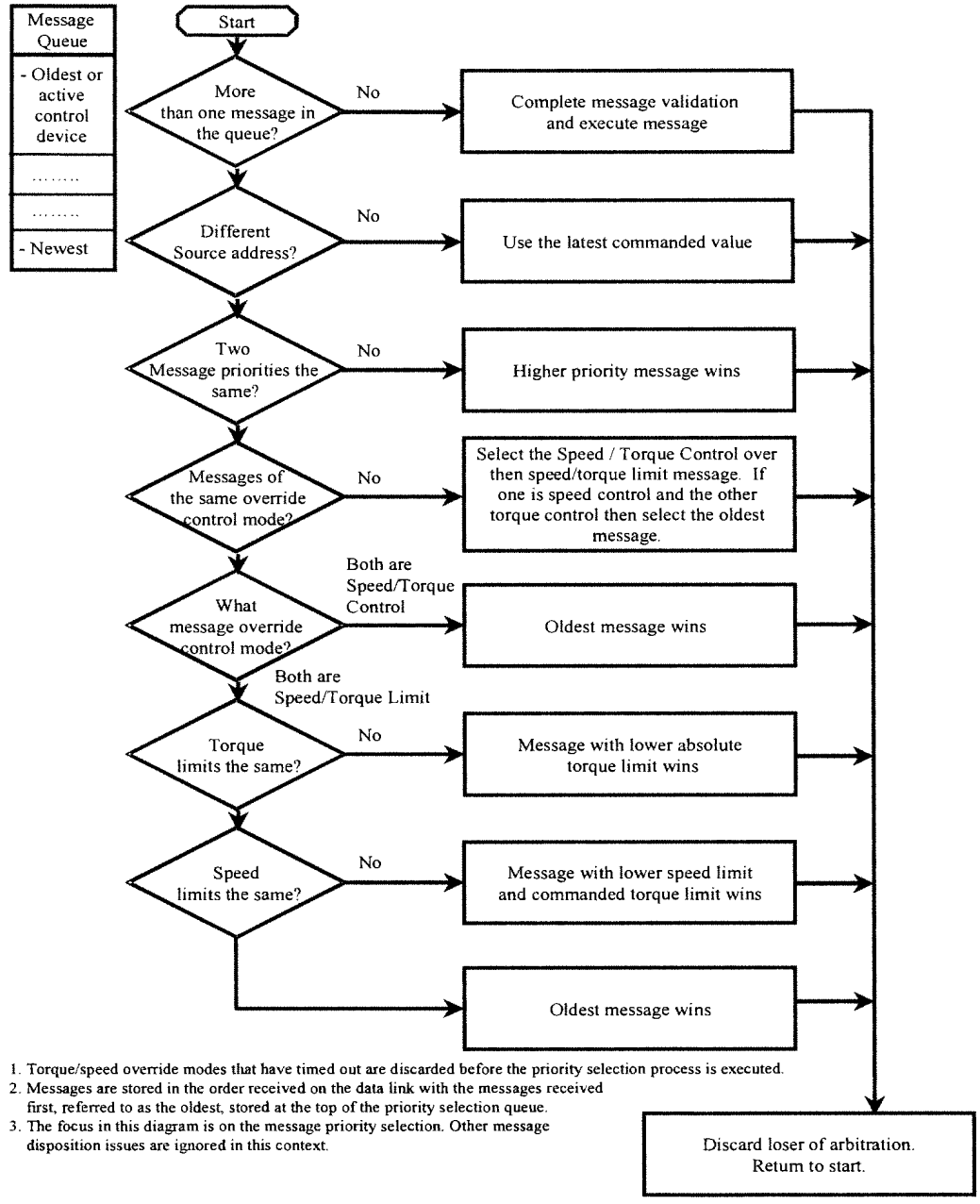
Condition 3 - When the IS Timer Override is inactive, then the IS has Shutdown Engine will be active after the "Y" time interval has expired.

Condition 4 - When the IS Timer Override is active during the "Y" time interval, then the IS feature shall be overridden and will no longer be available until the system has been re-initated.

NOTE —0 State – Inactive, disabled in calibration, or conditions for idle shutdown do not exist.
1 State – Active, enabled in calibration, or conditions for idle shutdown do exist.

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SPN 695 – Engine Override Control Mode



1. Torque/speed override modes that have timed out are discarded before the priority selection process is executed.
2. Messages are stored in the order received on the data link with the messages received first, referred to as the oldest, stored at the top of the priority selection queue.
3. The focus in this diagram is on the message priority selection. Other message disposition issues are ignored in this context.

FIGURE SPN695_A—TORQUE/SPEED CONTROL PRIORITY SELECTION LOGIC

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SPN 899 – Engine/Retarder Torque Modes

TABLE SPN899_A—ENGINE/RETARDER TORQUE MODES

Bit States	Engine/Retarder Torque Mode
0000	Low idle governor/no request (default mode)
0001	Accelerator pedal/operator selection
0010	Cruise control
0011	PTO governor
0100	Road speed governor
0101	ASR control
0110	Transmission control
0111	ABS control
1000	Torque limiting
1001	High speed governor
1010	Braking system
1011	Remote accelerator
1100	Service procedure
1101	not defined
1110	Other
1111	Not available

State Descriptions:
0000b Low Idle Governor/No request (Default mode) - This mode is active if the accelerator pedal (not necessarily the torque output of the driver input, see Figure SPN512_A and Figure SPN512_B) is zero. This is the default mode. At low speed, the low idle governor may be active while at higher speed, it is zero.

0001b Accelerator Pedal - This mode is active if the accelerator pedal position is active (being followed). This mode is active for the retarder if it is turned on by the operator. Note that it may be disabled by the accelerator pedal or clutch switches (operator selection).

0010b Cruise Control - This mode is active if cruise control is active and greater than the accelerator pedal request.

0011b PTO Governor - This mode is active if the PTO governor is active.

0100b Road Speed Governing - Indicates that road speed governing is active and limiting torque.

0101b ASR Control - Indicates that the ASR command is active (Speed, Torque, or Speed/Torque Limit Control).

0110b Transmission Control - Indicates that the transmission command is active (Speed, Torque, or Speed/Torque Limit Control).

0111b ABS Control - Indicates that the ABS is controlling torque.

1000b Torque Limiting - This mode is active if the demanded or commanded engine torque is limited by internal logic due to full load, smoke and/or emissions control, engine protection and/or other factors. A reduced torque limit may be necessary for engine protection if the engine temperature is too high or a sensor fails (speed, timing, or boost pressure), as examples.

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1001b High Speed Governor - This mode is active if the engine is controlled by the high speed governor due to normal operation.

1010b Brake System (Electronic) - This indicates that the brake pedal is controlling the torque. Note that this may include enabling of the retarder when the brake pedal is depressed (touched).

Note that if there is a request to the retarder but operating conditions do not allow braking, this situation will be reflected by the Percent Retarder Torque = 0 when broadcast.

1011b Remote Accelerator - This mode is active if the remote accelerator is controlling engine speed.

1100b Service procedure - This mode is active if the engine is operating in a specific service mode. For example, fuel injection may be disabled to allow a service procedure to crank the engine without fuel injection occurring.

1110b Other - Torque control by a type of device which is different than those defined in states 0000b to 1100b.

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SPN 901 – Retarder Type

TABLE SPN901_A —RETARDER TYPES

Bit States	Retarder Type
0000	Electric/Magnetic
0001	Hydraulic
0010	Cooled Friction
0011	Compression Release (Engine retarder)
0100	Exhaust
0101-1101	Not defined
1110	Other
1111	Not available

Electric/Magnetic Retarder - The electric/magnetic retarder functions by creating eddy currents generated in a conductive armature when placed in a variable magnetic field. Currently, electric retarders have a stator on which field coils are mounted. The rotors, mounted on both sides of the drive shaft, are ribbed for heat dissipation. In order to brake the vehicle, voltage is applied to the field coils which generate a magnetic field inducing eddy currents in the rotors as they pass through the field. Magnetic retarders use a permanent magnet to generate the eddy currents. Braking-torque is dependent on stator excitation and on the air gap between the rotor and the stator.

Hydraulic Retarder - The hydraulic retarder is a hydrodynamic coupling device. Two impellers which face each other, a rotor and a stator, are filled with oil. When the rotor, which is connected to the vehicle drive shaft rotates, it drives the oil in the direction of rotation. The mechanical energy produced by the rotor is converted into kinetic energy in the operating fluid. Hydrodynamic coupling between the rotor and stator converts the kinetic energy into heat and the rotor is retarded. This retardation effect is transmitted to the drive shaft and the vehicle is retarded.

Cooled Friction Brake - The cooled friction brake uses air or hydraulic fluid to dissipate heat from the friction surface of the service brake. By controlling the friction surface temperature, retarding torque is improved, along with a reduced rate of wear.

Compression Release Engine Retarder - The compression release engine retarder converts a power-producing diesel engine into a power-absorbing retarding mechanism by opening the exhaust valve near the top dead center in the engine compression cycle. No positive power will be produced, since the compressed air mass is released. The vehicle is retarded as it must provide energy to compress the cylinder air charge and subsequently to return the piston to the bottom position.

Exhaust Brake - The exhaust brake restricts the escape of the exhaust gas from the exhaust manifold. Each succeeding exhaust stroke builds up a back pressure in the manifold which exerts a retarding effect to the pistons during the exhaust stroke. The engine turns against this back pressure creating a braking effect to the vehicle.

Auxiliary Retarder - Fans, air conditioners, or any power-absorbing device in the vehicle can also function as retarders as they impose parasitic loading on the engine or vehicle.

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SPN 902 – Retarder Location

TABLE SPN902_A—RETARDER LOCATION

Bit States	Retarder Location
0000 (Primary)	Engine Compression Release Brake (Engine rpm)
0001 (Primary)	Engine Exhaust Brake (Exhaust pressure)
0010 (Primary)	Transmission Input (Engine rpm)
0011 (Secondary)	Transmission Output (Output Shaft rpm)
0100 (Secondary)	Driveline (Output Shaft rpm)
0101	Trailer (Vehicle speed)
0110-1101	Not defined
1110	Other
1111	Not available

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SPN 911 – Service Component Identification

TABLE SPN911_A—SERVICE COMPONENT IDENTIFICATION

Identification	Component
0	Service check for entire vehicle
1	Brake lining; left front axle
2	Brake lining; right front axle
3	Brake lining; left rear axle
4	Brake lining; right rear axle
5	Clutch lining
6-10	Not defined
11	Brake lining; left rear axle #2
12	Brake lining; right rear axle #2
13	Brake lining; left rear axle #3
14	Brake lining; right rear axle #3
15	Brake lining: general
16	Regulated general check for entire vehicle
17	Brake system special check
18	In-between check
19	Check trip recorder
20	Check exhaust gas
21	Check vehicle speed limiter
22-29	Not defined
30	Engine coolant change
31	Engine coolant filter change
32	Engine oil—engine #1
33	Engine oil—engine #2
34	Not defined
35	Steering oil
36	Not defined
37	Transmission oil—transmission #1
38	Transmission oil—transmission #2
39	Not defined
40	Intermediate transmission oil
41	Not defined
42	Front axle oil
43	Rear axle oil
44-47	Not defined
48	Tires
49	Engine air filter
50	Engine oil filter
51	Engine Fuel Filter
52-60	Not defined
61	Tachograph
62	Driver card #1
63	Driver card #2
64-239	Not defined
240-249	Manufacturer specific
250-251	Reserved
252	Reset all components
253	No action to be taken
254	Error
255	Component identification not available

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SPN 976 – PTO States

TABLE SPN976_A—PTO STATES

Bit States	PTO State
00000	Off/Disabled
00001	Hold
00010	Remote Hold
00011	Standby
00100	Remote Standby
00101	Set
00110	Decelerate/Coast
00111	Resume
01000	Accelerate
01001	Accelerator Override
01010	Preprogrammed set speed 1
01011	Preprogrammed set speed 2
01100	Preprogrammed set speed 3
01101	Preprogrammed set speed 4
01110	Preprogrammed set speed 5
01111	Preprogrammed set speed 6
10000	Preprogrammed set speed 7
10001	Preprogrammed set speed 8
10010	PTO set speed memory 1
10011	PTO set speed memory 2
10100-11110	Not defined
11111	Not available

Off/Disabled 00000b - Used to indicate that the PTO enable switch is in the off position.

Hold 00001b - Used to indicate that the PTO device is active and currently maintaining a captured operating speed.

Remote Hold 00010b - Used to indicate that the remote PTO device is active and currently maintaining a captured operating speed.

Standby 00011b - Used to indicate that the PTO device enable switch is in the ON position and it is possible to manage the PTO device.

Remote Standby 00100b - Used to indicate that the remote PTO device enable switch is in the ON position and it is possible to manage the PTO device.

Set 00101b - Used to indicate that the PTO device is establishing current speed as the operating speed (captured value).

Decelerate/Coast 00110b - Used to indicate that the PTO device is in the process of ramping down, or coasting, from the current operating speed.

Resume 00111b - Used to indicate that the PTO device is in the process of resuming the operating speed to a previously captured value.

Accelerate 01000b - Used to indicate that the PTO device is in the process of ramping up the operating speed.

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Accelerator Override 01001b - Used to indicate that the PTO device is active but for the present time the engine is controlled by a large driver's demand.

Preprogrammed Set Speed 1 01010b - Used to indicate that the PTO device is establishing a first preprogrammed set speed (user programmable) as the current operating speed.

Preprogrammed Set Speed 2 01011b - Used to indicate that the PTO device is establishing a second preprogrammed set speed (user programmable) as the current operating speed.

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SPN 988 – Trip Group 1

TABLE 988_A—TRIP GROUP 1

Parameter	SPN
Trip distance	244
Trip fuel	182
High resolution trip distance	918
Trip compression brake distance	990
Trip service brake applications	993
Trip maximum engine speed	1013
Trip average engine speed	1014
Trip drive average load factor	1015
Trip average fuel rate	1029
Trip average fuel rate (Gaseous)	1031
Parameter Group	**PGN**
Trip time information #2	65,200
Trip time information #1	65,204
Trip shutdown information	65,205
Trip vehicle speed/cruise distance information	65,206
Trip fuel information (Gaseous)	65,208
Trip fuel information	65,209
Trip distance information	65,210
Trip fan information	65,211

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SPN 1014 – Trip Average Engine Speed

The equation is as follows:

$$\text{Trip average engine speed} = \frac{\sum_{i=0}^{N} \text{RPM}(i)}{N} \qquad \text{(Eq.SPN1014\_A)}$$

where:

RPM is the engine speed at sample i, N is the number of samples of engine speed and is proportional to the current trip elapsed time

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SPN 1085 – Intended Retarder Percent Torque

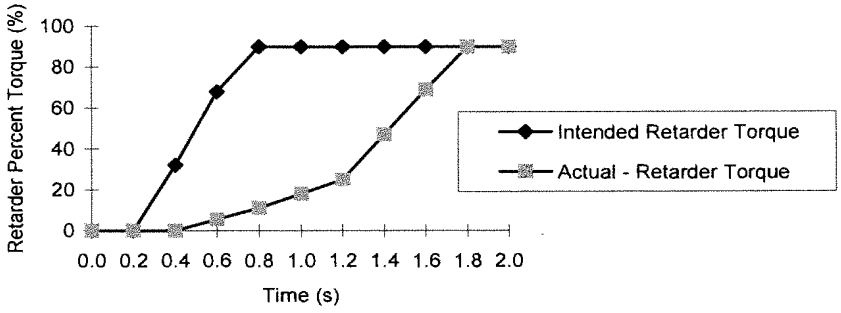
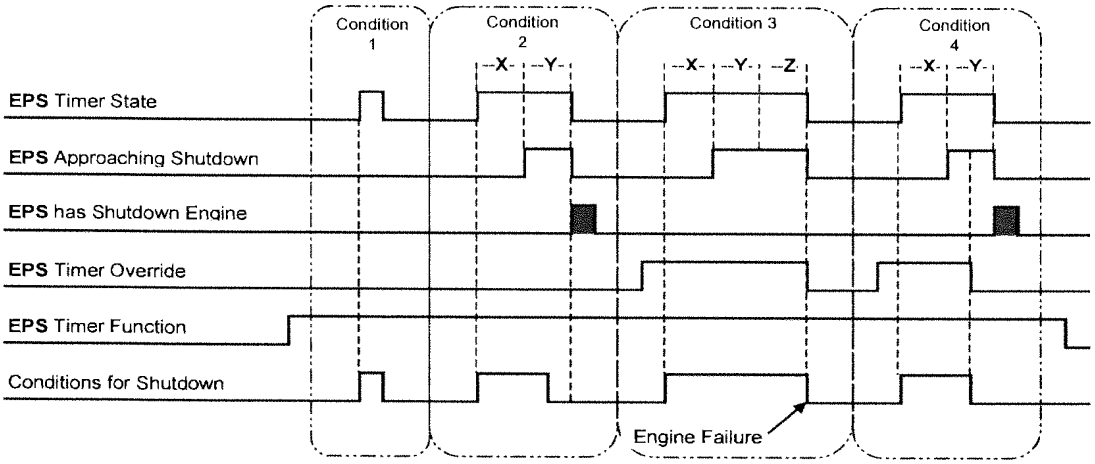


FIGURE SPN1085_A—INTENDED RETARDER PERCENT TORQUE

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Engine Protection System (EPS)



SPN 1107 – Engine Protection System Timer State

FIGURE SPN1107_A—ENGINE PROTECTION SYSTEM (EPS)

Condition 1 – When the EPS Timer Override is inactive, the EPS Timer State will become inactive if the conditions for shutdown no longer exist before the "X" time interval has expired or EPS Approaching Shutdown is activated.

Condition 2 – When the EPS Timer Override is inactive and conditions for shutdown exist during the "Y" time interval, then the Engine will shutdown, even though shutdown conditions subside before the "Y" time interval has expired.

Condition 3 – When the EPS Timer Override is active, then the EPS feature shall be overridden allowing for an engine failure when the "Z" time interval has expired.

Condition 4 – When the EPS Timer Override is active and then allowed to go inactive during the "Y" time interval, the response by the EPS shall be the same as condition 2. The time intervals for "X" and "Y" shall always start when conditions for shutdown first commence regardless whether the EPS Timer Override is enabled or not.

NOTE —0 State – Inactive, disabled in calibration, or conditions for Engine Protection do not exist.
1 State – Active, enabled in calibration, or conditions for Engine Protection do exist.

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SPN 1734 – Nominal Level Front Axle

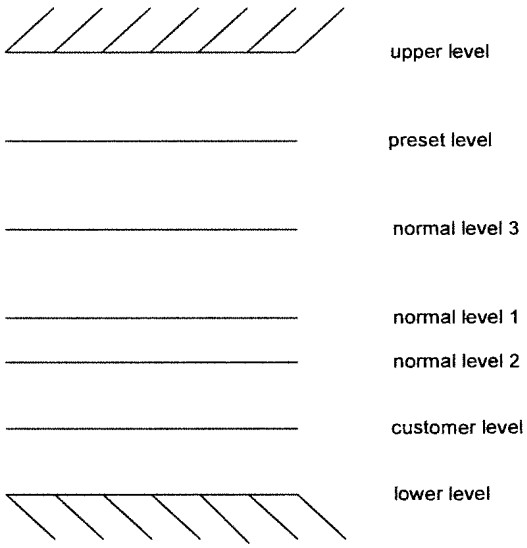


FIGURE SPN1734_A: EXAMPLE FOR NOMINAL LEVELS

If the vehicle height, to be controlled by the ASC, is not within the tolerances of the defined nominal levels, the nominal level is set to not specified.

The defined vehicle heights can be activated via the ASC 2 (PGN: 53760) message or via a remote control (see figure SPN1734_B). The remote control is an external unit to operate the suspension system.

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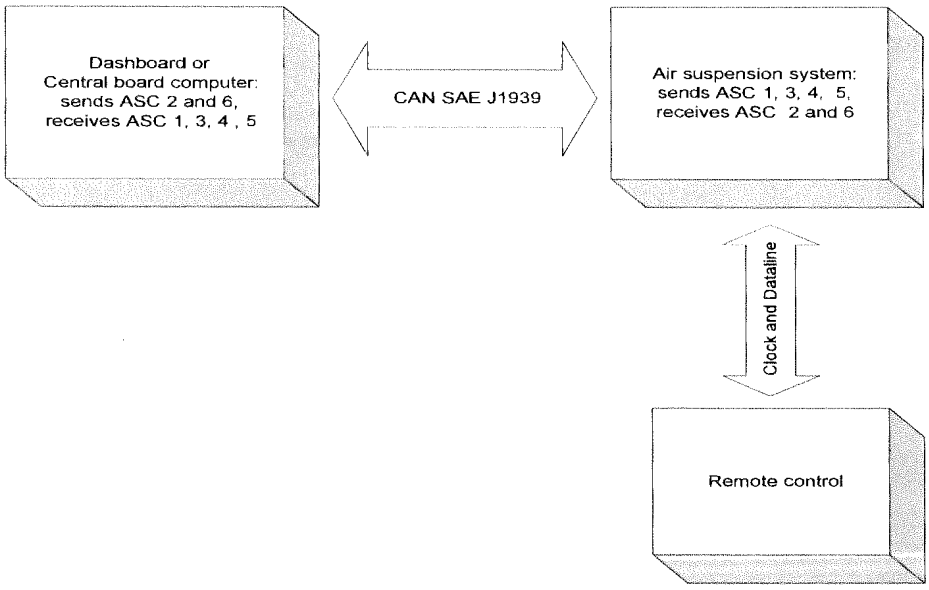


FIGURE SPN1734_B: POSSIBLE INTEGRATION OF ASC SYSTEM INTO VEHICLE NETWORK

An example: The nominal level is the normal level 1. Via remote control a new nominal level (for instance upper level) is requested. The nominal level is then set to upper level and during the height modification the ASC is indicating that the actual level is below nominal level until the upper level is reached.

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SPN 2432 – Engine Demand - Percent Torque

Background:

During periods of TSC#1 engine control, other devices on the J1939 network may wish to know where the engine wants to go once it is released from TSC#1 control. In order for option transitions of driveline torque between different devices, it becomes necessary to understand the *engine's* desired torque for all phases of a TSC#1 control sequence.

Driver's Demand Engine – Percent Torque (SPN 512) provides a partial prediction of the torque the engine wishes to produce after a TSC#1 command is removed. Included in Driver's Demand Torque are external requestors to the powertrain such as accelerator pedal, cruise control, and road speed limit governors. However, *excluded* from DDT are (1) dynamic commands within the powertrain such as smoke control, noise control, and low and high speed engine governing, and (2) external TSC#1 commands to the engine such as those generated by traction control.

For a controller to properly determine the engine's desired output torque during a TSC#1 sequence, it needs knowledge of the torque being scheduled by all active controls within the engine. Since DDT excludes many of these active controllers from its calculation, it cannot be used to accurately predict the desired output torque. The effects of the external TSC#1 commands can be approximated by other devices by means of monitoring TSC#1 messages to the engine; however the effects of the engine's internal dynamic commands are completely unknown and cannot be estimated.

Actual Engine – Percent Torque (SPN 513) provides a window to the engine's desired torque output when no TSC#1 commands are actively controlling the engine. However, when the engine is responding to TSC#1 commands, the Actual Engine – Percent Torque parameter is no longer indicative of the torque that the engine will produce once those TSC#1 commands are removed.

In simplest terms, Engine Demand – Percent Torque (or "EDT") contains the engine's internal dynamic commands that are excluded from the Driver's Demand Engine – Percent Torque definition, including smoke control, noise control, and low and high speed governing. With this additional piece of information, devices on the network that are controlling the engine via TSC#1 messages can determine the torque direction of the engine once the current TSC#1 command is relinquished.

It is important to note that the proposed EDT parameter is used as information. The addition of the EDT parameter should in no way cause a change to the engine's actual torque command architecture.

EDT Calculation:

When no devices are controlling the engine via TSC#1 messages, the value of EDT is equal to the Actual Engine – Percent Torque parameter. When the engine is being controlled via a TSC#1 message, it is necessary for the engine controller to calculate what its' target torque *would be* if there were no external commands being received. This "runner up" in engine control will come from internal dynamic engine commands.

In the calculation of Actual Engine – Percent Torque, the output of the engine's idle governor must be considered, along with the impact of the engine's full load governor, smoke controls and other internal limiting logic. In the determination of the Engine Demand Torque parameter, these same engine logic components are needed, as indicated in Figure SPN 2432_A. However, there is a significant difference: These components only affect the Actual Engine – Percent Torque parameter determination if they are the component *actively* controlling the engine. In EDT, any of these components will be used to calculate EDT if they are the *"runner up"* for engine control. Even though these components may lose in the

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engine's internal control arbitration, the engine output torque that they would produce if in command needs to be found to determine EDT.

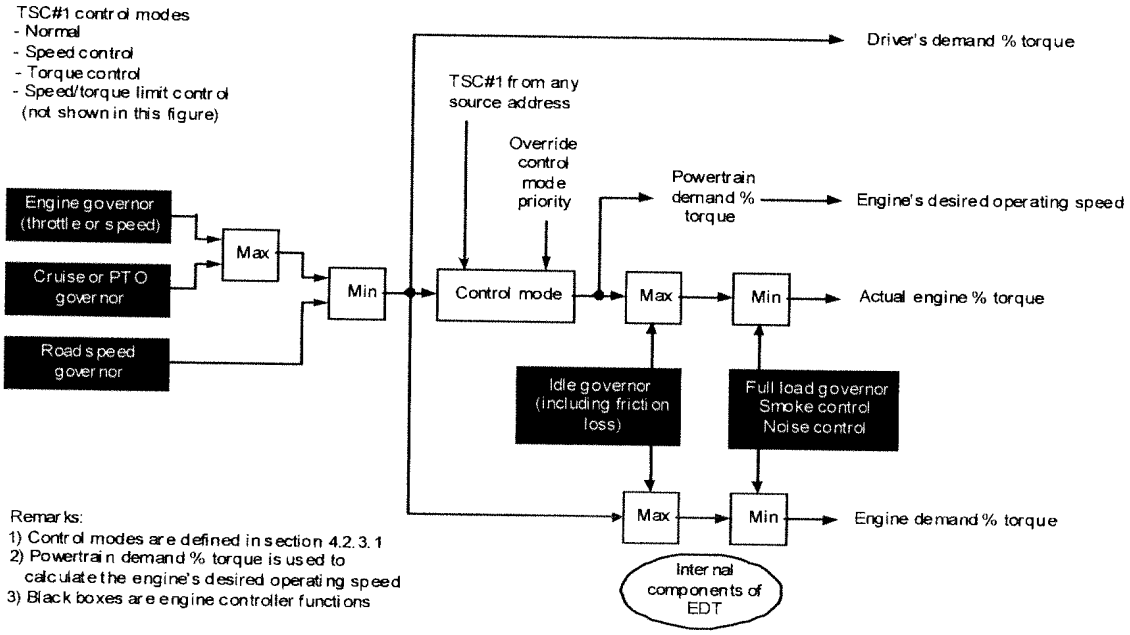


FIGURE SPN2432_A – TORQUE COMMANDS AND CALCULATIONS WHEN A "MAXIMUM LOW IDLE" TECHNIQUE IS USED

If speed governors are involved in determining these components of the EDT calculation, any of the following 3 special cases may need to be addressed:

Special Case #1: Speed Governors

If the engine governor referenced in Figure SPN2432_A is a speed-based governor instead of a throttle table arrangement, a new challenge is presented in determining EDT. Since the speed governor output is directly influenced by the TSC#1 command in control (for example, integrator anti-windup logic), the speed governor's output during TSC#1 commands cannot be used to calculate EDT.

Instead, an *approximation* of the speed governor output without the effects of any TSC#1 commands is required for use in the EDT calculation. "Approximation" refers to removing the effects of integrator terms and any other dynamic components that result from the controlling TSC#1 commands. All elements affecting the speed governor reference should be included before the reference is translated into terms of torque.

All control algorithms with dynamic elements (e.g., speed governors) that execute during TSC#1 commands need to have their outputs replaced by "steady-state" approximations for use in the EDT

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calculation. Again note that these approximations are for use only in the EDT calculation; the actual engine control logic remains unchanged.

Figure SPN2432_B illustrates EDT and speed governor output during a typical control sequence. The output of the speed governor may tend to lag the engine's torque trace during and after the TSC#1 command sequence. Note however that the TSC#1's influence is not factored into EDT; only when the command sequence ends or is no longer winning in terms of engine control arbitration do the dynamic effects of the speed governor(s) appear in the EDT signal.

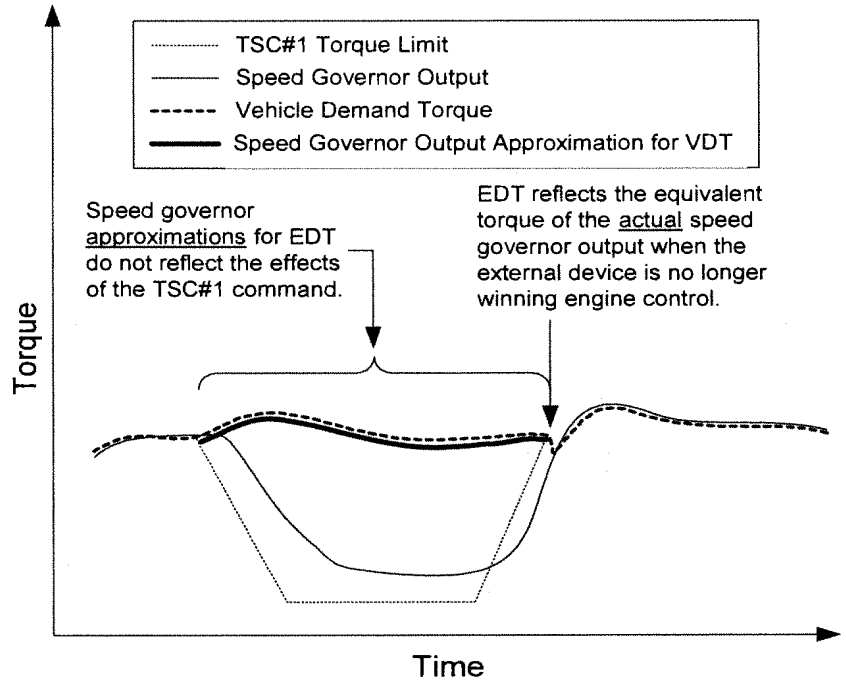


FIGURE SPN2432_B – EDT AND SPEED GOVERNOR OUTPUT RELATIONSHIP DURING A CONTROL SEQUENCE

One method of converting the speed governor reference to torque is shown in Figure SPN2432_C. The inputs of current engine speed, accelerator pedal position and the shape of the governor droop curves can be used to find the equivalent torque output of the governor. A lookup table or calculation could be used.

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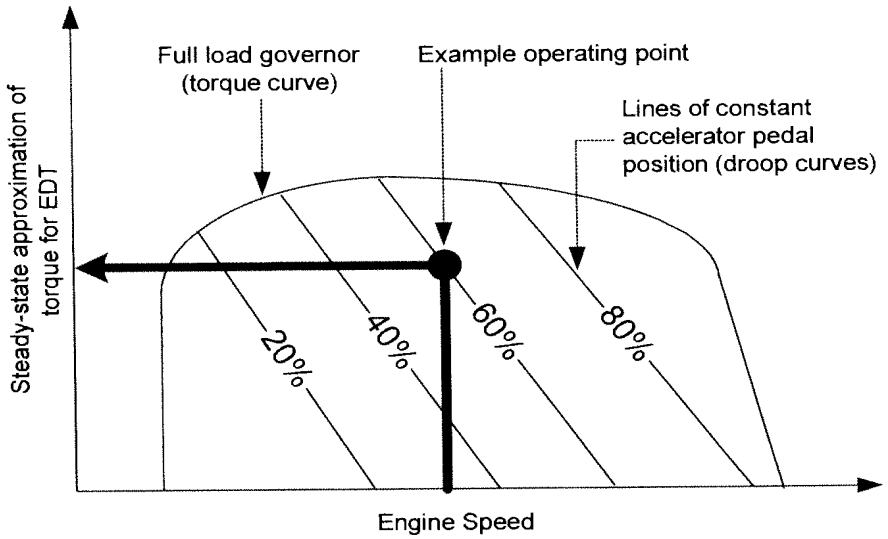


FIGURE SPN2432_C - FINDING EDT TORQUE APPROXIMATION FOR A SPEED GOVERNOR

Special Case #2: "Steep" or zero droop speed governors

Using a steady-state approximation with a "steep" or zero droop speed governor can cause large EDT changes over small speed changes. For example, if a cruise control governor has a zero droop and the vehicle speed is just below the cruise set speed, the steady-state torque approximation using the method described previously is very large. If vehicle speed increases a small amount to above the cruise set speed, the steady-state torque approximation becomes very small or zero.

As a result, a more accurate steady-state torque approximation is needed when steep droop governors are involved. A steep droop speed governor is defined as having a droop slope greater than 0.2% actual torque per rpm as seen below in Figure SPN2432_D.

The following method can be used to determine a steady-state torque approximation for steep or zero droop governors with fast responding integrator anti-windup / integrator resetting:

Upon a TSC#1 message actively controlling engine torque, save the last value of torque commanded by the speed governor (τ_{SGo}) and the last value of speed governor error (ε_{SGo}).

During this control sequence, calculate speed governor error (ε_{SGi})

Calculate an estimated torque for EDT determination use: $\tau_{SGestimated} = \tau_{SGo} + Kp_{SG} * (\varepsilon_{SGo} - \varepsilon_{SGi})$

where Kp_{SG} is the speed governor proportional gain

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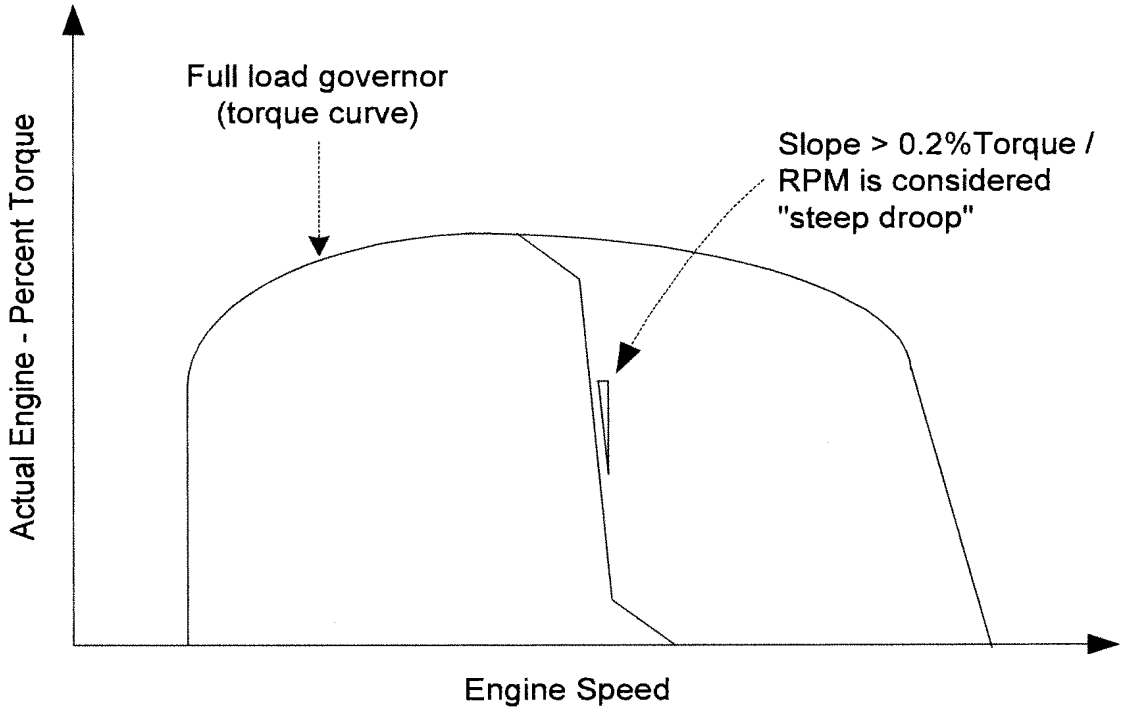


FIGURE SPN2432_D - EXAMPLE OF "STEEP DROOP" SPEED GOVERNOR

Special Case #3: "Slow Response" Speed Governors

If the speed governor dynamic elements are slow to respond to a 1 second torque derate, then the speed governor can simply be executed during the TSC#1 event and the output used directly in determining EDT. This is an alternative for a speed governor which does not contain an integrator, or if the integrator anti-windup logic is slow to respond. A guideline for "slow response" is that the governor output after 1 second of torque limiting has only moved 1/3 of the way to the limit, as shown for example in Figure SPN2432_E.

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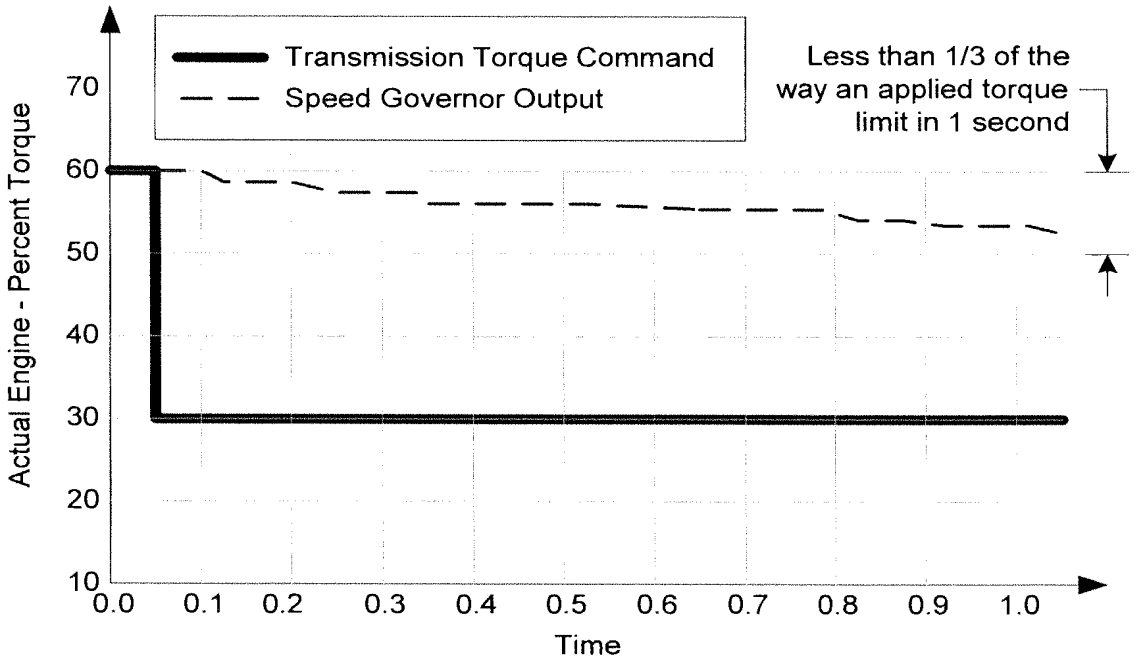


FIGURE SPN2432_E – EXAMPLE OF "SLOW TO RESPOND" SPEED GOVERNOR

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SPN 2927 - Actual Inner wheel steering angle

Following sketch shows an example for the actual inward wheel angles of the steering axles in the requested PGN :

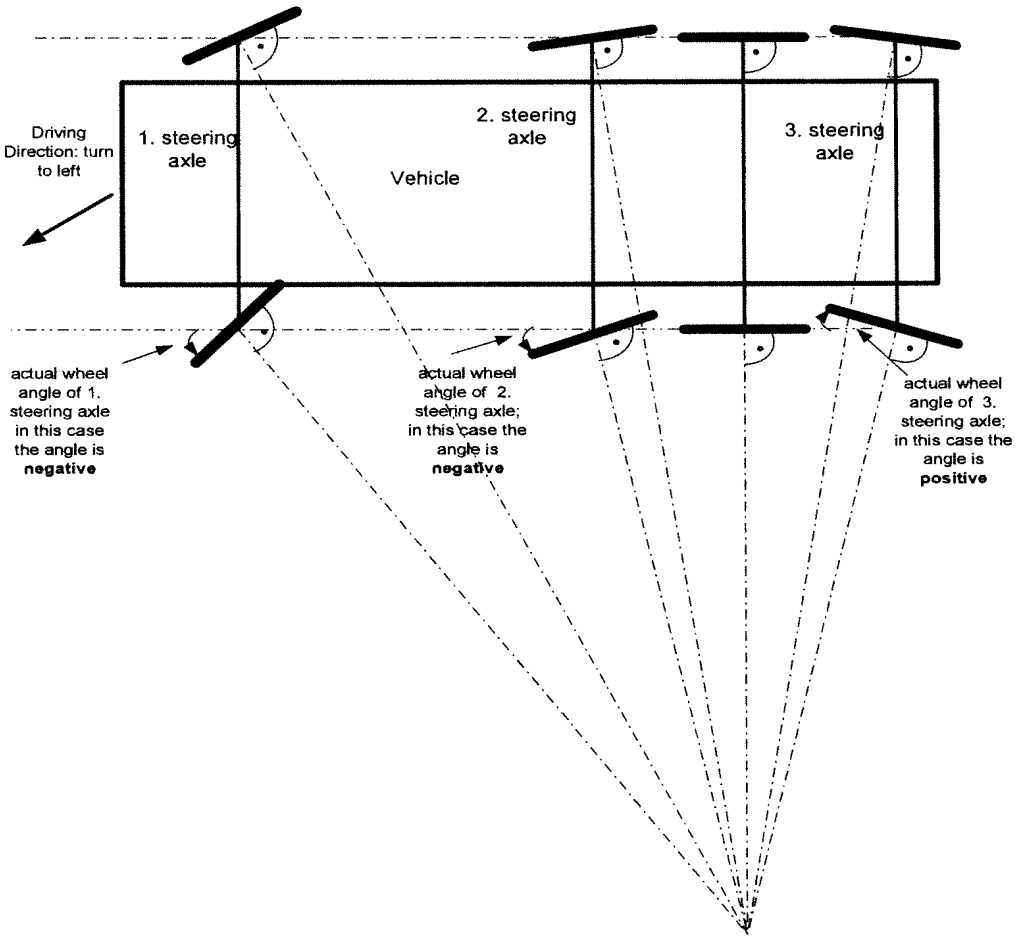


FIGURE SPN2927_A: STEERING AXLE ORIENTATION

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PGN 1024 – External Brake Request

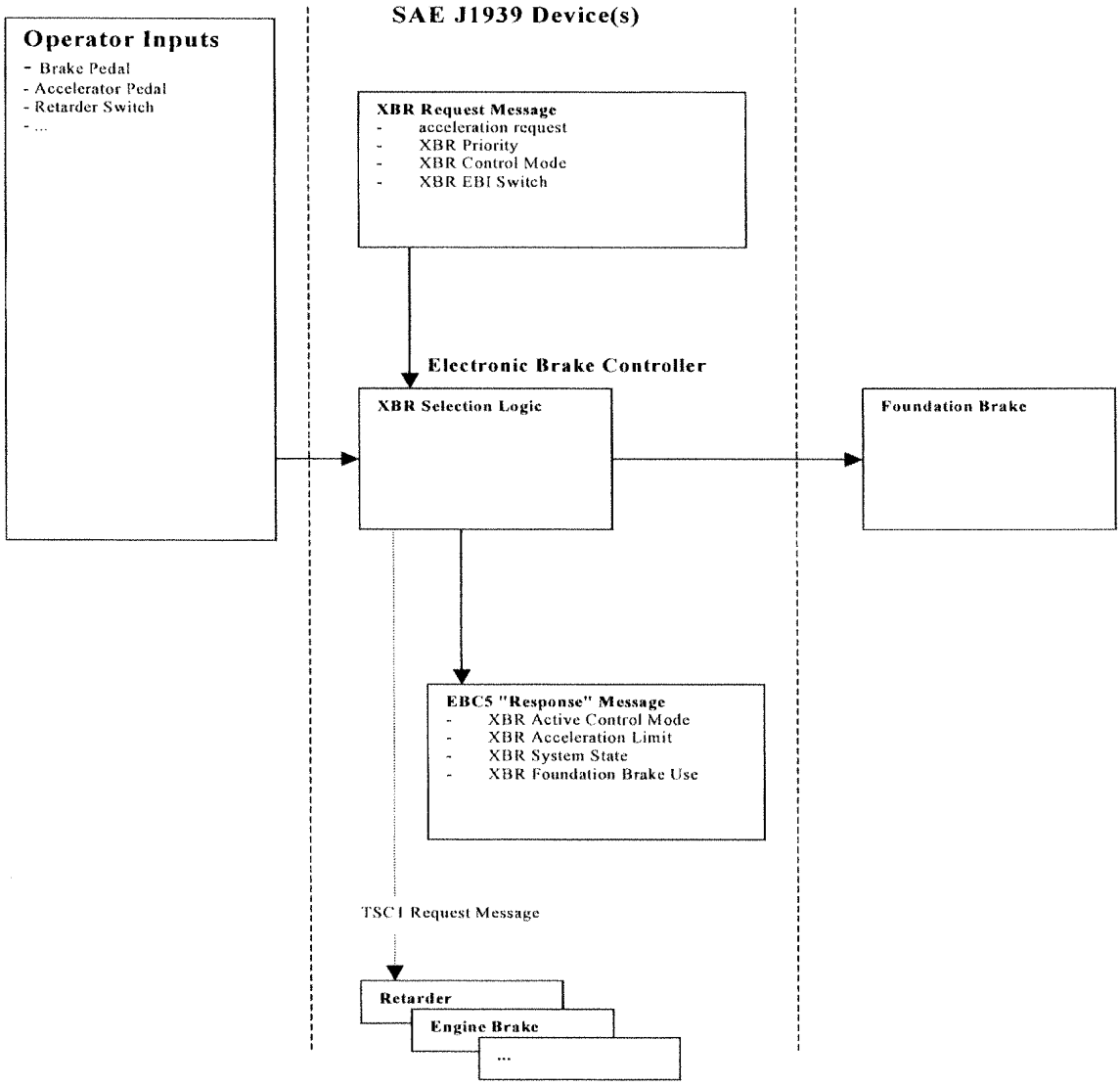
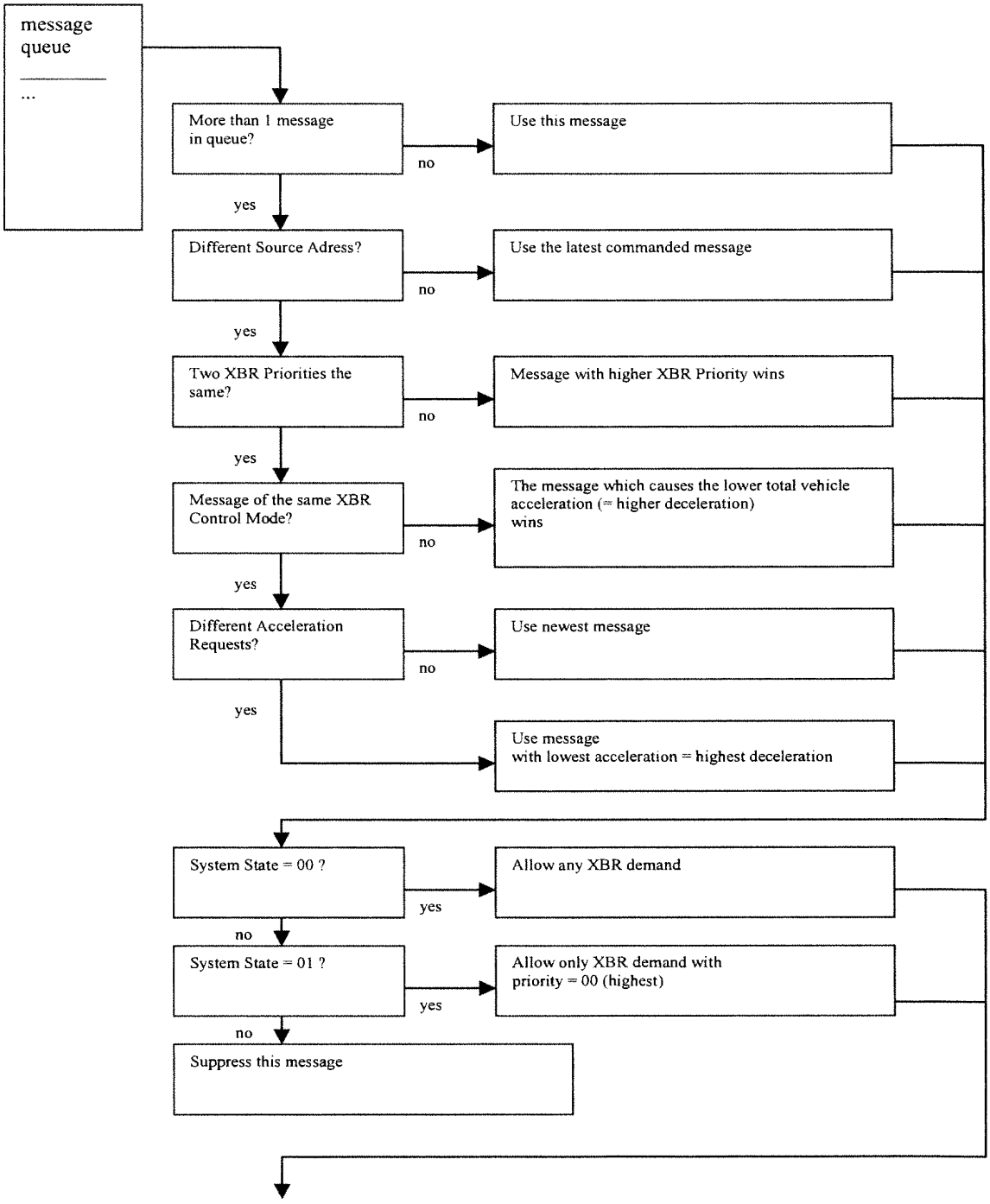


FIGURE PGN1024_A - DATA FLOW DIAGRAM FOR EXTERNAL BRAKE REQUEST

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Vehicle Application Layer – J1939-71 (through December 2003)



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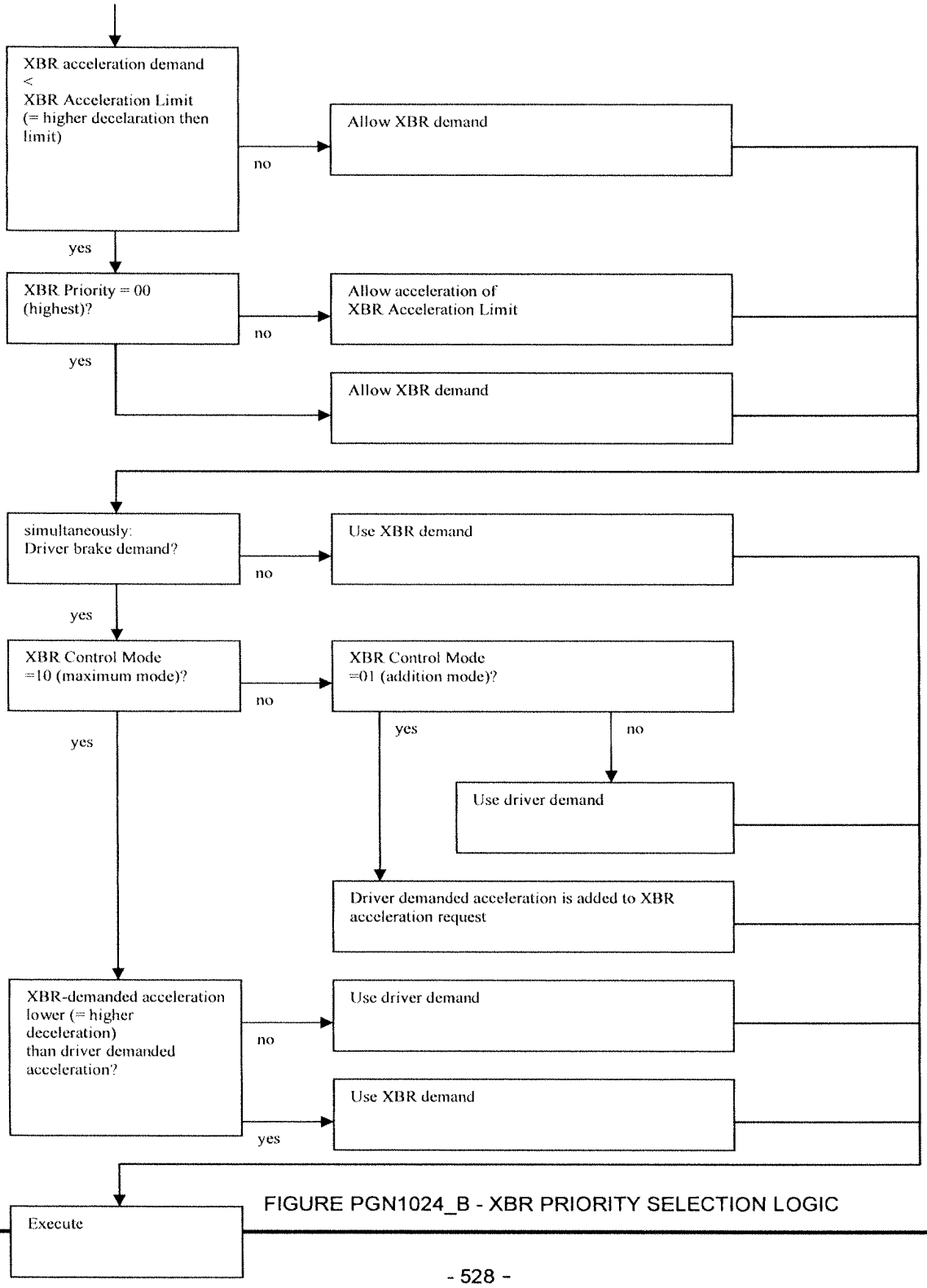


FIGURE PGN1024_B - XBR PRIORITY SELECTION LOGIC

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PGN 52992 – Continuous Torque & Speed Limit Request

The TSC1 message allows J1939 network devices to temporarily control engine and retarder speed and torque. This approach allows engine (and retarder) speed to be controlled by one device for a limited period of time. This may need to happen for brief emergency conditions (as requested by an anti-lock braking system for example) or in order to synchronize engine speed with some other device such as a transmission in order to allow a shift. Conflicting speed and torque requests from different devices are resolved by a predefined arbitration scheme.

Not every torque or speed need is satisfactorily addressed by this plan, however. Occasionally a network device may wish to impose longer lasting limits on speed and torque. For instance, as long as a transmission is in third gear, it may not be able to withstand all the torque the engine (or retarder) can produce. Or, an auxiliary device such as a pump may only operate correctly if engine speed and torque are kept within some fairly limited range *but not necessarily at one precise speed/torque!* In these cases, the network device does not need to command the precise speed or torque, but does have a legitimate desire to keep it within some boundary for an extended period of time. The TSC1 message doesn't provide this ability.

How: The ECM and retarder controller(s) first must define a "window" within the torque map. The window should be chosen carefully, and shouldn't be any larger than necessary. Any requests for continuous limits that attempt to intrude on this window will succeed only in setting limits at the very threshold of the window. For example, if the ECM declares that minimum continuous torque limits must be less than 900 lb-ft, and some device attempts to set a minimum continuous torque of 1000 lb-ft, the actual applied continuous limit will be 900 lb-ft (thus 900 lb-ft is the *minimum continuous* torque). When this limit is applied, the engine will always produce at least 900 lb-ft of torque. Similarly, if the engine declares that minimum continuous engine speed cannot be more than 1100 RPM, any attempts at setting a minimum continuous engine speed of over 1100 RPM will result in a minimum continuous engine speed of 1100 RPM. That is, the engine has declared beforehand that it will *always* be able to operate at least at 1100 RPM.

Periodically, the ECM and retarder controller(s) will transmit the dimensions of this window, as well as what actual continuous limits have been applied. This allows the engine to adjust the size and shape of the "window" to allow for derates and provides feedback to the various devices requesting continuous torque and/or speed limits.

The following figure shows an example torque curve with a "window" inside.

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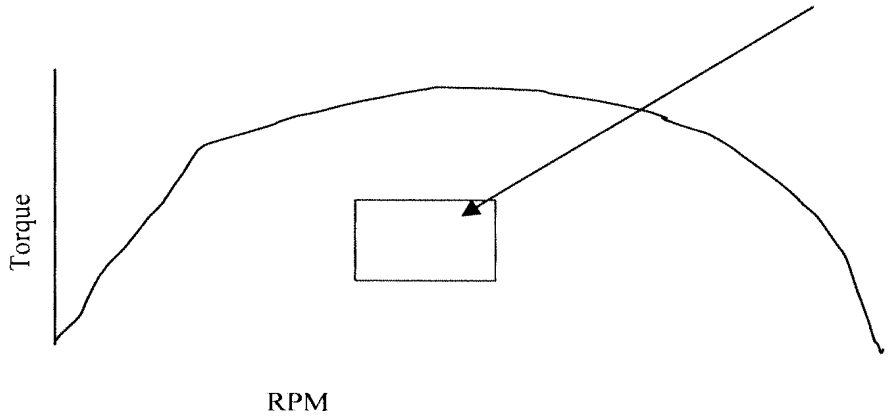


FIGURE PGN52992_A

The following figure shows how the ECM will treat requests that are outside of the bounds set by the "window." Note that the ECM has declared a "maximum allowable minimum" and a "minimum allowable maximum" for both speed and torque. These limits form a sort of rectangular "window" within the torque. The engine **must** be free to operate within this window; no continuous limits will be accepted that would intrude on it. In the diagram, some network device has ignored those values and attempted to set a minimum continuous speed higher than allowed. Remember, a minimum continuous speed means that the engine must always maintain an RPM of that value or greater. The ECM cannot accept the requested limit, so it applies a continuous limit as close as possible: right at the boundary set by "maximum value allowed for minimum continuous speed." Requests for Minimum Continuous Speed and Max/Min continuous torque are handled the same way.

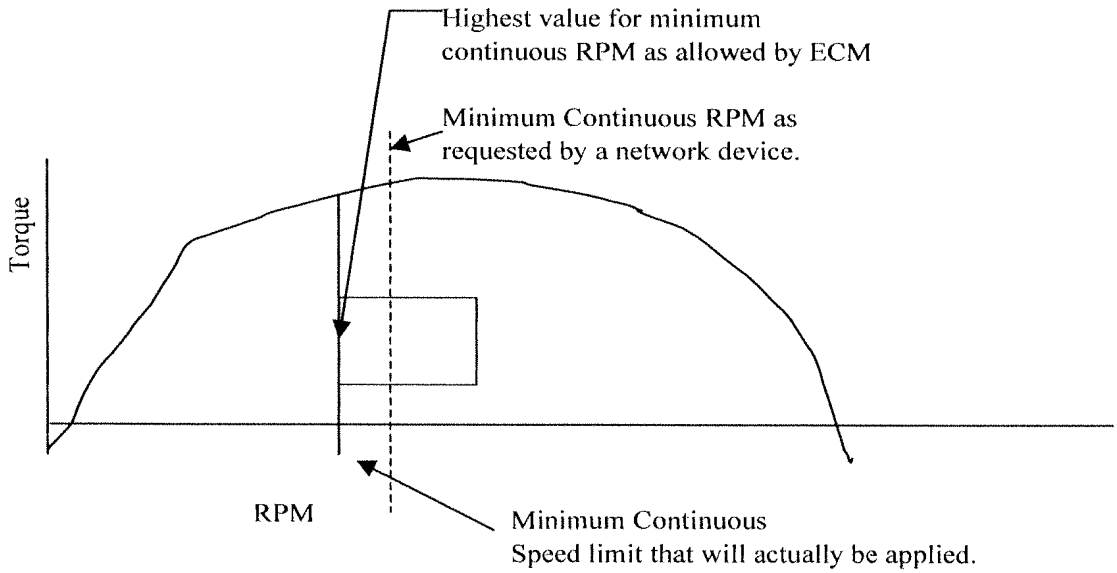


FIGURE PGN52992_B

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Things get a little more complicated when a retarder is included. Fortunately, only the engine compression brake retarder has any real relationship to the engine's torque map. Because other retarders may work against the engine, only the compression brake is generally controlled by the same ECU. For this reason, we must give it more careful attention.

The following figure illustrates one of the problems. Suppose continuous limits have been applied to the engine and retarder as indicated by the rectangular boxes within the torque maps. If the engine is prohibited from allowing torque to decrease below ***x***, how can the retarder be engaged? An engine compression brake retarder needs zero fueling for the engine in order to engage. The simple answer is that if there is a minimum continuous torque limit applied to the engine, the retarder will not be engaged. How does the reverse case behave? If the retarder is of a type other than engine compression brake, it may work against the engine and continuously produce a negative torque. Engine compression brake retarders must not send out a list of acceptable limits that would allow such conundrums. In practical terms, this means that engine compression brake retarders must set their Maximum Continuous Torque limit (think of it as MINIMUM continuous BRAKING torque limit) to zero in order for the retarder to ever be engaged. Similarly, the continuous limits as actually applied to the engine must allow zero torque if the retarder is to be engaged.

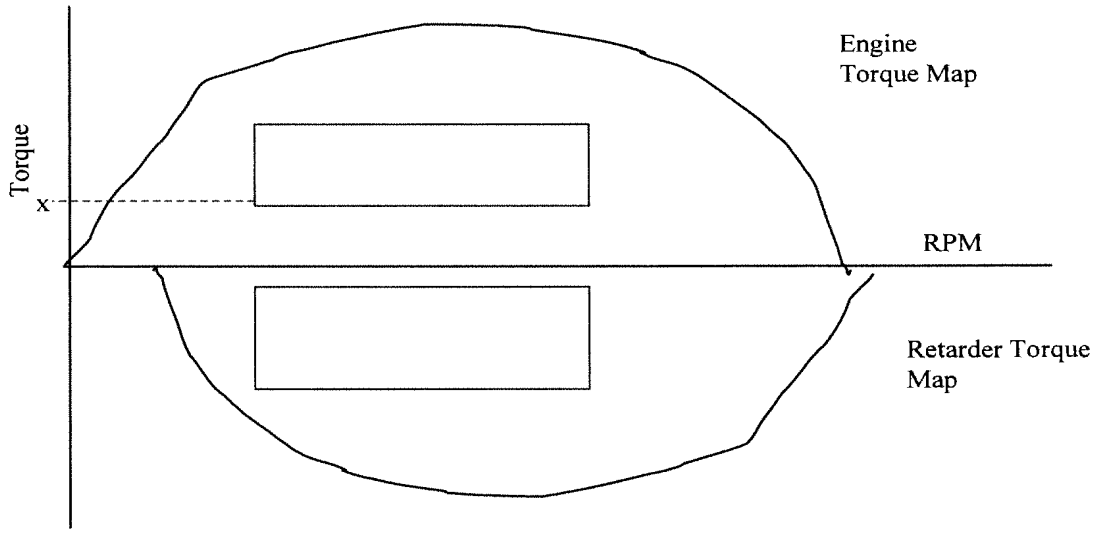


FIGURE PGN52992_C

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PGN 56320 – Anti-Theft Status

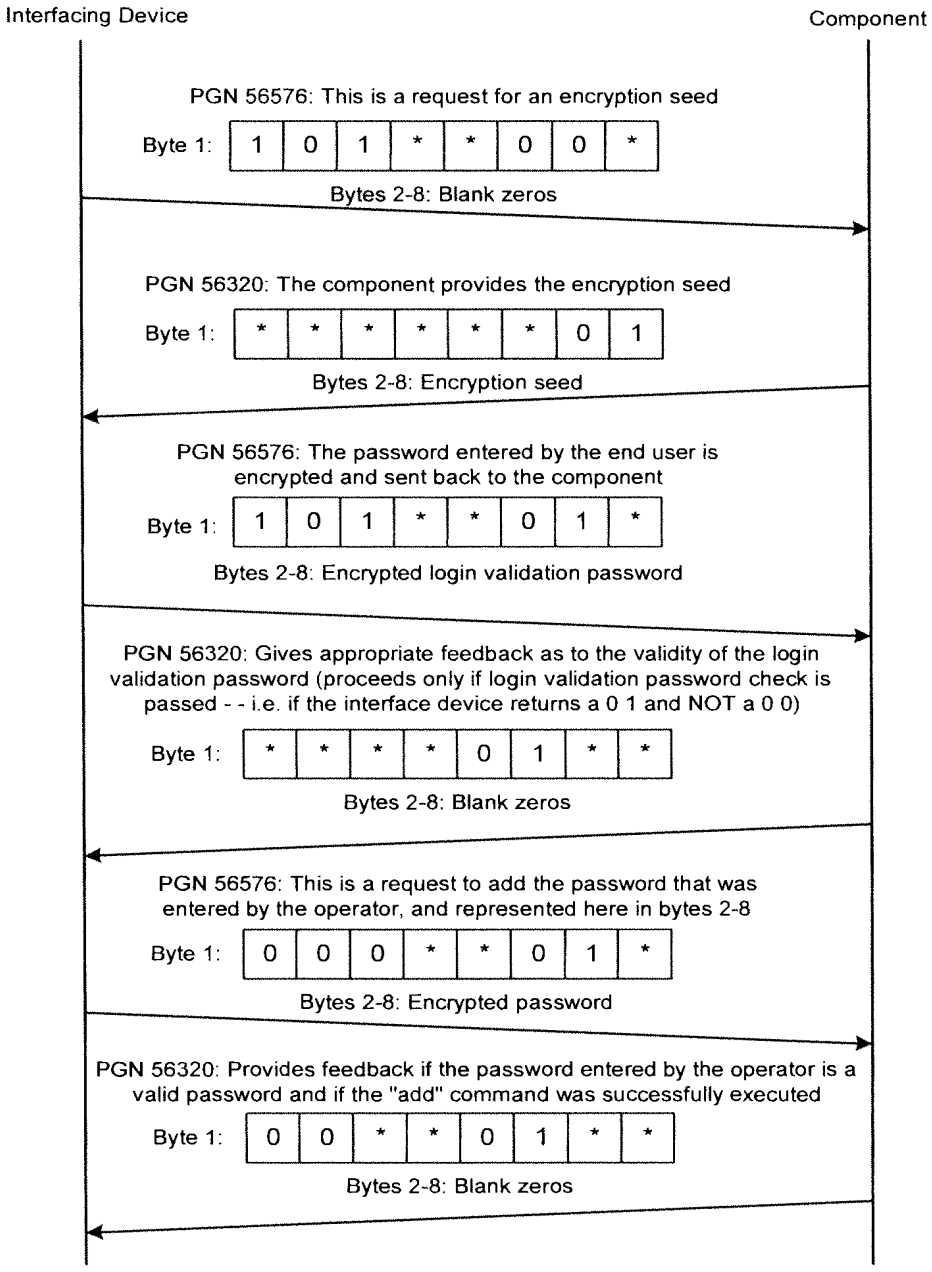


FIGURE PGN56320_A - OPERATOR DESIRES TO ADD A PASSWORD TO THE COMPONENT'S PASSWORD STRUCTURE

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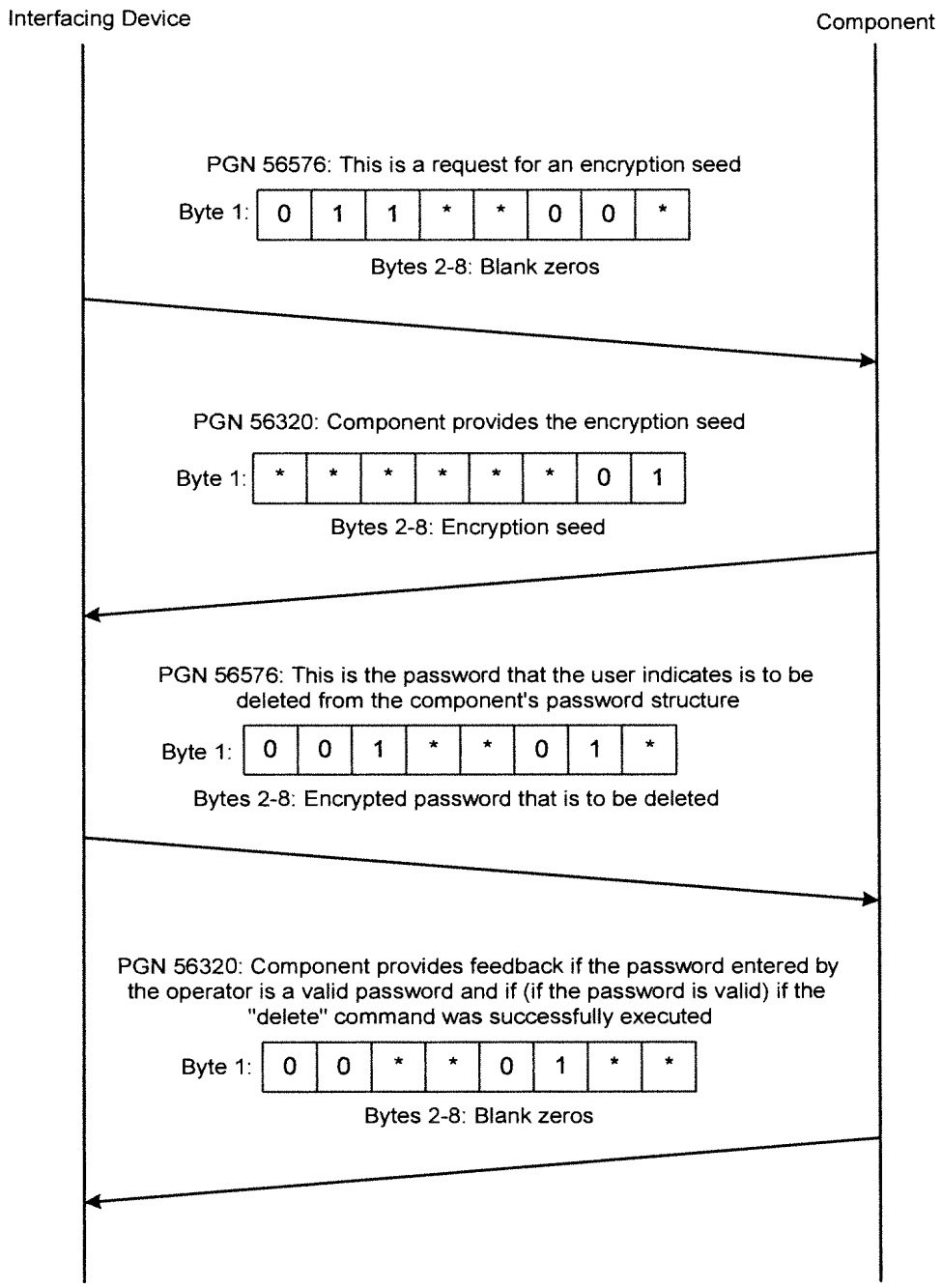


FIGURE PGN56320_B—OPERATOR DESIRES TO DELETE A PASSWORD FROM THE COMPONENT'S PASSWORD STRUCTURE

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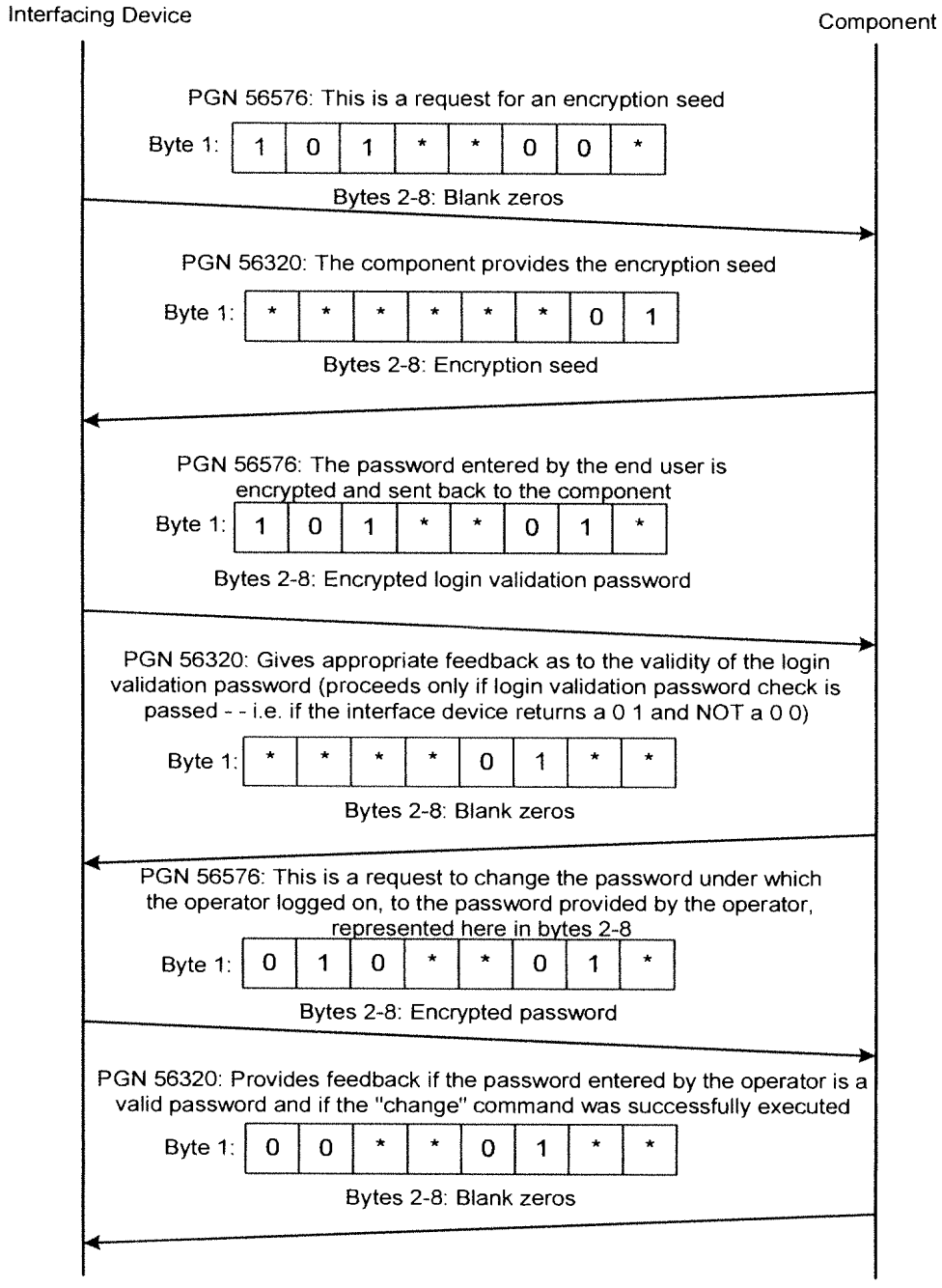


FIGURE PGN56320_C—OPERATOR DESIRES TO CHANGE A PASSWORD WITHIN THE COMPONENT'S PASSWORD STRUCTURE

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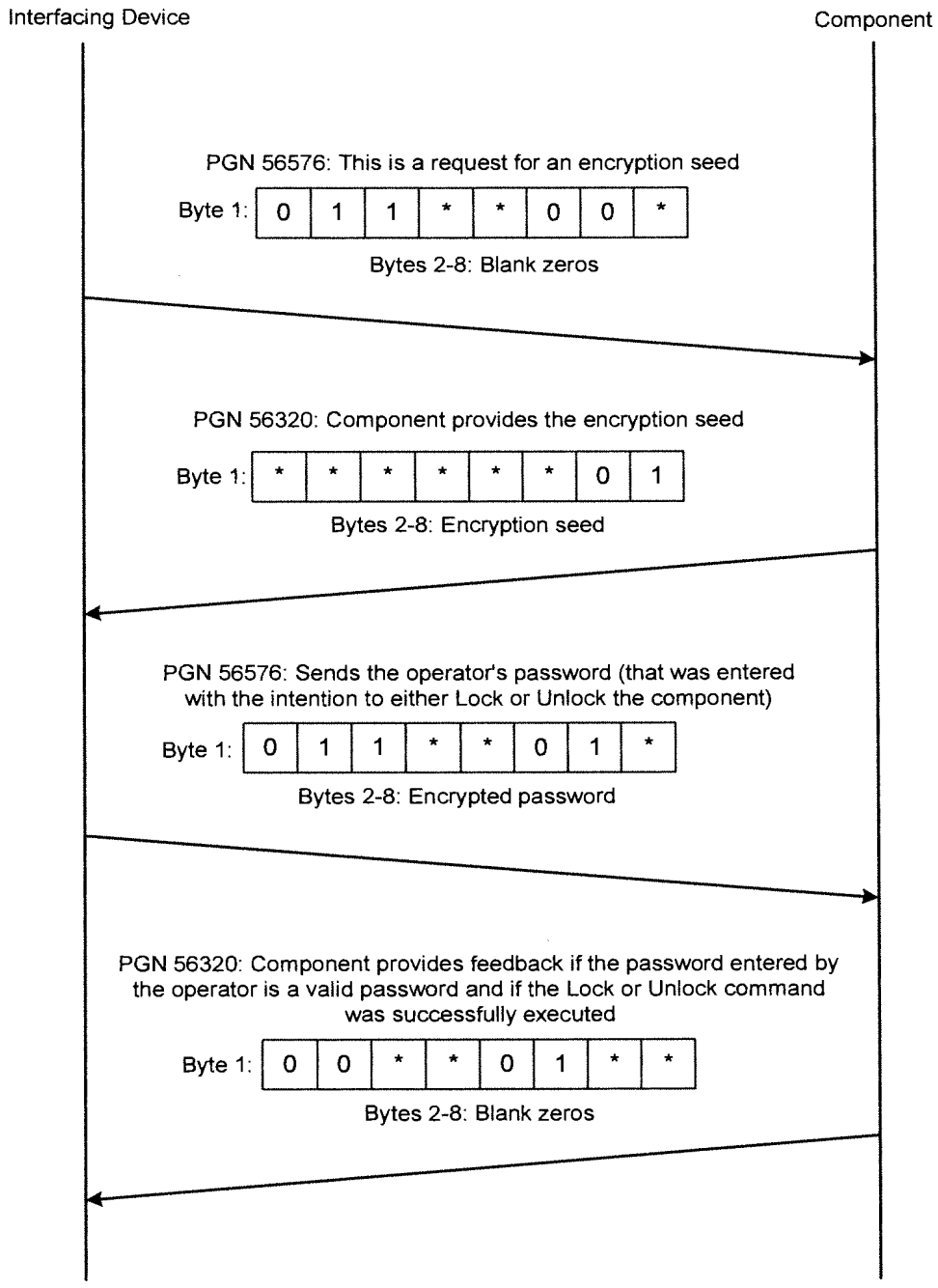


FIGURE PGN56320_D—OPERATOR DESIRES TO LOCK OR UNLOCK THE COMPONENT

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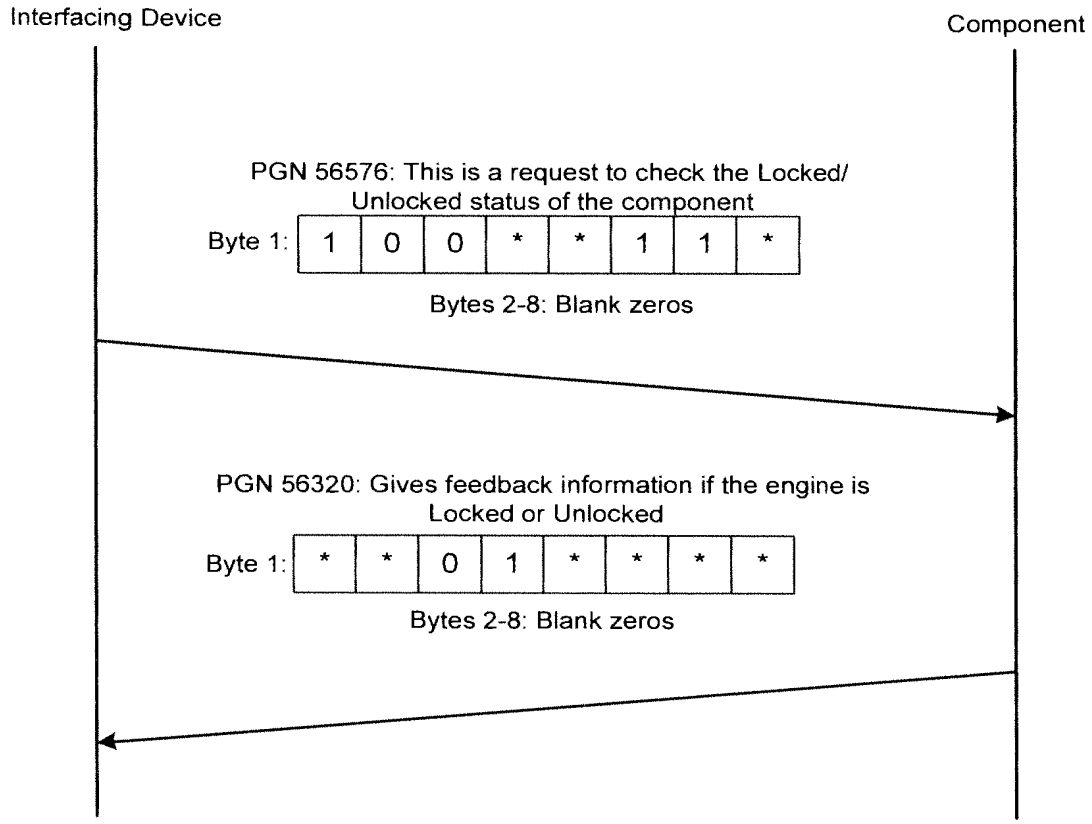


FIGURE PGN56320_E—CHECKING STATUS OF THE COMPONENT

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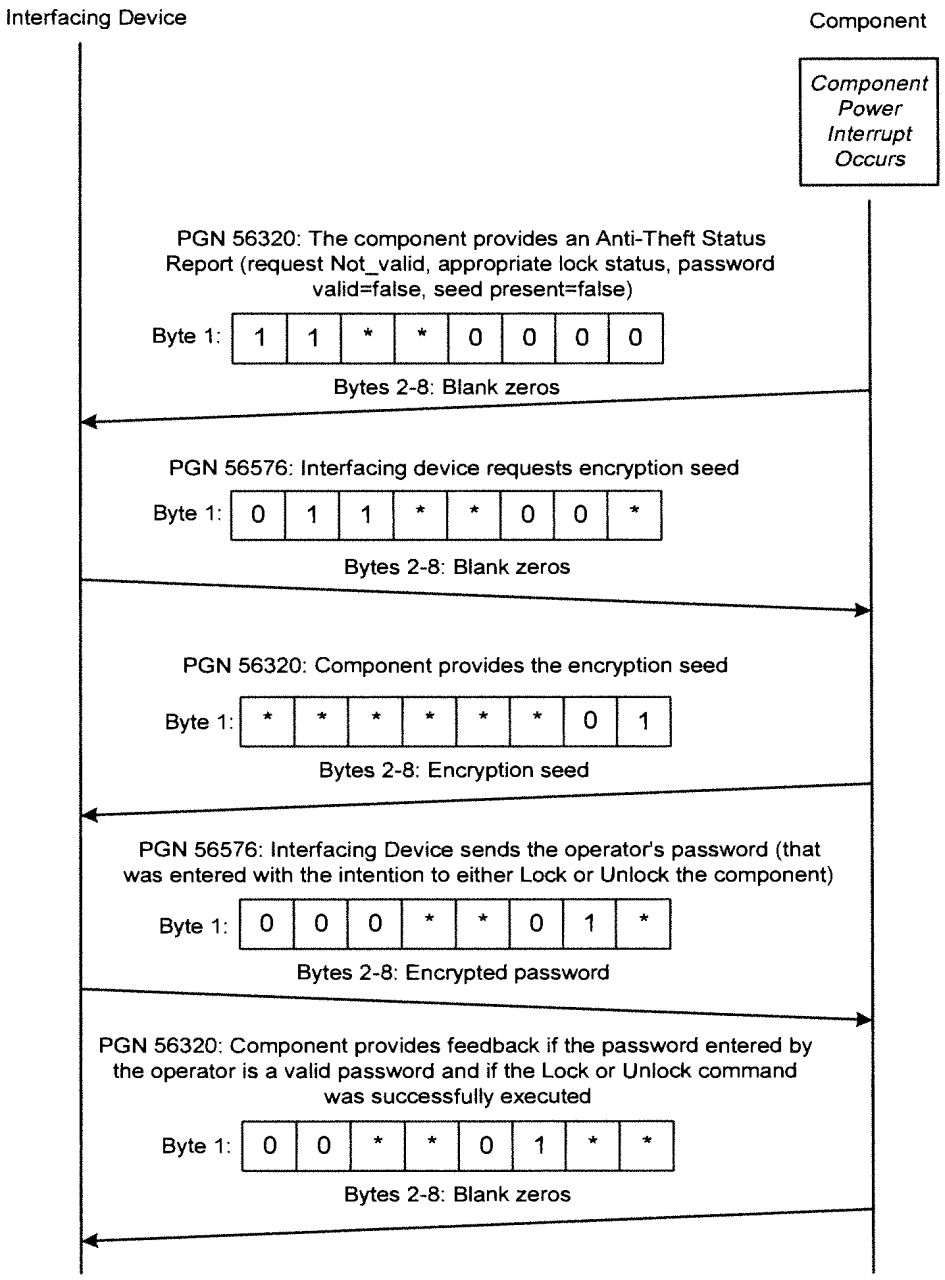


FIGURE PGN56320_F—ABNORMAL COMPONENT POWER INTERRUPTION (INTERFACING DEVICE POWER IS NOT INTERRUPTED)

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PGN 65135 – Adaptive Cruise Control

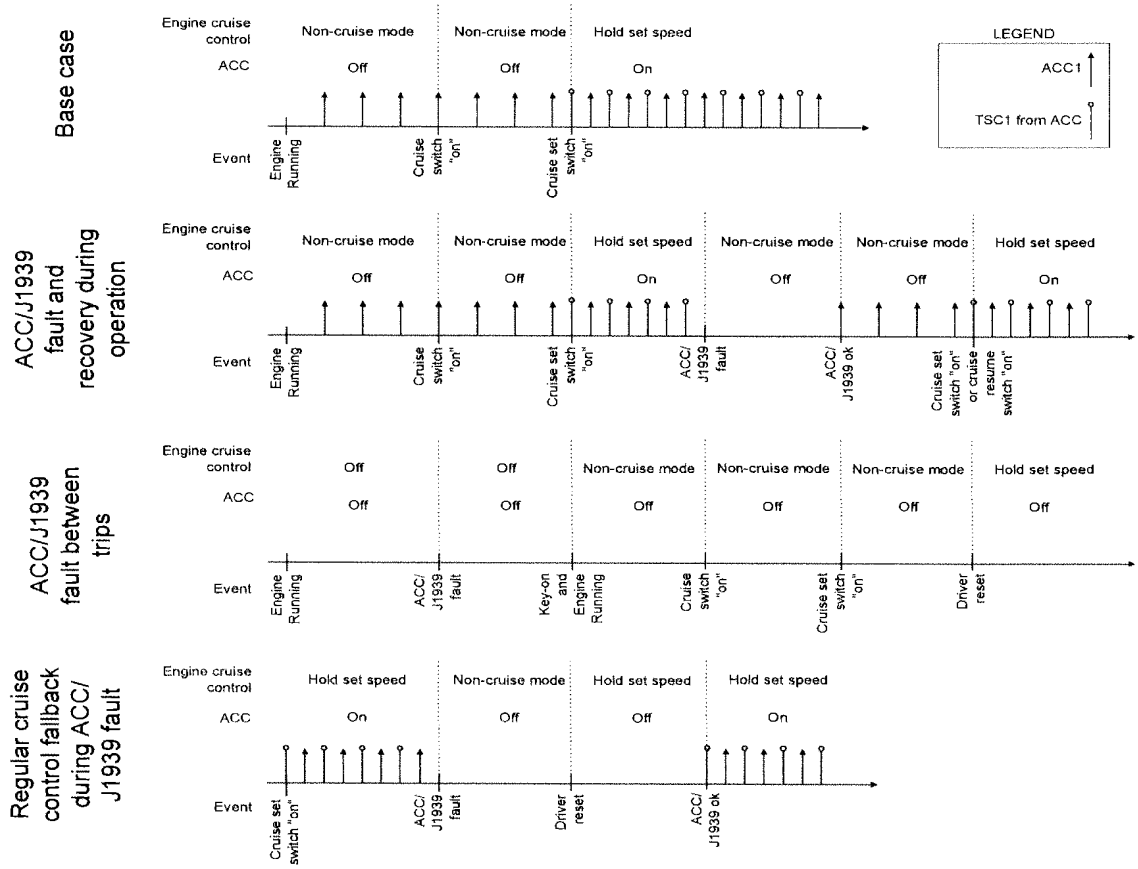


FIGURE PGN65135_A – ADAPTIVE CRUISE CONTROL TIMING DIAGRAM

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PGN 65249 – Retarder Configuration

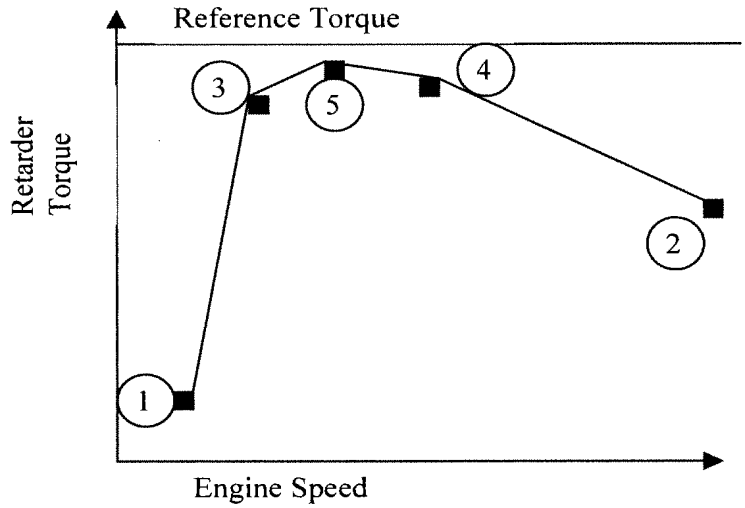


FIGURE PGN65249_A—TYPICAL HYDRAULIC RETARDER TORQUE CURVE

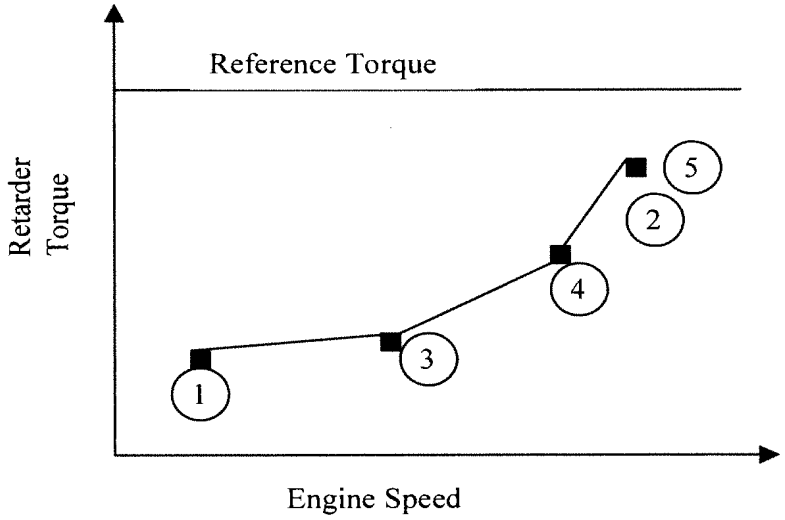


FIGURE PGN65249_B—TYPICAL ENGINE COMPRESSION BRAKE TORQUE CURVE

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PGN 65251 – Engine Configuration

TABLE PGN65251_A—ENGINE CONFIGURATION CHARACTERISTIC MODES

Mode	Torque/Speed Point 2	Governor Gain KP	High Idle Speed
1	Available	Not available	Available
2	Not Available	Available	Available
3	Available	Available	Not available

The following points are shown in Figures PGN65251_A, PGN65251_B, and PGN65251_C.

Point 1 (required):	Torque/speed point at idle
Point 2 (required):	Mode 1 & 3: Torque/speed point at which the high speed governor becomes active Mode 2: Normal torque/speed point
Point 3,4,5 (required):	Torque/speed points between points 1 and 2 to permit linear interpolation over the entire torque range. It is required that one of these points indicate the peak torque point for the current engine torque map.
Point 6 (mode dependent):	Mode 1 & 2: High idle speed (torque = 0) Mode 3: Not available (point is defined by the endspeed governor where torque = 0)
Point 7 (optional):	Maximum momentary engine override speed (torque = 0)
Reference engine torque:	Engine torque in Nm. This parameter is the reference value of 100% for all defined indicated engine torque parameters. It is only defined once and doesn't change if a different engine torque map becomes valid.

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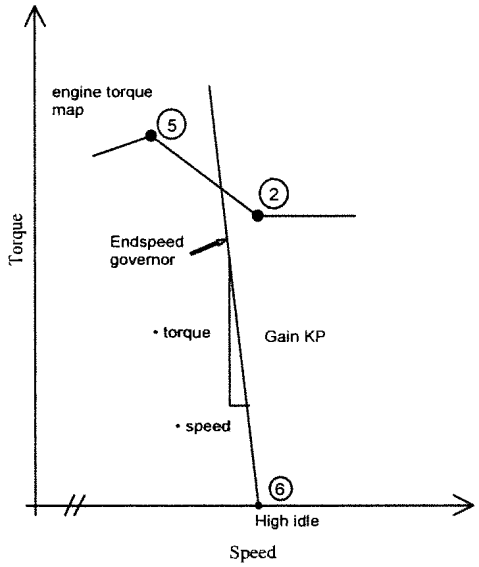


FIGURE PGN65251_A—ENGINE CONFIGURATION MAP-MODE 1

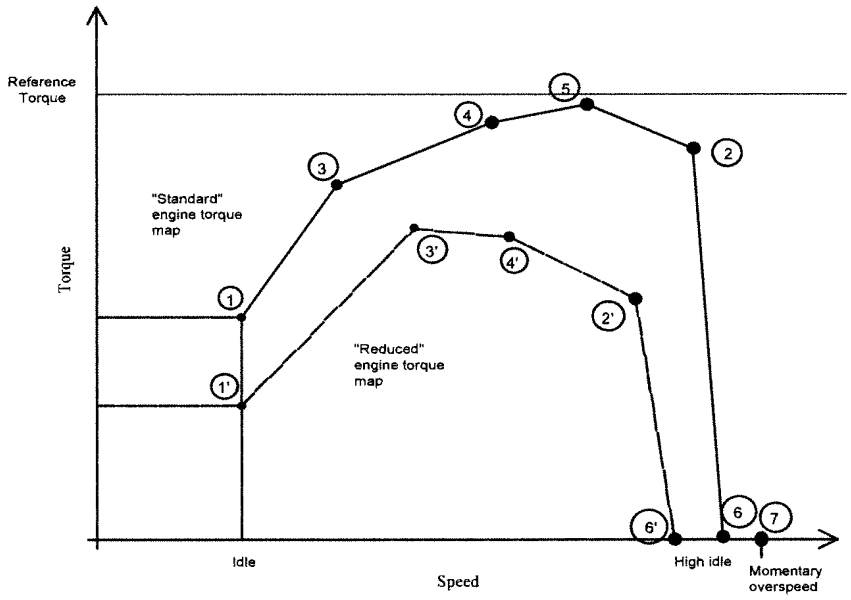


FIGURE PGN65251_B—ENGINE CONFIGURATION MAP-MODE 2

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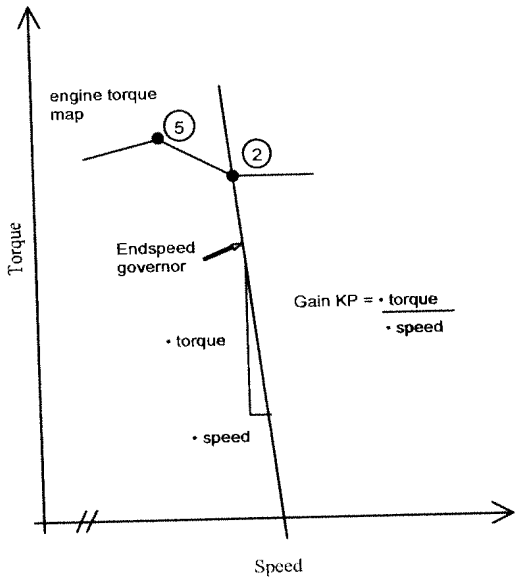


FIGURE PGN65251_C—ENGINE CONFIGURATION MAP-MODE 3

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Superseding J1708 OCT1993

Serial Data Communications Between Microcomputer Systems in Heavy-Duty Vehicle Applications

Foreword

The SAE group responsible for the content of this recommended practice was revised to the SAE Low Speed Communications Network Subcommittee sponsored by the SAE Truck and Bus Electrical and Electronics Committee. This Document was revised to comply with the new SAE Technical Standards Board format.

Earlier versions of this document stated: This SAE/TMC Joint Recommended Practice has been developed by the Truck and Bus Electronic Interface Subcommittee of the Truck and Bus Electrical Committee and by the S.1 Study Group of the Maintenance Council. The objectives of the subcommittee are to develop information reports, recommended practices, and standards concerned with the interface requirements and connecting devices required in the transmission of electronic signals and information among truck and bus components.

Objectives: Some of the goals of the subcommittee in developing this document were to:

a. Minimize hardware cost and overhead.
b. Provide flexibility for expansion and technology advancements with minimum hardware and software impact on in-place assemblies.
c. Utilize widely accepted electronics industry standard hardware and protocol to give designers flexibility in parts selection.
d. Provide a high degree of electromagnetic compatibility.
e. Provide original equipment manufacturers, suppliers, and aftermarket suppliers the flexibility to customize for product individuality and for proprietary considerations.

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1. *Scope*

This SAE Recommended Practice defines a recommended practice for implementing a bidirectional, serial communication link among modules containing microcomputers. This document defines those parameters of the serial link that relate primarily to hardware and basic software compatibility such as interface requirements, system protocol, and message format. The actual data to be transmitted by particular modules, which is an important aspect of communications compatibility, is not specified in this document. These and other details of communication link implementation and use should be specified in the separate application documents referenced in Section 2.

1.1 Purpose

The purpose of this document is to define a general-purpose serial data communication link that may be utilized in heavy-duty vehicle applications. It is intended to serve as a guide toward standard practice to promote serial communication compatibility among microcomputer-based modules. The primary use of the general-purpose communications link is expected to be the sharing of data among stand-alone modules to cost effectively enhance their operation. Communication links used to implement functions that require a dedicated communication link between specific modules may deviate from this document.

2. *References*

2.1 Applicable Publications

The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the latest revision of SAE publications shall apply.

It is recommended that a separate applications document be published by the manufacturer for each device using the serial link. These documents should define the data format, message I.D.s, message priorities, error detection (and correction), maximum message length, percent bus utilization, and methods of physically adding/removing units to/from the line for the particular application.

2.1.1 SAE PUBLICATIONS

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1455—Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design (Heavy-Duty Trucks)

SAE J1587—Joint SAE/TMC Recommended Practice for Electronic Data Interchange Between Microcomputer Systems in Heavy-Duty Vehicle Applications

SAE J1922—Powertrain Control Interface for Electronic Controls Used in Medium and Heavy-Duty Diesel on Highway Vehicle Applications

SAE J2497—Power Line Carrier Communications for Commercial Vehicles

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2.1.2 EIA PUBLICATION

Available from Electronic Industries Association, 12001 Pennsylvania Avenue, NW, Washington, DC 20006.

EIA RS-485—Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems, April 1983

3. *Definitions*

3.1 Bus Access Time

A time duration equal to the minimum time of an Idle Line plus the product of 2 bit times and the message priority (which ranges from 1 to 8). An example is shown in section 5.2.2.3.

3.2 Baud

The maximum number of analog signal transitions per second that can occur on a channel. In this coding system, this is the reciprocal of the bit time.

3.3 Bit Time

Duration or period of one unit of information.

3.4 Character

A character shall consist of 10 bit times. The character must start with a low-logic bit, then 8 bits of data (least significant bit first) followed by a high-logic level stop bit.

3.5 Character Time

The duration of one character which is equal to 10 bit times.

3.6 Contention

A state of the bus in which two or more transmitters are turned on simultaneously to conflicting logic states.

3.7 Differential Signal

A two-wire process in which both lines are switched as opposed to a single-ended signal wherein one line is grounded and the signal line is switched between logic states.

3.8 Idle State

The state that produces a high-logic level on the input of the bus receiver when all transmitters on the network are turned off.

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3.9 Idle Line

The condition that exists when the bus has remained in a continuous high-logic state for at least 10 bit times after the end of the last stop bit. The minimum time duration of an idle line is 10 bit times. An example is shown in section 5.2.1.

NOTE—The idle line serves as the delimiter between messages on the bus.

3.10 Message Priority

A measure of message criticality assigned on a scale of 1 to 8 by the appropriate applications document. The most critical message has a priority of one.

3.11 Node

A receiver or transceiver circuit connected to the bus.

3.12 Start Bit

Initial element of a character defined as a low-logic level of 1 bit time duration as viewed at the output of the bus receiver.

3.13 Stop Bit

Final element of a character defined as a high-logic level of 1 bit time duration as viewed at the output of the bus receiver.

4. Electrical Parameters

The electrical parameters of this serial data link are a modification of the EIA RS-485 standard. In some areas this document conflicts with EIA RS-485. This document shall serve as the guiding document in such cases. Appendix A details a serial data bus standard node which defines the interface circuit parameters. Operation of this standard node is detailed in this section.

4.1 Logic State

Positive true logic will be used when referring to the states of transmitted inputs and received outputs. Referring to Appendix A, the input of the transmitter (marked as point Tx) and the output of the receiver (marked as Rx) will be in logic 1 state when driven or passively pulled to +V, and will be at a logic 0 state when driven to ground.

4.2 Bus State

The bus is in a logic 1 (high) state whenever Point A is at least 0.2 V more positive than Point B. The bus is in a logic 0 (low) state whenever Point A is at least 0.2 V more negative than Point B (Points A and B, refer to Figure A1). The bus state is indeterminate when the differential voltage is less than 0.2 V.

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4.2.1 LOGIC HIGH STATE

The bus will be in a logic 1 (high) state when all connected transmitters are idle or sending logic 1. An idle state is produced when all transmitters on the network are turned off. All nodes shall include means to pull the bus to a logic 1 (high) when all transmitters are off (see Appendix A).

4.2.2 LOGIC LOW STATE

The bus will be in a logic 0 (low) state when one or more transmitters are sending logic 0, which guarantees that logic 0 (low) dominates when the bus is in contention.

4.3 Network Capacity

The bus will support a minimum of 20 standard nodes where each node is comprised of the circuit defined in Appendix A. Deviations from this circuit must be carefully analyzed to determine impact on bus loading and noise margins over the common mode range.

4.4 Bus Termination

Bus-termination resistors as referenced in EIA RS-485 are not required and shall not be used.

4.5 Ground

All assemblies using the link must have common ground reference.

4.6 Wire

A minimum of 18-gauge twisted-pair wire, with a minimum of one twist per inch (360 degrees/2.54 cm) is required. The twists shall be distributed evenly over the length of the wire.

4.7 Length

This document is intended for, but not limited to, applications with a maximum length of 131 feet (40 m).

5. Network Parameters

5.1 Network Topology

The network interconnect shall use a common or global bus. There is no restriction on the length between each Electronic Control Unit, but the total length of the network datalink (total length = A+B+C+D+E+F) shall not exceed 131 feet (40m).

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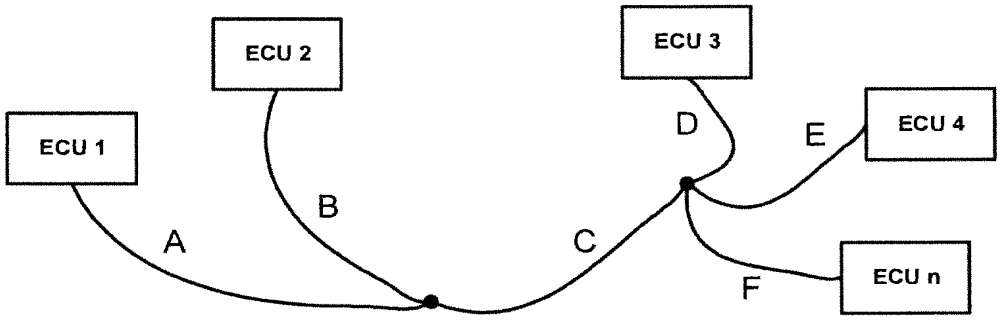


FIGURE 1—NETWORK TOPOLOGY

5.2 Network Access

The method of access to the network is random.

5.2.1 IDLE LINE – BUS SYNCHRONIZATION BY A RECEIVER

A receiver that cannot distinguish between a stop bit and any other high-logic state may become synchronized with the bus by noting the receipt of 12 consecutive high-logic bits. In the absence of errors, the first low-logic bit (0) following 12 consecutive high-logic bits (1) is the start bit of a message identification character (MID) (that is, the first character of a message).

EXAMPLE—A Receiver that has just connected to the data link will not know the current message strings being broadcast. The goal of the Receiver is to find an Idle Line, so the MID character of the next string can be determined. The Receiver could see the reception of all high-logic levels as shown in "Worst Case Character Time bit map" in Figure 2 in Section 5.2.2.3. In this case, there would be 8 high-logic level data bit times, 1 high-logic level for the stop bit, and up to 2 high-logic level inter-character bit times. This means that 11 bit times at high-logic level define the start of a new character, but not necessarily a MID character. If the next logic level seen by the Receiver is a low logic level, then another Character Time will follow and the Bus Synchronization must start over. If the next logic level seen by the Receiver is a high-logic level, then an Idle Line may have been identified. If, as shown in Figure 2, there was a Start Bit at the beginning of the 12 bit times, then a true Idle Line time has not occurred. The receiver will not see a start bit until a total of 19 high-logic levels plus the product of 2 bit times and the message priority (which ranges from 1 to 8) of the next message to be transmitted are seen. However, if the receiver did not see the first bit in the Figure 2 "Worst Case Character Time bit map" row, that is the Start bit shown at the far left, then it would have to assume that the string of 12 highlogic levels could be a valid Idle Line and therefore, the next low-logic level would be the start bit of a MID. When the next low-logic level is seen the receiver can assume that it has achieved Bus Synchronization.

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5.2.2 Bus Access

A transmitter shall begin transmitting a message only after an idle state has continuously existed on the bus for at least a bus access time.

5.2.2.1 Bus Access Verification

The transmitter must verify that the idle state continues to exist immediately prior to initiating a transmission. The time between the bus being verified while in the idle state (bus access verification) and the initiation of a transmission shall be less than one-half bit time.

5.2.2.2 Bus Access Time

Bus access time is a time duration equal to the minimum time of an idle line plus the product of 2 bit times and the message priority. This relationship can be expressed as follows:

$$T_a = T_i + [2 * T_b] * P \qquad \text{(Eq. 1)}$$

where:

T_a = Bus access time
T_b = Bit time, or period of one unit of information
P = Message priority
T_i = Minimum time duration of an idle line

TABLE 1—BUS ACCESS TIME

T_a	T_i	T_b	P
12 Bit times	10 Bit times	1 Bit time	1
14 Bit times	10 Bit times	1 Bit time	2
16 Bit times	10 Bit times	1 Bit time	3
18 Bit times	10 Bit times	1 Bit time	4
20 Bit times	10 Bit times	1 Bit time	5
22 Bit times	10 Bit times	1 Bit time	6
24 Bit times	10 Bit times	1 Bit time	7
26 Bit times	10 Bit times	1 Bit time	8

5.2.2.3 Bus Access Time Synchronization by a Transmitter

The minimum time duration of an idle line is defined in 3.9. However, a transmitter that cannot distinguish between a stop bit and any other high-logic state may not assume that T_i has elapsed until it has received 19 consecutive high-logic bits.

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EXAMPLE—A Transmitter that has just connected to the data link will not know the current message strings being broadcast. The goal of the Transmitter is to find an Idle Line, so message transmission can be initiated. The Transmitter could see the occurrence of all high-logic levels as shown in "Worst Case Character Time bit map" in Figure 2. In this case, there would be 8 high logic level data bit times, 1 high-logic level for the stop bit, and up to 2 high-logic level inter-character bit times. This means that 11 bit times at high-logic level define the start of a new character, but not necessarily a MID character. If the next logic level seen by the Transmitter is a low-logic level, then another Character Time will follow and the Bus Access Time Synchronization must start over. If the next eight logic levels seen by the Transmitter are high-logic levels, then Ti must have elapsed, and now the transmitter still must wait a time duration equal to the product of 2 bit times and the message priority (which ranges from 1 to 8) before beginning its message transmission.

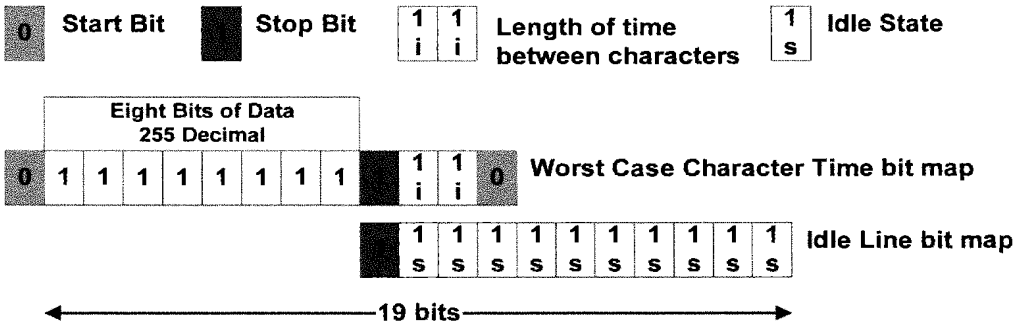


FIGURE 2—EXAMPLE BUS ACCESS TIME SYNCHRONIZATION

5.2.2.4 Message Priority Assignment

All messages will be assigned a priority from 1 to 8 as indicated in Table 2:

TABLE 2—MESSAGE PRIORITY ASSIGNMENT

Priority	Message Assignment
1 and 2	Reserved for messages that require immediate access to the bus
3 and 4	Reserved for messages that require prompt access to the bus in order to prevent severe mechanical damage
5 and 6	Reserved for messages that directly affect the economical or efficient operation of the vehicle
7 and 8	All other messages not fitting into the previous priority categories should be assigned a priority 7 or 8

The applications document shall define the priority associated with each message. In the event that more than one priority could be assigned to a particular message, the application document shall define each priority and the circumstances in which the priority is assigned.

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5.2.3 BUS CONTENTION

All transmitters shall monitor the message identification portion of their message to determine if another transmitter has attempted to gain access to the bus at the same time. If a transmitter detects a collision, the transmitter shall relinquish control of the bus after completing the transmission of the current character or sooner if possible. After relinquishing control, it is recommended that the transmitter become a receiver, using the received MID as the beginning of the incoming message. The transmitter may attempt to regain access to the bus after a bus access time has elapsed. An example bus reaccess procedure is shown in Appendix B.

6. Protocol

6.1 Bit Time

A bit time shall be 104.17 µs ± 0.5% (± 500 ns). This is equivalent to a baud rate of 9600 bits per second.

6.2 Character Format

A character shall consist of 10 bit times. The first bit shall always be a low-logic level and is called the start bit. The last (tenth) bit shall always be a high-logic level and is called the stop bit.

This conversion is consistent with standard UART operation. The remaining eight center bits are data bits that are transmitted least significant bit (LSB) first.

6.3 Message Format

6.3.1 MESSAGE CONTENT

A message appearing on the communication bus shall consist of the following:

a. Message Identification Character (MID)
b. Data Characters
c. Checksum

Example messages:

Shortest Message: MID Checksum
Single data string: MID Data1 Checksum
Multiple data string: MID Data1 Data2 Data3 Data(n) Checksum

As indicated in Section 5.2, a message shall always be preceded by an idle state of duration equal to or greater than the appropriate bus access time.

6.3.2 INTER-CHARACTER BIT TIME

The length of time between characters within a message shall not exceed 2 bit times. The minimum length of time between characters within a message can be zero bit times.

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6.3.3 MESSAGE IDENTIFICATION CHARACTER (MID)

The first character of every message shall be a MID. The permitted range of MIDs shall include the numbers 0 to 255.

6.3.3.1 MID Assignments

The MIDs 0 to 68 shall be assigned to transmitter categories as identified in Table 3. These assignments have been made to accommodate existing systems, or systems that may presently be under development, and to avoid conflicts, which otherwise might arise if indiscriminate use of MIDs were permitted.

MIDs 10 and 11 shall be used for trailer ABS Power Line Carrier (PLC) communications. See SAE J2497 Power Line Carrier Communications for Commercial Vehicles.

MIDs 69 to 86 have been set aside for use by the SAE J1922.

MID 87 is defined in SAE J2497 Power Line Carrier Communications for Commercial Vehicles.

MIDs 88 to 110 shall be allocated as reserved MIDs for transmitter categories beyond those that are identified in Table 3. These MIDs shall be individually assigned by the SAE Low Speed Communications Network Subcommittee of the SAE Truck and Bus Electrical and Electronic Committee on petition by a manufacturer at the time a new transmitter category is identified, or when additional MIDs are required within a previously identified category.

MID 111 shall be used exclusively for factory test of electronic modules. Since it is possible that during factory test the normal control software is bypassed, giving the tester direct control of module I/o, several precautions should be observed:

a. Entry into factory test should be granted by the module control software only after ensuring that it is safe to do so.
b. This MID should not be transmitted by any on-board module.

MIDs 112 to 127 are not assigned to any category and are not reserved for future assignment. These MIDs are available to any manufacturer or user for any message identification purpose outside the scope of this document.

MIDs in the range of 128 to 255 shall be reserved for applications using formatted data as set forth in the SAE J1587 document issued by the SAE Low Speed Communications Network Subcommittee. These MIDs shall only be used when the data format set forth within that document is strictly followed (see SAE J1587).

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TABLE 3—MESSAGE IDENTIFICATION CHARACTER ALLOCATION

Message Range	Transmitter Category
00-07	ENGINE
08-09	BRAKES, TRACTOR
10-11	BRAKES, TRAILER (USED BY SAE J2497)
12-13	TIRES, TRACTOR
14-15	TIRES, TRAILER
16-17	SUSPENSION, TRACTOR
18-19	SUSPENSION, TRAILER
20-27	TRANSMISSION
28-29	ELECTRICAL CHARGING SYSTEM
30-32	ELECTRICAL
33-35	CARGO REFRIGERATION/HEATING
36-40	INSTRUMENT CLUSTER
41-45	DRIVER INFORMATION CENTER
46-47	CAB CLIMATE CONTROL
48-55	DIAGNOSTIC SYSTEMS
56-61	TRIP RECORDER
62-63	TURBOCHARGER
64-68	OFF-BOARD DIAGNOSTICS
69-86	SET ASIDE FOR SAE J1922
87	SET ASIDE FOR SAE J2497
88-110	DEFINED BY SAE LOW SPEED COMMUNICATIONS NETWORK SUBCOMMITTEE
111	RESERVED--FACTORY ELECTRONIC MODULE TESTER (OFF VEHICLE)
112-127	UNASSIGNED—AVAILABLE FOR USE
128-255	DEFINED BY SAE LOW SPEED COMMUNICATIONS NETWORK SUBCOMMITTEE (see SAE J1587)

6.3.3.2 MID Definitions

MIDs in the 0 to 9, 12 to 68 and 88 to 127 ranges shall be defined in the manufacturer's applications document. Content and format of the data within these messages is not defined in this document but should be identified in a manufacturer's applications document as described in Section 2. It shall be the responsibility of the systems integrator or user to ensure that a particular MID is not used by more than one device on the same vehicle.

6.3.4 DATA CHARACTERS

Data characters shall be characters that convey the intelligence of the message and shall conform to the character format as defined in 6.2. The 8 bit data character may be given any value from 0 to 255. The data characters shall be defined in an appropriate applications document at the option of the supplier. The application document shall define parameters, parameter order, scaling, and error detection/correction coding if applicable.

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6.3.5 CHECKSUM

The last character of each message shall be the two's complement of the sum of the MID and the data characters. Simple message error detection may be implemented by adding the checksum to the sum of all previous message characters (including the MID). The 8 bit sum will be zero, neglecting the CARRY, for a correctly received message.

6.3.6 MESSAGE LENGTH

Total message length, including MID and checksum, shall not exceed 21 characters.

6.3.7 MESSAGE LENGTH EXCEPTIONS

a. The 21 byte length limitation may be exceeded when the engine is not running and the vehicle is not moving.
b. Messages longer than 21 characters may also be broken up into several separate messages of 21 or fewer characters and may then be transmitted while the engine is running and/or the vehicle is moving by conforming to the 21 character message length limitation of SAE J1708.

7. Notes

7.1 Marginal Indicia

The final balloted document will contain Marginal Indicia to show the revisions of the latest published version.

The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE LOW SPEED NETWORK COMMUNICATIONS SUBCOMMITTEE OF THE SAE TRUCK AND BUS ELECTRICAL AND ELECTRONICS COMMITTEE

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APPENDIX A
SERIAL DATA BUS STANDARD NODE (UNIPOLAR DRIVE WITH PASSIVE TERMINATION IN EACH MODULE)

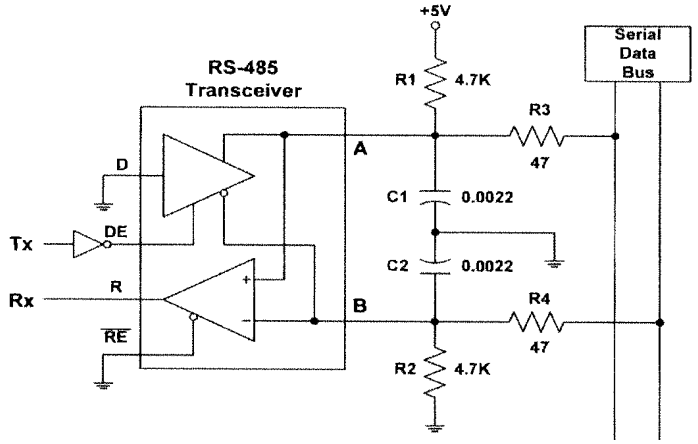


FIGURE A1—SERIAL DATA BUS STANDARD NODE DIAGRAM

A.1 This circuit utilizes standard RS-485 transceivers (less than or equal to one RS-485 unit load) connected to drive the differential data bus to the logic zero state only (unipolar drive). In the previous circuit, a standard RS- 485 receiver may be used in place of a transceiver in applications where data need not be placed on the bus (that is, receive only).

A.2 The logic 1 state (also idle state) is controlled by pull-up resistor R1 and pull-down resistor R2.

A.3 The transceiver output impedance, C1 and C2, form the transmit filter for transient and EMI suppression (approximately 6 MHz low pass).

A.4 R3, C1, R4, and C2 form the receive filter for EMI suppression (approximately 1.6 MHz low pass). These parts also form a pseudo line termination at high frequencies.

A.5 The active (high-to-low) transition delay is approximately 0.6 ms at the receiver with two nodes on the bus and 2.3 ms with 20 nodes on the bus.

A.6 The passive (low-to-high) transition delay at the receiver remains at 10 ms with any number of loads on the bus (up to 20).

A.7 The values shown were chosen for use with commercially available RS-485 drivers to provide maximum fan- out, EMI suppression, and bus termination. Remaining nodes may be in either the powered or unpowered state.

A.8 This method of unipolar drive prevents unresolved contention (logic 0 always wins).

A.9 The resistors shown should be 5% parts to assure sufficient noise margin under worst-case conditions. R3, R4, C1, and C2 should be balanced within 10% on each side of the data bus to minimize common mode electromagnetic radiation.

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APPENDIX B
EXAMPLE BUS REACCESS PROCEDURE

B.1 A method for reaccessing the bus can be described by the following example:

B.1.1 Sequence of Events

a. First crash occurs for the current attempt to access the bus.
b. Each device wishing to access the bus then waits their predefined bus access time (as described in 5.2.2).
c. Second crash occurs for the same attempt to access the bus.
d. Any device that has experienced two consecutive crashes in its attempt to transmit the same message shall follow the bus access procedure defined in 5.2.1 but with the bus access time calculated as follows:

$$T_a = T_i + [2 * T_b] * [P_2 + 1] \quad \text{(Eq. B1)}$$

where:

T_i and T_b are defined as in 5.2.1.1
P_2 = A three-bit pseudo random number such as the three least significant bits of the stack pointer

For example, if 18 is the location of stack pointer register, the contents of this register is the stack pointer. This value will be ANDED with 0007, which results in a number from 0 to 7, P_2 would, therefore, be a value from 0 to 7.

e. If any more consecutive crashes occur, the procedure described in d is repeated.

B.2 This example addresses the recognized possibility that two or more devices could continue to crash if their priorities were the same. The previous method would greatly reduce the possibility of a third crash with the same device or devices.

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Rationale

The J1708 document was reviewed during the five year SAE review period and was revised to clarify some of the information. J2497 references were added. The document was re-formatted from the original outline. Metric references were added to the English units of measure. A datalink network topology diagram was added to clarify total cable length. A message string example was added.

Relationship of SAE Standard to ISO Standard

Not applicable.

Application

This SAE Recommended Practice defines a recommended practice for implementing a bidirectional, serial communication link among modules containing microcomputers. This document defines those parameters of the serial link that relate primarily to hardware and basic software compatibility such as interface requirements, system protocol, and message format. The actual data to be transmitted by particular modules, which is an important aspect of communications compatibility, is not specified in this document. These and other details of communication link implementation and use should be specified in the separate application documents referenced in Section 2.

Reference Section

SAE J1455—Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design (Heavy-Duty Trucks)

SAE J1587—Joint SAE/TMC Recommended Practice for Electronic Data Interchange Between Microcomputer Systems in Heavy-Duty Vehicle Applications

SAE J1922—Powertrain Control Interface for Electronic Controls Used in Medium and Heavy-Duty Diesel on Highway Vehicle Applications

SAE J2497—Power Line Carrier Communications for Commercial Vehicles

EIA RS-485—Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems, April 1983

Developed by the SAE Low Speed Communications Network Subcommittee

Sponsored by the SAE Truck and Bus Electrical and Electronics Committee

In re Patent Application of:
Kenneth E. FLICK
Reexamination Control No. **90/014,419**
Filed: **12/16/2019**
_____/

CERTIFICATE OF SERVICE

Certificate of Service in compliance with 37 C.F.R. §1.530(c)

Pursuant to 37 C.F.R. §§1.530(c), 1.248, I hereby certify that on October 5, 2023, a complete copy of this Information Disclosure Statement is being served via First Class U.S. Mail upon Third Party Requester at the correspondence address as shown in PAIR:

Mark B. Garred
STETINA BRUNDA GARRED & BRUCKER
75 Enterprise, Suite 250
Aliso Viejo, California 92656

Respectfully submitted,

/JACK ABID/

_____
Jack G. Abid

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

GEOTAB USA, INC. AND GEOTAB, INC.,
Petitioners,

v.

OMEGA PATENTS, LLC,
Patent Owner.
U.S. Patent No. 8,032,278
Filing Date: July 3, 2007
Issue Date: October 4, 2011

Case No. IPR2023-00504

DECLARATION OF JOSEPH C. McALEXANDER, III IN SUPPORT OF RESPONSE TO PETITION OF *INTER PARTES* REVIEW

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I, Joseph C. McAlexander III declare as follows:

I. INTRODUCTION

1. I have been retained on behalf of Omega Patents, LLC ("Omega") for the above-captioned *inter partes* review (IPR) proceeding. I am being compensated for my time in connection with this IPR at my standard hourly consulting rate. I understand that this proceeding involves U.S. Patent No. 8,032,278 ("the *'278 Patent*") titled "Vehicle Tracking Unit With Download Codes and Associated Methods" by Kenneth E. Flick, and that the *'278 Patent* is currently assigned to Omega.

2. I have reviewed and am familiar with the specification of the *'278 Patent* filed July 3, 2007. I understand that the *'278 Patent* has been provided as Ex-1001. I will cite to the specification using the following format: Ex-1001, *'278 Patent*, 1:1-10. This example citation points to the *'278 Patent* specification at column 1, lines 1-10.

3. I have reviewed and am familiar with the file history of the *'278 Patent*. I understand that the file history has been provided as Ex-1002.

4. I understand that the *'278 Patent* has a filing date of July 3, 2007.

5. I have been asked to provide my technical review, analysis, insights, and opinions regarding the '*278 Patent* and the below identified references that Geotab USA, Inc. and Geotab, Inc. used as their bases for the grounds set forth in the Petition for *Inter Partes* Review of the '*278 Patent*.

II. QUALIFICATIONS

6. In formulating my opinions, I have relied upon my training, knowledge, and experience in the relevant art.

7. I am the Founder and President of McAlexander Sound, formerly the IP Director of CCI and Vice President of EPI Technologies, and have 50 years of experience in microcircuit and semiconductor technologies, including: device design, fabrication, assembly, testing, and marketing, and control system design, analysis, quality, reliability, and defect/failure analysis at Texas Instruments.

8. I am a technical expert in the subject matter areas relevant to this *inter partes* review, including design and testing of circuits and systems related to control systems, including wireless communication protocols and operation, information storage and transfer, user interfaces, information signal processing, applications and operating systems, and electronic device hardware and firmware design and control.

From 2000-2003, I represented Toyoto as its 30(b)(6) witness and technical expert focused on vehicle alarm systems.

9. I am qualified to reach the opinions and conclusions stated in this report.

10. I am a Registered Professional Engineer (#79454) in the State of Texas and hold a Bachelor of Science degree in Electrical Engineering from North Carolina State University.

11. I am an inventor on 31 U.S. patents and a number of foreign patents, and I am familiar with the patent process. Five of the 31 patents (3 U.S. and 2 EP) are directed to MEMs technology for vehicle air bag sensor deployment. Three of the 31 patents (2 U.S. and 1 EP) are directed to mobile device tracking, such as is used to track vehicles.

12. I have been an expert witness and technical consultant for the past 34 years in IP matters related to product/process analysis and investigation.

III. MATERIALS CONSIDERED

13. In forming my opinions, I have reviewed the following documents, and any other document cited in this declaration:

Exhibit	Description
1001	U.S. Patent No. 8,032,278 to Flick (the '278 Patent)
1002	Prosecution File History of U.S. Patent No. 8,032,278
1003	Declaration of Jeffrey Miller, Ph.D.
1004	Curriculum Vitae of Jeffrey Miller, Ph.D.
1005	Prosecution History of Ser. No. 90/013,587 (RX1)
1006	Prosecution History of Ser. No. 90/013,851 (RX2)
1007	Prosecution History of Ser. No. 90/014,309 (RX3)
1008	Prosecution History of Ser. No. 90/014,419 (RX4)
1009	Prosecution History of Ser. No. 90/014,675 (RX5)
1010	Claim Rejection, mailed May 6, 2016 in No. 90/013,587 (RX1)
1011	Decision granting ex parte reexamination request, mailed December 15, 2016 in No. 90/013,851 (RX2)
1012	Ex parte Omega Patents, LLC, No. 2018-008119 (Nov. 3, 2018)
1013	Decision granting ex parte reexamination request, mailed March 25, 2021 in No. 90/014,675 (RX5)
1014	Non-Final Rejection, mailed October 5, 2021 in No. 90/014,675 (RX5)
1015	Patent Owner's Appeal Brief, No. 90/014,675 (April 1, 2022)
1016	Transcript of oral argument in Ex parte Omega Patents, LLC, No. 2022-003758, Reexamination No. 90/014,675 (Oct. 28, 2022)
1017	*Ex parte Omega Patents, LLC*, No. 2022-003758 (Nov. 30, 2022)
1018	D.I. 50, Claim Construction Order, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb. 20, 2015) ("*CalAmp-CC*").
1019	D.I. 34, Claim Construction Order, *Omega Patents, LLC v. Firstech, LLC*, No. 2:20-cv-01344 (W.D. Wash. Nov. 22, 2021) ("*Firstech-CC*").

Exhibit	Description
1020	*Omega Patents, LLC v. CalAmp Corp.*, 920 F.3d 1337 (Fed. Cir. 2019) ("*CalAmp-I*")
1021	*Omega Patents, LLC v. CalAmp Corp.*, 13 F.4th 1361 (Fed. Cir. 2021) ("*CalAmp-II*")
1022	D.I. 14, Omega Patents Answering Brief In Opposition to Geotab USA, Inc.'s Motion to Dismiss, *Omega Patents, LLC v. Geotab USA, Inc. and Geotab, Inc.*, No. 1:22-cv-01044-CFC (D. Del. Nov. 16, 2022)
1023	U.S. Patent No. 6,957,133 ("Hunt")
1024	U.S. Patent No. 6,756,885 ("Flick-885")
1025	U.S. Patent No. 6,011,460 ("Flick-460")
1026	D.I. 040, Omega Patents Opposition to CalAmp Motion For Claim Construction, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Oct. 3, 2014)
1027	D.I. 144, Jury Verdict, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Sep. 30, 2019)
1028	D.I. 310, Jury Verdict, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb. 24, 2016)
1029	D.I. 143, Jury Instructions, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Nov. 24, 2016)
1030	D.I. 309, Jury Instructions, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Sep. 30, 2019)
1031	Y. Park and A. Fumiyuki, eds. *Enhanced Radio Access Technologies For Next Generation Mobile Communication*. Dordrecht: Springer, 2007.
1032	F. Delli Priscoli and M. Neri, "Integration of the ORBCOMM satellite network with the GSM Short Message Service." *Space Communications*, Vol. 19, no. 1, pp. 47-57, 2003.
1033	D.I. 180, Transcript, Civil Jury Trial–Day 3, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb. 18, 2016)
1034	Pages from D.I. 181, Transcript, Civil Jury Trial–Day 4, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb. 19, 2016)

Exhibit	Description
1035	*RESERVED*
1036	*RESERVED*
1037	*RESERVED*
1038	*RESERVED*
1039	Pages from D.I. 338, Transcript, Civil Jury Trial–Day 2, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Sep. 24, 2019)
1040	Pages from D.I. 339, Transcript, Civil Jury Trial–Day 3, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Sep. 25, 2019)
1041	*RESERVED*
1042	*RESERVED*
1043	*RESERVED*
1044	Comparison of limitations in '278 patent claims 13-22 with limitations in '278 patent claims 1-12
1045	U.S. District Court – Judicial Caseload Profile for the District of Delaware, *available at* https://www.uscourts.gov/sites/default/files/fcms_na_distprofile0630.2022_0.pdf (last visited December 19, 2022)
1046	Title 40 Code of Federal Regulations, Part 86, Subpart S—General Compliance Provisions for Control of Air Pollution From New and In-Use Light Duty Vehicles, Light-Duty Trucks, and Complete Otto-Cycle Heavy-Duty Vehicles (July 1, 2007)
1047	SAE J1939-71 Vehicle Application Layer (rev. DEC2004)
1048	SAE J1708 Serial Data Communications Between Microcomputer Systems in Heavy-Duty Vehicle Applications (rev. AUG2004)
1049	*RESERVED*
1050	International Standard ISO 15031-4 Road Vehicles—Communication between vehicle and external equipment for emissions related diagnostics—Part 4: External test equipment (1st ed. June 15, 2005) ("ISO 15031-4:2005")

Exhibit	Description
1051	Pages from Microsoft Internet & Networking Dictionary (2003)
1052	SAE J1978 OBD-II Scan Tool – Equivalent to ISO/DIS 15031-4: December 14, 2001 (revised 2002-04)
1053	Pages from IEEE 100 The Authoritative Dictionary of IEEE Standard Terms (7th Ed. 2000)
1054	D.I. 265, Federal Circuit Mandate, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. July 1, 2019)
1055	D.I. 392, Order Dismissing With Prejudice, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. June 16, 2022)
1056	U.S. Patent No. 8,856,266 B2
1057	U.S. Patent Application Publication No. US 2005/0032511 A1
1058	U.S. Patent Application Publication No. US 2004/0138790 A1
1059	U.S. Patent No. 6,611,740 to Lowrey
1060	U.S. Patent No. 7,209,813
1061	*RESERVED*
1062	*RESERVED*
1063	*RESERVED*
1064	U.S. Patent No. 7,617,727
1065	D.I. 145-85, PL104, 4/15/2015 Expert Report of Joseph C. McAlexander, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1066	13 Cal. Code Reg. §1968.2 Malfunction and Diagnostic System Requirements—2004 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines (2004)
1067	February 19, 2007 Internet Archive capture of startech.com webpage on computer cables at https://web.archive.org/web/20070219050320/http://www.startech.com/Product/Category.aspx?WCID=7&WCLID=2&MLID=2&menu=1&fro

Exhibit	Description
	m=more&c=US
1068	D.I. 145, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1069	*RESERVED*
1070	Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines; Modification of Federal On-Board Diagnostic Regulations for: Light-Duty Vehicles, Light-Duty Trucks, Medium Duty Passenger Vehicles, Complete Heavy Duty Vehicles and Engines Intended for Use in Heavy Duty Vehicles Weighing 14,000 Pounds GVWR or Less; Extension of Acceptance of California OBD II Requirements, 68 Fed. Reg. 35792 (June 17, 2003)
1071	SAE J1850 Class B Data Communications Network Interface, Rev. 2001-05 (May 2001)
1072	ISO 15765-4:2005(E) Road vehicles – Diagnostics on Controller Area Networks (CAN) – Part 4: Requirements for emissions-related systems (1st ed. ISO January 15, 2005)
1073	ISO 15031-5:2006(E) Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics — Part 5: Emissions-related diagnostic services (ISO 1st ed. January 15, 2006)
1074	ISO 14230-4 Road vehicles — Diagnostic systems — Keyword Protocol 2000 —Part 4: Requirements for emission-related systems (ISO 1st ed. June 1, 2000)
1075	SAE J1979 (R) E/E Diagnostic Test Modes – Equivalent to ISO/DIS 15031-5:April 30, 2002 (April 2002)
1076	SAE J2178-1 Class B Data Communication Network Messages— Detailed Header Formats and Physical Address Assignments (reaffirmed July 2004).
1077	D.I. 10, Geotab USA, Inc.'s Opening Brief In Support Of Motion To Dismiss, *Omega Patents, LLC v. Geotab USA, Inc. and Geotab, Inc.*, No. 1:22-cv-01044 (D. Del. Nov. 2, 2022)
1078	SAE J2178-4 Class B Data Communication Network Messages— Message Definitions for Three Byte Headers (reaffirmed July 2004).

Exhibit	Description
1079	Pages from Title 40 Code of Federal Regulations, Part 86, Subpart S—General Compliance Provisions for Control of Air Pollution From New and In-Use Light Duty Vehicles, Light-Duty Trucks, and Complete Otto-Cycle Heavy-Duty Vehicles (July 1, 2014)
1080	Pages from Collins English Dictionary (5th ed. 2000)
1081	Pages from Newton's Telecom Dictionary (2005)
1082	ISO 14230-2 Road vehicles—Diagnostic systems—Keyword Protocol 2000 – Part 2: data link layer (1st ed. Mar. 15, 1999)
1083	*RESERVED*
1084	*RESERVED*
1085	*RESERVED*
1086	*RESERVED*
1087	*RESERVED*
1088	*RESERVED*
1089	*RESERVED*
1090	D.I. 145-80, PL99, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1091	D.I. 145-54, PL68, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1092	D.I. 145-53, PL67, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1093	D.I. 145-67, PL81, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1094	D.I. 145-42, PL45, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1095	D.I. 145-57, PL71, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1096	D.I. 145-68, PL82, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)

Exhibit	Description
1097	D.I. 145-69, PL83, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1098	D.I. 145-70, PL84, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1099	D.I. 145-73, PL88, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1100	D.I. 145-74, PL90, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1101	D.I. 145-75, PL92, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1102	D.I. 145-76, PL93, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1103	D.I. 145-77, PL96, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1104	D.I. 145-79, PL98, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1105	D.I. 145-81, PL100, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13- cv-1950 (M.D. Fla. Feb 25, 2016)
1106	D.I. 145-83, PL102, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13- cv-1950 (M.D. Fla. Feb 25, 2016)
1107	D.I. 145-84, PL103, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13- cv-1950 (M.D. Fla. Feb 25, 2016)
1108	D.I. 145-88, PL141, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13- cv-1950 (M.D. Fla. Feb 25, 2016)
1109	D.I. 145-55, PL69, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1110	D.I. 145-71, PL85, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1111	D.I. 145-72, PL86, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
1112	D.I. 145-82, PL101, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13- cv-1950 (M.D. Fla. Feb 25, 2016)

Exhibit	Description
1113	D.I. 145-78, PL97, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb 25, 2016)
2001	U.S. Patent No. 6,636,790 to Lightner
2002	Declaration of Mr. Joseph C. McAlexander, III
2003	Curriculum Vitae of Mr. Joseph C. McAlexander, III
2004	D.I. 297-1, Deposition of Galin Chen, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13- cv-1950 (M.D. Fla. September 24, 2019)
2005	D.I. 297-4, Deposition of Peter Hergesheimer, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13- cv-1950 (M.D. Fla. September 24, 2019)
2006	D.I. 297-5, Deposition of Stephen Hall, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13- cv-1950 (M.D. Fla. September 24, 2019)
2007	D.I. 39, Defendant CalAmp Corp's Opening Claim Construction Brief, *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13- cv-1950 (M.D. Fla. September 5, 2014)
2008	Intent to issue Reexamination Certificate, mailed on April 14, 2023 in 90/014,675 (RX5)

14. I have also relied on my education, experience, research, training, and knowledge in the relevant art, and my understanding of any applicable legal principles described in this declaration.

15. All of the opinions contained in this declaration are based on the documents I reviewed and my knowledge and professional judgment. My opinions have also been guided by my understanding of how a person of ordinary skill in the art would have understood the claims of the '*278 Patent* at the time of invention.

For purposes of this declaration, I have been asked to assume that the date of the invention is July 3, 2007.

16. I reserve the right to supplement and amend any of my opinions in this declaration based on documents, testimony, and other information that becomes available to me after the date of this declaration.

IV. LEGAL UNDERSTANDING

17. Omega's counsel has advised me that anticipation under 35 U.S.C. §102 is a basis for invalidity. I understand for a claim to be "anticipated" the prior art reference must not only disclose all elements of the claim within the four corners of the document, but must also disclose those elements arranged as in the claim. I have been informed that the standard for anticipation in an *inter partes* review proceeding is by a preponderance of the evidence.

18. I have also been informed that a prior art reference can disclose a claim feature if that feature is expressly described by that reference, or inherent from its disclosure. I have been informed that something is inherent from a prior art reference if the missing descriptive matter must necessarily be present, and it would be so recognized by a person of ordinary skill in the art ("POSA"). I also have been

informed that inherency cannot be established by probabilities or possibilities, and that the mere fact that something may result from a given set of circumstances is not sufficient to show inherency.

19. I have further been informed that where a reference discloses multiple embodiments, the reference should not be limited to a preferred embodiment. Instead, each disclosed embodiment may anticipate. Moreover, I have been informed that, as part of an anticipation analysis, it is proper to take into account not only specific teachings of the reference, but also the inferences that one skilled in the art would reasonably be expected to draw therefrom. A reference can anticipate a claim even if it does not expressly spell out all the limitations arranged or combined as in the claim, if a person of skill in the art, reading the reference, would at once envisage the claimed arrangement or combination.

20. I have been informed that a prior art document can disclose a claim feature, and anticipate a claimed invention, if that feature is described in another document that has been incorporated by reference. I have also been informed that, to incorporate by reference, the host document must identify with detailed particularity what specific material it incorporates, and clearly indicate where that

material is found in the incorporated document. I have also been informed that, in making the determination of the extent to which that material incorporated into a host document can be used, the standard of a POSA should be to determine whether the host document describes the material to be incorporated by reference with sufficient particularity.

21. Omega's counsel has advised me that obviousness under 35 U.S.C. §103 is also a basis for invalidity. I understand that, where a prior art does not identically disclose all of the limitations of a given patent claim, that patent claim is invalid if the differences between the claimed subject matter and the prior art are such that the claimed subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art. Obviousness can be based on prior art in the form of a single prior art or a combination of references that either expressly or inherently disclose all limitations of the claimed invention.

22. It is my understanding that the question of obviousness is to be determined based on:

- The scope and content of the prior art;
- The difference or differences between the subject matter of the claim and the prior art (whereby in assessing the possibility of obviousness

one should consider the manner in which a patentee and/or a Court has construed the scope of a claim);

- The level of ordinary skill in the art at the time of the alleged invention of the subject matter of the claim; and
- Any relevant objective factors (the "secondary indicia") indicating non-obviousness, including evidence of any of the following: commercial success of the products or methods covered by the patent claims; a long-felt need for the alleged invention; failed attempts by others to make the alleged invention; copying of the alleged invention by others in the field; unexpected results achieved by the alleged invention; praise of the alleged invention by the alleged infringer or others in the field; the taking of licenses under the patent by others and the nature of those licenses; expressions of surprise by experts and those skilled in the art at the subject matter of the claim; and whether the patentee proceeded contrary to accepted wisdom of the prior art.

23. It is further my understanding that, for purposes of an obviousness determination, it is impermissible to rely on 20/20 hindsight reconstruction.

24. And still further, it is my understanding that a patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was independently known in the prior art. There must be an apparent reason why it would have been obvious to modify the prior art to arrive at the claimed invention. I understand that, in order to avoid impermissibly applying hindsight, it is helpful to determine whether there is a teaching, suggestion, or motivation in the prior art that would lead one of ordinary skill in the art to combine

the elements. When there is no suggestion, teaching, or motivation for the proposed combination, or when the prior art suggests something other than the combination, this weighs against a finding of obviousness. The patent challenger has the burden to show that a person of ordinary skill in the relevant field had a reason to combine the elements in the manner claimed when asserting obviousness in view of a combination of references.

25. It is my understanding that evidence of secondary considerations must be considered when determining obviousness and cannot be discounted, as they play a critical role in the obviousness analysis. Evidence of secondary considerations can weigh against a finding of obviousness and are often relied upon to provide guides against the forbidden use of hindsight.

V. LEVEL OF ORDINARY SKILL IN THE ART

26. I understand that Petitioners contend that a POSA "would have had a Bachelor's degree in electrical engineering, computer engineering, computer science, automotive engineering, or a related discipline, and at least two years of experience in networking or automotive engineering." Petition 9. I understand that Petitioners also contend that "POSAs would have understood networking

electronics, been familiar with vehicle data buses, regulations and industry standards involving on-board diagnostics ("OBD-II"), and at least one underlying network protocol used by OBD-II." Petition 9.

27. I disagree with Petitioners' characterization that a POSA "would have understood networking electronics, been familiar with vehicle data buses, regulations and industry standards involving on-board diagnostics ("OBD-II"), and at least one underlying network protocol used by OBD-II." The level of a POSA has already been determined, and this level, which is consistent with previous characterizations of a POSA by the opposing party in litigation and also used by me, should be adopted by the PTAB. In particular, in litigation regarding the *'278 Patent*, the opposing party, *CalAmp*, defined a POSA such that:

> "The relevant field of art for purposes of construing the claims of the patents-in suit is the vehicle telematics industry. A person of ordinary skill in the art in that field would have at least an undergraduate degree in electrical engineering, automotive engineering, or an equivalent engineering discipline, and several years' experience in

> designing, manufacturing, installing and/or working on vehicle telematics systems. Alternatively, additional years of practical experience may replace the engineering degree, or completion of post-graduate engineering studies may reduce the years of practical experience necessary." D.I. 39, p. 9; ¶ 116 (Ex-2007).

For the purpose of this Declaration, however, I have applied the Petitioners' heightened level of skill.

VI. CLAIM CONSTRUCTION

28. I understand that, in *inter partes* review, the U.S. Patent and Trademark Office applies the plain and ordinary meaning of claim terms, in view of the specification, as would have been understood by a POSA.

29. I also understand that two district courts have construed terms in challenged claims: Ex. 1018, D.I. 50, *Omega Patents v. CalAmp Corp.*, No. 6:13-cv-1950 (M.D. Fla. Feb. 20, 2015) (*CalAmp-CC*), and Ex. 1019, D.I. 34, *Omega Patents v. Firstech*, No. 2:20-cv-01344 (W.D. Wash. Nov. 22, 2021) (*Firstech-CC*). I also understand that the Federal Circuit issued opinions on two appeals from the

CalAmp litigation: Ex. 1020, 920 F.3d 1337 (Fed. Cir. 2019) (*CalAmp-I*) and Ex. 1021, 13 F.4th 1361 (Fed. Cir. 2021) (*CalAmp-II*).

30. I understand that all terms not specifically construed should be given their plain and ordinary meaning.

31. Based on my review of these materials and my personal knowledge and experience, I have considered each term of the *'278 Patent* claims not specifically construed and have applied plain and ordinary meaning to those terms as it would have been understood by one skilled in the art as of July 3, 2007.

VII. SUMMARY OF OPINIONS

32. Multiple patent licensees, multiple United States Patent and Trademark Office (USPTO) patent examiners, two different Patent Trial and Appeal Board (PTAB) panels, a jury, and a District Court all considered and determined the validity of the *'278 Patent.* Petitioners now argue these prior determinations are wrong because of yet another cumulative reference – this time to inventors Hunt, Lowrey and Banet (U.S. Pat No. 6,957,133) (Ex-1023, *Hunt*).

33. In the most-recent fifth ex parte reexam of the *'278 Patent*, the PTAB again found the originally filed claims patentable over a similar reference to Lowrey,

Banet, Lightner, Borrego, Myers and Williams (U.S. Pat. No. 6,611,740) (Ex-1059) either alone or in combination with a reference to Lightner, Borrego, Myers and Lowrey (U.S. Pat. No. 6,636,790) (Ex-2001).

34. The three patents to Hunt, Lowrey and Lightner are all currently assigned to Verizon Patent and Licensing Inc., New Jersey. It is basically the same rotating group of inventors and the same technology, yet Petitioners urge this time that it is somewhat different.

35. Even if *Hunt* were somehow "new," Petitioners concede that *Hunt* still fails to anticipate or render obvious claims 2-3, 7, 9-10, 23-27, 20, and 22. The majority of these claims are directed to a wired signal downloading interface -- one of the two species of downloading interfaces recited in the challenged claims -- the other being a wireless signal downloading interface.

36. To argue obviousness of these claims, Petitioners attempt to combine U.S. Patent No. 6,756,885 to Flick (*Flick885*), also owned by the Patent Owner, with *Hunt*.

37. *Flick885* is described in the Background of the *'278 Patent* and was considered by the examiner in the original prosecution. Accordingly, it is not new either.

38. Regarding its anticipation arguments for Claims 1, 4-6, 8, 11-12, 18-19 and 21, the Petitioners wrongly rely upon boilerplate language in the specification -- unrelated to the actual invention of *Hunt* -- in an attempt to piece together the elements of the challenged claims.

39. The relied-upon boilerplate language is at best unrelated, and at worst contradictory, to the inventors' description of their invention in the specification of *Hunt*. Accordingly, a Person of Ordinary Skill in the Art (POSA) would not read *Hunt* as argued by Petitioners.

40. This same deficiency also applies to the obviousness challenges to these claims where Petitioners' declarant attempts to supply the missing teachings of *Hunt*.

41. Petitioners' characterization of the Patent Owner's evidence of secondary considerations of non-obviousness as "phantom" is flawed. Significant parts of this evidence of secondary considerations was elicited from an infringer's employees in ligation involving the *'278 Patent*, who described the *'278 Patent* as

providing important features sought by its customers and increasing the value of their product -- technology they could not design around. D.I. 297-1, 26:11-20 (Ex. 2004); D.I. 297-4, 45:3-19, 46:25-47:19 (Ex. 2005); D.I. 297-5, 64:15-24, 102:16-103:13, 155:4-13 (Ex. 2006).

42. The compelling evidence of secondary considerations was already twice considered and adopted by the PTAB in the second and fifth *ex parte* reexams. *Ex Parte Omega Patents, LLC*, Appeal 2018-008119 (Ex-1012); *Ex Parte Omega Patents, LLC*, Appeal 2022-003758 (Ex-1017).

VIII. OVERVIEW OF PRIOR ART

A. U.S. Patent No. 6,957,133 to Hunt et al. (*Hunt*)

43. *Hunt* (Ex-1023) is directed to a wireless system for monitoring and analyzing a vehicle's GPS and diagnostic data. *Hunt* 2:23-25. The system performs the monitoring and analysis functions using a wireless appliance. *Hunt* 2:25-27. The wireless appliance is based upon an integrated, silicon-based architecture. *Id.* The architecture is in the form of an application specific integrated circuit (ASIC) for communicating with multiple systems on a data communications bus. *Hunt* 2:28-31. A GPS module collects location-based data. *Hunt* 2:23-25, 5:4-5, 6:18-26. A communications circuit collects diagnostic data relating to the vehicle. *Hunt* 5:8-10.

The communications circuit selects one supported communications protocol from among supported communications protocols. *Hunt* 5:7-19. Supported protocols are fixed and correspond to discrete hardware integrated circuit (IC) modules. *Hunt* 5:7-16, 5:43-6:18, and 8:14-9:45.

B. U.S. PATENT NO. 6,756,885 TO FLICK (*FLICK885*)

44. *Flick885* (Ex-1024), an earlier patent to Mr. Flick, the inventor of the *'278 Patent*, was cited by Patent Owner during prosecution of the *'278 Patent.* Ex-1002. *Flick885* is described in the Background of the Invention section of the *'278 Patent.* Accordingly, *Flick885* was specifically considered by the Examiner. *Id.*

45. *Flick885* discloses a multi-vehicle compatible control system for a vehicle that operates on a data communications bus. *Flick885,* 5:5-15. A multi-vehicle compatible controller of the system provides a bus interface for remote operation of devices on the data communications bus. *Id.,* 5:11-34, 6:33-40. The bus interface interfaces using proper signal levels and formats on the data communications bus. *Id.*, 6:35-40.

IX. THE '278 PATENT

46. The Background of the Invention section of the *'278 Patent* (Ex-1001) states that, "[m]otor vehicles, such as passenger cars, trucks, buses, fleet vehicles,

etc. are widely used and knowing the locations of such vehicles is often desired. For example, should a vehicle be stolen, it would be beneficial to know the vehicle's location so that authorities could be promptly and accurately directed to retrieve the vehicle. Indeed, the tracking system could plot the getaway path of the thief." *'278 Patent,* 1:30-36.

47. The Background of the Invention also defines problems addressed by the claimed invention of the *'278 Patent.* For example, the Background of the Invention provides that "[t]here are, of course, a number of vehicles which come from the manufacturer with some form of security system already installed. In addition, a number of vehicles are also equipped with aftermarket security systems.

48. Many conventional vehicle tracking units may not be readily installed in vehicles, particularly those vehicles already including a vehicle security system. In addition, complexity of installation may significantly increase the system costs." *'278 Patent*, 1:35-42. "Unfortunately, such advanced techniques for dealing with multiple device codes for a vehicle having a data communications bus have not yet been developed for vehicle tracking units." *Id.* 2:38-41.

49. Moreover, the Background of the Invention describes the inventor's prior developed technology relating to security and control systems that address data bus interoperability as follows:

> U.S. Pat. No. 5,719.551, assigned to Omega Patents, LLC, the assignee of the present invention, discloses a vehicle security system for a vehicle including a data bus connecting a plurality of vehicle devices. A signal enabling circuit enables the alarm controller to operate using a set of desired signals selected from a plurality of possible sets for different vehicles. U.S. Pat. No. 6,011,460, assigned to Omega Patents, LLC, discloses a similar system where the set of desired signals from the plurality of different sets of signals for different vehicles is obtained, such as by connection and communication with a downloading device. Additionally, U.S. Pat. No. 6,756,885, also assigned to Omega Patents, LLC, discloses a multi-vehicle control system whereby a multi

> vehicle compatible controller stores a set of device codes for a given vehicle device for a plurality of different vehicles. Device codes are read from the data communications bus, and a match between a read device code and the stored device codes is determined to provide compatibility with different vehicles. *Id.* 2:19-37.

50. The written description and associated drawings of the *'278 Patent* include embodiments having a downloading interface to address the potential difficulties of interfacing to a vehicle data bus and devices connected thereto. *'278 Patent,* 23:41-25:4, and FIGS. 10-13. Embodiments include a remote transmitter, and a remote start controller including a receiver and at least one processor to generate a climate control command on the data communications bus of the vehicle and remote start the vehicle. *Id.* The at least one processor of the remote start controller is also configured to perform a different respective function in each different embodiment.

51. There are two species or categories of signal downloading interfaces disclosed and claimed in the *'278 Patent*: (1) a wired signal downloading interface

(e.g. Claim 2) that may include a connector for temporary connection to a downloading device (e.g. Claim 3); and (2) a wireless signal downloading interface (e.g. Claim 4) that may include a wireless receiver for temporary connection to a downloading device (e.g. Claim 5). *'278 Patent* 24:14 – 25:28; 26:16-29.

X. GROUND 1: CLAIMS 1, 4-6, 8, 11-12, 18-19, 21 ARE NOT ANTICIPATED BY *HUNT*

52. The Petitioners rely on *Hunt* to challenge the patentability of Claims 1, 4-6, 8, 11-12, 18-19, and 21 as being anticipated by *Hunt*. *Hunt,* described herein, discloses an ASIC based wireless appliance that includes a microprocessor for determining which discrete component based protocol module to select for communication. *Hunt* 5:35-67; 8:46-9:43. Petitioners concede that *Hunt* fails to disclose the first category of downloading interfaces specifically recited in dependent Claims 2 and 3, that is, where the downloading interface comprises a wired signal downloading interface (Claim 2) and includes a connector for temporary connection to a downloading device (Claim 3). Petition 5, 67.

53. Regarding the second category of downloading interface – the wireless signal downloading interface (Claims 4 and 5) – Petitioners coble together disjoint and contradictory language in an attempt to invalidate these claims. Petition 34-43.

Indeed, Petitioners rely on superfluous and contradictory boilerplate as the sole basis for the purported disclosure. *Hunt* 10:35-12:67.

A. Hunt Fails to Disclose All the Claim Elements

54. *Hunt* fails to disclose a downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller. *Hunt*'s vehicle-communication circuit (box 4 in FIG. 1A; box 25 in FIG. 1B; and box 25 in FIG. 5) in combination with a microprocessor (box 8 in FIG. 1A; box 27 in FIG. 1B; and box 27 in FIG. 5) discloses the claimed multi-vehicle compatible controller. Petition 19-20. However, programming of the vehicle-communication circuit, which is either an ASIC or "transistors or conventional circuit elements," cannot be changed via a downloading interface. *Hunt* 9:43-44. Accordingly, *Hunt* fails to disclose the claimed downloading interface.

55. *Hunt* discloses a hardware based system in the form of an ASIC, which is, as recited in Claim 1 of *Hunt*, a single ASIC. *Hunt* 9:18-55; 12:1-17. The discrete individual circuit modules that correspond to each protocol are integrated directly into the ASIC and thus fixed. *Hunt* 9:18-55. *Hunt* discloses that "these logic

diagrams represent circuits that function as individual modules within the data-communications circuit and are integrated directly into the ASIC." *Id.* "These protocols can be implemented using integrated silicon-based solutions (e.g., a custom ASIC), or using transistors or conventional circuit elements." *Id.* In other words, protocols are fixed and cannot be added post manufacturing.

56. An ASIC is an integrated circuit chip, programmed during manufacture, which has been custom built or fabricated for a specific use rather than a generic use. Logic gates are photolithographically placed and then connected (wired) at the factory during the manufacturing process to perform specific, pre-determined functions. These structures and functions cannot be changed once the ASIC is manufactured.

57. In the case of *Hunt*, the ASIC is controlled by a microprocessor to select among the protocols for which the ASIC was created.

58. The *Hunt* vehicle communication circuit is expressly directed to an ASIC, but Petitioners attempt to broaden *Hunt* to cover other non-disclosed embodiments beyond the ASIC.

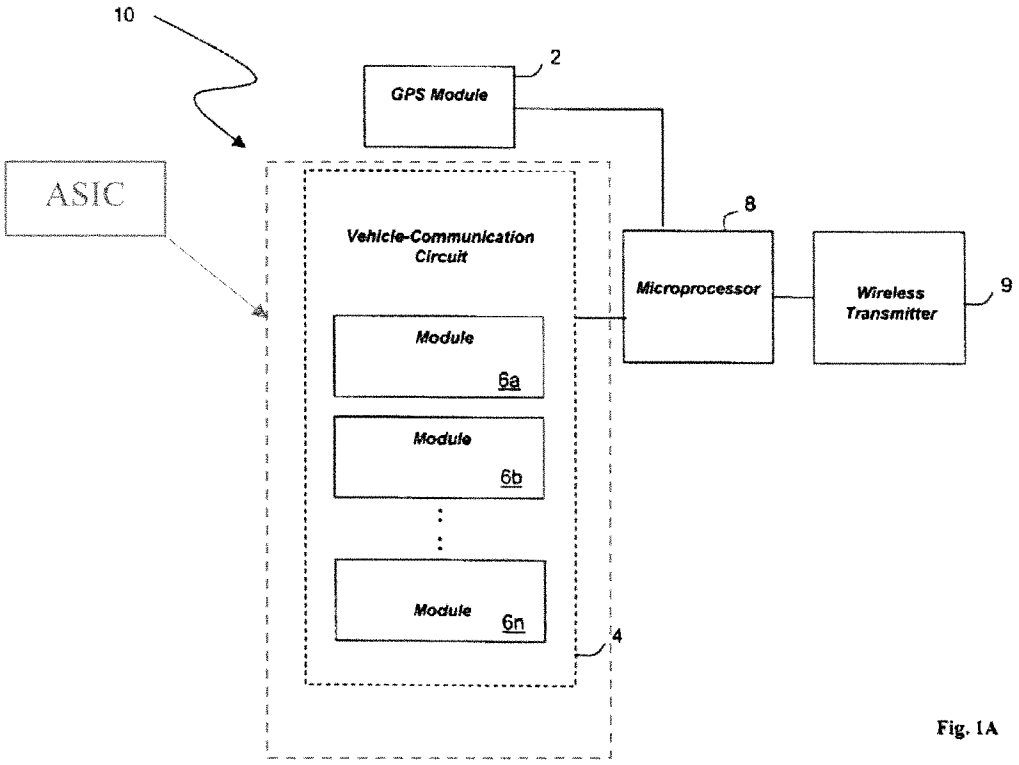
59. A POSA would understand that *Hunt* does not teach or suggest the claimed downloading interface since an ASIC is pre-programmed and fixed at a semiconductor fabrication level; and *Hunt* expressly touts the benefits of an ASIC.

60. By using an ASIC, "the entire wireless appliance **13** can be incorporated into a single 'chip set', described by a reference design, thereby reducing its size, manufacturing costs, and potential post-installation failures." *Hunt* 5:39-42.

61. *Hunt* teaches that the wireless appliance is embodied in an ASIC; and the claims of *Hunt* also require a microprocessor. *Hunt* 8:46-9:27. Claim 2 of *Hunt*, for example, recites a microprocessor and a vehicle-communication circuit. *Hunt* 12:41-48. The vehicle-communications circuity is in electrical communication with the microprocessor and integrated into a single ASIC. *Id.* The microprocessor does not perform interfacing with the ASIC using any of the protocols hard wired in the ASIC, as those functions are embodied only in an ASIC. *Hunt* 8:46-9:27 and FIGS. 1A and 1B.

62. Rather, the microprocessor performs basic computer functionality, for example, selecting one of the ASIC-embedded protocols, and determines the

communication of the host vehicle. *Id.* The microprocessor does not provide individual support for the communication protocols, which instead is done by the ASIC-based communication modules 25a-25e. *Id.*



Patent Owner's Annotated FIG. 1A of *Hunt*

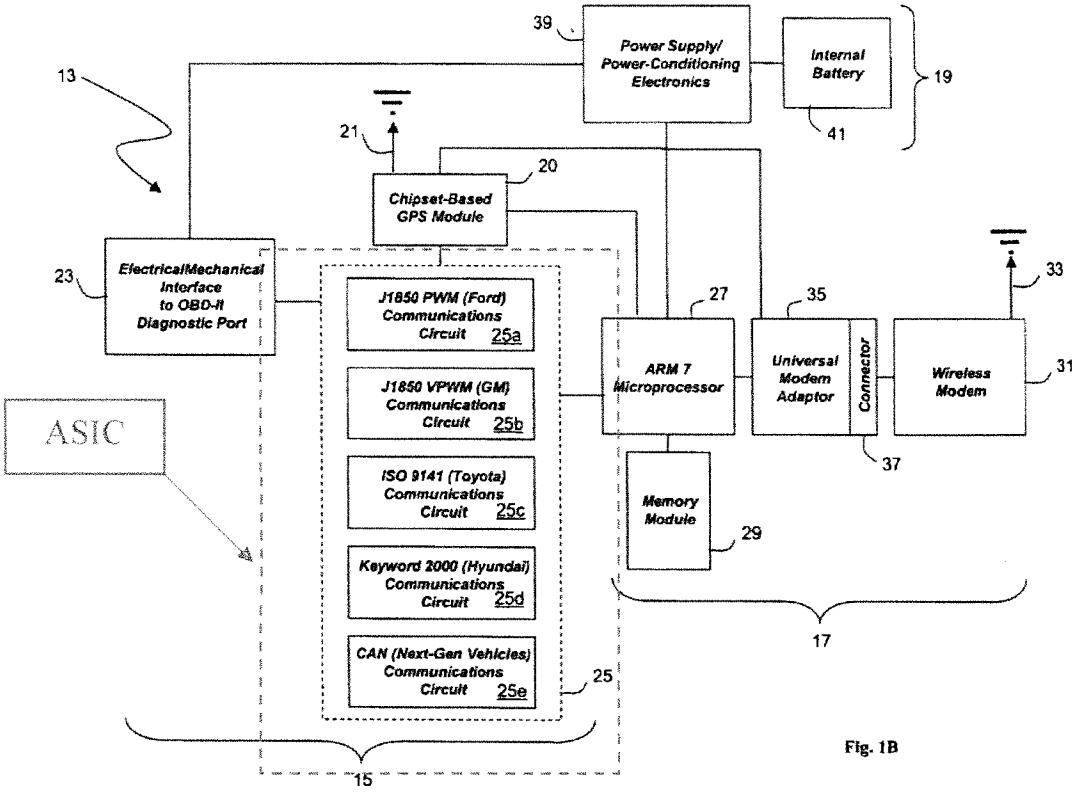


Fig. 1B

Patent Owner's Annotated FIG. 1B of *Hunt*

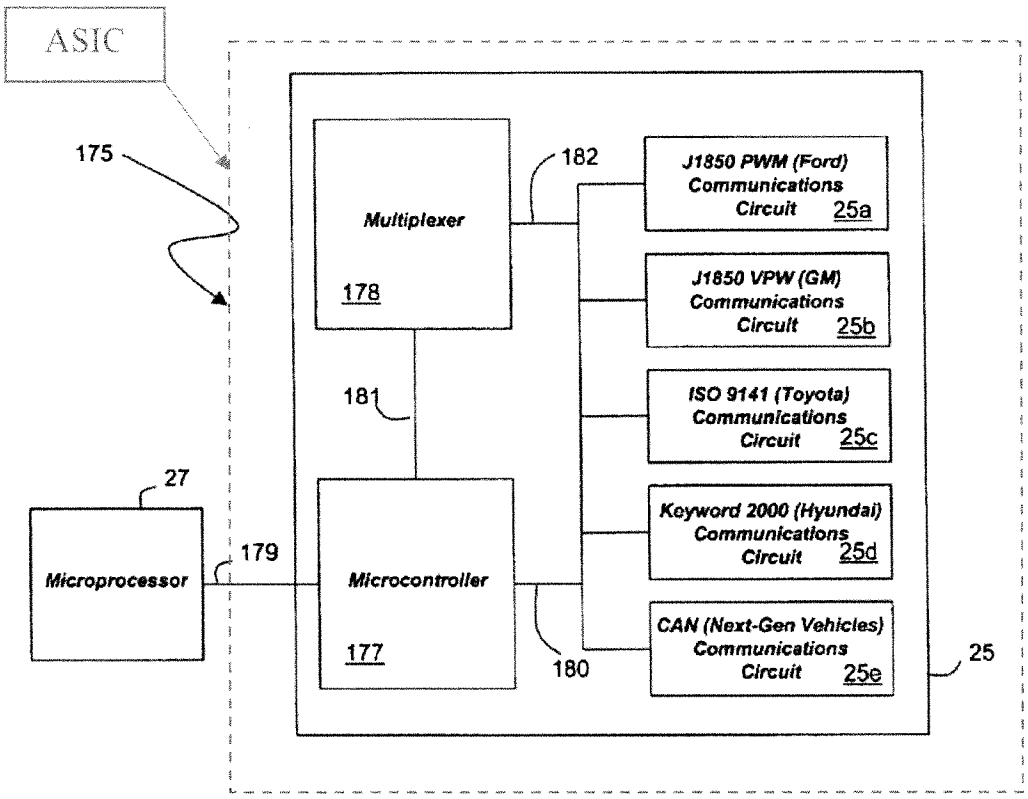


Fig. 5

Patent Owner's Annotated FIG. 5 of *Hunt*

63. Petitioners concede that *Hunt* fails to disclose a wired signal downloading interface. Petition 5, 67. The Petitioners turn to inconsistent boilerplate language in an attempt to find a wireless signal downloading interface. Petition 34-36 (citing *Hunt* 10:46-54 and 11:5-18). The boilerplate language relied

upon by Petitioners (*Hunt* 10:36-11:67) amounts to nothing more than unsupported speculation, inconsistent with the description of the invention of the *Hunt* reference.

64. The POSA would be unable to use the teachings of *Hunt* to somehow make a wired or wireless signal downloading interface. And since the ASIC is pre-loaded with the predetermined protocols, there is no reason for any additional downloading. Thus, such a need for a downloading interface is unnecessary and would additionally be inoperative since the ASIC is not programmable post manufacturing.

65. The *Hunt* specification concludes with nine paragraphs of boilerplate language. (*Hunt* 10:36-11:67). Petitioners point to *Hunt* 10:46-54 which describes, in part, "*some* embodiments of the present invention *may be* implemented *in part or in whole* as a *hard-wired circuit*, a circuit configuration fabricated into an application specific integrated circuit, *or* a firmware program loaded into non-volatile storage, *or* as a software program loaded from *or* into a data storage medium as machine readable code." (Emphasis Added). Petition 35. There is nothing in *Hunt* that would teach or suggest to a POSA how to logically reconcile the above boilerplate

passage, filled with generic alternative language, with the inventors' invention (i.e. the ASIC) being taught in *Hunt*.

66. *Hunt* fails to disclose all of the claim elements within its four corners specifically "arranged" as in the challenged claims.

67. Petitioners attempt to selectively apply pieces of the boilerplate passages to the actual device in *Hunt* -- but *Hunt* is silent as to what language could be implemented, how to do so, and to which data the language could be implemented (e.g., protocol implementation data, or programming instructions for how to perform the functions taught by *Hunt*, such as the microprocessor **27**, as discussed in further detail below).

68. Firmware, for example, are basic instructions for specific hardware. Firmware is typically embodied in an integrated circuit and provides basic instructions for the hardware. *Id.* A POSA, based upon the ASIC teachings of *Hunt*, would consider the "firmware loaded into non-volatile storage medium" as providing the basic operations, for example, for the microprocessor **27**, as the programming of the ASIC is fixed or fixed by conventional circuit elements,

transistors, integrated silicon based solutions. *Hunt* 8:14-65; 9:36-43; 11:11-19; FIGS. 1A and 1B.

69. There can be no anticipation where the POSA is left to guess how to arrange the disjointed elements in an attempt to arrive at the claimed invention.

70. *Hunt* describes microprocessor **27** such that it receives and processes diagnostic data and location based data operating to format the diagnostic data using firmware. *Hunt* 6:18-65. The firmware is configured to recognize the wireless modem and format outgoing vehicle diagnostics so that the wireless appliance can operate on different wireless networks throughout the world. *Id.* Microprocessor **27** also determines the protocol and communicates the protocol needed to the ASIC which selects one of the five modules to communicate with the host vehicle. *Hunt* 9:18-23; FIG. 5.

71. Petitioners contend that the ability of the microprocessor **27** to update firmware that tests "each protocol in an effort to establish communications" is somehow a downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller. Petition 40. In other words, the Petitioners contend

that, because the firmware of the microprocessor **27** can be updated, and the microprocessor **27** selects the appropriate protocol, *Hunt* somehow discloses a downloading interface as in the challenged claims. *Id.* This rationale is erroneous. This is not a claimed downloading interface.

72. Keeping in mind that Petitioners have already conceded *Hunt* fails to disclose a wired interface, there is nothing in *Hunt* that *discloses any downloading interface for permitting downloading* of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller.

73. For example, the circuity to implement the protocols cannot be changed as they are embodied in an ASIC. *Hunt* 9:18-45.

74. In other words, *Hunt* discloses that protocols cannot be added. *Id.*

75. The reference to "carrier wave modulated" does not supply the missing elements of *Hunt*. The "carrier wave modulated" term is simply boilerplate to reference a type of computer readable medium.

76. The POSA cannot fabricate missing puzzle pieces from mere blanket boilerplate statements. Indeed, as noted above, the claimed and disclosed

embodiments of *Hunt* identify the microprocessor **27**, and separate vehicle-communications circuit, in the form of an ASIC, in communication with the microprocessor. *Hunt* 8:15-20, 8:46-9:45; 12:4-17; 12:43-48; FIG. 1A, 1B, and 5. The separate circuit or circuits are discrete circuit elements embodied in an ASIC that includes modules corresponding to different protocols. *Id.*

77. There is no downloading interface for permitting downloading of enabling data relating to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller. *Id.*

78. Petitioners wrongly contend that *Hunt's* universal modem adapter and wireless modem together disclose the claimed downloading interface for permitting downloading of enabling data relating to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller. Petition 37.

79. As described above, microprocessor **27** receives and processes diagnostic data and location based data and operates to format the diagnostic data using firmware. *Hunt* 6:18-65.

80. The firmware is configured to recognize the wireless modem and to format outgoing vehicle diagnostic so that the wireless appliance can operate on different wireless networks throughout the world. *Id.*

81. This does not disclose the claimed downloading interface for enabling data related to the at least one corresponding vehicle device code, nor does this disclosure of *Hunt* permit the addition of a broad data interface to be based thereon.

82. Petitioners leap to yet another disjointed boilerplate section of *Hunt* in an attempt to show that *Hunt's* ASIC device can be a cellphone and thus includes the claimed downloading interface. Petition 37, citing *Hunt* 11:34-40.

83. The *Hunt* wireless appliance is hardwire installed in a vehicle. *Hunt* 5:5-6, 8:46-65. It is illogical to hardwire install a cellphone in the vehicle, particularly to the OBD-11 diagnostic port as taught by *Hunt*. *Id.*

84. *Hunt* teaches that any deviation from an ASIC is undesirable. As described *Supra*, by using an ASIC, "the entire wireless appliance **13** can be incorporated into a single 'chip set', described by a reference design, thereby reducing its size, manufacturing costs, and potential post-installation failures." *Hunt* 5:39-42.

85. Thus, there is no reason that a POSA would interpret the boilerplate language to include or disclose the claimed downloading interface. Petitioner's jump to use of boilerplate language would thus require undue experimentation on how to keep size and costs small and reduce post-installation failures, particularly in view of the express desire to achieve this using an ASIC.

86. The Petitioner's desire to treat the various boilerplate sections as simply being interchangeable with the various embodiments is improper and contrary to the teachings of *Hunt*, as will be understood by a POSA.

87. A POSA will understand that the boilerplate language does not apply to the vehicle-communication circuit including modules, as described in *Hunt*. Thus, *Hunt* fails to disclose a downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller as in the challenged claims.

B. All Claim Terms Must Be Given Patentable Weight

88. Petitioners also contend that the downloaded data content does not limit the downloading interface. Petition 38. More particularly, the Petitioners contend

that the claimed "enabling data" should not be given any patentable weight. *Id.,* at 38-40.

89. I understand that the issue of interpreting "enabling data" has already been considered in previous litigations and reexaminations, and Petitioners' desired claim construction is inconsistent with prior claim constructions. The PTAB, in what was the second reexamination in a string of reexaminations, highlighted:

> "...[i]n related litigation, the District Court did not construe the term 'downloading interface,' but did construe the term 'enabling data' as data relating to the at least one corresponding vehicle device code for use by said multi-vehicle compatible controller- a construction that matches the terms in the claim. See *Omega Patents, LLC v. CalAmp Corp.*, No. 6:13-cv-1950-0rl -40DAB, (M.D. Fla. Feb. 20, 2015) ("Dist. Ct. Claim Construction Order") at 20-23, 25."
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"According to the Specification, enabling data may be, for example, (1) the vehicle device code or codes; (2) an instruction to select a code or codes from among those already stored; or (3) the data or sequence to allow the controller 111 to generate the vehicle device code or codes. '278 patent, col. 24, 11. 9-13. Our emphasis on the permissive and exemplary language in this passage underscores that enabling data is not limited to these three alternatives." *Ex Parte Omega Patents, LLC*, Appeal 2018-008119 at 12-13 (2018) (Ex-1012).

"But despite this non-limiting description, what is clear from Appellant's disclosure is that downloading enabling data via the recited interface enables the recited controller to use a particular vehicle device code from among plural such codes for different vehicles by providing either (1) the code itself to the controller, or (2) data that otherwise

> enables the controller to select or generate the code. See '278 patent, col. 24, 1. 5-col. 25, 1. 28; Figs. 10-13." *Ex Parte Omega Patents, LLC*, Appeal 2018-008119 at 12-13 (2018) (Ex-1012).

90. Thus, not only was the term "enabling data" given patentable weight, the courts and this Board have provided clear guidance on its construction.

91. The enabling data has a functional relation to the claimed multi-vehicle compatible controller in that it is "used by the multi-vehicle compatible controller" for communicating with a vehicle device using the corresponding vehicle device code. *'278 Patent* Claim 1; 24:13-51.

92. The claim language of a downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller clearly communicates the content of the data and its effect on the multi-vehicle compatible controller to those having ordinary skill in the art.

93. In other words, the multi-vehicle compatible controller is programmed to perform the recited functions, and those functions are performed based upon the

enabling data. *Hunt* fails to disclose a downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller.

C. Claim 4

94. As explained in Section X(X.A above, *Hunt* fails to disclose a wireless downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller. For at least these reasons set forth in Section X(X.A above, dependent Claim 4 is also patentable.

D. Claim 5

95. *Hunt* fails to disclose a wireless signal downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller and that includes a wireless receiver for temporary connection to a downloading interface. Petitioners once again turn to the boilerplate of *Hunt* as allegedly disclosing this recitation too. Petition 42. In particular, the Petitioners, as described above in Section X(X.A above, desire to read the boilerplate language as disclosing more than it reasonably conveys to a POSA.

96. Petitioners then make a jump in logic that a POSA, in view of the boilerplate, would have turned to the host computer system **57** of *Hunt* as being a downloading device. Petition 42, citing to *Hunt* 7:40-49. The cited portions of *Hunt* merely describe that data packets sent to the *Hunt* appliance are sent over the Internet to a computer. *Hunt* 7:40-49.

97. Petitioners continue to mix and match disjointed embodiments for which there is no logical connection. There is no logical connection between a host computer that runs a website that communicates with the *Hunt* wireless appliance, boilerplate about computer instructions being on a computer readable medium, and logic circuits the function as individual protocol modules integrated into an ASIC, and specifically no logical connection to the contended wireless downloading interface and its temporary connection to a downloading device. *Hunt* 9:28-35, 11:11-19, 7:40-49.

98. A POSA would understand a host computer that runs a website cannot be a wireless downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-

vehicle compatible controller and that includes a wireless receiver for temporary connection to a downloading interface.

99. The host computer has nothing to do with protocols, nor selecting the communications protocol of the host vehicle. *Id.* Accordingly, dependent Claim 5 is also patentable.

E. Claim 6

100. Section X(X.A above explains that *Hunt* fails to disclose a wireless downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller. For at least these reasons set forth in Section X(X.A above, dependent Claim 6 is also patentable.

F. Claim 8

101. Section X(X.A above, explains that *Hunt* fails to disclose a wireless downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller. For at least these reasons set forth in Section X(X.A above, dependent Claim 8 is also patentable.

102. Moreover, despite the Petitioners' contentions, the *'278 Patent* claimed downloading interface is for permitting downloading of enabling data.

103. Dependent Claim 8 recites the downloading interface being *also* for permitting downloading of at least programming instruction. Thus, the downloading interface of the *'278 Patent* is for permitting downloading of *both* enabling data and at least one programming instruction. No matter how many passages of *Hunt* are cobbled together by Petitioners, *Hunt* fails to disclose a downloading interface that is for permitting downloading of enabling data *and also* for permitting downloading of at least programming instruction. For at least this additional reason, dependent Claim 8 is also patentable.

G. Claim 11

104. Section X(X.A above, explains that *Hunt* fails to disclose a wireless downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller. For at least these reasons set forth in Section X(X.A above, dependent Claim 11 is also patentable.

H. Claim 12

105. Section X(X.A above, explains that *Hunt* fails to disclose a wireless downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller. For at least these reasons set forth in Section X(X.A above, dependent Claim 12 is also patentable.

I. Claims 18-19, 21

106. Independent Claim 18 recites subject matter from independent Claim 1 and dependent Claim 5. *'278 Patent* 25:64-26:15, 26:26-29, and 27:27-28-15. Independent Claim 18 does not recite the downloading interface as a wireless downloading interface as recited in dependent Claim 5. *Id.* For the reasons set forth in Sections X(A) and (D above, independent Claim 18 is also patentable.

107. Dependent Claims 19 and 21 are also patentable for at least the same reasons.

XI. GROUND 2: CLAIMS 1, 4-6, 8, 11-12, 18-19, 21 ARE NOT OBVIOUS OVER *HUNT*

108. Petitioners, recognizing the shortcomings of *Hunt,* proffer alternatives that the POSA would simply fill in the missing pieces. Petition 46-48. A POSA would not have found it obvious to "fill in" the missing pieces of *Hunt*.

109. Additionally, evidence of secondary considerations weighs heavily in favor of patentability.

A. A POSA Would Not Have Found the Claims Obvious in View of *Hunt*

1. It Would Not Have Been Obvious for A POSA To Modify Hunt In the Way Proposed By Petitioners

110. In Ground 2, Petitioners concede that *Hunt* fails to disclose the downloading interface as in the challenged claims. However, Petitioners contend that "[t]o the extent Hunt's disclosure of programming the system 'later' than manufacture (Hunt, 11:5-18) is treated as not expressly disclosing programming the firmware, updating Hunt's ***firmware*** through its wireless modem and/or wired connection would have been the conventional and obvious way to implement Hunt's post-manufacture programming with a reasonable expectation of success." Emphasis in original; Petition 48, citing *Miller* (Ex-1003), ¶ 355.

111. As described above in Section X(A), there is no logical connection disclosed in *Hunt* between the firmware and the modules defined in the ASIC. The firmware may simply update the basic functions of the microprocessor, which is discrete and separate from the ASIC that includes the modules. *Hunt* 8:46-9:45, FIGS. 1a, 1b, and 5.

112. The modem delivers packets of data to an Internet-accessible website for display of diagnostic and location data. *Hunt* 6:35-7:61. Petitioners are attempting to use the boilerplate to fill in the gaps to tie together disjointed pieces of *Hunt*. Petition 48, *Miller* ¶¶ 356-357.

113. *Hunt* is silent as to updating the downloading data via a downloading interface because updating an ASIC post manufacture is not possible -- the functions of the ASIC are set during manufacture.

114. Petitioners' conclusory statement that it was "predictable" falls well short of any required technical rationale required to sustain an obviousness rejection – it is generic and bears no relation to any specific combination of prior art elements.

115. In other words, despite Petitioners' declarant's attempt to supply the missing teachings of *Hunt*, *Hunt* fails to render obvious the claims of the *'278 Patent*,

and specifically, fails to teach, suggest, or describe in any way the claimed downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller.

116. Moreover, the only way a POSA could possibly make the leap proposed by Petitioners would involve the improper use of hindsight based upon Patent Owner's own specification. Without that hindsight, a POSA would conclude that the ASIC was not programmable post manufacturing and thus, a downloading interface would be impractical and inoperable and to try to do so would add unnecessary cost.

117. *Hunt* discloses that its modem can operate on different wireless networks. *Hunt* 6:35-50.

118. Hunt further discloses that, "[w]ith firmware, the microprocessor **27** formats the diagnostic and location based data into separate packets and serially transfers these packets through a universal modem adaptor **35** to a wireless modem **31**." *Hunt* 6:35-38. A POSA would thus understand that, even if the firmware were

to be updated, it would be solely for formatting packets of diagnostic and location-based data for communication via the modem.

119. To make a connection that a firmware update is for updating the ASIC protocols in *Hunt* is neither supported by *Hunt*, nor would the POSA make that leap. *Id.* *Hunt* still fails to disclose a downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller.

120. To simply declare that a mash-up of *Hunt* to arrive at the claimed embodiments would be "predicable" is conclusory at best and, without more, amounts to a conclusory declaration that the combination is "common sense" since it is possible that the POSA could arrive at the claimed embodiments. This hindsight type of analysis is entirely opposite to what a POSA using common sense would derive since the Hunt ASIC was not programmable post manufacturing.

121. Petitioners fall well short of providing any evidence that a POSA would have, without hindsight, recognized the problem facing the inventor, turned to boilerplate language in *Hunt*, and apply the boilerplate language to desired selected sections of *Hunt*, all while considering the teachings of *Hunt* as a whole.

2. Petitioners' Proposed Combinations Ignore Compelling Evidence of Secondary Considerations

122. Truthful and compelling evidence of secondary considerations has been presented, most of which is already considered and confirmed twice by the PTAB. Ex-1012, Ex-1017. This evidence, which was already considered by the PTAB twice, included licensing, commercial success, copying by others, customer need, and limited value for accused products without the invention. See *Ex Parte Flick*, Appeal 2022-003758 at 14 (Ex-1017). The evidence of secondary considerations weighs heavily in favor of non-obviousness.

123. That is, this evidence is not just a cumulative or confirmatory part of the obviousness analysis, but rather is independent evidence of non-obviousness that is the most probative evidence in avoiding the trap of hindsight.

124. When the secondary considerations evidence is considered, the claims of the *'278 Patent* are not obvious in view of *Hunt*.

B. Claim 4

125. Sections X(A) and XI(A) above explain that *Hunt* fails to disclose or render obvious a wireless downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use

by the multi-vehicle compatible controller. For at least the reasons set forth in Sections X(A) and XI(A) , dependent Claim 4 is also patentable.

C. Claim 5

126. *Hunt* fails to disclose or render obvious a wireless signal downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller and that includes a wireless receiver for temporary connection to a downloading interface. That is, for at least the reasons set forth in Sections X(A) and XI(A) above, dependent Claim 5 is also patentable.

D. Claim 6

127. Sections X(A) and XI(A) above explain that *Hunt* fails to disclose or render obvious a wireless downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller. For at least the reasons set forth in Sections X(A) and XI(A) above, dependent Claim 6 is also patentable.

E. Claim 8

128. Sections X(A) and XI(A) above explain that *Hunt* fails to disclose or render obvious a wireless downloading interface for permitting downloading of

enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller. For at least the reasons set forth in Sections X(A) and XI(A) above, dependent Claim 8 is also patentable.

F. Claim 11

129. Sections X(A) and XI(A) above explain that *Hunt* fails to disclose or render obvious a wireless downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller. For at least the reasons set forth in Sections X(A) and XI(A) above, dependent Claim 11 is also patentable.

G. Claim 12

130. Sections X(A) and XI(A) above explain that *Hunt* fails to disclose or render obvious a wireless downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by the multi-vehicle compatible controller. For at least the reasons set forth in Sections X(A) and XI(A) above, dependent Claim 12 is also patentable.

H. Claims 18-19, 21

131. Independent Claim 18 recites subject matter from independent Claim 1 and dependent Claim 5. *'278 Patent* 25:64-26:15, 26:26-29, and 27:27-28-15.

Independent Claim 18 does not recite the downloading interface as a wireless downloading interface as recited in dependent Claim 5. *Id.* For the reasons set forth above in Sections X(A), and XI(A) and (C), independent Claim 18 is also patentable.

132. Dependent Claims 19 and 21 are also patentable for at least the reasons set forth above in Sections X(A) and XI(A).

XII. GROUND 3: *FLICK885* AND *HUNT* DO NOT RENDER OBVIOUS CLAIMS 1-22

133. Petitioners are improperly distilling the claims of the *'278 Patent* to make the argument that a POSA would have known to slap a GPS unit in a single housing with the other components.

134. Petitioners' contentions fail to consider the entire teachings of *Flick885* and *Hunt*, and Petitioners' declarant fails to supply the missing pieces and/or rationale for combination.

135. *Flick885* and the art that it incorporates by reference, namely U.S. Patent No. 6,011,460 to Flick (*Flick460*), were already considered and is cumulative. Petitioners' arguments for unpatentability must also fail in light of the Patent Owner's compelling evidence of secondary considerations of non-obviousness.

136. Petitioners contend that a combination of *Flick885* and *Hunt* renders obvious the claims of the *'278 Patent*. Petitioners contend that *Flick885* discloses "everything" except GPS and a single housing. Petition 49; *Miller* ¶ 361.

A. Flick885

137. *Flick885* (Ex-1024) was cited by Patent Owner during prosecution of the *'278 Patent*. Ex-1002. *Flick885* is described in the Background of the Invention section of *'278 Patent*. Accordingly, *Flick885* was specifically considered by the Examiner. *Id.*

138. *Flick885* discloses a multi-vehicle compatible control system for a vehicle that operates on a data communications bus. *Flick885,* 5:5-15. A multi-vehicle compatible controller of the system provides a bus interface for remote operation of devices on the data communications bus. *Id.,* 5:11-34, 6:33-40. The bus interface interfaces using proper signal levels and formats on the data communications bus. *Id.*, 6:35-40.

139. *Flick460* is directed to a vehicle security system for a vehicle having a data communications bus. *Flick460*, abstract. *Flick460,* like *Flick885* was *also* cited in the prosecution of the *'278 Patent* and *also* considered by the Examiner. Ex-1002.

Flick460, *also* similarly to *Flick885*, was described in the background section of the *'278 Patent*, specifically: "U.S. Pat. No. 6,011,460, assigned to Omega Patents, LLC, discloses a similar system where the set of desired signals from the plurality of different sets of signals for different vehicles is obtained, such as by connection and communication with a downloading device." *'278 Patent*, 2:25-29.

B. A POSA Would Not Have Found the Claims Obvious Over The Combination of *Flick885* and *Hunt*

1. A POSA Would Not Combine *Flick885* with *Hunt*

140. A POSA would not combine *Flick885* with *Hunt*.

141. Petitioners attempt to fill in the missing teachings in an attempt to arrive at the challenged claims using hindsight. Petition 50-51, *Miller* ¶¶ 365-367. *Flick885* addresses, among others, the problems of security system or car alarm compatibility, but does not disclose anything about vehicle position determining. *Flick885* 1:21-67.

142. *Hunt* is directed to the monitoring of a vehicle, particularly, for analyzing a vehicle's GPS and diagnostic data. *Hunt* 2:23-25, 4:11-27. *Hunt* does not address *ongoing* compatibility with different vehicles since *Hunt* discloses

protocol modules being embodied in an ASIC. *Hunt* 9:18-45; see also, e.g., Section X(A) above.

143. Petitioners contend that a POSA would add location services to *Flick885* to "achieve any or all of the 'advantages' *Hunt* describes." Petition 50-51, *Miller* ¶ 366. This statement amounts to nothing more than an unsupportable conclusion that a POSA would turn to *Hunt* simply to make *Flick885* better in ways *Flick885* did not comprehend or suggest.

144. Petitioners' declarant's statement is insufficient as a motivation to make or build something better – failing to explain why a POSA would have combined the specific elements to arrive at the challenged claims.

145. A combination of *Flick885* and *Hunt* can only be achieved through the use of improper hindsight.

146. The Petitioners' declarant's blanket conclusory statement that the "combination" is "no more than the 'predictable use of the prior art elements'" as the rationale for combining *Flick885* and *Hunt* is also improper as conclusory and lacking a technical rationale.

2. Petitioners Proposed Combination of *Flick885* and *Hunt* Fails to Consider Compelling Evidence of Secondary Considerations

147. Compelling evidence of secondary considerations, most of which is already recognized and confirmed twice by the PTAB, has been presented. This evidence, which was already considered by this Board on multiple occasions, included licensing, commercial success, copying by others, customer need, and limited value for accused products without the invention. See *Ex Parte Flick*, Appeal 2022-003758 at 14 (Ex-1017); D.I. 297-1, 26:11-20 (Ex. 2003); D.I. 297-4, 45:3-19, 46:25-47:19 (Ex. 2004); D.I. 297-5, 64:15-24, 102:16-103:13, 155:4-13 (Ex. 2005). The evidence of secondary considerations weighs in favor of non-obviousness, and thus in Patent Owner's favor in this regard. This evidence of secondary considerations is not just a cumulative or confirmatory part of the obviousness analysis, but is independent evidence of non-obviousness that is the most probative evidence in avoiding the forbidden use of hindsight.

148. When the secondary considerations evidence is properly weighed with respect to the proposed combination of *Flick885* and *Hunt*, particularly the adding of a vehicle position determining device and a multi-vehicle compatible controller

for cooperating with the vehicle position determining device to send vehicle position data, the claims of the *'278 Patent* are not obvious.

149. Petitioners are offering to simply slap a GPS from *Hunt* into the *Flick885* system and put it all in a single housing, and contend, nearly fifteen (15) years later and after careful consideration by a multitude of tribunals, that the combination would have been obvious. This, in my technical opinion, is wrong, flies in the face of common sense, and does not give proper weight to secondary consideration evidence.

C. The Combination of *Flick885* and *Hunt* is No Better Than the Combination of *Lowrey* and *Lightner*

150. The PTAB has previously considered the combination of *Lowrey* (Ex-1059) and *Lightner* (Ex-2001). *Ex Parte Flick*, Appeal 2022-003758 at 12 (Ex-1017). *Hunt* shares a common inventor with both *Lowrey* (Ex-1059), and *Lightner* (Ex-2001) – the same rotating inventor group and the same technology. Both *Lowrey* and *Lightner* disclose GPS. Thus, adding GPS to the already considered *Flick885* is not only duplicative of art already considered, but no better than art already considered.

D. Claims 2-12

151. Sections XII(B-C) above, explain that even the selective combination of *Flick885* and *Hunt* fails to disclose or render obvious the claimed embodiments. For at least these reasons set forth above in Sections XII(B-C), dependent Claims 2-12 are also patentable.

E. Claim 13

152. Independent Claim 13 includes subject matter from independent Claim 1 and dependent Claim 3. Sections XII(B-C) above, explain that even the selective combination of *Flick885* and *Hunt* fails to disclose or render obvious the claimed embodiments. For at least these reasons set forth above in Sections XII(B-C), independent Claim 13 is also patentable.

F. Claims 14-17

153. Dependent Claims 14-17 recite subject matter similar to dependent Claims 6-9. Sections XII(B-C) above, explain that even the selective combination of *Flick885* and *Hunt* fails to disclose or render obvious the claimed embodiments. For at least these reasons set forth above in Sections XII(B-C), dependent Claims 14-17 are also patentable.

G. Claim 18

154. Independent Claim 18 recites subject matter from independent Claim 1 and dependent Claim 5. *'278 Patent* 25:64-26:15, 26:26-29, and 27:27-28-15. Independent Claim 18 does not recite the downloading interface as a wireless downloading interface as recited in dependent Claim 5. *Id.* For the reasons set forth above in Sections XII(B-C), independent Claim 18 is also patentable over the combination of *Flick885* and *Hunt*.

H. Claims 19-22

155. Dependent Claims 19-22 recite subject matter similar to dependent Claims 6-9. Sections XII(B-C) above, explain that even the selective combination of *Flick885* and *Hunt* fails to disclose or render obvious the claimed embodiments. For at least these reasons set forth above in Sections XII(B-C), dependent Claims 19-22 are also patentable.

XIII. EVIDENCE OF SECONDARY CONSIDERATIONS SUPPORT PATENTABILITY

156. Petitioners advance a laundry list of reasons to discard all evidence of secondary considerations. Petition 76-81. Petitioners' contentions including the requirement that Petitioners be granted the opportunity to cross-examine witnesses,

the PTAB not considering the secondary considerations in a "adversarial proceeding," the weight of the secondary consideration evidence, Omega has "blocking patents" negating commercial success, there is no nexus, and there is no evidence of copying, licenses are missing, amount nothing more than a hand-waving in an attempt to get the PTAB to look past the evidence of secondary considerations.

157. This PTAB has twice considered the evidence of secondary considerations. *Ex Parte Omega Patents, LLC*, Appeal 2018-008119 (Ex-1012); *Ex Parte Omega Patents, LLC*, Appeal 2022-003758 (Ex-1017).

158. Petitioners want the PTAB to simply discard the evidence that the PTAB has already considered twice as it relates to the *'278 Patent*, and, most recently:

> "A key aspect of our finding in this regard is, as it was in a related appeal, (1) the jury's verdict in related litigation that there was a nexus between the evidence of secondary considerations of non-obviousness and the claimed invention, and (2) the Federal Circuit's affirming the district court's upholding the jury's infringement verdict.

See Omega Patents, 13 F.4 at 1365 (affirming the judgment of infringement of the '278 patent's asserted claims). *Ex Parte Flick*, Appeal 2022-003758 (Ex-1017), at 13-14; internal footnotes omitted.

Our holding in a related appeal involving similar secondary considerations evidence is instructive in this regard, albeit in connection with a different patent. *Cf.* Dec. 2019 Bd. Dec'n, at 10-18. In that appeal, we found Appellant's evidence of secondary considerations of non-obviousness of the claimed invention, including licensing, commercial success, and copying by others, outweighed the evidence of obviousness and was dispositive of error in the Examiner's rejections. *See id.* at 17-18.

In reaching this conclusion, we emphasized the jury's verdict that there was a nexus for each proffered secondary

consideration to the claimed invention. *See id.* at 13 (noting the jury's finding that eight licenses were key factors in the claimed invention's non-obviousness because the licenses were accepted *due to the merits of the claimed invention*), 14 (noting the jury's finding that the commercial success of products embodying the claimed invention was due to the claimed invention's merits---not other factors), and 16 (noting the jury's verdict that others copying the claimed invention was a key factor indicating non-obviousness of that invention). *Ex Parte Flick*, Appeal 2022-003758 (Ex-1017), at 13-14; internal footnotes omitted.

Notably, as Appellant indicates, the jury made similar findings here. *See* Appeal Br. 38 (reproducing jury verdict form indicating the jury's finding that others accepted licenses under patents *because of the merits of the claimed*

> *invention*), 39 (reproducing jury verdict form indicating the jury's finding that accused products covered by the claim were commercially successful *due to the merits of the claimed invention* rather than due to advertising, promotion, salesmanship, or product features other than those claimed), and 42 (reproducing jury verdict form indicating the jury's finding that others copying the claimed invention indicated non-obviousness of the claimed invention)." *Ex Parte Flick*, Appeal 2022-003758 (Ex-1017), at 13-14; internal footnotes omitted.

159. In other words, the PTAB has already, on multiple occasions, considered the ***same*** secondary evidence and determined the sufficiency of this evidence: there is a nexus, there is commercial success, there is copying, there is licensing, there is customer need, and there is limited value of accused products without the invention. *Id.* The PTAB has carefully considered and found this evidence sufficient *twice*, and taking into consideration a jury verdict, Federal Circuit Appeal, and testimony of the *opposing party* admitting to copying and

limited value of product without the claimed invention. *Id.*; *see also* D.I. 297-1, 26:11-20 (Ex-2004); D.I. 297-4, 45:3-19, 46:25-47:19 (Ex-2005); D.I. 297-5, 64:15-24, 102:16-103:13, 155:4-13 (Ex-2006).

160. Rarely does evidence get considered this many times and by such a variety of tribunals. The evidence of secondary considerations here should be fully considered consistent with the previous determinations of this Board and other tribunals.

XIV. INSTITUTION SHOULD BE DENIED

A. The Board Should Decline to Institute under 35 U.S.C. §325(d) Because the Same or Substantially the Same Prior Art Was Presented to the Office

1. *Hunt* Is Cumulative and Similar to the Prior Art Considered

161. Once issued as a Patent, the *'278 Patent* has been subject to a litany of challenges including five (5) reexaminations and multiple litigations. In the most recent reexamination of the *'278 Patent*, *the PTAB* evaluated both U.S. Patent No. 6,611,740 to *Lowrey* (Ex-1059) and U.S. Patent No. 6,636,790 to *Lightner* (Ex-2001). See *Ex Parte Omega Patents, LLC*, Appeal 2022-003758 (2022) (Ex-1017). *Hunt* is similar to *Lowrey* and *Lightner* and enjoys two of its three inventors in common with *Lowrey*, and a common inventor with *Lightner*. Ex-1023; Ex-1059;

Ex-2001. All four of the *Lightner* inventors enjoy commonality with the inventor group in *Lowrey*. *Id.* *Lowrey* is directed to an internet based vehicle diagnostic system that includes a wireless appliance in electrical contact with an in-vehicle computer and that can report position date from a GPS device, while *Lightner* is directed to a wireless diagnostic system and method for monitoring vehicles that includes a wireless appliance that can be physically and electrically installed. *Id.*

162. Similarly, *Hunt* is directed to small-scale integrated vehicle telematics device that collects, transmits, and analyzes diagnostic and location-based data from a motor vehicle. Ex-1023.

163. *Hunt*, *Lowrey*, and *Lightner* share the same inventor group, and, like most of the art cited against the *'278 Patent*, are directed to the same common technology.

164. *Lowrey* and *Lightner* were both cited in *Hunt*. *Hunt*, page 2. We have now come full circle with prior art rejections -- *Hunt* cites U.S. Patent No. 5,732,074 to *Spaur et al.* *Id.* (Ex-2009). *Spaur et al.* was used to formulate a rejection in the first reexamination – a rejection that was later withdrawn. See Reexamination Control No. 90/013,587 (RX1; Ex-1005). Patent Owner also now has one of its own

earlier patents, *Flick885*, cited in the Petition, despite being considered over fifteen years ago by the USPTO. Petition 48-75.

165. The PTAB determined that "collective teachings" of both *Lowrey* and *Lightner* fail to teach or suggest the claimed embodiments of the *'278 Patent*, including the claimed downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by said multi-vehicle compatible controller. *Ex Parte Omega Patents, LLC*, Appeal 2022-003758 at 12 (Ex-1017). The issue of whether a prior art reference discloses the claimed downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by said multi-vehicle compatible controller was also previously decided by the PTAB – again determining that the prior art, that time *Chou*, fails to teach or suggest the claimed downloading interface for permitting downloading of enabling data related to the at least one corresponding vehicle device code for use by said multi-vehicle compatible controller. *Ex Parte Omega Patents, LLC*, Appeal 2018-008119 at 14 (2018) (Ex-1012).

2. *Flick885* Was Already Considered

166. During prosecution of the *'278 Patent*, the Patent Owner cited *Flick885*. *'278 Patent*, page 2. Not only did the Patent Owner cite *Flick885*, the Patent Owner embraced *Flick885*, identifying it in the background section of the patent: "Additionally, U.S. Patent No. 6,756,885, also assigned to Omega Patents, LLC discloses a multi-vehicle control system whereby a multi-vehicle compatible controller stores a set of device codes for a given vehicle device for a plurality of different vehicles. Device codes are read from the data communications bus, and a match between a read device code and the stored device codes is determined to provide compatibility with different vehicles." *'278 Patent*, 2:29-37. Moreover, in determining that there was not a substantial new question of patentability raised, U.S. Patent Number 5,719,551 (*Flick551*) was considered. See Reexamination Control No. 90/014,419 (RX4; Ex-1008). *Flick551* is in the priority chain of *Flick885*. *Flick885*, page 1.

167. Accordingly, the substantial similarities between the now-asserted art and the prior art considered during the many rounds of examination is remarkably

similar. Petitioners failed to sufficiently point out how any Examiner erred in evaluation of any of the prior art, to which the asserted prior art is merely cumulative.

B. The Compelling Nature of Secondary Considerations Has Repeatedly Been Confirmed

168. The PTAB has twice considered the sufficiency of evidence of secondary considerations. See *Ex Parte Omega Patents, LLC*, Appeal 2022-003758 (Ex-1017), and *Ex Parte Omega Patents, LLC*, Appeal 2018-008119 (Ex-1012). In the most recent Decision on Appeal in Appeal 2022-003758 (Ex-1017), the PTAB specifically noted that consideration goes beyond the PTAB to two jury trials, and a Federal Circuit Appeal. *Ex Parte Omega Patents, LLC*, Appeal 2022-003758, 4-5. The PTAB noted that a key aspect in multiple appeals is a jury verdict in related litigation that there was a nexus between the evidence of secondary considerations and the claimed invention, and the Federal Circuit's upholding of the jury's infringement verdict affirming the judgment of infringement of the *'278 Patent's* asserted claims. *Id.* at 13-14. The jury found evidence of acceptance of licenses because of the merits of the claimed invention, evidence of commercial success because of the merits of the claimed invention, and copying. *Id.* The PTAB has considered this evidence, including its sufficiency, at least twice, a jury has

considered this evidence, and the Federal Circuit has also considered this evidence. *Id.*

169. Rarely does evidence get considered this many times by such a variety of tribunals, all of which have been deemed both credible and compelling.

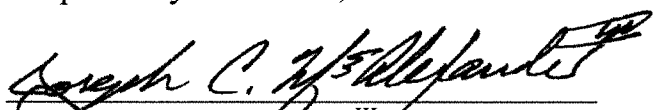
XV. CONCLUSION

170. In signing this declaration, I recognize that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

171. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed this 27th date of April, 2023.

Respectfully submitted,



Joseph C. McAlexander III

INTERNATIONAL STANDARD

ISO 15031-5

First edition
2006-01-15

Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics —

Part 5: Emissions-related diagnostic services

Véhicules routiers — Communications entre un véhicule et un équipement externe pour le diagnostic relatif aux émissions —

Partie 5: Services de diagnostic relatif aux émissions

Reference number
ISO 15031-5:2006(E)

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Geotab Exhibit 107
Geotab v. Omega

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Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
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E-mail copyright@iso.org
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15031-5 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronical equipment*.

ISO 15031 consists of the following parts, under the general title *Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics*:

— *Part 1: General information*

— *Part 2: Terms, definitions, abbreviations and acronyms*

— *Part 3: Diagnostic connector and related electrical circuits, specification and use*

— *Part 4: External test equipment*

— *Part 5: Emissions-related diagnostic services*

— *Part 6: Diagnostic trouble code definitions*

— *Part 7: Data link security*

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Introduction

ISO 15031 consists of a number of parts which, taken together, provide a coherent self-consistent set of specifications to facilitate emissions-related diagnostics. Parts 2 through 7 are based on SAE recommended practices. This part is based on SAE J1979 SEP97 (E/E Diagnostic Test Modes).

ISO 15031-1 provides an introduction to the series of International Standards.

This part of ISO 15031 is based on the Open Systems Interconnection (OSI) Basic Reference Model in accordance with ISO/IEC 7498 and ISO/IEC 10731, which structures communication systems into seven layers as shown in the table below.

Table 1 — Applicability and relationship between documents

Applicability	OSI 7 layer	Emissions-related diagnostics			
Seven layer according to ISO/IEC 7498 and ISO/IEC 10731	Physical (layer 1)	ISO 9141-2	ISO 14230-1	SAE J1850	ISO 11898, ISO 15765-4
	Data link (layer 2)	ISO 9141-2	ISO 14230-2	SAE J1850	ISO 11898, ISO 15765-4
	Network (layer 3)	—	—	—	ISO 15765-2, ISO 15765-4
	Transport (layer 4)	—	—	—	—
	Session (layer 5)	—	—	—	ISO 15765-4
	Presentation (layer 6)	—	—	—	—
	Application (layer 7)	ISO 15031-5	ISO 15031-5	ISO 15031-5	ISO 15031-5

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Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics —

Part 5:
Emissions-related diagnostic services

1 Scope

This part of ISO 15031 specifies diagnostic services and functionally addressed request/response messages required to be supported by motor vehicles and external test equipment for diagnostic purposes which pertain to motor vehicle emission-related data. Any external test equipment meeting the requirements of ISO 15031-4 use these messages to retrieve emissions-related information from the vehicle.

Each section of this part of ISO 15031, which specifies additional detail to existing sections of ISO 9141-2, ISO 14230-4, SAE J1850, and ISO 15765-4 supersede those specifications.

NOTE This part of ISO 15031 provides the mechanism to satisfy the requirements included in the country-specific regulations and not all capabilities included in this document are required by the country-specific regulations. This part of ISO 15031 also is not considered a final authority for interpretation of the regulations, so readers should determine the applicability of capabilities defined in this document for their specific needs.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9141-2, *Road vehicles — Diagnostic systems — Part 2: CARB requirements for interchange of digital information*

ISO 9141-2/Amendment 1, *Road vehicles — Diagnostic systems — Part 2: CARB requirements for interchange of digital information*

ISO 14230-4, *Road vehicles — Diagnostic systems — Keyword Protocol 2000 — Part 4: Requirements for emission-related systems*

ISO 15031-1, *Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics — Part 1: General information*

ISO/TS 15031-2, *Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics — Part 2: Terms, definitions, abbreviations and acronyms*

ISO 15031-3, *Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics — Part 3: Diagnostic connector and related electrical circuits, specification and use*

ISO 15031-4, *Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics — Part 4: External test equipment*

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ISO 15031-6, *Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics — Part 6: Diagnostic trouble code definitions*

ISO 15765-2, *Road vehicles — Diagnostics on Controller Area Networks (CAN) — Part 2: Network layer services*

ISO 15765-4, *Road vehicles — Diagnostics on Controller Area Networks (CAN) — Part 4: Requirements for emissions-related systems*

SAE J1850: *MAY2001, Class B Data Communications Network Interface*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 15031-2 and the following apply.

3.1
absolute throttle position sensor
value intended to represent the throttle opening

NOTE For systems where the output is proportional to the input voltage, this value is the percent of maximum input signal. For systems where the output is inversely proportional to the input voltage, this value is 100 % minus the percent of maximum input signal. Throttle position at idle usually indicates greater than 0 %, and throttle position at wide open throttle usually indicates less than 100 %.

3.2
bank
specific group of cylinders sharing a common control sensor, bank 1 always containing cylinder number 1, bank 2 the opposite bank

NOTE If there is only one bank, bank #1 DTCs is used, and the word bank may be omitted. With a single "bank" system utilising multiple sensors, bank #1 DTCs is used identifying the sensors as #1, #2, #3 in order as they move further away from the cylinder(s).

3.3
base fuel schedule
the fuel calibration schedule programmed into the Powertrain Control Module or PROM when manufactured or when updated by some off-board source, prior to any learned on-board correction

3.4
Calculated Load Value
for spark ignition engines, typically an indication of the current airflow divided by peak airflow at wide open throttle as a function of rpm, where airflow is corrected for altitude and ambient temperature

NOTE 1 This definition provides a unit-less number, and provides the service technician with an indication of the percent engine capacity that is being used.

NOTE 2 For diesel applications, the calculated load value shall be determined by substituting fuelflow in place of airflow in the calculation.

3.5
client
function that is part of the tester and that makes use of the diagnostic services

NOTE A tester normally makes use of other functions such as data base management, specific interpretation, man-machine interface.

3.6
continuous monitoring
sampling at a rate no less than two samples per second

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3.7
convention
Cvt
column integrated in each message table which marks each parameter included

NOTE The following conventions are used: C = Conditional: the parameter marked "C" in a request/response message is present only under a condition specified in the bottom row of the message table. M = Mandatory: the parameter marked "M" in a request/response message table is always present. U = User optional: the parameter marked "U" in a request/response message table is or is not supplied, depending on dynamic usage by the manufacturer. The convention recommends a mnemonic, which might be used for implementation. In no case is the specified mnemonic a mandatory requirement for any implementation.

3.8
Electronic Control Unit
ECU
generic term for any electronic control unit

3.9
Fuel Trim
FT
feedback adjustments to the base fuel schedule

NOTE Short-term fuel trim refers to dynamic or instantaneous adjustments. Long-term fuel trim refers to much more gradual adjustments to the fuel calibration schedule than short-term trim adjustments. These long-term adjustments compensate for vehicle differences and gradual changes that occur over time.

3.10
negative numbers
signed binary, the most significant bit (MSB) of the binary number used to indicate positive (0) / negative (1)

NOTE 1 2s complement: negative numbers are represented by complementing the binary number and then adding 1.

EXAMPLE $-0{,}99 = 8001$ hex $= 1000\ 0000\ 0000\ 0001$ binary
$0 = 0000$ hex $= 0000\ 0000\ 0000\ 0000$ binary
$+0{,}99 = 7FFF$ hex $= 0111\ 1111\ 1111\ 1111$ binary

NOTE 2 $(-0{,}99) + (+0{,}99) = 0$.

3.11
number
expressed by this symbol "#"

3.12
P2, P3 timing parameter
application timing parameters for the ECU(s) and the external test equipment

3.13
server
function that is part of an electronic control unit that provides the diagnostic services

NOTE This part of ISO 15031 differentiates between the server (i.e. the function) and the electronic control unit so that this document remains independent from the implementation.

3.14
service
information exchange initiated by a client (external test equipment) in order to require diagnostic information from a server (ECU) and/or to modify its behaviour for diagnostic purpose

NOTE This is also the equivalent of test mode or mode.

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4 Symbols and abbreviated terms

CVN	Calibration Verification Number
ECM	Engine Control Module
ISR	Interrupt Service Routine
LSB	Least Significant Bit
MSB	Most Significant Bit
NRC	Negative Response Code
PCM	Powertrain Control Module
SI	International System of Units
TCM	Transmission Control Module

5 Technical requirements

5.1 General requirements

The requirements specified in this clause are necessary to ensure proper operation of both the external test equipment and the vehicle during diagnostic procedures. External test equipment, when using messages specified, shall not affect normal operation of the emission control system.

5.2 Diagnostic service requirements

5.2.1 Multiple responses to a single data request

The request messages are functional messages, which means the external test equipment will request data without knowledge of which ECU(s) on the vehicle will respond. In some vehicles, multiple ECUs may respond with the information requested. Any external test equipment requesting information shall therefore have provisions for receiving multiple responses.

IMPORTANT — All emissions-related OBD ECUs which at least support one of the services defined in this part of ISO 15031 shall support service $01 and PID $00. Service $01 with PID $00 is defined as the universal "initialization/keep alive/ping" message for all emissions-related OBD ECUs.

5.2.2 Application timing parameter definition

5.2.2.1 Overview

The definition of P2 and P3 is included in this clause. A subscript is added to each timing parameter to identify the protocol:

— $P2_{K\text{-}line}$, $P3_{K\text{-}line}$: P2, P3 for ISO 9141-2 and ISO 14230-4 protocols

— $P2_{J1850}$: P2 for SAE J1850 protocol

— $P2_{CAN}$: P2 for ISO 15765-4 protocol

IMPORTANT — It is the vehicle manufacturer's responsibility to specify a shorter P2 timing window than specified in this part of ISO 15031 for each emission-related server/ECU in the vehicle to make sure that network topology delays of the vehicle architecture are considered.

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5.2.2.2 Definition for ISO 9141-2

For ISO 9141-2 interfaces, Data Link Layer response time requirements (P1, P4) are specified in ISO 9141-2.

Table 2 specifies the application timing parameter values for P2 and P3.

Table 2 — Definition ISO 9141-2 application timing parameter values

Parameter	Minimum value (ms)	Maximum value (ms)	Description
$P2_{K\text{-}line}$ Key Bytes: $08 $08	25	50	Time between external test equipment request message and the successful transmission of the ECU(s) response message(s). Each OBD ECU shall start sending its response message within $P2_{K\text{-}line}$ after the request message has been correctly received. Subsequent response messages shall also be transmitted within $P2_{K\text{-}line}$ of the previous response message for multiple message responses.
$P2_{K\text{-}line}$ Key Bytes: $94 $94	0	50	Time between external test equipment request message and the successful transmission of the ECU response message(s). The OBD ECU shall start sending its response message within $P2_{K\text{-}line}$ after the request message has been correctly received. Subsequent response messages shall also be transmitted within $P2_{K\text{-}line}$ of the previous response message for multiple message responses.
$P3_{K\text{-}line}$	55	5000	Time between the end of an ECU(s) successful transmission of response message(s) and start of new external test equipment request message. The external test equipment may send a new request message if all response messages related to the previously sent request message have been received and if $P3_{K\text{-}line}$ minimum time expired. ECU implementation guideline: TX (transmit) and RX (receive) line are connected. Each transmitted byte is read back by the receiver in the ECU. Upon the reception of a received byte, e.g. last byte of a request message (checksum) from the tester, the ECU shall reset the P3 timer value to zero. If the ECU supports the request message, it will start transmitting the response message within the P2 timing window. Each transmitted byte will cause the P3 timer value to be reset. If the ECU does not support the request and does not send a response message then in a single OBD ECU system the P3 is started with the last byte received of the request message. In a multiple OBD ECU system a response message by any one or more ECUs shall cause the P3 timer value to be reset in all ECUs including any ECU not supporting the request message.

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5.2.2.3 Definition for ISO 14230-4

For ISO 14230-4 interfaces, Data Link Layer response time requirements are specified in ISO 14230-4.

Table 3 specifies the application timing parameter values for P2 and P3.

Table 3 — Definitions of ISO 14230-4 application timing parameter values

Parameter	Minimum value (ms)	Maximum value (ms)	Description
$P2_{K\text{-}line}$	25	50	Time between external test equipment request message and the successful transmission of the ECU(s) response message(s). Each OBD ECU shall start sending its response message within $P2_{K\text{-}line}$ after the request message has been correctly received. Subsequent response messages shall also be transmitted within $P2_{K\text{-}line}$ of the previous response message for multiple message responses.
$P3_{K\text{-}line}$	55	5000	Time between the end of an ECU(s) successful transmission of response message(s) and start of new external test equipment request message. The external test equipment may send a new request message if all response messages related to the previously sent request message have been received and if $P3_{K\text{-}line}$ minimum time expired. ECU implementation guideline: TX (transmit) and RX (receive) line are connected. Each transmitted byte is read back by the receiver in the ECU. Upon the reception of a received byte, e.g. last byte of a request message (checksum) from the tester, the ECU shall reset the P3 timer value to zero. If the ECU supports the request message, it will start transmitting the response message within the P2 timing window. Each transmitted byte will cause the P3 timer value to be reset. If the ECU does not support the request and does not send a response message, then in a single OBD ECU system the P3 is started with the last byte received of the request message. In a multiple OBD ECU system, a response message by any one or more ECUs shall cause the P3 timer value to be reset in all ECUs including any ECU not supporting the request message.

5.2.2.4 Implementation guidance example for ISO 9141-2 and ISO 14230-4 protocols

This subclause provides an implementation example for client/external test equipment and server/ECU. It is assumed that the client (external test equipment) communicates to a vehicle with two (2) emission-related OBD servers (ECUs). The client requests a CVN, which is only supported by server #1 (ECU #1) with two (2) response messages. Server #2 (ECU #2) is not flash programmable. Figure 1 graphically depicts the timing handling in the client and two (2) servers for a functionally addressed request message. A description follows the figure that references the points marked in Figure 1.

From a server point of view, there is no difference in the timing handling compared to a physically addressed request message. The server shall reset the $P3_{K\text{-}line}$ timer value on each received byte regardless of whether the byte is part of a request message or a response message from any another server or an echo from its transmit line. There are several methods of how a server could implement the timing handling. The implementation of timing parameters is not part of this International Standard but an important system supplier responsibility. Some general server timing parameter implementation guidelines are described in this subclause. The server time stamps each receiver interrupt event and restarts/resets the $P3_{K\text{-}line\_server}$ timer or timing value, e.g. ISR time stamps received byte, and processing of the received information is performed outside the ISR. For simplification of the diagram, the Figure 1 only shows a $P3_{K\text{-}line\_server}$ restart after the reception of the first byte and last byte (checksum) of a received message. The $P3_{K\text{-}line\_server}$ restart is required on each received byte. The received message can be either a request message from the client or a response message from any other server connected and initialized by the 33 hex address. If the server has received a complete message, it compares the target address with the 33 hex address.

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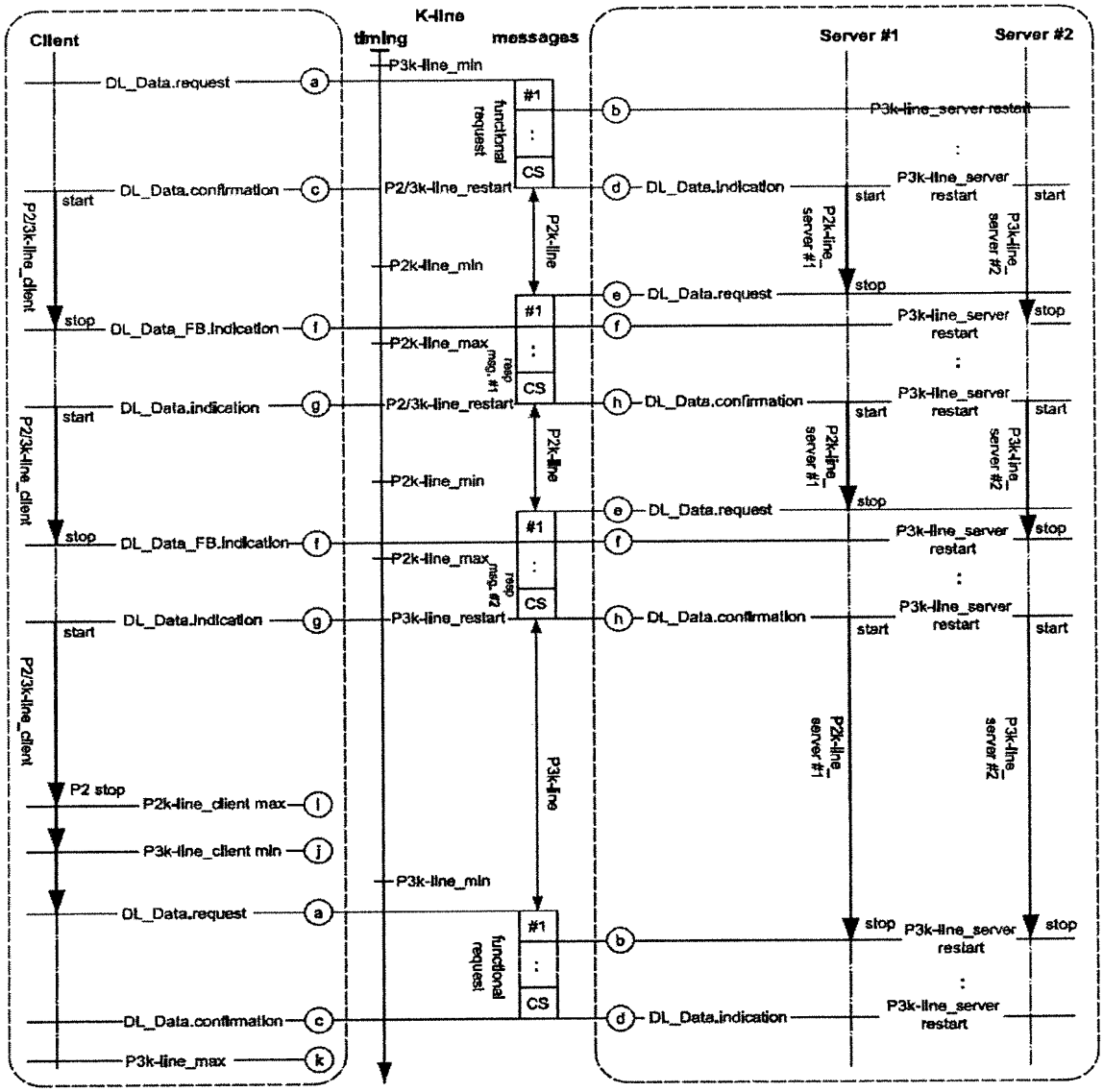


Figure 1 — ISO 9141-2 and ISO 14230-4 protocol client and server timing behaviour

Figure 1 shows the client and two (2) initialized servers connected via K-line (either ISO 9141-2 or ISO 14230-4 protocol). The relevant events for the client and both servers are marked and described.

a) The diagnostic application of the client starts the transmission of a functionally addressed request message by issuing a DL_Data.request to its data link layer. The data link layer transmits the request message to the servers.

b) Both servers and the client receive a byte of a message via a receive interrupt by the UART. The ISR (Interrupt Service Routine) either restarts the $P2_{K\text{-line}}/P3_{K\text{-line}}$ timers or time stamps the received byte.

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c) The completion of the request message is indicated in the client with DL_Data.confirmation. When receiving the DL_Data.confirmation, the client starts its $P2_{K\text{-}line}$ and $P3_{K\text{-}line}$ timer, using the default reload values $P2_{K\text{-}line\_max}$ and $P3_{K\text{-}line\_max}$.

d) If the last message byte is received, each server checks whether the received message includes a target address which matches the 33 hex address. If the result is a match (server #1 and #2), then the completion of the request message is indicated in the servers via DL_Data.indication and each server determines whether it supports the request and has a message available to respond with. If a server determines that the address in the received message is different from 33 hex, or if the address is a match but no response needs to be sent (server #2), the P2 timer is stopped. Since the $P3_{K\text{-}line}$ timer has already been restarted, no further action is required. If a response message is available and has to be sent (server #1, but not server #2), then the transmission of the response message shall be started after $P2_{K\text{-}line\_min}$ timing is expired.

e) Server #1 starts the response message by indicating a DL_Data.request from the application to the data link layer and at the same time stops its $P2_{K\text{-}line}$ timer.

f) Both servers and the client receive a byte of a message via a receive interrupt by the UART. The ISR (Interrupt Service Routine) restarts the $P2_{K\text{-}line}$/$P3_{K\text{-}line}$ timers or time stamps the received byte and the client issues a DL_Data_FB.indication to the application layer.

g) The completion of the response message is indicated in the client with DL_Data.indication. When receiving the DL_Data.indication, the client starts its $P2_{K\text{-}line}$ and $P3_{K\text{-}line}$ timer, using the default reload values $P2_{K\text{-}line\_max}$ and $P3_{K\text{-}line\_max}$.

h) Both servers have received the last byte of a message via a receive interrupt by the UART. The ISR (Interrupt Service Routine) either resets the $P2_{K\text{-}line}$/$P3_{K\text{-}line}$ timers or time stamps the received byte. The completion of the response message (e.g. length and checksum check) is indicated in server #1 via DL_Data.confirmation. If server #1 does not want to send further response messages, it stops its P2 timer. In server #2 the message is received and the $P3_{K\text{-}line}$ timer is restarted, but no DL_Data.indication is forwarded to the application because the target address does not match the 33 hex (target address of this message is the tester address F1 hex).

i) The client application detects a $P2_{K\text{-}line\_max}$ timeout, which indicates that all response messages from all servers are received.

j) The client application indicates that $P3_{K\text{-}line\_min}$ is reached and that the $P3_{K\text{-}line}$ timing window is now open to send a new request message [see a)].

5.2.2.5 Definition for SAE J1850

For SAE J1850 network interfaces, the on-board systems shall respond to a request within $P2_{J1850}$ of a request or a previous response message. With multiple response messages possible from a single request message, this allows as much time as is necessary for all ECUs to access the data link and transmit their response message(s). If there is no response message within this time period, the external test equipment can either assume no response message will be received, or if a response message has already been received, that no more response messages will be received. The application timing parameter value $P2_{J1850}$ is specified in Table 4.

Table 4 — Definition of SAE J1850 application timing parameter values

Parameter	Minimum value (ms)	Maximum value (ms)	Description
$P2_{J1850}$	0	100	Time between external test equipment request message and the successful transmission of the ECU(s) response message(s). Each OBD ECU shall attempt to send its response message (or at least the first of multiple response messages) within $P2_{J1850}$ after the request message has been correctly received. Subsequent response messages shall also be transmitted within $P2_{J1850}$ of the previous response message for multiple message responses.

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5.2.2.6 Definition for ISO 15765-4

For CAN bus systems based on ISO 15765-4, the (all) responding ECU(s) of the on-board system shall respond to a request message within $P2_{CAN}$. The table below specifies the application timing parameter values for P2.

Table 5 — Definition of ISO 15765-4 application timing parameter values

Parameter	Minimum value (ms)	Maximum value (ms)	Description
$P2_{CAN}$	0	50	Time between external test equipment request message and the receipt of all unsegmented response messages and all first frames of segmented response message(s). In case the vehicle's network architecture uses a gateway to report emissions-related diagnostic data, all unsegmented response messages and all first frames of segmented response message(s) shall be received by the external test equipment within $P2_{CAN}$.
$P2^{*}_{CAN}$	0	5000	Time between the successful reception of a negative response message with response code $78 and the next response message (positive or negative message). A negative response message with NRC 78 hex shall not be used as a response message to a service $01 request.

5.2.2.7 Implementation guidance example for ISO 15765-4 protocol

5.2.2.7.1 Functional OBD communication during defaultSession

Figure 2 graphically depicts the timing handling in the client and two (2) servers for a functionally addressed request message during the default session. A description follows the figure that references the points marked in Figure 2.

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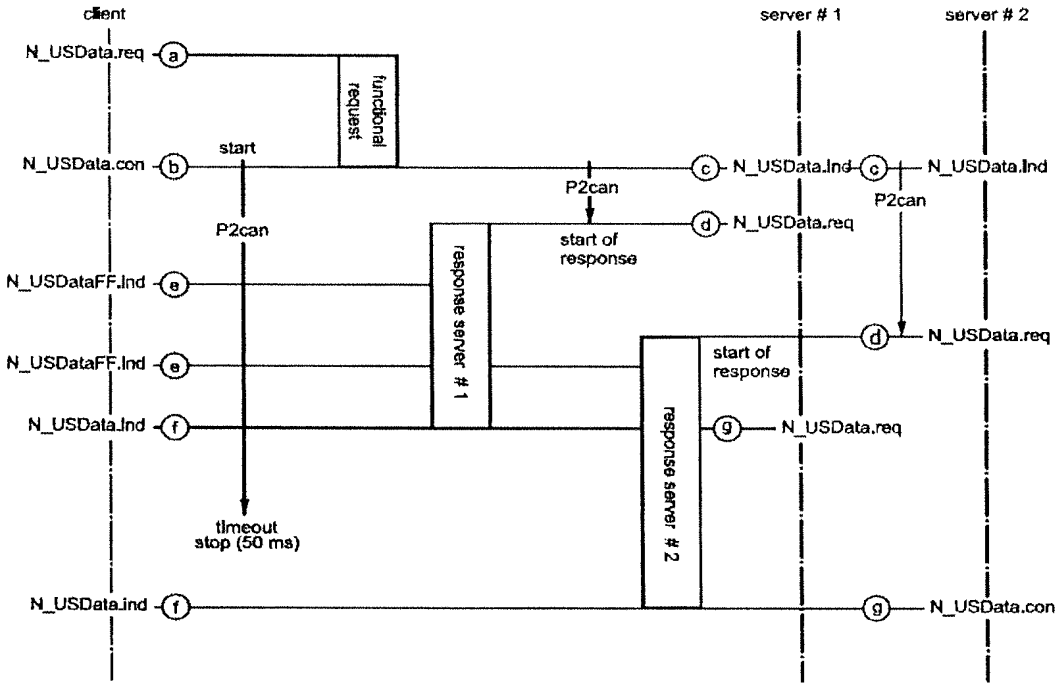


Figure 2 — Functional OBD communication: Default response timing

From a server point of view, there is no difference in the timing handling compared to a physically addressed request message, but the client shall handle the timing differently compared with physical communication.

a) The diagnostic application of the client starts the transmission of a functionally addressed request message by issuing an N_USData.req to its network layer. The network layer transmits the request message to the servers. A functionally addressed request message shall only be a single-frame message.

b) The completion of the request message is indicated in the client via N_USData.con. When receiving the N_USData.con, the client starts its $P2_{CAN}$ timer, using the default reload value $P2_{CAN}$. For simplicity, Figure 2 assumes that the client and the server are located on the same network.

c) The completion of the request message is indicated in the servers via N_USData.ind.

d) The functionally addressed servers are required to start with their response messages within $P2_{CAN}$ after the reception of N_USData.ind. This means that in case of multi-frame response messages, the FirstFrame shall be sent within $P2_{CAN}$ and, for single-frame response messages, that the SingleFrame shall be sent within $P2_{CAN}$.

e) In case of a multi-frame response message, the reception of the FirstFrame from any server is indicated in the client via the N_USDataFF.ind of the network layer. A single-frame response message is indicated via N_USData.ind.

f) When receiving the FirstFrame/SingleFrame indication of an incoming response message, the client either stops its $P2_{CAN}$ in case it knows the servers to be expected to respond and all servers have responded, or keeps the $P2_{CAN}$ running if the client does not know the servers to be expected to respond (client awaits the start of further response messages). The network layer of the client will generate a final N_USData.ind in case the complete message is received or an error occurred during the reception. The reception of a final N_USData.ind of a multi-frame message in the client will not have any influence on the $P2_{CAN}$ timer.

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g) The completion of the transmission of the response message will also be indicated in the servers via N_USData.con.

5.2.2.7.2 Functional OBD communication during defaultSession with enhanced response timing

Figure 3 graphically depicts the timing handling in the client and two (2) servers for a functionally addressed request message during the default session, where one server requests an enhanced response timing via a negative response message including response code 78 hex. A description follows the figure that references the points marked in Figure 3.

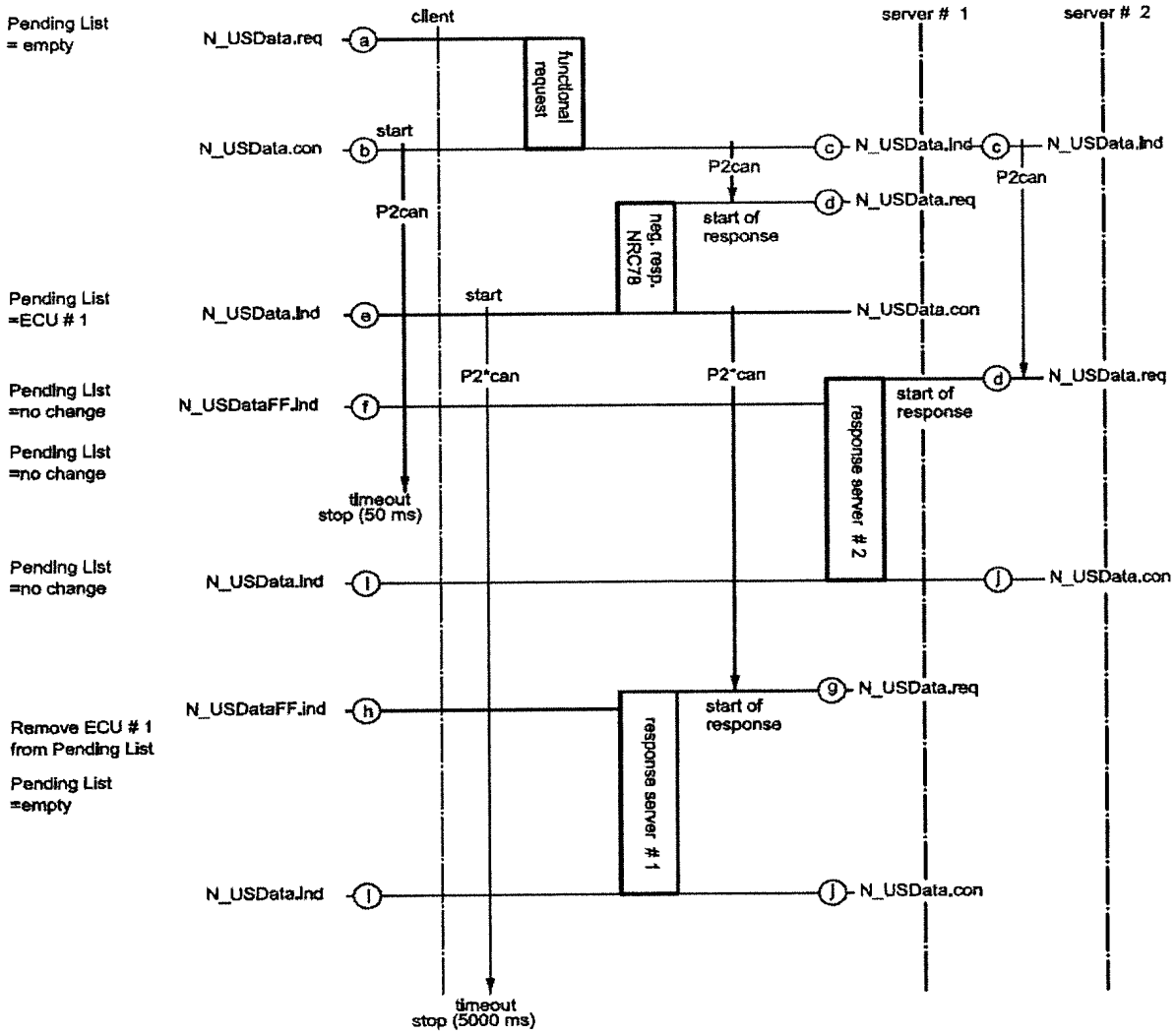


Figure 3 — Functional OBD communication – enhanced response timing

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From a server point of view, there is no difference in the timing handling compared to a physically addressed request message that requires enhanced response timing, but the client shall handle the timing differently compared with physical communication.

a) The diagnostic application of the client starts the transmission of the functionally addressed request message by issuing a N_USData.req to its network layer. The network layer transmits the request message to the servers. A functionally addressed request message shall only be a single-frame message.

b) The completion of the request message is indicated in the client via N_USData.con. When receiving N_USData.con, the client starts its $P2_{CAN}$ timer, using the default reload value $P2_{CAN}$. For the response message, the value of the $P2_{CAN}$ timer shall consider any latency that is involved based on the vehicle network design (e.g. communication over gateways, bus bandwidth, etc.). For simplicity, the figure assumes that the client and the server are located on the same network.

c) The completion of the request message is indicated in the servers via N_USData.ind.

d) The functionally addressed servers shall start with their response messages within $P2_{CAN}$ after the reception of N_USData.ind. This means that in case of a multi-frame response messages, the FirstFrame shall be sent within $P2_{CAN}$ and for single-frame response messages, that the SingleFrame shall be sent within $P2_{CAN}$. In case any of the addressed servers cannot provide the requested information within the $P2_{CAN}$ response timing, it can request an enhanced response-timing window by sending a negative response message including response code 78 hex (this is not allowed for service $01).

e) Upon the reception of the negative response message within the client, the client network layer generates a N_USData.ind. The reception of a negative response message with response code 78 hex causes the client to continue its $P2_{CAN}$ timer in order to observe other servers to respond within $P2_{CAN}$. In addition, the client establishes an enhanced $P2^*_{CAN}$timer for observation of further server #1 response(s). The client shall store a server identification in a list of pending response messages. Once a server that is stored as pending in the client starts with its final response message (positive response message or negative response message including a response code other than 78 hex), it is deleted from the list of pending response messages. For simplicity, Figure 5 only shows a single negative response message including response code 78 hex from server #1.

f) Server #2 transmits a FirstFrame of a multi-frame response message within $P2^*_{CAN}$. The reception of the FirstFrame is indicated in the client network layer by a N_USDataFF.ind. Figure 5 shows when the client receives the start of the response message of the second server.

g) Server #1 previously indicated to the client (e) enhanced response timing. Once server #1 can provide the requested information, it starts with its final response message by issuing a N_USData.req to its network layer. If server #1 can still not provide the requested information within the enhanced $P2^*_{CAN}$, then a further negative response message including response code 78 hex can be sent. This will cause the client to reload its $P2^*_{CAN}$ timer value again. A negative response message including response code 78 hex from a server that is already stored in the list of pending response messages has no affect to the client internal list of pending response message.

h) Server #1 transmits a FirstFrame of a multi-frame response message within $P2^*_{CAN}$. The reception of the FirstFrame is indicated in the client network layer by a N_USDataFF.ind. Figure 5 shows when the client receives the start of the response message of the server #1. The client removes server #1 from the internal list of pending response messages.

i) The client network layer will generate a N_USData.ind.

j) The server network layer will generate a N_USData.con based on the completion of the transmission.

5.2.3 Minimum time between requests from external test equipment

5.2.3.1 ISO 9141-2, ISO 14230-4 — Minimum time between requests from external test equipment

For ISO 9141-2 (K-line) interfaces, the required times between request messages are specified in ISO 9141-2.

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For ISO 14230-4 (K-line) interfaces, the required times between request messages are specified in ISO 14230-4. Figure 4 shows an example of a request message followed by four (4) response messages and another request message.

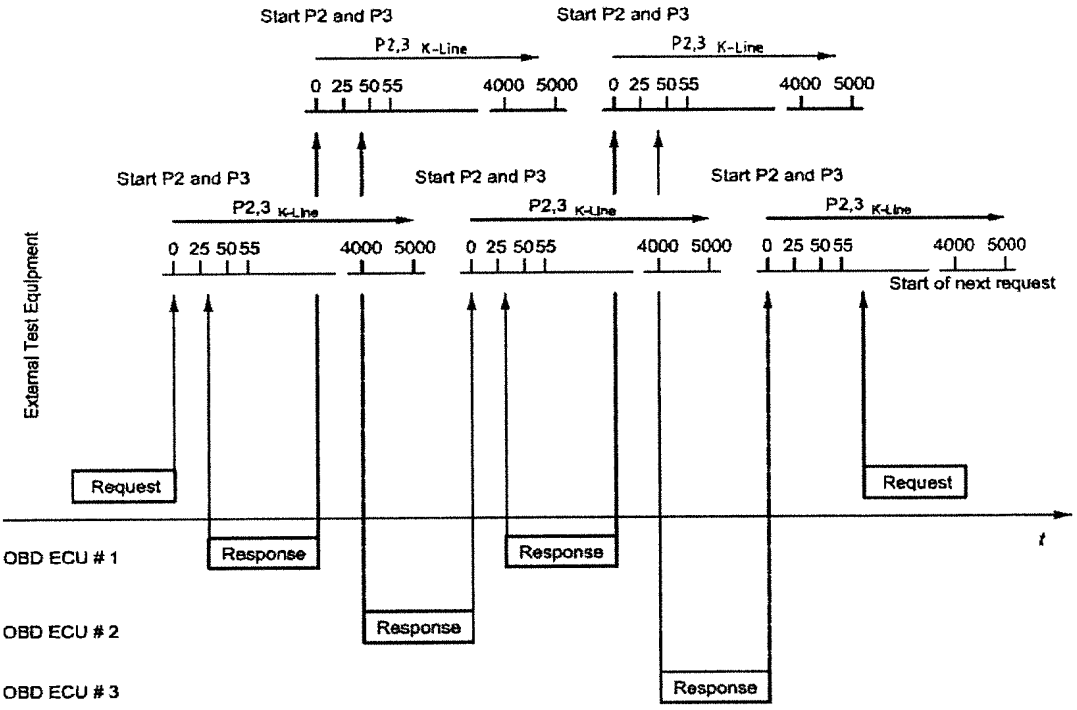


Figure 4 — ISO 9141-2 (Key Bytes: $08 $08) and ISO 14230-4 application timing parameter overview

5.2.3.2 SAE J1850 — Minimum time between requests from external test equipment

For SAE J1850 network interfaces, an external test equipment shall always wait for a response message from the previous request, or "no response" time-out before sending another request message. If the number of response messages is known and all response messages have been received, then the external test equipment is permitted to send the next request message immediately. If the number of response messages is not known, then the external test equipment shall wait at least $P2_{J1850}$ maximum time.

Figure 5 shows an example of a request message followed by four (4) response messages and another request message.

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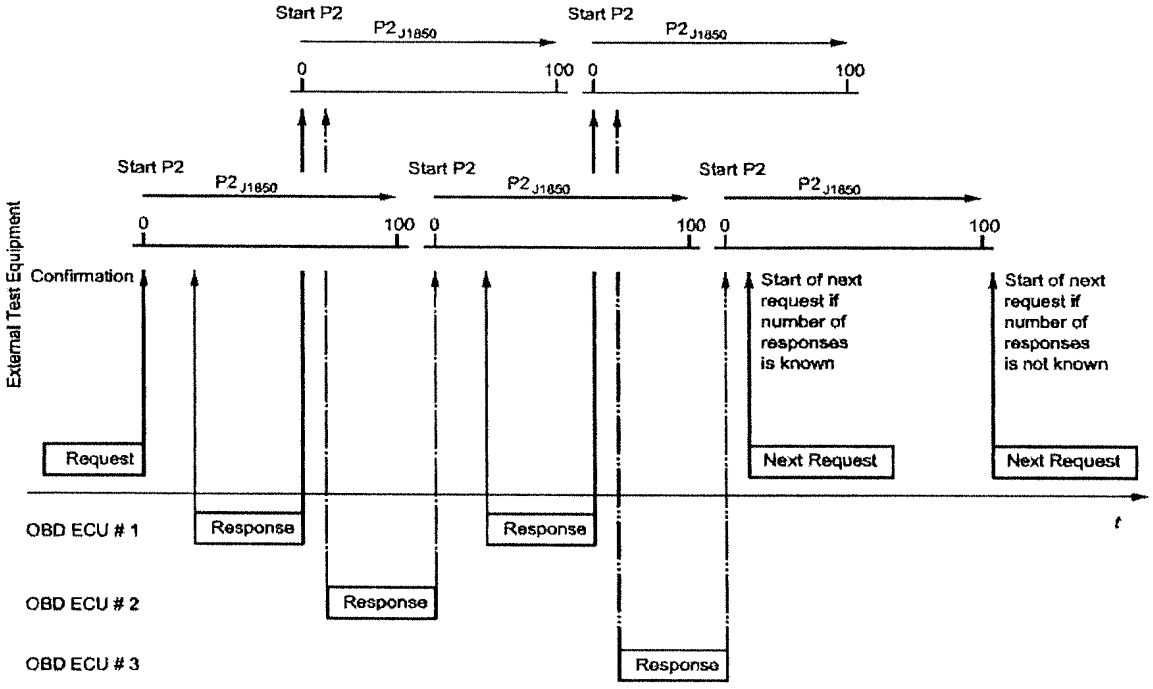


Figure 5 — SAE J1850 application timing parameter overview

5.2.3.3 ISO 15765-4 — Minimum time between requests from external test equipment

For ISO 15765-4 network interfaces, the external test equipment may send a new request message immediately after it has determined that all responses related to the previously sent request message have been received. If the external test equipment does not know whether it has received all response messages, (e.g. after sending the initial OBD request message: Service $01, PID $00), it shall wait ($P2_{CAN}$ maximum) after the last request (if no responses are sent) or the last response message. The timer $P2_{CAN}$ of the external test equipment starts with the confirmation of a successful transmission of the request message.

Figure 6 shows an example of a request message followed by three (3) single-frame response messages and another request message.

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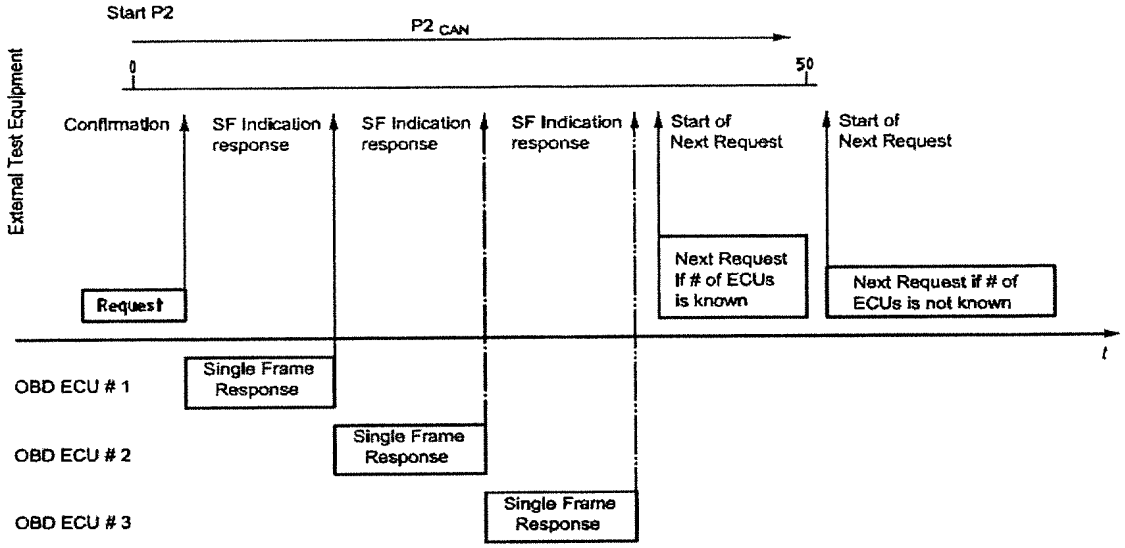


Figure 6 — ISO 15765-4 application timing parameter (Single Frame Response Messages) overview

Figure 7 shows an example of a request message followed by two (2) single frames, one (1) multiple frame response message and another request message. The next request message can be sent immediately by the external test equipment after completion of all response messages in case the transmission of the response messages takes longer than $P2_{CAN}$ even if the external test equipment does not know the number of responding ECUs.

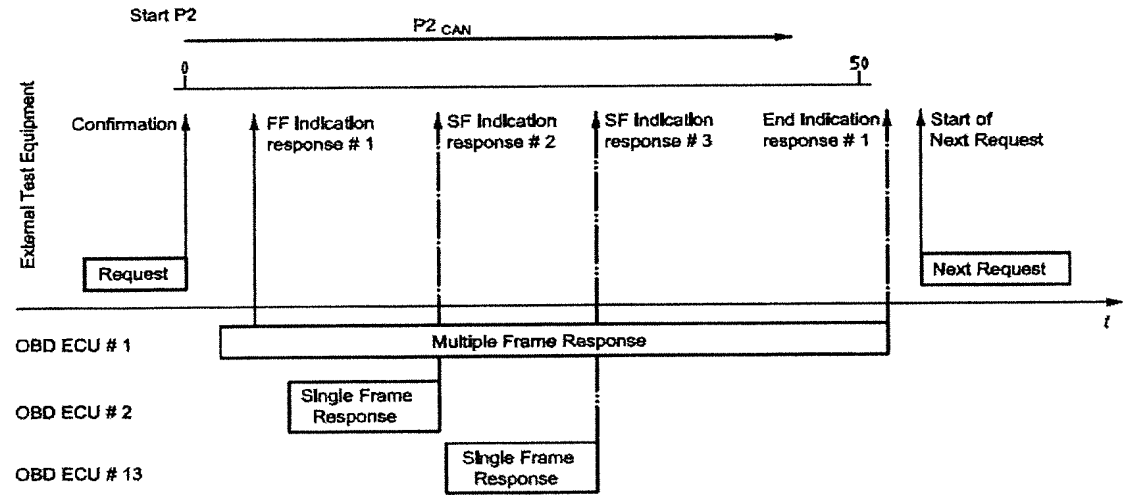


Figure 7 — ISO 15765-4 application timing parameter (Single and Multiple Frame Response Messages not finished within $P2_{CAN}$) overview

NOTE The Network Layer timing parameters for the multiple frame response are not shown. Network Layer timing requirements for legislated diagnostic messages are specified in ISO 15765-4.

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Figure 8 shows an example of a request message followed by one (1) single frame, one (1) multiple frame response message (completion within $P2_{CAN}$) and another request message. The next request message can be sent immediately by the external test equipment after completion of all response messages if the external test equipment knows the number of responding ECUs. If not, it needs to wait with the next request message to send until $P2_{CAN}$ is expired.

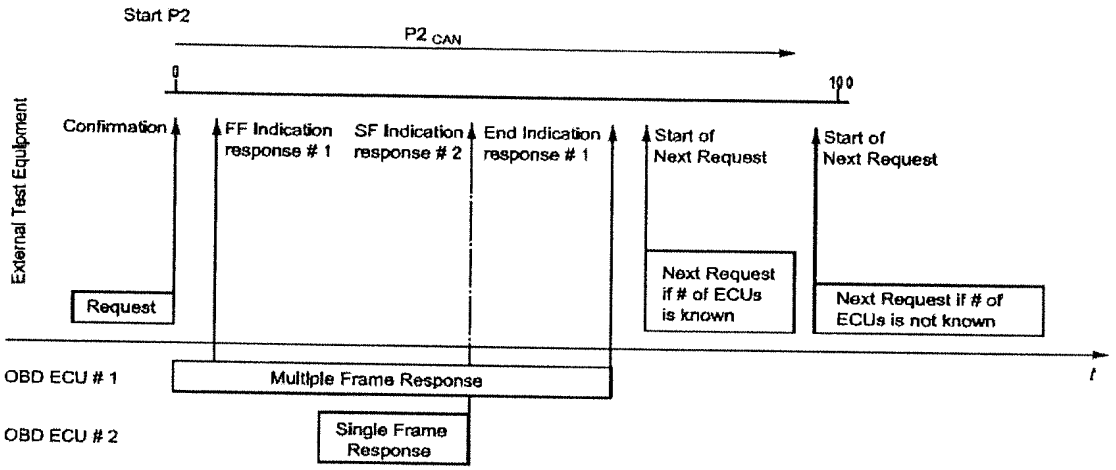
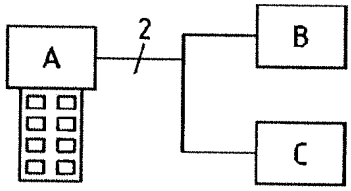


Figure 8 — ISO 15765-4 application timing parameter (Single and Multiple Frame Response Messages within $P2_{CAN}$) overview

NOTE The Network Layer timing parameters for the multiple frame response are not shown. Network Layer timing requirements for legislated diagnostic messages are specified in ISO 15765-4.

5.2.3.4 ISO 15765-4 — ECU behaviour to a request for supported/non-supported OBD information

Figure 9 shows an example of a typical vehicle OBD configuration.



Key

A External test equipment
B ECM (Engine Control Module)
C TCM (Transmission Control Module)

Figure 9 — External test equipment connected to two (2) OBD ECUs

A service shall only be implemented by an ECU if supported with data (e.g. PID/OBD Monitor ID/Test ID/InfoType supported), except for Service $01 and PID $00 which shall be supported by all emissions-related ECUs.

Typically, the ECM supports OBD Monitor IDs, which the TCM does not support. In case the external test equipment requests the status of such OBD Monitor ID supported by the ECM, the ECM sends a positive

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response message and the TCM does not send a response message (no negative response message allowed). The external test equipment knows that the TCM will not send a positive response message based on the OBD Monitor ID supported information retrieved prior to the latter request.

This shall be implemented to enhance the overall diagnostic communication performance between the external test equipment and the vehicle ECUs (see 5.2.3.3).

5.2.4 Data not available

5.2.4.1 ISO 9141-2, ISO 14230-4, and SAE J1850 — Data not available

There are two conditions for which data is not available. One condition is that the service is not supported, and the other is that the service is supported but data is currently not available.

For SAE J1850 and ISO 9141-2 interfaces, there will be no reject message to a functional request message if the request is not supported by the ECU. This prevents response messages from all ECUs that do not support a service or a specific data value.

For ISO 14230-4 interfaces, there will be a response message to every request message either positive (with data) or negative. In order to avoid unnecessary communication the ECU(s) which does (do) not support a functionally requested PID, TID, or INFOTYPE is permitted to not send a negative response message because another ECU will send a positive response message. Format and possible codes of negative responses are specified in 5.3.4.

Some services are supported by a vehicle, but data may not always be available when requested. For Services $05 and $06, if the test has not been run since test results were cleared, or for Service $02 if freeze frame data has not been stored, or for Service $09 if the engine is running, valid data will not be available. For these conditions, the manufacturer has the option either to not respond or to respond with data that is invalid (ISO 9141-2 and SAE J1850 only). The functional description for these services discuss the method to determine if the data is valid.

5.2.4.2 ISO 15765-4 — Data not available

There are four (4) conditions for which data is not available:

— **Request message is not supported:** The ECU(s) which does (do) not support the functional request message shall not send any response message.

— **Request message is supported but data is not supported:** The ECU(s) which does (do) support the functional request message but does (do) not support the requested data (e.g. PID, OBD Monitor ID, TID, or INFOTYPE) is (are) not allowed to send a negative response message because another ECU will send a positive response message. If the external test equipment sends a message including multiple PIDs and each emission-related ECU does not support all requested PIDs, then each ECU shall send a positive response message including the supported PID(s) and data values and shall not send a negative response message. If an ECU does not support any of the PIDs requested, it is not allowed to send a negative response message.

— **Request message is supported but data is currently not available:** The ECU(s) which does (do) support the functional request message but does (do) not currently have the requested data available shall respond with a negative response message with response code $22 - ConditionsNotCorrect (negative response message format is specified in 5.3.3). For Service $06 the use of a negative response message including response code $22 is not permitted. For Services $04 and $09 the use of a negative response message including negative response code $22 is allowed only during conditions specified by OBD regulations.

— **Request message is supported but data is not available within P2 timing:** The behaviour of the ECU(s) and the external test equipment is specified in 5.2.4.3.

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5.2.4.3 Data not available within P2 timing

5.2.4.3.1 Overview

The following subclauses specify the request/response message handling for each protocol if the data is not available within the P2 timing in the ECU(s). The description in the sub section only applies to Service $09, InfoType $06 Calibration Verification Numbers.

5.2.4.3.2 ISO 9141-2 — Data not available within P2 timing

If an ECU(s) supports the functional request message but does not have the requested data available within P2 timing, then a retry message handling routine shall be performed as follows:

a) If the response message is not received within $P2_{K\text{-}Line}$, the external test equipment shall stop retrying the request message after one (1) minute from the original request.

b) The retry message shall be sent at least every four (4) seconds (between 55 ms and 4 000 ms). The retry message keeps the bus alive and prevents the external test equipment from having to re-initialize the bus ($P3_{K\text{-}Line}$ time out).

c) The ECUs, which either have already sent a positive response message or have not sent a positive response message shall not restart the requested internal routine again.

d) The external test equipment shall record if all ECUs have sent the expected number of response messages.

e) After successful completion of all response messages, the external test equipment shall send a request message which is "not equal" to the "Repeated Request" message.

Additional description is included in the functional description of the corresponding service.

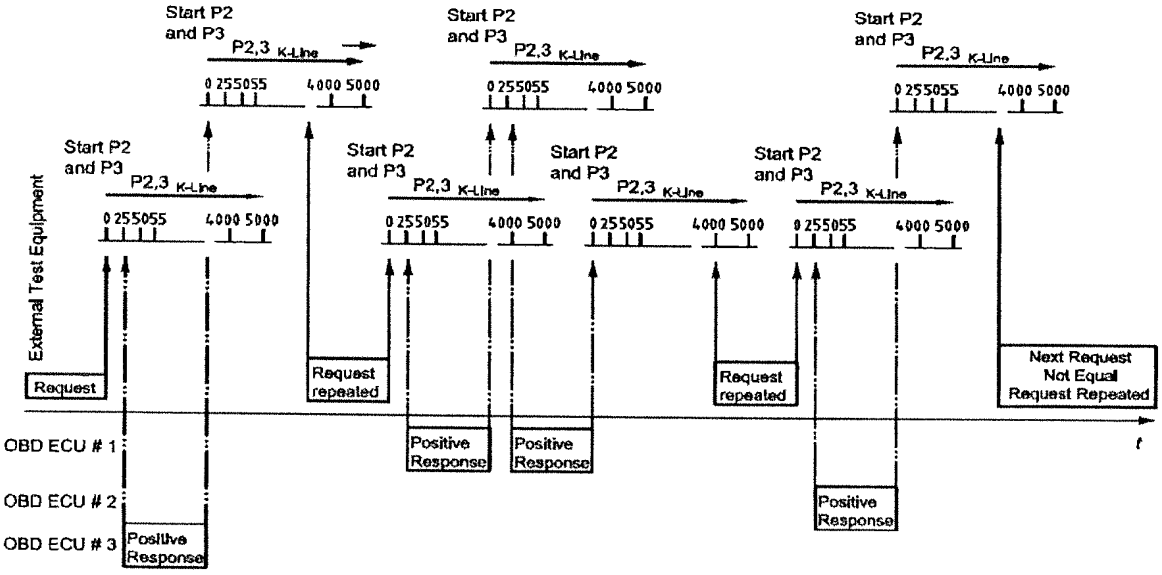


Figure 10 — ISO 9141-2 (Key Bytes: $08 $08) — Data not available within P2 timing handling overview

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For ISO 9141-2 with key bytes $94 $94, the response message timing $P2_{K\text{-}Line}$ shall be according to table "Definition of ISO 9141-2 application timing parameter values".

5.2.4.3.3 ISO 14230-4 — Data not available within P2 timing

If an ECU(s) supports the functional request message but does not have the requested data available within P2 timing, handling shall be performed as follows:

a) The ECU(s) shall respond with a negative response message with response code $78 - RequestCorrectlyReceived-ResponsePending within P2 timing.

b) ECUs which require more time than $P2_{K\text{-}Line}$ to perform the requested action shall repeat the negative response message with response code $78 prior to expiration of $P2_{K\text{-}Line}$ until the positive response message is available.

c) After all positive response messages have been received or a time out $P2_{K\text{-}Line}$max has occurred, the external test equipment shall wait until $P3_{K\text{-}Line}$min is reached to send a new request message.

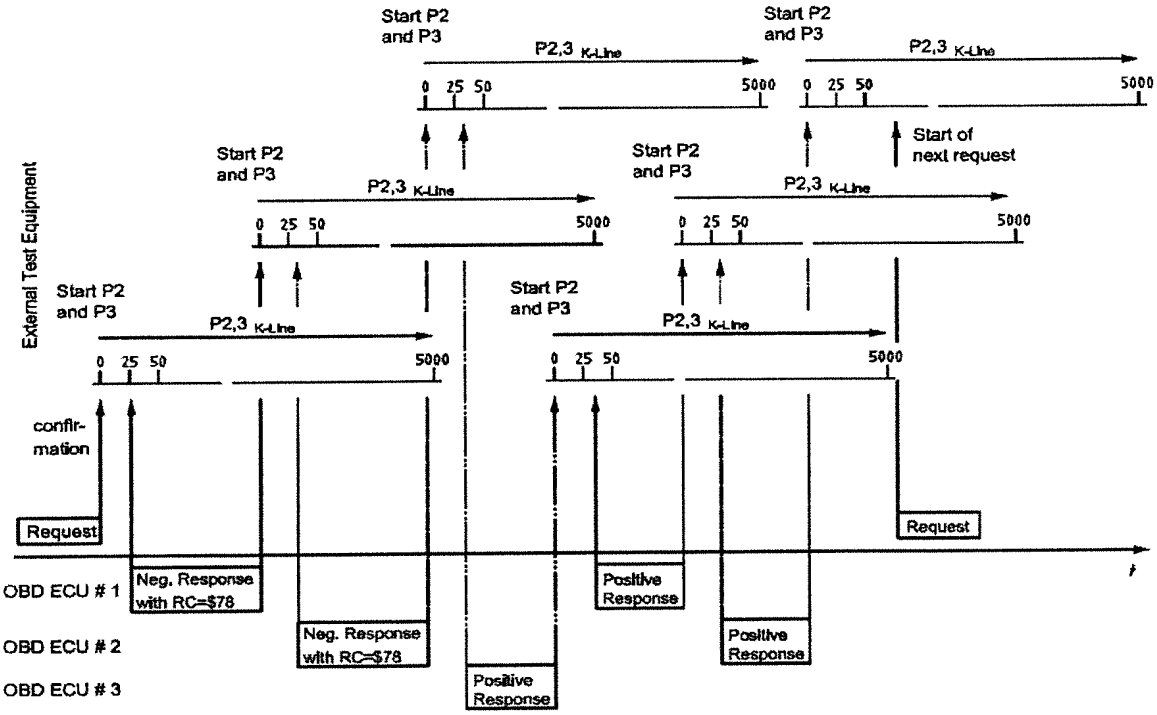


Figure 11 — ISO 14230-4 — Negative response code RC=$78 handling overview

5.2.4.3.4 SAE J1850 — Data not available within P2 timing

If an ECU(s) supports the functional request message but does not have the requested data available within P2 timing, then a retry message handling routine shall be performed as follows:

a) If the response message is not received within $P2_{J1850}$, the external test equipment shall stop retrying the request message after one (1) minute from the original request.

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b) The retry message shall be repeated after thirty (30 ± 1) seconds.

c) The external test equipment shall record if all ECUs have sent the expected number of response messages.

Additional description is included in the functional description of the corresponding service.

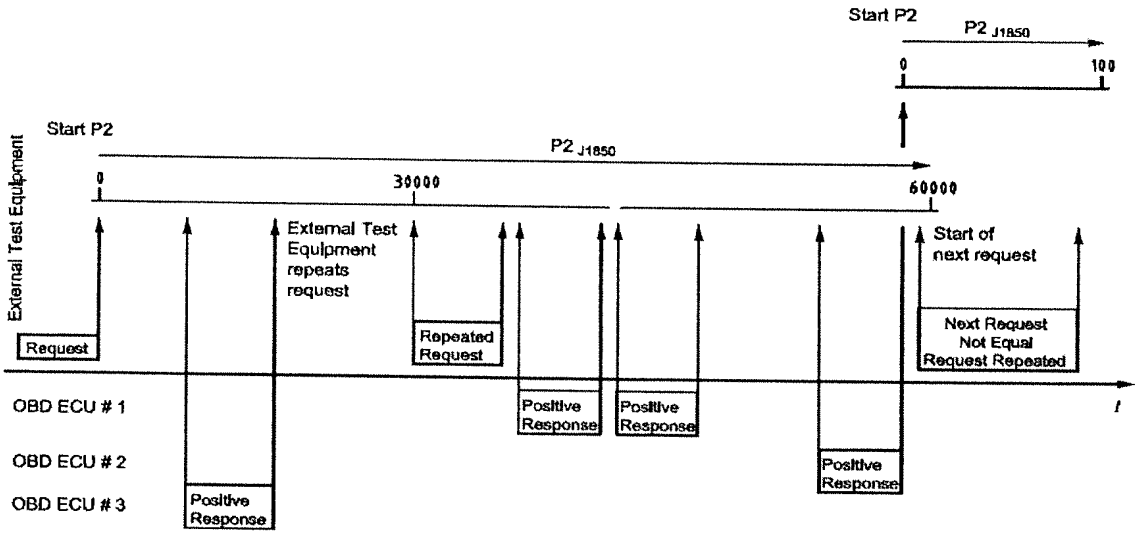


Figure 12 — SAE J1850 — Data not available within P2 timing handling overview

5.2.4.3.5 Data not available test conditions for protocols: ISO 9141-2, ISO 14230-4 and SAE J1850

There are two conditions for which data is not available:

a) Service is not supported.

b) Service is supported but data is not available at the time that the request is made.

Table 6 indicates the proper server/ECU response for each protocol as detailed in 5.2.4.1.

Table 6 — Proper response from server/ECU with ISO 9141-2, ISO 14230-4 and SAE J1850 protocol

Condition	ISO 9141-2	SAE J1850	ISO 14230-4
a) Service $01 not supported	All ECUs must respond to Service $01 PID $00 if Service $01 is supported. If Service $01 is not supported, no response is allowed.	All ECUs must respond to Service $01 PID $00 if Service $01 is supported. If Service $01 is not supported, no response is allowed.	All ECUs must respond to Service $01 PID $00 if Service $01 is supported. If Service $01 is not supported, ECU can either not respond or send a negative response ($7F, $01, $11)
b) Service $01 unsupported PID requested	No response preferred, positive response is allowed	No response preferred, positive response is allowed	ECU can either not respond or send a negative response ($7F, $01, $12)
c) Service $01 supported PID requested	Respond within P2 timing	Respond within P2 timing	Respond within P2 timing

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Table 6 (*continued*)

Condition	ISO 9141-2	SAE J1850	ISO 14230-4
d) Service $02 not supported	The ECU shall not respond	The ECU shall not respond	ECU can either not respond or send a negative response ($7F $02, $11)
e) Service $02 supported PID requested, no Freeze Frame stored	PID $02 indicates $0000, but if PIDs are requested, ECU can either not respond or send invalid data, except if supported PIDs ($00, $20, ...) have been requested, then the ECU shall send a response with the supported PID and data bytes	PID $02 indicates $0000, but if PIDs are requested, ECU can either not respond or send invalid data, except if supported PIDs ($00, $20, ...) have been requested, then the ECU shall send a response with the supported PID and data bytes	PID $02 indicates $0000, but if PIDs are requested, ECU can either not respond or send a negative response ($7F, $02, $12), except if supported PIDs ($00, $20, ...) have been requested, then the ECU shall send a response with the supported PID and data bytes
f) Service $02 unsupported PID requested, no Freeze Frame stored	No response preferred, positive response is allowed	No response preferred, positive response is allowed	ECU can either not respond or send a negative response ($7F $02, $12)
g) Service $02 supported PID requested, Freeze Frame stored	Respond within P2 timing	Respond within P2 timing	Respond within P2 timing
h) Service $02 unsupported PID requested, Freeze Frame stored	No response preferred, positive response is allowed	No response preferred, positive response is allowed	ECU can either not respond or send a negative response ($7F $02, $12)
i) Service $03/$07 not supported	The ECU shall not respond	The ECU shall not respond	ECU can either not respond or send a negative response ($7F $03, $11)
j) Service $03/$07 supported, no DTCs stored	No response preferred, positive response indicating no DTCs is allowed	No response preferred, positive response indicating no DTCs is allowed	Positive response indicating no DTCs is required.
k) Service $03/$07 supported, DTCs stored	Positive response is required	Positive response is required	Positive response is required
l) Service $04 not supported	The ECU shall not respond	The ECU shall not respond	ECU can either not respond or send a negative response ($7F $04, $11)
m) Service $04 supported, conditions not correct	The ECU shall not respond	The ECU shall not respond	Negative response is required ($7F, $04, $22)
n) Service $04 supported, conditions correct	Positive response is required	Positive response is required	Positive response is required
o) Service $05/$06 not supported	The ECU shall not respond	The ECU shall not respond	ECU can either not respond or send a negative response ($7F $05/$06, $11)
p) Service $05/$06 supported TID requested, no stored data available	If TIDs are requested, ECU can either not respond or send invalid data	If TIDs are requested, ECU can either not respond or send invalid data	If TIDs are requested, ECU can either not respond or send invalid data or send negative response ($7F, $05/$06, $12).
q) Service $05/$06 unsupported TID requested, no stored data available	No response preferred, positive response is allowed	No response preferred, positive response is allowed	ECU can either not respond or send a negative response ($7F $05/$06, $12)
r) Service $05/$06 supported TID requested, stored data available	Respond within P2 timing	Respond within P2 timing	Respond within P2 timing
s) Service $05/$06 unsupported TID requested, stored data available	No response preferred, positive response is allowed	No response preferred, positive response is allowed	ECU can either not respond or send a negative response ($7F $05/$06, $12)

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Table 6 (*continued*)

Condition	ISO 9141-2	SAE J1850	ISO 14230-4
t) Service $08 not supported	The ECU shall not respond	The ECU shall not respond	ECU can either not respond or send a negative response ($7F $08, $11)
u) Service $08 supported TID requested, conditions correct	Respond within P2 timing	Respond within P2 timing	Respond within P2 timing
v) Service $08 supported TID requested, conditions not correct	The ECU shall not respond or may respond with a manufacturer-specified value as DATA A, which corresponds to the reason the test cannot be run.	The ECU shall not respond or may respond with a manufacturer-specified value as DATA A, which corresponds to the reason the test cannot be run.	Negative response is required ($7F, $08, $22) or may respond with a manufacturer-specified value as DATA A which corresponds to the reason the test cannot be run.
w) Service $08 unsupported TID requested	No response preferred, positive response is allowed	No response preferred, positive response is allowed	ECU can either not respond or send a negative response ($7F $08, $12)
x) Service $09 not supported	The ECU shall not respond	The ECU shall not respond	ECU can either not respond or send a negative response ($7F $09, $11)
y) Service $09 supported INFOTYPE requested, data available (VIN, CVN, CALID)	Respond within P2 timing	Respond within P2 timing	Respond within P2 timing
z) Service $09 supported INFOTYPE requested, data not available, conditions correct (CVN)	Respond within 1 minute; do not restart CVN calculation. Test tool sends retry message every 0,055 to 4,0 seconds	Respond within 1 minute; do not restart CVN calculation. Test tool sends retry message after 30 seconds	One or multiple negative response message(s) ($7F, $09, $78) required within P2max (25 – 50 ms) until positive response is sent
aa) Service $09 supported INFOTYPE requested, data not available, conditions not correct (CVN), prior to 2005 MY only	The ECU shall not respond	The ECU shall not respond	Negative response is required ($7F, $09, $22)
bb) Service $09 unsupported INFOTYPE requested	No response preferred, positive response is allowed	No response preferred, positive response is allowed	ECU can either not respond or send a negative response ($7F $09, $12)

5.2.4.3.6 ISO 15765-4 - Data not available within P2 timing

The ECU(s) which does (do) support the functional request message but does (do) not have the requested data available within P2 timing, shall perform the following handling:

a) The ECU(s) shall respond with a negative response message with response code $78 - RequestCorrectlyReceived-ResponsePending within P2 timing (not allowed for Service $01 requests).

b) After correct reception of the negative response message with response code $78, the $P2_{CAN}max$ parameter timing value shall be set to $P2^*_{CAN}$ (5000 ms) by the external test equipment and the ECU which has sent the negative response message.

c) If another ECU also sends a negative response message with response code $78, the $P2_{CAN}max$ timing parameter value shall be reset to $P2^*_{CAN}$.

d) ECUs which require more than $P2^*_{CAN}$ to perform the requested action shall repeat the negative response message with response code $78 prior to expiration of $P2^*_{CAN}$ until correct reception of the positive response message.

e) After all positive response messages have been received or time out, $P2^*_{CAN}max$ has occurred.

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It is the vehicle manufacturer's responsibility to ensure the network architecture of the vehicle does not cause timing delays that exceed $P2_{CAN}$max timing when responding to Service $01 PID(s) request, hence a negative response message with response code $78 shall not be allowed.

Figure 13 shows the negative response message handling with response code $78 for the ISO 15765-4 interface.

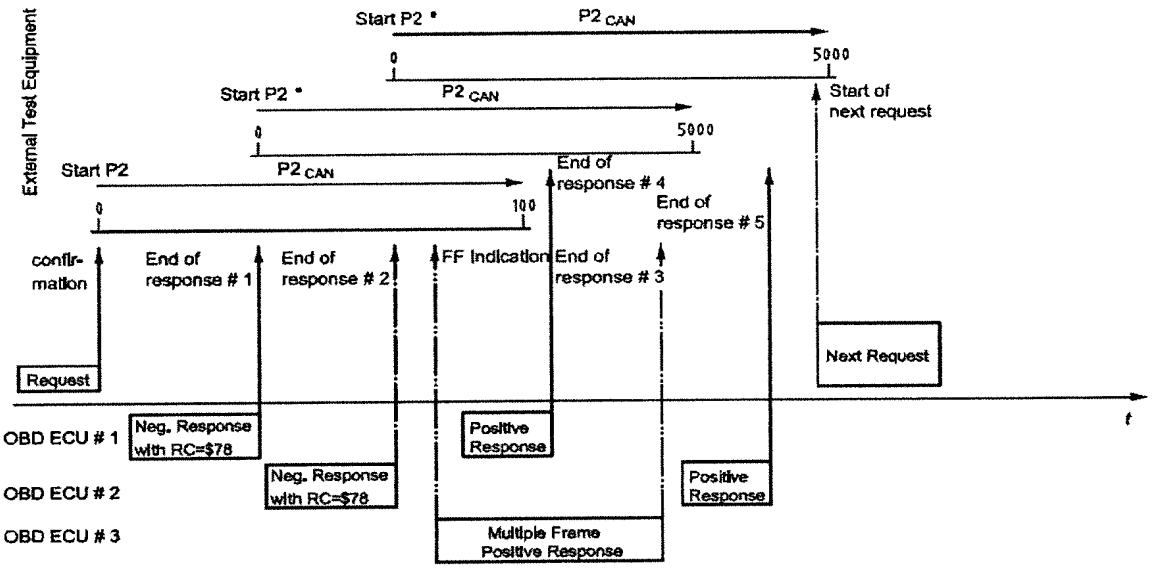


Figure 13 — ISO 15765-4 — Negative response code RC=$78 handling overview

5.2.4.3.7 Data not available test conditions for protocol: ISO 15765-4 Diagnostics on CAN

There are four conditions for which data is not available:

- Service is not supported.
- Service is supported but data is not supported.
- Service is supported but data is not available at the time that the request is made.
- Service is supported but data is not available within P2 timing.

Table 7 indicates the proper server/ECU response as detailed in 5.2.4.2.

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Table 7 — Proper response from server/ECU for ISO 15765-4 protocol

Condition		ISO 15765-4
a)	Service $01 not supported	All ECUs must respond to Service $01 PID $00 if Service $01 is supported. If Service $01 is not supported, no response is allowed.
b)	Service $01 unsupported PID requested	The ECU shall not respond
c)	Service $01 supported PID requested	Respond within P2 timing (no negative response message with response code $78 allowed)
d)	Service $02 not supported	The ECU shall not respond
e)	Service $02 supported PID requested, no Freeze Frame stored	PID $02 indicates $0000, but if PIDs are requested, ECU must not respond except if supported PIDs ($00, $20, ...) have been requested, then the ECU shall send a response with the supported PID and data bytes
f)	Service $02 unsupported PID requested, no Freeze Frame stored	PID $02 indicates $0000, but if PIDs are requested, ECU must not respond except for support PIDs $00, $20, etc.
g)	Service $02 supported PID requested, Freeze Frame stored	Respond within P2 timing
h)	Service $02 unsupported PID requested, Freeze Frame stored	The ECU shall not respond
i)	Service $03/$07 not supported	The ECU shall not respond
j)	Service $03/$07 supported, no DTCs stored	Positive response indicating no DTCs is required
k)	Service $03/$07 supported, DTCs stored	Positive response including the stored DTCs is required
l)	Service $04 not supported	The ECU shall not respond
m)	Service $04 supported, conditions not correct	Negative response is required ($7F, $04, $22)
n)	Service $04 supported, conditions correct	Positive response message required. Negative response messages(s) ($7F, $04, $78) allowed until positive response message available.
o)	Service $06 not supported	The ECU shall not respond
p)	Service $06 supported TID requested, no stored data available	Positive response required, test values, min and max limits must be set to $00
q)	Service $06 unsupported TID requested, no stored data available	The ECU shall not respond
r)	Service $06 supported TID requested, stored data available	Respond within P2 timing
s)	Service $06 unsupported TID requested, stored data available	The ECU shall not respond
t)	Service $08 not supported	The ECU shall not respond
u)	Service $08 supported TID requested, conditions correct	Respond within P2 timing
v)	Service $08 supported TID requested, conditions not correct	Negative response required ($7F, $08, $22)
w)	Service $08 unsupported TID requested	The ECU shall not respond
x)	Service $09 not supported	The ECU shall not respond
y)	Service $09 supported INFOTYPE requested, data available (VIN, CVN, CALID)	Respond within P2 timing
z)	Service $09 supported INFOTYPE requested, data not available, conditions correct (CVN)	Initial negative response message ($7F $09, $78) required within P2max (50 ms) and consecutive negative response message(s) ($7F, $09, $78) is (are) required within P2max (5,0 seconds) until positive response is sent
aa)	Service $09 supported INFOTYPE requested, data not available, conditions not correct (CVN), prior to 2005 MY only	Negative response required ($7F, $09, $22)
bb)	Service $09 unsupported INFOTYPE requested	The ECU shall not respond

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5.2.5 Maximum values

If the data value exceeds the maximum value possible to be sent, the on-board system shall send the maximum value possible ($FF or $FFFF). The external test equipment shall display the maximum value or an indication of data too high. This is not normally critical for real-time diagnostics, but for example in the case of a misfire at high vehicle speed with resulting freeze frame data stored, this will be very valuable diagnostic information.

5.2.6 Invalid signals

In distributed network architectures, certain OBD devices may be hardwired to other ECUs or may be independent OBD mechatronic devices, e.g. smart sensor or through a network from another ECU (both referred to as remote OBD devices). When remote OBD devices are not hardwired to the OBD ECU and the data is not received over the data bus from the specific remote OBD device, the primary OBD ECU shall report Service $01 and Service $02 data parameters as the minimum or maximum value to indicate that the signal has not been received. A PID which includes this invalid data (no signal) shall either be reported with a minimum value ($00 or $0000) or maximum value ($FF or $FFFF), e.g. PID $0D "Vehicle Speed Sensor" = $FF = 255 km/h, PID $2F "Fuel Level Input" = $00 = 0,0 %. The reported value shall be determined by the manufacturer based on system design and network architecture to represent the least likely value to be expected under normal conditions.

5.3 Diagnostic message format

5.3.1 Addressing method

Functional addressing shall be used for all request messages because the external test equipment does not know which system on the vehicle has the information that is needed.

5.3.2 Maximum message length

5.3.2.1 ISO 9141-2, ISO 14230-4, SAE J1850 — Maximum message length

The maximum message length for request and response messages is limited to seven (7) data bytes.

For SAE J1850 and ISO 9141-2 interfaces, each unique diagnostic message specified in this part of ISO 15031 is a fixed length, although not all messages are the same length. For Services $01 and $02, message length is determined by parameter identification (PID). Several PIDs e.g. $06 - $09 require reading of PIDs $13 and/or $1D to determine whether a data byte B is included in the response message. For Service $05, message length is determined by Test ID. For other services, the message length is determined by the service. This enables the external test equipment to check for proper message length, and to recognize the end of the message without waiting for possible additional data bytes. For ISO 14230-4 interfaces, the message length is always determined by the length information included in the first byte of the header.

5.3.2.2 ISO 15765-4 — Maximum message length

The maximum message length is specified in ISO 15765-2. For request messages, the message length is limited to seven (7) data bytes.

5.3.3 Request/response message format

5.3.3.1 ISO 9141-2, ISO 14230-4, SAE J1850, ISO 15765-4 — Request message format

Table 8 specifies the format of the request message.

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Table 8 — Request message format for ISO 9141-2, ISO 14230-4, SAE J1850, ISO 15765-4

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request Service Identifier	M	xx	SIDRQ
#2	service-specific data byte#1	U	xx	—
#3	service-specific data byte#2	U	xx	—
#4	service-specific data byte#3	U	xx	—
#5	service-specific data byte#4	U	xx	—
#6	service-specific data byte#5	U	xx	—
#7	service-specific data byte#6	U	xx	—

The message format defined for some services for the ISO 15765-4 protocol allows for an optional number of data bytes in the request message sent by the external test equipment. If these are included in the request message, support of those optional data bytes becomes mandatory for the server/ECU.

5.3.3.2 ISO 9141-2, ISO 14230-4, SAE J1850 — Positive response message format

Table 9 specifies the format of the positive response message.

Table 9 — Positive response message format for ISO 9141-2, ISO 14230-4, SAE J1850

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Positive Response Service Identifier	M	xx	SIDPR
#2	service-specific data byte#1	U	xx	—
#3	service-specific data byte#2	U	xx	—
#4	service-specific data byte#3	U	xx	—
#5	service-specific data byte#4	U	xx	—
#6	service-specific data byte#5	U	xx	—
#7	service-specific data byte#6	U	xx	—

5.3.3.3 ISO 15765-4 — Positive response message format

Table 10 specifies the format of the positive response message.

Table 10 — Positive response message format for ISO 15765-4

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Positive Response Service Identifier	M	xx	SIDPR
#2	service-specific data byte#1	U	xx	—
#3	service-specific data byte#2	U	xx	—
#4	service-specific data byte#3	U	xx	—
:	:	:	:	:
#n-2	service-specific data byte#m-2	U	xx	—
#n-1	service-specific data byte#m-1	U	xx	—
#n	service-specific data byte#m	U	xx	—

n: this value depends on the response message length
m: this value depends on the response message length - 1

5.3.3.4 ISO 14230-4, ISO 15765-4 — Negative response message format

This subclause includes additions, exceptions, and/or restrictions for the ISO standards which apply.

Table 11 specifies the format of the negative response message.

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Table 11 — Negative response message format for ISO 14230-4, ISO 15765-4

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Negative Response Service Identifier	M	7F	SIDNR
#2	Request Service Identifier	M	xx	SIDRQ
#3	ResponseCode	M	xx	RC_

5.3.4 Response code parameter definition

Response codes shall be implemented in an ECU, that supports a service(s) not having valid data available at the time of a request or cannot respond with valid data available within $P2_{K\text{-}Line}$ and $P2_{CAN}$ timing.

Table 12 — Negative response code definition

Supported by ISO	Hex Value	Definition of Response Code	Mnemonic
14230-4	10	**generalReject** This response code indicates that the service is rejected but the server (ECU) does not specify the reason of the rejection.	GR
14230-4	11	**serviceNotSupported** This response code indicates that the requested action will not be taken because the server (ECU) does not support the requested service.	SNS
14230-4	12	**subFunctionNotSupported-InvalidFormat** This response code indicates that the requested action will not be taken because the server (ECU) does not support the arguments of the request message or the format of the argument bytes do not match the prescribed format for the specified service.	SFNSIF
14230-4 15765-4	21	**busy-RepeatRequest** This response code indicates that the server (ECU) is temporarily too busy to perform the requested operation. For ISO 15765-4 protocol the client (external test equipment) shall behave as defined in ISO 15765-4. In a multi-client (more than one external test equipment, e.g. telematic client) environment the diagnostic request message of one client might be blocked temporarily by a negative response message with response code $21 while another client finishes a diagnostic task. Therefore this negative response code is only allowed to be used during the initialization sequence of the protocol. NOTE If the server (ECU) is able to perform the diagnostic task but needs additional time to finish the task and prepares the response message, the negative response message with response code $78 are used instead of $21.	BRR
14230-4 15765-4	22	**conditionsNotCorrectOrRequestSequenceError** This response code indicates that the requested action will not be taken because the server (ECU) prerequisite conditions are not met. This request may also occur when sequence-sensitive requests are issued in the wrong order.	CNCORSE
14230-4 15765-4	78	**requestCorrectlyReceived-ResponsePending** This response code indicates that the request message was received correctly, and that any parameters in the request message were valid, but the action to be performed may not be completed yet. This response code can be used to indicate that the request message was properly received and does not need to be re-transmitted, but the server (ECU) is not yet ready to receive another request. The negative response message with this response code may be repeated by the ECU(s) within $P2_{K\text{-}Line} = P2_{CAN} = P2^{*}_{max}$ until the positive response message with the requested data is available.	RCR-RP

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5.3.5 Header byte definition of ISO 9141-2, ISO 14230-4, and SAE J1850

The first three (3) bytes of all diagnostic messages are the header bytes.

For SAE J1850 and ISO 9141-2 interfaces, the value of the first header byte is dependant on the bit rate of the data link and the type of message, refer to SAE J1850 and ISO 9141-2. The second header byte has a value that depends on the type of message, either a request or a response.

For ISO 14230-4 interfaces, the value of the first header byte indicates the addressing mode (physical/functional) and the length of the data field. The second header byte is the address of the receiver of the message. The third header byte for all interfaces is the physical address of the sender of the message. The external test equipment has the address $F1. Other service tools shall use addresses in the range from $F0 to $FD. The response to all request messages will be independent of the address of the external test equipment requesting the information. Vehicle manufacturers shall not use the header bytes defined in ISO 15031-5 for any purpose other than emissions-related diagnostic messages. When they are used, they shall conform to this specification.

Table 13 — Diagnostic message format for ISO 9141-2, ISO 14230-4, SAE J1850

Header bytes (Hex)			Data bytes								
Priority/Type	Target address (hex)	Source address (hex)	#1	#2	#3	#4	#5	#6	#7	ERR	RESP
Diagnostic request at 10,4 kbit/s: SAE J1850 and ISO 9141-2											
68	6A	F1	Maximum 7 data bytes							Yes	No
Diagnostic response at 10,4 kbit/s: SAE J1850 and ISO 9141-2											
48	6B	ECU addr	Maximum 7 data bytes							Yes	No
Diagnostic request at 10,4 kbit/s (ISO 14230-4)											
11LL LLLLb	33	F1	Maximum 7 data bytes							Yes	No
Diagnostic response at 10,4 kbit/s (ISO 14230-4)											
10LL LLLLb	F1	ECU addr	Maximum 7 data bytes							Yes	No
Diagnostic request at 41,6 kbit/s (SAE J1850)											
61	6A	F1	Maximum 7 data bytes							Yes	Yes
Diagnostic response at 41,6 kbit/s (SAE J1850)											
41	6B	ECU addr	Maximum 7 data bytes							Yes	Yes

NOTE LL LLLL = Length of data bytes; RESP = In-frame response; ERR = Error Detection.

5.3.6 Header byte definition of ISO 15765-4

Each CAN frame is identified by a CAN Identifier. The size of the identifier is either 11 bit or 29 bit. The CAN identifier shall always be followed by an eight (8) byte CAN frame data field (refer to ISO 15765-4; see section "Data length code (DLC)"). Depending on the message type, up to three (3) bytes (FlowControl) are used for the PCI (Protocol Control Information) prior to the Service Identifier (only included in single frame or first frame) and data bytes of the message.

Table 14 — Diagnostic message format for ISO 15765-4

Header bytes	CAN frame data field							
CAN Identifier (11 or 29 bit)	#1	#2	#3	#4	#5	#6	#7	#8

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5.3.7 Data bytes definition of ISO 9141-2, ISO 14230-4, SAE J1850, and ISO 15765-4

For the ISO 9141-2, ISO 14230-4, and the SAE J1850 protocol, the first data byte following the header is the diagnostic service identifier, and the remaining data bytes vary depending on the specific diagnostic service. For the ISO 15765-4 protocol, the first data byte following the CAN Identifier in a single frame and first frame is the PCI (Protocol Control Information, number of bytes varies, depending on frame type), then diagnostic service identifier, and the remaining data bytes vary depending on the specific diagnostic service.

5.3.8 Non-data bytes included in diagnostic messages with SAE J1850

All diagnostic messages use a cyclic redundancy check (CRC) as in SAE J1850 as the error detection (ERR) byte. In-frame response (RSP) is specified as optional in SAE J1850. For messages specified in this part of ISO 15031, the RSP byte is required in all request and response messages at 41,6 kbit/s, and is not allowed for messages at 10,4 kbit/s. The in-frame response byte shall be the node address of the device transmitting the RSP. SAE J1850 specifies additional message elements that may be included in diagnostic messages. Use of these message elements is beyond the scope of this document, but needs to be considered when specifying total diagnostic messages.

5.3.9 Non-data bytes included in diagnostic messages with ISO 9141-2 and ISO 14230-4

Messages will include a checksum, specified in ISO 9141-2 and ISO 14230-4, after the data bytes as the error detection byte (ERR). There is no provision for an in-frame response.

5.3.10 Bit position convention

Some data byte values include descriptions that are based on bit positions within the byte. The convention used is that the most significant bit (MSB) is referred to as "bit 7", and the least significant bit (LSB) is referred to as "bit 0," as shown in Figure 14.

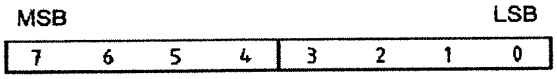


Figure 14 — Bit position within a data byte

5.4 Allowance for expansion and enhanced diagnostic services

This part of ISO 15031 allows for the addition of diagnostic services both as industry standards and manufacturer-specific services. The diagnostic Services $00 through $0F are ISO/SAE reserved.

5.5 Definition of PIDs for Services $01 and $02

All PIDs are defined in Annex B.

5.6 Format of data to be displayed

Table 15 indicates the type of data and minimum requirements for format of the display.

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Table 15 — Format of data to be displayed

Data	Services	Display Format
Device ID – source address of response	all	ISO 9141-2: Hexadecimal (00 to FF) ISO 14230-4: Hexadecimal (00 to FF) SAE J1850: Hexadecimal (00 to FF) ISO 15765-4: Hexadecimal (11 bit or 29 bit CAN Identifier)
Parameter ID (PID)	$01 & $02	Hexadecimal (00 to FF) description (see Annex B)
Frame number	$02	Decimal (0 to 255)
Data values	$01 & $02	See Annex B
Diagnostic trouble codes	$03 & $07	"P", "B", "C" or "U", plus 4 hexadecimal characters and/or DTC definition - see ISO 15031-6
Test ID	$05, $06 & $08	Hexadecimal (00 to FF)
Test value and test limits	$05	Engineering units for Test IDs less than $80 (see Annex C) - Decimal (0 to 255) for test IDs greater than $80
Test value and test limits	$06	Decimal (0 to 65535)
Component ID	$06	Hexadecimal (00 to 7F)
Optional data bytes	$08	4 bytes, each decimal (0 to 255) (see Annex F)
Vehicle information type	$09	Hexadecimal (00 to 7F) (see Annex G)
Vehicle information data	$09	ASCII for information types $02 and $04; Hexadecimal for information type $06; Decimal for information type $08 (see Annex G)

NOTE ISO 15031-4 specifies further guidelines and examples how to display Service $01 through $09 data.

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6 Diagnostic service definition for ISO 9141-2, ISO 14230-4, and SAE J1850

6.1 Service $01 — Request current powertrain diagnostic data

6.1.1 Functional description

The purpose of this service is to allow access to current emission-related data values, including analogue inputs and outputs, digital inputs and outputs, and system status information. The request for information includes a parameter identification (PID) value that indicates to the on-board system the specific information requested. PID specifications, scaling information, and display formats are included in Annex B.

The ECU(s) shall respond to this message by transmitting the requested data value last determined by the system. All data values returned for sensor readings will be actual readings, not default or substitute values used by the system because of a fault with that sensor.

Not all PIDs are applicable or supported by all systems. PID $00 is a bit-encoded PID that indicates, for each ECU, which PIDs that ECU supports. PID $00 shall be supported by all ECUs that respond to a Service $01 request, because the external test equipment that conforms to ISO 15031-4 use the presence of a response message by the vehicle to this request message to determine which protocol is supported for diagnostic communications. Annex A defines how to encode supported PIDs.

IMPORTANT — All emissions-related OBD ECUs which at least support one of the services defined in this part of ISO 15031 shall support Service $01 and PID $00. Service $01 with PID $00 is defined as the universal "initialization/keep alive/ping" message for all emissions-related OBD ECUs.

6.1.2 Message data bytes

6.1.2.1 Request current powertrain diagnostic data request message definition (read supported PIDs)

Table 16 — Request current powertrain diagnostic data request message (read supported PIDs)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request current powertrain diagnostic data request SID	M	01	SIDRQ
#2	PID (see Annex A)	M	xx	PID

6.1.2.2 Request current powertrain diagnostic data response message definition (report supported PIDs)

Table 17 — Request current powertrain diagnostic data response message (report supported PIDs)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request current powertrain diagnostic data response SID	M	41	SIDPR
	data record of supported PID = [			PIDREC_
#2	supported PID	M	xx	PID
#3	data A,	M	xx	DATA_A
#4	data B,	M	xx	DATA_B
#5	data C,	M	xx	DATA_C
#6	data D]	M	xx	DATA_D

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6.1.2.3 Request current powertrain diagnostic data request message definition (read PID value)

Table 18 — Request current powertrain diagnostic data request message (read PID value)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request current powertrain diagnostic data request SID	M	01	SIDRQ
#2	PID (see Annex B)	M/C[a]	xx	PID
[a] C = Conditional — PID value is one of the supported PIDs of previous response message.				

6.1.2.4 Request current powertrain diagnostic data response message definition (report PID value)

Table 19 — Request current powertrain diagnostic data response message (report PID value)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request current powertrain diagnostic data response SID	M	41	SIDPR
#2	data record of 1st supported PID = [PID	M	xx	PIDREC_ PID
#3	data A,	M	xx	DATA_A
#4	data B,	C[a]	xx	DATA_B
#5	data C,	C	xx	DATA_C
#6	data D]	C	xx	DATA_D
[a] C = Conditional — data B - D depend on selected PID value.				

The PID, which is included in the request message may be supported by all emission-related ECUs, which shall comply with this specification. Therefore, multiple response messages are sent by the vehicle ECUs.

6.1.3 Parameter definition

6.1.3.1 PIDs supported

Annex A specifies the interpretation of the data record of supported PIDs.

6.1.3.2 PID and data byte descriptions

Annex B specifies standardized emission-related parameters.

6.1.4 Message example

The example below shows how the "Request current powertrain diagnostic data" service shall be implemented.

6.1.4.1 Step #1: Request supported PIDs from vehicle

The external test equipment requests supported PIDs (PID = $00, $20) from the vehicle. Refer to Annex A to interpret the data bytes in the response messages.

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Table 20 — Request current powertrain diagnostic data request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request current powertrain diagnostic data request SID	01	SIDRQ
#2	PID used to determine PID support for PIDs 01-20	00	PID

Table 21 — Request current powertrain diagnostic data response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request current powertrain diagnostic data response SID	41	SIDPR
#2	PID requested	00	PID
#3	Data byte A, representing support for PIDs 01, 03-08	10111111b = $BF	DATA_A
#4	Data byte B, representing support for PIDs 09, 0B-10	10111111b = $BF	DATA_B
#5	Data byte C, representing support for PIDs 11, 13, 15	10101000b = $A8	DATA_C
#6	Data byte D, representing support for PIDs 19, 1C, 20	10010001b = $91	DATA_D

Table 22 — Request current powertrain diagnostic data response message

Message direction:	ECU#2 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request current powertrain diagnostic data response SID	41	SIDPR
#2	PID requested	00	PID
#3	Data byte A, representing support for PID 01	10000000b = $80	DATA_A
#4	Data byte B, representing support for PID 0D	00001000b = $08	DATA_B
#5	Data byte C, representing no support for PIDs 11-18	00000000b = $00	DATA_C
#6	Data byte D, representing no support for PIDs 19-20	00000000b = $00	DATA_D

Table 23 — Request current powertrain diagnostic data request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request current powertrain diagnostic data request SID	01	SIDRQ
#2	PID requested	20	PID

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Table 24 — Request current powertrain diagnostic data response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request current powertrain diagnostic data response SID	41	SIDPR
#2	PID requested	20	PID
#3	Data byte A, representing support for PID 21	10000000b = $80	DATA_A
#4	Data byte B, representing no support for PIDs 29-30	00000000b = $00	DATA_B
#5	Data byte C, representing no support for PIDs 31-38	00000000b = $00	DATA_C
#6	Data byte D, representing no support for PIDs 39-40	00000000b = $00	DATA_D

NOTE ECU #2 does not send a response message because it indicated with the previous response message that it does not support PID $20.

Now the external test equipment creates an internal list of supported PIDs for each ECU. The ECU #1 (ECM) supports the following PIDs: $01, $03 - $09, $0B - $11, $13, $15, $19, $1C, $20, $21. The ECU #2 (TCM) supports the PIDs $01 and $0D.

6.1.4.2 Step #2: Request PID from vehicle

The external test equipment requests the following PID from the vehicle:

— PID $01: Number of emission-related powertrain DTCs and MIL status, PID is supported by ECU #1 (ECM) and ECU #2 (TCM)

Table 25 — Request current powertrain diagnostic data request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request current powertrain diagnostic data request SID	01	SIDRQ
#2	PID: Number of emission-related powertrain DTCs and MIL status	01	PID

Table 26 — Request current powertrain diagnostic data response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request current powertrain diagnostic data response SID	41	SIDPR
#2	PID: Number of emission-related powertrain DTCs and MIL status	01	PID
#3	MIL: ON; Number of emission-related powertrain DTCs: 01	81	DATA_A
#4	Misfire -, Fuel system -, Comprehensive monitoring	33	DATA_B
#5	Catalyst -, Heated catalyst -, ..., monitoring supported	FF	DATA_C
#6	Catalyst -, Heated catalyst -, ..., monitoring test complete/not complete	63	DATA_D

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Table 27 — Request current powertrain diagnostic data response message

Message direction:	ECU#2 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request current powertrain diagnostic data response SID	41	SIDPR
#2	PID: Number of emission-related powertrain DTCs and MIL status	01	PID
#3	MIL: OFF; Number of emission-related powertrain DTCs: 01	01	DATA_A
#4	Comprehensive monitoring: supported, test complete	44	DATA_B
#5	Catalyst -, Heated catalyst -, ..., monitoring supported	00	DATA_C
#6	Catalyst -, Heated catalyst -, ..., monitoring test complete/not complete	00	DATA_D

The external test equipment requests the following PID from the vehicle:

— PID $19: Bank 2 - Sensor 2, PID is supported by ECU #1 (ECM)

Table 28 — Request current powertrain diagnostic data request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request current powertrain diagnostic data request SID	01	SIDRQ
#2	PID: Oxygen Sensor Output Voltage (B2 - S2) Short Term Fuel Trim (B2 - S2)	19	PID

Table 29 — Request current powertrain diagnostic data response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request current powertrain diagnostic data response SID	41	SIDPR
#2	PID: Oxygen Sensor Output Voltage (B2 - S2) Short Term Fuel Trim (B2 - S2)	19	PID
#3	Oxygen Sensor Output Voltage (B2 - S2): 0,8 Volt	A0	DATA_A
#4	Short Term Fuel Trim (B2 - S2): 93,7 %	78	DATA_B

NOTE ECU#2 does not support PID $19 and therefore does not send a response message.

6.2 Service $02 — Request powertrain freeze frame data

6.2.1 Functional description

The purpose of this service is to allow access to emission-related data values in a freeze frame. This allows expansion to meet manufacturer-specific requirements not necessarily related to the required freeze frame, and not necessarily containing the same data values as the required freeze frame. The request message includes a parameter identification (PID) value that indicates to the on-board system the specific information

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requested. PID specifications, scaling information and display formats for the freeze frame are included in Annex B.

The ECU(s) shall respond to this message by transmitting the requested data value stored by the system. All data values returned for sensor readings will be actual stored readings, not default or substitute values used by the system because of a fault with that sensor.

Not all PIDs are applicable or supported by all systems. PID $00 is a bit-encoded PID that indicates, for each ECU, which PIDs that ECU supports. Therefore, PID $00 shall be supported by all ECUs that respond to a Service $02 request as specified even if the ECU does not have a freeze frame stored at the time of the request.

Annex A defines how to encode supported PIDs.

PID $02 indicates the DTC that caused the freeze frame data to be stored. If freeze frame data is not stored in the ECU, the system shall report $00 00 as the DTC. Any data reported when the stored DTC is $00 00 may not be valid.

The frame number byte shall indicate $00 for the mandated freeze frame data. Manufacturers may optionally save additional freeze frames and use this service to obtain that data by specifying the freeze frame number in the request message. If a manufacturer uses these additional freeze frames, they will be stored under conditions specified by the manufacturer, and contain data specified by the manufacturer.

6.2.2 Message data bytes

6.2.2.1 Request powertrain freeze frame data request message definition (read supported PIDs)

Table 30 — Request powertrain freeze frame data request message (read supported PIDs)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request powertrain freeze frame data request SID	M	02	SIDRQ
#2	PID (see Annex A)	M	xx	PID
#3	frame #	M	xx	FRNO

6.2.2.2 Request powertrain freeze frame data response message definition (report supported PIDs)

Table 31 — Request powertrain freeze frame data response message (report supported PIDs)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request powertrain freeze frame data response SID	M	42	SIDPR
#2	PID	M	xx	PID
#3	frame #	M	xx	FRNO
	data record of supported PIDs = [			DATAREC_
#4	Data A: supported PIDs,	M	xx	DATA_A
#5	Data B: supported PIDs,	M	xx	DATA_B
#6	Data C: supported PIDs,	M	xx	DATA_C
#7	Data D: supported PIDs]	M	xx	DATA_D

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6.2.2.3 Request powertrain freeze frame data request message definition (read freeze frame PID value)

Table 32 — Request powertrain freeze frame data request message (read freeze frame PID value)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request current powertrain diagnostic data request SID	M	02	SIDRQ
#2	PID (see Annex B)	M/C[a]	xx	PID
#3	frame #	M	xx	FRNO
[a] C = Conditional — PID value shall be one of the supported PIDs of previous response message.				

6.2.2.4 Request powertrain freeze frame data response message definition (report freeze frame PID value)

Table 33 — Request powertrain freeze frame data response message (report freeze frame PID value)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request powertrain freeze frame data response SID	M	42	SIDPR
#2	PID	M	xx	PID
#3	frame #	M	xx	FRNO
	data record = [			DATAREC_
#3	Data A,	M	xx	DATA_A
#4	Data B,	C[a]	xx	DATA_B
#5	Data C,	C	xx	DATA_C
#6	Data D]	C	xx	DATA_D
[a] C = Conditional — data B - D depend on selected PID value.				

6.2.3 Parameter definition

6.2.3.1 PIDs supported

Annex A specifies the interpretation of the data record of supported PIDs.

6.2.3.2 PID and data byte descriptions

Annex B specifies standardized emission-related parameters.

6.2.3.3 Frame # description

The frame number identifies the freeze frame, which includes emission-related data values in case an emission-related DTC is detected by the ECU.

6.2.4 Message example

The example below shows how the "Request powertrain freeze frame data" service shall be implemented.

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6.2.4.1 Step #1: Request supported powertrain freeze frame PIDs from vehicle

The external test equipment requests all supported powertrain freeze frame PIDs of freeze frame $00 from the vehicle. Refer to the example of Service $01 how to request supported PIDs.

As a result of the supported PID request, the external test equipment creates an internal list of supported PIDs for each ECU. ECU #1 (ECM) supports the following PIDs: $02 - $09, $0B - $0E. ECU #2 (TCM) does not support any PIDs for this service.

6.2.4.2 Step #2: Request PID $02 "DTC which caused freeze frame to be stored" from vehicle

6.2.4.2.1 Case #1: Freeze frame data are stored in ECU #1

Now the external test equipment requests PID $02 of freeze frame $00 from the vehicle. Since the ECU #2 (TCM) does not store a freeze frame data record, only the ECU #1 (ECM) will send a response message.

In this example, the freeze frame data are stored based on a DTC P0130 occurrence. The parameter value of PID $02 "DTC that caused required freeze frame data storage" is set to the DTC P0130.

Table 34 — Request powertrain freeze frame data request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request powertrain freeze frame data request SID	02	SIDRQ
#2	PID: DTC that caused required freeze frame data storage	02	PID
#3	Frame #	00	FRNO

Table 35 — Request powertrain freeze frame data response message

Message direction:	ECU #1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request powertrain freeze frame data response SID	42	SIDPR
#2	PID: DTC that caused required freeze frame data storage	02	PID
#3	Frame #: 00	00	FRNO
#4	DTC High Byte of P0130	01	DATA_A
#5	DTC Low Byte of P0130	30	DATA_B

6.2.4.2.2 Case #2: No freeze frame data are stored in any ECU

If no freeze frame data are stored, then the ECU(s) which support this service but do not have any freeze frame stored shall send a response message with the parameter values of DATA_A and DATA_B of PID $02 "DTC that caused required freeze frame data storage" set to $0000.

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Table 36 — Request powertrain freeze frame data request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request powertrain freeze frame data request SID	02	SIDRQ
#2	PID: DTC that caused required freeze frame data storage	02	PID
#3	Frame #: 00	00	FRNO

Table 37 — Request powertrain freeze frame data response message (Service $02, PID $02, Frame # $00)

Message direction:	ECU #1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request powertrain freeze frame data response SID	42	SIDPR
#2	PID: DTC that caused required freeze frame data storage	02	PID
#3	Frame #: 00	00	FRNO
#4	DTC High Byte: zero value indicates that no freeze frame is stored	00	DATA_A
#5	DTC Low Byte: zero value indicates that no freeze frame is stored	00	DATA_B

NOTE The DTC value reported is $00 00, therefore no valid freeze frame data are stored for supported PIDs.

6.3 Service $03 — Request emission-related diagnostic trouble codes

6.3.1 Functional description

The purpose of this service is to enable the external test equipment to obtain "confirmed" emission-related DTCs. This shall be a two-step process for the external test equipment

— Step 1: Send a Service $01, PID $01 request to get the number of emission-related DTCs from all ECUs that have this available. Each ECU that has a DTC(s) stored will respond with a message that includes the number of stored codes to be reported. If an ECU that is capable of storing emission-related DTCs does not have stored DTCs, then that ECU shall respond with a message indicating zero (0) DTCs are stored.

— Step 2: Send a Service $03 request for all emission-related DTCs. Each ECU that has DTCs will respond with one or more messages, each containing up to three (3) DTCs. If no emission-related DTCs are stored in the ECU, then the ECU may not respond to this request.

If additional DTCs are set between the time that the number of DTCs are reported by an ECU, and the DTCs are reported by an ECU, then the number of DTCs reported could exceed the number expected by the external test equipment. In this case, the external test equipment shall repeat this cycle until the number of DTCs reported equals the number expected based on the Service $01, PID $01 response.

DTCs are transmitted in two (2) bytes of information for each DTC. The first two (2) bits (high order) of the first (1) byte for each DTC indicate whether the DTC is a Powertrain, Chassis, Body, or Network DTC (refer to ISO 15031-6 for additional interpretation of this structure). The second two (2) bits shall indicate the first (1) digit of the DTC (0 through 3). The second (2) nibble of the first (1) byte and the entire second (2) byte are the next three (3) hexadecimal characters of the actual DTC reported hexadecimal. A powertrain DTC transmitted as $0143 shall be displayed as P0143 (see Figure 15).

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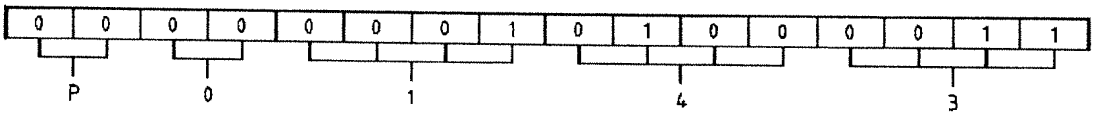


Figure 15 — Diagnostic trouble code encoding example DTC P0143

If less than three (3) DTCs are reported, the response message used to report DTCs shall have their unused bytes set to zero (0) to maintain the required fixed message length for all messages. If there are no DTCs to report, a response message is allowed, but not required for SAE J1850 and ISO 9141-2 interfaces. For ISO 14230-4 interfaces, the ECU will respond with a report containing no DTCs (DTC#1, DTC#2, and DTC#3 shall be all set to $00).

6.3.2 Message data bytes

6.3.2.1 Request current powertrain diagnostic data request message definition (PID $01)

Table 38 — Request current powertrain diagnostic data request message (PID $01)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request current powertrain diagnostic data request SID	M	01	SIDRQ
#2	PID {Number of emission-related DTCs and MIL status}	M	01	PID

6.3.2.2 Request current powertrain diagnostic data response message definition (PID $01)

Table 39 — Request current powertrain diagnostic data response message (PID $01)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request current powertrain diagnostic data response SID	M	41	SIDPR
#2	PID {Number of emission-related DTCs and MIL status}	M	01	PID
	data record = [			DATAREC_
#3	Data A,	M	xx	DATA_A
#4	Data B,	M	xx	DATA_B
#5	Data C,	M	xx	DATA_C
#6	Data D]	M	xx	DATA_D

6.3.2.3 Request emission-related DTC request message definition

Table 40 — Request emission-related DTC request message

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request emission-related DTC request SID	M	03	SIDRQ

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6.3.2.4 Request emission-related DTC response message definition

Table 41 — Request emission-related DTC response message

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request emission-related DTC response SID	M	43	SIDPR
#2 #3	DTC#1 (High Byte) DTC#1 (Low Byte)	M/C[a] M/C	xx xx	DTC1HI DTC1LO
#4 #5	DTC#2 (High Byte) DTC#2 (Low Byte)	M/C M/C	xx xx	DTC2HI DTC2LO
#6 #7	DTC#3 (High Byte) DTC#3 (Low Byte)	M/C M/C	xx xx	DTC3HI DTC3LO

[a] C = Conditional — DTC#1, DTC#2, and DTC#3 are always present. If no valid DTC number is included the DTC values shall contain $00.

6.3.3 Parameter definition

This service does not support any parameters.

6.3.4 Message example

The example below shows how the "Request emission-related DTCs" service shall be implemented. The external test equipment requests emission-related DTCs from the vehicle. The vehicle supports the ISO 14230-4 protocol. The ECU#1 (ECM) has six (6) DTCs stored, the ECU #2 (TCM) has one (1) DTC stored, and the ECU #3 (ABS/Traction Control) has no DTC stored.

— ECU #1 (ECM): P0143, P0196, P0234, P02CD, P0357, P0A24

— ECU #2 (TCM): P0443

— ECU #3 (ABS/Traction Control): no DTC stored (response message is optional for ISO 9141-2 and SAE J1850)

The external test equipment requests the following PID from the vehicle:

— PID $01: Number of emission-related DTCs and MIL status, PID is supported by ECU #1 (ECM), ECU #2 (TCM), and ECU #3 (ABS/Traction Control)

Table 42 — Request current powertrain diagnostic data request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request current powertrain diagnostic data request SID	01	SIDRQ
#2	PID: Number of emission-related DTCs and MIL status	01	PID

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Table 43 — Request current powertrain diagnostic data response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request current powertrain diagnostic data response SID	41	SIDPR
#2	PID: Number of emission-related DTCs and MIL status	01	PID
#3	MIL: ON; Number of emission-related DTCs: 06	86	DATA_A
#4	Misfire -, Fuel system -, Comprehensive monitoring	33	DATA_B
#5	Catalyst -, Heated catalyst -, ..., monitoring supported	FF	DATA_C
#6	Catalyst -, Heated catalyst -, ..., monitoring test complete/not complete	63	DATA_D

Table 44 — Request current powertrain diagnostic data response message

Message direction:	ECU#2 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request current powertrain diagnostic data response SID	41	SIDPR
#2	PID: Number of emission-related DTCs and MIL status	01	PID
#3	MIL: OFF; Number of emission-related DTCs: 01	01	DATA_A
#4	Comprehensive monitoring: supported, test complete	44	DATA_B
#5	Catalyst -, Heated catalyst -, ..., monitoring supported	00	DATA_C
#6	Catalyst -, Heated catalyst -, ..., monitoring test complete/not complete	00	DATA_D

Table 45 — Request current powertrain diagnostic data response message

Message direction:	ECU#3 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request current powertrain diagnostic data response SID	41	SIDPR
#2	PID: Number of emission-related DTCs and MIL status	01	PID
#3	MIL: OFF; Number of emission-related DTCs: 00	00	DATA_A
#4	Comprehensive monitoring: supported, test complete	00	DATA_B
#5	Catalyst -, Heated catalyst -, ..., monitoring supported	00	DATA_C
#6	Catalyst -, Heated catalyst -, ..., monitoring test complete/not complete	00	DATA_D

The external test equipment requests emission-related DTCs because ECU #1 has six (6) DTCs stored, ECU #2 has one (1) DTC stored, and ECU #3 has no (0) DTC stored.

Table 46 — Request emission-related diagnostic trouble codes request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request emission-related DTC request SID	03	SIDRQ

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Table 47 — Request emission-related diagnostic trouble codes response message

Message direction:	ECU #1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request emission-related DTC response SID	43	SIDPR
#2	DTC#1 High Byte of P0143	01	DTC1HI
#3	DTC#1 Low Byte of P0143	43	DTC1LO
#4	DTC#2 High Byte of P0196	01	DTC2HI
#5	DTC#2 Low Byte of P0196	96	DTC2LO
#6	DTC#3 High Byte of P0234	02	DTC3HI
#7	DTC#3 Low Byte of P0234	34	DTC3LO

Table 48 — Request emission-related diagnostic trouble codes response message

Message direction:	ECU #2 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request emission-related DTC response SID	43	SIDPR
#2	DTC#1 High Byte of P0443	04	DTC1HI
#3	DTC#1 Low Byte of P0443	43	DTC1LO
#4	DTC#2 High Byte: 00	00	DTC2HI
#5	DTC#2 Low Byte: 00	00	DTC2LO
#6	DTC#3 High Byte: 00	00	DTC3HI
#7	DTC#3 Low Byte: 00	00	DTC3LO

Table 49 — Request emission-related diagnostic trouble codes response message

Message direction:	ECU #1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request emission-related DTC response SID	43	SIDPR
#2	DTC#1 High Byte of P02CD	02	DTC1HI
#3	DTC#1 Low Byte of P02CD	CD	DTC1LO
#4	DTC#2 High Byte of P0357	03	DTC2HI
#5	DTC#2 Low Byte of P0357	57	DTC2LO
#6	DTC#3 High Byte of P0A24	0A	DTC3HI
#7	DTC#3 Low Byte of P0A24	24	DTC3LO

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Table 50 — Request emission-related diagnostic trouble codes response message

Message direction:	ECU #3 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request emission-related DTC response SID	43	SIDPR
#2	DTC#1 High Byte: 00	00	DTC1HI
#3	DTC#1 Low Byte: 00	00	DTC1LO
#4	DTC#2 High Byte: 00	00	DTC2HI
#5	DTC#2 Low Byte: 00	00	DTC2LO
#6	DTC#3 High Byte: 00	00	DTC3HI
#7	DTC#3 Low Byte: 00	00	DTC3LO

NOTE For ISO 9141-2 and SAE J1850 protocols, the ECU #3 response message is optional because there is no DTC stored. If ISO 14230-4 protocol is supported by the vehicle, ECU #3 shall send a positive response message with no DTCs.

6.4 Service $04 — Clear/reset emission-related diagnostic information

6.4.1 Functional description

The purpose of this service is to provide a means for the external test equipment to command ECUs to clear all emission-related diagnostic information. This includes:

- MIL and number of diagnostic trouble codes (can be read with Service $01, PID $01)
- Clear the I/M (Inspection/Maintenance) readiness bits (Service $01, PID $01 and $41)
- Confirmed diagnostic trouble codes (can be read with Service $03)
- Pending diagnostic trouble codes (can be read with Service $07)
- Diagnostic trouble code for freeze frame data (can be read with Service $02, PID $02)
- Freeze frame data (can be read with Service $02)
- Oxygen sensor test data (can be read with Service $05)
- Status of system monitoring tests (can be read with Service $01, PID $01)
- On-board monitoring test results (can be read with Service $06)
- Distance travelled while MIL is activated (can be read with Service $01, PID $21)
- Number of warm-ups since DTCs cleared (can be read with Service $01, PID $30)
- Distance travelled since DTCs cleared (can be read with Service $01, PID $31)
- Time run by the engine while MIL is activated (can be read with Service $01, PID $4D)
- Time since diagnostic trouble codes cleared (can be read with Service $01, PID $4E)

Other manufacturer-specific "clearing/resetting" actions may also occur in response to this request message. For safety and/or technical design reasons, some ECUs may not respond to this service under all conditions. All ECUs shall respond to this service request with the ignition ON and with the engine not running. ECUs that cannot perform this operation under other conditions, such as with the engine running, will ignore the request with SAE J1850 and ISO 9141-2 interfaces, or will send a negative response message with ISO 14230-4 interfaces, as described in ISO 14230-4.

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6.4.2 Message data bytes

6.4.2.1 Clear/reset emission-related diagnostic information request message definition

Table 51 — Clear/reset emission-related diagnostic information request message

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Clear/reset emission-related diagnostic information request SID	M	04	SIDRQ

6.4.2.2 Clear/reset emission-related diagnostic information response message definition

Table 52 — Clear/reset emission-related diagnostic information response message

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Clear/reset emission-related diagnostic information response SID	M	44	SIDPR

6.4.3 Parameter definition

This service does not support any parameters.

6.4.4 Message example

This example is based on the example of Service $03 as described in 7.3.4. The external test equipment commands the vehicle to clear/reset emission-related diagnostic information with the engine running. The ECU #1 (ECM) and ECU #2 (TCM) will send a response message to confirm that all emission-related diagnostic information is cleared. For ISO 9141-2 and SAE J1850 protocols, ECU #3 (ABS/Traction Control) will not send a response message because the conditions to perform the requested action are not met. For ISO 14230-4 protocol, ECU #3 will send a negative response message with response code $22 - conditionsNotCorrect. In such case the external test equipment shall post a message with "Stop engine and turn ON ignition" and then repeat the Service $04 command and check for response messages from all emission-related ECUs installed in the vehicle.

Table 53 — Clear/reset emission-related diagnostic information request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Clear/reset emission-related diagnostic information request SID	04	SIDRQ

Table 54 — Clear/reset emission-related diagnostic information response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Clear/reset emission-related diagnostic information response SID	44	SIDPR

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Table 55 — Clear/reset emission-related diagnostic information response message

Message direction:	ECU#2 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Clear/reset emission-related diagnostic information response SID	44	SIDPR

Table 56 — Negative response message

Message direction:	ECU#3 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Negative Response Service Identifier	7F	SIDNR
#2	Clear/reset emission-related diagnostic information request SID	04	SIDRQ
#3	Negative Response Code: conditionsNotCorrect	22	NR_CNC

For ISO 14230-4 protocol, the conditions of ECU#3 to Clear/reset emission-related diagnostic information are not met. Therefore, ECU #3 sends a negative response message with response code "conditionsNotCorrect". The external test equipment shall repeat the request after the conditions of the vehicle have changed by the user. Now, all ECUs shall send a positive response message to the external test equipment to confirm successful operation of the Clear/reset emission-related diagnostic information service.

6.5 Service $05 — Request oxygen sensor monitoring test results

6.5.1 Functional description

The purpose of this service is to allow access to the on-board oxygen sensor monitoring test results. The same information may be obtained by the use of Service $06.

The request message for test results includes a Test ID value that indicates the information requested. Test value definitions, scaling information, and display formats are included in Annex C.

Many methods may be used to calculate test results for this service by different manufacturers. If data values are to be reported using these messages that are different from those specified, ranges of test values have been assigned that can be used which have standard units of measure. The external test equipment can convert these values and display them in the standard units.

The ECU shall respond to this message by transmitting the requested test data last determined by the system. The latest test results are to be retained, even over multiple ignition OFF cycles, until replaced by more recent test results. Test results are requested by Test ID.

Not all test values are applicable or supported by all vehicles. An optional feature of this service is for the ECU to indicate which Test IDs are supported. Test ID $00 is a bit-encoded value that indicates support for Test IDs from $01 to $20. Test ID $20 indicates support for Test IDs $21 through $40, etc. This is the same concept as used for PID support in Services $01 and $02 as specified in Annex A. If Test ID $00 is not supported, then the ECU does not use this feature to indicate Test ID support.

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6.5.2 Message data bytes

6.5.2.1 Request oxygen sensor monitoring test results request message definition (read supported TIDs)

Table 57 — Request oxygen sensor monitoring test results request message (read supported TIDs)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request oxygen sensor monitoring test results request SID	M	05	SIDRQ
#2	Test ID (see Annex A)	M	xx	TID
#3	O2 Sensor #	M	xx	O2SNO

6.5.2.2 Request oxygen sensor monitoring test results response message definition (report supported TIDs)

Table 58 — Request oxygen sensor monitoring test results response message (report supported TIDs)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request oxygen sensor monitoring test results response SID	M	45	SIDPR
#2	Test ID	M	xx	TID
#3	O2 Sensor #	M	xx	O2SNO
#4	data record of supported Test IDs = [Data A: supported Test IDs,	M	xx	DATA_A
#5	Data B: supported Test IDs,	M	xx	DATA_B
#6	Data C: supported Test IDs,	M	xx	DATA_C
#7	Data D: supported Test IDs]	M	xx	DATA_D

6.5.2.3 Request oxygen sensor monitoring test results request message definition (read TID values)

Table 59 — Request oxygen sensor monitoring test results request message (read TID values)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request oxygen sensor monitoring test results request SID	M	05	SIDRQ
#2	Test ID	M	xx	TID
#3	O2 Sensor #	M	xx	O2SNO

6.5.2.4 Request oxygen sensor monitoring test results response message definition (report TID values)

Table 60 — Request oxygen sensor monitoring test results response message (report TID values)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request oxygen sensor monitoring test results response SID	M	45	SIDPR
#2	TEST ID	M	xx	TID
#3	O2 Sensor #	M	xx	O2SNO
#4	data record of Test ID = [Test Value	M	xx	TESTVAL
#5	Minimum Limit	C[a]	xx	MINLIMIT
#6	Maximum Limit]	C	xx	MAXLIMIT

[a] C = Conditional — if the supported Test ID is a constant ($01 - $04), the parameters Minimum and Maximum Limit shall not be included.

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6.5.3 Parameter definition

6.5.3.1 Test IDs supported

The Test IDs supported is the same concept as used for PID support in Services $01 and $02 as specified in Annex A.

6.5.3.2 Test ID and data byte descriptions

Annex C specifies standardized and vehicle manufacturer specific Test ID ranges.

6.5.3.3 Oxygen sensor location definition

The oxygen sensor location value used in the request message shall indicate the oxygen sensor location as defined by PID $13 or $1D as specified in Annex B.

Table 61 — Oxygen sensor location description

Oxygen sensor location (one, and only one bit can be set to a 1)		
Bit	Sensor location[a]	Alternative sensor location[b]
0	Bank 1 - Sensor 1	Bank 1 - Sensor 1
1	Bank 1 - Sensor 2	Bank 1 - Sensor 2
2	Bank 1 - Sensor 3	Bank 2 - Sensor 1
3	Bank 1 - Sensor 4	Bank 2 - Sensor 2
4	Bank 2 - Sensor 1	Bank 3 - Sensor 1
5	Bank 2 - Sensor 2	Bank 3 - Sensor 2
6	Bank 2 - Sensor 3	Bank 4 - Sensor 1
7	Bank 2 - Sensor 4	Bank 4 - Sensor 2

[a] If Service $01 PID $13 supported.

[b] If Service $01 PID $1D supported.

6.5.3.4 Test result description

Table 62 — Test Result description

Hex	# of bytes	Description
00 - FF	1	The Test Result parameter includes either a constant or a calculated value depending on the Test ID.

6.5.3.5 Minimum and Maximum Test Limit description

Table 63 defines Minimum and Maximum Test Limit. The Test Limit value is either a minimum or a maximum value to which the test results are compared. The Test Limit is a one-byte unsigned numeric value (0 - 255).

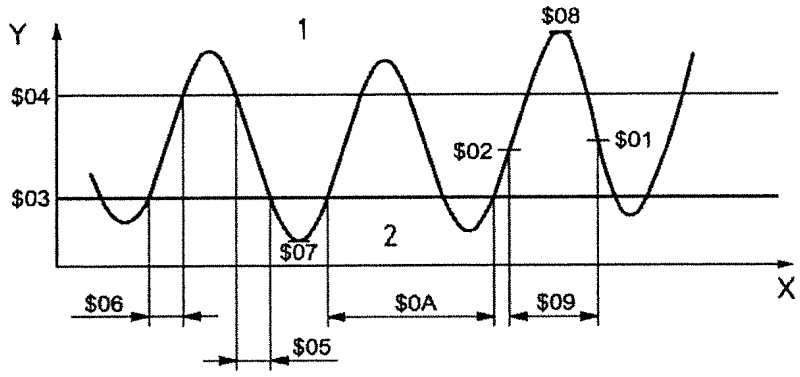
Table 63 — Minimum and Maximum Test Limit description

Test Limit	# of bytes	Description
Minimum	1	The minimum test limit (only for calculated test result) is the minimum value to which the test result is compared.
Maximum	1	The maximum test limit (only for calculated test result) is the maximum value to which the test result is compared.

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For results of latest mandated on-board oxygen sensor monitoring test, see Figure 16.



Key

1 Rich
2 Lean

Figure 16 — Test ID value example

6.5.4 Message example

The example below shows how the "Request oxygen sensor monitoring test results" service shall be implemented.

6.5.4.1 Step #1: Request oxygen sensor monitoring test results (request for supported Test IDs) from vehicle

The external test equipment requests all supported Test IDs from the vehicle. Refer to the example of Service $01 for how to request supported PIDs (same concept is used for supported TIDs). PID $13 is supported by ECU #1. This is important information for the external test equipment in order to identify the correct O2 Sensor location.

As a result of the supported TID request, the external test equipment creates an internal list of supported TIDs for each ECU: The ECU #1 (ECM) supports Test IDs $01 - $06, $70, $71 and $81. The ECU #2 (TCM) does not support any Test IDs.

6.5.4.2 Step #2: Request oxygen sensor monitoring test results from vehicle

The external test equipment sends two (2) "Request oxygen sensor monitoring test results" request messages to the vehicle. The two (2) request messages include the following Test IDs:

— 1st request message: Test IDs $01

— 2nd request message: Test IDs $05

NOTE In general, the external test equipment should read the test status of Service $01 PID $01 prior to execute Service $05 with Test Id $01 and $05 to verify, whether the tests are supported and completed. The test values reported may be invalid if the test is not completed.

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Table 64 — Request oxygen sensor monitoring test results request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request oxygen sensor monitoring test results request SID	05	SIDRQ
#2	TID: Rich to lean sensor threshold voltage (constant)	01	TID
#3	O2 Sensor #: Bank 1 - Sensor 1	01	O2SNO

Table 65 — Request oxygen sensor monitoring test results response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request oxygen sensor monitoring test results response SID	45	SIDPR
#2	TID: Rich to lean sensor threshold voltage (constant)	01	TID
#3	O2 Sensor #: Bank 1 - Sensor 1	01	O2SNO
#4	Test Limit: 450 mV	5A	TESTVAL

NOTE ECU#2 does not support any Test IDs and therefore does not send a response message.

Table 66 — Request oxygen sensor monitoring test results request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request oxygen sensor monitoring test results request SID	05	SIDRQ
#2	TID: Rich to lean sensor switch time (calculated)	05	TID
#3	O2 Sensor #: Bank 1 - Sensor 1	01	O2SNO

Table 67 — Request oxygen sensor monitoring test results response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request oxygen sensor monitoring test results response SID	45	SIDPR
#2	TID: Rich to lean sensor switch time (calculated)	05	TID
#3	O2 Sensor #: Bank 1 - Sensor 1	01	O2SNO
#4	Test Limit: 72 ms (milliseconds)	12	TESTVAL
#5	Minimum Limit: 0 ms	00	MINLIMIT
#6	Maximum Limit: 100 ms	19	MAXLIMIT

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6.6 Service $06 — Request on-board monitoring test results for specific monitored systems

6.6.1 Functional description

The purpose of this service is to allow access to the results of on-board diagnostic monitoring tests for specific components/systems. Examples are catalyst monitoring and the evaporative system monitoring.

The vehicle manufacturer is responsible for assigning Test IDs and Component IDs for tests of different systems and components. The latest valid test results are to be retained, even over multiple ignition OFF cycles, until replaced by more recent test results. Test results are requested by Test ID. Test results are reported only for supported combinations of test limit type and component ID, and are reported as positive (unsigned) values. Only one test limit is included in a response message, but that limit could be either a minimum or a maximum limit. If both a minimum and maximum test limit are to be reported, then two (2) response messages will be transmitted, in any order. The most significant bit of the "test limit type/component ID" byte will be used to indicate the test limit type.

An optional feature of this service is for the ECU to indicate which Test IDs are supported. Test ID $00 is a bit-encoded value that indicates support for Test IDs from $01 to $20. Test ID $20 indicates support for Test IDs $21 through $40, etc. This is the same concept as used for PID support in Services $01 and $02 as specified in Annex A. If Test ID $00 is not supported, then the ECU does not use this feature to indicate Test ID support.

This service can be used as an alternative to Service $05 to report oxygen sensor test results.

A unique method must be utilized for displaying data for monitors that have multiple tests. Many OBD monitors have multiple tests that that are done in either a serial or parallel manner. If a monitor uses multiple Test ID/Component ID combinations that may not all complete at the same time, the following method shall be used to update the stored test results at the time of monitor completion:

After the monitor completes, update all Test ID/Component ID combinations (or "test results") that were utilized by the monitor with appropriate passing or failing results. If a test result (or "Test ID/Component ID") was not utilized during this monitoring event, set the Test Values and Minimum and Maximum Test Limits to their initial values (test not completed). Test results from the previously completed monitoring events shall not be mixed with test results from the current completed monitoring event.

In some cases, test results (or "Test ID/Component ID combinations") will be displayed as being incomplete even though the monitor (as indicated by PID $41) was successfully completed and either passed or failed. In other cases, some Test IDs will show passing results while others will show failing results after the monitor (as indicated by PID $41) was successfully completed and failed. Note that OBD-II regulations prohibit a passing monitor from showing any failing test results. If an initial serial test indicates a failure and a subsequent re-test of the system indicates a passing result, the test that was utilized to make the passing determination should be displayed, while the failing test that was utilized to make the initial determination should be reset to its initial values (test not completed).

As an example of a serial monitor, an evaporative system monitor can fail for a large evaporative system leak and never continue to test for small leaks or very small leaks. In this case, the Component ID for the large leak would show a failing result, while the small leak test and the very small leak test would show incomplete. As an example of the parallel monitor, a purge valve flow monitor can pass by having a large rich lambda shift, a large lean lambda shift or a large engine rpm increase. If the purge valve is activated and a large rich lambda shift occurs, the Component ID for the rich lambda shift would show a passing result while the other two Component IDs would show incomplete. Since some Component IDs for a completed monitor will show incomplete, PID $41 must be used to determine monitor completion status.

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6.6.2 Message data bytes

6.6.2.1 Request on-board monitoring test results for specific monitored systems request message definition (read supported TIDs)

Table 68 — Request on-board monitoring test results for specific monitored systems request message (read supported TIDs)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request on-board monitoring test results for specific monitored systems request SID	M	06	SIDRQ
#2	Test ID (see Annex A)	M	xx	TID

6.6.2.2 Request on-board monitoring test results for specific monitored systems response message definition (report supported TIDs)

Table 69 — Request on-board monitoring test results for specific monitored systems response message (report supported TIDs)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request on-board monitoring test results for specific monitored systems response SID	M	46	SIDPR
#2	Test ID	M	xx	TID
#3	FillerByte	M	FF	FB
	data record of supported Test IDs = [			DATAREC_
#4	Data A: supported Test IDs,	M	xx	DATA_A
#5	Data B: supported Test IDs,	M	xx	DATA_B
#6	Data C: supported Test IDs,	M	xx	DATA_C
#7	Data D: supported Test IDs]	M	xx	DATA_D

6.6.2.3 Request on-board monitoring test results for specific monitored systems request message definition (read test results)

Table 70 — Request on-board monitoring test results for specific monitored systems request message (read test results)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request on-board monitoring test results for specific monitored systems request SID	M	06	SIDRQ
#2	Test ID (request test results)	M	xx	TID

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6.6.2.4 Request on-board monitoring test results for specific monitored systems response message definition (report test results)

Table 71 — Request on-board monitoring test results for specific monitored systems response message (report test results)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request on-board monitoring test results for specific monitored systems response SID	M	46	SIDPR
#2	Test ID (report test results)	M	xx	TID
#3	Test Limit Type & Component ID	M	xx	TLTCID
	data record of Test ID = [			TIDREC_
#4	Test Value (High Byte)	M	xx	TVHI
#5	Test Value (Low Byte)	M	xx	TVLO
#6	Test Limit (High Byte)	C[a]	xx	TLHI
#7	Test Limit (Low Byte)]	C	xx	TLLO

[a] C = Conditional — if Test Limit is either a Minimum or a Maximum Limit depends on the parameter Test Limit Type & Component ID value (bit 7).

6.6.3 Parameter definition

6.6.3.1 Test IDs supported

The Test IDs supported is the same concept as used for PID support in Services $01 and $02 as specified in Annex A.

6.6.3.2 Test ID and data byte descriptions

Annex C specifies standardized and vehicle manufacturer specific Test ID ranges, which are permitted to be supported in this service.

NOTE For ISO 9141-2, SAE J1850 and ISO 14230-4 protocols that Annex C is recommended but not required. This is for backward compatibility and only applies to Test ID range $01 – $1F.

6.6.3.3 Test Limit Type and Component ID description

The Test Limit Type and Component ID is a one (1) byte parameter and is defined in the table below.

Table 72 — Test Limit Type and Component ID description

Parameter Name	Bit	Description
Component ID	0 - 6	Component ID - manufacturer specified - necessary when multiple components or systems are present on the vehicle and have the same definition of Test ID. If the same test is performed on more than one component, multiple test results shall be reported for that Test ID. For example, a test for bank 1 catalyst can be the same as a test for a bank 2 catalyst, or a test for a pre-catalyst oxygen sensor can be the same as a test for a post-catalyst oxygen sensor. In either case, a request for a single Test ID would result in two test results being reported with different Component IDs.
Test Limit Type	7	Most Significant Bit (MSB) indicates type of test limit, where: 0 - test limit is maximum value - test fails if test value is greater than this value; and 1 - test limit is minimum value - test fails if test value is less than this value.

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6.6.3.4 Test Result description

The Test Result represents the test result and is defined in the table below.

Table 73 — Test Result description

Parameter Name	# of bytes	Description
Test Result	2 (High and Low Byte)	Test result - this value shall be less than or equal to the test limit if MSB of Test Limit Type and Component ID byte is "0", and shall be greater than or equal to the test limit if MSB of Test Limit Type and Component ID byte is "1". The Test Value is a two-byte unsigned numeric value (0 - 65535).

6.6.3.5 Test Limit description

The Test Limit is defined in the table below.

Table 74 — Test Limit description

Parameter Name	# of bytes	Description
Test Limit	2 (High and Low Byte)	The Test Limit value is either a minimum or a maximum value to which the test results are compared. The Test Limit is a two-byte unsigned numeric value (0 - 65535).

6.6.4 Message example

The example below shows how the "Request on-board monitoring test results for specific monitored systems" service shall be implemented.

6.6.4.1 Step #1: Request on-board monitoring test results for specific monitored systems (request for supported Test IDs)

The external test equipment requests all supported Test IDs from the vehicle. Refer to the example of Service $01 how to request supported PIDs (same concept is used for supported TIDs).

As a result of the supported TID request, the external test equipment creates an internal list of supported TIDs for each ECU. The ECU #1 (ECM) supports Test ID $02. The ECU #2 (TCM) does not support any Test IDs.

6.6.4.2 Step #2: Request on-board monitoring test results for specific monitored systems

The external test equipment sends a "Request on-board monitoring test results for specific monitored systems" request message with one (1) supported Test ID to the vehicle. The response messages indicate which Component IDs are supported. The request message includes the following Test ID:

Test ID $02 - Lean to rich sensor threshold voltage (constant), (supported Component IDs: $04, $16).

NOTE In general, the external test equipment should read the test status of Service $01 PID $01 prior to execute Service $06 with Test ID $01 and $06 to verify whether the tests are supported and completed. The test values reported may be invalid if the test is not completed.

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Table 75 — Request on-board monitoring test results for specific monitored systems request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request on-board monitoring test results for specific monitored systems request SID	06	SIDRQ
#2	TID Lean to rich sensor threshold voltage (constant)	02	TID

Table 76 — Request on-board monitoring test results for specific monitored systems response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request on-board monitoring test results for specific monitored systems response SID	46	SIDPR
#2	TID Lean to rich sensor threshold voltage (constant)	02	TID
#3	Test Limit Type: test limit is minimum value; Component ID: 04	84	TLTCID
#4	Test Value High Byte: test fails if test value is less than test limit	00	TVHI
#5	Test Value Low Byte: test fails if test value is less than test limit	10	TVLO
#6	Minimum Test Limit High Byte	00	TLHI
#7	Minimum Test Limit Low Byte	00	TLLO

NOTE ECU#2 does not support any Test IDs and therefore does not send a response message.

Table 77 — Request on-board monitoring test results for specific monitored systems response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request on-board monitoring test results for specific monitored systems response SID	46	SIDPR
#2	TID Lean to rich sensor threshold voltage (constant)	02	TID
#3	Test Limit Type: test limit is maximum value; Component ID: 16	16	TLTCID
#4	Test Value High Byte: test fails if test value is greater than test limit	00	TVHI
#5	Test Value Low Byte: test fails if test value is greater than test limit	32	TVLO
#6	Maximum Test Limit High Byte	00	TLHI
#7	Maximum Test Limit Low Byte	20	TLLO

NOTE The above example shows that the test in ECU #1 for Test ID 02 and Component ID 04 passed and that the test in ECU #1 for Test ID 02 and Component ID 16 failed.

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6.7 Service $07 - Request emission-related diagnostic trouble codes detected during current or last completed driving cycle

6.7.1 Functional description

The purpose of this service is to enable the external test equipment to obtain "pending" diagnostic trouble codes detected during current or last completed driving cycle for emission-related components/systems. Service $07 is required for all DTCs and is independent of Service $03. The intended use of this data is to assist the service technician after a vehicle repair, and after clearing diagnostic information, by reporting test results after a single driving cycle. If the test failed during the driving cycle, the DTC associated with that test will be reported. Test results reported by this service do not necessarily indicate a faulty component/system. If test results indicate a failure after additional driving, then the MIL will be illuminated and a DTC will be set and reported with Service $03, indicating a faulty component/system. This service can always be used to request the results of the latest test, independent of the setting of a DTC.

Test results for these components/systems are reported in the same format as the DTCs in Service $03 - refer to the functional description for Service $03.

If less than three (3) DTC values are reported for failed tests, the response messages used to report the test results shall be filled with $00 to fill seven (7) data bytes. This maintains the required fixed message length for all messages.

If there are no test failures to report, responses are permitted but not required for SAE J1850 and ISO 9141-2 interfaces. For ISO 14230-4 interfaces, the ECU will respond with a report containing no codes (all DTC values shall contain $00).

6.7.2 Message data bytes

6.7.2.1 Request emission-related diagnostic trouble codes detected during current or last completed driving cycle request message definition

Table 78 — Request emission-related diagnostic trouble codes detected during current or last completed driving cycle request message

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request emission-related diagnostic trouble codes detected during current or last completed driving cycle request SID	M	07	SIDRQ

6.7.2.2 Request emission-related diagnostic trouble codes detected during current or last completed driving cycle response message definition

Table 79 — Request emission-related diagnostic trouble codes detected during current or last completed driving cycle response message

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request emission-related diagnostic trouble codes detected during current or last completed driving cycle response SID	M	47	SIDPR
#2 #3	DTC#1 (High Byte) DTC#1 (Low Byte)	M/C[a] M/C	xx xx	DTC1HI DTC1LO
#4 #5	DTC#2 (High Byte) DTC#2 (Low Byte)	M/C M/C	xx xx	DTC2HI DTC2LO
#6 #7	DTC#3 (High Byte) DTC#3 (Low Byte)	M/C M/C	xx xx	DTC3HI DTC3LO

[a] C = Conditional — DTC#1, DTC#2, and DTC#3 are always present. If no valid DTC number is included the DTC values shall contain $00.

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6.7.3 Parameter definition

This service does not support any parameters.

6.7.4 Message example

Refer to message example of Service $03.

6.8 Service $08 — Request control of on-board system, test or component

6.8.1 Functional description

The purpose of this service is to enable the external test equipment to control the operation of an on-board system, test or component.

The data bytes will be specified, if necessary, for each Test ID in Annex F, and will be unique for each Test ID. If any data bytes are unused for any test, they shall be filled with $00 to maintain a fixed message length.

Possible uses for these data bytes in the request message are

— Turn on-board system/test/component ON;

— Turn on-board system/test/component OFF; and

— Cycle on-board system/test/component for 'n' seconds.

Possible uses for these data bytes in the response message are

— Report system status; and

— Report test results.

An optional feature of this service is for the ECU to indicate which Test IDs are supported. Test ID $00 is a bit-encoded value that indicates support for Test IDs from $01 to $20. Test ID $20 indicates support for Test IDs $21 through $40, etc. This is the same concept as used for PID support in Services $01 and $02 as specified in Annex A. If Test ID $00 is not supported, then the ECU does not use this feature to indicate Test ID support.

6.8.2 Message data bytes

6.8.2.1 Request control of on-board device request message definition (read supported TIDs)

Table 80 — Request control of on-board device request message (read supported TIDs)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request control of on-board device request SID	M	08	SIDRQ
#2	Test ID (see Annex A)	M	xx	TID
	data record of Test ID = [			TIDREC_
#3	Data A,	M	00	DATA_A
#4	Data B,	M	00	DATA_B
#5	Data C,	M	00	DATA_C
#6	Data D,	M	00	DATA_D
#7	Data E]	M	00	DATA_E

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6.8.2.2 Request control of on-board device response message definition (report supported TIDs)

Table 81 — Request control of on-board device response message (report supported TIDs)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request control of on-board device response SID	M	48	SIDPR
#2	Test ID	M	xx	TID
#3	FillerByte	M	00	FB
#4	data record of supported Test IDs = [			TIDREC_
#5	Data A: supported Test IDs,	M	xx	DATA_A
#6	Data B: supported Test IDs,	M	xx	DATA_B
#7	Data C: supported Test IDs,	M	xx	DATA_C
	Data D: supported Test IDs]	M	xx	DATA_D

6.8.2.3 Request control of on-board device request message definition (read TID values)

Table 82 — Request control of on-board device request message (read TID values)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request control of on-board device request SID	M	08	SIDRQ
#2	Test ID (request Test ID values)	M	xx	TID
#3	data record of Test ID = [			TIDREC_
#4	Data A,	M/C[a]	xx	DATA_A
#5	Data B,	M/C	xx	DATA_B
#6	Data C,	M/C	xx	DATA_C
#7	Data D,	M/C	xx	DATA_D
	Data E]	M/C	xx	DATA_E

[a] C = Conditional — Data A - E shall be filled with $00 if unused.

6.8.2.4 Request control of on-board device response message definition (report TID values)

Table 83 — Request control of on-board device response message (report TID values)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request control of on-board device response SID	M	48	SIDPR
#2	Test ID (report Test ID values)	M	xx	TID
#3	data record of Test ID = [			TIDREC_
#4	Data A,	M/C[a]	xx	DATA_A
#5	Data B,	M/C	xx	DATA_B
#6	Data C,	M/C	xx	DATA_C
#7	Data D,	M/C	xx	DATA_D
	Data E]	M/C	xx	DATA_E

[a] C = Conditional — Data A - E shall be filled with $00 if unused.

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6.8.3 Parameter definition

6.8.3.1 Test IDs supported

Refer to Annex A.

6.8.3.2 Test ID and data byte descriptions

Refer to Annex F.

6.8.4 Message example

The example below shows how "Request control of on-board system, test or component" service shall be implemented.

6.8.4.1 Step #1: Request control of on-board system, test or component (request for supported Test IDs)

The external test equipment requests all supported Test IDs from the vehicle. Refer to the example of Service $01 how to request supported Test IDs (same concept is used for supported TIDs).

As a result of the supported TID request, the external test equipment creates an internal list of supported PIDs for each ECU. The ECU #1 (ECM) supports Test ID $01. The ECU #2 (TCM) does not support any Test IDs and therefore does not send a response message.

6.8.4.2 Step #2: Request control of on-board device (Service $08, Test ID $01)

The external test equipment sends a "Request control of on-board device" message with one (1) supported Test ID $01 to the vehicle.

Table 84 — Request control of on-board device request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request control of on-board device request SID	08	SIDRQ
#2	TID: Evaporative system leak test	01	TID
#3	Data A: 00	00	DATA_A
#4	Data B: 00	00	DATA_B
#5	Data C: 00	00	DATA_C
#6	Data D: 00	00	DATA_D
#7	Data E: 00	00	DATA_E

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Table 85 — Request control of on-board device response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request control of on-board device response SID	48	SIDPR
#2	TID: Evaporative system leak test	01	TID
#3	Data A: 00	00	DATA_A
#4	Data B: 00	00	DATA_B
#5	Data C: 00	00	DATA_C
#6	Data D: 00	00	DATA_D
#7	Data E: 00	00	DATA_E

NOTE ECU#2 does not support the Test ID and therefore does not send a response message.

6.9 Service $09 — Request vehicle information

6.9.1 Functional description

The purpose of this service is to enable the external test equipment to request vehicle-specific vehicle information such as Vehicle Identification Number (VIN) and Calibration IDs. Some of this information may be required by regulations and some may be desirable to be reported in a standard format if supported by the vehicle manufacturer. INFOTYPEs are defined in Annex G.

An optional feature of this service is for the ECU to indicate which INFOTYPEs are supported (support of INFOTYPE $00 is required for ISO 9141-2). INFOTYPE $00 is a bit-encoded value that indicates support for INFOTYPEs from $01 to $20. INFOTYPE $20 indicates support for INFOTYPEs $21 through $40, etc. This is the same concept as used for PID support in Services $01 and $02 as specified in Annex A. If PID (Parameter ID)/TID (Test ID)/INFOTYPE $00 is not supported, then the ECU does not use this feature to indicate PID (Parameter ID)/TID (Test ID)/INFOTYPE support.

The external test equipment shall maintain a list of ECUs, which support the INFOTYPEs not equal to $00 in order to justify, whether it expects a response message from this ECU or not. For request messages with INFOTYPEs not equal to $00, the positive response messages may not be sent by the ECU(s) within the P2max timing window as specified in 5.2.2. This applies to the following protocols:

a) ISO 9141-2: If the positive response message is not received within $P2_{K\text{-}Line}$, the external test equipment shall stop retrying the request message after one (1) minute from the original request. The retry message shall be sent at least every four (4) seconds. The retry message keeps the bus alive and prevents the external test equipment from having to re-initialize the bus ($P3_{K\text{-}Line}$ time out). The ECU shall not re-initialize the Service $09 internal routine (see 5.2.4.3.2).

b) SAE J1850: If the response message is not received within thirty (30) seconds, the external test equipment shall re-send (retry) the request message. The ECU shall not re-initiate the Service $09 internal routine, but send the positive response message if not already sent. In order to achieve a maximum time out of one (1) minute, the external test equipment shall perform no more than one (1) retry (see 5.2.4.3.4).

If INFOTYPE $02 (VIN) is indicated as supported, the ECU shall respond within P2max timing even if the VIN is missing or incomplete. For example, a development ECU may respond with $FF characters for VIN because the VIN has not been programmed.

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6.9.2 Message data bytes

6.9.2.1 Request vehicle information request message definition (read supported InfoType)

Table 86 — Request vehicle information request message (read supported InfoType)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request vehicle information request SID	M	09	SIDRQ
#2	InfoType (see Annex A)	M	xx	INFTYP

6.9.2.2 Request vehicle information response message definition (report supported InfoType)

Table 87 — Request vehicle information response message (report supported InfoType)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request vehicle information response SID	M	49	SIDPR
#2	InfoType	M	xx	INFTYP_
#3	MessageCount	M	xx	MC_
	data record of InfoType = [			DATAREC_
#4	Data A: supported InfoTypes,	M	xx	DATA_A
#5	Data B: supported InfoTypes,	M	xx	DATA_B
#6	Data C: supported InfoTypes,	M	xx	DATA_C
#7	Data D: supported InfoTypes]	M	xx	DATA_D

6.9.2.3 Request vehicle information request message definition (read InfoType values)

Table 88 — Request vehicle information request message (read InfoType values)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request vehicle information request SID	M	09	SIDRQ
#2	InfoType	M	xx	INFTYP_

6.9.2.4 Request vehicle information response message definition (report InfoType values)

Table 89 — Request vehicle information response message (report InfoType values)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request vehicle information response SID	M	49	SIDPR
#2	InfoType	M	xx	INFTYP_
#3	MessageCount	M	xx	MC_
#4	data record of InfoType = [Data A,	M/C[a]	xx	DATA_A
#5	Data B,	M/C	xx	DATA_B
#6	Data C,	M/C	xx	DATA_C
#7	Data D]	M/C	xx	DATA_D

[a] C = Conditional — data A - D is only present if the requested InfoType equals an even number.

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6.9.3 Parameter definition

6.9.3.1 Vehicle information types supported

Refer to Annex A.

6.9.3.2 Vehicle information types and data byte descriptions

Refer to Annex G.

6.9.3.3 MessageCount description

The MessageCount parameter has two (2) definitions depending on the InfoType parameter value:

— Odd InfoType parameter values (1, 3, 5, etc.): In such a case, the MessageCount parameter includes a value which represents the number of response messages to be sent by the server (ECU) to report the Data A .. D referenced by the corresponding next higher even InfoType parameter value. The MessageCount parameter value is a "static value".

— Even InfoType parameter values (2, 4, 6, etc.): In such a case the MessageCount parameter includes a value which represents a dynamic counter starting with the value of 1 and incremented by 1 in the following response messages (assuming error-free transmission of the response message). The MessageCount parameter value is a "dynamic incremented value" (increments by 1). The last response message shall include an incremented MessageCount value, which matches the reported MessageCount parameter value previously reported by the server (ECU) with the odd InfoType (even InfoType – 1).

Refer to Annex G.

6.9.4 Message example

The example below shows how the "Request vehicle information" service shall be implemented.

6.9.4.1 Step #1: Request vehicle information (request supported InfoType) from vehicle

The external test equipment requests all supported InfoTypes from the vehicle. Refer to the example of Service $01 for how to request supported PIDs (same concept is used for supported InfoTypes). As a result of the supported InfoType request, the external test equipment creates an internal list of supported InfoTypes for each ECU: The ECU #1 (ECM) supports the following InfoTypes: $01, $02, $03, $04, $05, $06, $07, and $08. Since there is only one ECU, which meets emission-related legislative requirements, no response messages from another ECU will occur.

6.9.4.2 Step #2: Request InfoTypes from vehicle

Now the external test equipment requests the following InfoType:

— InfoType $01: MC_VIN = 5 response messages; supported by ECU#1

Table 90 — Request vehicle information request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request vehicle information request SID	09	SIDRQ
#2	InfoType: MessageCount VIN	01	INFTYP

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Table 91 — Request vehicle information response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: MessageCount VIN	01	INFTYP
#3	MessageCount VIN = 5 response messages	05	MC_VIN

Now the external test equipment requests the following InfoType:

— InfoType $02: VIN = [1G1JC5444R7252367] supported by ECU#1.

Table 92 — Request vehicle information request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information request SID	09	SIDRQ
#2	InfoType: VIN	02	INFTYP

Table 93 — Request vehicle information response message (1)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: VIN	02	INFTYP
#3	MessageCount VIN = 1st response message	01	MC_VIN
#4	Data A: Fill byte	00	DATA_A
#5	Data B: Fill byte	00	DATA_B
#6	Data C: Fill byte	00	DATA_C
#7	Data D: '1'	31	DATA_D

Table 94 — Request vehicle information response message (2)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: VIN	02	INFTYP
#3	MessageCount VIN = 2nd response message	02	MC_VIN
#4	Data A: 'G'	47	DATA_A
#5	Data B: '1'	31	DATA_B
#6	Data C: 'J'	4A	DATA_C
#7	Data D: 'C'	43	DATA_D

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Table 95 — Request vehicle information response message (3)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: VIN	02	INFTYP
#3	MessageCount VIN = 3rd response message	03	MC_VIN
#4	Data A: '5'	35	DATA_A
#5	Data B: '4'	34	DATA_B
#6	Data C: '4'	34	DATA_C
#7	Data D: '4'	34	DATA_D

Table 96 — Request vehicle information response message (4)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: VIN	02	INFTYP
#3	MessageCount VIN = 4th response message	04	MC_VIN
#4	Data A: 'R'	52	DATA_A
#5	Data B: '7'	37	DATA_B
#6	Data C: '2'	32	DATA_C
#7	Data D: '5'	35	DATA_D

Table 97 — Request vehicle information response message (5)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: VIN	02	INFTYP
#3	MessageCount VIN = 5th response message	05	MC_VIN
#4	Data A: '2'	32	DATA_A
#5	Data B: '3'	33	DATA_B
#6	Data C: '6'	36	DATA_C
#7	Data D: '7'	37	DATA_D

Now the external test equipment requests the following InfoType:

— InfoType $03: MessageCount Calibration ID = $08; supported by ECU#1

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Table 98 — Request vehicle information request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request vehicle information request SID	09	SIDRQ
#2	InfoType: MessageCount Calibration ID	03	INFTYP

Table 99 — Request vehicle information response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: MessageCount Calibration ID	03	INFTYP
#3	MessageCount Calibration ID = 8 response messages	08	MC_CALID

Now the external test equipment requests the following InfoType:

— InfoType $04: CALID#1 = [JMB*36761500]; supported by ECU#1;

— InfoType $04: CALID#2 = [JMB*47872611]; supported by ECU#1;

Table 100 — Request vehicle information request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request vehicle information request SID	09	SIDRQ
#2	InfoType: Calibration ID	04	INFTYP

Table 101 — Request vehicle information response message (1)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: Calibration ID	04	INFTYP
#3	MessageCount Calibration ID#1 = 1st response message	01	MC_CALID
#4	Data A: 'J'	4A	DATA_A
#5	Data B: 'M'	4D	DATA_B
#6	Data C: 'B'	42	DATA_C
#7	Data D: '*'	2A	DATA_D

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Table 102 — Request vehicle information response message (2)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: Calibration ID	04	INFTYP
#3	MessageCount Calibration ID#1 = 2nd response message	02	MC_CALID
#4	Data A: '3'	33	DATA_A
#5	Data B: '6'	36	DATA_B
#6	Data C: '7'	37	DATA_C
#7	Data D: '6'	36	DATA_D

Table 103 — Request vehicle information response message (3)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: Calibration ID	04	INFTYP
#3	MessageCount Calibration ID#1 = 3rd response message	03	MC_CALID
#4	Data A: '1'	31	DATA_A
#5	Data B: '5'	35	DATA_B
#6	Data C: '0'	30	DATA_C
#7	Data D: '0'	30	DATA_D

Table 104 — Request vehicle information response message (4)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: Calibration ID	04	INFTYP
#3	MessageCount Calibration ID#1 = 4th response message	04	MC_CALID
#4	Data A: Fill byte	00	DATA_A
#5	Data B: Fill byte	00	DATA_B
#6	Data C: Fill byte	00	DATA_C
#7	Data D: Fill byte	00	DATA_D

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Table 105 — Request vehicle information response message (5)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: Calibration ID	04	INFTYP
#3	MessageCount Calibration ID#2 = 5th response message	05	MC_CALID
#4	Data A: 'J'	4A	DATA_A
#5	Data B: 'M'	4D	DATA_B
#6	Data C: 'B'	42	DATA_C
#7	Data D: '*'	2A	DATA_D

Table 106 — Request vehicle information response message (6)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: Calibration ID	04	INFTYP
#3	MessageCount Calibration ID#2 = 6th response message	06	MC_CALID
#4	Data A: '4'	34	DATA_A
#5	Data B: '7'	37	DATA_B
#6	Data C: '8'	38	DATA_C
#7	Data D: '7'	37	DATA_D

Table 107 — Request vehicle information response message (7)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: Calibration ID	04	INFTYP
#3	MessageCount Calibration ID#2 = 7th response message	07	MC_CALID
#4	Data A: '2'	32	DATA_A
#5	Data B: '6'	36	DATA_B
#6	Data C: '1'	31	DATA_C
#7	Data D: '1'	31	DATA_D

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Table 108 — Request vehicle information response message (8)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: Calibration ID	04	INFTYP
#3	MessageCount Calibration ID#2 = 8th response message	08	MC_CALID
#4	Data A: Fill byte	00	DATA_A
#5	Data B: Fill byte	00	DATA_B
#6	Data C: Fill byte	00	DATA_C
#7	Data D: Fill byte	00	DATA_D

Now the external test equipment requests the following InfoType:

— InfoType $05: MessageCount Calibration Verification Number = $02; supported by ECU#1

Table 109 — Request vehicle information request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information request SID	09	SIDRQ
#2	InfoType: MessageCount Calibration Verification Number	05	INFTYP

Table 110 — Request vehicle information response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: MessageCount Calibration Verification Number	05	INFTYP
#3	MessageCount Calibration Verification Number = 2 response messages	02	MC_CVN

Now the external test equipment requests the following InfoType:

— InfoType $06: CVN#1 = [17 91 BC 82]; supported by ECU#1

— InfoType $06: CVN#2 = [16 E0 62 BE]; supported by ECU#1

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Table 111 — Request vehicle information request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information request SID	09	SIDRQ
#2	InfoType: Calibration Verification Number	06	INFTYP

Table 112 — Request vehicle information response message (1)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: Calibration Verification Number	06	INFTYP
#3	MessageCount Calibration Verification Number = 1st response message	01	MC_CVN
#4	Data A: 17	17	DATA_A
#5	Data B: 91	91	DATA_B
#6	Data C: BC	BC	DATA_C
#7	Data D: 82	82	DATA_D

NOTE Depending on which protocol the vehicle supports the following situations may occur:

— If the vehicle supports ISO 9141-2, the external test equipment may need to repeat the request message multiple times before the ECU(s) send a response message.

— If the vehicle supports SAE J1850, the external test equipment may need to repeat the request message before the ECU(s) send a response message.

— If the vehicle supports ISO 14230-4, the ECU(s) may send a negative response message with response code $22 - conditionsNotCorrect if e.g. the engine is running. After the vehicle conditions have been adjusted to meet this service request, the external test equipment shall repeat the request message and the ECU(s) shall send a positive response message.

Table 113 — Request vehicle information response message (2)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: Calibration Verification Number	06	INFTYP
#3	MessageCount Calibration Verification Number = 2nd response message	02	MC_CVN
#4	Data A: 16	16	DATA_A
#5	Data B: E0	E0	DATA_B
#6	Data C: 62	62	DATA_C
#7	Data D: BE	BE	DATA_D

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Now the external test equipment requests the following InfoType:

— InfoType $07: MessageCount In-use Performance Tracking = $08; supported by ECU#1.

Table 114 — Request vehicle information request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information request SID	09	SIDRQ
#2	InfoType: MessageCount In-use Performance Tracking	07	INFTYP

Table 115 — Request vehicle information response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: MessageCount In-use Performance Tracking	07	INFTYP
#3	MessageCount In-use Performance Tracking = 8 response messages	08	MC_IPT

Now the external test equipment requests the following InfoType:

— InfoType $08: MC_IPT = 8 response messages; supported by ECU#1.

Table 116 — Request vehicle information request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information request SID	09	SIDRQ
#2	InfoType: In-use Performance Tracking	08	INFTYP

Table 117 — Request vehicle information response message (1)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: In-use Performance Tracking	08	INFTYP
#3	MessageCount In-use Performance Tracking = 1st response message	01	MC_IPT
#4	OBDCOND_A: 1024 counts	04	OBDCOND_A
#5	OBDCOND_B: 1024 counts	00	OBDCOND_B
#6	IGNCYCCNTR_A: 3337 counts	0D	IGNCYCCNTR_A
#7	IGNCYCCNTR_B: 3337 counts	09	IGNCYCCNTR_B

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Table 118 — Request vehicle information response message (2)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: In-use Performance Tracking	08	INFTYP
#3	MessageCount In-use Performance Tracking = 2nd response message	02	MC_IPT
#4	CATCOMP1_A: 824 counts	03	CATCOMP1_A
#5	CATCOMP1_B: 824 counts	38	CATCOMP1_B
#6	CATCOND1_A: 945 counts	03	CATCOND1_A
#7	CATCOND1_B: 945 counts	B1	CATCOND1_B

Table 119 — Request vehicle information response message (3)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: In-use Performance Tracking	08	INFTYP
#3	MessageCount In-use Performance Tracking = 3rd response message	03	MC_IPT
#4	CATCOMP2_A: 711 counts	02	CATCOMP2_A
#5	CATCOMP2_B: 711 counts	C7	CATCOMP2_B
#6	CATCOND2_A: 945 counts	03	CATCOND2_A
#7	CATCOND2_B: 945 counts	B1	CATCOND2_B

Table 120 — Request vehicle information response message (4)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: In-use Performance Tracking	08	INFTYP
#3	MessageCount In-use Performance Tracking = 4th response message	04	MC_IPT
#4	O2SCOMP1_A: 737 counts	02	O2SCOMP1_A
#5	O2SCOMP1_B: 737 counts	E1	O2SCOMP1_B
#6	O2SCOND1_A: 924 counts	03	O2SCOND1_A
#7	O2SCOND1_B: 924 counts	9C	O2SCOND1_B

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Table 121 — Request vehicle information response message (5)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: In-use Performance Tracking	08	INFTYP
#3	MessageCount In-use Performance Tracking = 5th response message	05	MC_IPT
#4	O2SCOMP2_A: 724 counts	02	O2SCOMP2_A
#5	O2SCOMP2_B: 724 counts	D4	O2SCOMP2_B
#6	O2SCOND2_A: 833 counts	03	O2SCOND2_A
#7	O2SCOND2_B: 833 counts	41	O2SCOND2_B

Table 122 — Request vehicle information response message (6)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: In-use Performance Tracking	08	INFTYP
#3	MessageCount In-use Performance Tracking = 6th response message	06	MC_IPT
#4	EGRCOMP_A: 997 counts	03	EGRCOMP_A
#5	EGRCOMP_B: 997 counts	E5	EGRCOMP_B
#6	EGRCOND_A: 1010 counts	03	EGRCOND_A
#7	EGRCOND_B: 1010 counts	F2	EGRCOND_B

Table 123 — Request vehicle information response message (7)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: In-use Performance Tracking	08	INFTYP
#3	MessageCount In-use Performance Tracking = 7th response message	07	MC_IPT
#4	AIRCOMP_A: 937 counts	03	AIRCOMP_A
#5	AIRCOMP_B: 937 counts	A9	AIRCOMP_B
#6	AIRCOND_A: 973 counts	03	AIRCOND_A
#7	AIRCOND_B: 973 counts	CD	AIRCOND_B

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Table 124 — Request vehicle information response message (8)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: In-use Performance Tracking	08	INFTYP
#3	MessageCount In-use Performance Tracking = 8th response message	08	MC_IPT
#4	EVAPCOMP_A: 68 counts	00	EVAPCOMP_A
#5	EVAPCOMP_B: 68 counts	44	EVAPCOMP_B
#6	EVAPCOND_A: 97 counts	00	EVAPCOND_A
#7	EVAPCOND_B: 97 counts	61	EVAPCOND_B

7 Diagnostic service definition for ISO 15765-4

7.1 Service $01 — Request current powertrain diagnostic data

7.1.1 Functional description

The purpose of this service is to allow access to current emission-related data values, including analogue inputs and outputs, digital inputs and outputs, and system status information. The request for information includes a parameter identification (PID) value that indicates to the on-board system the specific information requested. PID specifications, scaling information and display formats are included in Annex B.

The ECU(s) shall respond to this message by transmitting the requested data value last determined by the system. All data values returned for sensor readings shall be actual readings, not default or substitute values used by the system because of a fault with that sensor.

Not all PIDs are applicable or supported by all systems. PID $00 is a bit-encoded value that indicates for each ECU which PIDs are supported. PID $00 indicates support for PIDs from $01 to $20. PID $20 indicates support for PIDs $21 through $40, etc. This is the same concept for PIDs/OBD Monitor IDs/TIDs/InfoTypes support in Services $01, $02, $06, $08, $09. PID $00 is required for those ECUs that respond to a corresponding Service $01 request message as specified in Annex A.

IMPORTANT — All emissions-related OBD ECUs which at least support one of the services defined in this document shall support Service $01 and PID $00. Service $01 with PID $00 is defined as the universal "initialization/keep alive/ping" message for all emissions-related OBD ECUs.

The request message may contain up to six (6) PIDs. An external test equipment is not allowed to request a combination of PIDs supported and PIDs, which report data values. The ECU shall support requests for up to six (6) PIDs. The request message may contain the same PID multiple times. The ECU shall treat each PID as a separate parameter and respond with data for each PID (data returned may be different for the same PID) as often as requested.

The order of the PIDs in the response message is not required to match the order in the request message.

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7.1.2 Message data bytes

7.1.2.1 Request current powertrain diagnostic data request message definition (read supported PIDs)

Table 125 — Request current powertrain diagnostic data request message (read supported PIDs)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request current powertrain diagnostic data request SID	M	01	SIDRQ
#2	PID#1 (PIDs supported: see Annex A)	M	xx	PID
#3	PID#2 (PIDs supported: see Annex A)	U[a]	xx	PID
#4	PID#3 (PIDs supported: see Annex A)	U	xx	PID
#5	PID#4 (PIDs supported: see Annex A)	U	xx	PID
#6	PID#5 (PIDs supported: see Annex A)	U	xx	PID
#7	PID#6 (PIDs supported: see Annex A)	U	xx	PID
[a] U = User Optional — PID may be included to avoid multiple PID supported request messages.				

To request PIDs supported range from $C1 - $FF another request message with PID#1 = $C0 and PID#2 = $E0 shall be sent to the vehicle.

7.1.2.2 Request current powertrain diagnostic data response message definition (report supported PIDs)

ECU(s) shall respond to all supported ranges if requested. A range is defined as a block of 32 PIDs (e.g. range #1: PID $01-$20). The ECU shall not respond to unsupported PID ranges unless subsequent ranges have a supported PID(s).

Table 126 — Request current powertrain diagnostic data response message (report supported PIDs)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request current powertrain diagnostic data response SID	M	41	SIDPR
	data record of supported PIDs = [			PIDREC_
#2	1st supported PID	M	xx	PID
#3	Data A: supported PIDs,	M	xx	DATA_A
#4	Data B: supported PIDs,	M	xx	DATA_B
#5	Data C: supported PIDs,	M	xx	DATA_C
#6	Data D: supported PIDs]	M	xx	DATA_D
:	:	:	:	:
	data record of supported PIDs = [			PIDREC_
#n-4	mth supported PID	C1[a]	xx	PID
#n-3	Data A: supported PIDs,	C2[b]	xx	DATA_A
#n-2	Data B: supported PIDs,	C2	xx	DATA_B
#n-1	Data C: supported PIDs,	C2	xx	DATA_C
#n	Data D: supported PIDs]	C2	xx	DATA_D
[a] C1 = Conditional — PID value shall be the same value as included in the request message if supported by the ECU.				
[b] C2 = Conditional — value indicates PIDs supported; range of supported PIDs depends on selected PID value (see C1).				

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The response message shall only include the PID(s) and Data A - D which are supported by the ECU. If the request message includes (a) PID value(s) which are not supported by the ECU, those shall not be included in the response message.

7.1.2.3 Request current powertrain diagnostic data request message definition (read PID values)

Table 127 — Request current powertrain diagnostic data request message

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request current powertrain diagnostic data request SID	M	01	SIDRQ
#2	PID#1 (see Annex B)	M	xx	PID
#3	PID#2 (see Annex B)	U[a]	xx	PID
#4	PID#3 (see) Annex B	U	xx	PID
#5	PID#4 (see Annex B)	U	xx	PID
#6	PID#5 (see) Annex B	U	xx	PID
#7	PID#6 (see) Annex B	U	xx	PID

[a] U = User Optional — the parameter may be present or not.

7.1.2.4 Request current powertrain diagnostic data response message definition (report PID values)

Table 128 — Request current powertrain diagnostic data response message

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request current powertrain diagnostic data response SID	M	41	SIDPR
	data record of 1st supported PID = [			PIDREC_
#2	PID#1	M	xx	PID
#3	data A,	M	xx	DATA_A
#4	data B,	C1[a]	xx	DATA_B
#5	data C,	C1	xx	DATA_C
#6	data D]	C1	xx	DATA_D
:	:	:	:	:
	data record of mth supported PID = [			PIDREC_
#n-4	PID#m	C2[b]	xx	PID
#n-3	data A,	C2	xx	DATA_A
#n-2	data B,	C3[c]	xx	DATA_B
#n-1	data C,	C3	xx	DATA_C
#n	data D]	C3	xx	DATA_D

[a] C1 = Conditional — "data B - D" depend on selected PID value.

[b] C2 = Conditional — parameter is only present if supported by the ECU.

[c] C3 = Conditional — parameters and values for "data B - D" depend on selected PID number and are only included if PID is supported by the ECU.

Not all PIDs which are included in the request message may be supported by all emission-related ECUs, which shall comply with this specification. Therefore, each vehicle ECU, which supports at least one (1) PID, shall send a response message including the PID(s) with data.

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7.1.3 Parameter definition

7.1.3.1 PIDs supported

Annex A specifies the interpretation of the data record of supported PIDs.

7.1.3.2 PID and data byte descriptions

Annex B specifies standardized emission-related parameters.

7.1.4 Message example

The example below shows how the "Request current powertrain diagnostic data" service shall be implemented.

7.1.4.1 Step #1: Request supported PIDs from vehicle

The external test equipment requests supported PIDs ($00, $20, $40, $60, $80, $A0) from the vehicle. Refer to Annex A to interpret the data bytes in the response messages.

ECU(s) shall respond to all supported ranges if requested. A range is defined as a block of 32 PIDs (e.g. range #1: PID $01-$20). The ECU shall not respond to unsupported PID ranges unless subsequent ranges have a supported PID(s).

Table 129 — Request current powertrain diagnostic data request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (All PID values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request current powertrain diagnostic data request SID	01	SIDRQ
#2	PID used to determine PID support for PIDs 01-20	00	PID
#3	PID used to determine PID support for PIDs 21-40	20	PID
#4	PID used to determine PID support for PIDs 41-60	40	PID
#5	PID used to determine PID support for PIDs 61-80	60	PID
#6	PID used to determine PID support for PIDs 81-A0	80	PID
#7	PID used to determine PID support for PIDs A1-C0	A0	PID

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Table 130 — ECU#1 response: Request current powertrain diagnostic data response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (All PID values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request current powertrain diagnostic data response SID	41	SIDPR
#2	PID requested	00	PID
#3	Data byte A, representing support for PIDs 01, 03-08	10111111b = $BF	DATA_A
#4	Data byte B, representing support for PIDs 09, 0B-10	10111111b = $BF	DATA_B
#5	Data byte C, representing support for PIDs 11, 13, 15	10101000b = $A8	DATA_C
#6	Data byte D, representing support for PIDs 19, 1C, 20	10010001b = $91	DATA_D
#7	PID requested	20	PID
#8	Data byte A, representing support for PID 21	10000000b = $80	DATA_A
#9	Data byte B, representing no support for PIDs 29-30	00000000b = $00	DATA_B
#10	Data byte C , representing no support for PIDs 31-38	00000000b = $00	DATA_C
#11	Data byte D, representing no support for PIDs 39-40	00000000b = $00	DATA_D

Table 131 — ECU#2 response: Request current powertrain diagnostic data response message

Message direction:	ECU#2 → External test equipment		
Message Type:	Response		
Data Byte	**Description (All PID values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request current powertrain diagnostic data response SID	41	SIDPR
#2	PID requested	00	PID
#3	Data byte A, representing support for PID 01	10000000b = $80	DATA_A
#4	Data byte B, representing support for PID 0D	00001000b = $08	DATA_B
#5	Data byte C, representing no support for PIDs 11-18	00000000b = $00	DATA_C
#6	Data byte D, representing no support for PIDs 19-20	00000000b = $00	DATA_D

Now the external test equipment creates an internal list of supported PIDs for each ECU. The ECU #1 (ECM) supports the following PIDs: $01, $03 - $09, $0B - $11, $13, $15, $19, $1C, $20, $21.

The ECU #2 (TCM) supports the following PIDs: $01 and $0D.

7.1.4.2 Step #2: Request multiple PIDs from vehicle

Now the external test equipment requests a combination of a maximum of six (6) PIDs in one request message to gain best performance of displaying current data.

- PID $15: Bank 1 - Sensor 2, PID is supported by ECU #1;
- PID $01: Number of emission-related DTCs and MIL status, PID is supported by ECU #1 and #2;
- PID $05: Engine coolant temperature, PID is supported by ECU #1;
- PID $03: Fuel system 1 status, PID is supported by ECU #1;
- PID $0C: Engine speed PID is supported by ECU #1; and
- PID $0D: Vehicle speed PID is supported by ECU #2.

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Table 132 — Request current powertrain diagnostic data request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (All PID values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request current powertrain diagnostic data request SID	01	SIDRQ
#2	PID: Bank 1 - Sensor 2	15	PID(15)
#3	PID: Number of emission-related DTCs and MIL status	01	PID(01)
#4	PID: Engine coolant temperature	05	PID(05)
#5	PID: Fuel system 1 status	03	PID(03)
#6	PID: Engine speed	0C	PID(0C)
#7	PID: Vehicle speed	0D	PID(0D)

Table 133 — ECU#1 response: Request current powertrain diagnostic data response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (All PID values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request current powertrain diagnostic data response SID	41	SIDPR
#2	PID: Engine coolant temperature	05	PID(05)
#3	Data byte A	6E	DATA(A)
#4	PID: Number of emission-related DTCs and MIL status	01	PID(01)
#5	MIL: ON; Number of emission-related DTCs: 03	83	DATA(A)
#6	Misfire -, Fuel system -, Comprehensive monitoring	33	DATA(B)
#7	Catalyst -, Heated catalyst -, ..., monitoring supported	FF	DATA(C)
#8	Catalyst -, Heated catalyst -, ..., monitoring test complete/not complete	63	DATA(D)
#9	PID: Bank 1 - Sensor 2	15	PID(15)
#10	Bank 2 - Sensor 2: 0,8 Volt	A0	DATA(A)
#11	Bank 2 - Sensor 2: 93,7 %	78	DATA(B)
#12	PID: Engine speed	0C	PID(0C)
#13	Data byte A: 667 rpm	0A	DATA(A)
#14	Data byte B: 667 rpm	6B	DATA(B)
#15	PID: Fuel system 1 status	03	PID(03)
#16	Data byte A: Closed loop - using oxygen sensor(s) as feedback for fuel control	02	DATA(A)
#17	Data byte B	00	DATA(B)

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Table 134 — ECU#2 response: Request current powertrain diagnostic data response message

Message direction:	ECU#2 → External test equipment		
Message Type:	Response		
Data Byte	Description (All PID values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request current powertrain diagnostic data response SID	41	SIDPR
#2	PID: Vehicle speed	0D	PID(0D)
#3	Data byte A	23	DATA(A)
#4	PID: Number of emission-related DTCs and MIL status	01	PID(01)
#5	MIL: OFF; Number of emission-related DTCs: 01	01	DATA(A)
#6	Comprehensive monitoring: supported, test complete	44	DATA(B)
#7	Catalyst -, Heated catalyst -, ..., monitoring supported	00	DATA(C)
#8	Catalyst -, Heated catalyst -, ..., monitoring test complete/not complete	00	DATA(D)

7.2 Service $02 — Request powertrain freeze frame data

7.2.1 Functional description

The purpose of this service is to allow access to emission-related data values in a freeze frame. This allows expansion to meet manufacturer-specific requirements not necessarily related to the required freeze frame, and not necessarily containing the same data values as the required freeze frame. The request message includes a parameter identification (PID) value that indicates to the on-board system the specific information requested. PID specifications, scaling information and display formats for the freeze frame are included in Annex B.

The ECU(s) shall respond to this message by transmitting the requested data value stored by the system. All data values returned for sensor readings shall be actual stored readings, not default or substitute values used by the system because of a fault with that sensor.

Service $02 PID $02 indicates the DTC that caused the freeze frame data to be stored. If freeze frame data is not stored in the ECU, the system shall report $00 00 as the DTC.

The frame number byte shall indicate $00 for the freeze frame data. Manufacturers may optionally save additional freeze frames and use this service to obtain that data by specifying the freeze frame number in the request message. If a manufacturer uses these additional freeze frames, they shall be stored under conditions specified by the manufacturer, and contain data specified by the manufacturer.

Not all PIDs are applicable or supported by all systems. PID $00 is a bit-encoded value that indicates for each ECU which PIDs are supported. PID $00 indicates support for PIDs from $01 to $20. PID $20 indicates support for PIDs $21 through $40, etc. This is the same concept for PIDs/TIDs/InfoTypes support in Services $01, $02, $06, $08, $09. PID $00 is required for those ECUs that respond to a corresponding Service $02 request message as specified in Annex A.

The order of the PIDs in the response message is not required to match the order in the request message.

The request message may contain up to three (3) PIDs. An external test equipment shall not request a combination of PIDs supported and PIDs, which report data values. The ECU shall support requests for up to three (3) PIDs. The request message may contain the same PID multiple times. The ECU shall treat each PID as a separate parameter and respond with data for each PID as often as requested.

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7.2.2 Message data bytes

7.2.2.1 Request powertrain freeze frame data request message definition (read supported PIDs)

Table 135 — Request powertrain freeze frame data request message (read supported PIDs)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request powertrain freeze frame data request SID	M	02	SIDRQ
#2	PID#1 (PIDs supported: Annex A)	M	xx	PID
#3	frame #	M	xx	FRNO_
#4	PID#2 (PIDs supported: Annex A)	U[a]	xx	PID
#5	frame #	U/C[b]	xx	FRNO_
#6	PID#3 (PIDs supported: Annex A)	U	xx	PID
#7	frame #	U/C	xx	FRNO_

[a] U = User Optional — PID may be included to reduce multiple PID supported request messages.

[b] C = Conditional — parameter is only included if preceding PID# is included.

To request PIDs supported range from $61 - $FF, multiple request messages with PIDs = $60, $80, $A0, $C0 and $E0 shall be sent to the vehicle.

7.2.2.2 Request powertrain freeze frame data response message definition (report supported PIDs)

ECU(s) must respond to all supported ranges if requested. A range is defined as a block of 32 PIDs (e.g. range #1: PID $01-$20). The ECU shall not respond to unsupported PID ranges unless subsequent ranges have a supported PID(s).

Table 136 — Request powertrain freeze frame data response message (report supported PIDs)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request powertrain freeze frame data response SID	M	42	SIDPR
#2	1st supported PID	M	00	PID
#3	frame #	M	xx	FRNO_
#4	data record of supported PIDs = [			DATAREC
#5	Data A: supported PIDs,	M	xx	DATA_A
#6	Data B: supported PIDs,	M	xx	DATA_B
#7	Data C: supported PIDs,	M	xx	DATA_C
	Data D: supported PIDs]	M	xx	DATA_D
:	:	:	:	:
#n-5	mth supported PID	C1[a]	xx	PID
#n-4	frame #	C1	xx	FRNO_
#n-3	data record of supported PIDs = [			DATAREC
#n-2	Data A: supported PIDs,	C2[b]	xx	DATA_A
#n-1	Data B: supported PIDs,	C2	xx	DATA_B
#n	Data C: supported PIDs,	C2	xx	DATA_C
	Data D: supported PIDs]	C2	xx	DATA_D

[a] C1 = Conditional — PID value shall be the same value as included in the request message if supported by the ECU.

[b] C2 = Conditional — value indicates PIDs supported; range of supported PIDs depends on selected PID value (see C1).

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The response message shall only include the PID(s) and Data A - D which are supported by the ECU. If the request message includes (a) PID value(s) which are not supported by the ECU, those shall not be included in the response message.

7.2.2.3 Request powertrain freeze frame data request message definition (read freeze frame PID values)

Table 137 — Request powertrain freeze frame data request message (read freeze frame PID values)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request powertrain freeze frame data request SID	M	02	SIDRQ
#2	PID#1 (see Annex B)	M	xx	PID
#3	frame #	M	xx	FRNO
#4	PID#2 (see Annex B)	U[a]	xx	PID
#5	frame #	C1[b]	xx	FRNO
#6	PID#3 (see Annex B)	U	xx	PID
#7	frame #	C1	xx	FRNO

[a] U = User Optional — the parameter may be present or not.

[b] C1 = Conditional — parameter is only present if preceding PID# is present.

7.2.2.4 Request powertrain freeze frame data response message definition (report freeze frame PID values)

Table 138 — Request powertrain freeze frame data response message (report freeze frame PID values)

Data Byte	Parameter Name		Cvt	Hex Value	Mnemonic
#1	Request powertrain freeze frame data response SID		M	42	SIDPR
#2	1st supported PID		M	xx	PID_
#3	frame #		M	xx	FRNO_
#4	data record of 1st supported PID = [	data A,	M	xx	DATA_A
#5		data B,	C1[a]	xx	DATA_B
#6		data C,	C1	xx	DATA_C
#7		data D]	C1	xx	DATA_D
:	:		:	:	:
#2	mth supported PID		C2[b]	xx	PID_
#3	frame #		C2	xx	FRNO_
#4	data record of mth supported PID = [	data A,	C3[c]	xx	DATA_A
#5		data B,	C4[d]	xx	DATA_B
#6		data C,	C4	xx	DATA_C
#7		data D]	C4	xx	DATA_D

[a] C1 = Conditional — "data B - D" depend on selected PID.

[b] C2 = Conditional — parameter shall be the same value as included in the request message and only present if supported.

[c] C3 = Conditional — data A shall be included if preceding PID is supported.

[d] C4 = Conditional — parameters and values for "data B - D" depend on selected PID number.

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7.2.3 Parameter definition

7.2.3.1 PIDs supported

Annex A specifies the interpretation of the data record of supported PIDs.

7.2.3.2 PID and data byte descriptions

Annex B specifies standardized emission-related parameters.

7.2.3.3 Frame # description

The frame number identifies the freeze frame, which includes emission-related data values in case an emission-related DTC is detected by the ECU.

7.2.4 Message example

The example below shows how the "Request powertrain freeze frame data" service shall be implemented.

7.2.4.1 Step #1: Request supported powertrain freeze frame PIDs from vehicle

The external test equipment requests all supported powertrain freeze frame PIDs of freeze frame $00 from the vehicle. Refer to the example of Service $01 for how to request supported PIDs.

As a result of the supported PID request, the external test equipment creates an internal list of supported PIDs for each ECU: ECU #1 (ECM) supports the following PIDs: $02 - $09, $0B - $0E, ECU #2 (TCM) does not support any PIDs for this service.

7.2.4.2 Step #2: Request PID $02 "DTC which caused freeze frame to be stored" from vehicle

Case #1: Freeze frame data are stored in ECU #1:

Now the external test equipment requests PID $02 of freeze frame $00 from the vehicle. Since the ECU #2 (TCM) doesn't store a freeze frame data record only, the ECU #1 (ECM) will send a response message. In this example, the freeze frame data are stored based on a DTC P0130 occurrence. The parameter value of PID $02 "DTC that caused required freeze frame data storage" is set to the DTC P0130.

Table 139 — Request powertrain freeze frame data request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request powertrain freeze frame data request SID	02	SIDRQ
#2	PID: DTC that caused required freeze frame data storage	02	PID
#3	Frame #	00	FRNO

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Table 140 — Request powertrain freeze frame data response message

Message direction:	ECU #1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request powertrain freeze frame data response SID	42	SIDRQ
#2	PID: DTC that caused required freeze frame data storage	02	PID
#3	Frame #	00	FRNO
#4	DTC High Byte of P0130	01	DATA_A
#5	DTC Low Byte of P0130	30	DATA_B

NOTE ECU#2 does not store freeze frame data and therefore does not send a response message.

Now the external test equipment requests the parameter value of PID $0C "Engine Speed", PID $05 "Engine coolant temperature", and PID $04 "Load" stored in the freeze frame.

Table 141 — Request powertrain freeze frame data request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request powertrain freeze frame data request SID	02	SIDRQ
#2	PID: Engine Speed	0C	PID
#3	Frame #	00	FRNO
#4	PID: Engine coolant temperature	05	PID
#5	Frame #	00	FRNO
#4	PID: Load	04	PID
#5	Frame #	00	FRNO

Table 142 — Request powertrain freeze frame data response message

Message direction:	ECU #1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request powertrain freeze frame data response SID	42	SIDRQ
#2	PID: Engine Speed	0C	PID
#3	Frame #	00	FRNO
#4	High Byte: Engine Speed: 2080 rpm	20	DATA_A
#5	Low Byte: Engine Speed: 2080 rpm	80	DATA_B
#6	PID: Load	04	PID
#7	Frame #	00	FRNO
#8	Load: 50,2 %	80	DATA_A
#9	PID: Engine coolant temperature	05	PID
#10	Frame #	00	FRNO
#11	Engine coolant temperature: 0 °C	28	DATA_A

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Case #2: No freeze frame data are stored in any ECU:

If no freeze frame data are stored, then the parameter value of PID $02 "DTC that caused required freeze frame data storage" is set to $00 00. If the external test equipment requests a PID excluding $00, $02, $20, $40, etc., the ECU shall not send a response message.

Table 143 — Request powertrain freeze frame data request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request powertrain freeze frame data request SID	02	SIDRQ
#2	PID: Number of emission-related DTCs and MIL status	01	PID
#3	Frame #	00	FRNO
#4	PID: DTC that caused required freeze frame data storage	02	PID
#5	Frame #	00	FRNO

Table 144 — Request powertrain freeze frame data response message

Message direction:	ECU #1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request powertrain freeze frame data response SID	42	SIDRQ
#2	PID: DTC that caused required freeze frame data storage	02	PID
#3	Frame #	00	FRNO
#4	DTC High Byte of P0000 (no freeze frame data stored)	00	DATA_A
#5	DTC Low Byte of P0000 (no freeze frame data stored)	00	DATA_B

7.3 Service $03 — Request emission-related diagnostic trouble codes

7.3.1 Functional description

The purpose of this service is to enable the external test equipment to obtain "confirmed" emission-related DTCs.

Send a Service $03 request for all emission-related DTCs. Each ECU that has DTCs shall respond with one (1) message containing all emission-related DTCs. If an ECU does not have emission-related DTCs, then it shall respond with a message indicating no DTCs are stored by setting the parameter # of DTC to $00.

DTCs are transmitted in two (2) bytes of information for each DTC. The first two (2) bits (high order) of the first (1) byte for each DTC indicate whether the DTC is a Powertrain, Chassis, Body, or Network DTC (refer to ISO 15031-6 for additional interpretation of this structure). The second two (2) bits shall indicate the first digit of the DTC (0 through 3). The second (2) nibble of the first (1) byte and the entire second (2) byte are the next three (3) hexadecimal characters of the actual DTC reported as hexadecimal. A Powertrain DTC transmitted as $0143 shall be displayed as P0143.

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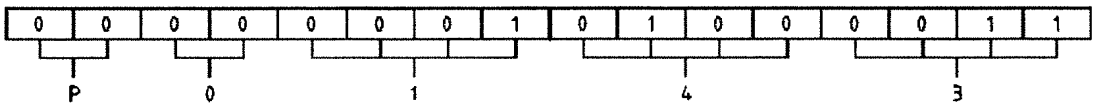


Figure 17 — Diagnostic trouble code encoding example DTC P0143

7.3.2 Message data bytes

7.3.2.1 Request emission-related DTC request message definition

Table 145 — Request emission-related DTC request message

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request emission-related DTC request SID	M	03	SIDRQ

7.3.2.2 Request emission-related DTC response message definition

Table 146 — Request emission-related DTC response message

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request emission-related DTC response SID	M	43	SIDPR
#2	# of DTC = [no emission-related DTCs stored emission-related DTCs stored]	M	xx = [00, 01 - FF	#OFDTC
#3 #4	DTC#1 (High Byte) DTC#1 (Low Byte)	C[a] C	xx xx	DTC1HI DTC1LO
:	:	:	xx	
#n-1 #n	DTC#m (High Byte) DTC#m (Low Byte)	C C	xx xx	DTCmHI DTCmLO
[a] C = Conditional — DTC#1 - DTC#m are only included if # of DTC parameter value ≠ $00.				

7.3.3 Parameter definition

7.3.3.1 # of DTC parameter description

The # of DTC parameter reports the emission-related DTC(s) currently (at the time of the request message processing) stored in the ECU(s).

7.3.4 Message example

The example below shows how the "Request emission-related DTCs" service shall be implemented. The external test equipment requests emission-related DTCs from the vehicle. The ECU#1 (ECM) has six (6) DTCs stored, the ECU #2 (TCM) has one (1) DTC stored, and the ECU #3 (ABS/Traction Control) has no DTC stored.

— ECU #1 (ECM): P0143, P0196, P0234, P02CD, P0357, P0A24

— ECU #2 (TCM): P0443

— ECU #3 (ABS/Traction Control): no emission-related DTC stored

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Table 147 — Request emission-related diagnostic trouble codes request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request emission-related DTCs request SID	03	SIDRQ

Table 148 — Request emission-related diagnostic trouble codes response message

Message direction:	ECU #1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request emission-related DTCs response SID	43	SIDPR
#2	# of DTC (number of emission-related DTCs stored in this ECU)	06	#OFDTC
#3	DTC High Byte of P0143	01	DTC1HI
#4	DTC Low Byte of P0143	43	DTC1LO
#5	DTC High Byte of P0196	01	DTC2HI
#6	DTC Low Byte of P0196	96	DTC2LO
#7	DTC High Byte of P0234	02	DTC3HI
#8	DTC Low Byte of P0234	34	DTC3LO
#9	DTC High Byte of P02CD	02	DTC4HI
#10	DTC Low Byte of P02CD	CD	DTC4LO
#11	DTC High Byte of P0357	03	DTC5HI
#12	DTC Low Byte of P0357	57	DTC5LO
#13	DTC High Byte of P0A24	0A	DTC6HI
#14	DTC Low Byte of P0A24	24	DTC6LO

Table 149 — Request emission-related diagnostic trouble codes response message

Message direction:	ECU #3 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request emission-related DTCs response SID	43	SIDPR
#2	# of DTC (number of emission-related DTCs stored in this ECU)	00	#OFDTC

Table 150 — Request emission-related diagnostic trouble codes response message

Message direction:	ECU #2 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request emission-related DTCs response SID	43	SIDPR
#2	# of DTC (number of emission-related DTCs stored in this ECU)	01	#OFDTC
#3	DTC High Byte of P0443	04	DTC1HI
#4	DTC Low Byte of P0443	43	DTC1LO

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7.4 Service $04 — Clear/reset emission-related diagnostic information

7.4.1 Functional description

The purpose of this service is to provide a means for the external test equipment to command ECUs to clear all emission-related diagnostic information. This includes:

- MIL and number of diagnostic trouble codes (can be read with Service $01, PID $01);
- Clear the I/M (Inspection/Maintenance) readiness bits (Service $01, PID $01 and $41);
- Confirmed diagnostic trouble codes (can be read with Service $03);
- Pending diagnostic trouble codes (can be read with Service $07);
- Diagnostic trouble code for freeze frame data (can be read with Service $02, PID $02);
- Freeze frame data (can be read with Service $02);
- Status of system monitoring tests (can be read with Service $01, PID $01);
- On-board monitoring test results (can be read with Service $06);
- Distance travelled while MIL is activated (can be read with Service $01, PID $21);
- Number of warm-ups since DTCs cleared (can be read with Service $01, PID $30);
- Distance travelled since DTCs cleared (can be read with Service $01, PID $31);
- Time run by the engine while MIL is activated (can be read with Service $01, PID $4D);
- Time since diagnostic trouble codes cleared (can be read with Service $01, PID $4E);
- Reset misfire counts of standardized Test ID $0B to zero (can be read with Service $06).

Other manufacturer-specific "clearing/resetting" actions may also occur in response to this request message. All ECUs shall respond to this request message with ignition ON and with the engine not running.

For safety and/or technical design reasons, ECUs that can not perform this operation under other conditions, such as with the engine running, shall send a negative response message with response code $22 - conditionsNotCorrect.

7.4.2 Message data bytes

7.4.2.1 Clear/reset emission-related diagnostic information request message definition

Table 151 — Clear/reset emission-related diagnostic information request message

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Clear/reset emission-related diagnostic information request SID	M	04	SIDRQ

7.4.2.2 Clear/reset emission-related diagnostic information response message definition

Table 152 — Clear/reset emission-related diagnostic information response message

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Clear/reset emission-related diagnostic information response SID	M	44	SIDPR

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7.4.3 Parameter definition

This service does not support any parameters.

7.4.4 Message example

The example below shows how the "Clear/reset emission-related diagnostic information" service shall be implemented if ignition is ON and with the engine not running.

The external test equipment commands the vehicle to "Clear/reset emission-related diagnostic information".

Table 153 — Clear/reset emission-related diagnostic information request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Clear/reset emission-related diagnostic information request SID	04	SIDRQ

Table 154 — Clear/reset emission-related diagnostic information response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Clear/reset emission-related diagnostic information response SID	44	SIDPR

Table 155 — Clear/reset emission-related diagnostic information response message

Message direction:	ECU#2 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Clear/reset emission-related diagnostic information response SID	44	SIDPR

Table 156 — Negative response message

Message direction:	ECU#3 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Negative Response Service Identifier	7F	SIDNR
#2	Clear/reset emission-related diagnostic information request SID	04	SIDRQ
#3	Negative Response Code: conditionsNotCorrect	22	NR_CNC

7.5 Service $05 — Request oxygen sensor monitoring test results

Service $05 is not supported for CAN. The functionality of Service $05 is implemented in Service $06.

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7.6 Service $06 — Request on-board monitoring test results for specific monitored systems

7.6.1 Functional description

The purpose of this service is to allow access to the results for on-board diagnostic monitoring tests of specific components/systems that are continuously monitored (e.g. misfire monitoring) and non-continuously monitored (e.g. catalyst system).

The request message for test values includes an On-Board Diagnostic Monitor ID (see Annex D) that indicates the information requested. Unit and Scaling information is included in Annex E.

The vehicle manufacturer is responsible for assigning "Manufacturer Defined Test IDs" for different tests of a monitored system. The latest valid test values (results) are to be retained, even over multiple ignition OFF cycles, until replaced by more recent test values (results). Test values (results) are requested by On-Board Diagnostic Monitor ID. Test values (results) are always reported with the Minimum and Maximum Test Limits. The Unit and Scaling ID included in the response message defines the scaling and unit to be used by the external test equipment to display the test values (results), Minimum Test Limit, and Maximum Test Limit information.

If an On-Board Diagnostic Monitor has not been completed at least once since Clear/reset emission-related diagnostic information or battery disconnect, then the parameters Test Value (Results), Minimum Test Limit, and Maximum Test Limit shall be set to zero ($0000) values.

Not all On-Board Diagnostic Monitor IDs are applicable or supported by all systems. On-Board Diagnostic Monitor ID $00 is a bit-encoded value that indicates for each ECU which On-Board Diagnostic Monitor IDs are supported. On-Board Diagnostic Monitor ID $00 indicates support for On-Board Diagnostic Monitor IDs from $01 to $20. On-Board Diagnostic Monitor ID $20 indicates support for On-Board Diagnostic Monitor IDs $21 through $40, etc. This is the same concept for PIDs/TIDs/InfoTypes support in Services $01, $02, $06, $08, and $09. On-Board Diagnostic Monitor ID $00 is required for those ECUs that respond to a corresponding Service $06 request message as specified in Annex A.

The request message including supported On-Board Diagnostic Monitor IDs may contain up to six (6) OBDMIDs. A request message including an On-Board Diagnostic Monitor ID, which reports test values shall only contain one (1) OBDMID. An external test equipment shall not request a combination of OBDMIDs supported and a single OBDMID, which report test values. The ECU shall support requests for up to six (6) supported OBDMIDs and only one (1) OBDMID which reports test values.

A unique method must be utilized for displaying data for monitors that have multiple tests. Many OBD monitors have multiple tests that are done in either a serial or parallel manner. If a monitor uses multiple OBD Monitor ID/Test ID combinations that may not all complete at the same time, the following method shall be used to update the stored test results at the time of monitor completion:

After the monitor completes, update all Monitor ID/Test ID combinations (or "test results") that were utilized by the monitor with appropriate passing or failing results. If a test result (or "Monitor ID/Test ID") was not utilized during this monitoring event, set the Test Values and Minimum and Maximum Test Limits to their initial values ($0000, test not completed). Test results from the previously completed monitoring events shall not be mixed with test results from the current completed monitoring event.

In some cases, test results (or "Monitor ID/Test ID combinations") will be displayed as being incomplete even though the monitor (as indicated by PID $41) was successfully completed and either passed or failed. In other cases, some Test IDs will show passing results while others will show failing results after the monitor (as indicated by PID $41) was successfully completed and failed. Note that OBD-II regulations prohibit a passing monitor from showing any failing test results. If an initial, serial test indicates a failure and a subsequent re-test of the system indicates a passing result, the test that was utilized to make the passing determination should be displayed, while the failing test that was utilized to make the initial determination should be reset to its initial values ($0000, test not completed).

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As an example of a serial monitor, an evaporative system monitor can fail for a large evaporative system leak and never continue to test for small leaks or very small leaks. In this case, the Test ID for the large leak would show a failing result, while the small leak test and the very small leak test would show incomplete. As an example of the parallel monitor, a purge valve flow monitor can pass by having a large rich lambda shift, a large lean lambda shift or a large engine rpm increase. If the purge valve is activated and a large rich lambda shift occurs, the Test ID for the rich lambda shift would show a passing result while the other two Test IDs would show incomplete. Since some Test IDs for a completed monitor will show incomplete, PID $41 must be used to determine monitor completion status.

7.6.2 Message data bytes

7.6.2.1 Request on-board monitoring test results for specific monitored systems request message definition (read supported OBDMIDs)

Table 157 — Request on-board monitoring test results for specific monitored systems request message (read supported OBDMIDs)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request on-board monitoring test results for specific monitored systems request SID	M	06	SIDRQ
#2	On-Board Diagnostic Monitor ID (OBDMIDs supported: Annex A)	M	xx	OBDMID
#3	On-Board Diagnostic Monitor ID (OBDMIDs supported: Annex A)	U[a]	xx	OBDMID
#4	On-Board Diagnostic Monitor ID (OBDMIDs supported: Annex A)	U	xx	OBDMID
#5	On-Board Diagnostic Monitor ID (OBDMIDs supported: Annex A)	U	xx	OBDMID
#6	On-Board Diagnostic Monitor ID (OBDMIDs supported: Annex A)	U	xx	OBDMID
#7	On-Board Diagnostic Monitor ID (OBDMIDs supported: Annex A)	U	xx	OBDMID

[a] U = User Optional — OBDMID may be included to avoid multiple OBDMID supported request messages.

To request OBDMIDs supported range from $C1 - $FF another request message with OBDMID#1 = $C0 and OBDMID#2 = $E0 shall be sent to the vehicle

7.6.2.2 Request on-board monitoring test results for specific monitored systems response message definition (report supported OBDMIDs)

ECU(s) must respond to all supported ranges if requested. A range is defined as a block of 32 OBDMIDs (e.g. range #1: OBDMID $01-$20). The ECU shall not respond to unsupported OBDMID ranges unless subsequent ranges have a supported OBDMID(s).

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Table 158 — Request on-board monitoring test results for specific monitored systems response message (report supported OBDMIDs)

Data Byte	Parameter Name		Cvt	Hex Value	Mnemonic
#1	Request on-board monitoring test results for specific monitored systems response SID		M	46	SIDPR
	data record of supported OBDMID = [				OBDMIDREC
#2		1st supported OBDMID	M	xx	OBDMID
#3		Data A: supported OBDMIDs,	M	xx	DATA_A
#4		Data B: supported OBDMIDs,	M	xx	DATA_B
#5		Data C: supported OBDMIDs,	M	xx	DATA_C
#6		Data D: supported OBDMIDs]	M	xx	DATA_D
:	:		:	:	:
	data record of supported OBDMID = [				OBDMIDREC
#n-4		mth supported OBDMID	C1[a]	xx	OBDMID
#n-3		Data A: supported OBDMIDs,	C2[b]	xx	DATA_A
#n-2		Data B: supported OBDMIDs,	C2	xx	DATA_B
#n-1		Data C: supported OBDMIDs,	C2	xx	DATA_C
#n		Data D: supported OBDMIDs]	C2	xx	DATA_D

[a] C1 = Conditional — OBDMID value shall be the same value as included in the request message if supported by the ECU.

[b] C2 = Conditional — Value indicates OBDMIDs supported; range of supported OBDMIDs depends on selected OBDMID value (see C1).

The response message shall only include the OBDMID(s) and Data A-D, which are supported by the ECU. If the request message includes (a) OBDMID value(s) which are not supported by the ECU, those shall not be included in the response message.

7.6.2.3 Request on-board monitoring test results for specific monitored systems request message definition (read OBDMID test values)

Table 159 — Request on-board monitoring test results for specific monitored systems request message (read OBDMID test values)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request on-board monitoring test results for specific monitored systems request SID	M	06	SIDRQ
#2	On-Board Diagnostic Monitor ID	M	xx	OBDMID

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7.6.2.4 Request on-board monitoring test results for specific monitored systems response message definition (report OBDMID test values)

Table 160 — Request on-board monitoring test results for specific monitored systems response message (report OBDMID test values)

Data Byte	Parameter Name		Cvt	Hex Value	Mnemonic
#1	Request on-board monitoring test results for specific monitored systems response SID		M	46	SIDPR
	data record of supported OBDMID = [				OBDMIDREC
#2		On-Board Diagnostic Monitor ID	M	xx	OBDMID
#3		Std./Manuf. Defined TID#1	M	xx	S/MDTID
#4		Unit And Scaling ID#1	M	xx	UASID
#5		Test Value (High Byte)#1	M	xx	TVHI
#6		Test Value (Low Byte)#1	M	xx	TVLO
#7		Min. Test Limit (High Byte)#1	M	xx	MINTLHI
#8		Min. Test Limit (Low Byte)#1	M	xx	MINTLLO
#9		Max. Test Limit (High Byte)#1	M	xx	MAXTLHI
#10		Max. Test Limit (Low Byte)#1]	M	xx	MAXTLLO
:	:		:	:	:
	data record of supported OBDMID = [				OBDMIDREC
#n-8		On-Board Diagnostic Monitor ID	C1[a]	xx	OBDMID
#n-7			C2[b]	xx	S/MDTID
#n-6		Std./Manuf. Defined TID#m	C2	xx	UASID
#n-5		Unit And Scaling ID#m	C2	xx	TVHI
#n-4		Test Value (High Byte)#m	C2	xx	TVLO
#n-3		Test Value (Low Byte)#m	C2	xx	MINTLHI
#n-2		Min. Test Limit (High Byte)#m	C2	xx	MINTLLO
#n-1		Min. Test Limit (Low Byte)#m	C2	xx	MAXTLHI
#n		Max. Test Limit (High Byte)#m	C2	xx	MAXTLLO
		Max. Test Limit (Low Byte)#m]			

[a] C1 = Conditional — Parameter is only present if more than one (1) Manufacturer Defined TID is supported by the ECU for the requested Monitor ID.

[b] C2 = Conditional — Parameter and value depend on selected Manufacturer Defined TID number and are only included if the Manufacturer Defined TID is supported by the ECU. The value shall be zero ($00) in case the On-Board Diagnostic Monitor has not been completed at least once since Clear/reset emission-related diagnostic information or battery disconnect.

7.6.3 Parameter definition

7.6.3.1 On-Board Diagnostic Monitor IDs supported

The On-Board Diagnostic Monitor IDs supported is the same concept as used for PID support in Services $01 and $02 as specified in Annex A.

7.6.3.2 On-Board Diagnostic Monitor ID description

The On-Board Diagnostic Monitor ID is a one (1) byte parameter and is defined in Annex D. An On-Board Diagnostic Monitor may have more than one (1) monitor test (Test ID).

NOTE The On-Board Diagnostic Monitor ID is similar to the Test ID parameter specified in Service $06 in 6.6.3.1.

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7.6.3.3 Standardized and Manufacturer Defined Test ID description

The Standardized and Manufacturer Defined Test ID is a one (1) byte parameter. For example, the On-Board Diagnostic Monitor "Oxygen Sensor Monitor Bank 1 - Sensor 1" or the On-Board Diagnostic Misfire Monitor may use some of the following Standardized Test IDs.

The table below specifies the range of identifiers.

Table 161 — Standardized Test ID description

Range (Hex)	Description
00	ISO/SAE reserved
01	Rich to lean sensor threshold voltage (constant)
02	Lean to rich sensor threshold voltage (constant)
03	Low sensor voltage for switch time calculation (constant)
04	High sensor voltage for switch time calculation (constant)
05	Rich to lean sensor switch time (calculated)
06	Lean to rich sensor switch time (calculated)
07	Minimum sensor voltage for test cycle (calculated)
08	Maximum sensor voltage for test cycle (calculated)
09	Time between sensor transitions (calculated)
0A	Sensor period (calculated)
0B	EWMA (Exponential Weighted Moving Average) misfire counts for last ten (10) driving cycles (calculated, rounded to an integer value) General EWMA calculation: 0,1 * (current misfire counts) + 0,9 * (previous misfire counts average) Initial value for (previous misfire counts average) = 0 NOTE Internal ECU calculation registers with precision higher than one count must be used and retained to calculate the contents of registers $0B and $0C to prevent rounding errors. If this is not done, these registers will never count back down to zero after misfire stops. The calculations must be done using the high-precision registers, then rounded to the nearest integer value to be output as register $0B and $0C. $High\_Precision\_EWMA\_Misfire\_Counts_{current} = Rounded\ [(0,1) * High\_Precision\_Misfire\_Counts_{current} + (0,9) * High\_Precision\_EWMA\_Misfire\_Counts_{previous}]$ Where: Rounded means rounded to the nearest integer. The high-precision values are never reported, they are only used for internal calculations. This TEST ID shall be reported with OBD Monitor IDs $A2 – $AD (refer to Annex D) and the Scaling ID $24 (refer to Annex E).
0C	Misfire counts for last/current driving cycles (calculated, rounded to an integer value)
0D - 7F	Reserved for future standardization

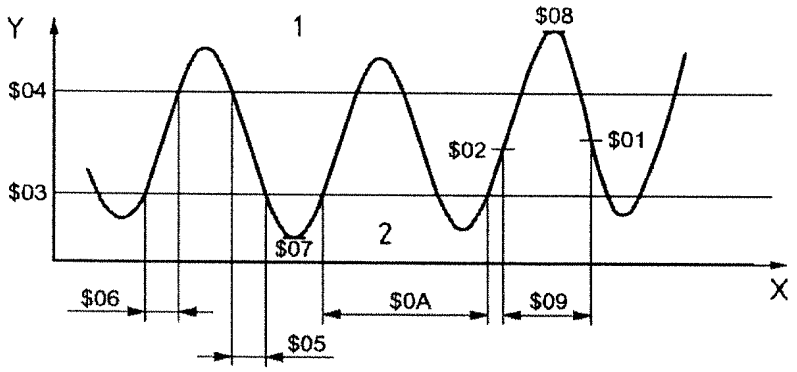
Table 162 — Manufacturer Defined Test ID description

Range (Hex)	Description
80 - FE	Manufacturer Defined Test ID range — This parameter is an identifier for the test performed within the On-Board Diagnostic Monitor.
FF	ISO/SAE reserved

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Results of latest mandated on-board oxygen sensor monitoring tests, see Figure 18.



Key

1 rich

2 lean

Figure 18 — Standardized Test ID value example

7.6.3.4 Example for Use of Standardized Test IDs for Misfire Monitor

OBD regulations may require reporting the number of misfires detected during the current driving cycle (Test ID $OC) and the average number of misfires detected during the last ten (10) driving cycles (Test ID $0B) for each cylinder. Therefore, for a 4-cylinder engine, eight (8) pieces of data must be reported for both Test IDs. The purpose of the misfire data is to help a service technician identify which cylinders are currently misfiring ($0C) and identify which cylinders have been consistently misfiring in the past ten (10) driving cycles ($0B). The actual misfire counts will depend on how the vehicle was driven, how long it was driven, etc. Misfire counts for cylinders shall only be compared relative to each other. If some cylinders have many more misfires than other cylinders, the technician should probably begin his troubleshooting with the cylinders that have the highest misfire counts.

The $0B registers contain the EWMA (Exponential Weighted Moving Average) values for misfire counted during the last ten (10) driving cycles. The EWMA values should only be re-calculated once per driving cycle. This calculation can be done every power-up, or every power-down sequence if the ECU stays alive after the ignition key is turned off. The EWMA value uses the misfire counts collected during the last/current driving cycle. The value of the $0C counters, after the driving cycle ends, is the number of misfires counted during the current/last driving cycle. The software shall take the contents of the $0B register (this is the previous average) multiply by 0,9 and add the contents of the $0C register (this is the current counts) multiplied by 0,1. This becomes the new EWMA value.

The internal ECU calculation registers with precision higher than one count shall be used and retained to calculate the contents of registers $0B and $0C to prevent rounding errors. If this is not done, these registers will never count back down to zero after misfire stops. The calculations shall be done using the high-precision registers, then rounded to the nearest integer value to be output as register $0B and $0C. The last row of Table 163 shows the high-precision internal calculation.

The Test ID $0C counters shall count misfires for each cylinder and save them in Keep Alive or Non-Volatile Memory. They should update continuously, in 200 or 1000 revolution increments, as a minimum. When the engine starts, the $0C misfire counters shall be reset to zero. Prior to engine start-up, the last value from the previous driving cycle shall be retained and displayed until the engine starts so that a service technician can see how many misfires occurred the last time the vehicle was driven.

If a vehicle has constant misfire in one or more cylinders, the service technician can watch the Test ID $0C counters count-up as he drives the vehicle, up to a maximum of 65,535 misfires. If the technician is driving and watching the $0C counters, he would be seeing misfire counts for the "current" driving cycle. If he turns off the ignition key, he has just ended the current driving cycle. If he then turns the key back on, but does not start the engine, the $0C counters will contain the number of misfires that occurred during the "last" driving cycle. If

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the technician now starts the engine, the $0C counters will be reset to zero and the software starts counting misfires all over again.

There are no minimum or maximum misfire monitor threshold limits for misfire counts. Test IDs $0B and $0C just accumulate the number of misfires that occurred. These counts should accumulate with or without a misfire DTC. If there was a little misfire, but not enough to store a DTC, Test ID $0B and $0C values for each cylinder should still show the number of misfires that occurred. The minimum test limit value should be 0; the maximum test limit value should be 65,535 so there will never be a "fail" result.

For this example, the vehicle PCM or ECM does not stay alive after shutdown so EWMA values are updated every power-up:

Table 163 — Misfire Test ID $0B and $0C example

Misfire counts	Cyl #1 Counts	Cyl #1 EWMA	Cyl #2 Counts	Cyl #2 EWMA	Cyl#3 Counts	Cyl#3 EWMA	Cyl#4 Counts	Cyl#4 EWMA
Monitor ID / Test ID	A2 / 0C	A2 / 0B	A3 / 0C	A3 / 0B	A4 / 0C	A4 / 0B	A5 / 0C	A5 / 0C
key on, drive cycle 1	0	0	0	0	0	0	0	0
start engine	0	0	0	0	0	0	0	0
drive with misfire	200	0	1	0	500	0	9	0
key off	200	0	1	0	500	0	9	0
key on, drive cycle 2	200	20	1	0	500	50	9	1
start engine	0	20	0	0	0	50	0	1
drive with misfire	1 000	20	4	0	3 000	50	12	1
key off	1 000	20	4	0	3 000	50	12	1
key on, drive cycle 3	1 000	118	4	0	3 000	345	12	2
start engine	0	118	0	0	0	345	0	2
drive with misfire	1 000	118	4	0	3 000	345	12	2
key off	1 000	118	4	0	3 000	345	12	2
key on, drive cycle 4	1 000	206	4	0	3 000	611	12	3
start engine	0	206	0	0	0	611	0	3
drive with misfire	1 000	206	4	0	3 000	611	12	3
key off	1 000	206	4	0	3 000	611	12	3
key on, drive cycle 5	1 000	286	4	0	3 000	849	12	4
start engine	0	286	0	0	0	849	0	4
drive with misfire	1 000	286	4	0	3 000	849	12	4
key off	1 000	285	4	0	3 000	849	12	4
key on, drive cycle 6	1 000	357	4	0	3 000	1 065	12	5
start engine	0	357	0	0	0	1 065	0	5
drive with misfire	1 000	357	4	0	3 000	1 065	12	5
key off	1 000	357	4	0	3 000	1 065	12	5
key on, drive cycle 12	1 000	692	4	0	3 000	2 074	12	8
start engine	0	692	0	0	0	2 074	0	8
drive with misfire	1 000	692	4	0	3 000	2 074	12	8
key off	1 000	692 (692,456)	4	0 (0,444)	3 000	2 074 (2 074,259)	12	8 (8,130)

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7.6.3.5 Unit and Scaling ID definition

The Unit and Scaling ID is a one (1) byte identifier to reference the scaling and unit to be used by the external test equipment to calculate and display the test values (results), Minimum Test Limit, and the Maximum Test Limit for the Standardized and Manufacturer Defined Test ID requested. All standardized Unit And Scaling IDs are specified in "Annex E" of this part of ISO 15031.

7.6.3.6 Test Value (result) description

The Test Value represents the test result and is defined in the table below.

Table 164 — Test Value description

Parameter name	# of bytes	Description
Test Value	2 (High and Low Byte)	Test Value (Result) — This value shall be calculated and displayed by the external test equipment based on the Unit and Scaling ID included in the response message. The Test Value shall be within the Minimum and Maximum Test Limit to indicate a "Pass" result.

7.6.3.7 Minimum Test Limit description

The Minimum Test Limit parameter is defined in Table 165.

Table 165 — Minimum Test Limit description

Parameter name	# of bytes	Description
Minimum Test Limit	2 (High and Low Byte)	The Minimum Test Limit shall be calculated and displayed by the external test equipment based on the Unit and Scaling ID included in the response message. The Unit and Scaling IDs are specified in Annex E of this part of ISO 15031. The Minimum Test Limit shall be the minimum value for the monitor identified by the On-Board Diagnostic Monitor ID. For the Standardized Test IDs that are constant values, the Minimum Test Limit shall be the same value as reported for the Test Value. The following conditions apply — if the Test Value is less than the Minimum Test Value results in a "Fail" condition; — if the Test Value equals the Minimum Test Value results in a "Pass" condition; — if the Test Value is greater than the Minimum Test Value results in a "Pass" condition.

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7.6.3.8 Maximum Test Limit description

The Maximum Test Limit parameter is defined in Table 166 below.

Table 166 — Maximum Test Limit description

Parameter name	# of bytes	Description
Maximum Test Limit	2 (High and Low Byte)	The Maximum Test Limit shall be calculated and displayed by the external test equipment based on the Unit and Scaling ID included in the response message. The Unit and Scaling IDs are specified in Annex E of this part of ISO 15031. The Maximum Test Limit shall be the maximum value for the monitor identified by the On-Board Diagnostic Monitor ID. For the Standardized Test IDs, that are constant values, the Maximum Test Limit shall be the same value as reported for the Test Value. The following conditions apply — if the Test Value is less than the Maximum Test Value results in a "Pass" condition; — if the Test Value equals the Maximum Test Value results in a "Pass" condition; — if the Test Value is greater than the Maximum Test Value results in a "Fail" condition.

7.6.4 Message example

The example below shows how the "Request on-board monitoring test results for specific monitored systems" service shall be implemented.

7.6.4.1 Step #1: Request on-board monitoring test results for specific monitored systems (request for supported OBDMIDs)

The external test equipment requests all supported OBDMIDs from the vehicle. Refer to the example of Service $01 how to request supported PIDs (same concept is used for supported OBDMIDs).

As a result of the supported OBDMID request, the external test equipment creates an internal list of supported OBDMIDs for each ECU: The ECU #1 (ECM) supports OBDMIDs $01, $05, $10, and $21. The ECU #2 (TCM) does not support any OBDMIDs.

7.6.4.2 Step #2: Request current powertrain diagnostic data (Service $01, PID $01)

Prior to requesting OBD Monitor test results, the external test equipment shall evaluate if the monitor is complete. The status of the monitor is included in the response message of Service $01, PID $01 data byte B-D (see Annex B).

7.6.4.3 Step #3: Request on-board monitoring test results for specific monitored systems

The external test equipment sends a "Request on-board monitoring test results for specific monitored systems" message with one supported OBDMID in the request message to the vehicle. In this example, the request message includes the following OBDMID:

— request message: OBDMID $01 - Oxygen Sensor Monitor Bank 1 - Sensor 1

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Table 167 — Request oxygen sensor monitoring test results request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request on-board monitoring test results for specific monitored systems request SID	06	SIDRQ
#2	OBDMID: 01 - Oxygen Sensor Monitor Bank 1 - Sensor 1	01	OBDMID

Table 168 — Request oxygen sensor monitoring test results response message

Message direction:	ECU #1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request on-board monitoring test results for specific monitored systems response SID	46	SIDPRQ
#2	OBDMID: 01 - Oxygen Sensor Monitor Bank 1 - Sensor 1	01	OBDMID
#3	Standardized Test ID: 01 - Rich to lean sensor threshold voltage (constant)	01	STID
#4	Unit And Scaling ID: Voltage	0A	UASID
#5	Test Value High Byte:	0B	TESTVAL
#6	Test Value Low Byte: 0,365 V	B0	TESTVAL
#7	Minimum Test Limit High Byte:	0B	MINLIMIT
#8	Minimum Test Limit Low Byte: 0,365 V	B0	MINLIMIT
#9	Maximum Test Limit High Byte:	0B	MAXLIMIT
#10	Maximum Test Limit Low Byte: 0,365 V	B0	MAXLIMIT
#11	OBDMID: 01 - Oxygen Sensor Monitor Bank 1 - Sensor 1	01	OBDMID
#12	Standardized Test ID: 05 - Rich to lean sensor switch time (calculated)	05	STID
#13	Unit And Scaling ID: Time	10	UASID
#14	Test Value High Byte	00	TESTVAL
#15	Test Value Low Byte: 0,072 s (0 min, 0 s)	48	TESTVAL
#16	Minimum Test Limit High Byte	00	MINLIMIT
#17	Minimum Test Limit Low Byte: 0,000 s (0 min, 0 s)	00	MINLIMIT
#18	Maximum Test Limit High Byte	00	MAXLIMIT
#19	Maximum Test Limit Low Byte: 0,100 s (0 min, 0 s)	64	MAXLIMIT
#20	OBDMID: 01 - Oxygen Sensor Monitor Bank 1 - Sensor 1	01	OBDMID
#21	Manufacturer Defined Test ID: 133 (The name of this Test ID shall be documented in the vehicle Service Information.)	85	MDTID
#22	Unit And Scaling ID: Counts	24	UASID
#23	Test Value High Byte	00	TESTVAL
#24	Test Value Low Byte: 150 counts	96	TESTVAL
#25	Minimum Test Limit High Byte	00	MINLIMIT
#26	Minimum Test Limit Low Byte: 75 counts	4B	MINLIMIT
#27	Maximum Test Limit High Byte	FF	MAXLIMIT
#28	Maximum Test Limit Low Byte: 65535 counts	FF	MAXLIMIT

NOTE ECU#2 does not support any Test IDs and therefore does not send a response message.

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7.6.4.4 Request on-board monitoring test results for specific monitored systems

In this example, the requested monitor has not been completed once. The request message includes the following OBDMID: request message: OBDMID $21 - Catalyst Monitor Bank 1.

Table 169 — Request Catalyst Monitor Bank 1 monitoring test results request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request on-board monitoring test results for specific monitored systems request SID	06	SIDRQ
#2	OBDMID: 21 - Catalyst Monitor Bank 1	21	OBDMID

Table 170 — Request Catalyst Monitor Bank 1 monitoring test results response message

Message direction:	ECU #1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request on-board monitoring test results for specific monitored systems response SID	46	SIDPRQ
#2	OBDMID: 21 - Catalyst Monitor Bank 1	21	OBDMID
#3	Manufacturer Defined Test ID: 135	87	MDTID
#4	Unit And Scaling ID: Percent	2E	UASID
#5	Test Value High Byte: Monitor not completed at least once since erasure	00	TESTVAL
#6	Test Value Low Byte: 0,00 %	00	TESTVAL
#7	Minimum Test Limit High Byte	00	MINLIMIT
#8	Minimum Test Limit Low Byte: 0,00 %	00	MINLIMIT
#9	Maximum Test Limit High Byte	00	MAXLIMIT
#10	Maximum Test Limit Low Byte: 0,00%	00	MAXLIMIT

NOTE ECU#2 does not support any Test IDs and therefore does not send a response message.

7.7 Service $07 — Request emission-related diagnostic trouble codes detected during current or last completed driving cycle

7.7.1 Functional description

The purpose of this service is to enable the external test equipment to obtain "pending" diagnostic trouble codes detected during current or last completed driving cycle for emission-related components/systems. Service $07 is required for all DTCs and is independent of Service $03. The intended use of this data is to assist the service technician after a vehicle repair, and after clearing diagnostic information, by reporting test results after a single driving cycle. If the test failed during the driving cycle, the DTC associated with that test shall be reported. Test results reported by this service do not necessarily indicate a faulty component/system. If test results indicate a failure after additional driving, then the MIL will be illuminated and a DTC will be set and reported with Service $03, indicating a faulty component/system. This service can always be used to request the results of the latest test, independent of the setting of a DTC.

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Test results for these components/systems shall be reported in the same format as the DTCs in Service $03 - refer to the functional description for Service $03.

7.7.2 Message data bytes

7.7.2.1 Request emission-related diagnostic trouble codes detected during current or last completed driving cycle request message definition

Table 171 — Request emission-related diagnostic trouble codes detected during current or last completed driving cycle request message

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request emission-related diagnostic trouble codes detected during current or last completed driving cycle request SID	M	07	SIDRQ

7.7.2.2 Request emission-related diagnostic trouble codes detected during current or last completed driving cycle response message definition

Table 172 — Request emission-related diagnostic trouble codes detected during current or last completed driving cycle response message

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request emission-related diagnostic trouble codes detected during current or last completed driving cycle response SID	M	47	SIDPR
#2	# of DTC = [no emission-related DTCs # of emission-related DTCs]	M	 00 01 - FF	#OFDTC
#3 #4	DTC#1 (High Byte) DTC#1 (Low Byte)	C[a] C	xx xx	DTC1HI DTC1LO
:	:	:	xx	
#n-1 #n	DTC#m (High Byte) DTC#m (Low Byte)	C C	xx xx	DTCmHI DTCmLO

[a] C = Conditional — DTC#1 - DTC#m are only included if # of DTC parameter value ≠ $00.

7.7.3 Parameter definition

This service does not support any parameters.

7.7.4 Message example

Refer to message example of Service $03.

7.8 Service $08 — Request control of on-board system, test or component

7.8.1 Functional description

The purpose of this service is to enable the external test equipment to control the operation of an on-board system, test or component.

The data bytes will be specified, if necessary, for each Test ID in Annex F, and will be unique for each Test ID.

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Possible uses for these data bytes in the request message are

— Turn on-board system/test/component ON;

— Turn on-board system/test/component OFF; and

— Cycle on-board system/test/component for 'n' seconds.

Possible uses for these data bytes in the response message are

— Report system status; and

— Report test results.

Not all TIDs are applicable or supported by all systems. TID $00 is a bit-encoded value that indicates for each ECU which TIDs are supported. TID $00 indicates support for TIDs from $01 to $20. TID $20 indicates support for TIDs $21 through $40, etc. This is the same concept for PIDs/TIDs/InfoTypes support in Services $01, $02, $06, $08, $09. TID $00 is required for those ECUs that respond to a corresponding Service $08 request message as specified in Annex A.

The order of the TIDs in the response message is not required to match the order in the request message.

The request message including supported Test IDs may contain up to six (6) Test IDs. A request message including a Test ID with optional data shall only contain one (1) Test ID. An external test equipment is not allowed to request a combination of Test IDs supported and a single Test ID with optional data. The ECU shall support requests for up to six (6) supported Test IDs and only one (1) Test ID with optional data.

7.8.2 Message data bytes

7.8.2.1 Request control of on-board device request message definition (read supported TIDs)

Table 173 — Request control of on-board device request message (read supported TIDs)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request control of on-board device request SID	M	08	SIDRQ
#2	TID#1 (Test IDs supported: Annex A)	M	xx	TID
#3	TID#2 (Test IDs supported: Annex A)	U	xx	TID
#4	TID#3 (Test IDs supported: Annex A)	U	xx	TID
#5	TID#4 (Test IDs supported: Annex A)	U	xx	TID
#6	TID#5 (Test IDs supported: Annex A)	U	xx	TID
#7	TID#6 (Test IDs supported: Annex A)	U	xx	TID
U = User Optional — TID may be included to avoid multiple TID supported request messages				

To request TIDs supported range from $C1 - $FF, another request message with TID#1 = $C0 and TID#2 = $E0 shall be sent to the vehicle.

7.8.2.2 Request control of on-board device response message definition (report supported TIDs)

ECU(s) must respond to all supported ranges if requested. A range is defined as a block of 32 TIDs (e.g. range #1: TID $01-$20). The ECU shall not respond to unsupported TID ranges unless subsequent ranges have a supported TID(s).

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Table 174 — Request control of on-board device response message (report supported TIDs)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request control of on-board device response message SID	M	48	SIDPR
#2	data record of supported TIDs = [1st supported TID	M	xx	TIDREC_TID
#3	Data A: supported TIDs,	M	xx	DATA_A
#4	Data B: supported TIDs,	M	xx	DATA_B
#5	Data C: supported TIDs,	M	xx	DATA_C
#6	Data D: supported TIDs]	M	xx	DATA_D
:	:	:	:	:
#n-4	data record of supported TIDs = [mth supported TID	C1[a]	xx	TIDREC_TID
#n-3	Data A: supported TIDs,	C2[b]	xx	DATA_A
#n-2	Data B: supported TIDs,	C2	xx	DATA_B
#n-1	Data C: supported TIDs,	C2	xx	DATA_C
#n	Data D: supported TIDs]	C2	xx	DATA_D

[a] C1 = Conditional — TID value shall be the same value as included in the request message if supported by the ECU.

[b] C2 = Conditional — Value indicates TIDs supported; range of supported TIDs depends on selected TID value (see C1).

The response message shall only include the TID(s) and Data A - D which are supported by the ECU. If the request message includes (a) TID value(s) which are not supported by the ECU, those shall not be included in the response message.

7.8.2.3 Request control of on-board system request message definition (read TID values)

Table 175 — Request control of on-board device request message (read TID values)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request control of on-board device request SID	M	08	SIDRQ
#2	data record of Test ID = [Test ID (request Test ID values)	M/C1[a]	xx	TIDREC_TID
#3	Data A,	C2[b]	xx	DATA_A
#4	Data B,	C2	xx	DATA_B
#5	Data C,	C2	xx	DATA_C
#6	Data D,	C2	xx	DATA_D
#7	Data E]	C2	xx	DATA_E

[a] C1 = Conditional — Test ID value shall be one of the supported Test IDs of previous response message.

[b] C2 = Conditional — Presence and values of Data A - E parameter depend on Test ID.

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7.8.2.4 Request control of on-board device response message definition (report TID values)

Table 176 — Request control of on-board device response message (report TID values)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request control of on-board device response SID	M	48	SIDPR
	data record of Test ID = [			TIDREC
#2	Test ID (report Test ID values)	M/C1[a]	xx	TID
#3	Data A,	C2[b]	xx	DATA_A
#4	Data B,	C2	xx	DATA_B
#5	Data C,	C2	xx	DATA_C
#6	Data D,	C2	xx	DATA_D
#7	Data E]	C2	xx	DATA_E

[a] C1 = Conditional — Test ID value shall be the same value as included in the request message.

[b] C2 = Conditional — Presence and values of Data A - E parameter depend on Test ID.

7.8.3 Parameter definition

7.8.3.1 Test IDs supported

Refer to Annex A.

7.8.3.2 Test ID description

Refer to Annex F.

7.8.4 Message example

The example below shows how "Request control of on-board system, test or component" service shall be implemented.

7.8.4.1 Step #1: Request control of on-board system, test or component (request for supported Test IDs)

The external test equipment requests all supported Test IDs from the vehicle. Refer to the example of Service $01 for how to request supported Test IDs (same concept is used for supported TIDs).

As a result of the supported TID request, the external test equipment creates an internal list of supported PIDs for each ECU: The ECU #1 (ECM) supports Test ID $01. The ECU #2 (TCM) does not support any Test IDs and therefore does not send a response message.

7.8.4.2 Step #2: Request control of on-board device (Service $08, Test ID $01)

The external test equipment sends a "Request control of on-board device" message with one (1) supported Test ID $01 to the vehicle.

Table 177 — Request control of on-board device request message

Message direction:	External test equipment → All ECUs
Message Type:	Request

mal)	Byte Value (Hex)	Mnemonic	Data Byte	Description (all values are in he
#1		Request control of on-board device request SID	08	SIDRQ
#2		Test ID: 01 - Evaporative system leak test	01	TID

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Table 178 — Request control of on-board device response message

Message direction:	ECU #1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request control of on-board device response SID	48	SIDPR
#2	Test ID: 01 - Evaporative system leak test	01	TID

In the following example, the conditions of the system are not proper to run the Evaporative system leak test. Therefore, the ECM (ECU #1) responds with a negative response message with response code $22 - conditionsNotCorrect. The TCM (ECU #2) does not respond because it previously reported that it does not support the Evaporative system leak test.

Table 179 — Request control of on-board device request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request control of on-board device request SID	08	SIDRQ
#2	Test ID: 01 - Evaporative system leak test	01	TID

Table 180 — Negative response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Negative Response Service Identifier	7F	SIDNR
#2	Request control of on-board device request SID	08	SIDRQ
#3	Negative Response Code: conditionsNotCorrect	22	NR_CNC

7.9 Service $09 — Request vehicle information

7.9.1 Functional description

The purpose of this service is to enable the external test equipment to request vehicle-specific vehicle information such as Vehicle Identification Number (VIN) and Calibration IDs. Some of this information may be required by regulations and some may be desirable to be reported in a standard format if supported by the vehicle manufacturer. INFOTYPEs are defined in Annex G.

Not all Infotypes are applicable or supported by all systems. Infotype $00 is a bit-encoded value that indicates for each ECU which Infotypes are supported. Infotype $00 indicates support for Infotypes from $01 to $20. Infotype $20 indicates support for Infotypes $21 through $40, etc. This is the same concept for PIDs/TIDs/Infotypes support in Services $01, $02, $06, $08, $09. Infotype $00 is required for those ECUs that respond to a corresponding Service $09 request message as specified in Annex A.

The request message including supported InfoTypes may contain up to six (6) Infotypes. A request message including an InfoType, which reports vehicle information shall only contain one (1) Infotype. An external test equipment shall not request a combination of Infotypes supported and a single Infotype, which reports vehicle

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information. The ECU shall support requests for up to six (6) supported Infotypes and only one (1) Infotype which reports vehicle information.

If INFOTYPE $02 (VIN) is indicated as supported, the ECU shall respond within P2max timing even if the VIN is missing or incomplete. For example, a development ECU may respond with $FF characters for VIN because the VIN has not been programmed.

7.9.2 Message data bytes

7.9.2.1 Request vehicle information request message definition (request supported InfoType)

Table 181 — Request vehicle information request message (request supported InfoType)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request vehicle information request SID	M	09	SIDRQ
#2	InfoType#1 (InfoTypes supported: Annex A)	M	xx	INFTYP
#3	InfoType#2 (InfoTypes supported: Annex A)	U[a]	xx	INFTYP
#4	InfoType#3 (InfoTypes supported: Annex A)	U	xx	INFTYP
#5	InfoType#4 (InfoTypes supported: Annex A)	U	xx	INFTYP
#6	InfoType#5 (InfoTypes supported: Annex A)	U	xx	INFTYP
#7	InfoType#6 (InfoTypes supported: Annex A)	U	xx	INFTYP

[a] U = User Optional — InfoType may be included to avoid multiple InfoType supported request messages.

To request InfoTypes supported range from $C1 - $FF, another request message with InfoType#1 = $C0 and InfoType#2 = $E0 shall be sent to the vehicle.

7.9.2.2 Request vehicle information response message definition (report supported InfoType)

ECU(s) shall respond to all supported ranges if requested. A range is defined as a block of 32 InfoTypes (e.g. range #1: InfoType $01-$20). The ECU shall not respond to unsupported InfoType ranges unless subsequent ranges have a supported InfoType(s).

Table 182 — Request vehicle information response message (report supported InfoType)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request vehicle information response SID	M	49	SIDPR
	data record of supported InfoTypes = [			INFTYPREC
#2	1st supported InfoType	M	xx	INFTYP
#3	Data A: supported InfoTypes,	M	xx	DATA_A
#4	Data B: supported InfoTypes,	M	xx	DATA_B
#5	Data C: supported InfoTypes,	M	xx	DATA_C
#6	Data D: supported InfoTypes]	M	xx	DATA_D
:	:	:	:	:
	data record of supported InfoTypes = [			INFTYPREC
#n-4	mth supported InfoType	C1[a]	xx	INFTYP
#n-3	Data A: supported InfoTypes,	C2[b]	xx	DATA_A
#n-2	Data B: supported InfoTypes,	C2	xx	DATA_B
#n-1	Data C: supported InfoTypes,	C2	xx	DATA_C
#n	Data D: supported InfoTypes]	C2	xx	DATA_D

[a] C1 = Conditional — INFOTYPE value shall be the same value as included in the request message if supported by the ECU.

[b] C2 = Conditional — Value indicates INFOTYPEs supported; range of supported INFOTYPEs depends on selected INFOTYPE value (see C1).

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The response message shall only include the INFOTYPEs and Data A - D, which are supported by the ECU. If the request message includes (an) INFOTYPE value(s), which are not supported by the ECU, those shall not be included in the response message.

7.9.2.3 Request vehicle information request message definition (read InfoType values)

Table 183 — Request vehicle information request message (read InfoType values)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request vehicle information request SID	M	09	SIDRQ
#2	InfoType (read InfoType values)	M	xx	INFTYP

7.9.2.4 Request vehicle information response message definition (report InfoType values)

Table 184 — Request vehicle information response message (report InfoType values)

Data Byte	Parameter Name	Cvt	Hex Value	Mnemonic
#1	Request vehicle information response SID	M	49	SIDPR
	data record of InfoType = [			INFTYPREC
#2	InfoType (report InfoType values)	M/C1[a]	xx	INFTYP
#3	NOfDataItems	M	xx	NODI
#4	data #1,	M	xx	DATA_#1
#5	data #2,	C2[b]	xx	DATA_#2
:	:	C2	xx	:
#m	data #m]	C2	xx	DATA_#m

[a] C1 = Conditional — InfoType value shall be the same value as included in the request message.

[b] C2 = Conditional — Data #1 - #m depend on selected InfoType value.

7.9.3 Parameter definition

7.9.3.1 Vehicle information types supported

Refer to Annex A.

7.9.3.2 Vehicle information type description

Refer to Annex G.

7.9.3.3 Number of data items data byte description

This parameter defines the number of data items included in the response message which are identified and belong to the InfoType reported.

EXAMPLE A request message with the InfoType for CVN (Calibration Verification Number) may cause the ECU to send a response message that contains multiple CVNs. The amount of CVNs is included in the "Number of data items" parameter.

For InfoType $08, In-use Performance Tracking, there are 16 data items specified in Annex G. Therefore, the parameter number of data items shall have a value of 16_{10} in a response message containing InfoType $08.

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7.9.4 Message example

The example below shows how the "Request vehicle information" service shall be implemented.

7.9.4.1 Step #1: Request vehicle information (request supported InfoType) from vehicle

The external test equipment requests all supported InfoTypes (InfoType#1 = $00) from the vehicle. The ECU #1 (ECM) and the ECU #2 (TCM) send a response message with InfoTypes supported information for InfoTypes $01 - $20.

Now the external test equipment creates an internal list of supported InfoTypes for each ECU. The ECU #1 (ECM) supports the following InfoTypes: $02, $04, $06, and $08. The ECU #2 (TCM) supports InfoTypes $04 and $06.

7.9.4.2 Step #2: Request InfoTypes from vehicle

Now the external test equipment requests a combination of three (3) InfoTypes:

- InfoType $02: VIN = [1G1JC5444R7252367] supported by ECU #1;
- InfoType $04: Cal. ID#1 = [JMB*36761500] supported by ECU #1;
- InfoType $04: Cal. ID#2 = [JMB*4787261111] supported by ECU #1;
- InfoType $06: Cal. CVN#1 = [1791BC82] supported by ECU #1;
- InfoType $06: Cal. CVN#2 = [16E062BE] supported by ECU #1;
- InfoType $08: IPT = [04000D09 ... 00440061] supported by ECU #1;
- InfoType $04: Cal. ID = [JMA*431299110000] supported by ECU #2; and
- InfoType $06: Cal. CVN = [98123476] supported by ECU #2.

Table 185 — Request vehicle information request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request vehicle information request SID	09	SIDRQ
#2	InfoType: 02 - VIN (Vehicle Identification Number)	02	INFTYP

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Table 186 — Request vehicle information response message

Message direction:	ECU #1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: 02 - VIN (Vehicle Information Number)	02	INFTYP
#3	Number of data items: 01	01	NODI
#4	1st ASCII character of VIN: '1'	31	VIN
#5	2nd ASCII character of VIN: 'G'	47	VIN
#6	3rd ASCII character of VIN: '1'	31	VIN
#7	4th ASCII character of VIN: 'J'	4A	VIN
#8	5th ASCII character of VIN: 'C'	43	VIN
#9	6th ASCII character of VIN: '5'	35	VIN
#10	7th ASCII character of VIN: '4'	34	VIN
#11	8th ASCII character of VIN: '4'	34	VIN
#12	9th ASCII character of VIN: '4'	34	VIN
#13	10th ASCII character of VIN: 'R'	52	VIN
#14	11th ASCII character of VIN: '7'	37	VIN
#15	12th ASCII character of VIN: '2'	32	VIN
#16	13th ASCII character of VIN: '5'	35	VIN
#17	14th ASCII character of VIN: '2'	32	VIN
#18	15th ASCII character of VIN: '3'	33	VIN
#19	16th ASCII character of VIN: '6'	36	VIN
#20	17th ASCII character of VIN: '7'	37	VIN

Now the external test equipment requests the following InfoType:

— InfoType $04: CALID#1 = [JMB*36761500] and CALID#2 =[JMB*4787261111]; supported by ECU#1.

Table 187 — Request vehicle information request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information request SID	09	SIDRQ
#2	InfoType: Calibration ID	04	INFTYP

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Table 188 — Request vehicle information response message (1st)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: Calibration ID	04	INFTYP
#3	Number of data items: 02	02	NODI
#4	Data A: 'J'	4A	DATA_A
#5	Data B: 'M'	4D	DATA_B
#6	Data C: 'B'	42	DATA_C
#7	Data D: '*'	2A	DATA_D
#8	Data E: '3'	33	DATA_E
#9	Data F: '6'	36	DATA_F
#10	Data G: '7'	37	DATA_G
#11	Data H: '6'	36	DATA_H
#12	Data I: '1'	31	DATA_I
#13	Data J: '5'	35	DATA_J
#14	Data K: '0'	30	DATA_K
#15	Data L: '0'	30	DATA_L
#16	Data M: Fill byte	00	DATA_M
#17	Data N: Fill byte	00	DATA_N
#18	Data O: Fill byte	00	DATA_O
#19	Data P: Fill byte	00	DATA_P
#20	Data A: 'J'	4A	DATA_A
#21	Data B: 'M'	4D	DATA_B
#22	Data C: 'B'	42	DATA_C
#23	Data D: '*'	2A	DATA_D
#24	Data E: '4'	34	DATA_E
#25	Data F: '7'	37	DATA_F
#26	Data G: '8'	38	DATA_G
#27	Data H: '7'	37	DATA_H
#28	Data I: '2'	32	DATA_I
#29	Data J: '6'	36	DATA_J
#30	Data K: '1'	31	DATA_K
#31	Data L: '1'	31	DATA_L
#32	Data M: '1'	31	DATA_M
#33	Data N: '1'	31	DATA_N
#34	Data O: Fill byte	00	DATA_O
#35	Data P: Fill byte	00	DATA_P

NOTE The same response message with different data byte content will be sent by ECU #2 in this example.

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In the following example, the ECUs need more time than $P2_{CAN}$ to calculate the Calibration Verification Number(s). Therefore, both ECUs respond with negative response messages with response code $78 - RequestCorrectlyReceived-ResponsePending as long as the positive response message is not ready in the ECU.

Now the external test equipment requests the following InfoType:

— InfoType $06: CVN#1 = [17 91 BC 82] and CVN#2 = [16 E0 62 BE]; supported by ECU#1; and

— InfoType $06: CVN = [98 12 34 76]; supported by ECU#2.

Table 189 — Request vehicle information request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request vehicle information request SID	09	SIDRQ
#2	InfoType: Calibration Verification Number	06	INFTYP

Table 190 — Negative response message

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Negative Response Service Identifier	7F	SIDNR
#2	Request vehicle information request SID	09	SIDRQ
#3	Negative Response Code: RequestCorrectlyReceived-ResponsePending	78	NR_RCR_RP

Table 191 — Negative response message

Message direction:	ECU#2 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Negative Response Service Identifier	7F	SIDNR
#2	Request vehicle information request SID	09	SIDRQ
#3	Negative Response Code: RequestCorrectlyReceived-ResponsePending	78	NR_RCR_RP

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Table 192 — Request vehicle information response message (1st)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: Calibration Verification Number	06	INFTYP
#3	Number of data items: 02	02	NODI
#4	Data A: 17	17	DATA_A
#5	Data B: 91	91	DATA_B
#6	Data C: BC	BC	DATA_C
#7	Data D: 82	82	DATA_D
#8	Data E: 16	16	DATA_E
#9	Data F: E0	E0	DATA_F
#10	Data G: 62	62	DATA_G
#11	Data H: BE	BE	DATA_H

Table 193 — Request vehicle information response message (1st)

Message direction:	ECU#2 → External test equipment		
Message Type:	Response		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: Calibration Verification Number	06	INFTYP
#3	Number of data items: 01	01	NODI
#4	Data A: 98	98	DATA_A
#5	Data B: 12	12	DATA_B
#6	Data C: 34	34	DATA_C
#7	Data D: 76	76	DATA_D

Now the external test equipment requests the following InfoType:

— InfoType $08: IPT; supported by ECU#1.

Table 194 — Request vehicle information request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	**Description (all values are in hexadecimal)**	**Byte Value (Hex)**	**Mnemonic**
#1	Request vehicle information request SID	09	SIDRQ
#2	InfoType: In-use Performance Tracking	08	INFTYP

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Table 195 — Request vehicle information response message (1)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: In-use Performance Tracking	08	INFTYP
#3	Number of data items: 16	10	NODI
#4	OBDCOND_A: 1024 counts	04	OBDCOND_A
#5	OBDCOND_B: 1024 counts	00	OBDCOND_B
#6	IGNCYCCNTR_A: 3337 counts	0D	IGNCYCCNTR_A
#7	IGNCYCCNTR_B: 3337 counts	09	IGNCYCCNTR_B
#8	CATCOMP1_A: 824 counts	03	CATCOMP1_A
#9	CATCOMP1_B: 824 counts	38	CATCOMP1_B
#10	CATCOND1_A: 945 counts	03	CATCOND1_A
#11	CATCOND1_B: 945 counts	B1	CATCOND1_B
#12	CATCOMP2_A: 711 counts	02	CATCOMP2_A
#13	CATCOMP2_B: 711 counts	C7	CATCOMP2_B
#14	CATCOND2_A: 945 counts	03	CATCOND2_A
#15	CATCOND2_B: 945 counts	B1	CATCOND2_B
#16	O2SCOMP1_A: 737 counts	02	O2SCOMP1_A
#17	O2SCOMP1_B: 737 counts	E1	O2SCOMP1_B
#18	O2SCOND1_A: 924 counts	03	O2SCOND1_A
#19	O2SCOND1_B: 924 counts	9C	O2SCOND1_B
#20	O2SCOMP2_A: 724 counts	02	O2SCOMP2_A
#21	O2SCOMP2_B: 724 counts	D4	O2SCOMP2_B
#22	O2SCOND2_A: 833 counts	03	O2SCOND2_A
#23	O2SCOND2_B: 833 counts	41	O2SCOND2_B
#24	EGRCOMP_A: 997 counts	03	EGRCOMP_A
#25	EGRCOMP_B: 997 counts	E5	EGRCOMP_B
#26	EGRCOND_A: 1010 counts	03	EGRCOND_A
#27	EGRCOND_B: 1010 counts	F2	EGRCOND_B
#28	AIRCOMP_A: 937 counts	03	AIRCOMP_A
#29	AIRCOMP_B: 937 counts	A9	AIRCOMP_B
#30	AIRCOND_A: 973 counts	03	AIRCOND_A
#31	AIRCOND_B: 973 counts	CD	AIRCOND_B
#32	EVAPCOMP_A: 68 counts	00	EVAPCOMP_A
#33	EVAPCOMP_B: 68 counts	44	EVAPCOMP_B
#34	EVAPCOND_A: 97 counts	00	EVAPCOND_A
#35	EVAPCOND_B: 97 counts	61	EVAPCOND_B

Now the external test equipment requests the following InfoType:

— InfoType $0A: ECUNAME; supported by ECU#1; The name of the ECU is: "ECM-Engine Control".

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Table 196 — Request vehicle information request message

Message direction:	External test equipment → All ECUs		
Message Type:	Request		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information request SID	09	SIDRQ
#2	InfoType: ECU's/module's acronym and text name	0A	INFTYP

Table 197 — Request vehicle information response message (1)

Message direction:	ECU#1 → External test equipment		
Message Type:	Response		
Data Byte	Description (all values are in hexadecimal)	Byte Value (Hex)	Mnemonic
#1	Request vehicle information response SID	49	SIDPR
#2	InfoType: ECU's/module's acronym and text name	0A	INFTYP
#3	Number of data items: 01	01	NODI
#4	Data A: 'E'	45	ECUNAME_A
#5	Data B: 'C'	43	ECUNAME_B
#6	Data C: 'M'	4D	ECUNAME_C
#7	Data D: filler byte	00	ECUNAME_D
#8	Data E: '-' delimiter	2D	ECUNAME_E
#9	Data F: 'E'	45	ECUNAME_F
#10	Data G: 'n'	6E	ECUNAME_G
#11	Data H: 'g'	67	ECUNAME_H
#12	Data I: 'i'	69	ECUNAME_I
#13	Data J: 'n'	6E	ECUNAME_J
#14	Data K: 'e'	65	ECUNAME_K
#15	Data L: ' ' (space)	20	ECUNAME_L
#16	Data M: 'C'	43	ECUNAME_M
#17	Data N: 'o'	6F	ECUNAME_N
#18	Data O: 'n'	6E	ECUNAME_O
#19	Data P: 't'	74	ECUNAME_P
#20	Data Q: 'r'	72	ECUNAME_Q
#21	Data R: 'o'	6F	ECUNAME_R
#22	Data S: 'l'	6C	ECUNAME_S
#23	Data T: filler byte	00	ECUNAME_T

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Annex A
(normative)

PID (Parameter ID)/OBDMID (On-Board Monitor ID)/TID (Test ID)/INFOTYPE supported definition

This annex specifies standardized hex values to be used in the request message for Services $01, $02, $05, $06, $08, and $09 to retrieve supported PIDs, OBDMIDs, TIDs, and INFOTYPEs.

Table A.1 — Supported PID/OBDMID/TID/INFOTYPE definition

Supported PID/OBDMID/ TID/INFOTYPE (hex)	Scaling/bit Number of data bytes = 4 Data A - D or B - E: bit evaluation PID/OBDMID/TID/INFOTYPE supported (Hex)			External test equipment SI (Metric) / English display
00	Data A bit 7 Data A bit 6 : Data D bit 0	01 02 : 20	0 = not supported 1 = supported	ISO 15031-4 specifies the behaviour of the external test equipment for how to interpret the data received to identify supported PIDs/OBDMIDs/TIDs/INFOTYPEs for each ECU. The ECU shall not respond to unsupported PID/TID/MID/InfoTypes ranges unless subsequent ranges have a supported PID(s)/MID(s)/TID(s)/InfoType(s).
20	Data A bit 7 Data A bit 6 : Data D bit 0	21 22 : 40	0 = not supported 1 = supported	
40	Data A bit 7 Data A bit 6 : Data D bit 0	41 42 : 60	0 = not supported 1 = supported	
60	Data A bit 7 Data A bit 6 : Data D bit 0	61 62 : 80	0 = not supported 1 = supported	
80	Data A bit 7 Data A bit 6 : Data D bit 0	81 82 : A0	0 = not supported 1 = supported	
A0	Data A bit 7 Data A bit 6 : Data D bit 0	A1 A2 : C0	0 = not supported 1 = supported	
C0	Data A bit 7 Data A bit 6 : Data D bit 0	C1 C2 : E0	0 = not supported 1 = supported	
E0	Data A bit 7 Data A bit 6 : Data D bit 1 Data D bit 0	E1 E2 : FF ISO/SAE reserved (set to 0)	0 = not supported 1 = supported	

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Annex B
(normative)

PIDs (Parameter ID) for Services $01 and $02 scaling and definition

B.1 Nomenclature

This Annex uses the following nomenclature for numbering and units for the U.S., European notation, and External Test Equipment display. Table B.1 includes an example.

Table B.1 — Numbering and units for the U.S. notation, European notation and External Test Equipment display

Annex example	U.S. notation	European notation	External Test Equipment display
4750,75 min^{-1}	4750,75 min^{-1}	4750,75 min^{-1}	4750,75 min^{-1}

B.2 Signals received via distributed networks

In distributed network architectures, certain OBD devices may be hardwired to other ECUs or be independent OBD mechatronic devices, e.g. smart sensor, or through a network from another ECU (both referred to as remote OBD devices). When remote OBD devices are not hardwired to the OBD ECU and the data is *not* received over the data bus from the specific remote OBD device, the following applies:

— The primary OBD ECU shall report Service $01 and Service $02 data parameters as the minimum or maximum value to indicate that the signal has not been received. A PID which includes this invalid data (no signal) shall either be reported with a minimum value ($00 or $0000) or maximum value ($FF or $FFFF), e.g. PID $0D "Vehicle Speed Sensor" = $FF = 255 km/h, PID $2F "Fuel Level Input" = $00 = 0,0 %. The reported value shall be determined by the manufacturer based on system design and network architecture to represent the least likely value to be expected under normal conditions.

— The OBD ECU is required to store a network communication DTC after appropriate filtering, if the ECU detects that any remote OBD signal is missing. It shall set a DTC for "Lost Communication with 'X' Control Module".

The network communication DTCs shall be obtained from ISO 15031-6.

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B.3 PID definitions

Table B.2 — PID $01 definition

PID (hex)	Description	Data byte	Scaling/bit	External test equipment SI (Metric) / English display
01	Monitor status since DTCs cleared			
	The bits in this PID shall report two pieces of information for each monitor: — monitor status since DTCs were last cleared, saved in NVRAM or Keep Alive RAM; and — monitors supported on this vehicle.			
	Number of emission-related DTCs and MIL status	A (bit)	byte 1 of 4	DTC and MIL status:
	# of DTCs stored in this ECU	0-6	hex to decimal	DTC_CNT: xxd
	Malfunction Indicator Lamp (MIL) Status	7	0 = MIL OFF; 1 = MIL ON	MIL: OFF or ON
	The MIL status shall indicate "OFF" during the key-on, engine-off bulb check unless the MIL has also been commanded "ON" for a detected malfunction. The status should reflect whether there is any confirmed DTC(s) stored that are illuminating the MIL. It should not reflect the status of the MIL, which could be on for a function check, flashing I/M readiness or flashing for misfire.			
	Supported tests which are continuous	B (bit)	byte 2 of 4 (Low Nibble)	Support status of continuous monitors:
	Misfire monitoring supported	0	0 = monitor not supported (NO) 1 = monitor supported (YES)	MIS_SUP: NO or YES
	Misfire monitoring shall be supported on both spark-ignition and compression-ignition vehicles if the vehicle utilizes a misfire monitor.			
	Fuel system monitoring supported	1	0 = monitor not supported (NO) 1 = monitor supported (YES)	FUEL_SUP: NO or YES
	Fuel system monitoring shall be supported on vehicles that utilize oxygen sensors for closed loop fuel feedback control, and utilize a fuel system monitor, typically spark-ignition engines.			
	Comprehensive component monitoring supported	2	0 = monitor not supported (NO) 1 = monitor supported (YES)	CCM_SUP: NO or YES
	Comprehensive component monitoring shall be supported on spark-ignition and compression-ignition vehicles that utilize comprehensive component monitoring.			
	ISO/SAE reserved (bit shall be reported as '0')	3		—
	Status of continuous monitoring tests since DTC cleared:	B (bit)	byte 2 of 4 (High Nibble)	Completion status of continuous monitors since DTC cleared:
	Misfire monitoring ready	4	0 = monitor complete, or not applicable (YES) 1 = monitor not complete (NO)	MIS_RDY: YES or NO

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Table B.2 (*continued*)

PID (hex)	Description	Data byte	Scaling/bit	External test equipment SI (Metric) / English display
	Misfire monitoring shall always indicate complete for spark-ignition engines. Misfire monitoring shall indicate complete for compression-ignition engines after the misfire evaluation is complete.			
	Fuel system monitoring ready	5	0 = monitor complete, or not applicable (YES) 1 = monitor not complete (NO)	FUEL_RDY: YES or NO
	Fuel system monitoring shall always indicate complete for both spark-ignition and compression-ignition engines.			
	Comprehensive component monitoring ready	6	0 = monitor complete, or not applicable (YES) 1 = monitor not complete (NO)	CCM_RDY: YES or NO
	Comprehensive component monitoring shall always indicate complete on both spark-ignition and compression-ignition engines. NOTE It can be assumed that by the time any non-continuous monitors are complete, continuous comprehensive component monitoring will also be complete. Bit 6 is allowed to always indicate "complete" on spark-ignition vehicles that support other non-continuous monitors.			
	ISO/SAE reserved (bit shall be reported as "0")	7		—
	Supported tests run at least once per trip	C (bit)	byte 3 of 4	Support status of non-continuous monitors:
	Catalyst monitoring supported	0		CAT_SUP: NO or YES
	Heated catalyst monitoring supported	1		HCAT_SUP: NO or YES
	Evaporative system monitoring supported	2		EVAP_SUP: NO or YES
	Secondary air system monitoring supported	3	0 = monitor not supported (NO)	AIR_SUP: NO or YES
	A/C system refrigerant monitoring supported	4	1 = monitor supported (YES)	ACRF_SUP: NO or YES
	Oxygen sensor monitoring supported	5		O2S_SUP: NO or YES
	Oxygen sensor heater monitoring supported	6		HTR_SUP: NO or YES
	EGR system monitoring supported	7		EGR_SUP: NO or YES
	Status of tests run at least once per trip	D (bit)	byte 4 of 4	Completion status of non-continuous monitors since DTCs cleared:
	Catalyst monitoring ready	0		CAT_RDY: YES or NO
	Heated catalyst monitoring ready	1		HCAT_RDY: YES or NO
	Evaporative system monitoring ready	2		EVAP_RDY: YES or NO
	Secondary air system monitoring ready	3	0 = monitor complete, or not applicable (YES)	AIR_RDY: YES or NO
	A/C system refrigerant monitoring ready	4	1 = monitor not complete (NO)	ACRF_RDY: YES or NO
	Oxygen sensor monitoring ready	5		O2S_RDY: YES or NO
	Oxygen sensor heater monitoring ready	6		HTR_RDY: YES or NO
	EGR system monitoring ready	7		EGR_RDY: YES or NO

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Table B.3 — PID $02 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling	External test equipment SI (Metric) / English display
02	DTC that caused required freeze frame data storage ($0000 indicates no freeze frame data)	A, B	00 00	FF FF	Hexadecimal e.g. P01AB (DTCs defined in ISO 15031-§6)	DTCFRZF: Pxxxx, Cxxxx, Bxxxx, Uxxxx

Table B.4 — PID $03 definition

PID (hex)	Description	Data Byte	Scaling/bit	External test equipment SI (Metric)/English display
03	Fuel system 1 status:	A (bit)	byte 1 of 2	FUELSYS1:
	(Unused bits shall be reported as '0'; no more than one bit at a time can be set to a '1' of that bank.)	0	1 = Open loop - has not yet satisfied conditions to go closed loop	OL
		1	1 = Closed loop - using oxygen sensor(s) as feedback for fuel control	CL
		2	1 = Open loop due to driving conditions (e.g. power enrichment, deceleration enleanment)	OL-Drive
		3	1 = Open loop - due to detected system fault	OL-Fault
		4	1 = Closed loop, but fault with at least one oxygen sensor - may be using single oxygen sensor for fuel control	CL-Fault
		5-7	ISO/SAE reserved (bits shall be reported as '0')	—
	NOTE Fuel systems do not normally refer to injector banks. Fuel systems are intended to represent completely different fuel systems that can independently enter and exit closed-loop fuel. Banks of injectors on a V-engine are generally not independent and share the same closed-loop enablement criteria. If the engine is off and the ignition is on, all bits in Data Byte A and Data Byte B shall be reported as '0'.			
	Fuel system 2 status:	B (bit)	byte 2 of 2	FUELSYS2:
	(Unused bits shall be reported as '0'; no more than one bit at a time can be set to a '1' of that bank.)	0	1 = Open loop - has not yet satisfied conditions to go closed loop	OL
		1	1 = Closed loop - using oxygen sensor(s) as feedback for fuel control	CL
		2	1 = Open loop due to driving conditions (e.g. power enrichment, deceleration enleanment)	OL-Drive
		3	1 = Open loop - due to detected system fault	OL-Fault
		4	1 = Closed loop, but fault with at least one oxygen sensor - may be using single oxygen sensor for fuel control	CL-Fault
		5-7	ISO/SAE reserved (bits shall be reported as '0')	—

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Table B.5 — PID $04 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
04	Calculated LOAD Value	A	0 %	100 %	100/255 %	LOAD_PCT: xxx.x %

The OBD regulations previously defined CLV as

(current airflow / peak airflow @ sea level) * (BARO @ sea level / BARO) * 100 %.

Various manufacturers have implemented this calculation in a variety of ways. The following definition, although a little more restrictive, will standardize and improve the accuracy of the calculation:

LOAD_PCT = [current airflow] / [(peak airflow at WOT@STP as a function of rpm) * (BARO/29,92) * SQRT(298/(AAT+273))]

— Where: STP = Standard Temperature and Pressure = 25 °C, 29,92 in Hg BARO, SQRT = square root;

— WOT = wide open throttle, AAT = Ambient Air Temperature and is in °C

NOTE At engine off and ignition on the LOAD_PCT = 0 %.

Characteristics of LOAD_PCT:

— Reaches 100 % at WOT at any altitude, temperature or rpm for both naturally aspirated and boosted engines, if no spark retard due to knock-control (dependant on load, fuel and temperature). Also, for boosted engines the altitude does not affect the load as long as the turbo could deliver the right amount of air.

— Indicates percent of peak available torque during normal, fault-free conditions.

— Linearly correlated with engine vacuum.

— Often used to schedule power enrichment.

— Compression-ignition engines (diesels) shall support this PID using fuel-flow in place of airflow for the above calculations.

Both spark-ignition and compression-ignition engines shall support PID $04. See PID $43 for an additional definition of engine LOAD.

Table B.6 — PID $05 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
05	Engine Coolant Temperature	A	– 40 °C	+215 °C	1 °C with – 40 °C offset	ECT: xxx °C (xxx °F)
	ECT shall display engine coolant temperature derived from an engine coolant temperature sensor or a cylinder head temperature sensor. Many diesels do not use either sensor and may substitute Engine Oil Temperature instead.					

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Table B.7 — PID $06 definition

PID (hex)	Description	Data byte	Min. value	Max. Value	Scaling/bit	External test equipment SI (Metric) / English display
06	Short Term Fuel Trim - Bank 1 (use if only 1 fuel trim value) Short Term Fuel Trim - Bank 3	A B	–100 % (lean)	+99,22 % (rich)	100/128 % (0 % at 128)	SHRTFT1: xxx.x % SHRTFT3: xxx.x %
	Short Term Fuel Trim Bank 1/3 shall indicate the correction being utilized by the closed-loop fuel algorithm. If the fuel system is in open loop, SHRTFT1/3 shall report 0 % correction. Data B shall only be included in the response to a PID $06 request if PID $1D (Location of Oxygen Sensors) indicates an oxygen sensor is present in Bank 3. The external test equipment can determine length of the response message based on the data content of PID $13 or $1D. In no case shall an ECU send an unsupported data byte A if data byte B is supported. See examples in the description of PID $09.					

Table B.8 — PID $07 definition

PID (hex)	Description	Data byte	Min. value	Max. Value	Scaling/bit	External test equipment SI (Metric) / English display
07	Long Term Fuel Trim – Bank 1 (use if only 1 fuel trim value) Long Term Fuel Trim – Bank 3	A B	–100 % (lean)	+99,22 % (rich)	100/128 % (0 % at 128)	LONGFT1: xxx.x % LONGFT3: xxx.x %
	Fuel trim correction for Bank 1/3 stored in Non-volatile RAM or Keep-alive RAM. LONGFT shall indicate the correction being utilized by the fuel control algorithm at the time the data is requested, in both open-loop and closed-loop fuel control. If no correction is utilized in open-loop fuel, LONGFT shall report 0 % correction. If long-term fuel trim is not utilized at all by the fuel control algorithm, the PID shall not be supported. Data B shall only be included in the response to a PID $07 request if PID $1D (Location of Oxygen Sensors) indicates an oxygen sensor is present in Bank 3. The external test equipment can determine length of the response message based on the data content of PID $13 or $1D. In no case shall an ECU send an unsupported data byte A if data byte B is supported. See examples in the description of PID $09.					

Table B.9 — PID $08 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
08	Short Term Fuel Trim - Bank 2 (use if only 1 fuel trim value) Short Term Fuel Trim - Bank 4	A B	–100 % (lean)	+99,22 % (rich)	100/128 % (0 % at 128)	SHRTFT2: xxx.x % SHRTFT4: xxx.x %
	Short Term Fuel Trim Bank 2/4 shall indicate the correction being utilized by the closed-loop fuel algorithm. If the fuel system is in open-loop, SHRTFT24 shall report 0 % correction. Data B shall only be included in the response to a PID $08 request if PID $1D (Location of Oxygen Sensors) indicates an oxygen sensor is present in Bank 4. The external test equipment can determine length of the response message based on the data content of PID $13 or $1D. In no case shall an ECU send an unsupported data byte A if data byte B is supported. See examples in the description of PID $09.					

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Table B.10 — PID $09 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
09	Long Term Fuel Trim – Bank 2 (use if only 1 fuel trim value)	A	–100 % (lean)	+99,22 % (rich)	100/128 % (0 % at 128)	LONGFT2: xxx.x %
	Long Term Fuel Trim - Bank 4	B				LONGFT4: xxx.x %
	Fuel trim correction for Bank 2/4 stored in Non-volatile RAM or Keep-alive RAM. LONGFT shall indicate the correction being utilized by the fuel control algorithm at the time the data is requested, in both open-loop and closed-loop fuel control. If no correction is utilized in open-loop fuel, LONGFT shall report 0 % correction. If long-term fuel trim is not utilized at all by the fuel control algorithm, the PID shall not be supported. Data B shall only be included in the response to a PID $09 request if PID $1D (Location of Oxygen Sensors) indicates an oxygen sensor is present in Bank 4. The external test equipment can determine length of the response message based on the data content of PID $13 or $1D if data byte B is supported.					

For vehicles with one (1) Engine ECU), the ECU indicates the support of PIDs $06, $07, $13, and many more PIDs. The data of PID $13 is $03 (00000011b). This indicates support of O2S11 and O2S12. Based on this information, only data A of PID $06 Short Term Fuel Trim - Bank 1 and PID $07 Long Term Fuel Trim - Bank 1 shall be reported upon an external test equipment request.

For vehicles with two (2) Engine ECUs), ECU#1 supports O2S11, O2S12, O2S31, and O2S32. The exhaust banks 1 and 3 are located at cylinder bank 1 or 1 and 3. The ECU#1 indicates the support of PIDs $06, $07, $1D, and many more PIDs. The data of PID $1D is $33 (00110011b). This indicates support of O2S11, O2S12, O2S31, and O2S32.

Based on above information the following data bytes shall be reported:

— data A of PID $06 Short Term Fuel Trim - Bank 1;

— data B of PID $06 Short Term Fuel Trim - Bank 3;

— data A of PID $07 Long Term Fuel Trim - Bank 1; and

— data B of PID $07 Long Term Fuel Trim - Bank 3.

ECU#2 supports O2S21, O2S22, O2S41 and O2S42. The exhaust banks 2 and 4 are located at cylinder bank 2 or 2 and 4. The ECU#2 indicates the support of PIDs $08, $09, $1D, and many more PIDs. The data of PID $1D is $33 (11001100b). This indicates support of O2S21, O2S22, O2S41, and O2S42.

Based on above information the following data bytes shall be reported:

— data A of PID $08 Short Term Fuel Trim - Bank 2;

— data B of PID $08 Short Term Fuel Trim - Bank 4;

— data A of PID $09 Long Term Fuel Trim - Bank 2; and

— data B of PID $09 Long Term Fuel Trim - Bank 4.

In no case shall an ECU send an unsupported data byte A if data byte B is supported.

For vehicles with one (1) Engine ECU, the ECU indicates the support of PIDs $06, $07, $08, $09, $1D, and many more PIDs. The data of PID $1D is $0F (00001111b). This indicates support of O2S11, O2S12, O2S21, and O2S22. Based on this information, only data A of PID $06 Short Term Fuel Trim - Bank 1 and PID $07 Long Term Fuel Trim - Bank 1 and data A of PID $08 of Short Term Fuel Trim - Bank 2 and PID $09 Long Term Fuel Trim - Bank 2 shall be reported upon an external test equipment request.

For vehicles with two (2) Engine ECUs and exhaust banks 1 + 2 connected to cylinder bank 1 and exhaust banks 3 + 4 connected to cylinder bank 2, which is the opposite side of cylinder bank 1, ECU#1 supports

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O2S11, O2S12, O2S21, and O2S22. Also PID $06, $07, $08, $09, $1D and many more PIDs are supported. The data of PID $1D is $0F (00001111b).

Based on above information the following data bytes shall be reported:

— data A of PID $06 of Short Term Fuel Trim - Bank 1 and data A of PID $07 of Long Term Fuel Trim - Bank 1;

— data B of PID $06 of Short Term Fuel Trim - Bank 3 and data B of PID $07 of Long Term Fuel Trim - Bank 3 (data B value shall be communicated through network from ECU#2);

— data A of PID $08 of Short Term Fuel Trim - Bank 2 and data A of PID $09 of Long Term Fuel Trim - Bank 2; and

— data B of PID $08 of Short Term Fuel Trim - Bank 4 and data B of PID $09 of Long Term Fuel Trim - Bank 4. (Data A value shall be communicated through network from ECU#2.)

ECU#2 supports O2S31, O2S32, O2S41 and O2S42. Also PIDs $06, $07, $08, $09, $1D and many more PIDs are supported. The data of PID $1D is $F0 (11110000b).

Based on above information the following data bytes shall be reported:

— data A of PID $06 of Short Term Fuel Trim - Bank 1 and data A of PID $07 of Long Term Fuel Trim - Bank 1 (data A value shall be communicated through network from ECU#1);

— data B of PID $06 of Short Term Fuel Trim - Bank 3 and data B of PID $07 of Long Term Fuel Trim - Bank 3;

— data A of PID $08 of Short Term Fuel Trim - Bank 2 and data A of PID $09 of Long Term Fuel Trim - Bank 2 (data A value shall be communicated through network from ECU#1);

— data B of PID $08 of Short Term Fuel Trim - Bank 4 and data B of PID $09 of Long Term Fuel Trim - Bank 4.

Table B.11 — PID $0A definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
0A	Fuel Rail Pressure (gauge)	A	0 kPa (gauge)	765 kPa (gauge)	3 kPa per bit (gauge)	FRP: xxx kPa (xx.x psi)
	FRP shall display fuel rail pressure at the engine when the reading is referenced to atmosphere (gauge pressure). For systems supporting a fuel pressure sensor, one of the following 3 PIDs is required: $0A, $22, or $23. Support for more than one of these PIDs is not allowed.					

Table B.12 — PID $0B definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
0B	Intake Manifold Absolute Pressure	A	0 kPa (absolute)	255 kPa (absolute)	1 kPa per bit (absolute)	MAP: xxxx.x kPa (xxx.x inHg)
	MAP shall display manifold pressure derived from a Manifold Absolute Pressure sensor, if a sensor is utilized. If a vehicle uses both a MAP and MAF sensor, both the MAP and MAF PIDs shall be supported. If PID $4F is not supported for this ECU, or if PID $4F is supported and includes $00 for Intake Manifold Absolute Pressure, the external test equipment shall use the scaling values included in this table for those values. If PID $4F is supported for this ECU, the external test equipment shall calculate scaling and range for this PID as explained in the PID $4F Data D definition.					

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Table B.13 — PID $0C definition

PID (hex)	Description	Data byte	Min. value	Max. Value	Scaling/bit	External test equipment SI (Metric) / English display
0C	Engine RPM	A, B	0 min^{-1}	16383,75 min^{-1}	1/4 rpm per bit	RPM: xxxxx min^{-1}
	Engine RPM shall display revolutions per minute of the engine crankshaft.					

Table B.14 — PID $0D definition

PID (hex)	Description	Data byte	Min. value	Max. Value	Scaling/bit	External test equipment SI (Metric) / English display
0D	Vehicle Speed Sensor	A	0 km/h	255 km/h	1 km/h per bit	VSS: xxx km/h (xxx mph)
	VSS shall display vehicle road speed, if utilized by the control module strategy. Vehicle speed may be derived from a vehicle speed sensor, calculated by the PCM using other speed sensors, or obtained from the vehicle serial data communication bus.					

Table B.15 — PID $0E definition

PID (hex)	Description	Data byte	Min. value	Max. Value	Scaling/bit	External test equipment SI (Metric) / English display
0E	Ignition Timing Advance for #1 Cylinder	A	– 64°	63,5°	1/2° with 0° at 128	SPARKADV: xx.x °
	Ignition timing spark advance for #1 cylinder (not including mechanical advance).					

Table B.16 — PID $0F definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
0F	Intake Air Temperature	A	– 40 °C	+215 °C	1 °C with – 40 °C offset	IAT: xxx °C (xxx °F)
	IAT shall display intake manifold air temperature, if utilized by the control module strategy. IAT may be obtained directly from a sensor, or may be inferred by the control strategy using other sensor inputs.					

Table B.17 — PID $10 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
10	Air Flow Rate from Mass Air Flow Sensor	A, B	0 g/s	655,35 g/s	0,01 g/s (1/100)	MAF: xxxx.xx g/s (xxxx.x lb/min)
	MAF shall display the airflow rate as measured by a vehicle that utilizes a MAF sensor or an equivalent source. If the engine is off and the ignition is on, the actual sensor value reading shall be reported. If the actual sensor reading can not be reported, the MAF value shall be reported as 0,00 g/s. If PID $50 is not supported for this ECU, or if PID $50 is supported and includes $00 for Air Flow Rate from Mass Air Flow Sensor, the external test equipment shall use the scaling values included in this table for those values. If PID $50 is supported for this ECU, the external test equipment shall calculate scaling and range for this PID as explained in the PID $50 Data A definition.					

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Table B.18 — PID $11 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
11	Absolute Throttle Position	A	0 %	100 %	100/255 %	TP: xxx.x %
	Absolute throttle position (not "relative" or "learned" throttle position) shall be displayed as a normalized value, scaled from 0 to 100 %. For example, if a 0 to 5,0 volt sensor is used (uses a 5,0 volt reference voltage), and the closed throttle position is at 1,0 volts, TP shall display (1,0 / 5,0) = 20 % at closed throttle and 50 % at 2,5 volts. Throttle position at idle will usually indicate greater than 0 %, and throttle position at wide open throttle will usually indicate less than 100 %. For systems where the output is proportional to the input voltage, this value is the percent of maximum input reference voltage. For systems where the output is inversely proportional to the input voltage, this value is 100 % minus the percent of maximum input reference voltage. A single throttle plate could have up to three throttle position sensors, A, B and C. There are no provisions for more than one throttle in this part of ISO 15031. This PID shall be used to report the sensors that are on the primary throttle. NOTE See PID $45 for a definition of Relative Throttle Position.					

Table B.19 — PID $12 definition

PID (hex)	Description	Data byte	Scaling/bit	External test equipment SI (Metric)/English display
12	Commanded Secondary Air Status	A (bit)	byte 1 of 1	AIR_STAT:
	(If supported, one, and only one bit at a time can be set to a 1.)	0	1 = upstream of first catalytic converter	AIR_STAT: UPS
		1	1 = downstream of first catalytic converter inlet	AIR_STAT: DNS
		2	1 = atmosphere / off	AIR_STAT: OFF
		3-7	ISO/SAE reserved (Bits shall be reported as '0'.)	—

Table B.20 — PID $13 definition

PID (hex)	Description	Data byte	Scaling/bit	External test equipment SI (Metric) / English display
13	Location of Oxygen Sensors	A (bit)	byte 1 of 1	O2SLOC:
	(Where sensor 1 is closest to the engine. Each bit indicates the presence or absence of an oxygen sensor at the following location.)	0	1 = Bank 1 - Sensor 1 present at that location	O2S11
		1	1 = Bank 1 - Sensor 2 present at that location	O2S12
		2	1 = Bank 1 - Sensor 3 present at that location	O2S13
		3	1 = Bank 1 - Sensor 4 present at that location	O2S14
		4	1 = Bank 2 - Sensor 1 present at that location	O2S21
		5	1 = Bank 2 - Sensor 2 present at that location	O2S22
		6	1 = Bank 2 - Sensor 3 present at that location	O2S23
		7	1 = Bank 2 - Sensor 4 present at that location	O2S24

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PID $13 shall only be supported by a given vehicle if PID $1D is not supported. In no case shall a vehicle support both PIDs.

Table B.21 — PID $14 - $1B definition

PID (hex)	Description Use if PID $13 is supported!	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
14	Bank 1 – Sensor 1		These PIDs shall be used for a conventional, 0 to 1 volt oxygen sensor. Any sensor with a different full scale value shall be normalized to provide nominal full scale at $C8 (200 decimal). Wide-range/linear oxygen sensors shall use PIDs $24 to $2B or PIDs $34 to $3B.			
15	Bank 1 – Sensor 2					
16	Bank 1 – Sensor 3					
17	Bank 1 – Sensor 4					
18	Bank 2 – Sensor 1					
19	Bank 2 – Sensor 2					
1A	Bank 2 – Sensor 3					
1B	Bank 2 – Sensor 4					
	Oxygen Sensor Output Voltage (Bx-Sy)	A	0 V	1,275 V	0,005 V	O2Sxy: x.xxx V
	Short Term Fuel Trim (Bx-Sy) (associated with this sensor $FF if this sensor is not used in the calculation)	B	– 100,00 % (lean)	99,22 % (rich)	100/128 % (0 % at 128)	SHRTFTxy: xxx.x %

The PIDs listed in the table above only apply if PID $13 is used to define the oxygen sensor location.

Table B.22 — PID $14 - $1B definition

PID (hex)	Description Use if PID $1D is supported!	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
14	Bank 1 – Sensor 1		These PIDs shall be used for a conventional, 0 to 1 volt oxygen sensor. Any sensor with a different full scale value shall be normalized to provide nominal full scale at $C8 (200 decimal). Wide-range/linear oxygen sensors shall use PIDs $24 to $2B or PIDs $34 to $3B.			
15	Bank 1 – Sensor 2					
16	Bank 2 – Sensor 1					
17	Bank 2 – Sensor 2					
18	Bank 3 – Sensor 1					
19	Bank 3 – Sensor 2					
1A	Bank 4 – Sensor 1					
1B	Bank 4 – Sensor 2					
	Oxygen Sensor Output Voltage (Bx-Sy)	A	0 V	1,275 V	0,005 V	O2Sxy: x.xxx V
	Short Term Fuel Trim (Bx-Sy) (associated with this sensor $FF if this sensor is not used in the calculation)	B	– 100,00 % (lean)	99,22 % (rich)	100/128 % (0 % at 128)	SHRTFTxy: xxx.x %

The PIDs listed in the table above only apply if PID $1D is used to define the oxygen sensor location.

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Table B.23 — PID $1C definition

PID (hex)	Description	Data byte	Scaling	External test equipment SI (Metric) / English display
1C	OBD requirements to which vehicle is designed	A (hex)	byte 1 of 1 (State Encoded Variable)	OBDSUP:
	OBD II (California ARB)	01		OBD II
	OBD (Federal EPA)	02		OBD
	OBD and OBD II	03		OBD and OBD II
	OBD I	04		OBD I
	Not OBD compliant	05		NO OBD
	EOBD	06		EOBD
	EOBD and OBD II	07		EOBD and OBD II
	EOBD and OBD	08		EOBD and OBD
	EOBD, OBD and OBD II	09		EOBD, OBD and OBD II
	JOBD	0A		JOBD
	JOBD and OBD II	0B		JOBD and OBD II
	JOBD and EOBD	0C		JOBD and EOBD
	JOBD, EOBD, and OBD II	0D		JOBD, EOBD, and OBD II
	Heavy Duty Vehicles (EURO IV) B1	0E		EURO IV B1
	Heavy Duty Vehicles (EURO V) B2	0F		EURO V B2
	Heavy Duty Vehicles (EURO EEC) C (gas engines)	10		EURO C
	Engine Manufacturer Diagnostics (EMD)	11		EMD
	ISO/SAE reserved	12 - FA		—
	ISO/SAE - Not available for assignment	FB - FF		SAE J1939 special meaning

Table B.24 — PID $1D definition

PID (hex)	Description	Data byte	Scaling/bit	External test equipment SI (Metric) / English display
1D	Location of oxygen sensors	A (bit)	byte 1 of 1	O2SLOC:
	(Where sensor 1 is closest to the engine. Each bit indicates the presence or absence of an oxygen sensor at the following location.)	0	1 = Bank 1 - Sensor 1 present at that location	O2S11
		1	1 = Bank 1 - Sensor 2 present at that location	O2S12
		2	1 = Bank 2 - Sensor 1 present at that location	O2S21
		3	1 = Bank 2 - Sensor 2 present at that location	O2S22
		4	1 = Bank 3 - Sensor 1 present at that location	O2S31
		5	1 = Bank 3 - Sensor 2 present at that location	O2S32
		6	1 = Bank 4 - Sensor 1 present at that location	O2S41
		7	1 = Bank 4 - Sensor 2 present at that location	O2S42

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PID $1D shall only be supported by a given vehicle if PID $13 is not supported. In no case shall a vehicle support both PIDs.

Table B.25 — PID $1E definition

PID (hex)	Description	Data byte	Scaling/bit	External test equipment SI (Metric) / English display
1E	Auxiliary Input Status	A (bit)	byte 1 of 1	Auxiliary Input Status
	Power Take Off (PTO) Status	0	0 = PTO not active (OFF); 1 = PTO active (ON).	PTO_STAT: OFF or ON
		1-7	ISO/SAE reserved (Bits shall be reported as '0'.)	—

Table B.26 — PID $1F definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
1F	Time Since Engine Start	A, B	0 sec.	65,535 sec.	1 second per count	RUNTM: xxxxx sec.
	RUNTM shall increment while the engine is running. It shall freeze if the engine stalls. RUNTM shall be reset to zero during every control module power-up and when entering the key-on, engine off position. RUNTM is limited to 65,535 seconds and shall not wrap around to zero.					

Table B.27 — PID $21 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/ bit	External test equipment SI (Metric) / English display
21	Distance Travelled While MIL is Activated	A, B	0 km	65535 km	1 km per count	MIL_DIST: xxxxx km (xxxxx miles)
	Conditions for "Distance travelled" counter: — reset to $0000 when MIL state changes from deactivated to activated by this ECU; — accumulate counts in km if MIL is activated (ON); — do not change value while MIL is not activated (OFF); — reset to $0000 if diagnostic information is cleared either by service $04 or at least 40 warm-up cycles without MIL activated; — do not wrap to $0000 if value is $FFFF.					

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Table B.28 — PID $22 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
22	Fuel Rail Pressure relative to manifold vacuum	A, B	0 kPa	5177,27 kPa	0,079 kPa (5178/65535) per bit unsigned, 1 kPa = 0,1450377 PSI	FRP: xxxx.x kPa (xxx.x PSI)
	FRP shall display fuel rail pressure at the engine when the reading is referenced to manifold vacuum (relative pressure). For systems supporting a fuel pressure sensor, one of the following three PIDs shall be used: $0A, $22, or $23. There shall be no support for more than one of these PIDs.					

Table B.29 — PID $23 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
23	Fuel Rail Pressure	A, B	0 kPa	655350 kPa	10 kPa per bit unsigned, 1 kPa = 0,1450377 PSI	FRP: xxxxxx kPa (xxxxx.x PSI)
	FRP shall display fuel rail pressure at the engine when the reading is referenced to atmosphere (gage pressure). Diesel fuel pressure and gasoline direct injection systems have a higher pressure range than FRP PID $0A. For systems supporting a fuel pressure sensor, one of the following three PIDs shall be used: $0A, $22, or $23. There shall be no support for more than one of these PIDs.					

Table B.30 — PID $24 - $2B definition

PID (hex)	Description Use if PID $13 is supported!	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
24	Bank 1 – Sensor 1 (wide range O2S)		PIDs $24 to $2B shall be used for linear or wide-ratio Oxygen Sensors when equivalence ratio and voltage are displayed. If PID $4F is not supported for this ECU, or if PID $4F is supported and includes $00 for either Equivalence Ratio or Maximum Oxygen Sensor Voltage, the external test equipment shall use the scaling values included in this table for those values. If PID $4F is supported for this ECU, the external test equipment shall calculate scaling and range for these PIDs as explained in the PID $4F definition.			
25	Bank 1 – Sensor 2 (wide range O2S)					
26	Bank 1 – Sensor 3 (wide range O2S)					
27	Bank 1 – Sensor 4 (wide range O2S)					
28	Bank 2 – Sensor 1 (wide range O2S)					
29	Bank 2 – Sensor 2 (wide range O2S)					
2A	Bank 2 – Sensor 3 (wide range O2S)					
2B	Bank 2 – Sensor 4 (wide range O2S)					
	Equivalence Ratio (lambda) (Bx-Sy)	A, B	0	1,999	0,0000305 (2/65535)	EQ_RATxy: xxx.xxx
	Oxygen Sensor Voltage (Bx-Sy)	C, D	0 V	7,999 V	0,000122 V (8/65535)	O2Sxy: xxx.xxx V

The PIDs listed in the table above only apply if PID $13 is used to define the oxygen sensor location.

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Table B.31 — PID $24 - $2B definition

PID (hex)	Description Use if PID $1D is supported!	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
24	Bank 1 - Sensor 1 (wide range O2S)		PIDs $24 to $2B shall be used for linear or wide-ratio Oxygen Sensors when equivalence ratio and voltage are displayed. If PID $4F is not supported for this ECU, or if PID $4F is supported and includes $00 for either Equivalence Ratio or Maximum Oxygen Sensor Voltage, the external test equipment shall use the scaling values included in this table for those values. If PID $4F is supported for this ECU, the external test equipment shall calculate scaling and range for these PIDs as explained in the PID $4F definition.			
25	Bank 1 - Sensor 2 (wide range O2S)					
26	Bank 2 - Sensor 1 (wide range O2S)					
27	Bank 2 - Sensor 2 (wide range O2S)					
28	Bank 3 - Sensor 1 (wide range O2S)					
29	Bank 3 - Sensor 2 (wide range O2S)					
2A	Bank 4 - Sensor 1 (wide range O2S)					
2B	Bank 4 - Sensor 2 (wide range O2S)					
	Equivalence Ratio (lambda) (Bx-Sy)	A, B	0	1,999	0,0000305 (2/65535)	EQ_RATxy: xxx.xxx
	Oxygen Sensor Voltage (Bx-Sy)	C, D	0 V	7,999 V	0,000122 V (8/65535)	O2Sxy: xxx.xxx V

The PIDs listed in the table above only apply if PID $1D is used to define the oxygen sensor location.

Table B.32 — PID $2C definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
2C	Commanded EGR	A	0 % (no flow)	100 % (max. flow)	100/255 %	EGR_PCT: xxx.x %
	Commanded EGR displayed as a percent. EGR_PCT shall be normalized to the maximum EGR commanded output control parameter. EGR systems use a variety of methods to control the amount of EGR delivered to the engine. If an on/off solenoid is used – EGR_PCT shall display 0 % when the EGR is commanded off, 100 % when the EGR system is commanded on. If a vacuum solenoid is duty cycled, the EGR duty cycle from 0 to 100 % shall be displayed. If a linear or stepper motor valve is used, the fully closed position shall be displayed as 0 %, the fully open position shall be displayed as 100 %. Intermediate positions shall be displayed as a percent of the full-open position. For example, a stepper-motor EGR valve that moves from 0 to 128 counts shall display 0 % at zero counts, 100 % at 128 counts and 50 % at 64 counts. Any other actuation method shall be normalized to display 0 % when no EGR is commanded and 100 % at the maximum commanded EGR position.					

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Table B.33 — PID $2D definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
2D	EGR Error = ((EGR actual – EGR commanded) / EGR commanded) * 100 %	A	– 100 % (less than commanded)	+99,22 % (more than commanded)	100/128 % (0 % at 128)	EGR_ERR: xxx.x %
	EGR error is a percent of commanded EGR. Often, EGR valve control outputs are not in the same engineering units as the EGR feedback input sensors. For example, an EGR valve can be controlled using a duty-cycled vacuum solenoid; however, the feedback input sensor is a position sensor. This makes it impossible to display "actual" versus "commanded" in the same engineering units. EGR error solved this problem by displaying a normalized (non-dimensional) EGR system feedback parameter. EGR error is defined to be ((EGR actual - EGR commanded) / EGR commanded) * 100 % For example, if 10 % EGR is commanded and 5 % is delivered to the engine, the EGR_ERR is ((5 % – 10 %) / 10 %) * 100 % = –50 % error. EGR_ERR may be computed using various control parameters such as position, steps, counts, etc. All EGR systems must react to quickly changing conditions in the engine; therefore, EGR_ERR will generally show errors during transient conditions. Under steady condition, the error will be minimized (not necessarily zero, however) if the EGR system is under control. If the control system does not use closed loop control, EGR_ERR shall not be supported. When commanded EGR is 0 %, EGR error is technically undefined. In this case EGR error should be set to 0 % when actual EGR = 0 % or EGR error should be set to 99,2 % when actual EGR > 0 %.					

Table B.34 — PID $2E definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
2E	Commanded Evaporative Purge	A	0 % no flow	100 % max. flow	100/255 %	EVAP_PCT: xxx.x %
	Commanded evaporative purge control valve displayed as a percent. EVAP_PCT shall be normalized to the maximum EVAP purge commanded output control parameter. If an on/off solenoid is used, EVAP_PCT shall display 0 % when purge is commanded off, 100 % when purge is commanded on. If a vacuum solenoid is duty-cycled, the EVAP purge valve duty cycle from 0 to 100 % shall be displayed. If a linear or stepper motor valve is used, the fully closed position shall be displayed as 0 %, and the fully open position shall be displayed as 100 %. Intermediate positions shall be displayed as a percent of the full-open position. For example, a stepper-motor EVAP purge valve that moves from 0 to 128 counts shall display 0 % at 0 counts, 100 % at 128 counts and 50 % at 64 counts. Any other actuation method shall be normalized to display 0 % when no purge is commanded and 100 % at the maximum commanded purge position/flow.					

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Table B.35 — PID $2F definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
2F	Fuel Level Input	A	0 % no fuel	100 % max. fuel capacity	100/255 %	FLI: xxx.x %
	FLI shall indicate nominal fuel tank liquid fill capacity as a percent of maximum, if utilized by the control module for OBD monitoring. FLI may be obtained directly from a sensor, may be obtained indirectly via the vehicle serial data communication bus, or may be inferred by the control strategy using other sensor inputs. Vehicles that use gaseous fuels shall display the percent of useable fuel capacity. If there are two tanks in a bi-fuel car, one for each fuel type, the Fuel Level Input reported shall be from the tank, which contains the fuel type the engine is running on.					

Table B.36 — PID $30 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
30	Number of warm-ups since diagnostic trouble codes cleared	A	0	255	1 warm-up per count	WARM_UPS: xxx
	Number of OBD warm-up cycles since all DTCs were cleared (via an external test equipment or possibly, a battery disconnect). A warm-up is defined in the OBD regulations to be sufficient vehicle operation such that coolant temperature rises by at least 22 °C (40 °F) from engine starting and reaches a minimum temperature of 70 °C (160 °F) (60 °C (140 °F) for diesels). This PID is not associated with any particular DTC. It is simply an indication for I/M, of the last time an external test equipment was used to clear DTCs. If greater than 255 warm-ups have occurred, WARM_UPS shall remain at 255 and not wrap to zero.					

Table B.37 — PID $31 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
31	Distance since diagnostic trouble codes cleared	A, B	0 km	65,535 km	1 km per count	CLR_DIST: xxxxx km (xxxxx miles)
	This is distance accumulated since DTCs were cleared (via an external test equipment or possibly, a battery disconnect). This PID is not associated with any particular DTC. It is simply an indication for I/M (Inspection/Maintenance), of the last time an external test equipment was used to clear DTCs. If greater than 65,535 km have occurred, CLR_DIST shall remain at 65,535 km and not wrap to zero.					

Table B.38 — PID $32 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
32	Evap System Vapour Pressure	A, B	($8000) −8192 Pa (−32,8878 inH2O)	($7FFF) 8191.75 Pa, (32,8868 in H2O)	0,25 Pa (1/4) per bit signed	EVAP_VP: xxxx.x Pa (xx.xxx in H_2O)
	This is evaporative system vapour pressure, if utilized by the control module. The pressure signal is normally obtained from a sensor located in the fuel tank (FTP – Fuel Tank Pressure) or a sensor in an evaporative system vapour line. If a wider pressure range is required, PID $54 scaling allows for a wider pressure range than PID $32. For systems supporting Evap System Vapour Pressure, one of the following two PIDs shall be used: $32 or $54. There shall be support for no more than one of these PIDs.					

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Table B.39 — PID $33 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
33	Barometric Pressure	A	0 kPa (absolute)	255 kPa (absolute)	1 kPa per bit (absolute)	BARO: xxx kPa (xx.x inHg)
	Barometric pressure utilized by the control module. BARO is normally obtained from a dedicated BARO sensor, from a MAP sensor at key-on and during certain modes of driving, or inferred from a MAF sensor and other inputs during certain modes of driving. The control module shall report BARO from whatever source it is derived from. NOTE 1 Some weather services report local BARO values adjusted to sea level. In these cases, the reported value may not match the displayed value on the external test equipment. NOTE 2 If BARO is inferred while driving and stored in non-volatile RAM or Keep-alive RAM, BARO may not be accurate after a battery disconnect or total memory clear.					

Table B.40 — PID $34 - $3B definition

PID (hex)	Description Use if PID $13 is supported!	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
34	Bank 1 – Sensor 1 (wide range O2S)		PIDs $34 to $3B shall be used for linear or wide-ratio Oxygen Sensors when equivalence ratio and current are displayed. If PID $4F is not supported for this ECU, or if PID $4F is supported and includes $00 for either Equivalence Ratio or Maximum Oxygen Sensor Current, the external test equipment shall use the scaling values included in this table for those values. If PID $4F is supported for this ECU, the external test equipment shall calculate scaling and range for these PIDs as explained in the PID $4F definition.			
35	Bank 1 – Sensor 2 (wide range O2S)					
36	Bank 1 – Sensor 3 (wide range O2S)					
37	Bank 1 – Sensor 4 (wide range O2S)					
38	Bank 2 – Sensor 1 (wide range O2S)					
39	Bank 2 – Sensor 2 (wide range O2S)					
3A	Bank 2 – Sensor 3 (wide range O2S)					
3B	Bank 2 – Sensor 4 (wide range O2S)					
	Equivalence Ratio (lambda) (Bx-Sy)	A, B	0	1,999	0,0000305 (2/65535)	EQ_RATxy: xxx.xxx
	Oxygen Sensor Current (Bx-Sy)	C, D	– 128 mA	127,99 6 mA	0,00390625 mA (128/32768) ($8000 = 0 mA)	O2Sxy: xxx.xx mA

The PIDs listed in the table above only apply if PID $13 is used to define the oxygen sensor location.

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Table B.41 — PID $34 - $3B definition

PID (hex)	Description Use if PID $1D is supported!	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
34	Bank 1 – Sensor 1 (wide range O2S)		PIDs $34 to $3B shall be used for linear or wide-ratio Oxygen Sensors when equivalence ratio and current are displayed. If PID $4F is not supported for this ECU, or if PID $4F is supported and includes $00 for either Equivalence Ratio or Maximum Oxygen Sensor Current, the external test equipment shall use the scaling values included in this table for those values. If PID $4F is supported for this ECU, the external test equipment shall calculate scaling and range for these PIDs as explained in the PID $4F definition.			
35	Bank 1 – Sensor 2 (wide range O2S)					
36	Bank 2 – Sensor 1 (wide range O2S)					
37	Bank 2 – Sensor 2 (wide range O2S)					
38	Bank 3 – Sensor 1 (wide range O2S)					
39	Bank 3 – Sensor 2 (wide range O2S)					
3A	Bank 4 – Sensor 1 (wide range O2S)					
3B	Bank 4 – Sensor 2 (wide range O2S)					
	Equivalence Ratio (lambda) (Bx-Sy)	A, B	0	1,999	0,0000305 (2/65535)	EQ_RATxy: xxx.xxx
	Oxygen Sensor Current (Bx-Sy)	C, D	– 128 mA	127,996 mA	0,00390625 mA (128/32768) ($8000 = 0 mA)	O2Sxy: xxx.xx mA

The PIDs listed in the table above only apply if PID $1D is used to define the oxygen sensor location.

Table B.42 — PID $3C definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
3C	Catalyst Temperature Bank 1, Sensor 1	A, B	– 40 °C	+ 6513,5 °C	0,1 °C / bit with – 40 °C offset	CATEMP11: xxxx °C (xxxx °F)
	CATEMP11 shall display catalyst substrate temperature for a bank 1 catalyst, if utilized by the control module strategy for OBD monitoring, or the Bank 1, Sensor 1 catalyst temperature sensor. CATEMP11 may be obtained directly from a sensor, or may be inferred by the control strategy using other sensor inputs.					

Table B.43 — PID $3D definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
3D	Catalyst Temperature Bank 2, Sensor 1	A, B	– 40 °C	+ 6513,5 °C	0,1 °C / bit with – 40 °C offset	CATEMP21: xxxx °C (xxxx °F)
	CATEMP21 shall display catalyst substrate temperature for a bank 2 catalyst, if utilized by the control module strategy for OBD monitoring, or the Bank 2, Sensor 1 catalyst temperature sensor. CATEMP21 may be obtained directly from a sensor, or may be inferred by the control strategy using other sensor inputs.					

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Table B.44 — PID $3E definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
3E	Catalyst Temperature Bank 1, Sensor 2	A, B	– 40 °C	+ 6513,5 °C	0,1 °C / bit with – 40 °C offset	CATEMP12: xxxx °C (xxxx °F)
	CATEMP12 shall display catalyst substrate temperature for an additional bank 1 catalyst, if utilized by the control module strategy for OBD monitoring, or the Bank 1, Sensor 2 catalyst temperature sensor. CATEMP12 may be obtained directly from a sensor, or may be inferred by the control strategy using other sensor inputs.					

Table B.45 — PID $3F definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
3F	Catalyst Temperature Bank 2, Sensor 2	A, B	– 40 °C	+ 6513,5 °C	0,1 °C / bit with – 40 °C offset	CATEMP22: xxxx °C (xxxx °F)
	CATEMP22 shall display catalyst substrate temperature for an additional bank 2 catalyst, if utilized by the control module strategy for OBD monitoring, or the Bank 2, Sensor 2 catalyst temperature sensor. CATEMP22 may be obtained directly from a sensor, or may be inferred by the control strategy using other sensor inputs.					

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Table B.46 — PID $41 definition

PID (hex)	Description	Data byte	Scaling/bit	External test equipment SI (Metric) / English display
41	Monitor status this driving cycle			
	The bit in this PID shall report two pieces of information for each monitor: 1) Monitor enable status for the current driving cycle. This bit shall indicate when a monitor is disabled in a manner such that there is no easy way for the driver to operate the vehicle to allow the monitor to run. Typical examples are — engine-off soak not long enough (e.g., cold start temperature conditions not satisfied); — monitor maximum time limit or number of attempts/aborts exceeded; — ambient air temperature too low or too high; — BARO too low (high altitude). The monitor shall not indicate "disabled" for operator-controlled conditions such as rpm, load, throttle position. The monitor shall not indicate "disabled" from key-on because minimum time limit has not been exceeded or engine warm-up conditions have not been met, since these conditions will eventually be met as the vehicle continues to be driven. If the operator drives the vehicle to a different altitude or ambient air temperature conditions, monitor status may change from enabled to disabled. The monitor shall not change from disable to enable if the conditions change back. This could result in a monitor showing "disabled" but eventually showing "complete". 2) Monitor completion status for the current driving/monitoring cycle. Status shall be reset to "not complete" upon starting a new monitoring cycle. Note that some monitoring cycles can include various engine-operating conditions; other monitoring cycles begin after the ignition key is turned off. Some status bits on a given vehicle can utilize engine-running monitoring cycles while others can utilize engine-off monitoring cycles. Resetting the bits to "not complete" upon starting the engine will accommodate most engine-running and engine-off monitoring cycles; however, manufacturers are free to define their own monitoring cycles. PID $41 bits shall be utilized for all non-continuous monitors which are supported, and change completion status in PID $01. If a non-continuous monitor is not supported or always shows "complete", the corresponding PID $41 bits shall indicate disabled and complete. PID $41 bits may be utilized at the vehicle manufacturer's discretion for all continuous monitors which are supported, with the exception of data byte B bit 2 which shall always show CCM (Comprehensive Component Monitoring) as enabled for spark-ignition and compression-ignition engines.			
		A (bit)	byte 1 of 4	
	Reserved – shall be reported as $00	0-7		—
	Enable status of continuous monitors this monitoring cycle:	B (bit)	byte 2 of 4 (Low Nibble)	Enable status of continuous monitors this monitoring cycle: NO means disabled for rest of this monitoring cycle or not supported in PID $01; YES means enabled for this monitoring cycle.
	Misfire monitoring enabled Fuel system monitoring enabled Comprehensive component monitoring enabled ISO/SAE reserved (Bit shall be reported as '0'.)	0 1 2 3	0 = monitor disabled for rest of this monitoring cycle or not supported (NO) 1 = monitor enabled for this monitoring cycle (YES)	MIS_ENA: NO or YES FUEL_ENA: NO or YES CCM_ENA: NO or YES
	Completion status of continuous monitors this monitoring cycle:	B (bit)	byte 2 of 4 (High Nibble)	Completion status of continuous monitors this monitoring cycle:

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Table B.46 (*continued*)

PID (hex)	Description	Data byte	Scaling/bit	External test equipment SI (Metric) / English display
	Misfire monitoring completed	4	See PID $01 to determine which monitors are supported. 0 = monitor complete this monitoring cycle, or not supported (YES) 1 = monitor not complete this monitoring cycle (NO)	MIS_CMPL: YES or NO
	Fuel system monitoring completed	5		FUELCMPL: YES or NO
	Comprehensive component monitoring completed	6		CCM_CMPL: YES or NO
	ISO/SAE reserved (Bit shall be reported as '0'.)	7		
	Enable status of non-continuous monitors this monitoring cycle:	C (bit)	byte 3 of 4	Enable status of non-continuous monitors this monitoring cycle:
	Catalyst monitoring	0	0 = monitor disabled for rest of this monitoring cycle (NO) 1 = monitor enabled for this monitoring cycle (YES)	CAT_ENA: NO or YES
	Heated catalyst monitoring	1		HCAT_ENA: NO or YES
	Evaporative system monitoring	2		EVAP_ENA: NO or YES
	Secondary air system monitoring	3		AIR_ENA: NO or YES
	A/C system refrigerant monitoring	4		ACRF_ENA: NO or YES
	Oxygen sensor monitoring	5		O2S_ENA: NO or YES
	Oxygen sensor heater monitoring	6		HTR_ENA: NO or YES
	EGR system monitoring	7		EGR_ENA: NO or YES
	Completion status of non-continuous monitors this monitoring cycle:	D (bit)	byte 4 of 4	Completion status of non-continuous monitors this monitoring cycle:
	Catalyst monitoring completed	0	See PID $01 to determine which monitors are supported. 0 = monitor complete this monitoring cycle, or not supported (YES) 1 = monitor not complete this monitoring cycle (NO)	CAT_CMPL: YES or NO
	Heated catalyst monitoring completed	1		HCATCMPL: YES or NO
	Evaporative system monitoring completed	2		EVAPCMPL: YES or NO
	Secondary air system monitoring completed	3		AIR_CMPL: YES or NO
	A/C system refrigerant monitoring completed	4		ACRFCMPL: YES or NO
	Oxygen sensor monitoring completed	5		O2S_CMPL: YES or NO
	Oxygen sensor heater monitoring completed	6		HTR_CMPL: YES or NO
	EGR system monitoring completed	7		EGR_CMPL: YES or NO

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Table B.47 — PID $42 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
42	Control module voltage	A, B	0 V	65,535 V	0,001 V (1/1000) per bit	VPWR: xx.xx V
	VPWR – power input to the control module. VPWR is normally battery voltage, less any voltage drop in the circuit between the battery and the control module. NOTE 42-volts vehicles may utilize multiple voltages for different systems on the vehicle. VPWR represents the voltage at the control module; it may be significantly different than battery voltage.					

Table B.48 — PID $43 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
43	Absolute Load Value	A, B	0 %	25700 %	100/255 %	LOAD_ABS: xxxxx.x %
	The absolute load value has some different characteristics than the LOAD_PCT defined in PID 04. This definition, although restrictive, will standardize the calculation. LOAD_ABS is the normalized value of air mass per intake stroke displayed as a percent: LOAD_ABS = [air mass (g / intake stroke)] / [1,184 (g / litre) * cylinder displacement (litres / intake stroke)] NOTE At engine off and ignition on the LOAD_ABS = 0 %. Derivation: — air mass (g / intake stroke) = [total engine air mass (g/sec)] / [rpm (revs/min)* (1 min / 60 sec) * (1/2 # of cylinders (intake strokes / rev)]; — LOAD_ABS = [air mass (g)/intake stroke] / [maximum air mass (g)/intake stroke at WOT@STP at 100 % volumetric efficiency] * 100 %. Where: — STP = Standard Temperature and Pressure = 25 °C, 29,92 in Hg (101,3 kPa) BARO, WOT = wide open throttle. — The quantity (maximum air mass (g)/intake stroke at WOT@STP at 100 % volumetric efficiency) is a constant for a given cylinder swept volume. The constant is 1,184 (g/litre) * cylinder displacement (litres/intake stroke) based on air density at STP. Characteristics of LOAD_ABS: — ranges from 0 % to approximately 95 % for naturally aspirated engines, 0 % to 400 % for boosted engines; — linearly correlated with engine indicated and brake torque; — often used to schedule spark and EGR rates; — peak value of LOAD_ABS correlates with volumetric efficiency at WOT; — indicates the pumping efficiency of the engine for diagnostic purposes. Spark-ignition engine are required to support PID $43. Compression-ignition (diesel) engines are not required to support this PID. See PID $04 for an additional definition of engine LOAD.					

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Table B.49 — PID $44 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
44	Commanded Equivalence Ratio	A, B	0	1,999	0,0000305 (2/65535)	EQ_RAT: xxx.xxx
	Fuel systems that utilize conventional oxygen sensor shall display the inverse of the commanded open loop equivalence ratio (also known as lambda) while the fuel control system is in open loop. EQ_RAT shall indicate 1,000 while in closed-loop fuel. NOTE Lambda is the inverse of F/A equivalence ratio. Fuel systems that utilize wide-range/linear oxygen sensors shall display the inverse of the commanded equivalence ratio (lambda) in both open-loop and closed-loop operation. To obtain the actual A/F ratio being commanded, multiply the stoichiometric A/F ratio by the inverse of the equivalence ratio (lambda). For example, for gasoline, stoichiometric is a ratio of 14,64:1. If the fuel control system was commanding an 0,95 EQ_RAT, the commanded A/F ratio to the engine would be 14,64 * 0,95 = 13,9 A/F. If PID $4F is not supported for this ECU, or if PID $4F is supported and includes $00 for Equivalence Ratio, the external test equipment shall use the scaling value included in this table. If PID $4F is supported for this ECU, the external test equipment shall calculate scaling for this PID as explained in the PID $4F definition.					

Table B.50 — PID $45 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
45	Relative Throttle Position	A	0 %	100 %	100/255 %	TP_R: xxx.x %
	Relative or "learned" throttle position shall be displayed as a normalized value, scaled from 0 to 100 %. TP_R should display a value of 0 % at the "learned" closed-throttle position. For example, if a 0 to 5,0 volt sensor is used (uses a 5,0 volt reference voltage), and the closed-throttle position is at 1,0 volts, TP shall display (1,0 – 1,0 / 5,0) = 0 % at closed throttle and 30 % at 2,5 volts. Because of the closed-throttle offset, wide-open throttle will usually indicate substantially less than 100 %. For systems where the output is proportional to the input voltage, this value is the percent of maximum input reference voltage. For systems where the output is inversely proportional to the input voltage, this value is 100 % minus the percent of maximum input reference voltage. See PID $11 for a definition of Absolute Throttle Position.					

Table B.51 — PID $46 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
46	Ambient air temperature (same scaling as IAT - $0F)	A	– 40 °C	+ 215 °C	1 °C with – 40 °C offset	AAT: xxx °C / xxx °F
	AAT shall display ambient air temperature, if utilized by the control module strategy for OBD monitoring. AAT may be obtained directly from a sensor, may be obtained indirectly via the vehicle serial data communication bus, or may be inferred by the control strategy using other sensor inputs.					

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Table B.52 — PID $47 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
47	Absolute Throttle Position B	A	0 %	100 %	100/255 %	TP_B: xxx.x %
	Absolute throttle position B, if utilized by the control module, (not "relative" or "learned" throttle position) shall be displayed as a normalized value, scaled from 0 to 100 %. For example, if a 0 to 5,0 volt sensor is used (uses a 5,0 volt reference voltage), and the closed-throttle position is at 1,0 volts, TP_B shall display (1,0 / 5,0) = 20 % at closed throttle and 50 % at 2,5 volts. Throttle position at idle will usually indicate greater than 0 %, and throttle position at wide-open throttle will usually indicate less than 100 %. For systems where the output is proportional to the input voltage, this value is the percent of maximum input reference voltage. For systems where the output is inversely proportional to the input voltage, this value is 100 % minus the percent of maximum input reference voltage. A single throttle plate could have up to three throttle position sensors, A, B and C. There are no provisions for more than one throttle in this part of ISO 15031. This PID shall be used to report the sensors that are on the primary throttle.					

Table B.53 — PID $48 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
48	Absolute Throttle Position C	A	0 %	100 %	100/255 %	TP_C: xxx.x %
	Absolute throttle position C, if utilized by the control module, (not "relative" or "learned" throttle position) shall be displayed as a normalized value, scaled from 0 to 100 %. For example, if a 0 to 5,0 volt sensor is used (uses a 5,0 volt reference voltage), and the closed-throttle position is at 1,0 volts, TP_C shall display (1.0 / 5.0) = 20 % at closed throttle and 50 % at 2,5 volts. Throttle position at idle will usually indicate greater than 0 %, and throttle position at wide-open throttle will usually indicate less than 100 %. For systems where the output is proportional to the input voltage, this value is the percent of maximum input reference voltage. For systems where the output is inversely proportional to the input voltage, this value is 100 % minus the percent of maximum input reference voltage. A single throttle plate could have up to three throttle position sensors, A, B and C. There are no provisions for more than one throttle in this part of ISO 15031. This PID shall be used to report the sensors that are on the primary throttle.					

Table B.54 — PID $49 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
49	Accelerator Pedal Position D	A	0 %	100 %	100/255 %	APP_D: xxx.x %
	Accelerator Pedal Position D, if utilized by the control module, (not "relative" or "learned" pedal position) shall be displayed as a normalized value, scaled from 0 to 100 %. For example, if a 0 to 5,0 volt sensor is used (uses a 5,0 volt reference voltage), and the closed-pedal position is 1,0 volt, APP_D shall display (1,0 / 5,0) = 20 % at closed pedal and 50 % at 2,5 volts. Pedal position at idle will usually indicate greater than 0 %, and pedal position at wide-open pedal will usually indicate less than 100 %. For systems where the output is proportional to the input voltage, this value is the percent of maximum input reference voltage. For systems where the output is inversely proportional to the input voltage, this value is 100 % minus the percent of maximum input reference voltage. The designation "D" shall match the diagnostic trouble code defined in ISO 15031-6. If additional DTCs are defined, those should match this PID designation. Pedal sensor designations are D, E and F.					

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Table B.55 — PID $4A definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
4A	Accelerator Pedal Position E	A	0 %	100 %	100/255 %	APP_E: xxx.x %
	Accelerator Pedal Position E, if utilized by the control module, (not "relative" or "learned" pedal position) shall be displayed as a normalized value, scaled from 0 to 100 %. For example, if a 0 to 5,0 volt sensor is used (uses a 5,0 volt reference voltage), and the closed-pedal position is 1,0 volt, APP_E shall display (1,0 / 5,0) = 20 % at closed pedal and 50 % at 2,5 volts. Pedal position at idle will usually indicate greater than 0 %, and pedal position at wide-open pedal will usually indicate less than 100 %. For systems where the output is proportional to the input voltage, this value is the percent of maximum input reference voltage. For systems where the output is inversely proportional to the input voltage, this value is 100 % minus the percent of maximum input reference voltage. The designation "E" shall match the diagnostic trouble code defined in ISO 15031-6. If additional DTCs are defined, those should match this PID designation. Pedal sensor designations are D, E and F.					

Table B.56 — PID $4B definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
4B	Accelerator Pedal Position F	A	0 %	100 %	100/255 %	APP_F: xxx.x %
	Accelerator Pedal Position F, if utilized by the control module, (not "relative" or "learned" pedal position) shall be displayed as a normalized value, scaled from 0 to 100 %. For example, if a 0 to 5,0 volt sensor is used (uses a 5.0 volt reference voltage), and the closed-pedal position is 1,0 volt, APP_F shall display (1,0 / 5,0) = 20 % at closed pedal and 50 % at 2,5 volts. Pedal position at idle will usually indicate greater than 0 %, and pedal position at wide-open pedal will usually indicate less than 100 %. For systems where the output is proportional to the input voltage, this value is the percent of maximum input reference voltage. For systems where the output is inversely proportional to the input voltage, this value is 100 % minus the percent of maximum input reference voltage. The designation "F" shall match the diagnostic trouble code defined in ISO 15031-6. If additional DTCs are defined, those should match this PID designation. Pedal sensor designations are D, E and F.					

Table B.57 — PID $4C definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
4C	Commanded Throttle Actuator Control	A	0 % (closed throttle)	100 % (wide-open throttle)	100/255 %	TAC_PCT: xxx.x %
	Commanded TAC displayed as a percent. TAC_PCT shall be normalized to the maximum TAC commanded output control parameter. TAC systems use a variety of methods to control the amount of throttle opening: 1) If a linear or stepper motor is used, the fully closed throttle position shall be displayed as 0 %, and the fully open throttle position shall be displayed as 100 %. Intermediate positions shall be displayed as a percent of the full-open throttle position. For example, a stepper-motor TAC that moves the throttle from 0 to 128 counts shall display 0 % at 0 counts, 100 % at 128 counts and 50 % at 64 counts. 2) Any other actuation method shall be normalized to display 0 % when the throttle is commanded closed and 100 % when the throttle is commanded open.					

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Table B.58 — PID $4D definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/ bit	External test equipment SI (Metric) / English display
4D	Time run by the engine while MIL is activated	A, B	0 min	65 535 min	1 min per count	MIL_TIME: xxxx hrs, xx min
	Conditions for "Time run by the engine while MIL is activated" counter: — reset to $0000 when MIL state changes from deactivated to activated by this ECU; — accumulate counts in minutes if MIL is activated (ON); — do not change value while MIL is not activated (OFF); — reset to $0000 if diagnostic information is cleared either by service $04 or at least 40 warm-up cycles without MIL activated; — do not wrap to $0000 if value is $FFFF.					

Table B.59 — PID $4E definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
4E	Time since diagnostic trouble codes cleared	A, B	0 min	65 535 min	1 min per count	CLR_TIME: xxxx hrs, xx min
	Time accumulated since DTCs were cleared (via an external test equipment or possibly a battery disconnect). This PID is not associated with any particular DTC. It is simply an indication for I/M (Inspection/Maintenance), of the last time an external test equipment was used to clear DTCs. If greater than 65 535 min have occurred, CLR_TIME shall remain at 65 535 min and not wrap to zero.					

Table B.60 — PID $4F definition

PID (hex)	Description External Test Equipment Configuration Information #1	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
4F	Maximum value for Equivalence Ratio	A	0	255	1	These values are not intended for display to the service technician.
	These values shall be used by the external test equipment to calculate scaling factors for linear or wide-ratio oxygen sensor data reported with PIDs $24 to $2B, PIDs $34 to $3B, and PID $44. Data A shall be used by the external test equipment to calculate the scaling per bit of PIDs $24 to $2B, PIDs $34 to $3B, and PID $44. If Data A is reported as $00, the external test equipment shall use the "Maximum value for Equivalence Ratio" included in the original PID definition (1,999 / 65535 = 0,0000305 per bit). If the value reported in Data A of PID $4F is greater than $00, that value shall be divided by 65535 to calculate the scaling per bit to use to display Equivalence Ratio. (Data A contains the new maximum value for PIDs $24 to $2B, PIDs $34 to $3B and PID $44.) The following is an example to calculate PID $24 with PID $4F supported and including a non-zero value. In this example, a manufacturer needs a range of equivalence ratio larger than 0 to 1,999. The manufacturer needs a range of 0 to 4 and sets Data A = 4. EXAMPLE $EQ\_RAT11_{(PID24)} = DATA\_A\_B_{(PID24)} * (DATA\_A_{(PID4F)} / 65535)$ New scaling per bit for PID $24 = $DATA\_A_{(PID4F)} / 65535 = 4_{(10)} / 65535_{(10)} = 0,0000610$ per bit $DATA\_A\_B_{(PID24)} = \$7D00 = 32000_{10}$ = value reported by vehicle ECU $EQ\_RAT11_{PID24} = 32000 * (4 / 65535) = 1,953$					

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Table B.60 (*continued*)

PID (hex)	Description External Test Equipment Configuration Information #1	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
	Maximum value for Oxygen Sensor Voltage	B	0 V	255 V	1 V	These values are not intended for display to the service technician.
	Data B shall be used by the external test equipment to calculate the scaling per bit of PIDs $24 to $2B. If Data B is reported as $00, the external test equipment shall use the "Maximum value for Oxygen Sensor Voltage" included in the original PID definition (7,999 V / 65535 bits = 0,000122 V per bit). If the value reported in Data B of PID $4F is greater than $00, that value shall be divided by 65535 to calculate the scaling per bit to use to display Oxygen Sensor Voltage. If PIDs $34 to $3B are supported by this ECU, this value shall be reported as $00. The following is an example to calculate PID $24 with PID $4F supported and including a non-zero value. In this example, a manufacturer needs a range of voltage larger than 0 to 7,999 V. The manufacturer needs a range of 0 to 16 V and sets Data A = 16. EXAMPLE $O2S11_{(PID24)} = DATA\_C\_D_{(PID24)} * (DATA\_B_{(PID4F)} * 1\ V / 65535)$ New scaling per bit for PID $24 = $DATA\_B_{(PID4F)} * 1\ V / 65535 = 16_{(10)} * 1\ V / 65535_{(10)} =$ 0,000244 V per bit $DATA\_C\_D_{(PID24)} = \$9C40 = 40000_{10}$ = value reported by vehicle ECU $O2S11_{(PID24)} = 40000 * (16\ V / 65535) = 9,766\ V$					
	Maximum value for Oxygen Sensor Current	C	0 mA	255 mA	1 mA	These values are not intended for display to the service technician.
	Data C shall be used by the external test equipment to calculate the scaling per bit of PIDs $34 to $3B. If Data C is reported as $00, the external test equipment shall use the "Maximum value for Oxygen Sensor Current" included in the original PID definition (128 mA / 32768 bits = 0,00390625 mA per bit). If the value reported in Data C of PID $4F is greater than $00, that value shall be divided by 32768 (oxygen sensor current is a signed value) to calculate the scaling per bit to use to display Oxygen Sensor Current. If PIDs $24 to $2B are supported by this ECU, this value shall be reported as $00. The following is an example to calculate PID $24 with PID $4F supported and including a non-zero value. In this example, a manufacturer doesn't need a range of –128 to 127,996 milliamps and wishes to increase the resolution. The manufacturer only needs a range of - 64 to +64 mA and sets Data A = 64 mA. EXAMPLE $O2S11_{(PID34)} = DATA\_C\_D_{(PID34)} * (DATA\_C_{(PID4F)} * 1\ mA / 32768)$ New scaling per bit for PID $34 = $DATA\_C_{(PID4F)} * 1\ mA / 32768 = 64_{(10)}\ mA / 32768_{(10)} =$ 0,001953 mA per bit $DATA\_C\_D_{(PID34)} = \$9C40 = -25536_{(10)}$ = negative value reported by vehicle ECU $O2S11_{(PID34)} = -25536 * (64\ mA / 32768) = -49,875\ mA$					
	Maximum value for Intake Manifold Absolute Pressure	D	0 kPa	2550 kPa	10 kPa	These values are not intended for display to the service technician.
	Data D shall be used by the external test equipment to calculate the scaling per bit of PID $0B. If Data D is reported as $00, the external test equipment shall use the "Intake Manifold Absolute Pressure" included in the original PID definition (255 kPa / 255 bits = 1 kPa per bit). If the value reported in Data D of PID $4F is greater than $00, that value shall be multiplied by 10 kPa per bit and then divided by 255 to calculate the scaling per bit to use to display Intake Manifold Absolute Pressure. The following is an example to calculate PID $0B with PID $4F supported and including a non-zero value. In this example, a manufacturer needs a range of pressure larger than 0 to 255 kPa. The manufacturer needs a range of 0 to 765 kPa and sets Data A = 77, the closest value possible to 76,5. EXAMPLE $MAP_{(PID0B)} = DATA\_A_{(PID0B)} * (DATA\_D_{(PID4F)} * 10\ kPa\ per\ bit / 255)$ New scaling per bit for PID $0B = $DATA\_D_{(PID4F)} * 10\ kPa / 255 = 77_{(10)} * 10\ kPa / 255 = 3,0196\ kPa$ per bit. $DATA\_A_{(PID0B)} = \$7F = 127_{(10)}$ = value reported by vehicle ECU */ $MAP_{(PID0B)} = 127 * (770\ kPa / 255) = 383,5\ kPa$					

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Table B.61 — PID $50 definition

PID (hex)	Description External Test Equipment Configuration Information #2	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
50	Maximum value for Air Flow Rate from Mass Air Flow Sensor	A	0 g/s	2550 g/s	10 g/s	These values are not intended for display to the service technician.
	Data A shall be used by the external test equipment to calculate the scaling per bit of PID $10. If Data A is reported as $00, the external test equipment shall use the "Air Flow Rate from Mass Air Flow Sensor" included in the original PID definition (655,35 g/s / 65535 bits = 0,01 g/s per bit). If the value reported in Data A of PID $50 is greater than $00, that value shall be multiplied by 10 g/s and then divided by 65 535 to calculate the scaling per bit to use to display Air Flow Rate from Mass Air Flow Sensor. The following is an example to calculate PID $10 with PID $50 supported and including a non-zero value. In this example, a manufacturer needs a range of air flow rate larger than 0 to 655,35 g/s. The manufacturer needs a range of 0 to 1000 g/s and sets Data A = 100, EXAMPLE $MAF_{(PID10)} = DATA\_A\_B_{(PID10)} * (DATA\_A_{(PID50)} * 10 g/s / 65535)$ New scaling per bit for PID $10 = $DATA\_A_{(PID50)} * 10 g/s / 65535 =$ $100_{(10)} * 10 g/s / 65535 = 0,01526 g/s$ per bit $DATA\_A\_B_{(PID10)} = \$E290 = 58000_{(10)}$ = value reported by vehicle ECU */ $MAF_{(PID10)} = 58000 * (1000 g/s / 65535) = 885,02 g/s$					
	Reserved for future expansion – report as $00	B				These values are not intended for display to the service technician.
	Reserved for future expansion – report as $00	C				These values are not intended for display to the service technician.
	Reserved for future expansion – report as $00	D				These values are not intended for display to the service technician.

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Table B.62 — PID $51 definition

PID (hex)	Description	Data byte	Scaling	External test equipment SI (Metric) / English display
51	Type of fuel currently being utilized by the vehicle	A (hex)	byte 1 of 1 (State Encoded Variable)	FUEL_TYP
		01	Gasoline/petrol	GAS
		02	Methanol	METH
		03	Ethanol	ETH
		04	Diesel	DSL
		05	Liquefied Petroleum Gas (LPG)	LPG
		06	Compressed Natural Gas (CNG)	CNG
		07	Propane	PROP
		08	Battery/electric	ELEC
		09	Bi-fuel vehicle using gasoline	BI_GAS
		0A	Bi-fuel vehicle using methanol	BI_METH
		0B	Bi-fuel vehicle using ethanol	BI_ETH
		0C	Bi-fuel vehicle using LPG	BI_LPG
		0D	Bi-fuel vehicle using CNG	BI_CNG
		0E	Bi-fuel vehicle using propane	BI_PROP
		0F	Bi-fuel vehicle using battery	BI_ELEC
		10 – FF	ISO/SAE reserved	—

EXAMPLE If a vehicle has less than 10 % ethanol in the gasoline/petrol, then the external test equipment shall display state $09. In such a case, the system would be using gasoline/petrol (fuel) tables and OBD thresholds. PID $52 should either artificially display 0 % or some number 10 % or less if the system has such resolution. If the ethanol in the gasoline/petrol is above 10 %, then the external test equipment shall display state $0B. PID $52 shall report the calculated ethanol/alcohol percentage.

Table B.63 — PID $52 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
52	Alcohol Fuel Percentage	A	0 % no alcohol	100 % max. alcohol	100/255 %	ALCH_PCT: xxx.x %
	ALCH_PCT shall indicate the percentage of alcohol contained in ethanol or methanol fuels, if utilized. For example, ethanol fuel (E85) normally contains 85 % ethanol, in which case ALCH_PCT shall display 85,0 %. Alcohol percentage can be determined using a sensor or can be inferred by the fuel control software.					

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Table B.64 — PID $53 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
53	Absolute Evap System Vapour Pressure	A, B	0 kPa (0,00 inH_2O)	327,675 kPa (1315.49 inH_2O)	0,005 kPa (1/200), unsigned	EVAP_VPA: xxx.xxx kPa (xxxx.xx inH_2O)
	Absolute evaporative system vapour pressure, if utilized by the control module. The pressure signal is normally obtained from a sensor located in the fuel tank (FTP – Fuel Tank Pressure) or a sensor in an evaporative system vapour line.					

Table B.65 — PID $54 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
54	Evap System Vapour Pressure	A, B	– 32767 Pa	32768 Pa (131,55 inH_2O)	1 Pa, signed	EVAP_VP: xxxxx Pa (xxx.xx inH_2O)
	Evaporative system vapour pressure, if utilized by the control module. The pressure signal is normally obtained from a sensor located in the fuel tank (FTP – Fuel Tank Pressure) or a sensor in an evaporative system vapour line. PID $54 scaling allows for a wider pressure range than PID $32. For systems supporting Evap System Vapour Pressure, one of the following 2 PIDs is required: $32, or $54. Support for more than one of these PIDs is not allowed.					

Table B.66 — PID $55 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
55	Short Term Secondary O2 Sensor Fuel Trim – Bank 1 (use if only 1 fuel trim value) Short Term Secondary O2 Sensor Fuel Trim – Bank 3	A B	– 100 % (lean)	+ 99,22 % (rich)	100/128 % (0 % at 128)	STSO2FT1: xxx.x % STSO2FT3: xxx.x %
	Short Term Secondary O2 Sensor Fuel Trim Bank 1/3 shall indicate the correction being utilized by the closed-loop fuel algorithm. If the fuel system is in open loop, STSO2FT shall report 0 % correction. Data B shall only be included in the response to a PID $55 request if PID $1D (Location of Oxygen Sensors) indicates an oxygen sensor is present in Bank 3. The external test equipment can determine length of the response message based on the data content of PID $13 or $1D. See examples in the description of PID $09.					

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Table B.67 — PID $56 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
56	Long Term Secondary O2 Sensor Fuel Trim – Bank 1 (use if only 1 fuel trim value) Long Term Secondary O2 Sensor Fuel Trim – Bank 3	A B	– 100 % (lean)	+ 99,22 % (rich)	100/128 % (0 % at 128)	LGSO2FT1: xxx.x % LGSO2FT3: xxx.x %
	Secondary O2 Sensor Fuel trim correction for Bank 1/3 stored in Non-volatile RAM or Keep-alive RAM. LGSO2FT shall indicate the correction being utilized by the fuel control algorithm at the time the data is requested, in both open-loop and closed-loop fuel control. If no correction is utilized in open-loop fuel, LGSO2FT shall report 0 % correction. If secondary O2 sensor long-term fuel trim is not utilized at all by the fuel control algorithm, the PID shall not be supported. Data B shall only be included in the response to a PID $56 request if PID $1D (Location of Oxygen Sensors) indicates an oxygen sensor is present in Bank 3. The external test equipment can determine length of the response message based on the data content of PID $13 or $1D. See examples in the description of PID $09.					

Table B.68 — PID $57 definition

PID (hex)	Description	Data byte	Min. value	Max. Value	Scaling/bit	External test equipment SI (Metric) / English display
57	Short Term Secondary O2 Sensor Fuel Trim - Bank 2 (use if only 1 fuel trim value) Short Term Secondary O2 Sensor Fuel Trim - Bank 4	A B	– 100 % (lean)	+ 99,22 % (rich)	100/128 % (0 % at 128)	STSO2FT2: xxx.x % STSO2FT4: xxx.x %
	Short Term Secondary O2 Sensor Fuel Trim Bank 2/4 shall indicate the correction being utilized by the closed-loop fuel algorithm. If the fuel system is in open loop, STSO2FT shall report 0 % correction. Data B shall only be included in the response to a PID $57 request if PID $1D (Location of Oxygen Sensors) indicates an oxygen sensor is present in Bank 4. The external test equipment can determine length of the response message based on the data content of PID $13 or $1D. See examples in the description of PID $09.					

Table B.69 — PID $58 definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
58	Long Term Secondary O2 Sensor Fuel Trim – Bank 2 (use if only 1 fuel trim value) Long Term Secondary O2 Sensor Fuel Trim - Bank 4	A B	– 100 % (lean)	+ 99,22 % (rich)	100/128 % (0 % at 128)	LGSO2FT2: xxx.x % LGSO2FT4: xxx.x %
	Secondary Sensor Fuel trim correction for Bank 2/4 stored in Non-volatile RAM or Keep-alive RAM. LGSO2FT shall indicate the correction being utilized by the fuel control algorithm at the time the data is requested, in both open-loop and closed-loop fuel control. If no correction is utilized in open-loop fuel, LGSO2FT shall report 0 % correction. If post O2 sensor long-term fuel trim is not utilized at all by the fuel control algorithm, the PID shall not be supported. Data B shall only be included in the response to a PID $58 request if PID $1D (Location of Oxygen Sensors) indicates an oxygen sensor is present in Bank 4. The external test equipment can determine length of the response message based on the data content of PID $13 or $1D. See examples in the description of PID $09.					

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Table B.70 — PID $59 definition

PID (hex)	Description	Data byte	Min. value	Max. Value	Scaling/bit	External test equipment SI (Metric) / English display
59	Fuel Rail Pressure (absolute)	A, B	0 kPa	655350 kPa	10 kPa per bit unsigned, 1 kPa = 0,1450377 PSI	FRP: xxxxxx kPa (xxxxx.x PSI)
	FRP shall display fuel rail pressure at the engine when the reading is absolute. Diesel fuel-pressure and gasoline direct-injection systems have a higher pressure range than FRP PID $0A. For systems supporting a fuel pressure sensor, one of the following 4 PIDs shall be used: $0A, $22, $23 or $59. There shall be no support for more than one of these PIDs.					

Table B.71 — PID $5A definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
5A	Relative Accelerator Pedal Position	A	0 %	100 %	100/255 %	APP_R: xxx.x %
	Relative or "learned" pedal position shall be displayed as a normalized value, scaled from 0 to 100 %. APP_R should display a value of 0 % at the "learned" closed-pedal position. For example, if a 0 to 5,0 volt sensor is used (uses a 5,0 volt reference voltage), and the closed-pedal position is at 1,0 volts, APP_R shall display (1,0 – 1,0 / 5,0) = 0,0 % at closed pedal and 30,0 % at 2,5 volts. Because of the closed-pedal offset, wide-open pedal will usually indicate substantially less than 100,0 %. In many cases, APP_R will be the average of multiple pedal sensor values. For systems where the output is proportional to the input voltage, this value is the percent of maximum input reference voltage. For systems where the output is inversely proportional to the input voltage, this value is 100,0 % minus the percent of maximum input reference voltage. See PID $49 for a definition of Absolute Pedal Position.					

Table B.72 — PID $5A - $FF definition

PID (hex)	Description	Data byte	Min. value	Max. value	Scaling/bit	External test equipment SI (Metric) / English display
5B - FF	ISO/SAE reserved	—	—	—	—	—

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Annex C
(normative)

TIDs (Test ID) scaling description

Table C.1 defines standardized Test IDs.

Table C.1 — Test ID scaling description

Test ID	Description	Min. ($00)	Max. ($FF)	Scaling/bit
$01	Rich to lean sensor threshold voltage (constant)	0 V	1,275 V	0,005 V
$02	Lean to rich sensor threshold voltage (constant)	0 V	1,275 V	0,005 V
$03	Low sensor voltage for switch time calculation (constant)	0 V	1,275 V	0,005 V
$04	High sensor voltage for switch time calculation (constant)	0 V	1,275 V	0,005 V
$05	Rich to lean sensor switch time (calculated)	0 s	1,02 s	0,004 s
$06	Lean to rich sensor switch time (calculated)	0 s	1,02 s	0,004 s
$07	Minimum sensor voltage for test cycle (calculated)	0 V	1,275 V	0,005 V
$08	Maximum sensor voltage for test cycle (calculated)	0 V	1,275 V	0,005 V
$09	Time between sensor transitions (calculated)	0 s	10,2 s	0,04 s
$0A	Sensor period (calculated)	0 s	10,2 s	0,04 s
$0B-$1F	ISO/SAE reserved			
$21-$2F	manufacturer Test ID description	0 s	1,02 s	0,004 s
$30-$3F	:	0 s	10,2 s	0,04 s
$41-$4F	:	0 V	1,275 V	0,005 V
$50-$5F	:	0 V	12,75 V	0,05 V
$61-$6F	:	0 Hz	25,5 Hz	0,1 Hz
$70-$7F	:	0 counts	255 counts	1 count
$81-$9F	manufacturer Test ID description	manufacturer specific values / units		
$A1-$BF	:	:		
$C1-$DF	:	:		
$E1-$FF	:	:		

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Annex D
(normative)

OBDMIDs (On-Board Diagnostic Monitor ID) definition for Service $06

This annex only applies to ISO 15765-4.

Table D.1 — Standard On-Board Diagnostic Monitor ID definition

OBDMID (Hex)	On-Board Diagnostic Monitor ID name
00	OBD Monitor IDs supported ($01 - $20)
01	Oxygen Sensor Monitor Bank 1 – Sensor 1
02	Oxygen Sensor Monitor Bank 1 – Sensor 2
03	Oxygen Sensor Monitor Bank 1 – Sensor 3
04	Oxygen Sensor Monitor Bank 1 – Sensor 4
05	Oxygen Sensor Monitor Bank 2 – Sensor 1
06	Oxygen Sensor Monitor Bank 2 – Sensor 2
07	Oxygen Sensor Monitor Bank 2 – Sensor 3
08	Oxygen Sensor Monitor Bank 2 – Sensor 4
09	Oxygen Sensor Monitor Bank 3 – Sensor 1
0A	Oxygen Sensor Monitor Bank 3 – Sensor 2
0B	Oxygen Sensor Monitor Bank 3 – Sensor 3
0C	Oxygen Sensor Monitor Bank 3 – Sensor 4
0D	Oxygen Sensor Monitor Bank 4 – Sensor 1
0E	Oxygen Sensor Monitor Bank 4 – Sensor 2
0F	Oxygen Sensor Monitor Bank 4 – Sensor 3
10	Oxygen Sensor Monitor Bank 4 – Sensor 4
11 – 1F	ISO/SAE reserved
20	OBD Monitor IDs supported ($21 – $40)
21	Catalyst Monitor Bank 1
22	Catalyst Monitor Bank 2
23	Catalyst Monitor Bank 3
24	Catalyst Monitor Bank 4
25 – 30	ISO/SAE reserved
31	EGR Monitor Bank 1
32	EGR Monitor Bank 2
33	EGR Monitor Bank 3
34	EGR Monitor Bank 4
35 – 38	ISO/SAE reserved
39	EVAP Monitor (Cap Off)
3A	EVAP Monitor (0,090")
3B	EVAP Monitor (0,040")
3C	EVAP Monitor (0,020")
3D	Purge Flow Monitor

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Table D.1 (*continued*)

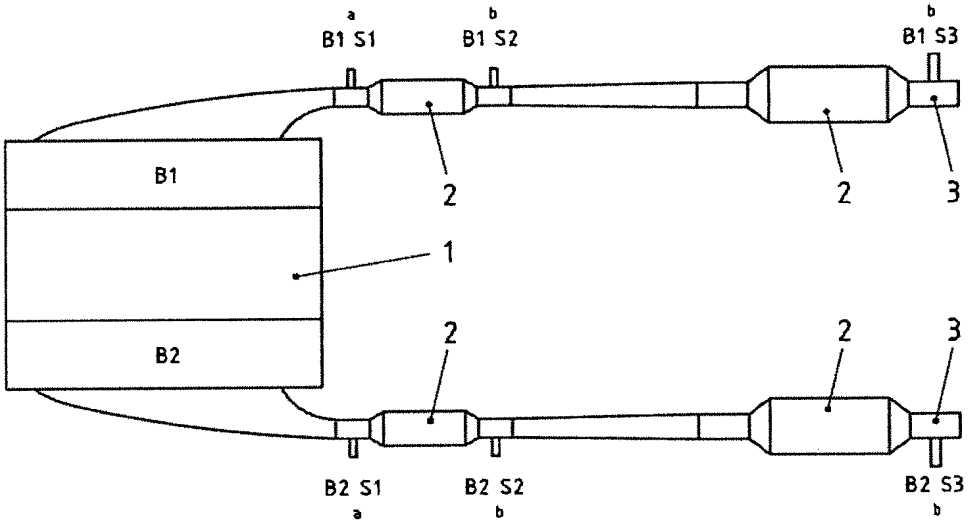
OBDMID (Hex)	On-Board Diagnostic Monitor ID name
3E – 3F	ISO/SAE reserved
40	OBD Monitor IDs supported ($41 – $60)
41	Oxygen Sensor Heater Monitor Bank 1 – Sensor 1
42	Oxygen Sensor Heater Monitor Bank 1 – Sensor 2
43	Oxygen Sensor Heater Monitor Bank 1 – Sensor 3
44	Oxygen Sensor Heater Monitor Bank 1 – Sensor 4
45	Oxygen Sensor Heater Monitor Bank 2 – Sensor 1
46	Oxygen Sensor Heater Monitor Bank 2 – Sensor 2
47	Oxygen Sensor Heater Monitor Bank 2 – Sensor 3
48	Oxygen Sensor Heater Monitor Bank 2 – Sensor 4
49	Oxygen Sensor Heater Monitor Bank 3 – Sensor 1
4A	Oxygen Sensor Heater Monitor Bank 3 – Sensor 2
4B	Oxygen Sensor Heater Monitor Bank 3 – Sensor 3
4C	Oxygen Sensor Heater Monitor Bank 3 – Sensor 4
4D	Oxygen Sensor Heater Monitor Bank 4 – Sensor 1
4E	Oxygen Sensor Heater Monitor Bank 4 – Sensor 2
4F	Oxygen Sensor Heater Monitor Bank 4 – Sensor 3
50	Oxygen Sensor Heater Monitor Bank 4 – Sensor 4
51 – 5F	ISO/SAE reserved
60	OBD Monitor IDs supported ($61 – $80)
61	Heated Catalyst Monitor Bank 1
62	Heated Catalyst Monitor Bank 2
63	Heated Catalyst Monitor Bank 3
64	Heated Catalyst Monitor Bank 4
65 – 70	ISO/SAE reserved
71	Secondary Air Monitor 1
72	Secondary Air Monitor 2
73	Secondary Air Monitor 3
74	Secondary Air Monitor 4
75 – 7F	ISO/SAE reserved
80	OBD Monitor IDs supported ($81 – $A0)
81	Fuel System Monitor Bank 1
82	Fuel System Monitor Bank 2
83	Fuel System Monitor Bank 3
84	Fuel System Monitor Bank 4
85 – 9F	ISO/SAE reserved
A0	OBD Monitor IDs supported ($A1 – $C0)
A1	Misfire Monitor General Data
A2	Misfire Cylinder 1 Data
A3	Misfire Cylinder 2 Data
A4	Misfire Cylinder 3 Data
A5	Misfire Cylinder 4 Data

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Table D.1 (*continued*)

OBDMID (Hex)	On-Board Diagnostic Monitor ID name
A6	Misfire Cylinder 5 Data
A7	Misfire Cylinder 6 Data
A8	Misfire Cylinder 7 Data
A9	Misfire Cylinder 8 Data
AA	Misfire Cylinder 9 Data
AB	Misfire Cylinder 10 Data
AC	Misfire Cylinder 11 Data
AD	Misfire Cylinder 12 Data
AE – BF	ISO/SAE reserved
C0	OBD Monitor IDs supported ($C1 – $E0)
C1 – DF	ISO/SAE reserved
E0	OBD Monitor IDs supported ($E1 – $FF)
E1 – FF	Vehicle manufacturer defined OBDMIDs

EXAMPLE Examples for sensor and catalyst configuration. The cylinder most remote of the flywheel is defined as cylinder number 1.



Key

S1 Sensor 1
S2 Sensor 2
S3 Sensor 3
B1 Cylinder Bank 1
B2 Cylinder Bank 2

[a] wide range

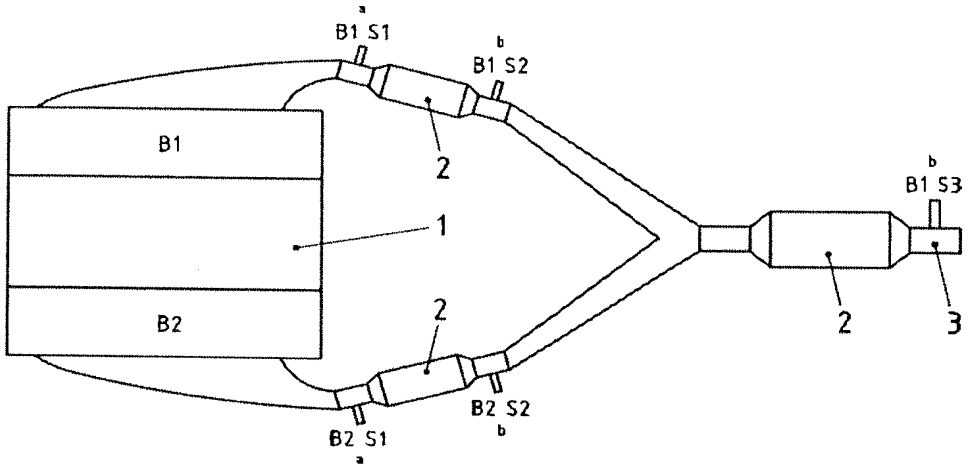
[b] heated

1 V6/V8/V12 Cylinder engine with exhaust banks
2 Catalyst
3 Tail pipe

Figure D.1 — V6/V8/V12 Cylinder Engine with 2 exhaust banks and 4 catalysts example

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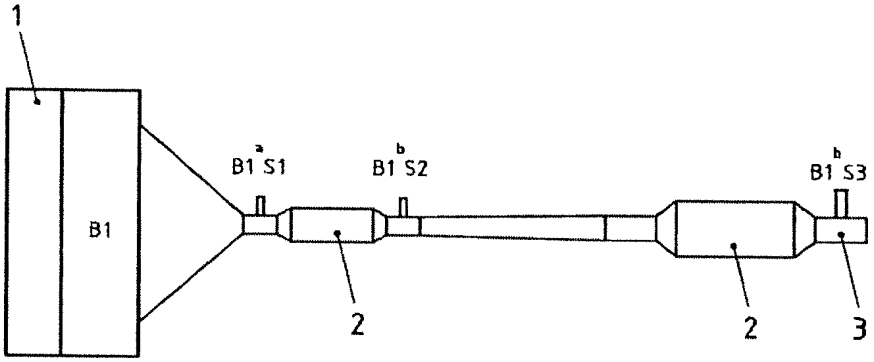
Key

S1 Sensor 1
S2 Sensor 2
S3 Sensor 3
B1 Cylinder Bank 1
B2 Cylinder Bank 2

[a] wide range
[b] heated

1 V6/V8/V12 Cylinder engine with exhaust banks
2 Catalyst
3 Tail pipe

Figure D.2 — V6 V8/V12 Cylinder Engine with 2 exhaust banks and 3 catalysts example



Key

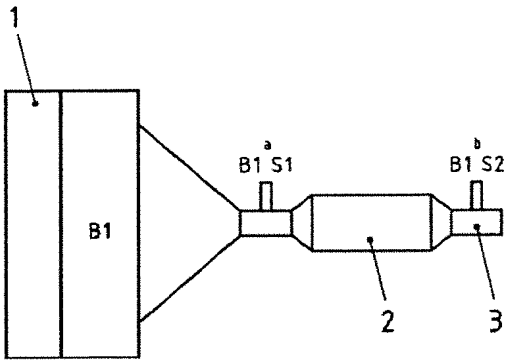
S1 Sensor 1
S2 Sensor 2
S3 Sensor 3
B1 Cylinder Bank 1

[a] wide range
[b] heated

1 L4-Cylinder engine with exhaust bank
2 Catalyst
3 Tail pipe

Figure D.3 — L4 Cylinder Engine with 1 exhaust bank and 2 catalysts example

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Key

S1	Sensor 1	1	L4-Cylinder engine with exhaust bank
S2	Sensor 2	2	Catalyst
B1	Cylinder Bank 1	3	Tail pipe

[a] wide range

[b] heated

Figure D.4 — L4 Cylinder Engine with 1 exhaust bank and 1 catalyst example

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Annex E
(normative)

Unit and Scaling definition for Service $06

This annex only applies to ISO 15765-4. The Unit and Scaling IDs are separated into two ranges; $01 - $7F are unsigned Scaling Identifiers, and $80 - $FE are signed Scaling Identifiers. Unit and Scaling IDs $00 and $FF are ISO/SAE reserved for future definition and shall not be defined as Unit and Scaling Identifiers.

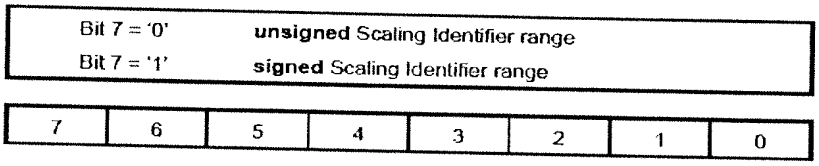


Figure E.1 — Unsigned/Signed Scaling Identifier range encoding

E.1 Unsigned Unit and Scaling Identifiers definition

Table E.1 — Unit and Scaling ID $01 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
01	Raw Value	1 per bit hex to decimal unsigned	0000	0	FFFF	65535	xxxxx
			Data Range examples:				Display examples:
			$0000		0		0
			$FFFF		+ 65535		65535

Table E.2 — Unit and Scaling ID $02 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
02	Raw Value	0,1 per bit hex to decimal unsigned	0000	0	FFFF	6553,5	xxxx.x
			Data Range examples:				Display examples:
			$0000		0		0,0
			$FFFF		+ 6553,5		6553,5

Table E.3 — Unit and Scaling ID $03 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
03	Raw Value	0,01 per bit hex to decimal unsigned	0000	0	FFFF	655,35	xxx.xx
			Data Range examples:				Display examples:
			$0000		0		0,00
			$FFFF		+ 655,35		655,35

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Table E.4 — Unit and Scaling ID $04 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
04	Raw Value	0,001 per bit hex to decimal unsigned	0000	0	FFFF	65,535	xx.xxx
			Data Range examples:				Display examples:
			$0000		0		0,000
			$FFFF		+ 65,535		65,535

Table E.5 — Unit and Scaling ID $05 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
05	Raw Value	0,0000305 per bit hex to decimal unsigned	0000	0	FFFF	1,999	x.xxx
			Data Range examples:				Display examples:
			$0000		0		0,000
			$FFFF		+ 1,999		1,999

Table E.6 — Unit and Scaling ID $06 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
06	Raw Value	0,000305 per bit hex to decimal unsigned	0000	0	FFFF	19,988	xx.xxx
			Data Range examples:				Display examples:
			$0000		0		0.000
			$FFFF		19.988		19,988

Table E.7 — Unit and Scaling ID $07 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
07	rotational frequency	0,25 rpm per bit unsigned	0000	0 rpm	FFFF	16384 rpm	xxxxx rpm
			Data Range examples:				Display examples:
			$0000		0 rpm		0 rpm
			$0002		+ 0,5 rpm		1 rpm
			$FFFC		+ 16383 rpm		16383 rpm
			$FFFD		+ 16383,25 rpm		16383 rpm
			$FFFE		+ 16383,50 rpm		16384 rpm
			$FFFF		+ 16383,75 rpm		16384 rpm

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Table E.8 — Unit and Scaling ID $08 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display	
			(hex)	(dec.)	(hex)	(dec.)		
08	Speed	0,01 km/h per bit unsigned	0000	0 km/h	FFFF	655,35 km/h	xxx.xx km/h (xxx.xx mph)	
			Data Range examples:				Display examples:	
	Conversion km/h -> mph: 1 km/h = 0,62137 mph		$0000		0 km/h		0,00 km/h	(0,00 mph)
			$0064		+ 1 km/h		1,00 km/h	(0,62 mph)
			$03E7		+ 9,99 km/h		9,99 km/h	(6,21 mph)
			$FFFF		+ 655,35 km/h		655,35 km/h	(407,21 mph)

Table E.9 — Unit and Scaling ID $09 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display	
			(hex)	(dec.)	(hex)	(dec.)		
09	Speed	1 km/h per bit unsigned	0000	0 km/h	FFFF	65535 km/h	xxxxx km/h (xxxxx mph)	
			Data Range examples:				Display examples:	
	Conversion km/h -> mph: 1 km/h = 0,62137 mph		$0000		0 km/h		0 km/h	(0 mph)
			$0064		+ 100 km/h		100 km/h	(62 mph)
			$03E7		+ 999 km/h		999 km/h	(621 mph)
			$FFFF		+ 65535 km/h		65535 km/h	(40721 mph)

Table E.10 — Unit and Scaling ID $0A definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
0A	Voltage	0,122 mV per bit unsigned	0000	0 V	FFFF	7,99 V	x.xxxx V
			Data Range examples:				Display examples:
	Conversion mV -> V: 1000 mV = 1 V		$0000		0 mV		0,0000 V
			$0001		+ 0,122 mV		0,0001 V
			$2004		+ 999,912 mV		0,9999 V
			$FFFF		+ 7995 mV		7,9953 V

Table E.11 — Unit and Scaling ID $0B definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
0B	Voltage	0,001 V per bit unsigned	0000	0 V	FFFF	65,535 V	xx.xxx V
			Data Range examples:				Display examples:
	Conversion mV -> V: 1000 mV = 1 V		$0000		0 mV		0,000 V
			$0001		+ 1 mV		0,001 V
			$FFFF		+ 65535 mV		65,535 V

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Table E.12 — Unit and Scaling ID $0C definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
0C	Voltage	0.01 V per bit unsigned	0000	0 V	FFFF	655,35 V	xxx.xxx V
			Data Range examples:				Display examples:
	Conversion mV -> V: 1000 mV = 1 V		$0000		0 mV		0.000 V
			$0001		+ 10 mV		0.010 V
			$FFFF		+ 655350 mV		655,350 V

Table E.13 — Unit and Scaling ID $0D definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
0D	Current	0,00390625 mA per bit, unsigned	0000	0 A	FFFF	255,996 mA	xxx.xxx mA
			Data Range examples:				Display examples:
			$0000		0 mA		0,000 mA
			$0001		0,004 mA		0,004 mA
			$8000		+ 128 mA		128,000 mA
			$FFFF		+ 255,996 mA		255,996 mA

Table E.14 — Unit and Scaling ID $0E definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
0E	Current	0,001 A per bit unsigned	0000	0 A	FFFF	65,535 A	xxx.xxx A
			Data Range examples:				Display examples:
	Conversion mA -> A: 1000 mA = 1 A		$0000		0 A		0,000 A
			$8000		+ 32,768 A		32,768 A
			$FFFF		+ 65,535 A		65,535 A

Table E.15 — Unit and Scaling ID $0F definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
0F	Current	0,01 A per bit unsigned	0000	0 A	FFFF	655.35 A	xxx.xxx A
			Data Range examples:				Display examples:
	Conversion mA -> A: 1000 mA = 1 A		$0000		0 mA		0,000 A
			$0001		+ 10 mA		0,010 A
			$FFFF		+ 655350 mA		655,350 A

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Table E.16 — Unit and Scaling ID $10 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment
			(hex)	(dec.)	(hex)	(dec.)	SI (Metric) display
10	Time	1 ms per bit unsigned	0000	0 ms	FFFF	65535 ms	xx.xxx s (x min, xx s)
			Data Range examples:				Display examples:
	Conversion s -> min -> h: 60 s = 1 min 60 min = 1 h		$0000	0 ms			0,000 s (0 min, 0 s)
			$8000	+ 32768 ms			32,768 s (0 min, 33 s)
			$EA60	+ 60000 ms (1 min)			60,000 s (1 min, 0 s)
			$FFFF	+ 65535 ms (1 min, 6 s)			65,535 s (1 min, 6 s)

Table E.17 — Unit and Scaling ID $11 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment
			(hex)	(dec.)	(hex)	(dec.)	SI (Metric) display
11	Time	100 ms per bit unsigned	0000	0 s	FFFF	6553,5 s	xxxx.x s (x h, x min, xx s)
			Data Range examples:				Display examples:
	Conversion s -> min -> h: 60 s = 1 min 60 min = 1 h		$0000	0 s			0,000 s (0 h, 0 min, 0 s)
			$8000	+ 3276.8 s			3276,8 s (0 h, 54 min, 37 s)
			$EA60	+ 6000 s (1 h 40 min)			6000 s (1 h, 40 min, 0 s)
			$FFFF	+ 6553.5 s (1h, 49 min 13 s)			6553,5 s (1 h, 49 min, 13 s)

Table E.18 — Unit and Scaling ID $12 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment
			(hex)	(dec.)	(hex)	(dec.)	SI (Metric) display
12	Time	1 second per bit unsigned	0000	0 s	FFFF	65535 s	xxxxx s (xx h, xx min xx s)
			Data Range examples:				Display examples:
	Conversion s -> min -> h: 60 s = 1 min 60 min = 1 h		$0000	0 s			0 s (0 h, 0 min, 0 s)
			$003C	+ 60 s			60 s (0 h, 1 min, 0 s)
			$0E10	+ 3600 s			3600 s (1 h, 0 min, 0 s)
			$FFFF	+ 65535 s			65535 s (18 h, 12 min, 15 s)

Table E.19 — Unit and Scaling ID $13 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment
			(hex)	(dec.)	(hex)	(dec.)	SI (Metric) display
13	Resistance	1 mOhm per bit unsigned	0000	0 mOhm	FFFF	65535 mOhm	xx.xxx Ohm
	Conversion mOhm -> Ohm: 1000 mOhm = 1 Ohm		Data Range examples:				Display examples:
			$0000	0 mOhm			0,000 Ohm
			$0001	+ 1 mOhm			0,001 Ohm
			$8000	+ 32768 mOhm			32,768 Ohm
			$FFFF	+ 65535 mOhm			65,535 Ohm

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Table E.20 — Unit and Scaling ID $14 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
14	Resistance	1 Ohm per bit unsigned	0000	0 Ohm	FFFF	65535 Ohm	xx.xxx kOhm
			Data Range examples:				Display examples:
	Conversion Ohm -> kOhm: 1000 Ohm = 1 kOhm		$0000		0 Ohm		0,000 kOhm
			$0001		+ 1 Ohm		0,001 kOhm
			$8000		+ 32768 Ohm		32,768 kOhm
			$FFFF		+ 65535 Ohm		65,535 kOhm

Table E.21 — Unit and Scaling ID $15 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
15	Resistance	1 kOhm per bit unsigned	0000	0 kOhm	FFFF	65535 kOhm	xxxxx kOhm
			Data Range examples:				Display examples:
			$0000		0 kOhm		0 kOhm
			$0001		+ 1 kOhm		1 kOhm
			$8000		+ 32768 kOhm		32768 kOhm
			$FFFF		+ 65535 kOhm		65535 kOhm

Table E.22 — Unit and Scaling ID $16 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display	
			(hex)	(dec.)	(hex)	(dec.)		
16	Temperature	(0.1 °C per bit) - 40 °C unsigned	0000	– 40 °C	FFFF	+ 6513.5 °C	xxxx.x °C (xxxxx.x °F)	
			Data Range examples:				Display examples:	
	Conversion °C -> °F: °F = °C * 1.8 + 32 °C		$0000		– 40 °C		– 40,0 °C	(– 40,0 °F)
			$0001		– 39,9 °C		– 39,9 °C	(– 39,8 °F)
			$00DC		– 18,0 °C		– 18,0 °C	(– 0,4 °F)
			$0190		0 °C		0,0 °C	(32,0 °F)
			$FFFF		+ 6513,5 °C		6513,5 °C	(11756,3 °F)

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Table E.23 — Unit and Scaling ID $17 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment
			(hex)	(dec.)	(hex)	(dec.)	SI (Metric) display
17	Pressure (Gauge)	0.01 kPa per bit unsigned	0000	0 kPa	FFFF	655.35 kPa	xxx.xx kPa (Gauge) (xx.x PSI)
Conversion kPa -> PSI:			Data Range examples:				Display examples:
1 kPa (10 HPa) = 0,1450377 PSI			$0000		0 kPa		0,00 kPa (0,0 PSI)
Additional Conversions:			$0001		+ 0,01 kPa		0,01 kPa (0,0 PSI)
1 kPa = 4,0146309 inH2O 1 kPa = 101,9716213 mmH2O (millimetre of water) 1 kPa = 7,5006151 mmHg (millimetre of mercury) 1 kPa = 0,010 bar			$FFFF		+ 655,35 kPa		655,35 kPa (95,1 PSI)

Table E.24 — Unit and Scaling ID $18 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment
			(hex)	(dec.)	(hex)	(dec.)	SI (Metric) display
18	Pressure (Air pressure)	0,0117 kPa per bit unsigned	0000	0 kPa	FFFF	766,76 kPa	xxx.xxx kPa (Air) (xxx.x PSI)
Conversion kPa -> PSI:			Data Range examples:				Display examples:
1 kPa (10 HPa) = 0.1450377 PSI			$0000		0 kPa		0,000 kPa (0,0 PSI)
Additional Conversions:			$0001		+ 0,0117 kPa		0,012 kPa (0,0 PSI)
1 kPa = 4.0146309 inH2O 1 kPa = 101.9716213 mmH2O (millimetre of water) 1 kPa = 7.5006151 mmHg (millimetre of mercury) 1 kPa = 0.010 bar			$FFFF		+ 766,7595 kPa		766,760 kPa (111,2 PSI)

Table E.25 — Unit and Scaling ID $19 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment
			(hex)	(dec.)	(hex)	(dec.)	SI (Metric) display
19	Pressure (Fuel pressure)	0,079 kPa per bit unsigned	0000	0 kPa	FFFF	5177,27 kPa	xxxx.xxx kPa (Gauge) (xxx.x PSI)
Conversion kPa -> PSI:			Data Range examples:				Display examples:
1 kPa (10 HPa) = 0.1450377 PSI			$0000		0 kPa		0,000 kPa (0,0 PSI)
Additional Conversions:			$0001		+ 0,079 kPa		0,079 kPa (0,0 PSI)
1 kPa = 4.0146309 inH2O 1 kPa = 101.9716213 mmH2O (millimetre of water) 1 kPa = 7.5006151 mmHg (millimetre of mercury) 1 kPa = 0.010 bar			$FFFF		+ 5177,265 kPa		5177,265 kPa (750,9 PSI)

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Table E.26 — Unit and Scaling ID $1A definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment
			(hex)	(dec.)	(hex)	(dec.)	SI (Metric) display
1A	Pressure (Gauge)	1 kPa per bit unsigned	0000	0 kPa	FFFF	65535 kPa	xxxxx kPa (Gauge) (xxxx.x PSI)
Conversion kPa -> PSI:			Data Range examples:				Display examples:
1 kPa (10 HPa) = 0.1450377 PSI			$0000		0 kPa		0 kPa (0,0 PSI)
Additional Conversions:			$0001		+ 1 kPa		1 kPa (0,1 PSI)
1 kPa = 4.0146309 inH2O 1 kPa = 101,9716213 mmH2O (millimetre of water) 1 kPa = 7,5006151 mmHg (millimetre of mercury) 1 kPa = 0,010 bar			$FFFF		+ 65535 kPa		65535 kPa (9505,0 PSI)

Table E.27 — Unit and Scaling ID $1B definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment
			(hex)	(dec.)	(hex)	(dec.)	SI (Metric) display
1B	Pressure (Diesel pressure)	10 kPa per bit unsigned	0000	0 kPa	FFFF	655350 kPa	xxxxxx kPa (Gauge) (xxxxx.x PSI)
Conversion kPa ->: PSI			Data Range examples:				Display examples:
1 kPa (10 HPa) = 0,1450377 PSI			$0000		0 kPa		0 kPa (0,0 PSI)
Additional Conversions:			$0001		+ 10 kPa		10 kPa (1,5 PSI)
1 kPa = 4,0146309 inH2O 1 kPa = 101,9716213 mmH2O (millimetre of water) 1 kPa = 7,5006151 mmHg (millimetre of mercury) 1 kPa = 0,010 bar			$FFFF		+ 655350 kPa		655350 kPa (95050,5 PSI)

Table E.28 — Unit and Scaling ID $1C definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment
			(hex)	(dec.)	(hex)	(dec.)	SI (Metric) display
1C	Angle	0,01 ° per bit unsigned	0000	0 °	FFFF	655,35 °	xxx.xx °
			Data Range examples:				Display examples:
			$0000		0 °		0,00 °
			$0001		+ 0,01 °		0,01 °
			$8CA0		+ 360 °		360,00 °
			$FFFF		+ 655,35 °		655,35 °

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Table E.29 — Unit and Scaling ID $1D definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment
			(hex)	(dec.)	(hex)	(dec.)	SI (Metric) display
1D	Angle	0,5 ° per bit unsigned	0000	0 °	FFFF	32767,5 °	xxxxx.x °
			Data Range examples:				Display examples:
			$0000		0 °		0,0 °
			$0001		0,5 °		0,5 °
			$FFFF		32767,5 °		32767,5 °

Table E.30 — Unit and Scaling ID $1E definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment
			(hex)	(dec.)	(hex)	(dec.)	SI (Metric) display
1E	Equivalence ratio (lambda)	0,0000305 per bit unsigned	0000	0	FFFF	1,999	x.xxx lambda
			Data Range examples:				Display examples:
	measured Air/Fuel ratio divided by the stoichiometric Air/Fuel ratio (14,64 for gasoline)		$0000		0		0,000 lambda
			$8013		1		1,000 lambda
			$FFFF		1.999		1,999 lambda

Table E.31 — Unit and Scaling ID $1F definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment
			(hex)	(dec.)	(hex)	(dec.)	SI (Metric) display
1F	Air/Fuel Ratio	0,05 per bit unsigned	0000	0	FFFF	3276,75	xxxx.xx A/F ratio
			Data Range examples:				Display examples:
	measured Air/Fuel ratio NOT divided by the stoichiometric Air/Fuel ratio (14,64 for gasoline)		$0000		0		0,00 A/F ratio
			$0001		0,05		0,05 A/F ratio
			$0014		1,00		1,00 A/F ratio
			$0126		14,7		14,70 A/F ratio
			$FFFF		3276,75		3276,75 A/F ratio

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Table E.32 — Unit and Scaling ID $20 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
20	Ratio	0,0039062 per bit	0000	0	FFFF	255.993	xxx.xxx
		unsigned	Data Range examples:				Display examples:
			$0000		0		0,000
			$0001		0,0039062		0,004
			$FFFF		255,993		255,993

Table E.33 — Unit and Scaling ID $21 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
21	Frequency	1 mHz per bit	0000	0	FFFF	65.535	xx.xxx Hz
		unsigned	Data Range examples:				Display examples:
	Conversion mHz -> Hz -> kHz:		$0000		0 mHz		0,000 Hz
	1000 mHz = 1 Hz		$8000		32768 mHz		32,768 Hz
			$FFFF		65535 mHz		65,535 Hz

Table E.34 — Unit and Scaling ID $22 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
22	Frequency	1 Hz per bit	0000	0 Hz	FFFF	65535 Hz	xxxxx Hz
		unsigned	Data Range examples:				Display examples:
	Conversion Hz -> KHz -> MHz:		$0000		0 Hz		0 Hz
	1000 Hz = 1 KHz		$8000		32768 Hz		32768 Hz
	1000 KHz = 1 MHz		$FFFF		65535 Hz		65535 Hz

Table E.35 — Unit and Scaling ID $23 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
23	Frequency	1 KHz per bit	0000	0 KHz	FFFF	65535 KHz	xx.xxx MHz
		unsigned	Data Range examples:				Display examples:
	Conversion Hz -> KHz -> MHz:		$0000		0 KHz		0,000 MHz
	1000 Hz = 1 KHz		$8000		32768 KHz		32,768 MHz
	1000 KHz = 1 MHz		$FFFF		65535 KHz		65,535 MHz

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Table E.36 — Unit and Scaling ID $24 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
24	Counts	1 count per bit unsigned	0000	0 counts	FFFF	65535	xxxxx counts
			Data Range examples:				Display examples:
			$0000		0 counts		0 counts
			$FFFF		65535 counts		65535 counts

Table E.37 — Unit and Scaling ID $25 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
25	Distance	1 km per bit unsigned	0000	0	FFFF	65535	xxxxx km (xxxxx miles)
			Data Range examples:				Display examples:
	Conversion km -> mile:		$0000		0 km		0 km (0 miles)
	1 km = 0,62137 miles		$FFFF		65535 km		65535 km (40721 miles)

Table E.38 — Unit and Scaling ID $26 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
26	Voltage per time	0,1 mV/ms per bit unsigned	0000	0 V/ms	FFFF	6,5535 V/ms	xx.xxxx V/ms
	Conversion mV/ms -> V/ms:		Data Range examples:				Display examples:
	1000 mV/ms = 1 V/ms		$0000		0 mV/ms		0,0000 V/ms
			$0001		0,1 mV/ms		0,0001 V/ms
			$FFFF		+ 6553,5 mV/ms		6,5535 V/ms

Table E.39 — Unit and Scaling ID $27 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
27	Mass per time	0.01 g/s per bit unsigned	0000	0 g/s	FFFF	655.35 g/s	xxx.xx g/s (x.xxx lb/s)
			Data Range examples:				Display examples:
	Conversion g/s -> lb/s:		$0000		0 g/s		0,00 g/s (0,000 lb/s)
	1 g/s = 0.0022046 lb/s		$0001		+ 0,01 g/s		0,01 g/s (0,000 lb/s)
			$FFFF		+ 655,35 g/s		655,35 g/s (1,445 lb/s)

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Table E.40 — Unit and Scaling ID $28 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
28	Mass per time	1 g/s per bit unsigned	0000	0 g/s	FFFF	65535 g/s	xxxxx g/s (xxx.xx lb/s)
			Data Range examples:				Display examples:
	Conversion g/s -> lb/s: 1 g/s = 0,0022046 lb/s		$0000	0 g/s			0 g/s (0,00 lb/s)
			$0001	+ 1 g/s			1 g/s (0,00 lb/s)
			$FFFF	+ 65535 g/s			65535 g/s (144,48 lb/s)

Table E.41 — Unit and Scaling ID $29 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
29	Pressure per time	0.25 Pa/s per bit unsigned	0000	0 kPa/s	FFFF	16.384 kPa/s	xx.xxx kPa/s (xx.xxx inH2O/s)
Conversion: inH2O/s -> kPa/s			Data Range examples:				Display examples:
1 inH2O/s = 0.2490889 kPa/s			$0000	0 Pa/s	0 inH2O/s		0,000 kPa/s (0,000 inH2O/s)
(inch of water) 1 inH2O = 249.0889 Pa			$0004	+ 1 Pa/s	+ 4,015 inH2O/s		0,001 kPa/s (4,015 inH2O/s)
(millimetre of water) 1 mmH2O = 9.80665 Pa (millimetre of mercury) 1 mmHg = 133.3224 Pa			$FFFF	+ 16384 Pa/s	+ 65,5348 inH2O/s		16,384 kPa/s (65,775 inH2O/s)

Table E.42 — Unit and Scaling ID $2A definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
2A	Mass per time	0,001 kg/h per bit unsigned	0000	0 kg/h	FFFF	65,535 kg/h	xx.xxx kg/h
	Conversion lbs/s -> kg/h: 1 lbs/s = 0,4535924 kg/h		Data Range examples:				Display examples:
			$0000	0 kg/h			0,000 kg/h
			$0001	+ 0,001 kg/h			0,001 kg/h
			$FFFF	+ 65,535 kg/h			65,535 kg/h

Table E.43 — Unit and Scaling ID $2B definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
2B	Switches	hex to decimal unsigned	0000	0	FFFF	65535	xxxxx switches
			Data Range examples:				Display examples:
			$0000	0 switches			0 switches
			$0001	+ 1 switches			1 switches
			$FFFF	+ 65535 switches			65535 switches

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Table E.44 — Unit and Scaling ID $2C definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
2C	mass per cylinder	0,01 g/cyl per bit unsigned	0000	0 g/cyl	FFFF	655,35 g/cyl	xxx.xx g/cyl
			Data Range examples:				Display examples:
			$0000		0 g/cyl		0,00 g/cyl
			$0001		+ 0,01 g/cyl		0,01 g/cyl
			$FFFF		+ 655,35 g/cyl		655,35 g/cyl

Table E.45 — Unit and Scaling ID $2D definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
2D	Mass per stroke	0,01 mg/stroke unsigned	0000	0 mg/stroke	FFFF	655,35 mg/stroke	xxx.xx mg/stroke
			Data Range examples:				Display examples:
			$0000		0 mg/stroke		0,00 mg/stroke
			$0001		+ 0,01 mg/stroke		0,01 mg/stroke
			$FFFF		+ 655,35 mg/stroke		655,35 mg/stroke

Table E.46 — Unit and Scaling ID $2E definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
2E	True/False	state encoded unsigned	0000	false	0001	true	
			Data Range examples:				Display examples:
			$0000		false		false
			$0001		true		true

Table E.47 — Unit and Scaling ID $2F definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
2F	Percent	0,01 % per bit unsigned	0000	0 %	FFFF	655,35 %	xxx.xx %
			Data Range examples:				Display examples:
			$0000		0 %		0,00 %
			$0001		+ 0,01 %		0,01 %
			$2710		+ 100 %		100,00 %
			$FFFF		+ 655,35 %		655,35 %

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Table E.48 — Unit and Scaling ID $30 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
30	Percent	0,001526 % per bit, unsigned	0000	0 %	FFFF	100,00 %	xxx.xx %
			Data Range examples:				Display examples:
			$0000		0 %		0,00 %
			$0001		+ 0,001526 %		0,00 %
			$FFFF		+ 100,00641 %		100,00 %

Table E.49 — Unit and Scaling ID $31 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
31	volume	0,001 L per bit, unsigned	0000	0 L	FFFF	65,535 L	xx.xxx L
			Data Range examples:				Display examples:
			$0000		0 L		0,000 L
			$0001		+ 0,001 L		0,001 L
			$FFFF		+ 65,535 L		65,535 L

Table E.50 — Unit and Scaling ID $32 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
32	length	0,0000305 inch per bit, unsigned	0000	0 inch	FFFF	1,999 inch	xx.xxx mm (x.xxx inch)
			Data Range examples:				Display examples:
	1 inch = 25,4 mm		$0000		0 inch		0,000 mm (0.000 inch)
			:		:		:
			$0010		+ 0,0004880 inch		0,012 mm (0.000 inch)
			$0011		+ 0,0005185 inch		0,013 mm (0.001 inch)
			$FFFF		+ 1,9988175 inch		50,770 mm (1.999 inch)

Table E.51 — Unit and Scaling ID $33 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
33	Equivalence ratio (lambda)	0,00024414 per bit, unsigned	0000	0	FFFF	15,99976	xx.xx lambda
			Data Range examples:				Display examples:
	measured Air/Fuel ratio divided by the stoichiometric Air/Fuel ratio (14,64 for gasoline)		$0000		0		0,00 lambda
			$0001		0,00		0,00 lambda
			$1000		1,00		1,00 lambda
			$E5BE		14,36		14,36 lambda
			$FFFF		16,00		16,00 lambda

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Table E.52 — Unit and Scaling ID $34 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value (hex)	Min. value (dec.)	Max. value (hex)	Max. value (dec.)	External test equipment SI (Metric) display
34	Time	1 minute per bit unsigned	0000	0	FFFF	65535	xx days, xx h, xx min
			Data Range examples:				Display examples:
	Conversion s -> min -> h: 60 min = 1 h 24 h = 1 day		$0000		0 min		0 days, 0 h, 0 min
			$003C		+ 60 min		0 days, 1 h, 0 min
			$0E10		+ 3,600 min		2 days, 12 h, 0 min
			$FFFF		+ 65,535 min		45 days, 12 h, 15 min

Table E.53 — Unit and Scaling ID $35 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value (hex)	Min. value (dec.)	Max. value (hex)	Max. value (dec.)	External test equipment SI (Metric) display
35	Time	10 ms per bit unsigned	0000	0	FFFF	655,350	xxx.xx s (x min, xx s)
			Data Range examples:				Display examples:
	Conversion s -> min -> h: 60 s = 1 min 60 min = 1 h		$0000		0 ms		0,00 s (0 min, 0 s)
			$8000		+ 327,680 ms		327,68 s (5 min, 28 s)
			$EA60		+ 600,000 ms		600,00 s (10 min, 0 s)
			$FFFF		+ 655,350 ms		655,35 s (10 min, 55 s)

Table E.54 — Unit and Scaling ID $36 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value (hex)	Min. value (dec.)	Max. value (hex)	Max. value (dec.)	External test equipment SI (Metric) display
36	Weight	0,01 g per bit unsigned	0000	0	FFFF	65535	xxx.xx g (x.xxx lbs)
			Data Range examples:				Display examples:
	Conversion g -> lbs: 1 lbs = 453 g		$0000		0 g		0,00 g (0.000 lbs)
			$0052		+ 0,82 g		0,82 g (0.002 lbs)
			$0E21		+ 36,17 g		36,17 g (0.079 lbs)
			$FFFF		+ 655,35 g		655,35 g (1.447 lbs)

Table E.55 — Unit and Scaling ID $37 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value (hex)	Min. value (dec.)	Max. value (hex)	Max. value (dec.)	External test equipment SI (Metric) display
37	Weight	0,1 g per bit unsigned	0000	0	FFFF	65535	x,xxx.xx g (xx.xxx lbs)
			Data Range examples:				Display examples:
	Conversion g -> lbs: 1 lbs = 453 g		$0000		0 g		0,00 g (0.000 lbs)
			$0052		+ 8,20 g		8,20 g (0.018 lbs)
			$0E21		+ 361,7 g		361,70 g (0.798 lbs)
			$FFFF		+ 6553,5 g		6553,50 g (14.467 lbs)

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Table E.56 — Unit and Scaling ID $38 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value (hex)	Min. value (dec.)	Max. value (hex)	Max. value (dec.)	External test equipment SI (Metric) display
38	Weight	1 g per bit unsigned	0000	0	FFFF	65535	xx,xxx g (xxx.xx lbs)
			Data Range examples:				Display examples:
	Conversion g -> lbs: 1 lbs = 453 g		$0000		0 g		0 g (0.00 lbs)
			$0052		+ 82 g		82 g (0.18 lbs)
			$0E21		+ 3617 g		3617 g (7.98 lbs)
			$FFFF		+ 65535 g		65535 g (144.67 lbs)

Table E.57 — Unit and Scaling ID $39 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value (hex)	Min. value (dec.)	Max. value (hex)	Max. value (dec.)	External test equipment SI (Metric) display
39	Percent	0.01% per bit unsigned	0000	– 327.68 %	FFFF	+ 327.67 %	xxx.xx %
			Data Range examples:				Display examples:
	Conversion H = E*100 – 32768		$0000		– 327.68 %		– 327.68 %
			$58F0		– 100.00%		– 100.00 %
			$7FFF		– 0.01 %		– 0.01 %
			$8000		0 %		0.00 %
			$8001		+ 0.01 %		+ 0.01 %
			$A710		+ 100 %		+ 100.00 %
			$FFFF		+ 327.67 %		+ 327.67 %

Unit And Scaling Identifiers in the unsigned range of $01 through $7F, which are not specified, are ISO/SAE reserved. Additional Scaling Identifiers shall be submitted to the SAE Vehicle E/E System Diagnostic Standards Committee or ISO/TC22/SC3/WG1 to consider for implementation in this document.

E.2 Signed Unit and Scaling Identifiers definition

Table E.58 — Unit and Scaling ID $81 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value (hex)	Min. value (dec.)	Max. value (hex)	Max. value (dec.)	External test equipment SI (Metric) display
81	Raw Value	1 per bit hex to decimal signed	8000	– 32768	7FFF	+ 32767	xxxxx
			Data Range examples:				Display examples:
			$8000		– 32768		– 32768
			$FFFF		– 1		– 1
			$0000		0		0
			$0001		+ 1		1
			$7FFF		+ 32767		32767

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Table E.59 — Unit and Scaling ID $82 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
82	Raw Value	0.1 per bit hex to decimal signed	8000	– 3276,8	7FFF	+ 3276.7	xxxx.x
			Data Range examples:				Display examples:
			$8000		– 3276,8		– 3276,8
			$FFFF		– 0,1		– 0,1
			$0000		0		0,0
			$0001		+ 0,1		0,1
			$7FFF		+ 3276,7		3276,7

Table E.60 — Unit and Scaling ID $83 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
83	Raw Value	0,01 per bit hex to decimal signed	8000	– 327,68	7FFF	+ 327,67	xxx.xx
			Data Range examples:				Display examples:
			$8000		– 327,68		– 327,68
			$FFFF		– 0,01		– 0,01
			$0000		0		0,00
			$0001		+ 0,01		0,01
			$7FFF		+ 327,67		327,67

Table E.61 — Unit and Scaling ID $84 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
84	Raw Value	0,001 per bit hex to decimal signed	8000	-32,768	7FFF	+ 32,767	xx.xxx
			Data Range examples:				Display examples:
			$8000		– 32,768		– 32,768
			$FFFF		– 0,001		– 0,001
			$0000		0		0,000
			$0001		+ 0,001		0,001
			$7FFF		+ 32,767		32,767

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Table E.62 — Unit and Scaling ID $85 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
85	Raw Value	0,0000305 per bit hex to decimal signed	8000	-0,999	7FFF	0,999	x.xxx
			Data Range examples:				Display examples:
			$8000		– 0,999424		– 0,999
			$FFFF		– 0,0000305		0,000
			$0000		0		0,000
			$0001		+ 0,0000305		0,000
			$7FFF		+ 0,999394		0,999

Table E.63 — Unit and Scaling ID $86 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
86	Raw Value	0,000305 per bit hex to decimal signed	8000	– 9,994	7FFF	9,994	x.xxx
			Data Range examples:				Display examples:
			$8000		– 9,99424		– 9,994
			$FFFF		– 0,000305		0,000
			$0000		0		0,000
			$0001		+ 0,000305		0,000
			$7FFF		+ 9,99394		9,994

Table E.64 — Unit and Scaling ID $8A definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
8A	Voltage	0,122 mV per bit signed	8000	– 3,9977 V	7FFF	3,9976 V	x.xxxx V
			Data Range examples:				Display examples:
	Conversion mV -> V: 1000 mV = 1 V		$8000		– 3997,696 mV		– 3,9977 V
			$FFFF		– 0,122 mV		– 0,0001 V
			$0000		0 mV		0,0000 V
			$0001		0,122 mV		0,0001 V
			$7FFF		+ 3997,574 mV		3,9976 V

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Table E.65 — Unit and Scaling ID $8B definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
8B	Voltage	0,001 V per bit, signed	8000	– 32,768 V	7FFF	32,767 V	xx.xxx V
			Data Range examples:				Display examples:
	Conversion mV -> V: 1000 mV = 1 V		$8000		– 32768 mV		– 32,768 V
			$FFFF		– 1 mV		– 0,001 V
			$0000		0 mV		0,000 V
			$0001		1 mV		0,001 V
			$7FFF		+ 32767 mV		32,767 V

Table E.66 — Unit and Scaling ID $8C definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
8C	Voltage	0,01 V per bit, signed	8000	– 327,68 V	7FFF	327,67 V	xxx.xx V
			Data Range examples:				Display examples:
	Conversion mV -> V: 1000 mV = 1 V		$8000		– 327680 mV		– 327,68 V
			$FFFF		– 10 mV		– 0,01 V
			$0000		0 mV		0,00 V
			$0001		+ 10 mV		0,01 V
			$7FFF		+ 327670 mV		327,67 V

Table E.67 — Unit and Scaling ID $8D definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
8D	Current	0,00390625 mA per bit, signed	8000	– 128.0 mA	7FFF	127.996 mA	xxx.xxx mA
			Data Range examples:				Display examples:
			$8000		– 128 mA		– 128,000 mA
			$FFFF		– 0,00390625 mA		– 0,004 mA
			$0000		+ 0 mA		0,000 mA
			$0001		0,00390625 mA		0,004 mA
			$FFFF		+ 127,996 mA		127,996 mA

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Table E.68 — Unit and Scaling ID $8E definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value (hex)	Min. value (dec.)	Max. value (hex)	Max. value (dec.)	External test equipment SI (Metric) display
8E	Current	0,001 A per bit, signed	8000	– 32,768 A	7FFF	32,767 A	xx.xxx A
			Data Range examples:				Display examples:
	Conversion mA -> A: 1000 mA = 1 A		$8000		– 32768 mA		– 32,768 A
			$FFFF		– 1 mA		– 0,001 A
			$0000		0 mA		0,000 A
			$0001		+ 1 mA		0,001 A
			$7FFF		+ 32767 mA		32,767 A

Table E.69 — Unit and Scaling ID $90 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value (hex)	Min. value (dec.)	Max. value (hex)	Max. value (dec.)	External test equipment SI (Metric) display
90	Time	1 ms per bit, signed	8000	– 32,768 s	7FFF	+ 32,767 s	xx.xxx s
			Data Range examples:				Display examples:
			$8000		– 32768 ms		– 32,768 s
			$0001		+ 1 ms		+ 0,001 s
			$7FFF		+ 32767 ms		+ 32,767 s

Table E.70 — Unit and Scaling ID $96 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value (hex)	Min. value (dec.)	Max. value (hex)	Max. value (dec.)	External test equipment SI (Metric) display	
96	Temperature	0,1 °C per bit, signed	8000	– 3276,8 °C	7FFF	+ 3276,7 °C	xxxx.x °C (xxxx.x °F)	
			Data Range examples:				Display examples:	
	Conversion °C -> °F: °F = °C * 1.8 + 32 °C		$8000		– 3276,8 °C		– 3276,8 °C	(– 5886,2 °F)
			$FE70		– 40 °C		– 40,0 °C	(– 40,0 °F)
			$FFFF		– 0,1 °C		-0,1 °C	(31,8 °F)
			$0000		0 °C		0,0 °C	(32,0 °F)
			$0001		+ 0,1 °C		0,1 °C	(32,2 °F)
			$4E20		+ 2000 °C		2000,0 °C	(3632,0 °F)
			$7FFF		+ 3276,7 °C		3276,7 °C	(5930,1 °F)

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Table E.71 — Unit and Scaling ID $9C definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
9C	Angle	0,01° per bit, signed	8000	– 327,68 °	7FFF	327,67 °	xxx.xx °
			Data Range examples:				Display examples:
			$8000		– 327,68 °		– 327,68 °
			$F060		– 40 °		– 40,00 °
			$FFFF		– 0,01 °		– 0,01 °
			$0000		0 °		0,00 °
			$0FA0		+ 40 °		+ 40,00 °
			$7FFF		+ 327,67 °		+ 327,67 °

Table E.72 — Unit and Scaling ID $9D definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
9D	Angle	0,5° per bit, signed	8000	-16384 °	7FFF	16383,5 °	xxxxx.x °
			Data Range examples:				Display examples:
			$8000		– 16384 °		– 16384,0 °
			$FF60		– 80 °		– 80,0 °
			$FFFF		– 0,5 °		– 0,5 °
			$0000		0 °		0,0 °
			$0001		+ 0,5 °		0,5 °
			$00A0		+ 80 °		80,0 °
			$7FFF		+ 16383,5 °		16383,5 °

Table E.73 — Unit and Scaling ID $A8 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
A8	Mass per time	1 g/s per bit, signed	8000	– 32768 g/s	7FFF	+ 32767 g/s	xxxxx g/s (xx.xx lb/s)
			Data Range examples:				Display examples:
	Conversion g/s -> lb/s:		$8000		– 32768 g/s		– 32768 g/s (– 72.24 lb/s)
	1 g/s = 0.0022046 lb/s		$FFFF		– 1 g/s		– 1 g/s (– 0.00 lb/s)
			$0000		0 g/s		0 g/s (0.00 lb/s)
			$0001		+ 1 g/s		1 g/s (0.00 lb/s)
			$7FFF		+ 32767 g/s		32767 g/s (72.24 lb/s)

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Table E.74 — Unit and Scaling ID $A9 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
A9	Pressure per time	0,25 Pa/s per bit signed	8000	– 8192 Pa/s	7FFF	8191,75 Pa/s	xxxx.xx Pa/s (xx.xxx inH2O/s)
	Conversion Pa -> inH2O		Data Range examples:				Display examples:
	1 Pa = 0.0040146309 inH2O		$8000	– 8192 Pa/s			– 8192,00 Pa/s (– 32,888 inH2O/s)
			$FFFC	– 1 Pa/s			– 1,00 Pa/s (– 0,004 inH2O/s)
			$0000	0 Pa/s			0,00 Pa/s (0,000 inH2O/s)
			$0004	+ 1 Pa/s			1,00 Pa/s (0,004 inH2O/s)
			$7FFF	+ 8191,75 Pa/s			8191,75 Pa/s (32,887 inH2O/s)

Table E.75 — Unit and Scaling ID $AF definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
AF	Percent	0,01 % per bit, signed	8000	– 327,68 %	7FFF	+ 327,67 %	xxx.xx %
			Data Range examples:				Display examples:
			$8000	– 327,68 %			– 327,68 %
			$D8F0	– 100 %			– 100,00 %
			$FFFF	– 0,01 %			– 0,10 %
			$0000	0 %			0,00 %
			$0001	+ 0,01 %			0,10 %
			$2710	+ 100 %			100,00 %
			$7FFF	+ 327,67 %			+ 327,67 %

Table E.76 — Unit and Scaling ID $B0 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value		Max. value		External test equipment SI (Metric) display
			(hex)	(dec.)	(hex)	(dec.)	
B0	Percent	0,003052 % per bit, signed	8000	– 100,01 %	7FFF	+ 100,00 %	xxx.xx %
			Data Range examples:				Display examples:
			$8000	– 100,007936 %			– 100,01 %
			$FFFF	– 0,003052 %			0,00 %
			$0000	0 %			0,00 %
			$0001	+ 0,003052 %			0,00 %
			$7FFF	+ 100,004884 %			+ 100,00 %

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Table E.77 — Unit and Scaling ID $B1 definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value (hex)	Min. value (dec.)	Max. value (hex)	Max. value (dec.)	External test equipment SI (Metric) display
B1	Voltage per time	2 mV/s per bit signed	8000	– 65536 mV/s	7FFF	65534 mV/s	xxxxx mV/s
			Data Range examples:				Display examples:
			$8000	– 65536 mV/s			– 65536 mV/s
			$FFFF	– 2 mV/s			– 2 mV/s
			$0000	0 mV/s			0 mV/s
			$0001	+ 2 mV/s			+ 2 mV/s
			$7FFF	+ 65534 mV			+ 65534 mV

Table E.78 — Unit and Scaling ID $FD definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value (hex)	Min. value (dec.)	Max. value (hex)	Max. value (dec.)	External test equipment SI (Metric) display
FD	Pressure (absolute)	0,001 kPa per bit, signed	8000	– 32,768 kPa	7FFF	+ 32,767 kPa	xx.xxx kPa
			Data Range examples:				Display examples:
			$8000	– 32,768 kPa			– 32,768 kPa
			$0001	+ 0,001 kPa			+ 0,001 kPa
			$7FFF	+ 32,767 kPa			+ 32,767 kPa

Table E.79 — Unit and Scaling ID $FE definition

Unit and Scaling ID (hex)	Description	Scaling/bit	Min. value (hex)	Min. value (dec.)	Max. value (hex)	Max. value (dec.)	External test equipment SI (Metric) display	
FE	Pressure (vacuum)	0,25 Pa per bit signed	8000	– 8192 Pa	7FFF	8191,75 Pa	xxxx.xx Pa (xx.xxx inH2O)	
Conversion Pa -> inH2O			Data Range examples:				Display examples:	
1 Pa = 0.0040146309 inH2O			$8000	– 8192 Pa			– 8192,00 Pa	(– 32,888 inH2O)
			$FFFC	– 1 Pa			– 1,00 Pa	(– 0,004 inH2O)
			$0000	0 Pa			0,00 Pa	(0,000 inH2O)
			$0004	+ 1 Pa			1,00 Pa	(0,004 inH2O)
			$7FFF	+ 8191,75 Pa			8191,75 Pa	(32,887 inH2O)

Unit And Scaling Identifiers in the signed range of $80 through $FE, which are not specified, are ISO/SAE reserved. Additional Scaling identifiers shall be submitted to the SAE Vehicle E/E System Diagnostic Standards Committee or ISO/TC22/SC3/WG1 to consider for implementation in this part of ISO 15031.

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Annex F
(normative)

TIDs (Test ID) for Service $08 scaling and definition

Table F.1 — Test ID description

Test ID #	Description
$01	**Evaporative system leak test** For ISO 9141-2, ISO 14230-4 and SAE J1850, DATA_A - DATA_E should be set to $00 for a request and response message. If the conditions are not proper to run the test, the vehicle may either not respond to the request, or may respond with a manufacturer-specified value as DATA_A which corresponds to the reason the test cannot be run. For ISO 15765-4 protocol, DATA_A - DATA_E shall not be included in the request and response message. If the conditions are not proper to run the test, the vehicle shall respond with a negative response message with a response code $22 – conditionsNotCorrect. This service enables the conditions required to conduct an evaporative system leak test, but does not actually run the test. An example is to close a purge solenoid, preventing leakage if the system is pressurized. The vehicle manufacturer is responsible to determine the criteria to automatically stop the test (open the solenoid in the example) such as engine running, vehicle speed greater than zero, or exceeding a specified time period.
$02 – $FF	ISO/SAE reserved

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Annex G
(normative)

INFOTYPEs for Service $09 scaling and definition

Table G.1 — MessageCount VIN data byte description

InfoType (Hex)	Vehicle information data byte description	Scaling	Mnemonic
01	**MessageCount VIN** Number of messages to report Vehicle Identification Number (VIN) — For ISO 9141-2, ISO 14230-4 and SAE J1850, the message count in the response shall always be $05, and shall be reported for consistency in the use of this service. For ISO 15765-4, support for this parameter is not recommended/required for the ECU and the external test equipment. The response message format is not specified.	1 byte unsigned numeric	MC_VIN

Table G.2 — Vehicle Identification Number data byte description

InfoType (Hex)	Description	Scaling	External test equipment SI (Metric) / English display
02	**Vehicle Identification Number**	17 ASCII characters	VIN: XXXXXXXXXXXXXXXXX
	For vehicles that provide electronic access to the VIN, it is recommended to report it using this format for ease of use by the external test equipment intended either for vehicle diagnostics or Inspection/Maintenance programmes. For ISO 9141-2, ISO 14230-4 and SAE J1850, the response consists of the following messages: — Message #1 shall contain three (3) filling bytes of $00, followed by VIN character #1; — Message #2 shall contain VIN characters #2 to #5 inclusive; — Message #3 shall contain VIN characters #6 to #9 inclusive; — Message #4 shall contain VIN characters #10 to #13 inclusive; — Message #5 shall contain VIN characters #14 to #17 inclusive. For ISO 15765-4, there is only one response message, which contains all VIN characters without any filling bytes.		

Table G.3 — MessageCount CALID data byte description

InfoType (Hex)	Vehicle information data byte description	Scaling	Mnemonic
03	**MessageCount CALID** Number of messages to report calibration identifications — For ISO 9141-2, ISO 14230-4 and SAE J1850, the message count in the response shall always be a multiple of four (4) because four (4) messages are used to report each calibration identification. For ISO 15765-4, support for this parameter is not recommended/required for the ECU and the external test equipment. The response message format is not specified.	1 byte unsigned numeric	MC_CALID

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Table G.4 — Calibration Identifications data byte description

InfoType (Hex)	Description	Scaling	External test equipment SI (Metric) / English display
04	**Calibration Identifications**	16 ASCII characters	CALID: XXXXXXXXXXXXXXXX
	Multiple calibration identifications may be reported for a controller, depending on the software architecture. Calibration identifications can include a maximum of sixteen (16) characters. Each calibration identification can contain only printable ASCII characters, and will be reported as ASCII values. Any unused data bytes shall be reported as $00 and filled at the end of the calibration identification. Calibration identifications shall uniquely identify the software installed in the ECU. If regulations require calibration identifications for emission-related software, those shall be reported in a standardized format. Calibrations developed by any entity other than the vehicle manufacturer shall also contain unique calibration identification to indicate that a calibration is installed in the vehicle that is different from that developed by the vehicle manufacturer. Vehicle controllers that contain calibration identifications shall store and report sixteen (16) ASCII-character calibration identifications, even though they may not use all sixteen (16) characters. This will allow modified calibration IDs to be reported that include additional characters.		

Table G.5 — MessageCount CVN data byte description

InfoType (Hex)	Vehicle information data byte description	Scaling	Mnemonic
05	**MessageCount CVN** Number of messages to report Calibration Verification Numbers — For ISO 9141-2, ISO 14230-4 and SAE J1850, the message count in the response shall be the number of CVNs to report, because one message is required to report each CVN. For ISO 15765-4, support for this parameter is not recommended/required for the ECU and the external test equipment. The response message format is not specified.	1 byte unsigned numeric	MC_CVN

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Table G.6 — Calibration Verification Numbers data byte description

InfoType (Hex)	Description	Scaling	External test equipment SI (Metric) / English display
06	**Calibration Verification Numbers**	4 byte hex (most significant byte reported as Data A)	CVN: XXXXXXXX
	A Calibration Verification Number (CVN) is used to verify the integrity of the vehicle software. The vehicle manufacturer is responsible for determining how many CVNs are required and how the CVNs are calculated, e.g. checksum, and the areas of memory to be included in each calculation. If regulations require calibration verification numbers for emission-related software, those shall be reported in a standardized format. Each calibration, as identified by a calibration ID number (InfoType $04), shall also have at least one unique calibration verification number (CVN) unless the entire ECU is not programmable. The CVN (or group of CVNs) assigned to a CALID shall be reported in the same order as the CALIDs are reported to the external test equipment. Two (2) response methods to report the CVN(s) to an external test equipment are allowed. The method to be implemented in the vehicle is specified by the applicable regulations. — Method #1: The CVN(s) shall not be computed on demand, but instead shall be computed at least once per trip. A trip shall be of reasonable length (e.g. 5 to 10 min). The computed CVN(s) shall be stored in NVM (Non Volatile Memory) for immediate access by the external test equipment. Once the computation is completed for the first time after a reprogramming event of the ECU(s) or a battery disconnect, the results shall be made available to the external test equipment, even if the engine is running. If the CVN(s) are requested before they have been computed, a negative response message with response code $78 – RequestCorrectlyReceived-ResponsePending shall be sent by the ECU(s) until the positive response message is available for the ISO 14230-4 and ISO 15765-4 protocols. For ISO 9141-2 and SAE J1850 protocols, the external test equipment and ECU(s) shall behave as specified in 5.2.4.3.2 and Figure 11. — Method #2: If method #1 does not apply, the on-board software of the ECU(s) shall compute the CVN(s) on an external test equipment request message. If the ECU(s) are not able to send an immediate positive response message, a negative response message with response code $78 – RequestCorrectlyReceived-ResponsePending shall be sent by the ECU(s) until the positive response message is available for the ISO 14230-4 and ISO 15765-4 protocols. For ISO 9141-2 and SAE J1850 protocols, the external test equipment and ECU(s) shall behave as specified in 5.2.4.3.2 and Figure 11. Calibrations developed by any entity other than the vehicle manufacturer will generally have a calibration verification number that is different from that calculated based on the calibration developed by the vehicle manufacturer. If the calculation technique does not use all four (4) bytes, the CVN shall be right justified and filled with $00.		

Table G.7 — MessageCount IPT data byte description

InfoType (Hex)	Vehicle information data byte description	Scaling	Mnemonic
07	**MessageCount IPT** Number of messages to report In-use Performance Tracking — For ISO 9141-2, ISO 14230-4 and SAE J1850, the message count in the response shall be $08, because at this time sixteen (16) values are required to be reported, and one message is required to report two values. For ISO 15765-4, support for this parameter is not recommended/required for the ECU and the external test equipment. The response message format is not specified.	1 byte unsigned numeric	MC_IPT

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Table G.8 — In-use Performance Tracking data byte description

InfoType (Hex)	Description	# of data bytes	External test equipment SI (Metric) / English display
08	**In-use Performance Tracking**	32 bytes	IPT:
	Scaling: unsigned numeric (most significant byte reported as Data A). This data is used to support possible regulatory requirements for In-use Performance Tracking. Manufacturers are required to implement software algorithms that track in-use performance for each of the following components: catalyst bank 1, catalyst bank 2, primary oxygen sensor bank 1, primary oxygen sensor bank 2, evaporative 0,020" leak detection system, EGR system, and secondary air system. The numerator for each component or system shall track the number of times that all conditions necessary for a specific monitor to detect a malfunction have been encountered. The denominator for each component or system shall track the number of times that the vehicle has been operated in the specified conditions. These conditions are specified for each monitored component or system. The ignition counter shall track the number of times that the engine has been started. All data items of the In-use Performance Tracking record shall be reported in the order as listed in this table. Data values, which are not implemented (e.g. bank 2 of the catalyst monitor of a 1-bank system) shall be reported as $0000. If a vehicle utilizes Variable Valve Timing (VVT) in place of EGR, the VVT in-use data shall be reported in place of the EGR in-use data. If a vehicle utilizes both an EGR system and a VVT system, the ECU shall track the in-use performance data for both monitors, but shall report only the data for the system with the lowest numerical ratio. If a vehicle utilizes an evaporative system monitor that is certified to 0,040" requirements instead of 0,020" requirements, the ECU shall report the 0,040" monitor in-use performance data in place of the 0,020" in-use performance data.		
	OBD Monitoring Conditions Encountered Counts	2 bytes	OBDCOND: xxxxx cnts
	OBD Monitoring Conditions Encountered Counts displays the number of times that the vehicle has been operated in the specified OBD monitoring conditions (general denominator).		
	Ignition Cycle Counter	2 bytes	IGNCYCCNTR: xxxxx cnts
	Ignition Cycle Counter displays the count of the number of times that the engine has been started.		
	Catalyst Monitor Completion Counts Bank 1	2 bytes	CATCOMP1: xxxxx cnts
	Catalyst Monitor Completion Counts Bank 1 displays the number of times that all conditions necessary to detect a catalyst system bank 1 malfunction have been encountered (numerator).		
	Catalyst Monitor Conditions Encountered Counts Bank 1	2 bytes	CATCOND1: xxxxx cnts
	Catalyst Monitor Conditions Encountered Counts Bank 1 displays the number of times that the vehicle has been operated in the specified catalyst monitoring conditions (denominator).		
	Catalyst Monitor Completion Counts Bank 2	2 bytes	CATCOMP2: xxxxx cnts
	Catalyst Monitor Completion Counts Bank 2 displays the number of times that all conditions necessary to detect a catalyst system bank 2 malfunction have been encountered (numerator).		
	Catalyst Monitor Conditions Encountered Counts Bank 2	2 bytes	CATCOND2: xxxxx cnts
	Catalyst Monitor Conditions Encountered Counts Bank 2 displays the number of times that the vehicle has been operated in the specified catalyst monitoring conditions (denominator).		
	O2 Sensor Monitor Completion Counts Bank 1	2 bytes	O2SCOMP1: xxxxx cnts
	O2 Sensor Monitor Completion Counts Bank 1 displays the number of times that all conditions necessary to detect an oxygen sensor bank 1 malfunction have been encountered (numerator).		
	O2 Sensor Monitor Conditions Encountered Counts Bank 1	2 bytes	O2SCOND1: xxxxx cnts
	O2 Sensor Monitor Conditions Encountered Counts Bank 1 displays the number of times that the vehicle has been operated in the specified oxygen sensor monitoring conditions (denominator).		

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Table G.8 (*continued*)

InfoType (Hex)	Description	# of data bytes	External test equipment SI (Metric) / English display
	O2 Sensor Monitor Completion Counts Bank 2	2 bytes	O2SCOMP2: xxxxx cnts
	O2 Sensor Monitor Completion Counts Bank 2 displays the number of times that all conditions necessary to detect an oxygen sensor bank 2 malfunction have been encountered (numerator).		
	O2 Sensor Monitor Conditions Encountered Counts Bank 2	2 bytes	O2SCOND2: xxxxx cnts
	O2 Sensor Monitor Conditions Encountered Counts Bank 2 displays the number of times that the vehicle has been operated in the specified oxygen sensor monitoring conditions (denominator).		
	EGR/VVT Monitor Completion Condition Counts	2 bytes	EGRCOMP: xxxxx cnts
	EGR/VVT Monitor Completion Condition Counts displays the number of times that all conditions necessary to detect an EGR/VVT system malfunction have been encountered (numerator).		
	EGR/VVT Monitor Conditions Encountered Counts	2 bytes	EGRCOND: xxxxx cnts
	EGR/VVT Monitor Conditions Encountered Counts displays the number of times that the vehicle has been operated in the specified EGR/VVT system monitoring conditions (denominator).		
	AIR Monitor Completion Condition Counts (Secondary Air)	2 bytes	AIRCOMP: xxxxx cnts
	AIR Monitor Completion Condition Counts (Secondary Air) displays the number of times that all conditions necessary to detect an AIR system malfunction have been encountered (numerator).		
	AIR Monitor Conditions Encountered Counts (Secondary Air)	2 bytes	AIRCOND: xxxxx cnts
	AIR Monitor Conditions Encountered Counts (Secondary Air) displays the number of times that the vehicle has been operated in the specified AIR system monitoring conditions (denominator).		
	EVAP Monitor Completion Condition Counts	2 bytes	EVAPCOMP: xxxxx cnts
	EVAP Monitor Completion Condition Counts displays the number of times that all conditions necessary to detect a 0,020" (or 0,040") EVAP system leak malfunction have been encountered (numerator).		
	EVAP Monitor Conditions Encountered Counts	2 bytes	EVAPCOND: xxxxx cnts
	EVAP Monitor Conditions Encountered Counts displays the number of times that the vehicle has been operated in the specified EVAP system leak malfunction monitoring conditions (denominator).		

Table G.9 — MessageCount ECU Name data byte description

InfoType (Hex)	Vehicle information data byte description	Scaling	Mnemonic
09	**MessageCount ECUNAME** Number of messages to report the ECU's/module's acronym and text name — For ISO 9141-2, ISO 14230-4 and SAE J1850, the message count in the response shall always be five (5). For ISO 15765-4, support for this parameter is not recommended/required for the ECU and the external test equipment. However, no support for INFOTYPE $09 should be reflected in the appropriate bit of INFOTYPE $00. The response message format is not specified.	1 byte unsigned Numeric	MC_ECUNM

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Table G.10 — ECU Name data byte description

InfoType (Hex)	Description	Scaling	External test equipment SI (Metric) / English display
0A	**ECUNAME**	Max. 20 ASCII characters	ECU: XXXX ECUNAME: YYYYYYYYYYYYYYY
	This data is used to support the reporting of the ECU's/module's acronym and text name to enable the external test equipment to display the acronym and text name of the ECU/module with the data retrieved from that device. A maximum of 20 ASCII characters shall be used to report the acronym and text name of the ECU/module. The format shall be a defined field of four characters for acronym, one character for delimiter, and 15 characters for text name, given in the following format "XXXX-YYYYYYYYYYYYYYY". Defined field assignment: — Data bytes 1-4, "XXXX", contains ECU acronym; — Data byte 5, "-", ($2D) contains delimiter; and — Data bytes 6-20, "YYYYYYYYYYYYYYY", contains text name. All bytes in each field are available for use, yet any unused bytes shall be filled with $00. The use of any filler bytes shall extend to the end of each field for ECU acronym and name. Each ECU name shall contain only printable ASCII characters, and these characters shall spell acronyms and names in the English language. All non-zero hex bytes (displaying valid text based information) are left justified within each field. EXAMPLE #1: $45 43 4D 00 2D 45 6E 67 69 6E 65 20 43 6F 6E 74 72 6F 6C 00 translates to "ECM-Engine Control" EXAMPLE #2: $41 42 53 31 2D 41 6E 74 69 6C 6F 63 6B 20 42 72 61 6B 65 31 translates to "ABS1-Antilock Brake1" This will benefit the technician to better understand which ECU/module provides the requested data.		
	The emissions-related ECUs (control modules) shall report the external test equipment acronym and name as listed below. This table is not complete and emissions-related ECUs not listed in the table shall be reported to ISO/SAE for definition.		
	External test equipment reported acronym (max 1 – 4 chars)	**Full name of Control Module/ emissions-related ECU**	**External test equipment reported name (max 15 chars)**
	ABS	Anti-Lock Brake System (ABS) Control Module	AntiLock Brake
	AFCM	Alternative Fuel Control Module	Alt. Fuel Crtl
	AHCM	Auxiliary Heater Control Module	Aux. Heat Crtl
	BECM	Battery Energy Control Module	B+ Energy Crtl
	BSCM	Brake System Control Module	Brake System
	CCM	Cruise Control Module	Cruise Control
	CTCM	Coolant Temperature Control Module	Cool Temp Crtl
	DMCM	Drive Motor Control Module	Drive Mot.Crtl
	ECCI	Emissions Critical Control Information	Emis Crit Info
	ECM	Engine Control Module	Engine Control
	FACM	Fuel Additive Control Module	Fuel Add. Crtl
	FICM	Fuel Injector Control Module	Fuel Inj. Crtl
	FPCM	Fuel Pump Control Module	Fuel Pump Crtl
	FWDC	Four-Wheel Drive Clutch Control Module	4 Whl Dr.Cl.Crtl
	GPCM	Glow Plug Control Module	Glow Plug Crtl
	GSM	Gear Shift Control Module	Gear Shift Crtl
	HPCM	Hybrid Powertrain Control Module	Hybrid Ptr Crtl
	IPC	Instrument Panel Cluster (IPC) Control Module	Inst. Panel Cl.
	PCM	Powertrain Control Module	Powertrain Crtl
	SGCM	Starter / Generator Control Module	Start/Gen. Crtl
	TACM	Throttle Actuator Control Module	Thr.Act. Crtl
	TCCM	Transfer Case Control Module	Transf Case Crtl
	TCM	Transmission Control Module	Transm. Crtl
	UDM	Urea Dosing Control Module	Urea Inj. Ctrl

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Table G.11 — ISO/SAE reserved

InfoType (Hex)	Vehicle information data byte description	Scaling	Mnemonic
0B – FF	ISO/SAE reserved.	—	—

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Bibliography

[1] SAE J1699-3, *OBD II Compliance Test Cases*

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SURFACE VEHICLE STANDARD

SAE J1850 REV. MAY2001

Issued 1988-11
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Superseding J1850 MAR1998

Class B Data Communications Network Interface

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1. ***Scope***—This SAE Standard establishes the requirements for a Class B Data Communication Network Interface applicable to all On- and Off-Road Land-Based Vehicles. It defines a minimum set of data communication requirements such that the resulting network is cost effective for simple applications and flexible enough to use in complex applications. Taken in total, the requirements contained in this document specify a data communications network that satisfies the needs of automotive manufacturers.

This specification describes two specific implementations of the network, based on media/Physical Layer differences. One Physical Layer is optimized for a data rate of 10.4 Kbps while the other Physical Layer is optimized for a data rate of 41.6 Kbps (see Appendix A for a checklist of application-specific features). The Physical Layer parameters are specified as they would be detected on the network media, not within any particular module or integrated circuit implementation.

Although devices may be constructed that can be configured to operate in either of the two primary implementations defined herein, it is expected that most manufacturers will focus specifically on either the 10.4 Kbps implementation or the 41.6 Kbps implementation depending on their specific application and corporate philosophy toward network usage. However, low-volume users of network-interface devices are expected to find it more effective to use a generic interface capable of handling either of the primary implementations specified in this document.

This SAE document is under the control and maintenance of the Vehicle Networks for Multiplexing and Data Communications (Multiplex) Committee. This committee will periodically review and update this document as needs dictate.

1.1 **Objectives**—This document constitutes the requirements for a vehicle-data communications network. These requirements are related to the lowest two layers of the ISO Open System Interconnect (OSI) model (Ref. ISO 7498). These layers are the Data Link Layer and the Physical Layer. This network has been described using the ISO conventions in ISO/TC 22/SC 3/WG1 N429 E, dated October, 1990. Both documents are intended to describe the same network requirements but using different descriptive styles. If any technical differences are identified, the very latest revision of these documents should be used.

This document has been submitted as an American National Standard. As such, its format is somewhat different from the formal ISO description in that descriptions have been expanded, but are in no way less precise. A more textual format has been adopted herein to allow explanations to be included.

The vehicle application for this class of data communication (Class B) network is defined (Reference SAE J1213 APR88) to allow the sharing of vehicle parametric information. Also per the definition, this Class B network shall be capable of performing Class A functions.

2. ***References***

2.1 **Applicable Publications**—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1113—Electromagnetic Susceptibility Measurements Procedures for Vehicle Components
SAE J1211A—Recommended Environmental Procedure for Electronic Equipment Design
SAE J1213/1—Glossary of Vehicle Networks for Multiplexing and Data Communications
SAE J1547—Electromagnetic Susceptibility Measurement Procedures for Common Mode Injection
SAEJ1879—General Qualification and Production Acceptance Criteria for Integrated Circuits in Automotive Applications
SAE J1962—Diagnostic Connector
SAE J1979—E/E Diagnostic Test Modes
SAE J2012—Diagnostic Codes/Messages

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SAE J2178—Class B Data Communication Network Messages
SAEJ2178/1—Class B Data Communication Network Messages: Detailed Header Formats and Physical Address Assignment
SAE J2190—Enhanced E/E Diagnostic Test Modes

2.1.2 CISPR PUBLICATION—Available from Kristi Hansen, SAE, Troy Office, 3001 West Big Beaver Road, Suite 320, Troy, MI 48084-3174.

CISPR/D/WG2 (Secretariat) 19 Sept 1989—Radiated Emissions Antenna and Probe Test

2.1.3 ISO PUBLICATIONS—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO/TC22/SC3/WG1 N429E OCT90—Road vehicles—Serial data communication for automotive applications, low speed (125 Kbps and below)
ISO 7498—Data processing systems—Open systems interconnection—Standard reference model
ISO7637/3—Road vehicles—Electrical disturbance by conduction and coupling—Part 3: Passenger cars and light commercial vehicles with nominal 12 V supply voltage and commercial vehicles with 24 V supply voltage—Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines

2.2 Related Publications—The following publication is provided for information purposes only and is not a required part of this document.

2.2.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1930—Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, & Acronyms

3. Definitions

3.1 Active State—The state of a bus wire which results when one or more nodes have "turned on" their physical layer circuitry. This is V_{oh} volts for Bus + (PWM and VPW) and V_{ol} volts for Bus – (PWM only). Refer to 9.3.2.2 (PWM DC Parameters) and 9.3.3.2 (VPW DC Parameters) for the values of V_{oh} and V_{ol}. The active state voltage level is determined by the source voltage of the physical layer drive circuitry.

3.2 Arbitration—The process of resolving which frame, or In-Frame Response data, continues to be transmitted when two or more nodes begin transmitting frames, or In-Frame Response data, simultaneously.

3.3 Class A Data Communications—A system whereby vehicle wiring is reduced by the transmission and reception of multiple signals over the same signal bus between nodes that would have been accomplished by individual wires in a conventionally wired vehicle. The nodes used to accomplish multiplexed body wiring typically did not exist in the same or similar form in a conventionally wired vehicle.

3.4 Class B Data Communications—A system whereby data (e.g., parametric data values) is transferred between nodes to eliminate redundant sensors and other system elements. The nodes in this form of a multiplex system typically already existed as stand-alone modules in a conventionally wired vehicle. A Class B network shall also be capable of performing Class A functions.

3.5 Class C Data Communications—A system whereby high data rate signals typically associated with real-time control systems, such as engine controls and anti-lock brakes, are sent over the signal bus to facilitate distributed control and to further reduce vehicle wiring. A Class C network shall also be capable of performing Class A and Class B functions.

3.6 Dominant Bit—A bit which wins arbitration when contending for the bus. For SAE J1850, a logic "0" is the dominant bit.

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3.7 **Dual Wire**—Two wires that are routed adjacently throughout the network and can be either a twisted or a parallel pair of wires.

3.8 **Fault Tolerance**—The ability of a system to survive a certain number of failures with allowance for possible downgraded performance while maintaining message transmission capability at the specified data rate.

3.9 **Frame**—One complete transmission of information, which may or may not include an "in-frame response." For this network, each frame contains one and only one message. A frame is delineated by the Start of Frame (SOF) and End of Frame (EOF) symbols.

3.10 **Functional Addressing**—Labeling of messages based on their operation code or data content. See 7.1.2 for an example of the typical usage for functional addressing.

3.11 **Message**—All of the data bytes contained in a frame. The message is what is left after the frame symbols have been removed from the frame. As such, the message is the sequence of bytes contained in the frame.

3.12 **Passive State**—The state of a bus wire which results when all nodes have "turned off" their physical layer circuitry. This is V_{ol} volts for Bus + (PWM and VPW) and V_{oh} volts for Bus – (PWM only). Refer to 9.3.2.2 (PWM DC Parameters) and 9.3.3.2 (VPW DC Parameters) for the values of V_{oh} and V_{ol}. The passive state voltage level is determined by the reference voltage of the bus wire termination resistor(s).

3.13 **Physical Addressing**—Labeling of messages for the physical location of their source and/or destination(s). See 7.1.1 for an example of the typical usage for physical addressing.

3.14 **Pulse Width Modulation (PWM)**— A data bit format, where the width of a pulse of constant voltage or current determines the value (typically one or zero) of the data transmitted.

3.15 **Recessive Bit**—A bit which loses arbitration when contending for the bus with a dominant bit. For SAE J1850, a logic "1" is the recessive bit.

3.16 **Sleep-Mode**—Node behavior in a low power consumption standby state waiting to be switched on by a frame or other activity. This is distinct from an off-mode where the node is disconnected from the power supply.

3.17 **Variable Pulse Width (VPW) Modulation**—A method of using both the state of the bus and the width of the pulse to encode bit information. This encoding technique is used to reduce the number of bus transitions for a given bit rate. One embodiment would define a "ONE" (1) as a short active pulse or a long passive pulse while a "ZERO" (0) would be defined as a long active pulse or a short passive pulse. Since a frame is comprised of random 1's and 0's, general byte or frame times cannot be predicted in advance.

4. *Abbreviations/Acronyms*

BRK: Break
CRC: Cyclic Redundancy Check
E/E: Electrical and Electronic
EMC: Electromagnetic Compatibility
EMI: Electromagnetic Interference
EOD: End of Data
EOF: End of Frame
IFR: In-Frame Response (Byte/Bytes)
IFS: Inter-Frame Separation
ISO: International Standards Organization
Kbps: Kilo bits per second
NA: Not Applicable
NB: Normalization Bit

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OSI: Open System Interconnect
SOF: Start of Frame

5. *Description of the Architecture*

5.1 General—It is the intent of this network to interconnect different electronic modules on the vehicle using an "Open Architecture" approach. An open architecture network is one in which the addition or deletion of one or more modules (data nodes) has minimal hardware and/or software impact on the remaining modules.

In order to support an open architecture approach, the Class B network utilizes the concept of Carrier Sense Multiple Access (CSMA) with nondestructive contention resolution. Additionally this network supports the prioritization of frames such that, in the case of contention, the higher priority frames will always win arbitration and be completed.

5.2 Network Topology

5.2.1 DATA BUS TOPOLOGY—Data bus topology is the map of physical connections of the data bus nodes to the data bus. It includes all nodes and data buses involved in the data bus integration of the vehicle. A single-level bus topology, the simplest bus topology, is currently being used in several automotive applications. In a single-level bus topology, all nodes are interconnected via the same data bus. The redundancy requirements of a particular application may require a single-level topology to be implemented using multiple interconnecting cables operating in various modes (active or passive). However, the requirement to use multiple buses for redundancy purposes does not change the single-level bus topology definition if the following criteria are maintained:

a. All nodes/devices transmit and receive from a single path.
b. All nodes/devices receive all frames at the same time.
c. Communication on each data bus is identical.

5.2.2 DATA BUS CONTROL—Although various methods of data bus control can be used, this Class B network is intended for "masterless" bus control. The principal advantage of the masterless bus control concept is its ability to provide the basis for an open-architecture data communications system. Since a master does not exist, each node has an equal opportunity to initiate a data transmission once an idle bus has been detected. However, not all nodes and/or data are of equal importance, prioritization of frames is allowed and the highest priority frame will always be completed. This also implies that frame/data contention will not result in lost data. Two disadvantages of the masterless bus concept are that data latency cannot be guaranteed, except for the single highest system priority frame, and bus utilization extremes are difficult to evaluate.

5.3 References to the OSI Model—Although this document focuses on the data link layer and the physical layer, references are included for the application layer since this needs to be included for emission-related, diagnostic communication legislation requirements. The Class B network maps into the OSI model as described in the following paragraphs. This "mapping" is illustrated in Figure 1.

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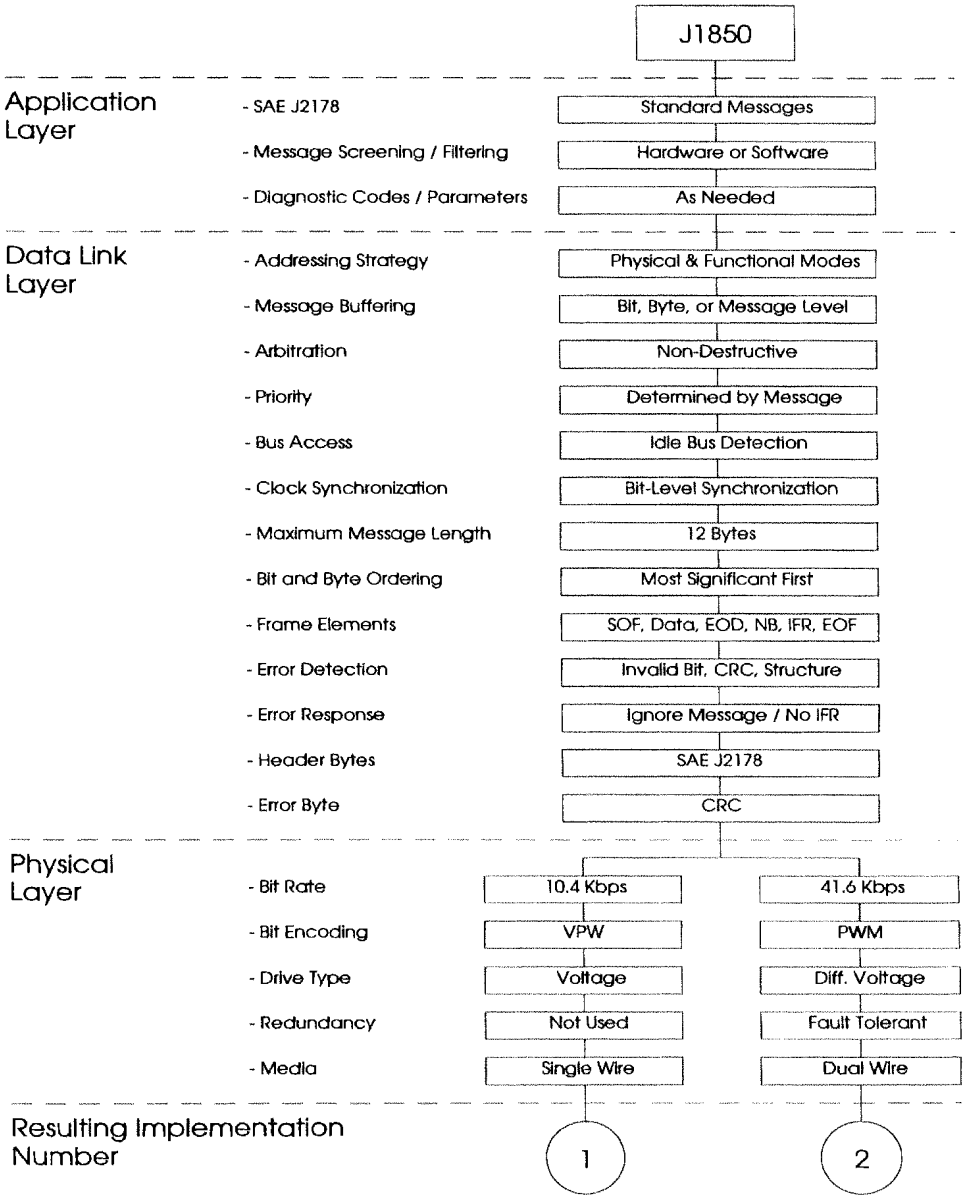


FIGURE 1—MAP OF SAE J1850 TO THE ISO OSI MODEL

5.3.1 APPLICATION LAYER—At the top of the OSI reference model is the Application Layer. This layer establishes the relationship between the various application input and output devices, including what is expected of human operators. This layer documents the high level description of the function including control algorithms if appropriate. An example of an Application Layer functional description might be: "Pressing the head lamp button shall cause the low beam head lamp, marker and tail lamp filaments to be energized." Legislated diagnostics is another area in which application layer requirements need to be specified.

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5.3.2 DATA LINK LAYER—The primary function of the Data Link Layer is to convert bits and/or symbols to validated error free frames/data. Typical services provided are serialization (parallel to serial conversion) and clock recovery or bit synchronization. An important additional service provided by the Data Link Layer is error checking. When errors are detected, they may be corrected or higher layers may be notified.

5.3.3 PHYSICAL LAYER—The Physical Layer and its associated wiring form the interconnecting path for information transfer between Data Link Layers. Typical Physical Layer protocol elements include voltage/current levels, media impedance, and bit/symbol definition and timing.

5.4 Network Implementation—The network implementations based on this document have been reduced to commonize hardware, software, messages, and tools. The consolidation of messages has been documented in SAE J2178. The first byte or the first three bytes of these messages are called the "Header" byte(s). These header bytes fully define the associated requirements of this network interface, which previously had been optional. Figure 2 shows the general format for single byte header forms. Figure 3 shows the three byte header form. Figure 4 shows the specific bit assignments for priority, In-Frame Response, and Functional/ Physical Address mapping in the three byte header format. For a complete description of the "KYZZ" bits shown in Figure 4 refer to SAE J2178/1.

Single Byte Header:

Bit 7	6	5	4	3	2	1	0
Message ID (256)							

One Byte Form of Consolidated Header:

Bit 7	6	5	4	3	2	1	0
x	x	x	H=1	x	x	x	x
Message ID (128)							

FIGURE 2—SINGLE BYTE HEADER AND ONE BYTE FORM OF CONSOLIDATED HEADER

Three Byte Form of Consolidated Header:

Byte 1	Byte 2	Byte 3
See Figure 4 Below	Target Address	Source Address

FIGURE 3—THREE BYTE FORM OF CONSOLIDATED HEADER

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Byte 1 of Three Byte Form of Consolidated Header:

Bit 7	6	5	4	3	2	1	0
P	P	P	0	K	Y	Z	Z
Priority (0 to 7)			H=0	Message Type (see below)			

Bit	Meaning	Value	Meaning
K	In-Frame Response (IFR)	0 1	IFR Required IFR Not Allowed
Y	Addressing Mode	0 1	Functional Addressing Physical Addressing
ZZ	Specific Message Type	0 0 0 1 1 0 1 1	The meaning for these values are dependent on K & Y above. These meanings can be found in J2178/1.

FIGURE 4—FIRST BYTE OF THREE BYTE FORM OF CONSOLIDATED HEADER

6. ***Application Layer Details***—The application of this communication network is the transfer of information from one node of the network to one or more other nodes. This transfer of information supports both operational and diagnostic needs. SAE has developed documents describing each of these types of applications, consistent with this document.

6.1 **Normal Vehicle Operation (Down the Road) Messages**—The messages sent during non-diagnostic operations are called normal vehicle operation messages. These normal vehicle operation messages are used for communication from a transmitter to one or more receivers across this network. The normal operation messages have been developed by the SAE for this communication network and are defined in SAE J2178. SAE defined messages and the "Reserved" messages of SAE J2178 shall remain specific to those definitions. In SAE J2178, there is also a set of "Reserved - Manufacturer" messages which, if used, will have meanings specific to a vehicle manufacturer but are likely to be different between manufacturers.

6.2 **Diagnostic Messages**—It is expected that this network will be used for diagnostics of the devices utilizing the network. These diagnostic procedures may include legislated diagnostics, industry standard diagnostics, or manufacturer-specific diagnostic procedures.

Legislated diagnostics, and some level of voluntary industry standard diagnostics that reference this document, should only specify procedures and frames that conform to this document. SAE J1979 and SAE J2190 define the set of recognized test modes that are available and have been reserved for diagnostic purposes.

Manufacturer-specific test procedures utilizing this network may specify procedures that do not conform to the requirements of this recommended practice.

6.2.1 DIAGNOSTIC PARAMETRIC DATA—SAE J1979 and SAE J2190 define test modes and frame formats for use by off-vehicle test equipment to obtain diagnostic data from the vehicle. SAE J1979 and SAE J2190 messages conform to the requirements and limitations of this document.

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6.2.2 DIAGNOSTIC MALFUNCTION CODES—SAE J2012 defines trouble codes to be assigned to various vehicle system malfunctions, and also assigns ranges of codes to be used for manufacturer-specific codes. SAE J1979 and SAE J2190 include messages to be used to retrieve these codes from the on-vehicle systems. When trouble codes are to be assigned to system malfunctions, the code structure of SAE J2012 should be used.

6.3 Frame Filtering—The network interface device may be capable of filtering frames on the network to select those appropriate to a given node. Because this Class B protocol may use more than one type of frame addressing (e.g., functional and physical; see 7.1), the criteria for these filtering operations may include multiple byte comparisons occurring over the first several frame bytes. Regardless of the exact technique used for frame filtering, the objective is to reduce the software and processing burden associated with network operations by limiting the number of received frames to just those necessary for any given node.

7. Data Link Layer Details—This section defines the requirements on the following Data Link Layer attributes:

a. Addressing Strategy
b. Network Access and Data Synchronization
c. Frame Elements and Structure
d. Error Detection
e. Error Response

7.1 Addressing Strategy—Two types of addressing strategies are defined and can co-exist on this network. The two strategies serve different types of tasks and the flexibility to use both types on the same network provides a major benefit.

7.1.1 PHYSICAL ADDRESSING—Frames are exchanged only between two devices based on their "Physical" address within the network. Each node must be assigned a unique physical address within the network. This type of addressing strategy is used when the communications involve specific nodes and not the others that may be on the network. Diagnostic access would be one case where identification of a specific module is important.

7.1.2 FUNCTIONAL ADDRESSING—Frames can be transmitted between many devices based on the function of that frame on the network. Each node is assigned the set of functions that it cares about, either as transmitter or receiver, and can be located anywhere in the network. This type of addressing strategy is used when the physical location of the function is not important but could move around from one module to another. In the case of functional addressing, the function of the message is important and not the physical addresses of the nodes.

7.2 Network Access and Data Synchronization—The network interface shall implement a multiple access arbitration-based protocol using nondestructive bit-by-bit arbitration to transparently resolve simultaneous access to the bus. Network access is allowed after detection of an idle bus. The definition of an idle bus is contained in 8.6.1.7.

Since a discrete clock wire is not used with this network, node synchronization can be derived from bit/symbol transitions on the bus.

7.2.1 FULL MESSAGE BUFFERING—One or more messages exist in their entirety in the interface device. This approach reduces software burden at the expense of hardware costs. Message filtering (or screening) is possible in such a device which reduces software burden even further.

7.2.2 BYTE BUFFERING—Each byte of a received message (or transmit message) is stored individually in the interface device. The controlling device is responsible for the timely servicing of the interface device to keep up with frame traffic.

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7.3 **Network Elements and Structure**—The general format is:

idle, SOF, DATA_0, ..., DATA_N, CRC, EOD, NB, IFR_1, ..., IFR_N, EOF, IFS, idle:

The preceding acronyms are defined as follows:

idle: Idle Bus (occurs before SOF and after IFS)
SOF: Start of Frame
DATA: Data bytes (each 8 bits long)
EOD: End of Data (only when IFR is used)
CRC: CRC Error Detection Byte (may occur in IFR as well)
NB: Normalization Bit (10.4 Kbps only)
IFR: In-Frame Response Byte(s)
EOF: End of Frame
IFS: Inter-Frame Separation

NOTE—Break (BRK) can occur (be sent) on a network at any time.

7.3.1 FRAME ELEMENTS—The frame elements other than the symbols SOF, EOD, NB, EOF, IFS, and BRK will be byte oriented and must end on byte boundaries. Each byte will be 8 bits in length.

7.3.2 BIT ORDERING—The first bit of each byte transmitted on the network shall be the most significant bit (i.e., MSB first).

7.3.3 MAXIMUM FRAME LENGTH—The maximum number of continuous bit times that a single node is able to control the bus shall not exceed the value specified in 9.2.

7.3.4 FUNCTION OF SOF, EOD, EOF, IFS, NB, AND BRK—In addition to actual data bytes (i.e., data, CRC, IFR) frame delimiter symbols are defined to allow the data bus to function properly in a multitude of different applications. An overview of these symbols is provided here. Detailed timing requirements on each symbol can be found in 9.3.

7.3.4.1 Start of Frame (SOF)—The SOF mark is used to uniquely identify the start of a frame. The SOF mark shall not be used in the calculation of the CRC error detection code.

7.3.4.2 End of Data (EOD)—End of Data (EOD) is used to signal the end of transmission by the originator of a frame. The in-frame response (IFR) section of the frame, if used, begins after the EOD time but before the EOF. If the IFR feature (see 7.3.7) is not used, then the bus would remain in the passive state thereby resulting in an End of Frame (EOF). If a frame includes an IFR, the originator of the frame will expect the recipient(s) of the frame to drive the network with one or more in-frame response bytes immediately following EOD.

7.3.4.3 End of Frame (EOF)—The completion of the EOF defines the end of a frame. After the last transmission byte (including in-frame response bytes where applicable), the bus will be left in a passive state. When EOF has expired, all receivers will consider the transmission complete.

7.3.4.4 Inter-Frame Separation (IFS)—Inter-Frame Separation is used to allow proper synchronization of various nodes during back-to-back frame transmissions. A transmitter must not initiate transmission on the bus before the completion of the IFS minimum period. However, receivers must synchronize to any other SOF occurring after the EOF minimum period in order to accommodate individual clock tolerances.

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A transmitter that desires bus access must wait for either of two conditions before transmitting a SOF:

a. IFS minimum has expired.
b. EOF minimum has expired and another rising edge has been detected.

7.3.4.5 *Normalization Bit (NB)*—Only applicable to 10.4 Kbps implementation. For Variable Pulse Width Modulation, the first bit of In-Frame Response data is also passive and, therefore it is necessary to generate a Normalization Bit to follow the EOD symbol. This Normalization Bit shall define the start of the in-frame response. The Normalization Bit is defined in 8.6.2.5.

7.3.4.6 *Break (BRK)*—BRK is allowed to accommodate those situations in which bus communication is to be terminated and all nodes reset to a "ready-to-receive" state. If BRK is used, it must adhere to the requirements as specified in 8.6.

7.3.5 IDLE BUS (IDLE)—Idle bus is defined as any period of passive bus state occurring after IFS. During an idle bus, any node may transmit immediately. Contention may still occur when two or more nodes transmit nearly simultaneously; therefore, resynchronization to rising edges must continue to occur.

7.3.6 DATA BYTE(S)—A number of data bytes, each eight (8) bits in length, can be transmitted at the discretion of the system designer. However, the total message length (from SOF to EOF) shall not exceed the limit defined in 9.2.

7.3.7 IN-FRAME RESPONSE (IFR)—For In-Frame Response, the response byte(s) are transmitted by the responders and begin after EOD. If the first bit of the in-frame response byte does not occur at this point and the bus remains passive for a period of time defined as EOF, then the originator and all receivers must consider the frame complete. In-frame response bytes may take one of the following forms (refer to Figure 5):

a. None
b. A single byte transmitted from a single recipient, typically a unique identifier (ID) or address.
c. Multiple bytes, a single byte transmitted from each recipient. The effect is to concatenate the individual response bytes into a response "stream." The response byte from each recipient must be unique, typically a physical address (ID n). Arbitration takes place during the response process so that each recipient, if arbitration is lost during its response byte, will retransmit the single byte until the recipient observes its unique byte in the response stream. Once a given recipient observes its own unique response byte, it discontinues the transmission process to allow any remaining responders to transmit their byte.
d. One or more data bytes, all from a single recipient. A CRC byte may be appended to the data byte(s). The CRC byte is calculated as described in 7.4.1, except only the data in the response is used for the CRC calculation.

Refer to SAE J2178/1 for a detailed discussion of the different IFR types and for determination of which message types utilize which IFR types.

If in-frame response bytes are used, the overall frame/message length limit remains in effect. The sum total of data bytes, CRC bytes, and in-frame response bytes shall not exceed the frame length as specified in 9.2.

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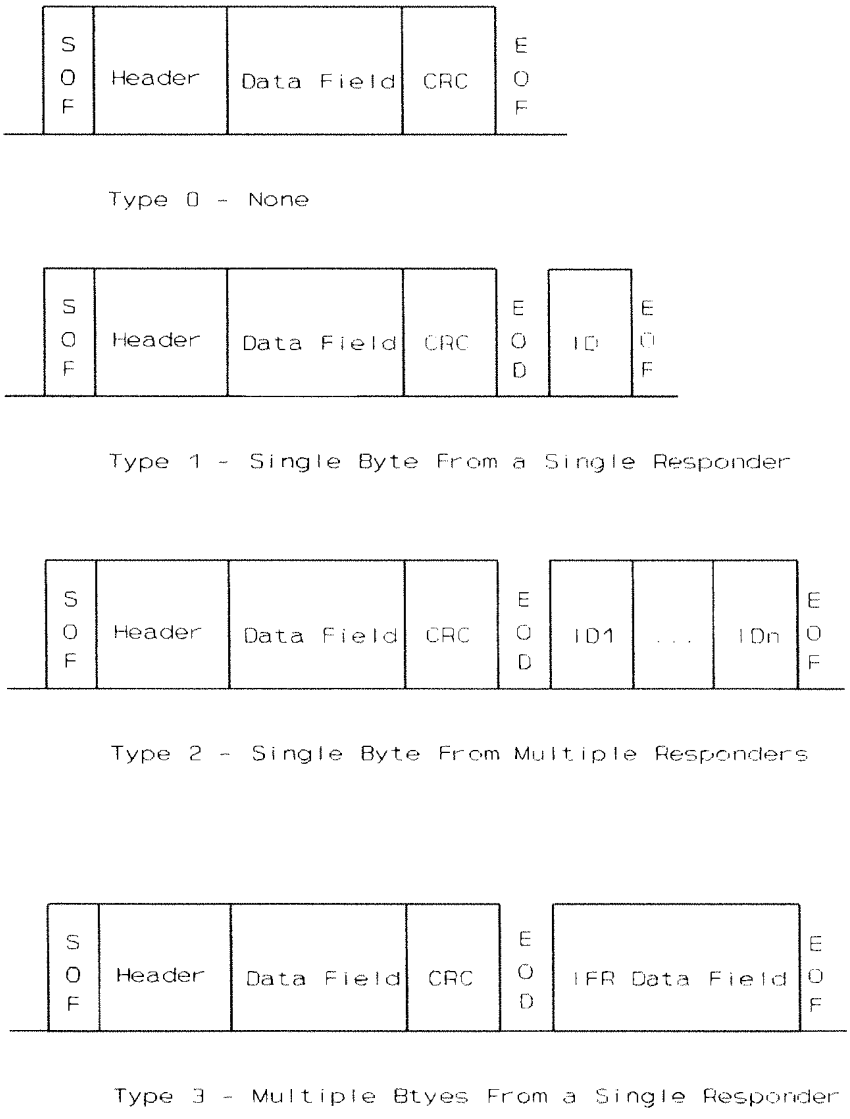


FIGURE 5—MAP OF SAE J1850 TO THE ISO OSI MODEL

7.3.7.1 Normalization Bit—If the In-Frame Response is employed in the 10.4 Kbps implementation then a "Normalization Bit" is required. The Normalization Bit is described in 8.6.2.5.

7.4 Error Detection—The error descriptions in this document are loosely defined and classified. In general, the action taken after an error condition has been detected is manufacturer-specific unless it has been specified in this document.

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7.4.1 CYCLIC REDUNDANCY CHECK (CRC)—The CRC is required with either of the header byte systems used. The method of calculating and checking the CRC byte is defined as follows. An invalid CRC byte may constitute a detected error.

a. The CRC calculation and the CRC checker shift registers (or memory locations) will be located in the sender and receiver nodes, respectively, and shall be initially set to the "all ones" state during SOF. (The setting to "ones" prevents an "all zeros" CRC byte with an all zero-data stream.)
b. All frame bits that occur after SOF and before the CRC field are used to form the Data Segment Polynomial which is designated as D(X). For any given frame, this number can be interpreted as an "n-bit" binary constant, where n is equal to the frame length, counted in bits.
c. The CRC division polynomial is $X^8 + X^4 + X^3 + X^2 + 1$. This polynomial is designated as P(X).
d. The Remainder Polynomial R(X) is determined from the following Modulo 2 division equation:

$$\frac{X^{8*}D(X) + X^n + X^{n+1} + \ldots + X^{n+7}}{P(X)} = Q(X) + \frac{R(X)}{P(X)} \qquad \text{(Eq. 1)}$$

NOTE—Q(X) is the quotient resulting from the division process.

e. The CRC byte is made equal to $\overline{R(X)}$ where $\overline{R(X)}$ is the ones complement of R(X).
f. The Frame Polynomial M(X) that is transmitted is shown in Equation 2:

$$M(X) = X^{8*}D(X) + \overline{R(X)} \qquad \text{(Eq. 2)}$$

g. The receiver checking process shifts the entire received frame, including the transmitted CRC byte, through the CRC checker circuit. An error-free frame will always result in the unique constant polynomial of $X^7 + X^6 + X^2$ (C4 hex) in the checker shift register regardless of the frame content.
h. Examples of frames with the appropriate CRC bytes are listed in Table 1.

TABLE 1—EXAMPLES OF FRAMES AND APPROPRIATE CRC BYTES

Data Bytes	(Hex)								CRC (hex)
00	00	00	00						59
F2	01	83							37
0F	AA	00	55						79
00	FF	55	11						B8
33	22	55	AA	BB	CC	DD	EE	FF	CB
92	6B	55							8C
FF	FF	FF	FF						74

i. A status flag may be used to indicate the occurrence of a received CRC error.
j. When In-Frame Response data is protected by a CRC field, the previous rules are used to define the CRC, except that the sender and receiver nodes are interchanged. The CRC calculation includes only the in-frame response bytes. (Note that the SOF, EOD, EOF, and NB are not used in the CRC calculation and serve as data delimiters.)

NOTE—Figure 6 illustrates a typical CRC generator and Figure 7 illustrates a typical CRC checker. With appropriate gating, the two circuits may be combined to use only a single-shift register for both CRC generation and CRC checking.

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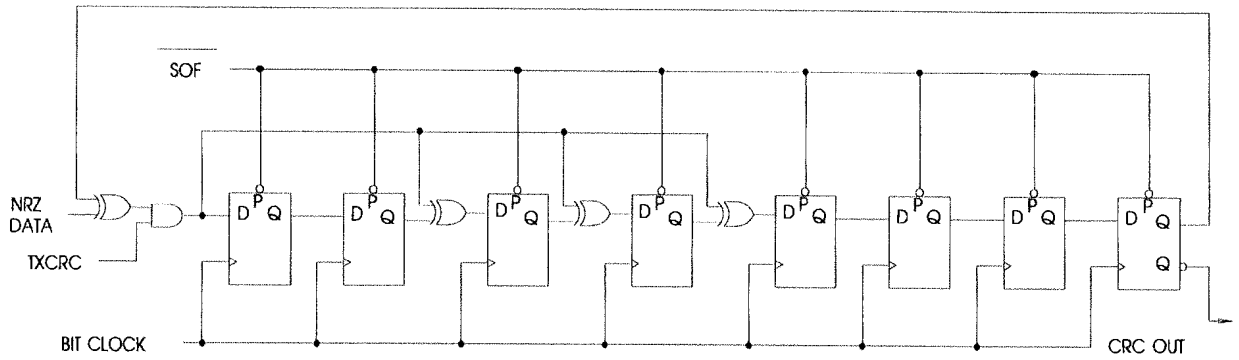


FIGURE 6—CRC GENERATOR

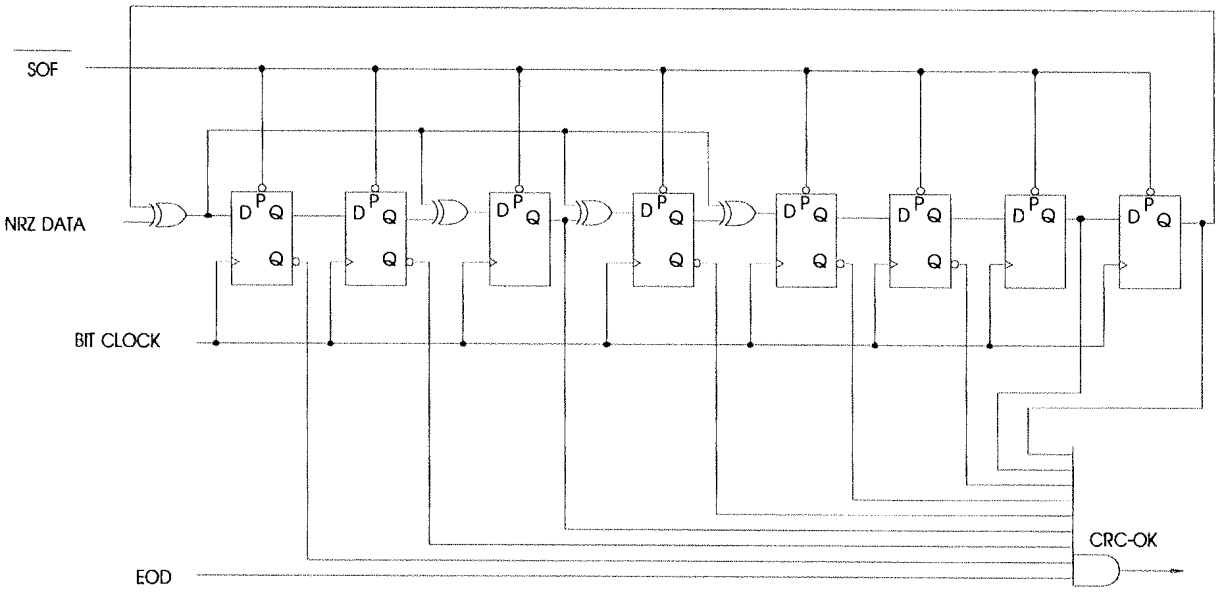


FIGURE 7—CRC CHECKER

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7.4.2 FRAME/MESSAGE LENGTH—A frame exceeding its defined length limit may constitute a detected error.

7.4.3 OUT-OF-RANGE—Data is corrupted in a vehicle network when transient interference is large enough to drive the receiver out of its dynamic range of operation. This out-of-range condition, where the receiver can no longer accurately decode the data, may be detected by an out-of-range detector. The following defines the operation of an out-of-range detector:

a. Data is recovered by holding the receiver output in the state it was prior to the out-of-range condition for the duration of the interference.
b. If the interfering transient is long enough to corrupt a desired bus symbol, accurate data recovery may not occur. This may constitute a detected error.

7.4.4 CONCEPT OF VALID/INVALID BIT/SYMBOL DETECTION

7.4.4.1 Invalid Bit Detection—In some cases, data integrity may be increased by detecting the condition in the data stream where the received data bit does not match the specifications for either a "one" or a "zero" bit.

7.4.4.2 Invalid Frame Structure Detection—Regardless of data encoding, data integrity may be increased by detecting the condition when an EOD or EOF occurs on a non-byte boundary within the data stream, or the frame exceeds the maximum frame length.

7.5 Error Response

7.5.1 TRANSMIT—When an originator of a frame detects an error condition on the network (i.e., one of the error conditions defined in 7.4), the originator must discontinue the transmit operation prior to the start of the next bit. After the specified period of IFS or reception of an edge after EOF, the originator is allowed to retransmit the frame.

7.5.2 RECEIVE—If a frame is received and the frame contains an error (i.e., one of the error conditions defined in 7.4), the frame is to be ignored. If "In-Frame Response" is being used, the receiver must not respond to a received frame containing an error. This lack of response serves as a signal to the originator that an error was detected by the receiver.

8. Physical Layer Details—This section defines the requirements on the following physical layer attributes:

a. Media
b. Unit Load Specifications
c. Maximum Number of Nodes
d. Maximum Network Length
e. Media Characteristics
f. Data Bit/Symbol Definition/Detection
g. Network Wake-Up Via Physical Layer
h. Physical Layer Fault Considerations
i. EMC Requirements

Specific parametric values associated with the physical layer are contained in Section 9.

8.1 Physical Layer Media—Although this specification focuses on the data carrying media, it is assumed that each node shall be supplied with appropriate power and ground.

8.1.1 SINGLE WIRE—The network medium for the single wire voltage drive shall be a single random lay wire.

8.1.2 DUAL WIRES—The network medium for the dual wire voltage drive shall be either a parallel wire pair separated by a constant distance, or a twisted pair of wires.

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8.1.3 ROUTING—No Restrictions

8.2 Unit Load Specifications—The electrical loading effect of each device connected to this network will be measured in terms of unit loads. A unit load is a nominal value which, if all nodes correspond to one unit load, will allow the maximum specified number of nodes to be connected to the network. There is no requirement that a given node must be equal to a standard unit load, but the combination of all load values must not exceed the limits for any given system.

8.3 Maximum Number of Nodes—The maximum number of nodes, assuming each node is the equivalent of a standard unit load, is specified in Section 9.

8.4 Maximum Network Length—The maximum medium length between any two nodes shall not exceed the value specified in Section 9.

8.4.1 ON-VEHICLE/OFF-VEHICLE—The maximum network length, maximum capacitance value and minimum load/termination resistance values for any off-vehicle equipment have been specified in Section 9.3. Because all applications must allow for such off-vehicle equipment, the allowed maximum on-vehicle loads shall be limited to account for this level of off-vehicle loading.

8.5 Media Characteristics—The characteristics of the media are as specified in Section 9.

8.6 Data Bit/Symbol Definition/Detection—The data bus can be in one of two valid states active or passive. For clarity in the following sections, a rising edge is a transition from the passive to active state and a falling edge is a transition from the active to the passive state.

There are two methods of bit encoding specified in this document, Pulse Width Modulation (PWM) and Variable Pulse Width (VPW) modulation. The timing diagrams that follow represent the requirements for the logical waveform. It is the transmitter's responsibility to transmit bits/symbols which are valid (i.e., meets these specifications). In some contention situations, the transmitter will have to re-synchronize to ensure that the falling edge is within specification. The requirements associated with the reception of these bits and symbols are not stated explicitly in this specification, but are to be derived from transmitter specifications by the module or circuit designer. It is expected that the receiver will employ a simple clock-driven digital filter and digital integrator or majority vote sampling circuit for decoding data and maintaining "clock" synchronization. All timing requirements are specified in Section 9.

The following bits/symbols are defined for both PWM and VPW:

a. One "1" bit
b. Zero "0" bit
c. Start of Frame (SOF)
d. End of Data (EOD)
e. End of Frame (EOF)
f. Inter-Frame Separation (IFS)

The Normalization Bit (NB) is only applicable for VPW implementations and is therefore only defined for VPW.

8.6.1 PULSE WIDTH MODULATION (PWM)—The following values represent nominal timing, detailed timing requirements for each bit/symbol can be found in Section 9.

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8.6.1.1 The One "1" and Zero "0" Bits—(see Figures 8 and 9)

a. "1" Bit - A "1" bit is characterized by:

1. A rising edge that follows the previous rising edge by at least Tp3. Two rising edges shall never be closer than Tp3.
2. A falling edge that occurs Tp1 after the rising edge.

b. "0" Bit - A "0" bit is characterized by:

1. A rising edge that follows the previous rising edge by at least Tp3. Two rising edges shall never be closer than Tp3.
2. A falling edge that occurs Tp2 after the rising edge.
3. A next data bit rising edge that occurs Tp11 after the previous falling edge (if applicable).

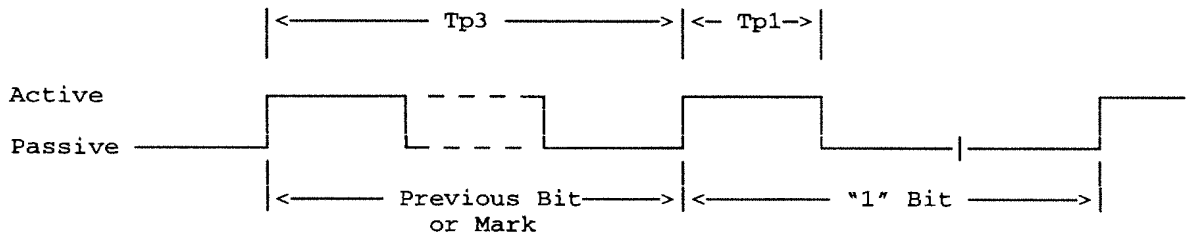


FIGURE 8—"0" BIT DEFINITION

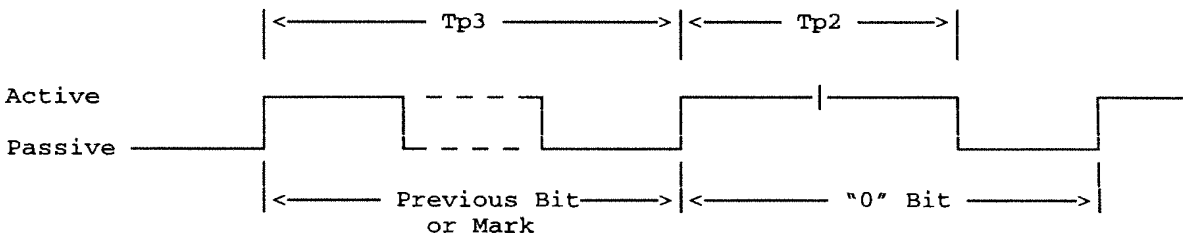


FIGURE 9—FRAME SYMBOLS

8.6.1.2 Start of Frame (SOF)—The Start of Frame (SOF) mark has the distinct purpose of uniquely determining the start of a frame (see Figure 10). The SOF is characterized by:

a. A reference rising edge that follows the previous rising edge by at least Tp5.
b. A falling edge that occurs Tp7 after the reference rising edge.
c. The rising edge of the first data bit will occur at Tp10 after the reference rising edge.

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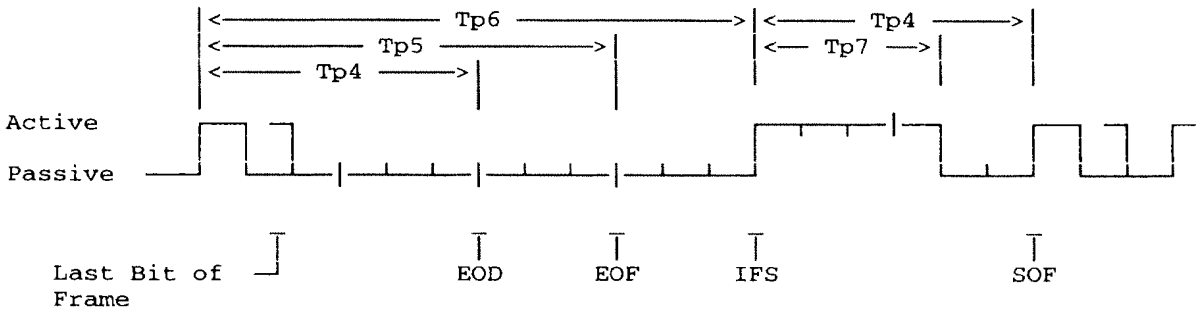


FIGURE 10—FRAME SYMBOLS

NOTE—Last bit of a frame may be the last data bit, last CRC bit, or last In-Frame Response bit.

8.6.1.3 *End of Data (EOD)*—End of Data is used to signal the end of transmission by the originator of a frame.

The In-Frame Response (IFR) section of the frame, if used, begins immediately after the EOD bit (see Figure 11). If the In-Frame Response feature is not used, then the bus would remain in the passive state for an additional bit time, thereby signifying an End of Frame (EOF).

For In-Frame Response, the response byte(s) are driven by the responders and begin with the rising edge of the first bit of the response, Tp4 after the rising edge of the last bit sent from the originator of the frame.

If the first bit of the response byte does not occur at Tp4, and the bus remains passive for one additional bit time (total time Tp5) then the originator and all receivers must consider the frame complete (i.e., EOD has been transformed into an EOF).

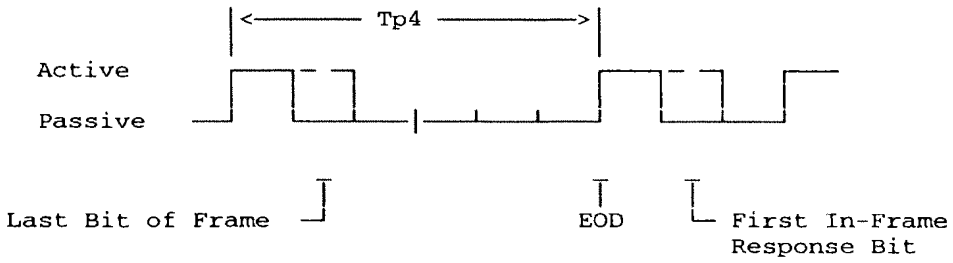


FIGURE 11—END OF DATA SYMBOL

NOTE—Last bit of a frame may be the last data bit, last CRC bit, or last In-Frame Response bit.

8.6.1.4 *End of Frame (EOF)*—The completion of the EOF defines the end of a frame (by definition, an EOD forms the first part of the EOF—see Figure 13). After the last transmission byte (including in-frame response bytes where applicable), the bus will be left in a passive state. When EOF has expired (Tp5 after the rising edge of the last bit), all receivers will consider the transmission complete.

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8.6.1.5 *Inter-Frame Separation (IFS)*—Inter-Frame Separation allows proper synchronization of various nodes during back-to-back frame operation.

A transmitter that desires bus access must wait for either of two conditions before transmitting a SOF:

a. IFS minimum has expired. (Tp6 after the rising edge of the last bit).
b. EOF minimum and another rising edge has been detected. (Tp5 after the rising edge of the last bit).

8.6.1.6 *Break (BRK)*—BRK is allowed to accommodate those situations in which bus communication is to be terminated and all nodes reset to a "ready-to-receive" state (see Figure 12). The PWM Break symbol is an extended SOF symbol and will be detected as an "invalid" symbol to some devices, which will then ignore the current frame, if any. Following the break symbol, an IFS following BRK period (Tp9 after the rising edge of the break) is needed to resynchronize the receivers. If the "Breaking" device wishes to obtain guaranteed access to the bus, the highest priority frame must then be sent, otherwise, other frames may gain access under the normal rules of arbitration.

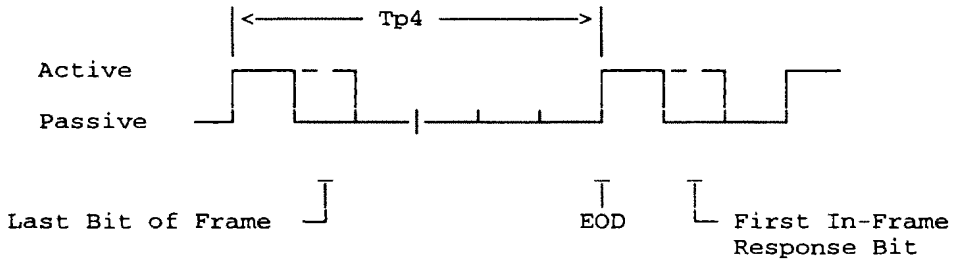


FIGURE 12—PWM BREAK SEQUENCE

8.6.1.7 *Idle Bus (Idle)*—Idle bus is defined as any period of passive bus state occurring after IFS minimum (see Figure 13). A node may begin transmission at any time during idle bus.

During an idle bus, any node may transmit immediately. Contention may still occur when two or more nodes transmit nearly simultaneously; therefore, resynchronization to rising edges must continue to occur.

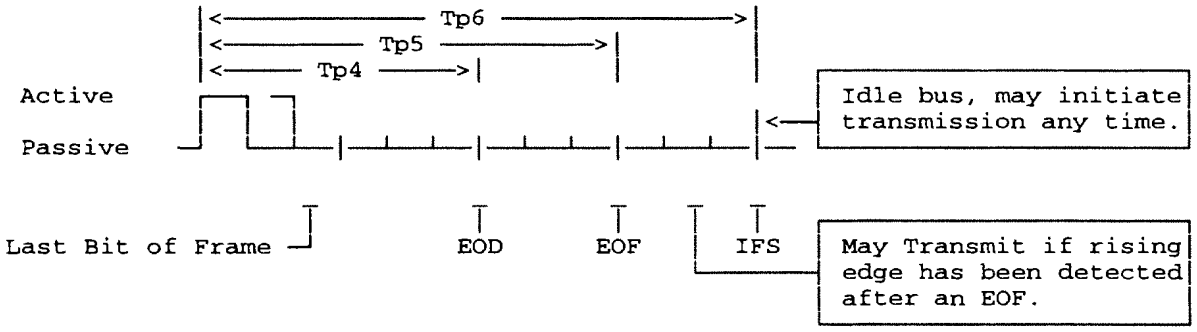


FIGURE 13—EOF AND IDLE BUS DEFINITION

NOTE—Last bit of a frame may be the last data bit, last CRC bit, or last In-Frame Response bit.

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8.6.1.8 PWM Symbol Timing Requirements—The symbol timing reference for PWM encoding is based on transitions from the passive state to the active state. The SOF and each data bit in PWM has a "leading edge" from which all subsequent timing is derived. The transition from active to passive (which occurs within the SOF or data bits) is not used as a timing reference. The leading edge is used as the only reference because the transition from passive to active appears on the bus wires as a fast clean edge while the transition from active to passive is slow and ambiguous due to variations in network capacitance.

Paragraph 9.3.2.1 defines the timing values for PWM at 41.6 Kbps. Values are provided for the transmitter and receiver (based on the suggested bit decoder implementation).

8.6.2 VARIABLE PULSE WIDTH MODULATION—The SOF symbol, "0" bit, and "1" bit are defined by the time between two consecutive transitions and the level of the bus, active or passive. The EOD, EOF, IFS, and Break symbols are defined simply by the amount of time that has expired since the last transition. EOD, EOF, and IFS are all passive symbols and the Break is an active symbol. Therefore, there is one symbol per transition and one transition per symbol. The end of the previous symbol starts the current symbol. The following values represent nominal timing, detailed timing requirements for each bit/symbol can be found in Section 9.

8.6.2.1 The One "1" and Zero "0" Bits—A "1" bit is either a Tv2 passive pulse or a Tv1 active pulse. Conversely, a "0" bit is either a Tv1 passive pulse or a Tv2 active pulse (see Figure 14). The pulse widths change between passive and active bus states in order to accommodate the arbitration and priority requirements as specified in 8.7.

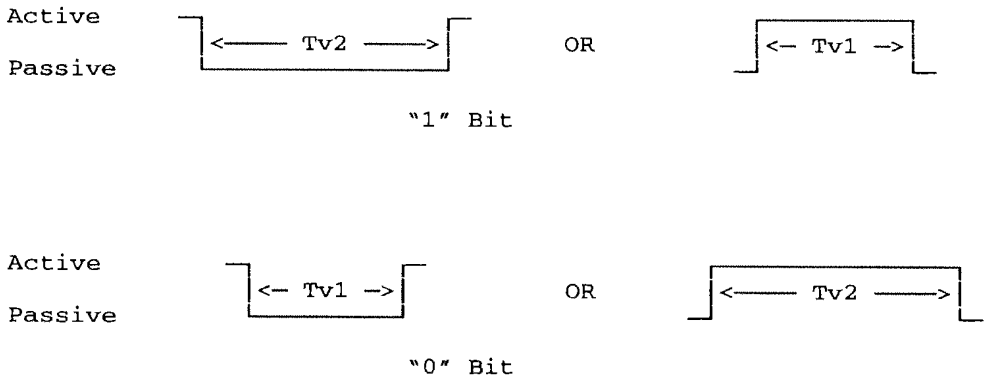


FIGURE 14—ONE AND ZERO BIT DEFINITIONS

8.6.2.2 Start Of Frame (SOF)—SOF is an active pulse, Tv3 in duration (see Figure 15).

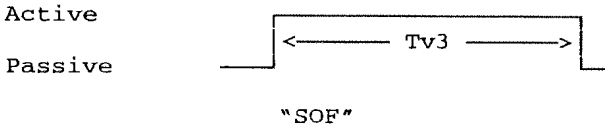


FIGURE 15—START OF FRAME (SOF) SYMBOL

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8.6.2.3 *End Of Data (EOD)*—EOD is a passive pulse, Tv3 in duration (see Figure 16).

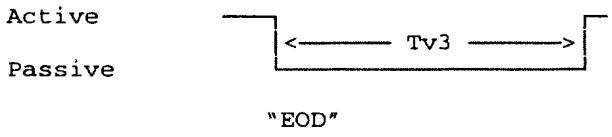


FIGURE 16—END OF DATA (EOD) SYMBOL

8.6.2.4 *End of Frame (EOF)*—EOF is a passive pulse, Tv4 in duration (see Figure 17).

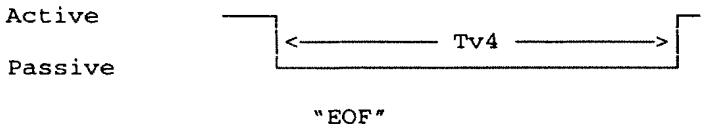


FIGURE 17—END OF FRAME (EOF) SYMBOL

8.6.2.5 *In-Frame Response Byte(s)/Normalization Bit*—The "In-Frame Response" (IFR) is transmitted by the responder and begins after the passive EOD symbol. For Variable Pulse Width Modulation, the first bit of the IFR data is also passive. Therefore, it is necessary to generate a normalization bit to follow the EOD symbol. The responding device generates the normalization bit prior to sending the IFR data. This normalization bit defines the start of the IFR and can take two forms. The first form is an active short period (Tv1) and the second form is an active long period (Tv2). Figure 18 illustrates the IFR using the normalization bit. The normalization bit can also be used to indicate what type of response is expected during the IFR portion of the frame. The preferred method is to use an active short bit (Tv1) to indicate that the IFR DOES NOT contain a CRC (i.e., IFR types 1 or 2). An active long bit (Tv2) would therefore indicate that the IFR DOES contain a CRC (i.e., IFR type 3). This is only a preferred method, and individual manufacturers are allowed to implement the normalization bit per their requirements. However, all future SAE J1850 applications are urged to implement the normalization bit using the preferred method described above.

If in-frame response bytes are used, the overall frame/message length limit remains in effect. The sum total of data bytes, CRC byte, and in-frame response bytes shall not exceed the value specified in Section 9.

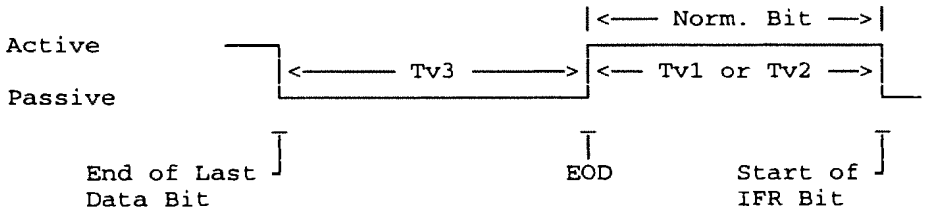


FIGURE 18—NORMALIZATION BIT

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8.6.2.6 *Inter-Frame Separation (IFS)*—Inter-Frame Separation is used to allow proper synchronization of various nodes during back-to-back frame operation.

A transmitter that desires bus access must wait for either of two conditions before transmitting a SOF (see Figure 19):

a. IFS minimum has expired (Tv6).
b. EOF minimum and another rising edge has been detected (Tv4).

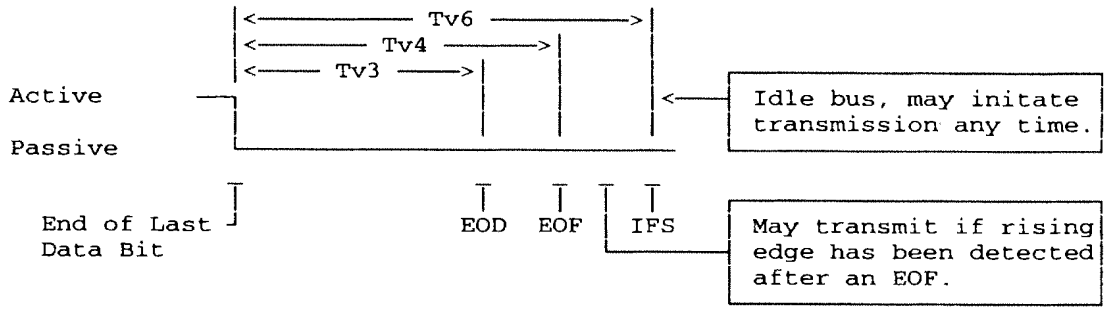


FIGURE 19—INTER-FRAME SEPARATION

8.6.2.7 *Break (BRK)*—BRK is allowed to accommodate those situations in which bus communication is to be terminated and all nodes reset to a "ready-to-receive" state (see Figure 20). The VPW Break symbol will be detected as an "invalid" symbol to some devices, which will then ignore the current frame, if any. The VPW Break symbol is a long active period (Tv5). Following the break symbol, an IFS period (Tv6) is needed to resynchronize the receivers and the normal IFS rules for transmitting a SOF during back-to-back operation apply. If the "Breaking" device wishes to obtain guaranteed access to the bus, the highest priority frame must then be sent, otherwise, other frames may gain access under the normal rules of arbitration.

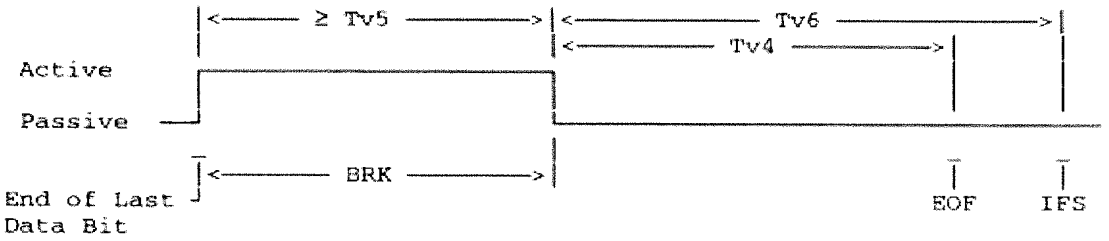


FIGURE 20—BREAK SIGNAL

8.6.2.8 *Idle Bus (Idle)*—Idle bus is defined as any period of passive bus state occurring after IFS. A node may begin transmission at any time during idle bus.

An idle bus will exist after IFS (Tv6). Contention may still occur when two or more nodes transmit nearly simultaneously; therefore, resynchronization to rising edges must continue to occur.

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8.6.2.9 VPW Symbol Timing Requirements—The most important factor in symbol timing uncertainty is the edge position uncertainty due to the time taken to make a transition between $V_{ol,max}$ and $V_{oh,min}$ (in either direction). The maximum allowable transition time, $T_{t,max}$ (the area between $V_{ol,max}$ and $V_{oh,min}$), bounds the time span between the earliest and latest node to recognize a transition and is a key design parameter. As $T_{t,max}$ is reduced it becomes more and more difficult to design a driver which also meets the necessary EMI requirements. In this manner, the corners of the waveform, which are a major contributor to the radiated contents of the signal, do not fall within the limits imposed by $T_{t,max}$ as found in Section 9.

Other factors that affect the transmitted pulse width are oscillator tolerance and variations in delay through the receiver, noise filter, and driver. For a fixed oscillator and a well-designed digital filter, most of the variation is in the time it takes the driver to leave the current state and start the transition. The various factors (plus some guard band and allowance for alternative implementations) can be lumped into a single set of limits, $T_{x,min}$ and $T_{x,max}$, for each symbol. Each is measured from the trip point of the previous transition as seen by the transmitting node (assuming a step input) to the beginning or end of the transition at Voh,min or Vol,max.

The pulse width as seen by another node, which may perceive the leading edge either sooner or later than the transmitting node, can range from $T_{x,min} - T_{t,max}$ to $T_{x,max} + T_{t,max}$ in absolute terms. This range represents a receiver's required acceptance range for a given symbol. The actual acceptance range must be wider to allow for receiver oscillator tolerance and any implementation-dependent uncertainties or constraints. The necessary guard band limits how close together symbols can be defined. To keep the symbols short, there is no space allocated for an unambiguous (with normal tolerances) forbidden zone between symbols.

The time windows are not affected by multiple nodes trying to transmit at the same time during arbitration. This is because a single node effectively dominates each transition. It is either the first node to leave the passive state or the last node to leave the active state. Although the fastest or slowest node dominates a particular transition, the contention scheme assures that the highest priority frame always wins regardless of which node started transmitting first.

The purpose of the noise filter is to eliminate impulse noise which may exceed the steady-state noise margin and to minimize the need for hysteresis at the receiver input. The delay through the filter is compensated for in the timing logic. A specific implementation of the filter is not required for compatibility so long as the delay is properly compensated and the uncertainty bounds are not exceeded. In the presence of arbitrary noise during the transition period, the filter should respond as though a single step input had occurred at some point within that period.

The symbol limits defined in Section 9 are consistent with $T_{t,max}$ and the specified oscillator tolerance. T_{nom} is the nominal symbol time with no oscillator error and the receiver detecting the transition at V_t (see analysis in Appendix D).

8.7 Contention/Arbitration/Priority—A contention situation arises when more than one node attempts to access the bus at essentially the same time.

8.7.1 CONTENTION DETECTION—Contention detection is the recognition of conflicting symbols or bits. The process of bit-by-bit arbitration allows conflicting frame transmissions to be detected. A node that detects a difference between the symbol or bit it receives and the symbol or bit it is currently transmitting has detected contention to the transmission of its frame. Only the one frame that wins all conflicts of different symbols and bits with all the other nodes that began transmitting during that frame will not detect contention.

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8.7.2 BIT-BY-BIT ARBITRATION—The bit-by-bit arbitration scheme described as follows settles the conflicts that occur when multiple nodes attempt to transmit frames simultaneously. This scheme is applied to each symbol/bit of the frame, starting with the SOF symbol and continuing until the end of the frame. Bit-by-bit arbitration is based on the use, at the physical layer, of two values of the bus called the active state and the passive state. All symbols and bits are encoded on the bus by the physical layer as combinations of active and passive state signals. During simultaneous transmissions of active state and passive state signals on the bus, the resultant state on the bus is always active (active state dominates). If the transmitting node detects a signal state on the bus that is different from the state being transmitted by the node during the header portion of the frame, the node must discontinue the transmit operation prior to the start of the next bit. If the transmitting node detects a signal state on the bus that is different from the state being transmitted by the node during the data portion of the frame (following the header), the process used to cease transmission is implementation specific. Some possible options are:

a. Discontinue the transmit operation prior to the start of the next bit (similar to the action taken if contention is detected during the header phase). If transmission of a message is prematurely terminated on a byte boundary due to unexpected contention detection following the header, care must be taken by receiving nodes not to accept the message as a valid one. There is a 1 in 256 chance that the last byte received is the CRC of the previous bytes and would therefore appear to be a valid message. In this case, a node may need to validate the received message to ensure it is of the correct length.
b. Transmit additional bits (<8) when contention is detected on a byte boundary. This ensures that a framing error will be received by all other receivers in the case of unexpected contention detection possibly due to noise.

Bus access is granted to nodes sending an active state signal over nodes sending a passive state signal. Figure 21 shows this operation on the physical layer, based on the two forms of modulation allowed (PWM and VPW).

The arbitration process begins with the SOF and continues through all the bits of the frames being sent. As each symbol or bit of all the simultaneous frames is transmitted, all of the nodes still transmitting after the last symbol or bit will detect whether any contention is taking place. Nodes that detect contention have, by definition, lost arbitration and will discontinue sending any further symbols or bits. Any remaining nodes will continue to send their symbols/bits until the next contention is detected. The node which obtains sole access to the medium is that which sends its symbols and bits without detecting any contention.

8.7.3 ARBITRATION AREA—The arbitration resolution described previously concerns all the symbols and bits between the SOF and the EOF including, in the case of an in-frame response, all the symbols and bits of the in-frame response. In other words, arbitration acts throughout the frame.

8.7.4 FRAME PRIORITY—The bit-by-bit arbitration mechanism allows the implementation of a frame priority system. When unique frames or, more particularly, when arbitration is resolved down to a single transmitter prior to any data values within the frame, a structure of relative frame priority is inherent.

Should two or more nodes attempt to access the bus within the same frame synchronization window (see IFS in 8.6.1.5 and 8.6.2.7), nondestructive arbitration will occur based on the bit value within each frame. The bus allows two states - active and passive. If an active state bit and a passive state bit are transmitted on the bus simultaneously, then the active state bit will override the passive state bit. Hence, frame arbitration occurs in a bit-wise manner. The result of the arbitration is that the node(s) sending lower priority frame(s) will recognize that they have lost arbitration and will discontinue transmitting before the next bit time. The node transmitting the highest priority frame will continue transmitting uninterrupted.

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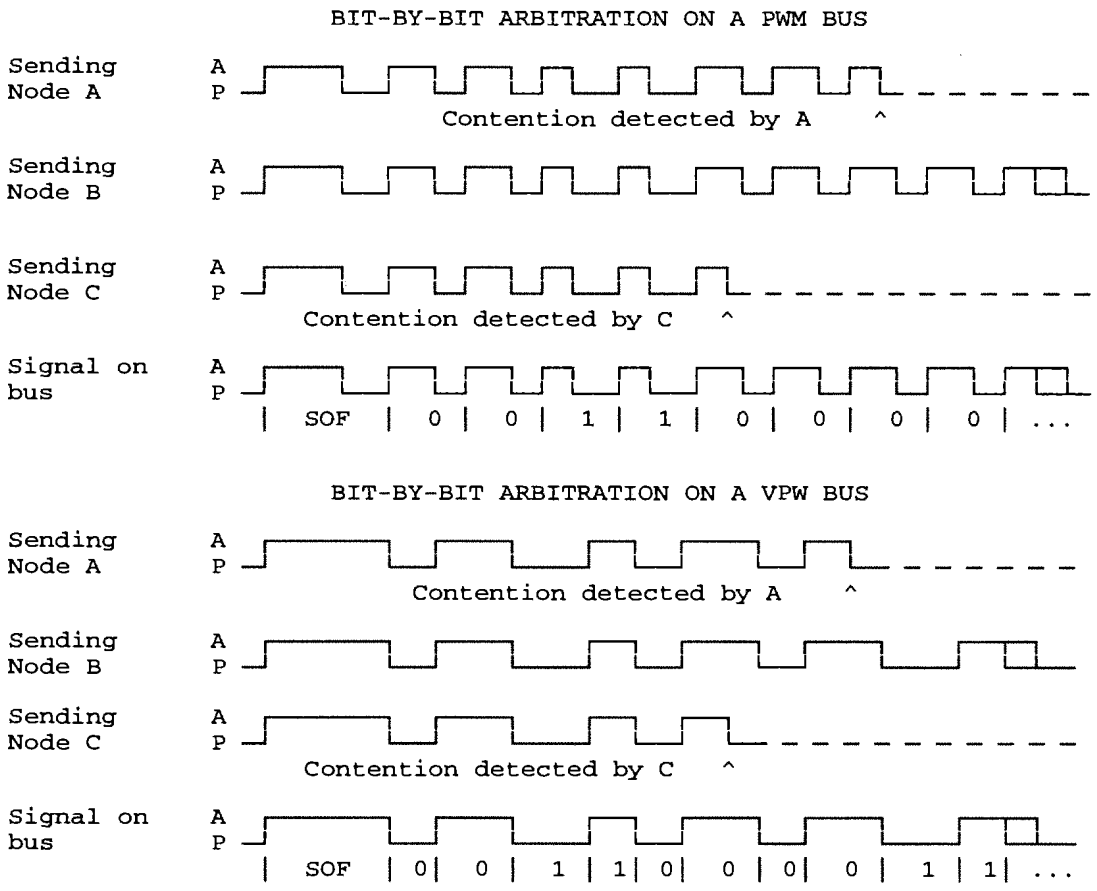


FIGURE 21—ARBITRATION

Based on the bit definitions contained in 8.6, the lowest value bytes immediately following the SOF will have the highest priority. Therefore, regardless of the number of bits allocated for "frame prioritization," the numerical value of zero will have the absolutely highest priority (that is, 000 is higher priority than 001 or 111).

8.8 Node Wake-Up Via Physical Layer—The transition to a functional/operating network from an unpowered or standby state is a common occurrence in vehicle multiplex systems. In the context of this document the Session Layer controls the transitions between the operating and the standby states.

Two perspectives are used to define the session layer:

a. The view of the media itself, without regard to the individual nodes on the network
b. The view from an individual node

Both are required for a complete definition of the possible states of network operation.

It is expected that a typical vehicle multiplex system may contain a mixture of unpowered and powered nodes, and that the individual nodes may themselves have both powered and standby states.

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8.8.1 NETWORK MEDIA

8.8.1.1 Unbiased Network—An unbiased network is all conductors at ground voltage and the impedance of the conductors not controlled. No communication is possible on an unbiased network. The media must first be brought to the biased state before communication can take place. The transition of the network from the unbiased to the biased state may serve as a node wake-up signal for certain applications, but this is not a requirement (i.e., it is possible for individual nodes to be in the sleep state on a fully biased network or in the awake state on an unbiased network).

8.8.1.2 Biased Network—A biased network is all conductors at the "passive" voltage level (with no communication occurring) and with appropriate impedances capable of supporting communication. Individual nodes on the network may exist in any of the three states described as follows. Note that nodes which use the optional sleep state are required to wake up from the appropriate network signal within a defined wake-up period. In other words, all nodes which are capable of wake-up from network signals must do so; otherwise these nodes are considered "unpowered." This requirement assures a finite and limited delay to establish communication with nodes which may be in the sleep state.

The time required for the media to make the transition from the unbiased to the biased state is not defined in this document, since this parameter is largely application dependent and, in fact, may not even occur (e.g., media always biased). For the same reason, the time required for a node to make the transition between the unpowered state and the sleep or awake state is also not defined.

8.8.2 INDIVIDUAL NODES

8.8.2.1 Unpowered Node—An unpowered node is not capable of network communication, nor wake-up from network signal transitions.

8.8.2.2 Sleeping Node—A sleeping node may have an optional low-power standby mode capable of detecting network signal transitions for the purpose of wake-up. Any interface device in the sleep state can be awakened by any other interface device via network activity or awakened by its host via its interface to the host. There is no specified requirement for the transition from the awake state to the sleep state, since this is an implementation-specific issue.

8.8.2.3 Awake/Operational—An awake/operational node is fully capable of receiving and transmitting frames on the network. The maximum amount of time from the wake-up stimulus until the node is capable of communicating is implementation specific. A transition of the bus from the passive state to the active state shall be considered a "wake-up" signal to a sleeping node. Proper bus bias must be supplied by all nodes designated to supply bias when the network is powered.

8.9 Physical Layer Fault Considerations

8.9.1 REQUIRED FAULT TOLERANT MODES—The network must meet the requirements as defined per the following failure modes:

a. Node Power Loss—All nodes must continue to meet the network leakage current requirement during a loss of power (or low voltage) condition.
b. Bus Short to Ground—Network data communications may be interrupted but there shall be no damage to any node when the bus is shorted to ground.
c. Bus Short to Battery—Network data communications may be interrupted but there shall be no damage to any node when the bus is shorted to battery power.
d. Loss of Node Connection to Ground—When a node loses its ground connection, the remaining nodes shall remain capable of communications.

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8.9.2 OPTIONAL FAULT TOLERANT MODES—The network may optionally meet the requirements as defined per the following failure modes:

a. Loss of Termination/Bias—Biasing and termination resistors shall be redundant such that no single point failure will cause the network to become inoperative.
b. Loss of Connection to Network—When a node becomes disconnected from the network the remaining nodes shall remain capable of communications.
c. Dual Wire Fault Tolerant Operation—Nodes on a dual wire bus may be capable of full communication (sending and receiving frames) at the specified bit rate in the presence of any one of the following faults occurring anywhere on the network:

1. Bus "+" wire Open Circuit
2. Bus "–" wire Open Circuit
3. Bus "+" wire Shorted to Ground
4. Bus "–" wire Shorted to Ground
5. Bus "+" wire Shorted to Battery + (Vbatt)
6. Bus "–" wire Shorted to Battery + (Vbatt)
7. Bus "+" wire Shorted to any voltage between Ground and Battery
8. Bus "–" wire Shorted to any voltage between Ground and Battery

Noise immunity and emissions may be somewhat degraded during the faulted period but shall return to normal after the fault is removed.

All nodes shall be protected from damage during the presence of these faults such that recovery to normal operation occurs automatically upon removal of the fault (i.e., faults shall not propagate through the network).

Continued communication is not required for the "Double Fault" condition of the Bus "+" wire shorted to the Bus "–" wire.

8.10 EMC Requirements—The vehicle manufacturer shall specify a minimum EMC level of operation for a module that utilizes this network interface device. A philosophical method for classification of functional performance can be found in SAE J1113 Part 1 Appendix B (formerly SAE J1113 Appendix B). A component manufacturer that designs the interface device to conform to the most severe classification of Class C Region I, for example, could be assured of adequate performance for all conditions.

The modules that communicate with each other via this interface device shall not generate levels of noise emissions (EMI) large enough to interfere with each other. For reference, the levels defined by CISPR/D/WG2 (Secretariat) 19 Sept 1989 may be used. In general, the specifications on wave shaping and transition rise and fall times control the EMI levels.

The vehicle manufacturers may find SAE J1211 helpful in specifying their multiplex systems. SAE J1879 may also be utilized for specifying components. This document recommends the vehicle manufacturers use the following documents and the outlined EMC test plan defined in Appendix B. EMC and voltage "level" requirements specified by the Test Plan are given for reference only and the vehicle manufacturer specifications shall be used for compliance testing.

a. Radiated Emissions Antenna & Probe Test (CISPR/D/WG2(Secretariat) 19 Sept 1989)
b. Transfer Function, Current probe monitoring (SAE J1113 Part 2)
c. Transfer Function, Antenna monitoring (SAE J1113 Part 3)
d. RF Susceptibility (SAE J1113 Part 13)
e. Transient Susceptibility (SAE J1113 Part 10)

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9. *Parameters*

9.1 Application Layer—The following Application Layer requirements shall exist whenever the network is used.

Bit Dominance - A "0" bit dominates over a "1" bit.

9.2 Data Link Layer

9.2.1 PULSE WIDTH MODULATION (PWM) AT 41.6 KBPS—The maximum frame length from SOF to EOF inclusive is 101 bit times. The maximum number of message bytes (i.e., excluding frame delimiters SOF, EOD, EOF, and IFS) is 12 bytes.

9.2.2 VARIABLE PULSE WIDTH (VPW) AT 10.4 KBPS—The maximum number of message bytes (i.e., excluding frame delimiters SOF, EOD, EOF, and IFS) is 12 bytes.

9.3 Physical Layer

9.3.1 GENERAL NETWORK REQUIREMENTS (SEE TABLE 2)

TABLE 2—GENERAL NETWORK PARAMETERS

Parameter Description	Parameter Value
On-Vehicle Network Length	35 meters(1)
Off-Vehicle Network Length	5 meters
Total Vehicle Network Length	40 meters(1)
Maximum number of standard unit loads (including off-vehicle equipment)	32 nodes
Off-vehicle load resistance	10.6 kohms min
Off-vehicle capacitance (each bus wire to signal or chassis ground, as measured at the SAE J1962 connector)	500 pF max

1. For VPW, the On-Vehicle Network Length and the Total Vehicle Network Length are for reference use. For PWM, these lengths specified shall not be exceeded.

9.3.2 PULSE WIDTH MODULATION (PWM)

9.3.2.1 *PWM Timing Requirements*—The following requirements, see Table 3, are for a nominal bit time of 24ms or 41.6 Kbps as seen on the network media.

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TABLE 3—PWM PULSE WIDTH TIMES (µs)

Symbol	Tx,min	Tx,nom	Tx,max	Rx,min	Rx,max
Tp1: Active phase "1"	≥ 7	8	≤ 9	≥ 6	≤ 11
Tp2: Active phase "0"	≥ 15	16	≤ 17	≥ 14	≤ 19
Tp3: Bit time	≥ 23	24	≤ 25.5	≥ 22	≤ 27
Tp4: SOF/EOD time	≥ 47	48	≤ 51	≥ 46	≤ 63
Tp5: EOF time	≥ 70	72	76.5	≥ 70	N/A(1)
Tp6: IFS time	≥ 94	96	N/A(2)	N/A	N/A(2)
Tp7: Active SOF	≥ 30	32	≤ 33	≥ 30	≤ 35
Tp8: Active BRK	≥ 38	40	≤ 41	≥ 38	≤ 43
Tp9: BRK to IFS time	≥118	120	N/A(2)	N/A	N/A(2)
Tp10: SOF to Data rising edge	≥ 47	48	≤ 51	≥ 45	≤ 52
TP11 Passive to next rising edge	≥ 6	N/A	N/A	≥ 4	N/A

1. EOF transitions into IFS and is not actually a "transmitted" symbol.
2. Maximum IFS ends at next SOF.

Transmit tolerances include oscillator tolerances, physical layer delays (i.e., turn-on and turn-off delays), and other miscellaneous tolerances. Receive tolerances include considerations for voltage offsets between transmitter and receiver and other miscellaneous tolerances.Symbols received in the "gray" areas previously can be decoded as either the symbol before or after that of the "gray" area. For example, an active pulse of 12.5 µs can be decoded as either an active phase "1" (Tp1) or an active phase "0" (Tp2). An incorrect decision will be detected in the CRC error detection byte. Figure 22 gives an example of how a signal should be decoded based on the received pulse width.

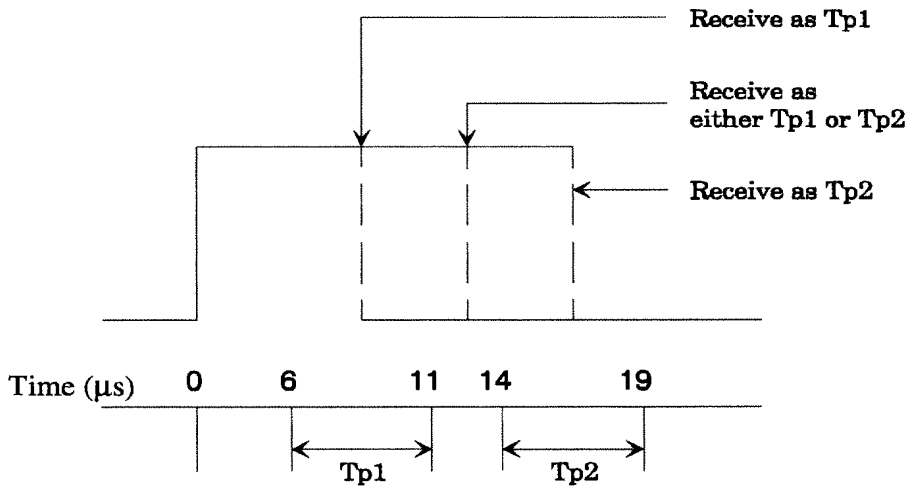


FIGURE 22—EXAMPLE OF RECEIVING A TP1 OR TP2 SYMBOL

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Note that a pulse width detected between Tp1(min) and Tp1(max) must be decoded as an active phase "1" and a pulse width detected between Tp2(min) and Tp2(max) must be decoded as an active phase "0." However, a pulse width detected between Tp1(max) and Tp2(min) can be decoded as either an active phase "1" or active phase "0."

9.3.2.2 PWM DC Parameters (see Table 4)

TABLE 4—PWM DC PARAMETERS(1)

Parameter	Symbol	Min	Typ	Max	Units
Input High Voltage	V_{ih}	2.80	—	6.25	V
Input Low Voltage	V_{il}	−1.00	—	2.20	V
Output High Voltage	V_{oh}	3.80	—	5.25	V
Output Low Voltage	V_{ol}	0.00	—	1.20	V
Absolute Ground Offset Voltage	V_{go}	0.00	—	1.00	V
Bus (+) Driver & Bus (–) Termination Supply Voltage	V_{sup}	4.75	5.00	5.25	V
Receiver Input Common Mode Operating Range	V_{cm}	1.80	—	2.75	V
Receiver Hysteresis & Overdrive	V_{hys}	—	—	180	mV
Network Resistance (each wire)	R_{load}	85	—	378	ohms
Network Capacitance (each wire)	C_{load}	500	—	15,000	pF
Network Time Constant(2)	T_{load}	—	—	1.35	µs
Signal Transition Time	T_t	—	—	1.75	µs
Node Resistance (unit load, each wire)	R_{ul}	—	2,880	—	ohms
Node Capacitance (unit load, each wire to ground)	C_{ulg}	—	250	—	pF
Node Capacitance (unit load, wire-to-wire)	C_{ulw}	—	10	—	pF
Node Leakage Current (each wire - active state)	I_{leakA}	—	—	100	µA
Node Leakage Current (each wire - passive state, unpowered node)	I_{leakPU}	—	—	250	µA
Node Leakage Current (each wire - passive state, powered node)	I_{leakPP}	—	—	250	µA

1. Refer to Appendix D for an analysis of the PWM waveform.
2. The network time constant (T_{load}) is the product of R_{load} and C_{load}. Therefore, some combinations of network resistance and network capacitance are not allowed. The product of R_{load} and C_{load} must always be less than T_{load}, max.

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9.3.3 VARIABLE PULSE WIDTH MODULATION (VPW)

9.3.3.1 VPW Timing Requirements—The following requirements, Table 5, show the VPW timing values.

TABLE 5—VPW PULSE WIDTH TIMES (µs)

Symbol	Tx,min	Tx,nom	Tx,max	Rx,min	Rx,max
Tv1: Short Pulse	≥ 49	64	≤ 79	> 34	≤ 96
Tv2: Long Pulse	≥ 112	128	≤ 145	> 96	≤ 163
Tv3: SOF/EOD time	≥ 182	200	≤ 218	> 163	≤ 239
Tv4: EOF time	≥ 261	280	N/A(1)	> 239	N/A(1)
Tv5: BRK time	≥ 280	300	≤ 5 ms	> 239	≤ 1.0 s
Tv6: IFS time	≥ 280	300	N/A(2)	> 280	N/A(2)

1. EOF transitions into IFS and is not actually a "transmitted" symbol.
2. Maximum IFS ends at next SOF.

9.3.3.2 VPW DC Parameters (see Table 6)

TABLE 6—VPW DC PARAMETERS(1)

Parameter	Symbol	Min	Typ	Max	Units
Input High Voltage(2)	V_{ih}	4.25	—	20.00	V
Input Low Voltage	V_{il}	—	—	3.50	V
Output High Voltage	V_{oh}	6.25	—	8.00	V
Output Low Voltage	V_{ol}	0.00	—	1.50	V
Absolute Ground Offset Voltage	V_{go}	0.00	—	2.00	V
Network Resistance	R_{load}	315	—	1,575	ohms
Network Capacitance	C_{load}	2,470	—	16,544	pF
Network Time Constant(3)	T_{load}	—	—	5.2	µs
Signal Transition Time	T_t	—	—	18.0	µs
Node Resistance (unit load)	R_{ul}	—	10,600	—	ohms
Node Capacitance (unit load)	C_{ul}	—	470	—	pF
Node Leakage Current	I_{leak}	—	—	10	µA

1. Refer to Appendix C for an analysis of the VPW waveform.
2. Individual manufacturers may require a higher upper limit ($V_{ih,\ max}$).
3. The network time constant (T_{load}) is the product of Rload and C_{load}. Therefore, some combinations of network reistance and network capacitance are not allowed. The product of R_{load} and C_{load} must always be less than $T_{load,\ max}$.

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10. Notes

10.1 Marginal Indicia—The change bar (|) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

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APPENDIX A

CHECKLIST OF APPLICATION-SPECIFIC FEATURES

A.1 Figure A1 is a checklist provided as an aid to highlight the communication features of J1850.

FEATURES	Tx	Rx	Comments
FRAME ELEMENTS			
General Frame Elements : IFS, SOF, Data, CRC, EOF.			
End of Data (EOD)			
Normalization Bit (NB) - Tv1/Tv2			
BUS ACCESS			
Idle Bus			
Break (BRK)			
IN-FRAME RESPONSE			
Type 0 (None)			
Type 1 (Single Byte, Single Responder)			
Type 2 (Single Byte, Multiple Responder)			
Type 3 (Multiple Byte, Single Responder)			
ERROR DETECTION			
Cyclic Redundancy Check (CRC)			
Out of Range			
Invalid Bit			
Invalid Symbol			
Invalid Structure			
Invalid Message Length			
Number of Arbitration Bytes			
FAULT TOLERANCE			
Node Power Loss			
Bus Short to Ground			
Bus Short to Battery			
Loss of Node Ground Connection			

FIGURE A1A—CHECKLIST OF APPLICATION-SPECIFIC FEATURES

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FEATURES	Tx	Rx	Comments
Loss of Termination Resistance			
Loss of Network Connection			
Dual Wire Fault Tolerance			
HEADER BYTES			
Single Byte			
One Byte Consolidated			
Three Byte Consolidated			
RATE/SYMBOL ENCODING			
10.4 KbpsVariable Pulse Width Modulation (VPWM)			
41.6 KbpsPulse Width Modulation (PWM)			
FEATURE ELEMENTS			
Maximum Frame Size			
Wake-Up Capability			

FIGURE A1B—CHECKLIST OF APPLICATION-SPECIFIC FEATURES (CONTINUED)

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APPENDIX B

I/O EMS TEST PLAN

B.1 Radio Disturbance From Vehicle Components—(CISPR/D/WG2(Secretariat) 19 Sept 1989)—See Figure B1 for diagram.

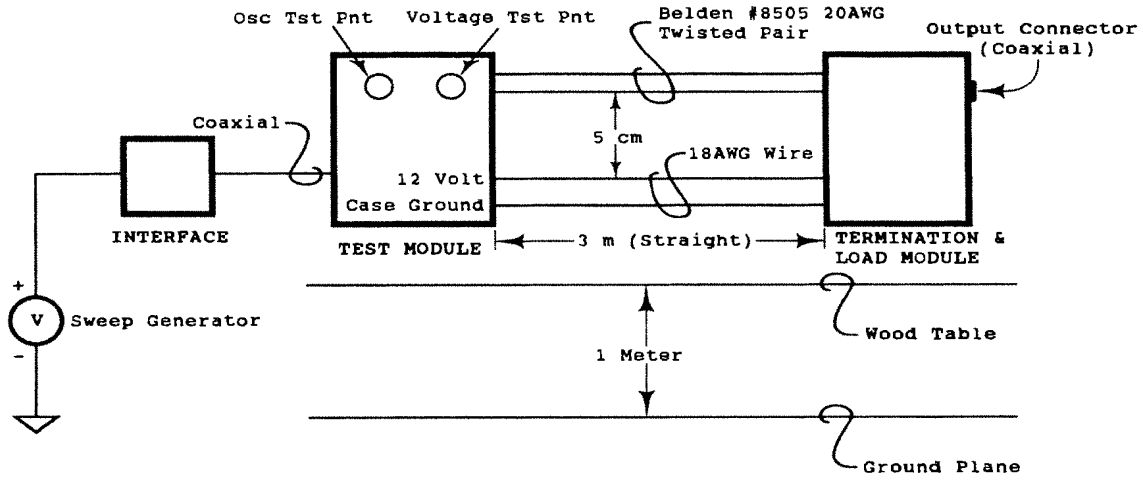


FIGURE B1—EMC TEST SETUP

B.1.1 Radiated Emissions Antenna Test

B.1.1.1 FREQUENCY RANGE—10 kHz to 1.0 GHz

B.1.1.2 BANDWIDTH SETTING

a. Frequency - 10 kHz to 149 kHz, Bandwidth - 1 kHz
b. Frequency - 150 kHz to 1 GHz, Bandwidth - 3 kHz

B.1.1.3 TEST DATA

B.1.1.3.1 Ambient Reference

a. 10 kHz modulation off
b. Both transmitter and receiver power off
c. Sweep signal off

B.1.1.3.2 Idle Bus State

a. 10 kHz modulation off
b. Both transmitter and receiver power on
c. Sweep signal off

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B.1.1.3.3 Active Bus State

a. 10 kHz modulation on
b. Both transmitter and receiver power on
c. Sweep signal off

B.1.2 Radiated Emissions Probe Test

B.1.2.1 FREQUENCY RANGE—10 kHz to 200 MHz

B.1.2.2 BANDWIDTH SETTING

a. Frequency - 10 kHz to 149 kHz, Bandwidth - 1 kHz
b. Frequency - 150 kHz to 1 GHz, Bandwidth - 3 kHz

B.1.2.3 PROBE TYPE—As required to make measurements

a. Recommended probe type - Tektronix A6302 (0 - 29 MHz)
b. Recommended probe type - Ailtech 94111-1 (30 - 200 MHz)

B.1.2.4 PROBE DISTANCE—5 cm from part

B.1.2.5 TEST DATA

B.1.2.5.1 Ambient Reference

a. 10 kHz modulation off
b. Both transmitter and receiver power off
c. Sweep signal off

B.1.2.5.2 Idle State

a. 10 kHz modulation off
b. Both transmitter and receiver power on
c. Sweep signal off

B.1.2.5.3 Active Bus

a. 10 kHz modulation on
b. Both transmitter and receiver power on
c. Sweep signal off

B.2 Transfer FunctionElectromagnetic Susceptibility Measurement Procedures for Vehicle Components

B.2.1 Current Probe Monitoring—Adapted from SAE J1113 Part 2 (Formerly SAE J1113 (Aug 87) Section 2).

a. Frequency - 30 Hz to 250 kHz
b. Amplitude - 1 V peak-to-peak at test point

B.2.2 Antenna Monitoring—Adapted from SAE J1113 Part 3 (Formerly SAE J1113 (Aug 87) Section 3).

a. Frequency: 250 kHz to 200 MHz
b. Attenuator input power:»25 mW to generate 1 V peak-to-peak at test point

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B.2.3 Test Data

B.2.3.1 TRANSFER FUNCTION FROM VCC TO BUS

a. 10 kHz modulation on
b. Both transmitter and receiver power on
c. Sweep signal on

B.2.3.2 TRANSFER FUNCTION FROM GROUND TO BUS

a. 10 kHz modulation on
b. Both transmitter and receiver power on
c. Sweep signal on

B.3 RF Susceptibility—Electromagnetic Susceptibility Measurement Procedures for Common Mode Injection for compliance, test per SAE J1113 Part 13 (formerly SAE J1547).

B.3.1 Frequency Range—1 MHz to 200 MHz.

B.3.2 Max Level— 100 mA RMS.

B.3.3 Procedure—Injection and monitoring to be applied to Bus pair only.

B.3.4 Test Data—Record the nature of any interaction occurring below the test level along with the current and frequency.

B.4 Transient Susceptibility—Test per SAE J1113 Part 12 (Adapted from ISO 7637/3).

Test Pulse Amplitude

a. Test Pulse 1: –30 V (Reference)
b. Test Pulse 2: +30 V (Reference)
c. Test Pulse 3a: –60 V (Reference)
d. Test Pulse 3b: +40 Vs (Reference)

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APPENDIX C

VPW WAVEFORM ANALYSIS

C.1 ***VPW Waveform Analysis***—Figure C1 shows a drawing of a bus waveform with various voltage levels and trip points. The voltage levels and trip points are defined as follows:

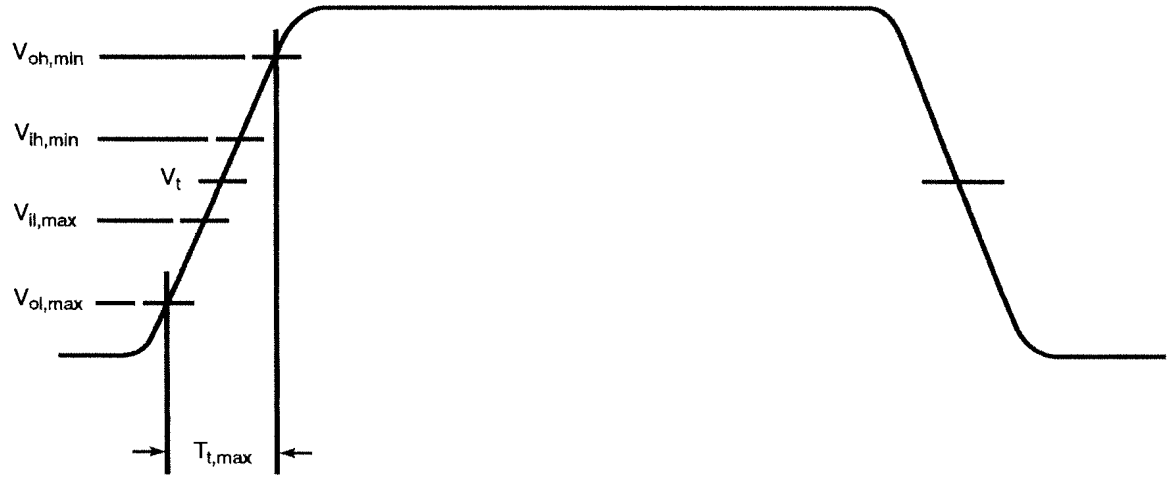


FIGURE C1—VOLTAGE LEVELS AND TRIP POINTS

C.2 Voltage Levels and Trip Points

C.2.1 $V_{oh,min}$—Minimum guaranteed output high voltage. This is also the highest trip point, with the source having no ground offset noise, and the receiver having 2 V of noise.

C.2.2 $V_{ol,max}$—Maximum guaranteed output low voltage. This is also the lowest trip point, with the receiver having no ground offset noise, and the source having 2 V of noise.

C.2.3 V_t—Ideal receiver trip point.

C.2.4 $V_{ih,min}$—Minimum guaranteed input high voltage and is also the highest trip point with no offset noise.

C.2.5 $V_{il,max}$—Maximum guaranteed input low voltage and is also the lowest trip point with no offset noise.

C.3 ***VPW Pulse Width Analysis***—Factors that affect the transmitted pulse width are oscillator tolerance and variations in delay through the source driver and the medium. These factors, along with some guard banding, are lumped into a single set of limits called $T_{x,min}$ and $T_{x,max}$ for each bus symbol.

For a $T_{nom} = T_{x,nom}$, Equations C1 and C2 are used to generate the transmitted pulse values shown in Table C1:

$$T_{x,min} = (T_{nom} - T_{t,max}/2)*0.98 - T_{x,mar} \quad \text{(Eq. C1)}$$

$$T_{x,max} = (T_{nom} + T_{t,max}/2)*1.02 + T_{x,mar} \quad \text{(Eq. C2)}$$

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TABLE C1—VPW PULSE WIDTH TIMES (MS)

Symbol	Tx,min	Tx,nom	Tx,max	Rx,min	Rx,max
Tv1: Short Pulse	49	64	79	34	96
Tv2: Long Pulse	112	128	145	95	162
Tv3: SOF/EOD time	182	200	218	164	237
Tv4: EOF time	261	280	N/A	241	N/A

The $(T_{nom} \pm T_{t,max}/2) * 2\%$ factor covers the 2% oscillator tolerance. The $T_{x,nom}$ and $T_{t,max}$ factors are given in Section 9. The $T_{x,mar}$ factor is assumed to be 5.0 which covers the rest of the factors (lumped variation in delay through the source driver and medium).

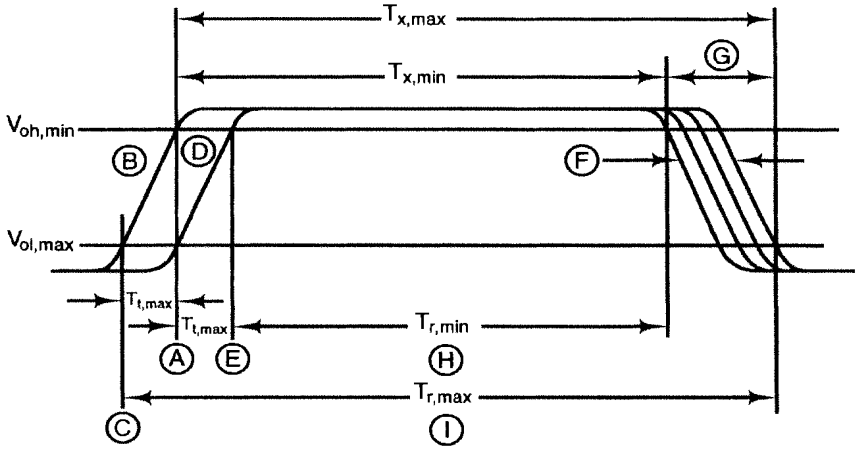
For VPW, node synchronization is an integral part of symbol timing. All transmitting nodes reference their transmit timing from their receiver's perception of the previous edge without regard to whether that edge was due to their own or another transmitter.

Figure C2 shows a plot of T_x, (i.e., $T_{x,min}$ and $T_{x,max}$). Each is measured from the ideal trip point on the leading edge of the waveform. The fact that what is seen at the source's own receiver contributes to the transmitted pulse width, implies that the source device could be using echoed back information to shape what is transmitted.

The pulse width seen by another node (receiver) can range from $T_{x,min} - T_{t,max}$ to $T_{x,max} + T_{t,max}$. This range comes from the variations in the transmitted pulse width combined with possible noise offset effects on the transmitted and receiving node. The $T_{x,min} - T_{t,max}$ situation occurs when a $T_{x,min}$ pulse width is transmitted by a source node with no ground offset noise, and received by a receiving node with a 2 V of ground offset noise. This sets up the possibility of the receiver tripping at $V_{oh,min}$ on the leading and trailing edge of the waveform. Therefore the pulse width seen by another node for this $T_{x,min} - T_{t,max}$ situation including the oscillator tolerance and guard banding is given by Equation C4. Equation C5 is derived by substituting Equation C1 for $T_{x,min}$ into Equation C4. Equation C6 is derived by including the effect of the real receiver trip point $T_{tp,max}$ in Equation C1 and substituting for $T_{x,min}$ in Equation C4. The $T_{t,max}/2$ factor is equal to zero, in Equation C6, since an ideal trip point and no ground offset was assumed. The $T_{x,max} + T_{t,max}$ situation occurs with a $T_{x,max}$ pulse being transmitted, the source node having 2 V of noise, and the receiver having no offset. This sets up the possibility of the receiving node tripping at $V_{ol,max}$. Again the actual acceptance range must be wider to allow for the receiving node's oscillator tolerance and any implementation dependent uncertainties or constraints. Similarly Equations C9 and C10 are derived.

The receiving node may perceive the leading edge sooner or later than the transmitting node (source node). This range represents a receiver's required acceptance range for a given bus symbol. Figure C2 shows a drawing of this acceptance range.

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A - The trigger point on waveform "B" or "D" where the transmitting node sees the transition ending the previous symbol, and starts timing the current symbol. Take note that a node could trigger at any level of a transition between $V_{ol,max}$ and $V_{oh,min}$. The maximum and minimum trigger points of any given transition are illustrated by showing line A cutting through two different waveform transitions. This method of illustration allows separating the uncertainties of nodes sensing the beginning and ending of a symbol.

B - The earliest waveform that could trigger the transmitter at point A.

C - The earliest point on waveform "B" that could trigger any other node.

D - The latest waveform that could trigger the transmitter at point A.

E - The latest point on waveform "D" that could trigger any other node.

F - The waveform dispersion due to transmitter tolerances in oscillator, driver, etc.

G - The total transmitter spread when transition time limits are combined with the other tolerances in "F".

H - The shortest legitimate symbol time which can legitimately be seen under worst case conditions.

I - The longest legitimate symbol time which can legitimately be seen under worst case conditions.

NOTES—$T_{x,max}$ - Starts at $V_{oh,min}$ on wave "B"; $T_{x,min}$ - Starts at $V_{ol,max}$ on wave "D"

FIGURE C2—WAVEFORM TIMING PARAMETERS

The calculations for the received $T_{r,min}$ and $T_{r,max}$ are derived using the factors specified in Section 9 for a 2 V ground offset range and a transition rise time of $T_{t,max}$. The transmitting node $T_{t,max}$ factor would be zero (0) if it was a perfect receiver and sensed a transition at the ideal trip point. However, for a real receiver the trip point $T_{tp,max}$ can be approximated by Equation C3 assuming a linear waveform rise time.

$$T_{tp,max} = T_{t,max} * ((V_{ih,min} - V_{il,max}) / (V_{oh,min} - V_{ol,max})) \quad \text{(Eq. C3)}$$

The values for this range shown in Table C1 were arrived at using Equations C7 and C11. Note these values compare favorably with the values specified in Section 9, Table 5.

$$T_{r,min} = (T_{x,min} - T_{t,max}) * 0.98 - T_{r,mar} \quad \text{(Eq. C4)}$$

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$$T_{r,min} = ([(T_{nom} - T_{t,max}/2)*0.98 - T_{x,mar}] - T_{t,max})*0.98 - T_{r,mar} \quad \text{(Eq. C5)}$$

NOTE—Equation C5 does not consider the effect of the rear receiver trip point, $T_{tp,max}$. Equation C6 is derived by including $T_{tp,max}$ in Equation C1 and substituting for $T_{x,min}$ in Equation C4.

$$T_{r,min} = ([(T_{nom} - T_{t,max}/2 - T_{tp,max}/2)*0.98 - T_{x,mar}] - T_{t,max})*0.98 - T_{r,mar} \quad \text{(Eq. C6)}$$

NOTE—Since an ideal trip point and no ground offset are assumed, the $T_{t,max}/2$ factor is set to zero(0), producing Equation C7.

$$T_{r,min} = ([(T_{nom} - T_{tp,max}/2)*0.98 - T_{x,mar}] - T_{t,max})*0.98 - T_{r,mar} \quad \text{(Eq. C7)}$$

$$T_{r,max} = (T_{x,max} + T_{t,max})*1.02 + T_{r,mar} \quad \text{(Eq. C8)}$$

$$T_{r,max} = ([(T_{nom} + T_{t,max}/2)*1.02 + T_{x,mar}] + T_{t,max})*1.02 + T_{r,mar} \quad \text{(Eq. C9)}$$

$$T_{r,max} = ([(T_{nom} + T_{t,max}/2 + T_{tp,max}/2)*1.02 + T_{x,mar}] + T_{t,max})*1.02 + T_{r,mar} \quad \text{(Eq. C10)}$$

$$T_{r,max} = ([(T_{nom} + T_{tp,max}/2)*1.02 + T_{x,mar}] + T_{t,max})*1.02 + T_{r,mar} \quad \text{(Eq. C11)}$$

The 2% guard bands cover the oscillator tolerances of both transmitter and receiver and $T_{r,mar}$ = 4.0 covers the other uncertainties, including receiver delay and digital filter delay. VPW bus symbols allow no forbidden zones between symbols.

Table C1 shows the VPW Pulse Width Timing Requirements

Filter Compensation—The reason for choosing a synchronous data encoding technique is to synchronize at every valid state transition. If the delays through the filter, receiver, and output drivers can be characterized into a constant value, this delay can be compensated for by the timing logic. If variations in delay caused by this Filter and I/O Hardware cannot be easily compensated for, then the Source Interface device variations should be included in the ±5.0 µs factor defined in $T_{x,min}$ and $T_{x,max}$. All further, variations in delay and including a safety factor for dead zones between symbols for the Receiving device should be included in the ±4 ms factor defined in $T_{r,min}$ and $T_{r,max}$.

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APPENDIX D

PWM WAVEFORM ANALYSIS

D.1 PWM Waveform Analysis—Figure D1 shows a drawing of a typical bus waveform with various voltage levels and trip points. Table D1 contains the DC parameter specifications.

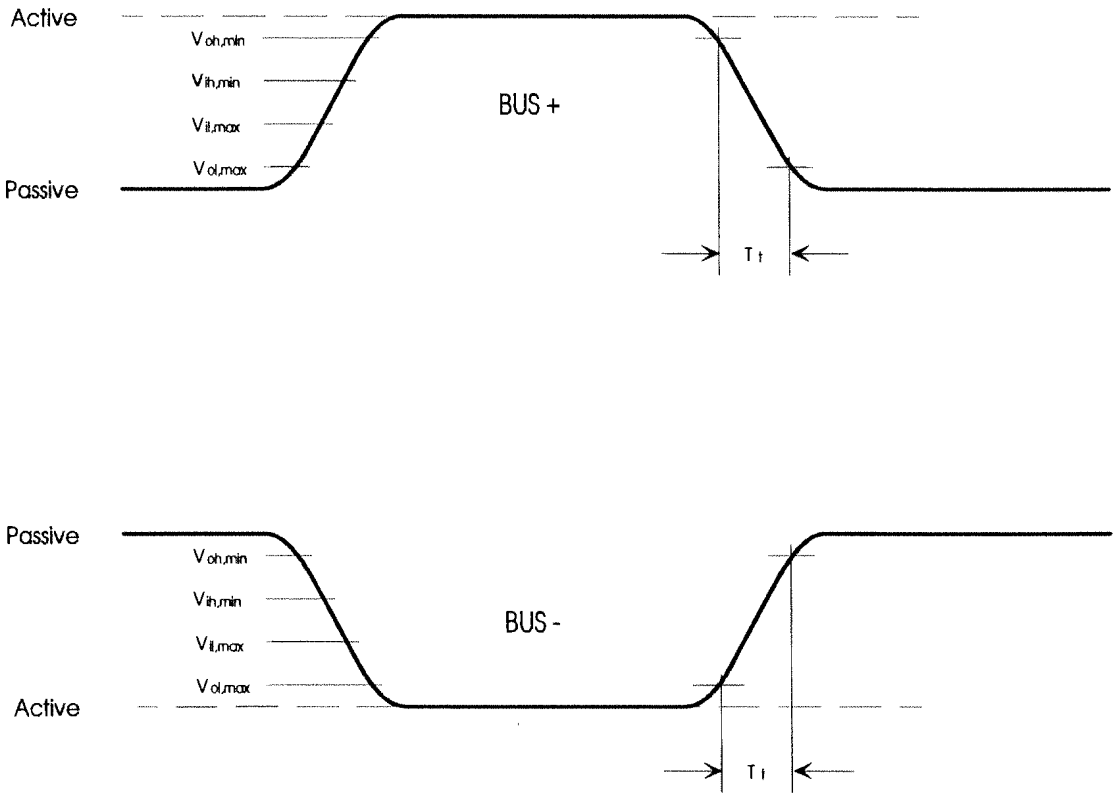


FIGURE D1—TYPICAL PWM WAVEFORM

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TABLE D1—PWM DC PARAMETERS

Parameter	Symbol	Min	Typ	Max	Units
Input High Voltage	V_{ih}	2.80	—	6.25	V
Input Low Voltage	V_{il}	−1.00	—	2.20	V
Output High Voltage	V_{oh}	3.80	—	5.25	V
Output Low Voltage	V_{ol}	0.00	—	1.20	V
Absolute Ground Offset Voltage	V_{go}	0.00	—	1.00	V
Bus (+) Driver & Bus (() Termination Supply Voltage	V_{sup}	4.75	5.00	5.25	V
Receiver Input Common Mode Operating Range	V_{cm}	1.80	—	2.75	V
Receiver Hysteresis & Overdrive	V_{hys}	—	—	180	mV
Network Resistance (each wire)	R_{load}	85	—	378	ohms
Network Capacitance (each wire)	C_{load}	500	—	15,000	pF
Network Time Constant(1)	T_{load}	—	—	1.35	µs
Signal Transition Time	T_t	—	—	1.75	µs
Node Resistance (unit load, each wire)	R_{ul}	—	2,880	—	ohms
Node Capacitance (unit load, each wire to ground)	C_{ulg}	—	250	—	pF
Node Capacitance (unit load, wire-to-wire)	C_{ulw}	—	10	—	pF
Node Leakage Current (each wire - active state)	I_{leakA}	—	—	100	µA
Node Leakage Current (each wire - passive state, unpowered node)	I_{leakPU}	—	—	250	µA
Node Leakage Current (each wire - passive state, powered node)	I_{leakPP}	—	—	250	µA

1. The network time constant (T_{load}) is the product of R_{load} and C_{load}. Therefore, some combinations of network resistance and network capacitance are not allowed. The product of R_{load} and G_{load} must always be less than $T_{load, max}$

D.2 Voltage Levels and Trip Points

D.2.1 V_{ih}—This is the input high voltage which a receiver must detect as an active state on bus (+) and as a passive state on bus (–).

D.2.2 V_{il}—This is the input low voltage which a transmitter must detect as an active state on bus (–) and as a passive state on bus (+).

D.2.3 V_{oh}—This is the output high voltage which a transmitter must drive bus (+) and the voltage which bus (–) must passively return to. Note that $V_{oh,min}$ is $V_{ih,min}$ plus the absolute maximum ground offset voltage ($V_{go,max}$).

D.2.4 V_{ol}—This is the output low voltage which a transmitter must drive bus (–) and the voltage which bus (+) must passively return to. Note that $V_{ol,max}$ is $V_{il,max}$ minus the absolute maximum ground offset voltage ($V_{go,max}$).

D.2.5 V_{og}—This is the absolute ground offset voltage that can exist between any two nodes on the network.

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D.2.6 V_{sup}—This is the supply voltage which a transmitter must use to drive bus (+) and terminate bus (–).

D.2.7 V_{cm}—This is the receiver input common mode operating range. In order for the differential receiver to recognize a valid signal transition, the bus (+) and bus (–) signals must cross at a voltage within this range.

D.2.8 V_{hys}—This is the receiver hysteresis and overdrive voltage including any power supply reference tolerance.

D.2.9 R_{load}—This is the equivalent network resistance from each bus wire to the corresponding passive voltage source.

D.2.10 C_{load}—This is the equivalent network capacitance from each bus wire to ground.

D.2.11 T_{load}—This is the network time constant for each bus wire. This is the product of R_{load} and C_{load} of each bus wire. The time constant determines the maximum active-to-passive transition time.

D.2.12 T_t—This is the signal transition time for each bus wire from either the active-to-passive state or passive-to-active state. The passive-to-active edge is driven by the transmitter and shall be no more than $T_{t,max}$. The active-to-passive edge is determined by the network time constant, bus voltage levels, and the passive state supply voltage level.

D.2.13 C_{ulg}—This is the unit load node capacitance of each wire to ground. This capacitance, along with the unit load node capacitance wire-to-wire, results in the total network capacitance referred to in C.2.10.

D.2.14 C_{ulw}—This is the unit load node capacitance wire-to-wire. This capacitance along with the node capacitance of each wire to ground results in the total network capacitance referred to in C.2.10.

D.2.15 I_{leakA}—This is the leakage current of each wire when the bus is in the active state.

D.2.16 I_{leakPU}—This is the leakage current of each wire when the bus is in the passive state and the node is unpowered.

D.2.17 I_{leakPP}—This is the leakage current of each wire when the bus is in the passive state and the node is powered.

D.3 Input Voltage Limits—Given the Bus (+) Driver & Bus (–) Termination Supply Voltage (V_{sup}) and the maximum Receiver Hysteresis and Overdrive Voltage (V_{hys}), V_{ih} and V_{il} can be derived. (See Equations D1 through D4.)

$$V_{il,\,min} = (\text{Ground Reference}) - V_{go} = 0.00 - 1.00 = -1.00\text{V} \quad \text{(Eq. D1)}$$

$$V_{il,\,max} = 1/2\,(V_{sup,min}) - V_{hys,\,min} = 1/2\,(4.75) - 0.18 = 2.20\text{V} \quad \text{(Eq. D2)}$$

$$V_{ih,\,min} = 1/2\,(V_{sup,\,max}) + V_{hys,\,max} = 1/2\,(5.25) + 0.18 = 2.81\text{V} \quad \text{(Eq. D3)}$$

$$V_{ih,\,max} = V_{sup,max} + V_{go} = 5.25 + 1.00 = 6.25\,\text{V} \quad \text{(Eq. D4)}$$

where 1/2 the $V_{il,max}$ and $V_{ih,min}$ assumes a receive comparator voltage level of one-half of the supply voltage. It turns out this is a good tradeoff for voltage ground offset capability versus output drive requirements.

D.4 Output Voltage Limits—Output voltage limits can be derived directly from the input voltage limits. (See Equations D5 through D8.)

$$V_{olmin} = V_{ilmin} + V_{go} = -1.00 + 1.00 = 0\text{V (Ground Reference)} \quad \text{(Eq. D5)}$$

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$$V_{ol,max} = V_{il,max} - V_{go} = 2.20 - 1.00 = 1.20V \quad \text{(Eq. D6)}$$

$$V_{oh,min} = V_{ih,min} + V_{go} = 2.80 + 1.00 = 3.80V \quad \text{(Eq. D7)}$$

$$V_{oh,max} = V_{ih,max} - V_{go} = 6.25 - 1.00 = 5.25(V_{sup,max}) \quad \text{(Eq. D8)}$$

D.5 ***D.5 Network Time Constant & Signal Transition Time***—In order to guarantee signal cross over in the Receiver Input Common Mode Operating Range (V_{cm}) the signal transition time must be less than 2.20 ms. This is $T_{t,max}$ + the worst case transition time from $V_{ol,min}$ to $V_{ol,max}$ for Bus (–), or $V_{oh,max}$ to $V_{oh,min}$ for Bus (+). Therefore, given Dt = 2.20 ms, the following relationship for $V_{oh,min}$ must be satisfied for Bus (–) and $V_{ol,max}$ for Bus (+). (See Equations D9 through D12.)

$$V_{oh,min} = V_{sup,min}(1 - e^{-(Dt/Tloadmax)}) \text{ for Bus}(-) \quad \text{(Eq. D9)}$$

$$V_{ol,max} = V_{oh,max}(e^{-(Dt/Tload,max)}) \text{ for Bus (+)} \quad \text{(Eq. D10)}$$

From this, the maximum network time constant ($T_{load,max}$) can be derived.

$$T_{load,max}(\text{Bus}-) = -\Delta t \div \ln(1 - (V_{oh,min}/V_{sup,min})) = -2.20 \div \ln(1 - (3.80/4.75)) = 1.37\mu s \quad \text{(Eq. D11)}$$

$$T_{load,max}(\text{Bus}+) = -\Delta t \div \ln(V_{ol,max}/V_{oh,max}) = -2.20 \div \ln(1.20/5.25) = 1.49\mu s \quad \text{(Eq. D12)}$$

Choosing a $T_{load,max}$ of 1.35 ms satisfies both equations. Given a maximum network time constant of 1.35 ms, the signal transition time $T_{t,max}$ can be found by subtracting the time from $V_{ol,min}$ to $V_{ol,max}$ (for Bus –) or the time from $V_{oh,max}$ to $V_{oh,min}$ (for Bus +) from 2.20 ms. (See Equations D13 through D16.)

Bus (–):

$$T(V_{ol,min} \text{ to } V_{ol,max}) = -T_{load,max}(\ln(1 - (V_{ol,max}/V_{sup,min}))) = -1.35(\ln(1 - (1.20/4.75))) = 0.39\mu s \quad \text{(Eq. D13)}$$

$$T_{load,max} = 2.20 - T(V_{ol,min} \text{ to } V_{ol,max}) = 2.20 - 0.39 = 1.81\mu s \quad \text{(Eq. D14)}$$

Bus (+)

$$T(V_{oh,max} \text{ to } V_{oh,min}) = -T_{load,max}(\ln(V_{oh,min}/V_{oh,max})) = -1.35(\ln(3.80/5.25)) = 0.44\mu s \quad \text{(Eq. D15)}$$

$$T_{load,max} = 2.20 - T(V_{oh,max} \text{ to } V_{oh,min}) = 2.20 - 0.44 = 1.76\mu s \quad \text{(Eq. D16)}$$

Therefore, choosing a network time constant $T_{load,max}$, of 1.35 ms and a signal transition time $T_{t,max}$ of 1.75 ms ensures that the two bus signals will cross within the Common Mode Operating Range.

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SAE J1850 Revised MAY2001

Rationale—This revision corrects a reference to SAE J1113-01 in Section B.4. The reference should be SAE J1113-12.

Relationship of SAE Standard to ISO Standard—Not applicable.

Application—This SAE Standard establishes the requirements for a Class B Data Communication Network Interface applicable to all On- and Off-Road Land-Based Vehicles. It defines a minimum set of data communication requirements such that the resulting network is cost effective for simple applications and flexible enough to use in complex applications. Taken in total, the requirements contained in this document specify a data communications network that satisfies the needs of automotive manufacturers.

Reference Section

SAE J1113—Electromagnetic Susceptibility Measurements Procedures for Vehicle Components

SAE J1211A—Recommended Environmental Procedure for Electronic Equipment Design

SAE J1213/1—Glossary of Vehicle Networks for Multiplexing and Data Communications

SAE J1547—Electromagnetic Susceptibility Measurement Procedures for Common Mode Injection

SAEJ1879—General Qualification and Production Acceptance Criteria for Integrated Circuits in Automotive Applications

SAE J1930—Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, & Acronyms

SAE J1962—Diagnostic Connector

SAE J1979—E/E Diagnostic Test Modes

SAE J2012—Diagnostic Codes/Messages

SAE J2178—Class B Data Communication Network Messages

SAEJ2178/1—Class B Data Communication Network Messages: Detailed Header Formats and Physical Address Assignment

SAE J2190—Enhanced E/E Diagnostic Test Modes

CISPR/D/WG2 (Secretariat) 19 Sept 1989—Radiated Emissions Antenna and Probe Test

ISO/TC22/SC3/WG1N429EOCT90—Road vehicles—Serial data communication for automotive applications, low speed (125 Kbps and below)

ISO 7498—Data processing systems—Open systems interconnection—Standard reference model

ISO7637/3—Road vehicles—Electrical disturbance by conduction and coupling—Part 3: Passenger cars and light commercial vehicles with nominal 12 V supply voltage and commercial vehicles with 24 V supply voltage—Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines

Developed by the SAE Vehicle Network for Multiplexing and Data Communications Standards Committee

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Parts 60, 61, 62, and 63

[FRL–7513–8]

Change of Address for Submission of Certain Reports; Technical Amendment

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final rule; technical amendment.

SUMMARY: This document announces a technical amendment revising the address for submittal of certain air pollution control documents to EPA Region VII and Iowa and Kansas.

DATES: This document is effective June 17, 2003.

FOR FURTHER INFORMATION CONTACT: Wayne Kaiser, Environmental Protection Agency, Air Planning and Development Branch, 901 North 5th Street, Kansas City, Kansas 66101; (913) 551–7603; or by E-mail at *kaiser.wayne@epa.gov.*

SUPPLEMENTARY INFORMATION: The EPA is correcting addresses for Region VII and the states of Iowa and Kansas in 40 CFR parts 60, 61, 62, and 63. Certain provisions of these regulations require the submittal of reports, applications, and other documents to the EPA regional office and to the state air agencies. This technical amendment updates and corrects the mailing addresses for Region VII and the states of Iowa and Kansas.

List of Subjects in 40 CFR Parts 60, 61, 62, and 63

Environmental protection, Air pollution control, Reporting and recordkeeping requirements.

Dated: June 8, 2003.

James B. Gulliford,

Regional Administrator, Region 7.

■ Chapter I, title 40 of the Code of Federal Regulations is amended as follows:

PART 60—[AMENDED]

■ 1. The authority citation for part 60 continues to read as follows:

Authority: 42 U.S.C. 7401 *et seq.*

Subpart A—General Provisions

■ 2. Section 60.4 is amended by revising the address for Region VII in paragraph (a) and paragraphs (b)(Q) and (b)(R) to read as follows:

§ 60.4 Address.

(a) * * *

Region VII (Iowa, Kansas, Missouri, Nebraska), Director, Air, RCRA, and Toxics Division, U.S. Environmental Protection Agency, 901 N. 5th Street, Kansas City, KS 66101.

* * * * *

(b) * * *

(Q) State of Iowa: Iowa Department of Natural Resources, Environmental Protection Division, Air Quality Bureau, 7900 Hickman Road, Suite 1, Urbandale, IA 50322.

(R) State of Kansas: Kansas Department of Health and Environment, Bureau of Air and Radiation, 1000 S.W. Jackson, Suite 310, Topeka, KS 66612–1366.

* * * * *

PART 61—[AMENDED]

■ 1. The authority citation for part 61 continues to read as follows:

Authority: 42 U.S.C. 7401 *et seq.*

Subpart A—General Provisions

■ 2. Section 61.04 is amended by revising the address for Region VII in paragraph (a) and paragraphs (b)(Q) and (b)(R) to read as follows:

§ 61.04 Address.

(a) * * *

Region VII (Iowa, Kansas, Missouri, Nebraska), Director, Air, RCRA, and Toxics Division, U.S. Environmental Protection Agency, 901 N. 5th Street, Kansas City, KS 66101.

* * * * *

(b) * * *

(Q) State of Iowa: Iowa Department of Natural Resources, Environmental Protection Division, Air Quality Bureau, 7900 Hickman Road, Suite 1, Urbandale, IA 50322.

(R) State of Kansas: Kansas Department of Health and Environment, Bureau of Air and Radiation, 1000 S.W. Jackson, Suite 310, Topeka, KS 66612–1366.

* * * * *

PART 62—[AMENDED]

■ 1. The authority citation for part 62 continues to read as follows:

Authority: 42 U.S.C. 7401 *et seq.*

Subpart A—General Provisions

■ 2. Section 62.10 is amended by revising the entry for Region VII to read as follows:

§ 62.10 Submission to Administrator.

* * * * *

Region and jurisdiction covered	Address
* * * * *	
VII—Iowa, Kansas, Missouri, Nebraska	Air, RCRA, and Toxics Division, 901 N. 5th Street, Kansas City, KS 66101.
* * * * *	

PART 63—[AMENDED]

■ 1. The authority citation for part 63 continues to read as follows:

Authority: 42 U.S.C. 7401 *et seq.*

Subpart A—General Provisions

■ 2. Section 63.13 is amended by revising the address for Region VII in paragraph (a) to read as follows:

§ 63.13 Addresses of State air pollution control agencies and EPA Regional Offices.

(a) * * *

EPA Region VII (Iowa, Kansas, Missouri, Nebraska), Director, Air, RCRA, and Toxics Division, U.S. Environmental Protection Agency, 901 N. 5th Street, Kansas City, KS 66101.

* * * * *

[FR Doc. 03–15257 Filed 6–16–03; 8:45 am]

BILLING CODE 6560–50–P

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 86

[FRL–7492–6]

RIN 2060–AJ77

Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines; Modification of Federal On-Board Diagnostic Regulations for: Light-Duty Vehicles, Light-Duty Trucks, Medium Duty Passenger Vehicles, Complete Heavy Duty Vehicles and Engines Intended for Use in Heavy Duty Vehicles Weighing 14,000 Pounds GVWR or Less; Extension of Acceptance of California OBD II Requirements

AGENCY: Environmental Protection Agency.

ACTION: Direct final rule.

SUMMARY: EPA is taking direct final action to amend and revise certain requirements associated with the Federal on-board diagnostic (OBD) system regulations. EPA previously promulgated an OBD rulemaking on December 22, 1998 (63 FR 70681) which

Geotab Exhibit 107
Geotab v. Omega

indefinitely extended the provision allowing compliance with California OBD II requirements to satisfy federal OBD requirements. The California Air Resources Board (CARB) has recently revised their OBD II requirements and, accordingly, today's rulemaking promulgates appropriate revisions to Federal OBD regulations including: an update to the acceptable version of the California OBD II regulations that allows compliance with California OBD II regulations to satisfy Federal OBD regulations; inclusion of relevant sections pertaining to California OBD II catalyst monitoring requirements when accepting manufacturers' demonstration of compliance with California OBD II; an update of the incorporation by reference of standardized practices developed by the Society of Automotive Engineers (SAE) and the International Organization for Standardization (ISO) to incorporate recently published versions, while also incorporating by reference a new standardized protocol developed by the International Organization for Standardization (ISO) and establishing a future date by which this protocol will be the only acceptable protocol; and a technical amendment to the optional chassis certification requirements for heavy-duty (HD) vehicles weighing 14,000 pounds GVWR or less. OBD systems in general provide substantial benefits to the environment by diagnosing and alerting operators, vehicle inspection and maintenance (I/M) personnel, and service providers of deterioration or malfunction of emission related control systems.

DATES: This direct final rule becomes effective August 18, 2003 without further notice, unless we receive adverse comments by July 17, 2003 or we receive a request for a public hearing by July 2, 2003. Should EPA receive any adverse comments on this direct final rule, we will publish a subsequent action in the **Federal Register** withdrawing an amendment, paragraph, or section of this final rule. The incorporation by reference of certain publications listed in the rule is approved August 18, 2003.

ADDRESSES: All comments and materials relevant to today's action should be submitted to Public Docket No. A–2002–20 at the following address: EPA Docket Center (EPA/DC), Public Reading Room, Room B102, EPA West Building,1301 Constitution Avenue, NW., Washington, DC. The EPA Docket Center Public Reading Room is open from 8:30 a.m. to 4:30 p.m., Monday through Friday, except on government holidays. You can reach the Reading Room by telephone at (202) 566–1742, and by facsimile at (202) 566–1741. The telephone number for the Air Docket is (202) 566–1742. You may be charged a reasonable fee for photocopying docket materials, as provided in 40 CFR part 2. A request for hearing should be made to the person noted in the **FOR FURTHER INFORMATION CONTACT** section.

FOR FURTHER INFORMATION CONTACT: Arvon L. Mitcham, Certification and Compliance Division, U.S. Environmental Protection Agency, 2000 Traverwood, Ann Arbor, Michigan 48105, Telephone 734–214–4522, or Internet e-mail at "*mitcham.arvon@epa.gov.*"

SUPPLEMENTARY INFORMATION: EPA is publishing this direct final rule without prior proposal because we view this action as noncontroversial and anticipate no adverse comment. However, in the "Proposed Rules" section of today's **Federal Register** publication, we are publishing a separate document that will serve as the proposal to adopt the provisions in this direct final rule if adverse comments are filed. This rule will be effective on August 18, 2003 without further notice unless we receive adverse comment by July 17, 2003 or a request for a public hearing by July 2, 2003. If we receive adverse comment on one or more distinct amendments, paragraphs, or sections of this rulemaking, we will publish a timely withdrawal in the **Federal Register** indicating which provisions are being withdrawn due to adverse comment. We may address all adverse comments in a subsequent final rule based on the proposed rule. We will not institute a second comment period on this action. Any parties interested in commenting must do so at this time. Any distinct amendment, paragraph, or section of today's rulemaking for which we do not receive adverse comment will become effective on the date set out above, notwithstanding any adverse comment on any other distinct amendment, paragraph, or section of today's rule.

Regulated Entities

Entities potentially regulated hy this action are those which manufacture new motor vehicles and engines.

Category	Examples of regulated entities	NAICS Codes [a]	SIC Codes [b]
Industry	New motor vehicle and engine manufacturers	33611, 336112, 336120	3711

[a] North American Industry Classification System (NAICS) Code.
[b] Standard Industrial Classification (SIC) System Code. This table is not intended to be exhaustive, but rather provides a guide for readers regarding entities EPA is now aware could potentially be regulated by this action. Other types of entities not listed in the table could also be regulated. To determine whether your product is regulated by this action, you should carefully examine the applicability criteria in §§ 86.005–17, 86.1806–04, and 86.1806–05 of title 40 of the Code of Federal Regulations. If you have questions regarding the applicability of this action to a particular product, consult the person listed in the preceding **FOR FURTHER INFORMATION CONTACT** section.

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OMEGA EXHIBIT 2038

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I. Electronic Availability

Today's action is available electronically on the day of publication from EPA's **Federal Register** Internet Web site listed below. Electronic copies of this preamble, regulatory language, and other documents associated with today's direct final rule are available from the EPA Office of Transportation and Air Quality Web site listed below shortly after the rule is signed by the Administrator. This service is free of charge, except any cost that you already incur for connecting to the Internet.

EPA **Federal Register** Web site: *http://www.epa.gov/docs/fedrgstr/epa-air/.* (Either select a desired date or use the Search feature.)

II. Introduction and Background

On February 19, 1993, pursuant to Clean Air Act (CAA) section 202(m), 42 U.S.C. 7521(m), EPA published a final rulemaking (58 FR 9468) requiring manufacturers of light-duty vehicles (LDVs) and light-duty trucks (LDTs) to install on-board diagnostic (OBD) systems on such vehicles beginning with the 1994 model year. The regulations promulgated in that final rulemaking require that manufacturers install OBD systems which monitor emission control components for any malfunction or deterioration causing exceedance of certain emission thresholds, and alert the vehicle operator to the need for repair. That rulemaking also requires that, when a malfunction occurs, diagnostic information must be stored in the vehicle's computer to assist the technician in diagnosis and repair.

Additionally, this original OBD regulation provided an allowance for manufacturers to satisfy federal OBD requirements through the 1998 model year by installing OBD systems satisfying the California OBD II requirements pertaining to those model years. On December 22, 1998 (63 FR 70681), EPA revised the federal OBD regulations such that the allowance of compliance with the California OBD II regulations (excluding anti-tampering provisions) extended indefinitely, rather than applying only through the 1998 model year. In addition, EPA updated the allowed version of the California OBD II regulations to the most recently published version, at that time, CARB Mail-Out #97–24 (December 9, 1997).

California has recently issued revisions to their OBD II requirements as described in CARB Mail-Out MSCD #02–11 (internet posting date October 7, 2002) and Attachment II, Modifications to Malfunction and Diagnostic System Requirements for 2004 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines (OBD II), Section 1968.2, Title 13, California Code of Regulations. In today's action, EPA is revising the federal OBD regulations to update the allowed version of the California OBD II regulations to the most recently issued version noted above, such that the allowance of compliance with the California OBD II regulations (with the exclusion of certain provisions as noted below) continues to be accepted. EPA is making this revision, and continuing to allow manufacturers to demonstrate compliance with California's OBD regulations, to encourage broader OBD development and calibration efforts. EPA believes that the benefits of a robust OBD program outweigh the benefits of the unique requirements of the federal OBD regulations. EPA also believes, as was noted in an August 30, 1996 final rule (61 FR 45898), that the California OBD II program fully meets the requirements of the Clean Air Act (CAA) and fulfills the intent of the federal OBD program.

Today's action also updates the incorporation by reference of standardized practices developed by the Society of Automotive Engineers (SAE) and the International Organization for Standardization (ISO) to recently published versions. EPA believes that by including these standardized practices in our regulations we ensure continuity and uniformity in the design of OBD II systems, which was mandated in section 202(m)(4) of the CAA. As a result, changes and updates to these standardized practices must be recognized by revising our regulations to incorporate by reference the latest versions of these documents.

Today's action also incorporates a new, optional standardized communication protocol, ISO 15765–4.3:2001, December 14, 2001, "Road Vehicles-Diagnostics on Controller Area Network (CAN)—Part 4: Requirements for emission-related systems", that can be used by manufacturers to design OBD systems. The standardized communication protocols provide a uniform language structure that facilitates compatibility between OBD II equipped vehicles and OBD II-related equipment. Manufacturers are planning to implement this new protocol on vehicles as early as the 2004 MY. In addition, EPA is requiring that commencing in the 2008 model year the only allowable protocol will be this new communication protocol, ISO 15765–4.3. With the 2008 model year, the other, currently-accepted protocols: SAE J1850, ISO 9141–2 and ISO 14230–4; will no longer be accepted and all manufacturers must implement OBD systems using only ISO 15765–4.3.

III. Requirements of the Direct Final Rule

Following are the provisions promulgated by this direct final rulemaking.

A. Update of Provision for Acceptance of California Air Resources Board (CARB) OBD II as Satisfying Federal OBD Requirements

EPA is revising the existing provisions that allow indefinite optional compliance with the California OBD II requirements, excluding the California OBD II anti-tampering provisions, as satisfying federal OBD. Although the existing allowances continue indefinitely, the referenced CARB mail-out (and corresponding regulation) has been revised by California and is thus outdated. Thus, rather than the currently allowed CARB Mail-Out #97–24 (December 9, 1997), the allowed version will be CARB's recently updated version contained in CARB Mail-Out MSCD #02–11 (internet posting date October 7, 2002) and Attachment II, Modifications to Malfunction and Diagnostic System Requirements for 2004 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines (OBD II), Section 1968.2, Title 13, California Code of Regulations. EPA recognizes that CARB may continue to make minor modifications to 13 CCR section 1968.2 before its full implementation. However, EPA believes it appropriate to revise its regulations at this time to reference the most recent version of CARB's requirements and EPA anticipates it will make the appropriate updated references by technical amendment or other appropriate rulemaking. Before such updated references occur, EPA believes that any changes made by CARB in its regulations would be minor and therefore the manufacturers will be able to utilize EPA's existing deficiency provisions in the rare circumstances where those CARB requirements that EPA references by today's action are more stringent than the OBD requirements met by the manufacturer under revised CARB regulations. Thus by today's rulemaking EPA is amending paragraph (j) as found respectively in 40 CFR 86.005–17 and 86.1806–05, to reflect CARB's most recent version of the OBD II requirements. In addition, because EPA's Tier 2 requirements commence in model year 2004, EPA is adding a new section (86.1806–04) to reflect the OBD requirements applicable

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to LDVs, LDTs, and MDPVs for model year 2004, including an optional compliance provision to CARB's recent OBD II requirements.

It should be noted, for purposes of EPA's regulations (where the vehicle is certified to federal emission standards), manufacturers choosing the California OBD II demonstration option need not comply with portions of that regulation pertaining to vehicles certified to certain emission standards under California's Low Emission Vehicle Program (LEV I or LEV II), Title 13 CCR section 1961, as those standards are not federal emission standards. By operation of CARB's OBD II regulations, a manufacturer's demonstration of compliance with California OBD II, where the vehicle is certified to federal emission standards, requires a manufacturer to correlate their malfunction thresholds to the applicable federal emission standards, not California standards (see 13 CCR section 1968.2(c)(19) and (20)). Additionally, manufacturers choosing the California OBD II demonstration option need not comply with 13 CCR section 1968.2(e)(4.2.2)(C) which requires evaporative system leak detection monitoring down to a 0.02 inch diameter orifice and represents a level of stringency beyond that required for federal OBD compliance. In lieu of this requirement, EPA will continue its current requirement as found at 40 CFR 86.005–17(b)(4), 40 CFR 86.1806–01(b)(4) and 40 CFR 86.1806–05 (b)(4) that requires evaporative system leak detection monitoring of a 0.040 inch diameter orifice and is clarified by today's rulemaking. As with EPA's current OBD regulations, manufacturers choosing the California OBD II demonstration option need not comply with 13 CCR section 1968.2(d)(1.4) which contains the anti-tampering provisions of the California OBD II regulations. In today's rulemaking EPA also clarifies that demonstration of compliance with 13 CCR 1968.2(e)(16.2.1)(C), to the extent such provisions apply to verification of proper alignment between the camshaft and crankshaft, only applies to vehicles equipped with variable valve timing. The requirement in 13 CCR 1968.2(e)(16.2.1)(C) regarding circuit continuity and rationality malfunctions is applicable to all vehicles. Also, as with EPA's current OBD regulations, the deficiency fine provisions of 13 CCR section 1968.2(i) do not apply. Therefore, as a continuation of EPA's current requirements, the deficiency provisions at 40 CFR 86.005–17(i), 86.1806–01(i), and 1806–05(i) remain applicable and are clarified by today's rulemaking.

B. Inclusion of California OBD II Catalyst Monitoring Requirements in Federal OBD Regulations When Accepting California OBD II Compliance

In EPA's rulemaking for heavy-duty engine and vehicle standards (65 FR 59896, October 6, 2000) (2004 HD Rule), EPA established new OBD system requirements for heavy-duty vehicles and engines, including aftertreatment monitoring requirements for all diesel-engine vehicles weighing 14,000 pounds GVWR or less regardless of whether the manufacturers demonstrated compliance with the Federal OBD requirements or with California's OBD requirements. Therefore, when accepting California OBD systems, it became necessary to exclude the particular section in the California OBD II regulations related to catalyst monitoring (Title 13, California Code of Regulations (CCR) 1968.1(b)(1.1.2)) because this regulation did not include requirements for aftertreatment of diesel-engines or complete vehicles. In California's recent OBD II revisions as described in CARB Mail-Out MSCD #02–11 (internet posting date October 7, 2002) and Attachment II, Modifications to Malfunction and Diagnostic System Requirements for 2004 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines (OBD II), Section 1968.2, Title 13, California Code of Regulations, provisions for aftertreatment monitoring on all diesel-engine vehicles weighing 14,000 pounds GVWR or less are included. As a result, it is no longer necessary to exclude Title 13, CCR 1968.1(b)(1.1.2) related to aftertreatment monitoring requirements when accepting California OBD II compliance. Thus, today's action removes the language requiring compliance with the federal aftertreatment requirements if demonstrating optional compliance with California's OBD requirements.

C. Technical Amendment to the Optional Chassis Certification Requirements for Heavy-duty (HD) Less Than 14,000 Pounds GVWR

In another final rule that revised EPA's heavy duty engine and vehicle standards and highway diesel fuel sulfur requirements beginning in the 2007 model year (66 FR 5002, January 18, 2001) (2007 HD Rule), we provided an option for manufacturers of HD diesel vehicles weighing 14,000 pounds GVWR or less to chassis certify to the HD vehicle standards (40 CFR Subpart S, 86.1863–07 for chassis certification). In § 86.1863–07(b), we state that diesel vehicles certified under this chassis certification option are subject to the OBD requirements of 40 CFR 86.005–17, which is the section in subpart A containing the OBD requirements for engines. However, for chassis certification, we should have referenced 40 CFR 86.1806–05 of subpart S, which contains the chassis OBD requirements. This correction is consistent with the Agency's original intent as expressed in the preamble to the 2007 HD Rule at 66 FR 5002, at 5043. Therefore, today's action revises the language in 40 CFR 86.1863–07 (b) for optional chassis certification of diesel engines such that chassis OBD requirements in 40 CFR 86.1806–05 of subpart S are referenced.

D. Applicability

Today's revisions to: update the acceptable version of the California OBD II regulations; include California OBD II catalyst monitoring requirements when accepting CARB OBD II compliance, update the incorporation by reference of standardized practices developed by the Society of Automotive Engineers (SAE) and the International Organization for Standardization (ISO); incorporate by reference a new standardized protocol developed by the International Organization for Standardization (ISO) and establish a future date by which this protocol will be the only acceptable protocol; and amend the optional chassis certification requirements for heavy-duty (HD) vehicle weighing 14,000 pounds GVWR or less, apply to all 2004 and later model year light-duty vehicles, light-duty trucks, medium duty passenger vehicles, heavy-duty vehicles and otto-cycle engines intended for vehicles weighing less than 14,000 pounds GVWR where the manufacturer chooses to comply with Option 1 or 2 according to 40 CFR 86.005–01(c)(1) or (c)(2), and all 2005 and later model year heavy-duty diesel engines intended for vehicles weighing less than 14,000 pounds GVWR subject to the phase-in schedule for heavy-duty vehicles and engine OBD compliance in 40 CFR 86.005–17(k) and 86.1806–05(l).

E. Update of Materials Incorporated by Reference

Today's action includes the adoption of ISO 15765–4.3 (December 14, 2001): "Road Vehicles—Diagnostics on Controller Area Network (CAN)—Part 4: Requirements for emission-related systems," as an acceptable protocol for standardized on-board to off-board communications and is incorporated by reference in today's regulatory language. This standardized procedure contains a more up-to-date communication protocol than that contained in SAE

J1850/ISO 9141–2 and ISO 14230–4 which will remain referenced in the table at 40 CFR 86.1(b)(5). By today's action EPA is clarifying that ISO 14230–4 is acceptable for vehicles being certified today as well as vehicles certified through the 2007 model year. Adoption of ISO 15765–4.3 is also acceptable, in addition to ISO 14230–4, to all 2004 and later model year light-duty vehicles, light-duty trucks, medium duty passenger vehicles, heavy-duty vehicles and otto-cycle engines intended for vehicles weighing less than 14,000 pounds GVWR where the manufacturer chooses to comply with Option 1 or 2 according to 40 CFR 86.005–01(c)(1) or (c)(2), and all 2005 and later model year heavy-duty diesel engines intended for vehicles weighing less than 14,000 pounds GVWR. Beginning in the 2008 and later model year, ISO 15765–4.3 will be the only acceptable protocol used for standardized on-board to off-board communications. Thus a new entry is added to the table at § 86.1(b)(5) for ISO 15765–4.3 and is incorporated by reference into §§ 86.005–17, 86.1806–04, and 86.1806–05 and ISO 14230–4 contains new part 86 regulatory references (§§ 86.1806–01 and 86.1806–04) incorporated by reference.

Today's action also updates the incorporation by reference of several SAE standardized practices. Specifically, procedures J1850, J1962, J1979, and J2012. The existing references to these four SAE procedures within the table at § 86.1(b)(2) remain in effect along with the other SAE procedures already referenced in the table. The four SAE procedures noted here have been updated and thus shall apply beginning in model year 2004. Thus new entries are added to incorporate the updated J1850, J1962, J1979, and J2012 and are incorporated by reference into §§ 86.005–17, 86.1806–04, and 86.1806–05. In addition, today's action also incorporates SAE J1930 and SAEJ1978 into the table found in § 86.1(b)(2). These new SAE procedures are incorporated by reference into §§ 86.005–17, 86.1806–04, and 86.1806–05. Lastly, the references to SAE J1939–11, J1939–13, J1939–21, J1939–71, J1931–73, and J1931–81 are modified to reflect that such procedures are applicable to all 2004 and later model year light-duty vehicles, light-duty trucks and medium-duty passenger vehicles and thus incorporate by reference the new regulatory provision at § 86.1806–04.

IV. Cost Effectiveness

This rulemaking alters an existing provision by allowing optional compliance with the most recently "revised" California OBD II requirements for the purposes of demonstrating compliance with federal OBD requirements. EPA believes that today's regulation will provide cost savings by eliminating the need to incur significant recalibration and/or retesting costs and efforts associated with having two sets of OBD regulations with which to comply. Because this rulemaking alters an existing provision that provides regulatory relief by means of optional compliance methods, and since most of the industry currently complies with the California OBD II requirements under our provisions for optional compliance and because industry may thus minimize resource requirements, EPA believes that continued cost savings will be achieved. No adverse environmental consequences are anticipated as EPA expects manufacturers with vehicles complying with the new California OBD II requirements, and which also seek anything but a California-only federal certificate, will have OBD systems calibrated to federal Tier 2 standards and thus will be as environmentally protective as systems calibrated to federal Tier 1 standards.

V. Statutory and Executive Order Reviews

A. Executive Order 12866: Regulatory Planning and Review

Under Executive Order 12866 (58 FR 51735, Oct. 4, 1993), the Agency is required to determine whether this regulatory action would be "significant" and therefore subject to review by the Office of Management and Budget (OMB) and the requirements of the Executive Order. The Order defines a "significant regulatory action" as any regulatory action that is likely to result in a rule that may: (1) Have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or state, local, or tribal governments or communities; (2) Create a serious inconsistency or otherwise interfere with an action taken or planned by another agency; (3) Materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or, (4) Raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order.

Pursuant to the terms of Executive Order 12866, we have determined that this final rule is not a "significant regulatory action."

B. Paperwork Reduction Act

Today's action does not impose any new information collection burden. The modifications noted above do not change the information collection requirements submitted to and approved by OMB in association with the OBD final rulemakings (58 FR 9468, February 19, 1993; and 59 FR 38372, July 28, 1994).

C. Regulatory Flexibility Act

EPA has determined that it is not necessary to prepare a regulatory flexibility analysis in connection with this direct final rule. After considering the economic impacts of today's direct final rule on small entities, EPA has determined that this action will not have a significant economic impact on a substantial number of small entities.

For purposes of assessing the impacts of today's direct final rule on small entities, small entity is defined as: (1) Those businesses meeting the definition provided by the Small Business Administration (2) a small governmental jurisdiction that is a government of a city, county, town, school district or special district with a population of less than 50,000; and (3) a small organization that is any not-for-profit enterprise which is independently owned and operated and is not dominant in its field.

This rulemaking will provide regulatory relief to both large and small volume automobile and heavy-duty vehicle and engine manufacturers by maintaining consistency with California OBDII requirements. This rulemaking will not have a significant impact on businesses that manufacture, rebuild, distribute, or sell automotive parts, nor those involved in automotive service and repair, as the revisions affect only requirements on automobile and heavy-duty truck and engine manufacturers. See United Distribution Companies v. FERC, 88 F. 3rd 1005, 1170 (D.C. Cir. 1996). Most manufacturers have thus far chosen to reduce their costs by producing vehicle OBD systems to California specifications, thereby avoiding the necessity of developing significantly different OBD calibrations meeting the existing federal specifications for the non-California markets. Today's continuation of the optional compliance option to California's OBDII requirements continues this cost reduction.

D. Unfunded Mandates Reform Act

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA), Public Law 104–4, establishes requirements for federal agencies to assess the effects of their regulatory actions on state, local, and tribal governments, and the private sector. Under section 202 of the UMRA, we generally must prepare a written statement, including a cost-benefit analysis, for proposed and final rules with "federal mandates" that may result in expenditures to state, local, and tribal governments, in the aggregate, or to the private sector, of $100 million or more for any single year. Before promulgating a rule for which a written statement is needed, section 205 of the UMRA generally requires us to identify and consider a reasonable number of regulatory alternatives and adopt the least costly, most cost-effective, or least burdensome alternative that achieves the objectives of the rule. The provisions of section 205 do not apply when they are inconsistent with applicable law. Moreover, section 205 allows us to adopt an alternative that is not the least costly, most cost-effective, or least burdensome alternative if we provide an explanation in the final rule of why such an alternative was adopted.

Before we establish any regulatory requirement that may significantly or uniquely affect small governments, including tribal governments, we must develop a small government plan pursuant to section 203 of the UMRA. Such a plan must provide for notifying potentially affected small governments, and enabling officials of affected small governments to have meaningful and timely input in the development of our regulatory proposals with significant federal intergovernmental mandates. The plan must also provide for informing, educating, and advising small governments on compliance with the regulatory requirements.

This rule contains no federal mandates for state, local, or tribal governments as defined by the provisions of Title II of the UMRA. The rule imposes no enforceable duties on any of these governmental entities. Nothing in the rule will significantly or uniquely affect small governments.

We have determined that this rule does not contain a federal mandate that may result in estimated expenditures of more than $100 million to the private sector in any single year.

E. Executive Order 13132: Federalism

Executive Order 13132, entitled "Federalism" (64 FR 43255, August 10, 1999), requires us to develop an accountable process to ensure "meaningful and timely input by state and local officials in the development of regulatory policies that have federalism implications." "Policies that have federalism implications" is defined in the Executive Order to include regulations that have "substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government.

Under Section 6 of Executive Order 13132, we may not issue a regulation that has federalism implications, that imposes substantial direct compliance costs, and that is not required by statute, unless the Federal Government provides the funds necessary to pay the direct compliance costs incurred by state and local governments, or we consult with state and local officials early in the process of developing the proposed regulation. We also may not issue a regulation that has federalism implications and that preempts state law, unless the Agency consults with state and local officials early in the process of developing the proposed regulation.

Section 4 of the Executive Order contains additional requirements for rules that preempt state or local law, even if those rules do not have federalism implications (*i.e.*, the rules will not have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government). Those requirements include providing all affected state and local officials notice and an opportunity for appropriate participation in the development of the regulation. If the preemption is not based on express or implied statutory authority, we also must consult, to the extent practicable, with appropriate state and local officials regarding the conflict between state law and federally protected interests within the Agency's area of regulatory responsibility.

This rule does not have federalism implications. It will not have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government, as specified in Executive Order 13132. This proposed rule updates provisions of an earlier rule that adopted national standards relating to OBD systems and the ability of manufacturers to demonstrate federal compliance based on demonstration of compliance with California OBD II regulations. The requirements of the rule will be enforced by the federal government at the national level. Thus, the requirements of Section 6 of the Executive Order do not apply to this rule.

F. Executive Order 13175: Consultation and Coordination With Indian Tribal Governments

Executive Order 13175, entitled "Consultation and Coordination with Indian Tribal Governments" (65 FR 67249, November 6, 2000), requires EPA to develop an accountable process to ensure "meaningful and timely input by tribal officials in the development of regulatory policies that have tribal implications." This final rule does not have tribal implications, as specified in Executive Order 13175. Today's rule does not uniquely affect the communities of American Indian tribal governments since the motor vehicle emission control system requirements in today's rule will have national applicability. Furthermore, today's rule does not impose any direct compliance costs on these communities and no circumstances specific to such communities exist that will cause an impact on these communities beyond those discussed in the other sections of today's document.

This rule does not significantly or uniquely affect the communities of Indian tribal governments. As noted above, this rule will be implemented at the federal level and imposes compliance obligations on private industry. Accordingly, the requirements of Executive Order 13084 do not apply to this rule.

G. Executive Order 13045: Protection of Children and Environmental Health & Safety Risks

Executive Order 13045, "Protection of Children from Environmental Health Risks and Safety Risks" (62 FR 19885, April 23, 1997) applies to any rule that (1) is determined to be "economically significant" as defined under Executive Order 12866, and (2) concerns an environmental health or safety risk that we have reason to believe may have a disproportionate effect on children. If the regulatory action meets both criteria, section 5–501 of the Executive Order directs us to evaluate the environmental health or safety effects of the planned rule on children, and explain why the planned regulation is preferable to other potentially effective and reasonably feasible alternatives considered by us.

This rule is not subject to the Executive Order because it is not an economically significant regulatory action as defined by Executive Order 12866. Furthermore, this rule does not

concern an environmental health or safety risk that we have reason to believe may have a disproportionate effect on children.

H. Executive Order 13211: Actions That Significantly Affect Energy Supply, Distribution, or Use

This rule is not subject to Executive Order 13211, "Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use" (66 FR 28355, May 22, 2001) because it is not a significant regulatory action under Executive Order 12866.

I. National Technology Transfer and Advancement Act

Section 12(d) of the National Technology Transfer and Advancement Act of 1995 (NTTAA), Section 12(d) of Public Law 104–113, directs us to use voluntary consensus standards in our regulatory activities unless it would be inconsistent with applicable law or otherwise impractical. Voluntary consensus standards are technical standards (*e.g.*, materials specifications, test methods, sampling procedures, and business practices) developed or adopted by voluntary consensus standards bodies. The NTTAA directs us to provide Congress, through OMB, explanations when we decide not to use available and applicable voluntary consensus standards.

This rule references technical standards adopted by us through previous rulemakings. No new technical standards are established in today's rule.

J. Congressional Review Act

The Congressional Review Act, 5 U.S.C. 801 *et seq.*, as amended by the Small Business Regulatory Enforcement Fairness Act of 1996, generally provides that before a rule may take effect, the agency promulgating the rule must submit a rule report, which includes a copy of the rule, to Congress and the comptroller General of the United States. We will submit a report containing this rule and other required information to the U.S. Senate, the U.S. House of Representatives, and the Comptroller General of the United States prior to publication of the rule in the **Federal Register**. A Major rule cannot take effect until 60 days after it is published in the **Federal Register**. This action is not a "major rule" as defined by 5 U.S.C. 804(2). This rule will be effective August 18, 2003.

Statutory and Legal Authority

Statutory authority for today's final rule comes from the Clean Air Act, 42 U.S.C. 7401 et seq., in particular, section 202(m) of the Act (42 U.S.C. 7521(m)).

List of Subjects in 40 CFR Part 86

Environmental protection, Administrative practice and procedure, Incorporation by reference, Motor vehicle pollution, On-board diagnostics

Dated: April 25, 2003.

Christine Todd Whitman,

Administrator.

■ For the reasons set out in the preamble, part 86 of title 40 chapter I of the Code of Federal Regulations is amended as follows:

PART 86—CONTROL OF EMISSIONS FROM NEW AND IN-USE HIGHWAY VEHICLES AND ENGINES

■ 1. The authority citation for part 86 continues to read as follows:

Authority: 42 U.S.C. 7401–7671q.

■ 2. Section 86.1 is amended as follows:

■ a. In the table to paragraph (b)(2) by adding the following entries to the end of the table.

■ b. In paragraph (b)(5) by revising the table.

The revisions and additions read as follows:

§ 86.1 Reference materials.

* * * * *

(b) * * *

(2) * * *

Document No. and name	40 CFR part 86 reference
* * * * *	* * * * *
SAE J1850, Class B Data Communication Network Interface. (Revised, May 2001)	86.005–17; 86.1806–04; 86.1806–05
SAE J1930, Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms—Equivalent to ISO/TR 15031–2: April 30, 2002. (Revised, April 2002).	86.005–17; 86.1806–04; 86.1806–05
SAE J1939–11, Physical Layer—250K bits/s, Shielded Twisted Pair. (Revised, October 1999)	86.005–17; 86.1806–04; 86.1806–05
SAE J1939–13, Off-Board Diagnostic Connector. (July 1999)	86.005–17; 86.1806–04; 86.1806–05
SAE J1939–21, Data Link Layer. (Revised, April 2001)	86.005–17; 86.1806–04; 86.1806–05
SAE J1939–31, Network Layer. (Revised, December 1997)	86.005–17; 86.1806–04; 86.1806–05
SAE J1939–71, Vehicle Application Layer—J1939–71 (through 1999). (Revised, August 2002)	86.005–17; 86.1806–04; 86.1806–05
SAE J1939–73, Application Layer-Diagnostics. (Revised, June 2001)	86.005–17; 86.1806–04; 86.1806–05
SAE J1939–81, Recommended Practice for Serial Control and Communications Vehicle Network Part 81—Network Management. (July 1997).	86.005–17; 86.1806–04; —86.1806–05
SAE J1962, Diagnostic Connector—Equivalent to ISO/DIS 15031–3:December 14, 2001. (Revised, April 2002).	86.005–17;86.1806–04; 86.1806–05
SAE J1978, OBD II Scan Tool—Equivalent to ISO/DIS 15031–4; December 14, 2001. (Revised, April 2002).	86.005–17;86.1806–04; 86.1806–05
SAE J1979, E/E Diagnostic Test Modes—Equivalent to ISO/DIS 15031–5: April 30, 2002. (Revised, April 2002).	86.099–17;86.005–17; 86.1806–01; 86.1806–04; 86.1806–05
SAE J2012, Diagnostic Trouble Code Definitions—Equivalent to ISO/DIS 15031–6: April 30, 2002. (Revised, April 2002,).	86.005–17; 86.1806–04; 86.1806–05

* * * * * (5) * * *

Document No. and name	40 CFR part 86 reference
ISO 9141–2, February 1, 1994, Road vehicles—Diagnostic systems—Part 2: CARB requirements for interchange of digital information.	86.099–17; 86.1806–01; 86.1806–04; 86.005–17; 86.1806–05
ISO 14230–4:2000(E) "Road vehicles—Diagnostic systems—KWP 2000 requirements for Emission-related systems", (June 1, 2000).	86.099–17; 86.1806–01; 86.1806–04; 86.005–17; 86.1806–05

Document No. and name	40 CFR part 86 reference
ISO 15765–4.3:2001, December 14, 2001, Road Vehicles—Diagnostics on Controller Area Network (CAN)—Part 4: Requirements for emission-related systems.	86.005–17; 86.1806–04; 86.1806–05

■ 3. Section 86.005–17 is amended by revising paragraphs (h) and (j) to read as follows:

§ 86.005–17 On-board diagnostics.

* * * * *

(h) Reference materials. The OBD system shall provide for standardized access and conform with the following Society of Automotive Engineers (SAE) standards and/or the following International Standards Organization (ISO) standards. The following documents are incorporated by reference, see § 86.1:

(1) SAE material. Copies of these materials may be obtained from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096–0001.

(i) SAE J1850 "Class B Data Communication Network Interface," (Revised, May 2001) shall be used as the on-board to off-board communications protocol. All emission related messages sent to the scan tool over a J1850 data link shall use the Cyclic Redundancy Check and the three byte header, and shall not use inter-byte separation or check sums.

(ii) Basic diagnostic data (as specified in § 86.094–17(e) and (f)) shall be provided in the format and units in SAE J1979 "E/E Diagnostic Test Modes—Equivalent to ISO/DIS 15031–5: April 30, 2002", (Revised, April 2002).

(iii) Diagnostic trouble codes shall be consistent with SAE J2012 "Diagnostic Trouble Code Definitions—Equivalent to ISO/DIS 15031–6: April 30, 2002", (Revised, April 2002).

(iv) The connection interface between the OBD system and test equipment and diagnostic tools shall meet the functional requirements of SAE J1962 "Diagnostic Connector—Equivalent to ISO/DIS 15031–3: December 14, 2001" (Revised, April 2002).

(v) All acronyms, definitions and abbreviations shall be formatted according to SAE J1930 "Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms" Equivalent to ISO/TR 15031–2: April 30, 2002", (Revised, April 2002).

(vi) All equipment used to interface, extract and display OBD-related information shall meet SAE J1978 "OBD II Scan Tool" Equivalent to ISO 15031–4: December 14, 2001", (Revised, April 2002).

(vii) As an alternative to the above standards, heavy-duty vehicles may conform to the specifications of the SAE J1939 series of standards (SAE J1939–11, J1939–13, J1939–21, J1939–31, J1939–71, J1939–73, J1939–81).

(2) ISO materials. Copies of these materials may be obtained from the International Organization for Standardization, Case Postale 56, CH–1211 Geneva 20, Switzerland.

(i) ISO 9141–2 "Road vehicles—Diagnostic systems—Part 2: CARB requirements for interchange of digital information," (February 1, 1994) may be used as an alternative to SAE J1850 as the on-board to off-board communications protocol.

(ii) ISO 14230–4:2000(E) "Road vehicles—Diagnostic systems—KWP 2000 requirements for Emission-related systems", (June 1, 2000) may also be used as an alternative to SAE J1850.

(iii) ISO 15765–4.3:2001 "Road Vehicles-Diagnostics on Controller Area Network (CAN)—Part 4: Requirements for emission-related systems", (December 14, 2001) may also be used as an alternative to SAE J1850.

(3) Beginning with the 2008 model year and beyond, ISO 15765–4.3:2001 "Road Vehicles-Diagnostics on Controller Area Network (CAN)—Part 4: Requirements for emission-related systems", (December 14, 2001) shall be the only acceptable protocol used for standardized on-board to off-board communications. At this time, all other standardized on-board to off-board communications protocols: SAE J1850 "Class B Data Communication Network Interface," (Revised, May 2001) in paragraph (h)(1)(i) of this section, ISO 9141–2 "Road vehicles—Diagnostic systems—Part 2: CARB requirements for interchange of digital information," (February 1, 1994) in paragraph (h)(2)(i) of this section, and ISO 14230–4 "Road vehicles—Diagnostic systems—KWP 2000 requirements for Emission-related systems", (June 1, 2000) in paragraph (h)(2)(ii) of this section will no longer be accepted.

* * * * *

(j) California OBDII compliance option. For heavy-duty engines weighing 14,000 pounds GVWR or less, demonstration of compliance with California OBD II requirements (Title 13 California Code of Regulations § 1968.2 (13 CCR 1968.2)), as modified pursuant to CARB Mail-Out MSCD #02–11 (internet posting date October 7, 2002), shall satisfy the requirements of this section, except that compliance with 13 CCR 1968.2(e)(4.2.2)(C), pertaining to 0.02 inch evaporative leak detection, and 13 CCR 1968.2(d)(1.4), pertaining to tampering protection, are not required to satisfy the requirements of this section. Also, the deficiency provisions of 13 CCR 1968.2(i) do not apply. The deficiency provisions of paragraph (i) of this section and the evaporative leak detection requirement of paragraph (b)(4) of this section apply to manufacturers selecting this paragraph for demonstrating compliance. In addition, demonstration of compliance with 13 CCR 1968.2(e)(16.2.1)(C), to the extent it applies to the verification of proper alignment between the camshaft and crankshaft, applies only to vehicles equipped with variable valve timing.

* * * * *

■ 4. A new § 86.1806–04 is added to subpart S to read as follows:

§ 86.1806–04 On-board diagnostics.

This § 86.1806–04 includes text that specifies requirements that differ from § 86.1806–01. Where a paragraph in § 86.1806–01 is identical and applicable to § 86.1806–04 this may be indicated by specifying the corresponding paragraph and the statement "[Reserved]. For guidance see § 86.1806–01."

(a)–(g). [Reserved]. For guidance see § 86.1806–01.

(h) Reference materials. The OBD system shall provide for standardized access and conform with the following Society of Automotive Engineers (SAE) standards and/or the following International Standards Organization (ISO) standards. The following documents are incorporated by reference, see § 86.1:

(1) SAE material. (i) SAE J1850 "Class B Data Communication Network Interface," (Revised, May 2001) shall be used as the on-board to off-board communications protocol. All emission related messages sent to the scan tool over a J1850 data link shall use the Cyclic Redundancy Check and the three byte header, and shall not use inter-byte separation or checksums.

(ii) Basic diagnostic data (as specified in §§ 86.094–17(e) and (f)) shall be provided in the format and units in SAE

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J1979 "E/E Diagnostic Test Modes—Equivalent to ISO/DIS 15031–5:April 30, 2002", (Revised, April 2002).

(iii) Diagnostic trouble codes shall be consistent with SAE J2012 "Diagnostic Trouble Code Definitions—Equivalent to ISO/DIS 15031–6:April 30, 2002", (Revised, April 2002).

(iv) The connection interface between the OBD system and test equipment and diagnostic tools shall meet the functional requirements of SAE J1962 "Diagnostic Connector—Equivalent to ISO/DIS 15031–3:December 14, 2001" (Revised, April 2002).

(v) All acronyms, definitions and abbreviations shall be formatted according to SAE J1930 "Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms" Equivalent to ISO/TR 15031–2:April 30, 2002", (Revised, April 2002).

(vi) All equipment used to interface, extract and display OBD-related information shall meet SAE J1978 "OBD II Scan Tool" Equivalent to ISO 15031–4:December 14, 2001", (Revised, April 2002).

(vii) As an alternative to the above standards, heavy-duty vehicles may conform to the specifications of the SAE J1939 series of standards (SAE J1939–11, J1939–13, J1939–21, J1939–31, J1939–71, J1939–73, J1939–81).

(2) ISO materials. Copies of these materials may be obtained from the International Organization for Standardization, Case Postale 56, CH–1211 Geneva 20, Switzerland.

(i) ISO 9141–2 "Road vehicles—Diagnostic systems—Part 2: CARB requirements for interchange of digital information," (February 1, 1994) may be used as an alternative to SAE J1850 as the on-board to off-board communications protocol.

(ii) ISO 14230–4:2000(E) "Road vehicles—Diagnostic systems—KWP 2000 requirements for Emission-related systems", (June 1, 2000) may also be used as an alternative to SAE J1850.

(iii) ISO 15765–4.3:2001 "Road Vehicles-Diagnostics on Controller Area Network (CAN)—Part 4: Requirements for emission-related systems", (December 14, 2001) may also be used as an alternative to SAE J1850.

(i) [Reserved]. For guidance see § 86.1806–01.

(j) *California OBDII compliance option.* For light-duty vehicles and light-duty trucks, demonstration of compliance with California OBD II requirements (Title 13 California Code § 1968.2 (13 CCR 1968.2)), as modified pursuant to CARB Mail-Out MSCD #02–11 (internet posting date October 7, 2002), shall satisfy the requirements of this section, except that compliance with 13 CCR 1968.2(e)(4.2.2)(C), pertaining to 0.02 inch evaporative leak detection, and 13 CCR 1968.2(d)(1.4), pertaining to tampering protection, are not required to satisfy the requirements of this section. Also, the deficiency fine provisions of 13 CCR 1968.2(i) does not apply. The deficiency provisions of paragraph (i) of this section and the evaporative leak detection requirement of paragraph (b)(4) of this section apply to manufacturers selecting this paragraph for demonstrating compliance. In addition, demonstration of compliance with 13 CCR 1968.2(e)(16.2.1)(C), to the extent it applies to the verification of proper alignment between the camshaft and crankshaft, applies only to vehicles equipped with variable valve timing.

(k) [Reserved]. For guidance see § 86.1806–01.

■ 5. Section 86.1806–05 is amended by revising paragraphs (h) and (J) to read as follows:

§ 86.1806–05 On-board diagnostics.

* * * * *

(h) Reference materials. The OBD system shall provide for standardized access and conform with the following Society of Automotive Engineers (SAE) standards and/or the following International Standards Organization (ISO) standards. The following documents are incorporated by reference, see § 86.1:

(1) *SAE material.* Copies of these materials may be obtained from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096–0001.

(i) SAE J1850 "Class B Data Communication Network Interface," (Revised, May 2001) shall be used as the on-board to off-board communications protocol. All emission related messages sent to the scan tool over a J1850 data link shall use the Cyclic Redundancy Check and the three byte header, and shall not use inter-byte separation or checksums.

(ii) Basic diagnostic data (as specified in §§ 86.094–17(e) and (f)) shall be provided in the format and units in SAE J1979 "E/E Diagnostic Test Modes—Equivalent to ISO/DIS 15031–5:April 30, 2002", (Revised, April 2002).

(iii) Diagnostic trouble codes shall be consistent with SAE J2012 "Diagnostic Trouble Code Definitions—Equivalent to ISO/DIS 15031–6: April 30, 2002", (Revised, April 2002).

(iv) The connection interface between the OBD system and test equipment and diagnostic tools shall meet the functional requirements of SAE J1962 "Diagnostic Connector—Equivalent to ISO/DIS 15031–3:December 14, 2001" (Revised, April 2002).

(v) All acronyms, definitions and abbreviations shall be formatted according to SAE J1930 "Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronym" Equivalent to ISO/TR 15031–2:April 30, 2002", (Revised, April 2002).

(vi) All equipment used to interface, extract and display OBD-related information shall meet SAE J1978 "OBD II Scan Tool" Equivalent to ISO 15031–4:December 14, 2001", (Revised, April 2002).

(vii) As an alternative to the above standards, heavy-duty vehicles may conform to the specifications of the SAE J1939 series of standards (SAE J1939–11, J1939–13, J1939–21, J1939–31, J1939–71, J1939–73, J1939–81).

(2) ISO materials. Copies of these materials may be obtained from the International Organization for Standardization, Case Postale 56, CH–1211 Geneva 20, Switzerland.

(i) ISO 9141–2 "Road vehicles—Diagnostic systems—Part 2: CARB requirements for interchange of digital information," (February 1, 1994) may be used as an alternative to SAE J1850 as the on-board to off-board communications protocol.

(ii) ISO 14230–4:2000(E) "Road vehicles—Diagnostic systems—KWP 2000 requirements for Emission-related systems", (June 1, 2000) may also be used as an alternative to SAE J1850.

(iii) ISO 15765–4.3:2001 "Road Vehicles-Diagnostics on Controller Area Network (CAN)—Part 4: Requirements for emission-related systems", (December 14, 2001) may also be used as an alternative to SAE J1850.

(3) Beginning with the 2008 model year and beyond, ISO 15765–4.3:2001 "Road Vehicles-Diagnostics on Controller Area Network (CAN)—Part 4: Requirements for emission-related systems", (December 14, 2001) will be the only shall be the only acceptable protocol used for standardized on-board to off-board communications. At this time, all other standardized on-board to off-board communications protocols: SAE J1850 "Class B Data Communication Network Interface," (Revised, May 2001) in paragraph (h)(1)(i), ISO 9141–2 "Road vehicles—Diagnostic systems—Part 2: CARB requirements for interchange of digital information," (February 1, 1994) in (h)(2)(i), and ISO 14230–4 "Road vehicles—Diagnostic systems—KWP 2000 requirements for Emission-related systems", (June 1, 2000) in paragraph (h)(2)(ii) of this section will no longer be accepted

* * * * *

(j) *California OBDII compliance option.* For light-duty vehicles, light-duty trucks, and heavy-duty vehicles weighing 14,000 pounds GVWR or less, demonstration of compliance with California OBD II requirements (Title 13 California Code § 1968.2 (13 CCR 1968.2)), as modified pursuant to CARB Mail-Out MSCD #02–11 (internet posting date October 7, 2002), shall satisfy the requirements of this section, except that compliance with 13 CCR 1968.2(e)(4.2.2)(C), pertaining to 0.02 inch evaporative leak detection, and 13 CCR 1968.2(d)(1.4), pertaining to tampering protection, are not required to satisfy the requirements of this section. Also, the deficiency fine provisions of 13 CCR 1968.2(i) does not apply. The deficiency provisions of paragraph (i) of this section and the evaporative leak detection requirement of paragraph (b)(4) of this section apply to manufacturers selecting this paragraph for demonstrating compliance. In addition, demonstration of compliance with 13 CCR 1968.2(e)(16.2.1)(C), to the extent it applies to the verification of proper alignment between the camshaft and crankshaft, applies only to vehicles equipped with variable valve timing.

* * * * *

■ 6. Section 86.1863–07 is amended by revising paragraphs (a) and (b) to read as follows:

§ 86.1863–07 Optional chassis certification for diesel vehicles.

(a) A manufacturer may optionally certify heavy-duty diesel vehicles weighing 14,000 pounds GVWR or less, to the standards specified in § 86.1816–08. Such vehicles must meet all requirements of Subpart S of this part that are applicable to Otto-cycle vehicles, except for evaporative, refueling, and OBD requirements where the diesel specific OBD requirements would apply.

(b) For OBD, diesel vehicles optionally certified under this section are subject to the OBD requirements of § 86.1806–05.

* * * * *

[FR Doc. 03–14569 Filed 6–16–03; 8:45 am]

BILLING CODE 6560–50–P

DEPARTMENT OF HOMELAND SECURITY

Coast Guard

46 CFR Parts 10 and 15

[USCG 1999–6224]

RIN 1625–AA15

Licensing and Manning for Officers of Towing Vessels

AGENCY: Coast Guard, DHS.

ACTION: Final rule.

SUMMARY: This final rule amends the rules on licensing and manning for officers of towing vessels. It makes final, minor revisions in response to comments to the several interim rules that preceded it. It will help mariners obtain the appropriate licenses and so it will increase the competence of mariners and the safety of navigation.

DATES: This final rule is effective September 15, 2003.

ADDRESSES: Comments and material received from the public, as well as documents mentioned in this preamble as being available in the docket, are part of docket USCG 1999–6224 and are available for inspection or copying at the Docket Management Facility, U.S. Department of Transportation, room PL–401, 400 Seventh Street, SW., Washington, DC, between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays. You may also find this docket on the Internet at *http://dms.dot.gov.*

FOR FURTHER INFORMATION CONTACT: If you have questions on this rule, call Lieutenant Commander Luke Harden, Office of Operating and Environmental Standards (G-MSO), Coast Guard, telephone 202–267–0229. If you have questions on viewing or submitting material to the docket, call Dorothy Beard, Chief, Dockets, Department of Transportation, telephone 202–366–5149.

SUPPLEMENTARY INFORMATION:

Background and Purpose

On November 19, 1999, we published a first interim rule with request for comments (64 FR 63213). It established updates to the licensing and manning for officers of towing vessels and the qualifications of those officers. We had chosen an interim rule to provide the towing industry further opportunity for comment; to answer comments received on the Supplemental Notice of Proposed Rulemaking (SNPRM) (62 FR 55548 (October 27, 1997)); to address concerns received at public meetings; and to provide the public an opportunity to respond to changes reflected in the SNPRM. On October 27, 2000, we published a second interim rule (65 FR 64388), which delayed the implementation of the first interim rule until May 21, 2001. Delaying the rule gave us the opportunity and time to clarify this rule through a third interim rule, which we published on April 26, 2001 (66 FR 20931), and to issue guidelines implementing it.

This final rule constitutes an essential part of a comprehensive initiative to improve navigational safety for towing vessels. (Although the Coast Guard shifted from the Department of Transportation to the Department Of Homeland Security on March 1, 2003, by authority of subsection 103(c) of the Homeland-Security Act of 2002 (Pub. L. 107–296), the current Secretary shares the judgment of the former that this rulemaking constitutes such an essential part.) You can glean the full background of the final rule from the preambles to the notice of proposed rulemaking (NPRM) (61 FR 31332 (June 19, 1996)); to the SNPRM; and to the first and third interim rules (64 FR 63213 (November 19, 1999) and 66 FR 20931 (April 26, 2001), respectively). The following are separate sections on Discussion of Comments for those two interim rules.

We now list and discuss comments from the first interim rule, treated together in groups by alphabetical order of topics:

Discussion of Comments on Interim Rule of November 19, 1999, Advancement Gap

Three comments stated that the interim rule would greatly disrupt the towing industry since steersmen's licenses would not be issued for 18 months and masters' licenses for 48 months after the effective date. The Coast Guard acknowledges a reduction in the number of mariners initially licensed as masters; however, we disagree that a gap will last 48 months. Further, in the third interim rule and in this final rule, we have also reduced these impacts by allowing unlicensed mariners with service on towing vessels before May 21, 2001, to seek licenses under the rules in place before that date.

Apprentice Mate (Steersman)

One comment asked whether we consider an apprentice mate (steersman) to be an officer of a towing vessel. As we stated in previous preambles, we do not.

One comment supported the concept of a steersman license, but recommended reducing the service time from 12 months to 6 months. Even

The Wayback Machine - https://web.archive.org/web/20070219050320/http://www.startech.com:80/Product/Category.aspx?WCID=7&WCLID=2&MLID=2&menu=1&from=more&c=US

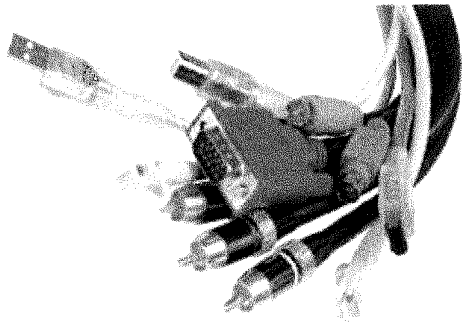
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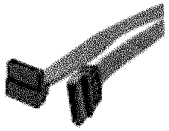
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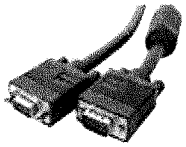
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Geotab Exhibit 1067
Geotab v. Omega

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Video/Monitor Cables
High-quality video cables, backed up by StarTech.com's lifetime warranty.



Internal PC Cables and I/O BackPlates
All the internal cables you need to build and upgrade computers.



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Various combinations of 4-pin and 6-pin IEEE-1394 interconnect cables for your iLink and FireWire peripherals.



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Assorted cables to connect Joysticks, MIDI and Audio devices to your PC.



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Extend cables to where you really need them.



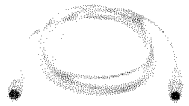
External Power Cables
Transfer power to external devices with these certified power cables.



Printer Cables
High-quality printer cables, backed up by StarTech.com's lifetime warranty.

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Keyboard/Mouse Cables
High-quality keyboard/mouse cables, backed up by StarTech.com's lifetime warranty.



Serial/Parallel Peripheral Cables
High-quality cables, backed up by StarTech.com's lifetime warranty.



Modem Cables
Various lengths and connector styles to allow almost any modem to be connected to your PC.



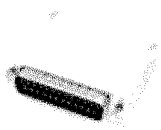
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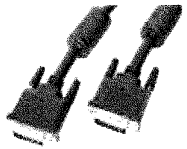
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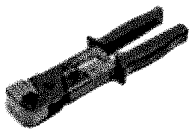
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OMEGA EXHIBIT 2038

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§ 1968.2. Malfunction and Diagnostic System Requirements--2004 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines

(a) Purpose

The purpose of this regulation is to establish emission standards and other requirements for onboard diagnostic systems (OBD II systems) that are installed on 2004 and subsequent model-year passenger cars, light-duty trucks, and medium-duty vehicles and engines certified for sale in California. The OBD II systems, through the use of an onboard computer(s), shall monitor emission systems in-use for the actual life of the vehicle and shall be capable of detecting malfunctions of the monitored emission systems, illuminating a malfunction indicator light (MIL) to notify the vehicle operator of detected malfunctions, and storing fault codes identifying the detected malfunctions.

(b) Applicability

Except as specified elsewhere in this regulation (title *13, CCR section 1968.2*), all 2004 and subsequent model-year vehicles, defined as passenger cars, light-duty trucks, and medium-duty vehicles, including medium-duty vehicles with engines certified on an engine dynamometer and medium-duty passenger vehicles, shall be equipped with an OBD II system and shall meet all applicable requirements of this regulation (title *13, CCR section 1968.2*).

(c) Definitions

(1) "Actual life" refers to the entire period that a vehicle is operated on public roads in California up to the time a vehicle is retired from use.

(2) "Alternate phase-in" is a phase-in schedule that achieves equivalent compliance volume by the end of the last year of a scheduled phase-in provided in this regulation. The compliance volume is the number calculated by multiplying the percent of vehicles (based on the manufacturer's projected sales volume of all vehicles) meeting the new requirements per year by the number of years implemented prior to and including the last year of the scheduled phase-in and then summing these yearly results to determine a cumulative total (e.g., a three year, 30/60/100 percent scheduled phase-in would be calculated as (30%*3 years) + (60%*2 years) + (100%*1 year) = 310). On phase-ins scheduled to begin prior to the 2004 model year, manufacturers are allowed to include vehicles introduced before the first year of the scheduled phase-in (e.g., in the previous example, 10 percent introduced one year before the scheduled phase-in begins would be calculated as (10%*4 years) and added to the cumulative total). However, on phase-ins scheduled to begin in 2004 or subsequent model years, manufacturers are only allowed to include vehicles introduced up to one model year before the first year of the scheduled phase-in. The Executive Officer shall consider acceptable any alternate phase-in which results in an equal or larger cumulative total by the end of the last year of the scheduled phase-in; however, all vehicles shall comply with the respective requirements subject to the phase-in within one model year following the last year of the scheduled phase-in.

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(3) "Base fuel schedule" refers to the fuel calibration schedule programmed into the Powertrain Control Module or PROM when manufactured or when updated by some off-board source, prior to any learned on-board correction.

(4) "Calculated load value" refers to an indication of the percent engine capacity that is being used and is defined in Society of Automotive Engineers (SAE) J1979 "E/E Diagnostic Test Modes - Equivalent to ISO/DIS 15031-5:April 30, 2002", April 2002 (SAE J1979), incorporated by reference (section (f)(1.9)1). For diesel applications, the calculated load value is determined by the ratio of current output torque to maximum output torque at current engine speed.

(5) "Confirmed fault code" is defined as the diagnostic trouble code stored when an OBD II system has confirmed that a malfunction exists (e.g., typically on the second driving cycle that the malfunction is detected) in accordance with the requirements of sections (e) and (f)(4.4).

(6) "Continuously," if used in the context of monitoring conditions for circuit continuity, lack of circuit continuity, circuit faults, and out-of-range values, means sampling at a rate no less than two samples per second. If for engine control purposes, a computer input component is sampled less frequently, the signal of the component may instead be evaluated each time sampling occurs.

(7) "Deactivate" means to turn-off, shutdown, desensitize, or otherwise make inoperable through software programming or other means during the actual life of the vehicle.

(8) "Diagnostic or emission critical" electronic powertrain control unit refers to the engine and transmission control unit(s). For the 2005 and subsequent model years, it also includes any other on-board electronic powertrain control unit containing software that has primary control over any of the monitors required by sections (e)(1.0) through (e)(15.0) and (e)(17.0) or has primary control over the diagnostics for more than two of the components required to be monitored by section (e)(16.0).

(9) "Diesel engines" refers to engines using a compression ignition thermodynamic cycle.

(10) "Driving cycle" consists of engine startup and engine shutoff and includes the period of engine off time up to the next engine startup. For vehicles that employ engine shutoff strategies (e.g., engine shutoff at idle), the manufacturer may request Executive Officer approval to use an alternate definition for driving cycle (e.g., key on and key off). Executive Officer approval of the alternate definition shall be based on equivalence to engine startup and engine shutoff signaling the beginning and ending of a single driving event for a conventional vehicle. Engine restarts following an engine shut-off that has been neither commanded by the vehicle operator nor by the engine control strategy but caused by an event such as an engine stall may be considered a new driving cycle or a continuation of the existing driving cycle.

(11) "Engine misfire" means lack of combustion in the cylinder due to absence of spark, poor fuel metering, poor compression, or any other cause. This does not include lack of combustion events in non-active cylinders due to default fuel shut-off or cylinder deactivation strategies.

(12) "Engine start" is defined as the point when the engine reaches a speed 150 rpm below the normal, warmed-up idle speed (as determined in the drive position for vehicles equipped with an automatic transmission). For hybrid vehicles or for engines employing alternate engine start hardware or strategies (e.g., integrated starter and generators, etc.), the manufacturer may request Executive Officer approval to use an alternate definition for engine start (e.g., ignition key "on"). Executive Officer approval of the alternate definition shall be based on equivalence to an engine start for a conventional vehicle.

(13) "Fault memory" means information pertaining to malfunctions stored in the onboard computer, including fault codes, stored engine conditions, and MIL status.

(14) "Federal Test Procedure (FTP) test" refers to an exhaust emission test conducted according to the test procedures incorporated by reference in title *13, CCR section 1961(d)* that is used to determine compliance with the FTP standard to which a vehicle is certified.