

APPENDIX A
WORKED EXAMPLES

A.1 SAE J1979 Messages as SAE J2205 Definitions

Mode 1 PID 00

00,16,24,0100,,8054,17 or 00,16,24,0100,,82A8,6D

Mode 1 PID 01

00,2E,24,0101,,2086519824208261208271208281,48

Mode 1 PID 03

00,20,24,0103,,83511F2083611F,66

Mode 1 PID 04 Calculated Load Value

00,1E,24,0104,,208E51FF9803,E8

Mode 1 PID 05 Engine Coolant Temperature

00,20,24,0105,,208851D8209801,DC

Mode 1 PID 06 Short Term Fuel Trim—Bank 1

00,1C,24,0106,,208F51D880,A7

Mode 1 PID 0A Fuel Pressure (gage)

00,1C,24,010A,,2089510300,50

Mode 1 PID 0B Intake Manifold Absolute Pressure

00,16,24,010B,,208651,47

Mode 1 PID 0C Engine RPM

00,16,24,010C,,905202,35

Mode 1 PID 0D Vehicle Speed

00,16,24,010D,,8651,27

Mode 1 PID 0F Intake Air Temperature

00,16,24,010F,,8851D8,05

Mode 1 PID 10 Air Flow Rate—MAF Sensor

00,16,24,0110,,905282,B9

A.2 Expanded SAE J1979 Worked Example

Mode 1 PID 01

00,2E,24,0101,,2086519824208261208271208281,48

id = 00

The id of this definition is 00. Because the id is in the range of 00 to 09, the scan tool will execute this definition immediately once entered successfully.

length = 2E

The length (2E = 46 decimal) indicates the number of characters in the definition, including the length field and the DSV field. It is checked for data entry accuracy.

type = 24

This is an SAE J1979 type definition. The first byte of the given transmit field will just be the SAE J1979 mode value. The rest of the transmit field will be defined by the mode value. The header for the transmit message is defined by the interface currently being used. The receive filter is defined by the actual transmit message header.

transmit field = 0101

This is a mode 01 SAE J1979 request message. A second byte, the PID, is defined for mode 01 request messages. The PID value is 01.

Receive filter field = <null>

The receive filter will be the default defined by the definition type and the actual transmit message header.

Received data processing field = 2086519824208261208271208281

20 ASCII code for 1 blank.

8651 Display bytes as unsigned decimal, field starts at byte 5, and is 1 byte in size. Byte 5 of the received response message is SAE J1979 response data byte 3, which is the number of emission-related powertrain diagnostic trouble codes.

9824 Display standard text \$24. This is "DTC."

20 Same as above.

8261 Display bytes as bits, field starts at byte 6 and is 1 byte in size. Byte 6 of the received response message is SAE J1979 response data byte 4, which is the evaluation/Mil status bits.

20 Same as above.

8271 Same as 8261 above, except this is for SAE J1979 response data byte 5, which is evaluation support bits.

20 Same as above.

8281

Same as above, except this is for SAE J1979 response data byte 6, which is the evaluation status bits.

DSV = 48

This is the DSV value for this definition.

SURFACE VEHICLE STANDARD

SAE J1850

REV.
MAY94

Issued 1988-11
Revised 1994-05-02

Superseding J1850 FEB94

Submitted for recognition as an American National Standard

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 Documents—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 J1211—A 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

SAE J1879—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

SAE J2178—Class B Data Communication Network Messages

SAE J2178/1—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 48064-3174.

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

ISO 7637/3—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 Publication—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

2.3 Definitions

2.3.1 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_{on} volts for Bus + (PWM and VPW) and V_{os} volts for Bus - (PWM only). Refer to 7.3.2.2 (PWM DC Parameters) and 7.3.3.2 (VPW DC Parameters) for the values of V_{on} and V_{os} . The active state voltage level is determined by the source voltage of the physical layer drive circuitry.

2.3.2 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.

- 2.3.3 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.
- 2.3.4 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.
- 2.3.5 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.
- 2.3.6 DOMINANT BIT**—A bit which wins arbitration when contending for the bus. For SAE J1850, a logic "0" is the dominant bit.
- 2.3.7 DUAL WIRE**—Two wires that are routed adjacently throughout the network and can be either a twisted or a parallel pair of wires.
- 2.3.8 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.
- 2.3.9 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.
- 2.3.10 FUNCTIONAL ADDRESSING**—Labeling of messages based on their operation code or data content. See 5.1.2 for an example of the typical usage for functional addressing.
- 2.3.11 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.
- 2.3.12 PASSIVE STATE**—The state of a bus wire which results when all nodes have "turned off" their physical layer circuitry. This is V_{oh} volts for Bus + (PWM and VPW) and V_{ol} volts for Bus - (PWM only). Refer to 7.3.2.2 (PWM DC Parameters) and 7.3.3.2 (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).
- 2.3.13 PHYSICAL ADDRESSING**—Labeling of messages for the physical location of their source and/or destination(s). See 5.1.1 for an example of the typical usage for physical addressing.
- 2.3.14 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.
- 2.3.15 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.
- 2.3.16 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.

- 2.3.17 **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.

2.4 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
OSI:	Open System Interconnect
SOF:	Start of Frame

3. Description of the Architecture

- 3.1 **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.

3.2 Network Topology

- 3.2.1 **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:

- All nodes/devices transmit and receive from a single path.
- All nodes/devices receive all frames at the same time.
- Communication on each data bus is identical.

3.2.2 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.

3.3 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.

3.3.1 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.

3.3.2 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.

3.3.3 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.

3.4 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.

4. 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.

4.1 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.

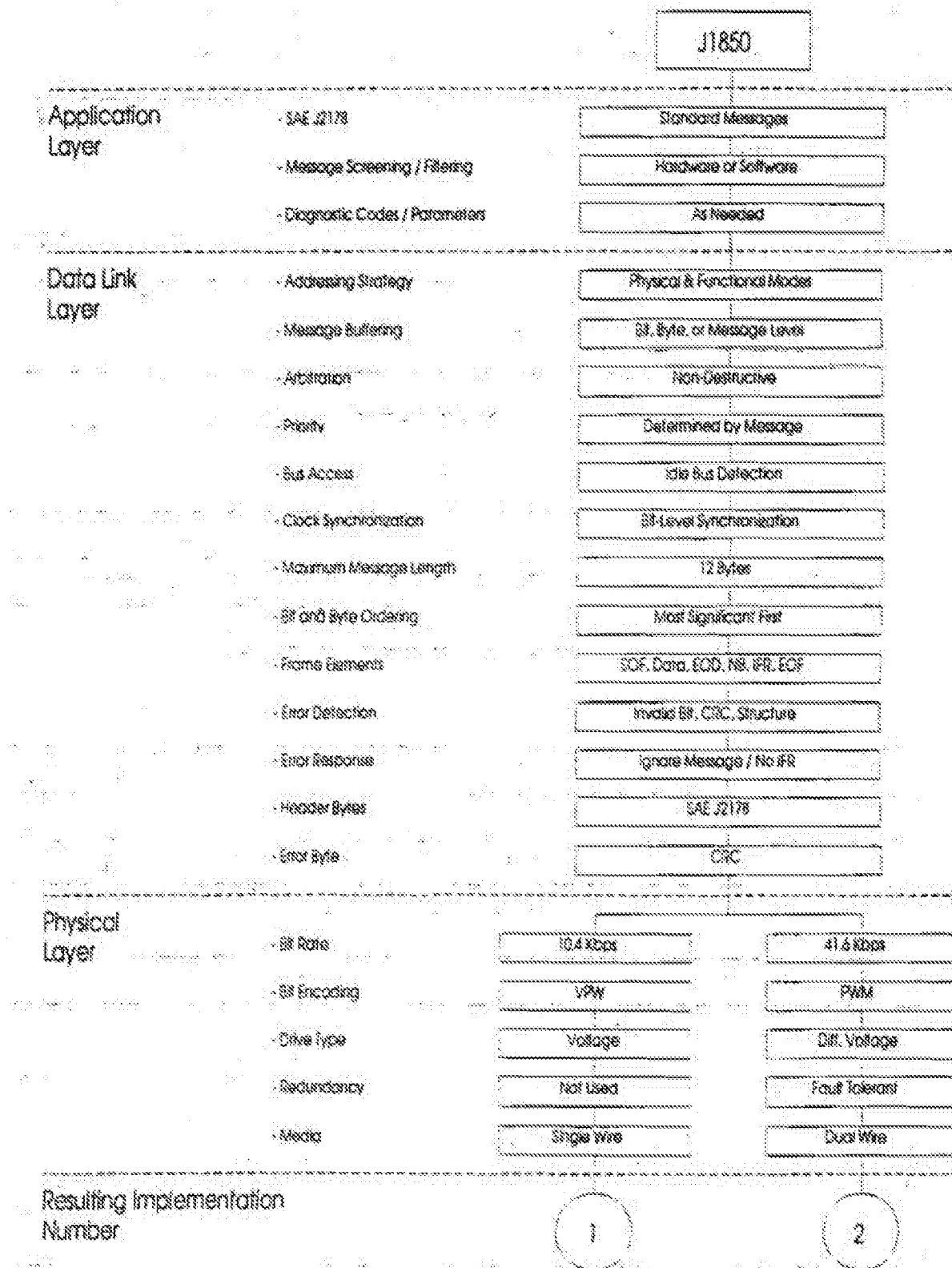


FIGURE 1--MAP OF SAE J1850 TO THE ISO OSI MODEL

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

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	IFR Required		
				1	IFR Not Allowed		
Y	Addressing Mode			0	Functional Addressing		
				1	Physical Addressing		
ZZ	Specific Message Type			0 0	The meaning for these values are dependent on K & Y above. These meanings can be found in J2178/1.		
				0 1			
				1 0			
				1 1			

FIGURE 4--FIRST BYTE OF THREE BYTE FORM OF CONSOLIDATED HEADER

4.2 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.

4.2.1 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.

4.2.2 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.

4.3 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 5.1), 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.

5. 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

5.1 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.

5.1.1 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.

5.1.2 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.

5.2 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 6.6.1.7.

Since a discrete clock wire is not used with this network, node synchronization can be derived from bit/symbol transitions on the bus.

5.2.1 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.

5.2.2 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.

5.3 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.

5.3.1 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.

5.3.2 BIT ORDERING—The first bit of each byte transmitted on the network shall be the most significant bit (i.e., MSB first).

5.3.3 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 7.2.

5.3.4 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 7.3.

5.3.4.1 *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.

5.3.4.2 *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 5.3.7) 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.

5.3.4.3 *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.

5.3.4.4 *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.

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.

5.3.4.5 *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 6.6.2.5.

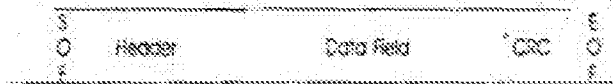
5.3.4.6 *Break (BRK)*—BRK is allowed to accommodate those situations in which bus communication is to be terminated and all nodes reset to a "ready-to-receive" state. If BRK is used, it must adhere to the requirements as specified in 6.6.

5.3.5 *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.

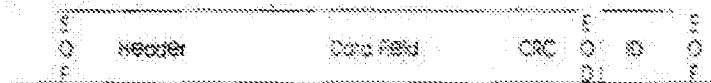
5.3.6 *DATA BYTE(s)*—A number of data bytes, each eight (8) bits in length, can be transmitted at the discretion of the system designer. However, the total message length (from SOF to EOF) shall not exceed the limit defined in 7.2.

5.3.7 *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):

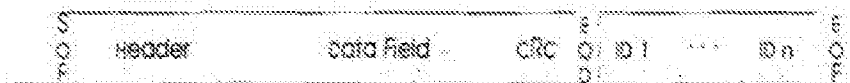
- a. None
- b. A single byte transmitted from a single recipient, typically a unique identifier (ID) or address.



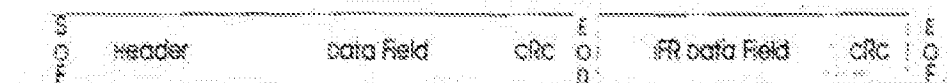
Type 0 - None



Type 1 - Single Byte From a Single Responder



Type 2 - Single Byte From Multiple Responders



Type 3 - Multiple Bytes From a Single Responder

FIGURE 5--TYPES OF IN-FRAME RESPONSE

- 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 5.4.1, 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 7.2.

5.3.7.1 *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 6.6.2.5.

5.4 *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.

5.4.1 *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:

$$\frac{X^8 + D(X) + X^8 + X^{n-1} + \dots + X^{n-7}}{P(X)} = Q(X) + \frac{R(X)}{P(X)} \quad (\text{Eq. 1})$$

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:

$$M(X) = X^9 + D(X) + \overline{R(X)} \quad (\text{Eq.2})$$

- 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						88
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 only includes 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.

5.4.2 FRAME/MESSAGE LENGTH—A frame exceeding its defined length limit may constitute a detected error.

5.4.3 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:

- 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.
- 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.

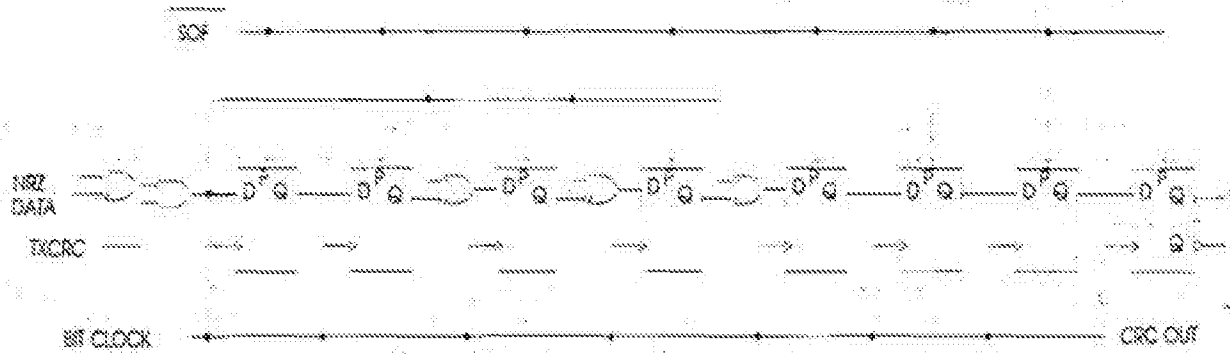


FIGURE 6-CRC GENERATOR

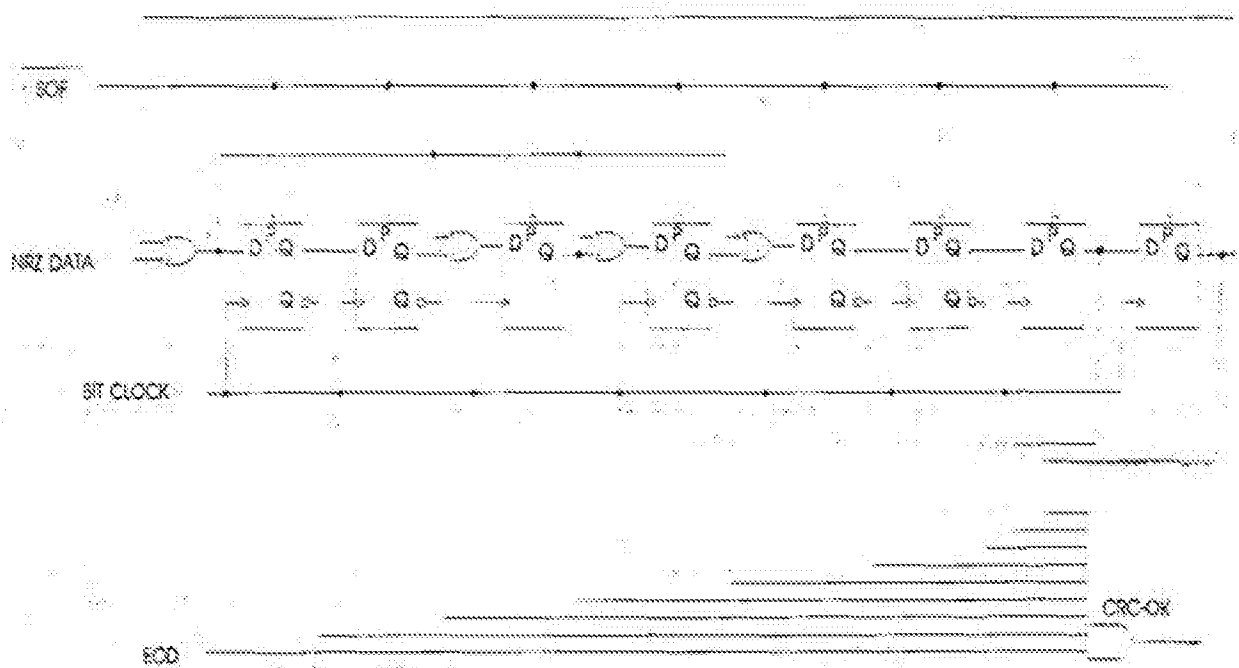


FIGURE 7-CRC CHECKER

5.4.4 CONCEPT OF VALID/INVALID BIT/SYMBOL DETECTION

5.4.4.1 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.

5.4.4.2 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.

5.5 Error Response

5.5.1 TRANSMIT--When an originator of a frame detects an error condition on the network (i.e., one of the error conditions defined in 5.4), 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.

5.5.2 RECEIVE--If a frame is received and the frame contains an error (i.e., one of the error conditions defined in 5.4), 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.

6. 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 7.

6.1 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.

6.1.1 SINGLE WIRE--The network medium for the single wire voltage drive shall be a single random lay wire.

6.1.2 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.

6.1.3 ROUTING--No Restrictions

6.2 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.

6.3 Maximum Number of Nodes—The maximum number of nodes, assuming each node is the equivalent of a standard unit load, is specified in Section 7.

6.4 Maximum Network Length—The maximum medium length between any two nodes shall not exceed the value specified in Section 7.

6.4.1 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 7.3. 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.

6.5 Media Characteristics—The characteristics of the media are as specified in Section 7.

6.6 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 7.

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.

6.6.1 PULSE WIDTH MODULATION (PWM)—The following values represent nominal timing, detailed timing requirements for each bit/symbol can be found in Section 7.

6.6.1.1 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 T_{p3} . Two rising edges shall never be closer than T_{p3} .
- (2) A falling edge that occurs T_{p1} after the rising edge.

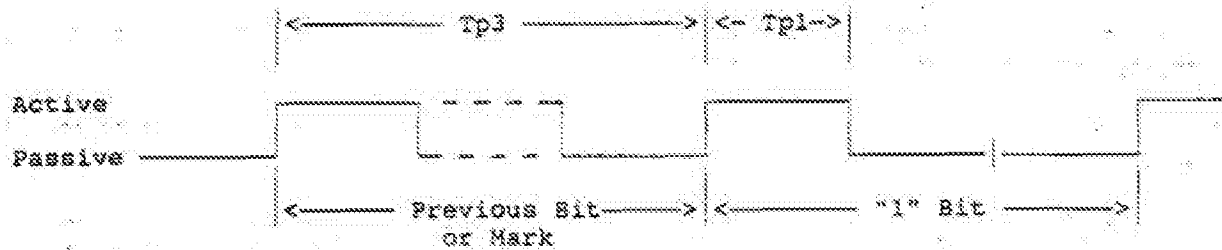
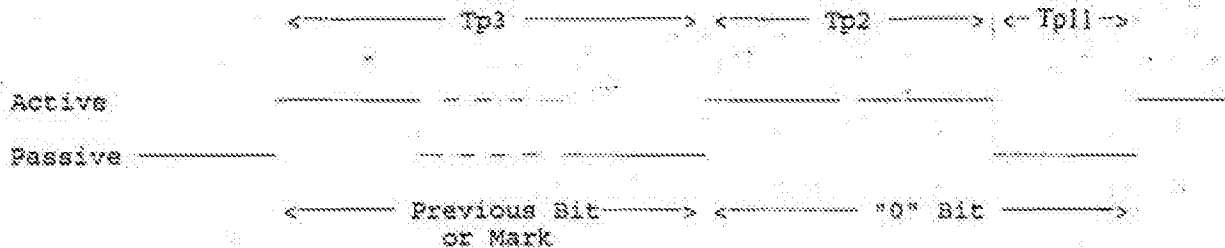


FIGURE 8—"1" BIT DEFINITION

b. "0" Bit - A "0" bit is characterized by:

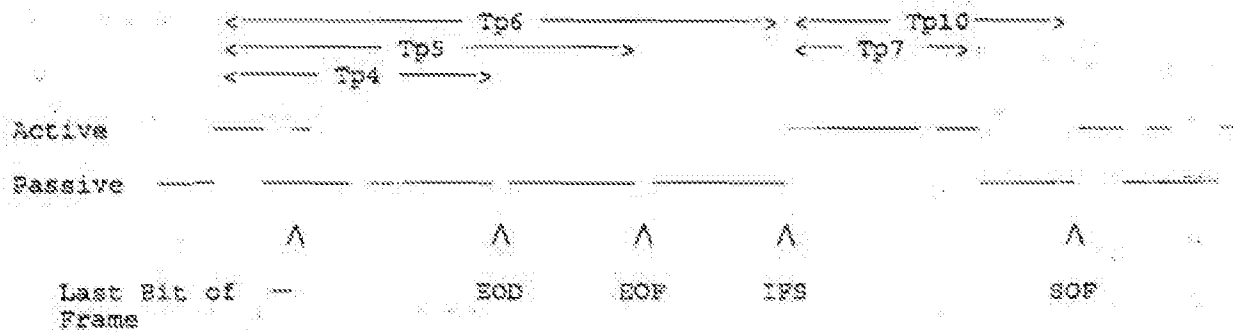
- (1) A rising edge that follows the previous rising edge by at least $Tp3$. Two rising edges shall never be closer than $Tp3$.
- (2) A falling edge that occurs $Tp2$ after the rising edge.
- (3) A next data bit rising edge that occurs $Tp11$ after the previous falling edge (if applicable).



(R) FIGURE 9—"0" BIT DEFINITION

6.6.1.2 *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.



(R) 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.

6.6.1.3 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).

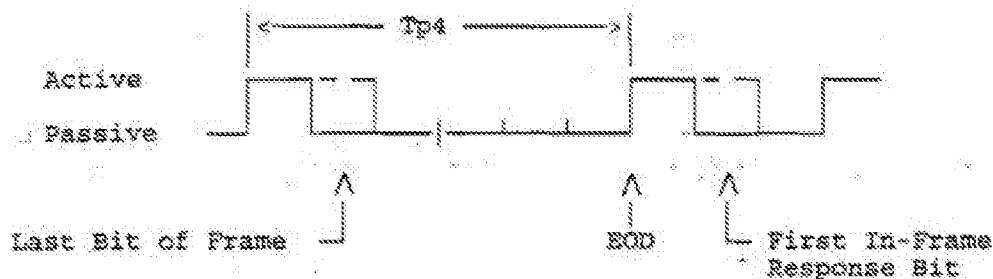


FIGURE 11--END OF DATA SYMBOL

NOTE—Last bit of a frame may be the last data bit, last CRC bit, or last In-Frame Response bit.

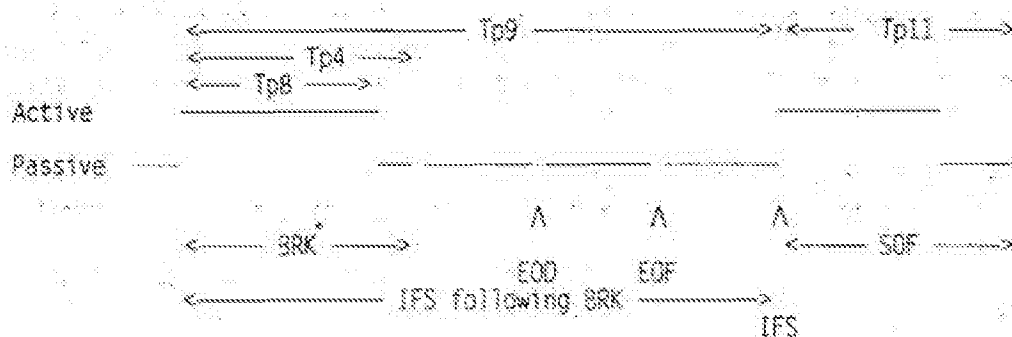
6.6.1.4 End of Frame (EOF)—The completion of the EOF defines the end of a frame (by definition, an EOD forms the first part of the EOF - see Figure 13). After the last transmission byte (including in-frame response bytes where applicable), the bus will be left in a passive state. When EOF has expired ($Tp5$ after the rising edge of the last bit), all receivers will consider the transmission complete.

6.6.1.5 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:

- IFS minimum has expired. (Tp6 after the rising edge of the last bit).
- EOF minimum and another rising edge has been detected. (Tp5 after the rising edge of the last bit).

6.6.1.6 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.



(R) FIGURE 12—PWM BREAK SEQUENCE

6.6.1.7 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.

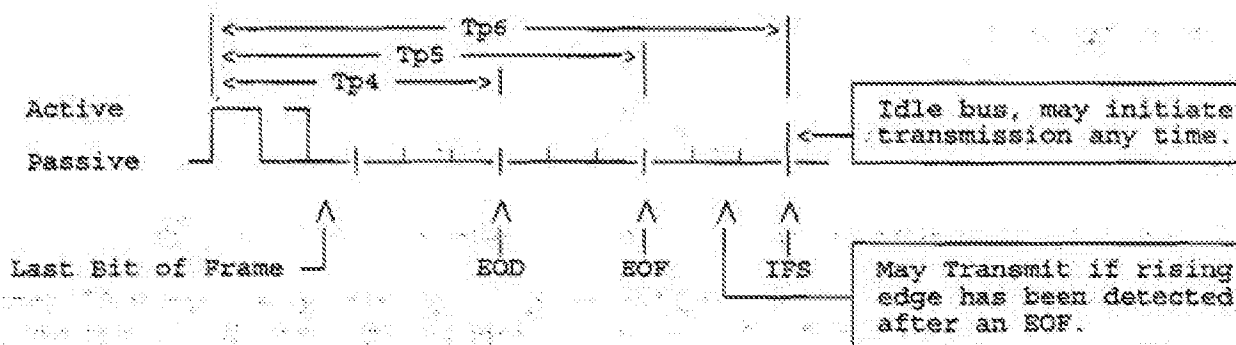


FIGURE 13—EOF AND IDLE BUS DEFINITION

NOTE—Last bit of a frame may be the last data bit, last CRC bit, or last In-Frame Response bit.

6.6.1.8 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 7.3.2.1 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).

6.6.2 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 7.

6.6.2.1 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 5.7.

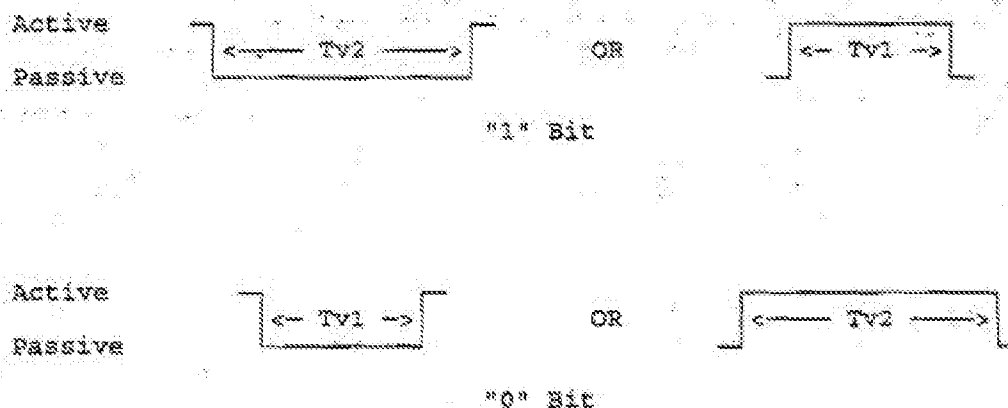


FIGURE 14—ONE AND ZERO BIT DEFINITIONS

6.6.2.2 Start Of Frame (SOF)—SOF is an active pulse, Tv3 in duration (see Figure 15).

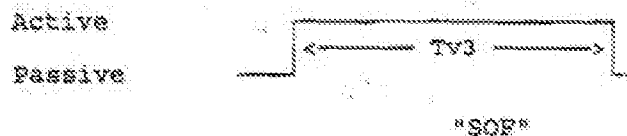


FIGURE 15—START OF FRAME (SOF) SYMBOL

6.6.2.3 *End Of Data (EOD)*—EOD is a passive pulse, $Tv3$ in duration (see Figure 16).

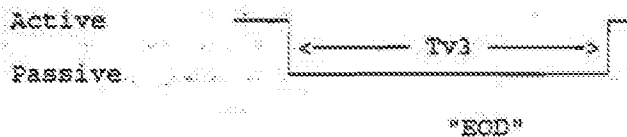


FIGURE 16—END OF DATA (EOD) SYMBOL

6.6.2.4 *End of Frame (EOF)*—EOF is a passive pulse, $Tv4$ in duration (see Figure 17).

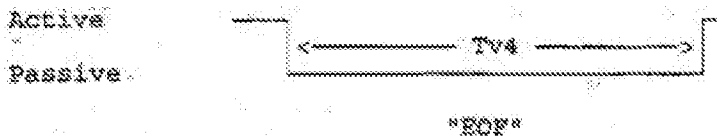


FIGURE 17—END OF FRAME (EOF) SYMBOL

6.6.2.5 *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 7.

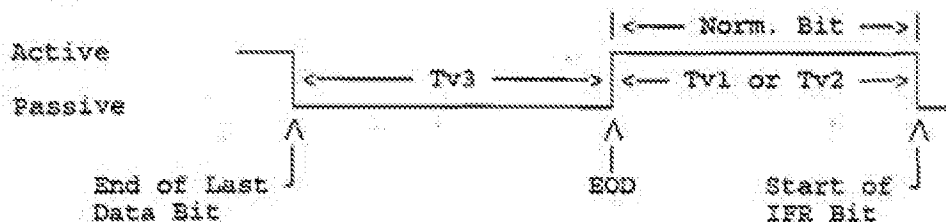


FIGURE 18—NORMALIZATION BIT

6.6.2.6 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):

- IFS minimum has expired (T_v6).
- EOF minimum and another rising edge has been detected (T_v4).

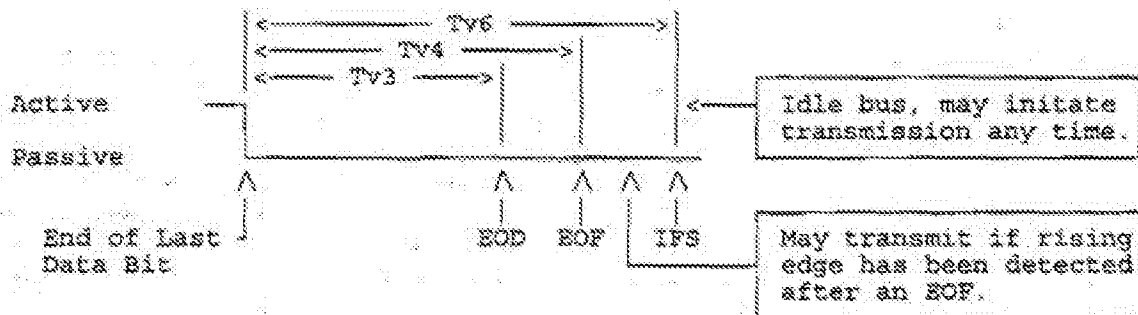


FIGURE 19—INTER-FRAME SEPARATION

6.6.2.7 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 ($\geq T_v5$). Following the break symbol, an IFS period (T_v6) 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.

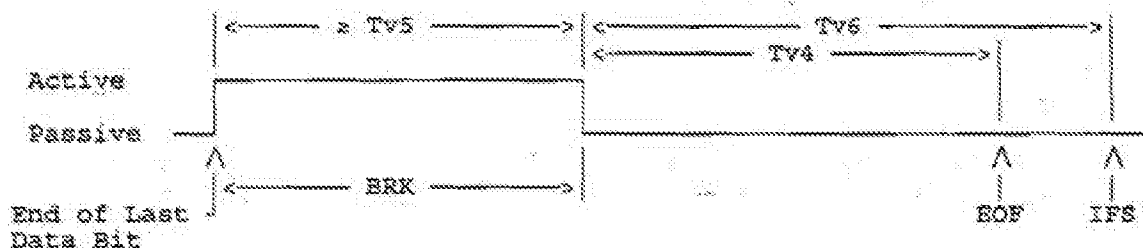


FIGURE 20—BREAK SIGNAL

6.6.2.8 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 (T_v6). Contention may still occur when two or more nodes transmit nearly simultaneously; therefore, resynchronization to rising edges must continue to occur.

6.6.2.9 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, $T_{l,max}$ (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 $T_{l,max}$ 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 $T_{l,max}$ as found in Section 7.

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 $V_{oh,min}$ or $V_{ol,max}$.

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 $T_{x,min} - T_{l,max}$ to $T_{x,max} + T_{l,max}$ 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 7 are consistent with $T_{l,max}$ and the specified oscillator tolerance. T_{nom} is the nominal symbol time with no oscillator error and the receiver detecting the transition at V_i (see analysis in Appendix D).

6.7 Contention/Arbitration/Priority—A contention situation arises when more than one node attempts to access the bus at essentially the same time.

6.7.1 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.

6.7.2 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).

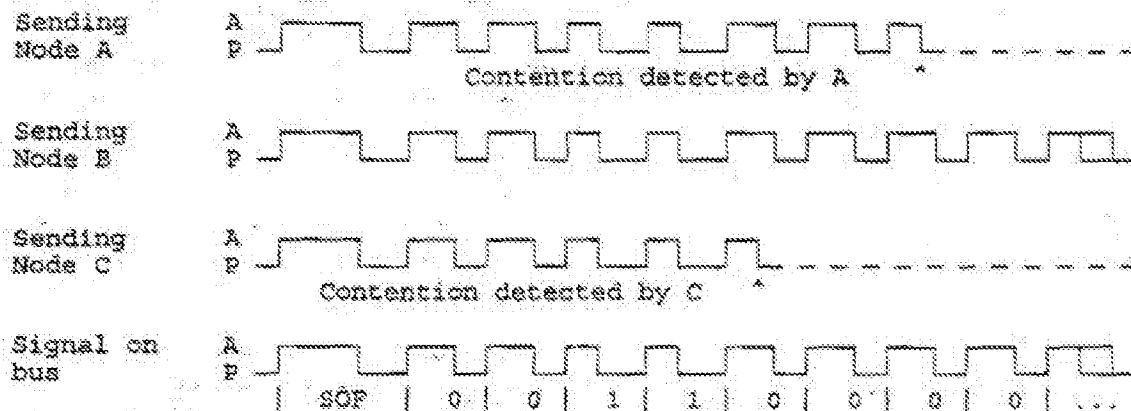
The arbitration process begins with the SOF and continues through all the bits of the frames being sent. As each symbol or bit of all the simultaneous frames is transmitted, all of the nodes still transmitting after the last symbol or bit will detect whether any contention is taking place. Nodes that 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.

6.7.3 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.

6.7.4 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 6.6.1.5 and 6.6.2.7), 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.

BIT-BY-BIT ARBITRATION ON A PWM BUS



BIT-BY-BIT ARBITRATION ON A VPW BUS

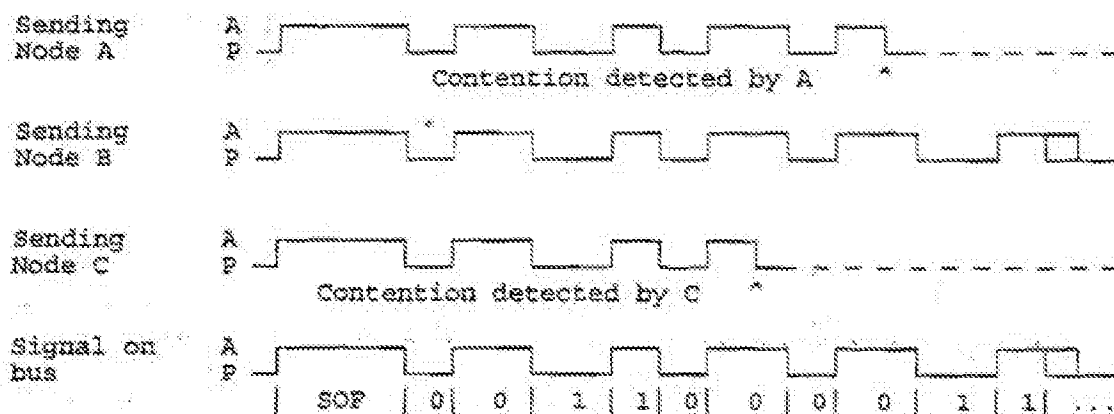


FIGURE 21-ARBITRATION

Based on the bit definitions contained in Section 6.6, 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).

6.8 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:

- The view of the media itself, without regard to the individual nodes on the network
- 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.

6.8.1 NETWORK MEDIA

6.8.1.1 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).

6.8.1.2 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.

6.8.2 INDIVIDUAL NODES

6.8.2.1 Unpowered Node—An unpowered node is not capable of network communication, nor wake-up from network signal transitions.

6.8.2.2 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.

6.8.2.3 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.

6.9 Physical Layer Fault Considerations

6.9.1 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.

6.9.2 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 + (V_{bat})
- (6) Bus "-" wire Shorted to Battery + (V_{bat})
- (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.

6.10 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)

7. Parameters

7.1 **Application Layer**—The following Application Layer requirements shall exist whenever the network is used.

Bit Dominance - A "0" bit dominates over a "1" bit.

7.2 Data Link Layer

7.2.1 **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.

7.2.2 **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.

7.3 Physical Layer

7.3.1 **GENERAL NETWORK REQUIREMENTS** (see Table 2)

TABLE 2—GENERAL NETWORK PARAMETERS

Parameter Description	Parameter Value
On-Vehicle Network Length	35 meters
Off-Vehicle Network Length	5 meters
Total Vehicle Network Length	40 meters
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

7.3.2 PULSE WIDTH MODULATION (PWM)

- (a) 7.3.2.1 *PWM Timing Requirements*—The following requirements, Table 3, are for a nominal bit time of 24 μ s or 41.6 Kbps as seen on the network media.

(R) TABLE 3—PWM PULSE WIDTH TIMES (μ s)

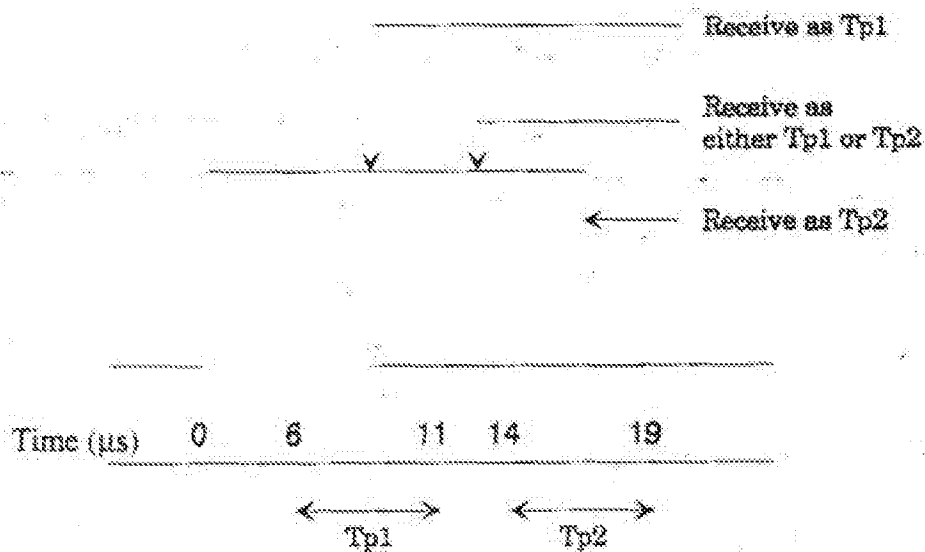
Symbol	Tx,min	Tx,nom	Tx,max	Rx,min	Rx,max
Tp1: Active phase "1"	≥ 7	8	≤ 9	≥ 6	≤ 11
Tp2: Active phase "0"	≥ 15	16	≤ 17	≥ 14	≤ 19
Tp3: Bit time	≥ 23	24	≤ 25.5	≥ 22	≤ 27
Tp4: SOF/EOD time	≥ 47	48	≤ 51	≥ 46	≤ 53
Tp5: EOF time	≥ 70	72	76.5	≥ 70	N/A ¹
Tp6: IFS time	≥ 94	96	N/A ²	N/A	N/A ²
Tp7: Active SOF	≥ 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.

- (a) 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 μ s 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.



(R) FIGURE 22--EXAMPLE OF RECEIVING A Tp1 OR Tp2 SYMBOL

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."

7.3.2.2 PWM DC Parameters (see Table 4)

TABLE 4—PWM DC PARAMETERS¹

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	μ s
Signal Transition Time	T_t	—	—	1.75	μ s
Node Resistance (unit load, each wire)	R_u	—	2,880	—	ohms
Node Capacitance (unit load, each wire to ground)	C_{ug}	—	250	—	pF
Node Capacitance (unit load, wire-to-wire)	C_{uw}	—	10	—	pF
Node Leakage Current (each wire - active state)	I_{leakA}	—	—	100	μ A
Node Leakage Current (each wire - passive state, unpowered node)	I_{leakPU}	—	—	100	μ A
Node Leakage Current (each wire - passive state, powered node)	I_{leakPP}	—	—	20	μ A

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 $T_{load,max}$.

7.3.3 VARIABLE PULSE WIDTH MODULATION (VPW)

7.3.3.1 VPW Timing Requirements-- The following requirements, Table 5, show the VPW timing values.

TABLE 5--VPW PULSE WIDTH TIMES (μ s)

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.

7.3.3.2 VPW DC Parameters (see Table 6)

TABLE 6--VPW DC PARAMETERS¹

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	μ s
Signal Transition Time	T_r	—	—	18.0	μ s
Node Resistance (unit load)	R_u	—	10,600	—	ohms
Node Capacitance (unit load)	C_u	—	470	—	pF
Node Leakage Current	I_{leak}	—	—	10	μ A

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 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 $T_{load,max}$.

8. Notes

- 8.1 **Marginal Indicia**—The (R) is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. If the symbol is next to the report title, it indicates a complete revision of the report.

PREPARED BY THE SAE VEHICLE NETWORK FOR MULTIPLEXING AND
DATA COMMUNICATIONS STANDARDS COMMITTEE

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 A1—CHECKLIST OF APPLICATION-SPECIFIC FEATURES

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 Kbps Variable Pulse Width Modulation (VPWM)			
41.6 Kbps Pulse Width Modulation (PWM)			
FEATURE ELEMENTS			
Maximum Frame Size			
Wake-Up Capability			

FIGURE A1 (CONTINUED)

APPENDIX B I/O EMC TEST PLAN

B.1 Radio Disturbance From Vehicle Components- (CISPR/D/WG2(Secretariat) 19 Sept 1989) - See Figure B1 for diagram.

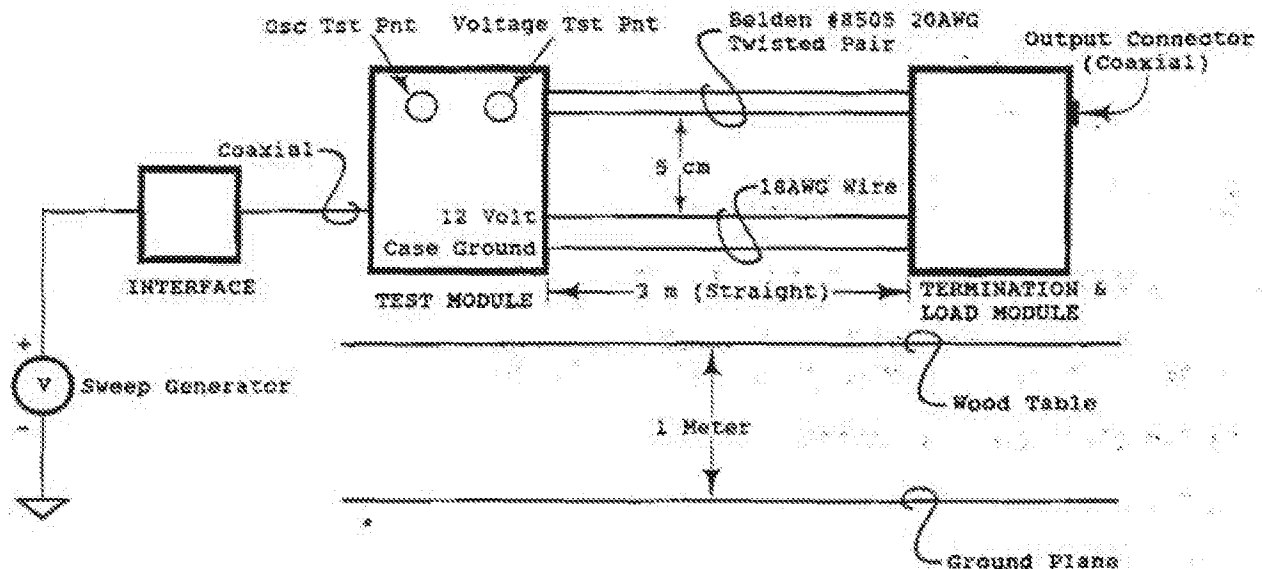


FIGURE B1--EMC TEST SETUP

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

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 - Altech 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 Function—Electromagnetic 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: $\approx$ 25 mW to generate 1 V peak-to-peak at test point

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 10 (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)

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:

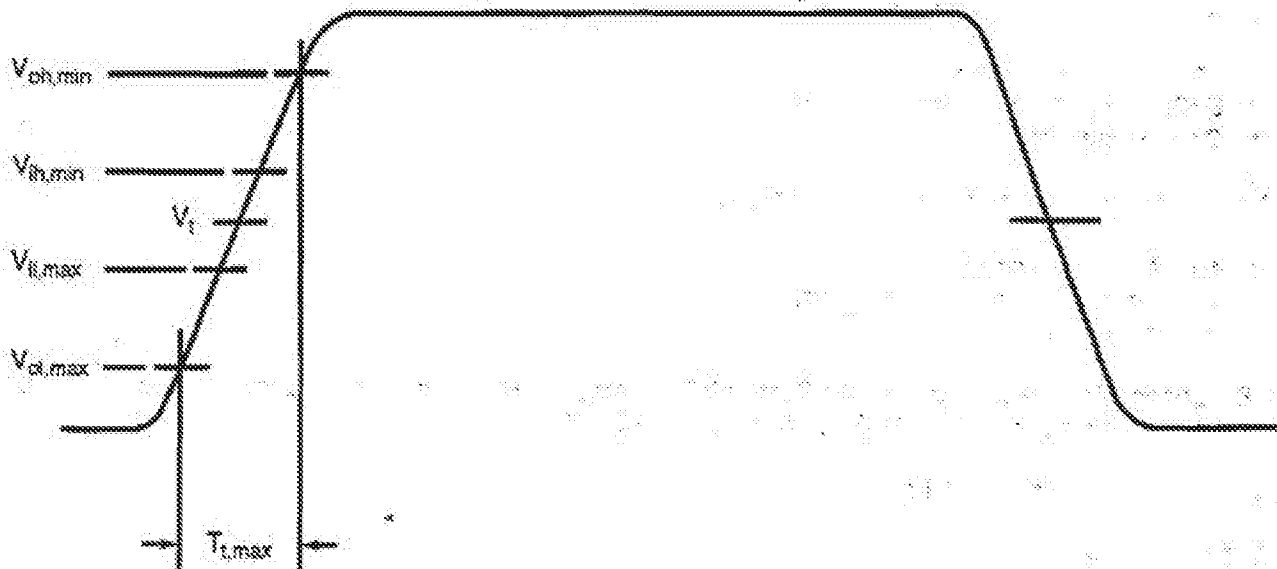


FIGURE C1—VOLTAGE LEVELS AND TRIP POINTS

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 highest trip point, with the receiver having no ground offset noise, and the source having 2 V of noise.

C.2.3 V_i —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.

Equations C1 and C2 are used to generate the transmitted pulse values shown in Table C1:

$$T_{x,min} = (T_{nom} - T_{L,max} / 2) * 0.98 - T_{x,max} \quad (\text{Eq. C1})$$

$$T_{x,max} = (T_{nom} + T_{L,max} / 2) * 1.02 + T_{x,max} \quad (\text{Eq. C2})$$

TABLE C1-VPW PULSE WIDTH TIMES (μ s)

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/EOF time	182	200	218	164	237
Tv4: EOF time	261	280	N/A	241	N/A

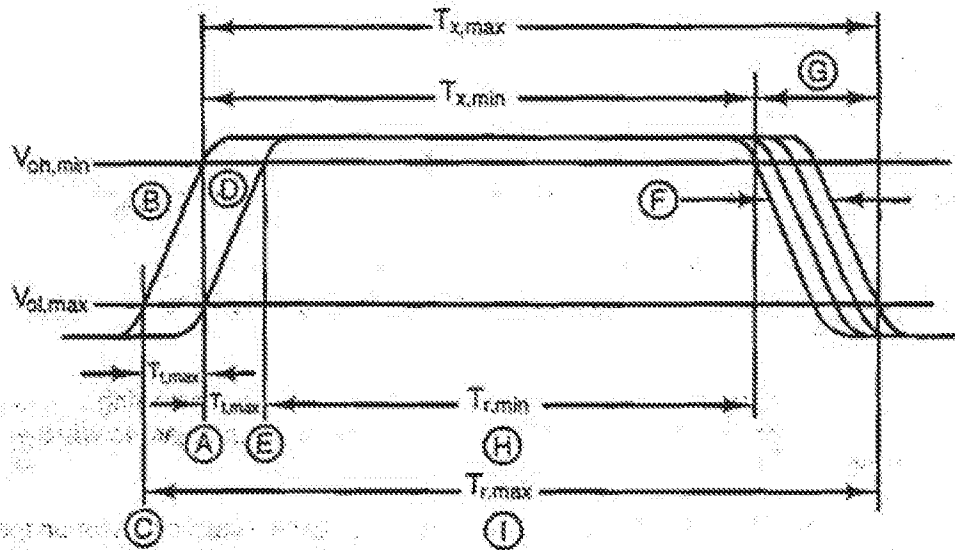
The $(T_{nom} \pm T_{L,max} / 2) * 2\%$ factor covers the 2% oscillator tolerance. The $T_{x,nom}$ and $T_{L,max}$ factors are given in Section 7. The $T_{x,min}$ factor is assumed to be 5.0 which covers the rest of the factors (lumped variation in delay through the source driver and medium).

For VPW, mode 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 , $T_{x,min}$ 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 and 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 $T_{x,min} - T_{L,max}$ to $T_{x,max} + T_{L,max}$. This range comes from the variations in the transmitted pulse width combined with possible noise offset effects on the transmitted and receiving node. The $T_{x,min} - T_{L,max}$ 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 2V of ground offset noise. This sets up the possibility of the receiver tripping at $V_{th,min}$ on the leading and trailing edge of the waveform. Therefore the pulse width seen by another node for the this $T_{x,min} - T_{L,max}$ situation including the oscillator tolerance and guard banding is given by Equation C4. Equation C5 is derived by substituting Equation C1 for $T_{x,min}$ in Equation C4. The $T_{L,max} / 2$ factor is equal to zero since an ideal trip point and no ground offset was assumed. The $T_{x,max} + T_{L,max}$ situation occurs with a $T_{x,max}$ pulse being transmitted, the source node having 2V of noise, and the receiver having no offset. This sets up the possibility of the receiving node tripping at $V_{th,max}$. 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 C7 and C8 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.



- 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 $V_{oh,min}$ and $V_{ol,max}$. 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 7 for a 2 V ground offset range and a transition rise time of $T_{l,max}$. The transmitting node $T_{l,max}$ 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 $T_{sp,max}$ can be approximated by Equation C3 assuming a linear waveform rise time.

$$T_{sp,max} = T_{l,max} * ((V_{th,min} - V_{th,max}) / (V_{oh,min} - V_{oh,max})) \quad (\text{Eq. C3})$$

The values for this range shown in Table C1 were arrived at using Equations C6 and C9. Note these values compare favorably with the values specified in Section 7, Table 5.

$$T_{r,min} = (T_{x,min} - T_{l,max}) * 0.98 - T_{r,max} \quad (\text{Eq. C4})$$

$$T_{r,min} = (((T_{nom} - T_{l,max}/2) * 0.98 - T_{x,max}) - T_{l,max}) * 0.98 - T_{r,max} \quad (\text{Eq. C5})$$

$$T_{r,min} = (((T_{nom} - T_{sp,max}/2) * 0.98 - T_{x,max}) - T_{l,max}) * 0.98 - T_{r,max} \quad (\text{Eq. C6})$$

$$T_{r,max} = (T_{x,max} + T_{l,max}) * 1.02 + T_{r,max} \quad (\text{Eq. C7})$$

$$T_{r,max} = (((T_{nom} + T_{l,max}/2) * 1.02 + T_{x,max}) + T_{l,max}) * 1.02 + T_{r,max} \quad (\text{Eq. C8})$$

$$T_{r,max} = (((T_{nom} + T_{sp,max}/2) * 1.02 + T_{x,max}) + T_{l,max}) * 0.98 + T_{r,max} \quad (\text{Eq. C9})$$

The 2% guard bands cover the oscillator tolerances of both transmitter and receiver and $T_{r,max} = 4.0$ 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 $\pm 5.0 \mu s$ 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 $\pm 4.0 \mu s$ factor defined in $T_{r,min}$ and $T_{r,max}$.

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.

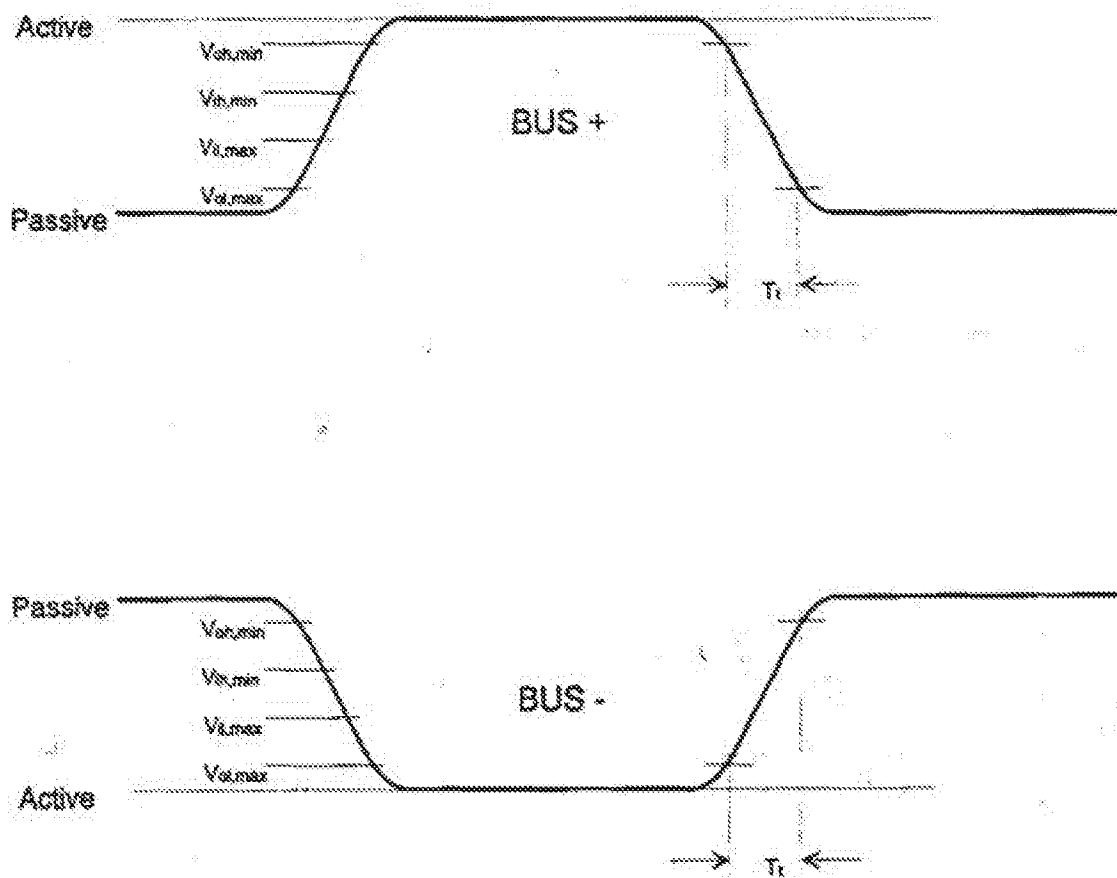


FIGURE D1—TYPICAL PWM WAVEFORM

TABLE D1-PWM DC PARAMETERS

Parameter	Symbol	Min	Typ	Max	Units
Input High Voltage	V_{ih}	2.60	—	6.25	V
Input Low Voltage	V_{il}	-1.00	—	2.20	V
Output High Voltage	V_{oh}	3.60	—	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_{bst}	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	μ s
Signal Transition Time	T_t	—	—	1.75	μ s
Node Resistance (unit load, each wire)	R_d	—	2,880	—	ohms
Node Capacitance (unit load, each wire to ground)	C_{dg}	—	250	—	pF
Node Capacitance (unit load, wire-to-wire)	C_{dw}	—	10	—	pF
Node Leakage Current (each wire - active state)	I_{leakA}	—	—	100	μ A
Node Leakage Current (each wire - passive state, unpowered node)	I_{leakPU}	—	—	100	μ A
Node Leakage Current (each wire - passive state, powered node)	I_{leakPP}	—	—	20	μ A

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 C_{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 ($V_{ga,max}$).
- 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 ($V_{ga,max}$).
- D.2.5 V_{og}** —This is the absolute ground offset voltage that can exist between any two nodes on the network.
- 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_{wg}** —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_{ww}** —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 & Overdrive Voltage (V_{ov}), V_{il} and V_{ih} can be derived. (See Equations D1 through D4.)

$$V_{il,min} = (\text{Ground Reference}) - V_{ov} = 0.00 - 1.00 = -1.00 \text{ V} \quad (\text{Eq. D1})$$

$$V_{il,max} = \frac{1}{2} (V_{sup,min}) - V_{ov,min} = \frac{1}{2} (4.75) - 0.18 = 2.20 \text{ V} \quad (\text{Eq. D2})$$

$$V_{ih,min} = \frac{1}{2} (V_{sup,max}) + V_{ov,max} = \frac{1}{2} (5.25) + 0.18 = 2.81 \text{ V} \quad (\text{Eq. D3})$$

$$V_{ih,max} = V_{sup,max} + V_{ov} = 5.25 + 1.00 = 6.25 \text{ V} \quad (\text{Eq. D4})$$

where the $\frac{1}{2}$ factor in $V_{il,max}$ 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.)

$$V_{ol,max} = V_{il,min} + V_{ov} = -1.00 + 1.00 = 0 \text{ V (Ground Reference)} \quad (\text{Eq. D5})$$

$$V_{ol,max} = V_{il,max} - V_{ov} = 2.20 - 1.00 = 1.20 \text{ V} \quad (\text{Eq. D6})$$

$$V_{oh,min} = V_{ih,min} + V_{ov} = 2.80 + 1.00 = 3.80 \text{ V} \quad (\text{Eq. D7})$$

$$V_{oh,max} = V_{ih,max} - V_{ov} = 6.25 - 1.00 = 5.25 (V_{sup,max}) \quad (\text{Eq. D8})$$

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 $2.20 \mu\text{s}$. This is $T_{l,max}$ + 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 $\Delta t = 2.20 \mu\text{s}$, the following relationship for $V_{oh,min}$ must be satisfied for Bus (–) and $V_{ol,max}$ for Bus (+). (See Equations D9 through D12.)

$$V_{oh,min} = V_{sup,min} (1 - e^{-(\Delta t/T_{load,max})}) \text{ for Bus (–)} \quad (\text{Eq. D9})$$

$$V_{ol,max} = V_{oh,max} (e^{-(\Delta t/T_{load,max})}) \text{ for Bus (+)} \quad (\text{Eq. D10})$$

From this, the maximum network time constant ($T_{load,max}$) can be derived.

$$\begin{aligned} T_{load,max}(\text{Bus–}) &= -\Delta t \div \ln(1 - (V_{oh,min}/V_{sup,min})) \\ &= -2.20 \div \ln(1 - (3.80/4.75)) = 1.37 \mu\text{s} \end{aligned} \quad (\text{Eq. D11})$$

$$\begin{aligned} T_{load,max}(\text{Bus+}) &= -\Delta t \div \ln(V_{ol,max}/V_{oh,max}) \\ &= -2.20 \div \ln(1.20/5.25) = 1.49 \mu\text{s} \end{aligned} \quad (\text{Eq. D12})$$

Choosing a $T_{load,max}$ of $1.35 \mu\text{s}$ satisfies both equations. Given a maximum network time constant of $1.35 \mu\text{s}$, the signal transition time $T_{l,max}$ 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 $2.20 \mu\text{s}$. (See Equations D13 through D16.)

Bus (-):

$$\begin{aligned} T(V_{ol,min} \text{ to } V_{ol,max}) &= -T_{load,max} (\ln(1 - (V_{ol,max}/V_{sup,min}))) \\ &= -1.35 (\ln(1 - (1.20/4.75))) = 0.39 \mu s \end{aligned} \quad (\text{Eq. D13})$$

$$\begin{aligned} T_{load,max} &= 2.20 - T(V_{ol,min} \text{ to } V_{ol,max}) \\ &= 2.20 - 0.39 = 1.81 \mu s \end{aligned} \quad (\text{Eq. D14})$$

Bus (+):

$$\begin{aligned} T(V_{oh,max} \text{ to } V_{oh,min}) &= -T_{load,max} (\ln(V_{oh,min}/V_{oh,max})) \\ &= -1.35 (\ln(3.80/5.25)) = 0.44 \mu s \end{aligned} \quad (\text{Eq. D15})$$

$$\begin{aligned} T_{load,max} &= 2.20 - T(V_{oh,max} \text{ to } V_{oh,min}) \\ &= 2.20 - 0.44 = 1.76 \mu s \end{aligned} \quad (\text{Eq. D16})$$

Therefore, choosing a network time constant $T_{load,max}$ of $1.35 \mu s$ and a signal transition time $T_{t,max}$ of $1.75 \mu s$ ensures that the two bus signals will cross within the Common Mode Operating Range.

Rationale—Not applicable.

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 J1211—A 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

SAE J1879—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

SAE J2178/1—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/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

ISO 7637/3—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

CLASS B DATA COMMUNICATION NETWORK MESSAGES: DETAILED HEADER FORMATS AND PHYSICAL ADDRESS ASSIGNMENTS—SAE J2178/1 JUN92 SAE Recommended Practice

Report of the SAE Vehicle Network for Multiplexing and Data Communications Standards Committee approved June 1992.

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APPENDIX A
A.1 Architectures of Networks
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APPENDIX B

1. Scope—This SAE Recommended Practice defines the information contained in the header and data fields of both diagnostic and non-diagnostic messages for automotive serial communications based on SAE J1850 Class B networks. This document describes and specifies the header fields, data fields, field sizes, scaling, representations, and data positions used within messages.

The general structure of a SAE J1850 message frame without in-frame response is shown in Figure 1. The structure of a SAE J1850 message with in-frame response is shown in Figure 2. Figures 1 and 2 also show the scope of frame fields defined by this document for non-diagnostic messages. Refer to SAE J1979 for specifications of emissions related diagnostic message header and data fields. Refer to SAE J2190 for the definition of other diagnostic message header and data fields. The description of the network interface hardware, basic protocol defi-

nition, the electrical specifications, and the CRC and Checksum fields (shown in the figures as ERR) are given in SAE J1850.

SAE J1850 defines two and only two formats of message headers. They are the Single Byte header format and the Consolidated header format. The consolidated header format has two forms, a single byte form and a 3 byte form. This document covers all of these formats and forms to identify the contents of messages which could be sent on a SAE J1850 network.

This document consists of four parts, each published separately. Part 1 of SAE J2178 (this part, Titled: Detailed Header Formats and Physical Address Assignments) describes the two allowed forms of message header formats, single byte and consolidated. It also contains the physical node address range assignments for the typical sub-systems of an automobile. The details of this part are more fully described in paragraph 3.1 of this document.

Part 2 of SAE J2178 (Titled: Data Parameter Definitions) defines the standard parametric data which may be exchanged on SAE J1850 (Class B) networks. The parameter scaling, ranges, and transfer functions are specified.

Part 3 of SAE J2178 (Titled: Target Address for Single Byte Forms of Headers) defines the message assignments for the single byte header format and the 1 byte form of the consolidated header format.

Part 4 of SAE J2178 (Titled: Target Address (Second Byte) for Three Byte Headers) defines the message assignments for the second byte in the 3 byte form of the consolidated header format.

2. Reference and Related Documents, Terms, Definitions, Abbreviations, and Acronyms

2.1 Applicable Documents—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 J1213/1—Glossary of Vehicle Networks for Multiplex and Data Communication

SAE J1850—Class B Data Communication Network Interface

SAE J1930—Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms

SAE J1979—E/E Diagnostic Test Modes

SAE J2190—Enhanced E/E Diagnostic Test Modes

2.2 Terms and Definitions

Data [Data Field]—Data and data field are used interchangeably in this document and they both refer to a field within a frame that may include bytes with parameters pertaining to the message and/or secondary ID and/or extended addresses and/or test modes which further defines a particular message content being exchanged over the network.

Extended Address—The extended address is a means to allow a message to be addressed to a specific geographical location or zone of the vehicle, independent of any node's physical address.

Frame—A frame is one complete transmission of information which

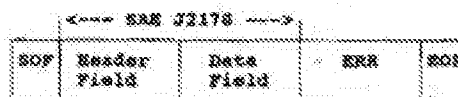


FIGURE 1—SCOPE OF SAE J2178 FOR A SAE J1850 FRAME WITHOUT IN-FRAME RESPONSE (IFR)

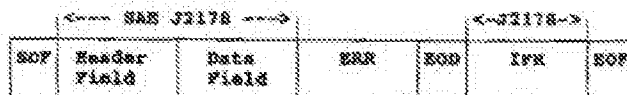


FIGURE 2—SCOPE OF SAE J2178 FOR A SAE J1850 FRAME WITH IN-FRAME RESPONSE (IFR)

may or may not include an In-Frame Response. The frame is enclosed by the start of frame and end of frame symbols. For Class B networks, each frame contains one and only one message (see "message" definition).

FUNCTIONAL ADDRESSING—Functional addressing allows a message to be addressed or sent to one or more nodes on the network interested in that function. Functional addressing is intended for messages that may be of interest to more than a single node. For example, an exterior lamp "off" message could be sent to all nodes controlling the vehicle exterior lamps by using a functional address. The functional address consists of a primary ID and may include a secondary ID.

HEADER (HEADER FIELD)—The header (or header field, used interchangeably) is a 1 or 3 byte field within a frame which contains information about the message priority, message source and target addressing, message type, and in-frame response type.

IN-FRAME RESPONSE (IFR) TYPE—The IFR type identifies the form of the in-frame response which is expected within that message.

LOAD—The load command indicates the operation of directly replacing the current/existing value of a parameter with the parameter value(s) contained in the message.

MESSAGE—A message consists of all of the bytes of a frame excluding the delimiter symbols (SOF, EOD, EOF, NB, IBS).

MODIFY—The modify command indicates the operation of using the message data parameter value to change (e.g., increment, decrement, or toggle) the current/existing value.

PARAMETER—A parameter is the variable quantity included in some messages. The parameter value, scaling, offset, units, transfer function, etc., are unique to each particular message. (The assigned parameters are contained herein.)

PHYSICAL ADDRESSING—Physical addressing allows a message to be addressed to a specific node or to all nodes or to a nonexistent, null node. The information in this message is only of relevance to a particular node, so the other nodes on the bus should ignore the message, except for the case of the "all nodes" address.

PRIMARY ID—The primary ID identifies the target for this functional message. This is the primary discriminator used to group functions into main categories.

PRIORITY—The priority describes the rank order and precedence of a message. Based upon the SAE J1850, Class B arbitration process, the message with the highest priority will win arbitration.

REPORT—A report indicates the transmission of parametric data values, based on: a change of state; a change of value; on a periodic rate basis; or as a response to a specific request.

REQUEST—A request is a command to, or a query for data, or action from another node on the network.

RESPONSE DATA—The response data is the information from a node on the network in response to a request from another node on the network. This may be an in-frame response or a report type of message.

SECONDARY ID—The secondary ID (along with the primary ID) identifies the functional target node for a message. The purpose of the secondary ID field within the frame is to further define the function or action being identified by the primary ID.

2.3 Abbreviations and Acronyms

CRC—Cyclic Redundancy Check

CS—Checksum

EOD—End of Data

EOF—End of Frame

ERR—Error Detection (CRC or CS)

IBS—Inter-Byte Separation

ID—Identifier

IFR—In-Frame Response

LSB—Least Significant Bit / Byte

MSB—Most Significant Bit / Byte

NB—Normalization Bit

PID—Parameter Identification number

SLOT—Scaling, Limit, Offset, and Transfer function

SOF—Start of Frame

3. General Information

3.1 Part 1 Overview—The messages defined by this four part document are specified for networks using single byte headers or consolidated 1 and 3 byte headers as specified in SAE J1850. Sections 4 and 5 of Part 1 provide the system architecture for the different possible headers used in Class B network communication (see Appendix A for supporting discussion). Section 6 of Part 1 defines the data fields used by the different header byte formats. Section 7 of Part 1 defines the physical address assignments.

Figure 3 shows an overview of this part (Part 1) which encompasses

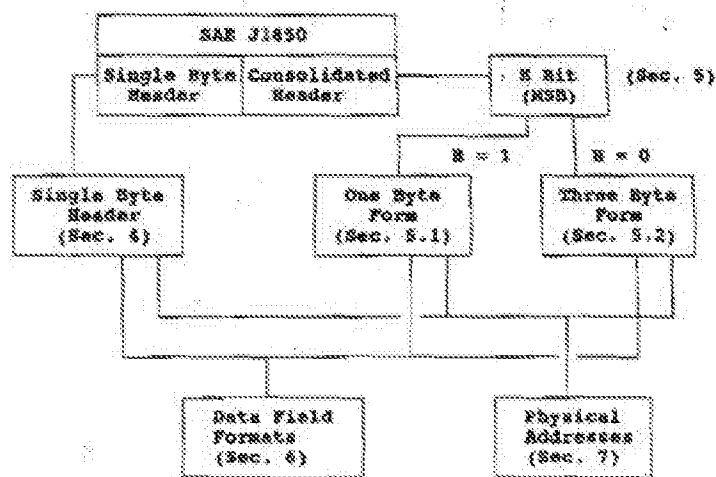


FIGURE 3—PART 1 OVERVIEW

the different possible messages and their component parts.

SAE J1850 defines two and only two formats of message headers. They are the Single Byte header format and the Consolidated header format. The consolidated header format has two forms, identified by the value of the H Bit. The two forms are: a 1 byte form and a 3 byte form. The information in the header field for both formats contains target, source, priority and message type information, while the data field contains additional addressing and/or parametric information and/or diagnostic test modes. This information is explicitly defined in some headers and implicitly defined in others. Messages defined by this document (Parts 1, 2, 3, and 4) are classified generally into two types:

a. Requests, that is, commands (load or modify) or queries for data, and

b. Responses, that is, reports or acknowledgements.

When a node generates a request, the target nodes which are responsible for the requested data or function must respond by reporting the requested information or by performing the requested function. For responses (that is, reports or acknowledgements), data information that a node responds with may have been previously requested by another node, or reported by the node when the desired information has changed, or reported by the node on a periodic basis.

Part 1 of this document describes the overall structure of messages. In total, parts 1, 2, 3, and 4:

- Fully defines SAE (automotive industry) standard messages.
- Reserves messages for future SAE standardization.
- Reserves messages for manufacturers to allocate, which are typically unique or proprietary to that manufacturer.

In order to comply with this document, implementations need to use the defined messages on SAE J1850 networks in the exact way that they are defined here. However, there are a large number of message codes which are reserved for each manufacturer to independently allocate.

3.2 In-Frame Response Field Formats

3.2.1 IN-FRAME RESPONSE TYPE 0—The in-frame response type 0 is used to indicate the form without any in-frame response.

3.2.2 IN-FRAME RESPONSE TYPE 1—The in-frame response type 1 is a single byte response from a single responder. The response byte shall be the physical address of a receiver of the message. No CRC or CS checking byte is included for this response data.

3.2.3 IN-FRAME RESPONSE TYPE 2—The in-frame response type 2 is a single byte response from multiple responders. The response byte(s) shall be the physical address of the receiver(s) of the message. No CRC or CS checking is included for the response data.

3.2.4 IN-FRAME RESPONSE TYPE 3—The in-frame response type 3 is a multiple byte response from a single responder. The response bytes shall be data (generally not its address) from a single responder. The second CRC or CS checking byte is included for the data integrity of the response data. The actual in-frame response data shall be 1 byte in length, as a minimum.

4. Single Byte Header Messages and Format—For single byte header messages, the entire byte is used to define the message identifier (ID) as shown in Figure 4. Standard message identifiers that utilize this header

format are found in SAE J2178; Part 3. Single byte header messages use a checksum (CS) for data integrity.

All single byte header messages utilize one of the four in-frame response (IFR) types. These four types are illustrated as follows:

- IFR Type 0—No response allowed. The number of data bytes cannot exceed ten. See Figure 5.
- IFR Type 1—Single byte response from a single responder. The response byte is the physical address of a receiver of the message. No CS is included for the response data. The number of data bytes plus the single response byte cannot exceed ten. See Figure 6.
- IFR Type 2—Single byte responses from multiple responders. The response byte(s) are the physical addresses of the receiver(s) of the message. No CS is included for the response data. The number of data bytes plus the "N" response bytes cannot exceed ten. See Figure 7.
- IFR Type 3—Multiple byte response from a single responder. The response bytes are data from a single responder. A second CS is included for the data integrity of the response data. The number of data bytes, including the in-frame response (IFR) data, cannot exceed nine. The actual in-frame response data must be one byte in length, as a minimum. See Figure 8.

5. Consolidated Header Messages and Format—The consolidated header format includes both a 1 byte form and a 3 byte form. All consolidated header format messages use a CRC code for data integrity.

In order to accommodate a 1 byte header form and a 3 byte header form on the same network, bit 4 (H bit) in the first byte of the message has been defined to indicate the header form. This bit is defined in Table 1.

TABLE 1—"H" BIT ASSIGNMENT

N BN	Header Byte Form
0	3 Byte Form
1	1 Byte Form

5.1 One Byte Form of the Consolidated Header Format—The 1 byte form utilizes 7 bits for the message identifier (ID) and bit 4 (the H bit) = 1 to indicate the 1 byte form. Figure 9 illustrates this message header form. Standard message identifiers that utilize this header form are defined in SAE J2178; Part 3.

All 1 byte header form messages of the consolidated header format utilize one of the four in-frame response (IFR) types. These four types are illustrated as follows:

- Type 0—No response allowed. The number of data bytes cannot exceed ten. See Figure 10.
- IFR Type 1—Single byte response from a single responder. The response byte is the physical address of a receiver of the message. No CRC is included for the response data. The number of data bytes plus the single response byte cannot exceed ten. See Figure 11.
- IFR Type 2—Single byte responses from multiple responders. The response byte(s) are the physical address of the receiver(s) of the message. No CRC is included for the response data. The number of data bytes plus the N response bytes cannot exceed ten. See Figure 12.
- IFR Type 3—Multiple byte response from a single responder.

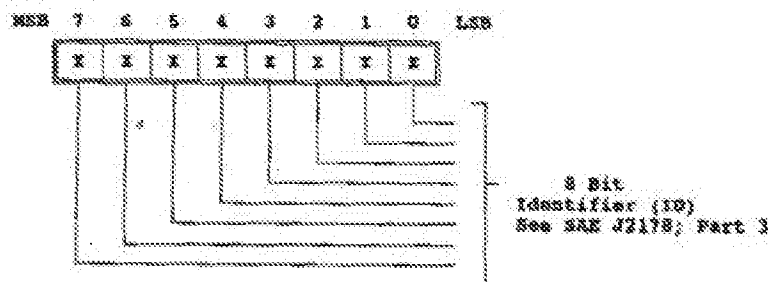


FIGURE 4—SINGLE BYTE HEADER FORMAT

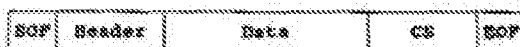


FIGURE 5—SINGLE BYTE HEADER, IFR TYPE 0

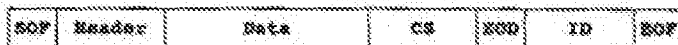


FIGURE 6—SINGLE BYTE HEADER, IFR TYPE 1

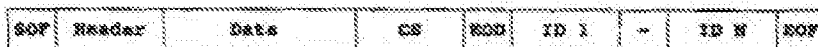


FIGURE 7—SINGLE BYTE HEADER, IFR TYPE 2



FIGURE 8—SINGLE BYTE HEADER, IFR TYPE 3

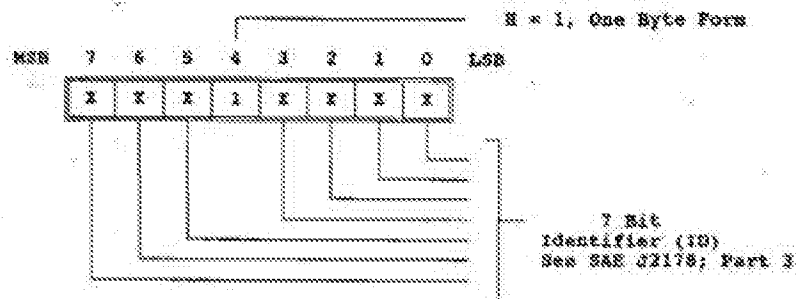


FIGURE 9--CONSOLIDATED HEADER, SINGLE BYTE FORM

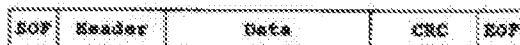


FIGURE 10--ONE BYTE CONSOLIDATED HEADER, IFR TYPE 0



FIGURE 11--ONE BYTE CONSOLIDATED HEADER, IFR TYPE 1

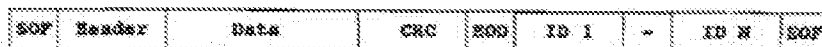


FIGURE 12--ONE BYTE CONSOLIDATED HEADER, IFR TYPE 2

The response bytes are data from a single responder. The second CRC is included for the data integrity of the response data. The number of data bytes, including the in-frame response (IFR) data, cannot exceed nine. The actual in-frame response data must be 1 byte in length as a minimum. See Figure 13.

5.2 Three Byte Form of the Consolidated Header Format—This header form utilizes the first 3 bytes of the message. In this form, the "H" bit is a zero (0), signifying that the 3 byte header form is used for this message. The remaining 7 bits of the first byte contain information about priority and message type (KYZZ). The second byte contains the target address information. The target can be either functionally addressed or physically addressed. The third byte contains the physical address of the source of the message. Arbitration is always resolved by the end of the third byte, since the source address must be unique. Figure 14 illustrates the 3 byte header form.

5.2.1 Priority/Type—Byte 1—The priority/type byte contains information about priority, in-frame response, addressing type, and type modifier. Each of the field definitions are described in the following paragraphs.

5.2.1.1 Priority (PPP Bits)—The priority field is 3 bits in length which are the most significant bits of the first byte. The priority bit assignments are shown in Table 2.

5.2.1.2 In-Frame Response (K Bit)—The necessity for in-frame response is encoded into a single bit in the priority/type byte. This bit definition is shown in Table 3.

5.2.1.3 Addressing Type (Y Bit)—Message addressing is encoded with a single bit in the priority/type byte. This bit definition is shown in Table 4.

5.2.1.4 Type Modifier (ZZ Bits)—The type modifier is encoded as a 2 bit field and is used in conjunction with the in-frame response bit (K) and the address type bit (Y) to define sixteen message types. See Table 5.

5.2.1.5 In-Frame Response (IFR) Types—All 3 byte form messages of the consolidated header format listed in Table 5 utilize one of four in-frame response (IFR) types. These four types are illustrated as follows:

- a. IFR Type 0—No response allowed. The number of data bytes cannot exceed eight. See Figure 15.
- b. IFR Type 1—Single byte response from a single responder. The response byte is the physical address of a receiver of the message. No CRC is included for the response data. The number of data bytes plus the single response byte cannot exceed eight. See Figure 16.
- c. IFR Type 2—Single byte responses from multiple responders. The response byte(s) are the physical address of the receiver(s) of the message. No CRC is included for the response data. The number of data bytes plus the N response bytes cannot exceed eight. See Figure 17.
- d. IFR Type 3—Multiple byte response from a single responder. The response bytes are data from a single responder. The second CRC is included for the data integrity of the response data. The number of data bytes, including the in-frame response (IFR) data, cannot exceed seven. The actual in-frame response data must be 1 byte in length, as a minimum. See Figure 18.

5.2.2 Target Address—Byte 2—The second byte of the 3 byte form of the consolidated header format contains either a functional or physical

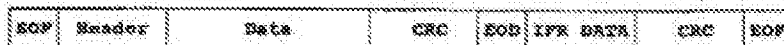


FIGURE 13--ONE BYTE CONSOLIDATED HEADER, IFR TYPE 3

TABLE 2--PRIORITY FIELD ASSIGNMENTS

PPP Bits	Priority	
000	0	Highest
001	1	
010	2	
011	3	
100	4	
101	5	
110	6	
111	7	Lowest

TABLE 3--"K" BIT ASSIGNMENT

K Bit	In-Frame Response
0	Required
1	Not Allowed

TABLE 4--"Y" BIT ASSIGNMENT

Y Bit	Addressing Type
0	Functional
1	Physical

TABLE 5--THE SIXTEEN MESSAGE TYPES

N	PPP	KYZZ	Type Num.	Response (R)	Address Type (Y)	IFR Type	Message Type (Name)
0	XXX	0000	0	Required	Functional	2	Function
0	XXX	0001	1	Required	Functional	1	Broadcast
0	XXX	0010	2	Required	Functional	2	Function Query
0	XXX	0011	3	Required	Functional	3	Function Read
0	XXX	0100	4	Required	Physical	1	Node-to-Node
0	XXX	0101	5	Required	Physical	Reserved	Reserved - MFG.
0	XXX	0110	6	Required	Physical	Reserved	Reserved - SAE
0	XXX	0111	7	Required	Physical	Reserved	Reserved - MFG.
0	XXX	1000	8	Not Allowed	Functional	8	Function (Command/Status)
0	XXX	1001	9	Not Allowed	Functional	9	Function (Request/Query)
0	XXX	1010	10	Not Allowed	Functional	0	Function Extended (Command/Status)
0	XXX	1011	11	Not Allowed	Functional	0	Function Extended (Request/Query)
0	XXX	1100	12	Not Allowed	Physical	0	Node-to-Node
0	XXX	1101	13	Not Allowed	Physical	0	Block Transfer
0	XXX	1110	14	Not Allowed	Physical	0	Reserved - MFG.
0	XXX	1111	15	Not Allowed	Physical	0	Reserved - MFG.

NOTES

- Functional Addresses for the 3 byte header form of header are defined in SAE J2178, Part 4. Physical Address Ranges are defined in Section 7.
- Message types 3 and 9 use the functional data format #2 only; Message types 10 and 11 use the functional data format #3 only.
- Reserved-SAE indicates reserved for future SAE Committee action. Reserved MFG indicates that manufacturers are allowed to allocate these definitions without requiring any commonality between motor vehicle manufacturers.

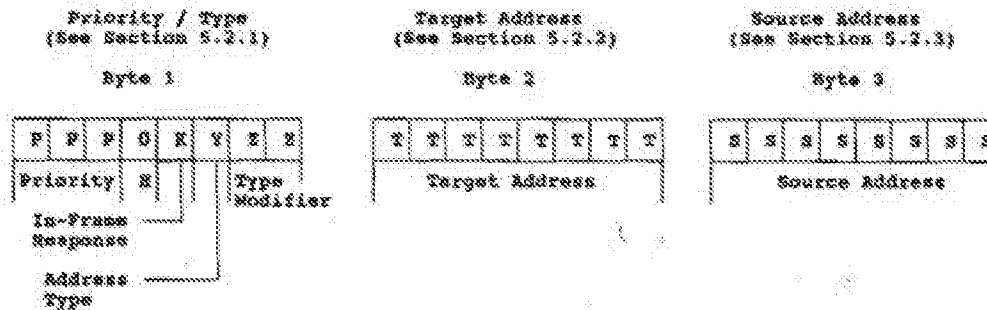


FIGURE 14--CONSOLIDATED HEADER, THREE BYTE FORM

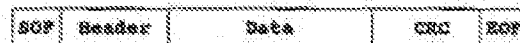


FIGURE 15--THREE BYTE CONSOLIDATED HEADER, IFR TYPE 0

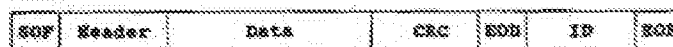


FIGURE 16--THREE BYTE CONSOLIDATED HEADER, IFR TYPE 1

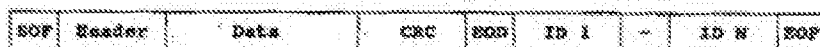


FIGURE 17--THREE BYTE CONSOLIDATED HEADER, IFR TYPE 2

target address. The physical address assignments are found in section 7 of this part, while functional message address assignments are in Part 4 (of SAE J2178).

5.2.3 **SOURCE ADDRESS - BYTE 3**—The third byte of the 3 byte format of the consolidated header format is the physical address of the source of the message. Physical address assignments are found in Section 7. These physical address assignments shall be unique for each node of a network.

6. **Data Fields**—In both message header formats, single byte and consolidated, the data field can usually be encoded in the same way. This section briefly describes the different ways that information can be formatted in the data field. The data field immediately follows the header field. The number of bytes in this field will vary, based upon the content of the header field. The maximum data field length is limited by the requirements of SAE J1850. Because of differences in functionally and physically addressed or with in-frame response data, these cases are defined separately.

6.1 Functional Data Field Formats

6.1.1 **FUNCTIONAL DATA FIELD FORMAT 0**—One of the functional data field formats is, in fact, no additional bytes of data (an empty data field). The message consists of the header, error checking byte, and in-frame response bytes. This is the format used for functional message types 2 and 3. Because the data field does not actually exist but to allow referencing in other parts of this document, it has been identified as the functional data field format 0.

6.1.2 **FUNCTIONAL DATA FIELD FORMAT 1**—In the simplest case including data (format 1), the data field contains only parametric data. The first byte of the data field in this case contains the most significant byte of data. The data field must contain 1 byte as a minimum. Figure 19 illustrates this message format. This data field format may be used for message types 0 and 1 only.

6.1.3 **FUNCTIONAL DATA FIELD FORMAT 2**—In a data field format 2 message, the data field contains a byte used as an identifier which further defines the target function being addressed. In this format type, the data field would appear as shown in Figure 20. This data format may be used for message types 0, 1, 8 and 9.

The secondary ID consists of a parameter / quantity bit Q (see 6.1.3.1) in which binary data (such as on/off or yes/no) can be encoded. There is a listing of the possible uses for this bit in other parts of this document. The control bit C (see 6.1.3.2) is used to distinguish between an immediate load of data or a modify of the current data for command messages. For message types 9 and 11, the control bit distinguishes between request and query. The remaining 6 bits specify an ID address (see 6.1.3.3). The order of these bits within the secondary ID byte is shown in Figure 21.

In many cases, a single data bit (the Q bit) is not adequate to define the parameter being sent. In this case, the identifier field is followed by a data field as illustrated in Figure 22. The combination of primary and secondary ID define if additional data is used by that message.

6.1.3.1 **The Parameter / Quantity Bit "Q"**—The parameter / quantity bit represents the data or information value for single, binary values. If the information being transmitted has one of two opposite values, it is reflected as shown in Table 6. The specific meaning or relevance of this bit is defined for each message in other parts of this document.

6.1.3.2 **The Control Bit "C"**—The control bit represents an action to be taken with the associated data values. Table 7 shows the two possible states for this bit. If the "C" bit indicates a load, the associated data value replaces the current/existing value. If the "C" bit indicates a modify or toggle, the current/existing data value is manipulated by the transmitted data value, based on the definition of each specific message (the 6 secondary identification address bits). For example, if the message indicates a toggle, the current/existing value is changed to the opposite state, independent of what that current/existing data value had been.

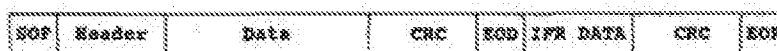


FIGURE 18—THREE BYTE CONSOLIDATED HEADER, IFR TYPE 3

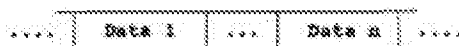


FIGURE 19—FUNCTIONAL DATA FIELD FORMAT 1

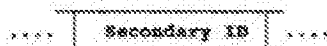


FIGURE 20—FUNCTIONAL DATA FIELD FORMAT 2

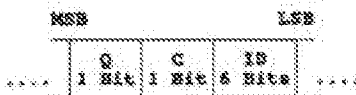


FIGURE 21—SECONDARY ID BYTE FORMAT

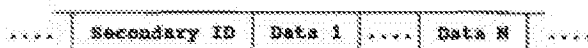


FIGURE 22—FUNCTIONAL DATA FIELD FORMAT 2, WITH DATA BYTES

TABLE 6—"Q" BIT ASSIGNMENT

Q BIT	Parameter/Quantity
0	No/False/Off/Down/...
1	Yes/True/On/Up/...

TABLE 7—"C" BIT ASSIGNMENT

C BIT	Command	Request/Query
0	Load	Request
1	Modify/Toggle	Query

For message types 9 and 11, the control bit distinguishes between request and query. The relevance of this bit is defined by the primary and secondary ID values and are specified in other parts of this document.

6.1.3.3 The Secondary Identification Address—The secondary identification address field is used to further identify the particular function or operation being addressed by this message. It is used to distinguish a function when the primary ID is not sufficient, or to define a specific operation to be performed by the function addressed by the primary ID. These secondary identification addresses are assigned in parts 3 and 4 of this document.

6.1.4 FUNCTIONAL DATA FIELD FORMAT 3—In a data field format 3 message, depending on the particular primary ID, the data field may also contain an extended address byte which defines the geographical location within the vehicle of the target function being addressed following the secondary ID byte. As an example, in a functional message whose primary ID target is window motion, an extended address byte is needed to identify which window, e.g., driver, passenger, all; along with the secondary ID byte needed to identify an operation such as Up or Down. This data field format may be used for message types 0 and 1 and must be used for message types 10 and 11. In this data field type, the data field appears as shown in Figure 23.

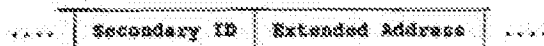


FIGURE 23—FUNCTIONAL DATA FIELD FORMAT 3, WITH EXTENDED ADDRESS

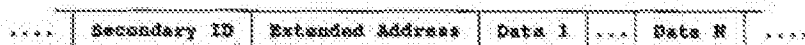


FIGURE 24—FUNCTIONAL DATA FIELD FORMAT 3, WITH DATA BYTES

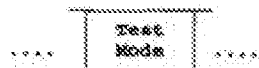


FIGURE 25—FUNCTIONAL DATA FIELD FORMAT 4

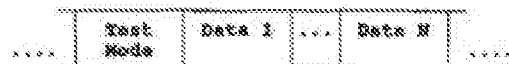


FIGURE 26—FUNCTIONAL DATA FIELD FORMAT 4, WITH DATA BYTES

The extended address byte is used to determine where, geographically on a vehicle, a particular function is located. The exact definition of the extended address values can be found in 6.3. The secondary ID in Figure 23 is used as defined in 6.1.3. As an example, to roll the rear driver's side window down, the header would contain information that identifies window motion as the functional target. The first data byte would contain a 6-bit ID identifying the function Down with the Q-bit used to indicate enable the down or disable the down command, followed by the extended address, which would indicate that the particular window being addressed is on the rear driver's side. The C-bit is unused (default value = 0) in this particular message.

As in the other data field formats, a parameter data field may also be needed and in this case it is then appended to the end of the other identifiers. This format is shown in Figure 24.

6.1.5 FUNCTIONAL DATA FIELD FORMAT 4—In this data field format message, the data field contains a byte which defines the diagnostic test mode of the target function being addressed. In this type, the data field would appear as shown in Figure 25. This data format may be used for message types 0, 1, 8, and 9.

The test mode byte is used to determine which diagnostic function is involved. It may then be followed by a "Parameter Identification" (PID) number or other parameter data fields. In this case, the additional data bytes follow the test mode byte. This format is shown in Figure 26. This is the format for functionally addressed diagnostic messages such as those found in SAE J1979.

6.2 Physical Data Field Formats—The previous section (6.1) defined the data field formats for functionally addressed messages. This section (6.2) defines the data field formats for physically addressed messages.

6.2.1 PHYSICAL DATA FIELD FORMAT 0—One of the physical data field formats is, in fact, no additional bytes of data (an empty data field). The message consists of the header, error checking byte, and may be with or without in-frame response bytes. This is the format used for the acknowledgement message type. This message type simply confirms to another node that this node has correctly received the message it is acknowledging. Because this data field does not actually exist but to allow

referencing in other parts of this document, it has been identified as the physical data field format 0.

6.2.2 Physical Data Field Format 1--(Node to Node)

Physical data field format 1 is generally associated with the node-to-node message types. This message type is the one utilized for enhanced E/E diagnostic test modes (see SAE J2190).

This format assumes the 3 byte form of the consolidated header format. The single byte format and the 1 byte form of the consolidated header format are covered in physical data field format 2. Many of the specific diagnostic messages are defined in SAE J2190. This description of the format is consistent with that document but expands the definition to allow the format to be used in other messages as well. In particular, the manufacturer specific applications of this node-to-node message are expected to follow this format. The basic format is similar to the functional data field format 4. The format is shown in Figure 27.

The format will often include data bytes as shown in Figure 28. The content of the test mode byte indicates if additional data bytes are used.

The physical test mode byte details are shown in Figure 29. The description of the individual parts of this byte are described in the following paragraphs.

6.2.2.1 *The Industry/Manufacturer Bit "I"*—The industry/manufacturer bit represents the organization responsible for the definition of this test mode. The information that has been defined by SAE (I = 0) can be interpreted in the same way for all vehicles that use those definitions. The bit assignment is shown in Table 8. The specific meaning for the SAE (industry) messages are defined in SAE J2190. SAE has also reserved for future definition some of the I = 1 test mode bytes. Manufacturer defined test modes can be independently defined by each vehicle manufacturer and there is no attempt made to make these definitions common between manufacturers.

Note—See SAE J2190 for specific assignments.

6.2.2.2 *The Request/Response Bit "R"*—The request/response bit represents the direction of information flow contained in this message. Table 9 shows the two possible states for this bit. If the "R" bit indicates a request, the associated data bytes, if any, indicate the information being requested. If the "R" bit indicates a response, the data, if any, represent the response information previously requested.

6.2.2.3 *The Test Mode Identification Reference*—The test mode identification reference field is used to further identify the particular operation being addressed by this message. It is used to define a specific test mode to be performed by, or reported to, the node addressed by the target byte. These test mode identification addresses are assigned in SAE J2190 for the industry standard case.

6.2.3 Physical Data Field Format 2--(Diagnostic Test Modes)

TABLE 8—"I" BIT ASSIGNMENT

I Bit	Industry / Manufacturer
0	Industry (SAE Defined)
1	Industry (SAE Reserved) Manufacturer Defined

TABLE 9—"R" BIT ASSIGNMENT

R Bit	Request/Response
0	Request
1	Response

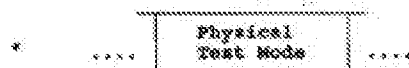


FIGURE 27—PHYSICAL DATA FIELD FORMAT 1

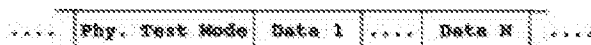


FIGURE 28—PHYSICAL DATA FIELD FORMAT 1, WITH DATA BYTES

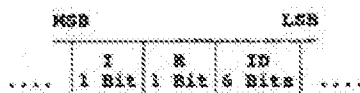


FIGURE 29—PHYSICAL TEST MODE BYTE FORMAT

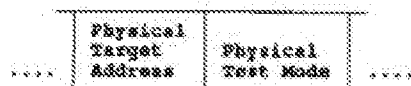


FIGURE 30—PHYSICAL DATA FIELD FORMAT 2

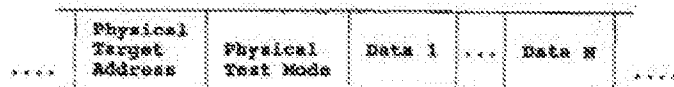


FIGURE 31—PHYSICAL DATA FIELD FORMAT 2, WITH DATA BYTES

In order to maximize commonality between the different header byte formats, the physical data field format 2 is essentially the same as for physical data field format 1 with the insertion of the physical target address byte ahead of the physical test mode byte. This allows the single byte header format and the 1 byte form of the consolidated header format to operate consistently with the 1 byte header form. The format is shown in Figures 30 and 31 for the two cases, with or without additional data bytes. The number of data bytes, if used, are not fixed length, unless so specified in other documents.

6.2.4 PHYSICAL DATA FIELD FORMAT 3—(Block Transfer)

This physical data field format is unique and dedicated to the transfer of large blocks of data from one physical node to another node of the network. It would have very limited application if it were restricted to the maximum message length requirements of SAE J1850. Therefore, this data format is allowed to exceed that limitation. The physical data field format 3 is shown in Figure 32.

Since the message length limitation of SAE J1850 has been extended, the data field format includes additional error checking bytes. Each group of bytes in this format is described in the following paragraphs.

NOTE—This format is normally limited to use for service diagnostics or module/vehicle manufacture. It should not normally be used during vehicle operation because of the potentially long interruption of other vehicle message traffic.

6.2.4.1 The Transfer Type Byte—The first byte of this physical data field format defines the type of block transfer that is being transmitted. The transfer type byte is reserved for future definition. It has been included as a place holder to allow future definition by SAE or manufacturers.

6.2.4.2 The Block Length Bytes—The next 2 bytes of this physical data field format define the length of the data block (N) included in the block. The value of N represents the number of data bytes, not the total number of bytes in the data field. The maximum value of N is 0FFF Hex for a data block maximum length of 4095 bytes. The upper nibble (upper 4 bits) of the MSB of the block length is thus reserved for future definition and should be set to zero as its default value.

6.2.4.3 The Starting Address Bytes—The next 3 bytes identify the starting address of the data block being transmitted. In other words, it is the memory location where data byte 1 is located. The other data bytes of the block (data 2 to data N) will then represent, sequentially, in ascending address order, the additional data bytes of the block.

6.2.4.4 The Data Bytes—The data itself contains from 1 to N data bytes being transferred between nodes.

6.2.4.5 The Block Checksum Bytes—Because the block length is most likely longer than most other messages on the network, additional error checking is required. The last 2 bytes are a calculated checksum value based on the contents of the data block only. The calculation begins with the first data byte (Transfer Type) and continues to the last data byte (data N). The checksum is a 16 bit sum of the values included. The general checksum calculation is comparable to the SAE J1850 checksum extended to 16 bits. The transmitted checksum should match the received, calculated checksum to verify correct reception.

NOTE—The header is not included in this checksum calculation.

NOTE—The data field described previously is followed by the error checking byte of the SAE J1850 format (EER byte, CS or CRC) to verify the integrity of the whole message, the same as all other Class B messages.

6.3 Extended Addressing—The extended addressing defines an extended (geographical) location in the vehicle. The extended address field (RR XXX YYY) is divided into three sub-fields:

- The two most significant bits (RR) are reserved for future use. (00 is the defined value for geographic location.)
- The three next most significant bits (XXX) indicate rows from front (001) to rear (111).

TABLE 10—NODE PHYSICAL ADDRESS ASSIGNMENTS

Node	Address (Hex)
Powertrain Controllers:	
Integration / Manufacturer Expansion	00 - 0F
Engine Controller	10 - 1F
Transmission Controller	18 - 1F
Chassis Controllers:	
Integration / Manufacturer Expansion	20 - 2F
Brake Controller	30 - 3F
Steering Controller	30 - 3F
Suspension Controller	30 - 3F
Body Controllers:	
Integration / Manufacturer Expansion	40 - 5F
Restraints	50 - 5F
Driver Information / Displays	60 - 6F
Lighting	70 - 7F
Entertainment / Audio	80 - 8F
Personal Communications	90 - 9F
HVAC	90 - 9F
Convenience (Doors, Seats, Windows, etc.)	A0 - BF
Security	C0 - CF
Future Expansion:	08 - CF
Manufacturer Specific:	D0 - EF
Off-Board Testers / Diagnostic Tools:	F0 - FF
All Nodes:	FE
Null Node:	FF

c. The three least significant bits (YYY) indicate columns from left (001) to right (111).

The codes XXX = 000 (for rows) and YYY = 000 (for columns) indicate that ALL rows and/or ALL columns are indicated. In other words, to address all of the items in a specific row, regardless of which column, use XXX = 000. For all items in the same column, independent of which row, use YYY = 000. This can be useful if needed to address all headlights, for example, to turn them all on, but for lamp outage, the particular location of the headlamp may be desirable.

A map illustrating 49 zones of the vehicle is shown in Figure 33. It generally represents a top view of the vehicle and supports both Left/Right and Driver/Passenger side references.

Appendix B shows some examples of this extended addressing as it identifies some common items in passenger vehicles.

7. Physical Address Assignments—The physical address assignment ranges for nodes on a network are shown in Table 10. It is important to note that node address assignments on any network must be unique. In other words, no two nodes can have the same physical address assignment.

NOTE—One address has been reserved to address all nodes on a network. The all nodes address, however, may or may not be recognized in a system. Additionally, one address has been reserved to address a "null node" which is never assigned to a real node. This "null node" allows some forms of testing network performance.

NOTE—The address ranges assigned to "Integration" are intended for modules which have more than one specific function. If this integration includes functions which involve crossing between Powertrain, Chassis, and Body, the highest priority (lowest address) range shall be selected, for example, if powertrain and chassis are integrated in one module, the 00 - 0F address range shall be used.

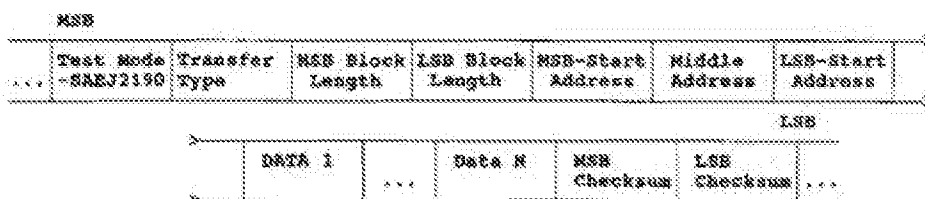


FIGURE 32—PHYSICAL DATA FIELD FORMAT 3—BLOCK TRANSFER

LEFT SIDE FRONT SURFACE (RR 001 001)	DRIVER'S SIDE FRONT SURFACE (RR 001 010)	LEFT CENTER FRONT SURFACE (RR 001 011)	CENTER POINT FRONT SURFACE (RR 001 100)	RIGHT CENTER FRONT SURFACE (RR 001 101)	PASSENGER SIDE FRONT SURFACE (RR 001 110)	RIGHT SIDE FRONT SURFACE (RR 001 111)
LEFT SIDE UNDER HOOD (RR 010 001)	DRIVER'S SIDE UNDER HOOD (RR 010 010)	LEFT CENTER UNDER HOOD (RR 010 011)	CENTER POINT UNDER HOOD (RR 010 100)	RIGHT CENTER UNDER HOOD (RR 010 101)	PASSENGER SIDE UNDER HOOD (RR 010 110)	RIGHT SIDE UNDER HOOD (RR 010 111)
LEFT SIDE APT BULKHEAD (RR 011 001)	DRIVER'S SIDE APT BULKHEAD (RR 011 010)	LEFT CENTER APT BULKHEAD (RR 011 011)	CENTER POINT APT BULKHEAD (RR 011 100)	RIGHT CENTER APT BULKHEAD (RR 011 101)	PASSENGER SIDE APT BULKHEAD (RR 011 110)	RIGHT SIDE APT BULKHEAD (RR 011 111)
LEFT SIDE APT "A" PILLAR (RR 100 001)	DRIVER'S SIDE APT "A" PILLAR (RR 100 010)	LEFT CENTER APT "A" PILLAR (RR 100 011)	CENTER POINT APT "A" PILLAR (RR 100 100)	RIGHT CENTER APT "A" PILLAR (RR 100 101)	PASSENGER SIDE APT "A" PILLAR (RR 100 110)	RIGHT SIDE APT "A" PILLAR (RR 100 111)
LEFT SIDE MID VEHICLE (RR 101 001)	DRIVER'S SIDE MID VEHICLE (RR 101 010)	LEFT CENTER MID VEHICLE (RR 101 011)	CENTER POINT MID VEHICLE (RR 101 100)	RIGHT CENTER MID VEHICLE (RR 101 101)	PASSENGER SIDE MID VEHICLE (RR 101 110)	RIGHT SIDE MID VEHICLE (RR 101 111)
LEFT SIDE TRUNK (RR 110 001)	DRIVER'S SIDE TRUNK (RR 110 010)	LEFT CENTER TRUNK (RR 110 011)	CENTER POINT TRUNK (RR 110 100)	RIGHT CENTER TRUNK (RR 110 101)	PASSENGER SIDE TRUNK (RR 110 110)	RIGHT SIDE TRUNK (RR 110 111)
LEFT SIDE REAR SURFACE (RR 111 001)	DRIVER'S SIDE REAR SURFACE (RR 111 010)	LEFT CENTER REAR SURFACE (RR 111 011)	CENTER POINT REAR SURFACE (RR 111 100)	RIGHT CENTER REAR SURFACE (RR 111 101)	PASSENGER SIDE REAR SURFACE (RR 111 110)	RIGHT SIDE REAR SURFACE (RR 111 111)

XXX = ROW -- FROM FRONT TO REAR 000 = ALL ROWS
YYY = COLUMN -- FROM SIDE TO SIDE 000 = ALL COLUMNS
RR = 00 (GEOGRAPHIC LOCATION)

FIGURE 35--EXTENDED ADDRESS MAP

APPENDIX A

NETWORK ARCHITECTURES AND HEADER SELECTION

A.1 Architectures of Networks--A wide variety of network topologies can be envisioned by network designers. The message structure described in this document is very flexible and useful in exchanging information between network nodes. The following discussion describes two network architectures which are likely configurations that can use this message definition set:

- A single network architecture
- A multiple network architecture

Which of the different message definitions to use for these two network architectures is left as the system designer's choice, since the selection would be application specific. It should be noted that the hardware that supports these two message structures is generally not interchangeable. It is recommended that care be taken in choosing which message definition to use because the selection is generally irreversible because of these hardware limitations.

Consideration must be given by the network designer as to whether a single network architecture or a multiple network architecture, within the same vehicle, is preferable for that application. For example, a multiple network architecture could be based on one network optimized around data communication (Class B) protocol requirements, and another network optimized around sensor type (Class A) multiplexing requirements. The Class B network may be characterized such that time is a significant characteristic of the protocol where the functional "broadcast" type of message strategy can most effectively be used. The functional messages strategy can, if required, define the source or destination of a particular message by making it part of the message. However, it is unnecessary to designate or specify the source or destination of functional broadcast type messages. Reception becomes the exclusive responsibility of the receiving node.

A Class A network could handle the vehicle's event-driven multiplexing requirements. See SAE J2057, Part 5, for more information on Class A multiplexing considerations. A single network architecture is based on the concept of a network which handles both Class A and B re-

quirements. It should be clear that both network architectures must be cost effective for the application and the specific nodes on each network.

In Class B communications, the network consists of the interconnection of intelligent nodes such as: an engine controller, a body computer, a vehicle instrument cluster, and other modules. Such a network normally does not significantly reduce the base vehicle wiring but provides an inter-module data communications capability for distributed processing. The data shared between modules may be repetitive in nature and sometimes requires handshaking between modules or acknowledgement of data reception. As a result of handling the repetitive data and response type data, a network can be optimized around functional addressing. Functional addressing sends data on the network which can be received by one or more nodes without regard to the physical location of the module but only by their "interest" in those specific functions. In general, the transmitting node doesn't care which, if any, nodes receive the data it is sending. When physical addressing is required in a data communications (Class B) network, it is usually for vehicle diagnostic purposes and can be easily handled without reducing network bandwidth. See Section 6 for a discussion of these two types of message addressing.

In Class A communications, the network generally consists of the interconnection of limited intelligence nodes, often simply sensors or actuators. These Class A networks can significantly reduce the base vehicle wiring as well as potentially remove redundant sensors from the vehicle. The data shared between nodes in this case are generally event driven in nature. In most vehicles, the number of event driven signals predominate but are only needed infrequently. The message to "turn headlamps on," for example can be easily seen as event driven. Because these messages are infrequent (only sent once when the signal changes), they generally require acknowledgement, either within the same message or a separate handshake/response message. Both of these approaches are supported by SAE J1850 and in this document.

The single network architecture carries both the Class A and Class B messages on one network. The characteristics of both time critical and event driven messages must be accommodated on a message by message

basis. In general, this level of complexity will need the flexibility of the consolidated header structure. For some applications, however, the single byte header may be adequate and is in no way limited by this specification.

The multiple network architecture tends to separate the Class A messages from the Class B messages and optimize each network and node interface for the specific characteristics of each network Class. The time critical messages could be exchanged on one network while the event driven messages sent on another. For example, the data communication (Class B) repetitive messages can be handled on one network and the sensor and control (Class A) multiplexing requirements on another network. This architecture requires both networks to work together to achieve the total vehicle network requirements. If information is needed between the multiple networks, care must be exercised to meet the needs of each of the networks. This concept of multiple networks is not limited to two, but can be extended to several separate networks, if desired.

A.2 Header Selection—The selection of headers is dependent on a number of factors. Hardware cost is related to the complexity of interface hardware required, as opposed to level of software required to implement the system. A CRC, for example, is most efficiently calculated in hardware. A Checksum (CS) is easily calculated in software.

The 3 byte form of the consolidated header offers systems designers advantages over the single byte only header format. More bits are available for use in assigning message identifiers, priorities, message types, etc. In addition, the 3 byte header is not restricted to 256 addresses. The most significant bit of the consolidated header format is used to indicate the use of 1 byte or 3 byte header messages which provides flexibility for future applications. This consolidated format generally requires increased hardware implementations because of the variety of message forms allowed. However, because of the increased hardware

definition, software complexity and coding error problems are reduced. The consolidated header format offers the flexibility to readily handle both Class A and Class B requirements, matching header length to each specific message, as needed.

The single byte only header format is a simple and efficient method of identifying messages in a Class B data communications optimized network. This type of header can be simply called the Message Identifier or ID. The ID becomes the name of the message that is broadcast to all the other nodes on the network. The message ID concept supports a very easily understood message protocol leading to the utilization of a simple hardware interface circuit. The single byte only header format in a Class B data communications environment is required to support a repetitive message strategy and manage network bandwidth efficiently. The results can yield an average message length of less than 4 bytes. Message overhead can be kept small and message latency minimized to improve the network's capability for handling time critical data. Another resulting feature of this method of message identification is that arbitration events are reduced (resolved within the first byte) and the need to carefully assign message priority is reduced.

As in the case of network architectures above, the choice of single byte header format or consolidated header format is left to the system designer. The choice must be made for each separate network for each application but this offers the ability to select which characteristic is important for the specific case.

APPENDIX B EXAMPLES OF EXTENDED ADDRESSING

B.1 Seat locations in the passenger compartment are shown in Figure B1.

B.2 Typical lighting locations and external access examples are shown in Figure B2.

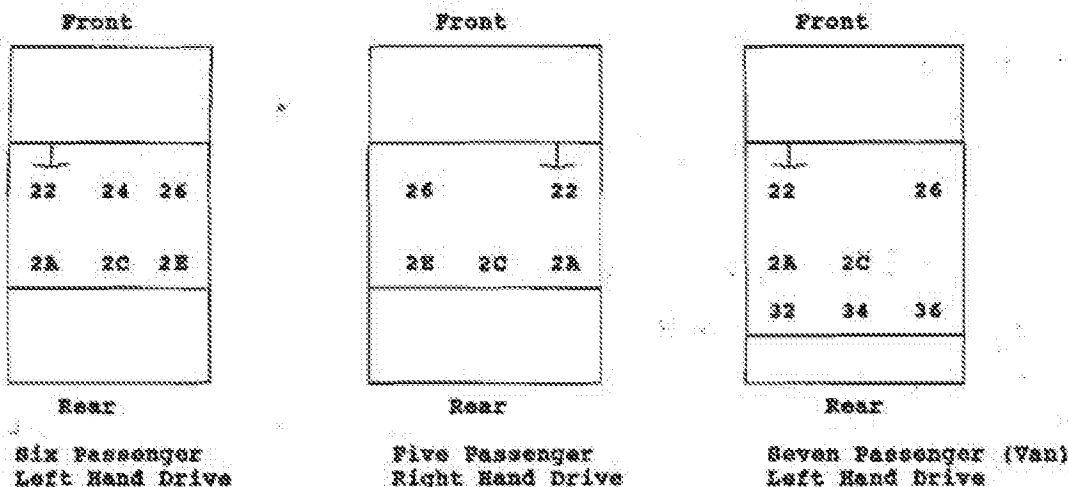


FIGURE B1—TYPICAL SEAT LOCATIONS

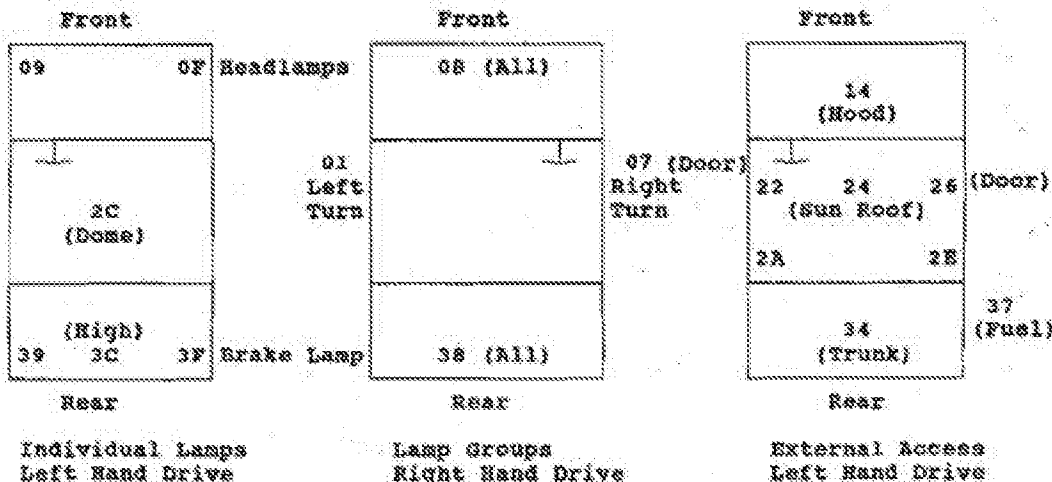


FIGURE B2—TYPICAL LIGHTING AND EXTERNAL ACCESS LOCATIONS

CLASS B DATA COMMUNICATION NETWORK MESSAGES

PART 2: DATA PARAMETER DEFINITIONS—

SAE J2178/2 JUN93

SAE Recommended Practice

Report of the Vehicle Network for Multiplexing and Data Communications Standards Committee approved June 1993.

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8.	Multiple Frame, Single Parameter Format

1. Scope—This SAE Recommended Practice defines the information contained in the header and data fields of non-diagnostic messages for automotive serial communications based on SAE J1850 Class B networks. This document describes and specifies the header fields, data fields, field sizes, scaling, representations, and data positions used within messages.

The general structure of a SAE J1850 message frame without in-frame response is shown in Figure 1. The structure of a SAE J1850 message with in-frame response is shown in Figure 2. Figures 1 and 2 also show the scope of frame fields defined by this document for non-diagnostic messages. Refer to SAE J1979 for specifications of emissions-related diagnostic message header and data fields. Refer to SAE J2190 for the definition of other diagnostic data fields. The description of the network interface hardware, basic protocol definition, the electrical specifications, and the CRC byte are given in SAE J1850.

SAE J1850 defines two and only two formats of message headers. They are the Single Byte header format and the Consolidated header format. The consolidated header format has two forms, a single byte form and a three byte form. This document covers all of these formats and forms to identify the contents of messages which could be sent on a SAE J1850 network.

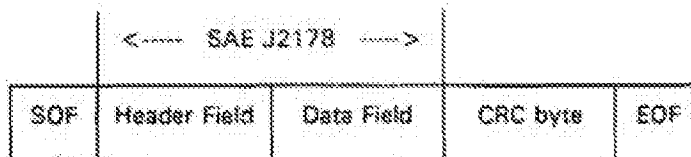


FIGURE 1—SCOPE OF SAE J2178 FOR A SAE J1850 FRAME WITHOUT IN-FRAME RESPONSE (IFR)

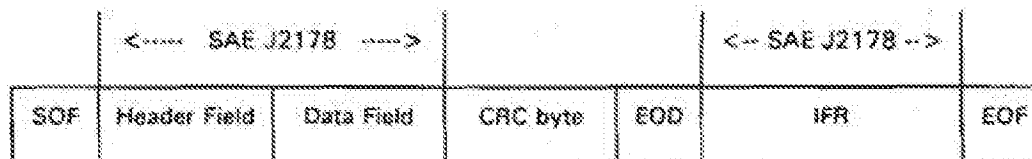


FIGURE 2—SCOPE OF SAE J2178 FOR A SAE J1850 FRAME WITH IN-FRAME RESPONSE (IFR)

This document consists of four parts, each published separately.

Part 1 of SAE J2178 (Titled: Detailed Header Formats and Physical Address Assignments) describes the two allowed forms of message header formats, single byte and consolidated. It also contains the physical node address range assignments for the typical subsystems of an automobile.

Part 2 of SAE J2178 (this part, Titled: Data Parameter Definitions) defines the standard parametric data which may be exchanged on SAE J1850 (Class B)

networks. The parameter scaling, ranges, and transfer functions are specified. Messages which refer to these parametric definitions shall always adhere to those parametric definitions. It is intended that at least one of the definitions for each parameter in this part match the SAE J1979 definition. The details of this part are fully described in 3.1.

Part 3 of SAE J2178 (Titled: Frame IDs for Single Byte Forms of Headers) defines the message assignments for the single byte header format and the one byte form of the consolidated header format.

Part 4 of SAE J2178 (Titled: Message Definition for Three Byte Headers) defines the message assignments for the three byte form of the consolidated header format.

1.1 Standardized Parameter Definitions—The parameters used to describe data variables are one of the most important functions of this document. To achieve commonality of messages in Class B networks, the data parameters must become standardized. This applies to data parameter definitions for use during normal vehicle operations as well as during diagnostic operations. By using common parameter definitions for non-diagnostic and diagnostic functions on the network, the modules which form the network can maintain one image or description of a data parameter.

Where parameters have been defined in the Diagnostic Test Modes documents (SAE J1979 and J2190), such as Parameter Identifiers for diagnostic purposes, the definitions in Part 2 of this document match the diagnostic definition.

SAE J2178, Part 2 defines the parameters to be used for non-diagnostic and diagnostic data format definitions. For new parameter definitions which are needed in the future, the new definitions, if they are expected to become widely used, must be integrated into this document for commonality across these types of applications. Of course, manufacturers are free to assign their own definitions to data parameters which are unique or proprietary to their products. They are, however, restricted to using the "Manufacturer Reserved" message header assignments in Parts 3 and 4 of this document when using these unique or proprietary data parameter definitions.

2. References

2.1 Applicable Documents—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 H850—Class B Data Communication Network Interface

SAE J1979—E/E Diagnostic Test Modes

SAE J2190—Enhanced E/E Diagnostic Test Modes

2.1.2 ANSI PUBLICATION—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI/IEEE Std 754-1985, August 12, 1985—IEEE Standard for Binary Floating-Point Arithmetic

2.2 Related Publications—The following publications are provided for information purposes only and are not a required part of this document.

2.2.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1213/1—Glossary of Vehicle Networks for Multiplex and Data Communication

SAE J1930—Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms

2.3 Terms and Definitions

2.3.1 DATA [DATA FIELD]—Data and data field are used interchangeably in this document and they both refer to a field within a frame that may include bytes with parameters pertaining to the message and/or secondary ID and/or extended addresses and/or test modes which further defines a particular message content being exchanged over the network.

2.3.2 EXTENDED ADDRESS—The extended address is a means to allow a message to be addressed to a specific geographical location or zone of the vehicle, independent of any node's physical address.

2.3.3 FRAME—A frame is one complete transmission of information which may or may not include an In-Frame Response. The frame is enclosed by the start of frame and end of frame symbols. For Class B networks, each frame contains one and only one message (see "message" definition).

2.3.4 FRAME ID—The Frame ID is the header byte for the Single Byte Header format and the one byte form of the consolidated header format. The definition of the frame ID is found in SAE J2178, Part 3. This header byte defines the target and source and content of the frame.

2.3.5 FUNCTIONAL ADDRESSING—Functional addressing allows a message to be addressed or sent to one or more nodes on the network interested in that function. Functional addressing is intended for messages that may be of interest to more than a single node. For example, an exterior lamp "off" message could be sent to all nodes controlling the vehicle exterior lamps by using a functional address. The functional address consists of a primary ID and may include a secondary ID and may also include an extended address.

2.3.6 HEADER [HEADER FIELD]—The header (or header field, used interchangeably) is a one or three byte field within a frame which contains

information about the message priority, message source and target addressing, message type, and in-frame response type.

2.3.7 IN-FRAME RESPONSE (IFR) TYPE—The IFR type identifies the form of the in-frame response which is expected within that message.

2.3.8 LOAD—The load command indicates the operation of directly replacing the current/existing value of a parameter with the parameter value(s) contained in the message.

2.3.9 MESSAGE—A message consists of all of the bytes of a frame excluding the delimiter symbols (SOF, EOD, EOF, NB).

2.3.10 MODIFY—The modify command indicates the operation of using the message data parameter value to change (e.g., increment, decrement, or toggle) the current/existing value.

2.3.11 PARAMETER—A parameter is the variable quantity included in some messages. The parameter value, scaling, offset, units, transfer function, etc., are unique to each particular message. (The assigned parameters are contained herein.)

2.3.12 PHYSICAL ADDRESSING—Physical addressing allows a message to be addressed to a specific node or to all nodes or to a non-existent, null node. The information in this message is only of relevance to a particular node, so the other nodes on the bus should ignore the message, except for the case of the "all nodes" address.

2.3.13 PRIMARY ID—The primary ID identifies the target for this functional message. This is the primary discriminator used to group functions into main categories.

2.3.14 PRIORITY—The priority describes the rank order and precedence of a message. Based upon the SAE J1850, Class B arbitration process, the message with the highest priority will win arbitration.

2.3.15 REPORT—A report indicates the transmission of parametric data values, based on: a change of state; a change of value; on a periodic rate basis; or as a response to a specific request.

2.3.16 REQUEST—A request is a command to, or a query for data, or action from another node on the network.

2.3.17 RESPONSE DATA—The response data is the information from a node on the network in response to a request from another node on the network. This may be an in-frame response or a report type of message.

2.3.18 SECONDARY ID—The secondary ID (along with the primary ID or Frame ID) identifies the functional target node for a message. The purpose of the secondary ID field within the frame is to further define the function or action being identified by the primary ID.

2.4 Abbreviations and Acronyms

A/C	Air Conditioning
ASC	ASCII Encoded SLOT
BCD	Binary Coded Decimal (BCD) SLOT
BMM	Bit Mapped with Mask SLOT
BMP	Bit Mapped without Mask SLOT
CRC	Cyclic Redundancy Check
CS	Checksum
DTC	Diagnostic Trouble Code
EOD	End of Data
EOF	End of Frame
ERR	Error Detection
HVAC	Heating, Ventilation, Air Conditioning
ID	Identifier
IFR	In-Frame Response
LSB	Least Significant Bit/Byte
MSB	Most Significant Bit/Byte
NB	Normalization Bit
PID	Parameter Identification (number, NOT the primary ID, See Section 6)
PKT	Multiple Parameter Packet SLOT
PRN	Parameter Reference Number
SED	State Encoded SLOT
SFP	Signed Floating Point (Scientific Notation) SLOT
SLOT	Scaling, Limit, Offset, and Transfer Function (See Section 7)
SNM	2's Complement Signed Numeric SLOT
SOF	Start of Frame
UNM	Unsigned Numeric SLOT
VIN	Vehicle Identification Number

3. General Information

3.1 Part 2 Overview—Section 4 provides a description of the parameter reference number (PRN) number groupings used for assigning PRN numbers to

individual parameters. Section 3 defines the formats used to define all standard parameters to be used in SAE J2178 messages. Section 6 defines the specific parameter assignments in terms of names, units, and scale factor reference. Section 7 defines the actual parameter specifications (SLOT), in terms of the length, bit resolution, range, scale factor details, etc. Section 8 describes the case of very long parameters which cannot be transmitted in a single message. Appendix A provides a numerical cross reference to assist in finding the correct name of a parameter if the parameter identification number is known. Appendix B is an alphabetical cross reference to assist in finding the correct parameter identification number if the parameter name is known.

The messages contain header fields and data fields, described in Part 1 of SAE J2178. The header field contains target, source, priority, and message type information, while the data field contains optional additional addressing and parametric information. This document defines the parametric information.

For some applications, it is desirable to include multiple parameters in a single message. The multiple parameter format is called a packet in this document. For example, some diagnostic messages consist of combinations of these parameters to improve information density or to insert simultaneous readings of different variables. A very limited set of these combinations are defined here as industry standards but individual manufacturers are free to use this form in manufacturer specific messages, as needed.

3.2 How To Use This Document—This part (Part 2 of SAE J2178) provides the definition of parameters which are commonly found, or could be expected in vehicle Electrical/Electronic Systems today. These parameters have been defined to allow messages on a Class B communication system to have consistent meaning between manufacturers and over time. The parameter definition consists of two parts, the "PRN" and the "SLOT." The "PRN" (Parameter Reference Number) is a number used to identify a specific parameter by name, unit of measure, and its associated "SLOT." The "SLOT" defines the

mathematical characteristics of parameters in terms of its representation (Binary, Unsigned Numeric, ASCII, BCD, etc.), its scaling (1 Bit =), its limits and offsets, and its transfer function.

To find a parameter by name or PRN number, Appendices A and B provide cross references to the page of this document where the PRN can be found. The PRN numbers have also been grouped by subsystem to enable the reader to look for parameters if the name is not known.

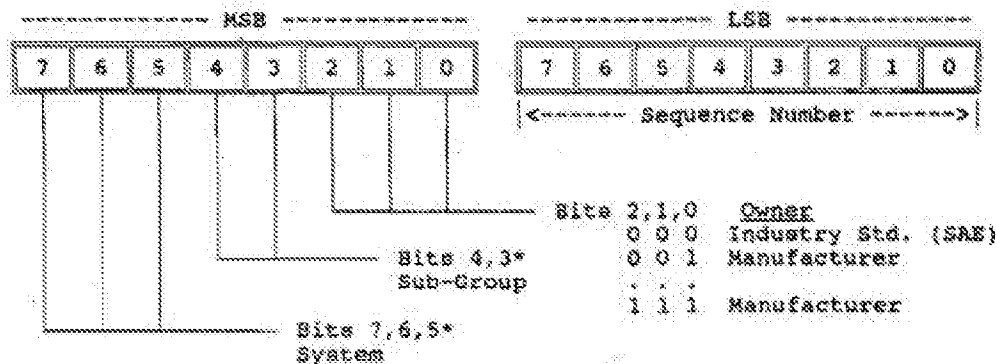
If the parameter has not as yet been included in the list of PRNs, users can define new parameters in terms of the SLOTS which have been defined.

4. Parameter Reference Number (PRN) Structure—Parameter Reference Numbers (PRNs) are used to simplify documentation. They do not, in themselves, have particular significance. PRNs do allow simplification of reference, particularly for diagnostic purposes. To this end, a structure for PRN number assignments has been developed. The structure is described in the following paragraphs. Some of the PRN numbers are assigned or reserved for SAE definitions but the majority are reserved for individual motor vehicle manufacturers to coordinate and assign.

All PRN addresses are two bytes long, with the first byte identifying a grouping or classification reference (refer to Tables 1 and 2). The second byte is then a sequence number pointing to the specific parameter used (refer to Tables 4 through 19). There has not been any attempt made to group or commonize the meaning in the second byte. The specific assignments are found in Section 6. Note that all PRN addresses are listed as hexadecimal numbers throughout this document.

SAE J1979 refers to PID numbers which are a single byte reference number. The first 256 PRNs defined here (first byte = 00), are identical with the SAE J1979 PID definitions.

Figure 3 shows the basic structure of PRNs and Tables 1 and 2 show bit assignments and address ranges based on these assignments.



* See Table 1

FIGURE 3—PRN STRUCTURE

5. Parameter Formats—Parameter values are represented in bit, byte, word, and multi-byte forms. The length of the parameter is uniquely associated with the message header and any included secondary ID field. These parameter definitions are referenced by one or more messages. The parameters allow a wide variety of variables, data definitions, and representations to provide the ability to use this definition for all messages, even when the industry standard messages are not useful for particular applications.

5.1 Bit Mapped Parameters—The bit mapped parameters, that is, those which have only two logical values (for example: True/False), are handled in one of two ways. The "Q" bit described in Section 6 of Part 1 of SAE J2178, is used if there is only one bit of information. In many cases, however, the bit values are associated together and form byte groupings, generally around common functional characteristics. Bit mapped data are transmitted either with or without corresponding mask bytes as described as follows.

5.1.1 BIT MAPPED DATA WITHOUT MASK BYTE(S)—In some cases, such as configuration identification, there is information which can be grouped as binary bits which represent whether, for example, a function or test is supported in a system. This form does not allow the bits to be supplied from different nodes in the network. If the bits potentially come from more than one node, the form with mask bytes described in 5.1.2, is used. The general form of the bit data bytes without mask is shown in Figure 4.

For these bit data cases, the bit names (that is: items) are somewhat different to emphasize the difference in format. These names are shown in Figure 5. If there is more than one byte of data of this form, the item numbers are incremented by one, sequentially, beginning at one from the MSB of the first byte.

For definition purposes, it is also possible to describe a single or multiple bit group which is smaller than a byte but which are combined into a byte or multiple bytes when the complete message is defined. This is a convenience used in this document to define some parameters. This definition notation applies equally to byte(s) with or without masks.

5.1.2 BIT MAPPED DATA WITH MASK BYTE(S)—For bit mapped data value groups that may come from several nodes or may not be valid for an application, a special format has been defined. Figures 6 and 7 show the data byte formats used. The data format allows two options in the number of bits in a group: 8 or 16. Since the defined bits for such groupings may not always come from a single network node, the format includes mask bytes indicating if an individual bit is valid for this message or if it should be ignored. The mask bytes map directly to the data bits with which they are associated. Figures 8 and 9 show how these bits are mapped within each byte. Table 3 shows the bit value for the mask bits.

TABLE 1—PRN GROUPINGS

7:5	System	4:3	Subgroup	Address (Hex)
000	Powertrain	00	J1979 Compatible	5000-5FFF
		00	Reserved	5100-57FF
		01	Reserved	5800-5FFF
		10	Engine	1000-17FF
		11	Transmission	1800-1FFF
001	Chassis	00	Reserved	2000-27FF
		01	Brakes/Tires/Wheels	2800-2FFF
		10	Steering	3000-37FF
		11	Suspension	3800-3FFF
010	Body 1	00	Reserved	4000-47FF
		01	Reserved	4800-4FFF
		10	Reserved	5000-57FF
		11	Restraints	5800-5FFF
011	Body 2	00	Driver Info.	6000-67FF
		01	Reserved	6800-6FFF
		10	Lighting	7000-77FF
		11	Reserved	7800-7FFF
100	Body 3	00	Audio	8000-87FF
		01	Reserved	8800-8FFF
		10	Pers. Comm.	9000-97FF
		11	HVAC	9800-9FFF
101	Body 4	00	Convenience	A000-A7FF
		01	Reserved	A800-AFFF
		10	Reserved	B000-B7FF
		11	Reserved	B800-BFFF
110	Other 1	00	Security	C000-C7FF
		01	Reserved	C800-CFFF
		10	Reserved	D000-D7FF
		11	Reserved	D800-DFFF
111	Other 2	00	Config. Codes	E000-E7FF
		01	Reserved	E800-EFFF
		10	Test/Diag.	F000-F7FF
		11	Miscellaneous	F800-FFFF

...	Data Byte 1	...	Data Byte N	...
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FIGURE 4—BIT DATA FIELD WITHOUT MASK FORMAT

MSB						LSB			
...	Bit 7 Item 1	Bit 6 Item 2	Bit 5 Item 3	Bit 4 Item 4	Bit 3 Item 5	Bit 2 Item 6	Bit 1 Item 7	Bit 0 Item 8	...

FIGURE 5—BITS WITHOUT MASK BYTE

...	Data Byte	Mask Byte	...
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FIGURE 6—FORMAT FOR 8-BIT DATA WITH MASK

...	Data Byte 1	Mask Byte 1	Data Byte 2	Mask Byte 2	...
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FIGURE 7—FORMAT FOR 16-BIT DATA WITH MASK

MSB					LSB				
...	Bit 7 Item 1	Bit 6 Item 2	Bit 5 Item 3	Bit 4 Item 4	Bit 3 Item 5	Bit 2 Item 6	Bit 1 Item 7	Bit 0 Item 8	...

FIGURE 8—BIT MAPPED DATA BYTE

TABLE 2—SAE/MFG PPN RANGES

System	Subgroup	Address Map	Size
Powertrain	J1979 Compatible - SAE	0000 - 00FF	0.25K
	Reserved - MFG	0100 - 07FF	1.75K
	Reserved - SAE	0800 - 08FF	0.25K
	Reserved - MFG	0900 - 0FFF	1.75K
	Engine - SAE	1000 - 10FF	0.25K
	Engine - MFG	1100 - 17FF	1.75K
	Transmission - SAE	1800 - 18FF	0.25K
	Transmission - MFG	1900 - 1FFF	1.75K
Chassis	Reserved - SAE	2000 - 20FF	0.25K
	Reserved - MFG	2100 - 27FF	1.75K
	Brakes/Tires/Wheels - SAE	2800 - 28FF	0.25K
	Brakes/Tires/Wheels - MFG	2900 - 2FFF	1.75K
	Steering - SAE	3000 - 30FF	0.25K
	Steering - MFG	3100 - 37FF	1.75K
	Suspension - SAE	3800 - 38FF	0.25K
	Suspension - MFG	3900 - 3FFF	1.75K
Body 1	Reserved - SAE	4000 - 40FF	0.25K
	Reserved - MFG	4100 - 47FF	1.75K
	Reserved - SAE	4800 - 48FF	0.25K
	Reserved - MFG	4900 - 4FFF	1.75K
	Reserved - SAE	5000 - 50FF	0.25K
	Reserved - MFG	5100 - 57FF	1.75K
	Restraints - SAE	5800 - 5900	0.25K
	Restraints - MFG	5900 - 5FFF	1.75K
Body 2	Driver Information - SAE	6000 - 60FF	0.25K
	Driver Information - MFG	6100 - 67FF	1.75K
	Reserved - SAE	6800 - 68FF	0.25K
	Reserved - MFG	6900 - 6FFF	1.75K
	Lighting - SAE	7000 - 70FF	0.25K
	Lighting - MFG	7100 - 77FF	1.75K
	Reserved - SAE	7800 - 78FF	0.25K
	Reserved - MFG	7900 - 7FFF	1.75K
Body 3	Audio - SAE	8000 - 80FF	0.25K
	Audio - MFG	8100 - 87FF	1.75K
	Reserved - SAE	8800 - 88FF	0.25K
	Reserved - MFG	8900 - 8FFF	1.75K
	Personal Communications - SAE	9000 - 90FF	0.25K
	Personal Communications - MFG	9100 - 97FF	1.75K
	HVAC - SAE	9800 - 98FF	0.25K
	HVAC - MFG	9900 - 9FFF	1.75K
Body 4	Convenience - SAE	A000 - A0FF	0.25K
	Convenience - MFG	A100 - A7FF	1.75K
	Reserved - SAE	A800 - A8FF	0.25K
	Reserved - MFG	A900 - AFFF	1.75K
	Reserved - SAE	B000 - B0FF	0.25K
	Reserved - MFG	B100 - B7FF	1.75K
	Reserved - SAE	B800 - B8FF	0.25K
	Reserved - MFG	B900 - BFFF	1.75K
Other 1	Security - SAE	C000 - C0FF	0.25K
	Security - MFG	C100 - C7FF	1.75K
	Reserved - SAE	C800 - C8FF	0.25K
	Reserved - MFG	C900 - CFFF	1.75K
	Reserved - SAE	D000 - D0FF	0.25K
	Reserved - MFG	D100 - D7FF	1.75K
	Reserved - SAE	D800 - D8FF	0.25K
	Reserved - MFG	D900 - DFFF	1.75K
Other 2	Configuration Codes - SAE	E000 - E0FF	0.25K
	Configuration Codes - MFG	E100 - E7FF	1.75K
	Reserved - SAE	E800 - E8FF	0.25K
	Reserved - MFG	E900 - EFFF	1.75K
	Tester/Diagnostics - SAE	F000 - F0FF	0.25K
	Tester/Diagnostics - MFG	F100 - F7FF	1.75K
	Miscellaneous - SAE	F800 - F8FF	0.25K
	Miscellaneous - MFG	F900 - FFFF	1.75K

MSB					LSB				
Mask Bit 7 Item 1	Mask Bit 6 Item 2	Mask Bit 5 Item 3	Mask Bit 4 Item 4	Mask Bit 3 Item 5	Mask Bit 2 Item 6	Mask Bit 1 Item 7	Mask Bit 0 Item 8		

FIGURE 9—BIT MAPPED MASK BYTE

TABLE 3—MASK BIT ASSIGNMENT

Mask Bit	Bit Mapped Meaning
0	Not A Valid Bit
1	Valid Bit

5.1.3 BIT VALUES—The general form of binary data is that 1 = true and 0 = false. One bit can carry a wide variety of interpretations, depending on the subject that it describes.

5.2 Byte (8 Bit) Parameters—Data parameters which can be expressed in 8 bits or less are expressed in a byte format. Byte parameters are the most common format. Figure 10 shows this format.

5.3 Word (16 Bit) Parameters—Data parameters which can be expressed in 9 to 16 bits are expressed in word format with the most significant byte transmitted first (high byte/low byte). Figure 11 shows this format.

5.4 Multi-Byte (>16 Bit) Parameters—Data parameters which can be expressed in more than 16 bits are expressed in multi-byte format with the most significant byte transmitted first (highest byte / lowest byte). Figure 12 shows this format.

5.5 Multiple Parameter Packets—It is often useful to group parameters

together into a packet to increase the information density of messages. For example, sending a fluid level and maximum capacity value in the same message, or a packet of single bit(s) or multiple bit definitions that may be smaller than a full byte, can be combined in this way. Parameter packets will be defined in this document in the same way as any other parameter, having a packet PRN number and SLOT reference assignment. If bit mapped parameters are included in a packet, the bit mapped byte(s) and the associated mask byte(s) are grouped together as a set representing a parameter. Thus, the data bytes and mask bytes for each parameter are together within the packet. Note that packets may be made of other packets, but each will be uniquely defined by combining each subpart into a message. Figure 13 shows the general form of a parameter packet.

A few examples, such as some of the SAE J1979 compatible PRN definitions in Section 6 will make this format clear.

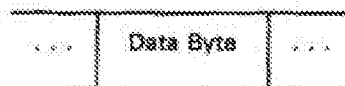


FIGURE 10—BYTE PARAMETERS

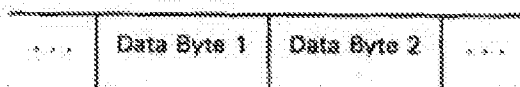


FIGURE 11—WORD PARAMETERS

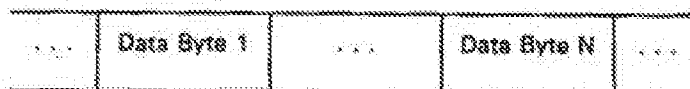


FIGURE 12—MULTI-BYTE PARAMETERS

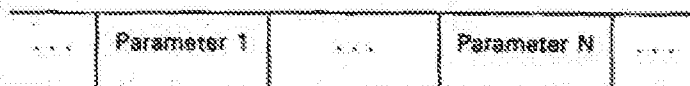


FIGURE 13—MULTIPLE PARAMETER PACKETS

6. Specific Parameter (PRN) Assignments—This section defines industry standard parameters used in messages found in parts 3 and 4. These parameters have been listed in random order based on when they were defined. Note that any PRN address in the SAE range that is not currently defined is reserved for SAE use. Cross references are provided in Appendices A and B of this part of SAE J2178 to assist the reader in finding the specific definition for each parameter.

6.1 Specific Parameters—The following definitions include the Parameter Reference Number (PRN), parameter name, units of measure, and associated SLOT number. The SLOT number is a reference to the Scaling, Limit, Offset, and Transfer function (SLOT) definition found in Section 7 as follows. The SLOT reference numbers have a format of: F-N-#, where F is a three-letter mnemonic indicating the format code type (see Section 7), N is the number of bits in the parameter, and # is the sequence number for that type of

SLOT. There is no relationship between sequence numbers for different format codes or number of bytes. Note that the sequence number is randomly assigned. Decimal sequence numbers of 1000 and above are available for manufacturers to assign. All SAE-assigned sequence numbers will be in the range from 1 to 999 exclusively and are not to be used by manufacturers. The sequence number ZERO (0) has the special purpose of a fill sequence which is used in packet definitions. The ZERO sequence number is all zeros, for the number of bits specified. The Parameter Reference Numbers (PRNs) are the index reference used by the message definitions found in Parts 3 and 4 of this document. The specific parameters are grouped as follows:

- Table 4 - SAE J1979 Compatible PRN Assignments
- Table 5 - Engine PRN Assignments
- Table 6 - Transmission PRN Assignments
- Table 7 - Brakes/Tires/Wheels PRN Assignments

- Table 8 - Steering PRN Assignments
- Table 9 - Suspension PRN Assignments
- Table 10 - Restraints PRN Assignments
- Table 11 - Driver Information PRN Assignments
- Table 12 - Lighting PRN Assignments
- Table 13 - Audio PRN Assignments
- Table 14 - Personal Communication PRN Assignments
- Table 15 - HVAC PRN Assignments
- Table 16 - Convenience PRN Assignments
- Table 17 - Security PRN Assignments
- Table 18 - Configuration Codes PRN Assignments
- Table 19 - Tester/Diagnostics PRN Assignments
- Table 20 - Miscellaneous PRN Assignments

TABLE 4—SAE J1979 COMPATIBLE PRN ASSIGNMENTS
(PRNs 0000 - 00FF)

PRN	Parameter Name	Resolution (1 Bit =)	Units Of Measure	Sent. # (P-M-F)
0000	PIDs Supported (01h - 20h)	-	Bit Mapped	SMP-32-1
0001	Number of Emission-Related Trouble Codes & MIL Status	-	Packaged	PCKT-32-1
0002	Trouble Code That Caused Freeze Frame Storage	-	Packaged	PCKT-16-1
0003	Fuel System Status	-	Packaged	PCKT-16-2
0004	Calculated Load Value	100/255	% Full Load	UNM-08-01
0005	Engine Coolant Temperature	1	Degrees Centigrade	UNM-08-102
0006	Short Term Fuel Trim - Bank 1	100/128	% Enrichment	UNM-08-02
0007	Long Term Fuel Trim - Bank 1	100/128	% Enrichment	UNM-08-02
0008	Short Term Fuel Trim - Bank 2	100/128	% Enrichment	UNM-08-02
0009	Long Term Fuel Trim - Bank 2	100/128	% Enrichment	UNM-08-02
000A	Fuel Pressure (Gage)	2	kPaG	UNM-08-121
000B	Intake Manifold Absolute Pressure	1	kPaA	UNM-08-101
000C	Engine RPM - High Resolution	1/4	RPM	UNM-16-31
000D	Vehicle Speed - Low Resolution - Metric	1	km/h	UNM-08-101
000E	Ignition Timing Advance (#1)	1/2	Degrees before TDC	UNM-08-72
000F	Intake Air Temperature	1	Degrees Centigrade	UNM-08-102
0010	Air Flow Rate from MAP	1/100	grams/sec	UNM-16-11
0011	Absolute Throttle #1 Position	100/255	% Full Throttle	UNM-08-01
0012	Commanded Secondary Air	-	Bit Mapped	SMP-08-5
0013	Oxygen Sensor Location	-	Bit Mapped	SMP-08-6
0014	Oxygen Sensor - BANK 1 - Sensor 1	-	Packaged	PCKT-16-3
0015	Oxygen Sensor - BANK 1 - Sensor 2	-	Packaged	PCKT-16-3
0016	Oxygen Sensor - BANK 1 - Sensor 3	-	Packaged	PCKT-16-3
0017	Oxygen Sensor - BANK 1 - Sensor 4	-	Packaged	PCKT-16-3
0018	Oxygen Sensor - BANK 2 - Sensor 1	-	Packaged	PCKT-16-3
0019	Oxygen Sensor - BANK 2 - Sensor 2	-	Packaged	PCKT-16-3
001A	Oxygen Sensor - BANK 2 - Sensor 3	-	Packaged	PCKT-16-3
001B	Oxygen Sensor - BANK 2 - Sensor 4	-	Packaged	PCKT-16-3
001C	Reserved SAE	-	-	-
001D	Reserved SAE	-	-	-
001E	Reserved SAE	-	-	-
001F	Reserved SAE	-	-	-
0020	PIDs Supported (21h - 40h)	-	Bit Mapped	SMP-32-2
0021-002F	Reserved SAE	-	-	-
0040	PIDs Supported (41h - 60h)	-	Bit Mapped	SMP-32-3
0041-00FF	Reserved SAE	-	-	-

TABLE 5—ENGINE PPN ASSIGNMENTS
(PPNs 1000 - 10FF)

PPN	PARAMETER NAME	RESOLUTION (1 SR =)	UNITS OF MEASURE	SLQT 2 (F-N-4)
1000	MIL Status	-	Bit Mapped	SNP-01-1
1001	Number of Emissions Related DTCs	1	Quantity	UNM-07-1
1002	Continuous Evaluation Supported	-	Bit Mapped	SNP-08-1
1003	Trip Evaluation Supported	-	Bit Mapped	SNP-08-2
1004	Trip Evaluation Complete	-	Bit Mapped	SNP-08-3
1005	Sub-System Category of DTC	-	State Encoded	SED-02-1
1006	Most Significant Digit of DTC	-	State Encoded	SED-02-2
1007	Lower 3 Digits of DTC	-	BCD	SED-02-3
1008	Fuel System Status - Bank 1	-	Bit Mapped	SNP-08-4
1009	Fuel System Status - Bank 2	-	Bit Mapped	SNP-08-5
100A	Oxygen Sensor Voltage	1/250	volts	UNM-08-11
100B	Short Term Fuel Trim	100/128	% Enrichment	UNM-08-02
100D	Most Significant Digit of VIN Number	-	ASCII	ASC-08-01
100E	A/C Clutch Load	35	Watts	UNM-08-105
1015	Injector On Time	2048	microseconds	UNM-08-031
1018	Crankshaft Torque - Absolute	4	Nm Torque	UNM-08-141
1020	Crankshaft Torque - Percent	100/255	% Maximum Torque	UNM-08-61
1021	Engine Boost	100/255	% Full Boost	UNM-08-61
1022	Engine RPM - Low Resolution	32	RPM	UNM-08-171
1023	Engine Idle RPM	16	RPM	UNM-08-181
1024	Engine Revolutions	2	Quantity	UNM-08-121
1025	Barometric Pressure	1	kPaA	UNM-08-101
1026	Engine Coolant Level - Percent	1/2	% Full	UNM-08-71
1027	Engine Coolant Level - Volume	1/10	Bars	UNM-08-41
1028	Engine Coolant Capacity	1/10	Bars	UNM-08-41
1029	Engine Coolant Pressure	4	kPaG	UNM-08-141
102A	Engine Coolant Fan #1 Speed	100/255	% Full On	UNM-08-61
102B	Engine Oil Temperature	1	Degrees Centigrade	UNM-08-102
102C	Engine Oil Level - Percent	1/2	% Full	UNM-08-71
102D	Engine Oil Level - Volume	1/10	Bars	UNM-08-41
102E	Engine Oil Capacity	1/10	Bars	UNM-08-41
102F	Engine Oil Pressure	4	kPaG	UNM-08-141
1030	Engine Oil Remaining Life	100/255	% Remaining Life	UNM-08-61
1031	Hydraulic Fan Speed	100/255	% Full On	UNM-08-61
1032	Methanol Content	100/255	% Methanol	UNM-08-61
1033	Maximum Crankshaft Torque	4	Nm Torque	UNM-08-141
1034	Accelerator Pedal Position	100/255	% Pressed Down	UNM-08-61
1035	Absolute Throttle #2 Position	100/255	% Full Throttle	UNM-08-61
1036	Absolute Throttle #3 Position	100/255	% Full Throttle	UNM-08-61
1037	Bank #1 - Converter #1 Temperature	8	Degrees Centigrade	UNM-08-151
1038	Bank #1 - Converter #2 Temperature	8	Degrees Centigrade	UNM-08-151
1039	Bank #2 - Converter #1 Temperature	8	Degrees Centigrade	UNM-08-151
103A	Bank #2 - Converter #2 Temperature	8	Degrees Centigrade	UNM-08-151
103B	Engine Coolant #2 Fan Speed	100/255	% Full On	UNM-08-61
103C	Engine Coolant Temperature - Low Range	1	Degrees Centigrade	UNM-08-104
103D	Engine Coolant Remaining Life	100/255	% Remaining Life	UNM-08-61
103F	Engine Oil Viscosity	1/10	Centistokes (cSt)	UNM-08-41
1040	Number of Engine Cylinders	1	Quantity	UNM-08-101
1041	Number of Valves per Cylinder	1	Quantity	UNM-08-101
1042	Engine Displacement	1/10	Bars	UNM-08-41
1044	Fuel Temperature	1	Degrees Centigrade	UNM-08-102
1047	Ignition Switch Position	-	State Encoded	SED-08-5
1045	Engine Rndline - Low Resolution	32	RPM	UNM-08-171
1043	Engine Rndline - High Resolution	1/4	RPM	UNM-18-31

TABLE 6--TRANSMISSION PRN ASSIGNMENTS
(PRNs 1800 - 18FF)

PRN	Parameter Name	Resolution (1 Bit =)	Units Of Measure	Std. # (F44-8)
1801	Transmission Fluid Level - Percent	1/2	% Full	UNM-08-71
1802	Transmission Fluid Level - Volume	1/10	liters	UNM-08-41
1803	Transmission Fluid Capacity	1/10	liters	UNM-08-41
1804	Transmission Oil Life	100/255	% Remaining Life	UNM-08-61
1805	Transmission Gear & Lockup Status	-	Packaged	PKT-08-1
1806	Transmission Range Actual (PRNDL)	-	State Encoded	SED-08-4
1807	Transmission Lockup Status	-	State Encoded	SED-08-3
1808	Transmission Actual Gear	-	State Encoded	SED-08-1
1809	Transmission Range Selected (PRNDL)	-	State Encoded	SED-08-4
180A	Transmission Transfer Case (4WD)	-	State Encoded	SED-08-6
180B	Transmission Fluid Temperature	1	Degrees Centigrade	UNM-08-102
180C	Transmission Fluid Pressure	8	kPaG	UNM-08-131
180D	Transmission Commanded Gear	-	State Encoded	SED-08-4
180E	Transmission Actual Gear	-	State Encoded	SED-08-4

TABLE 7--BRAKES/TIRES/WHEELS PRN ASSIGNMENTS
(PRNs 2800 - 28FF)

PRN	Parameter Name	Resolution (1 Bit =)	Units Of Measure	Std. # (F44-8)
2801	Wheel Speed - Low Resolution	1	km/h	UNM-08-101
2802	Wheel Speed - High Resolution	1/128	km/h	UNM-10-5
2809	Wheel Slip	1/255	Dimensionless	UNM-08-8
2819	Hydraulic Brake Fluid Supply Pump Pressure	32	kPaG	UNM-08-171
281A	Hydraulic Brake Fluid Temperature	1	Degrees Centigrade	UNM-08-102
281B	Hydraulic Brake Fluid Recirculation Pump Pressure	1	kPaG	UNM-08-101
2821	Wheel Rate	-	SAE Reserved	SAE Reserved
2829	Wheel Angular Velocity	-	SAE Reserved	SAE Reserved
2831	Wheel Angular Acceleration	-	SAE Reserved	SAE Reserved
2839	Wheel Load	100/255	% Full Load	UNM-08-61
2841	Brake Fluid Level - Percent	1/2	% Full	UNM-08-71
2842	Brake Fluid Level - Volume	1/100	liters	UNM-08-15
2843	Brake Fluid Remaining Life	100/255	% Remaining Life	UNM-08-61
2844	Brake Fluid Capacity	1/100	liters	UNM-08-15
2849	Tire Temperature	1	Degrees Centigrade	UNM-08-102
2851	Tire Pressure	4	kPaG	UNM-08-141
2859	Tire Type	-	SAE Reserved	SAE Reserved
2861	Tire Tread Wear Level	100/255	% tread remaining	UNM-08-61

TABLE 8--STEERING PRN ASSIGNMENTS
(PRNs 3000 - 30FF)

PRN	Parameter Name	Resolution (1 Bit =)	Units Of Measure	Std. # (F44-8)
3001	Steering Wheel Angle	8	Degrees CW from center	SNM-08-61
3005	Power Steering Fluid Temperature	1	Degrees Centigrade	UNM-08-102
3006	Power Steering Fluid Pressure	100	kPaG	UNM-08-185
3007	Power Steering Fluid Level - Percent	1/2	% Full	UNM-08-71
3008	Power Steering Fluid Level - Volume	1/100	liters	UNM-08-15
3009	Power Steering Fluid Remaining Life	100/255	% Remaining Life	UNM-08-61
3009	Power Steering Fluid Capacity	1/100	liters	UNM-08-15
300C	Steering Wheel Rate	1	RPM	UNM-08-101
300D	Steering Wheel Torque	1	N.m Torque	UNM-08-101
300E	Wheel Steer Angle	1/2	Degrees CW from Center	SNM-08-11

TABLE 9--SUSPENSION PRN ASSIGNMENTS
(PRNs 3800 - 38FF)

PRN	Parameter Name	Resolution (1 Bit =)	Units Of Measure	Std.# (F-N-#)
3801	Lateral Acceleration		SAE Reserved	SAE Reserved
3802	Longitudinal Acceleration		SAE Reserved	SAE Reserved
3803	Yaw Acceleration		SAE Reserved	SAE Reserved
3804	Suspension Ride Setting	100/255	% Ride Setting	UNM-08-61
3805	Suspension Fluid Temperature	1	Degrees Centigrade	UNM-08-102
3806	Suspension Fluid Pressure	100	kPaG	UNM-08-103
3807	Suspension Fluid Level - Percent	1/2	% Full	UNM-08-71
3808	Suspension Fluid Level - Volume	1/32	liters	UNM-08-26
3809	Suspension Fluid Remaining Life	100/255	% Remaining Life	UNM-08-61
380A	Suspension Fluid Capacity	1/32	liters	UNM-08-26
380B	Vehicle Lateral Velocity		SAE Reserved	SAE Reserved
380C	Vehicle Longitudinal Velocity		SAE Reserved	SAE Reserved
380D	Vehicle Yaw Velocity		SAE Reserved	SAE Reserved

TABLE 10--RESTRAINTS PRN ASSIGNMENTS
(PRNs 5800 - 58FF)

PRN	Parameter Name	Resolution (1 Bit =)	Units Of Measure	Std.# (F-N-#)
5801	Shoulder Belt Position	1	Uncolled A/D Counts	UNM-08-101

TABLE 11--DRIVER INFORMATION PRN ASSIGNMENTS
(PRNs 6000 - 60FF)

PRN	Parameter Name	Resolution (1 Bit =)	Units Of Measure	Std.# (F-N-#)
6001	Vehicle Speed - High Resolution - Metric	1/128	knots	UNM-16-5
6002	Vehicle Speed - High Resolution - English	1/128	mph	UNM-16-5
6003	Compass Direction	3/2	Degrees CW from North	UNM-08-51
6004	Odometer - Vehicle - Metric	1/64	kilometers	UNM-02-31
6005	Fuel Level - Percent	100/255	% Full	UNM-08-61
6006	Fuel Level - Volume	1/100	liters	UNM-16-11
6007	Fuel Capacity	1/100	liters	UNM-16-11
600A	Battery Voltage - Low Resolution	1/16	volts	UNM-08-32
600B	Battery Temperature	1	Degrees Centigrade	UNM-08-102
600C	Electrical Energy Load	1	amps	UNM-08-101
600D	Date (Day/Month/Year)	-	Packed	PKT-32-3
600E	Year (YY)	-	BCD	BCD-08-1
600F	Year (Yr)	1	year	UNM-08-103
6010	Month (Mn)	-	State Encoded	SED-04-2
6011	Month (MM)	-	BCD	BCD-08-1
6012	Day of Week (Dwy)	-	State Encoded	SED-04-1
6013	Day of Week (Dwg)	-	State Encoded	SED-08-2
6014	Day of Month (Dm)	-	State Encoded	SED-08-3
6015	Day of Month (DD)	-	BCD	BCD-08-1
6016	Time of Day (HH:MM:SS)	-	Packed	PKT-24-1
6017	Hours (Hr)	-	BCD	BCD-08-1
6018	Minutes (MM)	-	BCD	BCD-08-1
6019	Seconds (SS)	-	BCD	BCD-08-1
601A	Battery Voltage - High Resolution	1/128	volts	UNM-16-5
601B	Distance Traveled - English	1/8000	miles	UNM-08-1
601C	Fuel Used - Metric	1/64	liters	UNM-16-8
601D	Distance To Empty - English	1/10	miles	UNM-16-21
601E	Vehicle Speed - Low Resolution - English	1	MPH	UNM-08-101
601F	Hours (Hr) - 0 to 23 numeric	1	hour	UNM-08-101
6020	Average Fuel Economy - Low Resolution - Metric	1	liters/100 kilometers	UNM-08-101
6021	Average Fuel Economy - Low Resolution - English	1	MPG	UNM-08-101
6022	Elapsed Time - Seconds	1	Seconds	UNM-08-101
6023	Date (Dw/Mn/Dm)	-	Packed	PKT-16-6

Continued

TABLE 11—DRIVER INFORMATION PRN ASSIGNMENTS
(PRNs 6000 - 60FF) (CONTINUED)

PRN	Parameter Name	Resolution (1 Bit =)	Units Of Measure	Slot # (F-44-8)
6004	Elapsed Time - Minutes	1	Minutes	UNM-08-101
6025	Accumulated Ignition On Time	-	Packaged	PKT-24-2
6026	Fuel Used - English	1/64	gallons	UNM-16-8
6027	Distance To Empty - Metric	1/10	kilometers	UNM-16-21
6028	Average Fuel Economy - High Resolution - Metric	1/10	liters/100 kilometers	UNM-16-21
6029	Average Fuel Economy - High Resolution - English	1/10	MPG	UNM-16-21
602A	Elapsed Time - Hours	1	Hours	UNM-08-101
602B	Display Brightness	100/255	% Full On	UNM-08-01
602C	Ignition Off Duration	1	Minutes	UNM-08-101
602D	Outside Air Temperature - High Resolution	1/256	Degrees Centigrade	UNM-16-3
602E	Outside Air Temperature Display	1/2	Degrees Centigrade	UNM-08-73
602F	Minutes (Min) 0 - 59 numeric	1	minute	UNM-08-101
6030	Time (Hr:Min)	-	Packaged	PKT-16-5
6031	Odometer - Vehicle - High Resolution - English	1/8000	miles	UNM-24-11
6032	Odometer - Trip - High Resolution - English	1/80000	miles	UNM-24-21
6033	Odometer - Vehicle - Low Resolution - English	1/10	miles	UNM-24-11
6034	Odometer - Trip - Low Resolution - English	1/10	miles	UNM-16-21
6035	Charging Voltage - Low Resolution	1/16	volts	UNM-08-32
6036	Charging Voltage - High Resolution	1/128	volts	UNM-16-3
6037	Charging Current	1	amps	UNM-08-101
6038	Battery Current	1	amps	UNM-08-21
6039	Odometer - Trip - Metric	1/84	kilometers	UNM-24-41
603A	Instantaneous Fuel Economy - Low Resolution - Metric	1	liters/100 kilometers	UNM-08-101
603B	Fuel Used - Percent	100/255	% Used	UNM-08-61
603C	Fuel Used - Volume	1/100	liters	UNM-16-11
603D	Audible Signal Volume	100/255	% Full Volume	UNM-08-51
603E	Audible Signal Type	-	SAC Reserved	SAC Reserved
603F	Instantaneous Fuel Economy - High Resolution - Metric	1/10	liters/100 kilometers	UNM-16-21
6040	Instantaneous Fuel Economy - Low Resolution - English	1	MPG	UNM-08-101
6041	Instantaneous Fuel Economy - High Resolution - English	1/10	MPG	UNM-16-21
6042	Seconds (Sec) 0 - 59 numeric	1	seconds	UNM-08-101
6047	Alarm Time (HH:MM:SS) *	-	Packaged	PKT-24-1
6048	Elapsed Years	1	years	UNM-08-101
604A	Elapsed Months	1	months	UNM-08-101
604B	Elapsed Days	1	days	UNM-08-101

TABLE 12—LIGHTING PRN ASSIGNMENTS
(PRNs 7000 - 70FF)

PRN	Parameter Name	Resolution (1 Bit =)	Units Of Measure	Slot # (F-44-8)
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TABLE 13—AUDIO PRN ASSIGNMENTS
(PRNs 8000 - 80FF)

PRN	Parameter Name	Resolution (1 Bit =)	Units Of Measure	Slot # (F-44-8)
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TABLE 14—PERSONAL COMMUNICATION PRN ASSIGNMENTS
(PRNs 9000 - 90FF)

PRN	Parameter Name	Resolution (1 Bit =)	Units Of Measure	Slot # (F-44-8)
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TABLE 15—HVAC PRN ASSIGNMENTS
(PRNs 9800 - 98FF)

PRN	Parameter Name	Resolution (1 Bit =)	Units Of Measure	Slot # (F-N-F)
9801	HVAC Fan Speed	100/255	% Full On	UNM-08-61
9803	HVAC Door Position	100/255	% Open	UNM-08-61
9804	Electric Defrost Temperature	1	Degrees Centigrade	UNM-08-102
9808	HVAC High-Side Fluid Temperature	1	Degrees Centigrade	UNM-08-102
9809	HVAC Low-Side Fluid Temperature	1	Degrees Centigrade	UNM-08-103
980A	HVAC Low-Side Pressure	5/2	kPaG	UNM-08-128
980B	HVAC Fluid Charge - % Full Charge	100/255	% Full	UNM-08-61
980C	HVAC Fluid Charge - Absolute Weight	10	grams	UNM-08-155
980D	HVAC Fluid Charge Remaining Life	100/255	% Remaining Life	UNM-08-61
980E	HVAC Fluid Charge Capacity	10	grams	UNM-08-155
9810	HVAC Intake Temperature	1/2	Degrees Centigrade	UNM-08-73
9813	HVAC High-Side Pressure	14	kPaG	UNM-08-159
9815	Interior Humidity Level	100/255	% Relative Humidity	UNM-08-61
9816	Interior Air Filter Remaining Life	100/255	% Remaining Life	UNM-08-61
9817	Heat Load Sensor	1/2	mW/cm ²	UNM-08-71
9820	Interior Set Temperature	1/2	Degrees Centigrade	UNM-08-73
9830	HVAC Zone Temperature	1/2	Degrees Centigrade	UNM-08-73

TABLE 16—CONVENIENCE PRN ASSIGNMENTS
(PRNs A000 - A0FF)

PRN	Parameter Name	Resolution (1 Bit =)	Units Of Measure	Slot # (F-N-F)
A001	Seat Temperature	1/2	Degrees Centigrade	UNM-08-73
A003	Wiper Mode	-	State Encoded	SED-08-1
A004	Wiper Delay	1/4	seconds	UNM-08-51
A006	Washer Fluid Temperature	1	Degrees Centigrade	UNM-08-108
A007	Washer Fluid Pressure	4	kPaG	UNM-08-141
A008	Washer Fluid Level - Percent	100/255	% Full	UNM-08-61
A009	Washer Fluid Level - Volume	1/10	Bars	UNM-08-41
A00A	Washer Fluid Capacity	1/10	Bars	UNM-08-41
A00C	Mirror Dimming Level	100/255	% Full Dim	UNM-08-61
A00D	Mirror Horizontal Position	1	Unscaled A/D Counts	UNM-08-101
A00E	Mirror Vertical Position	1	Unscaled A/D Counts	UNM-08-101
A00F	Window Position	1	Unscaled A/D Counts	UNM-08-101
A010	Door Lock Cylinder State	-	State Encoded	SED-08-7
A011	Steering Column Horizontal Position	1	Unscaled A/D Counts	UNM-08-101
A012	Steering Column Vertical Position	1	Unscaled A/D Counts	UNM-08-101
A014	Autolock Off Delay Time	1	Seconds	UNM-08-101
A015	Vehicle Speed Setting - Low Resolution - Metric	1	km/h	UNM-08-101
A016	Vehicle Speed Setting - High Resolution - Metric	1/128	km/h	UNM-16-5
A017	Vehicle Speed Setting - Low Resolution - English	1	MPH	UNM-08-101
A018	Vehicle Speed Setting - High Resolution - English	1/128	MPH	UNM-16-5

TABLE 17—SECURITY PRN ASSIGNMENTS
(PRNs C000 - C0FF)

PRN	Parameter Name	Resolution (1 Bit =)	Units Of Measure	Slot # (F-N-F)
C001	Remote Transmitter ID	1	ID Number	UNM-08-101

TABLE 18—CONFIGURATION CODES PRN ASSIGNMENTS
(PRNs E000 - E0FF)

PRN	Parameter Name	Resolution (1 Bit =)	Units Of Measure	Slot # (F-N-F)
E021	Vehicle Id Number (VIN) #1	-	VIN character 1	PXT-32-2
E022	Vehicle Id Number (VIN) #2	-	VIN characters 2 - 3	ASC-32-1
E023	Vehicle Id Number (VIN) #3	-	VIN characters 6 - 9	ASC-32-1
E024	Vehicle Id Number (VIN) #4	-	VIN characters 10 - 13	ASC-32-1
E025	Vehicle Id Number (VIN) #5	-	VIN characters 14 - 17	ASC-32-1
E026	Vehicle Id Number (VIN) #6 (reserved for future use)	-	Reserved - SAE	Reserved - SAE
E027	Vehicle Id Number (VIN) #7 (reserved for future use)	-	Reserved - SAE	Reserved - SAE

TABLE 18--TESTER/DIAGNOSTICS PRN ASSIGNMENTS
(PRNs F000 - F0FF)

PRN	Parameter Name	Resolution (1 Bit =)	Units Of Measure	Slot # (F-44-#)
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TABLE 20--MISCELLANEOUS PRN ASSIGNMENTS
(PRNs F800 - F8FF)

PRN	Parameter Name	Resolution (1 Bit =)	Units Of Measure	Slot # (F-44-#)
F801	One Byte Zero Fill	0	Zero	UNM-08-0
F802	Two Byte Zero Fill	0	Zero	UNM-16-0
F803	Three Byte Zero Fill	0	Zero	UNM-24-0
F804	Four Byte Zero Fill	0	Zero	UNM-32-0
F806	Five Byte Zero Fill	0	Zero	UNM-40-0
F808	Six Byte Zero Fill	0	Zero	UNM-48-0
F807	Seven Byte Zero Fill	0	Zero	UNM-56-0

7. *Scaling, Limit, Offset, and Transfer Function (SLOT) Definitions*—This section defines the parameter scaling, limit(s), offset value, and transfer function for bit, byte, or larger variables. These SLOT definitions have been grouped together to avoid duplication in this document and to offer a common list of definitions for use in assigning new parameter definitions. The wide range of these definitions are expected to cover a large number of applications, and should be used for most new definitions as well. Each of these definitions has been assigned a SLOT number for reference purposes but are formatted to include a three-letter mnemonic representing the format, the parameter length in bits, followed by a random sequence number.

The transfer function is shown in two forms to allow use in implementing messages in modules and in interpreting messages found on a network. The two forms are identical but are solved for each of the two variables. The transfer function defines the relationship between computer units (N) in decimal, and engineering units (E) of the data.

The format of the SLOT, identified by the three-letter mnemonic, indicates the category of bit representation. These formats include:

- Multiple Parameter Packeted

PKT

- Bit Mapped with Mask BMM
 - Bit Mapped without Mask BMP
 - Unsigned Numeric UNM
 - 2's Complement Signed Numeric SNM
 - State Encoded SED
 - ASCII Encoded ASC
 - Binary Coded Decimal (BCD) BCD
 - Signed Floating Point (Scientific Notation) SFP

These formats for each are described in the following paragraphs.

7.1 Multiple Parameter Packeted (PKT) SLOTS—The multiple parameter packet is used to define PRNs which refer to more than one parameter as a group that are related. By grouping multiple parameters, the network bandwidth can be improved, if the groupings are done such that the individual parameters need to be associated such that the each need to be transmitted together. These packets are defined as a sequence of other PRN numbers, in the order that they appear in the message (MSB first). In some cases, a PRN may be assigned to fill bits or bytes with zeros. Each zero fill PRN is an unsigned numeric SLOT with zero as the sequence number.

7.1.1 MULTIPLE PARAMETER PACKETED ASSIGNMENTS

PKT-08-1 Transmission Gear & Lockup Status (PRN 1805)

MSB	PRN 1807	Transmission Lockup Status.....	2 bits
LSB	PRN 1808	Transmission Gear Engaged.....	6 bits

PKT-16-1 Trouble Code That Caused Freeze Frame Storage (PRN 0002)

MSB	PRN 1005	Sub-System Category.....	2 bits
	PRN 1006	MSB of Trouble Code.....	2 bits
LSB	PRN 1007	Lower Bytes of Trouble Code - BCD.....	12 bits

PKT-16-2 Fuel System Status (PRN 0003)

MSB	PRN 1008	Fuel System Status - Bank 1.....	8 bits
LSB	PRN 1009	Fuel System Status - Bank 2.....	8 bits

PET-16-3 Oxygen BANK 1, 2 - Sensor 1, 2, 3, or 4 (PRN 0014 - 001B)

MSB	PRN 100A	Oxygen Sensor Voltage.....	8 bits
LSB	PRN 100B	Short Term Fuel Trim.....	8 bits

PKT-16-5 Time (Hr:Min) (PRN 6030)

MSB	PRN 601F	Hours (0 - 23).....	8 bits
LSB	PRN 602F	Minutes (0 - 59).....	8 bits

PKT-16-6 Date (Dw/Mn/Dm) (PRN 6023)

MSB	PRN 6012	Day of Week (1 - 7).....	4 bits
	PRN 6010	Month (1 - 12).....	4 bits
LSB	PRN 6014	Day of Month (1 - 31).....	8 bits

PKT-24-1	Time of Day (HH:MM:SS) (PRN 6016)		
	MSB	PRN 6017	Hours (HH) - BCD 8 bits
		PRN 6018	Minutes (MM) - BCD 8 bits
	LSB	PRN 6019	Seconds (SS) - BCD 8 bits
PKT-24-2	Accumulated Ignition On Time (PRN 6025)		
	MSB	PRN 602A	Elapsed Time-Hours (0-99) 8 bits
		PRN 6024	Elapsed Time-Minutes (0-59) 8 bits
	LSB	PRN 6022	Elapsed Time-Seconds (0-59) 8 bits
PKT-32-1	Number of Emission-Related Trouble Codes & MIL Status (PRN 0001)		
	MSB	PRN 1000	MIL Status 1 bit
		PRN 1001	Number of Emission-Related Trouble Codes 7 bits
		PRN 1002	Continuous Evaluation Supported 8 bits
		PRN 1003	Trip Evaluation Supported 8 bits
	LSB	PRN 1004	Trip Evaluation Complete 8 bits
PKT-32-2	Vehicle Id Number (VIN) #1 (PRN 0021)		
	MSB	PRN F803	Three Byte - Zero Fill 24 bits
	LSB	PRN 100D	MSB of VIN Number 8 bits
PKT-32-3	Date (Dw, DD:MM:YY) (PRN 600D)		
	MSB	PRN 6013	Day of Week (1 - 7) 8 bits
		PRN 6015	Day of Month (DD) - BCD 8 bits
		PRN 6011	Month (MM) - BCD 8 bits
	LSB	PRN 600E	Year (YY) - BCD 8 bits

7.2 Bit Mapped Without Mask (BMP) SLOTS—Bit mapped (BMP) SLOTS are used to encode data that typically contains several binary parameters, such as status bits or flags, grouped into a single byte or several bytes. Bit

mapped SLOTS can also be used for discrete output control such as warning lamps where each bit would indicate the state of a particular lamp. The data in these bit mapped SLOTS is not followed by a MASK byte. There can be up to 4 bytes of data without a mask.

7.2.1 BIT MAPPED WITHOUT MASK PARAMETER ASSIGNMENTS

BMP-01-1 MIL Status (PRN 1000)

Length:	1 bit	0	1
Item 1:	Malfunction Indicator Lamp (MIL)	Not Commanded On	Commanded On

BMP-08-1 Continuous Evaluation Supported (PRN 1002)

Length:	8 bits	0	1
Item 1:	Not Used		
Item 2:	Not Used		
Item 3:	Not Used		
Item 4:	Not Used		
Item 5:	Not Used		
Item 6:	Comprehensive Component Monitoring	Not Supported	Supported
Item 7:	Fuel System Monitoring	Not Supported	Supported
Item 8:	Misfire Monitoring	Not Supported	Supported

BMP-08-2 Trip Evaluation Supported (PRN 1002)

Length:	8 bits	0	1
Item 1:	EGR System	Not Supported	Supported
Item 2:	Oxygen Sensor Heater	Not Supported	Supported
Item 3:	Oxygen Sensor	Not Supported	Supported
Item 4:	A/C System Refrigerant	Not Supported	Supported
Item 5:	Secondary Air System	Not Supported	Supported
Item 6:	Evaporative Purge System	Not Supported	Supported
Item 7:	Heated Catalyst	Not Supported	Supported
Item 8:	Catalyst	NotSupported	Supported

BMP-08-3 Trip Evaluation Complete (PRN 1004)

Length:	8 bits	0	1
Item 1:	EGR System	Test Complete	Test Not Complete
Item 2:	Oxygen Sensor Heater	Test Complete	Test Not Complete
Item 3:	Oxygen Sensor	Test Complete	Test Not Complete
Item 4:	A/C System Refrigerant	Test Complete	Test Not Complete
Item 5:	Secondary Air System	Test Complete	Test Not Complete
Item 6:	Evaporative Purge System	Test Complete	Test Not Complete
Item 7:	Heated Catalyst	Test Complete	Test Not Complete
Item 8:	Catalyst	Test Complete	Test Not Complete

BMP-08-4 Fuel System Status (PRN 1008 & 1009)

Length:	8 bits	0	1
Item 1:	Reserved		
Item 2:	Reserved		
Item 3:	Reserved		
Item 4:	Closed Loop, Faulty O ₂ Sensor	False	True
Item 5:	Open Loop, Detected Fault	False	True
Item 6:	Open Loop, Driving Conditions	False	True
Item 7:	Closed Loop, Using O ₂ Sensor	False	True
Item 8:	Open Loop, Not Ready for Closed	False	True

BMP-08-5 Commanded Secondary Air Status (PRN 0012)

Length:	8 bits	0	1
Item 1:	Reserved		
Item 2:	Reserved		
Item 3:	Reserved		
Item 4:	Reserved		
Item 5:	Reserved		
Item 6:	Atmosphere/Off	Not Supported	Supported
Item 7:	Downstream - First Catalyst	Not Supported	Supported
Item 8:	Upstream - First Catalyst	Not Supported	Supported

BMP-08-6 O₂ Sensor Location (PRN 0013)

Length:	8 bits	0	1
Item 1:	Bank 2 - Sensor 4 (B4 - S2)	Not Present	Present
Item 2:	Bank 2 - Sensor 3 (B4 - S1)	Not Present	Present
Item 3:	Bank 2 - Sensor 2 (B3 - S2)	Not Present	Present
Item 4:	Bank 2 - Sensor 1 (B3 - S1)	Not Present	Present
Item 5:	Bank 1 - Sensor 4 (B2 - S2)	Not Present	Present
Item 6:	Bank 1 - Sensor 3 (B2 - S1)	Not Present	Present
Item 7:	Bank 1 - Sensor 2	Not Present	Present
Item 8:	Bank 1 - Sensor 1	Not Present	Present

BMP-32-1 PIDs Supported 01h - 20h (PRN 0000)

Length:	32 bits	0	1
Byte 1:			
Item 1 - 8:	PID 01h - 08h Supported	Not Supported	Supported
Byte 2:			
Item 9 - 16:	PID 09h - 10h Supported	Not Supported	Supported
Byte 3:			
Item 17 - 24:	PID 11h - 18h Supported	Not Supported	Supported
Byte 4:			
Item 25 - 32:	PID 19h - 20h Supported	Not Supported	Supported

BMP-32-2 PIDs Supported 21h - 40h (PRN 0020)

Length:	32 bits	0	1
Byte 1: Item 1 - 8:	Byte 1: PID 21h - 28h Supported	Not Supported	Supported
Byte 2: Item 9 - 16:	Byte 2: PID 29h - 36h Supported	Not Supported	Supported
Byte 3: Item 17 - 24:	Byte 3: PID 37h - 38h Supported	Not Supported	Supported
Byte 4: Item 25 - 32:	Byte 4: PID 39h - 40h Supported	Not Supported	Supported

BMP-32-3 PIDs Supported 41h - 60h (PRN 0040)

Length:	32 bits	0	1
Byte 1: Item 1 - 8:	PID 41h - 48h Supported	Not Supported	Supported
Byte 2: Item 9 - 16:	PID 49h - 50h Supported	Not Supported	Supported
Byte 3: Item 17 - 24:	PID 51h - 58h Supported	Not Supported	Supported
Byte 4: Item 25 - 32:	PID 59h - 60h Supported	Not Supported	Supported

7.3 Bit Mapped With Mask Bytes (BMM) SLOTS—Bit mapped with mask (BMM) SLOTS are used to encode data that typically contains several binary parameters, such as status bits or flags, grouped into a single byte or several bytes. Bit mapped SLOTS can also be used for discrete output control such as warning lamps where each bit would indicate the state of a particular lamp. The data in these bit mapped SLOTS are always followed by a MASK byte which is used to indicate which bits of the data byte are valid. There can be up to 4 bytes of data including the mask bytes. Valid combinations include up to 2 data bytes each with mask.

7.3.1 BIT MAPPED WITH MASK PARAMETER ASSIGNMENTS—None Defined

7.4 Unsigned Numeric (UNM) SLOTS—Unsigned numeric (UNM) SLOTS are used to encode data that is typically associated with information such as temperature, speed, or percent. The SLOT can be 8, 16, 24, ... 56 bits in length (1 to 7 bytes) and may or may not have an offset. Unsigned numeric SLOTS can also be used for sequential data such as month (1 - 12) or day of month (1 - 31). Each SLOT definition contains a field for: resolution per bit; minimum and maximum value; and transfer function. The transfer function defines the relationship between computer units (N) in decimal, and engineering units (E) of the data.

7.4.1 UNSIGNED NUMERIC VARIABLE ASSIGNMENTS—The unsigned numeric variables have been grouped as follows:

Table 21 - ZEROs SLOT Assignments

Table 22 - UNM-xx, Short (< 8 Bit) SLOTS

- Table 23 - UNM-08, 8 Bit SLOTS
- Table 24 - UNM-16, 16 Bit SLOTS
- Table 25 - UNM-24, 24 Bit SLOTS
- Table 26 - UNM-32, 32 Bit SLOTS Assignments

TABLE 21—ZEROs SLOT ASSIGNMENTS

SLOT #	Description	Length
UNM-01-0	Zero (0)	1 Bit
UNM-02-0	Zero (0)	2 Bits
UNM-03-0	Zero (0)	3 Bits
UNM-04-0	Zero (0)	4 Bits
UNM-05-0	Zero (0)	5 Bits
UNM-06-0	Zero (0)	6 Bits
UNM-07-0	Zero (0)	7 Bits
UNM-08-0	Zero (0)	8 Bits
UNM-16-0	Zero (0)	16 Bits
UNM-24-0	Zero (0)	24 Bits
UNM-32-0	Zero (0)	32 Bits
UNM-48-0	Zero (0)	48 Bits
UNM-56-0	Zero (0)	56 Bits

TABLE 22 - UNM-xx, SHORT (< 8 BIT) SLOTS

SLOT #	Scaling (Resolution; 1 Bit =)	Minimum Unit	Maximum Unit	Invalid Range	Transfer Function N =	Transfer Function E =	Comment
01-1	1	0	1	-	E	N	
02-1	1	0	3	-	E	N	
03-1	1	0	7	-	E	N	
04-1	1	0	15	-	E	N	
05-1	1	0	31	-	E	N	
06-1	1	0	63	-	E	N	
07-1	1	0	127	-	E	N	

TABLE 23 - URM-68, 8 BIT SLOTS

Slot #	Scaling (Resolution; 1 Bit =)	Minimum Limit	Maximum Limit	Invalid Range	Transfer Function N =	Transfer Function E =	Comment
1	1/8000	0	0.001875	-	E * 8000	N / 8000	=0.000125
2	1/4000	0	0.00375	-	E * 4000	N / 4000	=0.00025
3	1/2000	0	0.1275	-	E * 2000	N / 2000	=0.0005
4	1/1000	0	0.255	-	E * 1000	N / 1000	=0.001
5	1/511	0	0.489	-	E * 511	N / 511	=0.001857
6	1/255	0	1	-	E * 255	N / 255	=0.003922
7	1/100	0	+1.27	-	(E+1.28) * 100	(N / 100)	=0.01 w/ offset
11	1/200	0	1.275	-	E * 200	N / 200	=0.005
15	1/100	0	2.55	-	E * 100	N / 100	=0.01
21	1/64	0	3.98	-	E * 64	N / 64	=0.0156
26	1/32	0	7.989	-	E * 32	N / 32	=0.03125
31	1/25	0	10.2	-	E * 25	N / 25	=0.04
33	1/16	0	15.84	-	E * 16	N / 16	=0.0625
41	1/10	0	25.5	-	E * 10	N / 10	=0.1
51	1/4	0	63.75	-	E * 4	N / 4	=0.25
55	1/3	0	85	-	E * 3	N / 3	=0.333333
61	100/255	0	100	-	E * 2.55	N / 2.55	=0.39215
71	1/2	0	127.5	-	E * 2	N / 2	=0.5
72	1/2	-64	+63.5	-	(E+64) * 2	(N / 2)	=0.5 w/ offset
73	1/2	-40	+37.5	-	(E+40) * 2	(N / 2)	=0.5 w/ offset
76	2/3	0	170	-	E * 1.5	N / 1.5	=0.666667
77	2/3	0	100	100.3 to 170	E * 1.5	N / 1.5	=0.666667 w/ limits
81	3/4	0	191.25	-	E / 0.75	N * 0.75	=0.75
82	3/4	-90	+90	90.75 (F1h - FFh)	(E+90) / 0.75	(N*0.75) -90	=0.75 w/ offset
91	100/128	0	199.22	-	E * 1.28	N / 1.28	=0.78125
92	100/128	-100	+99.22	-	(E+100) * 1.28	(N / 1.28) -100	=0.78125 w/ Offset
101	1	0	255	-	E	N	=1
102	1	-40	+315	-	E + 40	N - 40	=1 w/ Offset
104	1	-128	+127	-	E + 128	N - 128	=1 w/ Offset
111	3/2	0 (00h)	360 (F0h)	361.5 (F1h - FFh)	E / 1.5	N * 1.5	-
121	2	0	510	-	E / 2	N * 2	-
125	5/2	0	837.5	-	E * 2 / 5	N * 5 / 2	-
131	3	0	765	-	E / 3	N * 3	-
141	4	0	1020	-	E / 4	N * 4	-
151	5	0	1040	-	E / 5	N * 5	-
155	10	0	2550	-	E / 10	N * 10	-
159	14	0	3570	-	E / 14	N * 14	-
161	16	0	4080	-	E / 16	N * 16	-
165	25	0	6375	-	E / 25	N * 25	-
171	32	0	8160	-	E / 32	N * 32	-
181	64	0	16320	-	E / 64	N * 64	-
193	100	0	25500	-	E / 100	N * 100	-
191	128	0	32640	-	E / 128	N * 128	-
201	256	0	65280	-	E / 256	N * 256	-
211	512	0	130560	-	E / 512	N * 512	-
221	1024	0	261120	-	E / 1024	N * 1024	-
231	2048	0	522240	-	E / 2048	N * 2048	-
241	4096	0	1044480	-	E / 4096	N * 4096	-

TABLE 24 - URM-16, 16 BIT SLOTS

Slot #	Scaling (Resolution; 1 Bit =)	Minimum Limit	Maximum Limit	Invalid Range	Transfer Function N =	Transfer Function E =	Comment
2	1/256	0	255.99	-	E * 256	N / 256	=0.003906
3	1/256	-70	185.99	-	(E + 70) * 256	(N / 256) - 70	=0.003906 w/ offset
5	1/128	0	511.99	-	E * 128	N / 128	=0.007813
8	1/64	0	1023.984	-	E * 64	N / 64	=0.015625
11	1/32	0	2047.95	-	E * 32	N / 32	=0.03125
21	1/16	0	4095.9	-	E * 16	N / 16	=0.0625
31	1/8	0	8191.8	-	E * 8	N / 8	=0.125
41	1	0	16383.6	-	E	N	-

TABLE 25--UNM-24, 24 BIT SLOTS

Slot #	Scaling (Resolution: 1 Bit =)	Minimum Limit	Maximum Limit	Invalid Range	Transfer Function N =	Transfer Function E =	Comment
11	1/10	0	1077721.5	-	E * 10	N / 10	<0.1
21	125/8000	0	266435.44	-	(E/125) * 8000	(N * 125) / 8000	<0.016
31	125/4000	0	536870.88	-	(E/125) * 4000	(N * 125) / 4000	<0.032
41	1/64	0	262143.98	-	E * 64	N / 64	<0.01563

TABLE 26--UNM-32, 32 BIT SLOTS

Slot #	Scaling (Resolution: 1 Bit =)	Minimum Limit	Maximum Limit	Invalid Range	Transfer Function N =	Transfer Function E =	Comment
11	1/8000	0	336870.9	-	E * 8000	N / 8000	<0.000125
21	1/4000	0	1073741.8	-	E * 4000	N / 4000	<0.00025
31	1/64	0	6710884	-	E * 64	N / 64	<0.01563

7.5 2's Complement Signed Numeric (SNM) SLOTS—Signed numeric (SNM) SLOTS are represented in 2's complement notation. If the most significant bit of the number is set (one, 1), then the number is negative and the absolute value of the number is found by taking the 2's complement of the number. The 2's complement is found by inverting each bit of the number and

then adding a binary one (1) to the result. For example, the number FFh, which has its most significant bit set, corresponds to -1.

7.5.1 2'S COMPLEMENT SIGNED NUMERIC VARIABLE ASSIGNMENTS—The 2's complement signed numeric variables are grouped as follows:

Table 27 - SNM-08, 8 Bit SLOTS

TABLE 27--SNM-08, 8 BIT SLOTS

Slot #	Scaling (Resolution: 1 Bit =)	Minimum Limit	Maximum Limit	Invalid Range	Transfer Function N =	Transfer Function E =	Comment
11	1/2	-64	+63.5	-	E * 2	N / 2	<0.5
21	1	-128	+127	-	E	N	-
41	4	-512	+508	-	E / 4	N * 4	-
61	32	-192	+190.5	-	E * 28	N * 32	-
61	6	-768	+762	-	E / 6	N * 6	-

7.6 State Encoded (SED) SLOTS—State encoded (SED) SLOTS are used for data that can take one of several states such as Day of Week or Wiper Mode. Each SLOT definition contains a field for describing each state within the SLOT. There can be between 1 and 8 bits in any given SLOT with ⁿ2 possible states where n is the number of bits in the SLOT.

7.6.1 STATE ENCODED VARIABLE ASSIGNMENTS

SED-02-1 Sub-System Category Reference Letter (PRN 1005)

Length: 2 bits (0 - 3)

- 0 "P" = Powertrain
- 1 "C" = Chassis
- 2 "B" = Body
- 3 "U" = Undefined

SED-02-2 Most Significant Digit of Trouble Code (PRN 1006)

Length: 2 bits (0 - 3)

- 0 "0"
- 1 "1"
- 2 "2"
- 3 "3"

SED-02-3 Transmission Lock-up Status (PRN 1907)

Length: 2 bits (0 - 3)

- 0 Unlocked
- 1 Partial Lock
- 2 Full Lock
- 3 Invalid

SED-04-1 Day of the Week (PRN 6012)

Length: 4 bits (0 - F)

- 0 Unknown
- 1 Sunday
- 2 Monday
- 3 Tuesday
- 4 Wednesday
- 5 Thursday
- 6 Friday
- 7 Saturday
- 8 - F Invalid

SED-04-2 Month (PRN 6010)

Length: 4 bits (0 - F)

- 0 Unknown
- 1 January
- 2 February
- 3 March
- 4 April
- 5 May
- 6 June
- 7 July
- 8 August
- 9 September
- A October
- B November
- C December

D - F Invalid

SED-06-1 Transmission Gear Engaged (PRN 1808)

Length: 6 bits (00 - 3F)
 00 Neutral
 01 Reverse
 02 Forward 1
 04 Forward 2
 08 Forward 3
 10 Forward 4
 20 Forward 5
 Others Invalid

SED-08-1 Wiper Mode (PRN A003)

Length: 8 bits (00 - FF)
 00 Invalid
 01 OFF
 02 Intermittent
 03 Low Speed
 04 Medium Speed
 05 High Speed
 06 Pulse
 07 - FF Invalid

SED-08-2 Day of the Week (PRN 6013)

Length: 8 bits (00 - FF)
 00 Unknown
 01 Sunday
 02 Monday
 03 Tuesday
 04 Wednesday
 05 Thursday
 06 Friday
 07 Saturday
 08 - FF Invalid

SED-08-3 Day of Month (PRN 6014)

Length: 8 bits (00 - FF)
 00 Invalid
 01 1st
 02 2nd
 03 3rd
 04 4th
 05 5th
 06 6th
 07 7th
 08 8th
 09 9th
 0A 10th
 0B 11th
 0C 12th
 0D 13th
 0E 14th
 0F 15th
 10 16th
 11 17th
 12 18th
 13 19th
 14 20th
 15 21st
 16 22nd
 17 23rd
 18 24th
 19 25th
 1A 26th
 1B 27th
 1C 28th
 1D 29th
 1E 30th
 1F 31st
 20 - FF Invalid

SED-08-4 Transmission Range (PRN 1806, 1809, 180D, & 180E)

Length: 8 bits (00 - FF)
 00 Invalid
 01 Reverse
 02 Forward 1
 04 Forward 2
 08 Forward 3
 10 Forward 4
 30 Forward 5
 40 Forward 6/Park
 80 Neutral
 Others Invalid

SED-08-5 Ignition Switch Position (PRN 1047)

Length: 8 bits (00 - FF)
 00 Invalid
 01 ACC
 02 OFF/LOCK
 04 OFF/UNLOCK
 08 RUN
 10 START
 Others Invalid

SED-08-6 Transmission Transfer Case (4WD) (PRN 180A)

Length: 8 bits (00 - FF)
 00 Invalid
 01 Neutral
 02 Two Wheel Drive
 03 Four Wheel Drive - Low
 04 Four Wheel Drive - High
 05 - FF Invalid

SED-08-07 Door Lock Cylinder State (PRN C002)

Length: 8 bits (00 - FF)
 00 Key Out
 01 Key in Lock Position
 02 Key in Unlock Position
 03 - FF Invalid

7.7 ASCII Encoded (ASC) SLOTS—ASCII (ASC) SLOTS are used to encode ASCII data. The least significant 7 bits represent the standard ASCII codes from 0 to 127. The most significant bit is reserved at this time but may be assigned a special function in the future. Several ASCII characters can be included in a single message by placing up to 7 ASCII characters sequentially in the data field. This allows a character string of up to 7 characters to be sent in a single message.

The ASCII character set is included in Table 27.

7.7.1 ASCII ENCODED VARIABLE ASSIGNMENTS

ASC-08-1 One ASCII Character
 Length: 8 bits
 Byte 1: One ASCII Character

ASC-16-1 Two ASCII Characters
 Length: 16 bits
 Byte 1: Left Most Character
 Byte 2: Right Most Character

ASC-24-1 Three ASCII Characters
 Length: 24 bits
 Byte 1: Left Most Character
 Byte 2: Middle Character
 Byte 3: Right Most Character

ASC-32-1 Four ASCII Characters
 Length: 32 bits
 Byte 1: Left Most Character
 Byte 2: Middle Left Character
 Byte 3: Middle Right Character
 Byte 4: Right Most Character

ASC-40-1 Five ASCII Characters
 Length: 40 bits
 Byte 1: Left Most Character
 Byte 2: Middle Left Character
 Byte 3: Middle Character
 Byte 4: Middle Right Character
 Byte 5: Right Most Character

ASC-48-1 Six ASCII Characters
 Length: 48 bits
 Byte 1: Left Most Character
 Byte 2: Middle Left Character
 Byte 3: Middle Middle Left Character
 Byte 4: Middle Middle Right Character
 Byte 5: Middle Right Character
 Byte 6: Right Most Character

ASC-56-1 Seven ASCII Characters
 Length: 56 bits
 Byte 1: Left Most Character
 Byte 2: Middle Left Character
 Byte 3: Middle Middle Left Character
 Byte 4: Middle Character
 Byte 5: Middle Middle Right Character
 Byte 6: Middle Right Character
 Byte 7: Right Most Character

7.7.2 ASCII Character Set—The conversion chart, Table 28, can be used to convert from a two-digit (one byte) hexadecimal number to an ASCII character or from an ASCII character to a two-digit hexadecimal number.

TABLE 28—ASCII CONVERSION CHART

Bits 4 to 6 First Hex Digit (MSB)								
Bits 0 to 3 (LSB)	0	1	2	3	4	5	6	7
0	NUL	DLE	SP	0	@	P	.	8
1	SOH	DC1	!	1	A	Q	/	9
2	STX	DC2	"	2	B	R	b	:
3	ETX	DC3	#	3	C	S	c	;
4	EOY	DC4	\$	4	D	T	d	<
5	ENQ	NAR	%	5	E	U	e	=
6	ACK	SYN	&	6	F	V	f	>
7	BEL	ETB	'	7	G	W	g	?
8	BS	CAN	(	8	H	X	h	@
9	HT	EM	)	9	I	Y	i	A
A	LF	SUB	*	:	J	Z	j	B
B	VT	ESC	+	;	K	[	k	C
C	FF	FS	,	<	L	\	l	D
D	CR	GS	=	=	M	]	m	E
E	SO	RS	_	>	N	^	n	F
F	SI	US	?	?	O	_	o	GEL

7.8 Binary Coded Decimal (BCD) SLOTS—BCD SLOTS are similar to ASCII SLOTS and are used to encode BCD data. The upper nibble is used to represent the most significant digit in a two-digit number and the lower nibble the least significant digit. For example, the data value 38h would represent 38 decimal. Invalid data ranges include any value that has either nibble greater than 9 (i.e., A, B, ..., F in either nibble). Therefore, a valid value can represent a number from 0 to 9. Several BCD numbers can be included in a single message by placing up to 14 BCD digits sequentially in the data field. This allows any number from 0 to 99,999,999,999,999 to be sent in a single message.

7.8.1 Binary Coded Decimal (BCD) Variable Assignments

BCD-04-1 1 digit
 Length: 4 bits
 Scaling (Resolution): 1 bit = 1 (BCD)
 Limit:
 Minimum: 0
 Maximum: 9

BCD-08-1 2 digits
 Length: 8 bits
 Scaling (Resolution): 1 bit = 1 (BCD)

Limit:
 Minimum: 00
 Maximum: 99

BCD-12-1 3 digits
 Length: 12 bits
 Scaling (Resolution): 1 bit = 1 (BCD)
 Limit:
 Minimum: 000
 Maximum: 999

BCD-16-1 4 digits
 Length: 16 bits
 Scaling (Resolution): 1 bit = 1 (BCD)
 Limit:
 Minimum: 0000
 Maximum: 9999

BCD-20-1 5 digits
 Length: 20 bits
 Scaling (Resolution): 1 bit = 1 (BCD)
 Limit:
 Minimum: 00000
 Maximum: 99999

BCD-24-1 6 digits
 Length: 24 bits
 Scaling (Resolution): 1 bit = 1 (BCD)
 Limit:
 Minimum: 000000
 Maximum: 999999

BCD-28-1 7 digits
 Length: 28 bits
 Scaling (Resolution): 1 bit = 1 (BCD)
 Limit:
 Minimum: 0000000
 Maximum: 9999999

BCD-32-1 8 digits
 Length: 32 bits
 Scaling (Resolution): 1 bit = 1 (BCD)
 Limit:
 Minimum: 00000000
 Maximum: 99999999

BCD-36-1 9 digits
 Length: 36 bits
 Scaling (Resolution): 1 bit = 1 (BCD)
 Limit:
 Minimum: 000000000
 Maximum: 999999999

BCD-40-1 10 digits
 Length: 40 bits
 Scaling (Resolution): 1 bit = 1 (BCD)
 Limit:
 Minimum: 0000000000
 Maximum: 9999999999

BCD-44-1 11 digits
 Length: 44 bits
 Scaling (Resolution): 1 bit = 1 (BCD)
 Limit:
 Minimum: 00000000000
 Maximum: 99999999999

BCD-48-1 12 digits
 Length: 48 bits
 Scaling (Resolution): 1 bit = 1 (BCD)
 Limit:
 Minimum: 000000000000
 Maximum: 999999999999

BCD-52-1 13 digits
 Length: 52 bits
 Scaling (Resolution): 1 bit = 1 (BCD)
 Limit:
 Minimum: 0000000000000
 Maximum: 9999999999999

BCD-56-1 14 digits
 Length: 56 bits
 Scaling (Resolution): 1 bit = 1 (BCD)
 Limit:
 Minimum: 00000000000000
 Maximum: 99999999999999

7.9 Signed Floating Point (Scientific Notation) (SFP) SLOT—The Signed Floating Point (SFP) SLOT is used to encode data that needs to be represented in floating point arithmetic, and always includes a leading sign character. The format exactly follows the ANSI/IEEE Standard (Std 754-1985) Single format. Please note that the data byte boundaries of the transmitted frame do not align with the boundaries of this format. The floating point parameter is sent as a 32 bit (4 byte) variable. The bit order is shown in Figure 14.

7.9.1 SIGNED FLOATING POINT VARIABLE ASSIGNMENT

SFP-32-1

Floating Point

	1 bit	8 bits	23 bits	
...	Sign Bit	Exponent	Fractional Part	...
	MSB			LSB

FIGURE 14—SIGNED FLOATING POINT (SCIENTIFIC NOTATION) (SFP) SLOT

8. Multiple Frame, Single Parameter Format—This section defines the method of encoding long parameters that require more than one frame to complete. The first data byte for this format is a sequence number as shown in Figure 15. The sequence byte consists of an upper nibble that identifies this frame by number in the sequence. The lower nibble is the total number of frames that make up this grouping. The sequence byte is followed by up to the maximum number of data bytes allowed by SAE J1850, for each frame. The entire parameter is thus built up from the total number of frames shown in the sequence tracking byte, in the order carried in that byte. The data field format will thus have an order indicated by Figure 16.

A simple example of this format is shown in Figures 17, 18, and 19, sending an ASCII string of characters.

	MSB			LSB
...	Frame # (4 bits)	# of Frames (4 bits)		...

FIGURE 15—SEQUENCE TRACKING BYTE

...	Sequence Byte	Data Byte 1	Data Byte 2	Data Byte 3	...
-----	------------------	-------------	-------------	-------------	-----

FIGURE 16—MULTIPLE FRAME, SINGLE PARAMETER FIELD

...	Sequence 1 of 3	54h T	68h h	65h e	20h SP	51h O	75h u	69h l	...
-----	--------------------	----------	----------	----------	-----------	----------	----------	----------	-----

FIGURE 17—FIRST SEQUENCE FRAME

...	Sequence 2 of 3	63h c	68h k	20h SP	42h B	72h r	6Fh o	77h w	...
-----	--------------------	----------	----------	-----------	----------	----------	----------	----------	-----

FIGURE 18—SECOND SEQUENCE FRAME

...	Sequence 3 of 3	6Eh n	20h SP	54h T	72h r	6Fh o	75h u	74h t	...
-----	--------------------	----------	-----------	----------	----------	----------	----------	----------	-----

FIGURE 19—LAST SEQUENCE FRAME

SURFACE VEHICLE RECOMMENDED PRACTICE

Submitted for recognition as an American National Standard

SAE J2178/3

Issued 1993-09-07

CLASS B DATA COMMUNICATION NETWORK MESSAGES—PART 3 FRAME IDs FOR SINGLE BYTE FORMS OF HEADERS

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1. **Scope**—This SAE Recommended Practice defines the information contained in the header and data fields of nondiagnostic messages for automotive serial communications based on SAE J1850 Class B networks. This document describes and specifies the header fields, data fields, field sizes, scaling, representations, and data positions used within messages.

The general structure of a SAE J1850 message frame without in-frame response is shown in Figure 1. The structure of a SAE J1850 message with in-frame response is shown in Figure 2. Figures 1 and 2 also show the scope of frame fields defined by this document for nondiagnostic messages. Refer to SAE J1979 for specifications of emissions-related diagnostic message header and data fields. Refer to SAE J2190 for the definition of other diagnostic message header and data fields. The description of the network interface hardware, basic protocol definition, the electrical specifications, and the CRC field are given in SAE J1850.

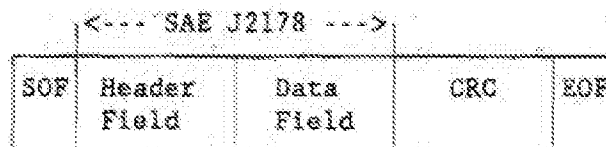


FIGURE 1—SCOPE OF SAE J2178 FOR A SAE J1850 FRAME WITHOUT IN-FRAME RESPONSE

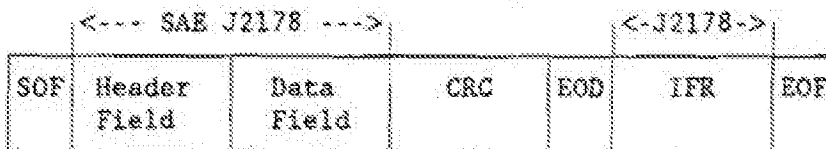


FIGURE 2—SCOPE OF SAE J2178 FOR A SAE J1850 FRAME WITH IN-FRAME RESPONSE (IFR)

SAE J1850 defines two and only two formats of message headers. They are the Single Byte header format and the Consolidated header format. The consolidated header format has two forms: a single byte form and a three byte form. This document covers all of these formats and forms to identify the contents of messages which could be sent on a SAE J1850 network.

This document consists of four parts, each published separately.

Part 1 of SAE J2178 (Titled: Detailed Header Formats and Physical Address Assignments) describes the two allowed forms of message header formats: single byte and consolidated. It also contains the physical node address range assignments for the typical subsystems of an automobile.

Part 2 of SAE J2178 (Titled: Data Parameter Definitions) defines the standard parametric data which may be exchanged on SAE J1850 (Class B) networks. The parameter scaling, ranges, and transfer functions are specified. Messages which refer to these parametric definitions shall always adhere to these parametric definitions. It is intended that at least one of the definitions for each parameter in this part match the SAE J1979 definition. The details of this part are fully described in 3.1.

Part 3 of SAE J2178 (this part, Titled: Frame IDs for Single Byte Forms of Headers) defines the message assignments for the single byte header format and the one byte form of the consolidated header format.

Part 4 of SAE J2178 (Titled: Target Address (Second Byte) for Three Byte Headers) defines the message assignments for the second byte in the three byte form of the consolidated header format.

- 1.1 Standardized Parameter Definitions**—The parameters used to describe data variables are one of the most important functions of this document. To achieve commonality of messages in Class B networks, the data parameters must become standardized. This applies to data parameter definitions for use during normal vehicle operations as well as during diagnostic operations. By using common parameter definitions for nondiagnostic and diagnostic functions on the network, the modules which form the network can maintain one image or description of a data parameter.

Where parameters have been defined in the Diagnostic Test Modes documents (SAE J1979 and J2190), such as Parameter Identifiers for diagnostic purposes, the definitions in Part 2 of this document match the diagnostic definition.

SAE J2178, Part 2 defines the parameters to be used for nondiagnostic and diagnostic data format definitions. For new parameter definitions which are needed in the future, the new definitions, if they are expected to become widely used, must be integrated into this document for commonality across these types of applications. Of course, manufacturers are free to assign their own definitions to data parameters which are unique or proprietary to their products. They are, however, restricted to using the "Manufacturer Reserved" message header assignments in Parts 3 and 4 of this document when using these unique or proprietary data parameter definitions.

2. References

- 2.1 Applicable Documents**—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

SAE J1850—Class B Data Communication Network Interface
 SAE J1979—E/E Diagnostic Test Modes
 SAE J2178/1—Detailed Header Formats and Physical Address Assignments
 SAE J2178/2—Data Parameter Definitions
 SAE J2178/4—Target Address (Second Byte) for Three Byte Headers (Draft)
 SAE J2190—Enhanced E/E Diagnostic Test Modes

- 2.2 Related Publications**—The following publications are provided for information purposes only and are not a required part of this document.

SAE J1213/1—Glossary of Vehicle Networks for Multiplex and Data Communication
 SAE J1930—Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms

2.3 Terms and Definitions

- 2.3.1 DATA [DATA FIELD]**—Data and data field are used interchangeably in this document and they both refer to a field within a frame that may include bytes with parameters pertaining to the message and/or secondary ID and/or extended addresses and/or test modes which further defines a particular message content being exchanged over the network.

- 2.3.2 **FRAME**—A frame is one complete transmission of information which may or may not include an In-Frame Response. The frame is enclosed by the start of frame and end of frame symbols. For Class B networks, each frame contains one and only one message (see "message" 2.3.5).
- 2.3.3 **HEADER [HEADER FIELD]**—The header (or header field, used interchangeably) is a one or three byte field within a frame which contains information about the message priority, message source and target addressing, message type, and in-frame response type.
- 2.3.4 **IN-FRAME RESPONSE (IFR) TYPE**—The IFR type identifies the form of the in-frame response which is expected within that message.
- 2.3.5 **MESSAGE**—A message consists of all of the bytes of a frame excluding the delimiter symbols (SOF, EOD, EOF, NB).
- 2.3.6 **PARAMETER**—A parameter is the variable quantity included in some messages. The parameter value, scaling, offset, units, transfer function, etc., are unique to each particular message. (The assigned parameters are contained herein.)
- 2.3.7 **PRIORITY**—The priority describes the rank order and precedence of a message. Based upon the SAE J1850, Class B arbitration process, the message with the highest priority will win arbitration.
- 2.3.8 **RESPONSE DATA**—The response data is the information from a node on the network in response to a request from another node on the network. This may be an in-frame response or a report type of message.

2.4 Abbreviations and Acronyms

CRC - Cyclic Redundancy Check
 EOD - End of Data
 EOF - End of Frame
 ID - Identifier
 IFR - In-Frame Response
 LSB - Least Significant Bit / Byte
 MSB - Most Significant Bit / Byte
 NB - Normalization Bit
 PKT - Multiple Parameter Packet SLOT
 PRN - Parameter Reference Number
 SLOT - Scaling, Limit, Offset, and Transfer Function
 SOF - Start of Frame

3. General Information

- 3.1 **Document Overview**—The messages defined by this document are specified for networks using one byte headers or the single byte form of the consolidated header as specified in SAE J1850. This document focuses on the Frame ID which is the first byte of the message. The first byte of the one byte header is defined in Section 4 under Frame ID as an 8 Bit hexadecimal number and the first byte of the single byte form of the consolidated header is defined under 7 Bit as a hexadecimal number. Bit four (H bit) of the 7 Bit header is always a logic "1" (see Section 5 of SAE J2178 Part 1). The information in the header field implicitly defines the target, source, priority and message type information, while the data field contains additional addressing and parametric information (see Section 4 of SAE J2178 Part 1). The header defines the Message Identifier or Frame ID and becomes the name that is broadcast normally periodically to all the nodes on the network.

This document describes the overall structure of messages and is expected to have wide application. Designers are required to use the defined messages on SAE J1850 networks in the exact way that they are defined here. There are a large number of message codes which are reserved for each manufacturer to define. If the user cannot find a needed message, he or she is expected to define a manufacturer-specific message in these reserved codes. Therefore, messages on different manufacturer's products using these "Manufacturer Reserved" codes will only have meaning for that manufacturer or specific vehicle. These will most likely be different between manufacturers. The codes that are defined here, however, shall always carry the same meaning from one manufacturer to another and from one model and year to the next.

3.2 Parameter Reference Number (PRN)—With the Single Byte form of header, the Frame ID corresponds with a particular Parameter Reference Number (PRN) or a grouping of PRNs (see Section 6 of SAE J2178 Part 2). The PRN is an arbitrarily assigned number and defines the following:

- a. Length of data in number of bits
- b. Units
- c. Scaling, Limit, Offset, and Transfer Function, i.e., SLOT (see Section 7 of SAE J2178 Part 2)
- d. Type or category of data

SAE J2178 Part 2, Section 7 defines the following data Types:

- (1) BMP Bit Mapped
- (2) UNM Unsigned Numeric
- (3) SNM 2's Complement Signed Numeric
- (4) SED State Encoded
- (5) ASC ASCII Encoded
- (6) BCD Binary Coded Decimal
- (7) SFP Signed Floating Point (Scientific Notation)

3.3 Message Identification (FRAME ID)—The FRAME ID of the single byte header implicitly and uniquely defines the following characteristics of the message:

- a. The message priority
- b. The data content of the message specified by a PRN or packet of PRNs
- c. The length of message
- d. Source of the message
- e. Type of the message
- f. The event or repetition rate for transmission
- g. CRC byte requirements

3.3.1 PRN ASSIGNMENTS—A FRAME ID shall have one or more PRNs assigned to it. Some PRNs may be composed of a packet (PKT) of PRNs (see paragraph 7.1 of SAE J2178 Part 2). The bytes of the data field shall be composed of the parameter given in the "PRNs" column of the figure defined in Section 4. When more than one PRN is shown, the data field shall contain the PRNs in the order given left to right.

3.3.2 IN-FRAME RESPONSE (IFR) TYPE—The IFR Type shall be given under "IFR Type" column of the figure defined in Section 4. The different IFR Types are defined in Section 3 of J2178 Part 1.

3.3.3 REPETITION RATE—The vehicle manufacturer shall choose which message frames are event driven or defined by a repetition rate. Refer to SAE J2178 Part 1 Appendix A for further information on event- or time-based message frames.

3.3.4 CRC BYTE REQUIREMENTS—The CRC byte requirements shall be defined by the manufacturer as specified by SAE J1850.

4. *Frame IDs for Single Byte Forms of Headers*—Figure 3 defines the Frame ID for one byte headers and the first byte of the single byte form of the consolidated header.

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FRAME ID				
7 Bit	8 Bit	IFR Type	Function	PRNs
10	00		Reserved - SAE	
	01		Reserved - SAE	
11	02		Reserved - Mfg.	
	03		Reserved - Mfg.	
12	04		Reserved - Mfg.	
	05		Reserved - Mfg.	
13	06		Reserved - Mfg.	
	07		Reserved - Mfg.	
14	08		Reserved - SAE	
	09		Reserved - SAE	
15	0A		Reserved - Mfg.	
	0B		Reserved - Mfg.	
16	0C		Reserved - Mfg.	
	0D		Reserved - Mfg.	
17	0E		Reserved - Mfg.	
	0F		Reserved - Mfg.	
18	10		Reserved - SAE	
	11		Reserved - SAE	
19	12		Reserved - Mfg.	
	13		Reserved - Mfg.	
1A	14		Reserved - Mfg.	
	15		Reserved - Mfg.	
1B	16		Reserved - Mfg.	
	17		Reserved - Mfg.	
1C	18		Reserved - SAE	
	19		Reserved - SAE	
1D	1A		Reserved - Mfg.	
	1B		Reserved - Mfg.	

FIGURE 3—FRAME IDs FOR SINGLE BYTE FORMS OF HEADERS

FRAME ID		IFR Type	Function	PRNs
7 Bit	8 Bit			
1E	1C		Reserved - SAE	
	1D		Reserved - SAE	
1F	1E		Reserved - Mfg.	
	1F		Reserved - Mfg.	
30	20	0	Injector Time & Dist.	1015, 601B
	21		Reserved - SAE	
31	22		Reserved - Mfg.	
	23		Reserved - Mfg.	
32	24	0	Vehicle Speed	601E, 000D
	25		Reserved - Mfg.	
33	26	0	Engine RPM & MAP	1022, 000B
	27		Reserved - Mfg.	
34	28		Reserved - SAE	
	29		Reserved - SAE	
35	2A	0	Barometric Pressure	1025
	2B		Reserved - Mfg.	
36	2C	0	Sys. Volts & Coolant Temperature	600A, 103C
	2D		Reserved - Mfg.	
37	2E		Reserved - Mfg.	
	2F		Reserved - Mfg.	
38	30		Reserved - SAE	
	31		Reserved - SAE	
39	32		Reserved - Mfg.	
	33		Reserved - Mfg.	
3A	34		Reserved - Mfg.	
	35		Reserved - Mfg.	
3B	36		Reserved - Mfg.	

FIGURE 3—FRAME IDs FOR SINGLE BYTE FORMS OF HEADERS (CONTINUED)

FRAME ID		IFR Type	Function	PRNs
7 Bit	8 Bit			
	37		Reserved - Mfg.	
3C	38		Reserved - SAE	
	39		Reserved - SAE	
3D	3A	0	Transmission Gear & Lock-up Status	1805
	3B		Reserved - Mfg.	
3E	3C	0	Throttle Position	0011
	3D		Reserved - Mfg.	
3F	3E		Reserved - Mfg.	
	3F		Reserved - Mfg.	
50	40	0	Transmission Range	1809
	41		Reserved Diagnostic Report	
51	42		Reserved - SAE	
	43		Reserved - SAE	
52	44		Reserved - Mfg.	
	45		Reserved - Mfg.	
53	46		Reserved - Mfg.	
	47		Reserved - Mfg.	
54	48	0	Leg. Diagnostic Report	Per SAE J1979
	49		Reserved - SAE	
55	4A		Reserved - SAE	
	4B		Reserved - SAE	
56	4C		Reserved - Mfg.	
	4D		Reserved - Mfg.	
57	4E		Reserved - Mfg.	
	4F		Reserved - Mfg.	
58	50		Reserved - SAE	
	51		Reserved - SAE	
59	52		Reserved - Mfg.	

FIGURE 3—FRAME IDs FOR SINGLE BYTE FORMS OF HEADERS (CONTINUED)

FRAME ID				
7 Bit	8 Bit	IFR Type	Function	PRNs
	53		Reserved - Mfg.	
5A	54		Reserved - Mfg.	
	55		Reserved - Mfg.	
5B	56		Reserved - Mfg.	
	57		Reserved - Mfg.	
5C	58		Reserved - SAE	
	59		Reserved - SAE	
5D	5A		Reserved - Mfg.	
	5B		Reserved - Mfg.	
5E	5C		Reserved - Mfg.	
	5D		Reserved - Mfg.	
5F	5E	0	Set Time	6030
	5F		Reserved - Mfg.	
70	60	0	Set Date	6023
	61		Reserved Diagnostic Request	
71	62		Reserved - Mfg.	
	63		Reserved - Mfg.	
72	64		Reserved - Mfg.	
	65		Reserved - Mfg.	
73	66		Reserved - SAE	
	67		Reserved - SAE	
74	68	0	Leg. Diagnostic Req.	Per SAE J1979
	69		Reserved - SAE	
75	6A		Reserved - Mfg.	
	6B		Reserved - Mfg.	
76	6C		Reserved - Mfg.	
	6D		Reserved - Mfg.	
77	6E		Reserved - Mfg.	

FIGURE 3—FRAME IDs FOR SINGLE BYTE FORMS OF HEADERS (CONTINUED)

FRAME ID		IFR Type	Function	PRNs
7 Bit	8 Bit			
	6F		Reserved - Mfg.	
78	70		Reserved - SAE	
	71		Reserved - SAE	
79	72	0	Vehicle Odometer	6031
	73		Reserved - Mfg.	
7A	74	0	Trip Odometer 1	6032
	75		Reserved - Mfg.	
7B	76	0	Trip Odometer 2	6032
	77		Reserved - Mfg.	
7C	78	0	Trip Odometer 3	6032
	79		Reserved - SAE	
7D	7A		Reserved - Mfg.	
	7B		Reserved - Mfg.	
7E	7C		Reserved - Mfg.	
	7D		Reserved - Mfg.	
7F	7E	0	Display Brightness Level	6028
	7F		Reserved - Mfg.	
90	80	0	Current Time	6030
	81		Reserved - SAE	
91	82	0	Oil Pressure	102F
	83		Reserved - Mfg.	
92	84		Reserved - SAE	
	85		Reserved - Mfg.	
93	86		Reserved - Mfg.	
	87		Reserved - Mfg.	
94	88		Reserved - Mfg.	
	89		Reserved - SAE	
95	8A		Reserved - SAE	

FIGURE 3—FRAME IDs FOR SINGLE BYTE FORMS OF HEADERS (CONTINUED)

FRAME ID				
7 Bit	8 Bit	IFR Type	Function	PRNs
	8B		Reserved - Mfg	
96	8C		Reserved - Mfg.	
	8D		Reserved - Mfg.	
97	8E		Reserved - Mfg.	
	8F		Reserved - Mfg.	
98	90	0	Fuel Economy, Present	6021, 6020
	91		Reserved - Mfg.	
99	92	0	Current Date	6023
	93		Reserved - Mfg.	
9A	94	0	Ign. Off Time	602C
	95		Reserved - Mfg.	
9B	96		Reserved - SAE	
	97		Reserved - SAE	
9C	98		Reserved - Mfg.	
	99		Reserved - Mfg.	
9D	9A	0	Accum. Ign. On Time	6025
	9B		Reserved - Mfg.	
9E	9C		Reserved - SAE	
	9D		Reserved - Mfg.	
9F	9E	0	Fuel Consumed	6026
	9F		Reserved - Mfg.	
B0	A0	0	Distance to Empty	6027
	A1		Reserved - SAE	
B1	A2	0	Fuel Economy, Average	6029, 6028
	A3		Reserved - Mfg.	
B2	A4	0	Fuel Tank Level	6005
	A5		Reserved - Mfg.	
B3	A6		Reserved - Mfg.	

FIGURE 3—FRAME IDs FOR SINGLE BYTE FORMS OF HEADERS (CONTINUED)

FRAME ID		IFR Type	Function	PRNs
7 Bk	8 Bk			
	A7		Reserved - Mfg.	
B4	A8		Reserved - SAE	
	A9		Reserved - SAE	
B5	AA		Reserved - Mfg.	
	AB		Reserved - Mfg.	
B6	AC		Reserved - Mfg.	
	AD		Reserved - Mfg.	
B7	AE		Reserved - Mfg.	
	AF		Reserved - Mfg.	
B8	B0		Reserved - Mfg.	
	B1		Reserved - Mfg.	
B9	B2		Reserved - SAE	
	B3		Reserved - SAE	
BA	B4		Reserved - Mfg.	
	B5		Reserved - Mfg.	
BB	B6		Reserved - Mfg.	
	B7		Reserved - Mfg.	
BC	B8		Reserved - Mfg.	
	B9		Reserved - Mfg.	
BD	BA		Reserved - Mfg.	
	BB		Reserved - Mfg.	
BE	BC		Reserved - Mfg.	
	BD		Reserved - Mfg.	
BF	BE		Reserved - Mfg.	
	BF		Reserved - Mfg.	
D0	C0		Reserved - SAE	
	C1		Reserved - SAE	
D1	C2		Reserved - Mfg.	

FIGURE 3—FRAME IDs FOR SINGLE BYTE FORMS OF HEADERS (CONTINUED)

FRAME ID				
7 Bit	8 Bit	IFR Type	Function	PRNs
	C3		Reserved - Mfg.	
D2	C4		Reserved - Mfg.	
	C5		Reserved - Mfg.	
D3	C6		Reserved - Mfg.	
	C7		Reserved - Mfg.	
D4	C8		Reserved - Mfg.	
	C9		Reserved - SAE	
D5	CA		Reserved - SAE	
	CB		Reserved - Mfg.	
D6	CC	0	Outside Temperature	602D
	CD		Reserved - Mfg.	
D7	CE		Reserved - Mfg.	
	CF		Reserved - Mfg.	
D8	D0		Reserved - Mfg.	
	D1		Reserved - Mfg.	
D9	D2		Reserved - Mfg.	
	D3		Reserved - Mfg.	
DA	D4		Reserved - Mfg.	
	D5		Reserved - Mfg.	
DB	D6		Reserved - Mfg.	
	D7		Reserved - Mfg.	
DC	D8		Reserved - SAE	
	D9		Reserved - SAE	
DD	DA		Reserved - Mfg.	
	DB		Reserved - Mfg.	
DE	DC		Reserved - Mfg.	
	DD		Reserved - Mfg.	
DF	DE		Reserved - Mfg.	

FIGURE 3—FRAME IDs FOR SINGLE BYTE FORMS OF HEADERS (CONTINUED)

FRAME ID		IFR Type	Function	PRNs
7 Bit	8 Bit			
	DF		Reserved - Mfg.	
F0	E0		Reserved - Mfg.	
	E1		Reserved - SAE	
F1	E2		Reserved - SAE	
	E3		Reserved - Mfg.	
F2	E4		Reserved - Mfg.	
	E5		Reserved - Mfg.	
F3	E6		Reserved - Mfg.	
	E7		Reserved - Mfg.	
F4	E8		Reserved - Mfg.	
	E9		Reserved - SAE	
F5	EA		Reserved - SAE	
	EB		Reserved - Mfg.	
F6	EC		Reserved - Mfg.	
	ED		Reserved - Mfg.	
F7	EE		Reserved - Mfg.	
	EF		Reserved - Mfg.	
F8	F0		Reserved - Mfg.	
	F1		Reserved - Mfg.	
F9	F2		Reserved - Mfg.	
	F3		Reserved - Mfg.	
FA	F4		Reserved - Mfg.	
	F5		Reserved - Mfg.	
FB	F6		Reserved - SAE	
	F7		Reserved - SAE	
FC	F8		Reserved - Mfg.	
	F9		Reserved - Mfg.	
FD	FA		Reserved - Mfg.	

FIGURE 3—FRAME IDs FOR SINGLE BYTE FORMS OF HEADERS (CONTINUED)

FRAME ID				
7 Bit	8 Bit	IFR Type	Function	PRNs
	FB		Reserved - Mfg.	
FE	FC		Reserved - Mfg.	
	FD		Reserved - Mfg.	
FF	FE		Reserved - Mfg.	
	FF		Reserved - Mfg.	

FIGURE 3—FRAME IDs FOR SINGLE BYTE FORMS OF HEADERS (CONTINUED)

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Exhibit H



SAE On-Board Diagnostics for Light and Medium Duty Vehicles Standards Manual

1997 Edition

SAE HS-3000

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Society of Automotive Engineers, Inc.
400 Commonwealth Drive
Warrendale, PA 15096-0001
U.S.A.
Phone: (412) 776-4841
Fax: (412) 776-5760

15096-01-02--041000

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Introduction

The SAE Vehicle E/E Systems Diagnostic Committee (Diagnostics Committee) was formed in June 1987 to address concerns of the automotive manufacturers and the automotive repair industry relating to repair of the increasingly complex electronic systems on new vehicles. The mission of this committee is:

The committee shall increase customer satisfaction and lower product life cycle costs by investigating and recommending "standards" that will promote more effective diagnosis of vehicle electrical and electronic system problems.

The resulting recommended practices will focus on model year 1992 and beyond. However, they may be useful for prior vehicle diagnosis/repair and may serve as a basis for additional recommended practices to pre-model year 1992 vehicles.

The committee adopted a "Vision of the Future" in July 1988. This vision, which has received very minor modifications, is:

A standard diagnostic connector (in a standard location) will be in all vehicles. Pin assignments for a portion of the connector will be also standardized.

All vehicles will implement a set of industry standard diagnostic test modes that can be executed over a standard communication data link (i.e., SAE J1850, ISO 9141-2). Industry standard test information will be associated with some of these diagnostic test modes.

An OBD II "scan" tool will be able to utilize a minimum set of standardized diagnostic test modes and test information.

A system will be in place that will allow standard "electronic" access of all E/E diagnostic service information.

Future "diagnostic" legislation will be in harmony with this vision and the resulting SAE recommended practices.

The Diagnostics Committee originally combined the needs of the repair industry and the capabilities of the tool and automotive manufacturers to develop recommended practices to achieve the Mission of the Committee. Subsequent California ARB and EPA on-board diagnostic regulations have recognized the Vision of the Committee and reference recommended practices developed by the Committee.

There has been a great deal of cooperation between the regulatory agencies and the Diagnostics Committee to include regulated requirements in the recommended practices. Regulations and recommended practices have simultaneously evolved to eliminate discrepancies and to satisfy all requirements.

In addition to the Diagnostics Committee, the SAE Vehicle Networks for Multiplexing and Data Communication Committee (Multiplex Committee) has developed documents that are significant to meet On-Board Diagnostic regulations. SAE Standard J1850, "Class B Data Communication Network Interface," describes a diagnostic data link that can be used by the vehicle manufacturers to meet the on-board to off-board communication requirements of the regulations. SAE J2178 and SAE J1699 address usage and compliance issues of an SAE J1850 data link.

Some recommended practices have been developed in cooperation with the regulatory agencies, and in some attempt to achieve commonality beyond that which is mandated by regulations. The following table indicates the documents included in this Handbook Supplement, the 1997 SAE On-Board Diagnostics for Light and Medium Duty Vehicles Standards Manual (HS-3000), and their relationship to anticipated regulations at this time. Regulations are constantly under review and subject to change, so the reader should verify the contents of this table for accuracy when necessary.

	Mandated	Voluntary
On-Board	J1850 Communication Protocol J1962 Diagnostic Connector J1979 Diagnostic Test Modes J2012 Diagnostic Trouble Codes	J2178 Class B Messages J2186 Tamper Resistance (CARB) J2190 Enhanced Test Modes J1899 J1850 Verification
Off-Board	J1930 Terms and Definitions J1978 OBD II Scan Tool J2205 Expanded Scan Tool Protocol*	J2201 Scan Tool Interface* J2006 Service Info**

* Referenced in J1978, but not specifically referenced in regulations.

** Published as a Draft Technical Report ---not included in this HS.

The International Organization for Standardization (ISO) Serial Data Communication Work Group (ISO/TC 22/SC 3/WG 1) has developed ISO 9141-2, "CARB Requirements for Interchange of digital information." This standard is allowed by OBD regulations as an alternative to SAE J1850 to meet diagnostic requirements. The ISO is also creating documents patterned after SAE documents. Some of the SAE Recommended Practices are being converted to ISO format, without technical changes, and are expected to be referenced in impending European regulations. Other ISO documents are being developed due to a desire to commonize diagnostic capabilities. The first of these documents are ISO 14299 (Diagnostic Services) and ISO 14230 (Keyword Protocol 2000).

Work on recommended practices is continuing in the Diagnostics Committee. Existing published documents are modified as needed to clarify specific sections or to expand the scope to meet revised regulations. New documents are developed as potential areas for standardization are identified. The SAE Committee and the ISO organization work closely together to ensure compatibility where possible.

ELECTRICAL/ELECTRONIC SYSTEMS DIAGNOSTIC TERMS, DEFINITIONS, ABBREVIATIONS, AND ACRONYMS—SAE J1930 SEP95

SAE Recommended Practice

Report of the SAE Vehicle E/E Systems Diagnostic Standards Committee approved June 1995, and subsequently revised September 1995 and June 1997. Revised by the J1930 Task Force of the SAE Vehicle E/E Systems Diagnostic Standards Committee September 1995.

Foreword—As the number of sophisticated electrical and electronic (E/E) systems on motor vehicles has increased, the number of terms, abbreviations, and acronyms which describe various components of these systems has increased enormously. To bring some order to the proliferation of such terms, abbreviations, and acronyms, the Vehicle E/E Diagnostic Systems Committee has prepared this document.

The nomenclature used to convey automotive service information is being standardized in order to more accurately convey information to technicians faced with the diagnosis and repair of increasingly complex vehicles.

To be properly descriptive, each type of automotive nomenclature requires a consistent methodology. This document is concerned with a methodology for naming objects and systems and with the set of words from which names are built.

The methodology allows objects and systems to be completely described without ambiguity. It also is able to generate names which distinguish among similar objects or systems without confusion but with brevity. Using terms which are well-defined within the context of the automotive service industry, the methodology allows already existing inspection names to be suitably changed and future names to be assigned in a predictable way which will reliably convey meaning to the technician.

The structure of this SAE document is open ended by design. As the need arises, additional entries can be added. Because of this flexibility, particular attention should be paid to the month and year publishing code contained in the full "F" number designation.

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1. Scope—This SAE Recommended Practice is applicable to all light-duty gasoline and diesel passenger vehicles and trucks, and to heavy-duty gasoline vehicles. Specific applications of this document include diagnostic, service and repair manuals, bulletin and updates, training manuals, repair databases, under-hood emission labels, and emission certification applications.

This document focuses on diagnostic terms applicable to electrical/electronic systems, and therefore also contains related mechanical terms, definitions, abbreviations, and acronyms.

Even though the use and appropriate updating of this document is strongly encouraged, nothing in this document should be construed as prohibiting the introduction of a term, abbreviation, or acronym not covered by this document.

Certain terms have already been in common use and are readily understood by manufacturers and technicians, but do not follow the methodology of this document. To preserve this understanding, these terms were included and have been identified with the footnote (2), "historically acceptable common usage," so they will not erroneously serve as a precedent in the construction of new names. These terms fall into three categories:

- a. Acronyms that do not logically fit the term.
- b. Acronyms existing at the component level, i.e., their terms contain the base word or noun that describes the generic item that is being further defined.
- c. Acronyms for terms that appear to contain the base word, but are frequently used as a modifier to another base word. (This use may possibly be thought of as following the methodology since the acronym is normally used as a modifier.)

2. References—There are no referenced publications specified herein.

3. How to Use This Document—To find the recommended term corresponding to an existing term, abbreviation or acronym, see Table 1, Cross Reference and Look Up. See Table 2, Recommended Terms, and Table 3, Glossary of Terms, for definitions of the recommended terms. Use Section 3.3, Methodology to construct a new name. Appropriate acceptable usage's of Recommended Terms and Acronyms are contained in Table 1.

4. Methodology—This naming methodology of denoting objects and systems uses modifiers attached to base words. Appropriate modifiers are added to a base word until an object or system is uniquely specified within its context.

4.1 Naming Objects—When building names, select the most descriptive base word from the Glossary of Terms (Table 3). Add modifiers as necessary or as desirable within the context, in the order of most significance to least significance. The most significant word will be the base word, which denotes the basic function of the object. The next significant modifier will be adjacent to the base word, the second most significant will be next to that modifier, and so on until the least significant modifier is added. For the sake of future clarity, an additional modifier can be added to a name at any time, even if there is no present conflict with another object name. Figure 1 illustrates how modifiers can be added to build the name, "Instrumentation Engine Coolant Temperature Sensor."

When naming an object, it is tempting to choose the first modifiers according to the initial purpose for which the object was designed, but this will not always result in the name which is most helpful in the long run to a service technician. The information a technician needs is most often supplied by a term which describes a functional attribute, not purpose.

FIGURE 1—NOCTESTER USAGE EXAMPLE

Abbreviations and acronyms may be constructed not only of the letters of the alphabet, but of numbers, space characters, punctuation marks (such as "&" and "%"), subscripts and any other ASCII characters. Treat the individual acronyms, modifier abbreviations, and base word abbreviations as words, separating them by space characters.

Figure 2 illustrates how several Recommended Terms and Acronyms can be further shortened into alphanumeric descriptors.

The following guidelines should be followed when using or developing alphanumeric descriptors:

- First consult Table 2, Recommended Terms in the Acronyms column.
- If the term is not included, build a suitable term using 4.1 Naming Object or 4.2 Naming System. Then shorten the term using 4.3 Shortened Names.
- If the resultant term is too long for a scan tool with an 8-character display limitation, build an Alphanumeric Descriptor for electronic delivery according to the pattern shown in Figure 2.
- Delete or replace characters as required.
- Omit spaces depending on the display limitation.
(example: FUEL PRES becomes FUELPRES)
- Consult Table 4 for a matching Alphanumeric Descriptor.
- If Table 4 does not contain a matching Alphanumeric Descriptor, request an addition, using the Request for Revision form in Appendix A.

5. Cross Reference and Look Up—See Table 1. The left column lists existing terms, acronyms and abbreviations. The center column provides the corresponding acceptable usage's constructed of recommended terms combined with other modifiers and/or base words. The acceptable acronymized usage is shown in the right column.

For information about using acronyms and abbreviations, see 4.3.1 (Acronyms) and 4.3.2 (Abbreviations). For additional information about Recommended Terms, see Tables 2 and 3.

Recommended Term	Acceptable Acronymized Usage	Alphanumeric Descriptor
Diagnostic Trouble Code Freeze Frame	DTC Freeze Frame	DTC FRZF
Engine Coolant Temperature	ECT	None Required
Flexible Fuel	EE	None Required
Freeze Frame	Freeze Frame	FRZF
Fuel Pressure	Fuel Pressure	FUEL PRES
Fuel System 1 Status	Fuel System 1 Status	FUEL SYS1
Long Term Fuel Trim Bank 2	Long Term FI Bank 2	LONG FT2
Oxygen Sensor Location Bank 1 Position 1	O2S Bank 1 Position 1	O2SLOC11

FIGURE 2—ALPHANUMERIC DESCRIPTORS EXAMPLE

TABLE 1—CROSS REFERENCE AND LOOK UP

Existing Usage	Acceptable Usage	Acceptable Acronymized Usage
AC (Air Conditioning)	Air Conditioning	ACC
ACC Cycling Switch	Air Conditioning Cycling Switch	ACC Cycling Switch
AT (Automatic Transaxle)	Automatic Transaxle ¹	AT ¹
AT (Automatic Transmission)	Automatic Transmission ¹	AT ¹
AAT (Ambient Air Temperature)	Ambient Air Temperature	AAT
AC (Air Conditioning)	Air Conditioning	ACC
ACC (Air Conditioning Clutch)	Air Conditioning Clutch	ACC Clutch
Accelerator	Accelerator Pedal	AP ¹
Accelerator Pedal Position	Accelerator Pedal Position ¹	APP ¹
ACCS (Air Conditioning Cycle Switch)	Air Conditioning Cycling Switch	ACC Cycling Switch
ACH (Air Cleaner Housing)	Air Cleaner Housing ¹	ACL Housing ¹
ACL (Air Cleaner)	Air Cleaner ¹	ACL ¹
ACL (Air Cleaner) Element	Air Cleaner Element ¹	ACL Element ¹
ACL (Air Cleaner) Housing	Air Cleaner Housing ¹	ACL Housing ¹
ACL (Air Cleaner) Housing Cover	Air Cleaner Housing Cover ¹	ACL Housing Cover ¹
ACS (Air Conditioning System)	Air Conditioning System	ACC System
ACT (Air Charge Temperature)	Intake Air Temperature ¹	IAT ¹
Adaptive Fuel Strategy	Fuel Trim ¹	FT ¹
AFG (Air Flow Control)	Mass Air Flow	MAF
APG (Air Flow Control)	Volume Air Flow	VAF
AFS (Air Flow Sensor)	Mass Air Flow Sensor	MAF Sensor
AFS (Air Flow Sensor)	Volume Air Flow Sensor	VAF Sensor
Air Cooler	Charge Air Cooler ¹	CAC ¹
AI (Air Injection)	Secondary Air Injection ¹	AIB ¹
AIP (Air Injection Pump)	Secondary Air Injection Pump ¹	AIB Pump ¹
AIR (Air Injection Reactor)	Pulsed Secondary Air Injection ¹	PAIB ¹
AIR (Air Injection Reactor)	Secondary Air Injection ¹	AIB ¹
AIRB (Secondary Air Injection Bypass)	Secondary Air Injection Bypass ¹	AIB Bypass ¹
AIRD (Secondary Air Injection Diverter)	Secondary Air Injection Diverter ¹	AIB Diverter ¹
Air Cleaner	Air Cleaner ¹	ACL ¹
Air Cleaner Element	Air Cleaner Element ¹	ACL Element ¹
Air Cleaner Housing	Air Cleaner Housing ¹	ACL Housing ¹
Air Cleaner Housing Cover	Air Cleaner Housing Cover ¹	ACL Housing Cover ¹
Air Conditioning	Air Conditioning	ACC
Air Conditioning Sensor	Air Conditioning Sensor	ACC Sensor
Air Control Valve	Secondary Air Injection Control Valve ¹	AIB Control Valve ¹
Air Flow Meter	Mass Air Flow Sensor ¹	MAF Sensor ¹
Air Flow Meter	Volume Air Flow Sensor ¹	VAF Sensor ¹
Air Intake System	Intake Air System ¹	IA System ¹
Air Flow Sensor	Mass Air Flow Sensor ¹	MAF Sensor ¹
Air Management 1	Secondary Air Injection Bypass ¹	AIB Bypass ¹
Air Management 2	Secondary Air Injection Diverter ¹	AIB Diverter ¹
Air Temperature Sensor	Intake Air Temperature Sensor ¹	IAT Sensor ¹
Air Valve	Idle Air Control Valve ¹	IAC Valve ¹
AIV (Air Injection Valve)	Pulsed Secondary Air Injection ¹	PAIB ¹
ALCL (Assembly Line Communication Link)	Data Link Connector ¹	DLC ¹
Alcohol Concentration Sensor	Flexible Fuel Sensor ¹	EE Sensor ¹
ALDL (Assembly Line Diagnostic Link)	Data Link Connector ¹	DLC ¹
ALT (Alternator)	Generator	GEN
Alternator	Generator	GEN
Ambient Air Temperature	Ambient Air Temperature	AAT
AM1 (Air Management 1)	Secondary Air Injection Bypass ¹	AIB Bypass ¹
AM2 (Air Management 2)	Secondary Air Injection Diverter ¹	AIB Diverter ¹

TABLE 1—CROSS REFERENCE AND LOOK UP (CONTINUED)

Existing Design	Acceptable Design	Acceptable Equivalent Usage
APP (Accelerator Pedal Position)	Accelerator Pedal Position ¹	APP ²
APD (Absolute Pressure Sensor)	Barometric Pressure Sensor ¹	BARO Sensor ²
ATS (Air Temperature Sensor)	Intake Air Temperature Sensor ¹	IAT Sensor ²
Automatic Transaxle	Automatic Transmission ¹	AT ²
Automatic Transmission	Automatic Transmission ¹	AT ²
B+ (Battery Positive Voltage)	Battery Positive Voltage	B+
Backpressure Transducer	Exhaust Gas Backpressure Backpressure Transducer ¹	EGP Backpressure Transducer ²
BARO (Barometric Pressure)	Barometric Pressure ¹	BARO ²
Barometric Pressure Sensor	Barometric Pressure Sensor ¹	BARO Sensor ²
Battery Positive Voltage	Battery Positive Voltage	B+
BLM (Block Learn Memory)	Long Term Fuel Trim ¹	Long Term ET ²
BLM (Block Learn Multiplier)	Long Term Fuel Trim ¹	Long Term ET ²
BLM (Block Learn Matrix)	Long Term Fuel Trim ¹	Long Term ET ²
Block Learn Integrator	Long Term Fuel Trim ¹	Long Term ET ²
Block Learn Matrix	Long Term Fuel Trim ¹	Long Term ET ²
Block Learn Memory	Long Term Fuel Trim ¹	Long Term ET ²
Block Learn Multiplier	Long Term Fuel Trim ¹	Long Term ET ²
BP (Barometric Pressure) Sensor	Barometric Pressure Sensor ¹	BARO Sensor ²
BPP (Brake Pedal Position)	Brake Pedal Position ¹	BPP ²
Brake Pressure	Brake Pressure	Brake Pressure
Brake Pedal Position	Brake Pedal Position ¹	BPP ²
CC (Computer Controlled Coil Ignition)	Electronic Ignition ¹	EL ²
CAC (Charge Air Cooler)	Charge Air Cooler ¹	CAC ²
Calculated Load Value	Calculated Load Value	LOAD ²
Camshaft Position	Camshaft Position ¹	CMP ²
Camshaft Position Actuator	Camshaft Position Actuator ¹	CMP Actuator ²
Camshaft Position Controller	Camshaft Position Actuator ¹	CMP Actuator ²
Camshaft Position Sensor	Camshaft Position Sensor ¹	CMP Sensor ²
Camshaft Sensor	Camshaft Position Sensor ¹	CMP Sensor ²
Camshaft Timing Actuator	Camshaft Position Actuator ¹	CMP Actuator ²
Canister	Canister ¹	CANIS ²
Canister	Exhaust Gas Canister ¹	EGC Canister ²
Canister Purge	Exhaust Gas Canister Purge ¹	EGP Canister Purge ²
Canister Purge Vacuum Switching Valve	Exhaust Gas Canister Canister Purge Valve ¹	EGC Canister Purge Valve ²
Canister Purge Valve	Exhaust Gas Canister Canister Purge Valve ¹	EGC Canister Purge Valve ²
Canister Purge VSV (Vacuum Switching Valve)	Exhaust Gas Canister Canister Purge Valve ¹	EGC Canister Purge Valve ²
CANP (Canister Purge)	Exhaust Gas Canister Canister Purge ¹	EGC Canister Purge ²
CARB (Carburetor)	Carburetor ¹	CARB ²
Carburetor	Carburetor ¹	CARB ²
Catalytic Converter Heater	Catalytic Converter Heater	Catalytic Converter Heater
CCC (Converter Clutch Control)	Torque Converter Clutch ¹	TCC ²
CCO (Converter Clutch Override)	Torque Converter Clutch ¹	TCC ²
CCS (Coast Clutch Solenoid)	Coast Clutch Solenoid	CCS
CCS (Coast Clutch Solenoid Valve)	Coast Clutch Solenoid Valve	CCS Valve
CCRM (Constant Control Relay Module)	Constant Control RM	Constant Control RM
CC (Capacitive Discharge Ignition)	Distributor Ignition ¹	DI ²
CCM (Compact Disc Read Only Memory)	Compact Disc Read Only Memory ¹	CDROM ²
CEB (Clutch Engage Switch)	Clutch Pedal Position Switch	CEP Switch ²
Central Multipoint Fuel Injection	Central Multipoint Fuel Injection ¹	Central MPI ²
Central Sequential Multipoint Fuel Injection	Central Sequential Multipoint Fuel Injection	Central SPI
CFI (Continuous Fuel Injection)	Continuous Fuel Injection ¹	CFI ²
CFI (Central Fuel Injection)	Throttle Body Fuel Injection ¹	TBI ²
CFI	Throttle Body Fuel Injection ¹	TBI ²
Chamber Canister	Exhaust Gas Canister ¹	EGC Canister ²
Charge Air Cooler	Charge Air Cooler	CAC ²
Check Engine	Service Indicator Indicator ¹	SI ²
Check Engine	Malfunction Indicator Lamp ¹	MIL ²
CID (Cylinder Identification) Sensor	Camshaft Position Sensor ¹	CMP Sensor ²
CIS (Continuous Injection System)	Continuous Fuel Injection ¹	CFI ²
CIS-E (Continuous Injection System Electronic)	Continuous Fuel Injection ¹	CFI ²
CIP (Crankshaft Position)	Camshaft Position ¹	CMP ²
CIP (Crankshaft Position) Sensor	Camshaft Position Sensor ¹	CMP Sensor ²
CL (Clutch Lock)	Clutch Lock ¹	CL ²
Clashed Bowl Distributor	Distributor Ignition ¹	DI ²
Clashed Throttle Position	Clashed Throttle Position ¹	CIP ²
Clashed Throttle Switch	Clashed Throttle Position Switch ¹	CIP Switch ²
CLS (Clutch Lock System)	Clutch Lock ¹	CL ²
CLV	Calculated Load Value	LOAD ²
Clutch Engage Switch	Clutch Pedal Position Switch ¹	CEP Switch ²
Clutch Pedal Position Switch	Clutch Pedal Position Switch ¹	CEP Switch ²
Clutch Start Switch	Clutch Pedal Position Switch ¹	CEP Switch ²
Clutch Switch	Clutch Pedal Position Switch ¹	CEP Switch ²
CMP (Central Multipoint Fuel Injection)	Central Multipoint Fuel Injection ¹	Central MPI ²
CMP (Camshaft Position)	Camshaft Position ¹	CMP ²
CMP (Camshaft Position) Sensor	Camshaft Position Sensor ¹	CMP Sensor ²
COC (Continuous Operation Catalyst)	Coast Clutch Solenoid	CCS
Coast Clutch Solenoid	Coast Clutch Solenoid	CCS
Coast Clutch Solenoid Valve	Coast Clutch Solenoid Valve	CCS Valve
Condenser	Condenser	COND
Constant Control Relay Module	Constant Control Relay Module	CCRM
Constant Volume Restrictor	Constant Volume Restrictor	CVR

TABLE 1—CROSS REFERENCE AND LOOK UP (CONTINUED)

Existing Usage	Acceptable Usage	Acceptable Authorized Usage
Continuous Fuel Injection	Continuous Fuel Injection ¹	CEI ¹
Continuous Injection System	Continuous Fuel Injection System ¹	CEI System ¹
Continuous Injection System-E	Electronic Continuous Fuel Injection System ¹	Electronic CEI System ¹
Continuous Trap Oxidizer	Continuous Trap Oxidizer ¹	CTOX ¹
Coolant Temperature Sensor	Engine Coolant Temperature Sensor ¹	ECT Sensor ¹
CP (Crankshaft Position)	Crankshaft Position ¹	CKP ¹
CPP (Clutch Pedal Position)	Clutch Pedal Position ¹	CCP ¹
CPP (Clutch Pedal Position) Switch	Clutch Pedal Position Switch ¹	CCP Switch ¹
CPS (Crankshaft Position Sensor)	Crankshaft Position Sensor ¹	CKP Sensor ¹
CPS (Crankshaft Position Sensor)	Crankshaft Position Sensor ¹	CKP Sensor ¹
Crank Angle Sensor	Crankshaft Position Sensor ¹	CKP Sensor ¹
Crankshaft Position	Crankshaft Position ¹	CKP ¹
Crankshaft Position Sensor	Crankshaft Position Sensor ¹	CKP Sensor ¹
Crankshaft Speed	Engine Speed ¹	ECM ¹
Crankshaft Speed Sensor	Engine Speed Sensor ¹	ECM Sensor ¹
Critical Flow Venturi	Critical Flow Venturi ¹	CFV ¹
CTO (Continuous Trap Oxidizer)	Continuous Trap Oxidizer ¹	CTOX ¹
CTOX (Continuous Trap Oxidizer)	Continuous Trap Oxidizer ¹	CTOX ¹
CTP (Closed Throttle Position)	Closed Throttle Position ¹	CTP ¹
CTS (Coolant Temperature Sensor)	Engine Coolant Temperature Sensor ¹	ECT Sensor ¹
CTS (Coolant Temperature Switch)	Engine Coolant Temperature Sensor ¹	ECT Sensor ¹
CVS	Control Valve Sensor ¹	CVS ¹
Cylinder ID (Identification) Sensor	Crankshaft Position Sensor ¹	CKP Sensor ¹
D-Jetronic	Multiport Fuel Injection ¹	MEI ¹
Data Link Connector	Data Link Connector ¹	DLC ¹
Detonation Sensor	Knock Sensor ¹	KS ¹
DFI (Direct Fuel Injection)	Direct Fuel Injection ¹	DFI ¹
DFI (Digital Fuel Injection)	Multiport Fuel Injection ¹	MEI ¹
DI (Direct Injection)	Direct Fuel Injection ¹	DFI ¹
DI (Distributor Ignition)	Distributor Ignition ¹	DS ¹
DI (Distributor Ignition) Capacitor	Distributor Ignition Capacitor ¹	DI Capacitor ¹
Diagnostic Test Mode	Diagnostic Test Mode ¹	DTM ¹
Diagnostic Trouble Code	Diagnostic Trouble Code ¹	DTC ¹
DID (Direct Injection - Diesel)	Direct Fuel Injection ¹	DFI ¹
Differential Pressure Feedback EGR (Exhaust Gas Recirculation) System	Differential Pressure Feedback Exhaust Gas Recirculation System ¹	Differential Pressure Feedback EGR System ¹
Digital EGR (Exhaust Gas Recirculation)	Exhaust Gas Recirculation ¹	EGR ¹
Direct Fuel Injection	Direct Fuel Injection ¹	DFI ¹
Direct Ignition System	Electronic Ignition System ¹	EI System ¹
DIS (Distributorless Ignition System)	Electronic Ignition System ¹	EI System ¹
DIS (Distributorless Ignition System) Module	Ignition Control Module ¹	ICM ¹
Distance Sensor	Vehicle Speed Sensor ¹	VSS ¹
Distributor Ignition	Distributor Ignition ¹	DS ¹
Distributorless Ignition	Electronic Ignition ¹	EI ¹
DLC (Data Link Connector)	Data Link Connector ¹	DLC ¹
DI (Distributorless Ignition)	Electronic Ignition ¹	EI ¹
Driver	Driver ¹	Driver ¹
DS (Detonation Sensor)	Knock Sensor ¹	KS ¹
DTM (Diagnostic Trouble Code)	Diagnostic Trouble Code ¹	DTC ¹
DTM (Diagnostic Test Mode)	Diagnostic Test Mode ¹	DTM ¹
Dual Bed	Three Way a Converter Catalytic Converter ¹	THC+OC ¹
Duty Solenoid for Purge Valve	Exhaust Gas Recirculation Purge Valve ¹	EGRP Purge Valve ¹
Dynamic Pressure Control	Dynamic Pressure Control ¹	Dynamic PC ¹
Dynamic Pressure Control Solenoid	Dynamic Pressure Control Solenoid ¹	Dynamic PC Solenoid ¹
Dynamic Pressure Control Solenoid Valve	Dynamic Pressure Control Solenoid Valve ¹	Dynamic PC Solenoid Valve ¹
EEPROM (Electrically Erasable Programmable Read Only Memory)	Electrically Erasable Programmable Read Only Memory ¹	EEPROM ¹
Early Fuel Evaporation	Early Fuel Evaporation ¹	EFE ¹
EATX (Electronic Automatic Transmission) Transaxle	Automatic Transmission ¹	ACT ¹
EC (Engine Control)	Engine Control ¹	EC ¹
ECA (Electronic Control Assembly)	Powertrain Control Module ¹	PCM ¹
ECL (Engine Coolant Level)	Engine Coolant Level ¹	ECL ¹
ECM (Engine Control Module)	Engine Control Module ¹	ECM ¹
ECT (Engine Coolant Temperature)	Engine Coolant Temperature ¹	ECT ¹
ECT (Engine Coolant Temperature) Sensor	Engine Coolant Temperature Sensor ¹	ECT Sensor ¹
ECT (Engine Coolant Temperature) Sensor	Engine Coolant Temperature Sensor ¹	ECT Sensor ¹
ECT (Engine Coolant Temperature) Switch	Engine Coolant Temperature Switch ¹	ECT Switch ¹
ECU (Electronic Control Unit 4)	Powertrain Control Module ¹	PCM ¹
EDF (Electric Drive Fan) Control	Fan Control ¹	FC ¹
EDIS (Electronic Distributor Ignition System)	Distributor Ignition System ¹	DI System ¹
EDIS (Electronic Distributorless Ignition System)	Electronic Ignition System ¹	EI System ¹
EDIS (Electronic Distributor Ignition System) Module	Distributor Ignition Control Module ¹	Distributor ICM ¹
EEC (Electronic Engine Control)	Engine Control ¹	EC ¹
EEC (Electronic Engine Control) Processor	Powertrain Control Module ¹	PCM ¹
EECS (Exhaustive Emission Control System)	Exhaustive Emission System ¹	EECS System ¹
EEPROM (Electrically Erasable Programmable Read Only Memory)	Electrically Erasable Programmable Read Only Memory ¹	EEPROM ¹
EFE (Early Fuel Evaporation)	Early Fuel Evaporation ¹	EFE ¹
EPI (Electronic Fuel Injection)	Multiport Fuel Injection ¹	MEI ¹
EPI (Electronic Fuel Injection)	Inertia Body Fuel Injection ¹	IBI ¹
EGC (Exhaust Gas Oxygen) Sensor	Oxygen Sensor ¹	O ₂ S ¹

TABLE 1—CROSS REFERENCE AND LOOK UP (CONTINUED)

Existing Usage	Acceptable Usage	Acceptable Authorized Usage
EGOS (Exhaust Gas Oxygen Sensor)	Exhaust Sensor ¹	EGS ¹
EGR (Exhaust Gas Recirculation)	Exhaust Gas Recirculation ¹	EGR ¹
EGR (Exhaust Gas Recirculation) Diagnostic Valve	Exhaust Gas Recirculation Diagnostic Valve ¹	EGR Diagnostic Valve ¹
EGR (Exhaust Gas Recirculation) System	Exhaust Gas Recirculation System ¹	EGR System ¹
EGR (Exhaust Gas Recirculation) Thermal Vacuum Valve	Exhaust Gas Recirculation Thermal Vacuum Valve ¹	EGR TVV ¹
EGR (Exhaust Gas Recirculation) Valve	Exhaust Gas Recirculation Valve ¹	EGR Valve ¹
EGR TVV (Exhaust Gas Recirculation Thermal Vacuum Valve)	Exhaust Gas Recirculation Thermal Vacuum Valve ¹	EGR TVV ¹
EGRT (Exhaust Gas Recirculation Temperature) Sensor	Exhaust Gas Recirculation Temperature Sensor ¹	EGRT ¹
EGRT (Exhaust Gas Recirculation Temperature) Sensor	Exhaust Gas Recirculation Temperature Sensor ¹	EGRT Sensor ¹
EGRV (Exhaust Gas Recirculation Valve)	Exhaust Gas Recirculation Valve ¹	EGR Valve ¹
EGRVC (Exhaust Gas Recirculation Valve Control)	Exhaust Gas Recirculation Valve Control ¹	EGR Valve Control ¹
EGS (Exhaust Gas Sensor)	Exhaust Sensor ¹	EGS ¹
EI (Electronic Ignition) (With Distributor)	Distributor Ignition ¹	DI ¹
EI (Electronic Ignition) (Without Distributor)	Electronic Ignition ¹	EI ¹
Electrically Erasable Programmable Read Only Memory	Electrically Erasable Programmable Read Only Memory ¹	EEPROM ¹
Electronic Engine Control	Electronic Engine Control ¹	Electronic EC ¹
Electronic Ignition	Electronic Ignition ¹	EI ¹
Electronic Spark Advance	Ignition Control ¹	IC ¹
Electronic Spark Timing	Ignition Control ¹	IC ¹
EM (Engine Modification)	Engine Modification ¹	EM ¹
EMR (Engine Maintenance Reminder)	Service Reminder Indicator ¹	SR ¹
Engine Control	Engine Control ¹	EC ¹
Engine Coolant Fan Control	Fan Control ¹	FC ¹
Engine Coolant Level	Engine Coolant Level ¹	ECL ¹
Engine Coolant Level Indicator	Engine Coolant Level Indicator ¹	ECL Indicator ¹
Engine Coolant Temperature	Engine Coolant Temperature ¹	ECT ¹
Engine Coolant Temperature Sender	Engine Coolant Temperature Sensor ¹	ECT Sensor ¹
Engine Coolant Temperature Sensor	Engine Coolant Temperature Sensor ¹	ECT Sensor ¹
Engine Coolant Temperature Switch	Engine Coolant Temperature Switch ¹	ECT Switch ¹
Engine Modification	Engine Modification ¹	EM ¹
Engine Oil Pressure Sender	Engine Oil Pressure Sensor ¹	EOP Sensor ¹
Engine Oil Pressure Sensor	Engine Oil Pressure Sensor ¹	EOP Sensor ¹
Engine Oil Pressure Switch	Engine Oil Pressure Switch ¹	EOP Switch ¹
Engine Oil Temperature	Engine Oil Temperature ¹	EOT ¹
Engine Speed	Engine Speed ¹	ESM ¹
EOS (Exhaust Oxygen Sensor)	Exhaust Sensor ¹	EGS ¹
EOT (Engine Oil Temperature)	Engine Oil Temperature ¹	EOT ¹
EP (Exhaust Pressure)	Exhaust Pressure ¹	EP ¹
EPROM (Erasable Programmable Read Only Memory)	Electrically Erasable Programmable Read Only Memory ¹	EEPROM ¹
Erasable Programmable Read Only Memory	Electrically Erasable Programmable Read Only Memory ¹	EEPROM ¹
ESA (Electronic Spark Advance)	Ignition Control ¹	IC ¹
ESAC (Electronic Spark Advance Control)	Distributor Ignition ¹	DI ¹
EST (Electronic Spark Timing)	Ignition Control ¹	IC ¹
EVAP (Evaporative Emission) CUP (Canister Purge)	Evaporative Emission Canister Purge ¹	EVAP Canister Purge ¹
EVAP (Evaporative Emission)	Evaporative Emission ¹	EVAP ¹
EVAP (Evaporative Emission) Canister	Evaporative Emission Canister ¹	EVAP Canister ¹
EVAP (Evaporative Emission) Purge Valve	Evaporative Emission Canister Purge Valve ¹	EVAP Canister Purge Valve ¹
Evaporative Emission	Evaporative Emission ¹	EVAP ¹
Evaporative Emission Canister	Evaporative Emission Canister ¹	EVAP Canister ¹
EVP (Exhaust Gas Recirculation Valve Position) Sensor	Exhaust Gas Recirculation Valve Position Sensor ¹	EGR Valve Position Sensor ¹
EVR (Exhaust Gas Recirculation Vacuum Regulator) Solenoid	Exhaust Gas Recirculation Vacuum Regulator Solenoid ¹	EGS Vacuum Regulator Solenoid ¹
EVTV (Exhaust Gas Recirculation Vacuum Regulator Valve)	Exhaust Gas Recirculation Vacuum Regulator Valve ¹	EGS Vacuum Regulator Valve ¹
Exhaust Gas Recirculation	Exhaust Gas Recirculation ¹	EGR ¹
Exhaust Gas Recirculation Temperature	Exhaust Gas Recirculation Temperature ¹	EGRT ¹
Exhaust Gas Recirculation Temperature Sensor	Exhaust Gas Recirculation Temperature Sensor ¹	EGRT Sensor ¹
Exhaust Gas Recirculation Vacuum Regulator Solenoid	Exhaust Gas Recirculation Vacuum Regulator Solenoid Valve ¹	EGS Vacuum Regulator Solenoid Valve ¹
Exhaust Gas Recirculation Vacuum Regulator Valve	Exhaust Gas Recirculation Vacuum Regulator Valve ¹	EGS Vacuum Regulator Valve ¹
Exhaust Gas Recirculation Valve	Exhaust Gas Recirculation Valve ¹	EGR Valve ¹
Exhaust Pressure	Exhaust Pressure ¹	EP ¹
4GR (Fourth Gear)	Fourth Gear ¹	4GR ¹
4WD (Four Wheel Drive)	Full Time Four Wheel Drive ¹	F4WD ¹
4WD (Four Wheel Drive)	Selectable Four Wheel Drive ¹	S4WD ¹
4WD	Full Time Four Wheel Drive ¹	F4WD ¹
Fan Control	Fan Control ¹	FC ¹
Fan Control Module	Fan Control Module ¹	FC Module ¹
Fan Control Relay	Fan Control Relay ¹	FC Relay ¹
Fan Motor Control Relay	Fan Control Relay ¹	FC Relay ¹
Fast Idle Thermo Valve	Idle Air Control Thermo Valve ¹	IAC Thermo Valve ¹
FBC (Fixed Back Carburetor)	Carburetor ¹	CB ¹
FBC (Fixed Back Control)	Mixture Control ¹	MC ¹
FC (Fan Control)	Fan Control ¹	FC ¹
FC (Fan Control) Relay	Fan Control Relay ¹	FC Relay ¹

TABLE 1—CROSS REFERENCE AND LOOK UP (CONTINUED)

Relating Usage	Acceptable Usage	Acceptable Associated Usage
EEPROM (Flash Electrically Erasable Programmable Read Only Memory)	Flash Electrically Erasable Programmable Read Only Memory ¹	EEPROM ²
EEPROM (Flash Erasable Programmable Read Only Memory)	Flash Erasable Programmable Read Only Memory ¹	EEPROM ²
EF (Flexible Fuel)	Flexible Fuel ¹	EE ³
FI (Fuel Injection)	Central Multinoz Fuel Injection ¹	Central MEI ²
FI (Fuel Injection)	Continuous Fuel Injection ¹	CEI ²
FI (Fuel Injection)	Direct Fuel Injection ¹	DEI ²
FI (Fuel Injection)	Indirect Fuel Injection ¹	IEI ²
FI (Fuel Injection)	Multinoz Fuel Injection ¹	MEI ²
FI (Fuel Injection)	Sequential Multinoz Fuel Injection ¹	SEI ²
FI (Fuel Injection)	Throttle Body Fuel Injection ¹	TBI ²
Flame Ionization Detector	Flame Ionization Detector	FID
Flash EEPROM (Electrically Erasable Programmable Read Only Memory)	Flash Electrically Erasable Programmable Read Only Memory ¹	EEPROM ²
Flash EPROM (Erasable Programmable Read Only Memory)	Flash Erasable Programmable Read Only Memory ¹	EEPROM ²
Flexible Fuel	Flexible Fuel ¹	EE ³
Flexible Fuel Sensor	Flexible Fuel Sensor ¹	EE Sensor ³
Fourth Gear	Fourth Gear	4GB
FP (Fuel Pump)	Fuel Pump	EP
FP (Fuel Pump) Module	Fuel Pump Module	EP Module
Frame Frame	Frame Frame	See Table 4
Front Wheel Drive	Front Wheel Drive	FWD
FRF (Frame Frame)	Frame Frame	See Table 4
FT (Fuel Trim)	Fuel Trim ¹	ET ³
Fuel Charging Station	Throttle Body ¹	TB ²
Fuel Concentration Sensor	Flexible Fuel Sensor ¹	EE Sensor ³
Fuel Injection	Central Multinoz Fuel Injection ¹	Central MEI ²
Fuel Injection	Continuous Fuel Injection ¹	CEI ²
Fuel Injection	Direct Fuel Injection ¹	DEI ²
Fuel Injection	Indirect Fuel Injection ¹	IEI ²
Fuel Injection	Multinoz Fuel Injection ¹	MEI ²
Fuel Injection	Sequential Multinoz Fuel Injection ¹	SEI ²
Fuel Injection	Throttle Body Fuel Injection ¹	TBI ²
Fuel Level Sensor	Fuel Level Sensor	Fuel Level Sensor
Fuel Module	Fuel Pump Module	EP Module
Fuel Pressure	Fuel Pressure ¹	Fuel Pressure ³
Fuel Pressure	Fuel Pressure	See Table 4
Fuel Pressure Regulator	Fuel Pressure Regulator ¹	Fuel Pressure Regulator ³
Fuel Pump	Fuel Pump	EP
Fuel Pump Relay	Fuel Pump Relay	EP Relay
Fuel Quality Sensor	Flexible Fuel Sensor ¹	EE Sensor ³
Fuel Regulator	Fuel Pressure Regulator ¹	Fuel Pressure Regulator ³
Fuel Sender	Fuel Pump Module	EP Module
Fuel Sensor	Fuel Level Sensor	Fuel Level Sensor
Fuel System Status	Fuel System Status	See Table 4
FUEL SYS	Fuel System Status	See Table 4
Fuel Tank Unit	Fuel Pump Module	EP Module
Fuel Trim	Fuel Trim ¹	ET ³
Full Time Four Wheel Drive	Full Time Four Wheel Drive	F4WD
Full Throttle	Wide Open Throttle ¹	WOT ²
FWD	Front Wheel Drive	FWD
GCM (Governor Control Module)	Governor Control Module	GCM
GEM (Governor Electronic Module)	Governor Control Module	GCM
GEN (Generator)	Generator	GEN
Generator	Generator	GEN
Glow Plug	Glow Plug ¹	Glow Plug ²
GND (Ground)	Ground	GND
Governor	Governor	Governor
Governor Control Module	Governor Control Module	GCM
Governor Electronic Module	Governor Control Module	GCM
Green Per Mile	Green Per Mile	QPM
GRD (Ground)	Ground	GND
Ground	Ground	GND
Heated Oxygen Sensor	Heated Oxygen Sensor ¹	HO2S ²
HEC (High Electro-Drive Fuel Control)	Fuel Control	EC
HEGO (Heated Exhaust Gas Oxygen) Sensor	Heated Oxygen Sensor ¹	HO2S ²
HEI (High Energy Ignition)	Distributor Ignition ¹	DI ²
High Speed FC (Fan Control) Switch	High Speed Fan Control Switch	High Speed FC Switch
HO2S (Heated Oxygen Sensor)	Heated Oxygen Sensor ¹	HO2S ²
HO2S (Heated Oxygen Sensor)	Heated Oxygen Sensor ¹	HO2S ²
Hot Wire Anemometer	Hot Air Flow Sensor ¹	MAF Sensor ³
IA (Intake Air)	Intake Air	IA
IA (Intake Air) Duct	Intake Air Duct	IA Duct
IAC (Idle Air Control)	Idle Air Control ¹	IAC ²
IAC (Idle Air Control) Thermal Valve	Idle Air Control Thermal Valve ¹	IAC Thermal Valve ²
IAC (Idle Air Control) Valve	Idle Air Control Valve ¹	IAC Valve ²
IACV (Idle Air Control Valve)	Idle Air Control Valve ¹	IAC Valve ²
IAT (Intake Air Temperature)	Intake Air Temperature ¹	IAT ²
IAT (Intake Air Temperature) Sensor	Intake Air Temperature Sensor ¹	IAT Sensor ²
IATS (Intake Air Temperature Sensor)	Intake Air Temperature Sensor ¹	IAT Sensor ²
IC (Ignition Control)	Ignition Control ¹	IC ²

TABLE 1—CROSS REFERENCE AND LOOK UP (CONTINUED)

Existing Usage	Acceptable Usage	Acceptable Acronyms Usage
ICM (Ignition Control Module)	Ignition Control Module ¹	ICM ¹
ICP (Injection Control Pressure)	Injection Control Pressure ¹	ICP ¹
IDFI (Indirect Fuel Injection)	Indirect Fuel Injection ¹	IEI ¹
IDI (Integrated Direct Ignition)	Electronic Ignition ¹	EI ¹
IDI (Indirect Diesel Injection)	Indirect Fuel Injection ¹	IEI ¹
Idle Air Bypass Control	Idle Air Control ¹	IAC ¹
Idle Air Control	Idle Air Control ¹	IAC ¹
Idle Air Control Valve	Idle Air Control Valve ¹	IAC Valve ¹
Idle Speed Control	Idle Air Control ¹	IAC ¹
Idle Speed Control	Idle Speed Control ¹	ISC ¹
Idle Speed Control Actuator	Idle Speed Control Actuator ¹	ISC Actuator ¹
IF (Indirect Fuel Injection)	Indirect Fuel Injection ¹	IEI ¹
IFS (Inertia Fuel Shutoff)	Inertia Fuel Shutoff	IFS
Ignition Control	Ignition Control ¹	IC ¹
Ignition Control Module	Ignition Control Module ¹	ICM ¹
IM (Inspection and Maintenance)	Inspection and Maintenance	IM
IMPC (Intake Manifold Runner Control)	Intake Manifold Runner Control	IMRC
Int Tank Module	Fuel Pump Module	FP Module
Indirect Fuel Injection	Indirect Fuel Injection ¹	IEI ¹
Inertia Fuel Shutoff	Inertia Fuel Shutoff	IFS
Inertia Fuel - Shutoff Switch	Inertia Fuel Shutoff Switch	IFS Switch
Inertia Switch	Inertia Fuel Shutoff Switch	IFS Switch
Injection Control Pressure	Injection Control Pressure ¹	ICP ¹
Input Shaft Speed	Input Shaft Speed	ISS
INT (Integrator)	Short Term Fuel Trim ¹	Short Term ET ¹
Inspection and Maintenance	Inspection and Maintenance	IM
Intake Air	Intake Air	IA
Intake Air Duct	Intake Air Duct	IA Duct
Intake Air Temperature	Intake Air Temperature ¹	IAT ¹
Intake Air Temperature Sensor	Intake Air Temperature Sensor ¹	IAT Sensor ¹
Intake Manifold Absolute Pressure Sensor	Manifold Absolute Pressure Sensor ¹	MAP Sensor ¹
Intake Manifold Runner Control	Intake Manifold Runner Control	IMRC
Integrated Pulley Module	Stem Module	SM
Integrator	Short Term Fuel Trim ¹	Short Term ET ¹
Inter Cooler	Charge Air Cooler ¹	CAC ¹
ISC (Idle Speed Control)	Idle Air Control ¹	IAC ¹
ISC (Idle Speed Control)	Idle Speed Control ¹	ISC ¹
ISC (Idle Speed Control) Actuator	Idle Speed Control Actuator ¹	ISC Actuator ¹
ISC BPA (Idle Speed Control By Pass Air)	Idle Air Control ¹	IAC
ISC (Idle Speed Control) Solenoid Vacuum Valve	Idle Speed Control Solenoid Vacuum Valve ¹	ISC Solenoid Vacuum Valve ¹
ISS (Input Shaft Speed)	Input Shaft Speed	ISS
K-Jetronic	Continuous Fuel Injection ¹	CEI ¹
KAM (Keep Alive Memory)	Non-Volatile Random Access Memory ¹	NVRAM ¹
KAM (Keep Alive Memory)	Keep Alive Random Access Memory ¹	Keep Alive RAM ¹
KE-Jetronic	Continuous Fuel Injection ¹	CEI ¹
KE-Jetronic	Continuous Fuel Injection ¹	CEI ¹
Knock Sensor	Knock Sensor ¹	KS ¹
KS (Knock Sensor)	Knock Sensor ¹	KS ¹
L-Jetronic	Multifuel Fuel Injection ¹	MEI ¹
Laminate	Crossed Sensor ¹	COS ¹
LH-Jetronic	Multifuel Fuel Injection ¹	MEI ¹
Light Off Catalyst	Warm-Up Three-Way Catalyst Converter ¹	WU-TC ¹
Light Off Catalyst	Warm-Up Oxidation Catalyst Converter ¹	WU-OC ¹
Line Pressure Control Solenoid Valve	Line Pressure Control Solenoid Valve	Line EC Solenoid Valve
LOAD (Calculated Load Value)	Calculated Load Value	LOAD
Lock Up Relay	Torque Converter Clutch Relay ¹	TCC Relay ¹
Long Term FT (Fuel Trim)	Long Term Fuel Trim ¹	Long Term ET ¹
Long Term Fuel Trim	Long Term ET	Long Term ET
LONG FT	Long Term Fuel Trim	See Table 4
Low Speed FC (Fan Control) Switch	Low Speed Fan Control Switch	Low Speed EC Switch
LUB (Lock Up Solenoid) Valve	Torque Converter Clutch Solenoid Valve ¹	TCC Solenoid Valve ¹
MIC (Mixture Control)	Mixture Control ¹	MIC ¹
MAF (Mass Air Flow)	Mass Air Flow ¹	MAF ¹
MAF (Mass Air Flow) Sensor	Mass Air Flow Sensor ¹	MAF Sensor ¹
Malfunction Indicator Lamp	Malfunction Indicator Lamp ¹	MIL ¹
Manifold Absolute Pressure	Manifold Absolute Pressure ¹	MAP ¹
Manifold Absolute Pressure Sensor	Manifold Absolute Pressure Sensor ¹	MAP Sensor ¹
Manifold Differential Pressure	Manifold Differential Pressure ¹	MCP ¹
Manifold Surface Temperature	Manifold Surface Temperature ¹	MST ¹
Manifold Vacuum Zone	Manifold Vacuum Zone ¹	MVZ ¹
Manual Lever Position Sensor	Transmission Range Sensor ¹	TR Sensor ¹
MAP (Manifold Absolute Pressure)	Manifold Absolute Pressure ¹	MAP ¹
MAP (Manifold Absolute Pressure) Sensor	Manifold Absolute Pressure Sensor ¹	MAP Sensor ¹
MAPS (Manifold Absolute Pressure Sensor)	Manifold Absolute Pressure Sensor ¹	MAP Sensor ¹
Mass Air Flow	Mass Air Flow ¹	MAF ¹
Mass Air Flow Sensor	Mass Air Flow Sensor ¹	MAF Sensor ¹
MAT (Manifold Air Temperature)	Intake Air Temperature ¹	IAT ¹
MATS (Manifold Air Temperature Sensor)	Intake Air Temperature Sensor ¹	IAT Sensor ¹
MC (Mixture Control)	Mixture Control ¹	MIC ¹
MCS (Mixture Control Solenoid)	Mixture Control Solenoid ¹	MIC Solenoid ¹
MCU (Microprocessor Control Unit)	Electronic Control Module ¹	ECM ¹
MCP (Manifold Differential Pressure)	Manifold Differential Pressure ¹	MICP ¹

TABLE 1—CROSS REFERENCE AND LOOK UP (CONTINUED)

Existing Usage	Acceptable Usage	Acceptable Acronized Usage
MPFI (Multiport Fuel Injection)	Multiport Fuel Injection ¹	MFI ¹
MIL (Malfunction Indicator Lamp)	Malfunction Indicator Lamp ¹	MIL ¹
Mixture Control	Mixture Control ¹	MFC ¹
MLPS (Manual Lever Position Sensor)	Transmission Range Sensor ¹	TR Sensor ¹
Mover	Compressor Test Mover ¹	CTM ¹
Mono-Jetronic	Throttle Body Injection ¹	TBI ¹
Mono-Motronic	Throttle Body Injection ¹	TBI ¹
Monotronic	Throttle Body Fuel Injection ¹	TBI ¹
Motronic Pressure	Multiport Fuel Injection ¹	MFI ¹
Motronic	Multiport Fuel Injection ¹	MFI ¹
MPFI (Multiport Injection)	Multiport Fuel Injection ¹	MFI ¹
MPFI (Multiport Injection)	Multiport Fuel Injection ¹	MFI ¹
MPFS (Manual Range Position Switch)	Transmission Range Switch	TR Switch
MST (Manifold Surface Temperature)	Manifold Surface Temperature ¹	MST ¹
Multiport Fuel Injection	Multiport Fuel Injection ¹	MFI ¹
MVZ (Manifold Vacuum Zone)	Manifold Vacuum Zone ¹	MVZ ¹
NDG (Neutral Drive Switch)	Hand/Neural Position Switch ¹	PSW Switch ¹
Neutral Safety Switch	Hand/Neural Position Switch ¹	PSW Switch ¹
NDG (Neutral Gear Switch)	Hand/Neural Position Switch ¹	PSW Switch ¹
Non-Dispersive Infrared	Non-Dispersive Infrared ¹	NDIR ¹
Non-Volatile Random Access Memory	Non-Volatile Random Access Memory ¹	NRAM ¹
NPS (Neutral Position Sensor)	Hand/Neural Position Switch ¹	PSW Switch ¹
NVM (Non-Volatile Memory)	Non-Volatile Random Access Memory ¹	NRAM ¹
NRAM (Non-Volatile Random Access Memory)	Non-Volatile Random Access Memory ¹	NRAM ¹
O ₂ (Oxygen) Sensor	Oxygen Sensor ¹	O ₂ ¹
O ₂ (Oxygen Sensor)	Oxygen Sensor ¹	O ₂ ¹
Oxygen Sensor Location	Oxygen Sensor Location	See Table 4
OBD (On Board Diagnostic)	On Board Diagnostic ¹	OBD ¹
OBD Status	OBD Status	see Table 4
OBD STAT	OBD Status	see Table 4
OC (Oxidation Catalyst)	Catalytic Converter Converter ¹	CC ¹
Oil Pressure Sensor	Engine Oil Pressure Sensor	EOP Sensor
Oil Pressure Sensor	Engine Oil Pressure Sensor	EOP Sensor
Oil Pressure Switch	Engine Oil Pressure Switch	EOP Switch
OL (Open Loop)	Open Loop ¹	OL ¹
On Board Diagnostic	On Board Diagnostic ¹	OBD ¹
Open Loop	Open Loop ¹	OL ¹
O ₂ (Oxygen Sensor)	Oxygen Sensor ¹	O ₂ ¹
OSS (Output Shaft Speed) Sensor	Output Shaft Speed Sensor ¹	OSS Sensor ¹
Output Drive	Output	Output
Output Shaft Speed Sensor	Output Shaft Speed Sensor ¹	OSS Sensor ¹
Oxidation Catalytic Converter	Catalytic Converter Converter ¹	CC ¹
O ₂ (Oxygen Sensor) Indicator	Sensor Indicator Indicator ¹	SI ¹
Oxygen Sensor	Oxygen Sensor ¹	O ₂ ¹
PSI (Pach/Metric)	Hand/Neural Position ¹	PSW ¹
PS (Power Steering) Pressure Switch	Power Steering Pressure Switch	PSW Switch
P- (Pressure) Sensor	Manifold Absolute Pressure Sensor ¹	MAP Sensor ¹
PSM (Pulsed Secondary Air Injection)	Pulsed Secondary Air Injection ¹	PSAI ¹
Parameter Identification	Parameter Identification	PIR
Parameter Identification Supported	Parameter Identification Supported	See Table 4
Park/Neutral Position	Hand/Neural Position ¹	PSW ¹
PC (Pressure Control) Solenoid Valve	Pressure Control Solenoid Valve ¹	PC Solenoid Valve ¹
PCM (Powertrain Control Module)	Powertrain Control Module ¹	PCM ¹
PCV (Positive Crankcase Ventilation)	Positive Crankcase Ventilation ¹	PCV ¹
PCV (Positive Crankcase Ventilation) Valve	Positive Crankcase Ventilation Valve ¹	PCV Valve ¹
Passent Alarm Sensor	Passent Alarm Sensor ¹	AS Sensor ¹
Periodic Trip Counter	Periodic Trip Counter ¹	PTC ¹
PFE (Pressure Feedback Exhaust Gas Recirculation) Sensor	Feedback Pressure Exhaust Gas Recirculation Sensor ¹	Feedback Pressure EGR Sensor ¹
PFI (Port Fuel Injection)	Multiport Fuel Injection ¹	MFI ¹
PG (Pulse Generator)	Vehicle Speed Sensor ¹	VSS ¹
PGM-PI (Programmed Fuel Injection)	Multiport Fuel Injection ¹	MFI ¹
PIG (Parameter Identification)	Parameter Identification	PIR
PIG SUP	Parameter Identification Supported	See Table 4
PIP (Position Indicator Pulse)	Hand/Neural Position ¹	PSW ¹
PIP (Hand/Neural Position)	Hand/Neural Position ¹	PSW ¹
Positive Crankcase Ventilation	Positive Crankcase Ventilation ¹	PCV ¹
Positive Crankcase Ventilation Valve	Positive Crankcase Ventilation Valve ¹	PCV Valve ¹
Power Steering Pressure	Power Steering Pressure	PSW
Power Steering Pressure Switch	Power Steering Pressure Switch	PSW Switch
Powertrain Control Module	Powertrain Control Module ¹	PCM ¹
Pressure Control Solenoid Valve	Pressure Control Solenoid Valve ¹	PC Solenoid Valve ¹
Pressure Feedback EGR (Exhaust Gas Recirculation)	Feedback Pressure Exhaust Gas Recirculation ¹	Feedback Pressure EGR ¹
Pressure Sensor	Manifold Absolute Pressure Sensor ¹	MAP Sensor ¹
Pressure Feedback EGR (Exhaust Gas Recirculation) System	Feedback Pressure Exhaust Gas Recirculation System ¹	Feedback Pressure EGR System ¹
Pressure Transducer EGR (Exhaust Gas Recirculation) System	Pressure Transducer Exhaust Gas Recirculation System ¹	Pressure Transducer EGR System ¹
PRNDL (Park-Reverse-Neutral-Drive-Low)	Transmission Range	TR
Programmable Read Only Memory	Programmable Read Only Memory ¹	PRAM ¹
PRAM (Programmable Read Only Memory)	Programmable Read Only Memory ¹	PRAM ¹
PSF (Power Steering Pressure)	Power Steering Pressure	PSW

TABLE 1—CROSS REFERENCE AND LOOK UP (CONTINUED)

Existing Usage	Acceptable Usage	Acceptable Alternative Usage
PSP (Power Steering Pressure) Switch	Power Steering Pressure Switch	ESP Switch
PSP's (Power Steering Pressure Switch)	Power Steering Pressure Switch	ESP Switch
PTCR (Positive Temperature Coefficient Thermistor)	Positive Temperature Coefficient Thermistor	PTCR
Pulse	Pulse	Pulse
Pulsed Secondary Air Injection	Pulsed Secondary Air Injection	PASIS
Pulse Width Modulation	Pulse Width Modulation	PWM
PWM	Pulse Width Modulation	PWM
QDM (Quad Driver Module)	Driver	Driver
Quad Driver Module	Driver	Driver
Radiator Fan Control	Fan Control	FC
Radiator Fan Relay	Fan Control Relay	FC Relay
RAM (Random Access Memory)	Random Access Memory	RAM
Random Access Memory	Random Access Memory	RAM
Read Only Memory	Read Only Memory	ROM
Rear Wheel Drive	Rear Wheel Drive	RWD
Recirculated Exhaust Gas Temperature Sensor	Exhaust Gas Recirculation Temperature Sensor	EGRT Sensor
Reed Valve	Reed Valve	RV
REETS (Recirculated Exhaust Gas Temperature Sensor)	Exhaust Gas Recirculation Temperature Sensor	EGRT Sensor
Relay Module	Relay Module	RM
Remote Mount TFI (Thick Film Ignitor)	Remote Mount Ignitor	RM
Revolutions per Minute	Engine Speed	RPM
RMA (Relay Module)	Relay Module	RM
ROM (Read Only Memory)	Read Only Memory	ROM
RPM (Revolutions per Minute)	Engine Speed	RPM
RWD	Rear Wheel Drive	RWD
SABD	Selectable Four Wheel Drive	SABD
SABV (Secondary Air Bypass Valve)	Secondary Air Injection Bypass Valve	ASB Bypass Valve
SACV (Secondary Air Check Valve)	Secondary Air Injection Control Valve	ASB Control Valve
SASV (Secondary Air Switching Valve)	Secondary Air Injection Switching Valve	ASB Switching Valve
SBEC (Single Board Engine Control)	Engine Control Module	ECM
SCB (Supercharger Bypass Solenoid)	Supercharger Bypass Solenoid	SCB Solenoid
SC (Supercharger)	Supercharger	SC
Scan Tool	Scan Tool	ST
SCB (Supercharger Bypass)	Supercharger Bypass	SCB
Secondary Air Bypass Valve	Secondary Air Injection Bypass Valve	ASB Bypass Valve
Secondary Air Check Valve	Secondary Air Injection Check Valve	ASB Check Valve
Secondary Air Injection	Secondary Air Injection	ASB
Secondary Air Injection Bypass	Secondary Air Injection Bypass	ASB Bypass
Secondary Air Injection Driver	Secondary Air Injection Driver	ASB Driver
Secondary Air Switching Valve	Secondary Air Injection Switching Valve	ASB Switching Valve
Selectable Four Wheel Drive	Selectable Four Wheel Drive	SABD
SEI (Sequential Electronic Fuel Injection)	Sequential Electronic Fuel Injection	SEI
Sell Test	Sell Test	ST
Sell Test Codes	Sell Test Codes	STC
Sell Test Connector	Sell Test Connector	STC
Sequential Multipoint Fuel Injection	Sequential Multipoint Fuel Injection	SMFI
Service Engine Soon	Service Engine Indicator	SES
Service Engine Soon	Service Engine Indicator	SES
Service Engine Indicator	Service Engine Indicator	SES
SEI (Sequential Electronic Fuel Injection)	Sequential Electronic Fuel Injection	SEI
SEI Solenoid	SEI Solenoid	SEI
SEI Solenoid Valve	SEI Solenoid Valve	SEI Valve
Short Term FT (Fuel Trim)	Short Term Fuel Trim	STFT
Short Term Fuel Trim	Short Term Fuel Trim	STFT
SMART FT	Short Term Fuel Trim	STFT
SLP (Selection Lever Position)	Selection Lever Position	SLP
SMEC (Single Module Engine Control)	Engine Control Module	ECM
Smoke Fuel Limiter	Smoke Fuel Limiter	SFL
SPARK ADV	Spark Advance	SA
Spark Advance	Spark Advance	SA
Spark Plug	Spark Plug	SP
SP (Single Point Injection)	Single Point Injection	SP
SPL (Smoke Fuel Limiter)	Smoke Fuel Limiter	SFL
SS (Shift Solenoid)	Shift Solenoid	SS
SPN (Service Parameter Indicator)	Service Parameter Indicator	SPI
SPY (System Readiness Test)	System Readiness Test	SRT
ST (Scan Tool)	Scan Tool	ST
Supercharger	Supercharger	SC
Supercharger Bypass	Supercharger Bypass	SCB
Syn Pick-up	Syn Pick-up	SP
System Readiness Test	System Readiness Test	SRT
T-278 (3-2 Timing Solenoid)	T-278 (3-2 Timing Solenoid)	T-278
T-278 Valve (3-2 Timing Solenoid Valve)	T-278 (3-2 Timing Solenoid Valve)	T-278 Valve
T-2 Timing Solenoid	T-2 Timing Solenoid	T-2
T-2 Timing Solenoid Valve	T-2 Timing Solenoid Valve	T-2 Valve
TGR (Third Gear)	Third Gear	TG
TAB (Throttle Actuator Bypass)	Throttle Actuator Bypass	TAB
TAC (Throttle Actuator Control)	Throttle Actuator Control	TAC
TAC (Throttle Actuator Control) Module	Throttle Actuator Control Module	TAC Module
TAD (Throttle Air Driver)	Throttle Air Driver	TAD
TB (Throttle Body)	Throttle Body	TB
TBS (Throttle Body Fuel Injection)	Throttle Body Fuel Injection	TBS

TABLE 1—CROSS REFERENCE AND LOOK UP (CONTINUED)

Existing Usage	Acceptable Usage	Acceptable Acronyms Usage
TRT (Throttle Body Temperature)	Intake Air Temperature ¹	IAT ²
TC (Turbocharger)	Turbocharger ¹	TC ²
TC (Turbocharger) Wastegate	Turbocharger Wastegate ¹	TC Wastegate ²
TC (Turbocharger) Wastegate Regulating Valve	Turbocharger Wastegate Regulating Valve ¹	TC Wastegate Regulating Valve ²
TCC (Torque Converter Clutch)	Torque Converter Clutch ¹	TCC ²
TCC (Torque Converter Clutch) Relay	Torque Converter Clutch Relay ¹	TCC Relay ²
TCC (Torque Converter Clutch) Solenoid	Torque Converter Clutch Solenoid ¹	TCC Solenoid ²
TCC (Torque Converter Clutch) Solenoid Valve	Torque Converter Clutch Solenoid Valve ¹	TCC Solenoid Valve ²
TCM (Transmission Control Module)	Transmission Control Module ¹	TCM ²
TCCP (Torque Converter Clutch Pressure)	Torque Converter Clutch Pressure	TCCP ²
TFI (Thick Film Ignition)	Distributor Ignition ¹	DI ²
TFI (Thick Film Ignition) Module	Ignition Control Module ¹	ICM ²
TFP (Transmission Fluid Pressure)	Transmission Fluid Pressure	TFP ²
TFI (Transmission Fluid Temperature) Sensor	Transmission Fluid Temperature Sensor	TFI Sensor ²
Thermac	Secondary Air Injection ¹	AIB ²
Thermac Air Diverter	Air Diverter ¹	AD ²
Thermactor	Secondary Air Injection ¹	AIB ²
Thermactor Air Bypass	Secondary Air Injection Bypass ¹	AIB Bypass ²
Thermactor Air Diverter	Secondary Air Injection Diverter ¹	AIB Diverter ²
Thermactor II	Purged Secondary Air Injection ¹	PASII ²
Thermal Vacuum Switch	Thermal Vacuum Valve ¹	TVV ²
Thermal Vacuum Valve	Thermal Vacuum Valve ¹	TVV ²
Third Gear	Third Gear	3GB ²
Three Way + Oxidation Catalytic Converter	Three Way + Oxidation Catalytic Converter ¹	THW+OC ²
Three Way Catalytic Converter	Three Way Catalytic Converter ¹	THW ²
Throttle Actuator Control	Throttle Actuator Control	TAC ²
Throttle Actuator Control Module	Throttle Actuator Control Module	TAC Module ²
Throttle Body	Throttle Body ¹	TB ²
Throttle Body Fuel Injection	Throttle Body Fuel Injection ¹	TBF ²
Throttle Operator	Idle Speed Control ¹	ISC ²
Throttle Operator Vacuum Switching Valve	Idle Speed Control Solenoid Vacuum Valve ¹	ISC Solenoid Vacuum Valve ²
Throttle Operator VSV (Vacuum Switching Valve)	Idle Speed Control Solenoid Vacuum Valve ¹	ISC Solenoid Vacuum Valve ²
Throttle Position	Throttle Position ¹	TP ²
Throttle Position Sensor	Throttle Position Sensor ¹	TP Sensor ²
Throttle Position Switch	Throttle Position Switch ¹	TP Switch ²
Throttle Potentiometer	Throttle Position Sensor ¹	TP Sensor ²
TDC (Trap Oxidizer - Continuous)	Continuous Trap Oxidizer ¹	CTOX ²
TDP (Trap Oxidizer - Periodic)	Periodic Trap Oxidizer ¹	PTOX ²
Torque Converter Clutch	Torque Converter Clutch ¹	TCC ²
Torque Converter Clutch Pressure	Torque Converter Clutch Pressure	TCCP ²
Torque Converter Clutch Relay	Torque Converter Clutch Relay ¹	TCC Relay ²
Torque Converter Clutch Solenoid	Torque Converter Clutch Solenoid ¹	TCC Solenoid ²
Torque Converter Clutch Solenoid Valve	Torque Converter Clutch Solenoid Valve ¹	TCC Solenoid Valve ²
TP (Throttle Position)	Throttle Position ¹	TP ²
TP (Throttle Position) Sensor	Throttle Position Sensor ¹	TP Sensor ²
TP (Throttle Position) Switch	Throttle Position Switch ¹	TP Switch ²
TP (Tuned Port Injection)	Multiport Fuel Injection ¹	MFI ²
TPNP (Transmission Park Neutral Position)	Park/Neutral Position ¹	PNP ²
TPS (Throttle Position Sensor)	Throttle Position Sensor ¹	TP Sensor ²
TPS (Throttle Position Switch)	Throttle Position Switch ¹	TP Switch ²
TR (Transmission Range)	Transmission Range	TR ²
Track Road Load Horsepower	Track Road Load Horsepower	TRLHP ²
Transmission Control Module	Transmission Control Module ¹	TCM ²
Transmission Fluid Pressure	Transmission Fluid Pressure	TFP ²
Transmission Fluid Temperature Sensor	Transmission Fluid Temperature Sensor	TFI Sensor ²
Transmission Park Neutral Position	Park/Neutral Position ¹	PNP ²
Transmission Position Switch	Transmission Range Switch ¹	TR Switch ²
Transmission Range Selection	Transmission Range	TR ²
Transmission Range Sensor	Transmission Range Sensor ¹	TR Sensor ²
TRS (Transmission Range Selection)	Transmission Range	TR ²
TRSS (Transmission Range Selection Switch)	Transmission Range Switch ¹	TR Switch ²
TSS (Turbine Shaft Speed) Sensor	Turbine Shaft Speed Sensor ¹	TSS Sensor ²
Tuned Port Injection	Multiport Fuel Injection ¹	MFI ²
Turbine Shaft Speed Sensor	Turbine Shaft Speed Sensor ¹	TSS Sensor ²
Turbo (Turbocharger)	Turbocharger ¹	TC ²
Turbocharger	Turbocharger ¹	TC ²
Turbocharger Wastegate	Turbocharger Wastegate ¹	TC Wastegate ²
Turbocharger Wastegate Regulating Valve	Turbocharger Wastegate Regulating Valve ¹	TC Wastegate Regulating Valve ²
TVS (Thermal Vacuum Switch)	Thermal Vacuum Valve ¹	TVV ²
TVV (Thermal Vacuum Valve)	Thermal Vacuum Valve ¹	TVV ²
TWC (Three Way Catalytic Converter)	Three Way Catalytic Converter ¹	THW ²
TWC + OC (Three Way + Oxidation Catalytic Converter)	Three Way + Oxidation Catalytic Converter ¹	THW+OC ²
VAC (Vacuum) Sensor	Manifold Differential Pressure Sensor ¹	MDE Sensor ²
Vacuum Switches	Manifold Vacuum Zone Switch ¹	MVZ Switch ²
VAF (Volume Air Flow)	Volume Air Flow ¹	VAF ²
Valve Position EGR (Exhaust Gas Recirculation) System	Valve Position Exhaust Gas Recirculation System ¹	Valve Position EGR System ²
Vane Air Flow	Volume Air Flow ¹	VAF ²
Variable Control Relay Module	Variable Control Relay Module	VCRM ²
Variable Fuel Sensor	Flexible Fuel Sensor	FF Sensor ²
VAT (Vane Air Temperature)	Intake Air Temperature ¹	IAT ²
VCC (Viscous Converter Clutch)	Torque Converter Clutch ¹	TCC ²

TABLE 1—CROSS REFERENCE AND LOOK UP (CONTINUED)

Existing Usage	Acceptable Usage	Acceptable Authorized Usage
VCM	Vehicle Control Module	VCM
VCRM	Vehicle Control Relay Module	VCRM
Vehicle Control Module	Vehicle Control Module	VCM
Vehicle Identification Number	Vehicle Identification Number	VIN
Vehicle Speed Sensor	Vehicle Speed Sensor	VSS ¹
VIN (Vehicle Identification Number)	Vehicle Identification Number	VIN
VIP (Vehicle In Process) Connector	Data Link Connector	DLC ¹
Vacuum Converter Check	Vacuum Converter Check	VCC ¹
Voltage Regulator	Voltage Regulator	VR
Volume Air Flow	Vacuum Air Flow	VAF ¹
VR (Voltage Regulator)	Voltage Regulator	VR
VSS (Vehicle Speed Sensor)	Vehicle Speed Sensor	VSS ¹
VSV (Vacuum Solenoid Valve) (Canister)	Evaporative Emission Canister Purge Valve	EVAP Canister Purge Valve ¹
VSV (Vacuum Solenoid Valve) (EVAP)	Evaporative Emission Canister Purge Valve	EVAP Canister Purge Valve ¹
VSV (Vacuum Solenoid Valve) (Throttle)	Idle Speed Control Solenoid Vacuum Valve	ISC Solenoid Vacuum Valve ¹
Warm Up Oxidation Catalyst Converter	Warm Up Oxidation Catalyst Converter	WUOC ¹
Warm Up Three Way Catalytic Converter	Warm Up Three Way Catalytic Converter	WU3WC ¹
Wide Open Throttle	Wide Open Throttle	WOT ¹
WOT (Wide Open Throttle)	Wide Open Throttle	WOT ¹
WOT3 (Wide Open Throttle Switch)	Wide Open Throttle Switch	WOT3 Switch ¹
WUOC (Warm Up Oxidation Catalyst Converter)	Warm Up Oxidation Catalyst Converter	WUOC ¹
WU3WC (Warm Up Three Way Catalytic Converter)	Warm Up Three Way Catalytic Converter	WU3WC ¹
Connector		
Recommended Terms and Recommended Acronyms See Table 2		
¹ Emission Related Term		
Bold indicates recommended entry		

4. Recommended Terms—Table 2 is an alphabetical listing of modifiers to be used in combination with base words.

TABLE 2—RECOMMENDED TERMS

Recommended Term	Acronym	Definition
3-2 Timing Solenoid	3-2TS	A device that controls the "3-2 to 2-3" timing valve.
Accelerator Pedal	AP ¹	See Glossary Entry "ACCELERATOR PEDAL."
Accelerator Pedal Position ¹	APP	See Glossary Entry "ACCELERATOR PEDAL."
Air Cleaner ¹	ACL	See Glossary Entry "CLEANER."
Air Conditioning	AC	See Glossary Entry "AIR CONDITIONING."
Ambient Air Temperature	AAT	Air Temperature Surrounding the vehicle.
Automatic Transaxle	AT	See Glossary Entry "TRANSMISSION."
Automatic Transmission	AT	See Glossary Entry "TRANSMISSION."
Barometric Pressure ¹	BAP ¹	See Glossary Entry "PRESSURE."
Battery Positive Voltage	B+ ¹	See Glossary Entry "BATTERY."
Brake Pedal Position ¹	BPP	See Glossary Entry "BRAKE."
Brake Pressure	—	Positive Pressure in the brake system.
Calculated Load Value	LOAD	Percent of engine capacity being used.
Camshaft Position ¹	CMP	See Glossary Entry "CAMSHAFT."
Canister ¹	—	See Glossary Entry "CANISTER."
Canister ¹	CAN ¹	See Glossary Entry "CAPTURED."
Catalytic Converter Heater ¹	—	A device to quickly heat a Catalytic Converter.
Charge Air Cooler ¹	CAC ¹	A device which lowers the temperature of the pressurized intake air.
Closed Loop ¹	CL	See Glossary Entry "CLOSED LOOP."
Closed Throttle Position ¹	CTP	See Glossary Entry "THROTTLE."
Clutch Pedal Position ¹	CPP	See Glossary Entry "CLUTCH."
Coast Clutch Solenoid	CCS	A device that controls the Coast Clutch Valve.
Constant Volume Sampler	CVS	An exhaust sampling system which flows a constant amount of ambient air diluted exhaust.
Continuous Fuel Injection ¹	CFI	A fuel injection system with the injector flow controlled by fuel pressure.
Continuous Trap Oxidizer ¹	CTOX	A system for trapping diesel engine particulate emissions by collecting exhaust particulates and continuously burning them through oxidation.
Crankshaft Position ¹	COP	See Glossary Entry "CRANKSHAFT."
Critical Flow Venturi	CFV	An air flow regulating device which uses a sonic orifice to limit air flow.
Data Link Connector ¹	DLC ¹	Connector providing access and/or control of the vehicle information, operating conditions, and diagnostic information.
Diagnostic Test Mode ¹	DTM	A level of diagnostic capability in an On-Board Diagnostic (OBD) system. This may include different functional states to observe signals, a basic level to read diagnostic trouble codes, a monitor level which includes information on signal levels, bi-directional control with on/off board aids, and the ability to interface with remote diagnosis.
Diagnostic Trouble Code ¹	DTC	An alphanumeric identifier for a fault condition identified by the On-Board Diagnostic System.
Direct Fuel Injection ¹	DPI	Fuel injection system that supplies fuel directly into the combustion chamber.
Distributor Ignition ¹	DI	A system in which the ignition coil secondary circuit is switched by a distributor in proper sequence to various spark plugs.
Driver	—	See Glossary Entry "Driver."
Early Fuel Evaporation ¹	EFE	Enhancing fuel vaporization during engine warm up.
EGR Temperature ¹	ESPT	Sensing EGR function based on temperature change. Primarily in systems with mechanical flow control devices.
Electrically Erasable Programmable Read	EEPROM	An electronic device named electrically erasable programmable read only memory.
Electronic Ignition ¹	EI	A system in which the ignition coil secondary circuit is dedicated to specific test plugs without the use of a distributor.

TABLE 2--RECOMMENDED TERMS (CONTINUED)

Recommended Term	Acronym	Definition
Engine Control ¹	EC	See Glossary Entries "ENGINE" and "CONTROL."
Engine Control Module ¹	ECM ²	See Glossary Entries "ENGINE," "CONTROL," and "MODULE."
Engine Coolant Level	ECL	See Glossary Entries "ENGINE," "COOLANT," and "LEVEL."
Engine Coolant Temperature ¹	ECT	See Glossary Entries "ENGINE" and "COOLANT."
Engine Modification ¹	EM	A method of lowering engine emissions through changes in basic engine construction or in fuel and spark calibration.
Engine Oil Pressure	EOP	Positive pressure in the engine's lubrication system.
Engine Oil Temperature	EOT	Temperature of engine lubricating oil.
Engine Speed ¹	RPM ³	See Glossary Entries "ENGINE" and "SPEED."
Erasable Programmable Read Only Memory ¹	EPROM	An electronic device named erasable programmable read only memory.
Evaporative Emission ¹	EVAP ³	A system used to prevent fuel vapor from escaping into the atmosphere. Typically includes a charcoal canister to store fuel vapors.
Exhaust Gas Recirculation ¹	EGR	Reducing NOx emissions levels by adding exhaust gas to the incoming air/fuel mixture.
Exhaust Pressure	EP	See Glossary Entries "EXHAUST" and "PRESSURE."
Fan Control	FC	See Glossary Entries "FAN" and "CONTROL."
Flame Ionization Detector	FID	A device used to measure hydrocarbon concentrations.
Flash-Electrically Erasable Programmable Read Only Memory ¹	EEPROM	An electronic device named flash electrically erasable programmable read only memory.
Flash Erasable Programmable Read Only Memory ¹	FEPRM	An electronic device named flash erasable programmable read only memory.
Flexible Fuel ²	FF	A system capable of using a variety of fuels for vehicle operation.
Fourth Gear	4GR ²	Identifies the gear in which the transmission is operating in at a particular moment (e.g., the Transmission Range (TR) switch may indicate that "drive" was selected, but the transmission is operating in 4th gear as indicated by 4GR switch).
Freeze Frame	---	A block of memory containing the vehicle operating conditions for a specific time.
Front Wheel Drive	FWD	A driveline configuration that transmits motive power only through the front axle.
Fuel Level Sensor	---	See Glossary Entries "FUEL" and "SENSOR."
Fuel Pressure	---	See Glossary Entries "FUEL" and "PRESSURE."
Fuel Pump	FP ²	See Glossary Entries "FUEL" and "PUMP."
Fuel System Status	---	Information describing operation of the fuel control. (i.e. Open Loop/Closed Loop)
Fuel Trim ¹	FT	A fuel correction term.
Full Time Four Wheel Drive	F4WD	A driveline configuration that transmit motive power to both axles. The system does not allow the driver to select between one axle and two axle operation.
Generator	GEN ³	See Glossary Entry "GENERATOR."
Glow Plug	---	See Glossary Entry "GLOW PLUG."
Governor	---	See Glossary Entry "GOVERNOR."
Governor Control Module	GCM ²	See Glossary Entries "GOVERNOR," "CONTROL," and "MODULE."
Grams Per Mile	GPM	Grams of pollutant emitted per mile.
Ground	GND	See Glossary Entry "GROUND."
Heated Oxygen Sensor ¹	HO2S ²	An oxygen sensor (OS) that is electrically heated.
Idle Air Control ¹	IAC	Electrical or mechanical control of throttle bypass air.
Idle Speed Control ¹	ISC	Electronic control of minimum throttle position.
Ignition Control ¹	IC	See Glossary Entries "IGNITION" and "CONTROL."
Ignition Control Module ¹	ICM ²	See Glossary Entries "IGNITION," "CONTROL," and "MODULE."
Indirect Fuel Injection ¹	IF	An injection system that supplies fuel into a combustion pre-chamber (disse)
Inertia Fuel Shutoff	IFS	An inertia system that shuts off the fuel delivery system when activated by predetermined force limits.
Injection Control Pressure ¹	ICP	Injection control pressure for hydraulically actuated injectors.
Input Shaft Speed	ISS	See Glossary Entries "Input Shaft" and "Speed."
Inspection and Maintenance	IM ³	An emission control program.
Intake Air ¹	IA	See Glossary Entry "INTAKE AIR."
Intake Air Temperature ¹	IAT	See Glossary Entry "INTAKE AIR."
Intake Manifold Runner Control	IMRC	Controls air flow through runners in the intake manifold.
Knock Sensor ¹	KS ²	See Glossary Entries "KNOCK" and "SENSOR."
Malfunction Indicator Lamp ¹	MIL ²	A required on-board indicator to alert the driver of an emission related malfunction.
Manifold Absolute Pressure ¹	MAP	See Glossary Entries "MANIFOLD" and "PRESSURE."
Manifold Differential Pressure ¹	MDP	See Glossary Entries "MANIFOLD" and "PRESSURE."
Manifold Gasket Temperature ¹	MST	See Glossary Entry "MANIFOLD."
Manifold Vacuum Zone ¹	MPVZ	See Glossary Entries "MANIFOLD" and "VACUUM."
Mass Air Flow ¹	MAF	A system which provides information on the mass flow rate of the intake air to the engine.
Mixture Control ¹	MC	A device which regulates bleed air, fuel, or both, on carbureted vehicles.
Multiport Fuel Injection ¹	MFI	A fuel-delivery system in which each cylinder is individually fueled.
Non Dispersive Infra Red	NDIR	An Emission measuring technique typically used for measuring carbon monoxide and carbon dioxide concentrations.
Non Volatile Random Access Memory ¹	NVRAM	An electronic device named non-volatile random access memory.
On Board Diagnostic ¹	OBD	A system that monitors some or all computer input and control signals. Signals) words of the predetermined lines imply a fault in the system or in a related system.
Open Loop ¹	OL	See Glossary Entry "OPEN LOOP."
Output Shaft Speed ¹	OSS	See Glossary Entry "OUTPUT SHAFT" and "SPEED."
Oxidation Catalytic Converter ¹	OC	A catalytic converter system that reduces levels of HC and CO.
Oxygen Sensor ¹	OS ²	A sensor which detects oxygen (O2) content in the exhaust gases.
Park/Neutral Position ¹	PnP	See Glossary Entry "PARK/NEUTRAL."
Parameter Identification	PID	Identifies an address in memory which contains vehicle operating information.

TABLE 3—RECOMMENDED TERMS (CONTINUED)

Recommended Term	Acronym	Definition
Periodic Trap Oxidizer ¹	PTOX	A system for lowering diesel engine particulate emissions by collecting exhaust particulates and periodically burning them through oxidation.
Positive Crankcase Ventilation ¹	PCV	Positive ventilation of crankcase emissions.
Power Steering Pressure	PSP	See Glossary Entry "POWER STEERING."
Powertrain Control Module ¹	PCM ²	See Glossary Entries "POWERTRAIN," "CONTROL," and "MODULE."
Pressure Control ¹	PC	See Glossary Entries "PRESSURE" and "CONTROL."
Programmable Read Only Memory ¹	PRAM	An electronic device named programmable (by the manufacturer) read only memory.
Pulsed Secondary Air Injection ¹	PASIF	A pulse-driven system for providing secondary air without an air pump by using the engine exhaust system pressure fluctuations or pulses.
Pulse Width Modulation	PWM	A rectangular wave with a variable on-off time.
Random Access Memory ¹	RAM	An electronic device named random access memory.
Read Only Memory ¹	ROM	An electronic device named read only memory.
Rear Wheel Drive	RWD	A driveline configuration that transmits motive power only through the rear axle.
Relay Module	RM ²	See Glossary Entries "RELAY" and "MODULE."
Scan Tool ¹	ST ²	See Glossary Entry "SCAN TOOL."
Secondary Air Injection ¹	ASIF	A pump-driven system for providing secondary air.
Selectable Four Wheel Drive	S4WD	A driveline configuration that allows the driver to select the option to transmit motive power either to both axles or only to one axle (front or rear).
Sequential Multipoint Fuel Injection ¹	SFI	A multipoint fuel delivery system in which each injector is individually energized and timed relative to its cylinder intake event. Normally fuel is delivered to each cylinder once per two crankshaft revolutions in four cycle engines and once per crankshaft revolution in two cycle engines.
Service Reminder Indicator ¹	SRI ²	An indicator used to identify a service requirement.
Shift Solenoid	SS	See Glossary Entry "SHIFT SOLENOID."
Smoke Puff Limiter ¹	SPL	A system to reduce diesel exhaust smoke during vehicle acceleration or gear changes.
Spark Advance	... ³	The relationship between the ignition timing and top dead center.
Spark Plug ¹	—	A device for producing an electrical spark inside the cylinder of an internal combustion engine to ignite the fuel mixture.
Supercharger ¹	SC ²	See Glossary Entry "SUPERCHARGER."
Supercharger Bypass ¹	SCB	See Glossary Entry "SUPERCHARGER."
System Readiness Test ¹	SRT	System readiness test as applicable to OBDII scan tool communications.
Thermal Vacuum Valve ¹	TVV ²	A valve that controls vacuum levels or routing based on temperature.
Third Gear ¹	3GR ²	Identifies the gear in which the transmission is operating in at a particular moment (e.g., the Transmission Range (TR) switch may indicate that "drive" was selected, but the transmission is operating in 3rd gear as indicated by 3GR switch).
Three Way + Oxidation Catalytic Converter ¹	TWC+O ₂	A catalytic converter system that has both Three Way Catalyst (TWC) and Oxidation Catalyst (O ₂). Usually secondary air is introduced between the two catalysts.
Three Way Catalytic Converter ¹	TWC	A catalytic converter system that reduces levels of HC, CO and NO _x .
Throttle Actuator Control	TAC	See Glossary Entries "THROTTLE," "ACTUATOR" and "CONTROL."
Throttle Body ¹	TB ²	See Glossary Entries "THROTTLE" and "BODY."
Throttle Body Fuel Injection ¹	TBI	An electronically controlled fuel injection system in which one or more fuel injectors are located in a throttle body.
Track Road Load Horsepower	TRLHP	The power required for a vehicle to maintain a constant speed taking into account power losses due to such things as wind resistance, tire losses, bearing friction, etc.
Throttle Position ¹	TP	See Glossary Entry "THROTTLE."
Torque Converter Clutch ¹	TCC ²	See Glossary Entries "CONVERTER" and "CLUTCH."
Torque Converter Clutch Pressure	TCCP	A positive pressure in a torque converter clutch hydraulic circuit.
Transmission Control Module	TCM ²	See Glossary Entries "TRANSMISSION," "CONTROL," and "MODULE."
Transmission Fluid Pressure	TFP	Positive pressure in a transmission hydraulic system.
Transmission Fluid Temperature	TFT	Temperature of transmission fluid.
Transmission Range	TR	See Glossary Entries "TRANSMISSION" and "RANGE."
Turbine Shaft Speed ¹	TSS	See Glossary Entries "TURBINE SHAFT" and "SPEED."
Turbocharger ¹	TC ²	See Glossary Entry "TURBOCHARGER."
Variable Control Relay Module	VCRLM	A module that variably controls engine cooling fan speed, operates the A/C compressor clutch, and controls some of the non A/C functions.
Vehicle Control Module ¹	VCM ²	An electronic module that controls the powertrain plus chassis and/or body related functions.
Vehicle Identification Number	VIN	A unique number on the vehicle used for identification.
Vehicle Speed Sensor ¹	VSS ²	A sensor which provides vehicle speed information.
Voltage Regulator	VR	See Glossary Entry "REGULATOR."
Volume Air Flow ¹	VAF	A system which provides information on the volume flow rate of the intake air to the engine.
Warm Up Oxidation Catalytic Converter ¹	WU-O ₂	A catalytic converter system designed to lower HC and CO emissions during engine warm up. Usually located in or near the exhaust manifold.
Warm Up Three Way Catalytic Converter ¹	WU-TWC	A catalytic converter system designed to lower HC, CO, & NO _x emissions during engine warm up. Usually located in or near the exhaust manifold.
Wide Open Throttle ¹	WOT	See Glossary Entry "THROTTLE."

— Use Recommended Term Only

¹ Emission-Related Term

² Historically acceptable common usage

³ For Alphabetic Description see Table 4

Bold indicates new/revised entry

7. Glossary of Terms—Table 3 is an alphabetical listing of base words and single word modifiers, together with their definitions.

TABLE 3—GLOSSARY OF TERMS

Baseword/Single Word Modifier	Definition
Accelerator Pedal	A foot operated device, which, directly or indirectly, controls the flow of fuel and/or air to the engine, thereby, controlling engine speed.
Accumulator	A vessel in which fluid is stored, usually at greater than atmospheric pressure.
Actuator	A mechanism for moving or controlling something indirectly instead of by hand. Compare: Solenoid, relay, and valve.
Air Conditioning	A vehicular accessory system that modifies the passenger compartment air by cooling and drying the air.
Alternator	See Generator.
Battery	An electrical storage device designed to produce a DC voltage by means of an electrochemical reaction.
Blower	A device designed to supply a current of air at a moderate pressure. A blower usually consists of an impeller assembly, a motor and a suitable case. The blower case is usually designed as part of a ventilation system. Compare: Fan.
Brake	A device for retarding motion, usually by means of friction.
Body	(1) The assembly of sheet metal components, windows, doors, seats, etc., that provide enclosures for passengers and/or cargo in a motor vehicle. It may or may not include the hood and fenders. (2) The primary, central or key part of a feature.
Bypass	Providing a secondary path to relieve pressure in the primary passage.
Camshaft	A shaft on which phased cams are mounted. The camshaft is used to regulate the opening and closing of the intake and exhaust valves.
Catalytic	An evaporative emission catalytic converter contains activated charcoal which adsorbs fuel vapors and holds them until the vapors can be purged at an appropriate time.
Capacitor	An electrical device for accumulating and holding a charge of electricity.
Carburetor	A mechanism which automatically mixes fuel with air in the proper proportions to provide a desired power output from a spark ignition internal combustion engine.
Catalyst	A substance that can increase or decrease the rate of a chemical reaction between substances without being consumed in the process.
Chassis	The suspension, steering, and braking elements of a vehicle.
Circuit	A complete electrical path or channel, usually includes the source of electric energy. Circuit may also describe the electrical path between two or more components. May also be used with fluids, air or liquid.
Cleaner	A device used in the intake system of parts that require clean air. An air cleaner usually has a filter in it to trap particulates and only pass clean air through.
Clocked Loop (Engine)	An operating condition or mode which enables modification of programmed instructions based on a feedback system.
Clutch	A mechanical device which uses mechanical, magnetic or friction type connections to facilitate engaging or disengaging of two shafts or rotating members.
Code	A system of symbols (as letters, numbers, or words) used to represent meaning of information.
Coil (Ignition)	A device consisting of windings of conductors around an iron core, designed to increase the voltage, and for use in a spark ignition system.
Control	A means or a device to direct and regulate a process or guide the operation of a machine, apparatus or system.
Converter (Catalytic)	An in-line, exhaust system device used to reduce the level of engine exhaust emissions.
Converter (Torque)	A device which by its design multiplies the torque in a fixed coupling between an engine and transmission/transaxle.
Coolant	A fluid used for heat transfer. Coolants usually contain additives such as rust inhibitors and antifreeze.
Cooler	A heat exchanger that reduces the temperature of the named medium.
Crankshaft	The part of an engine which converts the reciprocating motion of the pistons to rotary motion.
Data	General term for information, usually represented by numbers, letters, symbols.
Device	A piece of equipment or a mechanism designed for a specific purpose or function. DO NOT use "Device" in naming.
Diagnosis	The process of identifying the cause or nature of a condition, situation or problem. To determine corrective action in regard of automotive systems.
Differential	(1) A device with an arrangement of gears designed to permit the division of power to two shafts. (2) See Pressure.
Distributor	A mechanical device designed to switch a high voltage secondary circuit from an ignition coil to spark plugs in the proper firing sequence.
Drive	A device which provides a fluid increase or decrease ratio of relative rotation between its input and output shafts.
Driver	A switched electronic device that controls output state.
Electrical	A type of device or system using resistors, motors, generators, incandescent lamps, switches, capacitors, batteries, inductors or wires. Compare: Electronic.
Electronic	(1) A type of device or system using solid state devices or thermionic elements such as diodes, transistors, integrated circuits, vacuum fluorescent displays and liquid crystal displays. (2) The storage, retrieval and display of information through media such as magnetic tape, laser disc, electronic read only memory (ROM) and random access memory (RAM). Compare: Electrical.
Engine	A machine designed to convert thermal energy into mechanical energy to produce force or motion.
Exhaust	
Fan	A device designed to supply a current of air. A fan may also have a frame, motor, wiring harness and the like. Compare: Blower.
Fuel	Any combustible substance burned to provide heat or power. Typical fuels include gasoline and diesel fuel. Other types of fuel include ethanol, methanol, natural gas, propane or in combination.

TABLE 1—GLOSSARY OF TERMS (CONTINUED)

Baseword/Single Word Modifier	Definition
Generator	A rotating machine designed to convert mechanical energy into electrical energy.
Glow Plug	A combustion chamber heat generating device to aid starting diesel engines.
Governor	A device designed to automatically limit engine speed.
Ground	An electrical conductor used as a common return for an electric circuit(s) and with a relative zero potential.
Idle	Rotational speed of an engine with vehicle at rest and accelerator pedal not depressed.
Ignition	System used to provide high voltage spark for internal combustion engines.
Indicator	A device which visually presents vehicle condition information transmitted or relayed from some other source.
Injector	A device for delivering metered pressurized fuel to the intake system or the cylinders.
Input Shaft	A shaft in a device that is "driven" by the previous element in the powertrain.
Intake Air	Air drawn through a cleaner and distributed to each cylinder for use in combustion.
Knock (Engine)	The sharp, metallic sound produced when two pressure fronts collide in the combustion chamber of an engine.
Load	The magnitude of a quantity considered in relation to an arbitrary reference value.
Line	A generic service term used to describe a system of pipes, tubes and hoses.
Link (Electrical/Electronic)	General term used to indicate the existence of communication facilities between two points.
Manifold	A device designed to collect or distribute fluid, air or the like. Compare: Rail.
Memory	A device in which data can be stored and used when needed.
Mode	One of several alternative conditions or methods of operating a device or control module.
Module (Electrical/Electronic)	A self-contained group of electrical/electronic components, which is designed as a single replaceable unit.
Motor	A machine that converts kinetic energy, such as electricity, into mechanical energy. Compare: Actuator.
Open Loop	An operating condition or mode based on programmed instructions and not modified by a feedback system.
Output Shaft	A shaft in a device that drives the next element in the powertrain.
Park/Neutral	The selected non-drive modes of the transmission.
Power Steering	A system which provides additional force to the steering mechanism, reducing the driver's steering effort.
Powertrain	The elements of a vehicle by which motive power is generated and transmitted to the driven axles.
Pressure	(Unless otherwise noted, is gage pressure.)
Pressure (Absolute)	The pressure referenced to a perfect vacuum.
Pressure (Atmospheric)	The pressure of the surrounding air at any given temperature and altitude. Sometimes called Barometric Pressure.
Pressure (Barometric)	Pertaining to atmospheric pressure or the results obtained by using a barometer.
Pressure (Differential)	The pressure difference between two regions, such as between the intake manifold and the atmospheric pressures.
Pressure (Gage)	The amount by which the total absolute pressure exceeds the ambient atmospheric pressure.
Pump	A device used to raise, transfer, or compress fluids by suction, pressure or both.
Radiator	A radiator is a liquid to air heat transfer device having a tank(s) and core(s) specifically designed to reduce the temperature of the coolant in an internal combustion engine cooling system.
Rail	A manifold for fuel injection fuel. Compare: Manifold.
Range	The default position of the transmission manual valve.
Refrigerant	A substance used as a heat transfer agent in an air conditioning system.
Relay	A generally electromechanical device in which connections in one circuit are opened or closed by changes in another circuit. Compare: Actuator, Solenoid, and Switch.
Regulator (Voltage)	A device that automatically controls the functional output of another device by adjusting the voltage to meet a specified value.
Scan Tool	A device that interfaces with and communicates information on a data link.
Secondary Air	Air provided to the exhaust system.
Sensor	The generic name for a device that senses either the absolute value or a change in a physical quantity such as temperature, pressure or flow rate, and converts that change into an electrical quantity signal. Compare: Transducer.
Shift Solenoid	A device that controls shifting in an automatic transmission.
Signal (Electrical/Electronic)	A fluctuating electric quantity, such as voltage or current, whose variations represent information.
Solenoid	A device consisting of an electrical coil which when energized, produces a magnetic field in a plunger, which is pulled to a central position. A solenoid may be used as an actuator in a valve or switch.
Solid State	Compare: Actuator, Relay, and Switch. Crystalline circuit structures used to perform electronic functions. Examples of such structures include transistors, diodes, integrated circuits and other semiconductors.
Speed	The magnitude of velocity (regardless of direction).
Supercharger	A mechanically driven device that pressurizes the intake air, thereby increasing the density of charge air and the consequent power output from a given engine displacement.
Switch	A device for making, breaking, or changing the connections in an electrical circuit. Compare: Relay, Solenoid, and Valve.
System	A group of interacting mechanical or electrical components serving a common purpose.
Test	A procedure whereby the performance of a product is measured under various conditions.
Throttle	A valve for regulating the supply of a fluid, usually air or a fuel/air mix, to an engine.
Throatplate	A device consisting of a transmission and axle drive gears assembled in the same case. Compare: Transmission.
Transducer	A device that receives energy from one system and retransmits (transfers) it, often in a different form, to another system. For example, the cruise control transducer converts a vehicle speed signal to a modulated vacuum output to control a servo. Compare: Sensor.
Transmission	A device which selectively increases or decreases the ratio of relative rotation between its input and output shafts.

TABLE 3--GLOSSARY OF TERMS (CONTINUED)

Baseword/Single Word Modifier	Definition
Turbobolting	Compare: Thrustable.
Turbine Shaft	See Diagnostics.
Turbocharger	A shaft is a device that is driven by a turbine.
Unadvised	A centrifugal device driven by exhaust gases that pressurizes the intake air, thereby increasing the density of charge air and the consequent power output from a given engine displacement.
Vacuum	The portion of the electromagnetic spectrum between violet visible light and X-Rays.
Valve	A circuit in which pressure has been reduced below the ambient atmospheric pressure.
Vapor	A device by which the flow of liquid, gas, vacuum, or other material in bulk may be started, stopped or regulated by a movable part that opens, shuts or partially obstructs one or more ports or passageways. A "Valve" is also the movable part of such a device.
Vaporize	Compare: Actuator and Switch.
Vaporize	A substance in its gaseous state as distinguished from the liquid or solid state.
Wastegate	(1) Vaporizable at normal temperatures. (2) Not permanent.
Wheel	A valve used to vent charge air pressure by allowing exhaust gases to bypass the turbocharger.
Wheel	A circular frame of hard material that may be solid, partially solid, or coked and that is capable of rotating on an axle.

Word indicates manufacturer entry.

(8) 8. Alphabetic Descriptor Table--Table 4 is an alphabetical listing of alphanumeric descriptors to be used when required due to limited display sizes.

8. Revision Procedures--It will be appropriate to revise the published H100 on an ongoing basis. Requested revisions and updates will be controlled by the SAE Vehicle E/E Systems Diagnostics Standards Committee using the normal Recommended Practice Bulletin process. This will ensure proper distribution of the changes.

As required by SAE standards, the H100 document will be formally updated and balloted at least once every five years. When warranted by the number of requested modifications, H100 will be updated as often as every three months.

See Appendix A for submission of new information.

TABLE 4--ALPHABETIC DESCRIPTOR TABLE

Recommended Term	Acceptable Alternative Usage	Alphanumeric Description
Diagnostic Trouble Code	DTC Freeze Frame	DTC FRZFF
Freeze Frame	Freeze Frame	FRZFF
Fuel Pressure	Fuel Pressure	FUEL PRESS
Fuel System Status	Fuel System Status	FUEL SYS
Long Term Fuel Trim	Long Term FT	LONG FT
OBD Status	OBD Status	OBD STAT
Oxygen Sensor Location	O2S Location	O2S LOC
Parameter Identification	PID Supported	PID SUP
Supported	Supported	
Short Term Fuel Trim	Short Term FT	SHORT FT
Spark Advance	Spark Advance	SPARK ADV

b = byte

p = position

Word indicates manufacturer entry.

APPENDIX A

REQUEST FOR REVISION TO SAE J1930 ELECTRICAL / ELECTRONIC SYSTEMS DIAGNOSTIC TERMS, DEFINITIONS, ABBREVIATIONS & ACRONYMS

To insure that your request is accepted for ballot and incorporation into J1930, please supply the following information consistent with the Methodology of Section 4:

Please send completed form to: SAE J1930 Task Force, 3001 West Big Beaver Rd., Ste. 300, Troy, MI 48064-3174 U.S.A.

Rev. 01: (R10) 943-5425

PURPOSE or RATIONALE FOR REQUEST:

SECTION 5.0
EXISTING USAGE(S)

RECOMMENDED TERMS

SECTION 6.0

RECOMMENDED TERM

Add Delete Change

EXISTING:

☐

☐

☐

SUGGESTED:

ACRONYM / ABBREVIATIONS

EXISTING:

☐

☐

☐

SUGGESTED:

DEFINITION

EXISTING:

☐

☐

☐

SUGGESTED:

EMISSION RELATED? YES _____ NO _____

SECTION 7.0

GLOSSARY of TERMS

(*) SECTION 8.0

ALPHANUMERIC DESCRIPTOR

DESIRED

REQUESTOR: _____

Phone: _____

Fax: _____

Address: _____

Signature _____

Date _____

COMMITTEE USE ONLY

RECOMMEND FOR BALLOT? YES _____ NO _____ BALLOT TARGET DATE _____

COMMENTS _____

J1930 CHAIRPERSON _____ DATE _____

FIGURE A1--REQUEST FOR REVISION FORM

Report of the SAE Vehicle E/E Systems Diagnostics Standards Committee approved June 1993, completely revised June 1995, revised June 1996 and January 1997. Rationale document available.

Foreword—The purpose of this SAE Recommended Practice is to define a minimum set of diagnostic connector requirements that will promote the use of a common diagnostic connector throughout the motor vehicle industry.

It is intended that the connector specified herein be used on complex luxury vehicles as well as simple utility vehicles.

This SAE document is under the control and maintenance of the Vehicle E/E System Diagnostics Committee. This committee will periodically review and update this document as needs dictate.

Rationale relative to intent is provided, where applicable, to minimize ambiguity.

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5.6	Test Equipment Connector Terminal Protection

6. Minimum Current Available
7. Liability for Devices That Draw More Than 4.0 A

1. Scope—The SAE J1962 diagnostic connector consists of two mating connectors, the vehicle connector (see Figure 1) and the test equipment connector (see Figure 2).

This document:

- a. Defines the functional requirements for the vehicle connector. These functional requirements are separated into three principal areas: connector location/access, connector design, and connector terminal assignments.
- b. Defines the functional requirements for the test equipment connector. These functional requirements are separated into two principal areas: connector design and connector terminal assignments.

The scope of this document does not include the needs of long-term retention, such as in-flight recorder type applications. To ensure long-term retention, additional steps outside of the scope of this document must be taken.

2. References

2.1 Applicable Documents—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 J1850—Class B Data Communication Network Interface

SAE J1930—Electrical/Electronic Systems Diagnostic Acronyms, Terms, and Definitions

SAE J1978—OBD II Scan Tool

SAE J2201—OBD II Scan Tool Universal Interface

(R) SAE J2213-3—Connections for On-Board Road Vehicle Electrical Wiring Harnesses—Part 3: Multipole Connectors—Flat Blade Terminals—Dimensional Characteristics and Specific Requirements

2.1.2 ISO PUBLICATIONS—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO 9141-2:1994(E)—Road vehicles—Diagnostic systems—CARB requirements for interchange of digital information ISO 8092-3—Road vehicles—Flat, quick connection terminations

(R) **2.1.3 OTHER PUBLICATIONS**

California Code of Regulations, Title 13, 1968.1: Malfunction and Diagnostic Systems Requirements, - 1994 and subsequent model year passenger cars, light-duty trucks, and medium-duty vehicles with feedback fuel control systems

Environmental Protection Agency 40 CFR Part 85 Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines; Regulations Requiring On-Board Diagnostic Systems on 1994 and Later Model Year Light-Duty Vehicles and Light-Duty Trucks

2.2 Diagnostic Terms, Definitions, and Acronyms—SAE J1930 is hereby referenced as the basis for all such terms in this document, with the following additions:

N Newtons

SAE J1850 10.4 VPW - SAE J1850 One wire, 10.4 Kbps, VPW

SAE J1850 41.6 PWM - SAE J1850 Two wire, 41.6 Kbps, PWM

3. Vehicle Connector Location/Access

3.1 Consistency of Location—The vehicle connector shall be located in the passenger compartment in the area bounded by the driver's end of the instrument panel to 300 mm beyond the vehicle centerline, attached to the instrument panel, and accessible from the driver's seat. The preferred location is between the steering column and the vehicle centerline. The vehicle connector shall be mounted to facilitate mating and unmating.

3.2 Ease of Access—Access to the vehicle connector shall not require a tool for the removal of an instrument panel cover, connector cover, or any barriers. The vehicle connector should be fastened and located so as to permit a one-handed/blind insertion of the mating test equipment connector. Refer to Figure 1 for mated connector space requirements.

3.3 Visibility—The vehicle connector should be out of the occupant's (front and rear seat) normal line of sight but easily visible in a "crouched" technician.

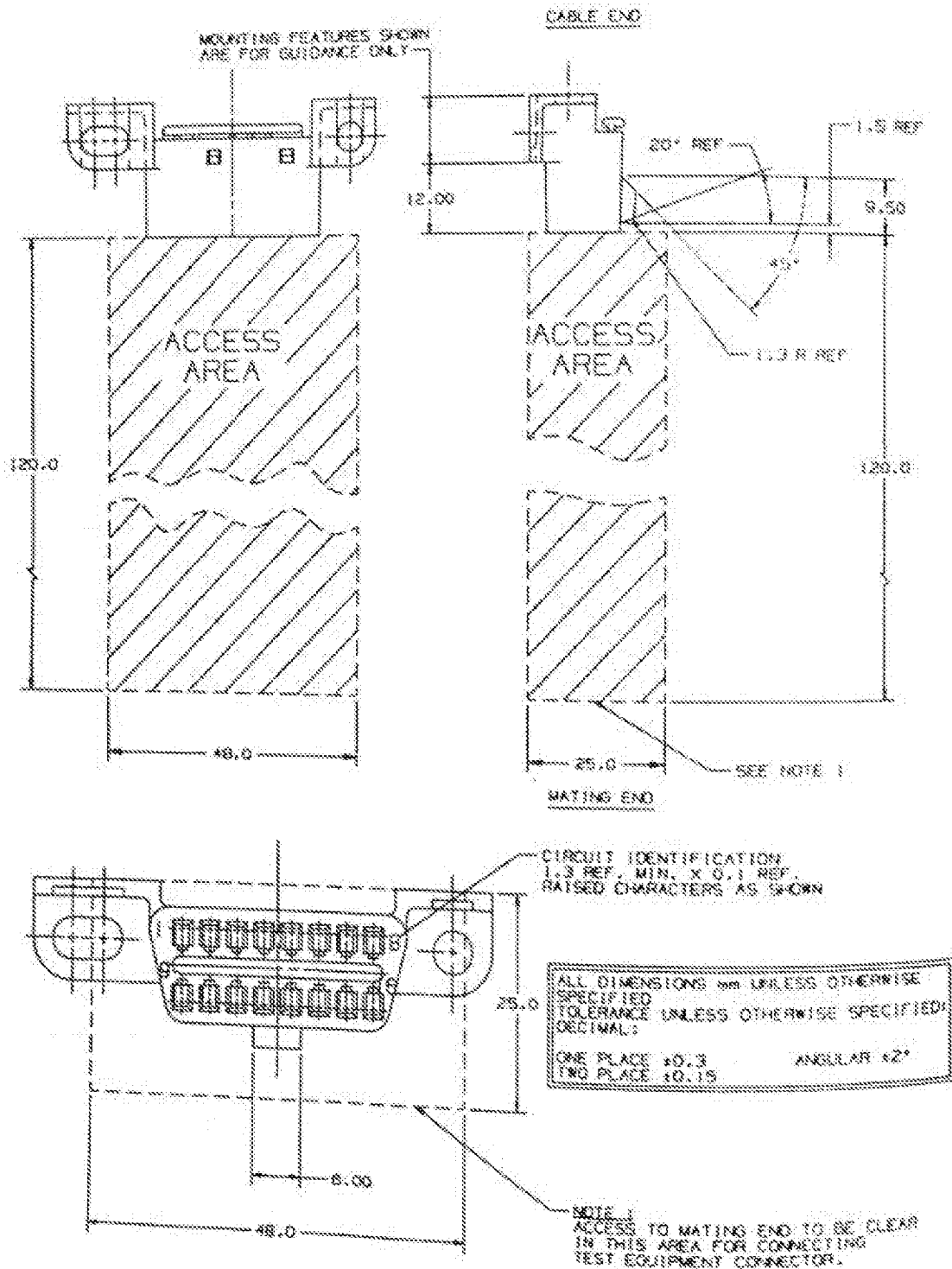
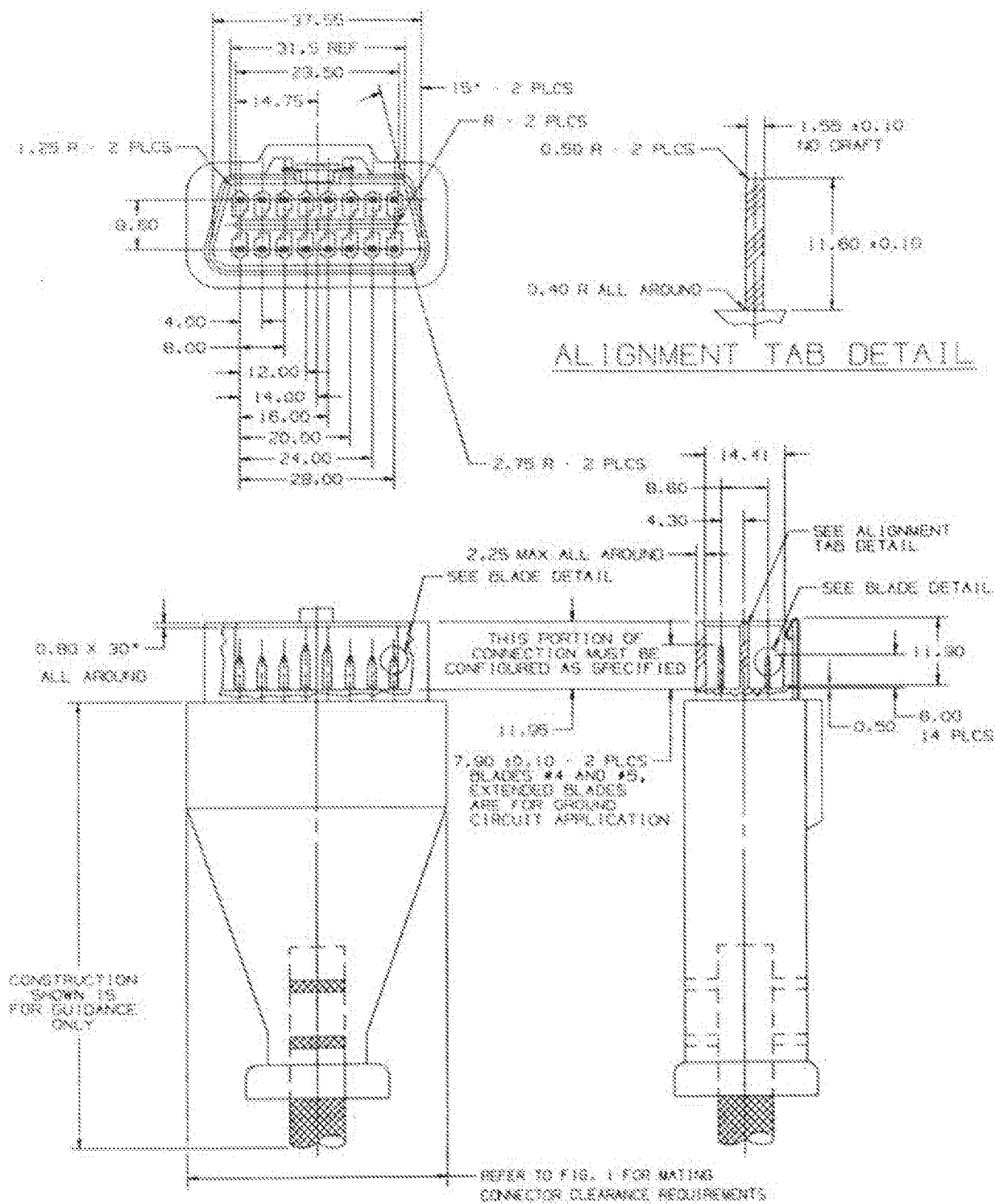


FIGURE 1—VEHICLE CONNECTOR



ALL DIMENSIONS mm UNLESS OTHERWISE SPECIFIED	
TOLERANCE UNLESS OTHERWISE SPECIFIED:	
DECIMAL	
ONE PLACE ± 0.3	ANGULAR ± 2°
TWO PLACE ± 0.15	

FIGURE 2—TEST EQUIPMENT CONNECTOR

3.4 Vehicle Operation—Attachment of any equipment to the vehicle connector should not preclude normal physical and electrical operation of the vehicle.

4. Vehicle and Test Equipment Connector Design

4.1 Previous Designs Acceptable—This version of this document includes changes to some of the dimensions of the Vehicle Connector and the Test Equipment Connector. Vehicle Connectors and Test Equipment Connectors manufactured to the specifications of the previous versions of this document that are compatible with connectors designed to the specifications of this document are acceptable. The specification changes made to the Test Equipment Connector were made to prevent potential heat terminal problems with the two extended ground terminals in the Test Equipment Connector.

4.2 Number of Terminals—The vehicle and test equipment connectors shall each be capable of accommodating 16 terminals.

4.3 Terminal Requirements—The terminals shall be rated for currents not to exceed 10 A DC continuous.

4.3.1 TERMINAL TYPES—The vehicle connector shall consist of female terminals that will mate with the test equipment connector male blade terminals.

4.3.2 TERMINAL SPACING—Terminal spacing is shown in Figure 2.

4.4 Connector Mating—The test equipment connector contact mating shall be designed so that the signal ground and the chassis ground terminals of the test equipment connector will make electrical contact prior to any other test equipment connector terminals making electrical contact. On the disconnect cycle, these same two terminals will not lose electrical contact until all of the other terminals have been disconnected.

4.5 Connector Shape/Features—The mating portions of both connectors shall be "D" shaped. The connectors shall have easily discernible keying features to allow for easy connection in a one-handed/blind operation.

The vehicle connector and the test equipment connector shall have latching features that assure the test equipment connector will remain mated when properly connected. The latching feature will be designed to provide a positive feel when the test equipment connector is fully mated. The latching feature should not require the activation of any levers on either connector to mate or unmate. Pulling on the test equipment connector to separate the two mated halves shall not result in any damage to either connector.

4.6 Spring Clip—An optional Spring Clip (see Figure 3) may be used on the Test Equipment Connector.

4.7 Material Selection

4.7.1 CONNECTOR MATERIAL—Selection and specification of connector material shall be made by the appropriate vehicle and test equipment manufacturers. However, the minimum recommended temperature range for the selected material is -40 to $+85$ °C.

4.7.2 TERMINAL MATERIAL—Selection and specification of terminal base material shall be made by the appropriate vehicle and test equipment manufacturers.

Selection of terminal material, especially plating if any, may be a significant factor to the durability of the terminals in the vehicle connector and/or the test equipment connector. Different applications of these connectors generally will require selection of different terminal material/plating, especially for the test equipment connector.

4.8 Vehicle Connector Cycle Life—The vehicle connector shall meet the requirements of this document after 200 mating cycles.

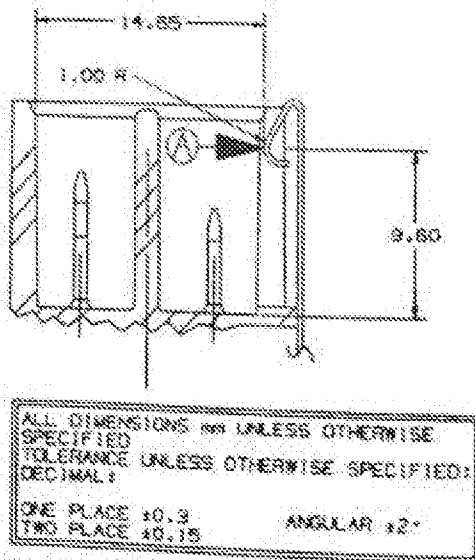
4.9 Test Equipment Connector Cycle Life—The test equipment manufacturer shall specify the minimum number of mating cycles the test equipment connector is capable of while meeting the requirements of this document.

4.10 Strain Relief—The test equipment connector shall have strain relief features for the wires/cable connected to it.

4.11 Terminal and Connector Parameters and Performance Requirements

4.11.1 FUNCTIONAL PARAMETERS FOR TERMINALS

- Blade Size for Test Equipment Connector: Shall conform to the dimensions shown in Figure 4
- Maximum Current DC: 10 A DC continuous
- Temperature Range: -40 to $+85$ °C
- Voltage Range DC: -0.05 to 30.0 V DC
- Suggested Maximum Cable Size: 0.8 mm² (18 AWG)



NOTE: SPRING CLIP PERFORMANCE

A FORCE APPLIED AS SHOWN BY ARROW "A" MUST DEFLECT CLIP OUTWARD FOR A DISTANCE OF 2.50 ± 0.15 mm. CLIP MUST RECOVER TO ORIGINAL POSITION. CONNECTOR MUST MEET SPECIFICATION SHOWN IN S.B.2.4.2 CONNECTOR MATING FORCE WITH 16 TERMINALS WITH SPRING CLIP, WITH SPRING CLIP IN PLACE.

FIGURE 3—SPRING CLIP DETAIL (Optional)

4.11.2 PERFORMANCE REQUIREMENTS FOR TERMINALS—The terminal system (i.e., mated terminal pairs) must meet the performance standards in (a) through (c) following each of the environmental exposures listed in 4.11.4. Performance measurements are to be taken at room temperature.

- a. Resistance Interface (measured at 1 A): 3 mΩ maximum
- b. Recommended Resistance Cable to Cable per Terminal Pair (measured at 1 A): 10 mΩ maximum
- c. Recommended Low Energy Resistance: 100 mΩ maximum at 100 μA at 30 mV (open circuit voltage) at initial mating

4.11.3 CONNECTOR SYSTEM PERFORMANCE REQUIREMENTS—The connector system must meet the performance standards outlined in (a) through (f) following each of the environmental exposures listed in 4.11.4. Performance measurements must be taken at room temperature.

- a. Isolation Resistance—Between adjacent terminals must exceed 20 MQ at 16 V DC.
- b. Retention Force—Terminal to connector retention force to exceed 80 N.
- c. Connector Disengagement Force with 16 terminal pairs—Not to exceed 88 N.
- d. Connector Mating Force with 16 terminal pairs:
 - (1) without spring clip 110 N maximum
 - (2) with spring clip 142 N maximum (see Figure 3)

- e. Indexing Feature—Must prevent mis mating of connectors when a force of 300 N is applied.

- f. Mounting Feature—The vehicle connector mounting feature shall withstand a 300 N force applied to the connector mating area in the direction of the mating and unmating process.

4.11.4 ACCELERATED ENVIRONMENTAL EXPOSURES FOR THE VEHICLE CONNECTOR—Accelerated environmental testing shall be conducted for the vehicle connector while not being mated to the test equipment connector. Following each environmental exposure, the vehicle connector shall be mated to an unused test equipment connector for the performance measurements specified in sections 4.11.2 and 4.11.3.

- a. Thermal Cycling—1000 cycles of 30 min at -40 °C and 30 min at 119 °C.
- b. Temperature/Humidity Cycling—13 cycles of the following:
 - 16 h at 95% RH and 40 °C
 - 2 h at -40 °C
 - 2 h at +85 °C
 - 4 h at room temperature
- c. Mechanical Shock—3 shocks of 50 G in each of 3 mutually perpendicular axes.
- d. Vibration—Sinusoidal 1.5 mm ± 0.13 mm amplitude by 15 G for 2 h in each of 3 mutually perpendicular axes.

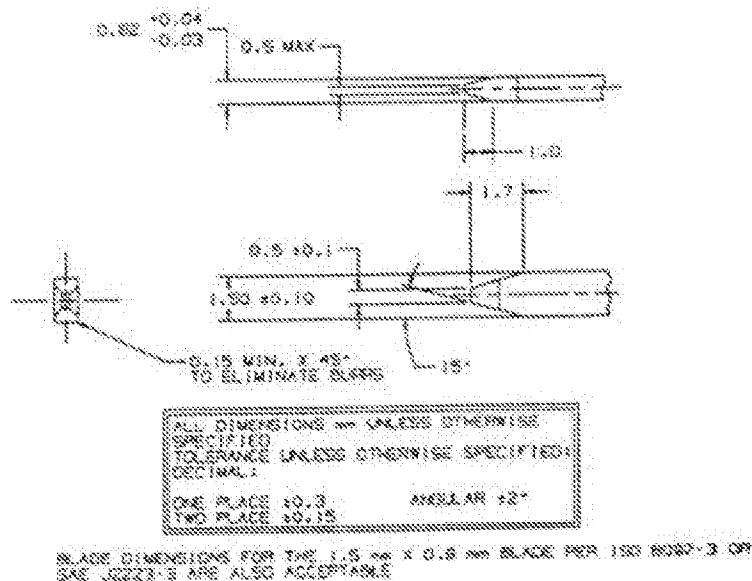


FIGURE 4—BLADE DETAIL

5. Vehicle and Test Equipment Connector Terminal Assignments

5.1 Vehicle and Test Equipment Connector Terminal Identification—See Figure 5 for vehicle connector and test equipment connector terminal identifications.

5.2 General Terminal Assignments—See Figure 5 for a summary of terminal assignments.

5.3 Vehicle Connector Terminal Assignments

5.3.1 VEHICLE CONNECTOR TERMINALS - GENERAL LIMITS—All sets of all terminals of vehicle connector are limited to the range of -0.05 to 30.0 V DC.

5.3.2 VEHICLE CONNECTOR TERMINALS 1, 3, 6, 8, 9, 11, 12, 13, AND 14—Assignment of vehicle connector terminals 1, 3, 6, 8, 9, 11, 12, 13, and 14 is left to the discretion of the vehicle manufacturer.

5.3.3 VEHICLE CONNECTOR TERMINAL 2—If SAE J1850 10.4 VPW is used in a vehicle to supply OBD II required communication services, then terminal 2 of the vehicle connector must be the SAE J1850 10.4 VPW connection.

If SAE J1850 41.6 PWM is used in a vehicle to supply OBD II required communication services, then terminal 2 of the vehicle connector must be the Run + Signal of the SAE J1850 41.6 PWM connection.

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16

FIGURE 5—VEHICLE CONNECTOR MATING END VIEW

If neither SAE J1850 10.4 VPW nor SAE J1850 41.6 PWM is used in a vehicle to supply OBD II required communication services, then assignment of this terminal is left to the discretion of the vehicle manufacturer, provided this assignment does not interfere with the operation of, nor cause damage to, tools conforming to SAE J1978.

5.3.4 VEHICLE CONNECTOR TERMINAL 4—Vehicle connector terminal 4 is designated Chassis Ground and must be connected to the vehicle in such a way as to provide a power ground for test equipment taking current as defined in SAE J1978. Paragraph 5.5.4 defines the use of this terminal by test equipment.

5.3.5 VEHICLE CONNECTOR TERMINAL 5—Vehicle connector terminal 5 is designated Signal Ground and must be implemented in the vehicle connector in such a way as to provide a ground reference for the communication transceivers in test equipment and as a possible power ground for test equipment taking current as defined in SAE J1978. Its implementation in the vehicle must take into consideration noise contributions and node to node voltage offset limitations of the OBD II communication interface used in the vehicle. The use of a battery minus (-), common vehicle clean signal ground, "clean," "logic," or other connection points within a vehicle that minimize node to node voltage offsets and noise is recommended. Paragraph 5.5.5 defines the use of this terminal by test equipment.

Terminal	General Assignment
1	Discretionary*
2	Bus + Line of SAE J1850**
3	Discretionary*
4	Chassis Ground
5	Signal Ground
6	Discretionary*
7	K Line of ISO 9141-2**
8	Discretionary*
9	Discretionary*
10	Bus - Line of SAE J1850**
11	Discretionary*
12	Discretionary*
13	Discretionary*
14	Discretionary*
15	L Line of ISO 9141-2**
16	Unswitched Vehicle Battery Positive

* Note, assignment of terminals 1, 3, 6, 8, 9, 11, 12, 13, and 14 in the vehicle connector is left to the discretion of the vehicle manufacturer.

** Note, for terminals 2, 7, 10, and 15 the related OBD II communication assignments are shown. These terminals may also be used for alternate assignments in the vehicle connector. See the section titled Vehicle Connector Terminal Assignments and the section titled Test Equipment Connector Terminal Assignments for further information.

FIGURE 6—GENERAL TERMINAL ASSIGNMENTS

5.3.6 VEHICLE CONNECTOR TERMINAL 7—If a two wire or a one wire ISO 9141-2 interface is used in a vehicle to supply OBD II required communication services, then terminal 7 of the vehicle connector must be the K Line of the ISO 9141-2 interface.

If neither a two wire nor a one wire ISO 9141-2 interface is used in a vehicle to supply OBD II required communication services, then assignment of this terminal is left to the discretion of the vehicle manufacturer, provided this assignment does not interfere with the operation of, nor cause damage to, tools conforming to SAE J1978.

5.3.7 VEHICLE CONNECTOR TERMINAL 10—If an SAE J1850 41.6 PWM interface is used in a vehicle to supply OBD II required communication services, then terminal 10 of the vehicle connector must be the Bus - signal of the SAE J1850 41.6 PWM interface.

If an SAE J1850 41.6 PWM interface is not used in a vehicle to supply OBD II required communication services, then assignment of this terminal is left to the discretion of the vehicle manufacturer, provided this assignment does not interfere with the operation of, nor cause damage to, tools conforming to SAE J1978.

5.3.8 VEHICLE CONNECTOR TERMINAL 15—If a two wire ISO 9141-2 interface is used in a vehicle to supply OBD II required communication services, then terminal 15 of the vehicle connector must be the L Line of the ISO 9141-2 interface.

If a two wire ISO 9141-2 interface is not used in a vehicle to supply OBD II required communication services, then assignment of this terminal is left to the discretion of the vehicle manufacturer, provided this assignment does not interfere with the operation of, nor cause damage to, tools conforming to SAE J1978.

(R) 5.3.9 VEHICLE CONNECTOR TERMINAL 16—Vehicle connector terminal 16 is designated Unswitched Vehicle Battery Positive and must be implemented in the vehicle connector. This terminal must be connected directly (i.e., unswitched) to the DC Positive of the vehicle's battery. This connection does not preclude the use of a fuse or other circuit protection elements. This circuit may be grouped with other similar circuits. This terminal must be able to supply a minimum of 4.0 A.

5.4 Vehicle Connector Terminal Protection—It is recommended that the vehicle manufacturer provide circuit protection in the event that the terminals of the vehicle connector are shorted together. This protection is limited to the ranges of voltages present at the vehicle connector before the test equipment connector is mated to it.

5.5 Test Equipment Connector Terminal Assignments

5.5.1 TEST EQUIPMENT CONNECTOR TERMINALS—GENERAL LIMITS—All uses of all terminals of test equipment connector are limited to the range of -0.05 to 30.6 V DC.

5.5.2 TEST EQUIPMENT CONNECTOR TERMINALS 1, 3, 6, 8, 9, 11, 12, 13, AND 14—The use of test equipment connector terminals 1, 3, 6, 8, 9, 11, 12, 13, and 14 is left to the discretion of the test equipment manufacturer.

These test equipment connector terminals shall normally be in a high impedance state, that is at greater than 500 kΩ impedance relative to Signal Ground and at greater than 500 kΩ impedance relative to Chassis Ground.

Before the condition of these test equipment connector terminals is changed from this high impedance state, the test equipment user and/or the test equipment must verify the proper usage of these vehicle connector terminals.

5.5.3 TEST EQUIPMENT CONNECTOR TERMINALS 2, 7, 10, AND 15—Assignment and use of test equipment connector terminals 2, 7, 10, and 15 must be compatible with the assignment and use of their mating terminal in the vehicle connector (see 5.3) and SAE J2201.

5.5.4 TEST EQUIPMENT CONNECTOR TERMINAL 4—Test equipment connector terminal 4 is designated Chassis Ground and is defined by SAE J2201. This terminal may be used by test equipment as a power ground. Implementation of this terminal in the test equipment connector is optional.

(R) 5.5.5 TEST EQUIPMENT CONNECTOR TERMINAL 5—Test equipment connector terminal 5 is designated Signal Ground and is defined by SAE J2201. This terminal must be used by the SAE J1978 OBD II Scan Tool as the signal reference for communication transceivers. This terminal must be implemented in the test equipment connector for support of SAE J2201. Test equipment must not draw more than 1.5 A through this terminal. (Note that the 1.5 A limit refers to uses of test equipment covered by this document [i.e., support of the requirements of SAE J1978]. Support of other uses of the SAE J1962 connector [e.g., connecting a vehicle manufacturer discretionary terminal to ground] is not covered by this limitation.)

5.5.6 TEST EQUIPMENT CONNECTOR TERMINAL 16—Test equipment connector terminal 16 is designated as Unswitched Vehicle Battery Positive and is available to supply operating power and a reference voltage to test equipment.

5.6 Test Equipment Connector Terminal Protection—It is recommended that all circuits connected to the terminals of the test equipment connector be protected to the extent that no damage will come to these circuits if ANY terminal of the test equipment connector:

- (R) a. Is connected to vehicle connector terminal 16 - Unswitched Vehicle Battery Positive for up to 10 A,
- b. Is connected to vehicle connector terminal 4 - Vehicle Chassis Ground, or
- c. Is connected to vehicle connector terminal 5 - Vehicle Signal Ground.

(R) 6. Minimum Current Available—In order to ensure that adequate current is available to operate diagnostic scan tools, the minimum current available through terminal 16 of the vehicle connector shall be no less than 4.0 A.

The vehicle manufacturer shall not be responsible for supplying more than 4.0 A.

(R) 7. Liability for Devices That Draw More Than 4.0 A—Manufacturers of devices that include a connection to the vehicle connector, and which draw in excess of 4.0 A from terminal 16 of the vehicle connector, may be responsible for any damage to the vehicle.

Report of the SAE E/E Systems Diagnostic Standards Committee approved March 1992 and revised June 1994.

Foreword—Title 13, California Code of Regulations, Section 1968.1 "Malfunction and Diagnostic System Requirements 1994 and Subsequent Model Year Passenger Cars, Light Duty Trucks, and Medium Duty Vehicles With Feedback Control Systems," more commonly known as OBD II (On-Board Diagnostics version II), defines diagnostic functions required to be supported by vehicles and functions to be supported by test equipment that interface with the vehicle diagnostic functions.

While a range of test equipment (e.g. handheld scan tools, PC based diagnostic computers, etc.) may be used to perform the required interface support functions, the term OBD II Scan Tool is used in this document to refer to any test equipment that meets the requirements of this document.

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1. **Scope**—This SAE Recommended Practice defines the requirements of OBD II Scan Tools, i.e., test equipment that will interface with vehicle modules in support of the OBD II diagnostic requirements. It covers the required capabilities of and conformance criteria for OBD II Scan Tools.

2. References

2.1 **Applicable Documents**—The following publications form a part of this specification to the extent specified herein. The latest issues 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 (Except Aircraft)

SAE J1850—Class B Data Communication Network Interface

SAE J1930—Electrical/Electronic Systems Diagnostic Acronyms, Terms and Definitions

SAE J1962—Diagnostic Connector

SAE J1979—E/E Diagnostic Test Modes

SAE J2012—Recommended Format and Messages for Diagnostic Trouble Codes

SAE J2201—Universal Interface for OBD II Scan Tools

SAE J2205—Expanded Diagnostic Protocol

2.1.2 **ISO PUBLICATIONS**—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO 7637—Road vehicles—Electrical disturbance by condition and coupling

ISO 9141-2:1994(E)—Road vehicles—Diagnostic systems—CARB requirements for interchange of digital information

2.1.3 OTHER PUBLICATIONS

California Code of Regulations, Section 1968.1, Title 13—Malfunction and Diagnostic System Requirements 1994 and Subsequent Model Year Passenger Cars, Light Duty Trucks, and Medium Duty Vehicles with Feedback Control Systems

(R) Environmental Protection Agency 40 CFR Part 86 Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines; Regulations Requiring On-Board Diagnostic Systems on 1994 and Later Model Year Light-Duty Vehicles and Light-Duty Trucks

3. **Application**—The requirements contained in this document apply to all test equipment (e.g., handheld scan tool, PC based test equipment, inspection and maintenance equipment, etc.) that will be used to access the OBD II functions supported in vehicles.

Only tools passing the conformance test(s) specified in this document may claim or advertise that they meet or exceed the requirements of this document.

Nothing in this document precludes the inclusion of additional capabilities or functions in test equipment.

(R) 4. **Diagnostic Terms, Definitions, and Acronyms**—SAE J1930 is hereby referenced as the basis for all such terms in this document.

(R) 5. **Required Functions**—The following are the basic functions that the OBD II Scan Tool is required to support or provide:

- Automatic hands-off determination of the communication interface used
- Obtaining and displaying the status and results of vehicle on-board diagnostic evaluations
- Obtaining and displaying OBD II emissions related diagnostic trouble codes (DTCs)
- Obtaining and displaying OBD II emissions related current data
- Obtaining and displaying OBD II emissions related freeze frame data
- Clearing the storage of OBD II emissions related diagnostic trouble codes, OBD II emissions related freeze frame data storage and OBD II emissions related diagnostic test status
- Ability to perform Expanded Diagnostic Protocol functions as described in SAE J2205
- Obtaining and displaying OBD II emissions related test parameters and results as described in SAE J1979
- Provide a user manual and/or help facility
- Vehicle Interface**—The following specifies the minimum vehicle interfaces to be supported by an OBD II Scan Tool.

(R) 6.1 Communication Data Link and Physical Layers—The OBD II Scan Tool must be able to communicate with vehicle control modules using the communication interfaces as described as follows. The OBD II Scan Tool must perform the communications required to support the State of California requirements referenced in the introduction to this document. SAE J2205 describes a set of functions and communication criteria.

(R) 6.1.1 SAE J1850 RECOMMENDED PRACTICE CLASS B DATA COMMUNICATION NETWORK INTERFACE—SAE J1850 describes two sets of data link and physical layers for a class B vehicle serial multiplex bus network. The OBD II Scan Tool must support both SAE J1850 protocols in a manner that is transparent to the user.

(R) 6.1.2 ISO 9141-2:1994(E) ROAD VEHICLES—DIAGNOSTIC SYSTEMS—CARB REQUIREMENTS FOR INTERCHANGE OF DIGITAL INFORMATION—ISO 9141-2 describes the physical and data link layers of a vehicle serial diagnostic bus. The following specifications clarify and, if in conflict with ISO 9141-2, override any related specifications in ISO 9141-2:

- The maximum sink current to be supported by the OBD II Scan Tool is 100 mA.
- The range for all tests performed relative to ISO 7637 is -1.0 to +40.0 V.
- The minimum bus life period before the tool shall transmit an address shall be 300 ms.

ISO 9141-2 specifies a time within which a module(s) that has successfully been initialized must receive a message or the module(s) will return to the address mode. Unless the OBD II Scan Tool user has indicated he/she wishes to terminate communication, once a module(s) has successfully been initialized, the OBD II Scan Tool must automatically send a message, to be identified as the idle message, before this time can elapse. Any use of any response received due to the idle message is left to the discretion of the scan tool manufacturer.

The SAE J1979 mode 1 PID 0 request message is the recommended idle message.

6.2 Connector—The OBD II Scan Tool must use a male SAE J1962 Diagnostic Connector to mate with the female SAE J1962 Diagnostic Connector required in vehicles. The OBD II Scan Tool must support the standard pin assignments defined in SAE J1962. The electrical interface in the OBD II Scan Tool for the manufacturer discretionary pin assignments shall be effectively open circuit as a default condition or state.

6.3 Messages—SAE J1979 describes the request messages to be sent by the OBD II Scan Tool to the vehicle and the response messages to be sent by the vehicle to the OBD II Scan Tool in order to perform the services required by OBD II.

(R) 6.4 Expanded Diagnostic Protocol—The OBD II Scan Tool must allow the user to enter and send vehicle specific messages defined and supplied in motor vehicle manufacturer documents and display the related response messages, as defined in SAE J2205.

6.5 Automatic Hands-off Determination of the Communication Interface Used in a Given Vehicle

(R) 6.5.1 GENERAL—While there are three types of communication interfaces that could be used to access the OBD II functions in a given vehicle (i.e., SAE J1850 41.6 Kbps PWM, SAE J1850 10.4 Kbps VPW and ISO 9141-2), only one is allowed to be used in any one vehicle to access all supported OBD II functions.

When connected to a vehicle and/or when the OBD II support is selected when such a selection is necessary, the OBD II Scan Tool will automatically attempt to determine which of the possible communication interfaces is being used in the vehicle to support OBD II related functions. The tool will continue to try to determine which interface is being used until it is successful in doing so. No user input will be required, nor allowed, to determine the appropriate interface.

Indicators or messages will be displayed during this process informing the user that initialization is taking place and, if all interface types have been tested and none is responding properly to the request for OBD II services, the OBD II Scan Tool must indicate to the user:

- To verify that the ignition is on.
- To check the Emissions Label or vehicle service information to verify that the vehicle is OBD II equipped.
- To check that the tool is connected to the vehicle correctly.

(R) If the ignition is on and the vehicle emissions label or service information indicates the vehicle is OBD II equipped, then there is a Data Link fault.

6.5.2 INITIALIZATION DETAILS—Only the following steps may be used by an OBD II Scan Tool to attempt to determine the type of communications interface used in a given vehicle to support OBD II functions.

- Test for SAE J1850 41.6 Kbps PWM.
- Step 1—Enable the SAE J1850 41.6 Kbps PWM interface.
- Step 2—Send a mode 1 PID 0 request message.

(3) Step 3—If a mode 1 PID 0 response message is received then the J1850 41.6 Kbps PWM is the type of interface used in a vehicle to support OBD II support.

(R) b. Test for SAE J1850 10.4 Kbps VPW

- Step 1—Enable the SAE J1850 10.4 Kbps VPW interface.
- Step 2—Send a mode 1 PID 0 request message.

(3) Step 3—If a mode 1 PID 0 response message is received then the J1850 10.4 Kbps VPW is the type of interface used in a vehicle to support OBD II support.

c. Test for ISO 9141 CARB

- Step 1—Enable the ISO 9141-2 interface.

(3) Step 2—If the initialization sequence defined in ISO 9141-2 is completed successfully, then ISO 9141-2 is the type of interface used in a vehicle for OBD II support.

The previous tests may be performed in any order and where possible may be performed in parallel.

The mode 1 PID 0 request and response messages are defined in SAE J1979. SAE J1850 defines the requirements of SAE J1850 interfaces.

ISO 9141-2 defines the requirements of an ISO 9141-2 interface.

6.6 On-Board Diagnostic Evaluations

(R) 6.6.1 COMPLETED ON-BOARD SYSTEM READINESS TESTS—Immediately after initial communications are established, the OBD II Scan Tool shall obtain status of the on-board system readiness tests. If any tests have not been completed, the OBD II Scan Tool shall indicate to the user: "Not all support on-board system readiness tests have been completed" or equivalent. The OBD II Scan Tool shall also allow the user to identify which readiness test (if any) have not been completed.

6.6.2 SUPPORTED ON-BOARD SYSTEM READINESS TESTS—The OBD II Scan Tool must be capable of indicating to the user which of the tests defined by SAE J1979 mode 1 PID 1 data bytes 4 and 5 are supported and which are completed.

6.6.3 MALFUNCTION INDICATOR LIGHT—The OBD II Scan Tool must be capable of indicating if the MIL has been commanded ON and if so, by which module or modules.

6.7 Use of SAE J2281 Universal Interface for OBD II Scan Tools—The OBD II Scan Tool shall use the interface described in SAE J2281, or an equivalent, as the interface to vehicles.

(R) 6.8 Handling of No Response From Vehicle—Vehicle modules may not respond to request messages from the OBD II Scan Tool because of incorrect communication of a request message or because the module does not support the request message. If a response is not received, the scan tool should:

- First, retransmit the request message.
- Second, if still no response is received, transmit a mode 1 PID 0 request message, in order to determine if communication with the vehicle is currently possible, and if the data desired is available.
- Third, if a mode 1 PID 0 response is received, transmit other messages if available, to determine if the data desired is supported by the vehicle.
- Lastly, if the previous steps fail then as appropriate indicate to the user that communication with the vehicle, the module or for the information the user has selected cannot be performed.

(R) 6.9 Connections to the Vehicle in Addition to the SAE J1962 Diagnostic Connector—When connections are made between external equipment and the vehicle in addition to connections made between the external equipment and the vehicle using the SAE J1962 Diagnostic Connector, any ground circuits must conform to the requirements of the Chassis Ground Circuit in the SAE J1962 connector. The intent of this requirement is to maintain the isolation between the vehicle ground and the signal ground in external equipment.

7. System Interaction Capability

(R) 7.1 Obtain and Display OBD II Emissions Related Diagnostic Trouble Codes—The OBD II Scan Tool must be capable of obtaining, converting, and displaying all of the OBD II emissions related diagnostic trouble codes from a vehicle that can be transmitted by a response to a SAE J1979 request. Either the diagnostic trouble code, its descriptive text, or both must be displayed. Diagnostic Trouble Codes and their descriptive text are defined in SAE J2012. When diagnostic trouble code data are selected for display, the OBD II Scan Tool will continuously request of the vehicle its diagnostic trouble code data and display the data received in the corresponding response messages.

7.2 Obtain and Display OBD II Emissions Related Current Data, Freeze Frame Data, and Test Parameters and Results—The OBD II Scan Tool must be capable of obtaining, converting, and displaying (a) OBD II emissions related current data, (b) OBD II emissions related freeze frame data, and (c) test parameters and results data as described in SAE J1979, SAE J2012.

details what data is available, the messages to be used to request the data, the messages to be used to return the data, the conversion values for the data and the format to be used to display the data.

When current data items are selected for display, the OBD II Scan Tool will continuously request of the vehicle the data to be displayed and will display the data received in the corresponding response messages. When freeze frame or test parameters and results are selected for display, the OBD II Scan Tool does not need to continuously request and display those items.

- (R) Where applicable, the OBD II Scan Tool must indicate whether a test limit is a high limit or a low limit. Where applicable, the display of test results must also show the test id and component id.

- (R) Data from the vehicle may indicate which items are supported, in which case this information should be made available to the user by the OBD II Scan Tool. The OBD II Scan Tool shall also allow users to specify requests for modes, parameters, test ids, etc. irrespective of whether the vehicle has indicated support for such items.

7.3 Responses from Multiple Modules—The OBD II Scan Tool must be capable of interfacing with a vehicle in which multiple modules may be used to support OBD II requirements.

The OBD II Scan Tool must alert the user when multiple modules respond to the same request.

The OBD II Scan Tool must advise/alert the user when multiple modules respond with different values for the same data item.

The OBD II Scan Tool must provide the user with the ability to select for display as separate display items the responses received from multiple modules for the same data item.

7.4 Code Clearing—The OBD II Scan Tool must be capable of sending a request to clear OBD II emissions related diagnostic trouble codes, OBD II emissions related freeze frame data and OBD II emissions related diagnostic test status information. The OBD II Scan Tool must require the user to validate a user's request to send this request before sending it (i.e., are you sure?).

8. General Characteristics

8.1 Display—The OBD II Scan Tool must be capable of displaying simultaneously at least two items of OBD II emissions related current data items, OBD II emissions related freeze-frame data items, or OBD II emissions related diagnostic trouble codes.

A list of the OBD II emissions related current data and freeze frame data items, their parameter ids, data resolution and data conversion information, units and display formats is provided in SAE J1979. The display units shall be the Standard International (SI) and English units as specified in SAE J1979. A user shall be able to select between English and SI values. The unit conversions specified in SAE J1979 shall be used.

The display of each OBD II emissions related current data or freeze frame data shall include the following:

- Data value
- Data Parameters id or name
- The module id of the module that supplied the data

The display of each OBD II emissions related diagnostic trouble code shall include the module id of the module that supplied the code.

As a minimum the data values of two data items must be displayed simultaneously. A display of the parameter ids of the data items and the ids of the modules that supplied the data items must be easily accessible if not displayed with the data values.

- (R) The units of measure associated with the data items displayed must either be displayed with the data values, easily accessible on another display, or otherwise readily available to the user (e.g., on the water body, as a part of the text on a cheat sheet, etc.). Having this information available in a user's manual separate from the body of the tool does not satisfy this requirement.

The display must be capable of showing alphanumeric characters.

8.2 User Input—The OBD II Scan Tool must include some form of user input that would allow the user to:

- Select between the basic functions required by OBD II (i.e., display current data, display freeze frame data, display trouble codes, clear emissions related data, and display test parameters and results).
- Select for simultaneous display at least two items of any one of the following:
 - OBD II emissions related current data
 - OBD II emissions related diagnostic trouble codes
 - OBD II emissions related freeze frame data
 - OBD II emissions related test parameters and results

Responses from multiple modules to requests for a current data item or a freeze frame data item are treated as separate data items for selection and display purposes.

- (R) c. To verify a request to clear and/or reset OBD II emissions related diagnostic information as defined by SAE J1979.
d. Enter and send Expanded Diagnostic Protocol messages.

9. Power Requirements if Powered by the Vehicle Through the SAE J1962 Diagnostic Connector

a. Voltage

- Must operate normally within a range of 8.0 to 18.0 V D.C.
- Must survive a steady-state voltage of up to 24.0 V D.C. for at least 18.0 min
- Must survive a steady-state reverse voltage of up to 24.0 V D.C. for at least 10 min

b. Current

- Must not draw more than 4.0 A at 14.4 V D.C.

10. Electromagnetic Compatibility (EMC)—The tool must not interfere with the normal operation of vehicle modules.

The normal operation of the tool must be immune to conducted and radiated emissions present in a service environment and when connected to a vehicle.

The tool must be immune to reasonable levels of Electrostatic Discharge (ESD).

EMC and ESD measurements and limits will be according to SAE H113.

11. Conformance Testing

11.1 General—Conformance testing defines the tests required to be passed in order for tools to be typed approved as "SAE J1978 JUN94 OBD II COMPATIBLE" or "CONFORMS TO SAE J1978 JUN94." Tools that do not pass these tests are not to be so labeled. Validation of conformance test is the responsibility of the Scan Tool manufacturer and the Scan Tool Manufacturer may elect to self-certify.

The tests in this section must be performed successfully five consecutive times in order to be considered passed.

Three examples of at least production intent level tools must pass all these tests in order for a given version of tool hardware and software to be considered passed.

Any changes to the hardware or software used in a tool for the functions described in this document will require a repeat of these tests or an explanation from the tool manufacturer as to why the change should not require a retest. Where an explanation is submitted in lieu of a retest due to a change, the organization originally performing these tests will determine whether the explanation is acceptable or whether a retest is required. Reasonable normal engineering criteria will be used when determining whether to accept an explanation.

The Scan Tool Manufacturer shall make available to the buying public:

- The methods used to make these tests

- The results of the tests

- Clear indication of the versions of hardware and software that conform (i.e., labeled as conforming to or are compatible with the requirements of SAE J1978 OBD II Scan Tool or other labeling to that effect).

- (R) Both proper and improper response messages will be employed during these tests. Improper responses are those that have incorrect first, second, or third bytes of the header, an incorrect mode, an incorrect PID id, an incorrect length of the response message, or with an incorrect CRC or CS. The tool must ignore all improper response messages and perform as if no response was received.

Situations involving multiple modules responding to a single request, single modules responding with multiple responses to a single request, and multiple modules responding with multiple responses to a single request will be tested.

The interval between the end of the request message and the beginning of the response message(s) will be varied from 0 ms up to the delay required to show a no response indication on the OBD II Scan Tool. The delay that causes the no response indication will be compared to the value defined in SAE J1979.

The format, content, and order of messages transmitted on the SAE J1850 and ISO 9141-2 buses will be observed and reviewed for correctness.

The ability to obtain and report the results of the on-board system readiness tests shall be verified. The ability to report which tests the vehicle supports and which have been completed shall be verified.

The requirements described in 11.3 through 11.7 (inclusive) shall be verified on each protocol specified in 6.1.

When performing these tests, observation of the indications and displays provided to the user and the signals on the SAE J1850 (bus +) and (bus -) lines and the ISO 9141-2 K and L lines will be the criteria for proper performance.

- (R) These tests will be executed in an environment of 25 °C ± 3 °C and between 30% and 80% relative humidity ±5%.

The hardware and software used in the OBD II Scan Tool version being tested must be identified.

11.2 Determine OBD II Communication Type—Items to be tested:

Automatic hands-off determination of interface type.

That it is automatic when the SAE J1962 connector is plugged into its mating connector in the vehicle and/or OBD II support is selected, where such a selection is necessary.

That a test of all OBD II communication interfaces is performed at least once per scan.

That the scan of all interfaces continues until successful or until terminated by the user.

That some indication is provided to the user that the scan of interfaces is being performed.

That a failure to successfully find an OBD II interface during a scan of all the possible interfaces is indicated to the user at the completion of each and every scan.

That when an OBD II interface is successfully found, the tool automatically prompts the user for function selection.

That the tool provides and uses the facilities and/or messages defined in SAE J2011 (or equivalent), SAE J1979, ISO 9141-2 and SAE J1850, and SAE J2012.

That the tool does not exceed the polling rates specified in SAE J1979.

That the tool provides the proper bits for the K and L lines as specified in ISO 9141-2.

That the tool performs the initialization tests according to 6.5.2 and indicates the information according to 6.5.1.

- (R) The interface determination tests will be performed: (a) with no modules available, (b) with an ISO 9141-2 module available, (c) with a SAE J1850 41.6 Kbps PWM module available, and (d) with a SAE J1850 10.4 Kbps VPW module available.

11.3 On-Board System Readiness Tests—Items to be tested:

That the tool automatically requests and reports the results of the supported on-board system readiness tests.

11.4 Select Functions—Items to be tested:

a. That the tool supports the functions described in Section 5.

b. That the user is able to move back and forth between these functions.

The criteria for successfully passing this test is to be able to easily move back and forth between all functions and observe the results. The support provided should allow the user to easily move between functions.

11.5 Select and Display Items—Items to be tested:

a. That the user is able to select and display simultaneously at least two items from any one of:

- (1) Available Diagnostic Trouble Codes
- (2) Current data items
- (3) Available freeze frame data items
- (4) Test parameters and results

b. That the module ids and the parameter ids or PID names associated with all the items mentioned previously can also be displayed either (a) simultaneously with the displayed items or (b) in some alternate method (printed material, etc.)

c. That the units of measure information associated with all the possible current data items and freeze frame data items is easily available either as a part of the data display, displayed separately, or otherwise available on, or with the tool body itself.

d. That the tool is able to handle multiple responses from the same module due to one request.

e. That the tool is able to handle responses from multiple modules due to one request.

f. That the tool is able to handle multiple responses from multiple modules due to one request.

g. That the tool alerts the user that responses from multiple modules due to one request were received. Responses from multiple modules to a request are to be made available to the user as separate items for display.

h. That the tool advises/alerts the user that different responses from multiple modules due to one request were received.

The criteria for successfully passing this test is to select back and forth between all the items and observe the results. The support provided should allow the user to easily move between display items.

11.6 Verify Requests to Clear Codes—Items to be tested:

a. That the selection of the Clear Codes function incorporates a request to the user to verify the request.

b. That both yes and no responses to the request to the user to verify the selection of the Clear Codes function are processed appropriately.

This test should involve situations where there are some DTCs to clear and other situations where there are no DTCs to clear. When making this test, the presence or absence of DTCs must be verified both before and after the Clear Codes function is selected.

11.7 General Diagnostic Communication Tests—When performing tests involving diagnostic messages, tests are to be made of the tool's ability to handle an immediate response, a slow response and a response delayed longer than the maximum allowed in SAE J1979.

The tool should be able to process all responses that are received within the maximum time allowed by SAE J1979 and indicate a no response condition to the user when the response is delayed longer than the maximum allowed by SAE J1979.

The tool must support the transmission of its mode address as an in-frame-response during the transmission of any response messages from modules on a SAE J1850 bus and must be able to handle both the presence and the absence of an in-frame-response during the tool's transmission of request messages.

11.8 Expanded Diagnostic Protocol—Items to be tested:

a. That the user is reasonably able to enter Expanded Diagnostic Protocol (EDP) input and that the OBD II Scan Tool correctly executes the entered EDP input.

11.9 Capacitance and Impedance at the SAE J1962 Connector—Items to be tested:

a. That the capacitance and impedance of the OBD II Scan Tool, connecting cables and the male SAE J1962 connector, as seen at the connector, are within the limits defined in SAE J1850 and ISO 9141-2.

Measurement of these parameters will be made by the testing agency at their discretion following generally acceptable engineering practices.

11.10 Operating Voltage and Current Draw—Items to be tested:

a. That the OBD II Scan Tool will correctly operate throughout the voltage range specified in Section 9 of this document and will not require more than the maximum current specified in Section 9 of this document.

b. That the tool will survive the use of supply voltages of up to the maximum survival voltage and survival reverse voltage specified in Section 9 of this document.

During other conformance tests, the voltage supplied to the OBD II Scan Tool is to be varied throughout the specified range and the results observed. Also the current draw is to be compared with the limit specified.

11.11 Protocol Check—Items to be tested:

a. That all the request messages defined by SAE J1979 are properly and appropriately used by the OBD II Scan Tool.

b. That the OBD II Scan Tool is able to correctly process all forms of response messages defined by SAE J1979.

- (R) c. That the OBD II Scan Tool is able to perform the previously mentioned, the SAE J1850 and ISO 9141-2 buses.

11.12 Alphanumeric Display—Items to be tested:

a. That the OBD II Scan Tool is able to display alphanumeric characters.

The results of the previous tests will be observed to determine the ability of the OBD II Scan Tool to display alphanumeric characters.

11.13 User Manual and Help Facility—Items to be tested:

a. That a useful user manual and/or HELP facility is provided with the OBD II Scan Tool.

b. That the user manual and/or HELP facility includes:

- (1) SAE J1979 definitions
- (2) How to select the functions
- (3) How to select items for simultaneous display
- (4) How to determine the PID id, item name, and module id of data returned for display
- (5) How to verify the selection of the Clear Codes function
- (6) How to obtain and display OBD II emissions related test parameters and results as described in SAE J1979
- (7) How multiple responses from one request is indicated
- (8) How different responses to the same request is indicated
- (9) What current and freeze frame data items are available through OBD II
- (10) How to enter requests for the Expanded Diagnostic Protocol and interpret the results

- (R) The OBD II Scan Tool will be tested for a HELP facility and/or the availability and coverage of a user manual.

(R) E/E DIAGNOSTIC TEST MODES —SAE J1979 JUL96

SAE Recommended Practice

Report of the SAE Vehicle E/E System Diagnostic Standards Committee approved December 1991, revised June 1994, and completely revised July 1996. Rationale statements available.

Foreword—This document describes the implementation of the Diagnostic Test Modes necessary to meet California On-Board Diagnostic (OBD II) and Federal On-Board Diagnostic (OBD) requirements for emission related test data. This document is one of several prepared by task forces of the SAE E/E Diagnostics Committee in order to satisfy the proposed regulations. The development of these recommended practices has been coordinated so that they are compatible with each other and with the legislation. Other documents necessary in addition to this document are:

- SAE J1930—E/E Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms
- SAE J1962—Diagnostic Connector
- SAE J1978—OBD II Scan Tool
- SAE J2012—Recommended Format and Messages for Diagnostic Trouble Codes

In addition, the diagnostic data communication link to be utilized with these recommended practices is specified by the regulation to be as specified in one of the following documents:

- SAE J1850—Class B Data Communication Network Interface
- ISO 9141-2:1994(E)—Road vehicles—Diagnostic systems—CARB requirements for interchange of digital information

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1. Scope—This SAE Recommended Practice defines diagnostic test modes, and request and response messages, necessary to be supported by vehicle manufacturers and test tools to meet the requirements of the California OBD II and Federal OBD regulations, which pertain to vehicle emission-related data only. These messages are intended to be used by any service tool capable of performing the mandated diagnostics.

In addition, capabilities are defined that are intended to meet other Federal and State regulations pertaining to related issues such as Inspection and Maintenance (I/M) and service information availability. This document is not considered a final authority for interpretation of the regulations, so the reader should determine the applicability of the capabilities defined in this document for their specific need.

Diagnostic Test Modes included in this document are:

- a. Mode \$01—Request Current Powertrain Diagnostic Data
 - Analog inputs and outputs
 - Digital inputs and outputs
 - System status information
 - Calculated values
- b. Mode \$02—Request Powertrain Freeze Frame Data
 - Analog inputs and outputs
 - Digital inputs and outputs
 - System status information
 - Calculated values
- c. Mode \$03—Request Emission-Related Powertrain Diagnostic Trouble Codes
- d. Mode \$04—Clear/Reset Emission-Related Diagnostic Information
- e. Mode \$05—Request Oxygen Sensor Monitoring Test Results
- f. Mode \$06—Request On-Board Monitoring Test Results for Non-Continuously Monitored Systems
- g. Mode \$07—Request On-Board Monitoring Test Results for Continuously Monitored Systems
- h. Mode \$08—Request Control of On-Board System, Test, or Component

For each test mode, this specification includes:

- a. Functional descriptions of test mode
 - b. Request and response message formats
- For some of the more complex test modes, an example of messages and an explanation of the interpretation of those messages is included.

2. References

2.1 Applicable Documents—The following publications form a part of this specification to the extent specified herein. Unless otherwise specified, the latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1850—Class B Data Communication Network Interface

SAE J1930—E/E Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms

SAE J1982—Diagnostic Connector

SAE J1978—OBD II Scan Tool

SAE J2013—Recommended Format and Messages for Diagnostic Trouble Codes

SAE J2186—Diagnostic Data Link Security

SAE J2190—Enhanced E/E Diagnostic Test Modes

2.1.2 ISO DOCUMENTS—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO 9141-2:1994(E)—Road vehicles—Diagnostic systems—CARR requirements for interchange of digital information

2.1.3 CALIFORNIA ARB DOCUMENTS—Available from California Air Resources Board, 9528 Telstar Avenue, El Monte, CA 91731.

California Code of Regulations, Title 13, Section 1968.1—Malfunction and Diagnostic System Requirements—1994 and Subsequent Model Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines (OBD II)

2.1.4 FEDERAL EPA DOCUMENTS—Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Environmental Protection Agency 40 CFR Part 86—Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines; Regulations Requiring On-Board Diagnostic Systems on 1994 and Later Model Year Light-Duty Vehicles and Light-Duty Trucks

3. Definitions—Most terms for components and systems contained in this document are included in SAE J1930. This section includes additional definitions of terms not included in SAE J1930.

3.1 Absolute Throttle Position Sensor—This value is intended to represent the throttle opening. 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 will usually indicate greater than 0%, and throttle position at wide open throttle will usually indicate less than 100%.

3.2 Bank—The group of cylinders which feed an oxygen sensor. Bank 1 contains the Number 1 cylinder.

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—An indication of the current airflow divided by peak airflow, where peak airflow is corrected for altitude, if available. Mass airflow and barometric pressure sensors are not required for this calculation. This definition provides a unitless number that is not engine specific, and provides the service technician with an indication of the percent engine capacity that is being used (with wide open throttle as 100%).

$$CLV = \frac{\text{Current airflow}}{\text{Peak airflow (@ sea level)}} \times \frac{\text{Atmospheric pressure (@ sea level)}}{\text{Barometric pressure}} \times 100\% \quad (\text{Eq. 1})$$

3.5 Continuous Monitoring—Sampling at a rate no less than two samples per second.

3.6 Fuel Trim—Feedback adjustments to the base fuel schedule. 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.

4. Technical Requirements

4.1 Diagnostic Test Mode General Conditions—These guidelines are necessary to ensure proper operation of both the test equipment and the vehicle during diagnostic procedures. Test equipment, when using messages defined in this document, should not affect normal operation of the emission control system.

4.1.1 MULTIPLE RESPONSES TO A SINGLE DATA REQUEST—The messages contained in this document are functional messages, which means the off-board test equipment will request data without knowledge of which module on the vehicle will respond. In some vehicles, multiple modules may respond with the information requested. In addition, a single module may send multiple responses to a single request. Any test device requesting information must, therefore, have provisions for receiving multiple responses.

4.1.2 RESPONSE TIME—For SAE J1850 network interfaces, the on-board systems should respond to a request within 100 ms of a request or a previous response. With multiple responses possible from a single request, this allows as

much time as is necessary for all modules to access the data link and transmit their responses. If there is no response within this time period, the tool can either assume no response will be received, or if a response has already been received, that no more responses will be received.

For ISO 9141-2 interfaces, response time requirements are specified in the ISO 9141-2 document.

4.1.3 MINIMUM TIME BETWEEN REQUESTS FROM SCAN TOOL—For SAE J1850 network interfaces, a tool should always wait for a response from the previous request, or "no response" timeout before sending another request. In no case should a request be sent less than 100 ms after the previous request.

For ISO 9141-2 interfaces, required times between requests are specified in the ISO 9141-2 document.

4.1.4 DATA NOT AVAILABLE—There are two conditions for which data is not available. One condition is that the test mode is not supported, and the other is that the test mode is supported, but data is not currently available.

There will be no reject message to a functional request if the request is not supported by the module. This prevents responses from all modules that do not support a test mode or a specific data value.

Some test modes are supported by a vehicle, but data may not always be available when requested. For Modes \$05 and \$06, if the test has not been run since test results were last cleared, or for Mode \$02 if freeze frame data has not been stored, valid data will not be available. For these conditions, the manufacturer has the option to either not respond or to respond with data that is invalid. The functional descriptions for these test modes discuss the method to determine if data is valid.

4.1.5 MAXIMUM VALUES—If the data value exceeds the maximum value possible to be sent, the on-board system should send the maximum value possible (\$FF or \$FFFF). The tool should display the maximum value or an indication of data too high. This is not normally critical for real time diagnostics, but in the case of a misfire at 260 km/h with resulting freeze frame data stored, this will be very valuable diagnostic information.

4.2 Diagnostic Message Format

4.2.1 ADDRESSING METHOD—Functional addressing will be used for all generic Diagnostic Test Mode messages because the test tool does not know which system on the vehicle has the information that is needed.

4.2.2 MAXIMUM MESSAGE LENGTH—SAE J1850 defines required message elements and maximum message lengths that effectively limit the number of bytes that can be defined by this document to 12 bytes.

4.2.3 DIAGNOSTIC MESSAGE FORMAT—To conform to the SAE J1850 limitation on message length, diagnostic messages specified in this document begin with a three byte header, have a maximum of 7 data bytes, require ERR (error detection byte), and allow RSP (in-frame response byte), as shown in Figure 1.

Header Bytes (Hex)			Data Bytes						
Priority (Type)	Target Address	Source Address	\$1	\$2	\$3	\$4	\$5	\$6	\$7
Diagnostic Request at 10.4 Kbaud (SAE J1850 and ISO 9141-2)									
\$08	SA	FS	Maximum 7 Data Bytes						
								ERR	RSP
Diagnostic Response at 10.4 Kbaud (SAE J1850 and ISO 9141-2)									
\$08	SR	addr	Maximum 7 Data Bytes						
								ERR	RSP
Diagnostic Request at 41.6 Kbaud (SAE J1850)									
\$01	SA	FS	Maximum 7 Data Bytes						
								ERR	RSP
Diagnostic Response at 41.6 Kbaud (SAE J1850)									
\$01	SR	addr	Maximum 7 Data Bytes						
								ERR	RSP

FIGURE 1—DIAGNOSTIC MESSAGE FORMAT

4.2.4 HEADER BYTES—The first three bytes of all diagnostic messages are the header bytes. The value of the first header byte is dependent on the bit rate of the data link and the type of message, as shown in 4.2.3. The second byte has a value that depends on the type of message, either a request or a response. The third header byte is the physical address of the device sending the message.

Device address \$F1 should be used for an OBD II Scan Tool, or any other tool that does not have a special reason to use another address. Other service tools should use addresses in the range from \$F0 to \$FD. The response to all request messages in this document will be independent of the address of the test equipment requesting the information.

Vehicle manufacturers should not use the SAE J1979 header bytes for any purpose other than diagnostic messages. When they are used, they must conform to this specification.

4.2.5 DATA BYTES—The maximum number of data bytes available to be specified in this document is 7. The first data byte following the header is the test mode, and the remaining 6 bytes vary depending on the specific test mode. Each unique diagnostic message defined in this document is a fixed length, although not all messages are the same length. For modes \$01 and \$02, message length is determined by Parameter Identification (PID). For Mode \$03, message length is determined by Test ID. For other modes, the message length is determined by the mode. This enables the tools to check for proper message length, and to recognize the end of the message without waiting for possible additional data bytes.

4.2.6 NON-DATA BYTES INCLUDED IN DIAGNOSTIC MESSAGES WITH SAE J1850—All diagnostic messages will use a Cyclic Redundancy Check (CRC), as defined in SAE J1850, as the error detection (ERR) byte.

In-frame response (RSP) is defined as optional in SAE J1850. For messages defined in this document, the RSP byte is required in all request and response messages at 41.5 Kbps, and is not allowed for messages at 10.4 Kbps.

SAE J1850 defines additional message elements that may be included in Diagnostic Messages. Use of these message elements is beyond the scope of this specification, but need to be considered when defining total diagnostic messages.

4.2.7 NON-DATA BYTES INCLUDED IN DIAGNOSTIC MESSAGES WITH ISO 9141-2—Messages will include a checksum, defined in ISO 9141-2, after the data bytes instead of the CRC used with SAE J1850.

There is no provision for an in-frame response in ISO 9141-2.

4.2.8 BIT POSITION CONVENTION—Some data byte values in this document include descriptions that are based on bit positions within the byte. The convention used in this document 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 3:



FIGURE 3—BIT POSITION WITHIN A DATA BYTE

4.3 Allowance for Expansion and Enhanced Diagnostic Test Modes—This document allows for the addition of Diagnostic Test Modes both as industry standards and manufacturer specific modes. Enhanced Diagnostic Test Modes are defined in a separate SAE document, J2190. That document reserves functional test modes \$00 through \$0F to be defined in SAE J1979 if needed to accommodate future legislated requirements.

4.4 Format of Data to be Displayed—The format of data to be displayed to the user of the data obtained with these test modes needs to be standardized so that vehicle manufacturers can write generic service information. The following table indicates the type of data and minimum requirements for format of the data. See Figure 3.

Data	Modes	Display Format
Device ID - source address of response	\$0	Hexadecimal (00 to FF)
Parameter ID (PID)	\$01 & \$02	Hexadecimal (00 to FF), description, or acronym (see table in 5.3)
Frame number	\$02	Decimal (0 to 255)
Data values	\$01 & \$02	see table in 5.3
Diagnostic Trouble Codes	\$03 & \$07	"P," "B," "C," or "U" plus 4 digits and/or DTC definition - see SAE J2012
Test ID	\$05, \$06, & \$08	Hexadecimal (00 to FF)
Test value and test units	\$05	Engineering units for Test IDs less than \$05 (see 5.3.2) Decimal (0 to 255) for Test IDs greater than \$05
Test value and test units	\$06	Decimal (0 to 65535)
Component ID	\$08 (part of data byte #3)	Hexadecimal (00 to FF)

FIGURE 3—FORMAT OF DATA TO BE DISPLAYED

5. Test Modes

5.1 Mode \$01—Request Current Powertrain Diagnostic Data

5.1.1 FUNCTIONAL DESCRIPTION—The purpose of this mode is to allow access to current emission related data values, including analog 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 definitions, scaling information, and display formats are included in this document.

The on-board module will 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 module, which PIDs that module supports. PID \$00 must be supported by all modules that respond to a Mode \$01 request as defined in this document, because diagnostic tools that conform to SAE J1979 use the presence of a response by the vehicle to this request to determine which protocol is supported for OBD II communications.

5.1.2 MESSAGE DATA BYTES—(See Figure 4.)

		Data Bytes (Hex)						
		#1	#2	#3	#4	#5	#6	#7
Request Current Powertrain Diagnostic Data								
Request Powertrain Diagnostic Data	Q1	PID						
Report Current Powertrain Diagnostic Data								
Report Powertrain Diagnostic Data	A1	PID	data A	data B	data C	data D		
			(hex)	(hex)	(hex)	(hex)		

FIGURE 4—MESSAGE DATA BYTES

5.2 Mode \$02—Request Powertrain Freeze Frame Data

5.2.1 FUNCTIONAL DESCRIPTION—The purpose of this mode is to allow access to emission related data values which were stored during the freeze frame required by OBD regulations. This mode 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 for information includes a Parameter Identification (PID) value that indicates to the on-board system the specific information requested. PID definitions, scaling information, and display formats for the required freeze frame are included in this document.

The on-board module will respond to this message by transmitting the requested data value stored 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 module, which PIDs that module supports. Therefore, PID \$00 must be supported by all modules that respond to a Mode \$02 request as defined in this document.

PID \$02 is the DTC that caused the freeze frame data to be stored. If freeze frame data is not stored in the module, the system should report \$00 00 as the DTC. Any data reported when the stored DTC is \$00 00 may not be valid.

The frame number byte will indicate \$00 for the OBD II mandated freeze frame data. Manufacturers may optionally save additional freeze frames and use this mode to obtain that data by specifying the freeze frame number in the request. If a manufacturer uses these additional freeze frames, they will be stored under conditions defined by the manufacturer, and contain data specified by the manufacturer.

5.2.2 MESSAGE DATA BYTES—(See Figure 5.)

		Data Bytes (Hex)						
		#1	#2	#3	#4	#5	#6	#7
Request Powertrain Freeze Frame Data								
Request Powertrain Freeze Frame Data	Q2	PID	frame no.					
Report Powertrain Freeze Frame Data								
(only valid if Mode \$02 PID \$02 DTC is not \$00 00)								
Report Powertrain Freeze Frame Data	A2	PID	frame no.	data A	data B	data C	data D	
				(hex)	(hex)	(hex)	(hex)	

FIGURE 5—MESSAGE DATA BYTES

5.3 PIDs for Modes \$01 and \$02—(See Figure 6.)

3.4 Mode \$03—Request Emission-Related Powertrain Diagnostic Trouble Codes

3.4.1 FUNCTIONAL DESCRIPTION—The purpose of this mode is to enable the off-board test device to obtain stored emission-related powertrain trouble codes. This should be a two step process for the test equipment.

- Step 1—Send a Mode \$01, PID \$01 request to get the number of stored emission-related powertrain trouble codes from all modules that have this available. Each on-board module that has stored codes will respond with a message that includes the number of stored codes which that module can report. If a module capable of storing powertrain codes does not have stored codes, then that module shall respond with a message indicating zero codes are stored.
- Step 2—Send a Mode \$03 request for all stored emission-related powertrain codes. Each module that has codes stored will respond with one or more messages, each containing up to 3 codes. If no codes are stored in the module, then the module may not respond to this request.

If additional trouble codes are set between the time that the number of codes are reported by a module, and the stored codes are reported by a module, then the number of codes reported could exceed the number expected by the tool. In this case, the tool should repeat this cycle until the number of codes reported equals the number expected based on the Mode \$01 response.

Diagnostic trouble codes are transmitted in two bytes of information for each code. The first two bits (high order) of the first byte for each code will be zeroes to indicate a powertrain code (refer to SAE J2012 for additional interpretation of this structure). The second two bits will indicate the first digit of the diagnostic code (0 through 3). The second nibble of the first byte and the entire second byte are the next three digits of the actual code reported as Binary Coded Decimal (BCD). A powertrain trouble code transmitted as \$0143 should be displayed as P0143. (See Figure 7.)

If less than 3 trouble codes are reported, the response messages used to report diagnostic trouble codes should be padded with \$00 to fill 7 data bytes. This maintains the required fixed message length for all messages.

If there are no diagnostic trouble codes to report, a response is allowed, but not required.

3.4.2 MESSAGE DATA BYTES—(See Figure 8.)

3.4.3 POWERTRAIN DIAGNOSTIC TROUBLE CODE EXAMPLE (ASSUME 10.4 Kbps)—(See Figure 9.)

3.5 Mode \$04—Clear/Reset Emission-Related Diagnostic Information

3.5.1 FUNCTIONAL DESCRIPTION—The purpose of this mode is to provide a means for the external test device to command on-board modules to clear all emission-related diagnostic information. This includes:

- Clear number of diagnostic trouble codes (Mode \$01, PID \$01)
 - Clear diagnostic trouble codes (Mode \$03)
 - Clear trouble code for freeze frame data (Mode \$01, PID \$02)
 - Clear freeze frame data (Mode \$03)
 - Clear oxygen sensor test data (Mode \$05)
 - Reset status of system monitoring tests (Mode \$01, PID \$01)
 - Clear on-board monitoring test results (Mode \$06 and \$07)
- Other manufacturer specific "clearing/resetting" actions may also occur in response to this request.

For safety and/or technical design reasons, some modules may not respond to this test mode under all conditions. All modules must respond to this test mode request with the ignition ON and with the engine not running. Modules that cannot perform this operation under other conditions, such as with the engine running, will ignore the request.

3.5.2 MESSAGE DATA BYTES—(See Figure 10.)

3.6 Mode \$05—Request Oxygen Sensor Monitoring Test Results

3.6.1 FUNCTIONAL DESCRIPTION—The purpose of this mode is to allow access to the on-board oxygen sensor monitoring test results as required in OBD II regulations. Use of this mode is optional, depending on the method used by the vehicle manufacturer to comply with the requirements for oxygen sensor monitoring.

The request for test results includes a Test ID value that indicates the information requested. Test value definitions, scaling information, and display formats are included in this document.

Many methods may be used by different manufacturers to comply with this requirement. If data values are to be reported using these messages that are different from those predefined in this document, ranges of test values have been assigned that can be used that have standard units of measure. The tool can convert these values and display them in the proper units.

The on-board module will respond to this message by transmitting the requested test data last determined by the system.

Modes		PID (HEX)	Description	Min (\$00) or (\$0000)	Max (\$FF) or (\$FFFF)	SI Metric Scaling and Display	English Scaling and Display
X	X	00	PIDs reported (\$01-\$20)			Size 00	00
			Module responds with a message that contains 4 bytes of 00-extended information, each 00 indicating support or non-support of a PID.			Data A 01	\$01
X	X	01	Module responds with a message that contains 4 bytes of 00-extended information, each 00 indicating support or non-support of a PID.			Data A 02	\$02
			where: 0 = PID not supported by this module 1 = PID supported by this module			Data B 03	\$03
X	X	02	Data A - Number of emission-related powertrain trouble codes and MIL status: bits 0-3: Number of codes stored in this module bits 4-7: 0 = MIL not commanded ON by this module 1 = MIL commanded ON by this module			Data B 04	\$04
			Data B (bits 0 to 3) and Data C - Each bit indicates support or non-support of an on-board diagnostic evaluation: Data B covers continuous monitoring tests Data C covers non-continuous tests where: 0 = test not supported by this module 1 = test supported by this module			Data C and Data D	\$05
X	X	03	Data B (bits 4 to 7) and Data C - Each bit indicates status of on-board diagnostic evaluation for this module, corresponding to tests included in Data B (bits 0 to 3) and Data C: 0 = test complete, or not applicable 1 = test not complete				\$06
			NOTE: Data B, bits 4 to 7, are required only for vehicles that do not support any non-continuous tests.				\$07

FIGURE 6—PIDS FOR MODES \$01 AND \$02

Modes *		PID (Hex)	Description	Min (\$00) or (\$0000)		Max (\$FF) or (\$FFFF)		SI (Metric) Scaling/Bit and Display	English Scaling/Bit and Display
\$01	\$02								
	X	02	Trouble code that caused required freeze frame data storage (2 byte value - \$0000 indicates no freeze frame data)	00	00	F0	00	Power Banner Green Freeze	
X	X	03	Data A: Fuel system 1 status Data B: Fuel system 2 status (\$00 if not used) For each data byte, six more than one bit at a time can be set to a 1 to indicate the status of that bank, where: bit 0 = Open loop - has not yet satisfied conditions to go closed loop bit 1 = Closed loop - using oxygen sensor(s) as feedback for fuel control bit 2 = Open loop due to driving conditions (power enrichment, deceleration enrichment) bit 3 = Open loop due to detected system fault bit 4 = Closed loop, but fault with at least one oxygen sensor - may be using single oxygen sensor for fuel control bits 5-7 = reserved (report as 0)						
X	X	04	Calculated load value	0%		100%		100/255%, xxx %	
X	X	05	Engine coolant temperature	-40 °C		215 °C		1 °C with -40 °C offset xxx °C	xxx °F
X	X	06	Short term fuel trim - Bank 1 (use 0 only 1 fuel trim value)	-100.00% (min)		99.99% (max)		100/128% (0% at 128) xxx %	
X	X	07	Long term fuel trim - Bank 1	-		-		-	
X	X	08	Short term fuel trim - Bank 2	-		-		-	
X	X	09	Long term fuel trim - Bank 2	-		-		-	
X	X	0A	Fuel pressure (psig)	0 kPaG		765 kPaG		3 kPaG xxx kPaG	xxx psig

FIGURE 6—PIDS FOR MODES \$01 AND \$02 (CONTINUED)

Modes *		PID (Hex)	Description	Min (\$00) or (\$0000)		Max (\$FF) or (\$FFFF)		SI (Metric) Scaling/Bit and Display	English Scaling/Bit and Display
\$01	\$02								
X	X	0B	Intake manifold absolute pressure	0 kPaA		356 kPaA		1 kPaA xxx kPaA	xxx in Hg
X	X	0C	Engine RPM (2 byte value - high byte/low byte)	0 rpm		18,383.75 rpm		1/4 rpm xxxx (100)	
X	X	0D	Vehicle speed	0 km/h		255 km/h		1 km/h xxx km/h	xxx MPH
X		0E	Ignition timing advance for #1 cylinder (fuel including mechanical advance)	-64 deg		+63.5 deg		1/2 deg with 0 deg at 128 xx x (100)	
X		0F	Intake air temperature	-40 °C		215 °C		1 °C with -40 °C offset xxx °C	xxx °F
X		10	Air flow rate from MAF sensor (2 byte value - high byte/low byte)	0 g/s		650.35 g/s		0.01 g/s xxx x (100)	xxx x (100)
X		11	Accelerator throttle position sensor	0%		100%		100/255% xxx %	
X		12	Commanded secondary air status (if supported, one, and only one bit at a time can be set to 1) bit 0 1 = upstream of first catalytic converter bit 1 1 = downstream of first catalytic converter inlet bit 2 1 = simultaneous bits 3-7 = reserved (report as 0)						

FIGURE 6—PIDS FOR MODES \$01 AND \$02 (CONTINUED)

Modes *		PID (Hex)	Description	Min (\$03 or \$0000)	Max (\$FF or \$FFFF)	SI (Metric) Scaling/Bit and display	English Scaling/bit and display
\$01	\$02						
X or PID \$10		13	Location of oxygen sensors installed in the vehicle, where sensor 1 is closest to the engine. Each bit indicates the presence or absence of an oxygen sensor at each of the following locations. Multiple bits may be set to 1: bit Sensor location: 0 Bank 1 - Sensor 1 1 Bank 1 - Sensor 2 2 Bank 1 - Sensor 3 3 Bank 1 - Sensor 4 4 Bank 2 - Sensor 1 5 Bank 2 - Sensor 2 6 Bank 2 - Sensor 3 7 Bank 2 - Sensor 4 where: 1 = sensor present at that location 0 = sensor not present at that location				
X		14 15 16 17 18 19 1A 1B	Bank 1 - Sensor 1 Bank 1 - Sensor 2 Bank 1 - Sensor 3 Bank 1 - Sensor 4 Bank 2 - Sensor 1 Bank 2 - Sensor 2 Bank 2 - Sensor 3 Bank 2 - Sensor 4 for each sensor: Data A - Oxygen sensor output voltage Data B - short term fuel trim associated with the sensor (\$FF if this sensor is not used in the calculation)	0 V -100.00% (lean)	1.275 V 99.99% (rich)	This scaling assumes a nominal 1 V full scale oxygen sensor; any sensor with a different full scale value should be normalized to provide nominal full scale at \$08 (200 decimal). 0.205 V x.xxx V 100/128% (% at 128) 000.0%	
X		1C	Onboard Diagnostics (OBD) requirements to which vehicle is designed, where: \$01 - OBD II (California ARB) \$02 - OBD (Federal EPA) \$03 - OBD and OBD II \$04 - OBD I \$05 - Not intended to meet any OBD requirements				
X or PID \$10		1D	Location of oxygen sensors installed in the vehicle, where sensor 1 is closest to the engine. Each bit indicates the presence or absence of an oxygen sensor at each of the following locations. Multiple bits may be set to 1: bit Absolute sensor location: 0 Bank 1 - Sensor 1 1 Bank 1 - Sensor 2 2 Bank 2 - Sensor 1 3 Bank 2 - Sensor 2 4 Bank 3 - Sensor 1 5 Bank 3 - Sensor 2 6 Bank 4 - Sensor 1 7 Bank 4 - Sensor 2 where: 1 = sensor present at that location 0 = sensor not present at that location				
X		1E	Auxiliary Input Status bit 0: Power Take-Off (PTO) Status where: 0 = PTO not active 1 = PTO active bits 1-7: reserved for future expansion (report as 0)				
X		1F	Reserved - reserved for future expansion				
X		20	PIDs supported (\$01 - \$40):				
						Spa Data A 7 \$21	
						Data A 8 \$22	
						Data B 7 \$29	
						Data D 0 \$40	
		21-2F	Reserved - to be specified in SAE J2130, if needed				
X		40	PIDs supported (\$41 - \$80):				
X		41-FF	Reserved for future expansion				

* NOTE—An "X" in the column under Mode \$01 or \$02 indicates that this value is included in OBD II regulations to be supported for this mode. Refer to the latest OBD II regulations to determine if each value is required to be supported on a given vehicle, or only required if available.

† Although only vehicles meeting California ARB OBD II and Federal OBD regulations are required to support this document, manufacturers of other vehicles may choose to support this request for the convenience of service technicians.

FIGURE 6—PIDS FOR MODES \$01 AND \$02 (CONTINUED)

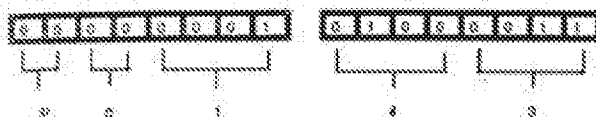


FIGURE 7—DIAGNOSTIC TROUBLE CODE ENCODING EXAMPLE

		Data Bytes (Hex)							
		#1	#2	#3	#4	#5	#6	#7	#8
Request number of codes from all modules									
Request number of Powertrain DTC		01	01						
Report number of codes (each module)									
Report number of stored powertrain DTC		#1	#1	# DTC & MIL	Evap. Open #1	Evap. Over #2	Evap. Status		
Request codes from all modules									
Request Powertrain DTC		01							
Report codes (each module)									
Report Powertrain DTC		43	Code #1 or 00 00	Code #2 or 00 00	Code #3 or 00 00				

NOTE—Refer to SAE J2012 for encoding method for trouble codes.

FIGURE 8—MESSAGE DATA BYTES

		Data Bytes (Hex)							
		#1	#2	#3	#4	#5	#6	#7	#8
Request Number of Powertrain DTC									
Request number of Powertrain DTC		00	SA	F1	01	01			
Report Number of Powertrain DTC									
Module 06 has 6 stored DTC		40	00	06	41	01	00	00	00
Module 02 has 3 stored DTC		40	00	03	41	01	01	00	00
Module 05 has 0 stored DTC		40	00	00	41	01	00	00	00
Module 08 has 2 stored DTC and MIL ON		40	00	02	41	01	00	00	00
Request All Stored Powertrain DTC									
Request Powertrain DTC		00	SA	F1	03				
Report All Stored Powertrain DTC									
Module 06 send codes P0143, P0198, & P0234		40	00	00	43	Code #1	Code #2	Code #3	
						01	40	01	00
								02	34
Module 02 send code P0443		40	00	03	43	Code #1			
						04	40	00	00
Module 08 send codes P0257, P0631, & P0691		40	00	06	43	Code #4	Code #5	Code #6	
						00	07	05	31
								06	91
Module 0E send codes P0112 & P0445		40	00	0C	43	Code #1	Code #2		
						01	12	04	45
								05	00

FIGURE 9—POWERTRAIN DIAGNOSTIC TROUBLE CODE EXAMPLE (ASSUME 10.4 Kbps)

		Data Bytes (Hex)							
		#1	#2	#3	#4	#5	#6	#7	#8
Request for Clear/Reset Emission-Related Diagnostic Information									
Clear Powertrain DTC		04							
Report when Emission-Related Diagnostic Information is Reset									
Powertrain DTC cleared		44							

FIGURE 10—MESSAGE DATA BYTES

The operation of this diagnostic mode in the on-board module is different from Mode \$01. Mode \$01 reports data value(s) that are stored internally at a single, or multiple contiguous, locations in memory. Mode \$05 can report data values that are stored in non-contiguous memory locations. Test results will be stored in RAM, and test limits, if the value is a calculated value, would normally be stored in ROM. Therefore, the on-board software has additional requirements to respond to this request than it does for Mode \$01 requests.

Not all test values are applicable or supported by all vehicles. An optional feature of this test mode is for the on-board module 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 test modes \$01 and \$02. If Test ID \$00 is not supported, then the module does not use this feature to indicate test ID support.

5.6.2 MESSAGE DATA BYTES—(See Figures 11, 12, and 13.)

		Data Bytes (Hex)						
		#1	#2	#3	#4	#5	#6	#7
Request Oxygen Sensor Test Results								
Request Oxygen Sensor Test Results		05	Test ID	025 #				
Report Oxygen Sensor Test ID Support - Optional (Test IDs \$00, \$05, \$45, \$80, \$80, \$80, \$80, \$80, \$80, \$80, \$80)								
Report Oxygen Sensor Test ID Support		45	Test ID	025 #	Support for the next 32 test IDs following the requested ID is indicated in data bytes #4 through #7			
Report Oxygen Sensor Test Results (All Test IDs That Don't Indicate Test ID Support Data is only valid if Mode \$01 PID \$01 indicates Oxygen sensor monitoring is supported and the test is complete)								
Report Oxygen Sensor Test Results		40	Test ID	025 #	Test value	min limit (opt)	max limit (opt)	

* NOTE—Report limits if value is a test result—not required for test constants, such as ID \$01 to \$04.

FIGURE 11—MESSAGE DATA BYTES

Results of latest mandated on-board oxygen sensor monitoring test.

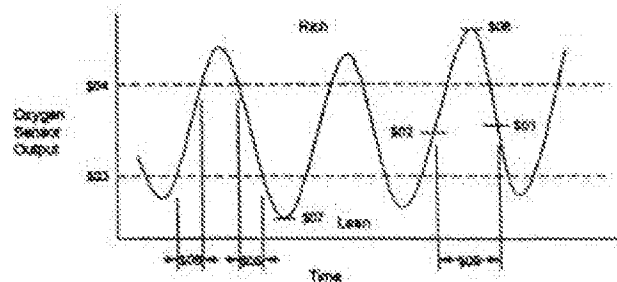


FIGURE 12—TEST ID VALUE EXAMPLE

Data Byte	Description
2	Which Test ID: \$00 - Test ID's supported - optional (\$01 to \$20) \$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 - \$0F - reserved \$20 - Test ID's supported - optional (\$21 to \$40) \$21 - \$2F - values with units of time less than 1.02 s \$30 - \$3F - values with units of time less than 10.2 s \$40 - Test ID's supported - optional (\$41 to \$60) \$41 - \$4F - values with units of voltage less than 1.275 V \$50 - \$5F - values with units of voltage less than 12.75 V \$60 - Test ID's supported - optional (\$61 to \$80) \$61 - \$6F - values with units of Hz less than 25.5 Hz \$70 - \$7F - values with units of counts less than 255 counts \$80 - Test ID's supported - optional (\$81 to \$A0) \$81 - \$8F - manufacturer specific values/units \$A0 - Test ID's supported - optional (\$A1 to \$C0) \$A1 - \$AF - manufacturer specific values/units \$C0 - Test ID's supported - optional (\$C1 to \$E0) \$C1 - \$CF - manufacturer specific values/units \$E0 - Test ID's supported - optional (\$E1 to \$F0) \$E1 - \$FF - manufacturer specific values/units

FIGURE 13—MESSAGE DATA BYTE DESCRIPTION

5.7 Mode \$06—Request On-Board Monitoring Test Results for Non-Continuously Monitored Systems

5.7.1 FUNCTIONAL DESCRIPTION—The purpose of this test mode is to allow access to the results for on-board diagnostic monitoring tests of specific components/systems that are not continuously monitored. Examples are catalyst monitoring and the evaporative system monitoring.

The vehicle manufacturer is responsible to assign test IDs and component IDs for tests of different systems and components. Test results are requested by test ID. 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 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.

This test mode can be used as an alternative to Mode \$05 to report oxygen sensor test results.

5.7.2 MESSAGE DATA BYTES—(See Figure 14.)

5.7.3 MESSAGE EXAMPLE—(See Figure 15.)

5.8 Mode \$07—Request On-Board Monitoring Test Results for Continuously Monitored Systems

5.8.1 FUNCTIONAL DESCRIPTION—The purpose of this mode is to enable the on-board test device to obtain test results for emission-related powertrain components/systems that are continuously monitored during normal driving conditions. 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 mode 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 Mode \$03, indicating a faulty component/system.

Test results for these components/systems are reported in the same format as the diagnostic trouble codes in Test Mode \$03—refer to the functional description for Mode \$03.

If less than 3 DTC values are reported for failed tests, the response messages used to report the test results should be padded with \$00 to fill 7 data bytes. This maintains the required fixed message length for all messages.

If there are no test failures to report, a response is allowed, but not required.

5.8.2 MESSAGE DATA BYTES—(See Figure 16.)

Data Byte	Description
3	Oxygen sensor location (one, and only one bit can be set to a 1): \$8 - Sensor location - Alternative sensor location: 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 2 - 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 where: 1 = data requested for this sensor 0 = data not requested for this sensor The following 4 bytes define data bytes for Test ID's that indicate support of other Test ID's - optional (Packets \$00, \$20, \$40, \$60, \$80, \$A0, \$C0, and \$E0) 4 - Support for Test ID, where 1 = support, 0 = non-support: b0 7 - support for Test ID \$01 b0 6 - support for Test ID \$02 b0 0 - support for Test ID \$06 5 - Support for Test ID, where 1 = support, 0 = non-support: b0 7 - support for Test ID \$09 b0 6 - support for Test ID \$0A b0 0 - support for Test ID \$10 6 - Support for Test ID, where 1 = support, 0 = non-support: b0 7 - support for Test ID \$19 b0 6 - support for Test ID \$1A b0 0 - support for Test ID \$20 The following 3 bytes define data bytes for Test ID's that report data values: 4 - Test ID, Min (\$00), Max (\$FF), Scaling: Test ID \$01 - 0 V - 1.275 V - 0.005 V Test ID \$02 - 0 V - 1.275 V - 0.005 V Test ID \$03 - 0 V - 1.275 V - 0.005 V Test ID \$04 - 0 V - 1.275 V - 0.005 V Test ID \$05 - 0 s - 1.02 s - 0.004 s Test ID \$06 - 0 s - 1.02 s - 0.004 s Test ID \$07 - 0 V - 1.275 V - 0.005 V Test ID \$08 - 0 V - 1.275 V - 0.005 V Test ID \$09 - 0 s - 10.2 s - 0.04 s Test ID \$10 - \$3F - 0 s - 10.2 s - 0.04 s Test ID \$41 - \$4F - 0 V - 1.275 V - 0.005 V Test ID \$50 - \$5F - 0 V - 12.75 V - 0.05 V Test ID \$61 - \$6F - 0 Hz - 25.5 Hz - 0.1 Hz Test ID \$70 - \$7F - 0 counts - 255 counts - 1 count 5 - Minimum test limit (only for calculated test result) see Data Byte #4 for minimum value, maximum value, and scaling 6 - Maximum test limit (only for calculated test result) see Data Byte #4 for minimum value, maximum value, and scaling

NOTE—Current oxygen sensors are nominally 1 V full scale. If an oxygen sensor is used with a different nominal output, the output voltage should be normalized to 1 V. Full scale should be reported as \$C8 (decimal 200), which allows for reporting an overvoltage condition.

FIGURE 13—MESSAGE DATA BYTE DESCRIPTION (CONTINUED)

Data Bytes (Hex)							
#1	#2	#3	#4	#5	#6	#7	
Request Test Results							
Request Test Results	00	Test ID					
Report Test ID Support							
(Test IDs \$00, \$20, \$40, \$60, \$80, \$A0, \$C0, \$E0)							
Report Test ID Support	40	Test ID	FF	Support for the next 32 test IDs following the requested ID for any component is indicated in data bytes #4 through #7			
Report Test Results - Multiple Responses may be Transmitted							
(Test IDs other than \$00, \$20, \$40, \$60, \$80, \$A0, \$C0, \$E0)							
Data is only valid if Mode \$01 PID \$01 indicates the monitoring test is supported and the test is complete							
Report Test Results	40	Test ID	Test Limit Type & Component ID	test value		test limit	
				MSB	LSB	MSB	LSB

FIGURE 14—MESSAGE DATA BYTES

Data Byte	Description
2	Test ID: \$00 - Test IDs supported (\$01 to \$20) \$01 - \$1F - values defined by manufacturer \$20 - Test IDs supported (\$21 to \$40) \$21 - \$3F - values defined by manufacturer \$40 - Test IDs supported (\$41 to \$60) \$41 - \$5F - values defined by manufacturer \$60 - Test IDs supported (\$61 to \$80) \$61 - \$7F - values defined by manufacturer \$80 - Test IDs supported (\$81 to \$A0) \$81 - \$9F - values defined by manufacturer \$A0 - Test IDs supported (\$A1 to \$C0) \$A1 - \$BF - values defined by manufacturer \$C0 - Test IDs supported (\$C1 to \$E0) \$C1 - \$DF - values defined by manufacturer \$E0 - Test IDs supported (\$E1 to \$FF) \$E1 - \$FF - values defined by manufacturer
3	bit 7: Most significant bit indicates type of test limit, where: 0 - test limit is maximum value - test fails if test value is greater than this value 1 - test limit is minimum value - test fails if test value is less than this value If the test result should be within a range of values, two messages will be returned, one with the maximum value and one with the minimum value bit 6 - bit 0: Component ID - manufacturer defined - necessary when multiple components or systems are present on the vehicle and have the same definition of test ID

FIGURE 14—MESSAGE DATA BYTES (CONTINUED)

Data Byte	Description
The following 4 bytes define data bytes for Test IDs that indicate support of other Test IDs (Test IDs \$00, \$20, \$40, \$60, \$80, \$A0, \$C0, and \$E0)	
4	Support for Test ID, where 1 = support, 0 = non-support: bit 7 - support for Test ID \$01 bit 6 - support for Test ID \$02 bit 5 - support for Test ID \$04
5	Support for Test ID, where 1 = support, 0 = non-support: bit 7 - support for Test ID \$08 bit 6 - support for Test ID \$10
6	Support for Test ID, where 1 = support, 0 = non-support: bit 7 - support for Test ID \$11 bit 6 - support for Test ID \$12 bit 5 - support for Test ID \$18
7	Support for Test ID, where 1 = support, 0 = non-support: bit 7 - support for Test ID \$19 bit 6 - support for Test ID \$1A bit 5 - support for Test ID \$20
The following 4 bytes define data bytes for Test IDs that report data values (multiple response messages will be received if there are multiple components that support the same test ID and SFF is included as data byte #3 in the request message)	
4-5	Test result (two byte value) - this value should be less than or equal to the test limit if most significant bit of data byte #3 is "0," and should be greater than or equal to the test limit if most significant bit of data byte #3 is "1"
6-7	Test limit (two byte value)

FIGURE 14—MESSAGE DATA BYTES (CONTINUED)

5.9 Mode \$08—Request Control of On-Board System, Test, or Component

5.9.1 FUNCTIONAL DESCRIPTION—The purpose of this mode is to enable the off-board test device to control the operation of an on-board system, test, or component.

The data bytes will be defined, if necessary, for each Test ID, and will be unique for each Test ID. If any data bytes are unused for any test, they should be filled with \$00 to maintain a fixed message length.

a. Possible uses for these data bytes in the request message are:

- (1) Turn device ON
- (2) Turn device OFF
- (3) Cycle device for nn seconds

b. Possible uses for these data bytes in the response message are:

- (1) Report system status
- (2) Report test results

5.9.2 MESSAGE DATA BYTES—(See Figure 17.)

5.9.3 TEST ID AND DATA BYTE DESCRIPTIONS—(See Figure 18.)

		Data Bytes (Hex)					
		#1	#2	#3	#4	#5	#7
Determine Test ID Support							
Request Test ID Support - ID in Hex	06	00					
Report Support for Test IDs 06, 10, 1E, and 20	46	50	FF	0000100	00000001	00000000	0000101
				=04	=01	=00	=05
Request Test ID Support	06	00					
Report Support for Test ID 45	46	50	FF	00000000	00000000	00000000	00000001
				=00	=00	=00	=01
Request Test ID Support	06	40					
Report Support for Test ID 60	46	40	FF	00000000	00000000	00000000	00000001
				=00	=00	=00	=01
Request Test ID Support	06	00					
Report Support for Test ID 80	46	80	FF	00000000	00000000	00000000	00000001
				=00	=00	=00	=01
Request Test ID Support	06	80					
Report Support for Test ID A0	46	80	FF	00000000	00000000	00000000	00000001
				=00	=00	=00	=01
Request Test ID Support	06	A0					
Report Support for Test ID A1 - no additional test IDs supported	46	A0	FF	10000000	00000000	00000000	00000000
				=00	=00	=00	=00
Following messages indicate test results for component 01 greater than the minimum							
Request Results for Test ID 06	06	06					
Report Results for component 01 - test value exceeds minimum - passed	46	06	81	test value		minimum test limit	
				32	C4	18	00
Following messages indicate test results greater than the maximum for component 01 and less than the maximum for component 02							
Request Results for Test ID 10	06	10					
Report Results for component 01 - test value greater than maximum - failed	46	10	01	test value		maximum test limit	
				02	06	7F	FF
Report Results for component 02 - test value less than maximum - passed	46	10	02	test value		maximum test limit	
				05	81	58	43
Following messages indicate test results for component 31 between the minimum and maximum limits							
Request Results for Test ID A1	06	A1					
Report Results for component 31 - test value greater than minimum - passed	46	A1	81	test value		minimum test limit	
				30	06	14	00
Report Results for component 31 - test value less than maximum - passed	46	A1	31	test value		maximum test limit	
				35	05	08	53

FIGURE 15—MESSAGE EXAMPLE

		Data Bytes (Hex)					
		#1	#2	#3	#4	#5	#7
Request test results for continuously monitored systems							
Request test results	07						
Report test results for continuously monitored systems							
Report test results	47	Code #1 or 00 00		Code #2 or 00 00		Code #3 or 00 00	

FIGURE 16—MESSAGE DATA BYTES

		Data Bytes (Hex)					
		#1	#2	#3	#4	#5	#7
Request control of on-board device							
Request control of on-board device	08	Test ID	Data A or \$00	Data B or \$00	Data C or \$00	Data D or \$00	Data E or \$00
Report control of on-board device							
Report control of on-board device	48	Test ID	Data A or \$00	Data B or \$00	Data C or \$00	Data D or \$00	Data E or \$00

FIGURE 17—MESSAGE DATA BYTES

Test ID (Hex)	Test ID and Data Byte Description
00	Test ID supported (\$01 to \$03); Request: Data bytes A to E should be set to \$00 Response: Data A - \$00 Data B - Same as Data Byte #4 in Mode \$06 Data C - Same as Data Byte #5 in Mode \$06 Data D - Same as Data Byte #6 in Mode \$06 Data E - Same as Data Byte #7 in Mode \$06
01	Evaporative system leak test. Data bytes A to E should be set to \$00 for request and response. 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 defined value as Data A which corresponds to the reason the test cannot be run. This test mode 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.
0E - FF	Reserved - to be defined by SAE

FIGURE 18—TEST ID AND DATA BYTE DESCRIPTIONS

RECOMMENDED PRACTICE FOR DIAGNOSTIC TROUBLE CODE DEFINITIONS—SAE J2012 JUL96

SAE Recommended Practice

Report of the SAE Vehicle EEC System Diagnostics Standards Committee approved March 1992, completely revised January 1994, and revised October 1994 and July 1996.
Revisions statement available.

Forward—Most automobile manufacturers are equipping at least a portion of their product line with some On-Board Diagnostic (OBD) capability. Although currently confined to California, emission regulations sponsored by the California Air Resources Board are requiring the implementation of OBD systems across all manufacturers' product lines of cars and light- and medium-duty trucks offered for sale in California, beginning with Model Year 1988. These systems are required to provide an indication in the service technician as to the general location of the diagnosed malfunction so that the proper service procedures are used to resolve the problem. In most cases, this information is provided through a numeric code.

Additional on-board diagnostic requirements have been defined by the OBD-II legislation in California and the Federal Clean Air Act. These requirements include the need for standardization of various parts of the system, including some of the Diagnostic Trouble Codes.

Currently, there is no uniformity in these numeric Diagnostic Trouble Codes (DTC) between manufacturers, and in some cases, even within the same manufacturer across different product lines. This document (SAE J2012) provides some recommended uniformity for these numeric codes. It further provides guidance for uniform messages associated with these codes.

The document itself (SAE J2012) is comprised of several sections addressing applicability, format structure, messages, and a few examples applying the recommendations of the document. The actual code assignments and messages are contained in four appendices attached to the document (Appendices A, B, C, and D). Codes and messages for Body systems are covered in Appendix A, Chassis systems in Appendix B, Powertrain systems in Appendix C, and Network Communication in Appendix D.

The recommended DTCs consist of a three-digit numeric code preceded by an alpha-numeric designator. The alpha-numeric designators are "B0," "B1," "B2," "B3," "C0," "C1," "C2," "C3," "P0," "P1," "P2," "P3," "U0," "U1," "U2," "U3," corresponding to four sets of Body, four sets of Chassis, four sets of Powertrain, and four sets of Network Communication Trouble Codes. The code structure itself is partially open-ended. A portion of the available numeric sequences (portions of "B0," "C0," "P0," and "U0") are reserved for uniform codes assigned by this or future updates of this document. Detailed specifications on the DTC format structure are covered in Section 3. Because of continued development in OBD systems and the flexibility of the partially open assignment structure, particular attention should be paid to the month and year of the publishing code contained in the full "J" number designation. It is possible that this document could be updated frequently, which would be reflected in the complete "J" number designation.

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APPENDIX C	POWERTRAIN SYSTEM DIAGNOSTIC TROUBLE CODES
APPENDIX D	NETWORK COMMUNICATION

1. Scope—This SAE Recommended Practice is applicable to all light-duty and medium-duty passenger vehicles and trucks with feedback fuel control system. Specific applications of this document include diagnostic, service and repair manuals, repair databases, and off-board readout devices.

This document focuses on a diagnostic code format and code messages for automotive electronic control systems.

The use and appropriate updating of this document is strongly encouraged; however, this document does not prohibit the use of additional codes for additional diagnostics.

1.1 Application—This document is applicable to all light-duty gasoline and diesel vehicles (LDV and LDDV), light-duty gasoline and diesel trucks (LDT and LDDT), and medium-duty gasoline vehicles (MDGV).

2. References

2.1 Applicable Documents—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 J1930—Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms

SAE J1979—E/E Diagnostic Test Modes

3. Definitions—Most circuit, component, or system Diagnostic Trouble Codes are defined by four basic categories: General Circuit Malfunction, Range/Performance Problem, Low or High Circuit Input. Most terms for components and systems contained in this document are included in SAE J1930. This section includes additional definitions of terms not included in SAE J1930.

While each manufacturer has the ability to define the specific DTCs to meet their specific controller algorithms, all DTC words must meet applicable SAE J1930.

3.1 GENERAL CIRCUIT MALFUNCTION—Fixed value or no response from the system. Manufacturers may choose to use this code in place of the dual High/Low (defined as follows) or use to indicate any other failure mode.

3.2 RANGE/PERFORMANCE—The circuit is functional but not in the normal operating range. May also be used to indicate stuck, erratic, intermittent, or skewed values indicating poor performance of a circuit, component, or system.

3.3 LOW INPUT—Circuit voltage, frequency, or other signal measured at the control module input terminal or pin that is at or near zero. This is measured with the external circuit, component, or system connected. The signal type

(voltage, frequency, etc.) shall be included in the message in place of the word "input."

3.4 HIGH INPUT—Circuit voltage, frequency, or other signal measured at the control module input terminal or pin that is at or near full scale for the particular signal being measured. This is measured with the external circuit, component, or system connected. The signal type (voltage, frequency, etc.) shall be included in the message in place of the word "input."

3.5 BANK—A specific group of cylinders sharing a common control sensor. Bank 1 contains cylinder #1. The next sensor in the same bank is number two, etc. If there is only one bank, use bank #1 DTCs and the word bank may be omitted. With a single "bank" system utilizing multiple sensors, use bank #1 DTCs identifying the sensors as #1, #2, #3 in order as they move further away from the cylinder(s).

3.6 SENSOR—If the sensors are numbered (i.e., Bank #1 Sensor #1) they follow the convention described previously in "Bank." If the sensors are indicated by a letter (i.e., A, B, C, etc.) this would be manufacturer defined. If a manufacturer uses only a single sensor then the number or letter may be omitted.

4. Format Structure

4.1 Description—The Diagnostic Trouble Code consists of an alpha-numeric designator, B0 — B3 for Body, C0 — C3 for Chassis, P0 — P3 for Powertrain, and U0 — U3 for Network Communication, followed by three digits. The assignment of the proper alpha designator should be determined by the controller into which the particular function being diagnosed is being integrated, or in the case of multiple controllers, the area most appropriate for that function. In most cases, the alpha designator will be implied since diagnostic information will be requested from a particular controller. In the cases where the source of the diagnostic information is not clear, the uppermost nibble of the two-byte code message as defined in SAE J1979 will define the source system as follows:

0000 - P0	- Powertrain codes SAE controlled
0001 - P1	- Powertrain codes Manufacturer controlled
0010 - P2	- Powertrain codes Reserved
0011 - P3	- Powertrain codes Reserved
0100 - C0	- Chassis codes SAE controlled
0101 - C1	- Chassis codes Manufacturer controlled
0110 - C2	- Chassis codes Manufacturer controlled
0111 - C3	- Chassis codes Reserved
1000 - B0	- Body codes SAE controlled
1001 - B1	- Body codes Manufacturer controlled
1010 - B2	- Body codes Manufacturer controlled
1011 - B3	- Body codes Reserved
1100 - U0	- Network Communication codes SAE controlled
1101 - U1	- Network Communication codes Manufacturer controlled
1110 - U2	- Network Communication codes Manufacturer controlled
1111 - U3	- Network Communication codes Reserved

Within each code class, the first of the three digits identifies a particular grouping of codes. These particular groupings each contain a series of 100 sequence numbers for particular code definitions.

Codes have been defined to indicate a suspected trouble or problem area and are intended to be used as a directive to the proper service procedure. To minimize service confusion, fault codes should not be used to indicate the absence of problems or the status of parts of the system (e.g., Powertrain System O.K., or MIL illuminated), but should be confined to indicate areas in need of service attention. The decision to illuminate the MIL for any DTC is manufacturer-specific based on their testing of how each system malfunction affects emissions.

4.2 Core DTCs—Core Diagnostic Trouble Codes are those codes where industry uniformity has been achieved. These codes were felt to be common enough across most manufacturers' applications that a common number and fault message could be assigned. All undefined numbers in each grouping of systems have been reserved for future growth. Although service procedures may differ widely amongst manufacturers, the fault being indicated is common enough to be assigned a particular fault code.

4.3 Nonuniform DTC—Areas within each alpha designator have been made available for nonuniform DTCs. These are fault codes that will not generally be used by a majority of the manufacturers due to basic system differences, implementation differences, or diagnostic strategy differences. Each vehicle manufacturer or supplier who designs and specifies diagnostic algorithms, software, and diagnostic trouble codes are strongly encouraged to remain consistent across their product line when assigning codes in the manufacturer controlled area. For Powertrain codes, the same groupings should

be used as in the SAE controlled area, (i.e., 100s and 200s for Fuel and Air Metering, 300s for Ignition System or Misfire, etc.).

Code groupings for nonpowertrain codes will be defined at a later date.

4.4 Body System Groupings

- 4.4.1 - B0XXX SAE CONTROLLED
- 4.4.2 - B1XXX MANUFACTURER CONTROLLED
- 4.4.3 - B2XXX MANUFACTURER CONTROLLED
- 4.4.4 - B3XXX RESERVED

4.5 Chassis System Groupings

- 4.5.1 - C0XXX SAE CONTROLLED
- 4.5.2 - C1XXX MANUFACTURER CONTROLLED
- 4.5.3 - C2XXX MANUFACTURER CONTROLLED
- 4.5.4 - C3XXX RESERVED

4.6 Powertrain System Groupings

- 4.6.1 - P0XXX SAE CONTROLLED
 - 4.6.1.1 - P01XX Fuel and Air Metering
 - 4.6.1.2 - P02XX Fuel and Air Metering
 - 4.6.1.3 - P03XX Ignition System or Misfire
 - 4.6.1.4 - P04XX Auxiliary Emission Controls
 - 4.6.1.5 - P05XX Vehicle Speed, Idle Control, and Auxiliary Inputs
 - 4.6.1.6 - P06XX Computer and Auxiliary Outputs
 - 4.6.1.7 - P07XX Transmission
 - 4.6.1.8 - P08XX Transmission
 - 4.6.1.9 - P09XX Reserved for SAE
 - 4.6.1.10 - P10XX Reserved for SAE
- 4.6.2 - P1XXX MANUFACTURER CONTROLLED
 - 4.6.2.1 - P11XX Fuel and Air Metering
 - 4.6.2.2 - P12XX Fuel and Air Metering
 - 4.6.2.3 - P13XX Ignition System or Misfire
 - 4.6.2.4 - P14XX Auxiliary Emission Controls
 - 4.6.2.5 - P15XX Vehicle Speed, Idle Control, and Auxiliary Inputs
 - 4.6.2.6 - P16XX Computer and Auxiliary Outputs
 - 4.6.2.7 - P17XX Transmission
 - 4.6.2.8 - P18XX Transmission
 - 4.6.2.9 - P19XX Category to be Determined by SAE
 - 4.6.2.10 - P10XX Category to be Determined by SAE
- 4.6.3 - P2XXX SAE RESERVED
- 4.6.4 - P3XXX SAE RESERVED

4.7 Network Communication Groupings

- 4.7.1 - U0XXX SAE CONTROLLED
- 4.7.2 - U1XXX MANUFACTURER CONTROLLED
- 4.7.3 - U2XXX MANUFACTURER CONTROLLED
- 4.7.4 - U3XXX RESERVED

5. Messages—Each defined fault code has been assigned a message to indicate the circuit, component, or system area that was determined to be at fault. The messages are organized such that different messages related to a particular sensor or system are grouped together. In cases where there are various fault messages for different types of faults, the group also has a "generic" message as the first Code/Message of the group. A manufacturer has a choice when implementing diagnostics, based on the specific strategy and complexity of the diagnostic, whether to use one "generic" code for any fault of that circuit, component, or system or to use the more specific codes for better defining the type of fault that was detected. The manufacturer must determine what codes and messages best fit the diagnostics actually implemented. The intent is to have only one code stored for each fault detected.

When messages are broken down into more specific fault descriptions for a circuit, component, or system, the manufacturer should choose the code most applicable to their diagnosable fault. The messages are intended to be somewhat general to allow manufacturers to use them as often as possible yet still not conflict with their specific repair procedures.

6. Examples—For manufacturers choosing to implement basic diagnostics that provide general fault information but depend on service procedures (Service Charts) and off-board techniques to isolate the problem, general circuit, component, and system codes would be used. If a fault is detected in the Throttle Position Sensor circuit, rather than burden the on-board system with determining the specific type of fault, a Code P0120 would be stored indicating some type of problem with that circuit, and the service procedure would then allow the technician to determine the type of fault and the specific location of the fault. On these types of systems, a shorted sensor input, an open sensor input, and even an out-of-range sensor input, would all set the same fault code.

Manufacturers choosing to allow the on-board diagnostics to better isolate the fault would not use the general fault code/message, but would use the more

specific codes/messages associated with the particular circuit, component, or system.

For example, in diagnosing a 5 V reference Throttle Position Sensor (TP Sensor), if the input signal at the Powertrain Control Module (PCM) is stuck at near 0 V, a manufacturer has the flexibility to select from either of two codes - P0120 (TP Sensor Circuit Malfunction) or P0122 (TP Sensor Low Input), depending on the manufacturer's diagnostic procedures. If the input signal at the PCM is stuck at near 5 V, a manufacturer has the flexibility to select from either of two codes - P0120 (TP Sensor Circuit Malfunction) or P0123 (TP Sensor High Input), depending on the manufacturer's diagnostic procedures. If the input signal at the PCM is stuck at 1.5 V at idle instead of the expected 1.0 V, the manufacturer has the flexibility to select from either of two codes - P0120 (TP Sensor Circuit Malfunction) or P0121 (TP Sensor Range/Performance), depending on the manufacturer's diagnostic procedures. The root cause of the higher than expected TP Sensor voltage may be either a faulty TP Sensor, corrosion in the TP Sensor connections or a misadjusted throttle plate. Identification of the root cause is done using the diagnostic procedures and is not implied by the DTC message, thus allowing the manufacturer the flexibility in assigning DTCs.

Change Requests—Any request for change or revision should be forwarded to:

SAE Headquarters
3001 Big Beaver
Suite 320
Troy, MI 48064
ATTN: D012 Powertrain Committee Chairman

APPENDIX A BODY SYSTEM DIAGNOSTIC CODES

FOR FUTURE DEFINITION

APPENDIX B CHASSIS SYSTEM DIAGNOSTIC CODES

FOR FUTURE DEFINITION

APPENDIX C POWERTRAIN SYSTEM DIAGNOSTIC TROUBLE CODES

C.1 Discussion—Following are the Recommended Industry Common Trouble Codes for the Powertrain Control System. These include systems that might be integrated into an electronic control module that would be used for controlling Engine functions, such as Fuel, Spark, Idle Speed, and Vehicle Speed (Cruise Control) as well as those for Transmission control. The fact that a code is recommended as a Common Industry Code does not imply that it is a Required Code (Legislated), an Emission Related Code, or that it indicates a fault that will cause the Malfunction Indicator Light to be illuminated.

C.1.1 P01XX Fuel and Air Metering

P0100	Mass or Volume Air Flow Circuit Malfunction
P0101	Mass or Volume Air Flow Circuit Range/Performance Problem
P0102	Mass or Volume Air Flow Circuit Low Input
P0103	Mass or Volume Air Flow Circuit High Input
P0104	Mass or Volume Air Flow Circuit Intermittent
P0105	Manifold Absolute Pressure/Barometric Pressure Circuit Malfunction
P0106	Manifold Absolute Pressure/Barometric Pressure Circuit Range/Performance Problem
P0107	Manifold Absolute Pressure/Barometric Pressure Circuit Low Input
P0108	Manifold Absolute Pressure/Barometric Pressure Circuit High Input
P0109	Manifold Absolute Pressure/Barometric Pressure Circuit Intermittent
P0110	Intake Air Temperature Circuit Malfunction
P0111	Intake Air Temperature Circuit Range/Performance Problem
P0112	Intake Air Temperature Circuit Low Input
P0113	Intake Air Temperature Circuit High Input
P0114	Intake Air Temperature Circuit Intermittent
P0115	Engine Coolant Temperature Circuit Malfunction

P0116	Engine Coolant Temperature Circuit Range/Performance Problem
P0117	Engine Coolant Temperature Circuit Low Input
P0118	Engine Coolant Temperature Circuit High Input
P0119	Engine Coolant Temperature Circuit Intermittent
P0120	Throttle/Pedal Position Sensor/Switch A Circuit Malfunction
P0121	Throttle/Pedal Position Sensor/Switch A Circuit Range/Performance Problem
P0122	Throttle/Pedal Position Sensor/Switch A Circuit Low Input
P0123	Throttle/Pedal Position Sensor/Switch A Circuit High Input
P0124	Throttle/Pedal Position Sensor/Switch A Circuit Intermittent
P0125	Insufficient Coolant Temperature for Closed Loop Fuel Control
P0126	Insufficient Coolant Temperature for Stable Operation
P0130	O ₂ Sensor Circuit Malfunction (Bank 1 ¹ Sensor 1)
P0131	O ₂ Sensor Circuit Low Voltage (Bank 1 ¹ Sensor 1)
P0132	O ₂ Sensor Circuit High Voltage (Bank 1 ¹ Sensor 1)
P0133	O ₂ Sensor Circuit Slow Response (Bank 1 ¹ Sensor 1)
P0134	O ₂ Sensor Circuit No Activity Detected (Bank 1 ¹ Sensor 1)
P0135	O ₂ Sensor Heater Circuit Malfunction (Bank 1 ¹ Sensor 1)
P0136	O ₂ Sensor Circuit Malfunction (Bank 1 ¹ Sensor 2)
P0137	O ₂ Sensor Circuit Low Voltage (Bank 1 ¹ Sensor 2)
P0138	O ₂ Sensor Circuit High Voltage (Bank 1 ¹ Sensor 2)
P0139	O ₂ Sensor Circuit Slow Response (Bank 1 ¹ Sensor 2)
P0140	O ₂ Sensor Circuit No Activity Detected (Bank 1 ¹ Sensor 2)
P0141	O ₂ Sensor Heater Circuit Malfunction (Bank 1 ¹ Sensor 2)
P0142	O ₂ Sensor Circuit Malfunction (Bank 1 ¹ Sensor 3)
P0143	O ₂ Sensor Circuit Low Voltage (Bank 1 ¹ Sensor 3)
P0144	O ₂ Sensor Circuit High Voltage (Bank 1 ¹ Sensor 3)
P0145	O ₂ Sensor Circuit Slow Response (Bank 1 ¹ Sensor 3)
P0146	O ₂ Sensor Circuit No Activity Detected (Bank 1 ¹ Sensor 3)
P0147	O ₂ Sensor Heater Circuit Malfunction (Bank 1 ¹ Sensor 3)
P0150	O ₂ Sensor Circuit Malfunction (Bank 2 Sensor 1)
P0151	O ₂ Sensor Circuit Low Voltage (Bank 2 Sensor 1)
P0152	O ₂ Sensor Circuit High Voltage (Bank 2 Sensor 1)
P0153	O ₂ Sensor Circuit Slow Response (Bank 2 Sensor 1)
P0154	O ₂ Sensor Circuit No Activity Detected (Bank 2 Sensor 1)
P0155	O ₂ Sensor Heater Circuit Malfunction (Bank 2 Sensor 1)
P0156	O ₂ Sensor Circuit Malfunction (Bank 2 Sensor 2)
P0157	O ₂ Sensor Circuit Low Voltage (Bank 2 Sensor 2)
P0158	O ₂ Sensor Circuit High Voltage (Bank 2 Sensor 2)
P0159	O ₂ Sensor Circuit Slow Response (Bank 2 Sensor 2)
P0160	O ₂ Sensor Circuit No Activity Detected (Bank 2 Sensor 2)
P0161	O ₂ Sensor Heater Circuit Malfunction (Bank 2 Sensor 2)
P0162	O ₂ Sensor Circuit Malfunction (Bank 2 Sensor 3)
P0163	O ₂ Sensor Circuit Low Voltage (Bank 2 Sensor 3)
P0164	O ₂ Sensor Circuit High Voltage (Bank 2 Sensor 3)
P0165	O ₂ Sensor Circuit Slow Response (Bank 2 Sensor 3)
P0166	O ₂ Sensor Circuit No Activity Detected (Bank 2 Sensor 3)
P0167	O ₂ Sensor Heater Circuit Malfunction (Bank 2 Sensor 3)
P0170	Fuel Trim Malfunction (Bank 1 ¹)
P0171	System too Lean (Bank 1 ¹)
P0172	System too Rich (Bank 1 ¹)
P0173	Fuel Trim Malfunction (Bank 2)
P0174	System too Lean (Bank 2)
P0175	System too Rich (Bank 2)
P0176	Fuel Composition Sensor Circuit Malfunction
P0177	Fuel Composition Sensor Circuit Range/Performance
P0178	Fuel Composition Sensor Circuit Low Input
P0179	Fuel Composition Sensor Circuit High Input
P0180	Fuel Temperature Sensor A Circuit Malfunction
P0181	Fuel Temperature Sensor A Circuit Range/Performance
P0182	Fuel Temperature Sensor A Circuit Low Input
P0183	Fuel Temperature Sensor A Circuit High Input
P0184	Fuel Temperature Sensor A Circuit Intermittent
P0185	Fuel Temperature Sensor B Circuit Malfunction
P0186	Fuel Temperature Sensor B Circuit Range/Performance
P0187	Fuel Temperature Sensor B Circuit Low Input
P0188	Fuel Temperature Sensor B Circuit High Input
P0189	Fuel Temperature Sensor B Circuit Intermittent

¹ For systems with single O₂ sensors, use codes for Bank 1 sensor. Bank 1 is closest to the engine. Sensor 1 is closest to the engine.