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APPLICANTS

INVENTORS

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DAVID H. KAVEH (3RD PTY REQ.), ANAHEIM, CA;
KPPB LLP, ANAHEIM, CA

**** CONTINUING DATA ***************************

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which is a CON of 10/383,496 03/07/2003 PAT 7149623
which is a CON of 09/859,972 05/17/2001 PAT 6606561
which claims benefit of 60/264,811 01/29/2001
and claims benefit of 60/258,005 12/22/2000
and claims benefit of 60/251,552 12/06/2000
and claims benefit of 60/252,125 11/20/2000
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and claims benefit of 60/205,178 05/17/2000

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				22	3

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TITLE

Vehicle Tracking Unit with Downloadable Codes and Associated Methods

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(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	11/773,272
Filing Date	July 3, 2007
First Named Inventor	Kenneth E. Flick
Art Unit	3661
Examiner Name	Cuong H. Nguyen
Attorney Docket Number	C13-03896.RE2

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US- 5,732,074	03-24-1998	Spaur et al.	
		US- 5,794,164	08-11-1998	Beckert et al.	
		US- 6,009,363	12-28-1999	Beckert et al.	
		US- 6,028,537	02-22-2000	Suman et al.	
		US- 6,330,499	12-11-2001	Chou et al	
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Sheet 2 of 2

Complete if Known	
Application Number	11/773,272
Filing Date	July 3, 2007
First Named Inventor	Kenneth E. Flick
Art Unit	3661
Examiner Name	Cuong H. Nguyen
Attorney Docket Number	C13-03896.RE2

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
		SAE On-Board Diagnostics for Light and Medium Duty Vehicles Standards Manual, SAE HS-3000, Society of Automotive Engineers, Inc., 1994 Edition.	
		SAE On-Board Diagnostics for Light and Medium Duty Vehicles Standards Manual, SAE HS-3000, Society of Automotive Engineers, Inc., 1997 Edition.	

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EFS ID:	27358279
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Customer Number:	71897
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14	Reexam - Affidavit/Decl/Exhibit Filed by 3rd Party	03896re2ExhibitB.pdf	645478 b3fd3d23a6560cc9ac531799f3799288733a2a90	no	41
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Exhibit G

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

SAE HS-3000

SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL

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

1994 Edition

SAE HS-3000

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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, other standardization committees have developed documents that are significant to meet On-Board Diagnostic regulations. The SAE Vehicle Networks for Multiplexing and Data Communication Committee (Multiplex Committee) has developed SAE Standard J1850, "Class B Data Communication Network Interface." The International Standards Organization Serial Data Communication Work Group (ISO/TC 22/SC

3/WG 1) has developed ISO 9141-2, "CARB Requirements for interchange of digital information." Either of these standards can be used by vehicle manufacturers to meet the on-board to off-board communication requirements of the regulations. The Multiplex Committee also has published J2178 "Class B Data Communication Network Messages," which is a four-part document that addresses primarily non-diagnostic messages, but includes the general structure of diagnostic messages.

Some recommended practices have been developed in cooperation with the regulatory agencies, and some attempt to achieve commonality beyond that which is mandated by regulations. The following table indicates the documents included in this Handbook Supplement, the 1994 SAE On-Board Diagnostics for Light and Medium Duty Vehicles Standards Manual (HS-3000), and their relationship to anticipated regulations at this time. Some regulations are not yet finalized, so the reader should verify the contents of this table as the regulations become finalized. (R)

	Mandated	Voluntary
On Board	J1850 Communication Protocol J1962 Diagnostic Connector J1979 Diagnostic Test Modes J2012 Diagnostic Trouble Codes J2186 Data Link Security (EPA)	J2178 Class B Messages J2186 Tamper Resistance (CARB) J2190 Enhanced Test Modes
Off Board	J1930 Terms and Definitions J1978 OBD II Scan Tool J2008 Service Info (EPA)** J2205 Expanded Scan Tool Protocol	J2201 Scan Tool Interface* J2008 Service Info (CARB)**

*Referenced in J1978, but not specifically referenced in regulations

**J2008 is not yet final, but is intended to meet proposed EPA regulations for service information availability.

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.

(R) ELECTRICAL/ELECTRONIC SYSTEMS DIAGNOSTIC TERMS, DEFINITIONS, ABBREVIATIONS, AND ACRONYMS—SAE J1930 JUN93

SAE Recommended Practice

Report of the Vehicle Electric and Electronic Systems Diagnostic Committee approved June 1988. Completely revised by the SAE Vehicle E/E Systems Diagnostic Standards Committee September 1991 and June 1993.

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 Systems Diagnostic 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 imprecise 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 "J" number designation.

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APPENDIX A Request for Revision to SAE J1930 Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms

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, bulletins and updates, training manuals, repair data bases, 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 Figure 1, Cross Reference and Look Up. See Figure 2, Recommended Terms, and Table 1, Glossary of Terms, for definitions of the recommended terms. Use Section 3.0, Methodology to construct a new name. Appropriate acceptable usages of Recommended Terms and Acronyms are contained in Figure 1.

4. *Methodology*—This naming methodology of describing 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 1). 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 most 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 3 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

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technician. The information a technician needs is most often supplied by a term which describes a functional attribute, not purpose.

To ensure accuracy, always check the Glossary definitions of base words and modifiers before including them in a name. The Glossary is intended for diagnostic purposes, but provides only electrical/electronic terms for base words. Base words which describe nonelectrical objects (e.g., bolt, screw, bumper) should be used as in the past. Often, names for these objects are created by attaching the appropriate electrical/electronic object name to the mechanical base word. When using a common multiple word modifier, see Figures 1 and 2 to be sure that the modifier is acceptable or if it should be replaced with a more precise term.

4.1.1 BASE WORDS—The base word is the most generic term in a name. Simply stated, it answers the question, "What is this object?" In answering this question, the base word does not include information about the location or function of an object within a particular system. Specific information like this is provided by modifiers that are added to the base word. The following are examples of base words: diode, engine, module, motor, pump, relay, sensor, solenoid, switch, valve. The base word is always a noun and the last term in a name.

4.1.2 MODIFIERS—Modifiers provide functional/applicational meaning, system differentiation, and locational/directional information. Modifiers usually express nonelectrical ideas to describe base words which, in turn, convey electrical/electronic meaning. The range of modifiers is not limited and is used as necessary to uniquely describe an object in light of present knowledge, past experience, and potential future conflicts.

Although modifiers are used as adjectives, they are not necessarily terms which would normally be classified as adjectives. While neither "Air" or "Flow" are adjectives, the meaning of "Air Flow Valve" is clear to technicians; it is the name of a valve which regulates the flow of air. Both modifiers are nouns functioning as adjectives because of their position.

System modifiers can be added to object names to describe an object's purpose. When using a system name as a modifier in an object name, the word "System" is not included. For example, the device that directs the exhaust gases in the Exhaust Gas Recirculation (EGR) System is named "Exhaust Gas Recirculation (EGR) Valve."

4.1.3 TECHNOLOGICAL TERMS—Technologically specific terms tend to lengthen names without adding a corresponding level of useful service information about the function of an object. Add an appropriate technological modifier to a name only when it describes the primary difference between two objects. For example, the "thick film" technology used to construct the internal circuit of an Air Flow Sensor should not be identified in the object's name. However, if necessary for clarity, it would be appropriate to differentiate the relation to a specific external provision by adding "Hot Wire" to "Air Flow Sensor."

A technological term should be the first modifier conversationally (farthest from the base word, the position of least significance), unless a directional modifier is also present.

4.2 Naming Systems—When constructing a name for a system, consider it to be a combination of a "concept" and the word "System." Develop the concept name according to the rules for object naming and add the word "System." Keep in mind that a concept's most basic attribute is its purpose and that this attribute is described by the term closest to the word "System." For example, "recirculation" is the basic attribute of the Exhaust Gas Recirculation (EGR) concept. The group of components that embody the concept are together named the "EGR System."

4.3 Shortened Names—Techniques of shortening, including acronyms and abbreviations, are often necessary when space is limited and when names become awkwardly long. It is preferable to create a name first and its shortened form later, rather than the other way around.

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.

4.3.1 ACRONYMS—Specific definitions of acronyms vary, but for the purpose of this document, an acronym is a memorable combination of the first letters of the words of a name. While abbreviations are useful in text where space is limited, acronyms are particularly convenient for shortening verbal communication in addition to written materials. For this reason, acronyms are often pronounceable, which also makes them easy to remember. They are especially useful if a name is long and bulky both on paper and in conversation.

Use acronyms as modifiers or base words within names, such as "EGR System" and "Primary ECM." Do not use them as entire names, like "EGRS." Acronyms and other modifiers may be combined in any meaningful order to modify a base word. The following are examples of acceptable uses of acronyms:

EGR System EGRT Sensor Low Speed FC Switch High Speed FC Switch

Because there are a limited number of useful letter combinations for acronyms, new acronyms should be created for only the most commonly used terms. Also, avoid creating new acronyms by adding letters to those that already exist. For example, when using the acronym "FC" (Fan Control), do not add "H" or "L" to indicate "High Speed" or "Low Speed." Instead, use additional modifiers.

Usually, the first letters of each word of a name are used to build an acronym, but if a particular word is of little significance, it may be omitted ("United States of America" becomes "USA"). Also, more than the first letter of each word may be used ("Radio Detecting And Ranging" becomes "RADAR"). An acronym like "USA" which contains three letters or fewer may have its letters spoken separately, but a longer acronym such as "RADAR" must be pronounceable or its purpose will be defeated.

All of the letters of an acronym should be capitalized. Acronyms should not contain periods. Until an acronym is widely well-known, it should be accompanied by the spelled-out form when necessary for accurate reader comprehension in any given context.

In the very rare cases of strong historical meaning across all manufacturers, the rules for naming and acronym usage may be broken. For example, "AIR" is the approved acronym for "Secondary Air Injection," instead of "SAI." In fact, because there is no approved name "Primary Air Injection," the term "Secondary Air Injection" would be considered inappropriate. Despite this, historical precedent renders "AIR" and "Secondary Air Injection" the most easily understood terms. "AIR" originally meant "Air Injection Reactor." However, vehicles no longer necessarily use a separate air injector reactor, but instead might have additional air injected to the catalytic converter. Because of the similarity to the previous system, technicians have expressed a strong desire to retain "AIR" rather than "SAI."

Before using a new acronym, be sure to check Figures 1 and 2 for any conflicts with acronyms already in use.

4.3.2 ABBREVIATIONS—Use abbreviations to shorten base words and directional modifiers in written materials. Unlike an acronym, an abbreviation should have only its first letter capitalized and should end with a period. Wire colors are an exception to the rules of capitalization and punctuation. As in the past, they should continue to be completely capitalized in text and not followed by a period (for example, "a BLK wire"). Currently identified abbreviations for base words and modifiers are found in Figure 1.

4.4 Indexing of Names—Service information index designers consider the importance of each term in a name, and select the most appropriate word(s) to index. They most frequently index base words; following each by its modifier(s) to enhance users' retrieval. This document allows the designer flexibility to choose the indexed word(s), while it describes, in detail, the methodology for the conversational word order in text and illustrations. For example, the designer can conform to the methodology of this document and provide the user with the effective retrieval of the conversational name "Left Front Wheel Speed Sensor" by indexing it as "Sensor, Left Front Wheel Speed."

5. Cross Reference and Look Up—See Figure 1. The left column lists existing terms, acronyms and abbreviations. The center column provides the corresponding acceptable usages constructed of recommended terms combined with other modifiers and/or base words. The acceptable acronized 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 Figure 2 and Table 1.

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

7. Glossary of Terms—Table 1 is an alphabetical listing of base words and single word modifiers, together with their definitions.

8. Revision Procedures—It will be appropriate to revise the published J1930 on an ongoing basis. Requested revisions and updates will be controlled by the SAE Vehicle E/E Systems Diagnostic Standards Committee using the normal Recommended Practice Ballot process. This will ensure proper distribution of the changes.

As required by SAE standards, the J1930 document will be formally updated and balloted at least once every five years. When warranted by the number of requested modifications, J1930 will be updated as often as every three months.

Use Appendix A for submission of new information.

Existing Usage	Acceptable Usage	Acceptable Accented Usage
3GR (Third Gear)	Third Gear	3GR
4GR (Fourth Gear)	Fourth Gear	4GR
A/C (Air Conditioning)	Air Conditioning	A/C
A/C Cycling Switch	Air Conditioning Cycling Switch	A/C Cycling Switch
A/T (Automatic Transaxle)	Automatic Transaxle	A/T
A/T (Automatic Transmission)	Automatic Transmission	A/T
AC (Air Conditioning)	Air Conditioning	A/C
ACC (Air Conditioning Clutch)	Air Conditioning Clutch	A/C Clutch
Accelerator	Accelerator Pedal	AP
ACCS (Air Conditioning Cycle Switch)	Air Conditioning Cycling Switch	A/C 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	A/C System
ACT (Air Charge Temperature)	Intake Air Temperature[1]	IAT[1]
Adaptive Fuel Strategy	Fuel Trim[1]	FT[1]
AFC (Air Flow Control)	Mass Air Flow[1]	MAF[1]
AFC (Air Flow Control)	Volume Air Flow[1]	VAF[1]
AFS (Air Flow Sensor)	Mass Air Flow Sensor[1]	MAF Sensor[1]
AFS (Air Flow Sensor)	Volume Air Flow Sensor[1]	VAF Sensor[1]
After Cooler	Charge Air Cooler[1]	CAC[1]
AI (Air Injection)	Secondary Air Injection[1]	AIR[1]
AIP (Air Injection Pump)	Secondary Air Injection Pump[1]	AIR Pump[1]
AIR (Air Injection Reactor)	Pulsed Secondary Air Injection[1]	PAIR[1]
AIR (Air Injection Reactor)	Secondary Air Injection[1]	AIR[1]
AIRB (Secondary Air Injection Bypass)	Secondary Air Injection Bypass[1]	AIR Bypass[1]
AIRD (Secondary Air Injection Diverter)	Secondary Air Injection Diverter[1]	AIR 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	A/C
Air Conditioning Sensor	Air Conditioning Sensor	A/C Sensor
Air Control Valve	Secondary Air Injection Control Valve[1]	AIR 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]	AIR Bypass[1]
Air Management 2	Secondary Air Injection Diverter[1]	AIR 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]	PAIR[1]
ALCL (Assembly Line Communication Link)	Data Link Connector[1]	DLC[1]
Alcohol Concentration Sensor	Flexible Fuel Sensor[1]	FF Sensor[1]
ALDL (Assembly Line Diagnostic Link)	Data Link Connector[1]	DLC[1]
ALT (Alternator)	Generator	GEN
Alternator	Generator	GEN
AM1 (Air Management 1)	Secondary Air Injection Bypass[1]	AIR Bypass[1]
AM2 (Air Management 2)	Secondary Air Injection Diverter[1]	AIR Diverter[1]
APS (Absolute Pressure Sensor)	Barometric Pressure Sensor[1]	BARO Sensor[1]
ATS (Air Temperature Sensor)	Intake Air Temperature Sensor[1]	IAT Sensor[1]
Automatic Transaxle	Automatic Transaxle[1]	A/T[1]
Automatic Transmission	Automatic Transmission[1]	A/T[1]
B+ (Battery Positive Voltage)	Battery Positive Voltage	B+
Backpressure Transducer	Exhaust Gas Recirculation Backpressure Transducer[1]	EGR Backpressure Transducer[1]
BARO (Barometric Pressure)	Barometric Pressure[1]	BARO[1]
Barometric Pressure Sensor	Barometric Pressure Sensor[1]	BARO Sensor[1]
Battery Positive Voltage	Battery Positive Voltage	B+
Block Learn Matrix	Long Term Fuel Trim[1]	Long Term FT[1]
BLM (Block Learn Memory)	Long Term Fuel Trim[1]	Long Term FT[1]
BLM (Block Learn Multiplier)	Long Term Fuel Trim[1]	Long Term FT[1]
BLM (Block Learn Matrix)	Long Term Fuel Trim[1]	Long Term FT[1]

Recommended Terms and Recommended Acronyms See Figure 2
[1] Emission-Related Term

FIGURE 1—CROSS REFERENCE AND LOOK UP

Existing Usage	Acceptable Usage	Acceptable Acronym/ Usage
Block Learn Memory	Long Term Fuel Trim[1]	Long Term FT[1]
Block Learn Multiplier	Long Term Fuel Trim[1]	Long Term FT[1]
BP (Barometric Pressure) Sensor	Barometric Pressure Sensor[1]	BARO Sensor[1]
CIS (Computer Controlled Coil Ignition)	Electronic Ignition[1]	EI[1]
CAC (Charge Air Cooler)	Charge Air Cooler[1]	CAC[1]
Camshaft Position	Camshaft Position[1]	CMP[1]
Camshaft Position Sensor	Camshaft Position Sensor[1]	CMP Sensor[1]
Camshaft Sensor	Camshaft Position Sensor[1]	CMP Sensor[1]
Canister	Canister[1]	Canister[1]
Canister	Evaporative Emission Canister[1]	EVAP Canister[1]
Canister Purge Valve	Evaporative Emission Canister Purge Valve[1]	EVAP Canister Purge Valve[1]
Canister Purge Vacuum Switching Valve	Evaporative Emission Canister Purge Valve[1]	EVAP Canister Purge Valve[1]
Canister Purge VSV (Vacuum Switching Valve)	Evaporative Emission Canister Purge Valve[1]	EVAP Canister Purge Valve[1]
CANP (Canister Purge)[1]	Evaporative Emission Canister Purge[1]	EVAP Canister Purge[1]
CARB (Carburetor)	Carburetor[1]	CARB[1]
Carburetor	Carburetor[1]	CARB[1]
CCC (Converter Clutch Control)	Torque Converter Clutch[1]	TCC[1]
CCO (Converter Clutch Override)	Torque Converter Clutch[1]	TCC[1]
CDI (Capacitive Discharge Ignition)	Distributor Ignition[1]	DI[1]
CDROM (Compact Disc Read Only Memory)	Compact Disc Read Only Memory[1]	CDROM[1]
CES (Clutch Engage Switch)	Clutch Pedal Position Switch	CPP Switch
Central Multiport Fuel Injection	Central Multiport Fuel Injection[1]	Central MFI[1]
CFI (Continuous Fuel Injection)	Continuous Fuel Injection[1]	CFI[1]
CFI (Central Fuel Injection)	Throttle Body Fuel Injection[1]	TBI[1]
Charcoal Canister	Evaporative Emission Canister	EVAP Canister[1]
Charge Air Cooler	Charge Air Cooler[1]	CAC[1]
Check Engine	Service Reminder Indicator[1]	SRI[1]
Check Engine	Malfunction Indicator Lamp[1]	MIL[1]
CID (Cylinder Identification) Sensor	Camshaft Position Sensor	CMP Sensor[1]
CIS (Continuous Injection System)	Continuous Fuel Injection[1]	CFI[1]
CIS-E (Continuous Injection System-Electronic)	Continuous Fuel Injection[1]	CFI[1]
CKP (Crankshaft Position)	Crankshaft Position[1]	CKP[1]
CKP (Crankshaft Position) Sensor	Crankshaft Position Sensor[1]	CKP Sensor[1]
CL (Closed Loop)	Closed Loop[1]	CL[1]
Closed Bowl Distributor	Distributor Ignition[1]	DI[1]
Closed Throttle Position	Closed Throttle Position[1]	CTP[1]
Closed Throttle Switch	Closed Throttle Position Switch[1]	CTP Switch[1]
CLS (Closed Loop System)	Closed Loop[1]	CL[1]
Clutch Engage Switch	Clutch Pedal Position Switch[1]	CPP Switch[1]
Clutch Pedal Position Switch	Clutch Pedal Position Switch[1]	CPP Switch[1]
Clutch Start Switch	Clutch Pedal Position Switch[1]	CPP Switch[1]
Clutch Switch	Clutch Pedal Position Switch[1]	CPP Switch[1]
CMFI (Central Multiport Fuel Injection)	Central Multiport Fuel Injection[1]	Central MFI[1]
CMP (Camshaft Position)	Camshaft Position[1]	CMP[1]
CMP (Camshaft Position) Sensor	Camshaft Position Sensor[1]	CMP Sensor[1]
COC (Continuous Oxidation Catalyst)	Oxidation Catalytic Converter[1]	OC[1]
Condenser	Distributor Ignition Capacitor[1]	DI Capacitor[1]
Continuous Fuel Injection	Continuous Fuel Injection[1]	CFI[1]
Continuous Injection System	Continuous Fuel Injection System[1]	CFI System[1]
Continuous Injection System-E	Electronic Continuous Fuel Injection System[1]	Electronic CFI 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]	CPP[1]
CPP (Clutch Pedal Position) Switch	Clutch Pedal Position Switch	CPP Switch[1]
CPS (Camshaft Position Sensor)	Camshaft Position Sensor[1]	CMP 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]	RPM[1]
Crankshaft Speed Sensor	Engine Speed Sensor[1]	RPM Sensor[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]

Recommended Terms and Recommended Acronyms See Figure 2
[1] Emission Related Term

FIGURE 1—CROSS REFERENCE AND LOOK UP (CONTINUED)

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Existing Usage	Acceptable Usage	Acceptable Acronized Usage
CTS (Coolant Temperature Switch)	Engine Coolant Temperature Switch[1]	ECT Switch[1]
Cylinder ID (Identification) Sensor	Camshaft Position Sensor[1]	CMP Sensor[1]
D-Jetronic	Multiport Fuel Injection[1]	MFI[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]	MFI[1]
DI (Direct Injection)	Direct Fuel Injection[1]	DFI[1]
DI (Distributor Ignition)	Distributor Ignition[1]	DI[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]	DI[1]
Distributorless Ignition	Electronic Ignition[1]	EI[1]
DLC (Data Link Connector)	Data Link Connector[1]	DLC[1]
DLI (Distributorless Ignition)	Electronic Ignition[1]	EI[1]
DS (Detonation Sensor)	Knock Sensor[1]	KS[1]
DTC (Diagnostic Trouble Code)	Diagnostic Trouble Code[1]	DTC[1]
DTM (Diagnostic Test Mode)	Diagnostic Test Mode[1]	DTM[1]
Dual Bed	Three Way + Oxidation Catalytic Converter[1]	TWC+OC[1]
Duty Solenoid for Purge Valve	Evaporative Emission Canister Purge Valve[1]	EVAP Canister Purge 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 Automatic Transaxle	AT AT
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	ECL
ECM (Engine Control Module)	Engine Control Module[1]	ECM[1]
ECT (Engine Coolant Temperature)	Engine Coolant Temperature[1]	ECT[1]
ECT (Engine Coolant Temperature) Sender	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]
ECU4 (Electronic Control Unit 4)	Powertrain Control Module[1]	PCM
EDF (Electro-Drive Fan) Control	Fan Control	FC
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
EEC (Electronic Engine Control)	Engine Control[1]	EC[1]
EEC (Electronic Engine Control) Processor	Powertrain Control Module[1]	PCM[1]
EECS (Evaporative Emission Control System)	Evaporative Emission System[1]	EVAP 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]
EFI (Electronic Fuel Injection)	Multiport Fuel Injection[1]	MFI[1]
EFI (Electronic Fuel Injection)	Throttle Body Fuel Injection[1]	TBI[1]
EGO (Exhaust Gas Oxygen) Sensor	Oxygen Sensor[1]	O2S[1]
EGOS (Exhaust Gas Oxygen Sensor)	Oxygen Sensor[1]	O2S[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)	Exhaust Gas Recirculation Temperature[1]	EGRT
EGRT (Exhaust Gas Recirculation Temperature) Sensor	Exhaust Gas Recirculation Temperature Sensor[1]	EGRT Sensor[1]

Recommended Terms and Recommended Acronyms See Figure 2
[1] Emission-Related Term

FIGURE 1—CROSS REFERENCE AND LOOK UP (CONTINUED)

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Existing Usage	Acceptable Usage	Acceptable Acronym/Usage
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)	Oxygen Sensor[1]	O2S[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]	SRI[1]
Engine Control	Engine Control[1]	EC[1]
Engine Coolant Fan Control	Fan Control	FC
Engine Coolant Level	Engine Coolant Level	ECL
Engine Coolant Level Indicator	Engine Coolant Level Indicator	ECL Indicator
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 Speed	Engine Speed[1]	RPM[1]
EOS (Exhaust Oxygen Sensor)	Oxygen Sensor[1]	O2S[1]
EPROM (Erasable Programmable Read Only Memory)	Erasable Programmable Read Only Memory[1]	EPROM[1]
Erasable Programmable Read Only Memory	Erasable Programmable Read Only Memory[1]	EPROM[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 CANP	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]	EGR Vacuum Regulator Solenoid[1]
EVRV (Exhaust Gas Recirculation Vacuum Regulator Valve)	Exhaust Gas Recirculation Vacuum Regulator Valve[1]	EGR 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 Valve	Exhaust Gas Recirculation Valve[1]	EGR Valve[1]
Fan Control	Fan Control	FC
Fan Control Module	Fan Control Module	FC Module
Fan Control Relay	Fan Control Relay	FC Relay
Fan Motor Control Relay	Fan Control Relay	FC Relay
Fast Idle Thermo Valve	Idle Air Control Thermal Valve[1]	IAC Thermal Valve[1]
FBC (Feed Back Carburetor)	Carburetor[1]	CARB[1]
FBC (Feed Back Control)	Mixture Control[1]	MC[1]
FC (Fan Control)	Fan Control	FC
FC (Fan Control) Relay	Fan Control Relay	FC Relay
FEEPROM (Flash Electrically Erasable Programmable Read Only Memory)	Flash Electrically Erasable Programmable Read Only Memory[1]	EEPROM[1]
FEPROM (Flash Erasable Programmable Read Only Memory)	Flash Erasable Programmable Read Only Memory[1]	EEPROM[1]
FF (Flexible Fuel)	Flexible Fuel[1]	FF[1]
FI (Fuel Injection)	Central Multiport Fuel Injection[1]	Central MFI[1]
FI (Fuel Injection)	Continuous Fuel Injection[1]	CFI[1]
FI (Fuel Injection)	Direct Fuel Injection[1]	DFI[1]
FI (Fuel Injection)	Indirect Fuel Injection[1]	IFI[1]
FI (Fuel Injection)	Multiport Fuel Injection[1]	MFI[1]
FI (Fuel Injection)	Sequential Multiport Fuel Injection[1]	SFI[1]
FI (Fuel Injection)	Throttle Body Fuel Injection[1]	TBI[1]
Flash EEPROM (Electrically Erasable Programmable Read Only Memory)	Flash Electrically Erasable Programmable Read Only Memory[1]	EEPROM[1]

Recommended Terms and Recommended Acronyms See Figure 3
[1] Emission-Related Term

FIGURE 1—CROSS REFERENCE AND LOOK UP (CONTINUED)

Existing Usage	Acceptable Usage	Acceptable Acronized Usage
Flash EPROM (Erasable Programmable Read Only Memory)	Flash Erasable Programmable Read Only Memory[1]	FEPROM[1]
Flexible Fuel	Flexible Fuel[1]	FF[1]
Flexible Fuel Sensor	Flexible Fuel Sensor[1]	FF Sensor[1]
Fourth Gear	Fourth Gear	4GR
FP (Fuel Pump)	Fuel Pump	FP
FP (Fuel Pump) Module	Fuel Pump Module	FP Module
FT (Fuel Trim)	Fuel Trim[1]	FT[1]
Fuel Charging Station	Throttle Body[1]	TB[1]
Fuel Concentration Sensor	Flexible Fuel Sensor[1]	FF Sensor[1]
Fuel Injection	Central Multiport Fuel Injection[1]	Central MFI[1]
Fuel Injection	Continuous Fuel Injection[1]	CFI[1]
Fuel Injection	Direct Fuel Injection[1]	DFI[1]
Fuel Injection	Indirect Fuel Injection[1]	IFI[1]
Fuel Injection	Multiport Fuel Injection[1]	MFI[1]
Fuel Injection	Sequential Multiport Fuel Injection[1]	SFI[1]
Fuel Injection	Throttle Body Fuel Injection[1]	TBI[1]
Fuel Level Sensor	Fuel Level Sensor	Fuel Level Sensor
Fuel Module	Fuel Pump Module	FP Module
Fuel Pressure	Fuel Pressure[1]	Fuel Pressure[1]
Fuel Pressure Regulator	Fuel Pressure Regulator[1]	Fuel Pressure Regulator[1]
Fuel Pump	Fuel Pump	FP
Fuel Pump Relay	Fuel Pump Relay	FP Relay
Fuel Quality Sensor	Flexible Fuel Sensor[1]	FF Sensor[1]
Fuel Regulator	Fuel Pressure Regulator[1]	Fuel Pressure Regulator[1]
Fuel Sender	Fuel Pump Module	FP Module
Fuel Sensor	Fuel Level Sensor	Fuel Level Sensor
Fuel Tank Unit	Fuel Pump Module	FP Module
Fuel Trim	Fuel Trim[1]	FT[1]
Full Throttle	Wide Open Throttle[1]	WOT[1]
GCM (Governor Control Module)	Governor Control Module	GCM
GEM (Governor Electronic Module)	Governor Control Module	GCM
GEN (Generator)	Generator	GEN
Generator	Generator	GEN
Governor	Governor	Governor
Governor Control Module	Governor Control Module	GCM
Governor Electronic Module	Governor Control Module	GCM
GND (Ground)	Ground	GND
GRD (Ground)	Ground	GND
Ground	Ground	GND
Heated Oxygen Sensor	Heated Oxygen Sensor[1]	HO2S[1]
HEDF (High Electro-Drive Fan) Control	Fan Control	FC
HEGO (Heated Exhaust Gas Oxygen) Sensor	Heated Oxygen Sensor[1]	HO2S[1]
HEI (High Energy Ignition)	Distributor Ignition[1]	DI[1]
High Speed FC (Fan Control) Switch	High Speed Fan Control Switch	High Speed FC Switch
HO2S (Heated Oxygen Sensor)	Heated Oxygen Sensor[1]	HO2S[1]
HOS (Heated Oxygen Sensor)	Heated Oxygen Sensor[1]	HO2S[1]
Hot Wire Anemometer	Mass Air Flow Sensor[1]	MAF Sensor[1]
IA (Intake Air)	Intake Air	IA
IA (Intake Air) Duct	Intake Air Duct	IA Duct
IAC (Idle Air Control)	Idle Air Control[1]	IAC[1]
IAC (Idle Air Control) Thermal Valve	Idle Air Control Thermal Valve[1]	IAC Thermal Valve[1]
IAC (Idle Air Control) Valve	Idle Air Control Valve[1]	IAC Valve[1]
IACV (Idle Air Control Valve)	Idle Air Control Valve[1]	IAC Valve[1]
IAT (Intake Air Temperature)	Intake Air Temperature[1]	IAT[1]
IAT (Intake Air Temperature) Sensor	Intake Air Temperature Sensor[1]	IAT Sensor[1]
IATS (Intake Air Temperature Sensor)	Intake Air Temperature Sensor[1]	IAT Sensor[1]
IC (Ignition Control)	Ignition Control[1]	IC[1]
ICM (Ignition Control Module)	Ignition Control Module[1]	ICM[1]
IDFI (Indirect Fuel Injection)	Indirect Fuel Injection[1]	IFI[1]
EDI (Integrated Direct Ignition)	Electronic Ignition[1]	EI[1]
IDI (Indirect Diesel Injection)	Indirect Fuel Injection[1]	IFI[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]

Recommended Terms and Recommended Acronyms See Figure 2
[1] Emission-Related Term

FIGURE 1—CROSS REFERENCE AND LOOK UP (CONTINUED)

Existing Usage	Acceptable Usage	Acceptable Acronized Usage
Idle Speed Control Actuator	Idle Speed Control Actuator[1]	ISC Actuator[1]
IFI (Indirect Fuel Injection)	Indirect Fuel Injection[1]	IFI[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]
In Tank Module	Fuel Pump Module	FP Module
Indirect Fuel Injection	Indirect Fuel Injection[1]	IFI[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
INT (Integrator)	Short Term Fuel Trim[1]	Short Term FT[1]
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]
Integrated Relay Module	Relay Module	RM
Integrator	Short Term Fuel Trim[1]	Short Term FT[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[1]
ISC (Idle Speed Control) Solenoid Vacuum Valve	Idle Speed Control Solenoid Vacuum Valve[1]	ISC Solenoid Vacuum Valve[1]
K-Jetronic	Continuous Fuel Injection[1]	CFI[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]	CFI[1]
KE-Motronic	Continuous Fuel Injection[1]	CFI[1]
Knock Sensor	Knock Sensor[1]	KS[1]
KS (Knock Sensor)	Knock Sensor[1]	KS[1]
L-Jetronic	Multiport Fuel Injection[1]	MFI[1]
Lambda	Oxygen Sensor[1]	O2S[1]
LH-Jetronic	Multiport Fuel Injection[1]	MFI[1]
Light Off Catalyst	Warm Up Three Way Catalytic Converter[1]	WU-TWC[1]
Light Off Catalyst	Warm Up Oxidation Catalytic Converter[1]	WU-OC[1]
Lock Up Relay	Torque Converter Clutch Relay[1]	TCC Relay[1]
Long Term FT (Fuel Trim)	Long Term Fuel Trim[1]	Long Term FT[1]
Low Speed FC (Fan Control) Switch	Low Speed Fan Control Switch	Low Speed EC Switch
LUS (Lock Up Solenoid) Valve	Torque Converter Clutch Solenoid Valve[1]	TCC Solenoid Valve[1]
M/C (Mixture Control)	Mixture Control[1]	MC[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	MAP Sensor[1]
Manifold Differential Pressure	Manifold Differential Pressure[1]	MDP[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]	MC[1]
MCS (Mixture Control Solenoid)	Mixture Control Solenoid[1]	MC Solenoid[1]
MCU (Microprocessor Control Unit)	Powertrain Control Module[1]	PCM[1]
MDP (Manifold Differential Pressure)	Manifold Differential Pressure[1]	MDP[1]
MFI (Multiport Fuel Injection)	Multiport Fuel Injection[1]	MFI[1]
MIL (Malfunction Indicator Lamp)	Malfunction Indicator Lamp[1]	MIL[1]
Mixture Control	Mixture Control[1]	MC[1]
Modes	Diagnostic Test Mode[1]	DTM[1]
Monotronic	Throttle Body Fuel Injection[1]	TBI[1]

Recommended Terms and Recommended Acronyms See Figure 8
[1] Emission-Related Term

FIGURE 1—CROSS REFERENCE AND LOOK UP (CONTINUED)

Existing Usage	Acceptable Usage	Acceptable Acronized Usage
Manifold	Multiport Fuel Injection[1]	MFI[1]
MFI (Multiport Injection)	Multiport Fuel Injection[1]	MFI[1]
MFI (Multiport Injection)	Multiport Fuel Injection[1]	MFI[1]
MRPS (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]
NDS (Neutral Drive Switch)	Park/Neutral Position Switch[1]	PNP Switch[1]
Neutral Safety Switch	Park/Neutral Position Switch[1]	PNP Switch[1]
NGS (Neutral Gear Switch)	Park/Neutral Position Switch[1]	PNP Switch[1]
Nonvolatile Random Access Memory	Nonvolatile Random Access Memory[1]	NVRAM[1]
NPS (Neutral Position Switch)	Park/Neutral Position Switch[1]	PNP Switch[1]
NVM (Nonvolatile Memory)	Nonvolatile Random Access Memory[1]	NVRAM[1]
NVRAM (Nonvolatile Random Access Memory)	Nonvolatile Random Access Memory[1]	NVRAM[1]
O2 (Oxygen) Sensor	Oxygen Sensor[1]	O2S[1]
O2S (Oxygen Sensor)	Oxygen Sensor[1]	O2S[1]
OBD (On Board Diagnostic)	On Board Diagnostic[1]	OBD[1]
OC (Oxidation Catalyst)	Oxidation Catalytic Converter[1]	OC[1]
Oil Pressure Sender	Oil Pressure Sensor	Oil Pressure Sensor
Oil Pressure Sensor	Oil Pressure Sensor	Oil Pressure Sensor
Oil Pressure Switch	Oil Pressure Switch	Oil Pressure 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]
OS (Oxygen Sensor)	Oxygen Sensor[1]	O2S[1]
Oxidation Catalytic Converter	Oxidation Catalytic Converter[1]	OC[1]
OXS (Oxygen Sensor) Indicator	Service Reminder Indicator[1]	SRI[1]
Oxygen Sensor	Oxygen Sensor[1]	O2S[1]
PIN (Park/Neutral)	Park/Neutral Position[1]	PNP[1]
PS (Power Steering) Pressure Switch	Power Steering Pressure Switch	PSP Switch
P- (Pressure) Sensor	Manifold Absolute Pressure Sensor[1]	MAP Sensor[1]
PAIR (Pulsed Secondary Air Injection)	Pulsed Secondary Air Injection[1]	PAIR[1]
Park/Neutral Position	Park/Neutral Position[1]	PNP[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]
Percent Alcohol Sensor	Flexible Fuel Sensor[1]	FF Sensor[1]
Periodic Trap Oxidizer	Periodic Trap Oxidizer[1]	PTOX[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-FI (Programmed Fuel Injection)	Multiport Fuel Injection[1]	MFI[1]
PIP (Position Indicator Pulse)	Crankshaft Position[1]	CKP[1]
PNP (Park/Neutral Position)	Park/Neutral Position[1]	PNP[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	PSP
Power Steering Pressure Switch	Power Steering Pressure Switch	PSP Switch
Powertrain Control Module	Powertrain Control Module[1]	PCM[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 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]	PROM[1]
PROM (Programmable Read Only Memory)	Programmable Read Only Memory[1]	PROM[1]
PSP (Power Steering Pressure)	Power Steering Pressure	PSP
PSP (Power Steering Pressure) Switch	Power Steering Pressure Switch	PSP Switch
PSPS (Power Steering Pressure Switch)	Power Steering Pressure Switch	PSP Switch
PTOX (Periodic Trap Oxidizer)	Periodic Trap Oxidizer[1]	PTOX[1]
Pulsair	Pulsed Secondary Air Injection[1]	PAIR[1]
Pulsed Secondary Air Injection	Pulsed Secondary Air Injection[1]	PAIR[1]
Radiator Fan Control	Fan Control	FC
Radiator Fan Relay	Fan Control Relay	FC Relay
RAM (Random Access Memory)	Random Access Memory[1]	RAM[1]

Recommended Terms and Recommended Acronyms See Figure 2
[1] Emission-Related Term

FIGURE 1—CROSS REFERENCE AND LOOK UP (CONTINUED)

Existing Usage	Acceptable Usage	Acceptable Abbreviated Usage
Random Access Memory	Random Access Memory[1]	RAM[1]
Read Only Memory	Read Only Memory[1]	ROM[1]
Recirculated Exhaust Gas Temperature Sensor	Exhaust Gas Recirculation Temperature Sensor[1]	EGRT Sensor[1]
Reed Valve	Pulsed Secondary Air Injection Valve[1]	PAIR Valve[1]
RECTS (Recirculated Exhaust Gas Temperature Sensor)	Exhaust Gas Recirculation Temperature Sensor[1]	EGRT Sensor[1]
Relay Module	Relay Module	RM
Remote Mount TFI (Thick Film Ignition)	Distributor Ignition[1]	DI[1]
Revolutions per Minute	Engine Speed[1]	RPM[1]
RM (Relay Module)	Relay Module	RM
ROM (Read Only Memory)	Read Only Memory[1]	ROM[1]
RPM (Revolutions per Minute)	Engine Speed[1]	RPM[1]
SABV (Secondary Air Bypass Valve)	Secondary Air Injection Bypass Valve[1]	AIR Bypass Valve[1]
SACV (Secondary Air Check Valve)	Secondary Air Injection Control Valve[1]	AIR Control Valve[1]
SASV (Secondary Air Switching Valve)	Secondary Air Injection Switching Valve[1]	AIR Switching Valve[1]
SBEC (Single Board Engine Control)	Powertrain Control Module[1]	PCM[1]
SBS (Supercharger Bypass Solenoid)	Supercharger Bypass Solenoid[1]	BCB Solenoid[1]
SC (Supercharger)	Supercharger[1]	SC[1]
Scan Tool	Scan Tool[1]	ST[1]
SCB (Supercharger Bypass)	Supercharger Bypass[1]	SCB[1]
Secondary Air Bypass Valve	Secondary Air Injection Bypass Valve[1]	AIR Bypass Valve[1]
Secondary Air Check Valve	Secondary Air Injection Check Valve[1]	AIR Check Valve[1]
Secondary Air Injection	Secondary Air Injection[1]	AIR[1]
Secondary Air Injection Bypass	Secondary Air Injection Bypass[1]	AIR Bypass[1]
Secondary Air Injection Diverter	Secondary Air Injection Diverter[1]	AIR Diverter[1]
Secondary Air Switching Valve	Secondary Air Injection Switching Valve[1]	AIR Switching Valve[1]
SEFI (Sequential Electronic Fuel Injection)	Sequential Multiport Fuel Injection[1]	SFI[1]
Self Test	On Board Diagnostic[1]	OBD[1]
Self Test Codes	Diagnostic Trouble Code[1]	DTC[1]
Self Test Connector	Data Link Connector[1]	DLC[1]
Sequential Multiport Fuel Injection	Sequential Multiport Fuel Injection[1]	SFI[1]
Service Engine Soon	Service Reminder Indicator[1]	SRI[1]
Service Engine Soon	Malfunction Indicator Lamp[1]	MIL[1]
Service Reminder Indicator	Service Reminder Indicator[1]	SRI[1]
SFI (Sequential Fuel Injection)	Sequential Multiport Fuel Injection[1]	SFI[1]
Short Term FT (Fuel Trim)	Short Term Fuel Trim[1]	Short Term FT[1]
SLP (Selection Lever Position)	Transmission Range	TR
SMEC (Single Module Engine Control)	Powertrain Control Module[1]	PCM[1]
Smoke Puff Limiter	Smoke Puff Limiter[1]	SPL[1]
SPI (Single Point Injection)	Throttle Body Fuel Injection[1]	TBI[1]
SPL (Smoke Puff Limiter)	Smoke Puff Limiter[1]	SPL[1]
SRI (Service Reminder Indicator)	Service Reminder Indicator[1]	SRI[1]
SRT (System Readiness Test)	System Readiness Test[1]	SRT[1]
ST (Scan Tool)	Scan Tool[1]	ST[1]
Supercharger	Supercharger[1]	SC[1]
Supercharger Bypass	Supercharger Bypass[1]	SCB[1]
Sync Pickup	Camshaft Position[1]	CMP[1]
System Readiness Test	System Readiness Test[1]	SRT[1]
TAB (Thermactor Air Bypass)	Secondary Air Injection Bypass[1]	AIR Bypass[1]
TAD (Thermactor Air Diverter)	Secondary Air Injection Diverter[1]	AIR Diverter[1]
TB (Throttle Body)	Throttle Body[1]	TB[1]
TBI (Throttle Body Fuel Injection)	Throttle Body Fuel Injection[1]	TBI[1]
TBT (Throttle Body Temperature)	Intake Air Temperature[1]	IAT[1]
TC (Turbocharger)	Turbocharger[1]	TC[1]
TCC (Torque Converter Clutch)	Torque Converter Clutch[1]	TCC[1]
TCC (Torque Converter Clutch) Relay	Torque Converter Clutch Relay[1]	TCC Relay[1]
TCM (Transmission Control Module)	Transmission Control Module	TCM
TFI (Thick Film Ignition)	Distributor Ignition[1]	DI[1]
TFI (Thick Film Ignition) Module	Ignition Control Module[1]	ICM[1]
Thermac	Secondary Air Injection[1]	AIR[1]
Thermac Air Cleaner	Air Cleaner[1]	ACL[1]
Thermactor	Secondary Air Injection[1]	AIR[1]
Thermactor Air Bypass	Secondary Air Injection Bypass[1]	AIR Bypass[1]
Thermactor Air Diverter	Secondary Air Injection Diverter[1]	AIR Diverter[1]
Thermactor II	Pulsed Secondary Air Injection[1]	PAIR[1]
Thermal Vacuum Switch	Thermal Vacuum Valve[1]	TVV[1]
Thermal Vacuum Valve	Thermal Vacuum Valve[1]	TVV[1]

Recommended Terms and Recommended Acronyms See Figure 2
[1] Emission-Related Term

FIGURE 1—CROSS REFERENCE AND LOOK UP (CONTINUED)

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Existing Usage	Acceptable Usage	Acceptable Acronized Usage
Third Gear	Third Gear	3GR
Three Way + Oxidation Catalytic Converter	Three Way + Oxidation Catalytic Converter[1]	TWC+OC[1]
Three Way Catalytic Converter	Three Way Catalytic Converter[1]	TWC[1]
Throttle Body	Throttle Body[1]	TB[1]
Throttle Body Fuel Injection	Throttle Body Fuel Injection[1]	TBI[1]
Throttle Opener	Idle Speed Control[1]	ISC[1]
Throttle Opener Vacuum Switching Valve	Idle Speed Control Solenoid Vacuum Valve[1]	ISC Solenoid Vacuum Valve[1]
Throttle Opener VSV (Vacuum Switching Valve)	Idle Speed Control Solenoid Vacuum Valve[1]	ISC Solenoid Vacuum Valve[1]
Throttle Position	Throttle Position[1]	TP
Throttle Position Sensor	Throttle Position Sensor[1]	TP Sensor[1]
Throttle Position Switch	Throttle Position Switch[1]	TP Switch[1]
Throttle Potentiometer	Throttle Position Sensor[1]	TP Sensor[1]
TOC (Trap Oxidizer - Continuous)	Continuous Trap Oxidizer[1]	CTOX[1]
TOP (Trap Oxidizer - Periodic)	Periodic Trap Oxidizer[1]	PTOX[1]
Torque Converter Clutch	Torque Converter Clutch[1]	TCC[1]
Torque Converter Clutch Relay	Torque Converter Clutch Relay[1]	TCC Relay[1]
TP (Throttle Position)	Throttle Position[1]	TP[1]
TP (Throttle Position) Sensor	Throttle Position Sensor[1]	TP Sensor[1]
TP (Throttle Position) Switch	Throttle Position Switch[1]	TP Switch[1]
TPI (Tuned Port Injection)	Multiport Fuel Injection[1]	MFI[1]
TPS (Throttle Position Sensor)	Throttle Position Sensor[1]	TP Sensor[1]
TPS (Throttle Position Switch)	Throttle Position Switch[1]	TP Switch[1]
TR (Transmission Range)	Transmission Range	TR
Transmission Control Module	Transmission Control Module	TCM
Transmission Position Switch	Transmission Range Switch	TR Switch
Transmission Range Selection	Transmission Range	TR
TRS (Transmission Range Selection)	Transmission Range	TR
TRSS (Transmission Range Selection Switch)	Transmission Range Switch	TR Switch
Tuned Port Injection	Multiport Fuel Injection[1]	MFI[1]
Turbo (Turbocharger)	Turbocharger[1]	TC[1]
Turbocharger	Turbocharger[1]	TC[1]
TVS (Thermal Vacuum Switch)	Thermal Vacuum Valve[1]	TVV[1]
TVV (Thermal Vacuum Valve)	Thermal Vacuum Valve[1]	TVV[1]
TWC (Three Way Catalytic Converter)	Three Way Catalytic Converter[1]	TWC[1]
TWC + OC (Three Way + Oxidation Catalytic Converter)	Three Way + Oxidation Catalytic Converter[1]	TWC+OC[1]
VAC (Vacuum) Sensor	Manifold Differential Pressure Sensor[1]	MDP Sensor
Vacuum Switches	Manifold Vacuum Zone Switch[1]	MVZ Switch[1]
VAF (Volume Air Flow)	Volume Air Flow[1]	VAF[1]
Vane Air Flow	Volume Air Flow[1]	VAF[1]
Variable Fuel Sensor	Flexible Fuel Sensor	FF Sensor[1]
VAT (Vane Air Temperature)	Intake Air Temperature[1]	IAT[1]
VCC (Viscous Converter Clutch)	Torque Converter Clutch[1]	TCC[1]
Vehicle Speed Sensor	Vehicle Speed Sensor[1]	VSS[1]
VIP (Vehicle In Progress) Connector	Data Link Connector[1]	DLC[1]
Viscous Converter Clutch	Torque Converter Clutch[1]	TCC[1]
Voltage Regulator	Voltage Regulator	VR
Volume Air Flow	Volume Air Flow[1]	VAF[1]
VR (Voltage Regulator)	Voltage Regulator	VR
VSS (Vehicle Speed Sensor)	Vehicle Speed Sensor[1]	VSS[1]
VSV (Vacuum Solenoid Valve) (Canister)	Evaporative Emission Canister Purge Valve[1]	EVAP Canister Purge Valve[1]
VSV (Vacuum Solenoid Valve) (EVAP)	Evaporative Emission Canister Purge Valve[1]	EVAP Canister Purge Valve[1]
VSV (Vacuum Solenoid Valve) (Throttle)	Idle Speed Control Solenoid Vacuum Valve[1]	ISC Solenoid Vacuum Valve[1]
Warm Up Oxidation Catalytic Converter	Warm Up Oxidation Catalytic Converter[1]	WU-OC[1]
Warm Up Three Way Catalytic Converter	Warm Up Three Way Catalytic Converter[1]	WU-TWC[1]
Wide Open Throttle	Wide Open Throttle[1]	WOT[1]
WOT (Wide Open Throttle)	Wide Open Throttle[1]	WOT[1]
WOTS (Wide Open Throttle Switch)	Wide Open Throttle Switch[1]	WOT Switch[1]
WU-OC (Warm Up Oxidation Catalytic Converter)	Warm Up Oxidation Catalytic Converter[1]	WU-OC[1]
WU-TWC (Warm Up Three Way Catalytic Converter)	Warm Up Three Way Catalytic Converter[1]	WU-TWC[1]

Recommended Terms and Recommended Acronyms See Figure 8
[1] Emission-Related Term

FIGURE 1—CROSS REFERENCE AND LOOK UP (CONTINUED)

Recommended Terms	Acronym/ Abbrev.	Definitions
Accelerator Pedal	AP[2]	See Glossary Entry "ACCELERATOR PEDAL."
Air Cleaner[1]	ACL	See Glossary Entry "CLEANER."
Air Conditioning	A/C	See Glossary Entry "AIR CONDITIONING."
Automatic Transaxle	A/T	See Glossary Entry "TRANSAXLE."
Automatic Transmission	A/T	See Glossary Entry "TRANSMISSION."
Barometric Pressure[1]	BARO[2]	See Glossary Entry "PRESSURE."
Battery Positive Voltage	B+[2]	See Glossary Entry "BATTERY."
Camshaft Position[1]	CMP[2]	See Glossary Entry "CAMSHAFT."
Canister[1]	---	See Glossary Entry "CANISTER."
Carburetor[1]	CARB[2]	See Glossary Entry "CARBURETOR."
Charge Air Cooler[1]	CAC[2]	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[1]	See Glossary Entry "CLUTCH."
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 lowering diesel engine particulate emissions by collecting exhaust particulates and continuously burning them through oxidation.
Crankshaft Position[1]	CKP	See Glossary Entry "CRANKSHAFT."
Data Link Connector[1]	DLC[2]	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 base level to read diagnostic trouble codes, a monitor level which includes information on signal levels, bidirectional control with onboard aids, and the ability to interface with remote diagnostic.
Diagnostic Trouble Code[1]	DTC	An alphanumeric identifier for a fault condition identified by the On Board Diagnostic System.
Direct Fuel Injection[1]	DFI	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.
Early Fuel Evaporation[1]	EFE	Enhancing air/fuel vaporization during engine warm up.
EGR Temperature[1]	EGRT	Sensing EGR function based on temperature change. Primarily in systems with mechanical flow control devices.
Electrically Erasable Programmable Read Only Memory[1]	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 spark plugs without the use of a distributor.
Engine Control[1]	EC	See Glossary Entries "ENGINE" and "CONTROL."
Engine Control Module[1]	ECM[2]	See Glossary Entries "ENGINE," "CONTROL," "MODULE."
Engine Coolant Level	ECL	See Glossary Entries "ENGINE," "COOLANT," "LEVEL."
Engine Coolant Temperature[1]	ECT	See Glossary Entries "ENGINE," "COOLANT."
Engine Modification[1]	EM	A method of lowering engine emissions through changes in basic engine construction or in fuel and spark calibration.
Engine Speed[1]	RPM[2]	See Glossary Entries "ENGINE," "SPEED."
Erasable Programmable Read Only Memory[1]	EPROM	An electronic device named erasable programmable read only memory.
Evaporative Emission[1]	EVAP[2]	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.
Fan Control	FC	See Glossary Entries "FAN," "CONTROL."
Flash Electrically Erasable Programmable Read Only Memory[1]	FEEPROM	An electronic device named flash electrically erasable programmable read only memory.
Flash Erasable Programmable Read Only Memory[1]	FEPROM	An electronic device named flash erasable programmable read only memory.
Flexible Fuel[1]	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 or 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).
Fuel Level Sensor	---	See Glossary Entries "FUEL," "SENSOR."
Fuel Pressure	---	See Glossary Entries "FUEL," "PRESSURE."
Fuel Pump	FP[2]	See Glossary Entries "FUEL," "PUMP."
Fuel Trim[1]	FT	A fuel correction term.
Generator	GEN[2]	See Glossary Entry "GENERATOR."
Governor	---	See Glossary Entry "GOVERNOR."
Governor Control Module	GCM[2]	See Glossary Entries "GOVERNOR," "CONTROL" and "MODULE."
Ground	GND	See Glossary Entry "GROUND."
Heated Oxygen Sensor[1]	HO2S[2]	An oxygen sensor (O2S) 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."

--- Use Recommended Term Only
[1] Emission Related Term
[2] Historically acceptable common usage

FIGURE 2—RECOMMENDED TERMS

Recommended Terms	Acronyms/ Abbrev.	Definitions
Ignition Control Module[1]	ICM[2]	See Glossary Entries "IGNITION," "CONTROL," "MODULE."
Inlined Fuel Injection[1]	IFI	An injection system that supplies fuel into a combustion pre-chamber (Diesel).
Inertia Fuel Shutoff	IFS	An inertia system that shuts off the fuel delivery system when activated by predetermined force limits.
Intake Air[1]	IA	See Glossary Entry "INTAKE AIR."
Intake Air Temperature[1]	IAT	See Glossary Entry "INTAKE AIR."
Knock Sensor[1]	KS[2]	See Glossary Entries "KNOCK," "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," "PRESSURE."
Manifold Differential Pressure[1]	MDP	See Glossary Entries "MANIFOLD," "PRESSURE."
Manifold Surface Temperature[1]	MST	See Glossary Entry "MANIFOLD."
Manifold Vacuum Zone[1]	MVZ	See Glossary Entries "MANIFOLD," "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.
Nonvolatile Random Access Memory[1]	NVRAM	An electronic device named nonvolatile random access memory.
Oil Pressure	—	Pressure in the lubrication system.
On Board Diagnostic[1]	OBD	A system that monitors some or all computer input and control signals. Signal(s) outside of the predetermined limits imply a fault in the system or in a related system.
Open Loop[1]	OL	See Glossary Entry "OPEN LOOP."
Oxidation Catalytic Converter[1]	OC	A catalytic converter system that reduces levels of HC and CO.
Oxygen Sensor[1]	O2S[2]	A sensor which detects oxygen (O2) content in the exhaust gases.
Park/Neutral Position[1]	PNP	See Glossary Entry "PARK/NEUTRAL."
Particle 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," "MODULE."
Programmable Read Only Memory[1]	PROM	An electronic device named programmable (by the manufacturer) read only memory.
Pulsed Secondary Air Injection[1]	PAIR[2]	A pulse driven system for providing secondary air without an air pump by using the engine exhaust system pressure fluctuations or pulses.
Random Access Memory[1]	RAM	An electronic device named random access memory.
Read Only Memory[1]	ROM	An electronic device named read only memory.
Relay Module	RM[2]	See Glossary Entries "RELAY," "MODULE."
Scan Tool[1]	ST[2]	See Glossary Entry "SCAN TOOL."
Secondary Air Injection[1]	AIR[2]	A pump driven system for providing secondary air.
Sequential Multiport Fuel Injection[1]	SFI	A multiport 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.
Smoke Puff Limiter[1]	SPL	A system to reduce diesel exhaust smoke during vehicle acceleration or gear changes.
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 in OBDII scan tool communications.
Thermal Vacuum Valve[1]	TVV[2]	A valve that controls vacuum levels or routing based on temperature.
Third Gear	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+OC	A catalytic converter system that has both Three Way Catalyst (TWC) and Oxidation Catalyst (OC). 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 NOx.
Throttle Body[1]	TB[2]	See Glossary Entries "THROTTLE," "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.
Throttle Position[1]	TP	See Glossary Entry "THROTTLE."
Torque Converter Clutch[1]	TCC[2]	See Glossary Entry "CONVERTER."
Transmission Control Module	TCM[2]	See Glossary Entries "TRANSMISSION," "CONTROL," "MODULE."
Transmission Range	TR	See Glossary Entries "TRANSMISSION," "RANGE."
Turbocharger[1]	TC[2]	See Glossary Entry "TURBOCHARGER."
Vehicle Speed Sensor[1]	VSS[2]	A sensor which provides vehicle speed information.
Voltage Regulator	VR[2]	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-OC	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, and NOx 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

FIGURE 2—RECOMMENDED TERMS (CONTINUED)

MODIFIERS				BASE WORD	
What is its purpose?	Where is it?	Which Temp?	What does it sense?	What is it?	
				Sensor	Most generic
			Temperature	Sensor	
		Coolant	Temperature	Sensor	
	Engine	Coolant	Temperature	Sensor	Most specific
Instrumentation	Engine	Coolant	Temperature	Sensor	

Least <---------- SIGNIFICANCE ----------> Most

FIGURE 3—MODIFIER USAGE EXAMPLE

TABLE 1—GLOSSARY OF TERMS

Basewood/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.
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.
Canister	An evaporative emission canister contains activated charcoal which absorbs 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.
Closed 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 fluid 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.
Diagnostics	The process of identifying the cause or nature of a condition, situation or problem. To determine corrective action in repair 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 fixed increase or decrease ratio of relative rotation between its input and output shafts.
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.
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.
Generator	A rotating machine designed to convert mechanical energy into electrical energy.

TABLE 1—GLOSSARY OF TERMS (CONTINUED)

Keyword/Single Word Modifier	Definition
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.
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.
Level	The magnitude of a quantity considered in relation to an arbitrary reference value.
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.
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.
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.
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. Compare: Actuator, Relay, and Switch.
Solid State	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.
Transaxle	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 (translates) 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. Compare: Transaxle.
Troubleshooting	See Diagnostics.
Turbocharger	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.
Ultraviolet	The portion of the electromagnetic spectrum between violet visible light and X-Rays.
Vacuum	A circuit in which pressure has been reduced below the ambient atmospheric pressure.
Valve	A device by which the flow of liquid, gas, vacuum, or loose 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 moveable part of such a device. Compare: Actuator and Switch.
Vapor	A substance in its gaseous state as distinguished from the liquid or solid state.
Volatile	(1) Vaporizable at normal temperatures. (2) Not permanent.
Wheel	A circular frame of hard material that may be solid, partially solid, or spoked and that is capable of turning on an axle.

APPENDIX A
REQUEST FOR REVISION TO SAE J1930 ELECTRICAL/ELECTRONIC SYSTEMS DIAGNOSTIC TERMS, DEFINITIONS, ABBREVIATIONS, AND 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 through 4.3.2:

Please send completed form to:
SAE J1930 Task Force, 3001 West Big Beaver Rd, Ste. 320, Troy MI 48084-3174 U.S.A. Fax number: (313) 649-0425

PURPOSE or RATIONALE FOR REQUEST: _____

SECTION 5
EXISTING USAGE(S) _____ RECOMMENDED TERMS _____

SECTION 6
RECOMMENDED TERM — circle one:
EXISTING: _____ Add Delete Change
SUGGESTED: _____ Add Delete Change
ACRONYM / ABBREVIATIONS
EXISTING: _____
SUGGESTED: _____ Add Delete Change
DEFINITION
EXISTING: _____
SUGGESTED: _____ Add Delete Change

EMISSION RELATED? YES _____ NO _____

SECTION 7
GLOSSARY of TERMS _____

REQUESTOR: _____ Phone: _____ Fax: _____

Signature: _____ Address: _____
Date: _____

COMMITTEE USE ONLY

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

J1930 CHAIRPERSON _____ DATE _____

OMEGA EXHIBIT 2036

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SURFACE VEHICLE RECOMMENDED PRACTICE

Submitted for recognition as an American National Standard

SAE J1962 | REV. JUN94

Issued 1992-06
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Superseding J1962 JUN93

DIAGNOSTIC CONNECTOR

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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OMEGA EXHIBIT 2036

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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
SAE J2223—Connections for On-Board Road Vehicle Wiring Harness

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

2.1.3 CARB PUBLICATION—Available from California Air Resources Board.

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

2.1.4 EPA PUBLICATION—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

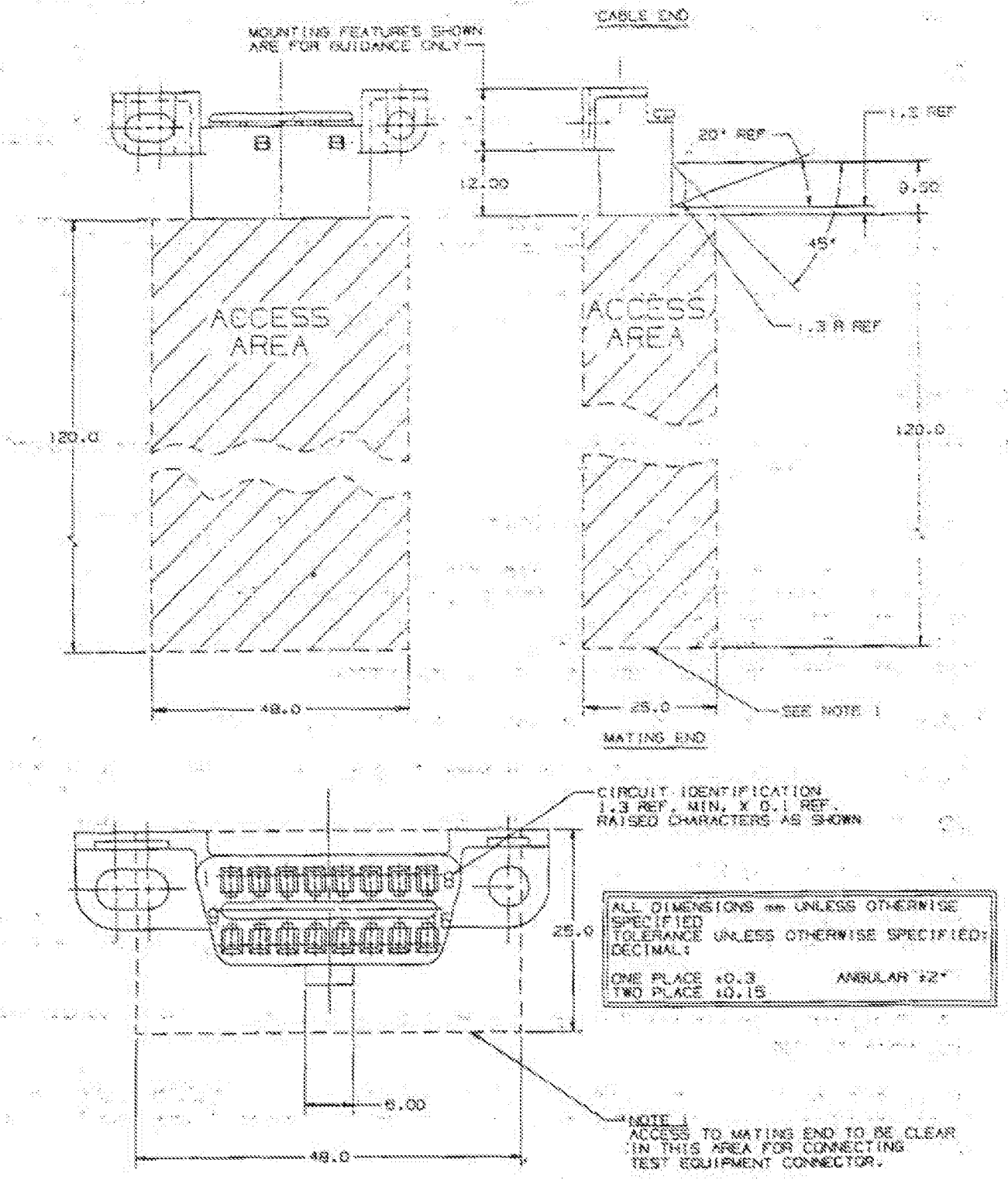


FIGURE 1—VEHICLE CONNECTOR

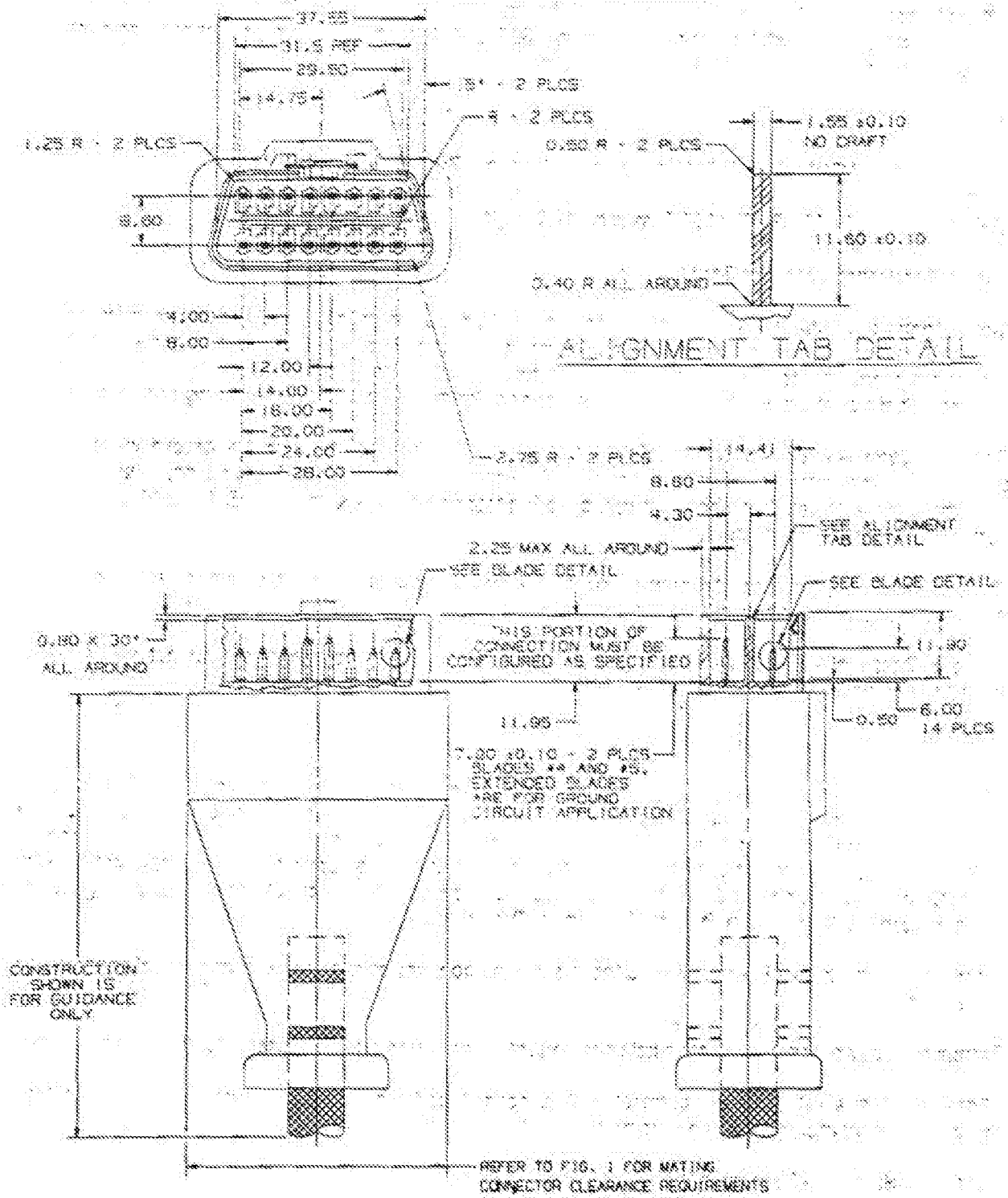


FIGURE 2—TEST EQUIPMENT CONNECTOR

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 to a "crouched" technician.

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 bent 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 seated. 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 4) 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.

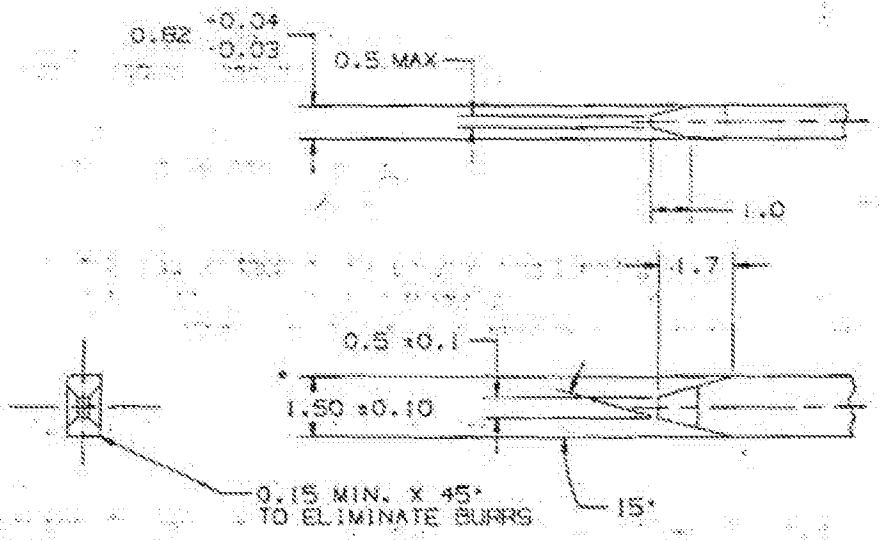
4.9 **Test Equipment Connector Cycle Life**—The test equipment manufacturer shall specify the minimum number of mating cycles the test equipment connector is capable of while meeting the requirements of this document.

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

a. Blade Size for Test Equipment Connector: Shall conform to the dimensions shown in Figure 3
b. Maximum Current DC: 10 A DC continuous
c. Temperature Range: -40 to +85 °C
d. Voltage Range DC: -0.05 to 30.0 V DC
e. Suggested Maximum Cable Size: 0.8 mm^2 (18 AWG)



ALL DIMENSIONS mm UNLESS OTHERWISE SPECIFIED
TOLERANCE UNLESS OTHERWISE SPECIFIED:
DECIMAL:

ONE PLACE ±0.3 ANGULAR ±2°
TWO PLACE ±0.15

BLADE DIMENSIONS FOR THE 1.5 mm X 0.8 mm BLADE PER ISO 8092-3 OR SAE J2223-3 ARE ALSO ACCEPTABLE

FIGURE 3—BLADE DETAIL

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 20 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 MΩ 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 4)

e. Indexing Feature—Must prevent mismating 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.

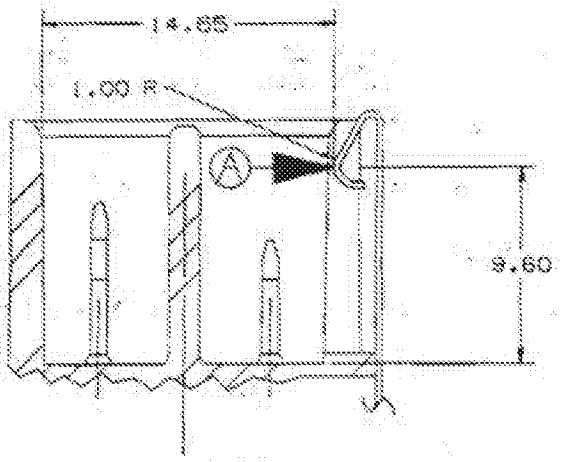
a. Thermal Cycling—1000 cycles of 30 min at -40 °C and 30 min at 110 °C.

b. Temperature/Humidity Cycling—15 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 ± 0.15 mm amplitude by 15 G for 2 h in each of 3 mutually perpendicular axes.



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

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 5.8.2.e.2 CONNECTOR MATING FORCE WITH 16 TERMINALS WITH SPRING CLIP, WITH SPRING CLIP IN PLACE.

FIGURE 4—SPRING CLIP DETAIL
(Optional)

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.

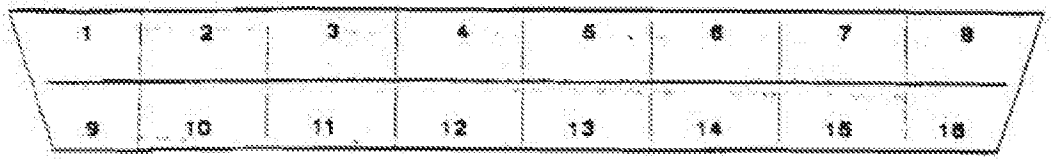


FIGURE 5—VEHICLE CONNECTOR MATING END VIEW

5.2 **General Terminal Assignments**—See Figure 6 for a summary of terminal assignments.

5.3 **Vehicle Connector Terminal Assignments**

5.3.1 VEHICLE CONNECTOR TERMINALS - GENERAL LIMITS—All uses 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 Bus + Signal of the SAE J1850 41.6 PWM connection.

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 5.3 and 5.5 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.

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 at 14.4 V DC.

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 30.0 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.

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.

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:

a. Is connected to vehicle connector terminal 16 - Unswitched Vehicle Battery Positive for up to 10 A at 14.4 V DC,

b. Is connected to vehicle connector terminal 4 - Vehicle Chassis Ground, or

c. Is connected to vehicle connector terminal 5 - Vehicle Signal Ground.

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 at 14.4 V DC.

The vehicle manufacturer shall not be responsible for supplying more than 4.0 A at 14.4 V DC.

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 at 14.4 V DC from terminal 16 of the vehicle connector, may be responsible for any damage to the vehicle.

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 E/E SYSTEMS DIAGNOSTIC STANDARDS COMMITTEE

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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

SURFACE VEHICLE RECOMMENDED PRACTICE

Submitted for recognition as an American National Standard

SAE J1978 | REV. JUN94

Issued 1992-03
Revised 1994-06

Superseding J1978 MAR92

OBD II SCAN TOOL

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.

OMEGA EXHIBIT 2036

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

» 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.

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

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

a. Automatic hands-off determination of the communication interface used
b. Obtaining and displaying the status and results of vehicle on-board diagnostic evaluations
c. Obtaining and displaying OBD II emissions related diagnostic trouble codes (DTCs)
d. Obtaining and displaying OBD II emissions related current data

e. Obtaining and displaying OBD II emissions related freeze frame data
f. 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 tests status
g. Ability to perform Expanded Diagnostic Protocol functions as described in SAE J2205
h. Obtaining and displaying OBD II emissions related test parameters and results as described in SAE J1979
i. Provide a user manual and/or help facility

6. *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:

a. The maximum sink current to be supported by the OBD II Scan Tool is 100 mA
b. The range for all tests performed relative to ISO 7637 is -1.0 to +40.0 V
c. The minimum bus idle 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

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.

Indications 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:

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

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.

a. Test for SAE J1850 41.6 Kbps PWM
   (1) Step 1—Enable the SAE J1850 41.6 Kbps PWM interface
   (2) Step 2—Send a mode 1 PID 0 request message
   (3) Step 3—If a mode 1 PID 0 response message is received then SAE J1850 41.6 Kbps PWM is the type of interface used in a vehicle for OBD II support.

b. Test for SAE J1850 10.4 Kbps VPW
   (1) Step 1—Enable the SAE J1850 10.4 Kbps VPW interface
   (2) Step 2—Send a mode 1 PID 0 request message
   (3) Step 3—If a mode 1 PID 0 response message is received then SAE J1850 10.4 Kbps VPW is the type of interface used in a vehicle for OBD II support.

c. Test for ISO 9141 CARB
   (1) Step 1—Enable the ISO 9141-2 interface
   (2) 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

(m) 6.6.1 COMPLETED ON-BOARD SYSTEM READINESS TESTS—Immediately after initial communications are established, the OBD II Scan Tool shall obtain the 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 supported on-board system readiness tests have been completed." or equivalent. The OBD II Scan Tool shall also allow the user to identify which readiness tests (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 J2201 Universal Interface for OBD II Scan Tools—The OBD II Scan Tool shall use the interface described in SAE J2201, or an equivalent, as the interface to vehicles.

(m) **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:

a. First, retransmit the request message.
b. 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.
c. 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.
d. 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.

(m) **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 same 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

(m) **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 J1979 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.

(m) 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.

(m) 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 tests 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:

a. Data value
b. Data Parameter id or name
c. 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 tester body, as a part of the tester 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:

a. 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).

b. Select for simultaneous display at least two items of any one of the following:

(1) OBD II emissions related current data
(2) OBD II emissions related diagnostic trouble codes
(3) OBD II emissions related freeze frame data
(4) 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

(1) Must operate normally within a range of 8.0 to 18.0 V D.C.
(2) Must survive a steady-state voltage of up to 24.0 V D.C. for at least 10.0 min
(3) Must survive a steady-state reverse voltage of up to 24.0 V D.C. for at least 10 min

b. Current

(1) 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 J1113.

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 retest 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:

a. The methods used to make these tests
b. The results of the tests
c. 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).

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.

(m) These tests will be executed in an environment of 25 °C ± 3 °C and between 30% and 90% 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 J2201 (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 bias 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.

(n) 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**—Item 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 node 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—Item 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—Item 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—Item 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

The OBD II Scan Tool will be tested for a HELP facility and/or the availability and coverage of a user manual.

12. *Notes*

12.1 **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 E/E SYSTEMS DIAGNOSTIC STANDARDS COMMITTEE

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SURFACE VEHICLE RECOMMENDED PRACTICE

Submitted for recognition as an American National Standard

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E/E DIAGNOSTIC TEST MODES

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.

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
(R) f. Mode $06—Request On-Board Monitoring Test Results for Non-Continuously Monitored Systems
(R) g. Mode $07—Request On-Board Monitoring Test Results for Continuously Monitored Systems

For each test mode, this specification includes:

a. Functional descriptions of test mode
b. Request and response message formats

(R) 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. 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 J1962—Diagnostic Connector
SAE J1978—OBD II Scan Tool
SAE J2012—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—CARB 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

2.2 **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.

2.2.1 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%.

2.2.2 BANK—The group of cylinders which feed an oxygen sensor. Bank 1 contains the Number 1 cylinder.

2.2.3 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.

2.2.4 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%).

$$CLV = \frac{\text{Current airflow}}{\text{Peak airflow (@ sea level)}} \times \frac{\text{Atmospheric pressure (@ sea level)}}{\text{Barometric pressure}} \times 100\% \qquad \text{(Eq.1)}$$

2.2.5 CONTINUOUS MONITORING—Sampling at a rate no less than two samples per second.

2.2.6 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.

3. Technical Requirements

3.1 **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.

3.1.1 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.

3.1.2 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 response(s). 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.

3.1.3 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.

3.1.4 DATA NOT AVAILABLE—There will be no reject message for a request for data if the data value is not supported by the module.

3.1.5 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.

3.2 Diagnostic Message Format

3.2.1 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.

3.2.2 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.

3.2.3 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	ERR	RSP
Diagnostic Request at 10.4 Kbps (J1850 and ISO 9141-2)											
68	6A	Fx	Maximum 7 data bytes							Yes	No
Diagnostic Response at 10.4 Kbps (J1850 and ISO 9141-2)											
48	6B	addr	Maximum 7 data bytes							Yes	No
Diagnostic Request at 41.6 Kbps (J1850)											
61	6A	Fx	Maximum 7 data bytes							Yes	Yes
Diagnostic Response at 41.6 Kbps (J1850)											
41	6B	addr	Maximum 7 data bytes							Yes	Yes

FIGURE 1—DIAGNOSTIC MESSAGE FORMAT

3.2.4 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 3.2.3. 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.

3.2.5 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 $05, 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.

(R) 3.2.6 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 41.6 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.

3.2.7 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.

3.2.8 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 2:



FIGURE 2—BIT POSITION WITHIN A DATA BYTE

(R) **3.3 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.

(R) **3.4 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.

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Data	Modes	Display Format
Device ID - source address of response	all	Hexadecimal (00 to FF)
Parameter ID (PID)	$01 & $02	Hexadecimal (00 to FF), description, or acronym (see table in Section 4.3)
Frame number	$02	Decimal (0 to 255)
Data values	$01 & $02	see table in Section 4.3
Diagnostic Trouble Codes	$03 & $07	"P" plus 4 digits and/or DTC definition - see SAE J2012
Test ID	$05 & $06	Hexadecimal (00 to FF)
Test value and test limits	$05	Engineering units for Test IDs less than $80 (see Section 4.6.2) - Decimal (0 to 255) for Test IDs greater than $80
Test value and test limits	$06	Decimal (0 to 65535)
Component ID	$06 (part of data byte #3)	Hexadecimal (00 to 7F)

(R) FIGURE 3—FORMAT OF DATA TO BE DISPLAYED

4. *Test Modes*

4.1 Mode $01—Request Current Powertrain Diagnostic Data

4.1.1 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 J1978 use the presence of a response by the vehicle to this request to determine which protocol is supported for OBD II communications.

4.1.2 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	01	PID					
Report Current Powertrain Diagnostic Data							
Report Powertrain Diagnostic Data	41	PID	data A	data B (opt)	data C (opt)	data D (opt)	

FIGURE 4—MESSAGE DATA BYTES

OMEGA EXHIBIT 2036

4.2 Mode $02—Request Powertrain Freeze Frame Data

4.2.1 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.

4.2.2 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	02	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	42	PID	frame no.	data A	data B (opt)	data C (opt)	data D (opt)

FIGURE 5—MESSAGE DATA BYTES

4.3 PIDs for Modes $01 and $02—(See Figure 6.)

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	00	PIDs supported ($01 - $20) Module responds with a message that contains 4 bytes of bit encoded information, each bit indicating support or non-support of a PID where: 0 = PID not supported by this module 1 = PID supported by this module			Byte Bit PID Data A 7 $01 Data A 6 $02 Data B 7 $03 Data D 0 $20	
X		01	Data A - Number of emission related powertrain trouble codes and MIL status: Bits 0-6: Number of codes stored in this module bit 7: 0 = MIL not commanded ON by this module 1 = MIL commanded ON by this module Data B 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 tests run at least once (per trip) where: 0 = test not supported by this module 1 = test supported by this module Data D - Each bit indicates status of on-board diagnostic evaluation for this module, corresponding to tests included in Data C: 0 = test complete, or not applicable 1 = test not complete			Data B: bit Evaluation supported 0 Misfire monitoring 1 Fuel system monitoring 2 Comprehensive component monitoring 3 reserved (report as 0) 4 reserved (report as 0) 5 reserved (report as 0) 6 reserved (report as 0) 7 reserved (report as 0) Data C and Data D: bit Evaluation supported / status 0 Catalyst monitoring 1 Heated catalyst monitoring 2 Evaporative system monitoring 3 Secondary air system monitoring 4 A/C system refrigerant monitoring 5 Oxygen sensor monitoring 6 Oxygen sensor heater monitoring 7 EGR system monitoring	

(R) 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			00	00	89	99		
	X	02	Trouble code that caused required freeze frame data storage (2 byte value - $0000 indicates no freeze frame data)					Pxxx	
X	X	03	Data A: Fuel system 1 status Data B: Fuel system 2 status ($00 if not used) For each data byte, no 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 enleanment) 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	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 if only 1 fuel trim value)	-100.00% (lean)		99.22% (rich)		100/128% (0% at 128) xxx.x%	
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 (gage)	0 kPaG		765 kPaG		3 kPaG xxx kPaG	xx x psig

(R) FIGURE 6—PIDS FOR MODES $01 AND $02 (CONTINUED)

Modes *		PID (Hex)	Description	Min (Dec) or (Binary)	Max (Dec) or (Binary)	SI (Metric) Scaling/bit and display	English scaling/bit and display
$01	$02						
X	X	0B	Intake manifold absolute pressure	0 kPaA	255 kPaA	1 kPaA xxx kPaA	xx.x in. Hg
X	X	0C	Engine RPM (2 byte value - high byte/low byte)	0 r/min	16,383.75 r/min	1/4 r/min xxxxx r/min	
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 (incl including mechanical advance)	-64	+63.5	1/2° with 0° at TDC xx.x°	
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 gm/sec	655.35 gm/sec	.01 gm/sec xxx.xx gm/sec	xxxx.x lb/min
X		11	Absolute throttle position sensor	0%	100%	100/255% xxx.x%	
X		12	Commanded secondary air status (if supported, one, and only one bit at a time can be set to a 1) bit 0 1 = upstream of first catalytic converter bit 1 1 = downstream of first catalytic converter inlet bit 2 1 = atmosphere / off bits 3 - 7 = reserved (report as 0)				

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	$02						
X		13	Location of oxygen sensors, where sensor 1 is closest to the engine. Each bit indicates the presence or absence of an oxygen sensor at the following location: bit Sensor location Alternative sensor location 0 Bank 1 - Sensor 1 Bank 1 - Sensor 1 1 Bank 1 - Sensor 2 Bank 1 - Sensor 2 2 Bank 1 - Sensor 3 Bank 2 - Sensor 1 3 Bank 1 - Sensor 4 Bank 2 - Sensor 2 4 Bank 2 - Sensor 1 Bank 3 - Sensor 1 5 Bank 2 - Sensor 2 Bank 3 - Sensor 2 6 Bank 2 - Sensor 3 Bank 4 - Sensor 1 7 Bank 2 - Sensor 4 Bank 4 - Sensor 2 where: 1 = sensor present at that location 0 = sensor not present at that location				
X		14 15 16 17 18 19 1A 1B	Bank 1 - Sensor 1 Bank 1 - Sensor 2 Bank 1 - Sensor 3 Bank 1 - Sensor 4 Bank 2 - Sensor 1 Bank 2 - Sensor 2 Bank 2 - Sensor 3 Bank 2 - Sensor 4 for each sensor: Data A - Oxygen sensor output voltage Data B - short term fuel trim associated with this sensor ($FF if this sensor is not used in the calculation)	0 volt -100.00% (lean)	1.275 volt 99.22% (rich)	.025 volt x.xxx volt 100/128% (0% at 128) xxx.x%	This scaling assumes a nominal 1 volt full scale oxygen sensor. any sensor with a different full scale value should be normalized to provide nominal full scale at $C8 (200 decimal).

(R) 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						
#		1C	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				
		1D-1F	Unused - reserved for future expansion				
x		20	PIDs supported ($21 - $40)			Byte, bit: PID Data A 7: $21 Data A 6: $22 ... Data B 7: $29 ... Data D 0: $40	
		21-3F	Reserved - to be specified in J2190, if needed				
X		40	PIDs supported ($41 - $60)				
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.

(R) FIGURE 6—PIDS FOR MODES $01 AND $02 (CONTINUED)

4.4 Mode $03—Request Emission-Related Powertrain Diagnostic Trouble Codes

4.4.1 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.

a. 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.
b. 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 will 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 1 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.)

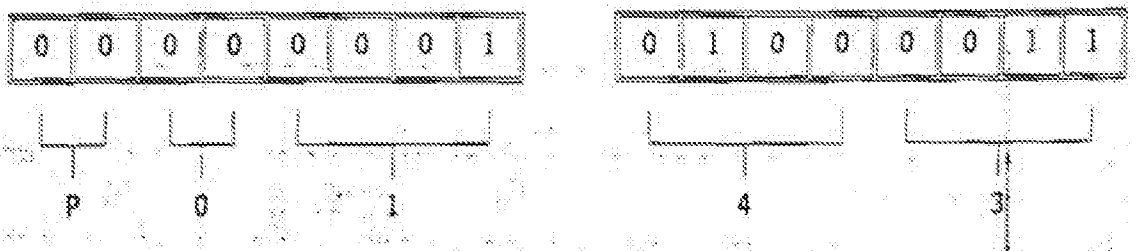


FIGURE 7—DIAGNOSTIC TROUBLE CODE ENCODING EXAMPLE

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.

4.4.2 MESSAGE DATA BYTES—(See Figure 8.)

	Data Bytes (Hex)						
	#1	#2	#3	#4	#5	#6	#7
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	41	01	# DTC & MIL	Eval. Supp. #1	Eval. Supp. #2	Eval. Status	
Request codes from all modules							
Request powertrain DTC	03						
Report codes (each module)							
Report powertrain DTC	43	Code #1		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

4.4.3 POWERTRAIN DIAGNOSTIC TROUBLE CODE EXAMPLE (ASSUME 10.4 Kbps)—(See Figure 9.)

	Header Bytes (Hex)			Data Bytes (Hex)						
	F/T	Tgt	Src	#1	#2	#3	#4	#5	#6	#7
Request Powertrain DTC										
Request number of Powertrain DTC	68	6A	F1	01	01					
Report Number of Powertrain DTC										
Module 06 has 6 stored DTC	48	6B	06	41	01	06	00	00	00	
Module C3 has 1 stored DTC	48	6B	C3	41	01	01	00	00	00	
Module 2B has 0 stored DTC	48	6B	2B	41	01	00	00	00	00	
Module 3E has 2 stored DTC and MIL ON	48	6B	3E	41	01	82	00	00	00	
* Request All Stored Powertrain DTC										
Request powertrain DTC	68	6A	F1	03						
Report All Stored Powertrain DTC										
Module 06 send codes P0143, P0196, & P0234	48	6B	06	43	Code #1		Code #2		Code #3	
					01	43	01	96	02	34
Module C3 send code P0443	48	6B	C3	43	Code #1		00	00	00	00
					04	43				
Module 06 send codes P0357, P0531, & P0661	48	6B	06	43	Code #4		Code #5		Code #6	
					03	57	09	31	06	61
Module 3E send codes P0112 & P0445	48	6B	3E	43	Code #1		Code #2		00	00
					01	12	04	45		

FIGURE 9—POWERTRAIN DIAGNOSTIC TROUBLE CODE EXAMPLE (ASSUME 10.4 Kbps)

4.5 Mode $04—Clear/Reset Emission-Related Diagnostic Information

4.5.1 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:

a. Clear number of diagnostic trouble codes (Mode $01, PID $01)
b. Clear diagnostic trouble codes (Mode $03)
c. Clear trouble code for freeze frame data (Mode $01, PID $02)
d. Clear freeze frame data (Mode $02)
e. Clear oxygen sensor test data (Mode $05)
f. Reset status of system monitoring tests (Mode $01, PID $01)
g. Clear on-board monitoring test results (Mode $06 and $07)

Other manufacturer specific "clearing/resetting" actions may also occur in response to this request.

(R) 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.

4.5.2 MESSAGE DATA BYTES—(See Figure 10.)

	Data Bytes (Hex)						
	#1	#2	#3	#4	#5	#6	#7
Request to 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

4.6 Mode $05—Request Oxygen Sensor Monitoring Test Results

4.6.1 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 requirement 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.

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.

8.2 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	O2S #				
Report Oxygen Sensor Test ID Support - Optional (Test IDs $00, $20, $40, $60, $80, $A0, $C0, $E0)							
Report Oxygen Sensor Test ID Support	45	Test ID	O2S #	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)							
Report Oxygen Sensor Test Results	45	Test ID	O2S #	test value	min limit *	max limit *	

* NOTE—Report limits if value is a test result—not required for test constants, such as ID $01 to $04.

(R) FIGURE 11—MESSAGE DATA BYTES

Results of latest mandated on-board oxygen sensor monitoring test.

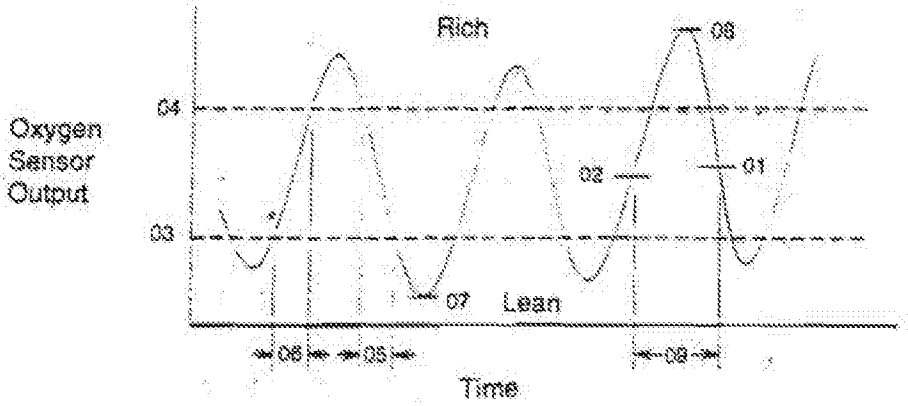


FIGURE 12—TEST ID VALUE EXAMPLE

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-$1F - reserved $20 - Test ID's supported - optional ($21 to $40) $21-$2F - values with units of time less than 1.02 seconds $30-$3F - values with units of time less than 10.2 seconds $40 - Test ID's supported - optional ($41 to $60) $41-$4F - values with units of voltage less than 1.275 volts $50-$5F - values with units of voltage less than 12.75 volts $60 - Test ID's supported - optional ($61 to $80) $61-$6F - values with units of Hertz 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-$9F - manufacturer specific values / units. $A0 - Test ID's supported - optional ($A1 to $C0) $A1-$BF - manufacturer specific values / units $C0 - Test ID's supported - optional ($C1 to $E0) $C1-$DF - manufacturer specific values / units $E0 - Test ID's supported - optional ($E1 to $FF) $E1-$FF - manufacturer specific values / units
3	Oxygen sensor location (one, and only one bit can be set to a 1): bit — 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 3 - Sensor 1 5 — Bank 2 - Sensor 2 — Bank 3 - Sensor 2 6 — Bank 2 - Sensor 3 — Bank 4 - Sensor 1 7 — Bank 2 - Sensor 4 — Bank 4 - Sensor 2 where: 1 = sensor present at that location 0 = sensor not present at that location

(R) FIGURE 13—MESSAGE DATA BYTE DESCRIPTION

Data Byte	Description
	The following 4 bytes define data bytes for Test IDs that indicate support of other Test IDs - optional (Modes $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 0 - support for Test ID $08
5	Support for Test ID, where 1=support, 0=non-support: bit 7 - support for Test ID $09 bit 6 - support for Test ID $0A . . bit 0 - 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 0 - 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 0 - support for Test ID $20

(R) FIGURE 13—MESSAGE DATA BYTE DESCRIPTION (CONTINUED)

Data Byte	Description			
	The following 3 bytes define data bytes for Test IDs that report data values			
4	Test ID:	Min ($00):	Max ($FF):	Scaling/bit
	Test ID $01	0 volt	1.275 v.	.005 v.
	Test ID $02	0 volt	1.275 v.	.005 v.
	Test ID $03	0 volt	1.275 v.	.005 v.
	Test ID $04	0 volt	1.275 v.	.005 v.
	Test ID $05	0 sec.	1.02 sec.	.004 sec.
	Test ID $06	0 sec.	1.02 sec.	.004 sec.
	Test ID $07	0 volt	1.275 v.	.005 v.
	Test ID $08	0 volt	1.275 v.	.005 v.
	Test ID $09	0 sec.	10.2 sec.	.04 sec.
	Test ID $21-$2F	0 sec.	1.02 sec.	.004 sec.
	Test ID $30-$3F	0 sec.	10.2 sec.	.04 sec.
	Test ID $41-$4F	0 volt	1.275 v.	.005 volt
	Test ID $50-$5F	0 volt	12.75 v.	.05 volt
	Test ID $61-$6F	0 Hz	25.5 Hz	.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.

(R) FIGURE 13—MESSAGE DATA BYTE DESCRIPTION (CONTINUED)

(R) **4.7 Mode $06—Request On-Board Monitoring Test Results for Non-Continuously Monitored Systems**

(R) 4.7.1 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.

(R) 4.7.2 MESSAGE DATA BYTES—(See Figure 14.)

	Data Bytes (Hex)						
	#1	#2	#3	#4	#5	#6	#7
Request Test Results							
Request Test Results	06	Test ID					
Report Test ID Support (Test IDs $00, $20, $40, $60, $80, $A0, $C0, $E0)							
Report Test ID Support	46	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)							
Report Test Results	46	Test ID	Test Limit Type & Component ID	test value		test limit	
				MSB	LSB	MSB	LSB

(R) FIGURE 14—MESSAGE DATA BYTES

Data Byte	Description
2	Test ID: $00 - Test ID's supported ($01 to $20) $01-$1F - values defined by manufacturer $20 - Test ID's supported ($21 to $40) $21-$3F - values defined by manufacturer $40 - Test ID's supported ($41 to $60) $41-$5F - values defined by manufacturer $60 - Test ID's supported ($61 to $80) $61-$7F - values defined by manufacturer $80 - Test ID's supported ($81 to $A0) $81-$9F - values defined by manufacturer $A0 - Test ID's supported ($A1 to $C0) $A1-$BF - values defined by manufacturer $C0 - Test ID's supported ($C1 to $E0) $C1-$DF - values defined by manufacturer $E0 - Test ID's supported ($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

(R) 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 (Modes $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 0 - support for Test ID $08
5	Support for Test ID, where 1=support, 0=non-support: bit 7 - support for Test ID $09 bit 6 - support for Test ID $0A . . bit 0 - 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 0 - 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 0 - 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 $FF 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)

(R) FIGURE 14—MESSAGE DATA BYTES (CONTINUED)

(R) 4.7.3 MESSAGE EXAMPLE—(See Figure 15.)

	Data Bytes (Hex)						
	#1	#2	#3	#4	#5	#6	#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	00	FF	00000100 =04	00000001 =01	00000000 =00	00000101 =05
Request Test ID Support	06	20					
Report Support for Test ID 40	46	20	FF	00000000 =00	00000000 =00	00000000 =00	00000001 =01
Request Test ID Support	06	40					
Report Support for Test ID 60	46	40	FF	00000000 =00	00000000 =00	00000000 =00	00000001 =01
Request Test ID Support	06	60					
Report Support for Test ID 80	46	60	FF	00000000 =00	00000000 =00	00000000 =00	00000001 =01
Request Test ID Support	06	80					
Report Support for Test ID A0	46	80	FF	00000000 =00	00000000 =00	00000000 =00	00000001 =01
Request Test ID Support	06	A0					
Report Support for Test ID A1 - no additional test IDs supported	46	A0	FF	10000000 =10	00000000 =00	00000000 =00	00000000 =00

(R) FIGURE 15—MESSAGE EXAMPLE

	Data Bytes (Hex)						
	#1	#2	#3	#4	#5	#6	#7
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	16	00
Following messages indicate test results greater than the maximum for component ID 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	
				92	36	7F	FF
Report Results for component 02 - test value less than maximum - passed	46	10	02	test value		maximum test limit	
				06	61	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	
				35	95	14	00
Report Results for component 31 - test value less than maximum - passed	46	A1	31	test value		maximum test limit	
				35	95	66	53

(R) FIGURE 15—MESSAGE EXAMPLE (CONTINUED)

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8.9 Mode $07—Request On-Board Monitoring Test Results for Continuously Monitored Systems

8.9.1 FUNCTIONAL DESCRIPTION—The purpose of this mode is to enable the off-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, no response is required.

8.9.2 MESSAGE DATA BYTES—(See Figure 16.)

	Data Bytes (Hex)						
	#1	#2	#3	#4	#5	#6	#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

PREPARED BY THE SAE VEHICLE E/E SYSTEMS DIAGNOSTIC STANDARDS COMMITTEE

DIAGNOSTIC TROUBLE CODE DEFINITIONS —SAE J2012 MAR92

SAE Recommended Practice

Report of the SAE Vehicle E/E System Diagnostic Standards Committee approved March 1992.

Foreword—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 to 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. SAE J2012 provides some recommended uniformity for these numeric codes. It further provides guidance for uniform messages associated with these codes.

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 three parts attached to the document (Appendices A, B, and C). Codes and messages for Body systems are covered in Appendix A, Chassis systems in Appendix B, and Powertrain systems in Appendix C.

The recommended Diagnostic Trouble Codes (DTC) consist of a three-digit numeric code preceded by an alphanumeric designator. The alphanumeric 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, as yet, undefined Trouble Codes. The code structure itself is partially open ended. A portion of the available numeric sequences (portions of "B0," "C0," and "P0") 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 4. 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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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 data bases, 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.

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 J1979—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.

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

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

3. 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).

4. Format Structure

4.1 Description—The Diagnostic Trouble Code consists of an alphanumeric designator, B0 – B3 for Body, C0 – C3 for Chassis, P0 – P3 for Powertrain, and U0 – U3 for some as yet undefined catch-all, 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

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code designator will be implied since diagnostic information will be received from a particular controller. In the cases where the source of the diagnostic information is not clear, the uppermost nibble of the two-byte message as defined in J1979 (E/E Diagnostic Test Modes) will show the source systems 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 – Undefined codes Reserved
1101 – U1 – Undefined codes Reserved
1110 – U2 – Undefined codes Reserved
1111 – U3 – Undefined 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 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 indicated areas in need of service attention.

4.1 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 among manufacturers, the fault being indicated is common enough to be assigned a particular fault code.

4.2 Non-Uniform DTC – Areas within each alpha designator have been made available for non-uniform 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 manufacturer will define their own code and error message definition for use in these assigned areas. It is understood that each manufacturer must remain consistent across their product line when assigning codes in the Manufacturer controlled areas. For Powertrain codes, the same groupings should be used as in the SAE controlled area, i.e., 100's and 200's for Fuel and Air Metering, 300's for Ignition System or Misfire, etc.

Code groupings for non-Powertrain codes will be defined at a later date.

4.3 Body System Groupings
4.3.1 – B0XXX SAE Controlled
4.3.2 – B1XXX Manufacturer Controlled
4.3.3 – B2XXX Manufacturer Controlled
4.3.4 – B3XXX Reserved

4.4 Chassis System Groupings
4.4.1 – C0XXX SAE Controlled
4.4.2 – C1XXX Manufacturer Controlled
4.4.3 – C2XXX Manufacturer Controlled
4.4.4 – C3XXX Reserved

4.5 Powertrain System Groupings
4.5.1 – P0XXX SAE Controlled
4.5.1.1 – P01XX Fuel and Air Metering
4.5.1.2 – P02XX Fuel and Air Metering
4.5.1.3 – P03XX Ignition System or Misfire
4.5.1.4 – P04XX Auxiliary Emission Controls
4.5.1.5 – P05XX Vehicle Speed Control and Idle Control System
4.5.1.6 – P06XX Computer and Output Circuits
4.5.1.7 – P07XX Transmission
4.5.1.8 – P08XX Transmission
4.5.1.9 – P09XX Reserved for SAE
4.5.1.10 – P0AXX Reserved for SAE
4.5.2 – P1XXX Manufacturer Controlled
4.5.2.1 – P11XX Fuel and Air Metering
4.5.2.2 – P12XX Fuel and Air Metering
4.5.2.3 – P13XX Ignition System or Misfire
4.5.2.4 – P14XX Auxiliary Emission Controls
4.5.2.5 – P15XX Vehicle Speed Control and Idle Control System
4.5.2.6 – P16XX Computer and Output Circuits
4.5.2.7 – P17XX Transmission
4.5.2.8 – P18XX Transmission
4.5.2.9 – P19XX Category to be Determined by SAE
4.5.2.10 – P1AXX Category to be Determined by SAE
4.5.3 – P2XXX SAE Reserved
4.5.4 – P3XXX SAE Reserved

5. Messages – Each defined fault code has been assigned a message to indicate the circuit or area that was determined to be at fault. The messages are organized such that different messages related to a particular system or subsystem are grouped together. In cases where there are several 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 in that circuit 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.

Where messages are broken down into more specific fault descriptions for a sensor or system, the manufacturer should choose the code most applicable to their diagnostic 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. The terms "LOW" and "HIGH" when used in a message, especially those related to input signals, refer to the voltage, frequency, etc., at the pin of the controller. The specific level of "LOW" and "HIGH" must be defined by each manufacturer to best meet their needs.

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 sensor 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 sensor or circuit. For example, in diagnosing the Throttle Position Sensor, if the input signal was outside of the normal operating range of the sensor, Code P0122 would be stored for a low signal with the associated message being Throttle Position Sensor – Low Input, or Code P0123 would be stored for a high signal with the associated message being Throttle Position Sensor – High Input. For a signal that is within operating range, but is determined to be otherwise in error for the given test conditions, Code P0121 could be stored (Throttle Position Sensor – Range/Performance), or some other code defined in the Manufacturers Specific Code Area could be used with a message that better indicates the type or location of the problem.

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 Fault 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.

P01XX Fuel and Air Metering

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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	
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	
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	
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	
P0120	Throttle Position Circuit Malfunction	
P0121	Throttle Position Circuit Range/Performance Problem	
P0122	Throttle Position Circuit Low Input	
P0123	Throttle Position Circuit High Input	
P0125	Excessive Time to Enter Closed Loop Fuel Control	
P0130	O_2 Sensor Circuit Malfunction	(Bank 1* Sensor 1)
P0131	O_2 Sensor Circuit Low Voltage	(Bank 1* Sensor 1)
P0132	O_2 Sensor Circuit High Voltage	(Bank 1* Sensor 1)
P0133	O_2 Sensor Circuit Slow Response	(Bank 1* Sensor 1)
P0134	O_2 Sensor Circuit No Activity Detected	(Bank 1* Sensor 1)
P0135	O_2 Sensor Heater Circuit Malfunction	(Bank 1* Sensor 1)
P0136	O_2 Sensor Circuit Malfunction	(Bank 1* Sensor 2)
P0137	O_2 Sensor Circuit Low Voltage	(Bank 1* Sensor 2)
P0138	O_2 Sensor Circuit High Voltage	(Bank 1* Sensor 2)
P0139	O_2 Sensor Circuit Slow Response	(Bank 1* Sensor 2)
P0140	O_2 Sensor Circuit No Activity Detected	(Bank 1* Sensor 2)
P0141	O_2 Sensor Heater Circuit Malfunction	(Bank 1* Sensor 2)
P0142	O_2 Sensor Circuit Malfunction	(Bank 1* Sensor 3)
P0143	O_2 Sensor Circuit Low Voltage	(Bank 1* Sensor 3)
P0144	O_2 Sensor Circuit High Voltage	(Bank 1* Sensor 3)
P0145	O_2 Sensor Circuit Slow Response	(Bank 1* Sensor 3)
P0146	O_2 Sensor Circuit No Activity Detected	(Bank 1* Sensor 3)
P0147	O_2 Sensor Heater Circuit Malfunction	(Bank 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)
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P0312	Cylinder 12 Misfire Detected
P0320	Ignition/Distributor Engine Speed Input Circuit Malfunction
P0321	Ignition/Distributor Engine Speed Input Circuit Range/

* For systems with single O_2 sensor, use codes for Bank 1 sensor. Bank 1 contains cylinder #1.

Sensor 1 is closest to engine.

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	Performance
P0322	Ignition/Distributor Engine Speed Input Circuit No Signal
P0325	Knock Sensor 1 Circuit Malfunction
P0326	Knock Sensor 1 Circuit Range/Performance
P0327	Knock Sensor 1 Circuit Low Input
P0328	Knock Sensor 1 Circuit High Input
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P0331	Knock Sensor 2 Circuit Range/Performance
P0332	Knock Sensor 2 Circuit Low Input
P0333	Knock Sensor 2 Circuit High Input
P0335	Crankshaft Position Sensor Circuit Malfunction
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P0412	Secondary Air Injection System Switching Valve/Circuit Malfunction
P0413	Secondary Air Injection System Switching Valve/Circuit Open
P0414	Secondary Air Injection System Switching Valve/Circuit Shorted
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P0421	Warm Up Catalyst Efficiency Below Threshold (Bank 1*)
P0422	Main Catalyst Efficiency Below Threshold (Bank 1*)
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P0431	Warm Up Catalyst Efficiency Below Threshold (Bank 2)
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P0711	Transmission Fluid Temperature Sensor Circuit Range/Performance
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P0752	Shift Solenoid A Stuck On
P0753	Shift Solenoid A Electrical

* Bank 1 contains Cylinder #1

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P0755	Shift Solenoid B Malfunction
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1. *Scope*—This SAE Recommended Practice establishes a uniform practice for protecting vehicle modules from "unauthorized" intrusion through a vehicle diagnostic data communication link. The security system represents a recommendation for motor vehicle manufacturers and provides flexibility for them to tailor their system to their specific needs. The vehicle modules addressed are those that are capable of having subsystem memory contents altered external to the electronic module through a diagnostic data communication link. Improper memory conservation could potentially damage the electronics or other vehicle systems, risk the vehicle compliance to government legislated requirements, or risk the vehicle manufacturer's security interests. This document is intended to meet the "tampering protection" provisions of California Air Resources Board OBD II regulations and does not imply that other security measures are not required nor possible.

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.

J1978 MARSE OBD II Scan Tool

2.1.2 CALIFORNIA AIR RESOURCES BOARD REGULATIONS—Available from Air Resources Board, Mobile Source Division, 9528 Telstar Avenue, El Monte, CA 91731.

Mail out #91-18 (OBD II)—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 Fuel Control Systems.

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.

J1850 AUG91—Class B Data Communication Network Interface

J1930 SEP91—Terms, Definitions, Abbreviations and Acronyms

J1979 DEC91—E/E Diagnostic Test Modes

2.2.1.1 The following publications are under development:

J1962 Draft Diagnostic Connector

J2012 Draft Format and Messages for Diagnostic Trouble Codes

J2190 Draft Enhanced E/E Diagnostic Test Modes

J2201 Draft Universal Interface for OBD II Scan Tool

J2205 Draft Expanded Diagnostic Protocol for OBD II Scan Tool

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

ISO/CD 9141-1 Road vehicles—Diagnostic systems—CARB requirements for April 1991 interchange of digital information.

3. *Definitions*

STANDARD SERVICE TOOL—A service tool providing basic emission related power train diagnostic tool functions, as required by CARB OBD II regulations. This service tool complies with SAE J1978 and is not necessarily limited to only OBD II functions.

ENHANCED SERVICE TOOL—A service tool providing expanded emission related power train diagnostic functions in excess of the standard service tool and/or non-power train systems diagnostic functions.

SECURED SERVICE TOOL—A service tool containing a feature for accessing secured data link functions. Use of this feature is limited by the vehicle manufacturer.

UNSECURED FUNCTIONS—Standard diagnostic functions that are provided by vehicle manufacturers. These are controlled and protected by the on-vehicle controller. The unsecured capability includes reprogramming of selected items for which the reprogrammer is liable.

SECURED FUNCTIONS—Manufacturer restricted functions that require "Unlocking" the on-vehicle controller to gain access. Typical functions include programming of vehicle emission systems.

READ DATA FUNCTION—Operation which reads parameters and codes via the data link.

SERVICE ALTERATION FUNCTION—Operation which temporarily alters the vehicle control system for the purpose of diagnosing the system's operation.

PERMANENT ALTERATION FUNCTION—Operation which permanently alters the operating characteristics of a vehicle module or system.

SEED—The data value sent from the on-board controller to the secured service tool.

KEY—The data value sent from the secured service tool to the on-board controller.

4. *Technical Requirements*—Proper "Unlocking" of the controller shall be a prerequisite to access certain critical on-board controller functions; the only access to the on-board controller permitted while in a "Locked" mode is through the product-specific software. This permits the product-specific software to protect itself and the rest of the vehicle control system from unauthorized intrusion.

This document does not attempt to define capability or information that is under security, this is left to the vehicle manufacturer. The security system shall not prevent basic diagnostic communications between the external tool and the on-board controller.

4.1 **Data Link Security Strategy**—As shown in Table 1, the data link access of function is divided into two classifications: Unsecured and Secured. Each of these functions are subclassified as: Read Data, Service Alteration, and Permanent Alteration. These classifications are allocated to three types of service tools: Standard Tools, Enhanced Tools, and Secured Tools. The allocation of access classification by service tool type should provide for normal service capability of the vehicle and protect the vehicle from "unauthorized" intrusion of certain critical functions.

TABLE 1—SECURITY AUTHORITY ACCESS
DATA LINK ACCESS FUNCTION (REFER TO SECTION 4.2)

Service Tool Type	Unsecured Read Data (4.2.1)	Unsecured Service Alteration (4.2.2)	Unsecured Permanent Alteration (4.2.3)	Secured Read Data (4.2.4)	Secured Service Alteration (4.2.5)	Secured Permanent Alteration (4.2.6)
Standard (SAE J1978)	X	B	B	NA	NA	NA
Enhanced	X	E	E	NA	NA	NA
Secured	X	X	X	X	X	X

X – Function Allowed
NA – Not Allowed
B – Basic Diagnostic Capability Per Vehicle Manufacturer's Specification
E – Enhanced Diagnostic Capability

4.2 **Data Link Access Function Examples**

4.2.1 UNSECURED READ DATA

Read emission related data.

Read emission related trouble codes.

4.2.2 UNSECURED SERVICE ALTERATION

Cycle device on/off.

Substitute sensor value.

4.2.3 UNSECURED PERMANENT ALTERATION

Change vehicle option/configuration data (i.e., tire size).

Reset electronic module.

4.2.4 SECURED READ DATA

Read keyless entry parameters.
Read executable code.

4.2.5 SECURED SERVICE ALTERATION

Vehicle assembly plant verification tests involving parameters not normally used in service.

4.2.6 SECURED PERMANENT ALTERATION

Alteration of a vehicle emission calibration.
Alteration of executable code.

4.3 Characteristics of Security—A special communications mode shall be provided to "Unlock" the on-board controllers which have secured or restricted functions. The security system is intended to make the emission related controller more immune to:

a. Unauthorized intrusion into the controller without full control of the product specific software.
b. Unauthorized alteration of the on-board control system or control parameters.

Disclosure of the "Seed/Key" relationship shall be limited to those persons, authorized by the vehicle manufacturer, who are responsible for the production of the secured service tool. The security system shall not prevent basic diagnostic or vehicle communications between external devices and the on-board controller.

There shall be three parameters which control the security access of the on-board controller:

a. The "Seed" and "Key" shall each be a minimum of 2 bytes in length. The relationship between the "Seed" and "Key" is the responsibility of the vehicle manufacturer. Multiple "Seed/Key" relationships may exist for access to different functions within a controller or systems within a vehicle.
b. The Delay Time (DT) shall be a minimum of 10 seconds; the vehicle manufacturer may specify an increased delay time to suit its specific requirements.
c. The Number of False Access Attempts (NFAA) shall be a maximum of two; the vehicle manufacturer may specify a reduced number of false attempts to suit its specific requirements. When the "Key" received by the controller is not correct, it shall be considered as a false access attempt; if access is rejected for any other reason, it shall not be considered a false access attempt.

4.4 Functional Requirements—Two request/response communication message pairs (Request #1/Response #1, Request #2/Response #2) shall be used to "Unlock" the on-board controller. The specific message content is not specified by this document and is the responsibility of the vehicle manufacturer.

a. Step 1—The external device shall request the on-board controller to "Unlock" itself by sending Request #1. The controller shall respond by sending a "Seed" using Response #1. A seed value of zero shall indicate that the controller is currently unlocked.
b. Step 2—The external device shall respond by returning a "Key" number back to the controller using Request #2. The controller shall compare this "Key" to one internally determined and issue Response #2.

If the two numbers agree, then the controller shall enable ("Unlock") the external device's access to secured communication modes.

If, upon "NFAA" attempts, the two keys do not compare (false attempt), then the controller shall insert the DT before allowing further attempts. The DT shall also be required at each controller power-up.

Three on-board controller responses shall be decoded by the external device:

a. Accept—The controller has "Unlocked" its access.
b. Invalid Key—The access attempt was rejected because the key was determined to be invalid by the controller; the access attempt was false.
c. Process Error—The access attempt was rejected for reasons other than receiving the wrong key; this shall not be counted as a false access attempt.

Termination of security access, "Locking" the product, shall result after any of the following conditions:

a. Each time the product is "powered up."
b. Upon commanding the product to a normal operational mode.
c. Conditions at the vehicle manufacturers discretion.

If an attempt is made to communicate with a "Locked" on-board controller and access a "Secured" function, the controller may return a special response indicating that the controller is "Locked" and cannot respond as requested.

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Appendix A - Diagnostic Test Mode Assignments

1. Scope—This SAE Recommended Practice describes the implementation of Enhanced Diagnostic Test Modes, which are intended to supplement the legislated Diagnostic Test Modes defined in SAE J1979. Modes are defined for access to emission related test data beyond what is included in SAE J1979, and for non-emission related data. This document describes the data byte values for diagnostic messages transmitted between diagnostic test equipment, either on-vehicle or off-vehicle, and vehicle electronic control modules. No distinction is made between test modes for emission related and non-emission related diagnostics. These messages can be used with a diagnostic serial data link such as described in SAE J1850 or ISO 9141-2.

For each test mode, this document includes a functional description of the test mode, request and response message data byte content, and an example if needed for clarification.

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—E/E Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms

SAE J1962—Diagnostic Connector

SAE J1978—OBD II Scan Tool

SAE J1979—E/E Diagnostic Test Modes

SAE J2012—Recommended Format and Messages for Diagnostic Trouble Codes

SAE J2178—Class B Data Communication Network Messages

SAE J2186—E/E Data Link Security

2.1.2 ISO PUBLICATIONS—Available from ANSI, 1 West 42nd Street, New York, NY 10036-8002.

ISO 9141-2—Road vehicles—Diagnostic systems—CARB requirements for interchange of digital information

2.1.3 CALIFORNIA ARB DOCUMENTS

Mail out #93-27—Title 13, California Code of Regulations: Section 1968.1 Malfunction and Diagnostic System: May 21, 1993Requirements—1994 and Subsequent Model Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines

2.1.4 FEDERAL EPA DOCUMENTS

40 CFR Part 86—Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines; Federal Register Regulations Requiring On-board Diagnostics

2.2 Definitions

2.2.1 DATA BYTES—Bytes between header bytes and error detection byte.

2.2.2 DIAGNOSTIC TEST MODE—See SAE J1930

2.2.3 OFFSET—A number used to refer to a data value by specifying its relative position in a list of data values.

2.2.4 PID—PARAMETER IDENTIFICATION NUMBER—A unique identifier used to refer to a specific data value within a module.

2.2.5 SEED / KEY—See SAE J2186

2.2.6 DPID—DATA PACKET IDENTIFICATION NUMBER—An identifier used to refer to a set of data values within a module.

2.2.7 BYTE—A group of eight bits of data, bits 0 through bit 7, where bit 7 is the most significant bit and bit 0 is the least significant bit.

2.2.8 $—Prefix defining a hexadecimal number

2.2.9 NIBBLE—Four bits of data. A byte may be split into two nibbles.

2.2.10 EPA—ENVIRONMENTAL PROTECTION AGENCY (FEDERAL AGENCY)

2.2.11 CARB—CALIFORNIA AIR RESOURCES BOARD (STATE AGENCY)

2.2.12 OBD II—Second generation of On-Board Diagnostic regulations required by the California Air Resources Board.

3. Technical Requirements

3.1 Test Mode Values—Figure 1 indicates the assignment of test mode values, and indicates the type of message and where they are defined, either in SAE J1979, this document, or by the manufacturer.

Test mode values $00 - $0F and $40 - $4F are reserved to be defined in SAE J1979, which currently only includes functionally addressed messages. Usage of shaded test mode values will be defined in this document. Appendix A indicates the test mode values currently defined by both SAE J1979 and SAE J2190.

There is a one-to-one correspondence between request messages and response messages, with bit 6 of the test mode value indicating the message type.

Test Mode Value	Message Type (bit 6)	Where defined
$00 - 0F	Request (bit 6 = 0)	SAE J1979
		SAE J2190
$41 - 4F	Response to Modes $00-$0F (bit 6 = 1)	SAE J1979
		SAE J2190
$10 - 3F	Request (bit 6 = 0)	Reserved for future expansion as needed
$50 - 5F		Defined by vehicle manufacturer
$60 - 6F	Response to Modes $00-$0F (bit 6 = 1)	Reserved for future expansion as needed
$70 - 7F		Defined by vehicle manufacturer

FIGURE 1—TEST MODE VALUES

3.2 Physical Addressing—Physical addressing is used for all diagnostic test mode messages defined in this document. Typically when using SAE J1850, this type of addressing requires that the target address of the device for which the message is intended be included in the header of the message. In ISO 9141, the addressing is typically done during initialization. Only that device being addressed will respond to the request. Each device will need to be assigned a unique address to be used for communication purposes.

3.3 Miscellaneous Requirements

3.3.1 MESSAGE RESPONSE TIME—The vehicle controllers should respond to a diagnostic request within 100 ms of a request. If there is no response within this time period, the tool can assume no response will be received.

3.3.2 AUTOMATIC RETURN TO NORMAL OPERATION—During a diagnostic procedure, the on-board controllers will often be put into an abnormal mode of operation to aid in diagnostics. Examples are to report diagnostic data periodically, to disable normal message transmission, or substitute an input or output parameter. In practice, the test procedure should return all on-board controllers to a normal mode of operation at the end of the procedure.

If a test device is disconnected from the vehicle before the on-board controllers have returned to normal operation, the controllers should automatically detect that the tool is disconnected and return to a normal mode of operation. This should be accomplished by the on-board controller looking for a diagnostic message from the test device, which should be apparent from the message header. If a diagnostic message is not received for a 5 s period of time, the on-board controller should automatically return to normal operation.

Some diagnostic procedures may require more than 5 s without a required diagnostic message. For these cases, this document specifies a "test tool present" message to be transmitted by the test device at least once every 5 s if there is no other message. On-board controllers should consider this as a diagnostic message and continue in the current mode of operation.

On-board controllers should also return to normal operation at power up or after a controller reset.

3.3.3 DIAGNOSTIC MESSAGE LENGTH—This document only defines the data bytes to be used in a diagnostic message. The actual number of data bytes in a message, referred to as "n" in the message data byte descriptions in this document, depends on the requirements of the test mode and the maximum number of bytes available in a diagnostic message. The maximum number of bytes available depends on the maximum allowable message length and the number of bytes used as a message header, error detection byte(s), or for other protocol specific purposes.

For example, the SAE J1850 data link effectively limits the total number of bytes in a message to 12. If the message strategy includes a 3 byte header, 1 byte CRC, and 1 byte in-message response, then 7 data bytes are available for SAE J2190 functionality. If the message strategy includes a 3 byte header and 1 byte CRC, then 8 data bytes are available.

If other data links are used as the diagnostic data link, such as ISO 9141, there may be other message length limitations and, therefore, different limits on the number of data bytes available for SAE J2190 functionality.

3.3.4 MESSAGE RESPONSE—All diagnostic request messages, except "Test Device Present (Mode $3F)," should receive a response from the target module. A response is optional for the "Test Device Present" message. There are two types of response messages, specific and general. Specific response messages are uniquely paired with each request message, and repeat enough data bytes of the request message to identify the specific request. The "General Response Message (Mode $7F)" has a single test mode value. The response message to be used for a request depends on the type of the request and whether or not the module can perform the request.

When the request is for data and the module can perform the request (positive response), only the specific form of the response can be used. The response will either be a single message, multiple messages with additional data, or periodic multiple messages with updated data values.

If the request is for action, such as a request for entering a mode of operation or command to perform a function, and the module can perform the request (positive response), either the specific response message or general response message can be used. Those requests for which either response type is a valid response have both response types indicated in this document.

If the request for either data or action cannot be performed by the module (negative response), only the general response message can be used.

Figure 2 summarizes the valid response types for different types of requests.

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	Positive responses	Negative responses
Request for data	Specific response only	General response only
Request for action	Specific or general response allowed	General response only

FIGURE 2—VALID RESPONSE TYPES

With the General Response Message a response code is returned. Response codes can indicate a negative or positive response. Standard response codes are included in the section with the definition of the General Response Message.

4. Test Modes

4.1 Modes $00 through $0F—Physically Addressed SAE J1979 Messages—Modes $00 through $0F are reserved to be defined in SAE J1979. The data byte content of the response to an SAE J1979 request when the device is addressed physically should be identical to the data byte content of the response when the device is addressed functionally. The only device that will respond to this request is the device to which the request is directed.

The response to one of these requests will be a Mode $40 through $4F message.

The same PID list as specified in SAE J1979 will apply when the device is physically addressed using the same test mode value. Although SAE J1979 reserves 256 PID values to be defined in that document, SAE J1979 specifies that PID values $21 to $3F are reserved to be defined in this document. Possible items which may be considered to be included are:

Number of header bytes and format
Use of CRC versus checksum for error detection
Use of in-message response
Maximum number of data bytes allowed (based on header and in-message response)
Use of manufacturer specific pins in the SAE J1962 connector

4.2 Mode $10—Initiate Diagnostic Operation

4.2.1 FUNCTIONAL DESCRIPTION—The purpose of this mode is to inform devices on the serial data link that a diagnostic tool is ready to start diagnostic procedures using the data link. The on-board devices may need to alter their normal operation in order for the diagnostic procedures to be effective. One example is that the system may need to reduce the amount of data being sent on the data link to make more time available for the diagnostic messages. Another possibility is that the system may need to degrade its normal operation in order to be able to process the diagnostic requests. Systems that rely on data from modules being diagnosed may not receive data from those modules as frequently as normal. Use of this mode could inform the receiving modules that diagnostic procedures are in progress and they should not set diagnostic trouble codes based on not receiving data at the normal frequency.

An optional "level of diagnostics" byte may be used to indicate how much the normal operation must be altered in order to accommodate the extra diagnostic procedures. These levels and their corresponding amount of change must be predefined in the module by the module manufacturer. The level of diagnostics can be changed by sending a subsequent Mode $10 command.

4.2.2 MESSAGE DATA BYTES—(See Figure 3.)

	Data Bytes (Hex)			
	#1	#2	#3 to #n-1	#n
Request from Tool to Vehicle				
Request diagnostic operation	10	Level (opt.)		
Positive Response from Vehicle to Tool (either of the following is a valid response)				
Confirm diagnostic operation	50	Level (opt.)		
General response	7F	Optional data bytes may be included (see Mode $7F description)		Resp. Code = 00

FIGURE 3—MESSAGE DATA BYTES FOR MODE $10

4.3 Mode $11—Request Module Reset

4.3.1 FUNCTIONAL DESCRIPTION—This mode requests the module to effectively perform a module power on reset. The response message may be sent either before or after the module is reset. The response message may also be sent by modules whenever they perform a power on reset, whether requested by this test mode or not.

An optional data byte may be included in the request to indicate different levels of reset. Examples are:

First time ever connected to vehicle
First time after battery disconnect
After a full normal power down / power up cycle
After minor power supply interruption

4.3.2 MESSAGE DATA BYTES—(See Figure 4.)

	Data Bytes (Hex)			
	#1	#2	#3 to #n-1	#n
Request from Tool to Vehicle				
Request module reset	11	Level (opt.)		
Positive Response from Vehicle to Tool (either of the following is a valid response)				
Confirm module reset	51	Level (opt.)		
General response	7F	Optional data bytes may be included (see Mode $7F description)		Resp. Code = 00

FIGURE 4—MESSAGE DATA BYTES FOR MODE $11

4.4 Mode $12—Request Diagnostic Freeze Frame Data

4.4.1 FUNCTIONAL DESCRIPTION—The purpose of this mode is to allow access to data values which were stored during freeze frame conditions specified by the vehicle manufacturer. Data content, data format, and method of retrieval are specified by the vehicle manufacturer. Typical uses for this mode are to report data stored upon detection of a system malfunction. Multiple frames of data may be stored before and/or after the malfunction is detected. The request for information includes a frame number followed by an optional indication of the data requested.

If the optional data byte is not used, or is $00, then all data for the requested freeze frame will be reported. If the optional byte is used, then the vehicle manufacturer will define the different methods used to specify which data is requested.

The on-board module will respond to this message by transmitting the requested data.

4.4.2 MESSAGE DATA BYTES—(See Figure 5.)

	Data Bytes (Hex)			
	#1	#2	#3	#4 to #n
Request from Tool to Vehicle				
Request diagnostic freeze frame data	12	Frame No.	Method to request data (optional) examples are: Request all data (not included or 00) Request by offset (1 byte) Request by PID (2 bytes) Request by memory address (3 bytes) Request by Data Packet ID Request starting address for data DTC which caused data to be stored Other manufacturer specific method	
Positive Response from Vehicle to Tool				
Report diagnostic freeze frame data	52	Frame No.	Data Byte	Additional optional data bytes that are in response to the request may be added to fill the message up to the maximum number of available data bytes.

FIGURE 5—MESSAGE DATA BYTES FOR MODE $12

4.5 Mode $13—Request Diagnostic Trouble Code Information

4.5.1 FUNCTIONAL DESCRIPTION—The purpose of this mode is to enable a diagnostic test tool to obtain stored emission and non-emission related diagnostic trouble code (DTC) information.

This mode includes the option to request DTC information by function, where function is either powertrain, body, chassis, or undefined. These are the functions used in SAE J2012 to group trouble codes. The first two bits of the first nibble for requests by function are encoded using the same convention as when codes are reported:

00 - powertrain

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01 - chassis
10 - body
11 - undefined

For requests by function using this test mode, the second two bits of the first nibble are 00, and the second nibble is all zeroes. This translates to the following function groups for DTC requests:

$00 - powertrain codes
$40 - chassis codes
$80 - body codes
$C0 - undefined

In addition, this document defines $FF as the function group to request DTC information for all functions.

This test mode can be used to either request diagnostic trouble codes, or request the number of diagnostic trouble codes. There are two ways this mode can request DTCs.

All codes can be requested by including only the test mode value in the request.

Codes can be requested by function group (Powertrain, Chassis, Body, Undefined, or All) by sending the function group followed by $00 as data bytes 2 and 3 ($00 00, $40 00, $80 00, $C0 00, or $FF 00). Requesting codes for all function groups by including $FF 00 yields the same response as not including function group in the request, but may be desired by a manufacturer for consistency with other messages.

There are also two ways this mode can request the number of DTCs.

Number of codes can be requested by including the function group as data byte 2, and not including data byte 3 ($FF as data byte 2 must be supported as a minimum to request the total number of DTC).

Number of codes can be requested by function group (Powertrain, Chassis, Body, Undefined, or All) by sending the function group followed by $FF as data bytes 2 and 3 ($00 FF, $40 FF, $80 FF, $C0 FF, or $FF FF). Requesting number of codes for all function groups by including $FF ff yields the same response as including only $FF as data byte 2 in the request, but may be desired by a manufacturer for consistency with other messages.

The response to a Mode $13 request for DTC will be one or more Mode $53 messages. If no codes are stored in the module, then the module will respond with one of the following:

Mode $53 with no additional data bytes
Mode $53 padded with $00 00 to fill response

Diagnostic trouble codes are transmitted as two bytes. 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 - "Recommended Format and Messages for Diagnostic Trouble Codes" 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 interpreted as P0143, as shown in Figure 6.

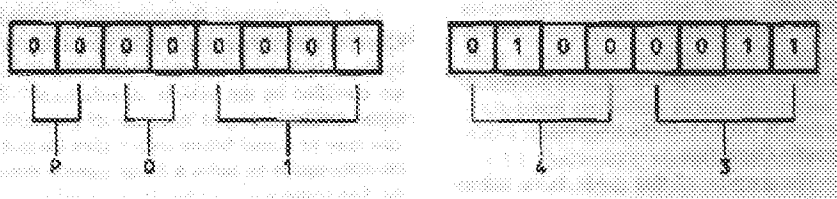


FIGURE 6—DIAGNOSTIC TROUBLE CODE EXAMPLE

4.5.2 MESSAGE DATA BYTES—(See Figure 7.)

	Data Bytes (Hex)			
	#1	#2	#3	#4 to #n
Request from Tool to Vehicle (either of the following messages can be used to request DTC)				
Request all DTC	13			
Request DTC by function group where group is: 00 - powertrain 40 - chassis 80 - body C0 - undefined FF - all	13	Group	00	
Request from Tool to Vehicle (either of the following messages can be used to request number of DTC)				
Request number of DTC by function where group is: 00 - powertrain 40 - chassis 80 - body C0 - undefined FF - all	13	Group		
FF in byte 3 is an optional code used to maintain a fixed length request	13	Group	FF	
Positive Response from Vehicle to Tool (Multiple messages may be required to report the DTCs)				
Report stored DTC (Number to receive for DTC)	53	Diagnostic trouble code or 00 00 (optional)	Additional optional diagnostic trouble codes may be added to fill the message up to the maximum number of available data bytes.	
Report # of stored DTC (Number to expect for number of DTC)	53	Number of codes		

NOTE: Refer to SAE J2012 for encoding method for trouble codes.

FIGURE 7—MESSAGE DATA BYTES FOR MODE $13

4.6 Mode $14—Clear Diagnostic Information

4.6.1 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 diagnostic information. This information includes primarily diagnostic trouble codes, but can also include freeze frame data or other on-board test results that may be stored as a result of the trouble code being set. This extra information is device dependent.

There are three ways this mode can be used. If only the test mode value is included in the request, then all diagnostic information stored in the module is to be cleared.

Diagnostic information can optionally be cleared by function (Powertrain, Chassis, or Body) by sending P0000, C0000, or B0000 as data bytes 2 and 3. These must be encoded using the same convention as when codes are reported (see description for Mode $13). The first two bits of the first nibble are:

00 - powertrain
01 - chassis
10 - body
11 - undefined

This translates to the following values for data bytes #2 and #3:

$00 00 - powertrain codes
$40 00 - chassis codes
$80 00 - body codes
$C0 00 - undefined

Diagnostic information can also optionally be cleared for a single trouble code by including the trouble code to clear as optional bytes in the request. The information stored with an individual trouble code would need to be clearly identified within the module and cleared at the same time.

Caution when clearing by single trouble code: This capability should not be provided and used unless consideration is given to the possible consequences of this option. If a single fault caused multiple trouble codes to be set, and a service technician found a defective component, repaired it, and cleared a single trouble code associated with that fault, then the device would still contain trouble codes that were set based on that fault. The next technician to check codes would read those codes, and if he did not know the vehicle history, he may try to repair the vehicle based only on the remaining trouble codes, which could waste time and result in replacement of good components.

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Allowing use of this feature to clear emission related trouble codes should be rendered very carefully to guard against improper diagnosis. Difficult interpretation can result if the system allowed clearing a single emission related trouble code. CARB required information could report that trouble codes are stored but they would not be reported when an SAE J1979 Mode $04 message is sent to request those codes. Freeze frame data could be stored for a given trouble code, but that code would not be reported as stored.

4.6.2 MESSAGE DATA BYTES—(See Figure 8.)

	Data Bytes (Hex)				
	#1	#2	#3	#4 to #n-1	#n
Request from Tool to Vehicle					
Clear stored diagnostic information	14	Data bytes 2 and 3 are optional if not used - clear all information if 00 00 - clear all powertrain information if 40 00 - clear all chassis information if 80 00 - clear all body information if C0 00 - clear all Dx or DTC information if FF 00 - clear all information any other value - trouble code to clear			
Positive Response from Vehicle to Tool (either of the following is a valid response)					
Request information OK	54	repeat data bytes 2 and 3 of request, if used			
Invalid response	7F	Optional data bytes may be included (see Mode $7F description)			Resp. Code - 00

FIGURE 8—MESSAGE DATA BYTES FOR MODE $14

4.7 Mode $17—Request Status of Diagnostic Trouble Codes

4.7.1 FUNCTIONAL DESCRIPTION—The purpose of this mode is to provide a means to determine the status of diagnostic trouble codes.

This mode is nearly identical in operation to Mode $13, except that only 2 byte DTC, followed by the status of that DTC, is reported in a single response. The mode also allows a request for the status of a single DTC. The classification of function groups and the method of reporting DTCs is identical to the description in Mode $13.

This test mode can be used to either request status of diagnostic trouble codes, or request the number of diagnostic trouble codes with a status bit set. There are two ways this mode can request DTCs.

All codes can be requested by only including the test mode value in the request.

Codes can be requested by function group (Powertrain, Chassis, Body, Undefined, or All) by sending the function group followed by $00 as data bytes 2 and 3 ($00 00, $40 00, $80 00, $C0 00, or $FF 00). Requesting codes for all function groups by including $FF 00 yields the same response as not including function group in the request, but may be desired by a manufacturer for consistency with other messages.

Status of a single trouble code can be requested by including the trouble code as data bytes 2 and 3 in the request.

There are two ways this mode can request the number of DTCs with a status bit set.

Number of codes can be requested by including the function group as data byte 2, and not including data byte 3 ($FF as data byte 2 must be supported as a minimum to request the total number of DTCs).

Number of codes can be requested by function group (Powertrain, Chassis, Body, Undefined, or All) by sending the function group followed by $FF as data bytes 2 and 3 ($00 FF, $40 FF, $80 FF, $C0 FF, or $FF FF). Requesting number of codes for all function groups by including $FF FF yields the same response as including only $FF as data byte 2 in the request, but may be desired by a manufacturer for consistency with other messages.

Multiple Mode $57 response messages may be reported due to a single Mode $17 request message, depending on the type of request and the number of diagnostic trouble codes stored in the module. Each response message will report the status of a single DTC. If no codes are stored in the module, then the module will respond with one of the following:

Mode $57 with no additional data bytes

Mode $57 with $00 00 for DTC and $00 for status

4.7.2 MESSAGE DATA BYTES—(See Figure 9.)

	Data Bytes (Hex)			
	#1	#2	#3	#4
Request from Tool to Vehicle (One of the following messages can be used to request DTC)				
Request status of all DTC	17			
Request status of DTC by function group where group: 00 - powertrain 40 - chassis 80 - body C0 - undefined FF - all	17	Group	00	
Request status of specific DTC	17	Diagnostic Trouble Code		
Request from Tool to Vehicle (either of the following messages can be used to request number of DTC)				
Request number of DTC with a status bit set by function where group is: 00 - powertrain 40 - chassis 80 - body C0 - undefined FF - all	17	Group		
FF in byte 3 is an optional byte used to maintain a fixed length request	17	Group	FF	
Positive Response from Vehicle to Tool (Multiple messages may be required to report the DTCs)				
Report status of stored DTC	57	Diagnostic trouble code or 00 00 (reserved)	Status of DTC or 00 (optional if DTC not reported); same definition as Data Byte #2 for Mode $18	
Report # of stored DTC with any status bit set	57	Number of DTC codes		

FIGURE 9—MESSAGE DATA BYTES FOR MODE $17

4.8 Mode $18—Request Diagnostic Trouble Codes by Status

4.8.1 FUNCTIONAL DESCRIPTION—This mode is used to retrieve diagnostic trouble codes based on the status by which they have been stored. There are various conditions under which codes are generated, for example, under normal customer driving conditions versus "on demand" codes which are generated by tests performed by the service technician. Another difference is that some codes illuminate a warning lamp while other codes do not. Some codes are retained in memory for at least 40 warmup cycles while some codes are retained only for one ignition/power up cycle.

This test mode is similar in operation to Mode $17, except that an additional data byte is inserted as data byte #2 to indicate the specific status bits of interest. Data bytes #3 and #4 in Mode $18 request have the same meaning as data bytes #2 and #3 in Mode $17 requests.

There are many philosophies among the various manufacturers for storing codes. Bit definitions have been assigned to the more commonly accepted methods. Codes stored under that definition can be requested by setting the appropriate bit(s) to "1" to retrieve the set of desired codes.

Table 1 shows the interpretation of each bit of the status byte. This definition is used for both Modes $13 and $18. Multiple bits can be set to "1". When requesting codes using Mode $18, codes with any of the requested status bits will be reported.

Multiple Mode $58 response messages may be reported to a single request, depending on the number of diagnostic trouble codes stored in the module. Each response message will report up to three DTCs for which at least one of the requested status bits is set. If no codes are stored in the module that meet the requested status, then the module will respond with one of the following:

Mode $58 with Status Requested and no additional data bytes

Mode $58 with $00 00 as data bytes 3 and 4

Mode $58 with $00 00 repeated to fill response

TABLE 1—INTERPRETATION OF EACH BIT OF THE STATUS BYTE

bit	status
7	Warning lamp illuminated for this code
6	Warning lamp pending for this code, not illuminated but malfunction was detected
5	Warning lamp was previously illuminated for this code, malfunction not currently detected, code not yet erased
4	Stored trouble code
3	Manufacturer specific status
2	Manufacturer specific status
1	Current code - present at time of request
0	Maturing/intermittent code - insufficient data to consider as a malfunction

4.8.2 MESSAGE DATA BYTES—(See Figure 10.)

	Data Bytes (Hex)				
	#1	#2	#3	#4	#5 to #n
Request from Tool to Vehicle (either of the following messages can be used to request DTC)					
Request all DTC with status	18	Status			
Request all DTC with status and function group where group is: 00 - powertrain 40 - chassis 80 - body C0 - undefined FF - all	18	Status	Group	00	
Request from Tool to Vehicle (either of the following messages can be used to request number of DTC)					
Request number of DTC with any specific status bits set by function group: 00 - powertrain 40 - chassis 80 - body C0 - undefined FF - all	18	Status	Group		
FF in byte # is an optional byte used to maintain a fixed length request	18	Status	Group	FF	
Positive Response from Vehicle to Tool					
Report DTC by status - response to request with last mode and status	58	Status mask	Diagnostic trouble code or 00 00 (optional)		Additional optional diagnostic trouble codes may be added to fill this message up to the maximum number of available data bytes.
Report DTC by status - response to request with last mode, status, and data byte #3	58	Status mask	number of DTC with mask's status		

FIGURE 10—MESSAGE DATA BYTES FOR MODE $18

4.9 Mode $20—Return to Normal Operation

4.9.1 FUNCTIONAL DESCRIPTION—The on-board device will return to the normal mode of operation when this message is received. All normal algorithms and normal communications will be resumed. All active diagnostic modes will be terminated without sending additional request or response messages. If the module had been unlocked using security access, then the module should also be locked.

4.9.2 MESSAGE DATA BYTES—(See Figure 11.)

	Data Bytes (Hex)		
	#1	#2 to #n-1	#n
Request from Tool to Vehicle			
Request return to normal operation	20		
Positive Responses from Vehicle to Tool (either of the following is a valid response)			
Confirm return to normal operation	60		
General response	7F	Optional data bytes may be included (see Mode $7F description)	Resp. Code - 00

FIGURE 11—MESSAGE DATA BYTES FOR MODE $20

4.10 Modes $21 to $23—Request Diagnostic Data

4.10.1 FUNCTIONAL DESCRIPTION—The purpose of these modes is to request data values, such as analog inputs and outputs, digital inputs and outputs, block frame data, calculated values, bit mapped fault code data, and system status information. The request for information can be by one of three methods:

Mode $21 - Offset (1 byte)

Mode $22 - Parameter Identification (PID) value (2 bytes)

Mode $23 - Memory Address (3 bytes)

System designers have the flexibility to maintain a table including PID numbers and data values, without having consecutive PID numbers. In this case, the tool can request either by PID number or offset. A request by offset is generally an easier method for the software to retrieve data because it does not need to search for the PID in the table. Mode $24 allows use of the PID number one time to get the offset, with successive requests by offset for better system performance.

Figure 12 is an example of a table that could be included in the system module to utilize all of these modes. The offset is the row number of the table and is not a table entry. The location of the information within this table can be calculated by multiplying the offset times the number of bytes in each row. The location in memory can then be calculated by adding the location within the table to the base location of the table in memory.

Offset	PID1	PID2	ADDR1	ADDR2	ADDR3	SCALING1	SCALING2
00	00	01	00	1B	F8		
01	0D	0A	00	2C	12		
02	01	FE	00	8A	1F		
..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..
XX	04	2C	00	45	8A		

FIGURE 12—OFFSET/PID/ADDRESS TABLE EXAMPLE

A Mode $21 request by offset would calculate the location of the offset information in the table, find the address and scaling for that value, and return the appropriate number of bytes of information starting at that address.

A Mode $22 request by PID would search through the table for the requested PID, find the address and scaling for that value, and return the appropriate number of bytes of information starting at that address.

A Mode $23 request by address would ignore this table and report data starting at the address specified in the request.

4.10.2 MODE $21 MESSAGE DATA BYTES—(See Figure 13.)

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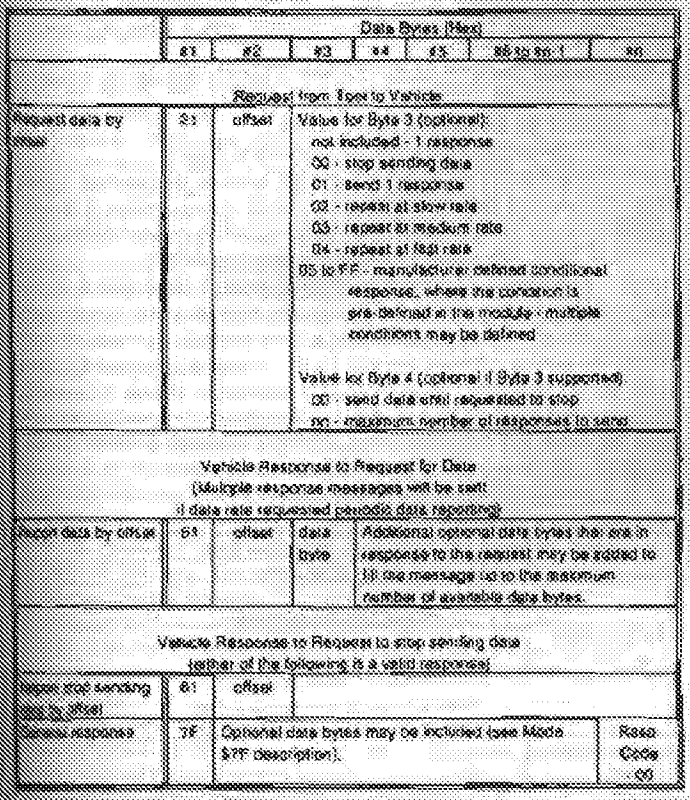


FIGURE 13—MESSAGE DATA BYTES FOR MODE $21

4.10.3 MODE $22 MESSAGE DATA BYTES—(See Figure 14.)

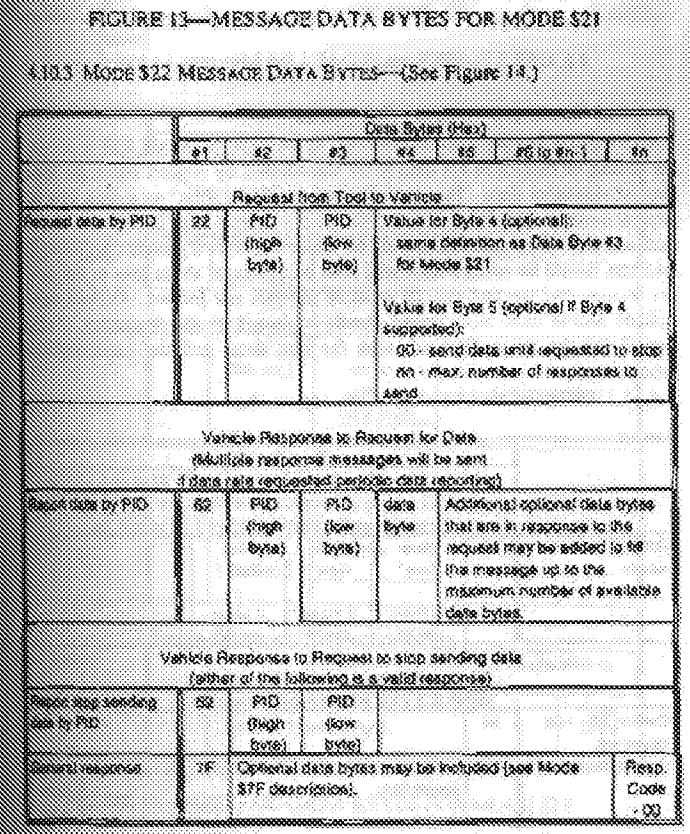


FIGURE 14—MESSAGE DATA BYTES FOR MODE $22

4.10.4 MODE $23 MESSAGE DATA BYTES—(See Figure 15.)

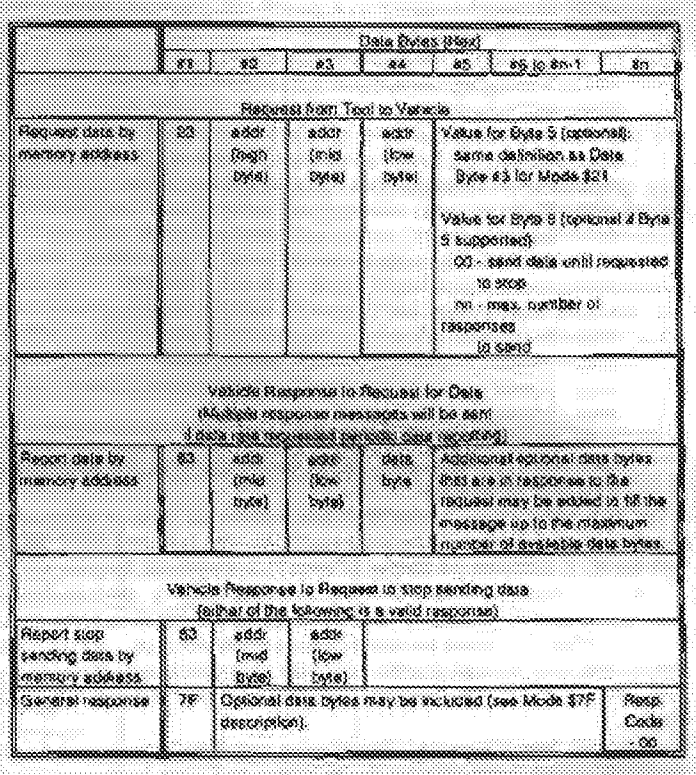


FIGURE 15—MESSAGE DATA BYTES FOR MODE $23

4.11 Mode $24—Request Scaling and Offset / PID

4.11.1 FUNCTIONAL DESCRIPTION—The purpose of Mode $24 is to request either scaling and PID information by specifying offset, or request scaling and offset information by specifying PID. $FF should be included in the request for the data byte value not being specified. If both offset and Parameter ID are specified, and the parameter ID is not correct for the offset specified, unexpected data values can be returned. Operation of this mode is similar to either Mode $21 or $22, depending on which value was specified in the request. The response would include offset, PID, and scaling for the requested entry. Any data byte values not supported by the module would report $FF.

Mode $24 can also be used to determine the PID table by incrementing the offset in repeated Mode $24 requests.

4.11.2 MESSAGE DATA BYTES—(See Figure 16.)

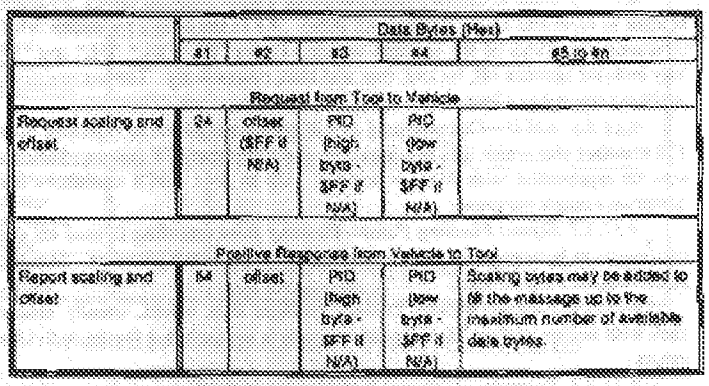


FIGURE 16—MESSAGE DATA BYTES FOR MODE $24

4.11.3 SCALING BYTE 1

High nibble (bits 7 to 4)

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	Data Bytes (Hex)						
	#1	#2	#3	#4	#5	#6 to #n-1	#n
Request from Tool to Vehicle							
Request data by offset	$21	offset	Value for Byte 3 (optional): not included - 1 response 00 - stop sending data 01 - send 1 response 02 - repeat at slow rate 03 - repeat at medium rate 04 - repeat at fast rate 05 to FF - manufacturer defined conditional responses, where the condition is pre-defined in the module - multiple conditions may be defined Value for Byte 4 (optional if Byte 3 supported): 00 - send data until requested to stop nn - maximum number of responses to send					
Vehicle Response to Request for Data (Multiple response messages will be sent if data rate requested periodic data reporting)							
Report data by offset	$61	offset	data byte	Additional optional data bytes that are in response to the request may be added to fill the message up to the maximum number of available data bytes.			
Vehicle Response to Request to stop sending data (either of the following is a valid response)							
Report stop sending data by offset	$61	offset					
General response	7F	Optional data bytes may be included (see Mode $7F description).					Resp. Code - 00

FIGURE 13—MESSAGE DATA BYTES FOR MODE $21

4.10.3 MODE $22 MESSAGE DATA BYTES—(See Figure 14.)

	Data Bytes (Hex)						
	#1	#2	#3	#4	#5	#6 to #n-1	#n
Request from Tool to Vehicle							
Request data by PID	$22	PID (high byte)	PID (low byte)	Value for Byte 4 (optional): same definition as Data Byte #3 for Mode $21 Value for Byte 5 (optional if Byte 4 supported): 00 - send data until requested to stop nn - max. number of responses to send			
Vehicle Response to Request for Data (Multiple response messages will be sent if data rate requested periodic data reporting)							
Report data by PID	$62	PID (high byte)	PID (low byte)	data byte	Additional optional data bytes that are in response to the request may be added to fill the message up to the maximum number of available data bytes.		
Vehicle Response to Request to stop sending data (either of the following is a valid response)							
Report stop sending data by PID	$62	PID (high byte)	PID (low byte)				
General response	7F	Optional data bytes may be included (see Mode $7F description).					Resp. Code - 00

FIGURE 14—MESSAGE DATA BYTES FOR MODE $22

4.10.4 MODE $23 MESSAGE DATA BYTES—(See Figure 15.)

	Data Bytes (Hex)						
	#1	#2	#3	#4	#5	#6 to #n-1	#n
Request from Tool to Vehicle							
Request data by memory address	$23	addr (high byte)	addr (mid byte)	addr (low byte)	Value for Byte 5 (optional): same definition as Data Byte #3 for Mode $21 Value for Byte 6 (optional if Byte 5 supported): 00 - send data until requested to stop nn - max. number of responses to send		
Vehicle Response to Request for Data (Multiple response messages will be sent if data rate requested periodic data reporting)							
Report data by memory address	$63	addr (mid byte)	addr (low byte)	data byte	Additional optional data bytes that are in response to the request may be added to fill the message up to the maximum number of available data bytes.		
Vehicle Response to Request to stop sending data (either of the following is a valid response)							
Report stop sending data by memory address	$63	addr (mid byte)	addr (low byte)				
General response	7F	Optional data bytes may be included (see Mode $7F description).					Resp. Code - 00

FIGURE 15—MESSAGE DATA BYTES FOR MODE $23

4.11 Mode $24—Request Scaling and Offset / PID

4.11.1 FUNCTIONAL DESCRIPTION—The purpose of Mode $24 is to request either scaling and PID information by specifying offset, or request scaling and offset information by specifying PID. $FF should be included in the request for the data byte value not being specified. If both offset and Parameter ID are specified, and the parameter ID is not correct for the offset specified, unexpected data values can be returned. Operation of this mode is similar to either Mode $21 or $22, depending on which value was specified in the request. The response would include offset, PID, and scaling for the requested entry. Any data byte values not supported by the module would report $FF.

Mode $24 can also be used to determine the PID table by incrementing the offset in repeated Mode $24 requests.

4.11.2 MESSAGE DATA BYTES—(See Figure 16.)

	Data Bytes (Hex)				
	#1	#2	#3	#4	#5 to #n
Request from Tool to Vehicle					
Request scaling and offset	$24	offset ($FF if N/A)	PID (high byte - $FF if N/A)	PID (low byte - $FF if N/A)	
Positive Response from Vehicle to Tool					
Report scaling and offset	$64	offset	PID (high byte - $FF if N/A)	PID (low byte - $FF if N/A)	Scaling bytes may be added to fill the message up to the maximum number of available data bytes.

FIGURE 16—MESSAGE DATA BYTES FOR MODE $24

4.11.3 SCALING BYTE 1

High nibble (bits 7 to 4)

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data type:
0000 - Unsigned numeric (1 to 4 bytes)
0001 - Signed numeric (1 to 4 bytes)
0010 - Bit mapped, reported without mask
0011 - Bit mapped, reported with mask
0100 - BCD (1 to 4 bytes)
0101 - State encoded
0110 - ASCII
0111 - Signed floating point (ANSI/IEEE Std 754-1985)
1000 - Packet
1001 - Formula
1010 thru 1111 - Reserved

Low nibble (bits 3 to 0):
number of bytes of value:
0000 - Reserved
0001 - 1 byte
0010 - 2 bytes
0011 - 3 bytes
0100 - 4 bytes
0101 thru 1111 - Reserved - may be greater than 4 for non-numeric data (ASCII or bit-mapped)

The high order nibble of the first byte defines the type of information encoding which is used to represent the parameter. The low order nibble can be read directly to determine the number of bytes used to represent the parameter.

4.11.3.1 Unsigned Numeric—This encoding uses a common binary weighting scheme to represent a value by means of discrete incremental steps. One byte affords 256 steps; two bytes yields 65 536 steps, etc. For example, vehicle speed may be encoded with a single unsigned numeric parameter ranging from 0 to 255 km/h. This unsigned numeric value may be up to 4 bytes in length.

4.11.3.2 Signed Numeric—This encoding uses a twos complement binary weighting scheme to represent a value by means of discrete incremental steps. One byte affords 256 steps; two bytes yields 65,536 steps, etc. A value can be encoded with a single unsigned numeric parameter ranging from -127 to 128. This signed numeric value may be up to 4 bytes in length.

4.11.3.3 Bit Mapped—Bit mapped encoding uses individual bits or small groups of bits to represent status. For every bit which represents status, a corresponding mask bit is required as part of the parameter definition. The mask indicates the validity of the bit for particular applications. A bit mapped parameter may contain 2 bytes; one representing status and one containing the validity mask, or 4 bytes; the first two representing status and the second two containing validity masks. Reference J2178, Part 2 for a discussion of bit mapped data values.

4.11.3.4 BCD—Conventional BCD encoding is used to represent two numeric digits per byte. The upper nibble is used to represent the most significant digit (0 - 9), and the lower nibble the least significant digit (0 - 9). Up to 8 characters (4 bytes) may comprise a single parameter.

4.11.3.5 State Encoded—This encoding uses a common binary weighing scheme to represent up to 256 distinct states. An example is a parameter which represents the status of the ignition switch. Codes "00," "01," "02," and "03" may indicate ignition off, locked, run, and start, respectively. The representation is always limited to 1 byte.

4.11.3.6 ASCII—Conventional ASCII encoding is used to represent up to 128 standard characters (MSB = logic 0). An additional 128 custom characters may be represented with MSB = logic 1. Up to four ASCII characters may comprise a single parameter.

4.11.3.7 Signed Floating Point—Floating point encoding is used for data that needs to be represented in floating point or scientific notation. Standard IEEE formats shall be used.

4.11.3.8 Packet—Packets contain multiple data values, usually related, each with unique scaling. Scaling information is not included for the individual values.

4.11.3.9 Formula—Different formulas are currently being discussed to be included. The formula type and constant values used in those formulas will be specified in scaling bytes, or reported as a different test mode.

4.11.4 SCALING BYTE 2—This byte is only relevant for signed and unsigned numbers and for bit mapped parameters. For other parameter types, this field is "padded" with $00. When used with signed and unsigned numbers, this byte specifies scaling by indicating the binary point location. The binary point may be moved 127 places to the right ($FF) or 128 places to the left ($80). The binary point is initially assumed to be to the right of the LSB without this information.

When this byte is used for bit mapped parameters that are reported without a mask, this byte indicates which bits of the PID are supported for the current application. When bit mapped data is reported with a mask, this byte is not used.

When the data type is "formula," this byte is used to indicate the formula type, where:

$00 - $7F are reserved for SAE to define
$80 - $FF are reserved for the manufacturer to define

4.11.5 SCALING BYTES 3 TO n—Optional bytes to be included if multiple bytes of bit mapped data are reported. This mode is more limiting in the number of masks that can be reported than the modes that allow retrieval of the data.

4.12 Mode $25—Stop Transmitting Requested Data

4.12.1 FUNCTIONAL DESCRIPTION—The purpose of Mode $25 is to stop a data transmission that was started by any test mode that can request repetitive data. If only an individual data request is to be stopped, then that value can be stopped by sending a request message for the mode that requested the data with a "0" for the data rate. In practice, if a message is already in an output message queue ready to be sent, this would probably not remove that message from the queue, but it would prevent additional messages from being added to the queue. Response is either Mode $65 or general response.

4.12.2 MESSAGE DATA BYTES—(See Figure 17.)

	Data Bytes (Hex)		
	#1	#2 to #n-1	#n
Request from Tool to Vehicle			
Request all data stop	25		
Positive Response from Vehicle to Tool (either of the following is a valid response)			
Confirm all data stopped	65		
General response	7F	Optional data bytes may be included (see Mode $7F description)	Resp. Code - 00

FIGURE 17—MESSAGE DATA BYTES FOR MODE $25

4.13 Mode $26—Specify Data Rates

4.13.1 FUNCTIONAL DESCRIPTION—The purpose of Mode $26 is to specify the setting of data rates for data to be transmitted by request messages that will request repetitive data. Those modes include "Data Rate" as a data byte in the request message. Modules will normally have default rates associated with slow, mid, and fast. The slow rate should be about one or two samples per second, the mid rate should be normal handheld scan tool rates of about four to ten samples per second, and the fast rate 20 or more samples per second. Default rates are defined within each module and should be based on the frequency of change typical for the value reported, uses for that data, and the capability of the processor.

4.13.2 MESSAGE DATA BYTES—(See Figure 18.)

	Data Bytes (Hex)					
	#1	#2	#3	#4	#5 to #n-1	#n
Request from Tool to Vehicle						
Request data rate values	26	Slow Rate * - 40 msec per bit	Mid Rate * - 2 msec per bit	Fast Rate * - 1 msec per bit		
Positive Response from Vehicle to Tool (either of the following is a valid response)						
Confirm data rate values set	66					
General response	7F	Optional data bytes may be included (see Mode $7F description)				Resp. Code - 00

* NOTE: A value of $00 should cause the data to be reported as fast as possible. A value of $FF will cause no change in the current data rate.

FIGURE 18—MESSAGE DATA BYTES FOR MODE $26

4.14 Mode $27—Security Access Mode

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4.14.1 FUNCTIONAL DESCRIPTION—The primary purpose of this mode is to prevent unauthorized intrusion into the on-board controller. Improper programs can potentially damage the electronics or other vehicle components or risk the vehicle's compliance to emission or safety standards. This mode is intended to be used to implement the data link security measures defined in SAE J2186.

The external device will request the controller to "Unlock" itself by sending Request #1. The controller will respond by sending a "Seed" using Response #1. The external device will respond by returning a "Key" number back to the controller using Request #2. The controller would compare this "Key" to one internally stored. If the two numbers agree, then the controller will enable (unlock) the external device's access to specific test modes and indicate that with Mode $67, Response #2. If upon two attempts of a Request #2 where the two keys do not compare, then the controller will insert a 10 s time delay before allowing further attempts. This time delay will also be required before responding to a Mode $27 request #1 for each controller power-on.

If a device supports security, but is already unlocked when a Request #1 is received, that device should respond with a Response #1 message with a seed of $0000. A test device could use this method to determine if a device is locked by looking for a non-zero seed.

The security system will not prevent normal diagnostic or vehicle communications between external devices and the on-board controller. Proper "unlocking" of the controller is a prerequisite to the external device's ability to select some of the more critical functions such as reading specific memory locations within the controller, downloading information to specific locations, or executing routines for execution by the controller. In other words, the only access to the controller permitted while in a "locked" mode is through the vehicle specific software. This permits the product specific software to protect itself from unauthorized intrusion.

Devices that provide security should support reject messages if a secure mode is requested while the device is locked. The reject message to be returned is a general response message Mode $7F, with a response code $33 to indicate the device is secured.

Some devices could support multiple levels of security, either for different features controlled by the device, or to allow different capabilities to be accessed. These additional levels of security can be accessed by using requests #3 and #4 etc. The second data byte of the request for seed should always be an odd number, and the second data byte of the message to send the key should be the next even number.

4.14.2 MESSAGE DATA BYTES—(See Figure 19.)

	Data Bytes (Hex)					
	#1	#2	#3	#4	#5 to #n-1	#n
Request #1 from Tool to Vehicle (data byte #2 can be an odd number greater than $01 if additional levels of security are supported)						
Request "Seed"	27	01 (03, etc.)				
Positive Response #1 from Vehicle to Tool						
Send "Seed"	67	01 (03, etc.)	Seed ($0000 if module is not locked)		(Optional data bytes may be specified by the vehicle manufacturer)	
Request #2 from Tool to Vehicle (data byte #2 can be an even number one greater than data byte #2 of request #1 if additional levels of security are supported)						
Send "Key"	27	02 (04, etc.)	Key			
Positive Response #2 from Vehicle to Tool						
Security access	67	02 (04, etc.)	Optional data bytes may be specified by the vehicle manufacturer			
General response	7F	Optional data bytes may be included (see Mode $7F description)				Resp. Code = 33

FIGURE 19—MESSAGE DATA BYTES FOR MODE $27

4.15 Mode $28—Disable Normal Message Transmission

4.15.1 FUNCTIONAL DESCRIPTION—The purpose of this mode is to inhibit the external device from transmitting normal operating data on the link, while still performing other functions normally. The device will continue to operate in whatever diagnostic mode it was operating in prior to the Mode $28 command.

If an unsafe or undesirable vehicle operating condition would result from the lack of normal messages, then this mode could cause all nonessential messages to be inhibited. The optional manufacturer specific "level" data byte could be used to indicate which normal mode messages to disable. Defining which messages to disable is determined by the system designer to ensure safe vehicle operation. When using this test mode, some provision must be made to allow for other devices that rely on information from the silenced device so that they do not set diagnostic trouble codes due to the lack of required information.

One use for this test mode is to reduce message traffic on the data link. This would make more time available for diagnostic messages. Another use for this mode is to allow the test equipment to emulate the remote device for diagnostic purposes. In this scenario, the test device would send a Mode $28 request to the device to be emulated. The test device would then respond to all normal communication request messages directed to that device, most likely with data intended to cause a known response by a system that uses the information in the response. The test device can then observe the actions of those systems.

4.15.2 MESSAGE DATA BYTES—(See Figure 20.)

	Data Bytes (Hex)			
	#1	#2	#3 to #n-1	#n
Request from Tool to Vehicle				
Request disable normal message transmission	28	Level (opt.)		
Positive Response from Vehicle to Tool (either of the following is a valid response)				
Confirm normal message transmission disabled	68	Level (opt.)		
General response	7F	Optional data bytes may be included (see Mode $7F description)		Resp. Code = 22

FIGURE 20—MESSAGE DATA BYTES FOR MODE $28

4.16 Mode $29—Enable Normal Message Transmission

4.16.1 FUNCTIONAL DESCRIPTION—The purpose of this mode is to cause an on-board device to resume normal communications after previously disabling those messages by a Mode $28 command. The device will continue to operate in whatever diagnostic modes were set by previous messages, such as executing on-board routines.

4.16.2 MESSAGE DATA BYTES—(See Figure 21.)

	Data Bytes (Hex)		
	#1	#2 to #n-1	#n
Request from Tool to Vehicle			
Request enable normal message transmission	29		
Positive Response from Vehicle to Tool (either of the following is a valid response)			
Confirm normal message transmission enabled	69		
General response	7F	Optional data bytes may be included (see Mode $7F description)	Resp. Code = 22

FIGURE 21—MESSAGE DATA BYTES FOR MODE $29

4.17 Mode $2A—Request Diagnostic Data Packet(s)

4.17.1 FUNCTIONAL DESCRIPTION—The purpose of this mode is to request diagnostic data packets that contain data values, such as analog inputs and outputs, digital inputs and outputs, freeze frame data, calculated values, bit mapped fault code data, and system status information. This Mode differs from Modes $21 through $23 in that multiple data packets can be requested, each containing multiple data values. These data packets can either be predefined in the on-board control module or dynamically defined using Mode $2B or $2C.

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The on-board module will respond to this message by transmitting multiple response messages specific to that device. The data packet ID bytes in the request allow multiple Mode $2A data packets to be requested. Data packets should be defined which include data that is commonly used together, or changes together.

Uses for these different data packets include data such as wheel speeds for an ABS system. Data can be returned quickly with a minimal length request and response. Another use for these different data packets is to return values that do not change, such as VIN and system contents. These values need to be known one time only during testing. Other data bytes may contain present values of analog and discrete device I/O, device software flags and status words, and failure codes.

4.17.2 MESSAGE DATA BYTES—(See Figure 22.)

	Data Bytes (Hex)				
	#1	#2	#3	#4 to #n-1	#n
Request from Tool to Vehicle					
Request diagnostic data packets	2A	Data rate *	DPID #	Additional optional data packet IDs may be requested to fill the message up to the maximum number of available data bytes.	
Positive Response from Vehicle to Tool (Multiple response messages will be sent if multiple DPIDs requested, or if data rate requested periodic data reporting)					
Report of diagnostic data packet requested for each requested data packet	6A	DPID #	Data Byte	Additional optional data bytes that are in response to the request may be added to fill the message up to the maximum number of available data bytes.	
Vehicle Response to Request to stop sending data (either multiple $6A messages or a single $7F message is a valid response)					
Report stop sending diagnostic data packets	6A	DPID# of DPID req.	(any additional DPID #s in this message could appear to be data)		
Request report stop sending diagnostic data packets for each DPID # requested	6A	DPID # of DPID req.			
General response	7F	Optional data bytes may be included (see Mode $7F description)		Resp. code 00	

* same data rate definition as Data Byte #3 for Mode $01

FIGURE 22—MESSAGE DATA BYTES FOR MODE $2A

4.18 Mode $2B—Dynamically Define Data Packet by Single Byte Offsets

4.18.1 FUNCTIONAL DESCRIPTION—This test mode can be used to dynamically define data packets that can subsequently be requested using a Mode $2A request. This mode is a special case alternative to using multiple Mode $2C messages, because a single request message can be used to completely define the contents of a data packet. All other methods to specify the data values to be included in data packets using Mode $2C would also require multiple messages, therefore, special modes to build data packets by PID or memory address are not included.

If the parameter for any offset value is longer than 1 byte, then offset data bytes in the request should be filled with $FF for each additional byte in the data value requested (see message example). This forces the data value byte locations in the response message to mirror the offset value byte locations in the request message.

4.18.2 MESSAGE DATA BYTES—(See Figure 23.)

4.18.3 MESSAGE EXAMPLE—Figure 24 is an example of messages required to define a data packet by offset and then request that data packet. The data packet can be defined with a single message and requested with another message.

	Data Bytes (Hex)				
	#1	#2	#3	#4 to #n-1	#n
Request from Tool to Vehicle					
Define diagnostic data packet	2B	DPID #	Offset	Additional optional data offset values may be added to fill the message up to the maximum number of available data bytes.	
Positive Response from Vehicle to Tool (either of the following is a valid response)					
Confirm diagnostic data packet defined	6B	DPID #			
General response	7F	Optional data bytes may be included (see Mode $7F description)		Resp. Code 00	

FIGURE 23—MESSAGE DATA BYTES FOR MODE $2B

	Data Bytes (Hex)							
	#1	#2	#3	#4	#5	#6	#7	#8
Define Diagnostic Data Packet #22 consisting of: Value at offset $30 (1 byte value) Value at offset $12 (2 byte value) Value at offset $26 (2 byte value) Value at offset $05 (1 byte value)								
Define diagnostic data packet #22	2B	22	30	12	FF	26	FF	05
Positive Response from Vehicle to Tool (either of the following is a valid response)								
Confirm data packet defined #22	6B	22						
General response	7F	2B	22	Resp. Code = 00				
Request from Tool to Vehicle								
Request data packet #22	2A	Data rate	22					
Positive Response from Vehicle to Tool								
Report data packet #22	6A	22	1 byte value from offset $30	2 byte value from offset $12	2 byte value from offset $26	1 byte value from offset $05		

FIGURE 24—DATA PACKET EXAMPLE

4.19 Mode $2C—Dynamically Define Diagnostic Data Packet

4.19.1 FUNCTIONAL DESCRIPTION—This test mode can be used to dynamically define data packets that can subsequently be requested using a Mode $2A request. This single test mode is an alternative to multiple modes to define data packets by offset, PID, and memory address.

This mode allows data packets to be defined in different ways, and also allows a single data packet to include data specified in different ways. Multiple messages must be sent to define a single data packet. Each message contains a portion of the data packet, and includes an indication of how the data is being requested, the starting byte of the data packet, and the number of bytes to be specified for the data packet.

Data packets can be shortened by sending a data packet definition with the starting byte indicating the first data byte not to be included, and 0 as the length. This should be interpreted as 0 bytes at the starting location, which means the data byte is not in the response message.

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Data packet definitions can be cleared by sending a message with 1 as the starting data byte and 0 as the number of bytes. Requesting this data packet would result in a response which would include the mode value, data packet ID, and no data.

Data packet definitions can be removed by sending a message with 0 as the starting data byte and 0 as the number of bytes. This would free memory space, if needed.

An optional feature of this mode is to request the present definition for the data packet. This is accomplished by sending a Mode $2B with the data packet ID as the only additional data byte. The result is multiple $6B responses, each including data bytes that resemble the $2B messages that created the data packet.

4.19.2 MESSAGE DATA BYTES—(See Figure 25.)

	Data Bytes (Hex)				
	#1	#2	#3	#4 to #n-1	#n
Request from Tool to Vehicle					
Define diagnostic data packet	2C	DPID #	Data byte #3 bits 7,6 0 0 - define by offset (1 byte) 0 1 - define by PID (2 bytes) 1 0 - define by memory address (3 bytes) 1 1 - reserved/user defined bits 5,4,3 starting byte for data, where 001 is the first byte after the DPID # bits 2,1,0 number of data bytes for this parameter Data bytes starting at byte #4 contain either the offset, PID, memory address, or manufacturer defined value for the data to be included in the packet		
Positive Response from Vehicle to Tool (either of the following is a valid response)					
Define diagnostic data packet defined	6C	DPID #	Received data byte #3		
General response	7F	Optional data bytes may be included (see above $7F description)			Resp. Code 00

FIGURE 25—MESSAGE DATA BYTES FOR MODE $2C

4.19.3 MESSAGE EXAMPLE—Figure 26 shows the messages required to define a data packet and then request that data packet. Data packet #26 is to be defined as:

Value for PID $01 04 (1 byte data value)
Value at offset $32 (2 byte data value)
2 bytes of data at memory address $24 81 70

This definition requires three sets of request / report messages, and the data packet request requires one set of messages.

4.20 Mode $2F—Input/Output Control by PID

4.20.1 FUNCTIONAL DESCRIPTION—This capability allows the tester to verify proper operation of external input and output components and circuitry by various techniques. Real world sensor inputs can be temporarily bypassed, and direct control of output devices can be achieved. Since substitution may cause the control module to operate in a manner which is unsuitable or unsafe for "on-the-road" operation, precautions must be taken to ensure safe operation. The substituted value is used only for the duration of the diagnostic procedure, and when the module is returned to normal operation, or control of the data value is returned to the vehicle, then the substituted value reverts back to the normal value determined by the control system.

Parameter IDs (PIDs) are assigned by the manufacturer for those input, output, and intermediate (calculated) values that are allowed to be substituted. The PID assignments can be the same PID values that are used with a Mode $22 request for data by PID.

4.20.2 MESSAGE DATA BYTES—(See Figure 27.)

	Data Bytes (Hex)						
	#1	#2	#3	#4	#5	#6	#7
Request from Tool to Vehicle							
PID $01 04 is 1 byte value to be included at data byte 3 (1 byte after DPID #)	2C	25	48 ..... 01 001 001 1 1	01	04		
Positive Response from Vehicle to Tool (either of the following is a valid response)							
PID $01 04 at data byte 3	6C	25	48				
General response	7F	2C	25	45	Resp. Code 00		
Request from Tool to Vehicle							
Offset $32 is 2 byte value to be included at data byte 4 (2 bytes after DPID #)	2C	25	12 ..... 00 010 010 2 2	32			
Positive Response from Vehicle to Tool (either of the following is a valid response)							
Offset $32 starting at data byte 4	6C	25	12				
General response	7F	2C	25	12	Resp. Code 00		
Request from Tool to Vehicle							
2 bytes starting at address $24 81 70 to be included at data bytes 6 and 7	2C	25	A2 ..... 10 100 010 4 2	24	81	70	
Positive Response from Vehicle to Tool (either of the following is a valid response)							
Addresses $24 81 70 and $24 81 71 at data bytes 6 and 7	6C	25	A2				
General response	7F	2C	25	A2	Resp. Code 00		
After the data packet is defined, the tool can request the data packet from the vehicle							
Request data packet #26	2A	26					
Positive Response from Vehicle to Tool							
Report data packet #26	6A	26	1 byte value for PID $01 04	2 byte value from offset $32	2 bytes at memory address $24 81 70		

FIGURE 26—DATA PACKET DEFINITION EXAMPLE

4.21 Mode $30—Input/Output Control by Data Value ID

4.21.1 FUNCTIONAL DESCRIPTION—This mode is identical in purpose and function to Mode $2F, except that the parameter to be controlled is specified by a 1 byte Data Value ID instead of a 2 byte PID.

Data value IDs are assigned by the manufacturer for those input, output, and intermediate (calculated) values that are allowed to be substituted.

4.21.2 MESSAGE DATA BYTES—(See Figure 28.)

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	Data Bytes (Hex)					
	#1	#2	#3	#4	#5 to #n-1	#n
Request from Tool to Vehicle						
Request Input/Output control by PID	2F	PID (high byte)	PID (low byte)	Data Byte #4 (optional): If not specified - control of identified data value is disabled If specified - value is substituted for identified data value in the module. Data Bytes after #4 may be used if needed to specify substitute value.		
Positive Response from Vehicle to Tool (either of the following is a valid response)						
Confirm Input/Output control by PID	6F	PID (high byte)	PID (low byte)	Rec. data byte 4 (opt)		
General response	7F	Optional data bytes may be included (see Mode $7F description)				Resp. Code = 00

FIGURE 27—MESSAGE DATA BYTES FOR MODE $2F

	Data Bytes (Hex)				
	#1	#2	#3	#4 to #n-1	#n
Request from Tool to Vehicle					
Request Input/Output control by data value ID	30	Data value ID	Data Byte #3 (optional): If not specified - control of identified data value is disabled If specified - value is substituted for identified data value in the module. Data Bytes after #3 may be used if needed to specify substitute value.		
Positive Response from Vehicle to Tool (either of the following is a valid response)					
Confirm Input/Output control by data value ID	70	Data value ID	Rec. data byte 3 (opt)		
General response	7F	Optional data bytes may be included (see Mode $7F description)			Resp. Code = 00

FIGURE 28—MESSAGE DATA BYTES FOR MODE $30

4.22 Modes $31 to $33—Perform Diagnostic Routine by Test Number

4.22.1 FUNCTIONAL DESCRIPTION—The purpose of these modes is to execute diagnostic tests and obtain test results. The diagnostic routines are manufacturer defined and executed in the control module by referencing the test number. Each module may support up to 255 distinct diagnostic routines. Definition of the routines is defined by the module manufacturer.

Reported results may consist of any set of return information, such as measured test values or fault codes.

Three sets of messages are used to perform tests resident in an on-board control module. These messages perform three functions:

Mode $31 - Enter/start Diagnostic Routine by Test Number
Mode $32 - Exit/stop Diagnostic Routine by Test Number
Mode $33 - Request Diagnostic Routine Results by Test Number

The tests are known by the module and identified by a test number. They are usually permanently stored in the module, but may have been downloaded by Modes $34 and $36.

These test numbers could either be tests that run instead of normal operating code, or could be routines that are enabled in this mode and execute with the normal operating code. In the first case, normal system operation for the controller being tested is not possible. In the second case, multiple diagnostic routines can be enabled that run while all other parts of the system are functioning normally.

Any combination of the messages can be used, depending on the implementation in the module. Some examples are:

Tester sends a Mode $31 message to start a test. The module reports that the test has started with a Mode $71 and runs the test until a Mode $32 is sent to stop the test. The module exits the test and informs the tester with a Mode $72 that the test has stopped. The tester then requests test results with a Mode $33, and the module reports the results with a Mode $73 message.

Tester sends a Mode $31 message to start a test. The Module confirms test has started, exits when the test is done and reports results using Mode $73.

Tester sends a Mode $31 message to start a test. The Module starts test and periodically reports results using Mode $73 until a Mode $32 is sent to stop the test.

The on-board controller starts a test automatically, stops the test automatically and reports results using a Mode $73 message automatically. This requires no request messages from the tester.

These examples demonstrate both maximum and minimum use of the available message. Test equipment needs to know what tests are available, which messages are required, and how to interpret the results.

The general purpose response, Mode $7F, may also be used instead of a Mode $71 or Mode $72 message to acknowledge entry or exit from a diagnostic routine.

4.22.2 MESSAGE DATA BYTES—(See Figure 29.)

	Data Bytes (Hex)				
	#1	#2	#3	#4 to #n-1	#n
Request from Tool to Vehicle					
Request entry by test number	31	Test #	Additional optional data bytes may be added to the request to fill the message up to the maximum number of available data bytes.		
Positive Response from Vehicle to Tool (either of the following is a valid response)					
Permit entry by test number	71	Test #	Additional optional data bytes that are in response to the request may be added to fill the message up to the maximum number of available data bytes.		
General response	7F	Optional data bytes may be included (see Mode $7F description).			Resp. code = 22
Request from Tool to Vehicle					
Request exit by test number	32	Test #	Additional optional data bytes may be added to the request to fill the message up to the maximum number of available data bytes.		
Positive Response from Vehicle to Tool (either of the following is a valid response)					
Permit exit by test number	72	Test #	Additional optional data bytes that are in response to the request may be added to fill the message up to the maximum number of available data bytes.		
General response	7F	Optional data bytes may be included (see Mode $7F description)			Resp. code = 00
Request from Tool to Vehicle					
Request results by test number	33	Test #	Additional optional data bytes may be added to the request to fill the message up to the maximum number of available data bytes.		
Positive Response from Vehicle to Tool					
Report results by test number	73	Test #	Additional optional data bytes that are in response to the request may be added to fill the message up to the maximum number of available data bytes.		

Note: Mode $33 reports the results of a test that was run on request from a tool. This differs from Mode $05, which reports the results of the latest on-board monitoring test that was run to meet OBD regulations.

FIGURE 29—MESSAGE DATA BYTES FOR MODES $31 THROUGH $33

4.23 Modes $34 to $37—Data Transfer

4.23.1 FUNCTIONAL DESCRIPTION—These modes allow the transfer of data either from a tester to an on-board module or from an on-board module to a tester. Modes defined are:

Mode $34 - Request Download - tool to module
Mode $35 - Request Upload - module to tool

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Mode $36 - Data Transfer
Mode $37 - Request Data Transfer Exit

Download is defined as data transfer from the tool to the controller in the vehicle. Upload is defined as data transfer from the controller in the vehicle to the tool.

4.23.1 MESSAGE DATA BYTES—(See Figure 30.)

	Data Bytes (Hex)		
	#1	#2 to #n-1	#n
Request from Tool to Vehicle			
Request download	34	Messages used to request download are defined by the vehicle/module manufacturer. This Mode value is reserved for a download request message.	
Positive Response from Vehicle to Tool (either of the following is a valid response)			
Reject download status	74	Messages used to request download are defined by the vehicle/module manufacturer. This Mode value is reserved for the response to a Mode $34.	
General response	7F	Optional data bytes may be included (see Mode $7F description).	Resp. code - 00
Request from Tool to Vehicle			
Request upload	35	Messages used to request upload are defined by the vehicle/module manufacturer. This Mode value is reserved for an upload request message.	
Positive Response from Vehicle to Tool (either of the following is a valid response)			
Reject upload status	75	Messages used to request download are defined by the vehicle/module manufacturer. This Mode value is reserved for the response to a Mode $35.	
General response	7F	Optional data bytes may be included (see Mode $7F description).	Resp. code - 00
Transfer Data			
Data transfer	36	Messages used to perform the data transfer are defined by the vehicle/module manufacturer. This Mode value is reserved for the data transfer request message.	
Data transfer	76	Messages used to perform the data transfer are defined by the vehicle/module manufacturer. This Mode value is reserved for the response to a Mode $36.	
Request from Tool to Vehicle			
Request exit	37	Messages used to exit data transfer are defined by the vehicle/module manufacturer. This Mode value is reserved for the exit data transfer request message.	
Positive Response from Vehicle to Tool (either of the following is a valid response)			
Reject exit	77	Messages used to exit data transfer are defined by the vehicle/module manufacturer. This Mode value is reserved for the response to a Mode $37.	
General response	7F	Optional data bytes may be included (see Mode $7F description).	Resp. code - 00

FIGURE 30—MESSAGE DATA BYTES FOR MODES $34 THROUGH $37

4.24 Modes $38 to $3A—Perform Diagnostic Routine at a Specified Address

4.24.1 FUNCTIONAL DESCRIPTION—These test modes are used to execute diagnostic routines resident in the on-board controller at the specified address. This executable code may be permanently stored in the controller or may have been downloaded using modes $34 and $36.

These three sets of messages are used to perform tests resident in an on-board control module. These messages perform these functions:

Mode $38 - Enter Diagnostic Routine by Address
Mode $39 - Exit Diagnostic Routine by Address
Mode $3A - Request Diagnostic Routine Results

4.24.2 MESSAGE DATA BYTES—(See Figure 31.)

	Data Bytes (Hex)						
	#1	#2	#3	#4	#5	#6 to #n-1	#n
Request from Tool to Vehicle							
Request test entry by starting address	38	Starting Address: high byte	mid byte	low byte	(opt)	Additional optional data bytes may be added to the request to fill the message up to the maximum number of available data bytes.	
Positive Response from Vehicle to Tool (either of the following is a valid response)							
Report entry	78	Starting Address: high byte	mid byte	low byte	(opt)		
General response	7F	Optional data bytes may be included (see Mode $7F description).					Resp. Code - 00
Request from Tool to Vehicle							
Request test exit by starting address	39	Starting Address: high byte	mid byte	low byte	(opt)	Additional optional data bytes may be added to the request to fill the message up to the maximum number of available data bytes.	
Positive Response from Vehicle to Tool (either of the following is a valid response)							
Report exit by starting address	79	Starting Address: high byte	mid byte	low byte	Exit Status (opt)	Additional optional data bytes that are in response to the request may be added to fill the message up to the maximum number of available data bytes.	
General response	7F	Optional data bytes may be included (see Mode $7F description).					Resp. code - (c)
Request/Report Diagnostic Routine Results							
Request results	3A	(opt.)	Additional optional data bytes may be added to the request to fill the message up to the maximum number of available data bytes.				
Positive Response from Vehicle to Tool							
Report results	7A	Additional optional data bytes that are in response to the request may be added to fill the message up to the maximum number of available data bytes.					

FIGURE 31—MESSAGE DATA BYTES FOR MODES $38 THROUGH $3A

4.25 Mode $3B—Write Data Block

4.25.1 FUNCTIONAL DESCRIPTION—The purpose of this mode is to provide a means for the external test device to change the contents of a data block. The data block numbers and associated memory locations need to be known by the on-board device. This mode does not allow off-board test equipment to change any memory locations other than for those data blocks predefined in the on-board device.

The number of data bytes included in the request message for each block number depends on the system design and intent of the usage for that block.

Possible uses for this mode are:

Clear non-volatile memory
Reset learned values in a single table
Set option content
Set Vehicle Identification Number (VIN)
Change calibration values

This mode can be used to clear or reset tables stored in non-volatile memory. A data block number could be defined as memory locations that need to be either cleared or reset to predefined initial values, such as learned values in a table. Sending the data block number with no data bytes could cause the on-board system to clear/reset all learned values associated with that data block number to known nominal values.

Another use is to allow the VIN to be input. A data block number could be defined to expect a portion of the VIN. Multiple messages would be required to send the entire 17-character VIN. Whatever data values were included in the request message would be stored in the memory locations known by the on-board system for VIN.

In some systems, this mode could be used for programming calibrations or vehicle specific information in the assembly plant or service without using secured methods for reprogramming. If desired that these values not be changed after production, the capability to modify these data blocks could be disabled after the initial change.

4.25.2 MESSAGE DATA BYTES—(See Figure 32.)

	Data Bytes (Hex)			
	#1	#2	#3 to #n-1	#n
Request from Tool to Vehicle				
Request to write data block	3B	Block number	Additional optional data value bytes to be written to memory may be added to fill the message up to the maximum number of available data bytes.	
Positive Response from Vehicle to Tool (either of the following is a valid response)				
Custom data block written	7B	Block number		
General response	7F	Optional data bytes may be included (see Mode $7F description).		Resp. code - 00

FIGURE 32—MESSAGE DATA BYTES FOR MODE $3B

4.26 Mode $3C—Read Data Block

4.26.1 FUNCTIONAL DESCRIPTION—The purpose of this mode is to provide a means for the external test device to read the contents of a data block. The data block numbers and associated memory locations need to be known by the on-board device. This mode does not allow off board test equipment to read any memory locations other than for those data blocks predefined in the on-board device.

The number of data bytes included in the Response for each block number depends on the system design and intent of the usage for that block.

Possible uses for this mode are to read:

Learned values in a single table
Option content
Vehicle Identification Number (VIN)
Calibration values

4.26.2 MESSAGE DATA BYTES—(See Figure 33.)

	Data Bytes (Hex)		
	#1	#2	#3 to #n
Request from Tool to Vehicle			
Request to read data block	3C	Block number	
Positive Response from Vehicle to Tool			
Report contents of data block	7C	Block number	Additional optional data bytes that are in response to the request may be added to fill the message up to the maximum number of available data bytes.

FIGURE 33—MESSAGE DATA BYTES FOR MODE $3C

4.27 Mode $3F—Test Device Present (no operation performed)

4.27.1 FUNCTIONAL DESCRIPTION—This mode can be used to indicate a tool or test device is present. This message may be required, in the absence of other diagnostic messages, to prevent modules from automatically returning to normal operation. The presence of this message will indicate that the system should remain in a diagnostic mode of operation.

This message will normally be sent to all modules in the vehicle. Because this message is not a specific request for a controller to do something, there is no required response message to the test tool present message. However if the message strategy includes a response to this, a general response message should be used. If the vehicle contains multiple modules, then multiple responses will be sent, using available data link time.

4.27.2 MESSAGE DATA BYTES—(See Figure 34.)

	Data Bytes (Hex)		
	#1	#2 to #n-1	#n
Request from Tool to Vehicle			
Test tool present	3F		
Positive Response from Vehicle to Tool (optional)			
General response	7F	Optional data bytes may be included (see Mode $7F description).	Resp. Code - 00

FIGURE 34—MESSAGE DATA BYTES FOR MODE $3F

4.28 Mode $7F—General Response Message

4.28.1 FUNCTIONAL DESCRIPTION—Physical requests for information must be responded to by the intended receiver of the request. This message is intended to be a generic response to any request message when data does not need to be returned to the test device. This is an alternative to a specific response when a request is for an action to be performed by the controller. This is also a valid message (negative response) for requests for data or for an action to be performed. See the "Message Response" section for a more detailed discussion about the use of this message.

The response may be an acknowledge that the message was received, or may include a code indicating the reason for rejection if a valid response is not possible. This response assumes that a valid message has been received, but is not intended to inform the sender of an invalid message or to report system failures. Valid response codes are included in this section. Response codes from $00 to $7F are reserved to be defined in this document, and codes from $80 to $FF are reserved to be defined by the vehicle manufacturer.

The format for the general response message is a $7F for the first data byte, after the header, optional data bytes that repeat data bytes of the request, and the response code. If a fixed message length is required and there are not enough data bytes in the request, the message should be padded with $00 to fill the remaining data bytes.

4.28.2 MESSAGE DATA BYTES—(See Figure 35.)

	Data Bytes (Hex)					
	#1	#2 to #n-1 (optional)				#n
Response from Vehicle to Tool						
General response	7F	Optional data bytes that repeat data bytes in the request message, in order to uniquely identify the request message, or in order to maintain a common message length, may be inserted between the Mode Value and the Response Code. The last data byte of this message is always the response code.				Resp. Code
		Request Mode value (out)	Data byte #2 of request (out)	Data byte #3 of request (out)	etc.	

FIGURE 35—MESSAGE DATA BYTES FOR MODE $7F

4.28.3 MESSAGE EXAMPLES—Figure 36 shows an example of a Mode $3B request containing 8 data bytes. Four valid general response messages are shown, with others possible to be defined by the vehicle manufacturer. Note that the response code is always the last data byte of the response message.

	Data Bytes (Hex)							
	#1	#2	#3	#4	#5	#6	#7	#8
Example Request from Tool to Vehicle								
Request to write data to memory	3B	Block number	Data value #1	Data value #2	Data value #3	Data value #4	Data value #5	Data value #6
Example Responses from Vehicle to Tool (any of the following is a valid response)								
Unused form of affirm response	7F	Resp. Code						
Vehicle has not made value last mode that is already set (data requested)	7F	3B	Resp. Code					
Vehicle has made value last block (data received)	7F	3B	Block number	Resp. Code				
Vehicle is much of block message (what is in error)	7F	3B	Block number	Data value #1	Data value #2	Data value #3	Data value #4	Resp. Code

FIGURE 36—GENERAL RESPONSE EXAMPLES

4.2.3.4 RESPONSE CODES—Figure 37 includes response codes and descriptions to be used with the general response messages.

Hex	Response Code Description
00	AFFIRMATIVE RESPONSE This response code is used to indicate affirmative response to a request message. It indicates that the requested action will be taken or is already complete.
10	GENERAL REJECT This response code is used to indicate a negative response to a request message. No reason or explanation for the rejection is given.
11	MODE NOT SUPPORTED This response code is used to indicate negative response to a request message. It indicates that the requested action will not be taken because the ECU does not support the requested mode.
12	SUB-FUNCTION NOT SUPPORTED or INVALID FORMAT This response code is used to indicate negative response to a request message. It indicates that the requested action will not be taken because the ECU does not support the arguments of the requested mode or the format of the arguments bytes do not match the prescribed format for the specified mode.
21	BUSY – REPEAT REQUEST This response code indicates that the ECU is temporarily too busy to perform the requested operation. In this circumstance repetition of the request will eventually result in an affirmative response. This code may be returned while an ECU is in the process of clearing stored codes or fetching information. Whenever completion of the requested operation will exceed the maximum response time limit, it is appropriate to use the BUSY – REPEAT REQUEST message to lengthen the acceptable response period.
22	CONDITIONS NOT CORRECT or REQUEST SEQUENCE ERROR This response code is used to indicate negative response to a request message. It indicates that the requested action will not be taken because the ECU prerequisite conditions are not met. This request may elicit an affirmative response at another time. This code may occur when sequence sensitive requests are issued in the wrong order.
23	ROUTINE NOT COMPLETE This response code is used to indicate that the message was properly received and the routine is in process, but not yet completed.
31	REQUEST OUT OF RANGE This response code is used to indicate negative response to a request message. It indicates that the requested action will not be taken because the ECU detects the request message contains a data byte which attempts to substitute a value beyond its range of authority (ex: attempting to substitute a data byte of 111 when the data is only defined to 100).
33	SECURITY ACCESS DENIED This response code is used to indicate negative response to a request message. It indicates that the requested action will not be taken because the ECU's security strategy has not been satisfied by the tester.
34	SECURITY ACCESS ALLOWED This response code is used to indicate positive response to a request message. It indicates that the ECU's security strategy has been satisfied by the tester.
35	INVALID KEY This response code is used to indicate negative response to a request message. It indicates that security access has not been given because the ECU's security key was not matched by the tester (this counts as an attempt to gain security access).
36	EXCEED NUMBER OF ATTEMPTS This response code is used to indicate negative response to a request message. It indicates that the requested action will not be taken because the Tester has unsuccessfully attempted to gain security access more times than the ECU's security strategy will allow.
37	REQUIRED TIME DELAY NOT EXPIRED This response code is used to indicate negative response to a request message. It indicates that the requested action will not be taken because the tester's latest attempt to gain security access was initiated before the ECU's required timeout period had elapsed.
40	DOWNLOAD NOT ACCEPTED This response code indicates that an attempt to download to an ECU's memory cannot be accomplished due to some fault condition.
41	IMPROPER DOWNLOAD TYPE This response code indicates that an attempt to download to an ECU's memory cannot be accomplished because the module does not support the type of download being attempted.
42	CAN'T DOWNLOAD TO SPECIFIED ADDRESS This response code indicates that an attempt to download to an ECU's memory cannot be accomplished because the module does not recognize the target address for the download as being available.
43	CAN'T DOWNLOAD NUMBER OF BYTES REQUESTED This response code indicates that an attempt to download to an ECU's memory cannot be accomplished because the module does not recognize the number of bytes requested for the download as being available.
44	READY FOR DOWNLOAD This response code indicates that a download to an ECU's memory can be accomplished.
50	UPLOAD NOT ACCEPTED This response code indicates that an attempt to upload from an ECU's memory cannot be accomplished due to some fault condition.
51	IMPROPER UPLOAD TYPE This response code indicates that an attempt to upload from an ECU's memory cannot be accomplished because the module does not support the type of upload being attempted.
52	CAN'T UPLOAD FROM SPECIFIED ADDRESS This response code indicates that an attempt to upload from an ECU's memory cannot be accomplished because the module does not recognize the target address for the upload as being available.
53	CAN'T UPLOAD NUMBER OF BYTES REQUESTED This response code indicates that an attempt to upload from an ECU's memory cannot be accomplished because the module does not recognize the number of bytes requested for the upload as being available.
54	READY FOR UPLOAD This response code indicates that an upload from an ECU's memory can be accomplished.
61	NORMAL EXIT WITH RESULTS AVAILABLE This response code is used to indicate response to a request message. It indicates that the requested exit action will be taken, or is already complete, and that additional information is available in the form of data, stored codes, or PIDs.

Continued

FIGURE 37—GENERAL RESPONSE CODES

Continued

FIGURE 37—GENERAL RESPONSE CODES (CONTINUED)

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62	NORMAL EXIT WITHOUT RESULTS AVAILABLE This response code is used to indicate response to a request message. It indicates that the requested exit action will be taken, or is already complete, but no additional information is available in the form of data, stored codes, or PIDs.
63	ABNORMAL EXIT WITH RESULTS This response code is used to indicate response to an exit request message. It indicates that the requested exit action will be taken, or is already complete. It is also indicates that the requested execution did not occur in the expected manner and that additional information is available in the form of data, stored codes, or PIDs.
64	ABNORMAL EXIT WITHOUT RESULTS This response code is used to indicate response to a exit request message. It indicates that the requested exit action will be taken, or is already complete. It is also indicates that the requested execution did not occur in the expected manner, but additional information is not available.
71	TRANSFER SUSPENDED This response code indicates that a block transfer operation was halted due to some fault, but will be completed later.
72	TRANSFER ABORTED This response code indicates that a block transfer operation was halted due to some fault, and will not be completed later.
73	BLOCK TRANSFER COMPLETE / NEXT BLOCK This response code indicates that a block transfer operation has been completed successfully.

Continued

FIGURE 37—GENERAL RESPONSE CODES (CONTINUED)

74	ILLEGAL ADDRESS IN BLOCK TRANSFER This response code indicates that the starting address included in the block transfer request message is either out of range, protected, the wrong type of memory for receiving data, or cannot be written to for some reason.
75	ILLEGAL BYTE COUNT IN BLOCK TRANSFER This response code indicates that the number of data bytes included in the block transfer request message is either more than the block transfer can accommodate, requires more memory than is available at the requested starting address, or cannot be handled by the block transfer software.
76	ILLEGAL BLOCK TRANSFER TYPE This response code is used to indicate that the block transfer type included in the request for block transfer is not valid for this application.
77	BLOCK TRANSFER DATA CHECKSUM ERROR This response code is used to indicate that the block transfer data checksum calculated for the block transfer message does not agree with the expected value.
78	BLOCK TRANSFER MESSAGE CORRECTLY RECEIVED This response code is used to indicate that the block transfer message was received correctly, and that any parameters included in the message were valid, but the action to be performed may not be completed yet. This response code can be used to indicate that the message was properly received and does not need to be retransmitted, but the receiving device is not yet ready to receive another block transfer.
79	INCORRECT BYTE COUNT DURING BLOCK TRANSFER This response code indicates that the number of bytes that was expected to be sent was not the same as the number of bytes received.
80 to FE	MANUFACTURER SPECIFIC CODES These response codes are reserved to be specified by the vehicle manufacturer.

FIGURE 37—GENERAL RESPONSE CODES (CONTINUED)

APPENDIX A
DIAGNOSTIC TEST MODE ASSIGNMENTS

A.1 See Table A1.

TABLE A1—DIAGNOSTIC TEST MODE ASSIGNMENTS

Mode	Message Name
00	
01	Request Current Powertrain Diagnostic Data
02	Request Powertrain Freeze Frame Data
03	Request Powertrain Diagnostic Trouble Codes
04	Request to Clear/Reset Diagnostic Trouble Codes
05	Request Oxygen Sensor Monitoring Test Results
06	Request On-Board Monitoring Test Results
07	Request Pending Powertrain Trouble Codes
08	
09	
0A	
0B	
0C	
0D	
0E	
0F	
10	Initiate Diagnostic Operation
11	Request Module Reset
12	Request Diagnostic Freeze Frame Data
13	Request Diagnostic Trouble Code Information
14	Clear Diagnostic Information
15	
16	
17	Request Status of Diagnostic Trouble Codes
18	Request Diagnostic Trouble Codes by Status
19	
1A	
1B	
1C	
1D	
1E	
1F	
20	Return to Normal Operation
21	Request Diagnostic Data by Offset
22	Request Diagnostic Data by PID
23	Request Diagnostic Data by Memory Address
24	Request Scaling and Offset/PID
25	Request to Stop Transmitting Data
26	Specify Setting of Data Rates
27	Data Link Security Access
28	Disable Normal Message Transmission
29	Enable Normal Message Transmission
2A	Request Diagnostic Data Packet(s)
2B	Define Diagnostic Data Packet by Offset
2C	Define Diagnostic Data Packet
2D	
2E	
2F	Input/Output Control by PID
30	Input/Output Control by Data Value ID
31	Request Start Diagnostic Routine by Test No.
32	Request Stop Diagnostic Routine by Test No.
33	Request Diagnostic Routine Results by Test No.
34	Request Download
35	Request Upload
36	Transfer Data

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Mode	Message Name
27	Request Stop Data Transfer
28	Request Start Diagnostic Routine by Address
29	Request Stop Diagnostic Routine by Address
2A	Request Diagnostic Routine Results by Address
2B	Write Data Block
2C	Read Data Block
2D	
2E	
2F	Test Device Present - No Operation Performed
30	
31	Report Current Powertrain Diagnostic Data
32	Report Powertrain Freeze Frame Data
33	Report Powertrain Diagnostic Trouble Codes
34	Report Diagnostic Trouble Codes Cleared
35	Report Oxygen Sensor Test Results
36	Report On-Board Monitoring Test Results
37	Report Pending Powertrain Trouble Codes
38	
39	
3A	
3B	
3C	
3D	
3E	
3F	
40	Confirm Diagnostic Operation
41	Confirm Module Reset
42	Report Diagnostic Freeze Frame Data
43	Report Diagnostic Trouble Code Information
44	Confirm Diagnostic Information Cleared
45	
46	
47	Report Status of Diagnostic Trouble Codes
48	Report Diagnostic Trouble Codes by Status
49	
4A	
4B	
4C	
4D	
4E	
4F	

Mode	Message Name
50	
51	
52	
53	
54	
55	
56	
57	
58	
59	
5A	
5B	
5C	
5D	
5E	
5F	
60	Confirm Normal Operation
61	Report Diagnostic Data by Offset
62	Report Diagnostic Data by PID
63	Report Diagnostic Data by Memory Address
64	Report Parameter Offset and Scaling/Mask
65	Confirm Data Stopped
66	Confirm Data Rates Set
67	Confirm Security Access
68	Confirm Normal Message Transmission Disabled
69	Confirm Normal Message Transmission Enabled
6A	Report Diagnostic Data Packet(s)
6B	Confirm Data Packet Defined by Offset
6C	Confirm Data Packet Defined
6D	
6E	
6F	Confirm Input/Output Control by PID
70	Confirm Input/Output Control by Data Value ID
71	Confirm Diagnostic Routine Started by Test No.
72	Confirm Diagnostic Routine Stopped by Test No.
73	Report Diagnostic Routine Results by Test No.
74	Report Download Status
75	Report Upload Status
76	Data Transfer
77	Confirm Data Transfer Stopped
78	Confirm Diagnostic Routine Started by Address
79	Confirm Diagnostic Routine Stopped by Address
7A	Report Diagnostic Routine Results by Address
7B	Confirm Data Block Written
7C	Report Contents of Data Block
7D	
7E	
7F	General Response Message (accept/reject)

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

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A.6.2.1 Host Interface
A.6.2.2 Communication Mode Selection
A.6.2.3 In-Frame Response and I.D. Byte
A.6.2.4 Message Transmission
A.6.2.5 Message Reception
A.6.3 IC3 Pin Names and Descriptions
A.6.4 Additional Capabilities
APPENDIX B SUPPORTING DOCUMENTS

1. *Scope*—SAE J1978 defines the requirements of the OBD II scan tool. SAE J2201 defines the minimum requirements of the vehicle communication interface for the SAE J1978 OBD II scan tool. This interface connects the SAE J1962 test equipment connector to the hardware/software of the SAE J1978 OBD II scan tool that will use this interface to communicate with vehicles for the purpose of accessing required OBD II functions.

Included in this SAE Recommended Practice are several definitions relating to the interface, and interface functionality evaluation.

Appendix A - Examples include several example interface circuit implementations, which are believed to meet the requirements of this document and of SAE J1978. These examples are NOT requirements of this document. They are provided to assist circuit designers in developing interface circuits.

Appendix B - Supporting Documents includes a list of supporting documents for the examples shown in Appendix A.

1.1 SAE Document Interrelationships—Figure 1 shows the interrelationships between SAE J1978, SAE J1962, and this document.

NOTE—See SAE J1962 Diagnostic Connector for pin assignments.

Where any conflict may exist between the requirements contained in SAE J1978 and this document, SAE J1978 is the overriding document.

2. *References*—The terms, definitions, abbreviations, and acronyms contained in SAE J1930 are included by reference.

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 Terms, Definitions, Abbreviations, and Acronyms

SAE J1962—Diagnostic Connector

SAE J1978—OBD II Scan Tool

SAE J1979—Diagnostic Test Modes

SAE J2205—Expanded Diagnostic Protocol

2.1.2 CALIFORNIA AIR RESOURCE BOARD DOCUMENTS

California Code of Regulation, Title 13, 1968.1 - Malfunction and Diagnostic System Requirements -- 1994 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles With Feedback Fuel Control Systems

2.1.3 EPA REGULATIONS

Federal Register Tuesday September 24,1991, Part II Environmental Protection Agency 40 CFR Part 86 - Air Pollution Control; New Motor Vehicles and Engines: On-Board Diagnostic Systems on 1994 and Later Model Year Light-Duty Vehicles and Light-Duty Trucks; Proposed Rule

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

ISO 9141-2—Road vehicles—Diagnostic systems—CARB requirements for interchange of digital information ISO/TC 22/SC 3/WG 1 - N 425 E/REV April 1991

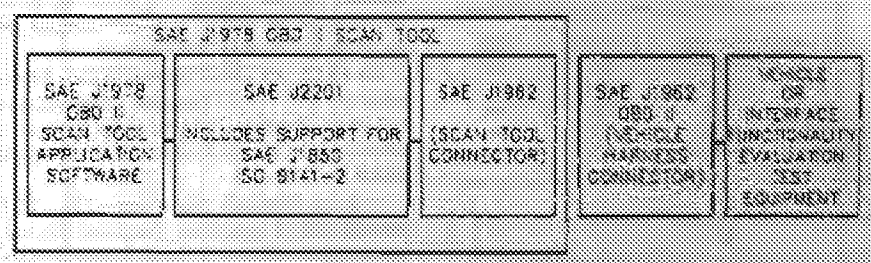


FIGURE 1—SAE DOCUMENT INTERRELATIONSHIPS

3. Terms and Definitions

3.1 APPLICATION SOFTWARE—As used in this document, this term refers to the microprocessor programming that controls the external equipment/scan tool software so as to perform required SAE J1978 OBD II Scan Tool functions.

3.2 DLCS—(Data Link Controller Serial) refers to the integrated circuit being developed by General Motors that supports SAE J1850 10.4 Kbps VPW CRC communication.

3.3 HBCC—(Hosted Bus Controller Circuit) refers to the integrated circuit developed by Ford Motor Co. that supports SAE J1850 41.6 Kbps PWM CRC communication.

3.4 OBD II—(On Board Diagnostics II) common term that refers to the requirements of the California legislation - California Code of Regulation, Title 13, 1968.1.

3.5 PCI—(Programmable Communications Interface) refers to a set of proposed circuits which includes a control microcomputer, the Symbol Encoder Decoder (SED) and the Integrated Driver Receiver (IDR). The PCI was developed by Chrysler Corporation and supports SAE J1850 10.4 VPW communication with both CRC and Checksum error techniques.

3.6 ICI—(SAE J1850 Communications Interface) refers to an integrated circuit manufactured by Motorola which supports both SAE J1850 10.4 VPW with CRC and SAE J1850 41.6 PWM with CRC communication.

2.3 Acronyms and Abbreviations

CRC - Cyclic Redundancy Check
CS - Checksum
EDP - Enhanced Diagnostic Protocol (SAE J2205)
IBS - Inter-Byte Separation
IFR - In-Frame Response
NRZ - Non Return to Zero
PWM - Pulse Width Modulation
SCI - Serial Communications Interface
SPI - Serial Peripheral Interface
UART - Universal Asynchronous Receiver/Transmitter
VDD - 5.0 VDC from Regulated Power Supply
VPW - Variable Pulse Width Modulation
"x" - Indicates Active Low Signals

3. *Requirements*—This section defines the required message structure, input, signal ground, chassis ground, minimum scan tool connector cable length and other requirements for the interface to be used by an SAE J1978 OBD II scan tool.

3.1 Interface and Message Protocol Support—The interface defined in this document must support the interface requirements and message protocol requirements of SAE J1978.

3.2 In-Frame Response—When a single byte in-frame response (IFR) is required during the reception of a 41.6 Kbps PWM SAE J1979 message, the interface will support the transmission of the node address as a single byte IFR.

3.3 Signal Ground—The Signal Ground pin of the scan tool side of the SAE J1962 diagnostic connector must be used as the signal ground reference for all interface transceivers required by this document.

3.4 Maximum Voltage Differentials—The interface described in this document includes any required interface transceivers and the cabling connecting the interface transceivers to the scan tool side of the SAE J1962 connector. Any interface connected to a vehicle through the SAE J1962 diagnostic connector is considered a part of the vehicle network and must operate within the limits of that network, which are described in SAE J1850 and ISO 9141-2.

The maximum voltage differential, e.g., due to load current, noise, etc., between any two nodes of a vehicle data communication network, where the interface described in this document is considered as a node on the vehicle network when connected to the vehicle, must be less than the limits specified in SAE J1850 and ISO 9141-2.

The following are maximum voltage differential values for the interface described in this document (as measured between the signal ground connection of all interface transceivers and the Signal Ground pin on the vehicle side of the SAE J1962 diagnostic connector) are:

0.25 V peak noise
0.1 VDC offset

3.5 Chassis Ground—The Chassis Ground pin of the scan tool side of the SAE J1962 diagnostic connector is available for any use, with the exception that the minimum DC impedance between the Chassis Ground and the Signal Ground is 1 MΩ.

3.6 Minimum Connector Cable Length—The minimum length between the ground reference connection of each interface transceiver and the Signal Ground connection of the vehicle side of the SAE J1962 diagnostic connector is 2 m.

3.7 Other Requirements—The interface must support the requirements of SAE J1850, SAE J1962, SAE J1978, SAE J1979, SAE J2205, and ISO 9141-2.

4. *Interface Functionality Evaluations*—The functionality of any proposed interface implementations must be evaluated by either of the following:

a. The use of multiplex bus interface equipment from I+ME, or equivalent equipment, that with appropriate software simulates vehicles that use the required implementations of SAE J1850 and ISO 9141-2, or
b. The use of representative vehicles of motor vehicle manufacturers that use the required implementations of SAE J1850 and ISO 9141-2.

APPENDIX A
EXAMPLES

A.1 General Example Information—This section shows example interface implementations that are believed to meet the requirements of this document.

These examples are NOT requirements of this document. These examples are intended as an assist to interface circuit designers.

Table A1 illustrates a summary of some of the capabilities available with these examples that are over and above the requirements of this document and some that are required.

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TABLE A1—SUMMARY OF CAPABILITIES FOR THE FOLLOWING EXAMPLES

	DLCS & HBCC Section A.2	PCI & HBCC Section A.3	ST9 Section A.4	Point to Point Section A.5	ASI Section A.6
Error Checking	CRC	CS & CRC	CS & CRC	CS & CRC	CRC
Comprehends IBS[2]	No	Yes	Yes	Yes	No
Header Bytes	3	1 & 3	1 & 3	1 & 3	3
Generate Break	Yes	Yes	Yes	Yes	Yes
Control Function[3]	No	Yes	Yes	No	No
Host Required	Yes	Optional[1]	Optional[1]	Yes	Yes

Error checking (CS or CRC), IBS, header bytes, and the break signal are defined in SAE J1850.

[1] Host Required refers to the need for a host microcomputer to perform the functionality of SAE J1979. Some interface implementations include a microcomputer as a part of the interface. In some of these implementations, the microcomputer may have enough excess capability so as to also be able to perform "host microcomputer" functions.

[2] IBS is part of only 10.4 Kbps VPW networks. It is not a part of 41.6 Kbps PWM networks, nor a part of ISO 9141-2 networks.

[3] Control Function refers to parts of an interface that are implemented in software and executed by some form of microcomputer.

A.1.1 Transient Protection—While some of the examples may show transient protection, this document does not specify or require transient protection.

A.1.2 Host Support Not Included—The examples shown here support a nominal type of host interface and are not meant to be directly applicable to any particular host microprocessor, host interface, and/or host software. The host application software (e.g., interface drivers, message building routines, message processing routines, etc.) and/or additional hardware (e.g., signal buffers, signal inverters, clock synchronization circuits, etc.) required to complete the interface to the example circuits shown in this document is the responsibility of the designer/implementor and is not shown here.

A.1.3 Supporting Documents—Appendix B - Supporting Documents identifies documentation that may be used to aid in the understanding of the examples shown in this document.

A.1.4 Common ISO 9141-2 Support—Many of the examples include a common implementation for ISO 9141-2. This common implementation is described here (see Figure 3 D ISO 9141-2).

The ISO 9141-2 document describes the requirements of the ISO 9141-2 interface. This interface is an asynchronous serial communication link using NRZ bit encoding. A 5 bps bit rate is used during module communication initialization and a 10.4 Kbps bit rate is used for all further communications.

This interface includes a K line which is bidirectional and used for all communication phases, and a L line which is output only from the scan tool and is only used during the 5 bps module communication initialization phase. When used to transmit data to a vehicle, both the L and K lines are driven to either ground or battery level, through a 510 Ω resistor, depending on the data value. When used to receive data from a vehicle, the K line is referenced to 1/2 the battery voltage, with a small amount of hysteresis for noise immunity, to determine the logic value of the data being transmitted by a vehicle module.

In all of the examples, the L and K lines are connected to the SCI port of either the host or a control microprocessor. A select signal from the host/control microprocessor is used to enable the L line when necessary.

A.1.5 Electromagnetic Compatibility—The Electromagnetic Compatibility (EMC) characteristics of these examples have not been investigated nor estimated. The ability of the examples to meet EMC or noise radiation requirements is unknown.

A.1.6 No Responsibility Assumed By Contributors—No responsibility is assumed by Chrysler Corporation, Ford Motor Co., General Motors Corporation, Delco Electronics Corporation, SAE, SGS-Thomson, Silicon Systems, Motorola, or any other company for use of any of the examples or products shown in this document nor for any infringements of patents and trademarks or other rights of other parties resulting from the use of these examples or products. No license is granted under any patents, patent rights, or trademarks of the previously named parties.

A.1.7 Additional Capabilities of Examples—Many of the examples support capabilities beyond the requirements of this document. Such capabilities are discussed in a separate section of each example.

A.2 DLCS, HBCC, and ISO 9141-2 Interface Example—This example (see Figure A1a) combines the use of the Data Link Controller Serial (DLCS) integrated circuit developed by Delco Electronics, the Hosted Bus Controller Circuit (HBCC) integrated circuit developed by Ford, a discrete 41.6 Kbps transmit driver, and the common ISO 9141-2 interface to provide the required interface support. (Figure A1b shows the detail of the DLCS, Figure A1c shows the detail of the HBCC with its Transmit Driver, and Figure A1d shows the detail for the common ISO 9141-2.)

The DLCS and HBCC communicate with the host through the host's SPI port, while the ISO 9141-2 interface communicates with the host through the host's SCI port. Separate logic interface lines are used by the host to individually select communication between the host and either the DLCS and HBCC, and to enable the L line.

A.2.1 General Overview—The DLCS and HBCC perform as communication peripheral integrated circuits. Following initialization, they isolate the host from bus communications tasks and are only serviced by the host when the host is loading a message for transmission or unloading a received message. The host receives an interrupt when a received message is available and when message transmission is completed. The host only handles communications as full messages. Several control and status registers are available in both the DLCS and HBCC to control their operation and indicate the status of their communications tasks.

This example uses chip select lines from the host to select which peripheral the host wishes to communicate with. Control data from the host enables or disables the DLCS and HBCC interfaces.

Because these devices are available from semiconductor suppliers who are also supplying them to major automotive manufacturers for use in production vehicles, compatibility with those vehicles should be readily verifiable.

The ISO 9141-2 interface is as described in A.1.4. The host uses its SCI interface to communicate with a vehicle through the ISO 9141-2 interface. A logic line is used by the host to enable the L line when necessary.

A.2.2 DLCS Operation—The DLCS contains a logic section and an analog section in a single integrated circuit. The logic section includes the SPI interface to the host, a transmit buffer, a receive buffer, status and control registers, bit timing, and symbol encoding and decoding logic. The analog section includes the transceiver circuitry. Data transfer between the host and the DLCS is done with two byte SPI transfers. The host sends to the DLCS a command byte and a data byte, while the DLCS sends to the host a status byte and a data byte. The content of the data bytes is dependent on the command.

a. Commands sent to the DLCS include:
   (1) General commands (e.g., send break, go to sleep, terminate transmit, may load configuration data)
   (2) Transmit commands (e.g., load transmit data, transmit message)
   (3) Receive commands (e.g., unload receive data, flush byte, flush message)

b. Status data send from the DLCS indicate the following:
   (1) Receive status (e.g., buffer contains bytes or messages)
   (2) Transmit status (e.g., buffer contains bytes or messages)
   (3) Data link status (e.g., data link shorted)

Operation of the DLCS consists primarily of three functions: initialization, transmission of a message, and reception of a message. Each of these will be discussed in more detail as follows:

A.2.2.1 INITIALIZATION—Initialization is accomplished by sending the DLCS a command byte to load the accompanying data from the host as configuration data. The DLCS can be configured to enable or disable it to interrupt the host, thereby allowing either polling or interrupt based signalling schemes to be used, and to configure the oscillator divider. Once the DLCS is initialized, normal transmission and reception can begin.

A.2.2.2 MESSAGE TRANSMISSION—Loading a message from the host to the DLCS for transmission on the bus is done by several 2 byte SPI transfers. Each transfer contains a command byte to load the accompanying data as transmit data. Loading the first and last byte of the message must be done with special command bytes. Once the command to load the accompanying data as the last transmit data byte is received by the DLCS, the DLCS will begin an attempt to transmit the message on the bus. With each 2 byte SPI transfer with the DLCS, a status byte and data byte will be transferred to the host. The status byte is used to determine the status of the transmit buffer, i.e., empty, contains some bytes, full, etc. The status byte also contains receive status. When loading a transmit message into the DLCS, the data bytes returned by the DLCS to the host are ignored.

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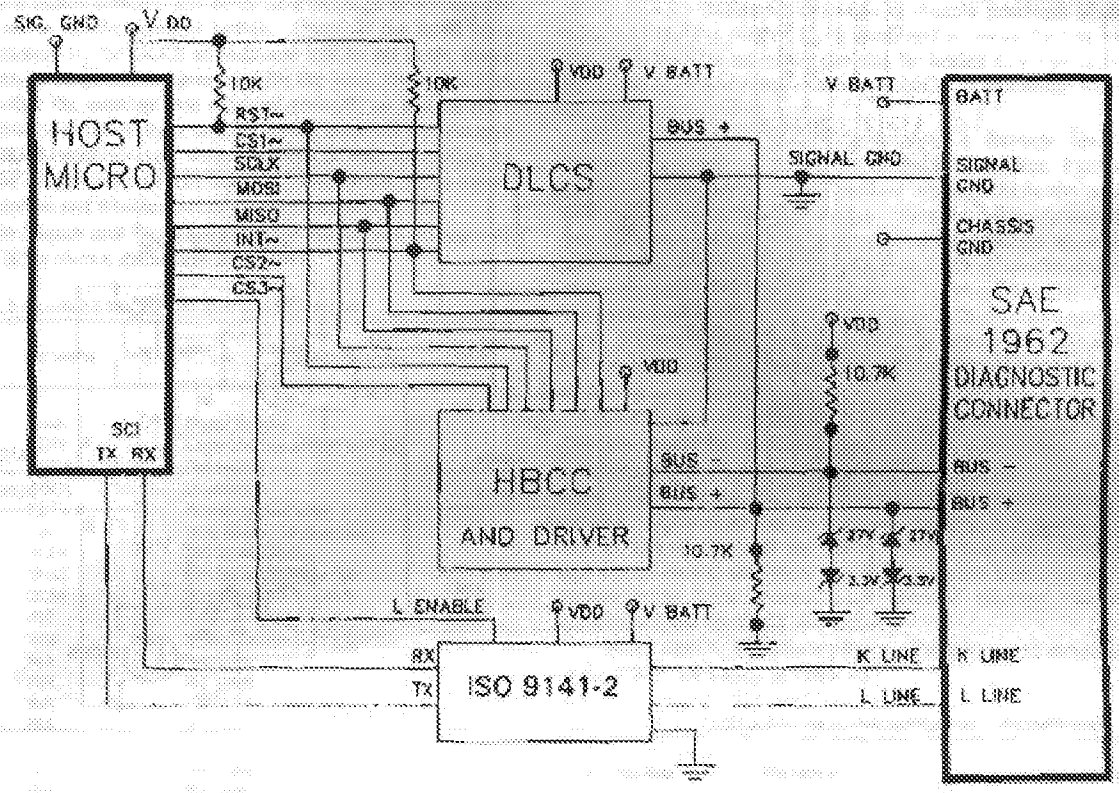


FIGURE A1a—DLCS, HBCC, AND ISO 9141-2 EXAMPLE

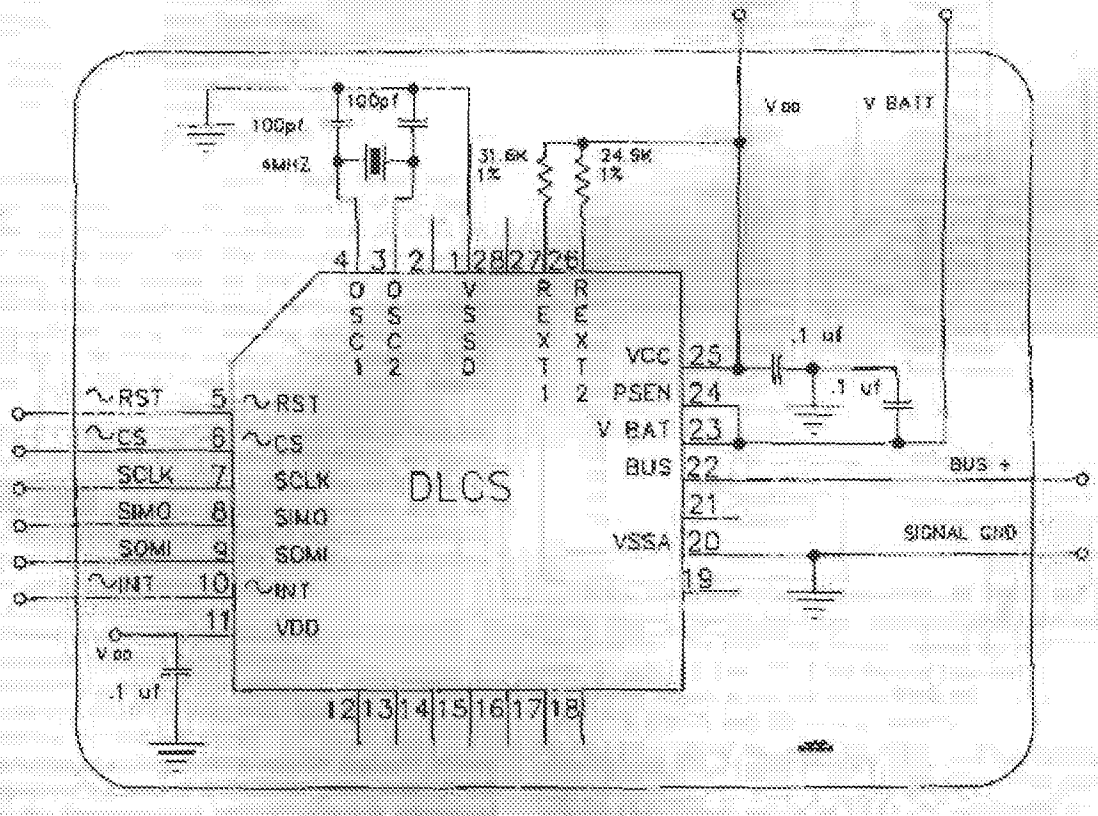


FIGURE A1b—DLCS DETAIL

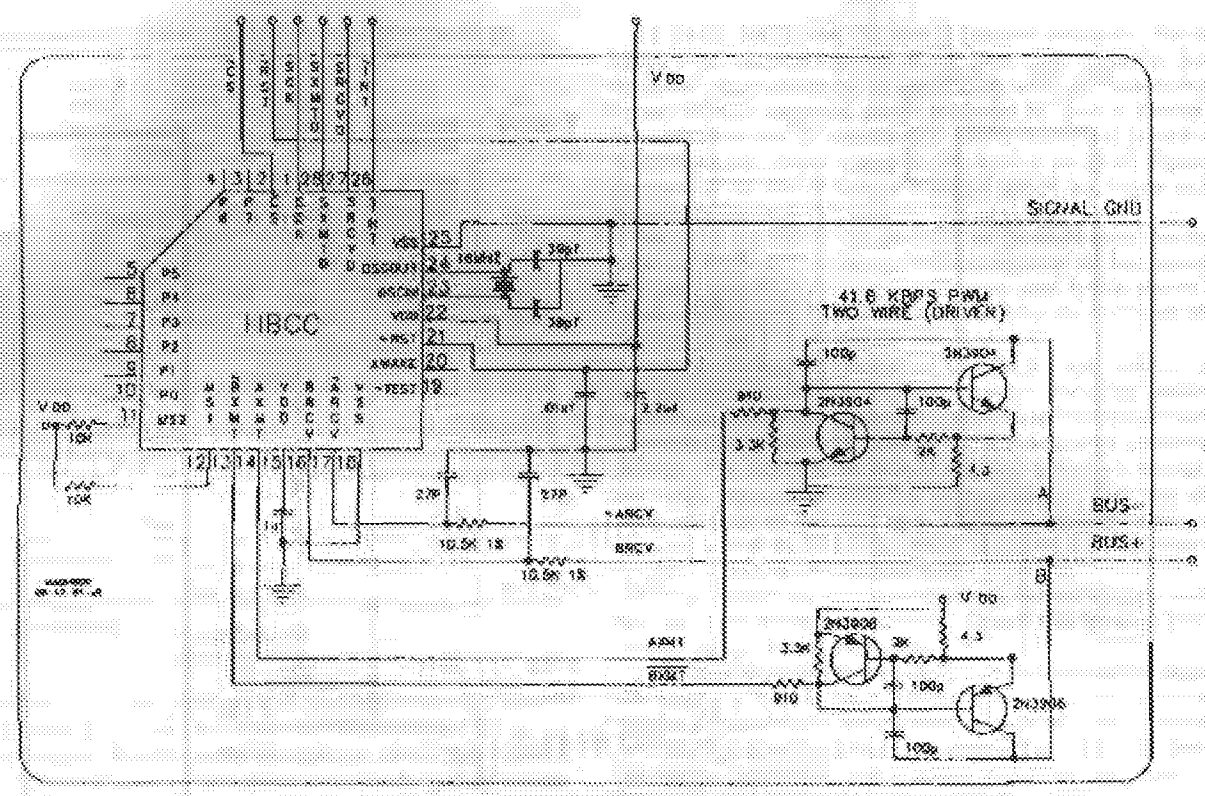


FIGURE A1c—HBCCC AND TRANSMIT DRIVER DETAIL

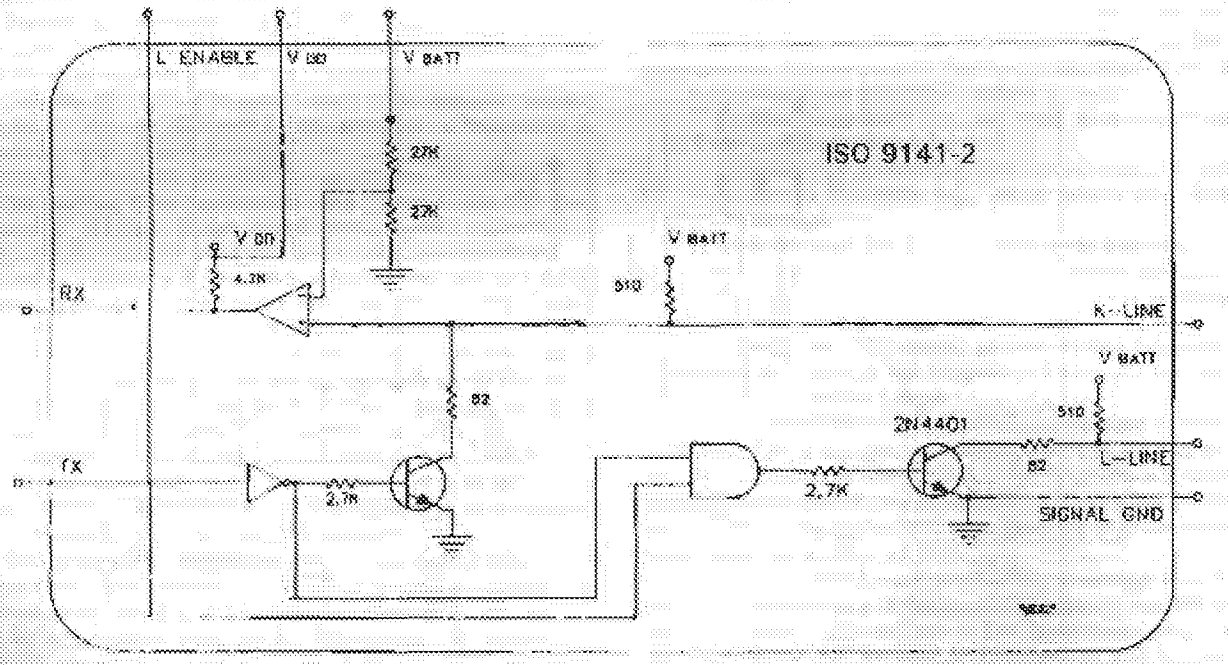


FIGURE A1d—ISO 9141-2 DETAILS

The DLCS handles all data link access responsibilities, i.e., idle bus detection, arbitration, automatic retry (if enabled), etc.

A.2.2.3 MESSAGE RECEPTION—The DLCS on its own receives and buffers a complete message from the bus, checks the received CRC, sets a status flag indicating a message has been received and if any errors occurred and, if enabled, interrupts the host. Retrieving a message received by the DLCS is done first by either polling the DLCS to determine if a message has been received or by servicing an enabled interrupt that occurs upon reception of a message. (The remainder of this discussion assumes the interrupt method is used.)

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upon receiving an interrupt, performing a 2 byte SPI transfer with the DLCS will result in the transfer of status and data to the host. The status byte is used to determine if the receive buffer contains any bytes of a message or a complete message and the status of the transmit buffer. Once all the bytes of a message have been received by the DLCS an indicator will be set in the status byte and, if enabled, an interrupt will be generated for the host. The status byte will also indicate whether the message was received correctly or that an error occurred (i.e., CRC error, incomplete byte, and bit timing error. If the message aborted from the DLCS was received while the DLCS was attempting to transmit a message, the status byte will also indicate transmission status values such as overrun or underrun and whether bus arbitration was won or lost.

A.2.3 DLCS Pin Names and Descriptions—The names and descriptions of the pins of the DLCS are shown in Table A2.

TABLE A2—DLCS PIN NAMES AND DESCRIPTIONS

Pin Number	Pin Name	Description
1	Vssd	Digital Ground
2	LQTI	Logic Out Transmitter In (Test)
3	OSC2	Oscillator 2
4	OSC1	Oscillator 1
5	RST–	Reset– (Active Low)
6	CS–	Chip Select– (Active Low)
7	SCLK	SPI Serial Clock
8	SIMO	SPI Slave In Master Out
9	SOMI	SPI Slave Out Master In
10	INT–	Interrupt– (Active Low)
11	Vdd	Digital Voltage Supply (+5 V)
12	N/A	Not Used
13	N/A	Not Used
14	N/A	Not Used
15	N/A	Not Used
16	N/A	Not Used
17	N/A	Not Used
18	N/A	Not Used
19	N/A	Not Used
20	Vssa	Analog Ground
21	LOAD	Bus Load
22	BUS	Bus Output
23	Vbat	Battery Voltage
24	PSEN	Power Supply Enable
25	Vdd	Analog Voltage Supply (+5 V)
26	REXT2	External Resistor 2
27	REXT1	External Resistor 1
28	LRQ	Logic In Transmitter Out (Test)

A.2.4 HBCC Operation—The HBCC contains a logic section and an analog section in a single integrated circuit. The logic section of the HBCC supports two types of serial and two parallel host interfaces. This allows for the HBCC to interface with standard Intel or Motorola microprocessors or others which have compatible ports. For this example, the Motorola SPI interface has been used. The logic section also includes a transmit buffer, a receive buffer, status and control registers, bit timing, symbol encoding, and decoding logic. The analog section is limited to the receiver circuitry. The transmitter driver stage and receiver input noise filter are implemented by external discrete parts.

Data transfer between a host and the HBCC is done with 2 byte SPI transfers. The host transfers an indirect address control byte (ACB) and a data byte to the HBCC. Generally the indirect address points to one of the internal registers of the HBCC and the data sent from the host is stored in the addressed register. During a 2 byte SPI transfer, the host receives a status byte and a data byte from the HBCC. Special address conventions also allow for block type data transfers between the host and the HBCC message buffers.

a. Commands sent to the HBCC include:
   (1) General commands (e.g., initialize node address)
   (2) Transmit commands (e.g., load transmit buffer)
   (3) Receive commands (e.g., read receive buffer)
b. Status data received from the HBCC include the following:
   (1) Receive status (e.g., received byte count)
   (2) Transmit status (e.g., transmission completed OK)
   (3) Network wire status (e.g., network wire shorted)

The operation of the HBCC consists primarily of three functions: initialization, transmission of a message, and reception of a message. Each of these will be discussed in more detail as follows:

A.2.4.1 INITIALIZATION—Initialization is accomplished by sending the HBCC commands to load the accompanying data as configuration information. The HBCC can be configured to enable or disable interrupts to the host, thereby allowing a polling scheme to be used, and to select the bus bit rate. Receive message filter look up tables can also be loaded to screen incoming messages, thus reducing host burden. Once the HBCC is initialized, normal transmission and reception can begin.

A.2.4.2 SENDING A MESSAGE—Loading a message into the HBCC for transmission on the bus is done by several SPI transfers. Each transfer contains an indirect address byte which defines where to store the accompanying data byte into the HBCC transmit buffer. Once the entire message has been loaded into the transmit buffer, the command to transmit the message is sent to the HBCC. The HBCC will then on its own begin to synchronize with the activity on the bus and transmit the message on the bus. The HBCC handles all data link access responsibilities, i.e., idle bus detection, arbitration, and automatic retry. When a message transmit attempt is completed, an interrupt is generated and the host can check the resultant status, including the status of an in-frame response.

A.2.4.3 RECEIVING A MESSAGE—Receiving bus messages using an HBCC is generally based on servicing the interrupt that occurs, if enabled, at the completion of message reception. The HBCC can be configured with interrupts either enabled or disabled, but for this example, interrupts are assumed to be enabled. Upon receiving an interrupt, the host will perform a two byte SPI transfer and receive from the HBCC a status byte and a data byte. The status byte can be used to determine how full the receive buffer is, and whether certain receive errors have occurred. A received message can subsequently be transferred from the HBCC to the host.

A.2.5 HBCC Pin Descriptions—The names and descriptions of the pins of the HBCC are shown in Table A3.

TABLE A3—HBCC PIN NAMES AND DESCRIPTIONS

Pin Number	Pin Name	Description
1	SCLK	Serial Clock
2	CS–	Chip Select– (Active Low)
3	USER7	User Input 7
4	USER6	User Input 6
5	USER5	User Input 5
6	USER4	User Input 4
7	USER3	User Input 3
8	USER2	User Input 2
9	USER1	User Input 1
10	USER0	User Input 0
11	MS2	Mode Select 2
12	MS1	Mode Select 1
13	BXMT–	Network B Drive– (Active Low)
14	AXMT	Network A Drive
15	Vdd	Analog Voltage Supply (+5 V)
16	BRCV	Network B Receive
17	ARCV–	Network A Receive (Active Low)
18	GND	Analog Ground
19	TESTENA–	Test Enable A (Active Low)
20	AWAKE	HBCC Awake
21	RST–	Reset– (Active Low)
22	Vdd	Digital Voltage Supply (+5 V)
23	OSCIN	Oscillator 1
24	OSCOUT	Oscillator 2
25	GND	Digital Ground
26	INT–	Interrupt– (Active Low)
27	SRCVDSDAT	Serial Data Receive/Serial Data I/O
28	SXMTDDIR	Serial Data Transmit/Data Direction

A.2.6 Additional Capabilities—Both the DLCS and HBCC include support for both transmit and receive message buffering and automatic message retransmission. The HBCC also includes support for receive message filtering, wake up, and 41.6 Kbps PWM bus physical layer fault tolerance. The DLCS also includes support to send and receive Break and for wake up.

A.3 PCI, HBCC, and ISO 9141-2 Interface Example—This example (see Figure A2a) combines the use of the Programmable Communication Interface (PCI) developed by Chrysler, the Hosted Bus Communication Controller (HBCC) developed by Ford, a discrete 41.6 Kbps transmit driver, and the common ISO 9141-2 interface to provide the required interface support. (Figure A2b shows the detail of the PCI.)

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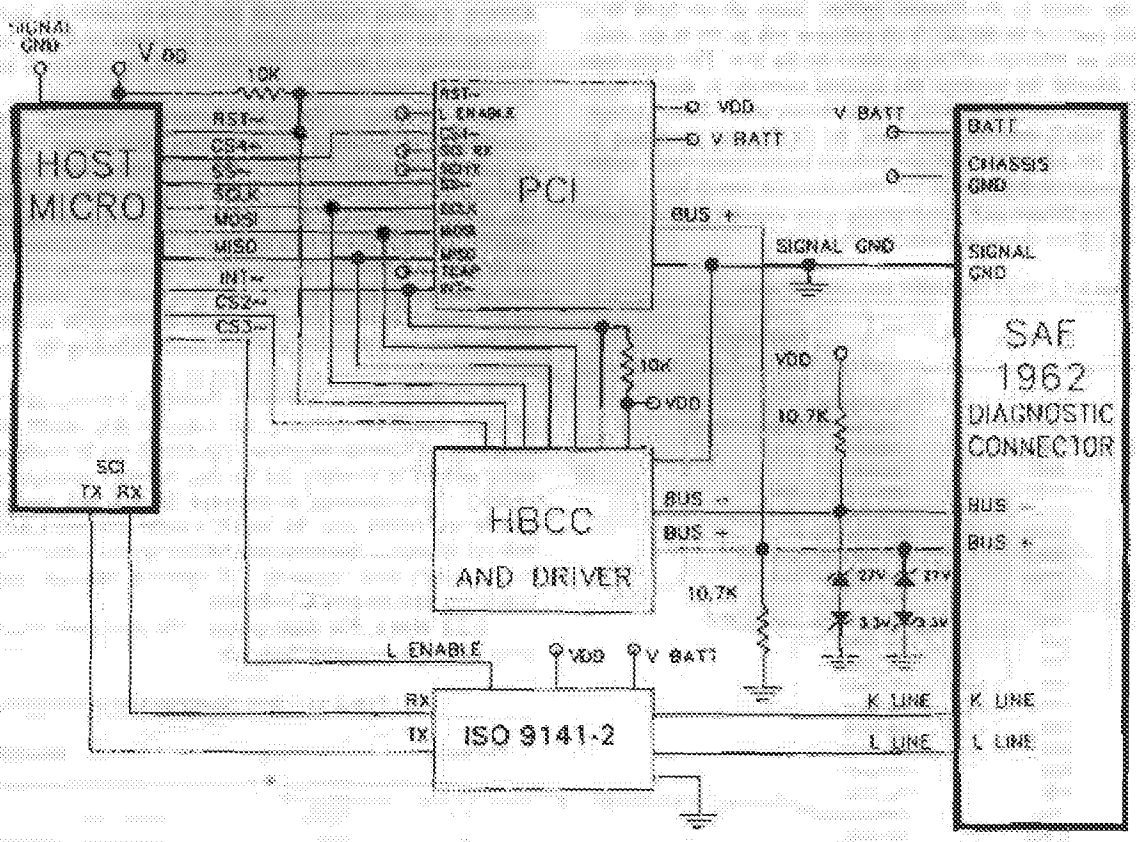


FIGURE A2a—PCI, HBCC, AND ISO 9141-2

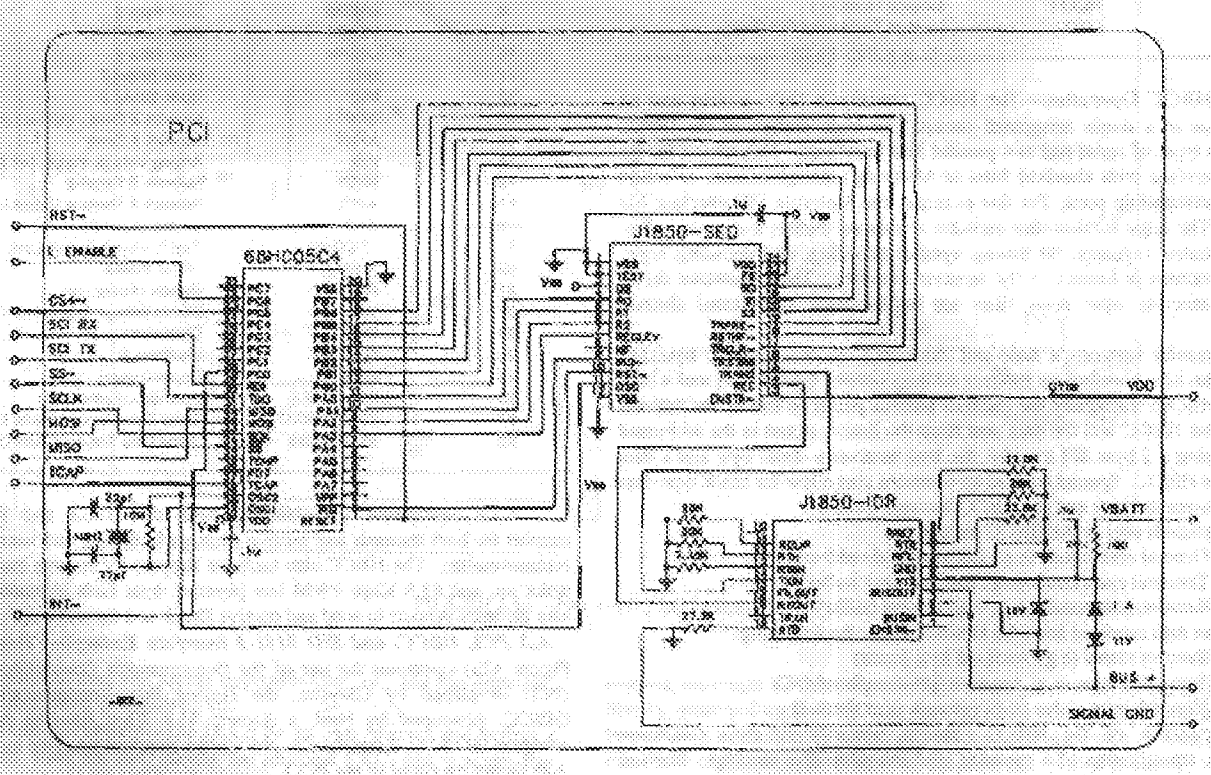


FIGURE A2b—PCI

A description of the HBCC interface is found in A.2.4.
A description of the ISO 9141-2 interface is found in A.2.4.
A description of the PCI is found in this section.
The host communicates with the PCI and the HBCC through the host's SPI interface. The host operates the SPI interface as the master and uses logic control lines to select either the PCI or the HBCC to communicate with. Control information sent from the host to the PCI and the HBCC causes the PCI and HBCC to be enabled or not. The ISO 9141-2 interface uses the SCI interface of the host and a logic line to enable the L line.

A.3.1 General Overview—The PCI operates at a 10.4 Kbps data rate using the symbols specified in SAE J1850.

The PCI is controlled by the coordinated interdependence of both hardware and software. The system consists of the interconnection of three devices:

a. A Control Microcomputer with custom software
b. A Symbol Encoder/Decoder (SED)
c. An Integrated Driver Receiver (IDR)

The control microprocessor controls the operation of the SED and interfaces with the host.

The SED is a digital gate array device which performs symbol encoding and decoding, timing and bus synchronization.

The IDR is an analog ASIC which performs as a 10.4 Kbps VPW bus transceiver for the PCI.

A.3.2 Control Microcomputer—The control microcomputer has overall control of the PCI's operation and interfaces with the host and the SED. The control microcomputer, under software control, interprets host commands and bus symbols.

A.3.2.1 CONTROL MICROCOMPUTER SOFTWARE STRUCTURE—The control microcomputer's most critical task is to service the IRQ interrupts generated by the SED. Less critical tasks are handled on an as-needed basis by the interruptable main program.

The IRQ interrupt processing task services the following:

a. Transmission of Frame Symbols
b. Reception of Frame Symbols
c. Bit-By-Bit Arbitration
d. Error Detection
e. Symbol encoding and decoding
f. In-frame response

The main program services the following:

a. Interface to the host
   (1) SPI (or Parallel) interface service
   (2) Chip selection of control microcomputer by the host
b. Bus calculations
   (1) Checksum or CRC
   (2) Transmit and receive message buffering
   (3) Error interpretation
c. Optional tasks when operating as host also
   (1) Keyboard inputs
   (2) Display drivers

A.3.2.2 CONTROL MICROCOMPUTER INTERFACE TO THE HOST MICROCOMPUTER—The PCI supports both a SPI or a parallel interface with the host. The host functions as interface master for both types of interfaces.

A.3.2.3 CONTROL MICROCOMPUTER INTERFACE TO THE SED—The interface between the control microcomputer and the SED shall be as defined by A.3.3 and Table A4.

TABLE A4—CONTROL MICROCOMPUTER AND SED INTERCONNECTION

Input Port	SED Output	Output Port	SED Input
PA0	R0	PB0	S0
PA1	R1	PB1	S1
PA2	R2	PB2	S2
PA3	RECLEV	PB3	TRPRE~
PA4	NF	PB4	RSTNF
IRQ~	IRQ~	PB5	TRCLR~
		PB6	TRSTRB

A.3.3 Symbol Encoder Decoder (SED)—The SED receives commands from the control microcomputer and converts these commands to SAE J1850 VPW symbols on a symbol-by-symbol bit-by-bit basis. Reception of messages is similarly accomplished, with the SED converting each received symbol into data that is fed to the control microcomputer for deciphering.

A.3.3.1 SYMBOL ENCODER—The control microcomputer initiates the transmission of a frame by first strobing Transmit Preset TRPRE~ to a logic "0" and strobing Transmit Strobe TRSTRB to a logic "1". The S0, S1, and S2 inputs are then set to the logic levels defined in Table A5 in order to activate the transmit symbol generator circuit. During each symbol, the Transmit Strobe TRSTRB is strobed. The transmit symbol generator produces the required symbol on the Transmit TRANS Output of the SED. When the symbol has completed transmission, the SED Receive Circuit generates an IRQ~ interrupt to the control microcomputer to obtain the next symbol. This cycle is repeated until the entire frame is transmitted.

TABLE A5—TRANSMIT SYMBOL DEFINITION

Inputs S2	Inputs S1	Inputs S0	Output Description J1850 Xmit Symbol
0	0	1	Tx1 Short
0	1	0	Tx2 Long
0	1	1	Tx3 SOF or EOD
1	0	0	Tx4 EOF
1	0	1	Tx5 IFS
1	1	0	Tx6 BRKDET

A.3.3.2 SYMBOL DECODER—Similarly to the operation of the symbol encoder, the completion of the reception of a symbol from the IDR by the SED causes the SED to interrupt the control microcomputer. The control microcomputer reads the SED's R0, R1, and R2 outputs to determine which symbol was received, as defined by Table A6.

The meaning of each received VPW symbol is dependent on whether the symbol level is dominant or passive. This level is read by the control microcomputer on the Receive Level RECLEV Output of the SED.

TABLE A6—RECEIVE SYMBOL DEFINITION

Outputs R2	Outputs R1	Outputs R0	Input Description J1850 Rec. Symbol
0	0	0	Invalid Symbol
0	0	1	Rx1 Short
0	1	0	Rx2 Long
0	1	1	Rx3 SOF or EOD
1	0	0	Rx4 EOF
1	0	1	Rx5 IFS
1	1	0	Rx6 BRK

A.3.3.3 INVALID SYMBOL—The reception of an Invalid Symbol (Refer to Table A6) sets a Noise Flag NF Output. This Output remains at a logic "1" level until cleared by Reset Noise Flag RSTNF Input.

A.3.3.4 SED INPUTS AND OUTPUTS—All inputs and outputs from the SED are at standard CMOS voltage levels.

The following discusses some particular SED inputs and outputs.

A.3.3.4.1 Transmit Clear (TRCLR~) Input—The SED's TRCLR~ Input can be used by the control microcomputer to terminate the transmission of a IBS or Break symbol. IBS may be terminated after the minimum Tv5 period has been generated and a Break symbol may be terminated after a period greater than the maximum Tv6 has been generated.

A.3.3.4.2 Reset (RST) Input—The RST Input to the SED is used to initialize the SED.

A.3.3.4.3 Oscillator (OSC) Input—The OSC Input to the SED is the Time Base Clock Signal. When the DS Input is connected to VCC, a 4.0 MHz clock is required. When DS Input is grounded, an 8.0 MHz clock is required.

A.3.3.4.4 Transmit Strobe (TRSTRB) Input—The TRSTRB Input to the SED operates as a watchdog circuit to insure that the control microcomputer is functioning correctly. The TRSTRB Circuit requires that each transmit symbol must be strobed into the SED or the SED will transmit an Idle Output. The TRSTRB Input is active when ENTRSTRB Input is grounded and disabled when the ENTRSTRB Input is connected to VCC.

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A.3.4 Integrated Driver/Receiver (IDR)—The IDR is the interface between the vehicle bus wiring and the SED. The IDR integrates and simultaneously performs both the bus driver and receiver functions. The bus output waveform is specifically shaped to conform to SAE J1850 requirements and to minimize EMI.

A.3.4.1 BUS OUTPUT WAVESHAPING—The IDR bus output is wave shaped to have symmetrical rise and fall voltage waveforms within the range of allowed bus loading tolerances and battery operating voltages and during message arbitration. The waveshaping consists of a set rise/fall and corner rounding times. The maximum rise/fall time is 16 µs with the corner rounding of 4 µs. The typical rise/fall time is set to 14 µs with corner rounding of 3 µs.

A.3.4.2 TRANSMITTING SIGNALS ON THE BUS—The IDR receives 1's and 0's from the SED on the CMOS compatible Transmit pin (Tx) and translates these to wave shaped high and low signals at the bus out pin (Bout). The propagation delay between the transition on the Tx pin and the corresponding transition on the Bout pin measured at 3.875 V is a maximum of 12 µs, with a typical value of 10 µs.

A.3.4.3 PROCESSING SIGNALS RECEIVED FROM THE BUS—The IDR receives 1's and 0's on the bus input pin (Bin) and translates these to 1's and 0's at the CMOS compatible Receive pin (Rx). The propagation delay between the transition on the Rx pin and the corresponding transition on the Bin pin measured at 3.875 V is a maximum of 2 µs, with a typical value of 1 µs.

A.3.5 Additional Capabilities—The additional capabilities of the HBCC are shown in A.2.6.

The PCI is able to buffer both transmit and receive messages, send and receive Break, support both CRC and Checksum for message error checking, and complement IFS.

The MPU used in this example for the control microcomputer is a Motorola 68HC05C4. This particular version of the 68HC05 family is used for the designer's convenience. A more simple 68HC05P7 microcomputer could also be used to perform the required PCI control tasks and in some cases do the tasks of a scan tool. The 68HC05C4's utilization during message transmission averages about 50% of the available CPU time. It is likely that with so much CPU time still available, the 68HC05C4 or the more powerful and fast 68HC11 could be used to perform both the control and host tasks.

A second example in this section (see Figure A3) shows the use of the control microprocessor associated with the PCI as the host also. As such, a control microcomputer is connected to the HBCC and ISO 9141-2 interface. The external equipment manufacturer is left to design the interface to the required keyboard and display, which are not shown. Similarly to the example shown in Figure A2a, the control microcomputer externally selects the HBCC or the ISO 9141-2 interface when needed.

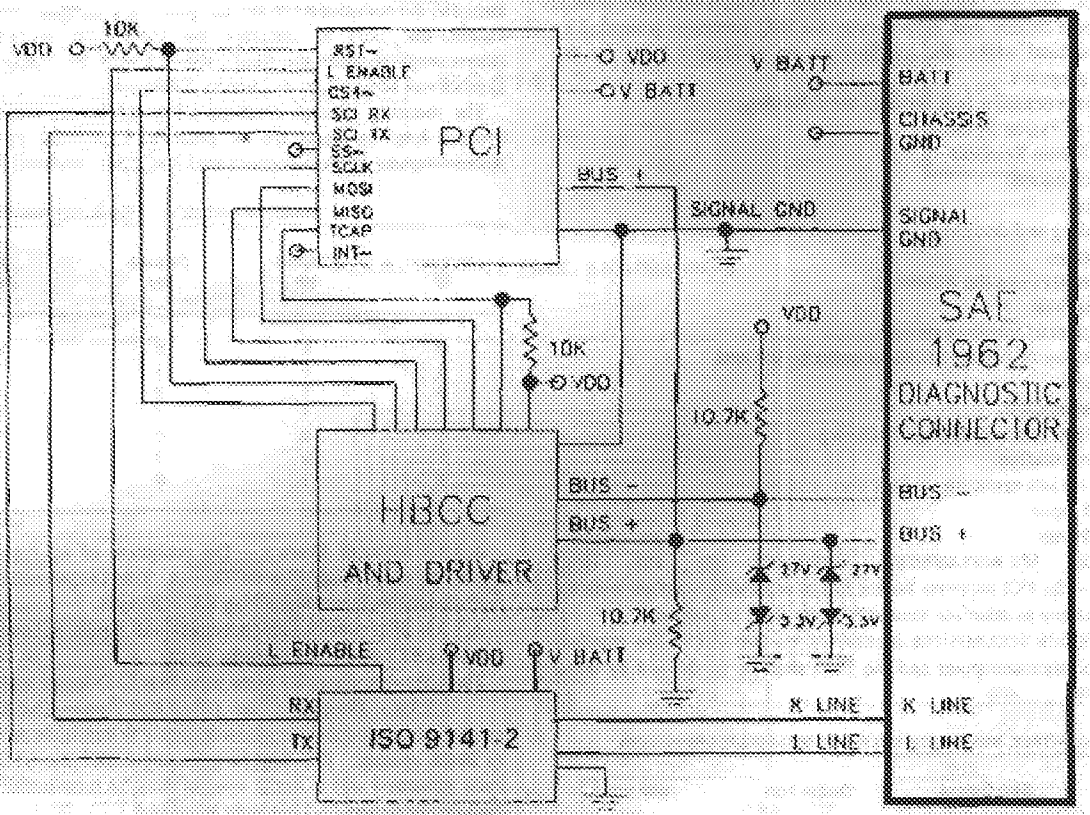


FIGURE A3—PCI, HBCC, AND ISO 9141-2 WITH PCI AS HOST ALSO

A.4 SGS-Thomson Protocol Engine Interface Example—This example (see Figure A4a) combines the use of an SGS-Thomson ST9 microprocessor as a control microcomputer, control microprocessor software, a GAL5001 programmable logic array device and discrete bus transceiver circuitry to provide the required interface support. Together these devices are identified as the SGS-Thomson Protocol Engine. (Figure A4b shows the detail of the ST9 and the GAL5001, Figure A4c shows the detail of the 10.4 Kbps Transceiver, Figure A4d shows the detail of the 41.6 Kbps Transceiver, and Figure A4e shows the detail of the ISO 9141 Transceiver.)

In this example the host microcomputer is connected to only one interface, the Protocol Engine. The Protocol Engine directly supports the required SAE J1850 and ISO 9141-2 interfaces and includes the ability to, on its own, determine the particular interface being used by a vehicle to support OBD II communications.

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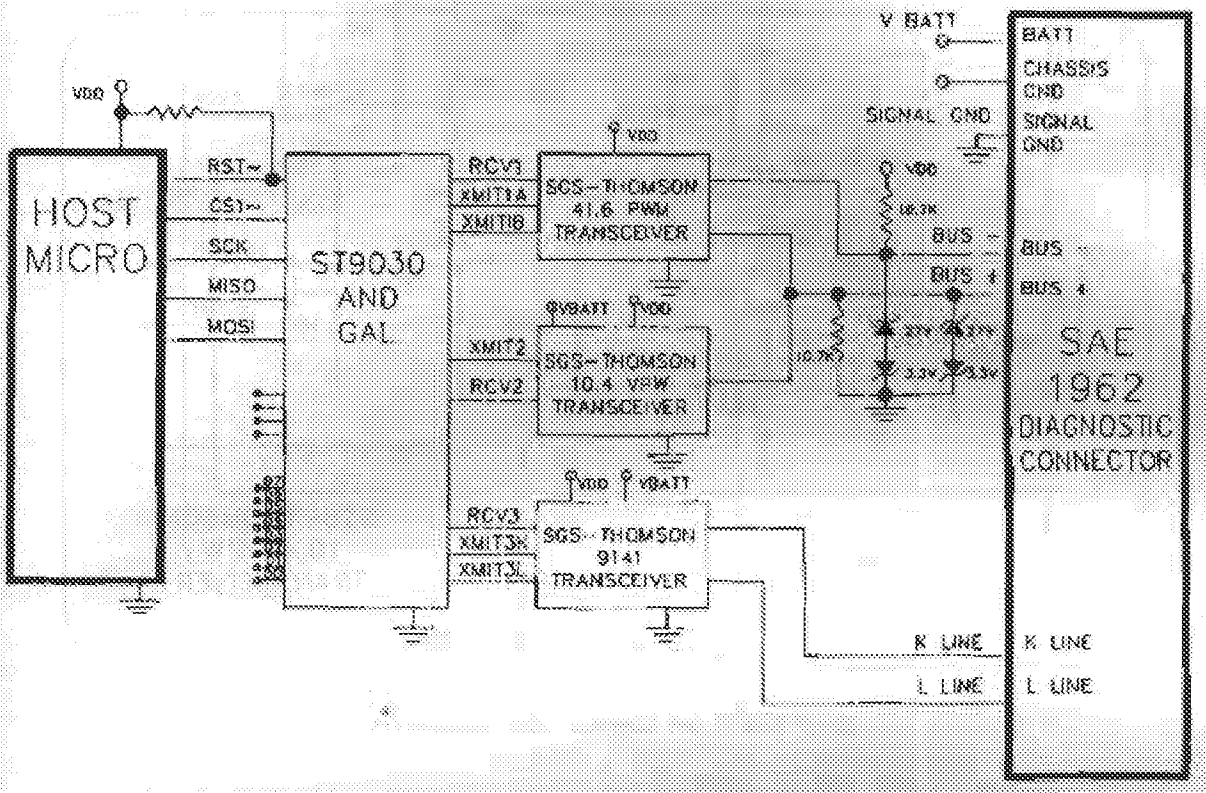


FIGURE A4a—SGS-THOMSON PROTOCOL ENGINE

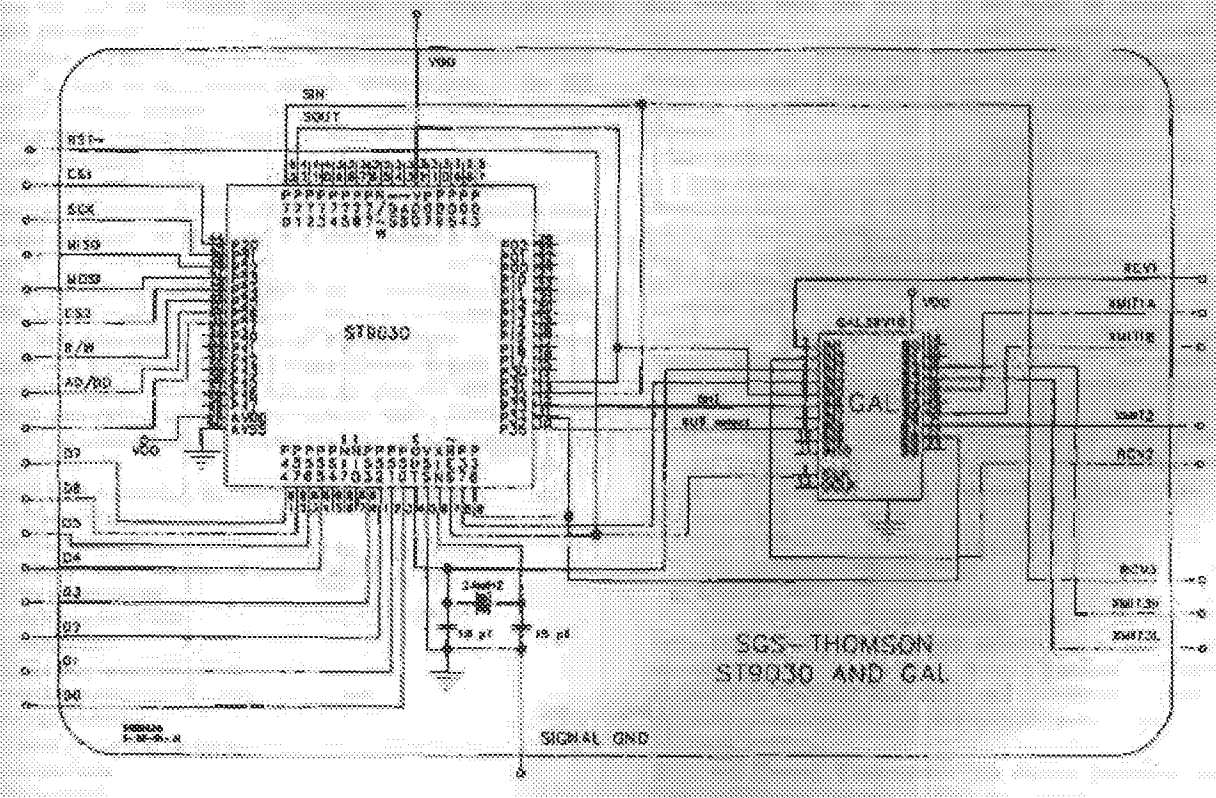


FIGURE A4b—SGS-THOMSON ST9030 AND GAL

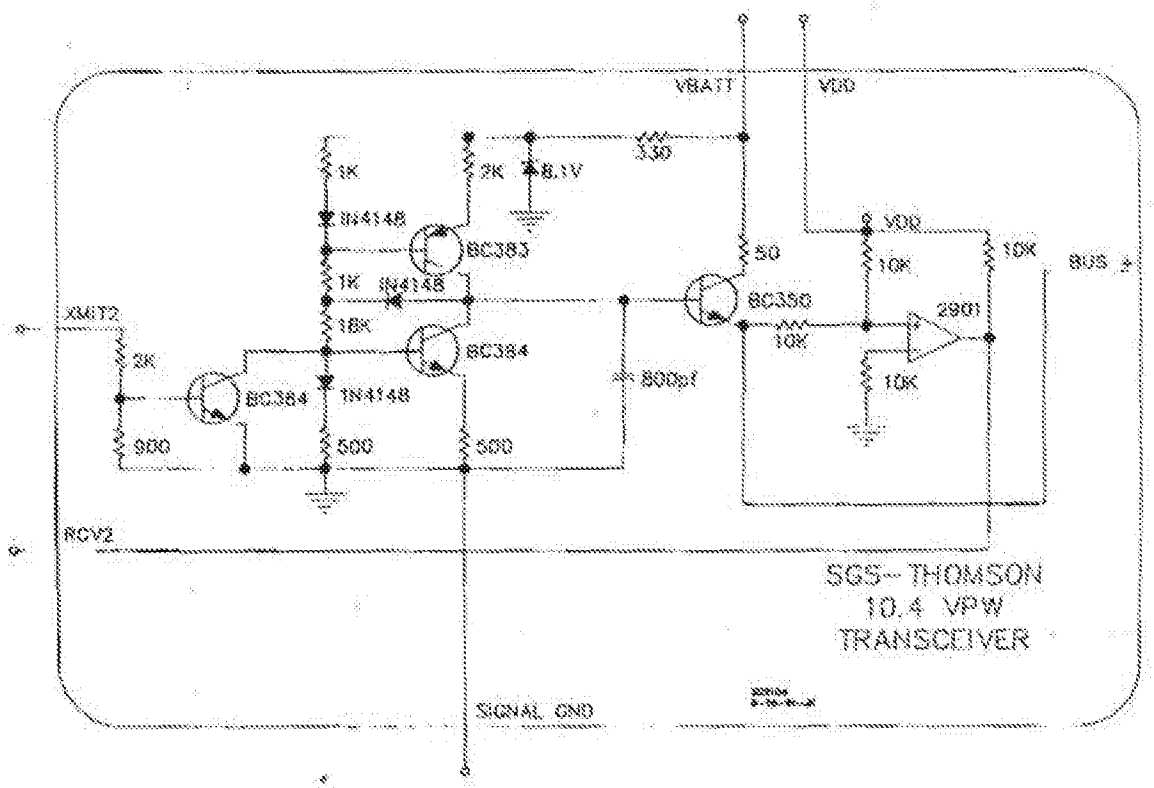


FIGURE A4c—SGS-THOMSON 10.4 VPW TRANSCEIVER

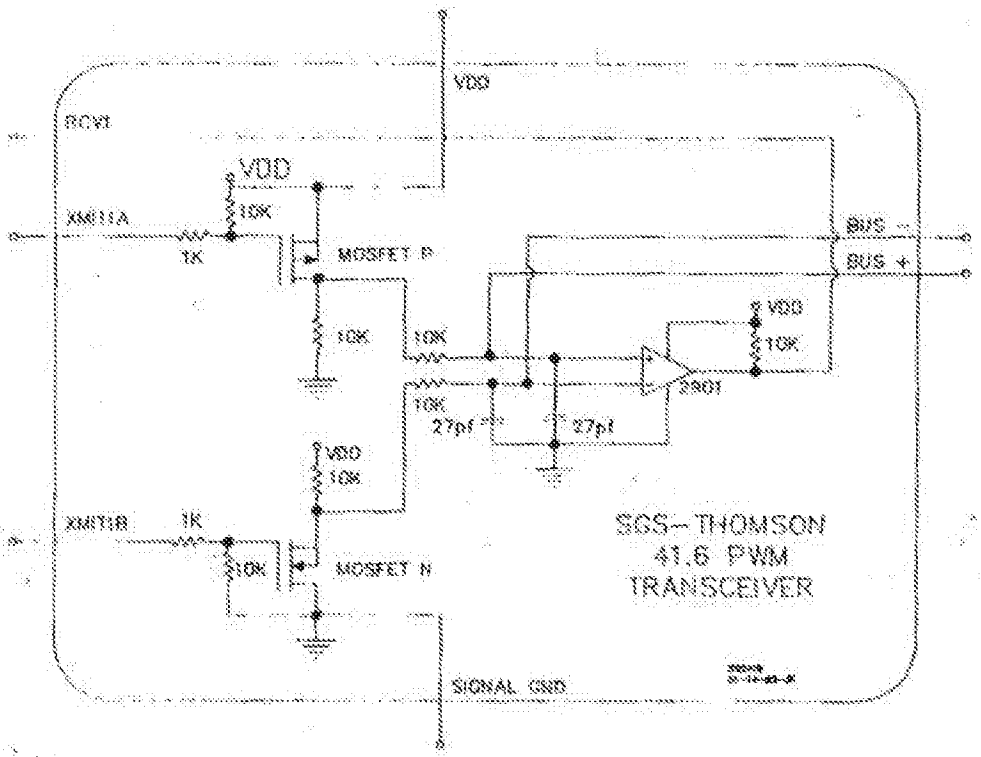


FIGURE A4d—SGS-THOMSON 41.6 PWM TRANSCEIVER

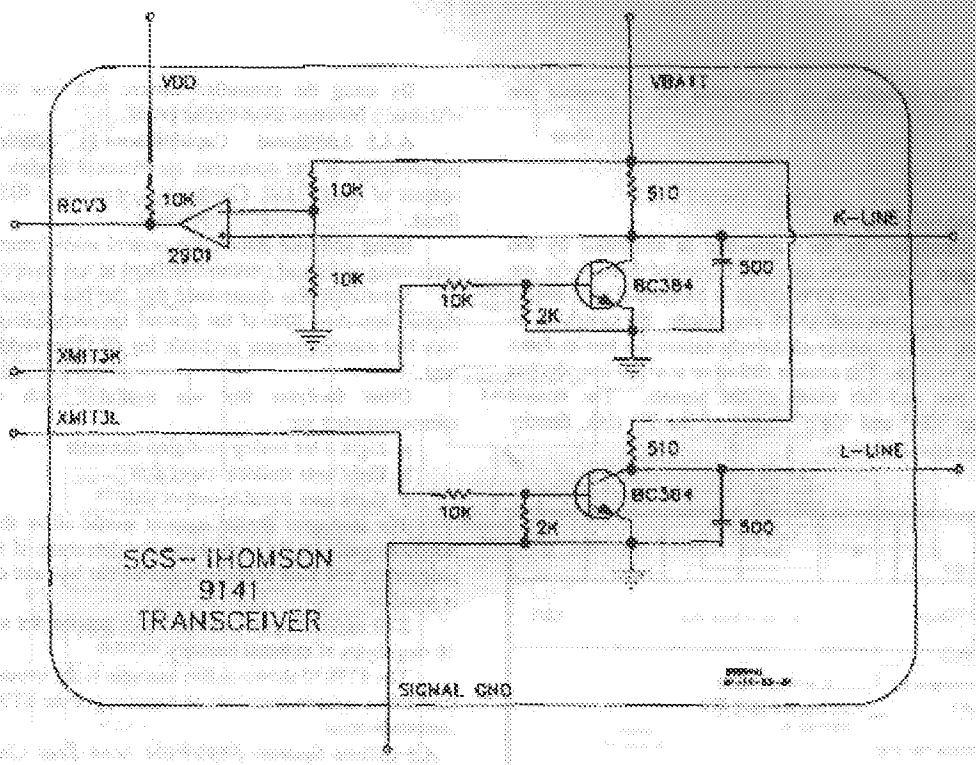


FIGURE A4c—SGS-THOMSON 9141 TRANSCEIVER

A.4.1 General Overview—As mentioned in Section A.4, the Protocol Engine is comprised of four parts: the ST9 control microcomputer, control microcomputer software, the GAL6001 programmable logic array device, and quad discrete transceivers.

A.4.2 Control Microcomputer—A SGS-Thomson ST9 family microcomputer is used as an interface control microcomputer. The ST9 microcomputer is a general purpose 8/16 bit microcomputer. Its timer facilities are used extensively to provide the control of transmitted waveforms and the detection of received signals.

Both SPI and parallel interfaces to host microcomputers are supported.

The host can request the Protocol Engine to either scan the possible OBD II interfaces and determine the type used on a given vehicle or use a selected interface type.

A.4.2.1 CONTROL MICROCOMPUTER SOFTWARE STRUCTURE—The highest priority tasks in the control microcomputer support the symbol-by-symbol processing of each transmitted and received message frame. The control microcomputer, and in particular the ST9's timers, directly controls the rise and fall of transmitted signals and directly follows the rise and fall of received signals. When transmitting a message, it performs both of these processes simultaneously. All other control microcomputer tasks are processed on a time available basis.

The following further identifies the control microcomputer's tasks:

a. Highest Priority Tasks:
   (1) Bus synchronization
   (2) Transmission and reception of frame symbols
   (3) Bit-by-bit arbitration
   (4) Comprehension of IFS
b. Background tasks:
   (1) CRC or checksum calculation
   (2) Symbol encoding and decoding
   (3) Message buffering
   (4) In-frame response processing
   (5) Error checking
   (6) Host interface

A.4.2.2 CONTROL MICROCOMPUTER INTERFACE TO THE HOST—Communication between the control microcomputer and the host is based on the host reading from and writing to 64 bytes of memory in the control microcomputer. Sixteen bytes are reserved for status and control of SAE J1850 related operations, 13 bytes are reserved for status and control of ISO 9141-2 related operations, 3 bytes are reserved for general status and control, and 32 bytes are reserved for receive and transmit buffers and related pointers and counters.

Data transfers between the host and the control microcomputer are performed as 2 byte transfers, a control byte and a data byte, initiated by the host. The control byte from the host indicates whether the host wishes to read or write a byte in the control microcomputer and what the address of the byte is (see Figure A5). The second SPI byte transfer moves the byte read from the control microcomputer to the host or the byte to be written from the host to the control microcomputer.

The control microprocessor supports both an SPI and a parallel type of interface with the host. In order to properly service bus communications, the control microcomputer controls the actual data transfers between itself and the host.

A.4.2.3 AUTOMATIC OBD II INTERFACE SCAN—Upon host request, the Protocol Engine will, by itself, automatically scan all of the possible OBD II interfaces and determine the one supported by a given vehicle. The interface scan sequence used is as follows:

a. SAE J1850 41.6 Kbps PWM
b. SAE J1850 10.4 Kbps VPW
c. ISO 9141-2

A.4.3 GAL6001 Programmable Logic Array—The GAL6001 Programmable Logic Array performs primarily as a digital filter of the signal received from the vehicle bus. It is a standard high-performance field programmable EEPROM logic device and is available in a variety of packages. The device chosen has a 20-year data retention specification. It is organized as a 78 X 64 X 36 FPLA.

A.4.4 Discrete Transceiver—The discrete transceiver circuitry includes all the components necessary to create the required transmit signal waveforms on a bus and to receive bus signals. This includes support for 41.6 PWM, 10.4

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VPW and ISO 9141-2. The transceiver is responsible for or controls the following:

a. Voltage on the bus
b. Current levels
c. Media impedance
d. Signal rise times and fall times

The overall signal transmitted by the transceiver is controlled by the control microcomputer. Signal transmission on a bus is created through the use of current sources/sinks. The 10.4 Kbps VPW driver is comprised of a current source of 1X magnitude and a current sink of 2X magnitude. By switching on and off the 2X current sink, the transceiver effectively causes the bus to make transitions from zero to one to zero. The current sinked or sourced into the bus capacitance controls the rise and fall times of the signals. The control microcomputer controls the "ON" and "OFF" timing of the 2X sink, thereby controlling the data and data rate on the bus.

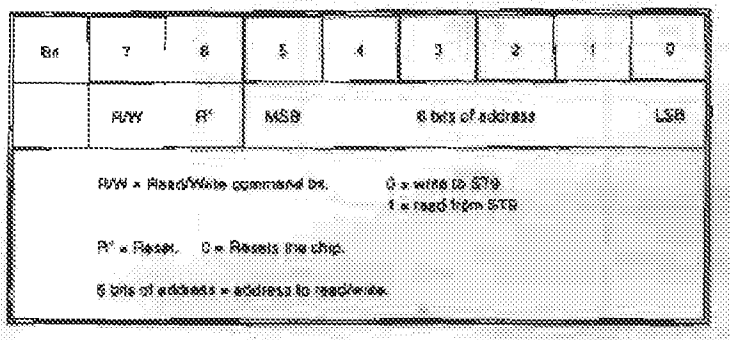


FIGURE A5—PROTOCOL ENGINE COMMAND BYTE

By using the controlled current sink and source approach this driver effectively becomes short-circuit proof.

A.4.5 Additional Capabilities—In addition to supporting the requirements of this document, the Protocol Engine also supports the following options of SAE J1850: Checksum, comprehend IBS, Single Byte Header, and Break.

Being software driven, the control microcomputer can be considered as supporting additional custom interfaces to test equipment host microcomputer.

Simulation has determined that the bus signal control and monitor task requires less than 30% of the control microcomputer leaving at least 70% of very fast microcomputer available for the other tasks such as performing as the host.

Other facilities that are available with various versions of the microcomputers are:

a. Eight 8-bit analog-to-digital channels
b. Eight user readable input pins
c. Eight user writable output pins

The analog to digital support would allow the host to have the control microcomputer to do such things as determine if the diagnostic connector is plugged in, and look at the voltages on the bus and determine if communication is possible.

ST9 microcomputer models have support for up to 32K of ROM or up to 16 megabytes of external memory.

The ST9030 shown in this example is the lowest member in the ST9 family currently available, therefore all members of the ST9 family can support this communication.

A.5 Silicon Systems F690/F691 Scan Tool Chipset Interface Example—This example (see Figure A6a) combines the use of the F690 Codec and the Transceiver scan tool chip set developed by Silicon Systems (SSI) to provide the required interface support. (Figure A6b shows the detail of the F690 Codec and Figure A6c shows the details of the F691 transceiver.)

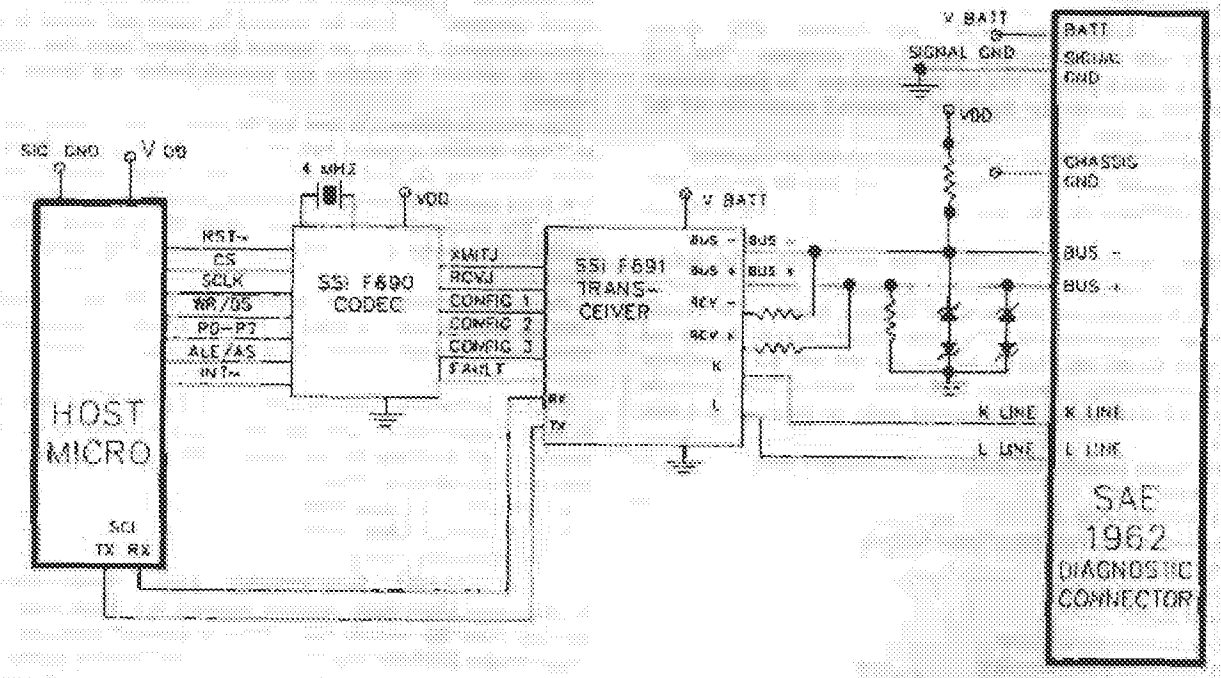


FIGURE A6a—SILICON SYSTEMS F690/F691 CHIPSET

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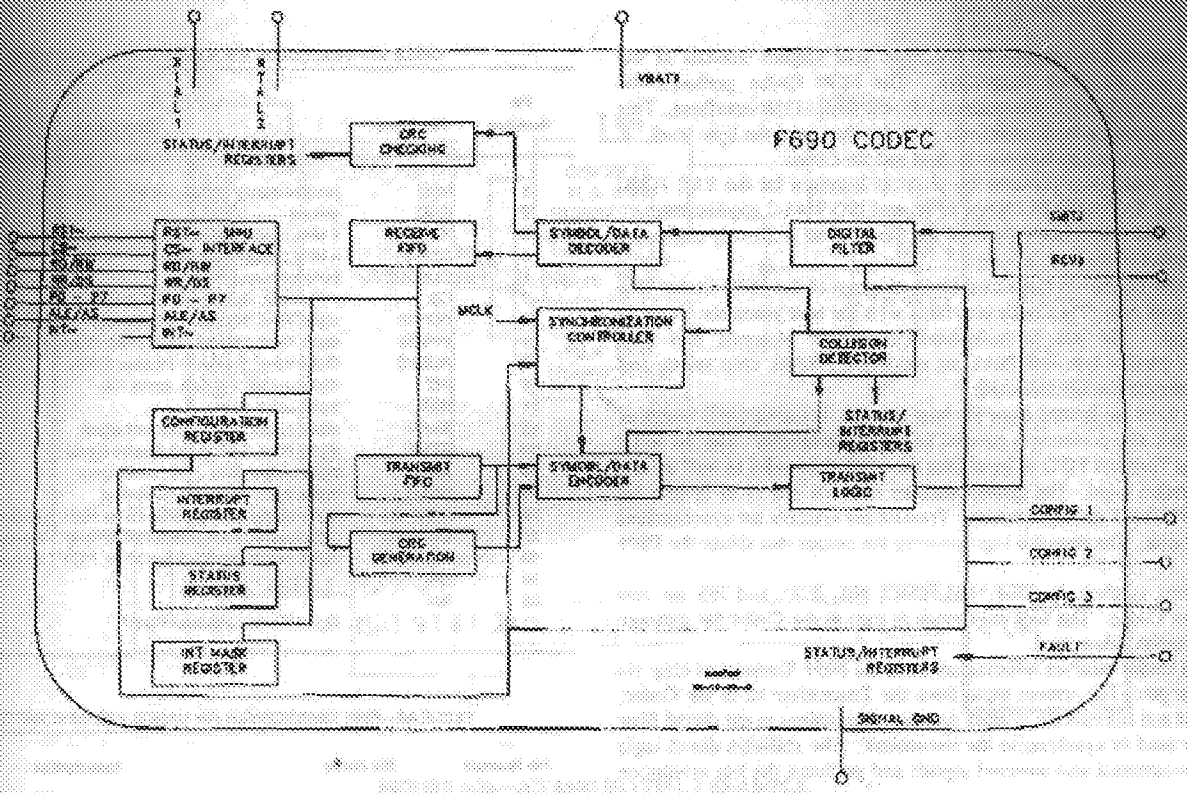


FIGURE A6—P690 CODEC

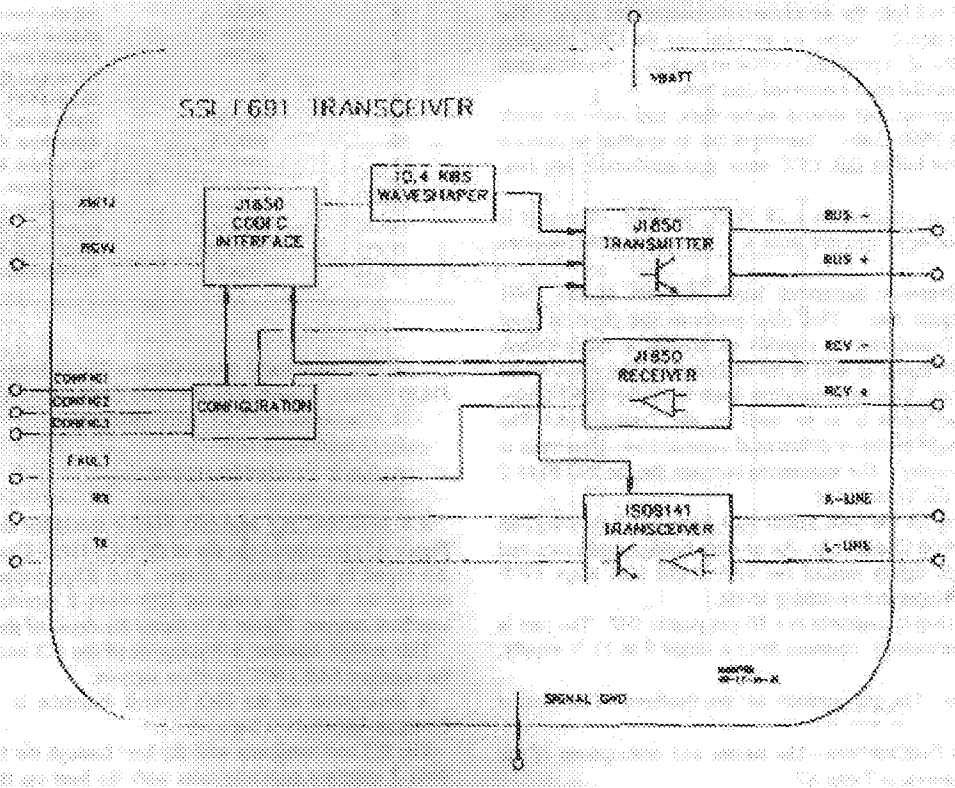


FIGURE A6a—P691 TRANSCEIVER

A.5.1 General Overview—The SSI Scan Tool chipset consists of the F690 Codec and the F691 Transceiver. The F690 Codec performs the bit/symbol level CODec/DECoder operations for the SAE J1850 interfaces. This allows the host processor to communicate with the chipset at the byte level. A parallel type interface is used between the host and the Codec.

The F691 Transceiver performs the physical interface for the SAE J1850 41.6 Kbps PWM, SAE J1850 10.4 Kbps VPW, and ISO 9141-2 requirements.

The ISO 9141-2 interface support of the Transceiver is directly connected to the SCI interface of the host.

A.5.2 F690 Codec—A functional block diagram of the F690 Codec chip is shown in Figure A6b. The Codec interfaces with the host processor via an 8-bit parallel bus. The bus is multiplexed and both Motorola and Intel microcomputer parallel type interfaces are supported. Reset, chip select, and interrupt line connections are also used.

Transmit bytes are loaded from the host into the Transmit FIFO buffer of the Codec, which also performs a parallel to serial conversion. The bit serial output from the Transmit FIFO is input into the symbol encoder as well as into the CRC generation logic. The symbol encoder converts bits (1 or 0) into the appropriate PWM/VPW timing symbols. Transmitted symbols are synchronized to the received data. The transmit logic controls the output that drives the F691 Transceiver.

The framing symbols for SOF, IBS, EOD, NB, EOF, and IFS are also generated by the Codec. The host only needs to pass to the Codec the message bytes, and checksum, when used.

The F690 Codec receives information from the F691 Transceiver chip via the RCVJ input pin. The receive input from the Transceiver is, in the Codec, digitally filtered and fed into the symbol decoder. Transitions at the digital filter output are also used to synchronize the transmitter. The collision detect logic compares the transmitted and received signals and performs the bus arbitration function.

The symbol decoder compares the digital filter output with known symbol templates. When a data bit match occurs, the proper bit (1 or 0) is shifted into the receive FIFO buffer. When framing symbols are detected, they are stripped from the received data and fed into the synchronization/controller logic. The data values from the symbol decoder output are also fed into the CRC checking logic. The receive FIFO buffer also performs a serial to parallel conversion such that the host processor can parallel read a received data byte.

Configuration data, transmit and receive status data, and interrupt mask registers are included on the F690 Codec. Interrupts can be enabled to indicate transmit buffer empty, receive buffer full, CRC error, lost arbitration, idle bus, fault detection, etc.

The F690 Codec chip is available in a 28 PLCC package. The part is fabricated in a CMOS technology, operates from a 5 V supply, and consumes less than 100 mW max.

A.5.3 F691 Transceiver—A functional block diagram of the F691 Transceiver is shown in Figure A6c. This chip performs the physical level interface functions. The Transceiver is capable of driving a single-ended, waveshaped, 10.4 Kbps VPW signal as well as the differential, 41.6 Kbps PWM signal onto SAE J1850 buses. Two configuration lines from the F690 Codec determine what xmit/receive mode is to be used by the Transceiver. The receiver consists of either single ended or differential comparators. Hysteresis is added to improve noise immunity. The transmitter/receiver for the ISO 9141-2 interface is also included on the Transceiver.

Other than waveshaping for the SAE J1850 10.4 Kbps VPW interface, all timing is controlled by the F690 Codec chip. An on-chip bandgap reference and prepackage trims are used to tightly control the SAE J1850 10.4 Kbps VPW waveshape parameters and comparator switching levels.

The F691 Transceiver chip is available in a 16-pin plastic DIP. The part is fabricated in a BIPOLAR technology, operates from a single 9 to 13 V supply, and dissipates 300 mW max.

A.5.4 Pin Description—The pin numbers are not finalized. This section describes pin function only.

A.5.4.1 F690 Codec Pin Description—The names and descriptions of the pins of the F690 Codec are shown in Table A7.

A.5.4.2 F691 Transceiver Pinout—The names and descriptions of the pins of the F691 Transceiver are shown in Table A8.

TABLE A7—F690 CODEC PIN NAMES AND DESCRIPTIONS

Pin Number	Pin Name	Description
1	VDD	positive supply voltage, +5 V
2	GND	ground
3	XTAL1	4 MHz crystal connection; can be driven by an external clock
4	XTAL2	4 MHz crystal connection
5	CLKOUT	buffered output clock
6	CS	chip select, digital input, active low
7	R/W	digital input, Intel/MOTO processor interface control
8	WR/DS	digital input, Intel/Moto processor interface control
9	ALE/AS	digital input, Intel/Moto address strobe
10	INT	digital output, interrupt, active low
11	RST	digital input, reset
12	XMITJ	digital output, SAE J1850 xmit signal
13	RCVJ	digital input, SAE J1850 receive signal
14	XMITJ	digital output, SAE J1850 xmit signal
15	BUSSEL	digital input, Intel/Moto bus select
16	CONFIG1	digital output, configuration bit for F691 Transceiver
17	CONFIG2	digital output, configuration bit for F691 Transceiver
18	CONFIG3	digital output, configuration bit for F691 Transceiver
19	N/A	
20	N/A	
21-28		digital I/O, bus interface P0-P7

TABLE A8—F691 TRANSCEIVER PIN NAMES AND DESCRIPTIONS

Pin Number	Pin Name	Description
1	VBAT	positive supply
2	GND	ground
3	BUSP	positive bus output drive
4	BUSN	negative bus output drive
5	RCVP	positive bus receiver input
6	RCVN	negative bus receiver input
7	K	ISO 9141-2 K line, input/output
8	L	ISO 9141-2 L line, output
9	ISO_RX	digital output, ISO 9141-2 receive signal
10	ISO_TX	digital input, ISO 9141-2 transmit signal
11	XMITJ	digital input, SAE J1850 xmit signal
12	RCVJ	digital output, SAE J1850 receive signal
13	CONFIG1	digital input, configuration bit
14	CONFIG2	digital input, configuration bit
15	CONFIG3	digital input, configuration bit
16	FAULT	digital output, fault detection

A.5.5 Additional Capabilities—The following is a list of additional SAE J1850 features supported by the F690 Codec/F691 Transceiver:

a. Checksum and CRC error checking
b. Comprehends IBS
c. Single Byte header support
d. generation of a Break signal

A.6 Motorola JCI and ISO 9141-2 Interface Example—This example (in Figure A7a) combines the use of the SAE J1850 Communications Interface (JCI) developed by Motorola, a discrete 41.6 Kbps transceiver, a discrete 10.4 Kbps transceiver, and the common ISO 9141-2 interface to provide the required interface support. Figure A7b shows the detail of the JCI.

This section contains a description of the JCI interface, which provides all of the required SAE J1850 interface support.

A description of the ISO 9141-2 interface is found in the section titled Common ISO 9141-2 Support.

The JCI communicates with the host through the host's SPI port, while the ISO 9141-2 interface communicates with the host via the host's SCI port. Separate logic interface lines from the host are used to enable either the JCI or the ISO 9141-2 interface.

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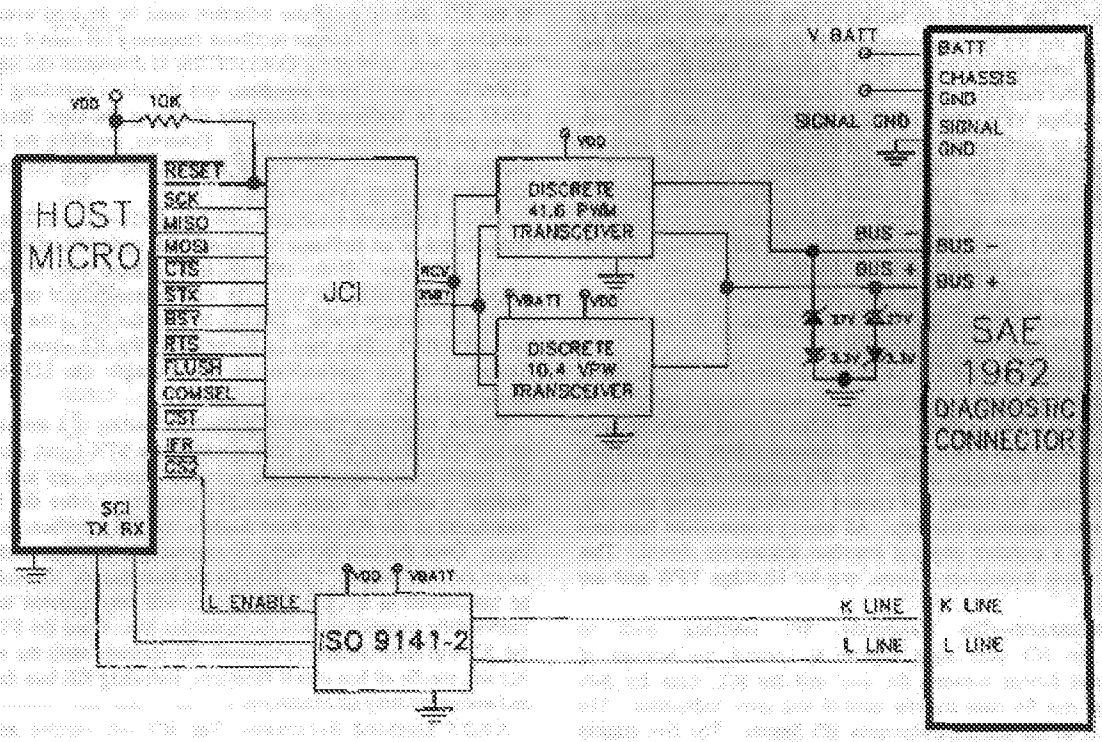


FIGURE A7a—JCI AND ISO 9141-2 EXAMPLE

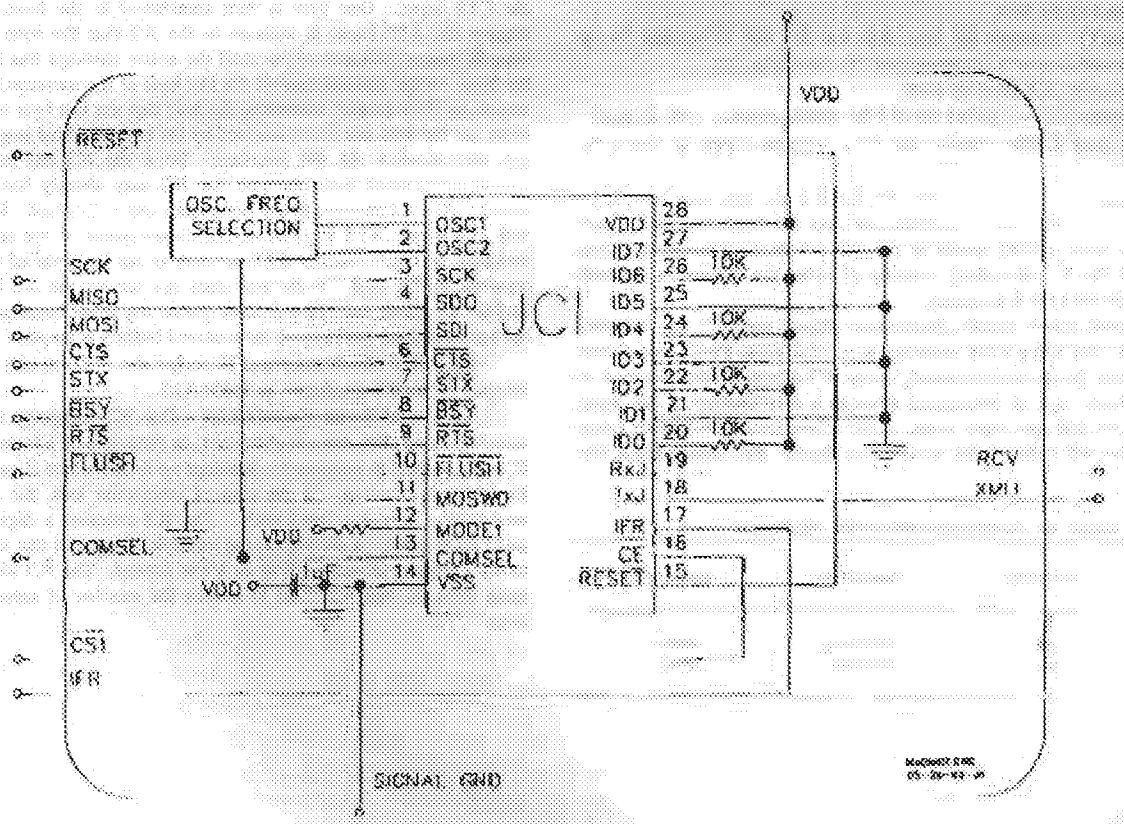


FIGURE A7b—MOTOROLA J1850 COMMUNICATIONS INTERFACE

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A.6.1 General Overview—The JCI is an all-digital communications peripheral device which performs all of the required SAE J1850 communications tasks. This reduces the burden on the host to the loading of complete messages into the JCI for transmission onto the multiplex bus, and the unloading of complete messages which the JCI has received from the multiplex bus. The JCI can transmit messages using either modulation technique specified by SAE J1850 (10.4 Kbps VPW and 41.6 Kbps PWM). A separate network transceiver is required to perform all drive, waveshaping, and input compare functions required for proper transmission and reception of each type. This example includes the use of the SGS-Thomson 41.6 Transceiver and 10.4 Transceiver. This example uses several logic lines from the host to enable the JCI interface, and to control the exchange of data between the host and the JCI, while the data exchange occurs via the host's SPI interface port. The ISO 9141-2 interface is as described in A.1.4. The host uses its SCI interface port to communicate with a vehicle through the ISO 9141-2 interface. A logic line is used by the host to enable the L line when necessary.

A.6.2 JCI Operation—The JCI is an all-digital integrated circuit which can support transmission of messages in both modulation formats specified in SAE J1850. The JCI also supports three different types of serial host interfaces, allowing the JCI to be used with a wide range of microcontrollers. This example utilizes the 'Handshake SPI' interface mode. The JCI contains a single transmit buffer, two receive buffers, bit timing and symbol encoding/decoding circuitry, and CRC generation and checking circuitry. All analog transmission functions must be performed by a separate physical interface transceiver circuit. This example uses two discrete transceiver circuits, one for 10.4kbps VPW and one for 41.6 Kbps PWM.

A.6.2.1 HOST INTERFACE—The Handshake SPI interface used to communicate with the JCI uses eight signals to control the transfer of information in a serial format between the host and the JCI, three for data transmission, and the rest for data transfer control and error indication. The actual data transfer is in the standard Motorola SPI format. The five control lines include two outputs from the JCI and three inputs to the JCI. The function of these lines are as follows:

a. Output signals from the JCI to the host:
   (1) Request to Send (RTS)—Informs the host that the JCI has data to be transmitted to the host.
   (2) Busy (BSY)—Informs the host that the JCI has a message in its transmit buffer to be transmitted onto the multiplex bus.

b. Input signals to the JCI from the host:
   (1) Chip Enable (CE)—Enables the JCI for communication with the host.
   (2) Clear to Send (CTS)—Enables the JCI to transmit a byte of data to the host.
   (3) Start Transmit (STX)—Informs the JCI that the host has data to be transmitted to the JCI for transmission onto the multiplex bus. There are also other control inputs to the JCI which control the operating mode of the JCI, and allow clearing of either the receive or transmit buffers by the host if necessary.

A.6.2.2 COMMUNICATION MODE SELECTION—Since the JCI can transmit messages in either 10.4 Kbps VPW modulation or 41.6 Kbps PWM modulation types, it is necessary for the host to specify to the JCI which modulation type to use. The modulation type is determined through a combination of the input oscillator frequency and the logic level of the Communication Select input (COMSEL). Table A9 outlines the modulation format and transmission rate selection.

TABLE A9—COMMUNICATION MODE SELECTION

Fosc	COMSEL	Baud Rate	Modulation
8 MHz	Logic 1	41.6 Kbps	PWM
4 MHz	Logic 0	10.4 Kbps	VPW

The different oscillator frequencies can be supplied to the JCI through a variety of techniques. If the host cannot supply 4 MHz and 8 MHz clock inputs to the JCI, then an oscillator selection must be devised which would allow the switching of the JCI's input oscillator frequency between 4 and 8 MHz, possibly using the logic level of the COMSEL line to determine the input frequency. The COMSEL input is level sensitive, and therefore switching between VPW and PWM can be performed simply by changing the logic level of the COMSEL input and the oscillator frequency. However, resetting the JCI when changing oscillator frequencies will ensure the JCI will begin communicating with the multiplex bus from a known state.

A.6.2.3 IN-FRAME RESPONSE AND I.D. BYTE—The JCI supports the optional transmission of an In-Frame Response. This option is selected by the logic level of the IFR input. If the IFR pin is at a logic one, a single byte In-Frame Response containing the I.D. byte will be transmitted at the appropriate time during the message frame. The I.D. byte of the JCI is the byte input on the I.D. pins (ID0-ID7). This byte is latched into the JCI upon reset, and should be hardwired in the application. In this example the I.D. byte of the JCI is hardwired to h55.

A.6.2.4 MESSAGE TRANSMISSION—The loading of a message for transmission by the JCI is begun by the host asserting the STX input, and then enabling the SPI interface and transferring a complete message (up to 11 bytes) to the JCI through a series of single byte SPI transfers. After the last byte has been transferred to the JCI, the host disables the SPI interface, and negates the STX input. Once the host has begun transmitting a message to the JCI, the JCI will assert the BSY output. This informs the host that the transmit buffer has data to be transmitted in it. The BSY output will stay asserted until the message is successfully transmitted onto the multiplex bus. Once the STX input is negated, the JCI will then attempt to transmit the message onto the multiplex bus. The JCI will handle all bus access functions, including idle bus detection, arbitration, and automatic retry (if necessary).

A.6.2.5 MESSAGE RECEPTION—The JCI will receive and buffer complete messages transmitted onto the multiplex bus. Once an entire message has been received with no errors, and the CRC byte verified as correct, the JCI will inform the host that a message is ready for delivery by asserting the RTS output. When the host is ready to receive the message, it enables the SPI interface, and asserts the CTS input. One byte is then transferred to the host, and the host then negates the CTS input to indicate to the JCI that the byte has been received. This is repeated for each byte until the entire message has been transmitted to the host. When transmission of the last byte of the message begins, the JCI will negate the RTS output, informing the host that the last byte is being transmitted. After the last byte has been received by the host, the host negates the CTS input and then disables the SPI interface. Since the JCI can buffer two complete messages received from the bus, the JCI may already have another message waiting for transmission to the host when one is finished. In this case, the JCI will still negate RTS to indicate the transmission of the last byte of the first message, and then reassert RTS as soon as the last byte of the first message is received by the host. If the host does not service the JCI before both receive buffers are filled, the JCI will then ignore any other messages transmitted over the multiplex bus until one of the received buffers is emptied by the host.

A.6.3 JCI Pin Names and Descriptions—The names and descriptions of the pins of the JCI are shown in Table A10.

A.6.4 Additional Capabilities—The JCI supports automatic message retransmission after loss of arbitration, or detection of a transmission error. The JCI will attempt to retransmit a message up to two times if an error is detected in the message received. In the case of arbitration loss, the JCI will attempt to retransmit a message indefinitely. The JCI contains a digital filter to reject short noise pulses occurring on the multiplex bus, and can transmit and receive Break symbols, in either PWM or VPW format. The JCI also contains a user mask optional message filter to reduce the number of messages passed to the host.

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TABLE A10—J1 PIN NAMES AND DESCRIPTIONS

Pin Number	Pin Name	Description
1	OSC1	Oscillator 1
2	OSC2	Oscillator 2
3	SCK	SPI Serial Clock
4	SDO	SPI Serial Data Out
5	SDI	SPI Serial Data In
6	CTS	Clear To Send (Active Low)
7	STX	Start Transmit (Active Low)
8	BSY	Busy (Active Low)
9	RTS	Request To Send (Active Low)
10	FLUSH	Flush Message Buffer (Active Low)
11	MODE0	Mode Select 0
12	MODE1	Mode Select 1
13	COMSEL	Communications Select
14	VSS	Ground
15	RESET	Reset (Active Low)
16	CE	Chip Enable (Active Low)
17	IFR	In Frame Response Enable
18	TxJ	Bus Transmit Output
19	RxJ	Bus Receive Input
20	IO0	I.O. Byte - bit 0
21	IO1	I.O. Byte - bit 1
22	IO2	I.O. Byte - bit 2
23	IO3	I.O. Byte - bit 3
24	IO4	I.O. Byte - bit 4
25	IO5	I.O. Byte - bit 5
26	IO6	I.O. Byte - bit 6
27	IO7	I.O. Byte - bit 7
28	VDD	Power Supply

APPENDIX B
SUPPORTING DOCUMENTS

The following is a list of documents that may be useful to the reader for a further understanding of the examples shown in Appendix A:

Ford Heated Bus Controller Chip User's Guide

Ford Heated Bus Controller Circuit

Delco Introduction to GM Class 2 Serial Data Bus XDE - 5100

Delco DLCS/P IC User's Guide XDE - 5101

Delco DLCS/P IC Data Sheets XDE - 5102

Silicon Systems, 7691 Transceiver Data Sheet - 67P686

SGS-Thomson, ST9 Family Technical Manual - DBST9TMST/1

SGS-Thomson, ST9 Family 8/16 Bit MCU Programming - DBST9PMST/1

SGS-Thomson, ST9X.X.X Databook - DBST92T/1

SGS-Thomson, ST9 Brochure - DBST9/1190

Motorola, MC68HC05C4/C8, Technical Data 8-Bit Microcomputer - AD1991.2

Motorola, M68HC05 Applications Guide - M68HC05AG/AD

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SURFACE VEHICLE RECOMMENDED PRACTICE

Submitted for recognition as an American National Standard

SAE J2205

Issued 1994-06

EXPANDED DIAGNOSTIC PROTOCOL FOR OBD II SCAN TOOLS

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, includes the requirement that motor vehicle manufacturers provide information for the diagnosis and service of emissions-related powertrain components using the SAE J1978 OBD II Scan Tool and commonly available non-microprocessor tools (x 2.1).

In order for motor vehicle manufacturers to use an SAE J1978 OBD II Scan Tool to diagnose and service emissions related powertrain components:

a. Vehicles must support a message protocol compatible with the facilities of the OBD II Scan Tool and capable of accessing the vehicle services required to diagnose and service vehicle emissions related powertrain components and systems
b. The SAE J1978 OBD II Scan Tool must include facilities that allow the scan tool user to enter, edit, select, and transmit messages to a vehicle; identify the messages to be received from the vehicle, and receive them; and describe how to process the data in the received messages, and process them.

The vehicle communication interface used for this purpose is the one used by the vehicle to support SAE J1979 messages.

The messages to be transmitted or received and processed must conform to the requirements defined in SAE J1979, SAE J1850, and ISO 9141-2, with the exception that the message header and data fields may be vehicle specific.

The purpose of the Expanded Diagnostic Protocol is to define the encoding techniques to be used:

a. To describe to the SAE J1978 OBD II Scan Tool the messages to be transmitted to a vehicle and how they are to be transmitted,
b. To describe to the SAE J1978 OBD II Scan Tool the messages to be received and processed by the scan tool, and
c. To describe to the SAE J1978 OBD II Scan Tool how to process the data in the received messages.

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1. *Scope*—This SAE Recommended Practice defines the Expanded Diagnostic Protocol (EDP), the requirements for the SAE J1978 OBD II Scan Tool for supporting the EDP protocol, and associated requirements for diagnosis and service information to be provided by motor vehicle manufacturers.

Appendix A includes worked examples of the use of the protocol.

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 J1962—Diagnostic Connector
SAE J1978—OBD II Scan Tool
SAE J1979—Common Diagnostic Test Modes
SAE J2008—Recommended Organization of Vehicle Service Information

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

2.1.3 OTHER PUBLICATIONS

AIAG-B-1 1984—Automotive Industry Action Group—Bar Code Symbology Standard—3 of 9 Bar Code Symbols

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

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

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:

CRC—Cyclic Redundancy Check—A byte of data appended to message data transmitted on SAE J1850 to ensure detection of corrupted data. CRC is defined in SAE J1850.

DSV—Data Security Verification—A byte of data appended to Extended Diagnostic Protocol definitions to ensure detection of corrupted data in EDP definitions, especially when they are entered and/or edited.

EDP—Extended Diagnostic Protocol—A method of encoding; messages to be transmitted, the selection of messages to be received, and how the data in the received messages are to be processed so that these messages can be processed by the SAE J1978 OBD II Scan Tool.

OBD II—A term commonly used to refer to Section 1968.1, Title 13, California Code of Regulations, "Malfunction and Diagnostic System Requirements 1994 and Subsequent Model Year Passenger Cars, Light Duty Trucks, and Medium Duty Vehicles With Feedback Control Systems."

RDPI—Received Data Processing Information—The information that describes how to process the data in received messages. This information includes a Received Data Processing Type and may include other type specific information.

RDPT—Received Data Processing Type—A code that indicates which data in the received message is to be processed, how the data is encoded, and how it is to be processed.

2.3 **Codes Used in This Document**—Unless otherwise specified, all codes shown in this document are hexadecimal. All codes shown preceded by a "$" (e.g., $1F) are also hexadecimal.

2.4 **Tolerance for Timing Values**—Unless otherwise specified, all timing values will have a ±10% tolerance (e.g., 10ms = 10 ms ± 1 ms).

2.5 **User Manual and/or Help Facility**—References to "user manual" and/or "help facility" in this document refer to the user manual and/or help facility requirement of SAE J1978 OBD II Scan Tool.

2.6 **Significance of Bytes in a Multiple Byte Field of a Received Message**—With respect to Received Data Processing Type definitions, a multiple byte field in a received message is interpreted first received byte, second received byte, third received byte, etc., and last received byte of the field as the most significant byte, less significant byte(s), and finally, the least significant byte, respectively.

3. ***Introduction***—EDP provides a way of describing to the SAE J1978 OBD II Scan Tool:

a. Messages to be transmitted to the vehicle, and associated operating information (i.e., message repetition rate, etc.),
b. The messages to be received from the vehicle and processed,
c. How to process the data contained in the received messages,
d. Miscellaneous ISO 9141-2 related information (e.g., stop communication message, idle message, when to use the stop message, idle message parameters, etc.).

EDP is intended as an open-ended means for allowing motor vehicle manufacturers to communicate, through the OBD II supported communication interface, with vehicle modules using vehicle and module specific messages. EDP, as a minimum, is available to support diagnosing and servicing emissions-related components and systems.

Motor vehicle manufacturers may include and reference EDP definitions within diagnostic and service procedures for emissions-related components and systems.

4. ***Communication Interfaces and Messages Supported***—The purpose of the functionality defined in this document is to support the use of the SAE J1978 OBD II Scan Tool for communicating with vehicles for the purpose of diagnosing and servicing vehicle emissions-related components and systems. This communication uses messages transmitted to and received from a vehicle that may be unique to a given vehicle manufacturer, model year, vehicle body type, powertrain module, etc. These messages will support facilities unknown at the time this document is developed. Compared to the SAE J1979 messages, these messages may have different message headers and different data fields.

   In order to support the communication requirements unique to ISO 9141-2, EDP must support:

   a. The user's selection of an address,
   b. The transmission of a message that terminates the communication link with the currently addressed module(s), and
   c. The definition of an idle message and the characteristics of its transmission.

   The other parameters defined by ISO 9141-2 and unmodified by SAE J1978 remain in effect.

   EDP messages will use the same vehicle interface that supports the SAE J1979 messages.

   Response messages received from an ISO 9141-2 interface must be no longer than 256 bytes.

5. ***SAE J1978 OBD II Scan Tool EDP Support Requirements***—The SAE J1978 OBD II Scan Tool must allow users to enter, edit, and delete EDP definitions, and to select EDP definitions for processing (i.e., execution) and termination.

   The SAE J1978 OBD II Scan Tool must be able to repeatedly transmit at least two messages, and monitor for, receive, and process the data in at least four receive message definitions and their associated processing information, simultaneously. A total of at least 256 bytes must be available to retain message bytes received due to active definitions.

   The OBD II Scan Tool must allow the entry and retention of a combined total of at least 15 EDP definitions, where each definition may require up to 256 characters. One byte in a definition consists of two characters (e.g., 3C). One field separator (i.e., ",") is one character. One "/" is one character.

   The determination of the retention time of EDP definitions after external power is disconnected from the scan tool is left to the discretion of the scan tool manufacturer.

   The format of all definitions will include input data security verification (DSV) information and definition length information to minimize data input errors. The scan tool shall indicate to the user the presence of data entry errors in any definition. The scan tool shall allow the user to enter and save definitions that include errors and edit them. The scan tool shall not allow the user to process definitions with errors.

   The user's manual/help facility of an SAE J1978 OBD II Scan Tool must document how to enter, edit, delete, select for processing, and select for termination EDP definitions.

   The scan tool must support the entry of all the characters used in message definitions, such as hexadecimal data (i.e., 0-9, A-F), a "don't care nibble" identifier character, shown in this document as a "/" (slash), and a field separator character, shown in this document as a "," (comma).

The actual means of performing these actions is left to the scan tool manufacturer. The scan tool user's manual/help facility must describe how to perform these actions.

The processing of EDP definitions shall have no effect on other functions of the SAE J1978 Scan Tool (e.g., automatic determination of OBD II interface, processing of SAE J1979 messages, etc.).

6. EDP Definitions

6.1 **Introduction**—There are four general types of EDP definitions:

a. Control type
b. Transmit type
c. Receive only type
d. Miscellaneous type

Each definition type includes a variable set of individual fields (e.g., id field (see 6.3), length field (see 6.4), type field (see 6.5), transmit message information (tx msg) field (see 6.6), receive filter information (rx filter) field (see 6.7), received data processing information (rx data processing info) field (see 6.8), and data security verification information (DSV) field (see 6.9)), each of which are further described in sections below.

The general forms of the four general EDP definition types are:

For control type definitions:

<id>,<length>,<type>,<DSV>

For transmit type definitions:

<id>,<length>,<type>,<tx msg>,<rx filter>,<rx data processing info>,<DSV>

For receive only type definitions:

<id>,<length>,<type>,<rx filter>,<rx data processing info>,<DSV>

For miscellaneous type definitions:

<id>,<length>,<type and additional information>,<DSV>

6.2 **Validation of Definition Data**—The SAE J1978 OBD II Scan Tool will check for the correctness of all values entered for a given definition. Correct values for all fields, including the length of the overall definition, the codes used, the lengths of subfields, and the DSV value are required in order for the definition to be allowed to be processed.

6.3 **Id Field**—The id of a definition is the identification tag that allows a user to select a given definition for editing, deletion, execution, and termination. Some id values (see 6.3.1) imply automatic execution. Id values are assigned by the vehicle manufacturer. Diagnostic and service information shall reference definitions by their id. The id is available for users to indicate definitions to be edited, deleted, executed, and terminated.

The actual method used by a given SAE J1978 OBD II Scan Tool to enable the user to indicate which definition(s) the user wishes the scan tool to process must be described in the scan tool user's manual/help facility.

If a given definition id is already associated with an EDP definition when another message definition using the same id is successfully entered then the previous definition shall be replaced by the new definition.

Relative to vehicle diagnostic or service procedure documentation, where it would be useful, it is recommended that some meaningful identification (i.e., test name - EGR TEST, procedure name - INITIALIZATION, etc.) be associated in vehicle repair procedures with one or a set of definitions that perform an identifiable diagnostic or service procedure. This associated name could be used to directly access effectively similar facilities in scan tools that support them.

6.3.1 AUTOMATIC EXECUTION FOR DEFINITION IDS 0 TO 9—If a message definition with an id in the range of 0 to 9 is successfully entered into the scan tool then the scan tool shall, in addition to recording this message definition, process it immediately as if it had been entered and selected for processing by the scan tool user. Any currently executing definition having the same definition id shall be terminated and replaced by the new definition.

6.4 **Definition Length Field**—The length field specifies the length or size of the definition in characters. Definition length is the number of characters in the definition, beginning with the definition id field and ending with the DSV field, inclusive. This includes any "don't care" symbols ("/") and field separators (","). The length field is one byte.

6.5 **Definition Type Field**—The type field indicates the type of definition.

Control type definitions (see 7.1.1 and 7.2) are used to define general operating parameters such as ones associated with the communication interface. When connected to a given vehicle, the SAE J1978 OBD II Scan Tool will automatically identify the communication interface used by the vehicle for CARB OBD II functions.

Transmit type definitions (see 7.1.2 and 7.2) define messages to be transmitted, how often they are to be transmitted when selected for processing, and optionally, an associated receive message filter and received data processing information.

Receive only type definitions (see 7.1.3 and 7.2) define only a receive message filter and associated received data processing information.

Miscellaneous type definitions are intended to define situations that fall out of the other definition types. Currently there are no miscellaneous definition types.

6.6 **Transmit Message Field**—The <type> and <tx msg> fields together describe what is to be transmitted and other miscellaneous transmit parameters such as how often the message will be transmitted.

The transmit message field, "<tx msg>", has the form:

aa bb cc ... zz

where:

aa bb cc ... zz are hexadecimal bytes that define the message to be transmitted

The actual message transmitted by the scan tool is determined by the definition type, the interface being used, and the values of aa bb cc ... zz.

If the transmit type is SAE J1979, the transmit message field, "aa bb ... zz", will be interpreted as the SAE J1979 request message mode and mode data. The header for the transmit message and the receive filter information will automatically be as defined by SAE J1979.

As defined in SAE J1850, a CRC will automatically be appended to all messages transmitted on an SAE J1850 interface. As defined in ISO 9141-2, a checksum will automatically be appended to all messages transmitted on an ISO 9141-2 interface.

6.7 **Receive Message Filter Field**—Receive message filter information, *<rx filter>*, is used by the scan tool to filter messages for processing from all the messages that may be received by the scan tool from the vehicle.

Specifying receive message filter information is optional but generally is a requirement for effective scan tool usage, particularly for SAE J1850 vehicle interfaces. If no receive message filter information is specified in a transmit or a receive only definition, default receive message filter information may be available in some cases. For example, if the transmit type is SAE J1979, then the associated SAE J1979 response message header definition will be used as the default receive message filter. If the vehicle OBD II interface is ISO 9141-2, then the default receive message filter information will be to use any message received.

Only one definition with a null receive message filter field (i.e., this field does not contain any filter information, such as ",,"), may be active at a time (i.e., all received messages will be processed by the received data processing instructions in this definition). All active non-null receive message filter fields shall take precedence over an active definition with a null receive message filter field. That is, any message detected by the scan tool should be processed against the active non-null received filters first, and processed against an active null receive filter last.

As defined in SAE J1850, a CRC will be expected for all messages received on a SAE J1850 interface. As defined in ISO 9141-2, a checksum will be expected for all messages received on an ISO 9141-2 interface.

The received message filter information has the form:

aa bb cc ... zz

where:

aa bb cc ... zz are nibble (i.e., 4 bits) by nibble indicators of whether to ignore or to match a supplied nibble value:

a = / to ignore a received nibble
= 0 - F to specify the value the received nibble must match

The comparison of received message data with all currently active receive message filters begins with the first byte of the received message and continues for the length of a given receive message filter. The received message must be at least as long as a given filter for that filter to be used. There is no implied meaning given to the data of the received message that are compared with received message filters. A particular vehicle's message protocol may interpret the data compared to received message filters as partial headers, full headers, headers and data, etc.

6.8 **Received Data Processing Information (RDPI) Field**—Associated with every receive message filter definition is default or specified sets of received data processing information.

Each set of received data processing information defines:

a. Which data in the received message the data processing information applies to
b. How that data is to be interpreted
c. How that data is to be formatted, if displayed
d. Other optional features, such as display constants
e. Other ways in which the data may be processed

If no received data processing information is specified with a given receive message filter, the following default received data processing information will be used:

All data of the received message will be displayed as hexadecimal values, beginning with the first byte of the received message through the last byte of the received message.

The display facilities of a given SAE J1978 OBD II Scan Tool implementation are subdivided into at least two display areas, in keeping with the SAE J1978 OBD II Scan Tool requirement to display simultaneously at least two data values. How a given scan tool actually implements display areas is left to the discretion of the scan tool manufacturer and must be described in the scan tool user's manual/help facility.

More than two display areas may be supported.

If data to be displayed from a given received message is larger than an available display area, the available display area is used as a window, displaying only a portion of the total data to be displayed, beginning with the first character of data to be displayed. The scan tool must allow the user to move the window back and forth over the entire data to be displayed.

The scan tool user's manual/help facility must specify how the display area window is moved back and forth over display data.

The complete set of received data processing information associated with a given received message filter is made up of one or more sets of Receive Data Processing Information <RDPI>:

<rx data processing info> = <RDPI><RDPI> ... <RDPI>

A set of Received Data Processing Instructions <RDPI> is of the form:

<RDPI> = <Received Data Processing Type><additional information>

Received Data Processing Types (RDPT) are further described in 7.3. Any "additional information" depends on the RDPT and is further explained in 7.4.3. The size of each received data processing information is defined by the type and any additional information.

6.9 **Data Security Verification Field**—The Data Security Verification Field <DSV> field is used with the length field to verify the correct entry of a definition into the scan tool. The value of DSV is the simple 1 byte sum without carry of all byte values in the message definition.

Where a "," is a part of a definition, the ASCII value for "," ($2C) will be included in the DSV calculation in place of the ",". Where an "/x" is a part of a definition, the ASCII value for "/" ($2F) and the value 0x will be included in the DSV calculation in place of the "/x". Where an "x/" is a part of a definition, the ASCII value for "/" ($2F) and the value x0 will be included in the DSV calculation in place of the "x/".

7. *Codes for EDP Definition Fields*

7.1 **Definition Type Codes**—The following sections briefly identify the values for Control, Transmit, and Receive Only definition type codes. These codes are more fully explained in 7.2.

7.1.1 CONTROL DEFINITION TYPE CODES—Figure 1 shows the codes defined for Control Type definitions and a short description of the meaning of the codes:

Type	Description
12	terminate the current ISO 9141-2 communication connection and begin the ISO 9141-2 addressing and initialization sequence with the given address
13	define the idle message to be used for ISO 9141-2 communication
14	define the stop 9141 communication message to be used to terminate ISO 9141-2 communication
17	set the standard message retransmission interval
18	use only two display areas
19	delete all current definitions
1A	delete a given definition by id
1B	deactivate all active receive filters
1C	deactivate a receive filter by definition id

FIGURE 1—CONTROL DEFINITION TYPE CODES

7.1.2 TRANSMIT DEFINITION TYPES—Figure 2 shows the codes defined for Transmit Type definitions and their descriptions:

Type	Description
20	transmit this message once per selection
21	transmit this message repeatedly at the standard interval once selected, until selected again, at which time stop the repeated retransmissions
22	transmit message repeatedly at given interval once selected, until selected again, at which time stop the repeated retransmission
23	transmit message repeatedly, once selected, at given interval for a given maximum interval, until selected again at which time stop the repeated retransmission
24	process this message as an SAE J1979 request and transmit once per selection
25	process this message as an SAE J1979 request and transmit repeatedly at the standard interval once selected, until selected again, at which time stop the repeated transmissions
26	process this message as an SAE J1979 request and transmit message repeatedly at given interval once selected, until selected again, at which time stop the repeated retransmission
27	process this message as an SAE J1979 request and transmit message repeatedly, once selected, at given interval for a given maximum interval, until selected again at which time stop the repeated retransmission

FIGURE 2—TRANSMIT DEFINITION TYPES

7.1.3 RECEIVE ONLY DEFINITION TYPES—Figure 3 shows the code defined for Receive Only Type definitions and its description:

Type	Description
30	receive only definition

FIGURE 3—RECEIVE ONLY DEFINITION TYPES

7.1.4 VEHICLE MANUFACTURER RESERVED DEFINITION TYPES—Definition type codes $80 - $FF are reserved for use by vehicle manufacturers.

7.2 **Definition Type Codes Defined**—For each message definition type, the form of the message type information field, the definition of any additional information, and the processing to be performed by the scan tool is shown.

12 Terminate the current ISO 9141-2 communication connection and begin the ISO 9141-2 addressing and initialization sequence with the given address

12 xx

where: xx = ISO 9141-2 address

When a message definition with this message type is processed by a scan tool and ISO 9141-2 is the OBD II communication interface, the scan tool will terminate the current ISO 9141-2 communication link using a stop 9141 message, if one has been defined, or if one is not defined, will terminate all communication for 5 s to force all active communication to terminate. After active communication has been terminated, a minimum of 300 (decimal) ms of bus idle will be allowed before the scan tool will begin the ISO 9141-2 addressing and initialization process, using the address given in the definition.

It is recommended that the scan tool indicate to the user what is going on whenever a 5 s delay is in progress.

13 Define the idle message to be used for ISO 9141-2 communication

13 aa bb ... zz

where: aa bb ... zz defines the idle message to be used to keep the ISO 9141-2 interface from reverting into address mode

This message definition defines the message to be used to keep the ISO 9141-2 communication link with the currently addressed module active.

14 Define the stop message to be used to terminate ISO 9141-2 communication

14 aa bb ... zz

where: aa bb ... zz defines the message to be used to terminate communication on the ISO 9141-2 interface

Subsequent redefinitions of the stop message replace previous definitions. If no aa bb ... zz data follows the 14, any previously defined stop message is deleted and the stop message facility is not available.

17 Set the standard retransmission interval

17 xx

where: xx becomes the standard retransmission interval, in 10 (decimal) ms increments

When a message definition with this message type is processed by a scan tool, the scan tool will begin to use the value specified for current and subsequent messages that are to be retransmitted at the standard rate.

Until a definition of this type specifies a message retransmission interval, an interval of 120 (decimal) ms shall be used. The retransmission interval is the time between the start of one message transmission and the start of the next transmission of the same message.

18 Use only two display areas

18

When a message definition with this message type is processed by a scan tool, the scan tool will use only two display areas, even if the scan tool is able to support more than two.

19 Delete all current message definitions

19

When this message type is processed by a scan tool, the scan tool will delete all current definitions.

1A Delete a given definition

1A xx

where: xx is a definition id

When this message type is processed by a scan tool, the scan tool will delete the message definition associated with the given id.

1B Deactivate all receive filters

1B

When a message definition with this message type is processed by the scan tool, the scan tool will deactivate all currently active receive message filters.

1C Deactivate a given receive filter

1C xx

where: xx is a definition id

When a message definition with this message type is processed by the scan tool, the scan tool will deactivate the receive filter associated with the given definition id.

20 Transmit given message once

20

When a message definition with this message type is processed by a scan tool, the scan tool will transmit the message contained in this definition, and enable any receive filter information contained in this definition. If the processing of this definition causes the limit of a given scan tool for simultaneously active transmit messages or simultaneously active receive filters to be exceeded, the oldest active transmit message will be terminated or the oldest active receive filter will be deactivated.

21 Transmit given message repeatedly at the standard interval

21

When a message definition with this message type is processed by a scan tool, the scan tool will begin to repeatedly transmit at the standard interval the message defined in this definition. The next time this definition is selected, message retransmission will be terminated. When selected again, the message will again begin to be repeatedly retransmitted, and so on.

The receive filter information associated with the definition selected will be added to the set of simultaneously active receive filters when the transmit message begins to be transmitted and will be deleted from the set of simultaneously active receive filters when message transmission is terminated.

22 Transmit a given message repeatedly at a given interval

22 xx

where: xx is the given interval in 10 (decimal) ms

Same processing as for type 21 except that the retransmission interval is specified in the definition.

23 Transmit a given message repeatedly at a given interval for a given maximum interval

23 xx yy yy

where: xx is the given retransmission interval in 10 (decimal) ms, and yy yy is the maximum transmission interval in seconds

Same processing as for type 22 except that the retransmissions will be terminated at the end of the maximum transmission interval or if this definition is selected again.

24 Process as a SAE J1979 request message and transmit it once per selection

24

When a message definition with this message type is processed by a scan tool, the scan tool will process the message as a SAE J1979 message. The transmit information supplied in this definition begins with the SAE J1979 mode value followed by any additional mode specific information. The header for the SAE J1979 message will be according to the OBD II interface type as defined in SAE J1979. The resultant transmit message will be transmitted once per selection. The default receive filter and received data processing information will be as defined for the selected SAE J1979 message.

25 Process this message as an SAE J1979 request and transmit it repeatedly at the standard interval

25

Process the transmit information as is defined for type 24 and transmit this message as is defined for type 21.

26 Process this message as an SAE J1979 request and transmit message repeatedly at given interval

26 xx

where: xx is the given interval in 10 (decimal) ms

Process the transmit information as is defined for type 24 and transmit this message as is defined for type 22.

27 Process this message as an SAE J1979 request and transmit message repeatedly at given interval for a given maximum interval

27 xx yy yy

where: xx is the given retransmission interval in 10 (decimal) ms, and yy yy is the maximum transmission interval in seconds

Process this message as is defined for type 24 and transmit this message as is defined for type 23.

30 Receive only definition

The transmit information field of this definition should be null. Use the receive message filter field of the definition to filter received messages, and process the received messages as defined in the received data processing information field.

7.3 **Received Data Processing Type (RDPT) Codes**—The following is a list of Received Data Processing Types and a short description of the processing type.

7.3.1 TEXT DISPLAY DATA IN A DEFINITION—Text to be displayed as a part of processing of the data from a received message may be defined in a definition. The text may be displayed before and/or after the processed data. RDPTs within the range $00 to $7F are interpreted as standard ASCII codes. Some of these codes are for non-displayable characters (e.g., $0D for carriage return may cause the scan tool to move to the next line or may cause the scan tool to not do anything) and generally should not be used. Character codes for "A" to "Z" and "a" to "z" may be displayed in the same way, if not supported uniquely.

7.3.2 DATA CONVERSION—Figure 4 shows RDPT codes that identify which data in the received message is to be processed, how the data is to be interpreted, and how the data is to be displayed.

RDPT	Description
80	display byte(s) as hexadecimal
81	display nibble(s) as hexadecimal
82	display byte(s) as bits
83	display byte(s) as bits with display mask
84	display nibble(s) as bits
85	display nibble(s) as bits with display mask
86	display byte(s) as unsigned decimal
87	display byte(s) as signed decimal
88	display byte(s) as signed decimal with signed offset
89	display byte(s) as Y = aX + b, X = signed decimal
8A	display byte(s) as decimal with binary point
8B	display byte(s) as DTC if not zero
8C	display byte(s) as ASCII coded data
8D	display standard string indexed by byte(s)
8E	display byte(s) as a percentage with given denominator y = x * (100 (decimal) / denominator)
8F	display byte(s) with a given signed offset as a percentage with a given denominator y = (x + offset) * (100 (decimal) / denominator)
90	display byte(s) using given scaling data
91	display byte(s) as BCD data
92	display one of indexed text set based on logic value of received data ANDed with given bit mask
93	display one of indexed text set based on inverse logic value of received data ANDed with given bit mask

FIGURE 4—DATA CONVERSION

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7.3.3 MISCELLANEOUS DISPLAY FUNCTIONS—Figure 5 shows RDPT codes that cause the scan tool to display standard text information, clear parts or all of the display, and control the location of the next information to be displayed.

RDPT	Description
98	display given standard string
99	clear entire display
9A	clear given display area
9B	position to beginning of display
9C	position to beginning of next display area
9D	position to beginning of given display area
9E	clear a given display area and position to the beginning of the display area
9F	display byte(s) as y = aX + b, X = unsigned decimal
B0	display 2 blanks
B1	display 4 blanks
B2	move right 1 position
B3	move right 2 positions
B4	move right 4 positions
B5	move right a given number of positions

FIGURE 5—MISCELLANEOUS DISPLAY FUNCTIONS

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7.3.4 RDPT CODES FOR ALTERING DEFINITION EXECUTION—Figure 6 shows RDPT codes that cause the scan tool to alter the execution of definitions based on the data received. They describe what received data is to be processed, what data is to be compared to the received data, what type of data comparison must be found to cause a change in definition execution, and what change to definition execution is to be made if the comparison is true.

RDPT	Description
A0	if byte(s) equal terminate processing of this definition
A1	if byte(s) equal terminate processing of this definition and start processing of a given definition
A2	if byte(s) equal terminate processing of the given definition
A8	if byte(s) not equal terminate processing of this definition
A9	if byte(s) not equal terminate processing of this definition and start processing of a given definition
AA	if byte(s) not equal terminate processing of the given definition

FIGURE 6—RDPT CODES FOR ALTERING DEFINITION EXECUTION

7.3.5 RDPT CODE FOR UNIQUE PROCESSING OF MULTIPLE RECEIVED MESSAGES—Normally, when multiple messages are received due to the same definition, each received message is processed as the latest version of the same message. The last message received is the last one processed and last one displayed. Any previous messages have been processed and replaced by the next received message. In some cases, however, multiple messages received due to the same definition each convey unique information that must be displayed separately. Examples are the response messages to a SAE J1979 mode 3 - Request DTC's message.

Figure 7 shows the RDPT code that causes the scan tool to separately process multiple messages, received due to the same definition, as unique data. The results of the received message processing of each message are to be concatenated, one after another, from the first received message to the last, within the limits of the scan tool to retain all the received data.

When used, this RDPT code must be the first one in a Received Data Processing information field. When a scan tool cannot retain any more received messages due to a definition that includes this RDPT code, the scan tool shall indicate such an error to the user, and document this error type in the user/help facility. The scan tool will allow the user to scan the processed data as described in SAE J1978 for displaying any data that cannot all be displayed because of the size of the data is greater than the size of the display.

RDPT	Description
C0	multiple messages received as the result of this definition, are to be processed as unique information and displayed, one after the other in the order received, to the limit of the scan tool to retain them. Each selection of the definition that includes this RDPT, or retransmission of any transmit message if included, will restart the collection and processing of received messages.

FIGURE 7—RDPT CODE FOR UNIQUE PROCESSING OF MULTIPLE RECEIVED MESSAGES

7.4 Received Data Processing Type Codes Defined

7.4.1 SYMBOLS USED IN DESCRIBING RECEIVED DATA PROCESSING TYPES—The following defines symbols used in 7.4.3 to describe RDPTs:

xx — Indicates an offset, in bytes, to the beginning of a data field in the received message ($00 = first byte in received message, $01 = second byte in received message, $FF = last byte in received message, $FE = second last byte in received message, etc. Note that the last byte of a received message is the message error detection byte. Some hardware may not make this byte available for processing. If the last message byte is referenced in a RDPT, but is not available, the RDPT will be ignored.)

yy — Indicates the length of a data field, in bytes

xy — Indicates a combination of an offset, in bytes, to the beginning of a data field and the length of a data field, in bytes, where the "x" and "y" are individual nibbles in one definition byte

where: x = offset, in bytes, to the beginning of a data field in the received message ($0 = first byte in received message, $1 = second byte in received message, $F = 16th (decimal) byte in received message, $E = 15th (decimal) byte in received message, etc.)

y = length of data field, in bytes ($1 = one byte, $2 = two bytes, etc.)

xy = $52 defines a 2 byte data field that begins with the 6th byte of the received message

aa — Indicates an offset, in nibbles, to beginning of a data field in the received message ($00 = first nibble in received message, $01 = second nibble, etc.). The first nibble of the message is the most significant nibble of the first byte of the message, the second nibble is the least significant nibble of the first byte of the received message.

bb — Indicates the length of a data field, in nibbles ($01 = one nibble, $02 = two nibbles, etc.)

cc ... cc — Is a given byte field that is compared with the received data. The length of this field is the same as the received data field, i.e., yy or y. A "/" is used in the given data field to indicate a "don't care" compare of a nibble in the received data field.

dd ... dd — Indicates a display mask. The size of the display mask is the same as the size of the data field the mask is to be applied to, i.e., yy or bb. For every bit in the mask whose value is 1, the value of the corresponding bit in the data field is to be displayed. For every bit in the mask whose value is 0, the value of the corresponding bit in the data field is NOT to be displayed. The value of a data bit is displayed as a "1" or a "0".

ee or ee ee — Indicates a one or two byte index, typically into a list of string constants ($00 or $0000 is index to first entry, $01 or $0001 is index to second entry, etc.)

ff ... ff — Is a bit mask for offset to an indexed standard string. One and only one bit in this bit mask must be a "1".

gg ... gg — Is a signed offset value. The length of the signed offset gg ... gg is the same as the received data field, i.e., yy.

7.4.2 DEFAULT DATA DISPLAY POSITION—The description of some received data processing type codes refer to display areas. Unless otherwise specified, the first data to be displayed in a given display area will be displayed at the left most position in the display area. All subsequent data to be displayed will follow this data to the right.

Display areas can be top to bottom, left to right, or both. Unless otherwise specified, the first display area will be the top left one. Subsequent display areas will follow left to right, first on the top line, and then from top to bottom for subsequent lines.

7.4.3 RECEIVED DATA PROCESSING TYPES WITH PARAMETERS—The following show received data processing types with any associated additional information. The following use the symbols shown in 7.4.1.

80 Display byte(s) as hexadecimal

80 xy

81 Display nibble(s) as hexadecimal

81 aa bb

82 Display byte(s) as bits

82 xy

83 Display byte(s) as bits with display mask

83 xy dd ... dd

84 Display nibble(s) as bits

84 aa bb

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85 Display nibble(s) as bits with display mask

85 aa bb dd ... dd

86 Display byte(s) as unsigned decimal, with a maximum field size in the received data of 4 bytes

86 xy

87 Display byte(s) as signed decimal data, with a maximum field size in the received data of 4 bytes

87 xy

88 Display byte(s) as signed decimal with signed offset with a maximum field size in the received data of 4 bytes

E = N + offset

where: E = value to be displayed
N = value of field in received message
offset = gg ... gg

89 Display byte(s) as y = aX + b, where X = signed decimal received bytes

89 xy jj kk ... kk

where: jj = one byte signed multiplier (a)
kk = signed offset (b) with same length as data byte(s)

8A Display byte(s) as decimal with binary point, with a maximum field size in the received data of 4 bytes

8A xy pp

where: pp = location of binary point in bits from the right end of the data field, $00 = to the right of the right most bit

8B Display byte(s) as DTC(s) if not zero

8B xy

The data length (y) must be a multiple of the DTC data length (i.e., 2 bytes). A DTC code of 0000 is not displayed.

8C Display byte(s) as ASCII codes

8C xy

8D Display standard text indexed by unsigned message byte

8D xy

The index value in the message must be within range of the standard text table (see 7.4.4). If index value is out of range then the tool shall indicate a "data out of range error" and this error shall be explained in the tool user manual/help facility. The maximum field size of the received data is 1 byte.

8E Display byte(s) as percentage with given denominator, with a maximum field size in the received data of 4 bytes

E = N * (100 (decimal)/denominator

where: E = value to be displayed
N = value of field in received message

8E xy zz ... zz

where: zz ... zz is the denominator, and has the same length as the data field

8F Display byte(s) with given signed offset as a percentage with given denominator, with a maximum field size in the received data of 4 bytes

E = (N + offset) * (100 (decimal)/denominator)

where: E = value to be displayed
N = value of field in received message

8F xy gg ... gg zz ... zz

where: zz ... zz is the signed decimal denominator, and has the same length as the data field

90 Display byte(s) using given scaling data, with a maximum field size in the received data of 4 bytes

90 xy ss

where: ss is scaling value:

bit 7 = scaling type:
0 = binary scaling
1 = decimal scaling

bit 6 - 0 = signed scaling power

If P = absolute value of bits 6 - 0:

for bits 7,6 = 00 then E = N * 2**P
= 01 then E = N / 2**P
= 10 then E = N * 10**P
= 11 then E = N / 10**P

where: E = value to be displayed
N = value of field in received message

91 Display byte(s) as BCD data. If any of received data is out of range then the tool shall indicate a "data out of range error" and this error shall be explained in the tool user manual/help facility.

91 xy

92 Display one of a set of two indexed logic texts (see 7.4.5). The index "ee" determines which text set in 7.4.5 to use. The selection of which of the two texts of the indexed set to display is based on ANDing the given bit mask "ff" with the received message byte at location "xx".

92 xx ff ee

93 Same as for 92, except that the result of the ANDing is inverted before selecting which text to display (see 7.4.5)

93 xx ff ee

98 Display given standard text (see 7.4.4)

98 ee

where: ee = index into standard text table

99 Clear entire display

99

9A Clear given area

9A hh

where: hh = display area id, $00 = top left display area, $01 = next display area

9B Position to beginning of top left display area

9B

9C Position to beginning of next display area

9C

9D Position to beginning of given display area

9D hh

where: hh = display area id, $00 = top left display area, $01 = next display area

9E Clear given display area and position to beginning of the display area

9E hh

where: hh = display area id, $00 = top left display area, $01 = next display area

9F Display byte(s) as y = aX + b, where X = unsigned decimal received byte(s), with a maximum field size in the received data of 4 bytes

9F xy jj kk ... kk

where: jj = one byte signed multiplier (a)
kk = signed offset (b) with same length as data byte(s)

A0 If received byte(s) equal given value then terminate this definition

A0 xy cc ... cc

A1 If received byte(s) equal given value then terminate this definition and start the given definition

A1 xy cc ... cc ww

where: ww = definition id

A2 If received byte(s) equal given value then terminate the given definition

A2 xy cc ... cc ww

where: ww = definition id

A8 If received byte(s) do not equal given value then terminate this definition

A8 xy cc ... cc

A9 If received byte(s) do not equal given value then terminate this definition and start the given definition

A9 xy cc ... cc ww

where: ww = definition id

AA If received byte(s) do not equal given value then terminate the given definition

AA xy cc ... cc ww

where: ww = definition id

B5 Move right given positions

B5 pp

where: pp = number of positions to move

C0 Process multiple received messages uniquely

C0

This RDPT must be the first RDPT in the received data processing information field.

7.4.4 STANDARD TEXT FOR USE WITH RECEIVED DATA PROCESSING TYPES—Figure 8 shows the standard text associated with RDPT's 8D and 98.

Scan tool manufacturers may use alternate text that conveys the same meaning as the standard text, if the alternative text is documented in the user manual/help facility associated with a given scan tool. Abbreviations found in SAE J1930 for the following phases may also be used. Other abbreviations may be used if they are documented in the scan tool user's guide/help facility.

Index	Standard Text	Index	Standard Text
01	degrees Centigrade or Centigrade	02	degrees Fahrenheit or Fahrenheit
03	% Calculated Load	04	% Full
05	% Full Delay	06	% Full Extended
07	% Full Off	08	% Full On
09	% Full Up	0A	% Maximum Torque
0B	% Methanol	0C	% Open
0D	% Remaining Life	0E	% Rich
0F	Counts	10	kilo Pascal Absolute
11	kilo Pascal Gage	12	grams per second
13	Revolutions	14	Revolutions Per Minute
15	Kilometers Per Hour	16	Miles Per Hour
17	liter	19	g's
1A	degrees CW	1B	degrees CCW
1D	Liters per 100 Km	1E	millisecond
1F	Volts	20	Hertz
21	seconds	22	minutes
23	hours	24	Diagnostic Trouble Code
25	gallons	26	gallons per minute
27	Ampere	30	Catalyst

FIGURE 8—STANDARD TEXT FOR USE WITH RECEIVED DATA PROCESSING TYPES

31	Purge	32	EGR
33	Misfire	34	Fuel
35	Rich	36	Lean
37	Pass	38	Fail
39	Calculated Load Value	3A	Heated Catalyst
3B	Evaporative	3C	Secondary Air
3D	Oxygen Sensor	3E	Oxygen Sensor Heater
3F	Coolant Temperature	40	Ambient Temperature
41	System	42	Short Term Fuel Trim
43	Long Term Fuel Trim	44	Fuel Pressure
45	MAP	46	BARO
47	Spark Advance	48	Intake Air Temperature
49	Absolute Throttle Position	4A	AIR Status
4B	Bank	4C	Sensor
4D	OBD Support	4E	Freeze Frame

FIGURE 8—STANDARD TEXT FOR USE WITH RECEIVED DATA PROCESSING TYPES (CONTINUED)

7.4.5 LOGIC TEXT USED WITH RECEIVED DATA PROCESSING TYPES—Figure 9 shows the logic text associated with RDPT's 92 and 93.

Scan tool manufacturers may also use standard abbreviations. Scan tool manufacturers may use alternate text or alternate abbreviations if such are documented in the user manual/help facility associated with a given scan tool.

Each of the following indexed sets consists of two values. Based on the RDPT type, if the resultant logic value after processing the message data and the additional data is "0," then the text shown under the "0" column, for the index value contained in the RDPI, is to be displayed. In a similar way, if the resultant logic value is "1," then the text shown under the "1" column is to be displayed.

8. ***Optional Ways of Entering EDP Information***—Some form of user input interface, such as a keyboard, must be available to the scan tool user to enter EDP definition information into the scan tool. However, other means may optionally be used to enter EDP definitions.

8.1 **Use of Bar Codes for Entry of EDP Information**—Optionally, the OBD II Scan Tool may also support the use of a bar code for entering EDP information.

Optionally, motor vehicle manufacturer diagnostic and service information may include EDP definitions in bar coded form.

Index	"0"	"1"
00	OFF	ON
01	FALSE	TRUE
02	DISABLE	ENABLE
03	CLOSED	OPEN
04	METRIC	ENGLISH
05	UNLOCK	LOCK
06	UNSECURED	SECURE
09	SPEED DENSITY	MASS AIRFLOW
0F	DECREASE	INCREASE
10	DECREMENT	INCREMENT
11	DOWN	UP
12	OUT	IN
13	BACKWARD	FORWARD
15	NOT SUPPORTED	SUPPORTED
16	MINUS	PLUS
17	LEFT	RIGHT
18	DOWNSTREAM	UPSTREAM
19	BACK	FRONT
1A	Open Loop	Closed Loop

FIGURE 9—LOGIC TEXT USED WITH RECEIVED DATA PROCESSING TYPES

In both of these cases the bar code type to be used is defined in AIAG-B-1 1984 AUTOMOTIVE INDUSTRY ACTION GROUP—BAR CODE SYMBOLOGY STANDARD—3 OF 9 BAR CODE SYMBOLS.

8.2 **Other Ways of Entering EDP Information**—Optionally, the OBD II Scan Tool may receive EDP information through a RS-232 interface, an allowed vehicle communication interface, or a cartridge.

The RS-232 interface or the vehicle communication interface, including the SAE J1962 connector, may be used to receive EDP information from sources such as a terminal connected to a SAE J2008 data base.

9. ***Guidelines for Showing EDP Definitions in Print and by the Scan Tool***—It can be difficult to read EDP definitions, especially long ones, in documents. However, some printing techniques can be used to make it easier for users to read and keep track of their place in a definition.

Printed definitions can be broken down into small groups with separating white space, alternating background shading, alternating fonts (e.g., italic and non-italic), etc. Alternating RDPI fields could have alternating backgrounds.

The scan tool could display the fields of a definition with white space separators, alternating colors, or alternating shading.

White space could, at the discretion on the scan tool manufacturer, be entered and displayed as a part of the definition. The white space would not be considered as a part of a definition as far as any checking and processing of the definition was concerned. Any scan tool memory required for support of white space entry and display would be over and above the requirement for non-white space definition data. The scan tool user manual/help facility would document any such features.

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