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## E/E Diagnostic Data Communications

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1. **Scope**—This SAE Information Report describes the diagnostic data communications required for implementation of a set of diagnostic test modes for all electronic systems on the vehicle's serial data link. These test modes can be used by off-board test equipment for both service and assembly plant testing.

The goal of this document is to provide standard methods to perform common functions for all electronic systems. This standard set of procedures will aid development, production, and field service of those systems. Use of the standard data communications in this specification will potentially result in the following benefits:

- Common methods and procedures for developers to use, without the need to invent methods to perform these functions
- Common programming techniques for system programmers, with increased sharing of software procedures
- Common hardware, software and test procedures for assembly plant testing
- Common hardware, software and service procedures for service diagnostics across different vehicle manufacturers and systems

This specification includes:

- Diagnostic Message Formats
- Device ID's
- Functional descriptions of all diagnostic test modes
- Message and response formats for all diagnostic test modes

- 1.1 **Purpose**—The diagnostic test modes (DTM) provide off-board test equipment with communication access to the on-board vehicle electronic systems. The off-board equipment shall be able to interrogate the electronic systems on the vehicle, and exercise control over these systems for the purposes of verifying system operation and diagnosing malfunction conditions.

Diagnostic test modes are predefined and standardized for all systems on the vehicle. Each device on the vehicle will implement only those DTMs which are appropriate for that device. Not all modes will be implemented on each device. If use of these modes is not appropriate for a given application, or during some operating modes, then that device is responsible to verify safe and proper operation and not respond to the request.

## 2. References

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

- 2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Dr., Warrendale, PA 15096-0001.

- SAE J1850—Class B Data Communication Network Interface
- SAE J2037—Off-Board Diagnostic Message Formats
- SAE J2062—A Class B Serial Bus Diagnostic Protocol
- SAE J2086—An Application Layer Protocol for a Generic Scan Tool

**3. Diagnostic Message Summary**—This specification defines 14 Diagnostic Test Modes.

Mode 0—Return to Normal Mode  
 Mode 1—Transmit Diagnostic Data  
 Mode 2—Memory Dump  
 Mode 3—Examine RAM Memory  
 Mode 4—Device Control Functions  
 Mode 5—RAM Download Request  
 Mode 6—RAM Download and Execute  
 Mode 7—Command Normal Message  
 Mode 8—Disable Normal Communications  
 Mode 9—Enable Normal Communications  
 Mode 10—Clear Malfunction Codes  
 Mode 11—Suspend Normal Message  
 Mode 12—Define Diagnostic Message by Data Position  
 Mode 13—Define Diagnostic Message by Memory Address

**4. Diagnostic Test Mode General Message Format**—DTM messages all conform to the following general format:

| BYTE | DESCRIPTION                                                              |
|------|--------------------------------------------------------------------------|
| 1    | Priority—first 4 bits<br>Message Length—second 4 bits                    |
| 2    | Device ID for Target                                                     |
| 3    | Device ID for Source                                                     |
| 4    | Message type/format—first 4 bits<br>Diagnostic Mode Number—second 4 bits |

The first byte of the message is a combination of priority (4 bits) and message length (4 bits). Message length is used as one check for data integrity. This also allows shorter messages with the same priority as longer messages to be transmitted first, which can improve the efficiency of the data link.

Each device will be assigned an ID unique to that device. The second byte of all DTM messages is the Device ID for the intended receiver of the message, and the third byte is the Device ID for the source of the message.

The fourth byte contains a combination of Message type / format (4 bits) and diagnostic mode number (4 bits). Various types of messages will be defined for normal mode communications and for diagnostic modes. This value indicates the structure for the remaining bytes of the message. The mode number indicates the action the device shall take in response to the message. Those actions are defined in the functional description section for each mode.

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. Those elements are:

Start of Message (SOM)  
 Error Detection Byte (ERR)  
 End of Data (EOD)  
 Response Byte(s) (RSP)  
 End of Message (EOM)  
 Inter-Message Separation (IMS)  
 Inter-Byte Separation (IBS)

5. **Device IDs**—A unique device ID should be assigned for each type of electronic system that will be used on different vehicles (see Table 1). Wherever possible, those codes should remain constant for that type of device on all vehicles. This will enable that same device to be utilized on other vehicles without software modifications to alter the device code. If those codes are unique, it will also eliminate any message conflict with other devices trying to use the same device code.

Device ID \$FF applies to all devices on the serial data link. This ID can be used to send the same request to all devices on the vehicle for purposes such as retrieving malfunction codes, disabling normal communications, or returning all devices to normal operation. All devices on the data link should then respond to this request with a response that includes their unique device ID. This enables the test device to determine which devices are on the data link and able to communicate.

**TABLE 1—ASSIGNED DEVICE ID'S  
(ALL IDS SHOWN IN HEX NOTATION)**

| Device ID | Device/Function                    |
|-----------|------------------------------------|
| FF        | All Devices                        |
| F0        | DTM Test Device                    |
| F1        | Body/Central Control Module        |
| F2        | Primary Display Device             |
| F3        | Secondary Display Device           |
| F4        | Engine Control                     |
| F5        | Transmission Control               |
| F6        | Compass                            |
| E6        | Engine Oil Life Monitor            |
| F7        | Ride Control                       |
| F8        | Steering Control                   |
| F9        | Brake/Traction Control             |
| FA        | Supplemental Inflatable Restraint  |
| EA        | HVAC Control                       |
| FB        | Audio Warning (Voice Module/Chime) |
| EB        | Remote Accessory Control           |
| FC        | Throttle Control                   |
| EC        | Calculator                         |
| FD        | Cellular Phone                     |
| ED        | Memory Seat/Mirror                 |

6. **Diagnostic Test Mode General Conditions**—If any on-board device is in a requested diagnostic mode, and if there is no other diagnostic message on the data link for a period of more than 5 s, that device shall terminate any active diagnostic mode and resume normal system operation. This solves the condition of a test device requesting a nonnormal mode of operation for a device and then disconnecting from the vehicle without returning operation of on-board devices to normal operation. If there is any diagnostic activity on the serial data link, then the on-board devices should assume that the test device may be controlling operation of some or all systems, and should remain in the present state of operation until instructed to change.

Diagnostic mode operation requires that test equipment be aware of previously requested modes, and accommodate for any desired changes. The automatic return to normal also requires that a test device transmit a diagnostic message at least once every 5 s if it needs to prevent on-board devices from returning to normal operation. That message does not need to be directed at any particular device on the link.

The potential exists in response messages for the contents of a multibyte variable to change after the first byte is sent, but before the last byte is sent, resulting in bad data. To maintain data integrity under this condition, hardware or software provisions must be included in each application to ensure that all bytes of multibyte variables are read simultaneously.

## 7. Diagnostic Test Mode Functional Description

### 7.1 Mode 0—Return to Normal Mode

7.1.1 FUNCTIONAL DESCRIPTION—The on-board device will return to the normal mode of operation when this command is received. All normal algorithms and normal communications will be resumed.

#### 7.1.2 MODE 0 REQUEST

| BYTE | DESCRIPTION                        |
|------|------------------------------------|
| 1-4  | Message Header (includes Mode = 0) |

#### 7.1.3 MODE 0 RESPONSE

| BYTE | DESCRIPTION                        |
|------|------------------------------------|
| 1-4  | Message Header (includes Mode = 0) |

### 7.2 Mode 1—Transmit Diagnostic Data

7.2.1 FUNCTIONAL DESCRIPTION—The on-board device will respond to this message by transmitting from 1 to 8 requested diagnostic data messages specific to that device. The message number bytes in the request allow multiple Mode 1 messages to be requested. Up to 32 messages can be defined for each device. These can either be predefined or defined during the diagnostic procedure using Mode 12 or 13. Messages should be defined with group data that is commonly used together or changes together.

Uses for these different messages 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 messages is to return values that do not change, such as VIN and option content. 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.

#### 7.2.2 MODE 1 REQUEST

| BYTE | DESCRIPTION                        |
|------|------------------------------------|
| 1-4  | Message Header (includes Mode = 0) |
| 5    | Transmit Message #1                |
| 6    | Transmit Message #2 - Optional     |
| 7    | Transmit Message #3 - Optional     |
| 8    | Transmit Message #4 - Optional     |
| 9    | Transmit Message #5 - Optional     |
| 10   | Transmit Message #6 - Optional     |
| 11   | Transmit Message #7 - Optional     |
| 12   | Transmit Message #8 - Optional     |

Message number is in the range from \$00 to \$1F.