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THE UNITED STATES OF AMERICA
Legally Binding Document

By the Authority Vested By Part 5 of the United States Code § 552(a) and Part 1 of the Code of Regulations § 51 the attached document has been duly INCORPORATED BY REFERENCE and shall be considered legally binding upon all citizens and residents of the United States of America. *HEED THIS NOTICE*: Criminal penalties may apply for noncompliance.

Document Name: SAE J2012: Diagnostic Trouble Code Definitions

CFR Section(s): 40 CFR 86.1806-04(h)(1)(iii)

Standards Body: Society of Automotive Engineers

APPROVED

Official Incorporator:
THE EXECUTIVE DIRECTOR
OFFICE OF THE FEDERAL REGISTER
WASHINGTON, D.C.

DIAGNOSTIC TROUBLE CODE DEFINITIONS EQUIVALENT TO ISO/DIS 15031-6:APRIL 30, 2002 —SAE J2012 APR2002

SAE Recommended Practice

Report of the SAE Vehicle E/E System Diagnostics Standards Committee approve dMarch 1992, completely revised January 1994, and revised October 1994, July 1996, and march 1999. Rationale statement available. Completely revised by the SAE Vehicle Electrical and Electronics Diagnostic Systems Standards Committee April 2002.

This document supersedes SAE J2012 MAR1999, and is technically equivalent to ISO/DIS 15031-6:April 30, 2002, except for minor reorganization of Paragraphs 1 and 2.

Foreword—On-Board Diagnostic (OBD) regulations require passenger cars, and light and medium duty trucks, to report standardized fault codes for malfunctions detected by the OBD system. This document defines the standardized set of fault codes.

SAE J2012 was originally developed to meet U.S. OBD requirements for 1996 and later model year vehicles. ISO 15031-6 was based on SAE J1962 and was intended to meet European OBD requirements for 2000 and later model year vehicles. This document is technically equivalent to ISO 15031-6, with new and revised fault codes included.

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1. Scope

1.1 Purpose—This SAE Recommended Practice supersedes SAE J2012 MAR1999, and is technically equivalent to ISO/DIS 15031-6:April 30, 2002.

This document is intended to define the standardized Diagnostic Trouble Codes (DTC) that On-Board Diagnostic (OBD) systems in vehicles are required to report when malfunctions are detected.

This document includes:

a. Diagnostic Trouble Code format

b. A standardized set of Diagnostic Trouble Codes and descriptions

1.2 Differences from ISO Document—There are no technical differences between this document and ISO/DIS 15031-6:April 30, 2002.

2. References

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated, the latest version of SAE publications shall apply.

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

SAE J1930—Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms - Equivalent to ISO/TR 15031-2:April 30, 2002

SAE J1979—E/E Diagnostic Test Modes - Equivalent to ISO/DIS 15031-5:April 30, 2002

2.1.2 ISO DOCUMENT—Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002.

ISO/DIS 15031-6: April 30, 2002—Road vehicles—Communication between vehicle and external test equipment for emissions-related diagnostics—Part 6: Diagnostic trouble code definitions

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

SAE J1978—OBD II Scan Tool—Equivalent to ISO/DIS 15031-4:December 14, 2001

2.2.2 ISO DOCUMENT—Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002.

ISO 15031-1:2001—Road vehicles—Communication between vehicle and external test equipment for emissions-related diagnostics—Part 1: General information

3. Terms and Definitions—This document is not intended to be used for terms and definitions of vehicle component terminology. These may appear in SAE J1930.

3.1 Circuit/Open—Fixed value or no response from the system where specific high or low detection is not feasible or can be used in conjunction with circuit low and high codes where all three circuit conditions can be detected.

NOTE—The term "malfunction" has, in most cases, been deleted from the DTC description.

3.2 Range/Performance—Circuit is in the normal operating range, but not correct for current operating conditions, it may be used to indicate stuck or skewed values indicating poor performance of a circuit, component, or system.

3.3 Low Input—Circuit voltage, frequency, or other characteristic measured at the control module input terminal or pin that is below the normal operating range.

3.4 High Input—Circuit voltage, frequency, or other characteristic measured at the control module input terminal or pin that is above the normal operating range.

3.5 Bank—Specific group of cylinders sharing a common control sensor, bank 1 always contains cylinder number 1, bank 2 is the opposite bank

NOTE—If there is only one bank, use bank #1 DTCs and the word bank may be omitted. With a single "bank" system using multiple sensors, use bank #1.

3.6 Sensor Location—Location of a sensor in relation the engine air flow, starting from the fresh air intake through to the vehicle tailpipe or fuel flow from the fuel tank to the engine in order numbering 1,2,3 and so on

NOTE—See Figures 1 to 4.

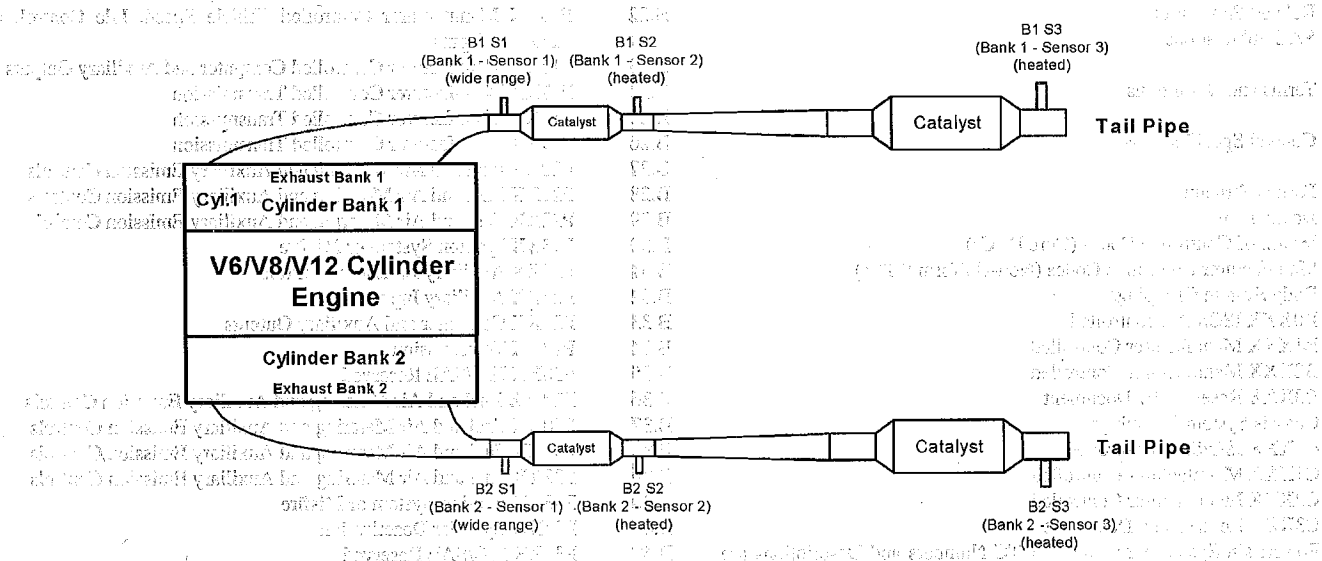

FIGURE 1—V6/V8/V12 CYLINDER ENGINE WITH 2 EXHAUST BANKS AND 4 CATALYSTS EXAMPLE

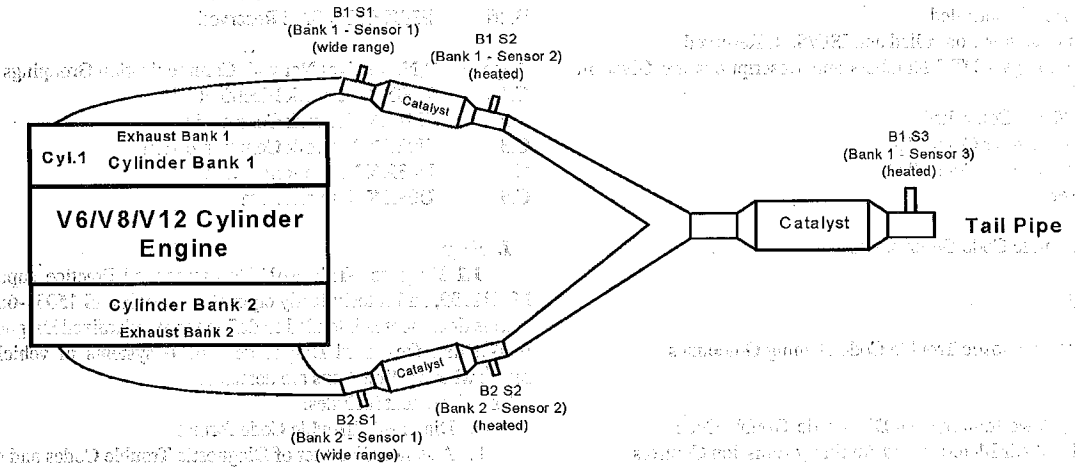

FIGURE 2—V6/V8/V12 CYLINDER ENGINE WITH 2 EXHAUST BANKS AND 3 CATALYSTS EXAMPLE

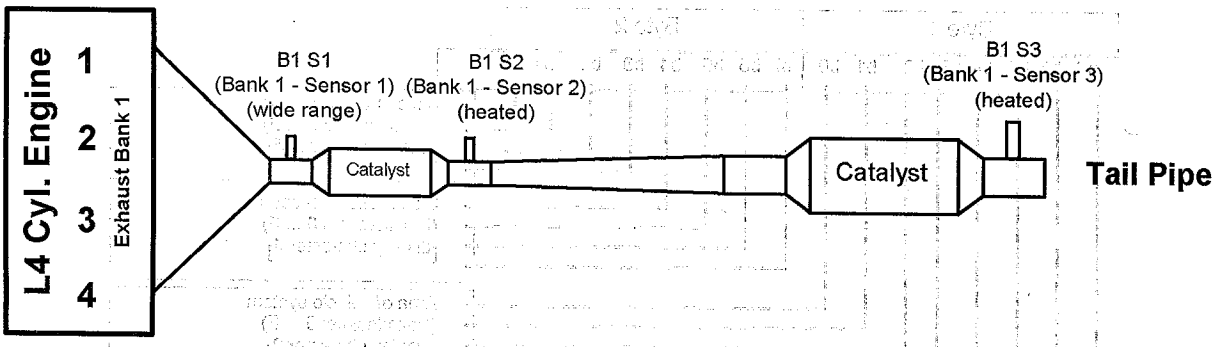

FIGURE 3—L4/L5/L6 CYLINDER ENGINE WITH 1 EXHAUST BANK AND 2 CATALYSTS EXAMPLE

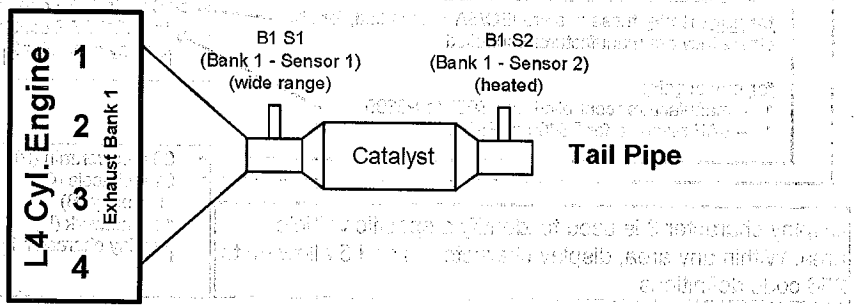

FIGURE 4—L4/L5/L6 CYLINDER ENGINE WITH 1 EXHAUST BANK AND 1 CATALYST EXAMPLE

3.7 Left/Right and Front/Rear—Component identified by its position as if it can be viewed from the drivers seating position.

3.8 "A" "B"—Where components are indicated by a letter (i.e., A, B, C, etc.) this would be manufacturer defined, starting with component "A".

3.9 Intermittent/Erratic—The signal is temporarily discontinuous, the duration of the fault is not sufficient to be considered an open or short, or the rate of change is excessive.

4. General Specifications—The following table specifies systems, code categories, hexadecimal values and particular sections of electrical/electronic systems diagnostic.

TABLE 1—GENERAL CODE SPECIFICATIONS

System	Code categories	Hex value	DTC Prefix
Body	B0xxx - B3xxx	8xxx - Bxxx	B
Chassis	C0xxx - C3xxx	4xxx - 7xxx	C
Powertrain	P0xxx - P3xxx	0xxx - 3xxx	P
Network	U0xxx - U3xxx	Cxxx - Fxxx	U

The recommended DTCs 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 network trouble codes. The code structure itself is partially open-ended. A portion of the available numeric sequences (portions of "B0", "C0", "P0" and "U0") is reserved for uniform codes assigned by this or future updates. Detailed specifications of the DTC format structure are specified in Section 5. Most circuit, component, or system diagnostic trouble codes are specified by four basic categories:

— General circuit /open
— Range/Performance problem
— Circuit Low
— Circuit High

Circuit Low is measured with the external circuit, component, or system connected. The signal type (voltage, frequency, etc.) shall be included in the message after Circuit Low or Circuit High.

Circuit High is measured with the external circuit, component, or system connected. The signal type (voltage, frequency, etc.) may be included in the message after Circuit Low or Circuit High.

5. Format Structure

5.1 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 network communication, followed by three characters. The assignment of the proper alpha designator should be determined by the area most appropriate for that function. In most cases, the alpha designator will be implied since diagnostic information will be requested from a particular controller. However, this does not imply that all codes supported by a particular controller shall have the same alphanumeric designator. The codes are structured as in the following figure.

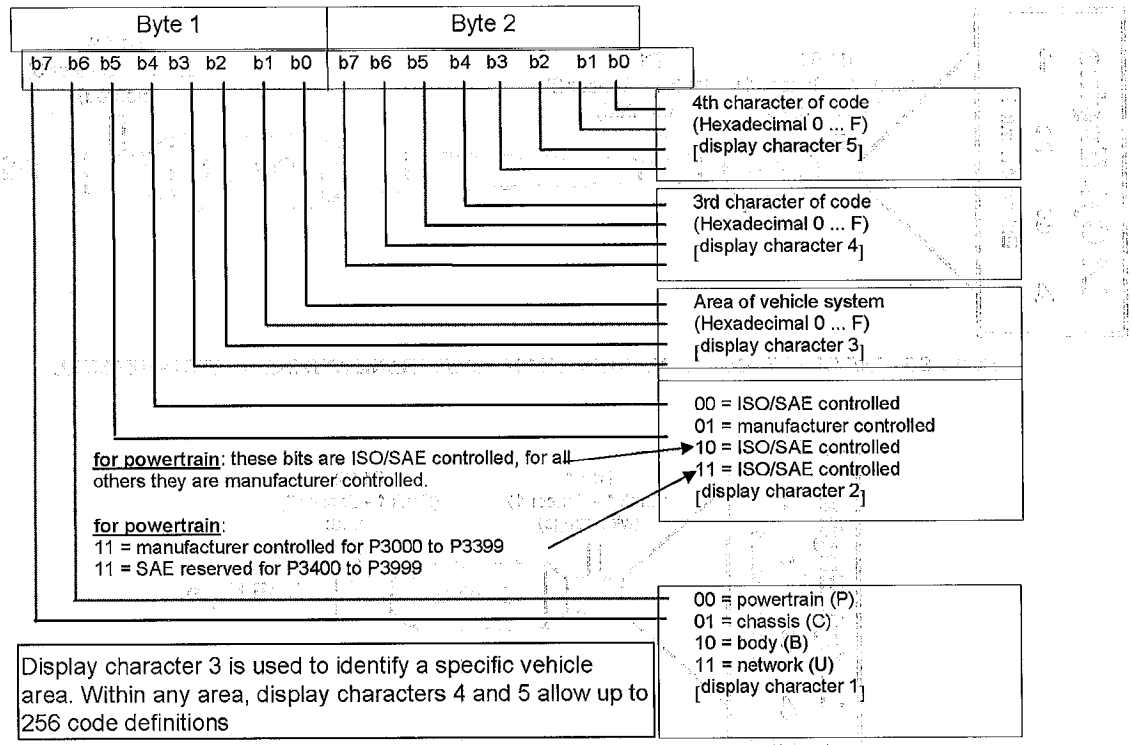

FIGURE 5—STRUCTURE OF DIAGNOSTIC TROUBLE CODES

EXAMPLE — The data bus value $9234 would be displayed to technicians as the manufacturer controlled body code B1234, see the figure below.

$9				$2				$3				$4			
1	0	0	1	0	0	1	0	0	0	1	1	0	1	0	0
B		1		2				3				4			

FIGURE 6—EXAMPLE OF TROUBLE CODE STRUCTURE

Codes have been specified to indicate a suspected trouble or problem area and are intended to be used as a directive to the proper service procedure. To minimize service confusion, fault codes should not be used to indicate the absence of problems or the status of parts of the system (e.g., powertrain system O.K., or MIL activated), but should be confined to indicate areas in need of service attention.

Some ranges have been expanded beyond 100 numbers by using the hexadecimal base 16 number system.

5.2 ISO/SAE Controlled Codes (Core DTCs)—ISO/SAE controlled 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 unspecified numbers in each grouping have been reserved for future growth. Although service procedures may differ widely amongst manufacturers, the fault being indicated is common enough to be assigned a particular fault code. Codes in this area are not to be used by manufacturers until they have been approved by ISO/SAE.

5.3 Manufacturer Controlled Codes (Non-Uniform DTCs)—Areas within each alpha designator have been made available for manufacturer-controlled DTCs. These are fault codes that will not generally be used by a majority of the manufacturers due to basic system differences, implementation differences, or diagnostic strategy differences. Each vehicle manufacturer or supplier who designs and specifies diagnostic algorithms, software, and diagnostic trouble codes are strongly encouraged to remain consistent across their product line when assigning codes in the manufacturer controlled area. For powertrain codes, the same groupings should be used as in the ISO /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 specified at a later date.

While each manufacturer has the ability to define the controlled DTCs to meet their specific controller algorithms, all DTC words shall meet SAE J1930.

5.4 Body System Groupings

5.4.1 B0XXX ISO/SAE CONTROLLED
5.4.2 B1XXX MANUFACTURER CONTROLLED
5.4.3 B2XXX MANUFACTURER CONTROLLED
5.4.4 B3XXX RESERVED BY DOCUMENT

5.5 Chassis System Groupings

5.5.1 C0XXX ISO/SAE CONTROLLED
5.5.2 C1XXX MANUFACTURER CONTROLLED
5.5.3 C2XXX MANUFACTURER CONTROLLED
5.5.4 C3XXX RESERVED BY DOCUMENT

5.6 Powertrain System Groupings—DTC Numbers and Cescriptions are Given in Appendix B

5.6.1 P0XXX ISO/SAE CONTROLLED
5.6.2 P1XXX MANUFACTURER CONTROL
5.6.3 P2XXX ISO/SAE CONTROLLED
5.6.4 P3XXX MANUFACTURER CONTROLLED AND ISO/SAE RESERVED

5.7 Network Groupings—DTC Numbers and Descriptions are given in Appendix C

5.7.1 U0XXX ISO/SAE CONTROLLED
5.7.2 U1XXX MANUFACTURER CONTROLLED
5.7.3 U2XXX MANUFACTURER CONTROLLED
5.7.4 U3XXX RESERVED

6. Diagnostic Trouble Code Descriptions—Each specified fault code has been assigned a description to indicate the circuit, component or system area that was determined to be at fault. The descriptions are organized such that different descriptions related to a particular sensor or system are grouped together. In cases where there are various fault descriptions for different types of faults, the group also has a "generic" description 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.

Where more specific fault descriptions for a circuit, component, or system exist, the manufacturer should choose the code most applicable to their diagnosable fault. The descriptions 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 description, 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" shall be specified by each manufacturer to best meet their needs.

For example, in diagnosing a 5 V reference Throttle Position Sensor (TP Sensor), if the input signal at the Powertrain Control Module (PCM) is stuck at near 0 V, a manufacturer has the flexibility to select from either of two codes - P0120 (Throttle/Pedal Position Sensor/Switch A Circuit) or P0122 (Throttle/Pedal Position Sensor/Switch A Circuit Low Input), depending on the manufacturer's diagnostic procedures. If the input signal at the PCM is stuck at near 5 V, a manufacturer has the flexibility to select from either of two codes - P0120 (Throttle/Pedal Position Sensor/Switch A Circuit) or P0123 (Throttle/Pedal Position Sensor/Switch A Circuit High Input), depending on the manufacturer's diagnostic procedures. If the input signal at the PCM is stuck at 1.5 V at idle instead of the expected 1.0 V, the manufacturer has the flexibility to select from either of two codes - P0120 (Throttle/Pedal Position Sensor/Switch A Circuit) or P0121 (Throttle/Pedal Position Sensor/Switch A Circuit Range/Performance Problem), depending on the manufacturer's diagnostic procedures. The root cause of the higher than expected TP Sensor voltage may be either a faulty TP Sensor, corrosion in the TP Sensor connections or an improperly adjusted throttle plate. Identification of the root cause is done using the diagnostic procedures and is not implied by the DTC message, thus allowing the manufacturer the flexibility in assigning DTCs Change requests.

7. Change Requests—Use this form to pass your request.

REQUEST FORM FOR NEW SAE J2012 SAE CONTROLLED DTC

What is the purpose of the component, circuit, or system?

Example: Exhaust Gas Recirculation.

What is the purpose of the diagnostic?

Example: detect low EGR flow

Requested Group Number _____

Requested DTC Number _____

Requested DTC Nomenclature _____

Example: EGR Low Flow Detected

Requested by: _____

Phone/Fax _____

Email _____

Address _____

Date:

Please send completed form(s) to:

SAE Headquarters
755 West Big Beaver Road
Suite 1600
Troy, MI 48084
USA

ATTN: SAE J2012 Powertrain Committee Chairman

APPENDIX A
(NORMATIVE)
DIAGNOSTIC TROUBLE CODE NAMING GUIDELINES

A.1 Discussion—The following Table A1 is a guideline used to help in determining DTC descriptions. Appendix B shows applications for recommended industry common trouble codes for the powertrain control system. These include systems that might be integrated into an electronic control module that would be used for controlling engine functions, such as fuel, spark, idle speed, and vehicle speed (cruise control) as well as those for transmission control. The fact that a code is recommended as a common industry code does not imply that it is a required code (legislated), an emission related code, nor that it indicates a fault that will cause the malfunction indicator to be illuminated.

TABLE A1—DTC NAMING GUIDELINES FOR SIGNALS FROM COMPONENTS

Component/System SAE J1930 1)	Acronym SAEJ1930 1)	Modifier (if used) 1)	Noun Name 1	Circuit 1)	Intermittent (if used) 1)	State (if used) 1)	Parameter (if used) 1)	Location (if used) 1)
Throttle Position	TP		Sensor	Circuit		Low	Voltage	
Throttle Position	TP		Sensor	Circuit		Performance		
Manifold Absolute Pressure	MAP		Sensor	Circuit		High	Voltage	
Engine Coolant Temperature	ECT		Sensor	Circuit		Low	Voltage	
Intake Air Temperature	IAT		Sensor	Circuit		High	Voltage	
Vehicle Speed Sensor	VSS		included in acronym	Circuit		High	Voltage	
Vehicle Speed Sensor	VSS		included in acronym	Circuit	Intermittent			
Heated Oxygen Sensor	HO2S		included in Acronym Heater	Circuit				
Heated Oxygen Sensor	HO2S		included in Acronym Heater	Circuit		Low	Voltage	Bank (B1) Sensor 1 (S1)
Idle Air Control	IAC		Valve	Circuit		Low	Voltage	
Mass Air Flow	MAF		Sensor	Circuit		High	Frequency	
Mass Air Flow	MAF		Sensor	Circuit		Performance		
Knock Sensor	KS		included in acronym Module Sensor	Circuit				Bank 1
Knock Sensor	KS		included in acronym Module Sensor	Circuit		Performance		
Crankshaft Position	CKP		Sensor	Circuit				
Evaporative Emissions	EVAP	Canister Purge	Valve	Circuit				
Engine Speed	RPM		Input	Circuit				
Air Conditioning	A/C	Clutch Status	N/A	Circuit		Low	Voltage	
Heated Oxygen Sensor	HO2S			Circuit		Transition Time Ratio		Bank 1 (B1) Sensor (S1)
Heated Oxygen Sensor	HO2S			Circuit		Insufficient Switching		Bank 1 (B1) Sensor 1 (S1)
Distributor Ignition	DI		Low Resolution	Circuit	Intermittent			
Distributor Ignition	DI		High Resolution	Circuit				

NOTE 1) The Service Information uses Component/System from SAE J1930 or Acronym from SAE J1930, Modifier, Noun Name, Circuit, Intermittent, State, Parameter, and Location.

TABLE A2—DTC NAMING GUIDELINES FOR SIGNALS TO COMPONENTS

Component/System SAE J1930 1)	Acronym SAE J1930 1)	Modifier (if used) 1)	Noun Name1)	Control 1)	Circuit 1)	Intermittent (if used) 1)	State (if used) 1)	Parameter (if used) 1)	Location (if used) 1)
Malfunction Indicator lamp	MIL		included in acronym	Control	Circuit				
Injector	N/A			Control	Circuit				
Fan Control	FC		Relay 1	Control	Circuit				
Fan Control	FC		Relay 2	Control	Circuit		Low		
Exhaust Gas Recirculation	EGR		Solenoid	Control	Circuit		High		
Secondary Air Injection	AIR		Solenoid	Control	Circuit		High		
Evaporative Emissions	EVAP	Purge	Solenoid	Control	Circuit				
Air Conditioning	A/C	Clutch	Relay	Control	Circuit				
Idle Air Control	IAC		Valve	Control	Circuit		Low		
Ignition Control	IC		N/A	included in acronym	Circuit		Low	Voltage	
Ignition Control	IC		N/A	included in acronym	Circuit		High	Voltage	
Torque Converter Clutch	TCC		Solenoid	Control	Circuit		Stuck on		

NOTE 1) The Service Information uses Component/System from SAE J1930 or Acronym from SAE J1930, Modifier, Noun Name, Circuit, Intermittent, State, Parameter, and Location.

TABLE A3—DTC NAMING GUIDELINES INVOLVING SEVERAL COMPONENTS OR SYSTEMS

Component/System SAE J1930[1)]	Acronym SAE J1930[1)]	Modifier[1)]	System[1)]	Intermittent[1)]	State[1)]	Parameter[1)]	Location[1)]
Exhaust Gas Recirculation	EGR		System				
Fuel Trim	FT		System		Lean		Bank 1
Secondary Air Injection	AIR		System				Bank 1

NOTE 1) The Service Information uses Component/System from SAE J1930 or Acronym from SAE J1930, Modifier, Noun Name, Circuit, Intermittent, State, Parameter, and Location.

APPENDIX B
(NORMATIVE)
POWERTRAIN SYSTEM DIAGNOSTIC TROUBLE CODE

B.1 P00XX Fuel and Air Metering and Auxiliary Emission Controls

TABLE B1—P00XX FUEL AND AIR METERING AND AUXILIARY EMISSION CONTROLS

DTC number	DTC naming	Location
P0001	Fuel Volume Regulator Control Circuit/Open	
P0002	Fuel Volume Regulator Control Circuit Range/Performance	
P0003	Fuel Volume Regulator Control Circuit Low	
P0004	Fuel Volume Regulator Control Circuit High	
P0005	Fuel Shutoff Valve "A" Control Circuit/Open	
P0006	Fuel Shutoff Valve "A" Control Circuit Low	
P0007	Fuel Shutoff Valve "A" Control Circuit High	
P0008	Engine Position System Performance	Bank 1
P0009	Engine Position System Performance	Bank 2
P0010 [a)]	"A" Camshaft Position Actuator Circuit	Bank 1
P0011 [a)]	"A" Camshaft Position - Timing Over-Advanced or System Performance	Bank 1
P0012 [a)]	"A" Camshaft Position - Timing Over-Retarded	Bank 1
P0013 [b)]	"B" Camshaft Position - Actuator Circuit	Bank 1
P0014 [b)]	"B" Camshaft Position - Timing Over-Advanced or System Performance	Bank 1
P0015 [b)]	"B" Camshaft Position - Timing Over-Retarded	Bank 1
P0016	Crankshaft Position – Camshaft Position Correlation	Bank 1 Sensor A
P0017	Crankshaft Position – Camshaft Position Correlation	Bank 1 Sensor B
P0018	Crankshaft Position – Camshaft Position Correlation	Bank 2 Sensor A
P0019	Crankshaft Position – Camshaft Position Correlation	Bank 2 Sensor B
P0020 [a)]	"A" Camshaft Position Actuator Circuit	Bank 2
P0021 [a)]	"A" Camshaft Position - Timing Over-Advanced or System Performance	Bank 2
P0022 [a)]	"A" Camshaft Position - Timing Over-Retarded	Bank 2
P0023 [b)]	"B" Camshaft Position - Actuator Circuit	Bank 2
P0024 [b)]	"B" Camshaft Position - Timing Over-Advanced or System Performance	Bank 2
P0025 [b)]	"B" Camshaft Position - Timing Over-Retarded	Bank 2
P0026	Intake Valve Control Solenoid Circuit Range/Performance	Bank 1
P0027	Exhaust Valve Control Solenoid Circuit Range/Performance	Bank 1
P0028	Intake Valve Control Solenoid Circuit Range/Performance	Bank 2
P0029	Exhaust Valve Control Solenoid Circuit Range/Performance	Bank 2
P0030	HO2S Heater Control Circuit	Bank 1 Sensor 1
P0031	HO2S Heater Control Circuit Low	Bank 1 Sensor 1
P0032	HO2S Heater Control Circuit High	Bank 1 Sensor 1
P0033	Turbo Charger Bypass Valve Control Circuit	
P0034	Turbo Charger Bypass Valve Control Circuit Low	
P0035	Turbo Charger Bypass Valve Control Circuit High	
P0036	HO2S Heater Control Circuit	Bank 1 Sensor 2
P0037	HO2S Heater Control Circuit Low	Bank 1 Sensor 2
P0038	HO2S Heater Control Circuit High	Bank 1 Sensor 2
P0039	Turbo/Super Charger Bypass Valve Control Circuit Range/Performance	

TABLE B1—P00XX FUEL AND AIR METERING AND AUXILIARY EMISSION CONTROLS (continued)

DTC number	DTC naming	Location
P0040	O2 Sensor Signals Swapped Bank 1 Sensor 1/ Bank 2 Sensor 1	
P0041	O2 Sensor Signals Swapped Bank 1 Sensor 2/ Bank 2 Sensor 2	
P0042	HO2S Heater Control Circuit	Bank 1 Sensor 3
P0043	HO2S Heater Control Circuit Low	Bank 1 Sensor 3
P0044	HO2S Heater Control Circuit High	Bank 1 Sensor 3
P0045	Turbo/Super Charger Boost Control Solenoid Circuit/Open	
P0046	Turbo/Super Charger Boost Control Solenoid Circuit Range/Performance	
P0047	Turbo/Super Charger Boost Control Solenoid Circuit Low	
P0048	Turbo/Super Charger Boost Control Solenoid Circuit High	
P0049	Turbo/Super Charger Turbine Overspeed	
P0050	HO2S Heater Control Circuit	Bank 2 Sensor 1
P0051	HO2S Heater Control Circuit Low	Bank 2 Sensor 1
P0052	HO2S Heater Control Circuit High	Bank 2 Sensor 1
P0053	HO2S Heater Resistance	Bank 1 Sensor 1
P0054	HO2S Heater Resistance	Bank 1 Sensor 2
P0055	HO2S Heater Resistance	Bank 1 Sensor 3
P0056	HO2S Heater Control Circuit	Bank 2 Sensor 2
P0057	HO2S Heater Control Circuit Low	Bank 2 Sensor 2
P0058	HO2S Heater Control Circuit High	Bank 2 Sensor 2
P0059	HO2S Heater Resistance	Bank 2 Sensor 1
P0060	HO2S Heater Resistance	Bank 2 Sensor 2
P0061	HO2S Heater Resistance	Bank 2 Sensor 3
P0062	HO2S Heater Control Circuit	Bank 2 Sensor 3
P0063	HO2S Heater Control Circuit Low	Bank 2 Sensor 3
P0064	HO2S Heater Control Circuit High	Bank 2 Sensor 3
P0065	Air Assisted Injector Control Range/Performance	
P0066	Air Assisted Injector Control Circuit or Circuit Low	
P0067	Air Assisted Injector Control Circuit High	
P0068	MAP/MAF – Throttle Position Correlation	
P0069	Manifold Absolute Pressure – Barometric Pressure Correlation	
P0070	Ambient Air Temperature Sensor Circuit	
P0071	Ambient Air Temperature Sensor Range/Performance	
P0072	Ambient Air Temperature Sensor Circuit Low	
P0073	Ambient Air Temperature Sensor Circuit High	
P0074	Ambient Air Temperature Sensor Circuit Intermittent	
P0075	Intake Valve Control Solenoid Circuit	Bank 1
P0076	Intake Valve Control Solenoid Circuit Low	Bank 1
P0077	Intake Valve Control Solenoid Circuit High	Bank 1
P0078	Exhaust Valve Control Solenoid Circuit	Bank 1
P0079	Exhaust Valve Control Solenoid Circuit Low	Bank 1
P0080	Exhaust Valve Control Solenoid Circuit High	Bank 1
P0081	Intake Valve Control Solenoid Circuit	Bank 2
P0082	Intake Valve Control Solenoid Circuit Low	Bank 2
P0083	Intake Valve Control Solenoid Circuit High	Bank 2
P0084	Exhaust Valve Control Solenoid Circuit	Bank 2
P0085	Exhaust Valve Control Solenoid Circuit Low	Bank 2
P0086	Exhaust Valve Control Solenoid Circuit High	Bank 2
P0087	Fuel Rail/System Pressure - Too Low	
P0088	Fuel Rail/System Pressure - Too High	
P0089	Fuel Pressure Regulator 1 Performance	
P0090	Fuel Pressure Regulator 1 Control Circuit	
P0091	Fuel Pressure Regulator 1 Control Circuit Low	
P0092	Fuel Pressure Regulator 1 Control Circuit High	
P0093	Fuel System Leak Detected – Large Leak	
P0094	Fuel System Leak Detected – Small Leak	

TABLE B1—P00XX FUEL AND AIR METERING AND AUXILIARY EMISSION CONTROLS (continued)

DTC number	DTC naming	Location
P0095	Intake Air Temperature Sensor 2 Circuit	
P0096	Intake Air Temperature Sensor 2 Circuit Range/Performance	
P0097	Intake Air Temperature Sensor 2 Circuit Low	
P0098	Intake Air Temperature Sensor 2 Circuit High	
P0099	Intake Air Temperature Sensor 2 Circuit Intermittent/Erratic	

[a] The "A" camshaft shall be either the "intake," "left," or "front" camshaft. Left/Right and Front/Rear are determined as if viewed from the driver's seating position. Bank 1 contains cylinder number one, Bank 2 is the opposite bank.

[b] The "B" camshaft shall be either the "exhaust," "right," or "rear" camshaft. Left/Right and Front/Rear are determined as if viewed from the driver's seating position. Bank 1 contains cylinder number one, Bank 2 is the opposite bank.

B.2 P01XX Fuel and Air Metering

TABLE B2—P01XX FUEL AND AIR METERING

DTC number	DTC naming	Location
P0100	Mass or Volume Air Flow Circuit	
P0101	Mass or Volume Air Flow Circuit Range/Performance	
P0102	Mass or Volume Air Flow Circuit Low Input	
P0103	Mass or Volume Air Flow Circuit High Input	
P0104	Mass or Volume Air Flow Circuit Intermittent	
P0105	Manifold Absolute Pressure/Barometric Pressure Circuit	
P0106	Manifold Absolute Pressure/Barometric Pressure Circuit Range/Performance	
P0107	Manifold Absolute Pressure/Barometric Pressure Circuit Low Input	
P0108	Manifold Absolute Pressure/Barometric Pressure Circuit High Input	
P0109	Manifold Absolute Pressure/Barometric Pressure Circuit Intermittent	
P0110	Intake Air Temperature Sensor 1 Circuit	
P0111	Intake Air Temperature Sensor 1 Circuit Range/Performance	
P0112	Intake Air Temperature Sensor 1 Circuit Low	
P0113	Intake Air Temperature Sensor 1 Circuit High	
P0114	Intake Air Temperature Sensor 1 Circuit Intermittent	
P0115	Engine Coolant Temperature Circuit	
P0116	Engine Coolant Temperature Circuit Range/Performance	
P0117	Engine Coolant Temperature Circuit Low	
P0118	Engine Coolant Temperature Circuit High	
P0119	Engine Coolant Temperature Circuit Intermittent	
P0120	Throttle/Pedal Position Sensor/Switch "A" Circuit	
P0121	Throttle/Pedal Position Sensor/Switch "A" Circuit Range/Performance	
P0122	Throttle/Pedal Position Sensor/Switch "A" Circuit Low	
P0123	Throttle/Pedal Position Sensor/Switch "A" Circuit High	
P0124	Throttle/Pedal Position Sensor/Switch "A" Circuit Intermittent	
P0125	Insufficient Coolant Temperature for Closed Loop Fuel Control	
P0126	Insufficient Coolant Temperature for Stable Operation	
P0127	Intake Air Temperature Too High	
P0128	Coolant Thermostat (Coolant Temperature Below Thermostat Regulating Temperature)	
P0129	Barometric Pressure Too Low	
P0130	O2 Sensor Circuit	Bank 1 Sensor 1
P0131	O2 Sensor Circuit Low Voltage	Bank 1 Sensor 1
P0132	O2 Sensor Circuit High Voltage	Bank 1 Sensor 1
P0133	O2 Sensor Circuit Slow Response	Bank 1 Sensor 1
P0134	O2 Sensor Circuit No Activity Detected	Bank 1 Sensor 1
P0135	O2 Sensor Heater Circuit	Bank 1 Sensor 1
P0136	O2 Sensor Circuit	Bank 1 Sensor 2
P0137	O2 Sensor Circuit Low Voltage	Bank 1 Sensor 2
P0138	O2 Sensor Circuit High Voltage	Bank 1 Sensor 2
P0139	O2 Sensor Circuit Slow Response	Bank 1 Sensor 2
P0140	O2 Sensor Circuit No Activity Detected	Bank 1 Sensor 2
P0141	O2 Sensor Heater Circuit	Bank 1 Sensor 2

TABLE B2—P01XX FUEL AND AIR METERING (continued)

DTC number	DTC naming	Location
P0142	O2 Sensor Circuit	Bank 1 Sensor 3
P0143	O2 Sensor Circuit Low Voltage	Bank 1 Sensor 3
P0144	O2 Sensor Circuit High Voltage	Bank 1 Sensor 3
P0145	O2 Sensor Circuit Slow Response	Bank 1 Sensor 3
P0146	O2 Sensor Circuit No Activity Detected	Bank 1 Sensor 3
P0147	O2 Sensor Heater Circuit	Bank 1 Sensor 3
P0148	Fuel Delivery Error	
P0149	Fuel Timing Error	
P0150	O2 Sensor Circuit	Bank 2 Sensor 1
P0151	O2 Sensor Circuit Low Voltage	Bank 2 Sensor 1
P0152	O2 Sensor Circuit High Voltage	Bank 2 Sensor 1
P0153	O2 Sensor Circuit Slow Response	Bank 2 Sensor 1
P0154	O2 Sensor Circuit No Activity Detected	Bank 2 Sensor 1
P0155	O2 Sensor Heater Circuit	Bank 2 Sensor 1
P0156	O2 Sensor Circuit	Bank 2 Sensor 2
P0157	O2 Sensor Circuit Low Voltage	Bank 2 Sensor 2
P0158	O2 Sensor Circuit High Voltage	Bank 2 Sensor 2
P0159	O2 Sensor Circuit Slow Response	Bank 2 Sensor 2
P0160	O2 Sensor Circuit No Activity Detected	Bank 2 Sensor 2
P0161	O2 Sensor Heater Circuit	Bank 2 Sensor 2
P0162	O2 Sensor Circuit	Bank 2 Sensor 3
P0163	O2 Sensor Circuit Low Voltage	Bank 2 Sensor 3
P0164	O2 Sensor Circuit High Voltage	Bank 2 Sensor 3
P0165	O2 Sensor Circuit Slow Response	Bank 2 Sensor 3
P0166	O2 Sensor Circuit No Activity Detected	Bank 2 Sensor 3
P0167	O2 Sensor Heater Circuit	Bank 2 Sensor 3
P0168	Fuel Temperature Too High	
P0169	Incorrect Fuel Composition	
P0170	Fuel Trim	Bank 1
P0171	System Too Lean	Bank 1
P0172	System Too Rich	Bank 1
P0173	Fuel Trim	Bank 2
P0174	System Too Lean	Bank 2
P0175	System Too Rich	Bank 2
P0176	Fuel Composition Sensor Circuit	
P0177	Fuel Composition Sensor Circuit Range/Performance	
P0178	Fuel Composition Sensor Circuit Low	
P0179	Fuel Composition Sensor Circuit High	
P0180	Fuel Temperature Sensor A Circuit	
P0181	Fuel Temperature Sensor A Circuit Range/Performance	
P0182	Fuel Temperature Sensor A Circuit Low	
P0183	Fuel Temperature Sensor A Circuit High	
P0184	Fuel Temperature Sensor A Circuit Intermittent	
P0185	Fuel Temperature Sensor B Circuit	
P0186	Fuel Temperature Sensor B Circuit Range/Performance	
P0187	Fuel Temperature Sensor B Circuit Low	
P0188	Fuel Temperature Sensor B Circuit High	
P0189	Fuel Temperature Sensor B Circuit Intermittent	
P0190	Fuel Rail Pressure Sensor Circuit	
P0191	Fuel Rail Pressure Sensor Circuit Range/Performance	
P0192	Fuel Rail Pressure Sensor Circuit Low	
P0193	Fuel Rail Pressure Sensor Circuit High	
P0194	Fuel Rail Pressure Sensor Circuit Intermittent	
P0195	Engine Oil Temperature Sensor	
P0196	Engine Oil Temperature Sensor Range/Performance	

TABLE B2—P01XX FUEL AND AIR METERING (continued)

DTC number	DTC naming	Location
P0197	Engine Oil Temperature Sensor Low	
P0198	Engine Oil Temperature Sensor High	
P0199	Engine Oil Temperature Sensor Intermittent	

B.3 P02XX Fuel and Air Metering

TABLE B3—P02XX FUEL AND AIR METERING

DTC number	DTC naming	Location
P0200	Injector Circuit/Open	
P0201	Injector Circuit/Open – Cylinder 1	
P0202	Injector Circuit/Open – Cylinder 2	
P0203	Injector Circuit/Open – Cylinder 3	
P0204	Injector Circuit/Open – Cylinder 4	
P0205	Injector Circuit/Open – Cylinder 5	
P0206	Injector Circuit/Open – Cylinder 6	
P0207	Injector Circuit/Open – Cylinder 7	
P0208	Injector Circuit/Open – Cylinder 8	
P0209	Injector Circuit/Open – Cylinder 9	
P0210	Injector Circuit/Open – Cylinder 10	
P0211	Injector Circuit/Open – Cylinder 11	
P0212	Injector Circuit/Open – Cylinder 12	
P0213	Cold Start Injector 1	
P0214	Cold Start Injector 2	
P0215	Engine Shutoff Solenoid	
P0216	Injector/Injection Timing Control Circuit	
P0217	Engine Coolant Over Temperature Condition	
P0218	Transmission Fluid Over Temperature Condition	
P0219	Engine Overspeed Condition	
P0220	Throttle/Pedal Position Sensor/Switch "B" Circuit	
P0221	Throttle/Pedal Position Sensor/Switch "B" Circuit Range/Performance	
P0222	Throttle/Pedal Position Sensor/Switch "B" Circuit Low	
P0223	Throttle/Pedal Position Sensor/Switch "B" Circuit High	
P0224	Throttle/Pedal Position Sensor/Switch "B" Circuit Intermittent	
P0225	Throttle/Pedal Position Sensor/Switch "C" Circuit	
P0226	Throttle/Pedal Position Sensor/Switch "C" Circuit Range/Performance	
P0227	Throttle/Pedal Position Sensor/Switch "C" Circuit Low	
P0228	Throttle/Pedal Position Sensor/Switch "C" Circuit High	
P0229	Throttle/Pedal Position Sensor/Switch "C" Circuit Intermittent	
P0230	Fuel Pump Primary Circuit	
P0231	Fuel Pump Secondary Circuit Low	
P0232	Fuel Pump Secondary Circuit High	
P0233	Fuel Pump Secondary Circuit Intermittent	
P0234	Turbo/Super Charger Overboost Condition	
P0235	Turbo/Super Charger Boost Sensor "A" Circuit	
P0236	Turbo/Super Charger Boost Sensor "A" Circuit Range/Performance	
P0237	Turbo/Super Charger Boost Sensor "A" Circuit Low	
P0238	Turbo/Super Charger Boost Sensor "A" Circuit High	
P0239	Turbo/Super Charger Boost Sensor "B" Circuit	
P0240	Turbo/Super Charger Boost Sensor "B" Circuit Range/Performance	
P0241	Turbo/Super Charger Boost Sensor "B" Circuit Low	
P0242	Turbo/Super Charger Boost Sensor "B" Circuit High	
P0243	Turbo/Super Charger Wastegate Solenoid "A"	
P0244	Turbo/Super Charger Wastegate Solenoid "A" Range/Performance	
P0245	Turbo/Super Charger Wastegate Solenoid "A" Low	
P0246	Turbo/Super Charger Wastegate Solenoid "A" High	

TABLE B3---P02XX FUEL AND AIR METERING (continued)

DTC number	DTC naming	Location
P0247	Turbo/Super Charger Wastegate Solenoid "B"	
P0248	Turbo/Super Charger Wastegate Solenoid "B" Range/Performance	
P0249	Turbo/Super Charger Wastegate Solenoid "B" Low	
P0250	Turbo/Super Charger Wastegate Solenoid "B" High	
P0251	Injection Pump Fuel Metering Control "A" (Cam/Rotor/Injector)	
P0252	Injection Pump Fuel Metering Control "A" Range/Performance (Cam/Rotor/Injector)	
P0253	Injection Pump Fuel Metering Control "A" Low (Cam/Rotor/Injector)	
P0254	Injection Pump Fuel Metering Control "A" High (Cam/Rotor/Injector)	
P0255	Injection Pump Fuel Metering Control "A" Intermittent (Cam/Rotor/Injector)	
P0256	Injection Pump Fuel Metering Control "B" (Cam/Rotor/Injector)	
P0257	Injection Pump Fuel Metering Control "B" Range/Performance (Cam/Rotor/Injector)	
P0258	Injection Pump Fuel Metering Control "B" Low (Cam/Rotor/Injector)	
P0259	Injection Pump Fuel Metering Control "B" High (Cam/Rotor/Injector)	
P0260	Injection Pump Fuel Metering Control "B" Intermittent (Cam/Rotor/Injector)	
P0261	Cylinder 1 Injector Circuit Low	
P0262	Cylinder 1 Injector Circuit High	
P0263	Cylinder 1 Contribution/Balance	
P0264	Cylinder 2 Injector Circuit Low	
P0265	Cylinder 2 Injector Circuit High	
P0266	Cylinder 2 Contribution/Balance	
P0267	Cylinder 3 Injector Circuit Low	
P0268	Cylinder 3 Injector Circuit High	
P0269	Cylinder 3 Contribution/Balance	
P0270	Cylinder 4 Injector Circuit Low	
P0271	Cylinder 4 Injector Circuit High	
P0272	Cylinder 4 Contribution/Balance	
P0273	Cylinder 5 Injector Circuit Low	
P0274	Cylinder 5 Injector Circuit High	
P0275	Cylinder 5 Contribution/Balance	
P0276	Cylinder 6 Injector Circuit Low	
P0277	Cylinder 6 Injector Circuit High	
P0278	Cylinder 6 Contribution/Balance	
P0279	Cylinder 7 Injector Circuit Low	
P0280	Cylinder 7 Injector Circuit High	
P0281	Cylinder 7 Contribution/Balance	
P0282	Cylinder 8 Injector Circuit Low	
P0283	Cylinder 8 Injector Circuit High	
P0284	Cylinder 8 Contribution/Balance	
P0285	Cylinder 9 Injector Circuit Low	
P0286	Cylinder 9 Injector Circuit High	
P0287	Cylinder 9 Contribution/Balance	
P0288	Cylinder 10 Injector Circuit Low	
P0289	Cylinder 10 Injector Circuit High	
P0290	Cylinder 10 Contribution/Balance	
P0291	Cylinder 11 Injector Circuit Low	
P0292	Cylinder 11 Injector Circuit High	
P0293	Cylinder 11 Contribution/Balance	
P0294	Cylinder 12 Injector Circuit Low	
P0295	Cylinder 12 Injector Circuit High	
P0296	Cylinder 12 Contribution/Balance	
P0297	Vehicle Overspeed Condition	
P0298	Engine Oil Over Temperature	
P0299	Turbo/Super Charger Underboost	

B.4 P03XX Ignition System or Misfire

TABLE B4—P03XX IGNITION SYSTEM OR MISFIRE

DTC number	DTC naming	Location
P0300	Random/Multiple Cylinder Misfire Detected	
P0301	Cylinder 1 Misfire Detected	
P0302	Cylinder 2 Misfire Detected	
P0303	Cylinder 3 Misfire Detected	
P0304	Cylinder 4 Misfire Detected	
P0305	Cylinder 5 Misfire Detected	
P0306	Cylinder 6 Misfire Detected	
P0307	Cylinder 7 Misfire Detected	
P0308	Cylinder 8 Misfire Detected	
P0309	Cylinder 9 Misfire Detected	
P0310	Cylinder 10 Misfire Detected	
P0311	Cylinder 11 Misfire Detected	
P0312	Cylinder 12 Misfire Detected	
P0313	Misfire Detected with Low Fuel	
P0314	Single Cylinder Misfire (Cylinder not Specified)	
P0315	Crankshaft Position System Variation Not Learned	
P0316	Engine Misfire Detected on Startup (First 1000 Revolutions)	
P0317	Rough Road Hardware Not Present	
P0318	Rough Road Sensor "A" Signal Circuit	
P0319	Rough Road Sensor "B"	
P0320	Ignition/Distributor Engine Speed Input Circuit	
P0321	Ignition/Distributor Engine Speed Input Circuit Range/Performance	
P0322	Ignition/Distributor Engine Speed Input Circuit No Signal	
P0323	Ignition/Distributor Engine Speed Input Circuit Intermittent	
P0324	Knock Control System Error	
P0325	Knock Sensor 1 Circuit	Bank 1 or Single Sensor
P0326	Knock Sensor 1 Circuit Range/Performance	Bank 1 or Single Sensor
P0327	Knock Sensor 1 Circuit Low	Bank 1 or Single Sensor
P0328	Knock Sensor 1 Circuit High	Bank 1 or Single Sensor
P0329	Knock Sensor 1 Circuit Input Intermittent	Bank 1 or Single Sensor
P0330	Knock Sensor 2 Circuit	Bank 2
P0331	Knock Sensor 2 Circuit Range/Performance	Bank 2
P0332	Knock Sensor 2 Circuit Low	Bank 2
P0333	Knock Sensor 2 Circuit High	Bank 2
P0334	Knock Sensor 2 Circuit Input Intermittent	Bank 2
P0335	Crankshaft Position Sensor "A" Circuit	
P0336	Crankshaft Position Sensor "A" Circuit Range/Performance	
P0337	Crankshaft Position Sensor "A" Circuit Low	
P0338	Crankshaft Position Sensor "A" Circuit High	
P0339	Crankshaft Position Sensor "A" Circuit Intermittent	
P0340	Camshaft Position Sensor "A" Circuit	Bank 1 or Single Sensor
P0341	Camshaft Position Sensor "A" Circuit Range/Performance	Bank 1 or Single Sensor
P0342	Camshaft Position Sensor "A" Circuit Low	Bank 1 or Single Sensor
P0343	Camshaft Position Sensor "A" Circuit High	Bank 1 or Single Sensor
P0344	Camshaft Position Sensor "A" Circuit Intermittent	Bank 1 or Single Sensor
P0345	Camshaft Position Sensor "A" Circuit	Bank 2
P0346	Camshaft Position Sensor "A" Circuit Range/Performance	Bank 2
P0347	Camshaft Position Sensor "A" Circuit Low	Bank 2
P0348	Camshaft Position Sensor "A" Circuit High	Bank 2
P0349	Camshaft Position Sensor "A" Circuit Intermittent	Bank 2
P0350	Ignition Coil Primary/Secondary Circuit	
P0351	Ignition Coil "A" Primary/Secondary Circuit	
P0352	Ignition Coil "B" Primary/Secondary Circuit	
P0353	Ignition Coil "C" Primary/Secondary Circuit	

TABLE B4—P03XX IGNITION SYSTEM OR MISFIRE (continued)

DTC number	DTC naming	Location
P0354	Ignition Coil "D" Primary/Secondary Circuit	
P0355	Ignition Coil "E" Primary/Secondary Circuit	
P0356	Ignition Coil "F" Primary/Secondary Circuit	
P0357	Ignition Coil "G" Primary/Secondary Circuit	
P0358	Ignition Coil "H" Primary/Secondary Circuit	
P0359	Ignition Coil "I" Primary/Secondary Circuit	
P0360	Ignition Coil "J" Primary/Secondary Circuit	
P0361	Ignition Coil "K" Primary/Secondary Circuit	
P0362	Ignition Coil "L" Primary/Secondary Circuit	
P0363	Misfire Detected – Fueling Disabled	
P0364	Reserved	
P0365	Camshaft Position Sensor "B" Circuit	Bank 1
P0366	Camshaft Position Sensor "B" Circuit Range/Performance	Bank 1
P0367	Camshaft Position Sensor "B" Circuit Low	Bank 1
P0368	Camshaft Position Sensor "B" Circuit High	Bank 1
P0369	Camshaft Position Sensor "B" Circuit Intermittent	Bank 1
P0370	Timing Reference High Resolution Signal "A"	
P0371	Timing Reference High Resolution Signal "A" Too Many Pulses	
P0372	Timing Reference High Resolution Signal "A" Too Few Pulses	
P0373	Timing Reference High Resolution Signal "A" Intermittent/Erratic Pulses	
P0374	Timing Reference High Resolution Signal "A" No Pulse	
P0375	Timing Reference High Resolution Signal "B"	
P0376	Timing Reference High Resolution Signal "B" Too Many Pulses	
P0377	Timing Reference High Resolution Signal "B" Too Few Pulses	
P0378	Timing Reference High Resolution Signal "B" Intermittent/Erratic Pulses	
P0379	Timing Reference High Resolution Signal "B" No Pulses	
P0380	Glow Plug/Heater Circuit "A"	
P0381	Glow Plug/Heater Indicator Circuit	
P0382	Glow Plug/Heater Circuit "B"	
P0383-P0384	Reserved by document	
P0385	Crankshaft Position Sensor "B" Circuit	
P0386	Crankshaft Position Sensor "B" Circuit Range/Performance	
P0387	Crankshaft Position Sensor "B" Circuit Low	
P0388	Crankshaft Position Sensor "B" Circuit High	
P0389	Crankshaft Position Sensor "B" Circuit Intermittent	
P0390	Camshaft Position Sensor "B" Circuit	Bank 2
P0391	Camshaft Position Sensor "B" Circuit Range/Performance	Bank 2
P0392	Camshaft Position Sensor "B" Circuit Low	Bank 2
P0393	Camshaft Position Sensor "B" Circuit High	Bank 2
P0394	Camshaft Position Sensor "B" Circuit Intermittent	Bank 2

B.5 P04XX Auxiliary Emission Controls

TABLE B5—P04XX AUXILIARY EMISSION CONTROLS

DTC number	DTC naming	Location
P0400	Exhaust Gas Recirculation Flow	
P0401	Exhaust Gas Recirculation Flow Insufficient Detected	
P0402	Exhaust Gas Recirculation Flow Excessive Detected	
P0403	Exhaust Gas Recirculation Control Circuit	
P0404	Exhaust Gas Recirculation Control Circuit Range/Performance	
P0405	Exhaust Gas Recirculation Sensor "A" Circuit Low	
P0406	Exhaust Gas Recirculation Sensor "A" Circuit High	
P0407	Exhaust Gas Recirculation Sensor "B" Circuit Low	
P0408	Exhaust Gas Recirculation Sensor "B" Circuit High	
P0409	Exhaust Gas Recirculation Sensor "A" Circuit	

TABLE B5—P04XX AUXILIARY EMISSION CONTROLS (continued)

DTC number	DTC naming	Location
P0410	Secondary Air Injection System	
P0411	Secondary Air Injection System Incorrect Flow Detected	
P0412	Secondary Air Injection System Switching Valve "A" Circuit	
P0413	Secondary Air Injection System Switching Valve "A" Circuit Open	
P0414	Secondary Air Injection System Switching Valve "A" Circuit Shorted	
P0415	Secondary Air Injection System Switching Valve "B" Circuit	
P0416	Secondary Air Injection System Switching Valve "B" Circuit Open	
P0417	Secondary Air Injection System Switching Valve "B" Circuit Shorted	
P0418	Secondary Air Injection System Control "A" Circuit	
P0419	Secondary Air Injection System Control "B" Circuit	
P0420	Catalyst System Efficiency Below Threshold	Bank 1
P0421	Warm Up Catalyst Efficiency Below Threshold	Bank 1
P0422	Main Catalyst Efficiency Below Threshold	Bank 1
P0423	Heated Catalyst Efficiency Below Threshold	Bank 1
P0424	Heated Catalyst Temperature Below Threshold	Bank 1
P0425	Catalyst Temperature Sensor	Bank 1
P0426	Catalyst Temperature Sensor Range/Performance	Bank 1
P0427	Catalyst Temperature Sensor Low	Bank 1
P0428	Catalyst Temperature Sensor High	Bank 1
P0429	Catalyst Heater Control Circuit	Bank 1
P0430	Catalyst System Efficiency Below Threshold	Bank 2
P0431	Warm Up Catalyst Efficiency Below Threshold	Bank 2
P0432	Main Catalyst Efficiency Below Threshold	Bank 2
P0433	Heated Catalyst Efficiency Below Threshold	Bank 2
P0434	Heated Catalyst Temperature Below Threshold	Bank 2
P0435	Catalyst Temperature Sensor	Bank 2
P0436	Catalyst Temperature Sensor Range/Performance	Bank 2
P0437	Catalyst Temperature Sensor Low	Bank 2
P0438	Catalyst Temperature Sensor High	Bank 2
P0439	Catalyst Heater Control Circuit	Bank 2
P0440	Evaporative Emission System	
P0441	Evaporative Emission System Incorrect Purge Flow	
P0442	Evaporative Emission System Leak Detected (small leak)	
P0443	Evaporative Emission System Purge Control Valve Circuit	
P0444	Evaporative Emission System Purge Control Valve Circuit Open	
P0445	Evaporative Emission System Purge Control Valve Circuit Shorted	
P0446	Evaporative Emission System Vent Control Circuit	
P0447	Evaporative Emission System Vent Control Circuit Open	
P0448	Evaporative Emission System Vent Control Circuit Shorted	
P0449	Evaporative Emission System Vent Valve/Solenoid Circuit	
P0450	Evaporative Emission System Pressure Sensor/Switch	
P0451	Evaporative Emission System Pressure Sensor/Switch Range/Performance	
P0452	Evaporative Emission System Pressure Sensor/Switch Low	
P0453	Evaporative Emission System Pressure Sensor/Switch High	
P0454	Evaporative Emission System Pressure Sensor/Switch Intermittent	
P0455	Evaporative Emission System Leak Detected (large leak)	
P0456	Evaporative Emission System Leak Detected (very small leak)	
P0457	Evaporative Emission System Leak Detected (fuel cap loose/off)	
P0458	Evaporative Emission System Purge Control Valve Circuit Low	
P0459	Evaporative Emission System Purge Control Valve Circuit High	
P0460	Fuel Level Sensor "A" Circuit	
P0461	Fuel Level Sensor "A" Circuit Range/Performance	
P0462	Fuel Level Sensor "A" Circuit Low	
P0463	Fuel Level Sensor "A" Circuit High	
P0464	Fuel Level Sensor "A" Circuit Intermittent	

TABLE B5—P04XX AUXILIARY EMISSION CONTROLS (continued)

DTC number	DTC naming	Location
P0465	EVAP Purge Flow Sensor Circuit	
P0466	EVAP Purge Flow Sensor Circuit Range/Performance	
P0467	EVAP Purge Flow Sensor Circuit Low	
P0468	EVAP Purge Flow Sensor Circuit High	
P0469	EVAP Purge Flow Sensor Circuit Intermittent	
P0470	Exhaust Pressure Sensor	
P0471	Exhaust Pressure Sensor Range/Performance	
P0472	Exhaust Pressure Sensor Low	
P0473	Exhaust Pressure Sensor High	
P0474	Exhaust Pressure Sensor Intermittent	
P0475	Exhaust Pressure Control Valve	
P0476	Exhaust Pressure Control Valve Range/Performance	
P0477	Exhaust Pressure Control Valve Low	
P0478	Exhaust Pressure Control Valve High	
P0479	Exhaust Pressure Control Valve Intermittent	
P0480	Fan 1 Control Circuit	
P0481	Fan 2 Control Circuit	
P0482	Fan 3 Control Circuit	
P0483	Fan Rationality Check	
P0484	Fan Circuit Over Current	
P0485	Fan Power/Ground Circuit	
P0486	Exhaust Gas Recirculation Sensor "B" Circuit	
P0487	Exhaust Gas Recirculation Throttle Position Control Circuit	
P0488	Exhaust Gas Recirculation Throttle Position Control Range/Performance	
P0489	Exhaust Gas Recirculation Control Circuit Low	
P0490	Exhaust Gas Recirculation Control Circuit High	
P0491	Secondary Air Injection System Insufficient Flow	Bank 1
P0492	Secondary Air Injection System Insufficient Flow	Bank 2
P0493	Fan Overspeed	
P0494	Fan Speed Low	
P0495	Fan Speed High	
P0496	Evaporative Emission System High Purge Flow	
P0497	Evaporative Emission System Low Purge Flow	
P0498	Evaporative Emission System Vent Valve Control Circuit Low	
P0499	Evaporative Emission System Vent Valve Control Circuit High	

B.6 P05XX Vehicle Speed, Idle Control, and Auxiliary Inputs

TABLE B6—P05XX VEHICLE SPEED, IDLE CONTROL, AND AUXILIARY INPUTS

DTC number	DTC naming	Location
P0500	Vehicle Speed Sensor "A"	
P0501	Vehicle Speed Sensor "A" Range/Performance	
P0502	Vehicle Speed Sensor "A" Circuit Low Input	
P0503	Vehicle Speed Sensor "A" Intermittent/Erratic/High	
P0504	Brake Switch "A"/"B" Correlation	
P0505	Idle Air Control System	
P0506	Idle Air Control System RPM Lower Than Expected	
P0507	Idle Air Control System RPM Higher Than Expected	
P0508	Idle Air Control System Circuit Low	
P0509	Idle Air Control System Circuit High	
P0510	Closed Throttle Position Switch	
P0511	Idle Air Control Circuit	
P0512	Starter Request Circuit	
P0513	Incorrect Immobilizer Key	
P0514	Battery Temperature Sensor Circuit Range/Performance	

TABLE B6—P05XX VEHICLE SPEED, IDLE CONTROL, AND AUXILIARY INPUTS (continued)

DTC number	DTC naming	Location
P0515	Battery Temperature Sensor Circuit	
P0516	Battery Temperature Sensor Circuit Low	
P0517	Battery Temperature Sensor Circuit High	
P0518	Idle Air Control Circuit Intermittent	
P0519	Idle Air Control System Performance	
P0520	Engine Oil Pressure Sensor/Switch Circuit	
P0521	Engine Oil Pressure Sensor/Switch Range/Performance	
P0522	Engine Oil Pressure Sensor/Switch Low Voltage	
P0523	Engine Oil Pressure Sensor/Switch High Voltage	
P0524	Engine Oil Pressure Too Low	
P0525	Cruise Control Servo Control Circuit Range/Performance	
P0526	Fan Speed Sensor Circuit	
P0527	Fan Speed Sensor Circuit Range/Performance	
P0528	Fan Speed Sensor Circuit No Signal	
P0529	Fan Speed Sensor Circuit Intermittent	
P0530	A/C Refrigerant Pressure Sensor "A" Circuit	
P0531	A/C Refrigerant Pressure Sensor "A" Circuit Range/Performance	
P0532	A/C Refrigerant Pressure Sensor "A" Circuit Low	
P0533	A/C Refrigerant Pressure Sensor "A" Circuit High	
P0534	Air Conditioner Refrigerant Charge Loss	
P0535	A/C Evaporator Temperature Sensor Circuit	
P0536	A/C Evaporator Temperature Sensor Circuit Range/Performance	
P0537	A/C Evaporator Temperature Sensor Circuit Low	
P0538	A/C Evaporator Temperature Sensor Circuit High	
P0539	A/C Evaporator Temperature Sensor Circuit Intermittent	
P0540 [1)]	Intake Air Heater "A" Circuit	
P0541 [1)]	Intake Air Heater "A" Circuit Low	
P0542 [1)]	Intake Air Heater "A" Circuit High	
P0543 [1)]	Intake Air Heater "A" Circuit Open	
P0544	Exhaust Gas Temperature Sensor Circuit	Bank 1 Sensor 1
P0545	Exhaust Gas Temperature Sensor Circuit Low	Bank 1 Sensor 1
P0546	Exhaust Gas Temperature Sensor Circuit High	Bank 1 Sensor 1
P0547	Exhaust Gas Temperature Sensor Circuit	Bank 2 Sensor 1
P0548	Exhaust Gas Temperature Sensor Circuit Low	Bank 2 Sensor 1
P0549	Exhaust Gas Temperature Sensor Circuit High	Bank 2 Sensor 1
P0550	Power Steering Pressure Sensor/Switch Circuit	
P0551	Power Steering Pressure Sensor/Switch Circuit Range/Performance	
P0552	Power Steering Pressure Sensor/Switch Circuit Low Input	
P0553	Power Steering Pressure Sensor/Switch Circuit High Input	
P0554	Power Steering Pressure Sensor/Switch Circuit Intermittent	
P0555	Brake Booster Pressure Sensor Circuit	
P0556	Brake Booster Pressure Sensor Circuit Range/Performance	
P0557	Brake Booster Pressure Sensor Circuit Low Input	
P0558	Brake Booster Pressure Sensor Circuit High Input	
P0559	Brake Booster Pressure Sensor Circuit Intermittent	
P0560	System Voltage	
P0561	System Voltage Unstable	
P0562	System Voltage Low	
P0563	System Voltage High	
P0564	Cruise Control Multi-Function Input "A" Circuit	
P0565	Cruise Control On Signal	
P0566	Cruise Control Off Signal	
P0567	Cruise Control Resume Signal	
P0568	Cruise Control Set Signal	

TABLE B6—P05XX VEHICLE SPEED, IDLE CONTROL, AND AUXILIARY INPUTS (continued)

DTC number	DTC naming	Location
P0569	Cruise Control Coast Signal	
P0570	Cruise Control Accelerate Signal	
P0571	Brake Switch "A" Circuit	
P0572	Brake Switch "A" Circuit Low	
P0573	Brake Switch "A" Circuit High	
P0574	Cruise Control System - Vehicle Speed Too High	
P0575	Cruise Control Input Circuit	
P0576	Cruise Control Input Circuit Low	
P0577	Cruise Control Input Circuit High	
P0578 [2)]	Cruise Control Multi-Function Input "A" Circuit Stuck	
P0579 [2)]	Cruise Control Multi-Function Input "A" Circuit Range/Performance	
P0580 [2)]	Cruise Control Multi-Function Input "A" Circuit Low	
P0581 [2)]	Cruise Control Multi-Function Input "A" Circuit High	
P0582	Cruise Control Vacuum Control Circuit/Open	
P0583	Cruise Control Vacuum Control Circuit Low	
P0584	Cruise Control Vacuum Control Circuit High	
P0585	Cruise Control Multi-Function Input "A"/"B" Correlation	
P0586	Cruise Control Vent Control Circuit/Open	
P0587	Cruise Control Vent Control Circuit Low	
P0588	Cruise Control Vent Control Circuit High	
P0589	Cruise Control Multi-Function Input "B" Circuit	
P0590	Cruise Control Multi-Function Input "B" Circuit Stuck	
P0591	Cruise Control Multi-Function Input "B" Circuit Range/Performance	
P0592	Cruise Control Multi-Function Input "B" Circuit Low	
P0593	Cruise Control Multi-Function Input "B" Circuit High	
P0594	Cruise Control Servo Control Circuit/Open	
P0595	Cruise Control Servo Control Circuit Low	
P0596	Cruise Control Servo Control Circuit High	
P0597	Thermostat Heater Control Circuit/Open	
P0598	Thermostat Heater Control Circuit Low	
P0599	Thermostat Heater Control Circuit High	
NOTE 1) For DTCs P0540 - P0543 also see P2604 - P2609		
NOTE 2) For DTCs P0578 - P0581 also see P0564		

B.7 P06XX Computer and Auxiliary Outputs

TABLE B7—P06XX COMPUTER AND AUXILIARY OUTPUTS

DTC number	DTC naming	Location
P0600	Serial Communication Link	
P0601	Internal Control Module Memory Check Sum Error	
P0602	Control Module Programming Error	
P0603	Internal Control Module Keep Alive Memory (KAM) Error	
P0604	Internal Control Module Random Access Memory (RAM) Error	
P0605	Internal Control Module Read Only Memory (ROM) Error	
P0606	ECM/PCM Processor	
P0607	Control Module Performance	
P0608	Control Module VSS Output "A"	
P0609	Control Module VSS Output "B"	
P0610	Control Module Vehicle Options Error	
P0611	Fuel Injector Control Module Performance	
P0612	Fuel Injector Control Module Relay Control	
P0613	TCM Processor	
P0614	ECM / TCM Incompatible	
P0615	Starter Relay Circuit	
P0616	Starter Relay Circuit Low	

TABLE B7—P06XX COMPUTER AND AUXILIARY OUTPUTS (continued)

DTC number	DTC naming	Location
P0617	Starter Relay Circuit High	
P0618	Alternative Fuel Control Module KAM Error	
P0619	Alternative Fuel Control Module RAM/ROM Error	
P0620	Generator Control Circuit	
P0621	Generator Lamp/L Terminal Circuit	
P0622	Generator Field/F Terminal Circuit	
P0623	Generator Lamp Control Circuit	
P0624	Fuel Cap Lamp Control Circuit	
P0625	Generator Field/F Terminal Circuit Low	
P0626	Generator Field/F Terminal Circuit High	
P0627	Fuel Pump "A" Control Circuit /Open	
P0628	Fuel Pump "A" Control Circuit Low	
P0629	Fuel Pump "A" Control Circuit High	
P0630	VIN Not Programmed or Incompatible – ECM/PCM	
P0631	VIN Not Programmed or Incompatible – TCM	
P0632	Odometer Not Programmed – ECM/PCM	
P0633	Immobilizer Key Not Programmed – ECM/PCM	
P0634	PCM/ECM/TCM Internal Temperature Too High	
P0635	Power Steering Control Circuit	
P0636	Power Steering Control Circuit Low	
P0637	Power Steering Control Circuit High	
P0638	Throttle Actuator Control Range/Performance	Bank 1
P0639	Throttle Actuator Control Range/Performance	Bank 2
P0640	Intake Air Heater Control Circuit	
P0641	Sensor Reference Voltage "A" Circuit/Open	
P0642	Sensor Reference Voltage "A" Circuit Low	
P0643	Sensor Reference Voltage "A" Circuit High	
P0644	Driver Display Serial Communication Circuit	
P0645	A/C Clutch Relay Control Circuit	
P0646	A/C Clutch Relay Control Circuit Low	
P0647	A/C Clutch Relay Control Circuit High	
P0648	Immobilizer Lamp Control Circuit	
P0649	Speed Control Lamp Control Circuit	
P0650	Malfunction Indicator Lamp (MIL) Control Circuit	
P0651	Sensor Reference Voltage "B" Circuit/Open	
P0652	Sensor Reference Voltage "B" Circuit Low	
P0653	Sensor Reference Voltage "B" Circuit High	
P0654	Engine RPM Output Circuit	
P0655	Engine Hot Lamp Output Control Circuit	
P0656	Fuel Level Output Circuit	
P0657	Actuator Supply Voltage "A" Circuit/Open	
P0658	Actuator Supply Voltage "A" Circuit Low	
P0659	Actuator Supply Voltage "A" Circuit High	
P0660	Intake Manifold Tuning Valve Control Circuit/Open	Bank 1 [a)]
P0661	Intake Manifold Tuning Valve Control Circuit Low	Bank 1 [a)]
P0662	Intake Manifold Tuning Valve Control Circuit High	Bank 1 [a)]
P0663	Intake Manifold Tuning Valve Control Circuit/Open	Bank 2 [a)]
P0664	Intake Manifold Tuning Valve Control Circuit Low	Bank 2 [a)]
P0665	Intake Manifold Tuning Valve Control Circuit High	Bank 2 [a)]
P0666	PCM/ECM/TCM Internal Temperature Sensor Circuit	
P0667	PCM/ECM/TCM Internal Temperature Sensor Range/Performance	
P0668	PCM/ECM/TCM Internal Temperature Sensor Circuit Low	
P0669	PCM/ECM/TCM Internal Temperature Sensor Circuit High	
P0670	Glow Plug Module Control Circuit	

TABLE B7—P06XX COMPUTER AND AUXILIARY OUTPUTS (continued)

DTC number	DTC naming	Location
P0671	Cylinder 1 Glow Plug Circuit	
P0672	Cylinder 2 Glow Plug Circuit	
P0673	Cylinder 3 Glow Plug Circuit	
P0674	Cylinder 4 Glow Plug Circuit	
P0675	Cylinder 5 Glow Plug Circuit	
P0676	Cylinder 6 Glow Plug Circuit	
P0677	Cylinder 7 Glow Plug Circuit	
P0678	Cylinder 8 Glow Plug Circuit	
P0679	Cylinder 9 Glow Plug Circuit	
P0680	Cylinder 10 Glow Plug Circuit	
P0681	Cylinder 11 Glow Plug Circuit	
P0682	Cylinder 12 Glow Plug Circuit	
P0683	Glow Plug Control Module to PCM Communication Circuit	
P0684	Glow Plug Control Module to PCM Communication Circuit Range/Performance	
P0685	ECM/PCM Power Relay Control Circuit /Open	
P0686	ECM/PCM Power Relay Control Circuit Low	
P0687	ECM/PCM Power Relay Control Circuit High	
P0688	ECM/PCM Power Relay Sense Circuit /Open	
P0689	ECM/PCM Power Relay Sense Circuit Low	
P0690	ECM/PCM Power Relay Sense Circuit High	
P0691	Fan 1 Control Circuit Low	
P0692	Fan 1 Control Circuit High	
P0693	Fan 2 Control Circuit Low	
P0694	Fan 2 Control Circuit High	
P0695	Fan 3 Control Circuit Low	
P0696	Fan 3 Control Circuit High	
P0697	Sensor Reference Voltage "C" Circuit/Open	
P0698	Sensor Reference Voltage "C" Circuit Low	
P0699	Sensor Reference Voltage "C" Circuit High	

[a] DTC Application note for Intake Manifold Tuning Valves and Intake Manifold Runner controls:
Active controls are used modify or control airflow within the engine air intake system. These controls may be used to enhance or modify in-cylinder airflow motion (charge motion), modify the airflow dynamics (manifold tuning) within the intake manifold or both.
Devices that control charge motion are commonly called Intake Manifold Runner Control, Swirl Control Valve, and Charge Motion Control Valve. The SAE recommended term for any device that controls charge motion is Intake Manifold Runner Control (IMRC).
Devices that control manifold dynamics or manifold tuning are commonly called Intake Manifold Tuning Valve, Long/Short Runner Control and Intake Manifold Communication Control. The SAE recommended term for any device that controls manifold tuning is Intake Manifold Tuning (IMT) Valve.

B.8 P07XX Transmission

TABLE B8—P07XX TRANSMISSION

DTC number	DTC naming	Location
P0700	Transmission Control System (MIL Request)	
P0701	Transmission Control System Range/Performance	
P0702	Transmission Control System Electrical	
P0703	Brake Switch "B" Circuit	
P0704	Clutch Switch Input Circuit Malfunction	
P0705	Transmission Range Sensor Circuit Malfunction (PRNDL Input)	
P0706	Transmission Range Sensor Circuit Range/Performance	
P0707	Transmission Range Sensor Circuit Low	
P0708	Transmission Range Sensor Circuit High	
P0709	Transmission Range Sensor Circuit Intermittent	
P0710	Transmission Fluid Temperature Sensor "A" Circuit	
P0711	Transmission Fluid Temperature Sensor "A" Circuit Range/Performance	
P0712	Transmission Fluid Temperature Sensor "A" Circuit Low	
P0713	Transmission Fluid Temperature Sensor "A" Circuit High	
P0714	Transmission Fluid Temperature Sensor "A" Circuit Intermittent	
P0715	Input/Turbine Speed Sensor "A" Circuit	
P0716	Input/Turbine Speed Sensor "A" Circuit Range/Performance	

TABLE B8—P07XX TRANSMISSION (continued)

DTC number	DTC naming	Location
P0717	Input/Turbine Speed Sensor "A" Circuit No Signal	
P0718	Input/Turbine Speed Sensor "A" Circuit Intermittent	
P0719	Brake Switch "B" Circuit Low	
P0720	Output Speed Sensor Circuit	
P0721	Output Speed Sensor Circuit Range/Performance	
P0722	Output Speed Sensor Circuit No Signal	
P0723	Output Speed Sensor Circuit Intermittent	
P0724	Brake Switch "B" Circuit High	
P0725	Engine Speed Input Circuit	
P0726	Engine Speed Input Circuit Range/Performance	
P0727	Engine Speed Input Circuit No Signal	
P0728	Engine Speed Input Circuit Intermittent	
P0729	Gear 6 Incorrect Ratio	
P0730	Incorrect Gear Ratio	
P0731	Gear 1 Incorrect Ratio	
P0732	Gear 2 Incorrect Ratio	
P0733	Gear 3 Incorrect Ratio	
P0734	Gear 4 Incorrect Ratio	
P0735	Gear 5 Incorrect Ratio	
P0736	Reverse Incorrect Ratio	
P0737	TCM Engine Speed Output Circuit	
P0738	TCM Engine Speed Output Circuit Low	
P0739	TCM Engine Speed Output Circuit High	
P0740	Torque Converter Clutch Circuit/Open	
P0741	Torque Converter Clutch Circuit Performance or Stuck Off	
P0742	Torque Converter Clutch Circuit Stuck On	
P0743	Torque Converter Clutch Circuit Electrical	
P0744	Torque Converter Clutch Circuit Intermittent	
P0745	Pressure Control Solenoid "A"	
P0746	Pressure Control Solenoid "A" Performance or Stuck Off	
P0747	Pressure Control Solenoid "A" Stuck On	
P0748	Pressure Control Solenoid "A" Electrical	
P0749	Pressure Control Solenoid "A" Intermittent	
P0750	Shift Solenoid "A"	
P0751	Shift Solenoid "A" Performance or Stuck Off	
P0752	Shift Solenoid "A" Stuck On	
P0753	Shift Solenoid "A" Electrical	
P0754	Shift Solenoid "A" Intermittent	
P0755	Shift Solenoid "B"	
P0756	Shift Solenoid "B" Performance or Stuck Off	
P0757	Shift Solenoid "B" Stuck On	
P0758	Shift Solenoid "B" Electrical	
P0759	Shift Solenoid "B" Intermittent	
P0760	Shift Solenoid "C"	
P0761	Shift Solenoid "C" Performance or Stuck Off	
P0762	Shift Solenoid "C" Stuck On	
P0763	Shift Solenoid "C" Electrical	
P0764	Shift Solenoid "C" Intermittent	
P0765	Shift Solenoid "D"	
P0766	Shift Solenoid "D" Performance or Stuck Off	
P0767	Shift Solenoid "D" Stuck On	
P0768	Shift Solenoid "D" Electrical	
P0769	Shift Solenoid "D" Intermittent	
P0770	Shift Solenoid "E"	
P0771	Shift Solenoid "E" Performance or Stuck Off	

TABLE B8—P07XX TRANSMISSION (continued)

DTC number	DTC naming	Location
P0772	Shift Solenoid "E" Stuck On	
P0773	Shift Solenoid "E" Electrical	
P0774	Shift Solenoid "E" Intermittent	
P0775	Pressure Control Solenoid "B"	
P0776	Pressure Control Solenoid "B" Performance or Stuck off	
P0777	Pressure Control Solenoid "B" Stuck On	
P0778	Pressure Control Solenoid "B" Electrical	
P0779	Pressure Control Solenoid "B" Intermittent	
P0780	Shift Error	
P0781	1-2 Shift	
P0782	2-3 Shift	
P0783	3-4 Shift	
P0784	4-5 Shift	
P0785	Shift/Timing Solenoid	
P0786	Shift/Timing Solenoid Range/Performance	
P0787	Shift/Timing Solenoid Low	
P0788	Shift/Timing Solenoid High	
P0789	Shift/Timing Solenoid Intermittent	
P0790	Normal/Performance Switch Circuit	
P0791	Intermediate Shaft Speed Sensor "A" Circuit	
P0792	Intermediate Shaft Speed Sensor "A" Circuit Range/Performance	
P0793	Intermediate Shaft Speed Sensor "A" Circuit No Signal	
P0794	Intermediate Shaft Speed Sensor "A" Circuit Intermittent	
P0795	Pressure Control Solenoid "C"	
P0796	Pressure Control Solenoid "C" Performance or Stuck off	
P0797	Pressure Control Solenoid "C" Stuck On	
P0798	Pressure Control Solenoid "C" Electrical	
P0799	Pressure Control Solenoid "C" Intermittent	

B.9 P08XX Transmission

TABLE B9—P08XX TRANSMISSION

DTC number	DTC naming	Location
P0800	Transfer Case Control System (MIL Request)	
P0801	Reverse Inhibit Control Circuit	
P0802	Transmission Control System MIL Request Circuit/Open	
P0803	1-4 Upshift (Skip Shift) Solenoid Control Circuit	
P0804	1-4 Upshift (Skip Shift) Lamp Control Circuit	
P0805	Clutch Position Sensor Circuit	
P0806	Clutch Position Sensor Circuit Range/Performance	
P0807	Clutch Position Sensor Circuit Low	
P0808	Clutch Position Sensor Circuit High	
P0809	Clutch Position Sensor Circuit Intermittent	
P0810	Clutch Position Control Error	
P0811	Excessive Clutch Slippage	
P0812	Reverse Input Circuit	
P0813	Reverse Output Circuit	
P0814	Transmission Range Display Circuit	
P0815	Upshift Switch Circuit	
P0816	Downshift Switch Circuit	
P0817	Starter Disable Circuit	
P0818	Driveline Disconnect Switch Input Circuit	
P0819	Up and Down Shift Switch to Transmission Range Correlation	
P0820	Gear Lever X-Y Position Sensor Circuit	
P0821	Gear Lever X Position Circuit	

TABLE B9—P08XX TRANSMISSION (continued)

DTC number	DTC naming	Location
P0822	Gear Lever Y Position Circuit	
P0823	Gear Lever X Position Circuit Intermittent	
P0824	Gear Lever Y Position Circuit Intermittent	
P0825	Gear Lever Push-Pull Switch (Shift Anticipate)	
P0826	Up and Down Shift Switch Circuit	
P0827	Up and Down Shift Switch Circuit Low	
P0828	Up and Down Shift Switch Circuit High	
P0829	5-6 Shift	
P0830	Clutch Pedal Switch "A" Circuit	
P0831	Clutch Pedal Switch "A" Circuit Low	
P0832	Clutch Pedal Switch "A" Circuit High	
P0833	Clutch Pedal Switch "B" Circuit	
P0834	Clutch Pedal Switch "B" Circuit Low	
P0835	Clutch Pedal Switch "B" Circuit High	
P0836	Four Wheel Drive (4WD) Switch Circuit	
P0837	Four Wheel Drive (4WD) Switch Circuit Range/Performance	
P0838	Four Wheel Drive (4WD) Switch Circuit Low	
P0839	Four Wheel Drive (4WD) Switch Circuit High	
P0840	Transmission Fluid Pressure Sensor/Switch "A" Circuit	
P0841	Transmission Fluid Pressure Sensor/Switch "A" Circuit Range/Performance	
P0842	Transmission Fluid Pressure Sensor/Switch "A" Circuit Low	
P0843	Transmission Fluid Pressure Sensor/Switch "A" Circuit High	
P0844	Transmission Fluid Pressure Sensor/Switch "A" Circuit Intermittent	
P0845	Transmission Fluid Pressure Sensor/Switch "B" Circuit	
P0846	Transmission Fluid Pressure Sensor/Switch "B" Circuit Range/Performance	
P0847	Transmission Fluid Pressure Sensor/Switch "B" Circuit Low	
P0848	Transmission Fluid Pressure Sensor/Switch "B" Circuit High	
P0849	Transmission Fluid Pressure Sensor/Switch "B" Circuit Intermittent	
P0850	Park/Neutral Switch Input Circuit	
P0851	Park/Neutral Switch Input Circuit Low	
P0852	Park/Neutral Switch Input Circuit High	
P0853	Drive Switch Input Circuit	
P0854	Drive Switch Input Circuit Low	
P0855	Drive Switch Input Circuit High	
P0856	Traction Control Input Signal	
P0857	Traction Control Input Signal Range/Performance	
P0858	Traction Control Input Signal Low	
P0859	Traction Control Input Signal High	
P0860	Gear Shift Module Communication Circuit	
P0861	Gear Shift Module Communication Circuit Low	
P0862	Gear Shift Module Communication Circuit High	
P0863	TCM Communication Circuit	
P0864	TCM Communication Circuit Range/Performance	
P0865	TCM Communication Circuit Low	
P0866	TCM Communication Circuit High	
P0867	Transmission Fluid Pressure	
P0868	Transmission Fluid Pressure Low	
P0869	Transmission Fluid Pressure High	
P0870	Transmission Fluid Pressure Sensor/Switch "C" Circuit	
P0871	Transmission Fluid Pressure Sensor/Switch "C" Circuit Range/Performance	
P0872	Transmission Fluid Pressure Sensor/Switch "C" Circuit Low	
P0873	Transmission Fluid Pressure Sensor/Switch "C" Circuit High	
P0874	Transmission Fluid Pressure Sensor/Switch "C" Circuit Intermittent	
P0875	Transmission Fluid Pressure Sensor/Switch "D" Circuit	
P0876	Transmission Fluid Pressure Sensor/Switch "D" Circuit Range/Performance	

TABLE B9—P08XX TRANSMISSION (continued)

DTC number	DTC naming	Location
P0877	Transmission Fluid Pressure Sensor/Switch "D" Circuit Low	
P0878	Transmission Fluid Pressure Sensor/Switch "D" Circuit High	
P0879	Transmission Fluid Pressure Sensor/Switch "D" Circuit Intermittent	
P0880	TCM Power Input Signal	
P0881	TCM Power Input Signal Range/Performance	
P0882	TCM Power Input Signal Low	
P0883	TCM Power Input Signal High	
P0884	TCM Power Input Signal Intermittent	
P0885	TCM Power Relay Control Circuit/Open	
P0886	TCM Power Relay Control Circuit Low	
P0887	TCM Power Relay Control Circuit High	
P0888	TCM Power Relay Sense Circuit	
P0889	TCM Power Relay Sense Circuit Range/Performance	
P0890	TCM Power Relay Sense Circuit Low	
P0891	TCM Power Relay Sense Circuit High	
P0892	TCM Power Relay Sense Circuit Intermittent	
P0893	Multiple Gears Engaged	
P0894	Transmission Component Slipping	
P0895	Shift Time Too Short	
P0896	Shift Time Too Long	
P0897	Transmission Fluid Deteriorated	
P0898	Transmission Control System MIL Request Circuit Low	
P0899	Transmission Control System MIL Request Circuit High	

B.10 P09XX Transmission

TABLE B10—P09XX TRANSMISSION

DTC number	DTC naming	Location
P0900	Clutch Actuator Circuit/Open	
P0901	Clutch Actuator Circuit Range/Performance	
P0902	Clutch Actuator Circuit Low	
P0903	Clutch Actuator Circuit High	
P0904	Gate Select Position Circuit	
P0905	Gate Select Position Circuit Range/Performance	
P0906	Gate Select Position Circuit Low	
P0907	Gate Select Position Circuit High	
P0908	Gate Select Position Circuit Intermittent	
P0909	Gate Select Control Error	
P0910	Gate Select Actuator Circuit/Open	
P0911	Gate Select Actuator Circuit Range/Performance	
P0912	Gate Select Actuator Circuit Low	
P0913	Gate Select Actuator Circuit High	
P0914	Gear Shift Position Circuit	
P0915	Gear Shift Position Circuit Range/Performance	
P0916	Gear Shift Position Circuit Low	
P0917	Gear Shift Position Circuit High	
P0918	Gear Shift Position Circuit Intermittent	
P0919	Gear Shift Position Control Error	
P0920	Gear Shift Forward Actuator Circuit/Open	
P0921	Gear Shift Forward Actuator Circuit Range/Performance	
P0922	Gear Shift Forward Actuator Circuit Low	
P0923	Gear Shift Forward Actuator Circuit High	
P0924	Gear Shift Reverse Actuator Circuit/Open	
P0925	Gear Shift Reverse Actuator Circuit Range/Performance	
P0926	Gear Shift Reverse Actuator Circuit Low	

TABLE B10-1 P09XX TRANSMISSION (continued)

DTC number	DTC naming	Location
P0927	Gear Shift Reverse Actuator Circuit High	
P0928	Gear Shift Lock Solenoid Control Circuit/Open	
P0929	Gear Shift Lock Solenoid Control Circuit Range/Performance	
P0930	Gear Shift Lock Solenoid Control Circuit Low	
P0931	Gear Shift Lock Solenoid Control Circuit High	
P0932	Hydraulic Pressure Sensor Circuit	
P0933	Hydraulic Pressure Sensor Range/Performance	
P0934	Hydraulic Pressure Sensor Circuit Low	
P0935	Hydraulic Pressure Sensor Circuit High	
P0936	Hydraulic Pressure Sensor Circuit Intermittent	
P0937	Hydraulic Oil Temperature Sensor Circuit	
P0938	Hydraulic Oil Temperature Sensor Range/Performance	
P0939	Hydraulic Oil Temperature Sensor Circuit Low	
P0940	Hydraulic Oil Temperature Sensor Circuit High	
P0941	Hydraulic Oil Temperature Sensor Circuit Intermittent	
P0942	Hydraulic Pressure Unit	
P0943	Hydraulic Pressure Unit Cycling Period Too Short	
P0944	Hydraulic Pressure Unit Loss of Pressure	
P0945	Hydraulic Pump Relay Circuit/Open	
P0946	Hydraulic Pump Relay Circuit Range/Performance	
P0947	Hydraulic Pump Relay Circuit Low	
P0948	Hydraulic Pump Relay Circuit High	
P0949	Auto Shift Manual Adaptive Learning Not Complete	
P0950	Auto Shift Manual Control Circuit	
P0951	Auto Shift Manual Control Circuit Range/Performance	
P0952	Auto Shift Manual Control Circuit Low	
P0953	Auto Shift Manual Control Circuit High	
P0954	Auto Shift Manual Control Circuit Intermittent	
P0955	Auto Shift Manual Mode Circuit	
P0956	Auto Shift Manual Mode Circuit Range/Performance	
P0957	Auto Shift Manual Mode Circuit Low	
P0958	Auto Shift Manual Mode Circuit High	
P0959	Auto Shift Manual Mode Circuit Intermittent	
P0960	Pressure Control Solenoid "A" Control Circuit/Open	
P0961	Pressure Control Solenoid "A" Control Circuit Range/Performance	
P0962	Pressure Control Solenoid "A" Control Circuit Low	
P0963	Pressure Control Solenoid "A" Control Circuit High	
P0964	Pressure Control Solenoid "B" Control Circuit/Open	
P0965	Pressure Control Solenoid "B" Control Circuit Range/Performance	
P0966	Pressure Control Solenoid "B" Control Circuit Low	
P0967	Pressure Control Solenoid "B" Control Circuit High	
P0968	Pressure Control Solenoid "C" Control Circuit/Open	
P0969	Pressure Control Solenoid "C" Control Circuit Range/Performance	
P0970	Pressure Control Solenoid "C" Control Circuit Low	
P0971	Pressure Control Solenoid "C" Control Circuit High	
P0972	Shift Solenoid "A" Control Circuit Range/Performance	
P0973	Shift Solenoid "A" Control Circuit Low	
P0974	Shift Solenoid "A" Control Circuit High	
P0975	Shift Solenoid "B" Control Circuit Range/Performance	
P0976	Shift Solenoid "B" Control Circuit Low	
P0977	Shift Solenoid "B" Control Circuit High	
P0978	Shift Solenoid "C" Control Circuit Range/Performance	
P0979	Shift Solenoid "C" Control Circuit Low	
P0980	Shift Solenoid "C" Control Circuit High	
P0981	Shift Solenoid "D" Control Circuit Range/Performance	

TABLE B10—P09XX TRANSMISSION (continued)

DTC number	DTC naming	Location
P0982	Shift Solenoid "D" Control Circuit Low	
P0983	Shift Solenoid "D" Control Circuit High	
P0984	Shift Solenoid "E" Control Circuit Range/Performance	
P0985	Shift Solenoid "E" Control Circuit Low	
P0986	Shift Solenoid "E" Control Circuit High	
P0987	Transmission Fluid Pressure Sensor/Switch "E" Circuit	
P0988	Transmission Fluid Pressure Sensor/Switch "E" Circuit Range/Performance	
P0989	Transmission Fluid Pressure Sensor/Switch "E" Circuit Low	
P0990	Transmission Fluid Pressure Sensor/Switch "E" Circuit High	
P0991	Transmission Fluid Pressure Sensor/Switch "E" Circuit Intermittent	
P0992	Transmission Fluid Pressure Sensor/Switch "F" Circuit	
P0993	Transmission Fluid Pressure Sensor/Switch "F" Circuit Range/Performance	
P0994	Transmission Fluid Pressure Sensor/Switch "F" Circuit Low	
P0995	Transmission Fluid Pressure Sensor/Switch "F" Circuit High	
P0996	Transmission Fluid Pressure Sensor/Switch "F" Circuit Intermittent	
P0997	Shift Solenoid "F" Control Circuit Range/Performance	
P0998	Shift Solenoid "F" Control Circuit Low	
P0999	Shift Solenoid "F" Control Circuit High	

B.11 P0AXX Hybrid Propulsion

TABLE B11—P0AXX HYBRID PROPULSION

DTC number	DTC naming	Location
P0A00	Motor Electronics Coolant Temperature Sensor Circuit	
P0A01	Motor Electronics Coolant Temperature Sensor Circuit Range/Performance	
P0A02	Motor Electronics Coolant Temperature Sensor Circuit Low	
P0A03	Motor Electronics Coolant Temperature Sensor Circuit High	
P0A04	Motor Electronics Coolant Temperature Sensor Circuit Intermittent	
P0A05	Motor Electronics Coolant Pump Control Circuit/Open	
P0A06	Motor Electronics Coolant Pump Control Circuit Low	
P0A07	Motor Electronics Coolant Pump Control Circuit High	
P0A08	DC/DC Converter Status Circuit	
P0A09	DC/DC Converter Status Circuit Low Input	
P0A10	DC/DC Converter Status Circuit High Input	
P0A11	DC/DC Converter Enable Circuit/Open	
P0A12	DC/DC Converter Enable Circuit Low	
P0A13	DC/DC Converter Enable Circuit High	
P0A14	Engine Mount Control Circuit/Open	
P0A15	Engine Mount Control Circuit Low	
P0A16	Engine Mount Control Circuit High	
P0A17	Motor Torque Sensor Circuit	
P0A18	Motor Torque Sensor Circuit Range/Performance	
P0A19	Motor Torque Sensor Circuit Low	
P0A20	Motor Torque Sensor Circuit High	
P0A21	Motor Torque Sensor Circuit Intermittent	
P0A22	Generator Torque Sensor Circuit	
P0A23	Generator Torque Sensor Circuit Range/Performance	
P0A24	Generator Torque Sensor Circuit Low	
P0A25	Generator Torque Sensor Circuit High	
P0A26	Generator Torque Sensor Circuit Intermittent	
P0A27	Battery Power Off Circuit	
P0A28	Battery Power Off Circuit Low	
P0A29	Battery Power Off Circuit High	

B.12 P0BXX Reserved by Document
B.13 P0CXX Reserved by Document
B.14 P0DXX Reserved by Document
B.15 P0EXX Reserved by Document
B.16 P0FXX Reserved by Document
B.17 P10XX Manufacturer Controlled Fuel and Air Metering and Auxiliary Emission Controls
B.18 P11XX Manufacturer Controlled Fuel and Air Metering
B.19 P12XX Manufacturer Controlled Fuel and Air Metering
B.20 P13XX Manufacturer Controlled Ignition System or Misfire
B.21 P14XX Manufacturer Controlled Auxiliary Emission Controls
B.22 P15XX Manufacturer Controlled Vehicle Speed, Idle Control, and Auxiliary Inputs
B.23 P16XX Manufacturer Controlled Computer and Auxiliary Outputs
B.24 P17XX Manufacturer Controlled Transmission
B.25 P18XX Manufacturer Controlled Transmission
B.26 P19XX Manufacturer controlled Transmission
B.27 P20XX Fuel and Air Metering and Auxiliary Emission Controls

TABLE B12—P20XX FUEL AND AIR METERING AND AUXILIARY EMISSION CONTROLS

DTC number	DTC naming	Location
P2000	NOx Trap Efficiency Below Threshold	Bank 1
P2001	NOx Trap Efficiency Below Threshold	Bank 2
P2002	Particulate Trap Efficiency Below Threshold	Bank 1
P2003	Particulate Trap Efficiency Below Threshold	Bank 2
P2004	Intake Manifold Runner Control Stuck Open	Bank 1 [a)]
P2005	Intake Manifold Runner Control Stuck Open	Bank 2 [a)]
P2006	Intake Manifold Runner Control Stuck Closed	Bank 1 [a)]
P2007	Intake Manifold Runner Control Stuck Closed	Bank 2 [a)]
P2008	Intake Manifold Runner Control Circuit/Open	Bank 1 [a)]
P2009	Intake Manifold Runner Control Circuit Low	Bank 1 [a)]
P2010	Intake Manifold Runner Control Circuit High	Bank 1 [a)]
P2011	Intake Manifold Runner Control Circuit/Open	Bank 2 [a)]
P2012	Intake Manifold Runner Control Circuit Low	Bank 2 [a)]
P2013	Intake Manifold Runner Control Circuit High	Bank 2 [a)]
P2014	Intake Manifold Runner Position Sensor/Switch Circuit	Bank 1 [a)]
P2015	Intake Manifold Runner Position Sensor/Switch Circuit Range/Performance	Bank 1 [a)]
P2016	Intake Manifold Runner Position Sensor/Switch Circuit Low	Bank 1 [a)]
P2017	Intake Manifold Runner Position Sensor/Switch Circuit High	Bank 1 [a)]
P2018	Intake Manifold Runner Position Sensor/Switch Circuit Intermittent	Bank 1 [a)]
P2019	Intake Manifold Runner Position Sensor/Switch Circuit	Bank 2 [a)]
P2020	Intake Manifold Runner Position Sensor/Switch Circuit Range/Performance	Bank 2 [a)]
P2021	Intake Manifold Runner Position Sensor/Switch Circuit Low	Bank 2 [a)]
P2022	Intake Manifold Runner Position Sensor/Switch Circuit High	Bank 2 [a)]
P2023	Intake Manifold Runner Position Sensor/Switch Circuit Intermittent	Bank 2 [a)]
P2024	Evaporative Emissions (EVAP) Fuel Vapor Temperature Sensor Circuit	
P2025	Evaporative Emissions (EVAP) Fuel Vapor Temperature Sensor Performance	
P2026	Evaporative Emissions (EVAP) Fuel Vapor Temperature Sensor Circuit Low Voltage	
P2027	Evaporative Emissions (EVAP) Fuel Vapor Temperature Sensor Circuit High Voltage	
P2028	Evaporative Emissions (EVAP) Fuel Vapor Temperature Sensor Circuit Intermittent	
P2029	Fuel Fired Heater Disabled	
P2030	Fuel Fired Heater Performance	
P2031	Exhaust Gas Temperature Sensor Circuit	Bank 1 Sensor 2
P2032	Exhaust Gas Temperature Sensor Circuit Low	Bank 1 Sensor 2
P2033	Exhaust Gas Temperature Sensor Circuit High	Bank 1 Sensor 2
P2034	Exhaust Gas Temperature Sensor Circuit	Bank 2 Sensor 2
P2035	Exhaust Gas Temperature Sensor Circuit Low	Bank 2 Sensor 2
P2036	Exhaust Gas Temperature Sensor Circuit High	Bank 2 Sensor 2
P2037	Reductant Injection Air Pressure Sensor Circuit	
P2038	Reductant Injection Air Pressure Sensor Circuit Range/Performance	
P2039	Reductant Injection Air Pressure Sensor Circuit Low Input	
P2040	Reductant Injection Air Pressure Sensor Circuit High Input	
P2041	Reductant Injection Air Pressure Sensor Circuit Intermittent	
P2042	Reductant Temperature Sensor Circuit	
P2043	Reductant Temperature Sensor Circuit Range/Performance	

TABLE B12—P20XX FUEL AND AIR METERING AND AUXILIARY EMISSION CONTROLS (continued)

DTC number	DTC naming	Location
P2044	Reductant Temperature Sensor Circuit Low Input	
P2045	Reductant Temperature Sensor Circuit High Input	
P2046	Reductant Temperature Sensor Circuit Intermittent	
P2047	Reductant Injector Circuit/Open	Bank 1 Unit 1
P2048	Reductant Injector Circuit Low	Bank 1 Unit 1
P2049	Reductant Injector Circuit High	Bank 1 Unit 1
P2050	Reductant Injector Circuit/Open	Bank 2 Unit 1
P2051	Reductant Injector Circuit Low	Bank 2 Unit 1
P2052	Reductant Injector Circuit High	Bank 2 Unit 1
P2053	Reductant Injector Circuit/Open	Bank 1 Unit 2
P2054	Reductant Injector Circuit Low	Bank 1 Unit 2
P2055	Reductant Injector Circuit High	Bank 1 Unit 2
P2056	Reductant Injector Circuit/Open	Bank 2 Unit 2
P2057	Reductant Injector Circuit Low	Bank 2 Unit 2
P2058	Reductant Injector Circuit High	Bank 2 Unit 2
P2059	Reductant Injection Air Pump Control Circuit/Open	
P2060	Reductant Injection Air Pump Control Circuit Low	
P2061	Reductant Injection Air Pump Control Circuit High	
P2062	Reductant Supply Control Circuit/Open	
P2063	Reductant Supply Control Circuit Low	
P2064	Reductant Supply Control Circuit High	
P2065	Fuel Level Sensor "B" Circuit	
P2066	Fuel Level Sensor "B" Performance	
P2067	Fuel Level Sensor "B" Circuit Low	
P2068	Fuel Level Sensor "B" Circuit High	
P2069	Fuel Level Sensor "B" Circuit Intermittent	
P2070	Intake Manifold Tuning (IMT) Valve Stuck Open	a)
P2071	Intake Manifold Tuning (IMT) Valve Stuck Closed	a)
P2075	Intake Manifold Tuning (IMT) Valve Position Sensor/Switch Circuit	a)
P2076	Intake Manifold Tuning (IMT) Valve Position Sensor/Switch Circuit Range/Performance	a)
P2077	Intake Manifold Tuning (IMT) Valve Position Sensor/Switch Circuit Low	a)
P2078	Intake Manifold Tuning (IMT) Valve Position Sensor/Switch Circuit High	a)
P2079	Intake Manifold Tuning (IMT) Valve Position Sensor/Switch Circuit Intermittent	a)
P2080	Exhaust Gas Temperature Sensor Circuit Range/Performance	Bank 1 Sensor 1
P2081	Exhaust Gas Temperature Sensor Circuit Intermittent	Bank 1 Sensor 1
P2082	Exhaust Gas Temperature Sensor Circuit Range/Performance	Bank 2 Sensor 1
P2083	Exhaust Gas Temperature Sensor Circuit Intermittent	Bank 2 Sensor 1
P2084	Exhaust Gas Temperature Sensor Circuit Range/Performance	Bank 1 Sensor 2
P2085	Exhaust Gas Temperature Sensor Circuit Intermittent	Bank 1 Sensor 2
P2086	Exhaust Gas Temperature Sensor Circuit Range/Performance	Bank 2 Sensor 2
P2087	Exhaust Gas Temperature Sensor Circuit Intermittent	Bank 2 Sensor 2
P2088 [1)]	"A" Camshaft Position Actuator Control Circuit Low	Bank 1 [b)]
P2089 [1)]	"A" Camshaft Position Actuator Control Circuit High	Bank 1 [b)]
P2090 [1)]	"B" Camshaft Position Actuator Control Circuit Low	Bank 1 [c)]
P2091 [1)]	"B" Camshaft Position Actuator Control Circuit High	Bank 1 [c)]
P2092 [1)]	"A" Camshaft Position Actuator Control Circuit Low	Bank 2 [b)]
P2093 [1)]	"A" Camshaft Position Actuator Control Circuit High	Bank 2 [b)]
P2094 [1)]	"B" Camshaft Position Actuator Control Circuit Low	Bank 2 [c)]
P2095 [1)]	"B" Camshaft Position Actuator Control Circuit High	Bank 2 [c)]
P2096	Post Catalyst Fuel Trim System Too Lean	Bank 1
P2097	Post Catalyst Fuel Trim System Too Rich	Bank 1
P2098	Post Catalyst Fuel Trim System Too Lean	Bank 2
P2099	Post Catalyst Fuel Trim System Too Rich	Bank 2

TABLE B12—P20XX FUEL AND AIR METERING AND AUXILIARY EMISSION CONTROLS (continued)

DTC number	DTC naming	Location
NOTE 1) For DTCs P2088 - P2095 also see P0010 - P0023		
a) DTC Application note for Intake Manifold Tuning Valves and Intake Manifold Runner controls: Active controls are used modify or control airflow within the engine air intake system. These controls may be used to enhance or modify in-cylinder airflow motion (charge motion), modify the airflow dynamics (manifold tuning) within the intake manifold or both. Devices that control charge motion are commonly called Intake Manifold Runner Control, Swirl Control Valve, and Charge Motion Control Valve. The SAE recommended term for any device that controls charge motion is Intake Manifold Runner Control (IMRC). Devices that control manifold dynamics or manifold tuning are commonly called Intake Manifold Tuning Valve, Long/Short Runner Control and Intake Manifold Communication Control. The SAE recommended term for any device that controls manifold tuning is Intake Manifold Tuning (IMT) Valve.		
b) The "A" camshaft shall be either the "intake," "left," or "front camshaft. Left/Right and Front/Rear are determined as viewed from the driver's seating position. Bank 1 contains cylinder number one, Bank 2 is the opposite bank.		
c) The "B" camshaft shall be either the "exhaust," "right," or "rear" camshaft. Left/Right and Front/Rear are determined as viewed from the driver's seating position. Bank 1 contains cylinder number one, Bank 2 is the opposite bank.		

B.28 P21XX Fuel and Air Metering and Auxiliary Emission Controls

TABLE B13—P21XX FUEL AND AIR METERING AND AUXILIARY EMISSION CONTROLS

DTC number	DTC naming	Location
P2100 1)	Throttle Actuator Control Motor Circuit/Open	
P2101 1)	Throttle Actuator Control Motor Circuit Range/Performance	
P2102 1)	Throttle Actuator Control Motor Circuit Low	
P2103 1)	Throttle Actuator Control Motor Circuit High	
P2104 1)	Throttle Actuator Control System - Forced Idle	
P2105 1)	Throttle Actuator Control System - Forced Engine Shutdown	
P2106 1)	Throttle Actuator Control System - Forced Limited Power	
P2107 1)	Throttle Actuator Control Module Processor	
P2108 1)	Throttle Actuator Control Module Performance	
P2109 1)	Throttle/Pedal Position Sensor "A" Minimum Stop Performance	
P2110 1)	Throttle Actuator Control System - Forced Limited RPM	
P2111 1)	Throttle Actuator Control System - Stuck Open	
P2112 1)	Throttle Actuator Control System - Stuck Closed	
P2113	Throttle/Pedal Position Sensor "B" Minimum Stop Performance	
P2114	Throttle/Pedal Position Sensor "C" Minimum Stop Performance	
P2115	Throttle/Pedal Position Sensor "D" Minimum Stop Performance	
P2116	Throttle/Pedal Position Sensor "E" Minimum Stop Performance	
P2117	Throttle/Pedal Position Sensor "F" Minimum Stop Performance	
P2118 1)	Throttle Actuator Control Motor Current Range/Performance	
P2119 1)	Throttle Actuator Control Throttle Body Range/Performance	
P2120	Throttle/Pedal Position Sensor/Switch "D" Circuit	
P2121	Throttle/Pedal Position Sensor/Switch "D" Circuit Range/Performance	
P2122	Throttle/Pedal Position Sensor/Switch "D" Circuit Low Input	
P2123	Throttle/Pedal Position Sensor/Switch "D" Circuit High Input	
P2124	Throttle/Pedal Position Sensor/Switch "D" Circuit Intermittent	
P2125	Throttle/Pedal Position Sensor/Switch "E" Circuit	
P2126	Throttle/Pedal Position Sensor/Switch "E" Circuit Range/Performance	
P2127	Throttle/Pedal Position Sensor/Switch "E" Circuit Low Input	
P2128	Throttle/Pedal Position Sensor/Switch "E" Circuit High Input	
P2129	Throttle/Pedal Position Sensor/Switch "E" Circuit Intermittent	
P2130	Throttle/Pedal Position Sensor/Switch "F" Circuit	
P2131	Throttle/Pedal Position Sensor/Switch "F" Circuit Range Performance	
P2132	Throttle/Pedal Position Sensor/Switch "F" Circuit Low Input	
P2133	Throttle/Pedal Position Sensor/Switch "F" Circuit High Input	
P2134	Throttle/Pedal Position Sensor/Switch "F" Circuit Intermittent	
P2135	Throttle/Pedal Position Sensor/Switch "A" / "B" Voltage Correlation	
P2136	Throttle/Pedal Position Sensor/Switch "A" / "C" Voltage Correlation	
P2137	Throttle/Pedal Position Sensor/Switch "B" / "C" Voltage Correlation	
P2138	Throttle/Pedal Position Sensor/Switch "D" / "E" Voltage Correlation	

TABLE B13—P21XX FUEL AND AIR METERING AND AUXILIARY EMISSION CONTROLS (continued)

DTC number	DTC naming	Location
P2139	Throttle/Pedal Position Sensor/Switch "D" / "F" Voltage Correlation	
P2140	Throttle/Pedal Position Sensor/Switch "E" / "F" Voltage Correlation	
P2141 [2)]	Exhaust Gas Recirculation Throttle Control Circuit Low	
P2142 [2)]	Exhaust Gas Recirculation Throttle Control Circuit High	
P2143	Exhaust Gas Recirculation Vent Control Circuit/Open	
P2144	Exhaust Gas Recirculation Vent Control Circuit Low	
P2145	Exhaust Gas Recirculation Vent Control Circuit High	
P2146	Fuel Injector Group "A" Supply Voltage Circuit/Open	
P2147	Fuel Injector Group "A" Supply Voltage Circuit Low	
P2148	Fuel Injector Group "A" Supply Voltage Circuit High	
P2149	Fuel Injector Group "B" Supply Voltage Circuit/Open	
P2150	Fuel Injector Group "B" Supply Voltage Circuit Low	
P2151	Fuel Injector Group "B" Supply Voltage Circuit High	
P2152	Fuel Injector Group "C" Supply Voltage Circuit/Open	
P2153	Fuel Injector Group "C" Supply Voltage Circuit Low	
P2154	Fuel Injector Group "C" Supply Voltage Circuit High	
P2155	Fuel Injector Group "D" Supply Voltage Circuit/Open	
P2156	Fuel Injector Group "D" Supply Voltage Circuit Low	
P2157	Fuel Injector Group "D" Supply Voltage Circuit High	
P2158	Vehicle Speed Sensor "B"	
P2159	Vehicle Speed Sensor "B" Range/Performance	
P2160	Vehicle Speed Sensor "B" Circuit Low	
P2161	Vehicle Speed Sensor "B" Intermittent/Erratic	
P2162	Vehicle Speed Sensor "A" / "B" Correlation	
P2163	Throttle/Pedal Position Sensor "A" Maximum Stop Performance	
P2164	Throttle/Pedal Position Sensor "B" Maximum Stop Performance	
P2165	Throttle/Pedal Position Sensor "C" Maximum Stop Performance	
P2166	Throttle/Pedal Position Sensor "D" Maximum Stop Performance	
P2167	Throttle/Pedal Position Sensor "E" Maximum Stop Performance	
P2168	Throttle/Pedal Position Sensor "F" Maximum Stop Performance	
P2169	Exhaust Pressure Regulator Vent Solenoid Control Circuit/Open	
P2170	Exhaust Pressure Regulator Vent Solenoid Control Circuit Low	
P2171	Exhaust Pressure Regulator Vent Solenoid Control Circuit High	
P2172	Throttle Actuator Control System – Sudden High Airflow Detected	
P2173	Throttle Actuator Control System – High Airflow Detected	
P2174	Throttle Actuator Control System – Sudden Low Airflow Detected	
P2175	Throttle Actuator Control System – Low Airflow Detected	
P2176	Throttle Actuator Control System – Idle Position Not Learned	
P2177 [a)]	System Too Lean Off Idle	Bank 1
P2178 [a)]	System Too Rich Off Idle	Bank 1
P2179 [a)]	System Too Lean Off Idle	Bank 2
P2180 [a)]	System Too Rich Off Idle	Bank 2
P2181	Cooling System Performance	
P2182	Engine Coolant Temperature Sensor 2 Circuit	
P2183	Engine Coolant Temperature Sensor 2 Circuit Range/Performance	
P2184	Engine Coolant Temperature Sensor 2 Circuit Low	
P2185	Engine Coolant Temperature Sensor 2 Circuit High	
P2186	Engine Coolant Temperature Sensor 2 Circuit Intermittent/Erratic	
P2187	System Too Lean at Idle	Bank 1
P2188	System Too Rich at Idle	Bank 1
P2189	System Too Lean at Idle	Bank 2
P2190	System Too Rich at Idle	Bank 2
P2191	System Too Lean at Higher Load	Bank 1
P2192	System Too Rich at Higher Load	Bank 1

TABLE B13—P21XX FUEL AND AIR METERING AND AUXILIARY EMISSION CONTROLS (continued)

DTC number	DTC naming	Location
P2193	System Too Lean at Higher Load	Bank 2
P2194	System Too Rich at Higher Load	Bank 2
P2195	O2 Sensor Signal Stuck Lean	Bank 1 Sensor 1
P2196	O2 Sensor Signal Stuck Rich	Bank 1 Sensor 1
P2197	O2 Sensor Signal Stuck Lean	Bank 2 Sensor 1
P2198	O2 Sensor Signal Stuck Rich	Bank 2 Sensor 1
P2199	Intake Air Temperature Sensor 1 / 2 Correlation	
NOTE 1) For Throttle Actuator Control DTCs also see P0638 - P0639		
NOTE 2) DTCs P2141 - P2142 should be used with P0487 - P0488		
[a)] Use P2177 – P2180 for fuel systems with multiple load ranges.		

B.29 P22XX Fuel and Air Metering and Auxiliary Emission Controls

TABLE B14—P22XX FUEL AND AIR METERING AND AUXILIARY EMISSION CONTROLS

DTC number	DTC naming	Location
P2200	NOx Sensor Circuit	Bank 1
P2201	NOx Sensor Circuit Range/Performance	Bank 1
P2202	NOx Sensor Circuit Low Input	Bank 1
P2203	NOx Sensor Circuit High Input	Bank 1
P2204	NOx Sensor Circuit Intermittent Input	Bank 1
P2205	NOx Sensor Heater Control Circuit/Open	Bank 1
P2206	NOx Sensor Heater Control Circuit Low	Bank 1
P2207	NOx Sensor Heater Control Circuit High	Bank 1
P2208	NOx Sensor Heater Sense Circuit	Bank 1
P2209	NOx Sensor Heater Sense Circuit Range/Performance	Bank 1
P2210	NOx Sensor Heater Sense Circuit Low Input	Bank 1
P2211	NOx Sensor Heater Sense Circuit High Input	Bank 1
P2212	NOx Sensor Heater Sense Circuit Intermittent	Bank 1
P2213	NOx Sensor Circuit	Bank 2
P2214	NOx Sensor Circuit Range/Performance	Bank 2
P2215	NOx Sensor Circuit Low Input	Bank 2
P2216	NOx Sensor Circuit High Input	Bank 2
P2217	NOx Sensor Circuit Intermittent Input	Bank 2
P2218	NOx Sensor Heater Control Circuit/Open	Bank 2
P2219	NOx Sensor Heater Control Circuit Low	Bank 2
P2220	NOx Sensor Heater Control Circuit High	Bank 2
P2221	NOx Sensor Heater Sense Circuit	Bank 2
P2222	NOx Sensor Heater Sense Circuit Range/Performance	Bank 2
P2223	NOx Sensor Heater Sense Circuit Low	Bank 2
P2224	NOx Sensor Heater Sense Circuit High	Bank 2
P2225	NOx Sensor Heater Sense Circuit Intermittent	Bank 2
P2226	Barometric Pressure Circuit	
P2227	Barometric Pressure Circuit Range/Performance	
P2228	Barometric Pressure Circuit Low	
P2229	Barometric Pressure Circuit High	
P2230	Barometric Pressure Circuit Intermittent	
P2231 [1)]	O2 Sensor Signal Circuit Shorted to Heater Circuit	Bank 1 Sensor 1
P2232 [1)]	O2 Sensor Signal Circuit Shorted to Heater Circuit	Bank 1 Sensor 2
P2233 [1)]	O2 Sensor Signal Circuit Shorted to Heater Circuit	Bank 1 Sensor 3
P2234 [1)]	O2 Sensor Signal Circuit Shorted to Heater Circuit	Bank 2 Sensor 1
P2235 [1)]	O2 Sensor Signal Circuit Shorted to Heater Circuit	Bank 2 Sensor 2
P2236 [1)]	O2 Sensor Signal Circuit Shorted to Heater Circuit	Bank 2 Sensor 3
P2237 [2)]	O2 Sensor Positive Current Control Circuit/Open	Bank 1 Sensor 1
P2238 [2)]	O2 Sensor Positive Current Control Circuit Low	Bank 1 Sensor 1

TABLE B14—P22XX FUEL AND AIR METERING AND AUXILIARY EMISSION CONTROLS (continued)

DTC number	DTC naming	Location
P2239 [2)]	O2 Sensor Positive Current Control Circuit High	Bank 1 Sensor 1
P2240 [2)]	O2 Sensor Positive Current Control Circuit/Open	Bank 2 Sensor 1
P2241 [2)]	O2 Sensor Positive Current Control Circuit Low	Bank 2 Sensor 1
P2242 [2)]	O2 Sensor Positive Current Control Circuit High	Bank 2 Sensor 1
P2243 [2)]	O2 Sensor Reference Voltage Circuit/Open	Bank 1 Sensor 1
P2244 [2)]	O2 Sensor Reference Voltage Performance	Bank 1 Sensor 1
P2245 [2)]	O2 Sensor Reference Voltage Circuit Low	Bank 1 Sensor 1
P2246 [2)]	O2 Sensor Reference Voltage Circuit High	Bank 1 Sensor 1
P2247 [2)]	O2 Sensor Reference Voltage Circuit/Open	Bank 2 Sensor 1
P2248 [2)]	O2 Sensor Reference Voltage Performance	Bank 2 Sensor 1
P2249 [2)]	O2 Sensor Reference Voltage Circuit Low	Bank 2 Sensor 1
P2250 [2)]	O2 Sensor Reference Voltage Circuit High	Bank 2 Sensor 1
P2251 [2)]	O2 Sensor Negative Current Control Circuit/Open	Bank 1 Sensor 1
P2252 [2)]	O2 Sensor Negative Current Control Circuit Low	Bank 1 Sensor 1
P2253 [2)]	O2 Sensor Negative Current Control Circuit High	Bank 1 Sensor 1
P2254 [2)]	O2 Sensor Negative Current Control Circuit/Open	Bank 2 Sensor 1
P2255 [2)]	O2 Sensor Negative Current Control Circuit Low	Bank 2 Sensor 1
P2256 [2)]	O2 Sensor Negative Current Control Circuit High	Bank 2 Sensor 1
P2257	Secondary Air Injection System Control "A" Circuit Low	
P2258	Secondary Air Injection System Control "A" Circuit High	
P2259	Secondary Air Injection System Control "B" Circuit Low	
P2260	Secondary Air Injection System Control "B" Circuit High	
P2261	Turbo/Super Charger Bypass Valve - Mechanical	
P2262	Turbo Boost Pressure Not Detected - Mechanical	
P2263	Turbo/Super Charger Boost System Performance	
P2264	Water in Fuel Sensor Circuit	
P2265	Water in Fuel Sensor Circuit Range/Performance	
P2266	Water in Fuel Sensor Circuit Low	
P2267	Water in Fuel Sensor Circuit High	
P2268	Water in Fuel Sensor Circuit Intermittent	
P2269	Water in Fuel Condition	
P2270	O2 Sensor Signal Stuck Lean	Bank 1 Sensor 2
P2271	O2 Sensor Signal Stuck Rich	Bank 1 Sensor 2
P2272	O2 Sensor Signal Stuck Lean	Bank 2 Sensor 2
P2273	O2 Sensor Signal Stuck Rich	Bank 2 Sensor 2
P2274	O2 Sensor Signal Stuck Lean	Bank 1 Sensor 3
P2275	O2 Sensor Signal Stuck Rich	Bank 1 Sensor 3
P2276	O2 Sensor Signal Stuck Lean	Bank 2 Sensor 3
P2277	O2 Sensor Signal Stuck Rich	Bank 2 Sensor 3
P2278	O2 Sensor Signals Swapped Bank 1 Sensor 3 / Bank 2 Sensor 3	
P2279	Intake Air System Leak	
P2280	Air Flow Restriction / Air Leak Between Air Filter and MAF	
P2281	Air Leak Between MAF and Throttle Body	
P2282	Air Leak Between Throttle Body and Intake Valves	
P2283	Injector Control Pressure Sensor Circuit	
P2284	Injector Control Pressure Sensor Circuit Range/Performance	
P2285	Injector Control Pressure Sensor Circuit Low	
P2286	Injector Control Pressure Sensor Circuit High	
P2287	Injector Control Pressure Sensor Circuit Intermittent	
P2288	Injector Control Pressure Too High	
P2289	Injector Control Pressure Too High – Engine Off	
P2290	Injector Control Pressure Too Low	
P2291	Injector Control Pressure Too Low – Engine Cranking	

TABLE B14—P22XX FUEL AND AIR METERING AND AUXILIARY EMISSION CONTROLS (continued)

DTC number	DTC naming	Location
P2292	Injector Control Pressure Erratic	
P2293	Fuel Pressure Regulator 2 Performance	
P2294	Fuel Pressure Regulator 2 Control Circuit	
P2295	Fuel Pressure Regulator 2 Control Circuit Low	
P2296	Fuel Pressure Regulator 2 Control Circuit High	
P2297	O2 Sensor Out of Range During Deceleration	Bank 1 Sensor 1
P2298	O2 Sensor Out of Range During Deceleration	Bank 2 Sensor 1
P2299	Brake Pedal Position / Accelerator Pedal Position Incompatible	
NOTE 1) P2231-P2236, This diagnostic is for the sensors (both wide band and switching) that have a PWM controlled heater. If the heater shorts to the signal circuit, the control module can determine this since the signal circuit will be shorted high at the same frequency that the heaters are operating at.		
NOTE 2) P2237-P2256, These are the diagnostics for the primary circuits of the wide band oxygen sensors.		

B.30 P23XX Ignition System or Misfire

TABLE B15—P23XX IGNITION SYSTEM OR MISFIRE

DTC number	DTC naming	Location
P2300	Ignition Coil "A" Primary Control Circuit Low	
P2301	Ignition Coil "A" Primary Control Circuit High	
P2302	Ignition Coil "A" Secondary Circuit	
P2303	Ignition Coil "B" Primary Control Circuit Low	
P2304	Ignition Coil "B" Primary Control Circuit High	
P2305	Ignition Coil "B" Secondary Circuit	
P2306	Ignition Coil "C" Primary Control Circuit Low	
P2307	Ignition Coil "C" Primary Control Circuit High	
P2308	Ignition Coil "C" Secondary Circuit	
P2309	Ignition Coil "D" Primary Control Circuit Low	
P2310	Ignition Coil "D" Primary Control Circuit High	
P2311	Ignition Coil "D" Secondary Circuit	
P2312	Ignition Coil "E" Primary Control Circuit Low	
P2313	Ignition Coil "E" Primary Control Circuit High	
P2314	Ignition Coil "E" Secondary Circuit	
P2315	Ignition Coil "F" Primary Control Circuit Low	
P2316	Ignition Coil "F" Primary Control Circuit High	
P2317	Ignition Coil "F" Secondary Circuit	
P2318	Ignition Coil "G" Primary Control Circuit Low	
P2319	Ignition Coil "G" Primary Control Circuit High	
P2320	Ignition Coil "G" Secondary Circuit	
P2321	Ignition Coil "H" Primary Control Circuit Low	
P2322	Ignition Coil "H" Primary Control Circuit High	
P2323	Ignition Coil "H" Secondary Circuit	
P2324	Ignition Coil "I" Primary Control Circuit Low	
P2325	Ignition Coil "I" Primary Control Circuit High	
P2326	Ignition Coil "I" Secondary Circuit	
P2327	Ignition Coil "J" Primary Control Circuit Low	
P2328	Ignition Coil "J" Primary Control Circuit High	
P2329	Ignition Coil "J" Secondary Circuit	
P2330	Ignition Coil "K" Primary Control Circuit Low	
P2331	Ignition Coil "K" Primary Control Circuit High	
P2332	Ignition Coil "K" Secondary Circuit	
P2333	Ignition Coil "L" Primary Control Circuit Low	
P2334	Ignition Coil "L" Primary Control Circuit High	
P2335	Ignition Coil "L" Secondary Circuit	
P2336	Cylinder #1 Above Knock Threshold	
P2337	Cylinder #2 Above Knock Threshold	
P2338	Cylinder #3 Above Knock Threshold	
P2339	Cylinder #4 Above Knock Threshold	

TABLE B15—P23XX IGNITION SYSTEM OR MISFIRE (continued)

DTC number	DTC naming	Location
P2340	Cylinder #5 Above Knock Threshold	
P2341	Cylinder #6 Above Knock Threshold	
P2342	Cylinder #7 Above Knock Threshold	
P2343	Cylinder #8 Above Knock Threshold	
P2344	Cylinder #9 Above Knock Threshold	
P2345	Cylinder #10 Above Knock Threshold	
P2346	Cylinder #11 Above Knock Threshold	
P2347	Cylinder #12 Above Knock Threshold	

B.31 P24XX Auxiliary Emission Controls

TABLE B16—P24XX AUXILIARY EMISSION CONTROLS

DTC number	DTC naming	Location
P2400	Evaporative Emission System Leak Detection Pump Control Circuit/Open	
P2401	Evaporative Emission System Leak Detection Pump Control Circuit Low	
P2402	Evaporative Emission System Leak Detection Pump Control Circuit High	
P2403	Evaporative Emission System Leak Detection Pump Sense Circuit/Open	
P2404	Evaporative Emission System Leak Detection Pump Sense Circuit Range/Performance	
P2405	Evaporative Emission System Leak Detection Pump Sense Circuit Low	
P2406	Evaporative Emission System Leak Detection Pump Sense Circuit High	
P2407	Evaporative Emission System Leak Detection Pump Sense Circuit Intermittent/Erratic	
P2408	Fuel Cap Sensor/Switch Circuit	
P2409	Fuel Cap Sensor/Switch Circuit Range/Performance	
P2410	Fuel Cap Sensor/Switch Circuit Low	
P2411	Fuel Cap Sensor/Switch Circuit High	
P2412	Fuel Cap Sensor/Switch Circuit Intermittent/Erratic	
P2413	Exhaust Gas Recirculation System Performance	
P2414	O2 Sensor Exhaust Sample Error	Bank 1 Sensor 1
P2415	O2 Sensor Exhaust Sample Error	Bank 2 Sensor 1
P2416	O2 Sensor Signals Swapped Bank 1 Sensor 2 / Bank 1 Sensor 3	
P2417	O2 Sensor Signals Swapped Bank 2 Sensor 2 / Bank 2 Sensor 3	
P2418	Evaporative Emission System Switching Valve Control Circuit /Open	
P2419	Evaporative Emission System Switching Valve Control Circuit Low	
P2420	Evaporative Emission System Switching Valve Control Circuit High	
P2421	Evaporative Emission System Vent Valve Stuck Open	
P2422	Evaporative Emission System Vent Valve Stuck Closed	
P2423	HC Adsorption Catalyst Efficiency Below Threshold	Bank 1
P2424	HC Adsorption Catalyst Efficiency Below Threshold	Bank 2
P2425	Exhaust Gas Recirculation Cooling Valve Control Circuit/Open	
P2426	Exhaust Gas Recirculation Cooling Valve Control Circuit Low	
P2427	Exhaust Gas Recirculation Cooling Valve Control Circuit High	
P2428	Exhaust Gas Temperature Too High	Bank 1
P2429	Exhaust Gas Temperature Too High	Bank 2
P2430	Secondary Air Injection System Air Flow/Pressure Sensor Circuit	Bank 1
P2431	Secondary Air Injection System Air Flow/Pressure Sensor Circuit Range/Performance	Bank 1
P2432	Secondary Air Injection System Air Flow/Pressure Sensor Circuit Low	Bank 1
P2433	Secondary Air Injection System Air Flow/Pressure Sensor Circuit High	Bank 1
P2434	Secondary Air Injection System Air Flow/Pressure Sensor Circuit Intermittent/Erratic	Bank 1
P2435	Secondary Air Injection System Air Flow/Pressure Sensor Circuit	Bank 2
P2436	Secondary Air Injection System Air Flow/Pressure Sensor Circuit Range/Performance	Bank 2
P2437	Secondary Air Injection System Air Flow/Pressure Sensor Circuit Low	Bank 2
P2438	Secondary Air Injection System Air Flow/Pressure Sensor Circuit High	Bank 2
P2439	Secondary Air Injection System Air Flow/Pressure Sensor Circuit Intermittent/Erratic	Bank 2
P2440	Secondary Air Injection System Switching Valve Stuck Open	Bank 1
P2441	Secondary Air Injection System Switching Valve Stuck Closed	Bank 1

TABLE B16—P24XX AUXILIARY EMISSION CONTROLS (continued)

DTC number	DTC naming	Location
P2442	Secondary Air Injection System Switching Valve Stuck Open	Bank 2
P2443	Secondary Air Injection System Switching Valve Stuck Closed	Bank 2
P2444	Secondary Air Injection System Pump Stuck On	Bank 1
P2445	Secondary Air Injection System Pump Stuck Off	Bank 1
P2446	Secondary Air Injection System Pump Stuck On	Bank 2
P2447	Secondary Air Injection System Pump Stuck Off	Bank 2

B.32 P25XX Auxiliary Inputs

TABLE B17—P25XX AUXILIARY INPUTS

DTC number	DTC naming	Location
P2500	Generator Lamp/L-Terminal Circuit Low	
P2501	Generator Lamp/L-Terminal Circuit High	
P2502	Charging System Voltage	
P2503	Charging System Voltage Low	
P2504	Charging System Voltage High	
P2505 [1)]	ECM/PCM Power Input Signal	
P2506 [1)]	ECM/PCM Power Input Signal Range/Performance	
P2507 [1)]	ECM/PCM Power Input Signal Low	
P2508 [1)]	ECM/PCM Power Input Signal High	
P2509 [1)]	ECM/PCM Power Input Signal Intermittent	
P2510	ECM/PCM Power Relay Sense Circuit Range/Performance	
P2511	ECM/PCM Power Relay Sense Circuit Intermittent	
P2512	Event Data Recorder Request Circuit/ Open	
P2513	Event Data Recorder Request Circuit Low	
P2514	Event Data Recorder Request Circuit High	
P2515	A/C Refrigerant Pressure Sensor "B" Circuit	
P2516	A/C Refrigerant Pressure Sensor "B" Circuit Range/Performance	
P2517	A/C Refrigerant Pressure Sensor "B" Circuit Low	
P2518	A/C Refrigerant Pressure Sensor "B" Circuit High	
P2519	A/C Request "A" Circuit	
P2520	A/C Request "A" Circuit Low	
P2521	A/C Request "A" Circuit High	
P2522	A/C Request "B" Circuit	
P2523	A/C Request "B" Circuit Low	
P2524	A/C Request "B" Circuit High	
P2525	Vacuum Reservoir Pressure Sensor Circuit	
P2526	Vacuum Reservoir Pressure Sensor Circuit Range/Performance	
P2527	Vacuum Reservoir Pressure Sensor Circuit Low	
P2528	Vacuum Reservoir Pressure Sensor Circuit High	
P2529	Vacuum Reservoir Pressure Sensor Circuit Intermittent	
P2530	Ignition Switch Run Position Circuit	
P2531	Ignition Switch Run Position Circuit Low	
P2532	Ignition Switch Run Position Circuit High	
P2533	Ignition Switch Run/Start Position Circuit	
P2534	Ignition Switch Run/Start Position Circuit Low	
P2535	Ignition Switch Run/Start Position Circuit High	
P2536	Ignition Switch Accessory Position Circuit	
P2537	Ignition Switch Accessory Position Circuit Low	
P2538	Ignition Switch Accessory Position Circuit High	
P2539	Low Pressure Fuel System Sensor Circuit	
P2540	Low Pressure Fuel System Sensor Circuit Range/Performance	
P2541	Low Pressure Fuel System Sensor Circuit Low	
P2542	Low Pressure Fuel System Sensor Circuit High	
P2543	Low Pressure Fuel System Sensor Circuit Intermittent	

TABLE B17—P25XX AUXILIARY INPUTS (continued)

DTC number	DTC naming	Location
P2544	Torque Management Request Input Signal "A"	
P2545	Torque Management Request Input Signal "A" Range/Performance	
P2546	Torque Management Request Input Signal "A" Low	
P2547	Torque Management Request Input Signal "A" High	
P2548	Torque Management Request Input Signal "B"	
P2549	Torque Management Request Input Signal "B" Range/Performance	
P2550	Torque Management Request Input Signal "B" Low	
P2551	Torque Management Request Input Signal "B" High	
P2552	Throttle/Fuel Inhibit Circuit	
P2553	Throttle/Fuel Inhibit Circuit Range/Performance	
P2554	Throttle/Fuel Inhibit Circuit Low	
P2555	Throttle/Fuel Inhibit Circuit High	
P2556	Engine Coolant Level Sensor/Switch Circuit	
P2557	Engine Coolant Level Sensor/Switch Circuit Range/Performance	
P2558	Engine Coolant Level Sensor/Switch Circuit Low	
P2559	Engine Coolant Level Sensor/Switch Circuit High	
P2560	Engine Coolant Level Low	
P2561	A/C Control Module Requested MIL Illumination	
P2562	Turbocharger Boost Control Position Sensor Circuit	
P2563	Turbocharger Boost Control Position Sensor Circuit Range/Performance	
P2564	Turbocharger Boost Control Position Sensor Circuit Low	
P2565	Turbocharger Boost Control Position Sensor Circuit High	
P2566	Turbocharger Boost Control Position Sensor Circuit Intermittent	
P2567	Direct Ozone Reduction Catalyst Temperature Sensor Circuit	
P2568	Direct Ozone Reduction Catalyst Temperature Sensor Circuit Range/Performance	
P2569	Direct Ozone Reduction Catalyst Temperature Sensor Circuit Low	
P2570	Direct Ozone Reduction Catalyst Temperature Sensor Circuit High	
P2571	Direct Ozone Reduction Catalyst Temperature Sensor Circuit Intermittent/Erratic	
P2572	Direct Ozone Reduction Catalyst Deterioration Sensor Circuit	
P2573	Direct Ozone Reduction Catalyst Deterioration Sensor Circuit Range/Performance	
P2574	Direct Ozone Reduction Catalyst Deterioration Sensor Circuit Low	
P2575	Direct Ozone Reduction Catalyst Deterioration Sensor Circuit High	
P2576	Direct Ozone Reduction Catalyst Deterioration Sensor Circuit Intermittent/Erratic	
P2577	Direct Ozone Reduction Catalyst Efficiency Below Threshold	
NOTE 1) For DTCs P2505 - P2509 also see P0685		

B.33 P26XX Computer and Auxiliary Outputs

TABLE B18—P26XX COMPUTER AND AUXILIARY OUTPUTS

DTC number	DTC naming	Location
P2600	Coolant Pump Control Circuit/Open	
P2601	Coolant Pump Control Circuit Range/Performance	
P2602	Coolant Pump Control Circuit Low	
P2603	Coolant Pump Control Circuit High	
P2604 1)	Intake Air Heater "A" Circuit Range/Performance	
P2605 1)	Intake Air Heater "A" Circuit/Open	
P2606 1)	Intake Air Heater "B" Circuit Range/Performance	
P2607 1)	Intake Air Heater "B" Circuit Low	
P2608 1)	Intake Air Heater "B" Circuit High	
P2609 1)	Intake Air Heater System Performance	
P2610	ECM/PCM Internal Engine Off Timer Performance	
P2611	A/C Refrigerant Distribution Valve Control Circuit/Open	
P2612	A/C Refrigerant Distribution Valve Control Circuit Low	
P2613	A/C Refrigerant Distribution Valve Control Circuit High	

TABLE B18—P26XX COMPUTER AND AUXILIARY OUTPUTS (continued)

DTC number	DTC naming	Location
P2614	Camshaft Position Signal Output Circuit/Open	
P2615	Camshaft Position Signal Output Circuit Low	
P2616	Camshaft Position Signal Output Circuit High	
P2617	Crankshaft Position Signal Output Circuit/Open	
P2618	Crankshaft Position Signal Output Circuit Low	
P2619	Crankshaft Position Signal Output Circuit High	
P2620	Throttle Position Output Circuit/Open	
P2621	Throttle Position Output Circuit Low	
P2622	Throttle Position Output Circuit High	
P2623	Injector Control Pressure Regulator Circuit/Open	
P2624	Injector Control Pressure Regulator Circuit Low	
P2625	Injector Control Pressure Regulator Circuit High	
P2626	O2 Sensor Pumping Current Trim Circuit/Open	Bank 1 Sensor 1
P2627	O2 Sensor Pumping Current Trim Circuit Low	Bank 1 Sensor 1
P2628	O2 Sensor Pumping Current Trim Circuit High	Bank 1 Sensor 1
P2629	O2 Sensor Pumping Current Trim Circuit/Open	Bank 2 Sensor 1
P2630	O2 Sensor Pumping Current Trim Circuit Low	Bank 2 Sensor 1
P2631	O2 Sensor Pumping Current Trim Circuit High	Bank 2 Sensor 1
P2632	Fuel Pump "B" Control Circuit /Open	
P2633	Fuel Pump "B" Control Circuit Low	
P2634	Fuel Pump "B" Control Circuit High	
P2635	Fuel Pump "A" Low Flow / Performance	
P2636	Fuel Pump "B" Low Flow / Performance	
P2637	Torque Management Feedback Signal "A"	
P2638	Torque Management Feedback Signal "A" Range/Performance	
P2639	Torque Management Feedback Signal "A" Low	
P2640	Torque Management Feedback Signal "A" High	
P2641	Torque Management Feedback Signal "B"	
P2642	Torque Management Feedback Signal "B" Range/Performance	
P2643	Torque Management Feedback Signal "B" Low	
P2644	Torque Management Feedback Signal "B" High	
P2645 [a]	"A" Rocker Arm Actuator Control Circuit/Open	Bank 1
P2646 [a]	"A" Rocker Arm Actuator System Performance or Stuck Off	Bank 1
P2647 [a]	"A" Rocker Arm Actuator System Stuck On	Bank 1
P2648 [a]	"A" Rocker Arm Actuator Control Circuit Low	Bank 1
P2649 [a]	"A" Rocker Arm Actuator Control Circuit High	Bank 1
P2650 [b]	"B" Rocker Arm Actuator Control Circuit/Open	Bank 1
P2651 [b]	"B" Rocker Arm Actuator System Performance or Stuck Off	Bank 1
P2652 [b]	"B" Rocker Arm Actuator System Stuck On	Bank 1
P2653 [b]	"B" Rocker Arm Actuator Control Circuit Low	Bank 1
P2654 [b]	"B" Rocker Arm Actuator Control Circuit High	Bank 1
P2655 [a]	"A" Rocker Arm Actuator Control Circuit/Open	Bank 2
P2656 [a]	"A" Rocker Arm Actuator System Performance or Stuck Off	Bank 2
P2657 [a]	"A" Rocker Arm Actuator System Stuck On	Bank 2
P2658 [a]	"A" Rocker Arm Actuator Control Circuit Low	Bank 2
P2659 [a]	"A" Rocker Arm Actuator Control Circuit High	Bank 2
P2660 [b]	"B" Rocker Arm Actuator Control Circuit/Open	Bank 2
P2661 [b]	"B" Rocker Arm Actuator System Performance or Stuck Off	Bank 2
P2662 [b]	"B" Rocker Arm Actuator System Stuck On	Bank 2
P2663 [b]	"B" Rocker Arm Actuator Control Circuit Low	Bank 2
P2664 [b]	"B" Rocker Arm Actuator Control Circuit High	Bank 2
P2665	Fuel Shutoff Valve "B" Control Circuit/Open	

TABLE B18—P26XX COMPUTER AND AUXILIARY OUTPUTS (continued)

DTC number	DTC naming	Location
P2666	Fuel Shutoff Valve "B" Control Circuit Low	
P2667	Fuel Shutoff Valve "B" Control Circuit High	
P2668	Fuel Mode Indicator Lamp Control Circuit	
P2669	Actuator Supply Voltage "B" Circuit /Open	
P2670	Actuator Supply Voltage "B" Circuit Low	
P2671	Actuator Supply Voltage "B" Circuit High	
NOTE 1) For DTCs P2604 - P2609 also see P0540 - P0543		
a) The "A" rocker arm actuator shall be either the "intake," "left," or "front" rocker arm actuator. Left/Right and Front/Rear are determined as if viewed from the driver's seating position. Bank 1 contains cylinder number one, Bank 2 is the opposite bank. Where only one rocker arm actuator is used for both conditions "A" and "B", use the DTCs for "A".		
b) The "B" rocker arm actuator shall be either the "exhaust," "right," or "rear" rocker arm actuator. Left/Right and Front/Rear are determined as if viewed from the driver's seating position. Bank 1 contains cylinder number one, Bank 2 is the opposite bank. Where only one rocker arm actuator is used for both conditions "A" and "B", use the DTCs for "A".		

B.34 P27XX Transmission

TABLE B19—P27XX TRANSMISSION

DTC number	DTC naming	Location
P2700	Transmission Friction Element "A" Apply Time Range/Performance	
P2701	Transmission Friction Element "B" Apply Time Range/Performance	
P2702	Transmission Friction Element "C" Apply Time Range/Performance	
P2703	Transmission Friction Element "D" Apply Time Range/Performance	
P2704	Transmission Friction Element "E" Apply Time Range/Performance	
P2705	Transmission Friction Element "F" Apply Time Range/Performance	
P2706	Shift Solenoid "F"	
P2707	Shift Solenoid "F" Performance or Stuck Off	
P2708	Shift Solenoid "F" Stuck On	
P2709	Shift Solenoid "F" Electrical	
P2710	Shift Solenoid "F" Intermittent	
P2711	Unexpected Mechanical Gear Disengagement	
P2712	Hydraulic Power Unit Leakage	
P2713	Pressure Control Solenoid "D"	
P2714	Pressure Control Solenoid "D" Performance or Stuck Off	
P2715	Pressure Control Solenoid "D" Stuck On	
P2716	Pressure Control Solenoid "D" Electrical	
P2717	Pressure Control Solenoid "D" Intermittent	
P2718	Pressure Control Solenoid "D" Control Circuit / Open	
P2719	Pressure Control Solenoid "D" Control Circuit Range/Performance	
P2720	Pressure Control Solenoid "D" Control Circuit Low	
P2721	Pressure Control Solenoid "D" Control Circuit High	
P2722	Pressure Control Solenoid "E"	
P2723	Pressure Control Solenoid "E" Performance or Stuck Off	
P2724	Pressure Control Solenoid "E" Stuck On	
P2725	Pressure Control Solenoid "E" Electrical	
P2726	Pressure Control Solenoid "E" Intermittent	
P2727	Pressure Control Solenoid "E" Control Circuit / Open	
P2728	Pressure Control Solenoid "E" Control Circuit Range/Performance	
P2729	Pressure Control Solenoid "E" Control Circuit Low	
P2730	Pressure Control Solenoid "E" Control Circuit High	
P2731	Pressure Control Solenoid "F"	
P2732	Pressure Control Solenoid "F" Performance or Stuck Off	
P2733	Pressure Control Solenoid "F" Stuck On	
P2734	Pressure Control Solenoid "F" Electrical	
P2735	Pressure Control Solenoid "F" Intermittent	
P2736	Pressure Control Solenoid "F" Control Circuit/Open	
P2737	Pressure Control Solenoid "F" Control Circuit Range/Performance	
P2738	Pressure Control Solenoid "F" Control Circuit Low	
P2739	Pressure Control Solenoid "F" Control Circuit High	

TABLE B19—P27XX TRANSMISSION (continued)

DTC number	DTC naming	Location
P2740	Transmission Fluid Temperature Sensor "B" Circuit"	
P2741	Transmission Fluid Temperature Sensor "B" Circuit Range Performance	
P2742	Transmission Fluid Temperature Sensor "B" Circuit Low	
P2743	Transmission Fluid Temperature Sensor "B" Circuit High	
P2744	Transmission Fluid Temperature Sensor "B" Circuit Intermittent	
P2745	Intermediate Shaft Speed Sensor "B" Circuit	
P2746	Intermediate Shaft Speed Sensor "B" Circuit Range/Performance	
P2747	Intermediate Shaft Speed Sensor "B" Circuit No Signal	
P2748	Intermediate Shaft Speed Sensor "B" Circuit Intermittent	
P2749	Intermediate Shaft Speed Sensor "C" Circuit	
P2750	Intermediate Shaft Speed Sensor "C" Circuit Range/Performance	
P2751	Intermediate Shaft Speed Sensor "C" Circuit No Signal	
P2752	Intermediate Shaft Speed Sensor "C" Circuit Intermittent	
P2753	Transmission Fluid Cooler Control Circuit/Open	
P2754	Transmission Fluid Cooler Control Circuit Low	
P2755	Transmission Fluid Cooler Control Circuit High	
P2756	Torque Converter Clutch Pressure Control Solenoid	
P2757	Torque Converter Clutch Pressure Control Solenoid Control Circuit Performance or Stuck Off	
P2758	Torque Converter Clutch Pressure Control Solenoid Control Circuit Stuck On	
P2759	Torque Converter Clutch Pressure Control Solenoid Control Circuit Electrical	
P2760	Torque Converter Clutch Pressure Control Solenoid Control Circuit Intermittent	
P2761	Torque Converter Clutch Pressure Control Solenoid Control Circuit/Open	
P2762	Torque Converter Clutch Pressure Control Solenoid Control Circuit Range/Performance	
P2763	Torque Converter Clutch Pressure Control Solenoid Control Circuit High	
P2764	Torque Converter Clutch Pressure Control Solenoid Control Circuit Low	
P2765	Input/Turbine Speed Sensor "B" Circuit	
P2766	Input/Turbine Speed Sensor "B" Circuit Range/Performance	
P2767	Input/Turbine Speed Sensor "B" Circuit No Signal	
P2768	Input/Turbine Speed Sensor "B" Circuit Intermittent	
P2769	Torque Converter Clutch Circuit Low	
P2770	Torque Converter Clutch Circuit High	
P2771	Four Wheel Drive (4WD) Low Switch Circuit	
P2772	Four Wheel Drive (4WD) Low Switch Circuit Range/Performance	
P2773	Four Wheel Drive (4WD) Low Switch Circuit Low	
P2774	Four Wheel Drive (4WD) Low Switch Circuit High	
P2775	Upshift Switch Circuit Range/Performance	
P2776	Upshift Switch Circuit Low	
P2777	Upshift Switch Circuit High	
P2778	Upshift Switch Circuit Intermittent/Erratic	
P2779	Downshift Switch Circuit Range/Performance	
P2780	Downshift Switch Circuit Low	
P2781	Downshift Switch Circuit High	
P2782	Downshift Switch Circuit Intermittent/Erratic	
P2783	Torque Converter Temperature Too High	
P2784	Input/Turbine Speed Sensor "A"/"B" Correlation	
P2785	Clutch Actuator Temperature Too High	
P2786	Gear Shift Actuator Temperature Too High	
P2787	Clutch Temperature Too High	
P2788	Auto Shift Manual Adaptive Learning at Limit	
P2789	Clutch Adaptive Learning at Limit	
P2790	Gate Select Direction Circuit	
P2791	Gate Select Direction Circuit Low	
P2792	Gate Select Direction Circuit High	
P2793	Gear Shift Direction Circuit	
P2794	Gear Shift Direction Circuit Low	

TABLE B19—P27XX TRANSMISSION (continued)

DTC number	DTC naming	Location
P2795	Gear Shift Direction Circuit High	

B.35 P28XX ISO/SAE Reserved

B.36 P2AXX Fuel and Air Metering and Auxiliary Emission Controls

TABLE B20—P2AXX FUEL AND AIR METERING AND AUXILIARY EMISSION CONTROLS

DTC number	DTC naming	Location
P2A00	O2 Sensor Circuit Range/Performance	Bank 1 Sensor 1
P2A01	O2 Sensor Circuit Range/Performance	Bank 1 Sensor 2
P2A02	O2 Sensor Circuit Range/Performance	Bank 1 Sensor 3
P2A03	O2 Sensor Circuit Range/Performance	Bank 2 Sensor 1
P2A04	O2 Sensor Circuit Range/Performance	Bank 2 Sensor 2
P2A05	O2 Sensor Circuit Range/Performance	Bank 2 Sensor 3

B.37 P30XX Fuel and Air Metering and Auxiliary Emission Controls

B.38 P31XX Fuel and Air Metering and Auxiliary Cmission Controls

B.39 P32XX Fuel and Air Metering and Auxiliary Emission Controls

B.40 P33XX Ignition System or Misfire

B.41 P34XX Cylinder Deactivation

TABLE B21—P34XX CYLINDER DEACTIVATION

DTC number	DTC naming	Location
P3400	Cylinder Deactivation System	*Bank 1*
P3401	Cylinder 1 Deactivation/Intake Valve Control Circuit/Open	
P3402	Cylinder 1 Deactivation/Intake Valve Control Performance	
P3403	Cylinder 1 Deactivation/Intake Valve Control Circuit Low	
P3404	Cylinder 1 Deactivation/Intake Valve Control Circuit High	
P3405	Cylinder 1 Exhaust Valve Control Circuit/Open	
P3406	Cylinder 1 Exhaust Valve Control Performance	
P3407	Cylinder 1 Exhaust Valve Control Circuit Low	
P3408	Cylinder 1 Exhaust Valve Control Circuit High	
P3409	Cylinder 2 Deactivation/Intake Valve Control Circuit/Open	
P3410	Cylinder 2 Deactivation/Intake Valve Control Performance	
P3411	Cylinder 2 Deactivation/Intake Valve Control Circuit Low	
P3412	Cylinder 2 Deactivation/Intake Valve Control Circuit High	
P3413	Cylinder 2 Exhaust Valve Control Circuit/Open	
P3414	Cylinder 2 Exhaust Valve Control Performance	
P3415	Cylinder 2 Exhaust Valve Control Circuit Low	
P3416	Cylinder 2 Exhaust Valve Control Circuit High	
P3417	Cylinder 3 Deactivation/Intake Valve Control Circuit/Open	
P3418	Cylinder 3 Deactivation/Intake Valve Control Performance	
P3419	Cylinder 3 Deactivation/Intake Valve Control Circuit Low	
P3420	Cylinder 3 Deactivation/Intake Valve Control Circuit High	
P3421	Cylinder 3 Exhaust Valve Control Circuit/Open	
P3422	Cylinder 3 Exhaust Valve Control Performance	
P3423	Cylinder 3 Exhaust Valve Control Circuit Low	
P3424	Cylinder 3 Exhaust Valve Control Circuit High	
P3425	Cylinder 4 Deactivation/Intake Valve Control Circuit/Open	
P3426	Cylinder 4 Deactivation/Intake Valve Control Performance	
P3427	Cylinder 4 Deactivation/Intake Valve Control Circuit Low	
P3428	Cylinder 4 Deactivation/Intake Valve Control Circuit High	
P3429	Cylinder 4 Exhaust Valve Control Circuit/Open	
P3430	Cylinder 4 Exhaust Valve Control Performance	
P3431	Cylinder 4 Exhaust Valve Control Circuit Low	
P3432	Cylinder 4 Exhaust Valve Control Circuit High	
P3433	Cylinder 5 Deactivation/Intake Valve Control Circuit/Open	
P3434	Cylinder 5 Deactivation/Intake Valve Control Performance	
P3435	Cylinder 5 Deactivation/Intake Valve Control Circuit Low	

TABLE B21—P34XX CYLINDER DEACTIVATION (continued)

DTC number	DTC naming	Location
P3436	Cylinder 5 Deactivation/Intake Valve Control Circuit High	
P3437	Cylinder 5 Exhaust Valve Control Circuit/Open	
P3438	Cylinder 5 Exhaust Valve Control Performance	
P3439	Cylinder 5 Exhaust Valve Control Circuit Low	
P3440	Cylinder 5 Exhaust Valve Control Circuit High	
P3441	Cylinder 6 Deactivation/Intake Valve Control Circuit/Open	
P3442	Cylinder 6 Deactivation/Intake Valve Control Performance	
P3443	Cylinder 6 Deactivation/Intake Valve Control Circuit Low	
P3444	Cylinder 6 Deactivation/Intake Valve Control Circuit High	
P3445	Cylinder 6 Exhaust Valve Control Circuit/Open	
P3446	Cylinder 6 Exhaust Valve Control Performance	
P3447	Cylinder 6 Exhaust Valve Control Circuit Low	
P3448	Cylinder 6 Exhaust Valve Control Circuit High	
P3449	Cylinder 7 Deactivation/Intake Valve Control Circuit/Open	
P3450	Cylinder 7 Deactivation/Intake Valve Control Performance	
P3451	Cylinder 7 Deactivation/Intake Valve Control Circuit Low	
P3452	Cylinder 7 Deactivation/Intake Valve Control Circuit High	
P3453	Cylinder 7 Exhaust Valve Control Circuit/Open	
P3454	Cylinder 7 Exhaust Valve Control Performance	
P3455	Cylinder 7 Exhaust Valve Control Circuit Low	
P3456	Cylinder 7 Exhaust Valve Control Circuit High	
P3457	Cylinder 8 Deactivation/Intake Valve Control Circuit/Open	
P3458	Cylinder 8 Deactivation/Intake Valve Control Performance	
P3459	Cylinder 8 Deactivation/Intake Valve Control Circuit Low	
P3460	Cylinder 8 Deactivation/Intake Valve Control Circuit High	
P3461	Cylinder 8 Exhaust Valve Control Circuit/Open	
P3462	Cylinder 8 Exhaust Valve Control Performance	
P3463	Cylinder 8 Exhaust Valve Control Circuit Low	
P3464	Cylinder 8 Exhaust Valve Control Circuit High	
P3465	Cylinder 9 Deactivation/Intake Valve Control Circuit/Open	
P3466	Cylinder 9 Deactivation/Intake Valve Control Performance	
P3467	Cylinder 9 Deactivation/Intake Valve Control Circuit Low	
P3468	Cylinder 9 Deactivation/Intake Valve Control Circuit High	
P3469	Cylinder 9 Exhaust Valve Control Circuit/Open	
P3470	Cylinder 9 Exhaust Valve Control Performance	
P3471	Cylinder 9 Exhaust Valve Control Circuit Low	
P3472	Cylinder 9 Exhaust Valve Control Circuit High	
P3473	Cylinder 10 Deactivation/Intake Valve Control Circuit/Open	
P3474	Cylinder 10 Deactivation/Intake Valve Control Performance	
P3475	Cylinder 10 Deactivation/Intake Valve Control Circuit Low	
P3476	Cylinder 10 Deactivation/Intake Valve Control Circuit High	
P3477	Cylinder 10 Exhaust Valve Control Circuit/Open	
P3478	Cylinder 10 Exhaust Valve Control Performance	
P3479	Cylinder 10 Exhaust Valve Control Circuit Low	
P3480	Cylinder 10 Exhaust Valve Control Circuit High	
P3481	Cylinder 11 Deactivation/Intake Valve Control Circuit/Open	
P3482	Cylinder 11 Deactivation/Intake Valve Control Performance	
P3483	Cylinder 11 Deactivation/Intake Valve Control Circuit Low	
P3484	Cylinder 11 Deactivation/Intake Valve Control Circuit High	
P3485	Cylinder 11 Exhaust Valve Control Circuit/Open	
P3486	Cylinder 11 Exhaust Valve Control Performance	
P3487	Cylinder 11 Exhaust Valve Control Circuit Low	
P3488	Cylinder 11 Exhaust Valve Control Circuit High	
P3489	Cylinder 12 Deactivation/Intake Valve Control Circuit/Open	
P3490	Cylinder 12 Deactivation/Intake Valve Control Performance	

TABLE B21—P34XX CYLINDER DEACTIVATION (continued)

DTC number	DTC naming	Location
P3491	Cylinder 12 Deactivation/Intake Valve Control Circuit Low	
P3492	Cylinder 12 Deactivation/Intake Valve Control Circuit High	
P3493	Cylinder 12 Exhaust Valve Control Circuit/Open	
P3494	Cylinder 12 Exhaust Valve Control Performance	
P3495	Cylinder 12 Exhaust Valve Control Circuit Low	
P3496	Cylinder 12 Exhaust Valve Control Circuit High	
P3497	Cylinder Deactivation System	Bank 2

B.42 P35XX ISO/SAE Reserved
B.43 P36XX ISO/SAE Reserved
B.44 P37XX ISO/SAE Reserved
B.45 P38XX ISO/SAE Reserved
B.46 P39XX ISO/SAE Reserved.

APPENDIX C
(NORMATIVE)
NETWORK COMMUNICATION GROUPINGS

C.1 U00XX Network Electrical

TABLE C1—U00XX NETWORK ELECTRICAL

DTC number	DTC naming	Location
U0001	High Speed CAN Communication Bus	
U0002	High Speed CAN Communication Bus Performance	
U0003	High Speed CAN Communication Bus (+) Open	
U0004	High Speed CAN Communication Bus (+) Low	
U0005	High Speed CAN Communication Bus (+) High	
U0006	High Speed CAN Communication Bus (–) Open	
U0007	High Speed CAN Communication Bus (–) Low	
U0008	High Speed CAN Communication Bus (–) High	
U0009	High Speed CAN Communication Bus (–) shorted to Bus (+)	
U0010	Medium Speed CAN Communication Bus	
U0011	Medium Speed CAN Communication Bus Performance	
U0012	Medium Speed CAN Communication Bus (+) Open	
U0013	Medium Speed CAN Communication Bus (+) Low	
U0014	Medium Speed CAN Communication Bus (+) High	
U0015	Medium Speed CAN Communication Bus (–) Open	
U0016	Medium Speed CAN Communication Bus (–) Low	
U0017	Medium Speed CAN Communication Bus (–) High	
U0018	Medium Speed CAN Communication Bus (–) shorted to Bus (+)	
U0019	Low Speed CAN Communication Bus	
U0020	Low Speed CAN Communication Bus Performance	
U0021	Low Speed CAN Communication Bus (+) Open	
U0022	Low Speed CAN Communication Bus (+) Low	
U0023	Low Speed CAN Communication Bus (+) High	
U0024	Low Speed CAN Communication Bus (–) Open	
U0025	Low Speed CAN Communication Bus (–) Low	
U0026	Low Speed CAN Communication Bus (–) High	
U0027	Low Speed CAN Communication Bus (–) shorted to Bus (+)	
U0028	Vehicle Communication Bus A	
U0029	Vehicle Communication Bus A Performance	
U0030	Vehicle Communication Bus A (+) Open	
U0031	Vehicle Communication Bus A (+) Low	
U0032	Vehicle Communication Bus A (+) High	
U0033	Vehicle Communication Bus A (–) Open	
U0034	Vehicle Communication Bus A (–) Low	
U0035	Vehicle Communication Bus A (–) High	

TABLE C1—U00XX NETWORK ELECTRICAL (continued)

DTC number	DTC naming	Location
U0036	Vehicle Communication Bus A (–) shorted to Bus A (+)	
U0037	Vehicle Communication Bus B	
U0038	Vehicle Communication Bus B Performance	
U0039	Vehicle Communication Bus B (+) Open	
U0040	Vehicle Communication Bus B (+) Low	
U0041	Vehicle Communication Bus B (+) High	
U0042	Vehicle Communication Bus B (–) Open	
U0043	Vehicle Communication Bus B (–) Low	
U0044	Vehicle Communication Bus B (–) High	
U0045	Vehicle Communication Bus B (–) shorted to Bus B (+)	
U0046	Vehicle Communication Bus C	
U0047	Vehicle Communication Bus C Performance	
U0048	Vehicle Communication Bus C (+) Open	
U0049	Vehicle Communication Bus C (+) Low	
U0050	Vehicle Communication Bus C (+) High	
U0051	Vehicle Communication Bus C (–) Open	
U0052	Vehicle Communication Bus C (–) Low	
U0053	Vehicle Communication Bus C (–) High	
U0054	Vehicle Communication Bus C (–) shorted to Bus C (+)	
U0055	Vehicle Communication Bus D	
U0056	Vehicle Communication Bus D Performance	
U0057	Vehicle Communication Bus D (+) Open	
U0058	Vehicle Communication Bus D (+) Low	
U0059	Vehicle Communication Bus D (+) High	
U0060	Vehicle Communication Bus D (–) Open	
U0061	Vehicle Communication Bus D (–) Low	
U0062	Vehicle Communication Bus D (–) High	
U0063	Vehicle Communication Bus D (–) shorted to Bus D (+)	
U0064	Vehicle Communication Bus E	
U0065	Vehicle Communication Bus E Performance	
U0066	Vehicle Communication Bus E (+) Open	
U0067	Vehicle Communication Bus E (+) Low	
U0068	Vehicle Communication Bus E (+) High	
U0069	Vehicle Communication Bus E (–) Open	
U0070	Vehicle Communication Bus E (–) Low	
U0071	Vehicle Communication Bus E (–) High	
U0072	Vehicle Communication Bus E (–) shorted to Bus E (+)	
U0073	Control Module Communication Bus Off	
U0074	Reserved by Document	
U0075	Reserved by Document	
U0076	Reserved by Document	
U0077	Reserved by Document	
U0078	Reserved by Document	
U0079	Reserved by Document	
U0080	Reserved by Document	
U0081	Reserved by Document	
U0082	Reserved by Document	
U0083	Reserved by Document	
U0084	Reserved by Document	
U0085	Reserved by Document	
U0086	Reserved by Document	
U0087	Reserved by Document	
U0088	Reserved by Document	
U0089	Reserved by Document	
U0090	Reserved by Document	

TABLE C1—U00XX NETWORK ELECTRICAL (continued)

DTC number	DTC naming	Location
U0091	Reserved by Document	
U0092	Reserved by Document	
U0093	Reserved by Document	
U0094	Reserved by Document	
U0095	Reserved by Document	
U0096	Reserved by Document	
U0097	Reserved by Document	
U0098	Reserved by Document	
U0099	Reserved by Document	

C.2 U01XX Network Communication

TABLE C2—U01XX NETWORK COMMUNICATION

DTC number	DTC naming	Location
U0100	Lost Communication With ECM/PCM "A"	
U0101	Lost Communication with TCM	
U0102	Lost Communication with Transfer Case Control Module	
U0103	Lost Communication With Gear Shift Module	
U0104	Lost Communication With Cruise Control Module	
U0105	Lost Communication With Fuel Injector Control Module	
U0106	Lost Communication With Glow Plug Control Module	
U0107	Lost Communication With Throttle Actuator Control Module	
U0108	Lost Communication With Alternative Fuel Control Module	
U0109	Lost Communication With Fuel Pump Control Module	
U0110	Lost Communication With Drive Motor Control Module	
U0111	Lost Communication With Battery Energy Control Module "A"	
U0112	Lost Communication With Battery Energy Control Module "B"	
U0113	Lost Communication With Emissions Critical Control Information	
U0114	Lost Communication With Four-Wheel Drive Clutch Control Module	
U0115	Lost Communication With ECM/PCM "B"	
U0116	Reserved by Document	
U0117	Reserved by Document	
U0118	Reserved by Document	
U0119	Reserved by Document	
U0120	Reserved by Document	
U0121	Lost Communication With Anti-Lock Brake System (ABS) Control Module	
U0122	Lost Communication With Vehicle Dynamics Control Module	
U0123	Lost Communication With Yaw Rate Sensor Module	
U0124	Lost Communication With Lateral Acceleration Sensor Module	
U0125	Lost Communication With Multi-axis Acceleration Sensor Module	
U0126	Lost Communication With Steering Angle Sensor Module	
U0127	Lost Communication With Tire Pressure Monitor Module	
U0128	Lost Communication With Park Brake Control Module	
U0129	Lost Communication With Brake System Control Module	
U0130	Lost Communication With Steering Effort Control Module	
U0131	Lost Communication With Power Steering Control Module	
U0132	Lost Communication With Ride Level Control Module	
U0133	Reserved by Document	
U0134	Reserved by Document	
U0135	Reserved by Document	
U0136	Reserved by Document	
U0137	Reserved by Document	
U0138	Reserved by Document	
U0139	Reserved by Document	
U0140	Lost Communication With Body Control Module	

TABLE C2—U01XX NETWORK COMMUNICATION (continued)

DTC number	DTC naming	Location
U0141	Lost Communication With Body Control Module "A"	
U0142	Lost Communication With Body Control Module "B"	
U0143	Lost Communication With Body Control Module "C"	
U0144	Lost Communication With Body Control Module "D"	
U0145	Lost Communication With Body Control Module "E"	
U0146	Lost Communication With Gateway "A"	
U0147	Lost Communication With Gateway "B"	
U0148	Lost Communication With Gateway "C"	
U0149	Lost Communication With Gateway "D"	
U0150	Lost Communication With Gateway "E"	
U0151	Lost Communication With Restraints Control Module	
U0152	Lost Communication With Side Restraints Control Module	Left
U0153	Lost Communication With Side Restraints Control Module	Right
U0154	Lost Communication With Restraints Occupant Sensing Control Module	
U0155	Lost Communication With Instrument Panel Cluster (IPC) Control Module	
U0156	Lost Communication With Information Center "A"	
U0157	Lost Communication With Information Center "B"	
U0158	Lost Communication With Head Up Display	
U0159	Lost Communication With Parking Assist Control Module	
U0160	Lost Communication With Audible Alert Control Module	
U0161	Lost Communication With Compass Module	
U0162	Lost Communication With Navigation Display Module	
U0163	Lost Communication With Navigation Control Module	
U0164	Lost Communication With HVAC Control Module	
U0165	Lost Communication With HVAC Control Module	Rear
U0166	Lost Communication With Auxiliary Heater Control Module	
U0167	Lost Communication With Vehicle Immobilizer Control Module	
U0168	Lost Communication With Vehicle Security Control Module	
U0169	Lost Communication With Sunroof Control Module	
U0170	Lost Communication With "Restraints System Sensor A"	
U0171	Lost Communication With "Restraints System Sensor B"	
U0172	Lost Communication With "Restraints System Sensor C"	
U0173	Lost Communication With "Restraints System Sensor D"	
U0174	Lost Communication With "Restraints System Sensor E"	
U0175	Lost Communication With "Restraints System Sensor F"	
U0176	Lost Communication With "Restraints System Sensor G"	
U0177	Lost Communication With "Restraints System Sensor H"	
U0178	Lost Communication With "Restraints System Sensor I"	
U0179	Lost Communication With "Restraints System Sensor J"	
U0180	Lost Communication With Automatic Lighting Control Module	
U0181	Lost Communication With Headlamp Leveling Control Module	
U0182	Lost Communication With Lighting Control Module	Front
U0183	Lost Communication With Lighting Control Module	Rear
U0184	Lost Communication With Radio	
U0185	Lost Communication With Antenna Control Module	
U0186	Lost Communication With Audio Amplifier	
U0187	Lost Communication With Digital Disc Player/Changer Module "A"	
U0188	Lost Communication With Digital Disc Player/Changer Module "B"	
U0189	Lost Communication With Digital Disc Player/Changer Module "C"	
U0190	Lost Communication With Digital Disc Player/Changer Module "D"	
U0191	Lost Communication With Television	
U0192	Lost Communication With Personal Computer	
U0193	Lost Communication With "Digital Audio Control Module A"	
U0194	Lost Communication With "Digital Audio Control Module B"	
U0195	Lost Communication With Subscription Entertainment Receiver Module	

TABLE C2—U01XX NETWORK COMMUNICATION (continued)

DTC number	DTC naming	Location
U0196	Lost Communication With Rear Seat Entertainment Control Module	
U0197	Lost Communication With Telephone Control Module	
U0198	Lost Communication With Telematic Control Module	
U0199	Lost Communication With "Door Control Module A"	

C.3 U02XX Network Communication

TABLE C3—U02XX NETWORK COMMUNICATION

DTC number	DTC naming	Location
U0200	Lost Communication With "Door Control Module B"	
U0201	Lost Communication With "Door Control Module C"	
U0202	Lost Communication With "Door Control Module D"	
U0203	Lost Communication With "Door Control Module E"	
U0204	Lost Communication With "Door Control Module F"	
U0205	Lost Communication With "Door Control Module G"	
U0206	Lost Communication With Folding Top Control Module	
U0207	Lost Communication With Moveable Roof Control Module	
U0208	Lost Communication With "Seat Control Module A"	
U0209	Lost Communication With "Seat Control Module B"	
U0210	Lost Communication With "Seat Control Module C"	
U0211	Lost Communication With "Seat Control Module D"	
U0212	Lost Communication With Steering Column Control Module	
U0213	Lost Communication With Mirror Control Module	
U0214	Lost Communication With Remote Function Actuation	
U0215	Lost Communication With "Door Switch A"	
U0216	Lost Communication With "Door Switch B"	
U0217	Lost Communication With "Door Switch C"	
U0218	Lost Communication With "Door Switch D"	
U0219	Lost Communication With "Door Switch E"	
U0220	Lost Communication With "Door Switch F"	
U0221	Lost Communication With "Door Switch G"	
U0222	Lost Communication With "Door Window Motor A"	
U0223	Lost Communication With "Door Window Motor B"	
U0224	Lost Communication With "Door Window Motor C"	
U0225	Lost Communication With "Door Window Motor D"	
U0226	Lost Communication With "Door Window Motor E"	
U0227	Lost Communication With "Door Window Motor F"	
U0228	Lost Communication With "Door Window Motor G"	
U0229	Lost Communication With Heated Steering Wheel Module	
U0230	Lost Communication With Rear Gate Module	
U0231	Lost Communication With Rain Sensing Module	
U0232	Lost Communication With Side Obstacle Detection Control Module	Left
U0233	Lost Communication With Side Obstacle Detection Control Module	Right
U0234	Lost Communication With Convenience Recall Module	
U0235	Lost Communication With Cruise Control Front Distance Range Sensor	

C.4 U03XX Network Software

TABLE C4—U03XX NETWORK SOFTWARE

DTC number	DTC naming	Location
U0300	Internal Control Module Software Incompatibility	
U0301	Software Incompatibility with ECM/PCM	
U0302	Software Incompatibility with Transmission Control Module	
U0303	Software Incompatibility with Transfer Case Control Module	
U0304	Software Incompatibility with Gear Shift Control Module	
U0305	Software Incompatibility with Cruise Control Module	

TABLE C4—U03XX NETWORK SOFTWARE (continued)

DTC number	DTC naming	Location
U0306	Software Incompatibility with Fuel Injector Control Module	
U0307	Software Incompatibility with Glow Plug Control Module	
U0308	Software Incompatibility with Throttle Actuator Control Module	
U0309	Software Incompatibility with Alternative Fuel Control Module	
U0310	Software Incompatibility with Fuel Pump Control Module	
U0311	Software Incompatibility with Drive Motor Control Module	
U0312	Software Incompatibility with Battery Energy Control Module A	
U0313	Software Incompatibility with Battery Energy Control Module B	
U0314	Software Incompatibility with Four-Wheel Drive Clutch Control Module	
U0315	Software Incompatibility with Anti-Lock Brake System Control Module	
U0316	Software Incompatibility with Vehicle Dynamics Control Module	
U0317	Software Incompatibility with Park Brake Control Module	
U0318	Software Incompatibility with Brake System Control Module	
U0319	Software Incompatibility with Steering Effort Control Module	
U0320	Software Incompatibility with Power Steering Control Module	
U0321	Software Incompatibility with Ride Level Control Module	
U0322	Software Incompatibility with Body Control Module	
U0323	Software Incompatibility with Instrument Panel Control Module	
U0324	Software Incompatibility with HVAC Control Module	
U0325	Software Incompatibility with Auxiliary Heater Control Module	
U0326	Software Incompatibility with Vehicle Immobilizer Control Module	
U0327	Software Incompatibility with Vehicle Security Control Module	
U0328	Software Incompatibility with Steering Angle Sensor Module	
U0329	Software Incompatibility with Steering Column Control Module	
U0330	Software Incompatibility with Tire Pressure Monitor Module	
U0331	Software Incompatibility with Body Control Module "A"	

C.5 U04XX Network Data

TABLE C5—U04XX Network Data

DTC number	DTC naming	Location
U0400	Invalid Data Received	
U0401	Invalid Data Received From ECM/PCM	
U0402	Invalid Data Received From Transmission Control Module	
U0403	Invalid Data Received From Transfer Case Control Module	
U0404	Invalid Data Received From Gear Shift Control Module	
U0405	Invalid Data Received From Cruise Control Module	
U0406	Invalid Data Received From Fuel Injector Control Module	
U0407	Invalid Data Received From Glow Plug Control Module	
U0408	Invalid Data Received From Throttle Actuator Control Module	
U0409	Invalid Data Received From Alternative Fuel Control Module	
U0410	Invalid Data Received From Fuel Pump Control Module	
U0411	Invalid Data Received From Drive Motor Control Module	
U0412	Invalid Data Received From Battery Energy Control Module A	
U0413	Invalid Data Received From Battery Energy Control Module B	
U0414	Invalid Data Received From Four-Wheel Drive Clutch Control Module	
U0415	Invalid Data Received From Anti-Lock Brake System Control Module	
U0416	Invalid Data Received From Vehicle Dynamics Control Module	
U0417	Invalid Data Received From Park Brake Control Module	
U0418	Invalid Data Received From Brake System Control Module	
U0419	Invalid Data Received From Steering Effort Control Module	
U0420	Invalid Data Received From Power Steering Control Module	
U0421	Invalid Data Received From Ride Level Control Module	
U0422	Invalid Data Received From Body Control Module	
U0423	Invalid Data Received From Instrument Panel Control Module	
U0424	Invalid Data Received From HVAC Control Module	
U0425	Invalid Data Received From Auxiliary Heater Control Module	

TABLE C5—U04XX Network Data (continued)

DTC number	DTC naming	Location
U0426	Invalid Data Received From Vehicle Immobilizer Control Module	
U0427	Invalid Data Received From Vehicle Security Control Module	
U0428	Invalid Data Received From Steering Angle Sensor Module	
U0429	Invalid Data Received From Steering Column Control Module	
U0430	Invalid Data Received From Tire Pressure Monitor Module	
U0431	Invalid Data Received From Body Control Module "A"	

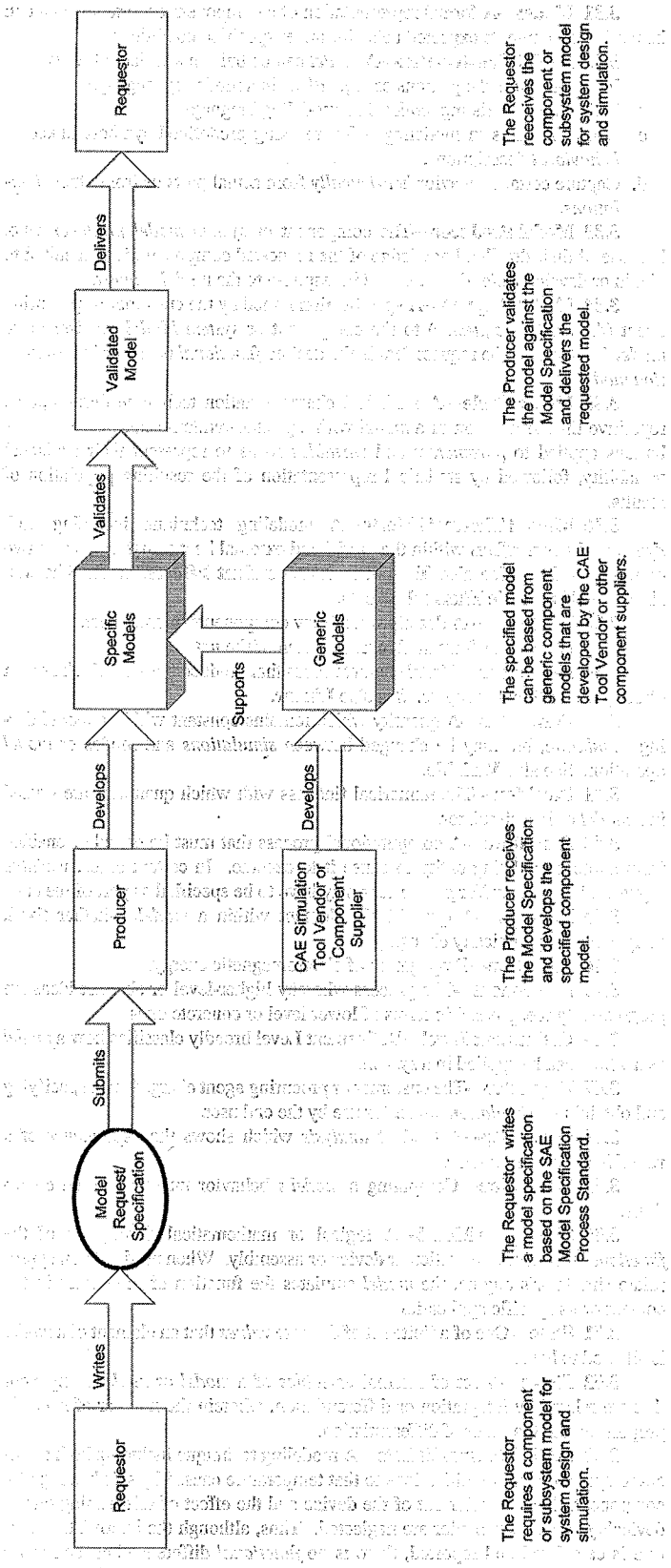

FIGURE 1—SIMULATION MODEL DEVELOPMENT UNDER THE MODEL SPECIFICATION PROCESS STANDARD

This Process has the benefits of having a common vocabulary and standard interpretation of what is being requested and what will be delivered. Essentially, this Standard improves the communication between the system integrators and the component manufacturers in the automotive industry and will enable the development of automotive systems that represent high customer *value*.

This document will focus on developing the *model* requirement guidelines (highlighted oval in Figure 1) and this will allow the development of the SAE Commodity Model Standards.

1.4 Application—This standard provides a guide for the development of *model request* specifications on a commodity-by-commodity basis. Each request specification describes the fundamentals of commodity behavior and contains a general "request form." This request form in turn contains pre-defined checklist table entries for *feature*/level options as well as placeholders for free-form text descriptions, graphics and other request-dependent information. A *model Requester* can then fill out a "blank" form for a given commodity to specify the level of detail and desired functionality that is expected for a generic *model* of a particular device. a *model Requester* can also request characterization of an existing generic *model* to make a *model* of a specific component or part number.

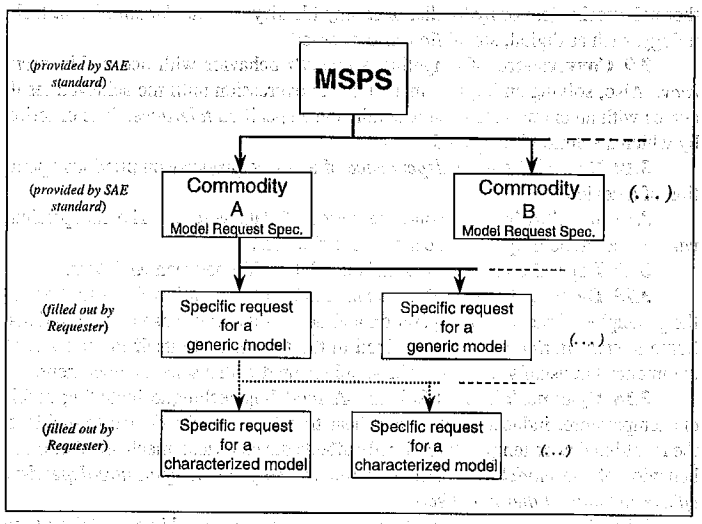

FIGURE 2—HIERARCHY OF COMMODITY MODEL SPECIFICATIONS IN RELATION TO DEFINED STANDARDS

2. *References*

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

2.1.1 IEEE PUBLICATIONS—Available From ANSI, 25 West 43rd Street, New York, NY 10036-8002 or Web server http://web.ansi.org, or http://standards.ieee.org.

IEEE Std 1076.1-1999—IEEE Standard VHDL Analog and Mixed Signal Extensions

IEEE Std 1076.4-1995—IEEE Standard for VITL Application-Specific Integrated Circuit-ASIC

IEEE Std 1364-1995—IEEE Standard Hardware Description Language Based on Verilog

IEEE Std 1499-1998—IEEE Standard Interface for Hardware Description Models of Electronic Components

IEEE Std 1481-1999—IEEE Standard for Integrated Circuit (IC) Delay and Power Calculation System

2.1.2 RELATED MODELICA INFORMATION—Modelica and the Modelica Association, http://www.modelica.org/documents.shtml.

The object-oriented modeling language Modelica is designed to allow convenient, component-oriented modeling of complex physical systems, e.g., systems containing mechanical, electrical, electronic, hydraulic, thermal, control, electric power or process-oriented subcomponents. The free Modelica language, free modelica libraries and Modelica simulation tools are available, ready-to-use and have been utilized in demanding industrial applications, including hardware-in-the-loop simulations. The development and promotion of Modelica is organized by the non-profit Modelic Association.

3. *Definitions*

3.1 Accuracy—The numerical closeness of fit of *model* behavior in *simulation*, to target data from the real world.

3.2 Algorithm—A formal recipe for solving a specific type of problem.

3.3 Analysis—Extracting behavior from description.

3.4 Argument—A piece of information that can be assigned or "passed" to an *instance* of a *model* prior to *simulation*. an avenue for setting or passing a *parameter* or a *variable*.

3.5 Behavioral—Descriptive of a *model* designed around results that represent physical behavior and internal workings of a device. see also *Functional*.

3.6 Connection—A modeling artifact that represents communication of data or signals into or out of other *model* components such as junctions, blocks, or circuit components. For electrical circuit *models*, *instances* of a component are embedded into a design document or *netlist* with their pins or *connection points* linked by *nets*.

3.7 Connection Point—An external linkage point on a *model*, usually corresponding to a port, terminal, connector or cavity on the physical device. in most cases, *connection points* must be attached to one or more external components for a valid *simulation*.

3.8 Connection Type—The specific technology or character of a *connection point* on a *model*, defining the allowable *connections* between *models*. The type may determine the physical character of a *connection*, such as electrical, thermal, mechanical or hydraulic, or it may identify a particular *simulation* technology, such as digital, signal *flow* or conserved.

3.9 Convergence—Computing a *model's* behavior with acceptable *accuracy*. Also, solving an implicit mathematical expression until the achieved result agrees with an extrapolated result within some specified *tolerance*. The criterion by which a solution is accepted.

3.10 Degradation—A *dependence* of a device *property* on previous operation of a device.

3.11 Distribution—A non-time series of data *values*. The independent *variable* could be frequency, location, deviation, etc.

3.12 Dependence—A characteristic relationship between *variables*.

3.13 Documentation—The *documentation* of a *model* explains to the user the principles of the *model's* operation and defines its proper use and limitations. Some *documentation* may be contained in the *template* file itself in the form of comments, but usually these must be supplemented with a separate document.

3.14 Dynamic Thermal Effects—A modeling technique including ambient temperature, induced heating and heat transfer from the device to ambient. the resulting device temperature directly affects the electrical, mechanical or other behavior of the *model*. see also *static thermal effects*, *temperature-dependent effects* and *mutual thermal effects*.

3.15 Feature—An aspect of an object's nature captured in a *model*, and the capability to control or acquire that aspect in *simulation*.

3.16 Feature Level—Feature Level classifies how an individual *feature* of a *model* can be applied.

3.17 Fidelity—The degree to which a representation, such as a *model*, captures the nature of the real object being represented.

3.18 Flat Model—A *model* that has no hierarchical structure, and which makes no use of subsidiary *models*, hence the opposite of *macromodel*.

3.19 Flow—A channel for data transfer within or among *models* during *simulation*.

3.20 Functional—Descriptive of a *model* designed to statically or dynamically represent its outputs as functionally dependent on its inputs, without regard for the physical processes involved. See also **Behavioral**.

3.21 Generation—Conversion of some other form of energy to thermal energy.

3.22 Heuristic—An adaptive framework for solving a class of problems.

3.23 Hierarchy—Use of the relationships and *dependencies* amongst the elementary components of a system as a basis for allocating functions and their associated higher levels of abstraction such as *Subsystems*.

3.24 High-level—Refers To levels of abstraction in a *model* that represent reduced *functional* specificity and detail; opposite of **Low-level**.

3.25 Instance—An *instance* is a single use of a *model* in a design, analogous to a subroutine call. Each *instance* identifies its parent *template*, its own unique identifier, the *interface* links to the design, and *values* for its attributes.

3.26 Interface—An element of a *model* which offers transfer of data into and out of the *model* during *simulation*. Compare to **Connection Point**.

3.27 Linear—*Model* characteristics that produce outputs which are directly proportional to inputs and give additive results from additive inputs. see also **Non-linear**.

3.28 Low-level—Refers to levels of abstraction in a *model* that represent increased *functional* specificity and detail; opposite of **High-level**.

3.29 Macromodel—A *simulation model* made up primarily or entirely of subsidiary *models*, with few or no mathematical or logical expressions at the immediate level of *model* definition.

3.30 Message—A text string emitted by a *model* during *simulation* to signify the occurrence of some significant event.

3.31 Model—A formal representation of a component or *system* which can be used to compute its expected behavior under specified conditions.

3.32 Model Construction—A *model* can be built in a variety of ways:

a. Write *behavioral* equations or *algorithms* in a modeling language.
b. Write calls to existing *models* in a modeling language.
c. Draw diagrams in modeling software using predefined symbols linked to *behavioral* descriptions.
d. Capture certain behavior *heuristically* from actual parts or from other *simulations*.

3.33 Model Producer—The component or *system model producer* who, because of their detailed knowledge of the requested component, is best suited to obtain or develop a *simulation model* in response to the *model request*.

3.34 Model Request—A specification issued by the customer or procuring agent (the *model Requester*) to the component or *system Model Producer* (the *model Producer*). The request details the desired *functional* behavior in a *simulation model*.

3.35 Monte Carlo—A statistical characterization technique that employs repetitive time-simulation of a *model* with a pseudo-random sequence of perturbations applied to *parameters* and *variables* so as to represent their statistical variability, followed by statistical representation of the resulting population of results.

3.36 Mutual Thermal Effects—A modeling technique including both *dynamic thermal effects* within the *model* and external heat transfer between two or more *models*. See also **Temperature-Dependent Effects**, **Static Thermal Effects** and **Dynamic Thermal Effects**.

3.37 Net (Nets)—A description of how components interconnect.

3.38 Netlist—A formatted representation of the *net*.

3.39 Non-linear—*Model* characteristics that produce outputs which are not directly proportional to inputs. See also **Linear**.

3.40 Parameter—A quantity which remains constant within a *model* during *simulation*, but may be changed between *simulations* and modes of *model* operation. See also **Variable**.

3.41 Precision—The numerical fineness with which quantities are treated in a *model* or in a simulator.

3.42 Procedure—A computational process that must be called or enabled from another modeling entity to cause it to execute. In certain cases, *variable* inputs and outputs and/or *parameters* may have to be specified as part of the call.

3.43 Property—A quantifiable element within a *model*, whether fixed, assignable or dynamically changing.

3.44 Radiation—Propagation of electromagnetic energy.

3.45 Refinement—The process whereby higher-level or abstract ideas are progressively reexpressed in terms of lower level or concrete ones.

3.46 Refinement Level—Refinement Level broadly classifies how a *model* as a whole can be applied in a *system*.

3.47 Requester—The customer or procuring agent charged with specifying and obtaining a *simulation model* for use by the end user.

3.48 Sensitivity—A kind of *analysis* which shows the *dependence* of a *variable* upon a *parameter*.

3.49 Simulation—Computing a *model's* behavior under specified conditions.

3.50 Simulation Model—A logical or mathematical description of the *functional* behavior of a particular device or assembly. When used with an appropriate simulator's engine, the *model* emulates the function of the device in the context of its specific application.

3.51 State—One of a finite set of discrete *values* that an element of a *model* is allowed to have.

3.52 States—A set of internal *variables* of a *model* or *model* component that are related by integration or differentiation, wherein the number of *states* is proportional to the order of differentiation.

3.53 Static Thermal Effects—A modeling technique including both ambient temperature and modifications to that temperature caused by self-heating of a component. Heat transfer out of the device and the effect of self-heating on the device's *functional* behavior are neglected. Thus, although the internal temperature is calculated and reported, there is no *functional* difference between *static thermal* and *temperature-dependent* behavior. See also **Dynamic Thermal Effects**, **Temperature-Dependent Effects** and **Mutual Thermal Effects**.

3.54 Steady-state—Conditions in a *simulation* which can be effectively extrapolated as being directly proportional to time beyond the end of simulated time.

3.55 Stress—A measure of a *property* or *model parameter* exceeding its desired or usual range.

3.56 Subsystem—A *system* that is a part of a larger *system*.

3.57 System—A group of interdependent components which perform a function.

3.58 Temperature-Dependent Effects—A modeling technique wherein certain *model parameters* are represented via user input as being dependent upon ambient temperature. See also **Static Thermal Effects**, **Dynamic Thermal Effects** and **Mutual Thermal Effects**.

3.59 Template—The master copy of a *model* from which *instances* are drawn. The *template* defines the *model's* name, *interfaces*, attributes and behavior.

3.60 Tolerance—The allowable range of values of a *parameter* or *variable*.

3.61 Validation—Testing a *model* via *simulation* to confirm compliance to requirements.

3.62 Value—A single quantity associated with a *model property* at some converged stage of a *simulation*.

3.63 Variable—A *model* quantity that is subject to variation with respect to time or internal *states* of the *model*. See also **Parameter**.

3.64 Waveform—A time series of data *values*. The *values* may be discrete or samples of a continuous *waveform*. The sequence of data *values* may represent a periodic function, a continuously-varying signal without any repetitive *features* or a combination of periodic and non-periodic *features*.

4. EE Commodity Analysis and Modeling Considerations—Automotive EE Commodities are electrical or electronic components of automobiles that are subject to procurement by automobile manufacturers. A structured list of automotive EE commodities is provided in Appendix A as a reference example of the range of electrical and electronic components that are considered to be automotive EE Commodities as of 1998.

The *Requester* shall specify analysis requirements for the EE Commodity subject to model procurement (and possible eventual commodity procurement). The R analysis requirements implicitly define most of the modeling requirements; however, the *Requester* may wish to define specific requirements for how modeling is to be accomplished within the context of the modeling and simulation tools specified in the analysis requirements. The following sections address the analysis requirements first, and then build upon that foundation in discussion of the modeling requirements.

4.1 Analysis Requirements—This section provides guidance as to what analyses the *Requester* will provide for in the model. Other chapters of the Specification define requirements for specifying model composition.

As applicable to a particular model, the analysis requirements defined by the *Requester* shall specify the following (each point is discussed in greater detail elsewhere in this document):

a. The system context and tool environment in which the model is to be used (4.1.1, 4.1.2).
b. Which commodity the model is to represent (Appendix A).
c. Which aspects of the commodity are to be represented in the model (Section 5).
d. Identifiers such as the filename, model name and graphical symbol representation (9.1.1.4).
e. The *connection points*, along with the name, type and unit designation of each (6.2).
f. Model *arguments*, their names, unit designations, default *values* and definitions (6.6).
g. Existing models that may be used as sub-models within the model (7.2).
h. Existing models that serve as useful examples in the development of the model (6.3).
i. *Properties* or behaviors to be characterized within the model (5.2).
j. The modeling style or methodology that should be followed (9.1).
k. Any empirical data that should be directly incorporated into the model (8.2).
l. Any physical principles that should be incorporated into the model (4.2).
m. Any test data or test conditions to be used in validating the model (Section 8).
n. The expected range of inputs and physical environments applied during simulation (6.5).
o. The model's response to overstress conditions (7.3.2).
p. Expected warning and error *messages* to be issued by the model (7.3).
q. Any special *features* desired in the model (5.2).

Each component model shall be validated by means of simulations providing deliverable data. These are intended to characterize the model's performance in the context of the actual component's physical environment as well as the model's simulation environment.

4.1.1 TYPES OF ANALYSIS—Several different types of analysis may be required for each commodity, at the discretion of the *Requester*. The electrical inputs, model *parameter* variations, and operating environments for each analysis level shall be defined by the *Requester* as part of the Analysis Requirements. The *Requester* shall specify which types of analysis must be performed by the Producer to provide a basis for verification and *validation*. Examples of common analysis types that may be required include the following:

a. **Continuity and Loads Analysis**, wherein the internal circuit paths and resistance of such paths are completely specified, and the *steady-state* currents drawn by the commodity are determined by the *model producer* for the specified input voltage ranges.
b. **Nominal Analyses**, wherein the electrical inputs and operating environments of the commodity are within the range of normal usage and the model *parameters* and inputs are not stochastically represented. the ranges of the electrical inputs and the operating environments shall be defined in the analysis requirements. nominal analyses may include:
   1. DC analysis.
   2. Transient analyses such as step response.
   3. Frequency-domain or Fourier analysis including frequency response in the form of Bode or Nichols analyses, and stability analyses including root loci and eigenvalues.
c. ***Stress* Analysis**, wherein the performance of individual components within a circuit or system is evaluated for operation outside of accepted electrical, thermal or mechanical limits.
d. **Perturbation or *Sensitivity* Analyses**, wherein the performance results are subjected to statistical or operating-band characterization, while the model *parameters*, inputs, and operating environments are not subjected to stochastic or deterministic variation from the norm. Modeling of electrical noise and its associated effects may be required.
e. **Worst-Case Analyses**, wherein simulations are accomplished with the model *parameters*, inputs, and operating environments applied at their upper and lower extremes.
f. **Failure Modes and Effects Analyses (FMEA)**, wherein failure modes of the commodity are identified, represented in the model, and simulated to determine the model outputs over a range of *parameter values*, electrical inputs and operating environments.
g. **Sneak Circuit Analysis (SCA)**, wherein an unintentional current path or voltage level caused by a switch-*state* combination, also referred to as a circuit state (whether under failure or no failure conditions), or an unanticipated interaction between components may cause an undesired function to occur or inhibit a desired function.

4.1.2 ANALYSIS METHODOLOGY AND SIMULATION TOOLS—The *Requester* shall specify which analysis tools the Producer is to use, making sure that they are identical to those used by the *Requester* for purposes of verification and *validation*. The range of applications covered by commercially-available modeling and simulation tools is comprehensive, as indicated by the following examples of generic applications and associated languages:

a. Analog hardware description language or AHDL
   (Examples: Saber/Mast, Spice, P-Spice, Simplorer)
b. Digital hardware description language such as VHDL or Verilog
   (Example vendors: Synopsis, Mentor, Verilog)
c. Mixed Signal hardware description language or VHDL-AMS (IEEE VHDL1076.1)
   (Examples: Saber/Mast, Accusim II, Simplorer, hAMSteR)
d. Block Diagram or Dataflow programming
   (Examples: MATRIXx, Simulink, Easy-5, ACSL, Simplorer)
e. Statecharts or *State* Transition Diagrams
   (Examples: Statemate, Betterstate, MATRIXx/SystemBuild, Simulink/Stateflow, RDD2000, ObjecTime, Simplorer)
f. Network modeling applied to quantitative *flow* (cost, power, energy, etc.) problems
   (Examples: Directed Graphs, BondGraphs, MPORT, Opnet)
g. Mechanical dynamics modeling environments
   (Examples: ADAMS, DADS, IDEAS, ANSYs)
h. Mathematical-language *behavioral* programming (Metalanguage or scripting capability)
   (Examples: Mathcad, MATRIXx/ Xmath, MATLAB, Maple, Mathematica)
i. Higher-Order-language (HOL) programming in a binary-compilable language
   (Examples: C, C++, Ada, Fortran, JAVA, LISP, PERL, FORTH)

4.2 Modeling Considerations—The analysis requirements defined by the *Requester*, as above, fully define the form and extent of analyses to be performed.

However, many automotive EE Commodities contain multiple differentiated components, and may require multiple modeling domains to properly model and simulate the desired behaviors. Such commodities generally require special modeling techniques to correctly capture the desired attributes in simulation, as discussed in the following subsections.

4.2.1 MODELING OF WHOLLY ELECTRICAL COMMODITIES—Whenever a subject automotive electrical or electronic commodity can be modeled entirely as an electrical circuit, the *Requester* should require the Producer to utilize digital, analog, or mixed-signal circuit modeling and simulation tools to implement the model and perform the required analyses. Wholly Electrical Commodities may consist of simple electrical components (resistors, capacitors, inductors, transistors and diodes), electrical networks composed of such components, and integrated circuits in the form of analog devices, mixed analog/digital devices and digital processing units. Electronic Control Modules (ECMS) are also considered to be Wholly Electrical Commodities, although their complex logical behavior requires some special consideration (4.2.4).

4.2.2 MODELING OF MECHATRONIC COMMODITIES—Mechatronic commodities embody some combination of electrical and physical (non-electrical) inputs, outputs, or internal functions, and are generally actuators, sensors, or electrical relays or fuses. Actuators utilize electrical inputs to produce exogenous effects such as mechanical forces and associated motion, fluid (gas or liquid phase) transport, or heat *generation*; examples include solenoids, solenoid or motor-driven valves, electric motors, ignition circuits, spark plugs and heating elements. Sensors convert the physical *states*, environments, or fluid compositions they are exposed to into electrical signals; examples include manifold pressure and temperature sensors, shaft angular position and speed sensors, and oxygen sensors.

Means of representing the mechanical inputs or outputs of mechatronic components must be defined by the *Requester* or specifically assigned to the Producer. This includes specification of parametric loads and load models to be applied to actuator outputs or sensor inputs.

The modeling and simulation environment/tools may have to support concurrent electrical circuit simulation, mechanical dynamics simulation, heat and fluid mass transport (thermodynamics and fluid dynamics) simulation, and arbitrary *algorithm* simulation. Most of the analysis and simulation tools listed above can represent most of these mixed-mode modeling and simulation requirements to varying degrees of *fidelity*. In some cases, co-simulation using multiple communicating modeling environments may be required. The *Requester* shall specify how the required modeling and simulation tools and tool-specific modeling methodologies are to be used in analysis of mechatronic commodities, including any application of co-simulation methods.

4.2.3 MODELING NON-ELECTRICAL ENTITIES IN THE CONTROL LOOP—Every closed-loop control system is composed of actuators, the controlled entity (the "Plant"), sensors, and a control processing element. Therefore, thorough analysis of actuator, sensor, and control processing commodities requires modeling and simulation of a controlled entity to an extent where cause-and-effect relationships between actuators and sensors are captured in the model. Examples of controlled entities include hydraulics and suspension/wheel dynamics associated with anti-skid braking systems, and engines subject to control of ignition timing, injector pulsewidth and throttle position.

When controlled entities are relevant to the required analyses for actuator or sensor commodities, the *Requester* shall specify the modeling Level (as outlined in Section 5) as minimum, and consideration shall be given to the controlled entity model to be used. If the *Requester* is procuring a controller, models of controlled entities must represent their input/output gain and phase characteristics with sufficient *accuracy* that variation of the model *parameters* can represent all *instances* of behavior of the controlled entity. The modeling, simulation and analysis Requirements provided by the *Requester* shall clearly define the controlled-entity components to be modeled, as well as the modeling basis and modeling *accuracy* required. It may be adequate to represent non-electrical controlled entities using simple transfer functions.

4.2.4 MODELING OF CONTROL MODULES—Control Modules incorporate analog circuits, digital logic, or both. Examples of control modules include controllers for powertrains, ABS, power steering transfer cases, power steering, lighting, navigation and HVAC. A key *property* of these devices is they will typically include embedded software.

Modeling and analysis of the analog and digital electrical circuits may require an analog simulator, a digital system simulator that captures the device behavior down to the register transfer level, or a mixed-signal simulator that concurrently represents the analog and digital functionality of the device. Analysis of the logical and algorithmic functionality of the control module may require a gate-array simulator, or software representation of the logical behavior and *algorithms* in some higher-level simulation language such as VHDL, C, or a graphical block-diagram or dataflow programming language that represents *state* transitions (control of *flow*) and algorithmic processes directly in the form of executable mathematical entities.

4.2.5 CONTROL SYSTEM MODELING—The *Requestor* shall specify the extent to which modeling and simulation of the complete control system shall be performed by the producer, including the control module simulation and simulations of the control actuators, the controlled entity and the sensors that feed information back to the control module. If closed-loop modeling and simulation is required, the *Requester* shall define the modeling *fidelity* level required for the actuators, sensors, and controlled entity, and either completely define these models or allocate their definition to the Producer.

It is often necessary to implement closed-loop simulations within a single modeling environment, which may require the transfer of models from one modeling environment to another. However, co-simulation standards such as CORBA (Common Object Reference Broker Architecture) are being adopted by several tool vendors, making it unnecessary to convert models from one environment to another if all of the modeling environments used have common co-simulation *interfaces*.

***5. Modeling Fidelity Levels*—**Models can be classified according to sophistication, capability and captured intelligence. This is challenging because of the many dimensions of model fidelity, which may be sequential, parallel, independent, contradictory and/or redundant. Two such dimensions, model *refinement* and *feature* control, are each quantified on a scale of 0 to 7.

5.1 Levels of Model Refinement—The following level definitions provide a useful shorthand for discussing progressive stages of model *refinement*. Each successive level includes the capabilities of the previous levels. These broad categories range from no model at all, to a model representing all relevant dimensions. Finer distinctions of *refinement level* become difficult to classify in a *linear* progression.

level 0 - **"Null"** - no model exists -
No representation yet exists in electronic form.

level 1 - **"Place"** - A placeholder with identifying attributes but no connectivity or behavior -
This could be a database representation of a component. it may include name, description, part number, cost, etc. Such a representation could be used to generate bills of material, cost reports, size or reliability estimates of a system.

level 2 - **"Pins"** - A model with named *interfaces* to the external system, but no internal *features* -
A representation including the component's *interface* elements or pinouts. This could take the form of a schematic symbol of the component or a pinout table. Such a representation could be used to build a *system* design, a schematic diagram, to perform placement and routing, or for complexity analysis.

level 3 - **"Paths"** - a model with identification of internal *states* and connectivity, but no behavior -
This is the first level that allows the most basic forms of simulation, such as sneak circuit analysis. A model at this level contains qualitative information about the component's internal structure, its possible *states* and *flows*, but without quantitative definitions. For example, a relay has ON and OFF *states*, and conduction paths for the contacts, but no electrical resistance or *behavioral* coupling between coil and contacts.

level 4 - **"Static"** - a model with time-invariant, *steady-state* internal behavior -
A model of this level has primary quantitative *properties*. It is typically useful for dc or *steady-state* ac analysis, but is not sufficient for transient analysis. for example, a motor armature might be treated as a resistor, or a wire could be treated as a resistance.

level 5 - **"Dynamic"** - a model with time-varying behavior -
A model of this level is suitable for transient analysis, and may include *nonlinear* characteristics. This level captures the principal time-dependent behavior of the component, but may ignore more subtle effects. For example, a motor may have inductance, as well as mechanical effects like inertia and friction, but not cogging or backlash. A wire's resistance could vary with self-heating.

level 6 - **"*Precision*"** - a model with significant secondary behavior patterns -
A model of this level goes beyond the primary requirements for time-varying behavior. A motor model might have core saturation, cogging, brush arcing, bearing wobble, etc. A wire could react to external thermal loading. A switch could have bounce, arcing, wetting current and aging effects.

level 7 - **"Vector"** - a model with directional or spatial *interfaces* -

A model of this level goes beyond one-dimensional lumped *connection points* to *interface* with neighboring components. it may use multiple *connection points* or a *distribution* function to achieve this. For example, a wire model may have an axial heat *flow* for each end plus a radial heat *flow* from the center. A lamp or antenna may have a *radiation* pattern.

Most models in general use would probably be in the range of levels 4 to 6. Levels 3 and 7 have more specialized applications. Levels 0 through 2 are not suitable for simulation, but support other types of design verification.

The level of refinement needed in a model can depend on the type of analysis to be performed or the application. Consider a solenoid model. In a level 4 context, the dc electrical resistance may be sufficient. In a level 5 context, it would include inductance. In level 6, electromechanical coupling and mechanical effects would be required and their effects reported.

A model could be regarded as having the *fidelity* level of its most central *feature* in the context of interest, but this does not necessarily signify the *fidelity* of individual *features* of the model. For example, a wire model may or may not have self-inductance at level 5, depending whether the intended applications cover a frequency range where inductance is significant. However, the wire model could still be classified as level 5, because it has time-dependent self-heating behavior. Feature-specific level classification is treated in the next section.

5.2 Levels of Feature Content—Similar level definitions may be used to describe individual model *feature* content, and thereby imply a level of intelligence contained in the model. *There are several channels through which captured model* features, *including* instance arguments, *global* parameters and connection points *are referenced to internal* variables. Examples of individual *features* include such effects as temperature dependency, manufacturing *tolerance*, aging efects, cycling effects and *stress* behavior in the model.

level 0 - **"none"** - *feature* not included in model -
For example, there may be neither temperature *dependence* nor manufacturing variation implemented in the model.

level 1 - **"Named"** - *feature* acknowledged in model, but not implemented -
For example, the temperature limit of wire insulation may be documented in the model (possibly as a comment), but there is no result from exceeding the limit, neither catastrophic change, nor *stress* ratio, nor warning *message*.

level 2 - **"Fixed"** - *feature* can be adjusted only by editing the model or by adjusting a non-related *argument* -
For example, as applied to the resistance of an element, the model has a fixed *value*. As applied to *tolerance* on the resistance, the nominal resistance might be specified by the user, but the model does not have a *tolerance* "perturbation" *argument*, nor does it respond to *Monte Carlo* commands. However, the user could resort to tweaking the nominal resistance *argument* to see the effect of *tolerance*.

level 3 - **"Index"** - *feature* offers a choice of discrete *values* or modes -
For example, a *tolerance feature* might offer a choice of "min," "nom" and "max." An aging *feature* might offer "new," "fiveyears," "tenyears," "endoflife," etc. A temperature dependent *feature* might offer "-40C," "25C" and "100C."

level 4 - **"Static"** - *feature* accepts any *parameter value* as set prior to simulation run -
For example, a resistance can be set to any positive real *value* by *argument*. A local ambient temperature can be set by *argument*. With respect to temperature *dependence*, the resistance would be affected by the local or global ambient temperature. An arbitrary statistical variation could be set prior to simulation, by *argument*, or by the simulator in *Monte Carlo* or worst-case analysis. With respect to an aging *feature*, an arbitrary age could be set prior to simulation and the component's behavior would reflect the predetermined *degradation* for that age.

level 5 - **"Dynamic"** - *feature* adapts to internal conditions during simulation -
For example, resistance could vary dynamically with self-heating, as would the device temperature. The effects of aging would run their course during the simulation, provided the time scale of the run is appropriately long. Notice that this last example suggests a need for a multi-level strategy to accommodate very short and very long time scales in the case of certain *features* like aging and cycling.

level 6 - **"Mutual"** - *feature* adapts to external influences during simulation -
For example, the self-heating of a resistance is affected dynamically by heating or cooling from an external model, such as a heat sink. This would require a "thermal pin" or a co-simulation link. Aging or cycling effects could be accelerated by connecting a ramp generator to an "age pin."

level 7 - **"Directional"** - *feature* adapts to directional external influences during simulation -
For example, a fuse could dissipate heat to both ambient air and through each of its terminals. A light sensor might respond to distance, angle and brightness signals from a light source model.

In general, the *feature level* of one model *feature* is independent of the *feature level* of other *features*. Therefore, each *feature* requires its own level classification. This can range from a *feature* not being included in the model at all, to fully automatic behavior based on information contained in the model.

The example of a simple resistor model can be used to show a variety of *features*: variation with temperature, manufacturing *tolerances*, aging, on/off cycles, temperature cycles, self inductance, noise, power rating and derating, thermal response, etc. Model *features* should be chosen in accordance with the intended applications.

5.3 Forms of Simulation Results—A *model request* may require results in a variety of forms. The form of result may depend upon the type of simulation performed on the model. The result may be available dynamically during the simulation run, or only at the completion of the simulation.

Common types of simulation results include the following:

a. "Flag" - a true/false, or pass/fail result.
b. "*Message*" - an event during simulation generates an informative textual output.
c. "Scalar" - a single value results from simulation with regard to the property.
d. "*Waveform*" - a series expressing the change in *value* of a *variable* over time or frequency.
e. "Relation" - a non-time series expressing the interaction of two or more *variables* (temperature, *sensitivity*, statistical *distribution*, etc.).
f. "Link" - dynamic transfer of simulation results among two or more simulators.

5.4 Diminishing Returns of *Fidelity*—A simulation model can never capture all aspects of a component's behavior. Even if it could, the computation cost would be prohibitive, as would the development time and cost. Therefore a model is designed to a limited level of fidelity, acceptable for a particular range of applications.

The most detailed model is not always the most applicable for a given objective. "Good" is relative to the needs of the analysis. The higher the level of *features*, the longer the simulation may take, the more likely *convergence* difficulties may be encountered during simulation, and the greater the cost and time needed to develop the model.

In fact, a detailed model built from a *hierarchy* of lower level component models may be less accurate than a *flat model* based on simple *behavioral* equations, because of accumulated error in the *hierarchy*.

5.5 Accommodating Different Fidelity Needs in a Model—To specify model requirements, it is first necessary to determine the desired level of model *refinement* for the intended application. Then, the desired model's *features* should be specified with associated levels of *feature* content for each.

There are several ways to maintain versatility in model *fidelity*:

a. Use a model having an *argument* that switches certain *features* on or off.
b. Maintain separate models for different kinds of analysis.
c. Generate models on demand from a higher-level description or a user-interface tool.

***6. Model Assumptions*—**This section defines the macroscopic conditions within which the model will be expected to operate. The conditions include the units of measurement, the *connection types*, the external conditions that will be applied to the model, the input/output specifications and compatibility issues.

6.1 Units of Measurement—Units of measure shall be defined for all input and output *parameters* of the model, including *messages*; SI units are preferred.

6.2 Connection Type Definition—This section will be used to define the types of *connections* to the model, such as electrical, mechanical, hydraulic, etc., and the names of *connection points* that will be referred to from other models and from within this model. The *Requester* shall specify allowable *connection types* for the producer to use in the deliverable simulation models.

A *connection* is defined as a point from which information is allowed to *flow* into or out of the model. These *connection points* are commonly referred to as "pins." For models where conservation principles are used in the system solution, the pins define the only points at which the conserved quantity (current, fluid *flow*, etc.) can enter or leave the model. For models where nonconservative quantities are used, pins represent local data flowing into or out of the device, and any *variable* required for use in another model should be defined as a pin.

TABLE 1—CONNECTION TYPE EXAMPLES

Connection Type	Name	Description	Units
Electrical	Out	Output pin of the device	Volts, Amps
Thermal	Th	Thermal connection to bulb	° C, Watts
Mechanical – rotational	Shaft	Motor shaft speed & torque	Rad/s, N-m
Data flow	Error	Output error signal	(data dependent)

The component and *system* modeling environments available *feature* a variety of ways to represent communication of electrical signals and data between components. For example, the electrical *connection type* (or "electrical pin") captures the behavior of an electrical *connection*. The connection has the attributes allowing current or signals to *flow* in either of two directions, and the *flow* of current in response to potential difference is represented in accordance with fundamental electrical rules (Kirchoff's Voltage and Current Laws, etc.).

6.2.1 STANDARD SIGN CONVENTION—To ensure compatibility between models, the standard conserved quantity *flow* shall be defined as positive when it *flows* into a *connection point*, negative otherwise. This standard interpretation applies to conserved component models, which require mechanical, thermal, hydraulic, and/or other types of *connections* wherein continuity conditions are enforced on both sides of component *interfaces*.

Non-conserved models will employ simpler dataflow *connections* wherein components are defined as having distinct data inputs and outputs that *flow* in one direction between components. No sign convention is required for these *connection types*, as the *value* of the unidirectional signal determines its sign.

For quantities where the sign is relevant to a physical interpretation of the model, such as the rotational direction of a motor, the *Requester* shall specify the *connection points* so as to conform to the desired physical interpretation as well as the sign conventions defined above.

6.3 Reference—This section is used to identify any referenceable source of information to be used in defining the model.

6.4 Modeling Assumptions—This section should detail any assumptions regarding what model behaviors are to be represented. Behaviors such as thermal effects should be documented as being either considered in detail or simplified. In addition to the positive assumptions about included model behavior, it is important to specify any negative assumptions about which behaviors or technologies are to be neglected.

6.5 Environmental And Operating Conditions—Describe the environmental and operating conditions that will be applied to this model. These shall include all valid regions of operation, such as temperature ranges, voltage ranges, minimum and maximum torque, or pressure.

6.6 Input Parameters—*Parameters* are those *values* that are fixed for the duration of a particular simulation run. The *Requester* shall define the simulation model's input *parameters* and valid ranges for each. This includes *parameters* that represent characteristics of the component as well as those implementing control of the model.

TABLE 2—INPUT PARAMETER EXAMPLES

Parameter	Default Value	Units	Parameter Description
Cable	PVC	None	Class (insulation, wall)
Gauge	None	AWG	List of wire sizes
TempC	27	°C	Ambient Temperature
Messages	ON	[ON | OFF]	Enable or disable messages

6.7 Supplementary Output *Variables*—Specify the desired output *variables* that must be made available from the model. Output *variables* consist of internal model *variables* that are made available as part of the simulation results. It is also possible to specify an optional valid range for each output to be used in *message* creation.

TABLE 3—SUPPLEMENTARY OUTPUT VARIABLE EXAMPLES

Variable	Allowed Range	Units	Variable Description
RPM	0 to 4000	Revolutions/minute	Motor speed
Speed	Any	Km/Hour	Vehicle Speed
TempC	-40 to 125	°C	Device temperature

7. Model Architecture—This section outlines the general requirements for requesting and developing standard simulation model architectures. Wwhereas the previous section described assumptions about the model's environment and external *interfaces*, this section is concerned with internal model characteristics, which dictate how the model responds to its simulated environment. Included are *functional* requirements for input and output signals, and basic requirements for defining component behavior. in each case, the model and *feature level* designations will determine the degree of detail required in its behavior.

7.1 External Signal Interface Requirements—All time-varying input signals to a model shall be defined as external *connections*. The model specification should make it clear whether time-invariant *connections*, such as power supply and ground signals, should be considered as external *connections*. All time-varying output signals corresponding to an electrical or other transport *property* output of the model, including logic and dataflow outputs, shall also be defined as external *connections*.

Any limitations a model may impose on an input signal (such as frequency or magnitude) should be clearly identified. Input or output conditions that would result in damage to the physical device should, at a minimum, generate a warning *message*. Depending on the model requirements, the model may also exhibit appropriate output behavior, device failure effects or other phenomena in response to an excessive internal condition.

Input and output signals can be defined as logic *states*, dataflow inputs, conserved electrical *connections* or conserved non-electrical *connections*. External signal handling in a model will be implemented as a function of model and *feature levels*, as defined in Section 3.

7.2 Model Internal Requirements—The purpose of the model is to use mathematical and/or logical constructs to emulate the *functional* behavior of the component to a degree mandated by the requested model level. Within the constraints imposed by input and output considerations detailed in the previous section, the model may use any capabilities available in the target simulator to implement the required functionality. If possible, model functions should be independent of factors outside the simulation environment, such as computer type, operating system, software language compiler or simulator version. If this is not possible, any external *dependencies* should be clearly defined in the *documentation*, and some means should be provided to allow use of the model outside its native environment. aAs an example, source code should be provided to the *Requester* for any software *procedures* used in a model.

If supported by the simulation tool, the model may reference subsidiary models or *procedures* to implement common behaviors. For example, a network of passive electronic components could be used to implement input impedance. the type and interconnection of subsidiary models need not correspond to structures in the physical device; *behavioral accuracy* is the sole objective. In some cases, the entire model will be made up of subsidiary models or *procedures*, with no mathematical or logical expressions at the topmost level of model definition. These *macromodels* enable the reuse of standard components for model development, and may reflect the physical structure of the device to allow greater insight into the internal operation of the component.

The description and implementation of model internals shall be specified, either explicitly or as an implicit function of model and *feature levels* as defined in Section 5.

7.3 Textual Messages—Certain conditions encountered by a model are of sufficient interest to be brought to the operator's attention. Textual *messages* may be displayed on the terminal, placed in a *message* file, presented in a separate window or issued by other means, depending on the capabilities of the simulation environment and the requirements of the *Requester*.

In general, *messages* should be issued only once, when the specified condition is first detected. However, the *Requester* may require that a *message* be issued periodically or each time the condition is detected. Except in the case of error *messages*, it should be possible to turn the display of *messages* on or off by means of a flag or model *parameter*.

7.3.1 INFORMATIONAL MESSAGES—Informational *messages* may be issued when a condition arises which is not critical to the *accuracy* or operation of the model, but nevertheless is of particular interest to the end user. Examples might be a change in operating mode ("airbag squib fired") or a unique operating condition ("ignition switch in START position").

7.3.2 OVERSTRESS MESSAGES—When models are subjected to conditions such as voltage, current, heat or power dissipation that cause a monitored *value* to go out of normal operating range, the model may be required to write a *message* to the *system* output describing the overstressed condition.

7.3.3 WARNING MESSAGES—Warning *messages* may be required whenever a condition occurs which is critical to the *accuracy* or operation of the model, but not fatal to the simulation run. The model may have warning *messages* similar to the following:

a. Model is being operated outside its validated range.
b. Model does not support this application.

c. Model *accuracy* degraded in this region of operation.

7.3.4 ERROR MESSAGES—An error *message* will be issued, and the simulation run shall be aborted, when a condition occurs which compromises the validity of the entire simulation. In developing the model, effort should be devoted to avoiding conditions where a fatal error is possible. For example, model code should be arranged to detect and prevent divide-by-zero errors. At the level of the individual model, error *messages* are usually implemented for unspecified, invalid, or out of range input *parameters*.

***8. Validation Requirements*—**This section outlines the *validation* requirements for the simulation model, assuming that the model corresponds to an existing physical component. The *Requester* shall require the Producer to perform *validation* of the subject model and correlate the model's response to empirical data in the model deliverables, as defined in 9.1.

8.1 Functional Test Procedures—This section shall define the test *procedures* to verify that the behaviors specified for the model were in fact implemented as required. These tests normally include qualitative functions such as *functional* testing in various system configurations, *parameter* handling, operating range verification and *messaging* functions.

8.2 Characterization Test Procedures—This section shall define the test *procedures* and equipment used to collect quantitative data for purposes of component characterization. The *procedures* relate the *parameters* of the device model to readily obtainable device data. The *Requester* may require the Provider to perform component characterization tests, and may further specify how the characterization is to be accomplished. The *Requester* may also specify a representative sample size to verify the statistical validity of the measured device data.

8.3 Data Reduction Procedure—If the component characterization data is processed in any manner more involved than observing the average and spread of directly observable quantities, then the characterization data reduction *procedure* must be detailed in the *documentation*.

8.4 Validation Procedure and Data—This section shall determine the *accuracy* of the model relative to the empirical data acquired from the physical device. The data to be used for *validation* shall consist of component *validation* data and simulation test data. Tests and *procedures* employed to obtain both kinds of data shall be outlined. The relative correlation of simulation test data against component *validation* data shall be documented. Any physical device data generated by the producer, as well as a description of the test fixtures used, shall also be included.

8.5 Validation Criteria—This section defines what it means for the model to have good correlation with the test data, proving that it is an acceptably accurate model according to the *Requester's* specifications. Correlation criteria apply to the characterized model rather than the base model, since only a specific model can be compared against empirical test results.

***9. Deliverables*—**This section outlines the deliverables required of the model producer relative to the simulation model(s) created for the model *Requester*. The associated files, schematics and block-diagrams of the model(s) as well as the *documentation* for the model(s) are detailed. A printout of the *netlists*, *templates*, schematics, block diagrams, and/or flowcharts shall be provided as appropriate to the model.

9.1 Model Deliverables—The Producer shall be required to deliver models and modeling information to the *requester* in accordance with the following list of deliverable items:

a. Model Source code, as defined in 9.1.1 and provided both electronically and as hard copy as agreed upon with the *Requester*. The *Requester* should define the methods to be used to transfer information; either by electronic file transfer (internet/intranet) or physical media (CD-ROM, 3.5" disk, etc.).

b. Copies of schematics, flowcharts and/or block diagrams where applicable.

9.1.1 SOURCE CODE—All *netlists*, model-files that correspond to specified modeling and simulation tools, and external routines created to model the component are defined as source code and shall be provided to the *Requester*. Data encryption may be employed at the mutual agreement of *Requester* and producer.

9.1.1.1 Header—Source code provided in the form of statement lists, including *netlists*, ASCII model-files, and external routines, shall contain a header conforming to the *Requester's* requirements. a representative example is shown in Appendix B. Source code that defines the model in a graphical programming environment shall incorporate the content of the header in a comment block or other commenting *feature* of the modeling environment.

9.1.1.2 Comments—Source code shall contain sufficient comments to be understandable and useable to an experienced analytical engineer. Comments shall include definitions of input and output *arguments*, definition of units, node *connections*, and the valid range of operation where appropriate. For deliverable source code associated with a graphical programming environment, comments shall be incorporated into the comment fields of individual blocks or other documenting *features* of the environment.

9.1.1.3 Programming Languages—Models shall be implemented in the required modeling environment and/or language, as specified by the *Requester*. Use of foreign routines or external support code should not be used unless specifically permitted by the *Requester*.

The range of application domains covered by commercially available modeling and simulation tools is comprehensive, as indicated by the list of generic application domains and associated languages provided in Section 4 of this document.

9.1.1.4 Drawing Symbols—Schematic symbols corresponding to the model code shall be supplied as specified by the *Requester*. the symbol will exhibit *connection points* and *properties* appropriate to the model, and shall reference the model code by either naming convention or *property value*. the symbol graphics shall conform to drafting standards supplied by the *Requester*, if applicable.

9.1.2 SUPPORTING DELIVERABLES—Supplemental tools to be used by the model Producer may be specified by the *requester*. Any supplemental schematic drawings, spreadsheets, flowcharts, command scripts, test files, etc. shall be included in the model deliverables. *Functional* block diagrams, if required, may be prepared and submitted in any "draw" program or formal block-diagram programming environment the model Producer finds to be suitable, but the deliverable graphics file shall be represented in Postscript or other standard graphics language.

Schematics and *functional* block diagrams may also be provided in hardcopy format.

9.2 Documentation—All model *documentation* shall indicate the current level of model release. Model *documentation* shall be supplied per the *Requester's* specifications. At a minimum, the *documentation* should address both model applications (applying the model in a *system* analysis) and model support (continuing model development and support).

9.2.1 MODEL APPLICATION DOCUMENTATION—This *documentation* shall be directed toward analytical engineers applying the model in a *system* analysis.

9.2.1.1 Description—This section shall include the *functional* description of the model. it shall include all the model's equivalent circuits, *functional* block diagrams, *algorithms*, *parameters* and simulation methods, as applicable.

9.2.1.2 Netlist or Dataflow Hierarchy—This section shall describe how the circuit models are embedded in the circuit *netlist*, or otherwise reveal the hierarchical structure of the model.

9.2.1.3 Input Parameters—This section shall include a table that will list: name (default), type, units and description of all the model's input *parameters*.

9.2.1.4 Connection Points—This section shall include a table that will list: name, type and description of the model's *connections* between circuit or *functional* elements.

9.2.1.5 Output Variables—This section shall include a table that will list: name, type, units and description of the model's output *variables*.

9.2.1.6 Usage Notes—This section shall describe how to use the model. A truth table shall be included, if applicable. It shall also describe the model output *messages* (such as warning and error *messages*) as applicable.

9.2.2 SUPPORT DOCUMENTATION—This *documentation* shall be directed toward experienced analytical engineers providing model support and continuing development. The support *documentation* shall describe the development and implementation of the model. This *documentation* shall explain the concepts used in the development of the model, the methods used to verify its *accuracy* and how this model can be used in a simulation.

9.2.2.1 Model Features—This section shall describe the modeling domain features, as applicable.

9.2.2.1.1 Connection Points—The type of *connection points* involved, such as electrical, mechanical or hydraulic *connection points* shall be defined. These *connection points* may be defined as "pin types," meaning that they handle through and across *variables*.

9.2.2.1.2 Parameters—Specify whether the model requires any internal *parameters*.

9.2.2.2 Template Usage—This section should reference the application *documentation* which contains the description of the input and output *variables*.

9.2.2.3 Model Limitations—This section shall summarize the operational range, *accuracy* and underlying assumptions made during model development.

9.2.2.4 Model Theory—This section shall describe the model theory in detail. it shall include all the appropriate diagrams along with their *functional* description. It shall include the transfer function that characterizes the behavior of the model.

9.2.2.5 Characterization Test Procedures and Data—This section shall outline the process used in gathering data for the model. it shall describe all test fixtures, instrumentation, required environmental conditions and *procedures* used to acquire the desired data.

9.2.2.5.1 Equipment Used—This section shall list all equipment used in testing the model and physical device.

9.2.2.5.2 Data Acquisition Procedure—This section shall describe the test fixtures and equipment arrangements used in acquiring data for the model. The *procedures* employed in gathering data shall be outlined. Test fixture schematics shall also be included under this section.

9.2.2.6 Model Validation Data—*Validation* data shall be provided in accordance with the requirements set forth in Section 8 of this document.

9.2.2.7 Model Datafile—This Section shall include the actual model datafile representing the device in the selected modeling environment, written in ASCII format.

9.2.2.8 Appendices—All raw test data used to validate the model shall be contained in an appendix. Additional appendices should be used for additional information, as deemed appropriate.

9.3 Support—The Producer shall provide support after delivery of the final model, as required by the model *Requester*.

APPENDIX A
AUTOMOTIVE EE COMMODITIES

A.1 Automotive EE Commodities are electrical or electronic components of automobiles that are subject to procurement by automobile manufacturers. A structured list of automotive EE commodities is provided below, wherein the top-level commodity is defined as a generic component, and specific components are grouped as Sub_Classes under an application Class heading. The listing provided is fairly comprehensive down to Sub_Class I, but only a few instructive examples are provided at Sub_Class II. This list is not claimed to be fully comprehensive, and is only intended to illustrate the extent of automotive ee commodities that may be subject to modeling and simulation.

A.2 Electronic Modules (EE Commodities)
A.2.1 Body (Class)
A.2.1.1 AUDIO (SUB_CLASS I)
A.2.1.2 CLIMATE (SUB_CLASS I)
A.2.1.3 MEMORY SEAT (SUB_CLASS I)
A.2.1.4 SECURITY (SUB_CLASS I)
A.2.1.5 OTHERS... (SUB_CLASS I)
A.2.2 Chassis (Class)
A.2.2.1 BRAKES (SUB_CLASS I)
A.2.2.2 SUSPENSION (SUB_CLASS I)
A.2.2.3 STEERING (SUB_CLASS I)
A.2.2.3.1 Speed Sensitive (Sub_Class II)
A.2.2.3.2 Power Assist [Electric] (Sub_Class II)
A.2.3 Lighting (Class)
A.2.4 Power Train (Class)
A.2.4.1 ENGINE (SUB_CLASS I)
A.2.4.2 TRANSMISSION (SUB_CLASS I)
A.2.4.3 TRANSFER CASE (SUB_CLASS I)
A.2.5 Safety (Class)
A.2.5.1 AIR BAG (SUB_CLASS I)
A.2.5.2 COLLISION AVOIDANCE (SUB_CLASS I)
A.2.5.3 OTHERS... (SUB_CLASS I)
A.2.6 Switch Modules (Class)
A.2.7 Communications (Class)
A.2.7.1 MULTIPLEXERS (SUB_CLASS I)
A.2.7.2 GATEWAY (SUB_CLASS I)
A.2.7.3 OTHERS... (SUB_CLASS I)
A.2.8 Miscellaneous Modules (Class)
A.3 Sensors (EE Commodities)
A.3.1 Air Flow (Class)
A.3.1.1 MANIFOLD [MAF] (SUB_CLASS I)
A.3.1.2 OTHERS... (SUB_CLASS I)
A.3.2 Temperature (Class)
A.3.2.1 COOLANT (SUB_CLASS I)
A.3.2.1.1 Positive Temperature Coefficient [PTC] Resistors (Sub_Class II)
A.3.2.2 MANIFOLD AIR [MAT] (SUB_CLASS I)
A.3.2.3 TRANSMISSION (SUB_CLASS I)
A.3.2.4 AMBIENT AIR (SUB_CLASS I)
A.3.2.4.1 Non-linear Negative Temperature Coefficient [NTC] Thermistors (Sub_Class II)
A.3.2.5 BATTERY (SUB_CLASS I)
A.3.2.6 FUEL (SUB_CLASS I)
A.3.2.7 SUN LOAD (SUB_CLASS I)
A.3.3 Pressure (Class)
A.3.3.1 MANIFOLD AIR [MAP] (SUB_CLASS I)
A.3.3.2 ENGINE OIL (SUB_CLASS I)
A.3.3.3 AIR CONDITIONER FLUID (SUB_CLASS I)
A.3.3.4 SUPERCHARGER BOOST (SUB_CLASS I)
A.3.3.5 FUEL RAIL (SUB_CLASS I)
A.3.3.6 OTHERS... (SUB_CLASS I)
A.3.4 Load/Strain (Class)
A.3.4.1 PIEZOELECTRIC (SUB_CLASS I)
A.3.4.1.1 Knock (Sub_Class II)
A.3.5 Resistive (Class)
A.3.6 Displacement (Class)
A.3.6.1 LINEAR VARIABLE DIFFERENTIAL TRANSFORMER [LVDT] (SUB_CLASS I)
A.3.6.1.1 Throttle Position (Sub_Class II)
A.3.6.1.2 Transmission Range (Sub_Class II)
A.3.7 Rotation (Class)
A.3.7.1 HALL EFFECT (SUB_CLASS I)
A.3.7.2 VARIABLE RELUCTANCE (SUB_CLASS I)
A.3.7.2.1 Magnetic (Sub_Class II)
A.3.7.3 TACHOMETERS [GENERATOR] (SUB_CLASS I)
A.3.7.4 PAIRED LIGHT EMITTING DIODES AND PHOTO DETECTORS (SUB_CLASS I)
A.3.8 Inertial (Class)
A.3.8.1 ACCELEROMETERS (SUB_CLASS I)
A.3.8.2 GYROS (SUB_CLASS I)
A.3.9 Composition (Class)
A.3.9.1 OXYGEN [EXHAUST] (SUB_CLASS I)
A.3.10 Fluid Level (Class)
A.4 Actuators (EE Commodities)
A.4.1 Air Conditioning Clutch (Class)
A.4.2 Squibs/Igniters (Class)
A.4.2.1 AIR BAGS (SUB_CLASS I)
A.4.3 Motors (Class)
A.4.3.1 STEPPER (SUB_CLASS I)
A.4.3.2 DC PERMANENT MAGNET FIELD (SUB_CLASS I)
A.4.3.3 DC BRUSHLESS (SUB_CLASS I)
A.4.3.4 DC SERIES WOUND FIELD (SUB_CLASS I)
A.4.3.4.1 Starters (Sub_Class II)
A.4.4 Pumps (Class)
A.4.4.1 FUEL (SUB_CLASS I)
A.4.5 Solenoids (Class)
A.4.5.1 STARTER (SUB_CLASS I)
A.4.5.2 TRANSMISSION SHIFT (SUB_CLASS I)
A.5 Interconnects (EE Commodities)
A.5.1 Splices (Class)
A.5.2 Terminals (Class)
A.5.3 Connectors (Class)
A.5.4 ClockSprings (Class)
A.5.5 Fiber-Optics (Class)
A.6 User Electronics (EE Commodities)
A.6.1 Navigation Systems (Class)
A.6.2 Cellular Phones (Class)
A.6.3 Entertainment Systems (Class)
A.6.3.1 RADIO AND ANTENNA (SUB_CLASS I)
A.6.3.2 SPEAKER (SUB_CLASS I)
A.6.3.3 TAPE PLAYER (SUB_CLASS I)
A.6.3.4 COMPACT DISK PLAYER (SUB_CLASS I)
A.7 Digital Communication Sub-System (EE Commodities)
A.7.1 J1850 Class II (Class)
A.7.2 CANbus (Class)
A.7.3 PCM Driver (Class)

A.7.4 RS232 (Class)
A.7.5 Ethernet (Class)
A.8 Power Generation and Control (EE Commodities)
A.8.1 Alternators (Class)
A.8.2 Battery (Class)
A.8.3 Fuses (Class)
A.8.3.1 THERMAL FUSES (SUB_CLASS I)
A.8.3.2 FUSIBLE LINKS (SUB_CLASS I)
A.8.4 Circuit Breakers (Class)
A.8.4.1 POLYMER POSITIVE TEMPERATURE COEFFICIENT THERMISTORS [PPTC] (SUB_CLASS I)
A.8.4.2 BI-METALLIC (SUB_CLASS I)
A.8.5 Relays (Class)
A.8.6 Switches (Class)
A.8.6.1 BASICS (SUB_CLASS I)
A.8.6.1.1 SPST, SPDT, SP3T, ... (Sub_Class II)
A.8.6.1.2 [One or More in a Package] (Sub_Class II)
A.8.6.2 ASSEMBLY (SUB_CLASS I)
A.8.6.2.1 Others... (Sub_Class II)
A.8.7 Voltage Regulators (Class)
A.9 Alarm and Display (EE Commodities)
A.9.1 Indicator Bulbs (Class)
A.9.2 Light Emitting Diodes (Class)
A.9.3 Buzzers (Class)
A.9.3.1 CHIMES (SUB_CLASS I)
A.9.4 Liquid Crystal Displays (Class)
A.9.5 Flasher (Class)
A.9.6 Gauges (Class)
A.9.6.1 AIR CORE GAUGES (SUB_CLASS I)
A.9.6.2 STEPPER MOTOR GAUGES (SUB_CLASS I)
A.9.7 Horn (Class)
A.10 Illumination (EE Commodities)
A.10.1 Single Filament (Class)
A.10.1.1 TURN SIGNAL (SUB_CLASS I)
A.10.1.2 PARKING (SUB_CLASS I)
A.10.1.3 DOME (SUB_CLASS I)
A.10.1.4 MAP LIGHT (SUB_CLASS I)
A.10.1.5 FOG (SUB_CLASS I)
A.10.1.6 HEAD LAMPS (SUB_CLASS I)
A.10.1.7 TAIL LAMPS (SUB_CLASS I)
A.10.2 Double Filament (Class)
A.10.2.1 HEAD LAMPS (SUB_CLASS I)
A.10.2.2 TAIL/STOP/TURN SIGNALS (SUB_CLASS I)
A.10.2.3 PARKING/TURN SIGNALS (SUB_CLASS I)
A.10.3 Light Emitting Diodes [LEDS] (Class)
A.10.4 High Intensity Discharge [HID] (Class)
A.10.4.1 HEAD LAMP (SUB_CLASS I)
A.10.4.2 CENTRAL LIGHTING (SUB_CLASS I)
A.10.5 Light Transmission Devices (Class)
A.11 Basic Electronic Components (EE Commodities)
A.11.1 Coils/Inductors (Class)
A.11.2 Diodes (Class)
A.11.3 Transistors (Class)
A.11.4 Resistors (Class)
A.11.5 Capacitors (Class)
A.12 Power Distribution (EE Commodities)
A.12.1 Wires and Cables (Class)
A.12.1.1 BARE [SOLID AND STRANDED] (SUB_CLASS I)
A.12.1.1.1 Ground Strap (Sub_Class II)
A.12.1.2 INSULATED (SUB_CLASS I)
A.12.1.2.1 Single (Sub_Class II)
A.12.1.2.2 Twisted Pairs (Sub_Class II)
A.12.1.2.3 Bundled (Sub_Class Ii)
A.12.1.2.4 ClockSprings (Sub_Class II)
A.12.1.3 SHIELDED (SUB_CLASS I)
A.12.1.3.1 Coaxial Cables (Sub_Class II)
A.12.2 Grounds (Class)
A.12.3 Electrical Distribution Boxes (Class)
A.12.4 Wiring Harnesses (Class)
A.13 Heaters (EE Commodities)
A.13.1 Glow Plugs (Class)
A.13.2 Heated Element (Class)
A.13.3 Resistive Film (Class)
A.13.3.1 HEATED BACKLIGHT (SUB_CLASS I)
A.13.4 Resistive Wire (Class)
A.13.4.1 HEATED BACKLIGHT (SUB_CLASS I)

APPENDIX B
EXAMPLE SABER MODELFILE HEADER LAYOUT

B.1 See Figure B1.

```
# MODELFILE HEADER TEMPLATE:
# (template name).xyz    DESCRIPTIVE NAME OF TEMPLATE WITH TOOL-SPECIFIC EXTENSION
##########################################################################################
#
#                          THIS TEMPLATE WAS CREATED BY:
#                        SOCIETY OF AUTOMOTIVE ENGINEERS
#                   ELECTRONIC DESIGN AUTOMATION COMMITTEE
#                            MODELING TASK FORCE
#
#
#THE SOCIETY OF AUTOMOTIVE ENGINEERS DOES NOT ASSUME LIABILITY FOR THE USE
#OF THIS TEMPLATE OR THE RESULTS OBTAINED FROM USING IT.
#
##########################################################################################
#
#       RESPONSIBILITY          NAME and DEPT.                  DATE
#
#       PROGRAMMING             (programmer name)               mm/dd/yy
#       DATA COLLECTION         (test person/data-source)
#       MODEL THEORY            (developer of theory author)
#       SOURCES OF THEORY
#       SPECIFICATIONS          (specification writer)
#
##########################################################################################
#
# DESCRIPTION:
#
# Fully describe the model's physics, limitations, inaccuracies, intended use, assumptions, and any other
# useful information to the user.
#
# NODE CONNECTIONS (If Applicable):
#
#       Name                    Type                    Description
#
#
# INPUT ARGUMENTS:
#
#       Name                    Type        Units       Description
#
#
# OUTPUT SOLUTIONS:
#
#       Name                                Units       Description
#
#
# MESSAGES:
#
# List any messages that the model will display and fully describe their meaning. These may include any
# information that the model developer(s) thought would be useful to a simulation.
#
```

FIGURE B1a—

```
# WARNINGS:
#
# List any warnings that the model will display and fully describe the implications of these warnings. These
# may include operation in invalidated or inaccurate regions. These may also include stresses
# that may be exceeding rated values: temperature, current voltage, etc...
#
#
# ERRORS:
#
# List any errors that may occur in the model that are sufficient to cause the simulation to abort. Fully
# describe the meaning of these errors, their associated messages, and the basis for deciding to abort a
# simulation. These may include entry of highly inaccurate regions, erroneous results,
# operation beyond unmodeled device failure, etc...
#
#
# SUPPORTING FILES:
#
# List the name and description of additional files necessary for the model to function properly. These can
# be foreign subroutines, external functions, sublevel templates when hierarchy is used, and special units
# files. An adequate description of each should follow, including key parameters exchanges and/or node
# connections.
#
#
# REVISION HISTORY:
#
# Programmer Name and Date:
# Fully describe the revision and what necessitated it.
#
################################################################################
```

FIGURE B1b—

```
# WARNINGS:
#
# List any warnings that the model will display and fully describe the implications of these warnings. These
# may include operation in invalidated or inaccurate regions. These may also include stresses
# that may be exceeding rated values: temperature, current voltage, etc...
#
#
# ERRORS:
#
# List any errors that may occur in the model that are sufficient to cause the simulation to abort. Fully
# describe the meaning of these errors, their associated messages, and the basis for deciding to abort a
# simulation. These may include entry of highly inaccurate regions, erroneous results,
# operation beyond unmodeled device failure, etc...
#
#
# SUPPORTING FILES:
#
# List the name and description of additional files necessary for the model to function properly. These can
# be foreign subroutines, external functions, sublevel templates when hierarchy is used, and special units
# files. An adequate description of each should follow, including key parameters exchanges and/or node
# connections.
#
#
# REVISION HISTORY:
#
# Programmer Name and Date:
# Fully describe the revision and what necessitated it.
#
################################################################################
```

FIGURE B1b—