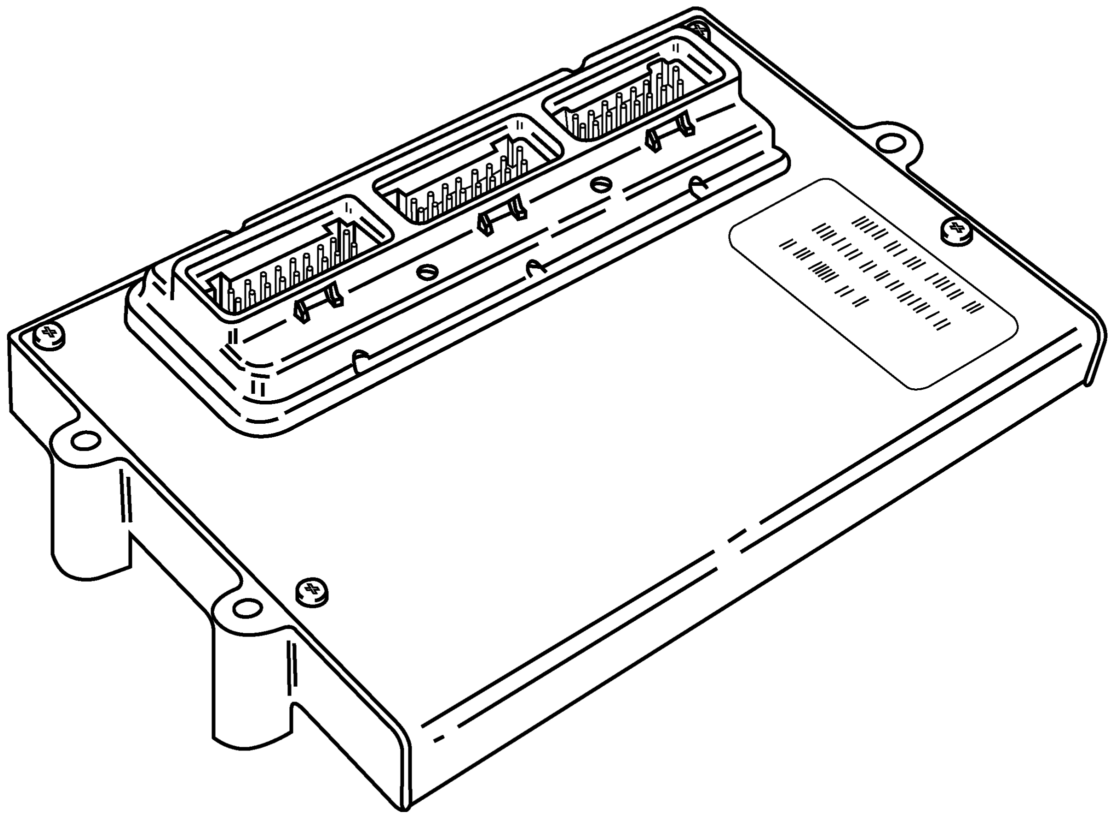
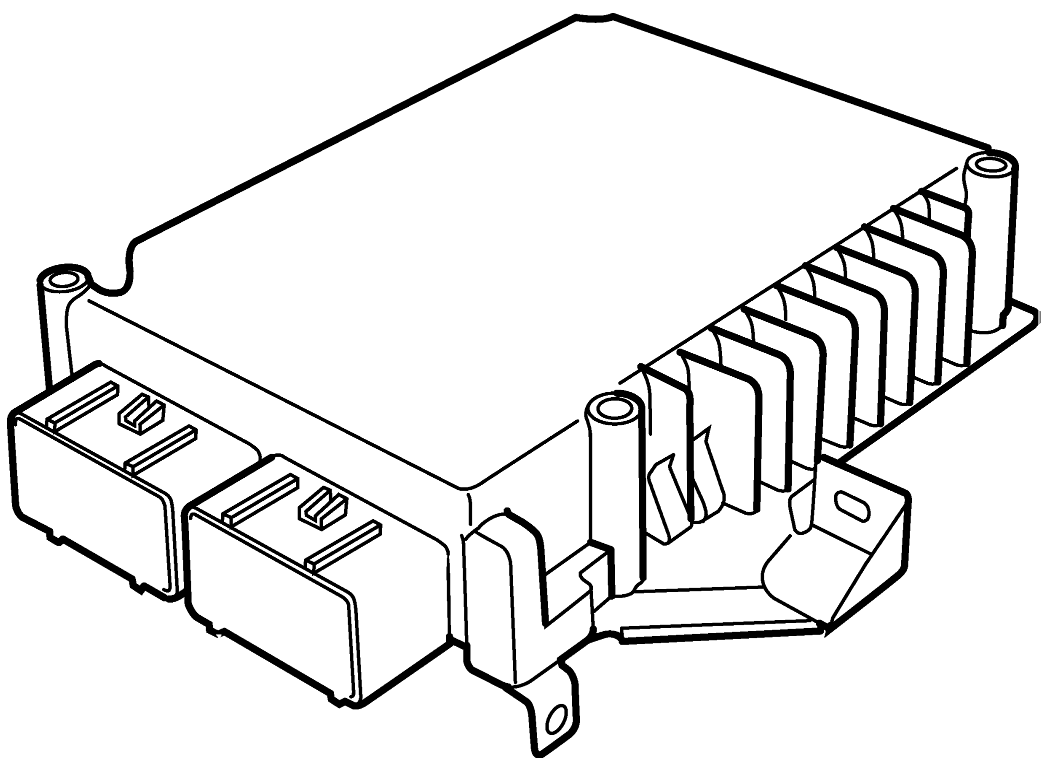
Speed Density Operation and Diagnosis





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INTRODUCTION

STUDENT LEARNING OBJECTIVES

Upon completion of this course, the technician will be able to:

- Diagnose a vehicle with a faulty 2-wire sensor.
- Diagnose a vehicle with a faulty 3-wire sensor.
- Diagnose a vehicle with a faulty Hall-effect sensor.
- Diagnose a vehicle with a faulty oxygen sensor or oxygen sensor circuit.
- Diagnose a faulty oxygen sensor heater circuit.
- Diagnose a vehicle with a faulty output circuit.
- Diagnose a vehicle with a faulty speed control circuit.
- Diagnose a vehicle with a faulty generator circuit or system.
- Diagnose a vehicle with a Lean or a Rich Running condition.
- Diagnose a vehicle with a vacuum leak.
- Diagnose a vehicle with an injector circuit malfunction.
- Diagnose a vehicle with a dirty or tampered throttle body.
- Diagnose a vehicle with a faulty LDP pump or circuit.

ACRONYMS

• A/C	Air Conditioning
• ACM	Air Bag Control Module
• ASD Relay	Auto Shutdown Relay
• Baro	Barometric Pressure
• BCM	Body Control Module
• BTS	Battery Temperature Sensor
• CAB	Controller Antilock Brakes
• CCD BUS	Chrysler Collision Detection Bus
• CKP Sensor	Crankshaft Position Sensor
• CMP Sensor	Camshaft Position Sensor
• COP Ignition	Coil On Plug Ignition
• CTM	Central Timer Module
• DCP Solenoid	Duty-Cycle Purge Solenoid
• DIS	Direct Ignition System
• DLC	Data Link Connector
• DMM	Digital Multimeter
• DRBIII®	Diagnostic Readout Box – 3rd Generation
• DTC	Diagnostic Trouble Code
• ECT Sensor	Engine Coolant Temperature Sensor
• EEPROM	Electrically Erasable Programmable Read Only Memory
• EGR Valve	Exhaust Gas Recirculation Valve
• EMI	Electro-Magnetic Interference
• EPP	Engine Position Pulse
• EVAP	Evaporative Emission System
• IAC Motor	Idle Air Control Motor
• IAT Sensor	Intake Air Temperature Sensor
• JTEC	Jeep/Truck Engine Controller
• LDP	Leak Detection Pump
• LSIACV	Linear Solenoid Idle Air Control Valve
• MAF	Mass Air flow
• MAP Sensor	Manifold Absolute Pressure Sensor
• MDS_2®	Mopar Diagnostic System - 2nd Generation
• MIL	Malfunction Indicator Lamp
• MTV	Manifold Tuning Valve
• NTC	Negative Temperature Coefficient
• NVLD	Natural Vacuum Leak Detection
• O_2 Sensor	Oxygen Sensor
• OBD II	On-Board Diagnostics – Second Generation
• ORVR	On-Board Refueling Vapor Recovery
• P/N	Park/Neutral

- PCI BUS Programmable Communications Interface BUS (J1850)
- PCM Powertrain Control Module
- PDC Power Distribution Center
- PPS Proportional Purge Solenoid
- PS Power Steering
- PSP Power Steering Pressure (Switch)
- PTC Positive Temperature Coefficient
- PWM Pulse-Width Modulation
- RAM Random Access Memory
- RFI Radio Frequency Interference
- RKE Remote Keyless Entry
- SBEC Single Board Engine Controller
- SKIM Sentry Key Immobilizer Module
- SRV Short Runner Valve
- TCM Transmission Control Module
- TDC Top Dead Center
- TPS Throttle Position Sensor
- VSS Vehicle Speed Signal
- VTSS Vehicle Theft Security System

GENERAL DESCRIPTION

This publication contains information regarding the systems controlled by the SBEC and JTEC Powertrain Control Modules (PCM). These include fuel, emissions, speed control, charging, radiator fan and PCM-related A/C control functions on all 1996 and later passenger cars and minivans equipped with an SBEC III engine controller and trucks, Jeeps, and Vipers with JTEC controllers.

The fuel system for all these engines utilizes a speed density sequential multiport fuel injection system to deliver precise amounts of fuel to the engine. An in-tank pump module delivers fuel for most vehicles.

Most engines use a distributorless ignition. Ignition and fuel injector operation are controlled by the PCM. The PCM provides outputs to fuel and ignition components to promote the most efficient operation possible.

POWERTRAIN CONTROL MODULES (PCM)

SBEC III

The Single Board Engine Controller III (SBEC III) was introduced in 1995 and is the third generation SBEC. The SBEC III has a shielded case to prevent Radio Frequency Interference (RFI) and Electro–Magnetic Interference (EMI). The SBEC III does not require air to flow through the controller for cooling. Tool #6932 is used to service the connector terminals.

Note: *Pin locations for various functions are not the same between platforms. Nineteen ninety-eight and later SBEC IIIA controllers have different pin arrangements than SBEC III and SBEC III+ controllers to prevent inadvertent interchange.*

JTEC

The Jeep/Truck Engine Controller (JTEC) was introduced in 1996 and contains an increased number of terminals in the connector, from 60 to three 32-way connectors (96 total). The JTEC has gold-plated, low insertion-force terminals and uses tool #6934 to service the terminals.

PCM REPLACEMENT

Any time the PCM is replaced always check applicable diagnostic manuals for the proper procedure to program the VIN.

Warning: ***Vehicles equipped with SKIM require a specific procedure for writing the VIN in the PCM. If the proper procedure is not followed, PCM and SKIM module damage could occur.***

Notes:

SPEED DENSITY OVERVIEW

PULSE-WIDTH EQUATION

Load	Base PW Calculation		Adaptives	
RPM / MAX RPM (X) MAP / BARO	(X) TPS (X) ECT (X) IAT (X) Sensed B+ (X) LT*	(X) O2	Short (X)Term Long (X)Term	Pulse = Width

* After long-term adaptive information is stored in memory, it becomes part of the Base PW Equation, and is used under ALL operating conditions; hot or cold, open or closed loop.

A speed density fuel system measures the engine RPM, as well as the intake manifold absolute pressure (vacuum), to determine the air flow into the engine. On most speed density vehicles, **BOTH** the crankshaft and camshaft position inputs are needed to start and run the engine. Some vehicles only require the crankshaft position sensor to stay running. The crankshaft position signal tells the PCM when there are two cylinders at Top Dead Center (TDC) and how often to add fuel and fire the ignition. The Camshaft Position (CMP) Sensor tells the PCM which of those two cylinders is on the compression stroke, thus identifying which cylinder gets the fuel and ignition charge. The Manifold Absolute Pressure (MAP) sensor input determines how much fuel the engine receives. MAP is the sensor that has the greatest authority in controlling pulse-width.

After the PCM determines the starting point for the pulse-width based on the crankshaft position and MAP inputs, it is further modified based on throttle position, coolant temperature, intake air temperature, sensed battery voltage, short-term correction and long-term adaptive compensation.

For a speed density system to operate, the first and most important piece of information that must be determined is the amount of air entering the engine. To do this, the PCM looks first at the current RPM divided by the MAX RPM. This allows the PCM to calculate the greatest volume of air entering the engine at that RPM. The PCM then looks at the present manifold vacuum compared to the barometric pressure that was seen at key on. This gives the PCM the reference for current air pressure in the intake system. With these two pieces of information the PCM determines the current load being placed on the engine. For example, if RPM is low and vacuum nearly matched Baro (WOT), then the PCM knows the engine is under a heavy load and inhaling as much air as possible for that RPM.

The PCM then looks at the Throttle Position Sensor (TPS) to help verify the condition determined in step one. The TPS is used as a modifier. If the TPS increases rapidly, then extra fuel is given to the engine to help prevent stumble and hesitation. If the TPS is closed and the vehicle is moving, then the PCM limits and/or closes off injectors during coast down. Because this formula must have a value in every position (0 times any value = 0), the PCM uses TPS and RPM to determine the current load if the MAP sensor fails.

The next modifier is Engine Coolant Temperature (ECT), which is the second biggest modifier of pulse-width after MAP, but is the most important sensor to establish pulse-width at key-on. At key-on, minor changes in the ECT voltages have a dramatic effect on the starting pulse-width. Once the vehicle starts the ECT functions only as a modifier with a limited correction factor. If the engine is cold, the fuel does not atomize easily. To overcome this problem the PCM adds extra fuel depending on the value from the ECT. Conversely, if the engine is very hot, fuel is limited. ECT is also used for engine cooling fan control. If the ECT value becomes too high, the PCM automatically turns the cooling fans on. If the ECT signal is lost, the PCM substitutes a preset or calculated (limp-in) value and turns the cooling fans on high speed.

Intake Air Temperature (IAT) is also used to modify the amount of fuel delivered, although it is not as important a modifier as ECT. If ECT is high and IAT shows cold (dense air), then the PCM adds extra fuel. IAT also limits spark advance if the air is hot (thin). If the IAT signal is lost, the PCM substitutes a value based on ECT.

Sensed battery voltage is needed as a modifier because the injectors are rated for a specific flow at a specific voltage. If the voltage is lower than what the injector is rated at, it takes longer for the injector to open and it may not open as far. The PCM needs to know the voltage so it can compensate by changing the pulse-width on time. Sensed B+ is also used to control the charging system target voltage and to control coil pack saturation (dwell).

Up to this point, the PCM has calculated the required fuel based on the input of the above sensors. If the information from the inputs was accurate, and if the PCM made the proper calculations, the vehicle should be running at the stoichiometric fuel ratio of 14.7:1.

After the fuel is delivered, the PCM looks at the O_2 signal to determine how well it did on its initial calculation. The O_2 sensor provides the PCM with the raw input about how much oxygen was left over after the combustion process. As long as the oxygen sensor is switching above and below the predetermined switching point (goal voltage), the PCM has met its goal of Stoichiometry. Anytime the oxygen sensor stops switching, the system may not be operating at the stoichiometric ratio and vehicle emissions may increase.

The adaptive memories allow the PCM to do two things. First, it has the capability to add or subtract fuel from the pulse-width, up to +/- 25% on SBEC and +/- 33% on JTEC, to allow the O_2 sensor to start to switch again (short-term correction). Second, it allows for storage of this correction in long-term memory locations (long-term adaptive). Short-term correction is volatile and is lost when the vehicle is powered down, but long-term adaptives are stored in non-volatile memory and are retained in memory.

Based on all of these inputs, the PCM delivers what it *believes* to be the optimum pulse-width to deliver the correct emissions, performance, fuel economy, and driveability.

POWER SUPPLIES AND GROUNDS

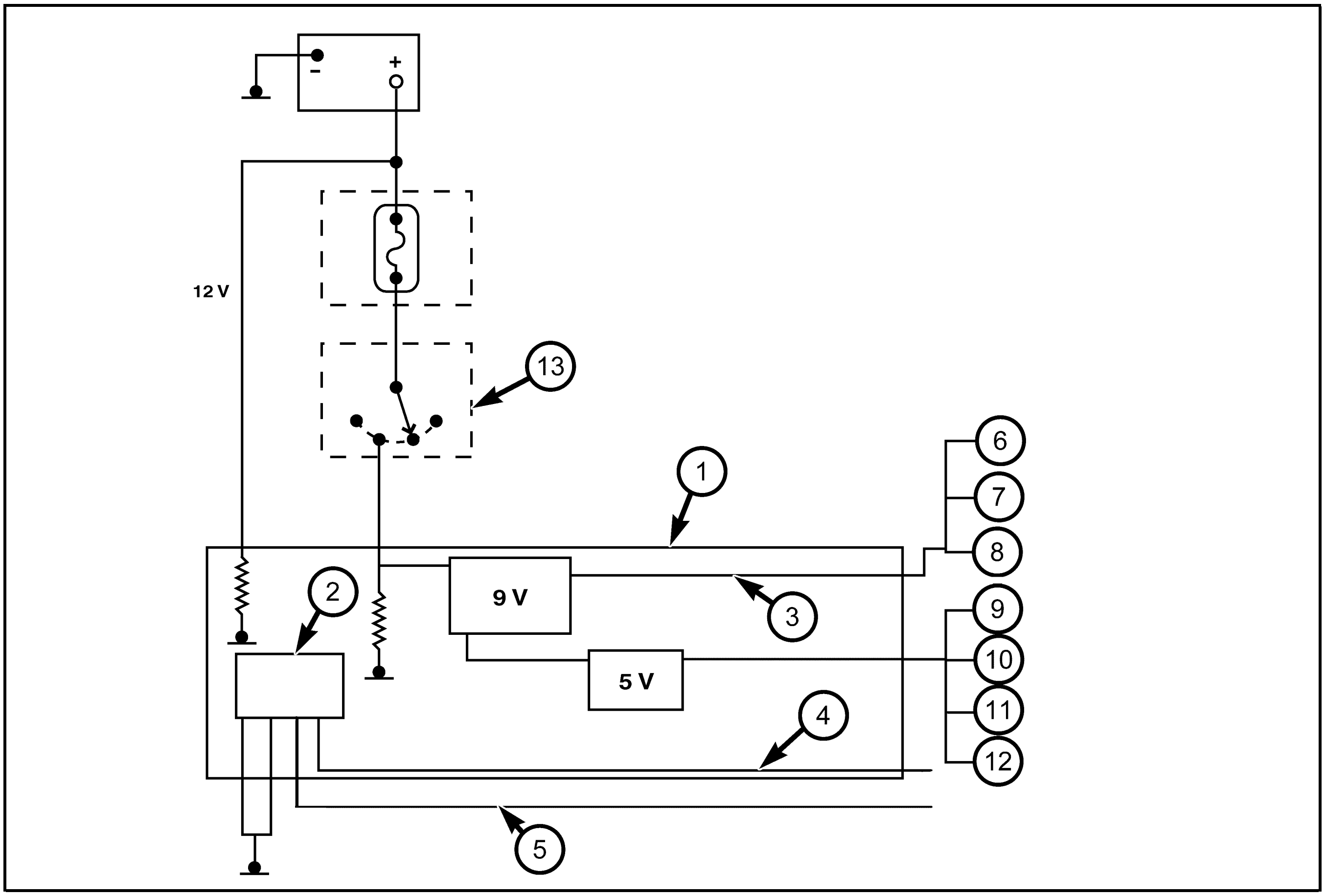

Figure 1 Power Supplies and Grounds (SBEC)

1	PCM	8	Camshaft Position Sensor
2	RFI/EMI Filter	9	Manifold Absolute Pressure Sensor
3	To Hall-effects	10	Throttle Position Sensor
4	Sensor Ground	11	A/C Pressure Transducer
5	O_2 Sensor Ground	12	Linear EGR (if equipped)
6	Hall-effect VSS (if equipped)	13	Ignition Switch
7	Crankshaft Position Sensor		

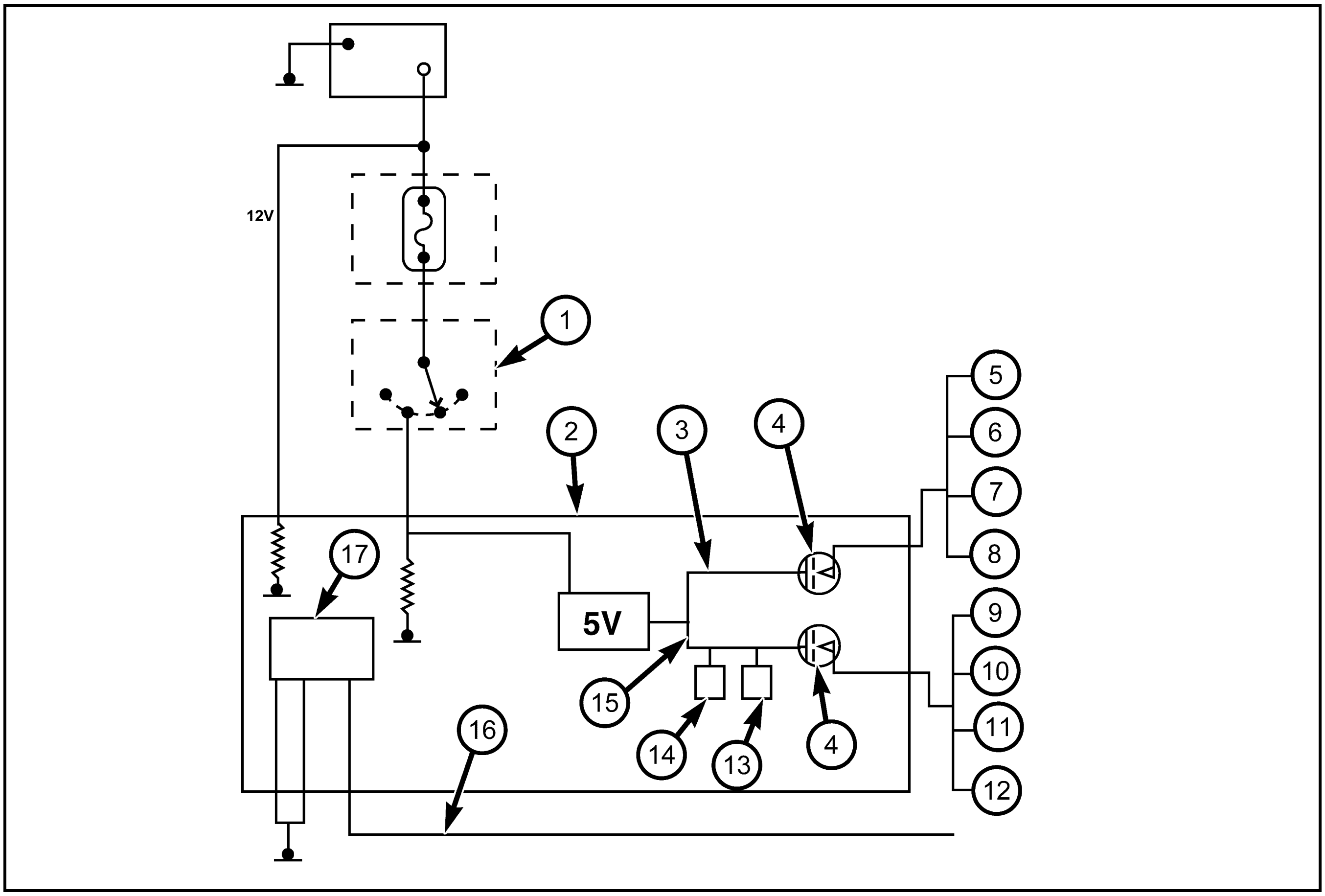

Figure 2 Power Supplies and Ground (JTEC)

1	Ignition Switch	10	Governor Pressure Sensor (if equipped)
2	PCM	11	Hall-effect VSS (if equipped)
3	Primary Output	12	3-wire OPS (if equipped)
4	FET	13	RAM
5	Camshaft Position Sensor	14	Micro
6	Crankshaft Position Sensor	15	Secondary Output
7	Throttle Position Sensor	16	Sensor Ground
8	Manifold Absolute Pressure Sensor	17	RFI/EMI Filter
9	A/C Transducer (if equipped)		

Direct Battery Feed (SBEC and JTEC)

In order for the PCM to function, it must be supplied with battery voltage and a ground. The PCM monitors battery voltage during engine operation. If the voltage level falls, the PCM increases the initial injector opening point to compensate for low voltage at the injector. Low voltage causes a decrease in current flow through the injector, and can prevent the injector plunger from fully opening in the allotted time, resulting in decreased fuel flow.

Battery charging rate is also controlled by the PCM. The target charging rate voltage is based on inputs from a Battery Temperature Sensor (BTS) or an ambient temperature sensor. The BTS is located on the PCM's circuit board or on the battery tray. The ambient sensor is located on the radiator support panel.

The PCM must be able to store diagnostic information. This information is stored in a battery backed RAM. Once a DTC is read by the technician, the technician can clear the RAM by disconnecting the battery or using the DRBIII® scan tool.

The PCM monitors the direct battery feed input to determine charging rate, to control the injector initial opening point, and to back-up the RAM used to store DTCs. Direct battery feed is also used to perform key-off diagnostics and to supply working voltage to the controller. This is called Sensed Battery and is discussed later.

Ignition Feed (SBEC and JTEC)

Ignition voltage is supplied to the PCM. Battery voltage is supplied to this pin through the ignition switch when the ignition key is in the RUN or CRANK position. This ignition input acts as a "wake up" signal to the PCM. On SBEC vehicles, battery voltage on this line is supplied to the 9-volt regulator which then feeds a power-up supply to the 5-volt regulator. On JTEC vehicles, the ignition circuit feeds a 12-volt transformer which drops the voltage to 5 volts. Voltage on the ignition input can be as low as 6 volts and the PCM may still function, but certain diagnostic routines may not run.

SBEC Specific Power Supplies

On SBEC vehicles, a 9-volt power supply is provided to supply the VSS (3-speed A/T and M/T only), the CKP sensor and the CMP sensor with a regulated voltage (fig. 1). The same power supply also provides the 5-volt regulator with power. The 9-volt regulator is protected from short circuits. If the regulator were externally shorted to ground, a circuit in the regulator would cause the external supply voltage to shut down, but still provide power to the 5-volt regulator.

A 5-volt power supply is used to provide a regulated power supply to most of the inputs to the PCM. This circuit is also protected from shorts to ground, and a circuit in the regulator allows the 5-volt signal to be sent to other inputs if the 5-volt power supply were shorted to ground at the MAP sensor, TPS, Linear EGR solenoid (if equipped), or the A/C pressure transducer.

Previously, shorting the 5-volt power supply at any of these sensors would cause the PCM to shut down completely. This would cause not only a "No Start" situation, but it would also cause a total loss of all PCM functions, including diagnostics. With the protected 5-volt power supply, the engine still shuts down, but diagnostics can still be performed. There is a Diagnostic Trouble Code (DTC) if the 5-volt power supply becomes shorted to ground. Refer to the Diagnostic Procedures Manual for more details on any On-Board diagnostic information.

JTEC Specific Power Supplies

On JTEC vehicles there is a primary and secondary 5-volt power supply (fig. 2). A transformer inside the controller is used to convert the 12-volt ignition feed to dual 5-volt supplies that feed the primary and secondary outputs. The primary output provides the CMP sensor, the CKP sensor, the TPS, and the MAP sensor with a regulated voltage. The secondary output provides the governor pressure sensor (if equipped), the 3-wire oil pressure sensor (if equipped), the Hall-effect vehicle speed sensor (if equipped), and the A/C pressure transducer (if equipped) with a regulated voltage. If there is a short to ground on the primary or secondary feed it results in a no response condition and clears all memory in the PCM.

Power and Sensor Grounds

Ground is provided through multiple pins on the PCM. Depending on the vehicle, there may be as many as three different ground pins. Internally, all the ground pins are connected. However, there is noise suppression on the sensor ground which is used for Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI) protection. This filtered ground is known as *Sensor Return or Sensor Ground*.

The power grounds are used to control the ground side of relays, solenoids, the ignition coil(s), and injectors. The sensor ground is used for any input that uses the sensor return circuit as a ground, and as the ground side of any internal processing component. The case is also grounded separately from the ground pins.

If resistance develops in the sensor ground circuit, the sensor signal voltages rise above their normal values and result in performance and emission problems. A DTC will most likely not be set because the sensor voltages are still within a range that the PCM accepts as normal. However, if the oxygen sensor uses the sensor return circuit as ground, a DTC is set. On these vehicles, excessive resistance eventually sets the DTC "O_2 Sensor Shorted to Voltage."

Both the SBEC-equipped vehicles and the JTEC-equipped vehicles use the K4 circuit as sensor ground. On SBEC-equipped vehicles beginning in 1998 and on all packages by 1999, the oxygen sensors gained their own dedicated sensor ground circuit, K127, to reduce the burden on the K4 circuit.

FUEL DELIVERY SYSTEM

An in-tank pump module pressurizes the fuel system. The PCM controls the operation of the fuel system by providing battery voltage to the fuel pump through the fuel pump relay. The PCM requires only three inputs and a good ground to operate the fuel pump relay. The three inputs are:

- Ignition voltage
- Crankshaft position (CKP) sensor
- Camshaft position (CMP) sensor

All current production passenger cars use a high-density polyethylene fuel tank and a returnless fuel system to minimize heat in the fuel tank, which leads to excessive hydrocarbon vapors being generated. All returnless fuel vehicles up to 1999 have a fuel pressure rating of approximately 49 psi. Beginning in 2000 on some SBEC models, and extending to all 2001 SBEC vehicles, fuel pressure has been increased to 58 psi (+/- 5 psi). All model year JTEC vehicles are 49 psi +/- 5 psi.

Note: *Consult the applicable Service Manual for further details on the vehicle you are servicing.*

EMISSION SYSTEMS

The emissions system has several components used to lower the quantities of hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NOx). The emissions systems are not only required to control the quantity of emissions out the tailpipe, but also any hydrocarbon emissions that might be escaping into the atmosphere from the fuel system and engine. The emissions system includes:

- Evaporative emission controls
- Exhaust emissions

The PCM controls the evaporative emissions by the operation of a Duty-Cycle Purge (DCP) solenoid or Proportional Purge Solenoid, and may diagnose the evaporative emissions system on some OBD II vehicles by using a Leak Detection Pump.

The Exhaust emissions are controlled by the use of a catalytic converter, EGR valve, and almost every input and output of the PCM.

IDLE CONTROL SYSTEM

The PCM maintains a quality idle by controlling the Idle Air Control (IAC) motor or Linear Solenoid Idle Air Control Valve (LSIACV). Inputs to the PCM that are required to operate the IAC devices include:

- TPS
- MAP sensor
- ECT sensor
- VSS
- Spark scatter (output)
- Power steering pressure switch
- Park/Neutral switch
- A/C switch
- CCD or PCI BUS
- Ambient/Battery temperature sensor

Minimum Air Flow

Minimum airflow is the volume of air flowing past the throttle blades at idle and through any other components that might allow air to flow into the intake manifold at idle, such as the PCV valve or purge.

Minimum air flow specifications aid in complete engine system diagnostics. Items such as poor driveability, worn engine components, engine components out of adjustment (timing belt) exhaust restrictions and many other items can have an effect on minimum airflow. In short, a minimum air flow check can be done only after all fuel, ignition, emission, and engine mechanical components have been verified as "good.” Other concerns include components that might put a load on the engine at idle, such as the radiator or condenser fans operating or the A/C compressor being engaged during the test.

When performing a minimum airflow check, all accessories should be off. On most SBEC vehicles, the test is performed with Miller Tool #6457 (Metering Orifice) and the DRBIII® scan tool. JTEC-equipped vehicles use Miller Tool #6714. The tool is simply a 0.125 in. orifice (SBEC) or a 0.185 in. orifice (JTEC), and the DRBIII® scan tool is used to access a program that causes the IAC motor to completely close off the idle air bypass port. The tool is installed to allow the engine to run on a calibrated airflow. The minimum airflow specifications vary from vehicle to vehicle.

Note: *2001 RS minivans with 3.3L / 3.8L engines are equipped with a LSIAC valve. These packages use Miller Tool #6714 (JTEC) orifice tool to check Minimum Airflow.*

Refer to the service or diagnostic procedure manuals for proper tool installation procedures and specifications. In general, you need to place the orifice into one of the two *natural* vacuum leaks, either PCV or purge, and plug the other.

If idle speed is too high, check for a vacuum leak or an IAC motor not fully seated. If idle speed is too low, check for a dirty throttle body or mechanical problems. DO NOT adjust the idle stop screw.

CHARGING CONTROL SYSTEMS

The PCM maintains battery voltage within a range of approximately 13.04 volts to 15.19 volts by providing battery voltage to the generator field through the ASD relay and by controlling the ground side of the generator field. The inputs that are required to maintain the proper battery voltage are:

- Battery voltage
- Battery temperature sensor, air inlet sensor or ambient temperature sensor
- Engine speed

VEHICLE SPEED CONTROL SYSTEMS

The PCM is designed to operate the speed control system to allow the driver of the vehicle to maintain a constant vehicle speed automatically. The speed control servo is supplied battery voltage directly from the PCM through the brake switch. The PCM on all vehicles operates the ground side of the vacuum and vent solenoids of the servo. The brake switch controls the dump solenoid.

ENGINE COOLING CONTROL SYSTEMS

To maintain engine temperature, the PCM controls the radiator fans by providing battery voltage to the fans through the radiator fan relays or solid state control relay. The PCM controls the ground side of the radiator fan relay coils. The following inputs to the PCM are used to operate the radiator fan relays:

- ECT sensor
- VSS
- A/C switch
- BTS or ambient temperature sensor
- Transmission temperature (some vehicles)

AIR CONDITIONING CONTROL SYSTEMS

Finally, the PCM is the ultimate authority on whether the A/C compressor clutch should be energized or not. Under certain conditions, A/C clutch engagement may result in stalling, decreased engine power or escalated engine temperatures. The PCM also prevents A/C operation in the event of a low refrigerant charge, low ambient air temperatures, or increased A/C discharge pressures. The PCM uses the A/C switch sense circuit to identify when to energize the A/C relay.

The A/C relay provides the A/C compressor clutch with battery voltage when energized. Besides the A/C switch sense circuit, the PCM uses the following inputs to determine when the A/C relay should be energized:

- Engine speed
- TPS
- A/C pressure transducer (some vehicles)
- ECT sensor
- Ambient temperature

Notes:

DIAGNOSING PCM INPUT DEVICES

HALL-EFFECT SWITCHES

Hall-effect devices (fig. 3) are frequently used for PCM inputs where accuracy and fast response are important. Another important difference between a Hall-effect device and an analog sensor input is that it provides the PCM with a digital input that does not need to be converted by an analog to digital converter. All Hall-effect devices operate in the exact same manner and are wired the same way. The only difference is the purpose for which they are used.

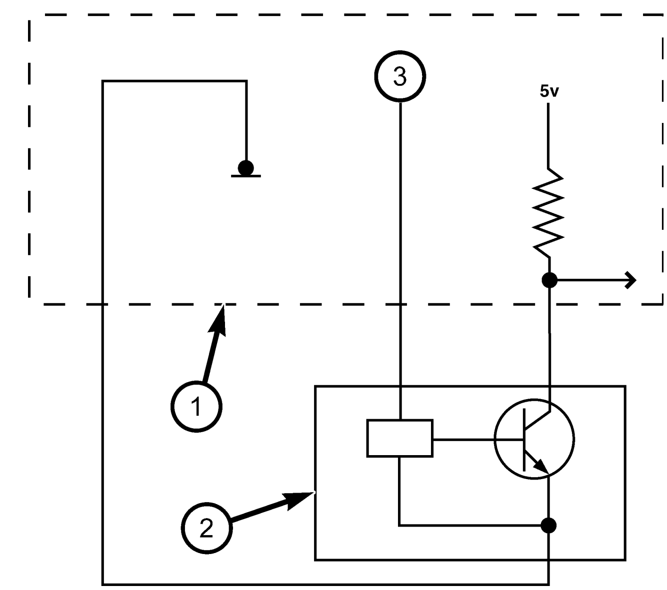

Figure 3 Hall-effect Switch

1	PCM	3	8v/9v (SBEC) or 5v (JTEC)
2	Hall-effect Switch		

The PCM sends approximately 8-9 volts (SBEC) or 5 volts (JTEC) to the Hall-effect sensor. This voltage is required to operate the Hall-effect chip and the electronics inside the sensor. A ground for the sensor is provided through the sensor ground circuit. The input to the PCM occurs on a 5-volt reference circuit.

The Hall-effect sensor contains a powerful magnet. As the magnetic field passes over the dense portion of a counterweight, flexplate or trigger wheel, the 5-volt signal is pulled to ground (0.3 volts) through a transistor in the sensor. When the magnetic field passes over the notches in the crankshaft counterweight, flexplate or trigger wheel, the magnetic field is lost, turning off the transistor in the sensor, causing the PCM to register the 5-volt signal.

Speed Density Operation and Diagnosis

It is important to remember that, on SBEC-equipped vehicles, the 9-volt supply feeding the CKP, CMP and VSS sensors all comes from the same pin of the PCM. On SBEC-equipped vehicles, a VSS shorted internally can result in a No-Start.

On JTEC-equipped vehicles, the primary circuit feeds the CMP sensor, the CKP sensor, the TPS, and the MAP sensor. It is important to note that if there is a short to ground on any sensor on the primary OR secondary power supplies all sensors on those circuits are affected, usually resulting in a No-Start situation.

See appendix for typical cam and crank scope patterns.

Notes:

ACTIVITY 1

This is a group activity led by your instructor. The vehicle that you are going to diagnose has a customer complaint of a "No Start." Please make sure that you fill in the applicable blanks as you progress through this activity.

1. Are there any DTCs that stored in memory? If so, which ones? ___________________

2. Using the DRBIII®, select the "No Start" monitor and record the status of the following items:

	Key-On	**Engine Cranking**
CMP		
CKP		
SYNC		

3. Based on the above data, what would be the next logical step in the diagnostic process? ____

4. Unplug either the CMP or CKP connector. Using the applicable wiring schematic, record the readings below:

	(5V, 9V) Supply	**5-Volt Signal**	**Sensor Ground**
CMP			
CKP			

5. Explain the results of the readings taken: ____

   ____

6. Repeat your measurements with the second sensor disconnected:

	(5V, 9V) Supply	**5-Volt Signal**	**Sensor Ground**
CMP			
CKP			

7. Explain the results of the readings taken: ____________________

____

8. What is the next step in your diagnostic process? ____________________

____

	(5V, 9V) Supply	5-Volt Signal	Sensor Ground
CMP			
CKP			

9. What happened to the voltage readings when you performed the previous step?

____

10. What step should be performed next? ____________________

	(5V, 9V) Supply	5-Volt Signal	Sensor Ground
CMP			
CKP			

11. Explain the results of the readings taken: ____________________

____

12. Using the wiring schematics as a guide, gently back-probe the signal wire at the CMP and/or CKP sensors and momentarily "scratch" to the signal ground pin. What did you observe? ____________________

13. What is this verifying? ____________________

____

14. If the vehicle fails the "scratch test," what would be your next step? ____________________

____

15. Plug in either the CMP or CKP sensors and observe the "No Start" monitor while cranking the engine. It is important to note that the DRBIII® is only indicating the PCM is receiving a signal from that sensor, and it is not an indication of the *quality* of that signal.

16. When your instructor scratches the CKP or CMP to ground, the DRBIII® most likely does not indicate the signal was lost, though it may indicate a loss of sync. This phenomenon occurs due to the large number of signals being generated by the Hall effect, which are too many for the DRBIII® to see.

17. Some important considerations when viewing a lab scope trace:

    - A scope trace is a visual representation of voltage over time. Anything that can be done with a voltmeter can be achieved visually with a scope.
    - Hall-effect signal voltage must go up to 5 volts. If not, there is resistance in the circuit.
    - Hall-effect signal voltage must be pulled all the way down to zero volts. If not, resistance is indicated in the sensor ground circuit.
    - The wave should be a clean, square wave. Steps are normal due to the refresh rate (remember, we are watching voltage over time)

18. A function that was added to the PEP Module at version 22, is the ability to record CMP and CKP position sensor signals. During the normal viewing of the CMP and CKP signals, the DRBIII® must sample these signals and then draw a graphical representation on the screen. This consumes a tremendous amount of memory. That is why you may not see a glitch when viewed in the normal mode.

    The Lab Scope's *Cam and Crank Recording* overcomes these limitations by functioning very similar to the Data Recorders; it records in an endless loop until the *ENTER* key is depressed. After the data is locked into memory, the PEP Lab Scope then draws the traces onto the screen, and allows you to scroll through the entire recording to find the suspected glitch.

    Another major advantage to using this mode, is that you are looking at the live electrical signals being generated directly by the sensors, without having the PCM "sample" the information and then display it in Standalone Mode.

19. How to setup the Lab Scope for *Cam and Crank Recording*:

    - Setup the vehicle to monitor Channels 1 and 2 as done previously
    - Select *Cam and Crank Recording*
    - Depress F2 for both recording channels and then F3 to start
    - Run the leads into the vehicle and place the DRBIII® in a convenient location (on your lap is the most convenient)

- Operate the vehicle until the glitch is felt. Quickly depress the *ENTER* key to trigger the event.
- The vehicle may then be turned off to play back the recording.
- Notice there are two brackets on the line of the recording. The trace you are viewing is what is between the brackets.
- Navigate forward and backwards using the left and right arrow keys.
- A shortcut to navigation is to use the numerical keys on the keypad. 0 = beginning of recording, 1 = 10%, 2 = 20%, etc.

Notes:

SHARED INPUTS

There are more PCM inputs than there are available microprocessor input pins. To accommodate all the required inputs, the microprocessor may receive inputs from two circuits on one pin by using multiplexing. The microprocessor keeps track of which input is being received by the discharging of a capacitor controlled by the PCM's internal clock. If there is a problem that does not allow the capacitor to discharge (for example, an input shorted to voltage), the PCM may set a DTC for the companion input. For example, a cruise MPX circuit that is shorted to power may set a TPS fault. This phenomenon ONLY applies to JTEC vehicles.

The following tables reference the shared inputs on JTEC-equipped vehicles:

Table 1 1996-1998 JTEC Multiplexed Inputs

Name	Comments	JTEC Pin #
TPS Cruise MPX		A23 C32
O_2S Up L MAP	1/1 (All applicable models)	A24 A27
O_2S Up R Fuel Pressure	2/1 (5.9L HD 8.0L HD) CNG	A26 A28
O_2 Dn L Trans Press	1/2 (All LD) 1/3 (8.0L MD)	A25 B29
O_2S Dn R PTO	1/2 (8.0L MD) BR only	A29 A13
Spare Fuel Level		A30 A14

Table 2 1999 and Later JTEC+ Multiplexed Inputs

Name	Comments	JTEC Pin #
TPS Cruise MPX		A23 C32
O_2S Up L MAP	1/1 (All applicable models)	A24 A27
O_2S Up R Fuel Temperature	2/1 (5.9L HD 8.0L HD) CNG	A26 A28
O_2S Dn L Trans Press	1/2 (All LD) 1/3 (8.0L MD)	A25 B29
O_2S Dn R Spare	1/2 (8.0L MD)	A29 A13
Spare Fuel Level		A30 A14

THREE WIRE SENSOR DIAGNOSIS

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

Like the cam, crank and VSS sensors, 5 volts are supplied from the PCM and returns a voltage signal to the PCM that reflects manifold pressure. The MAP (fig. 4) is also provided with a 5-volt power supply that is shared with the TPS, Linear EGR (if equipped) and A/C Transducer (if equipped) on SBEC vehicles, or TPS, CMP and CKP on JTEC vehicles. The MAP sensor operating range is from 0.45 volts (high vacuum) to 4.8 volts (low vacuum). The sensor is supplied a regulated 4.8 to 5.1 volts to operate the sensor. Like the cam and crank sensors, ground is provided through the sensor ground circuit.

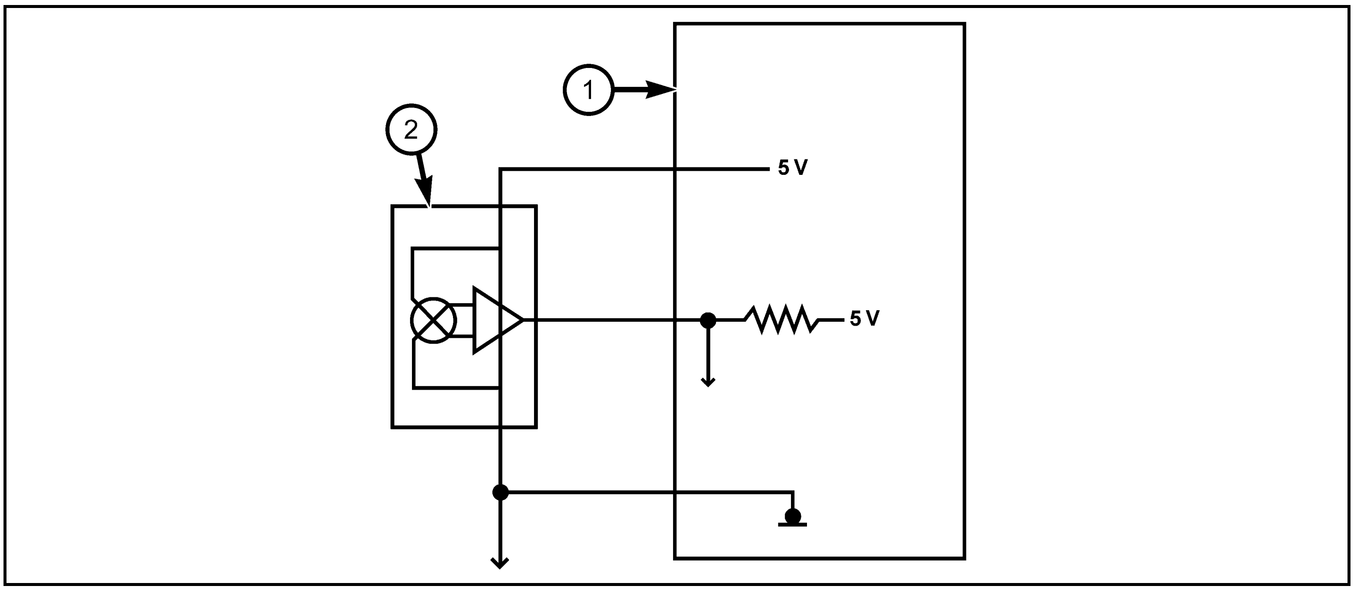

Figure 4 MAP Sensor

1	PCM	2	MAP Sensor

MAP Sensor Diagnostics

Listed below are the MAP sensor diagnostic routines:

- MAP voltage high: signal open or shorted to power, may be caused by a faulty 1/1 O_2 sensor or circuit on JTEC vehicles only
- MAP voltage low: signal shorted to ground, or no 5-volt supply (No 5-volt: SBEC ONLY)
- No change in MAP voltage at start-to-run transfer (vacuum)
- No 5-volt (power) to MAP sensor (JTEC only)
- TPS Does Not Agree With MAP

With the engine running between 600 to 3500 rpm, near closed throttle, if MAP voltage is above 4.6 volts, the voltage high fault is set.

There could be three different ways to set the voltage low fault:

- If MAP voltage is below 1.2 volts at startup
- If MAP voltage below 0.02 volts while the engine is running.
- If there is an open in the MAP power feed (SBEC only)

Note: *If you are attempting to generate the opposite code while performing diagnostics, it is important to remember the PCM does not perform diagnostics unless the engine is within the specified rpm range (the vehicle must be running).*

Note: *Make sure the ignition is OFF, prior to unplugging the MAP sensor, or damage the MAP sensor will occur.*

THROTTLE POSITION SENSOR

The TPS (fig. 5) is supplied with a regulated voltage that ranges from 4.8 to 5.1 volts from the PCM. This output regulated voltage is the same regulated voltage the MAP sensor uses. The TPS receives its ground from the PCM. The input of the TPS to the PCM is through a 5-volt sensor circuit.

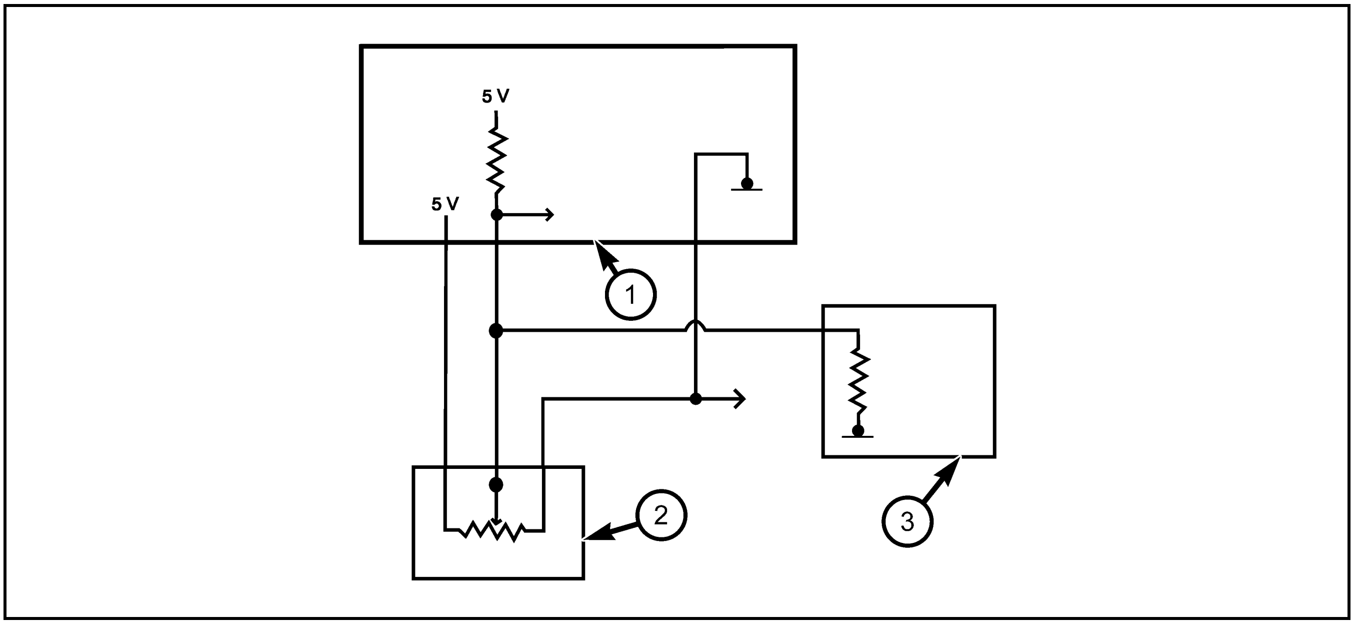

Figure 5 TPS

1	PCM	3	EATX TCM (if equipped)
2	Throttle Position Sensor		

TPS Diagnostics

There are three TPS diagnostic routines:

- TPS voltage too high (signal open or short to power), may be caused by a faulty cruise MPX circuit on JTEC only.
- TPS voltage too low (signal shorted to ground or no 5-volt supply).
- TPS voltage does not agree with MAP (rationality fault).

The “TPS voltage does not agree with MAP” fault is set when the PCM interrupts the MAP indication as a load condition which does not agree with what it sees from the TPS. If the voltage gets too low, the PCM sets the short to ground (voltage low) fault. If the voltage gets too high, it sets the open circuit (voltage high) fault.

Note: *On vehicles equipped with a TCM, the TPS open-circuit voltage does not go to 5 volts, due to the pull-down circuit in the TCM.*

A/C PRESSURE TRANSDUCER

The A/C pressure sensor is a transducer that senses refrigerant pressure in the discharge line of the A/C system. The transducer replaces the high and low side pressure switches. The transducer is a 0 to 500 psi sensor that changes the resistance of its circuit based upon pressure. The PCM sends a 5-volt signal to operate the sensor's circuit. The PCM also sends a 5-volt monitoring circuit to the sensor. The resistance of the sensor is directly proportional to the pressure on the transducer. As pressure increases on the transducer, the monitoring voltage increases.

A/C Pressure Transducer Diagnostics

- A/C Pressure Sensor Volts Too Low is set when sensor voltage goes below 0.058 Volts.
- A/C Pressure Sensor Volts Too High is set when sensor voltage goes above 4.9 Volts.

EGR POSITION SENSOR

The EGR position sensor informs the PCM of the exact position of the EGR pintle. This allows for more precise control over the amount of EGR that is flowed for better NOx control. The EGR position sensor shares the same feed as MAP sensor, TPS, A/C transducer and works similar to the TPS.

EGR Position Sensor Diagnostics

- EGR Rationality Fault is set when flow or valve movement is not what is expected.
- EGR Position Sensor Too Low is set when the signal is less than 0.157 volts.
- EGR Position Sensor Too High is set when the signal is greater than 4.9 volts for 6 seconds

Notes:

TWO WIRE SENSOR DIAGNOSIS

NEGATIVE TEMPERATURE COEFFICIENT (NTC) THERMISTORS

The PCM relies on several NTC thermistors (fig. 6) for information regarding various temperatures. All NTC thermistors have a high resistive value when cold and a low resistance value when warm. The PCM sends 5 volts to each sensor and watches for the voltage drop to sensor ground through the thermistor. When the sensor indicates a cold operating environment, there is little drop across the thermistor and the PCM sees a high voltage signal. As the temperature increases, there is a larger drop across the thermistor and the PCM sees a lower voltage signal.

A feature specific to the SBEC PCM only is a dual ranging circuit (fig. 7). The 5-volt signal normally flows through a 10,000 ohm pull-up resistor. When the PCM senses about 120°F (about 1.25 volts), it turns on a transistor that places a 1000 ohm resistor in parallel to the 10,000 ohm resistor. This effectively lowers the total circuit resistance to 909 ohms. As a result, there is less of a voltage drop across the pull-up resistors, and the signal voltage goes back up. This increases the accuracy of the intake air and coolant temperature sensors.

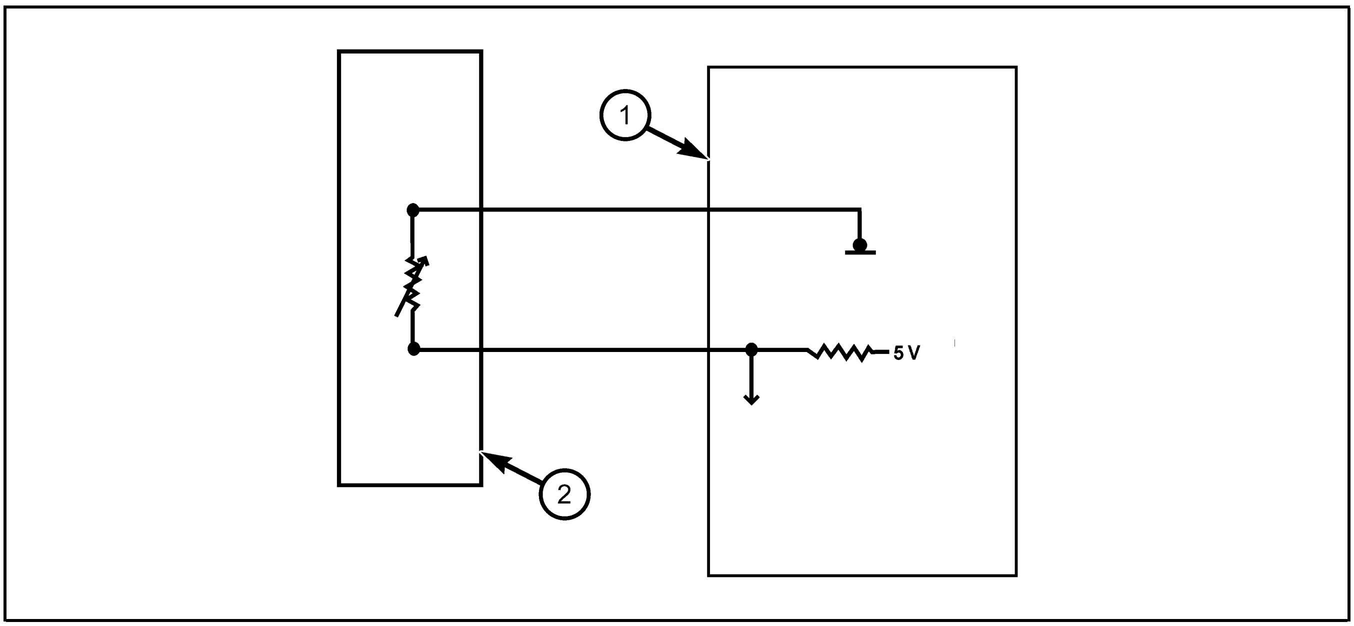

Figure 6 NTC Thermistor Single Ranging Circuit (JTEC)

1	PCM	2	NTC Thermistor

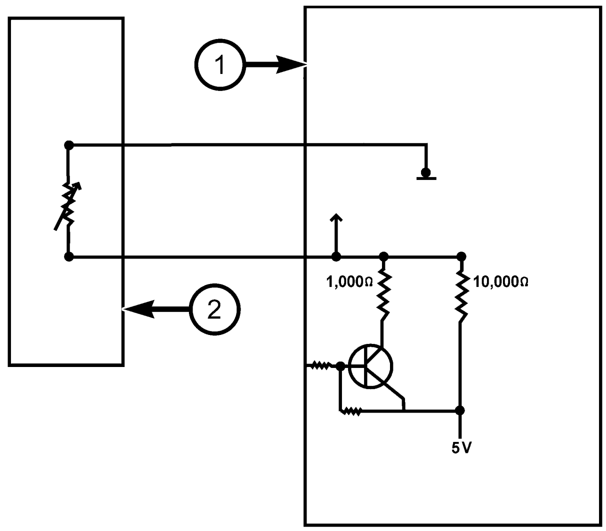

Figure 7 NTC Thermistor Dual Ranging Circuit (SBEC)

1	PCM	2	NTC Thermistor

ECT Sensor Diagnostics

There are four ECT diagnostic routines:

- ECT too high (signal open)
- ECT too low (signal shorted to ground)
- ECT too cold too long (rationality)
- Closed loop temperature not reached (rationality)

IAT Sensor Diagnostics

- Voltage Too Low is set when voltage is below 0.157 volts
- Voltage Too High is set when voltage is above 4.9 volts.

BATTERY/AMBIENT TEMPERATURE SENSOR

The battery temperature sensor is located directly under the battery on JTEC vehicles. Passenger vehicles with SBEC, may use an Ambient Temperature Sensor, Air Inlet Sensor, or a thermistor inside the PCM.

Battery Temperature Sensor Diagnostics

- Battery Temp Sensor Voltage Low is set if the sensor voltage is below 0.5 volts.
- Battery Temp Sensor Voltage High is set if sensor voltage is above 4.9 volts.

Notes:

SUMMARY OF THREE WIRE AND TWO WIRE DIAGNOSIS

Methods of Diagnosing Open (Voltage High) and Short (Voltage Low) DTCs

Note: *The methods described are not a suggestion to steer away from using the Diagnostic Procedure Manuals. These are legitimate methods of performing open and short circuit electrical diagnostics that, once learned, enhance your abilities and help you determine whether a procedure is leading you down the wrong path. The appropriate manuals should **always** be referenced for rationality-based faults.*

More times than not, the procedure below is detailed in the diagnostic book. However, you are usually instructed to disconnect connectors and ohm-out the circuits prior to doing the procedure below. There are two problems with that strategy: if the Voltage High fault is a result of a bad connection at the PCM, you can probably "fix it" temporarily by disconnecting and then reconnecting the connector. Also, there is a possibility of a meter being incorrectly read. The method below allows the PCM to perform diagnostics for us, without disturbing connections, and without having to interpret a meter reading.

VOLTAGE TOO HIGH

2-Wire Sensors

- Disconnect the appropriate sensor.
- Using a paper clip, jumper the connector.
- If the DRBIII® indicates the opposite DTC was set (Voltage Too Low), check the connector to make sure the terminals are not spread. If they are not spread, replace the sensor.
- If the opposite DTC was not set, identify the signal wire in the connector. Jumper the signal to an engine ground and recheck the DTCs. If Voltage Too Low was set, repair the open sensor ground wire.
- If the opposite code was not set, back-probe the signal at the PCM and ground the signal wire. If the opposite code sets, repair the open signal wire.
- If the opposite code does not set, check the PCM connector and pin. If OK, replace PCM.

3-Wire Sensors

- Follow above procedure, but test the power feed as well. An open power feed does not generate Voltage Too High, but checking it is a good practice.

VOLTAGE TOO LOW

2-Wire Sensors

- Unplug the sensor and check for the opposite DTC, Voltage Too High. If the fault sets, carefully inspect the connectors for stray metal. If OK, replace the sensor.
- If the opposite fault is not set, unplug the PCM connector, remove the sense wire from the connector, plug the PCM back in again (without the sense circuit) and recheck for DTCs. If the opposite DTC is now set, repair the short in the signal wire. If it doesn't set, replace the faulty PCM.

3-Wire Sensors

- Follow 2-wire procedure, except:
- Test power feed. On SBEC vehicles, a 3-wire sensor sets the Voltage Too Low DTC if there is an open in the power supply. JTECs do not do this. They set a No 5v (power) to MAP sensor fault.

ACTIVITY 2

Your objective is to document the most effective process to diagnose this vehicle failure. Do not repair the vehicle unless directed to by your instructor. Your diagnosis is not as important as the process you use to come to your conclusion. Do not waste your time looking for a bug. If you really want to know what was done to the vehicle, ask your instructor. Your objective is to prove it using proven diagnostic methods.

Customer's Complaint: MIL On

DTCs: ____

List the steps you used to diagnose the customer's complaint: ____________

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In conclusion, what is the root cause of the failure? ____________________

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ACTIVITY 3

Your objective is to document the most effective process to diagnose this vehicle failure. Do not repair the vehicle unless directed to by your instructor. Your diagnosis is not as important as the process you use to come to your conclusion. Do not waste your time looking for a bug. If you really want to know what was done to the vehicle, ask your instructor. Your objective is to prove it using proven diagnostic methods.

Customer's Complaint: MIL On

DTCs: ____

List the steps you used to diagnose the customer's complaint: __________

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In conclusion, what is the root cause of the failure? ________________

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ACTIVITY 4

Your objective is to document the most effective process to diagnose this vehicle failure. Do not repair the vehicle unless directed to by your instructor. Your diagnosis is not as important as the process you use to come to you conclusion. Do not waste your time looking for a bug. If you really want to know what was done to the vehicle, ask your instructor. Your objective is to prove it using proven diagnostic methods.

Customer's Complaint: MIL On

DTCs: ____

List the steps you used to diagnose the customer's complaint: ________________

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In conclusion, what is the root cause of the failure? ______________________

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ACTIVITY 5

Your objective is to document the most effective process to diagnose this vehicle failure. Do not repair the vehicle unless directed to by your instructor. Your diagnosis is not as important as the process you use to come to you conclusion. Do not waste your time looking for a bug. If you really want to know what was done to the vehicle, ask your instructor. Your objective is to prove it using proven diagnostic methods.

Customer's Complaint: MIL On

DTCs: ____

List the steps you used to diagnose the customer's complaint: ________________

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In conclusion, what is the root cause of the failure? ________________________

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Notes:

TWO STATE INPUTS

Many inputs to the PCM operate as a two state switch. The PCM sees either high voltage (circuit open) (fig. 8) or low voltage (circuit closed) (fig. 9). The PCM monitors the circuit with an internal pull-up resistor. If the switch is open, a high voltage value is read by the PCM's monitoring circuit. The voltage passes through a resistor inside the PCM and, in this case, there is no path to ground (open circuit) and no voltage drop across the PCM's internal resistor occurs. If the switch is closed, a voltage reading taken after the internal resistor is very low. In a closed circuit, a path to ground is provided and a voltage drop occurs across the internal resistor. By knowing the state of the input circuit (closed circuit or open circuit), the PCM can regulate specific outputs.

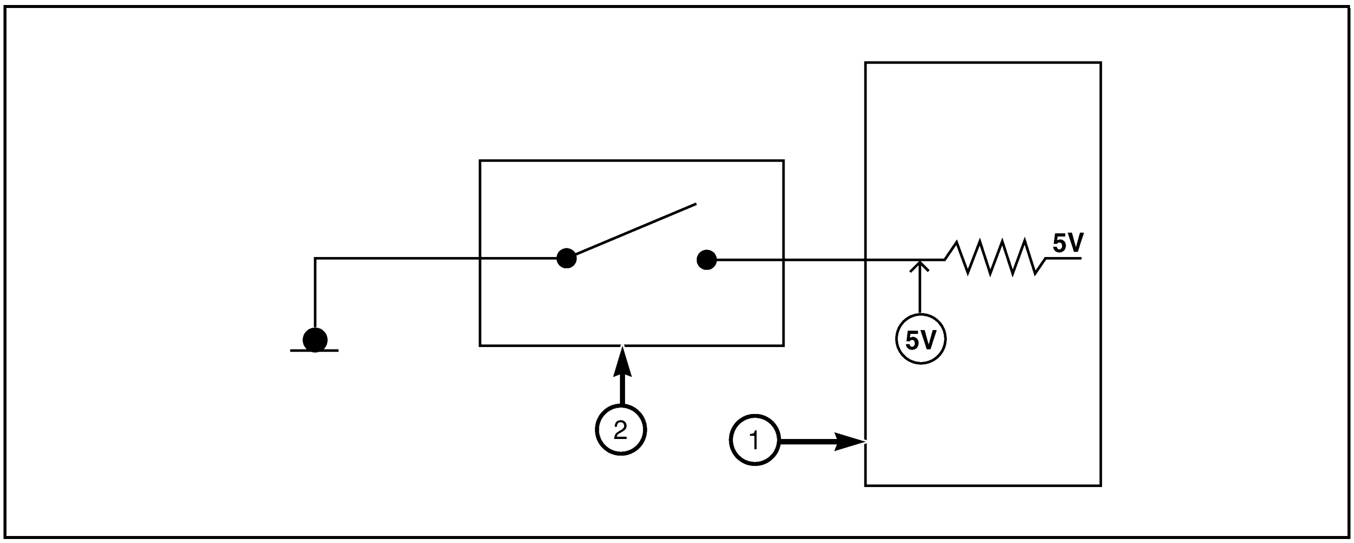

Figure 8 Two State Switch (Open Circuit)

1	PCM	2	Two State Switch

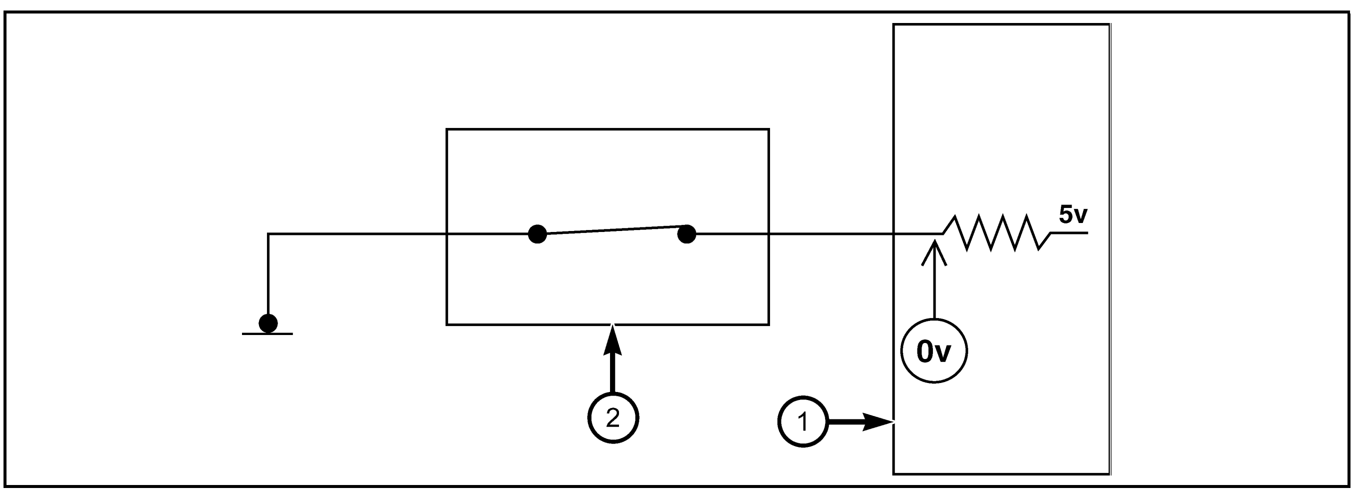

Figure 9 Two State Switch (Closed Circuit)

1	PCM	2	Two State Switch

PARK/NEUTRAL SWITCH (AUTO TRANSAXLE ONLY)

The PCM sends a signal voltage to the Park/Neutral switch or Transmission Range Sensor (fig. 10). When the gear shift lever is moved to either the PARK or the NEUTRAL position, the PCM receives a ground signal from the Park/Neutral switch. With the shift lever positioned in DRIVE or REVERSE, the Park/Neutral switch contacts open, causing the signal to the PCM to go high.

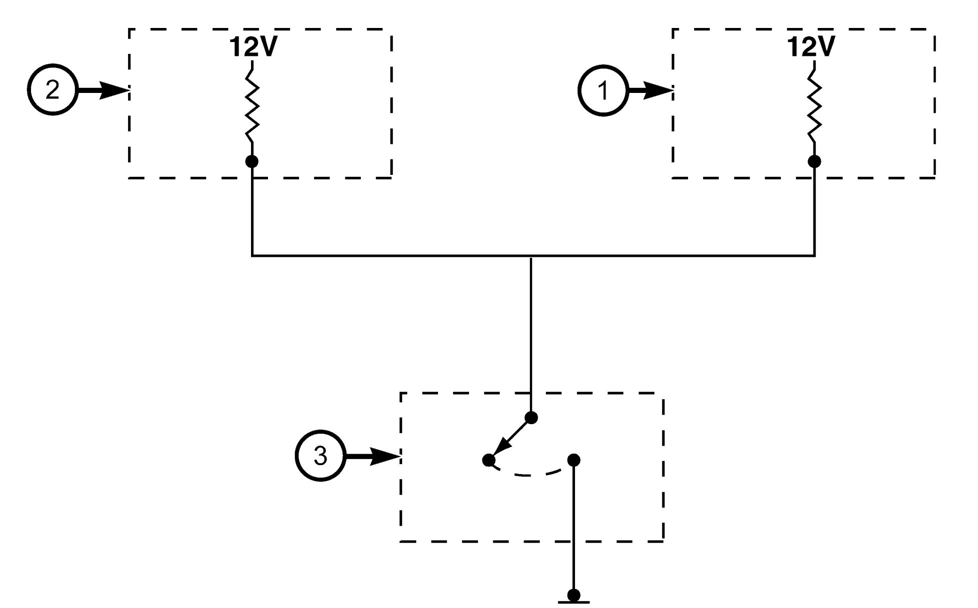

Figure 10 Park/Neutral Switch or Transmission Range Sensor

1	PCM	3	TRS or P/N switch
2	TCM (if applicable)		

BRAKE SWITCH

The brake switch (fig. 11) is equipped with three sets of contacts, one normally open and the other two normally closed (brakes disengaged). The PCM sends a 12-volt signal to one of the normally closed contacts in the brake switch, which is connected to a ground. With the contacts closed, the 12-volt signal is pulled to ground causing the signal to go low. The low voltage signal, monitored by the PCM, indicates that the brakes are not applied. When the brakes are applied, the contacts open, causing the PCM's output voltage to go high, disengaging the speed control, if equipped.

If the brake switch circuit is pulled high, with or without brake pedal application:

- Speed control does not work.
- If the vehicle is equipped with an automatic transmission there is not any torque converter lockup.

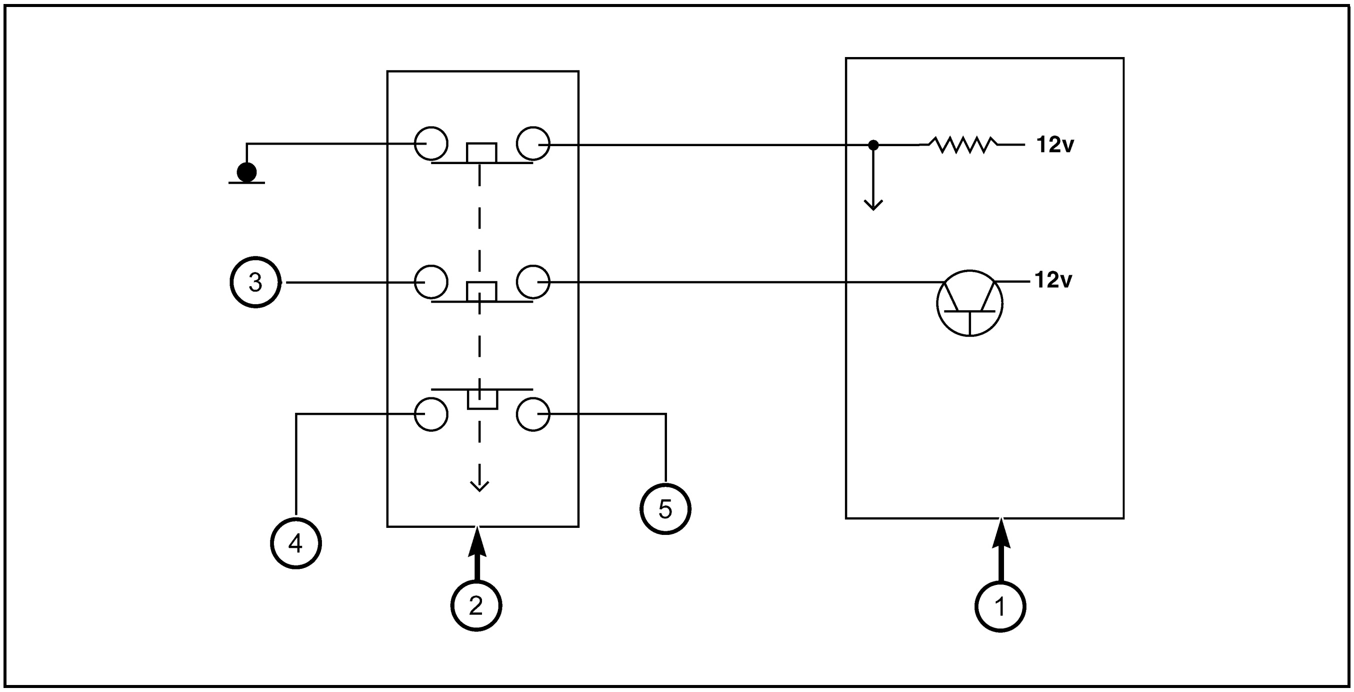

Figure 11 Brake Switch

1	PCM	4	From Battery
2	Brake Switch	5	To Stop Lamps
3	To Speed Control Solenoids		

POWER STEERING PRESSURE SWITCH

A pressure switch is located on the power steering pump or high pressure line. The switch signals periods of high pump load and high pressure, such as those that occur during parking maneuvers. This information allows the PCM to slightly raise and maintain target idle speed. To compensate for the additional engine load, the PCM increases air flow by adjusting the IAC motor.

ASD SENSE CIRCUIT

The main purpose of the ASD relay is to supply voltage to the generator field, the injectors, and the ignition system but the monitoring of the circuit is a two state input. The PCM receives a battery voltage signal from the output of the ASD relay indicating the Automatic Shutdown (ASD) relay has energized. It uses this input for diagnostic purposes. The PCM provides the relay coil with a path to ground as an output function. Refer to the Output Section on the ASD relay for more information.

MISCELLANEOUS OTHER INPUTS

SENSED BATTERY VOLTAGE

The direct battery feed to the PCM is also used, as a reference point, to sense battery voltage for controlling injector pulse-width, coil pack saturation, and charging system control. It is important to remember that resistance in this circuit can lead to an overcharge or rich-running condition.

Fuel Injectors

Fuel injectors are rated for operation at a specific voltage. If the voltage increases, the plunger opens faster and further (more efficient) and conversely, if voltage is low the injector is slow to open and does not open as far. If sensed battery voltage drops, the PCM increases pulse-width to maintain the same volume of fuel through the injector.

Charging

The PCM uses sensed battery voltage to verify that target charging voltage (determined by Battery or Ambient Temperature Sensor) is being reached. To maintain the target charging voltage, the PCM full fields the generator to 0.5 volts above target then turns off to 0.5 volts below target. This continues to occur up to a 100 Hz frequency (100 times per second).

KNOCK SENSOR

Diagnostics

A DTC is set if:

- The Knock Sensor circuit voltage falls below a minimum value at idle or decelerations (look–up table internal to the PCM and based on engine RPM).
- The Knock Sensor output voltage is above 5 volts.

FUEL LEVEL SENSOR INPUT

Fuel level is an input that is used for OBD II decision making.

Many different configurations are used. On some vehicles, the fuel level signal is sent directly to the PCM. On others, it may be sent directly to another controller, such as the BCM or “Smart Instrument Cluster”. Consult applicable wiring schematics for more details.

TORQUE REDUCTION (TORQUE MANAGEMENT)

The PCM sends a 9-volt signal to the TCM. The TCM requests torque reduction, by momentarily grounding the 9-volt circuit, commanding the PCM to decrease injection pulse-width. When the TCM determines the transaxle is about to make a high torque, high RPM shift, the TCM momentarily grounds this wire. The PCM then has one second to acknowledge this message by returning the signal over the bus to the TCM (fig. 12).

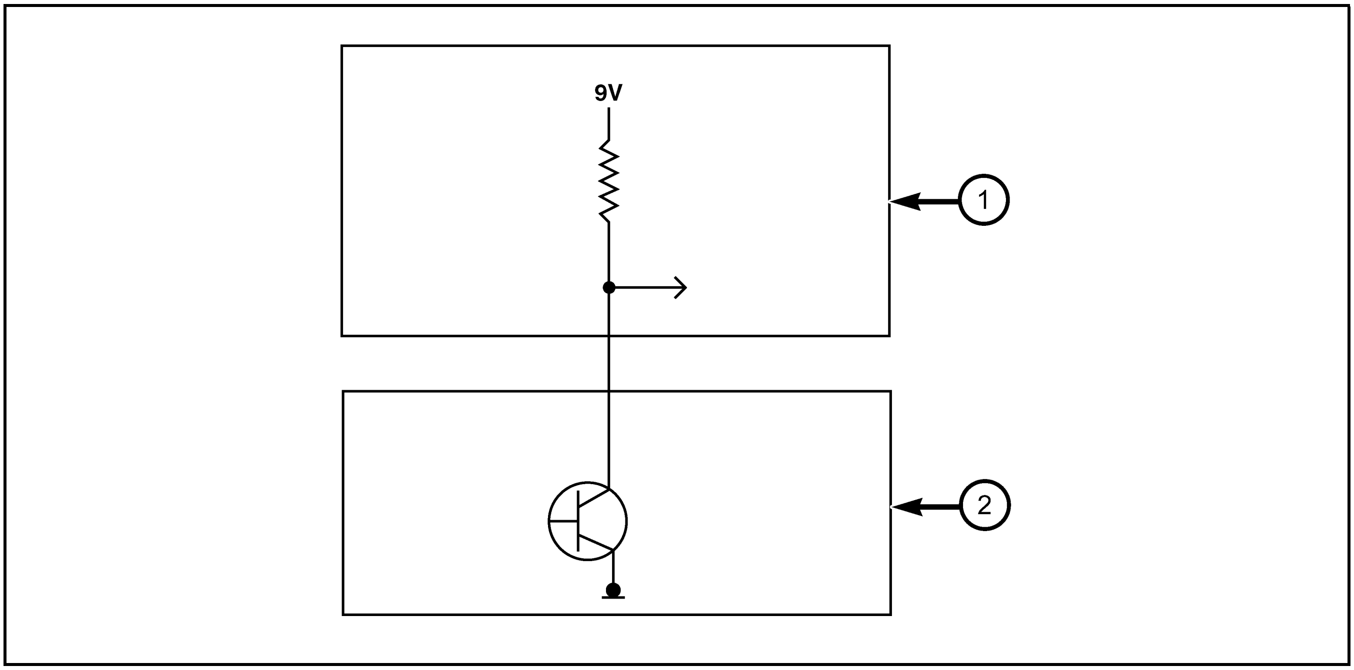

Figure 12 Torque Reduction Circuit

1	PCM	2	TCM

VEHICLE SPEED SENSOR (VSS)

As previously discussed, vehicles equipped with 3-speed automatic or manual transaxles, use a Hall-effect vehicle speed sensor. On vehicles equipped with 41TE or 42LE automatic transaxles, the Transmission Control Module (TCM) provides the VSS signal electronically (fig. 13). Vehicles with a 45RFE/545FE and all XXRE transmissions use the CAB to generate the vehicle speed signal.

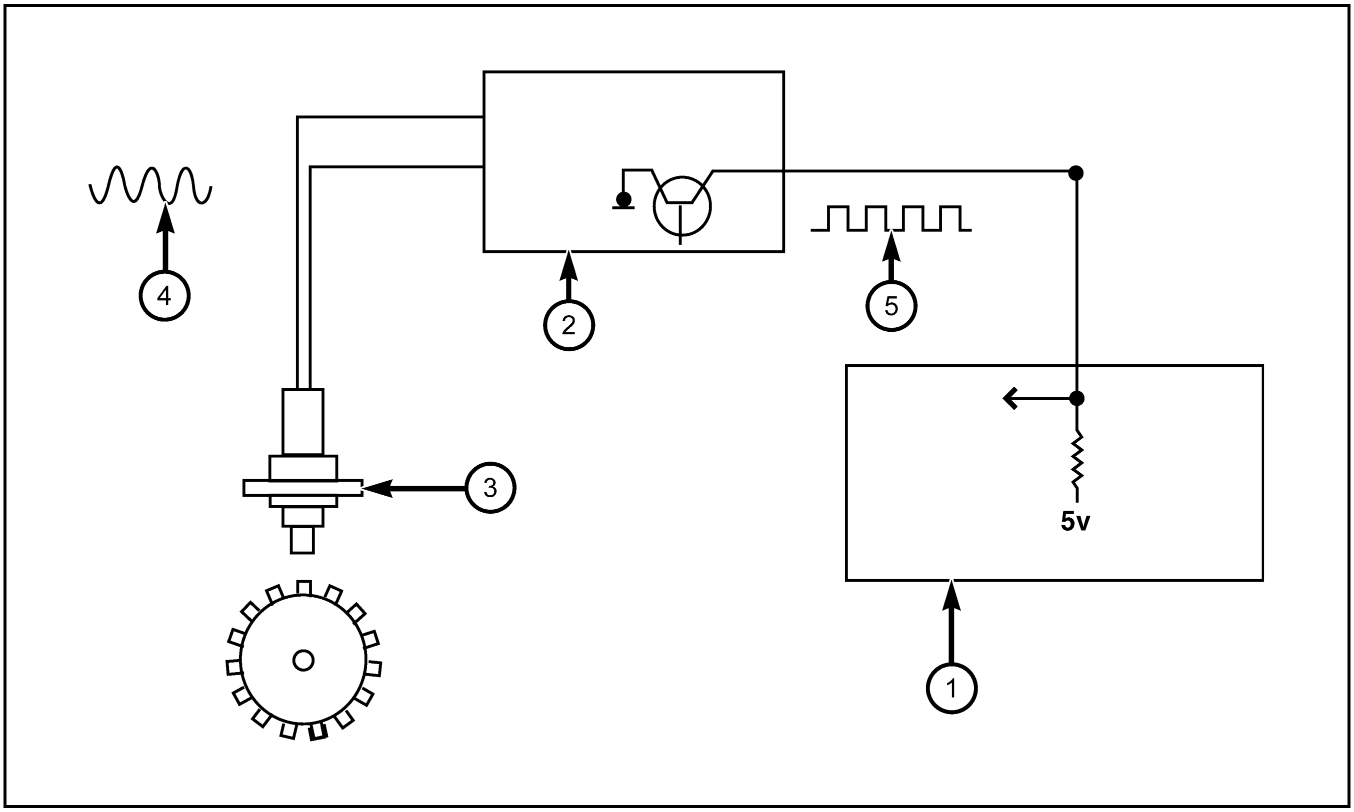

Figure 13 Vehicle Speed Sensor

1	PCM	4	AC Sine Wave
2	TCM or CAB	5	Digital Signal
3	Output Shaft / Wheel Speed Sensor		

4-Speed Automatic

On all vehicles equipped with a 41TE/42LE transaxle and on most JTEC-equipped vehicles (except AW4 or vehicles with a three wire VSS) the TCM or CAB provides VSS information, which has been designated "electronic pinion."

The term "electronic pinion" refers to the replacement of the pinion gear on the VSS with an electronic calibration programmed into the TCM or CAB

The TCM or CAB uses an AC pulse generator to monitor transmission output-shaft speed, wheel speed, or differential speed. As the trigger device rotates, the speed sensor provides an AC signal with a frequency in direct proportion to the number of teeth on the trigger device. The TCM or CAB converts the AC sine waves from the trigger device into a speed signal. Once the TCM or CAB is programmed with information about tire size and axle ratios, the TCM or CAB delivers a signal to the PCM indicating vehicle speed.

The PCM sends a 5-volt signal to the TCM or CAB. The TCM or CAB switches this signal to a ground, and then opens the circuit at a rate of 8000 pulses per mile (FJ = 4100 pulses per mile/Viper = 10000 pulses per mile). The PCM calculates the VSS signal on an automatic transaxle vehicle the same way it does on a manual transaxle vehicle.

Note: *When the TCM or CAB is replaced, the new TCM or CAB must be programmed with tire size and/or axle family information in order to function. The TCMs or CABs are programmed not to output the VSS signal until the technician has programmed tire size information.*

FUEL CONTROL

OXYGEN (O_2) SENSORS

Naming Conventions

Oxygen sensors are typically represented as 1/1, 1/2, 1/3, etc (fig. 14 and fig 15). The first digit indicates the bank of the engine the O_2 sensor is on. The digit “1” indicates the O_2 sensor is on the same bank as the number 1 cylinder. The digit “2” represents a location on the bank opposite the number 1 cylinder. The second digit represents upstream (1), downstream (2) or mid-catalyst (3) locations.

As an example, 2/2 would represent an O_2 sensor located downstream, on the bank opposite the number 1 cylinder.

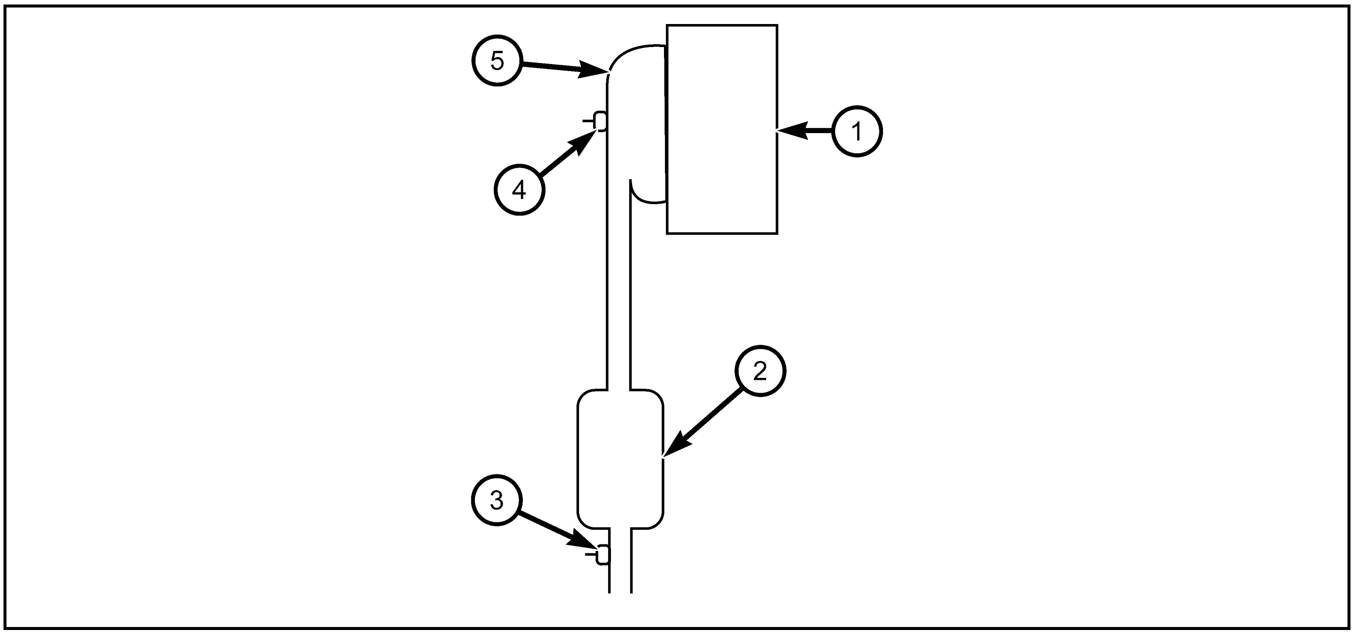

Figure 14 Naming Conventions of O_2 Sensors (1/1 and 1/2)

1	Engine	4	Oxygen Sensor (1/1)
2	Catalytic Converter	5	Exhaust Manifold
3	Oxygen Sensor (1/2)		

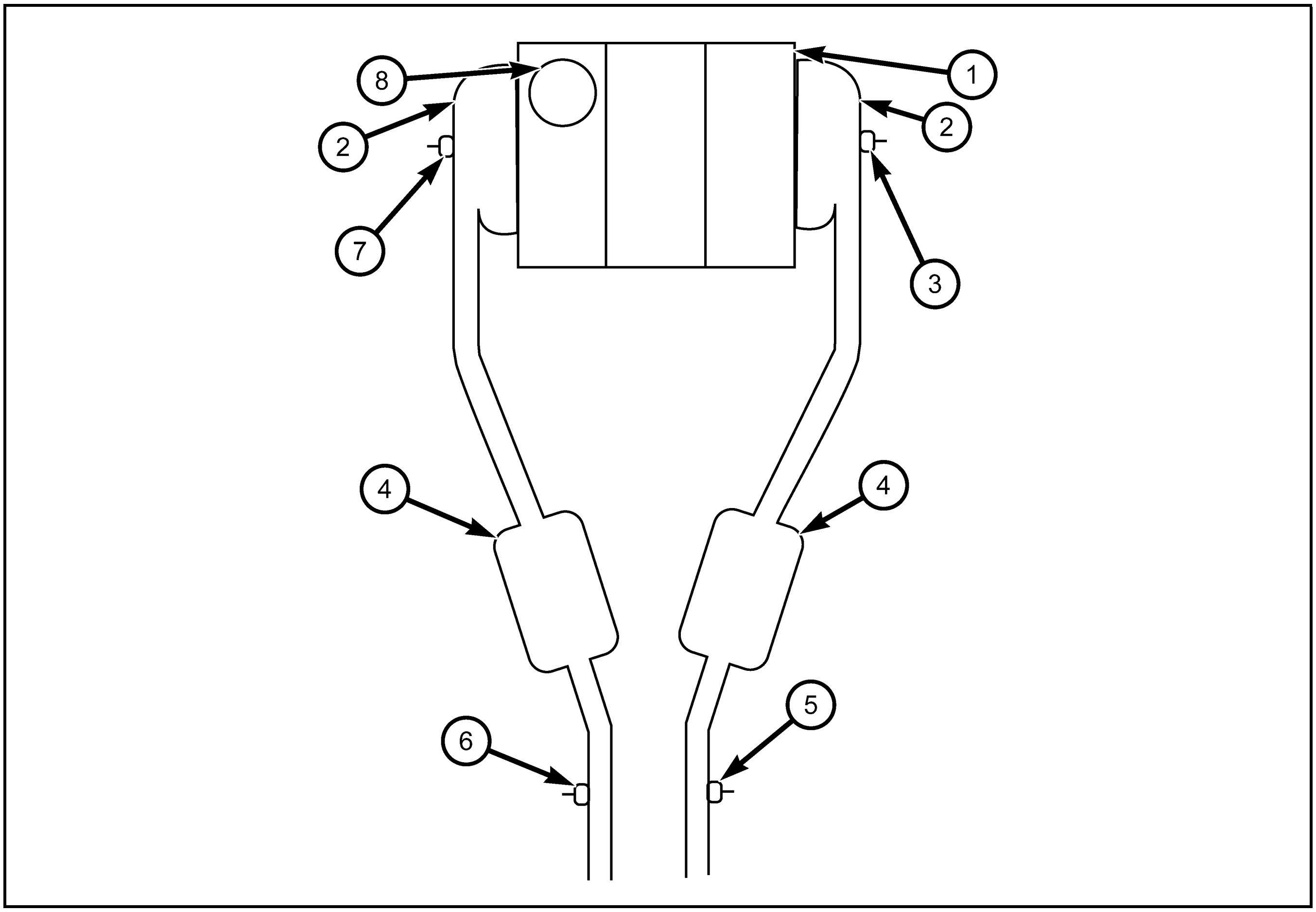

Figure 15 Naming Conventions of O2 Sensors (1/1, 1/2, 2/1, and 2/2)

1	Engine	5	Oxygen Sensor (2/2)
2	Exhaust Manifold	6	Oxygen Sensor (1/2)
3	Oxygen Sensor (2/1)	7	Oxygen Sensor (1/1)
4	Catalytic Converter	8	Cylinder #1

General Information

Starting in 1996, all vehicles use at least one Upstream O_2 sensor and one Downstream O_2 sensor (fig. 16). An O_2 sensor provides the PCM with a voltage signal (0-1 volt) inversely proportional to the amount of oxygen in the exhaust. If the oxygen content is low, the voltage output is high; if the oxygen content is high, the output voltage is low. The PCM uses this information to adjust injector pulse-width to achieve the air/fuel ratio necessary for proper engine operation and to control emissions.

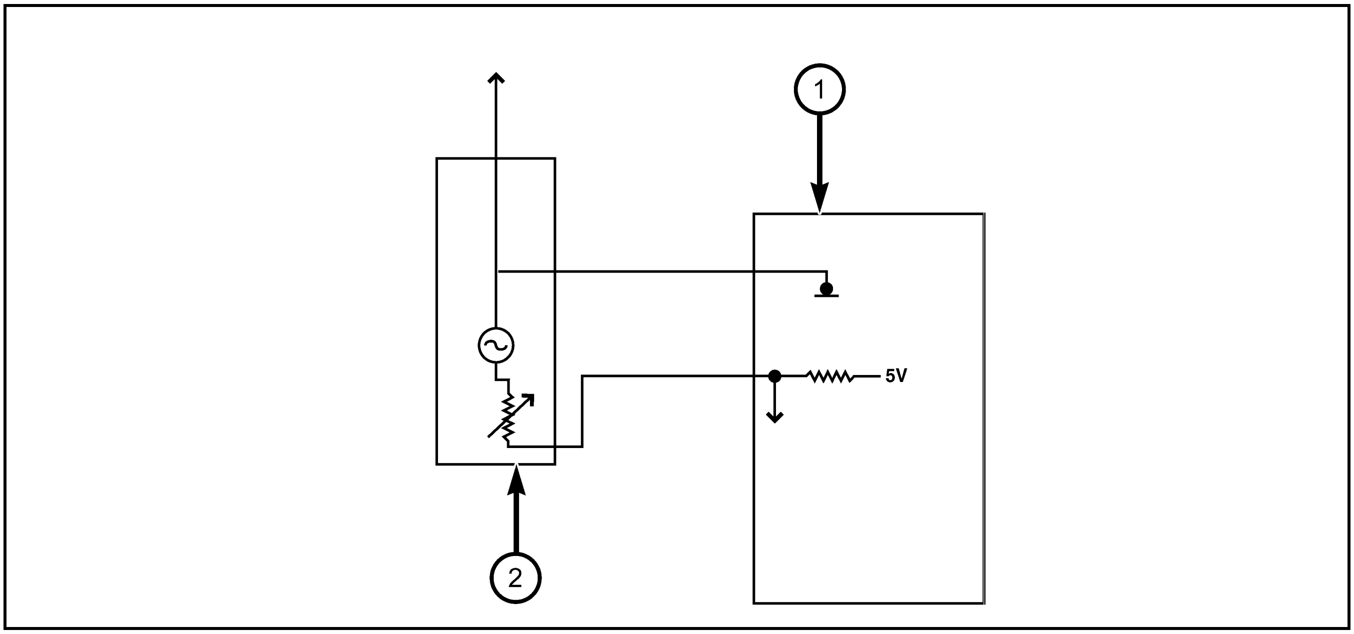

Figure 16 Oxygen Sensor

1	PCM	2	Oxygen Sensor

An O_2 sensor must have a source of oxygen from outside of the exhaust stream for comparison (fig. 17). Current O_2 sensors receive their fresh oxygen supply through the wire harness. This is why it is important to never solder an O_2 sensor connector or pack the connector with grease.

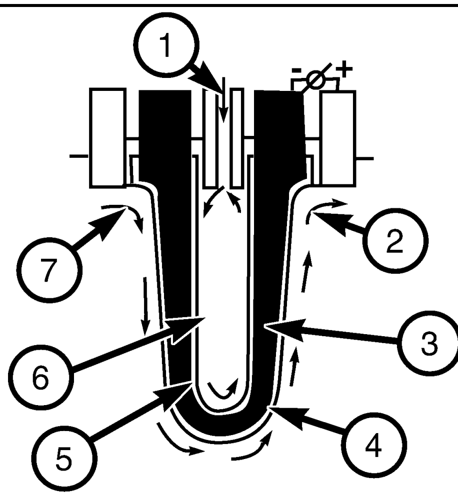

Figure 17 Oxygen Sensor Internal Operation

1	Outside Air	5	Inner Electrode
2	Exhaust Oxygen	6	Ambient Oxygen
3	Solid Electrolyte	7	Exhaust Oxygen
4	Outer Electrode		

The downstream sensor is located just after the catalytic converter, or between the catalyst biscuits, and produces a similar signal input to the PCM that is used for two purposes. One function is to verify catalytic converter efficiency as a requirement of OBD II diagnostics. The other function is to provide fuel correction information based on actual catalytic converter output.

Both upstream and downstream O_2 sensors are zirconium dioxide, 4-wire, and heated. The heaters on both sensors are either fed battery voltage from the ASD relay or the sensor relay (some JTEC), which are controlled by the PCM. Both sensor heaters either uses a common ground, or they are pulse-width modulated (PWM) by the PCM.

The O_2 sensor uses a Positive Thermal Co-efficient (PTC) heater element. As temperature increases, resistance increases. Even though these are heating elements, current flow is low. Although O2 sensors operate the same way there are physical differences, due to the environment that they operate in, that keeps them from being interchangeable.

The last two wires are the signal input to the PCM and the sensor ground. Both circuits are isolated from each other and the sensor housing. The sensor ground may be an independent circuit (K127) starting in the 1998 model year for SBEC-equipped vehicles. JTEC-equipped vehicles continue to share the K4 sensor ground with the O_2 sensor.

O_2 Sensor Electrical Operation

When the O_2 Sensor is cold the resistance of the sensor is extremely high (infinite). As the sensor heats up two things happen. First, the resistance of the sensor drops. Second, once the sensor heats to a temperature, above 660° F, the sensor becomes a galvanic battery, actually creating a voltage output.

When the engine is at operating temperature and signal voltage from the sensor is higher than 1.2 volts on SBEC, or higher than 1.5 volts on JTEC, the PCM considers the signal shorted to voltage and sets a fault. If the voltage is lower than a predetermined value, the PCM considers the signal shorted to ground and sets a fault.

Note: *Resistance in the signal (sensor) ground circuit can set the DTC "O_2 Sensor Shorted to Voltage."*

O_2 Sensor Heater Controls

There are three methods of heating oxygen sensors. The first method utilizes a Positive Temperature Coefficient (PTC) thermistor heater element. This heater element receives power from the ASD relay and has a constant ground (fig. 18).

The second method is a Pulse-Width Modulated (PWM) heater circuit (fig. 19). The heater element receives power from the ASD relay and the ground is pulse-width modulated by the PCM. A variable current is provided by the control of a duty-cycle from 0% to 100%. The heaters in the PWM O_2 sensor cannot tolerate 12 volts 100% of the time. Therefore, 100% is applied after start up for some period, and then the duty-cycle is ramped down to some lower level to protect the heater element.

PWM O_2 sensor heaters allow for a short-term closed loop condition as early as 5 to 10 seconds after start up. The conventionally heated O_2 sensors take as long as 35 seconds to go into short-term closed loop. Going into closed loop earlier allows the cold-start emissions to be reduced.

To summarize, some of the advantages of the PWM heaters are:

- Meet tighter emissions regulations of LEV and ULEV
- Allow closed loop operation as early as 5 to 10 seconds after start
- Allows a delay in activation after an overnight soak to allow moisture to burn off to prevent cracking of the thimble

The third method includes an O_2 heater relay (fig. 20). On these vehicles, power is provided to the O_2 heater element by the O_2 heater relay and its ground is fixed. The

O_2 heater relay receives power from the ASD relay. The PCM controls the ground of the O_2 heater relay.

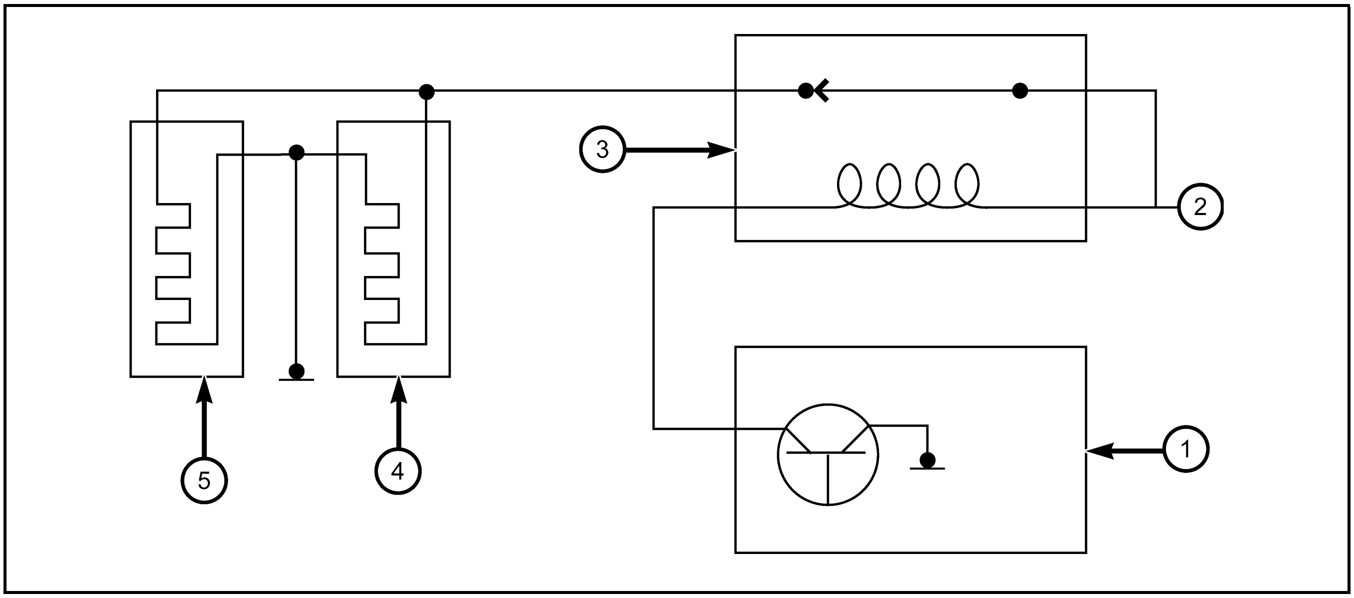

Figure 18 O_2 Heater Element – ASD Power/Constant Ground

1	PCM	4	Oxygen Sensor
2	12 volts from battery or ignition	5	Oxygen Sensor
3	ASD Relay		

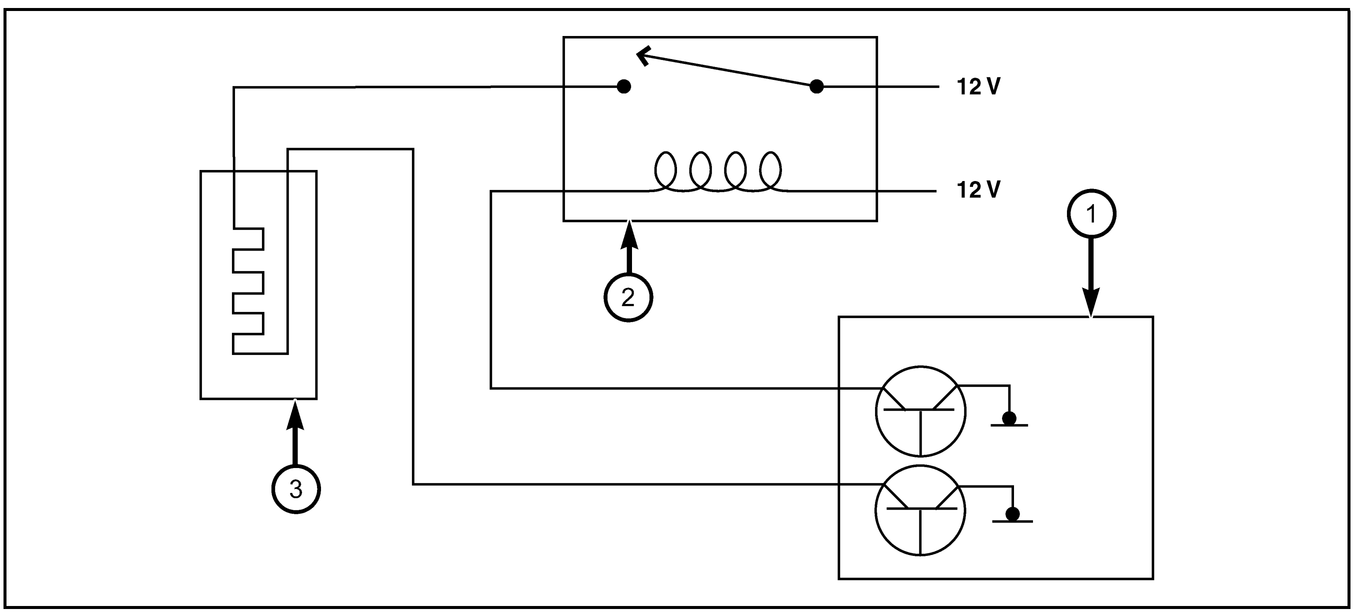

Figure 19 O_2 Heater Element – ASD Power/PWM Ground

1	PCM	3	Oxygen Sensor
2	ASD Relay		

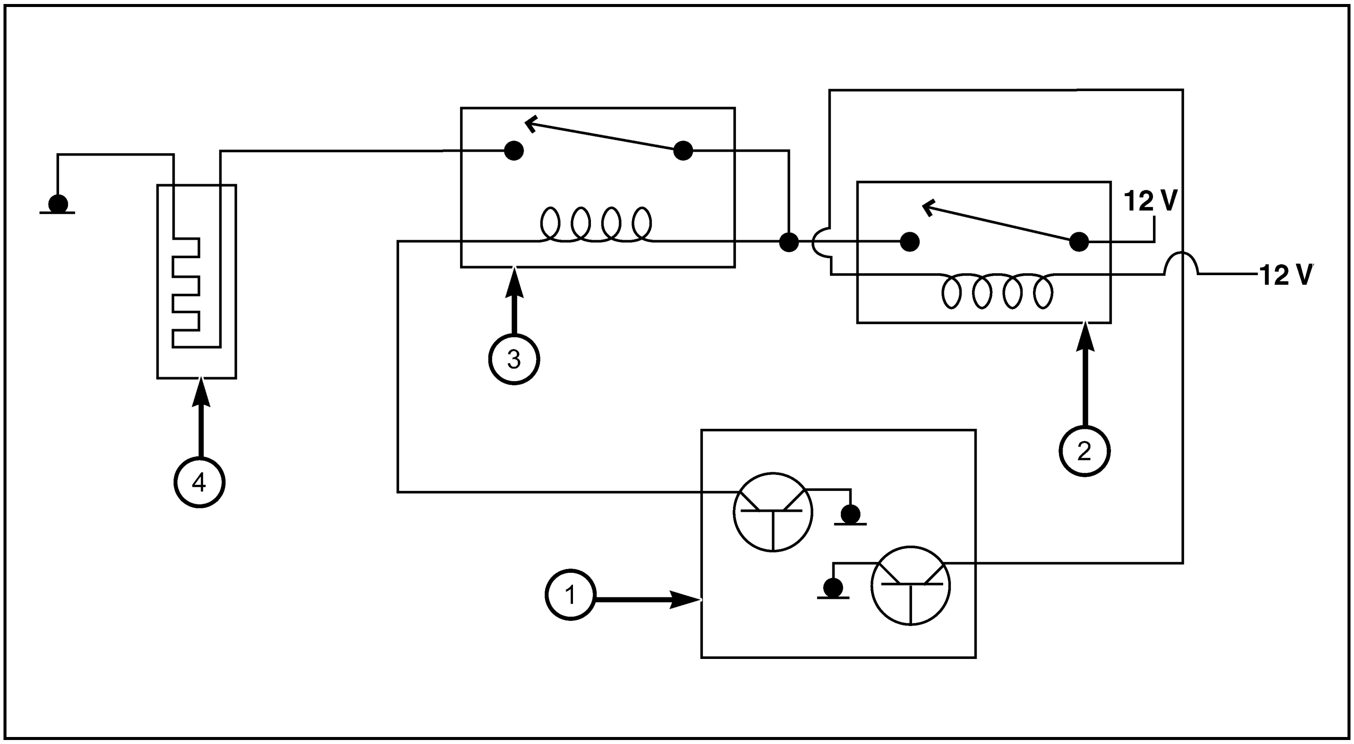

Figure 20 O_2 Heater Element – Relay Power/Constant Ground

1	PCM	3	O_2 Heater Relay
2	ASD Relay	4	Oxygen Sensor

O_2 Sensor Diagnostics

- O_2 shorted to ground. At a cold start, ECT below 98° F, ambient/battery temperatures within 27° F, if O_2 sensor voltage is below 0.156 volts for 28 seconds, the fault is set.
- O_2 shorted to voltage (SBEC) is set if the engine is running in closed loop, Battery voltage is above 10 volts, ECT is above 180°F and voltage is above 1.2 volts. O_2 shorted to voltage (JTEC) is set if the engine is running for more than 4 minutes, Battery voltage above 10.4 volts, ECT is above 180°F and voltage is above 1.5 volts.
- O_2 stays at center (SBEC only) is set if voltage stays between 0.35 volts and 0.58 volts for a total of 121 seconds, when the engine is running in closed loop and the coolant temperature exceeds 150.8° F
- There are also tests required for OBD II that test the ability of the oxygen sensor to generate a voltage above 0.80 and below 0.20, and to respond quickly to pulse-width changes.

Upstream O_2 Sensor

The upstream sensor is located ahead of the catalyst and is used to maintain an Air/Fuel (A/F) ratio of approximately 14.7:1 (stoichiometric). This accomplished by the fact that an O_2 sensor acts like a switch when the A/F ratio is near 14.7:1. When the A/F is lean (extra oxygen) the sensor output is very close to 0 volts. As the A/F becomes richer (less oxygen) the sensor output changes rapidly to 0.5 volts and can continue movement up to 1 volt if the mixture becomes too rich.

Based on these operating characteristics, the PCM is programmed with switch points to maintain the proper A/F ratio. To provide optimum functioning of the O_2 sensor, the PCM waits until the system goes into closed loop before it controls the air/fuel ratio; it does not attempt to control the ratio immediately after start-up.

Closed Loop

There are two types of closed loop:

Short-Term: Immediate corrections are made to the pulse-width in response to the oxygen sensor, but these values are not stored in memory. The parameters are:

- Engine temperature exceeds 30-35° F
- O_2 sensor is switching
- All timers have timed out, following the START to RUN transfer (the timer lengths vary, based upon engine temperature at key-on)

Long-Term: Values are stored in non-volatile memory based on short-term corrective values. The parameters are:

- Full Operating Temperature
- All timers have expired

Note: *These times and temperatures may vary for each engine package.*

Downstream O_2 Sensor

As mentioned previously, the downstream O_2 sensor has two functions. One function is measuring catalyst efficiency. This is an OBD II requirement. The oxygen content of the exhaust gases leaving the converter has significantly less fluctuation than at the inlet if the converter is working properly. The PCM compares the upstream and downstream O_2 sensor switch rates under specific operating conditions to determine if the catalyst is functioning properly. Refer to the OBD II Training Course for more information.

Another function is to help establish the upstream O_2 sensor's goal voltage. While the upstream O_2 sensor input is used to maintain the 14.7:1 AF, variations in engines, exhaust systems and catalytic converters may cause this ratio to not be the most ideal for a particular catalyst and engine. To help maintain the catalyst operating at maximum efficiency, the PCM fine-tunes the A/F ratio entering the catalyst based on the oxygen content leaving the catalyst. This is accomplished by modifying the upstream O_2 sensor goal voltage (figs. 21, 22, and 23).

In the past this goal was a preprogrammed fixed-value based on where it was believed the catalyst operated most efficiently. With the new downstream O_2 sensor fuel control, the upstream O_2 goal is moved up and down within the window of operation of the O_2 sensor. If the oxygen content leaving the catalyst is too high (excess oxygen) the PCM moves the upstream O_2 goal up, which increases fuel in the mixture causing less oxygen to be left over. Conversely, if the oxygen content leaving the catalyst is too low (not enough oxygen) the PCM moves the upstream O_2 goal down which removes fuel from the mixture causing more oxygen to be left over.

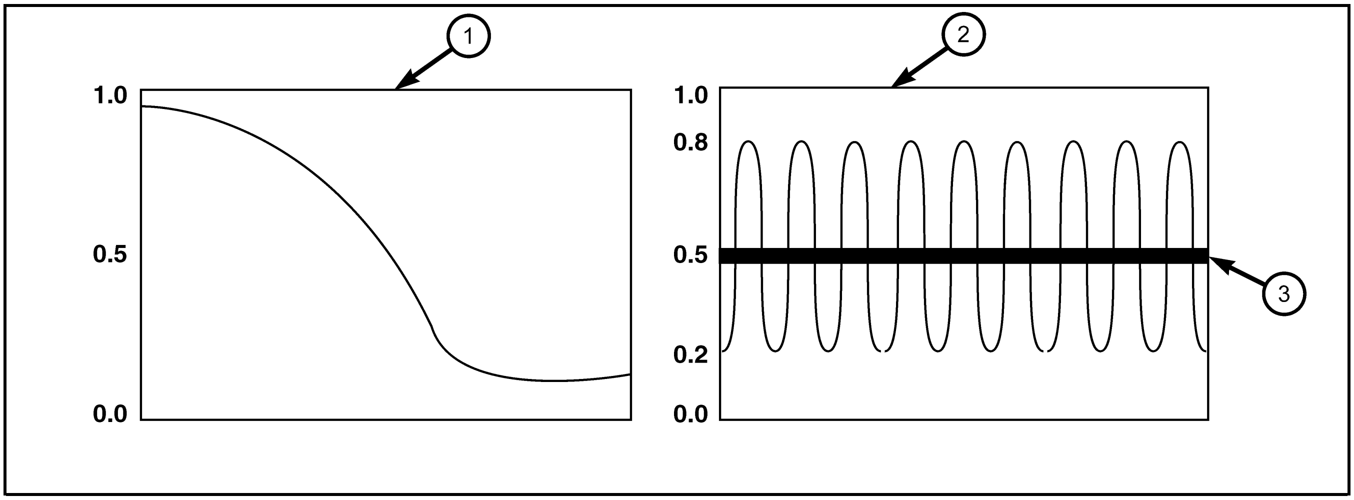

Figure 21 Downstream and Upstream O_2 signal with efficient catalyst

1	Downstream O_2 signal	3	Goal Voltage
2	Upstream O_2 signal		

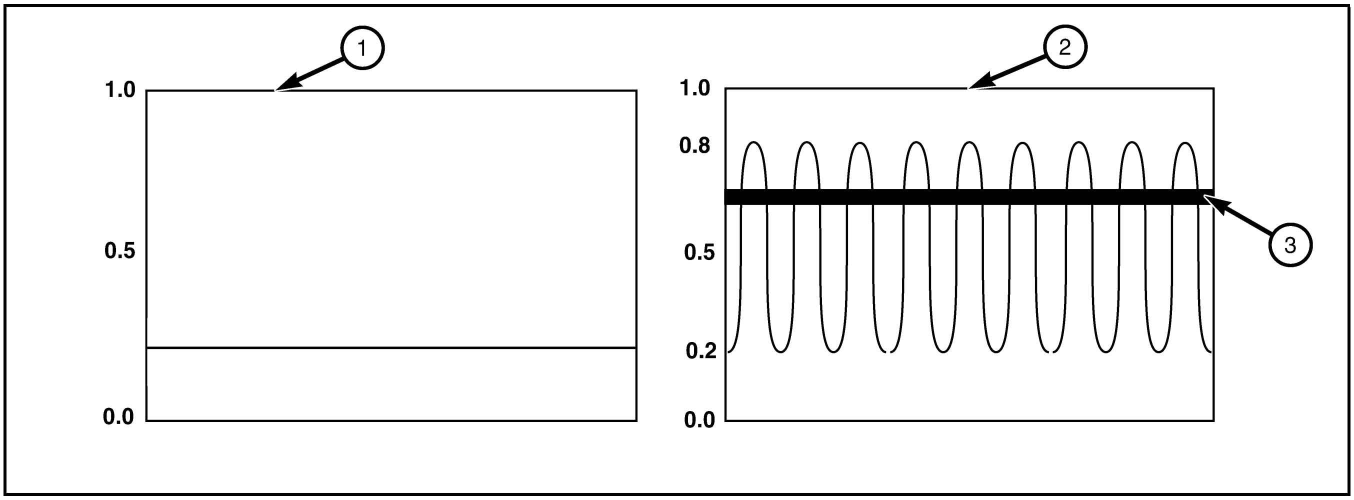

Figure 22 **Downstream** – High O_2 content **Upstream** – Goal Voltage shift to correct

1	Downstream O_2 signal	3	Goal Voltage
2	Upstream O_2 signal		

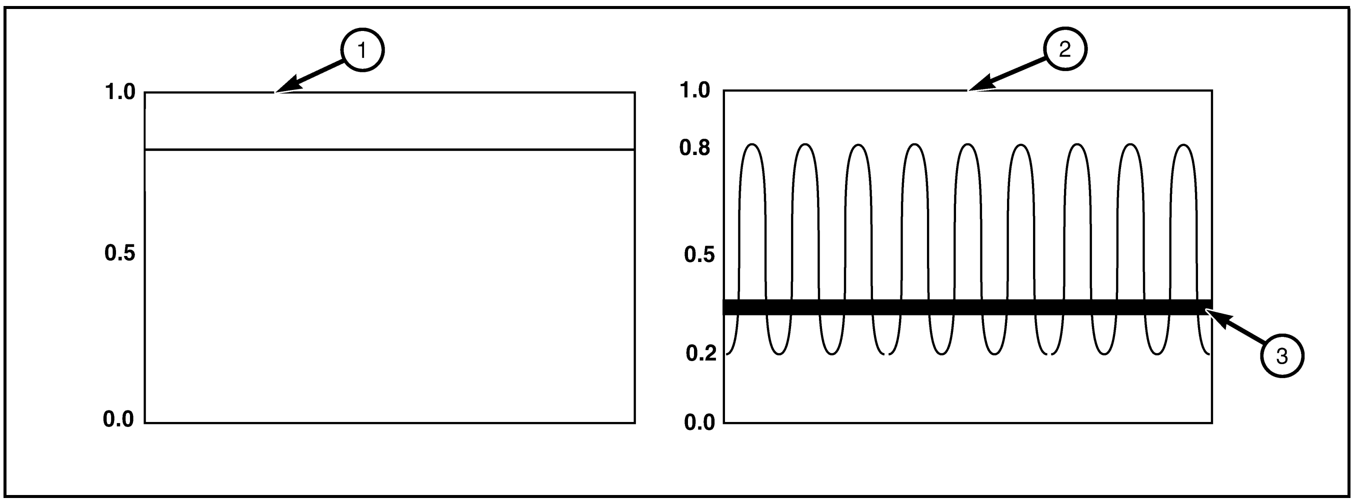

Figure 23 **Downstream** – Low O_2 content **Upstream -** Goal voltage shift to correct

1	Downstream O_2 signal	3	Goal Voltage
2	Upstream O_2 signal		

STOICHIOMETRIC RATIO

Engineers found they could maximize catalyst efficiency to a point that would minimize hydrocarbon, carbon monoxide and oxides of nitrogen emissions by controlling the air-fuel ratio. This air-fuel ratio is 14.7:1 and is the point where carbon monoxide, hydrocarbons, and oxides of nitrogen are at their lowest points *simultaneously*. This ratio is called the Stoichiometric (stoy-key-oh-met-rick) ratio.

However, conditions inside an engine's combustion chamber are not ideal. There is not enough time in the engine's operating cycle to allow complete combustion to take place. Even with a stoichiometric ratio, the engine's exhaust gases contain a certain percentage of pollutants in the form of HC and CO. The severe conditions (principally high temperatures) inside the combustion chamber cause some of the free oxygen and nitrogen in the air-fuel mixture to combine, forming various oxides of nitrogen (NOx). All things considered, the stoichiometric ratio is the optimum air-fuel ratio for minimizing undesirable emissions.

CATALYST

The latest technology provides the use of a three-way catalytic converter on most automobiles. The three-way catalyst simultaneously converts three harmful exhaust emissions into harmless gases. Specifically, HC and CO emissions are converted into water (H^2O) and carbon dioxide (CO^2). Oxides of Nitrogen (NO_x) are converted into elemental Nitrogen (N) and oxygen. The three-way catalyst is most efficient in converting HC, CO and NO_x at the stoichiometric air fuel ratio of 14.7:1. If the mixture becomes leaner than 14.7:1 (extra oxygen) the ability to convert NO_x drops. As the mixture becomes richer than 14.7:1 (less oxygen) the ability to convert HC and CO drops. BUT...a catalytic converter does require the byproducts of running slightly rich and slightly lean to effectively reduce emissions. It is for this reason that the oxygen sensor indicates an AVERAGE of 14.7:1, constantly switching back and forth across the threshold (fig 24). The PCM needs to make “Cat Food.” For a catalyst to oxidize hydrocarbons and carbon monoxide, it needs to receive a source of oxygen. This is accomplished every time the O_2 switches lean. Conversely, the catalyst also requires carbon monoxide to reduce the oxides of nitrogen. This is provided during the rich swing of the O_2.

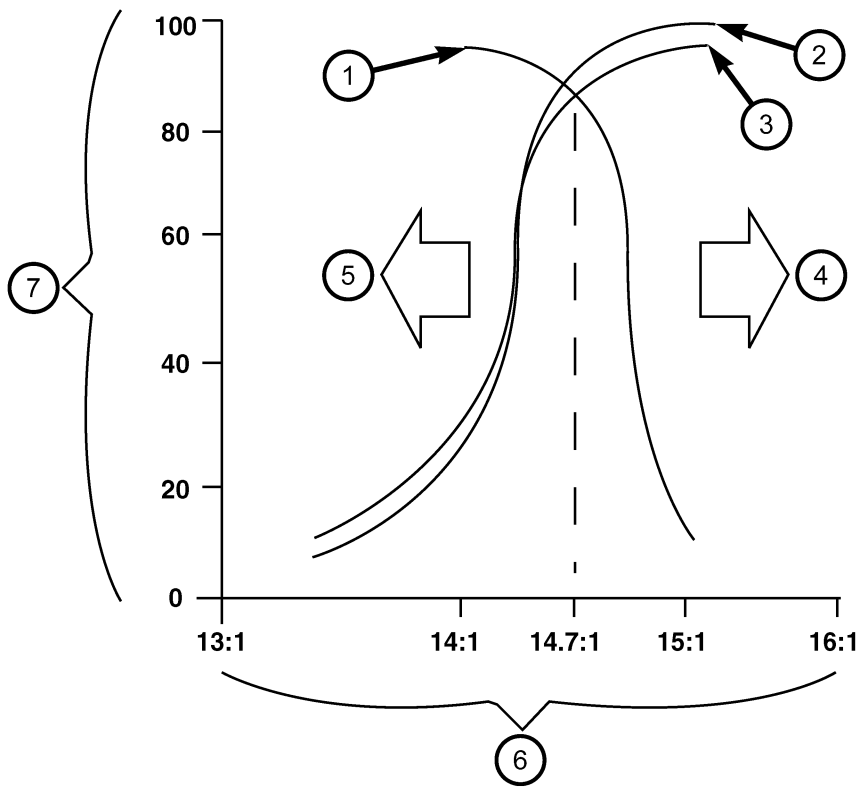

Figure 24 Conversion Efficiencies of a Three-Way Catalyst

1	NOx	5	Rich
2	CO	6	Air/Fuel Ratio
3	HC	7	Conversion Efficiency %
4	Lean		

ADAPTIVE MEMORIES

Short-Term Adaptive Memory

Earlier it was mentioned that when the fuel system goes into closed loop operation there are two adaptive memory systems that begin to operate. The first system that becomes functional is called short-term correction. This system corrects fuel delivery in direct proportion to the readings from the upstream O_2 sensor. In other words, as the Air/Fuel (AF) mixture changes, the O_2 sensor voltage tells the PCM that the AF ratio contains either more or less oxygen. The PCM then begins to either add or remove fuel until the O_2 sensor reaches its switch point. When the switch point is reached, short-term correction begins with a quick change (kicks), then ramps slowly until the O_2 sensor's output voltage indicates the switch point in the opposite direction. Short-term adaptive memory keeps increasing or decreasing injector pulse- width based on the O_2 sensor input. The maximum range of authority for short-term memory is ±25% (SBEC) or ±33% (JTEC) of base pulse-width.

For example, if there is a low fuel pressure problem, the O_2 sensor starts moving toward 0 volts, lean mixture (excess oxygen). Short-term fuel correction begins to add fuel and continues to add, up to 25% (SBEC) or 33% (JTEC) of total pulse-width, until the O_2 sensor begins switching again.

The PCM's goal is to keep the O_2 sensor switching around the goal voltage.

Long-Term Adaptive Memory

The second system is called Long-Term adaptive memory. In order to maintain correct emission throughout all operating ranges of the engine, it was decided that a cell structure based on load, engine RPM and MAP, should be used. There are up to 16 cells on SBEC-equipped vehicles (Table 3) and 22 cells on JTEC-equipped vehicles (Table 4). Two are used only during idle, based upon TPS and Park/Neutral switch inputs. There may be another two cells used for deceleration, based on TPS, engine RPM, and vehicle speed. The other cells represent a manifold pressure and an RPM range. Half of the remaining cells are high RPM and the other half are low RPM.

Each of these cells has a specific MAP voltage range. The values shown in the illustrations are an example only. These values are calibrated for each powertrain package. As the engine enters one of these cells, the PCM looks at the amount of short-term correction being used. Because the goal is to keep short-term at 0 (O_2 switching at 0.5 volts) long-term updates in the same direction as short-term correction was moving to bring the short-term back to 0. Once short-term is back at 0, this long-term correction factor is stored in memory.

The values stored in long-term adaptive memory are used for **all operating conditions, including open loop**. However, the updating of the long-term memory occurs after the engine has exceeded approximately 170° F, with fuel control in closed loop and 2 minutes of engine run time. This is done to prevent any transitional temperature or start-up compensations from corrupting long-term fuel correction.

Using the low fuel pressure example, the PCM had stored a fuel correction in long-term memory to compensate for the low fuel pressure. At key ON, cold engine, when the PCM does its pulse-width calculation, the long-term factor is added because it knows there was a problem in that cell, hence the name long-term.

Table 3 Typical SBEC Long-term Adaptive Memory Fuel Cells

RPM	Open Throttle	Open Throttle	Open Throttle	Open Throttle	Open Throttle	Open Throttle	Idle	Decel
Above X RPM	1	3	5	7	9	11	13 "D"	15
Below X RPM	0	2	4	6	8	10	12 "N"	14
Map"	20	17	13	9	5	0		

Table 4 Typical JTEC Long-term Adaptive Memory Fuel Cells
(not all cells are used on every package)

RPM	Open Throttle	Open Throttle	Open Throttle	Open Throttle	Open Throttle	Open Throttle	Decel	Idle
Above Y RPM	2	5	8	11	14	17	N/A	N/A
Between X and Y RPM	1	4	7	10	13	16	19	21
Below X RPM	0	3	6	9	12	15	18	20
MAP"	23.58	19.57	15.71	11.81	9.33	4.45		

Purge-Free Cells

Purge-free memory cells are used to identify the fuel vapor content of the evaporative canister (fig. 25). Since the evaporative canister is not purged 100% of the time, the PCM stores information about the evaporative canister's vapor content in a memory cell. The purge-free cells are constructed similar to certain purge-normal cells. The purge-free cells can be monitored by the DRBIII® scan tool. They are represented by "Purge-free Cell X, Purge-free Cell Y, and Purge-free Cell Z" (“X, Y and Z” represents a specific cell differing by calibrations). The only difference between the purge-free cells and normal adaptive cells is that in purge-free, the purge solenoid is completely turned off. This gives the PCM the ability to compare the difference in fuel correction during purge and purge-free operation.

Purge Corruption Reset Feature

At each start, the PCM compares the value of the purge-free cell to the value in long-term memory. If the difference is too large, the PCM replaces the value in long-term memory with the corresponding purge-free cell value. The cells that do not have corresponding purge-free are replaced with the largest purge free value. If a cell is already higher than the highest purge-free it is not changed.

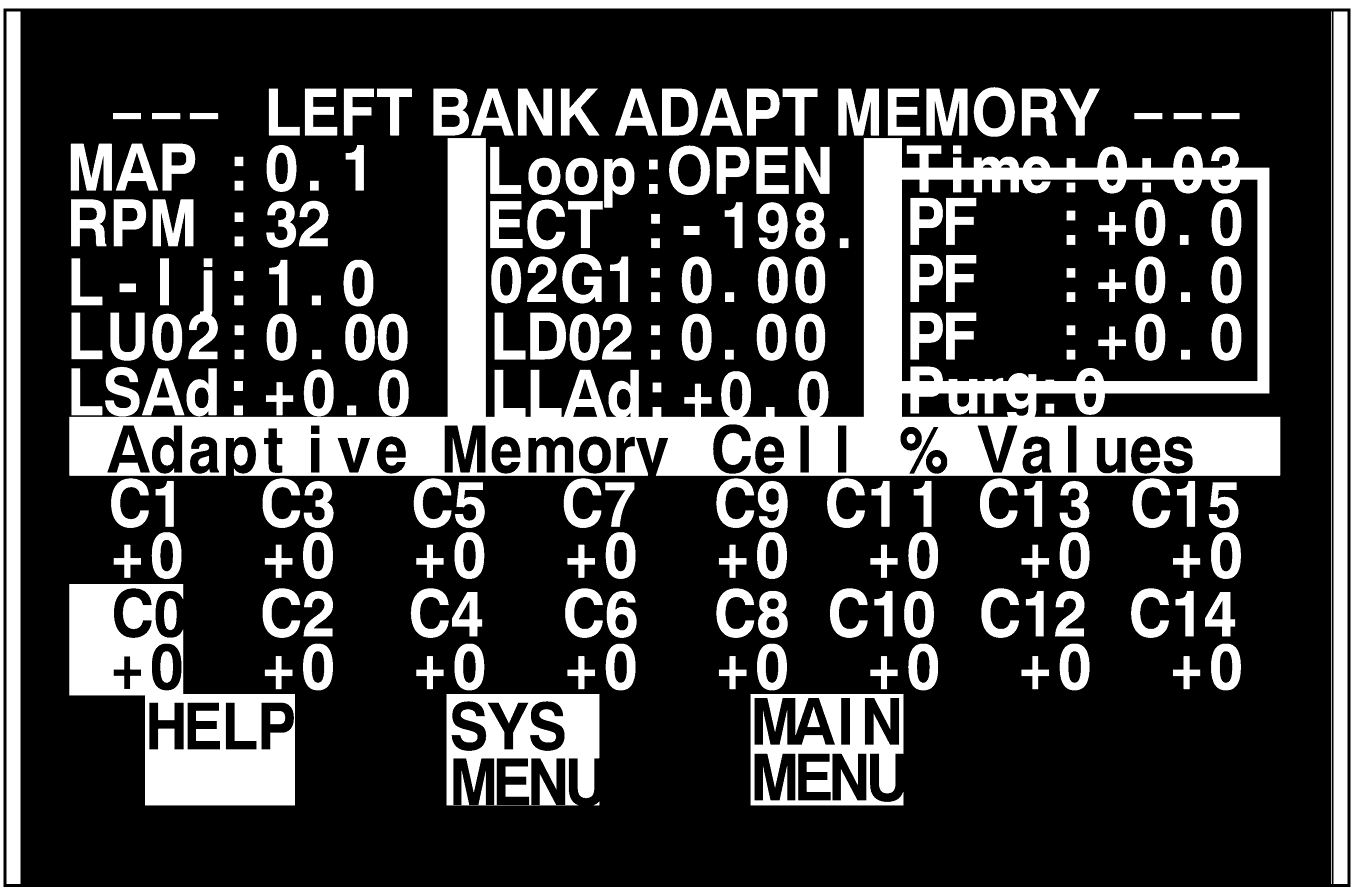

Figure 25 Purge-Free Cells in Box (Typical SBEC)

Notes:

ACTIVITY 6

Your objective is to document the most effective process to diagnose this vehicle failure. Do not repair the vehicle unless directed to by your instructor. Your diagnosis is not as important as the process you use to come to you conclusion. Do not waste your time looking for a bug. If you really want to know what was done to the vehicle, ask your instructor. Your objective is to prove it using proven diagnostic methods.

Customer's Complaint: MIL On

DTCs: ____

List the steps you used to diagnose the customer's complaint: _______________

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In conclusion, what is the root cause of the failure? _____________________

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ACTIVITY 7

Your objective is to document the most effective process to diagnose this vehicle failure. Do not repair the vehicle unless directed to by your instructor. Your diagnosis is not as important as the process you use to come to you conclusion. Do not waste your time looking for a bug. If you really want to know what was done to the vehicle, ask your instructor. Your objective is to prove it using proven diagnostic methods.

Customer's Complaint: Runs poorly

DTCs: ____

List the steps you used to diagnose the customer's complaint: ____________

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In conclusion, what is the root cause of the failure? ____________________

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ACTIVITY 8

Your objective is to document the most effective process to diagnose this vehicle failure. Do not repair the vehicle unless directed to by your instructor. Your diagnosis is not as important as the process you use to come to you conclusion. Do not waste your time looking for a bug. If you really want to know what was done to the vehicle, ask your instructor. Your objective is to prove it using proven diagnostic methods.

Customer's Complaint: Intermittently stalls when coming to a stop

DTCs: ____

List the steps you used to diagnose the customer's complaint: ________________

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In conclusion, what is the root cause of the failure? ___________________________

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ACTIVITY 9

Your objective is to document the most effective process to diagnose this vehicle failure. Do not repair the vehicle unless directed to by your instructor. Your diagnosis is not as important as the process you use to come to you conclusion. Do not waste your time looking for a bug. If you really want to know what was done to the vehicle, ask your instructor. Your objective is to prove it using proven diagnostic methods.

Customer's Complaint: Intermittent surge, erratic idle speed

DTCs: ______________________________

List the steps you used to diagnose the customer's complaint: ______________

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In conclusion, what is the root cause of the failure? ______________

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ACTIVITY 10

This is an instructor-led, technician-assisted activity. The objective of this activity is to demonstrate the effects of various conditions on fuel adaptive compensation.

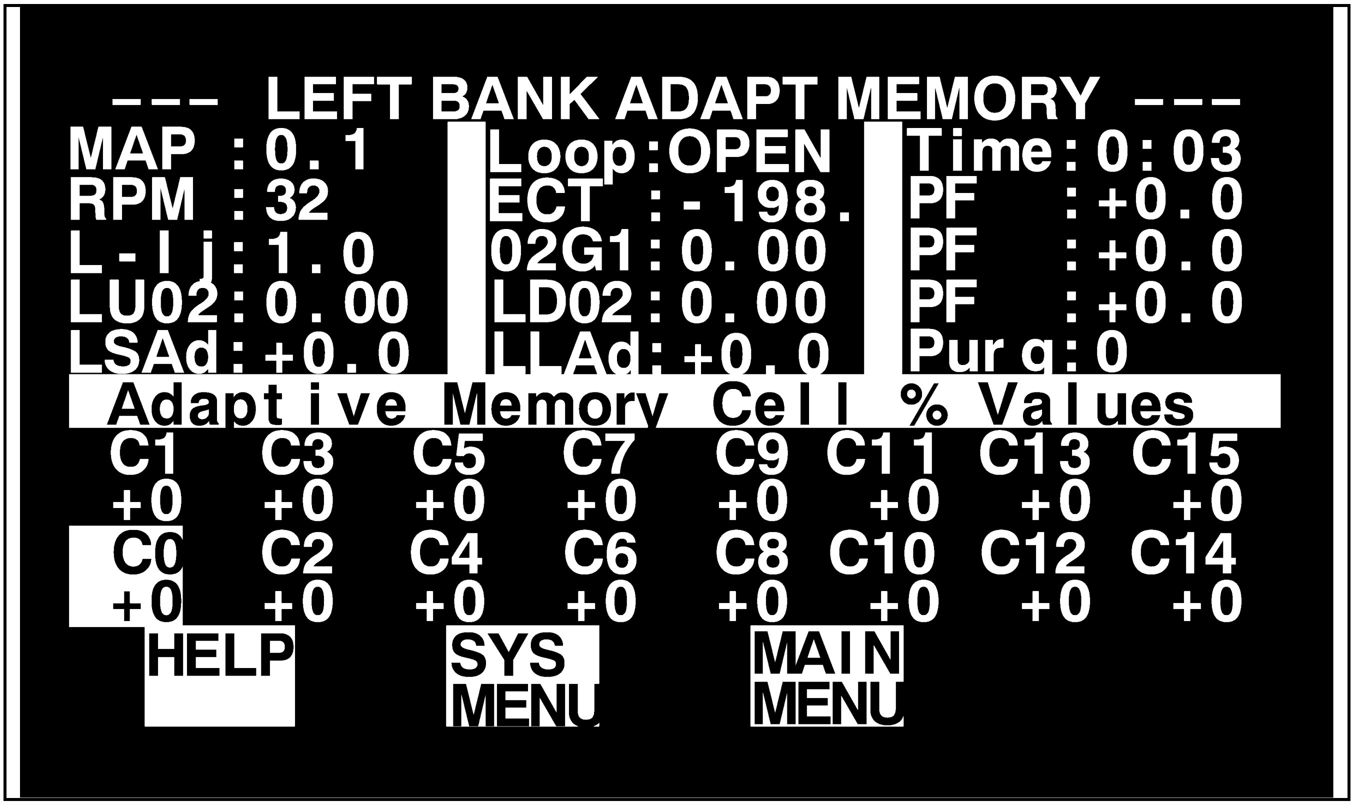

Figure 26 SBEC Fuel Adaptives

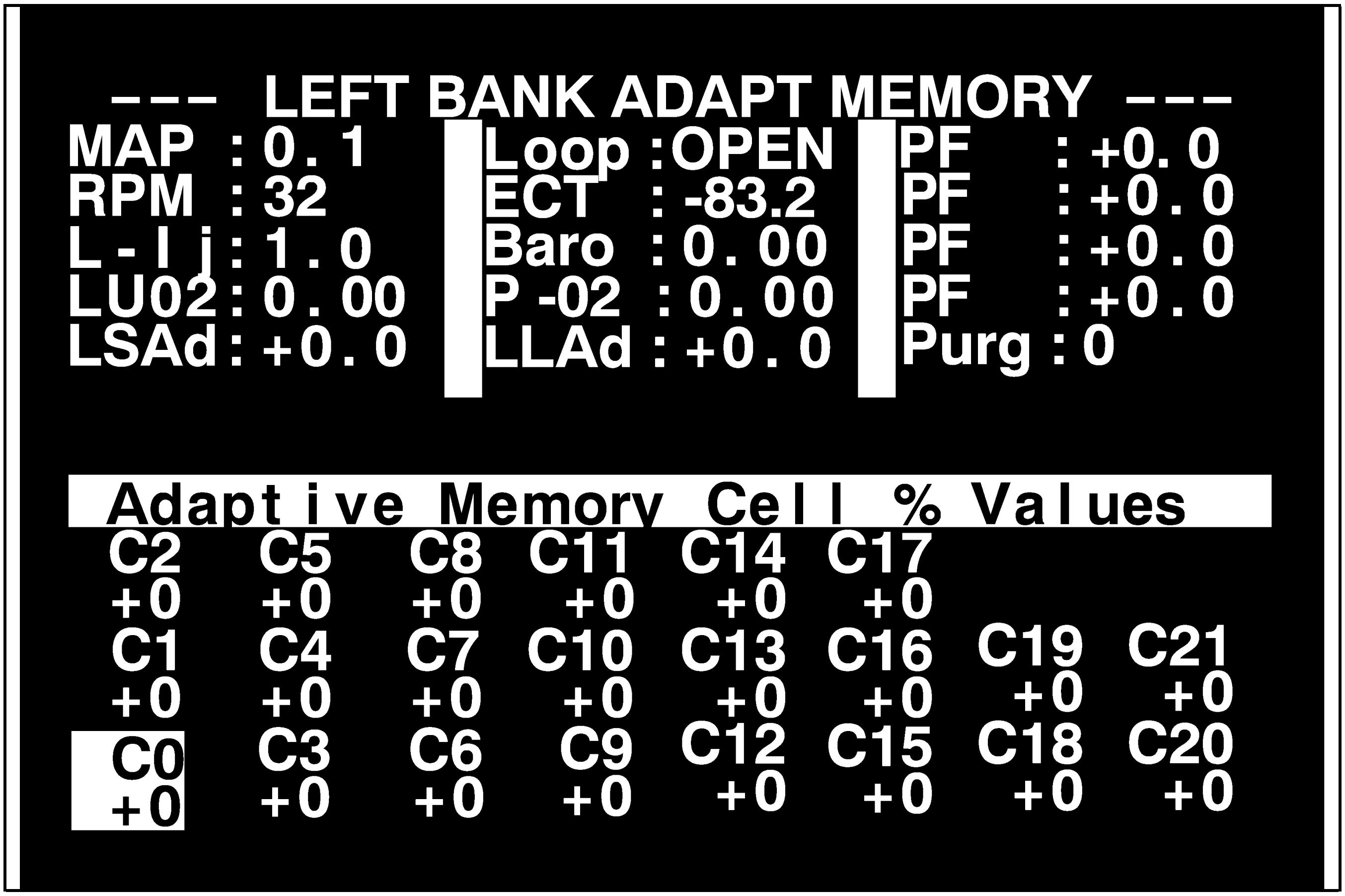

Figure 27 JTEC Fuel Adaptives

Notes:

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FUEL INJECTION SYSTEM - PCM OUTPUTS

SOLENOID AND RELAY CONTROL

SBEC

On SBEC-equipped vehicles a serial peripheral interface/output (SPIO) circuit controls most of the output relays and solenoids (fig. 28 and fig. 29). This circuit, within the PCM, is used for controlling high current output devices. The SPIO has the added advantage of being able to provide diagnostics.

The SPIO circuit gives the PCM the ability to determine whether the actual state of the relay or solenoid matches the PCM's expected state. When the PCM is not controlling the device, a high voltage state should be seen (CONTROL HI). When the PCM energizes the device, there should be a voltage drop (CONTROL LO).

Note: *The PCM performs diagnostics on SOME circuits only when a change of state has been requested. This means a circuit could go bad and the PCM would not know it until it was told to change the state.*

JTEC

On JTEC-equipped vehicles most of the output relays and solenoids are controlled by quad drivers. A quad driver is a single microchip that contains four separate driver circuits that are used for controlling high current output devices.

A voltage divider circuit has been added to diagnose the operation of the driver circuit. This voltage divider is located between the output of the driver and the input command (from microprocessor) to the driver.

<u>CAUTION:</u> ***Both diode and resistor suppressed relays have been used. If an incorrect relay is used, damage may occur to the relay, circuit, or PCM. Never swap relays for diagnostic purposes unless the relays have the EXACT part number.***

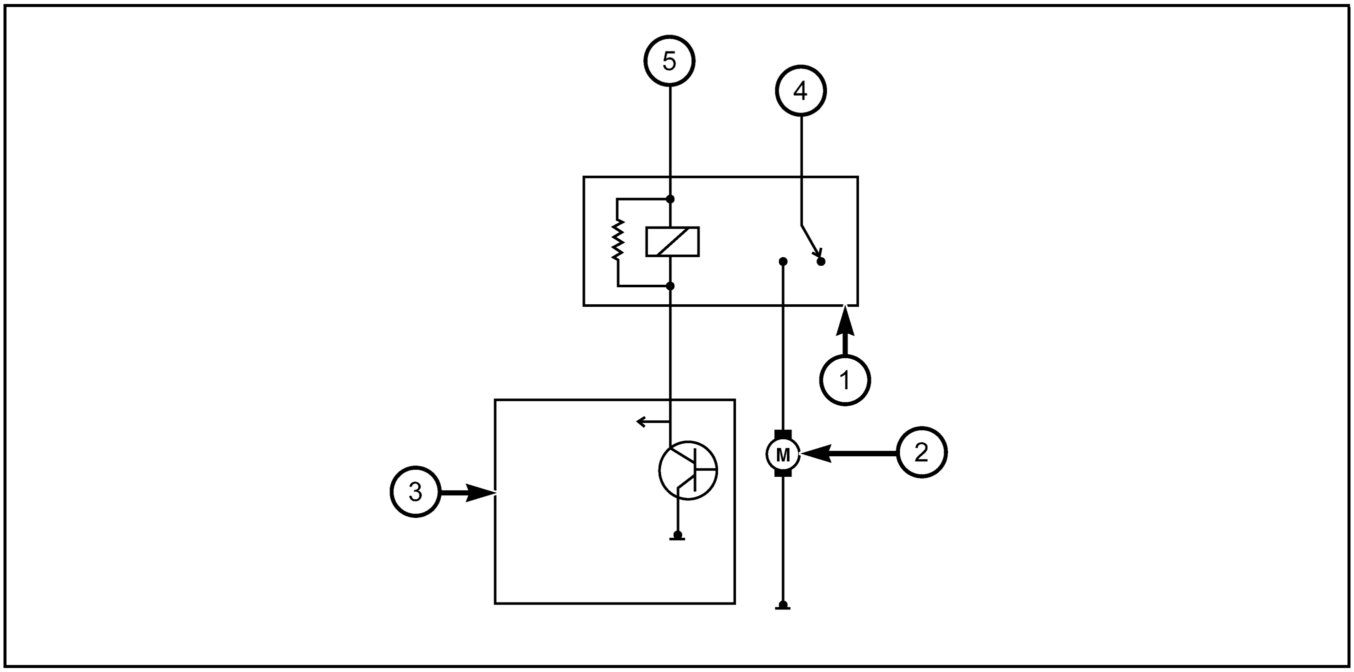

Figure 28 Relay

1	Relay	4	From Power Supply
2	Motor	5	From Power Supply
3	PCM		

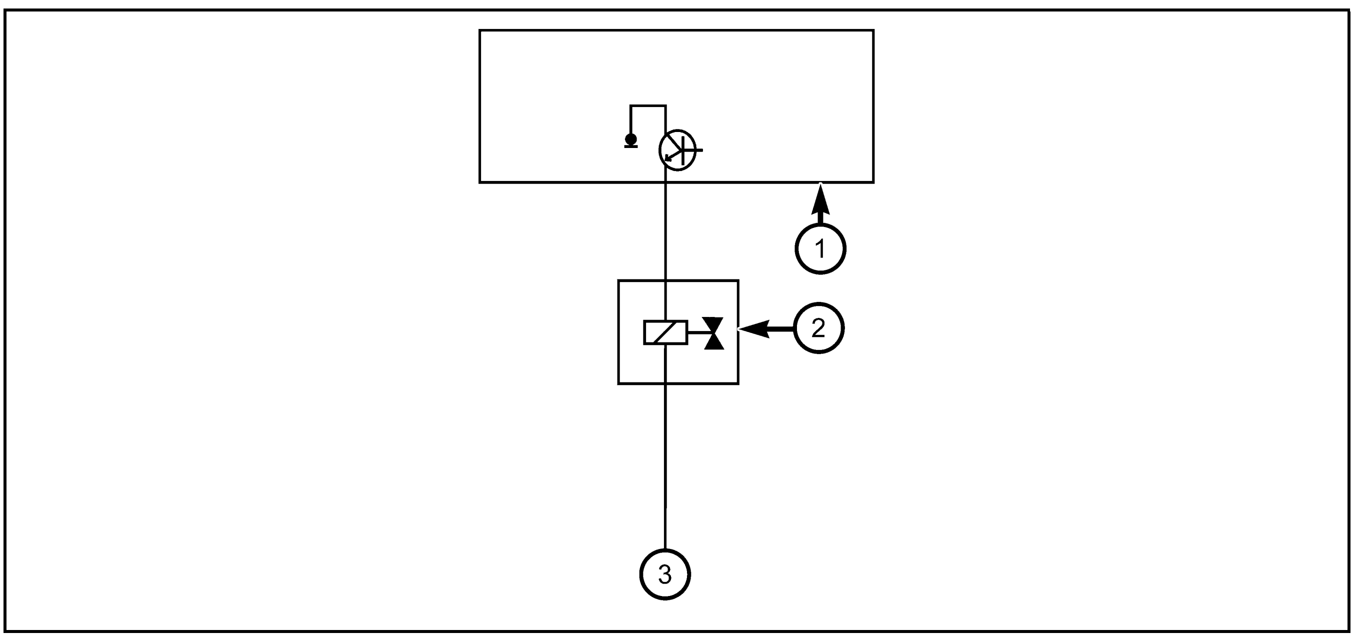

Figure 29 Solenoid

1	PCM	3	From Power Supply
2	Solenoid		

AUTOMATIC SHUTDOWN RELAY (ASD)

When energized, the ASD relay provides power to operate the injectors, ignition coil, generator field, O_2 sensor heaters (both upstream and downstream) and also provides a sense circuit to the PCM for diagnostic purposes.

On SBEC-equipped vehicles, the ASD relay's electromagnet is fed battery voltage for OBD II diagnostics after the key is turned off (fig. 30). On JTEC-equipped vehicles, the relay's electromagnet is fed ignition voltage (fig. 31). The PCM provides the ground for the relay of both SBEC and JTEC-equipped vehicles.

The ASD output on JTEC vehicles goes into the PCM first, before it is distributed to the other circuits.

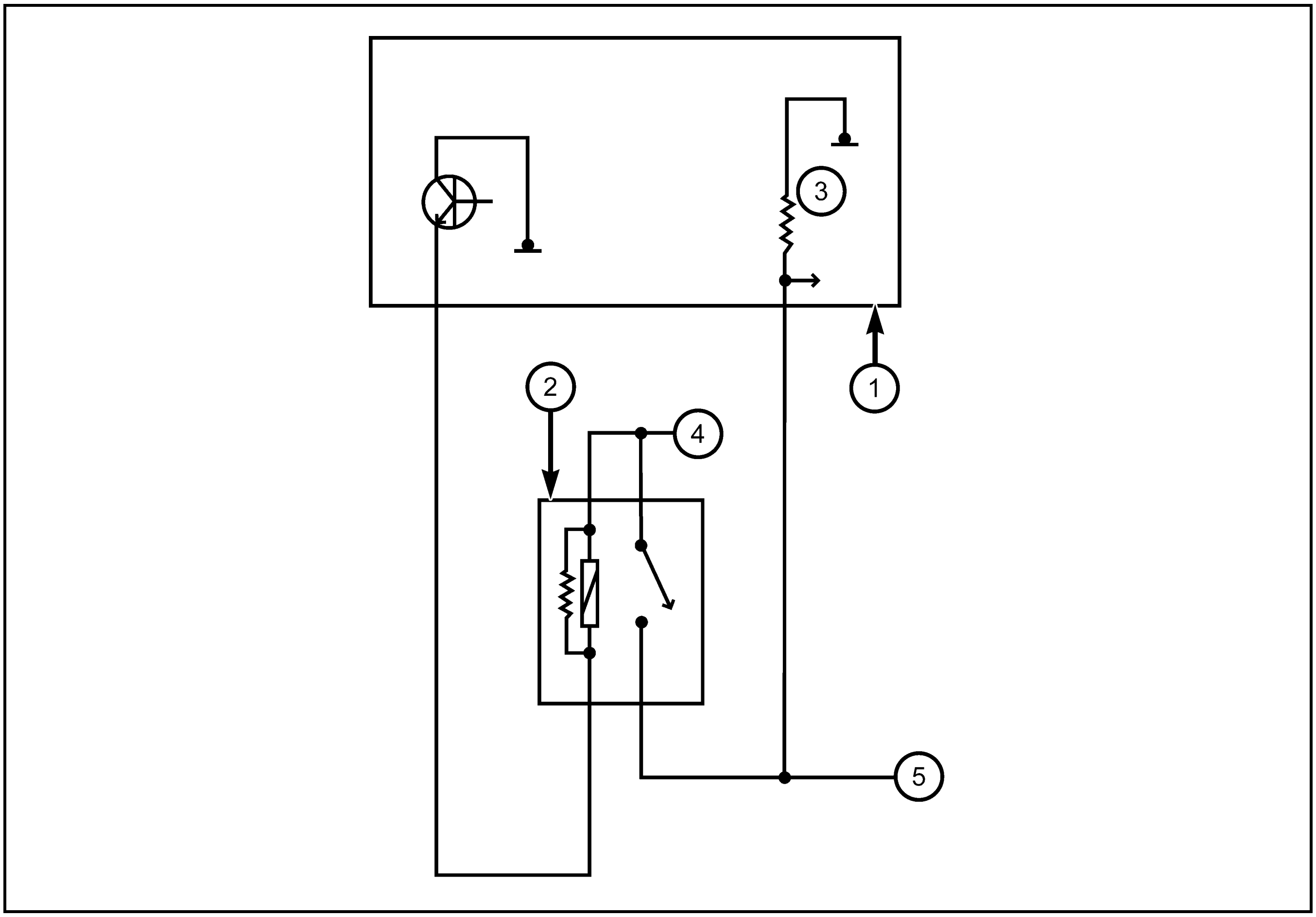

Figure 30 ASD Relay (SBEC)

1	PCM	4	From Battery
2	ASD Relay	5	To Injectors, etc.
3	ASD Sense Circuit		

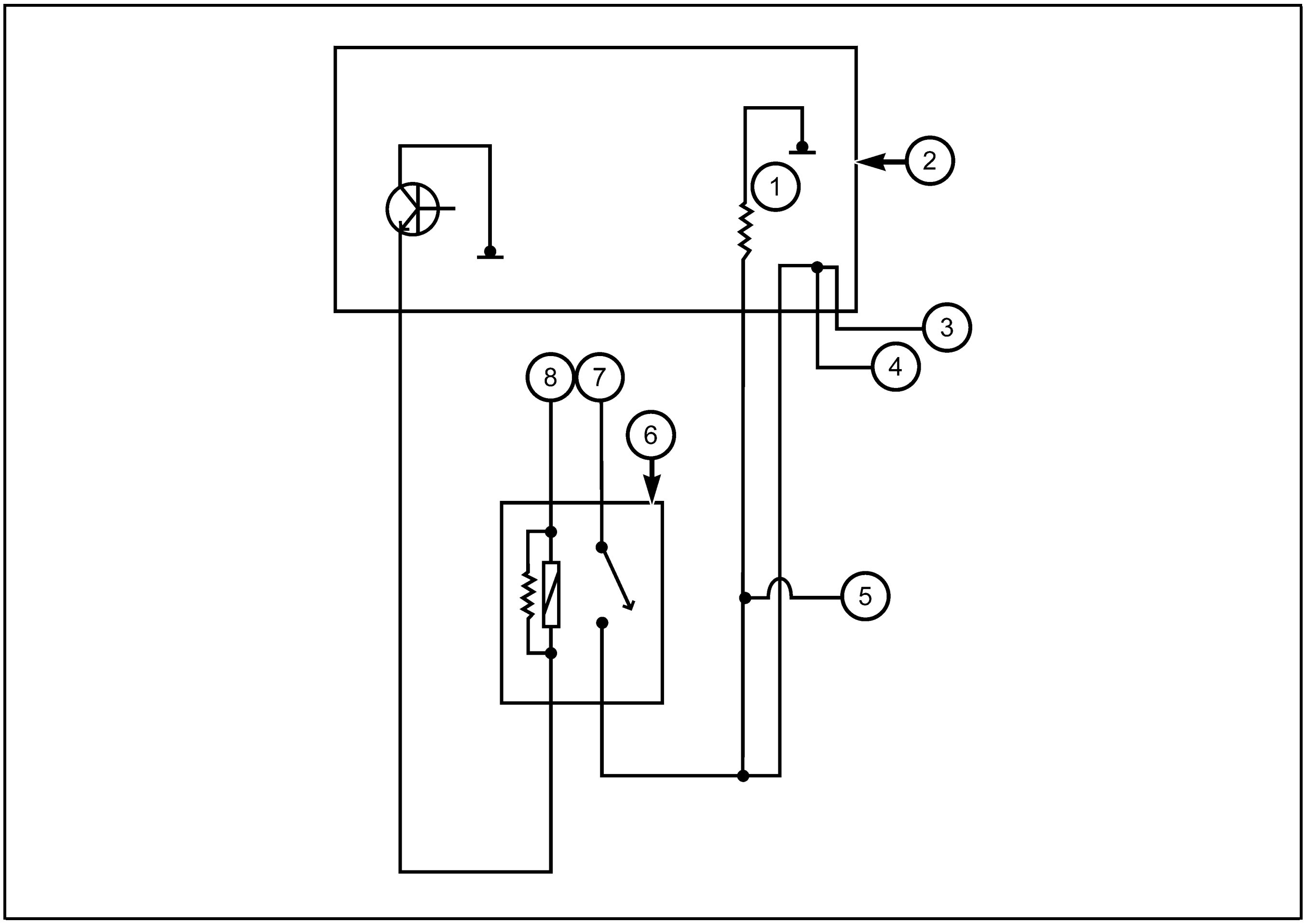

Figure 31 ASD Relay (JTEC)

1	ASD Sense Circuit	5	To Injectors, etc.
2	PCM	6	ASD Relay
3	To brake switch and speed control	7	From Battery
4	To LDP, Trans relay, and Generator	8	From Ignition

FUEL PUMP RELAY

Ignition voltage is provided to the fuel pump relay's coil any time the key is in the RUN position. The PCM provides the ground control to energize the relay.

STARTER RELAY (DOUBLE START OVERRIDE)

On some vehicles, the starter relay ground is provided by the PCM, to prevent starter over-run or inadvertent starter actuation while the vehicle is running. When the park/neutral switch or clutch switch contacts are closed, indicating Park or Neutral or that the clutch has been depressed, the PCM supplies the ground path for the starter relay at key ON. This only occurs if the engine RPM is below a predetermined value.

FUEL INJECTORS

The PCM provides battery voltage to each injector through the ASD relay. Injector operation is controlled by a ground path provided for each injector by the PCM. Injector on-time (pulse-width) is variable, and is determined by the duration of the ground path provided.

Fuel Injector Diagnostics

To diagnose an injector the PCM monitors the continuity of the circuit as well as the voltage spike created by the collapse of the magnetic field through the injector coil. The inductive kick is typically above 60 volts (fig. 32). Any condition that restricts maximum current flow would not allow the kick to occur, resulting in an injector fault (Injector Peak Not Reached) (fig. 33).

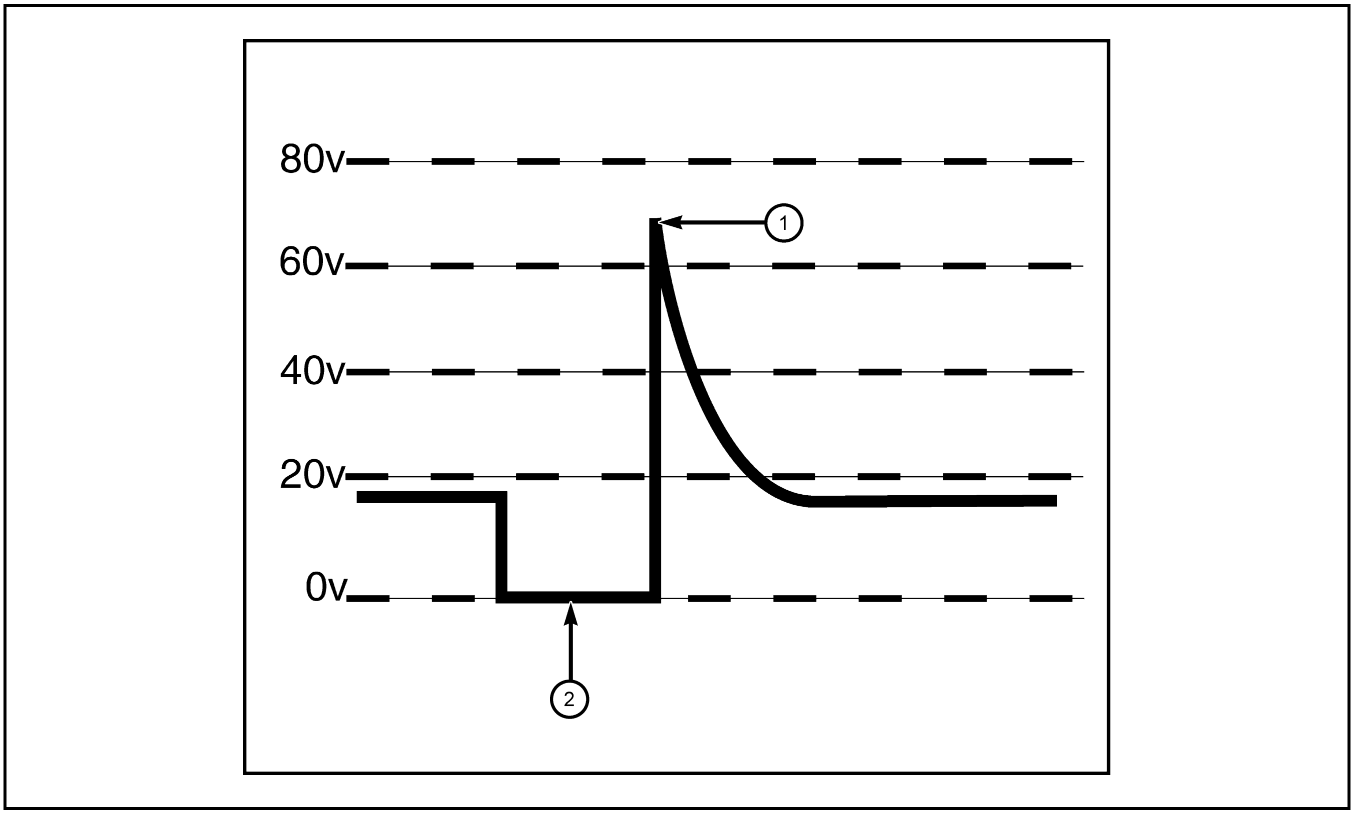

Figure 32 Fuel Injector Spike

1	Kick	2	Pulse Width

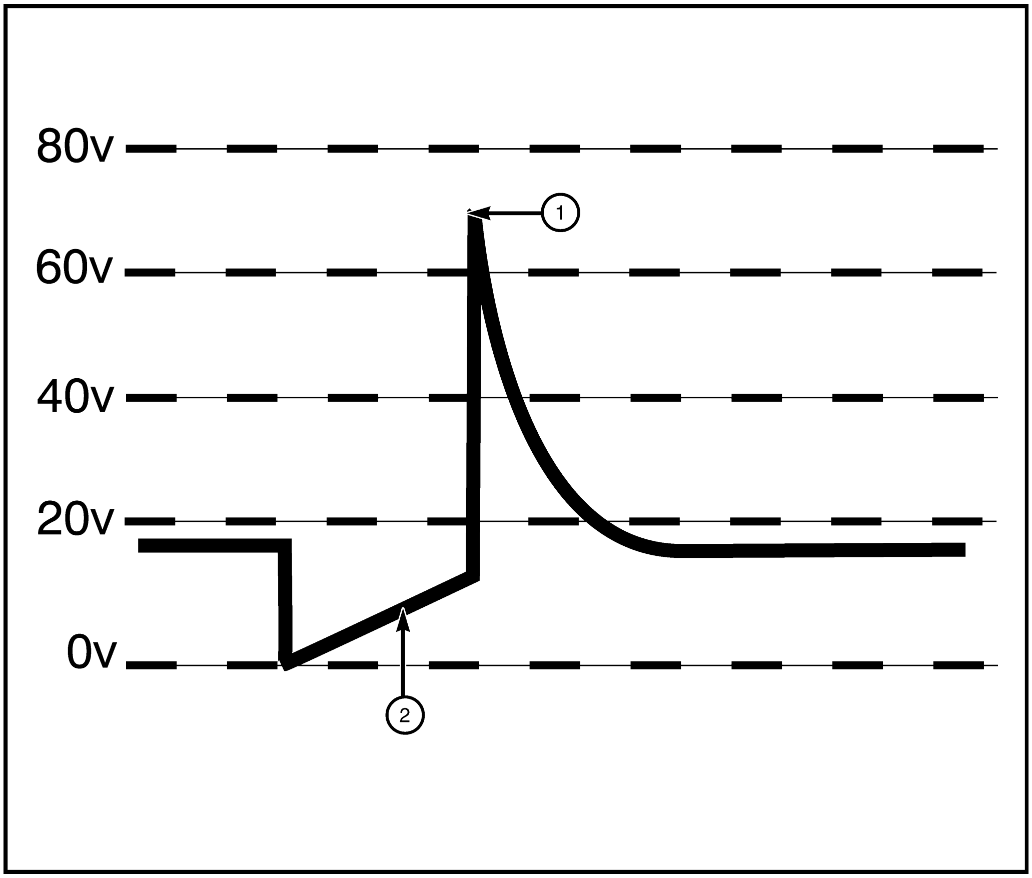

Figure 33 Resistance in Fuel Injector Control Circuit

1	Kick	2	Pulse Width

IGNITION COILS

There are three different configurations of coils used on Chrysler vehicles: single coil (fig. 34), DIS coil packs (fig. 35), and Coil-On-Plug (COP) (fig. 36).

For all three types of coils, each ignition coil primary receives power from the ASD relay. The ASD relay provides battery feed to the ignition coil, while the PCM provides a ground. When the PCM breaks the ground contact, the electro-magnetic field built in the primary circuit winding collapses and creates an inductive current in the secondary circuit winding, causing the spark. On DIS and COP systems, the PCM determines which coils to fire and when to fire them, based on CMP and CKP sensor inputs. A type of DIS coil pack system is the DIS with coil rail found on 4.0L JTEC vehicles. It operates the same as the DIS coil pack system; however, instead of being located remotely the coil packs are located on a rail directly above the spark plugs. Each coil is responsible for 2 spark plugs. All DIS systems operate on a waste spark system.

Essentially the only difference between the three types of coils is the number of cylinders they fire. Single coils are used with distributor ignition systems and must fire all of the engine cylinders. Coil packs fire two spark plugs every power stroke. One plug fires the cylinder under compression, and the second plug fires the cylinder on the exhaust stroke. On COP systems, each cylinder has a dedicated coil, which is individually controlled by the PCM.

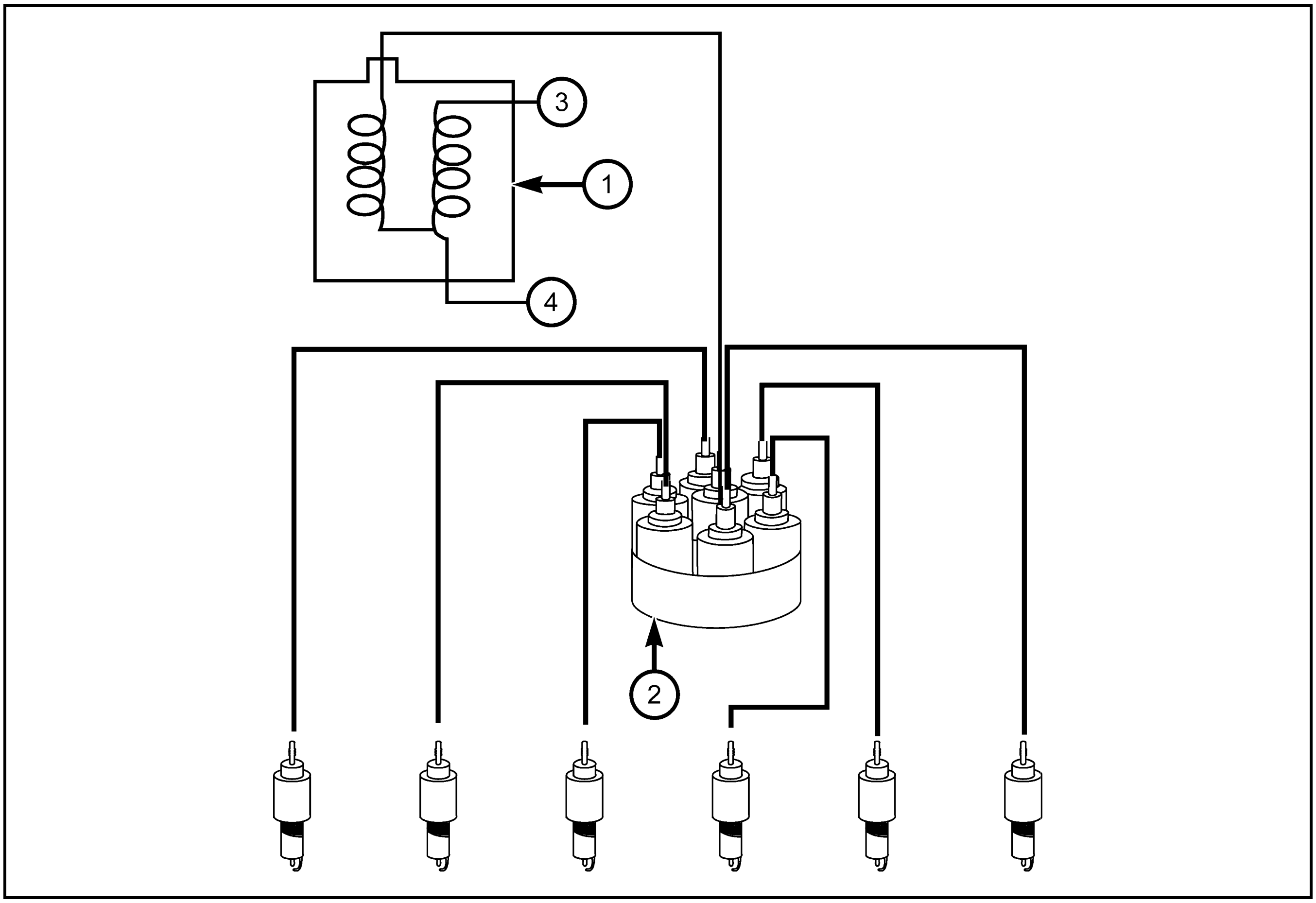

Figure 34 Single Coil Ignition

1	Ignition Coil	3	From ASD Relay
2	Distributor	4	To Ground Circuit in PCM

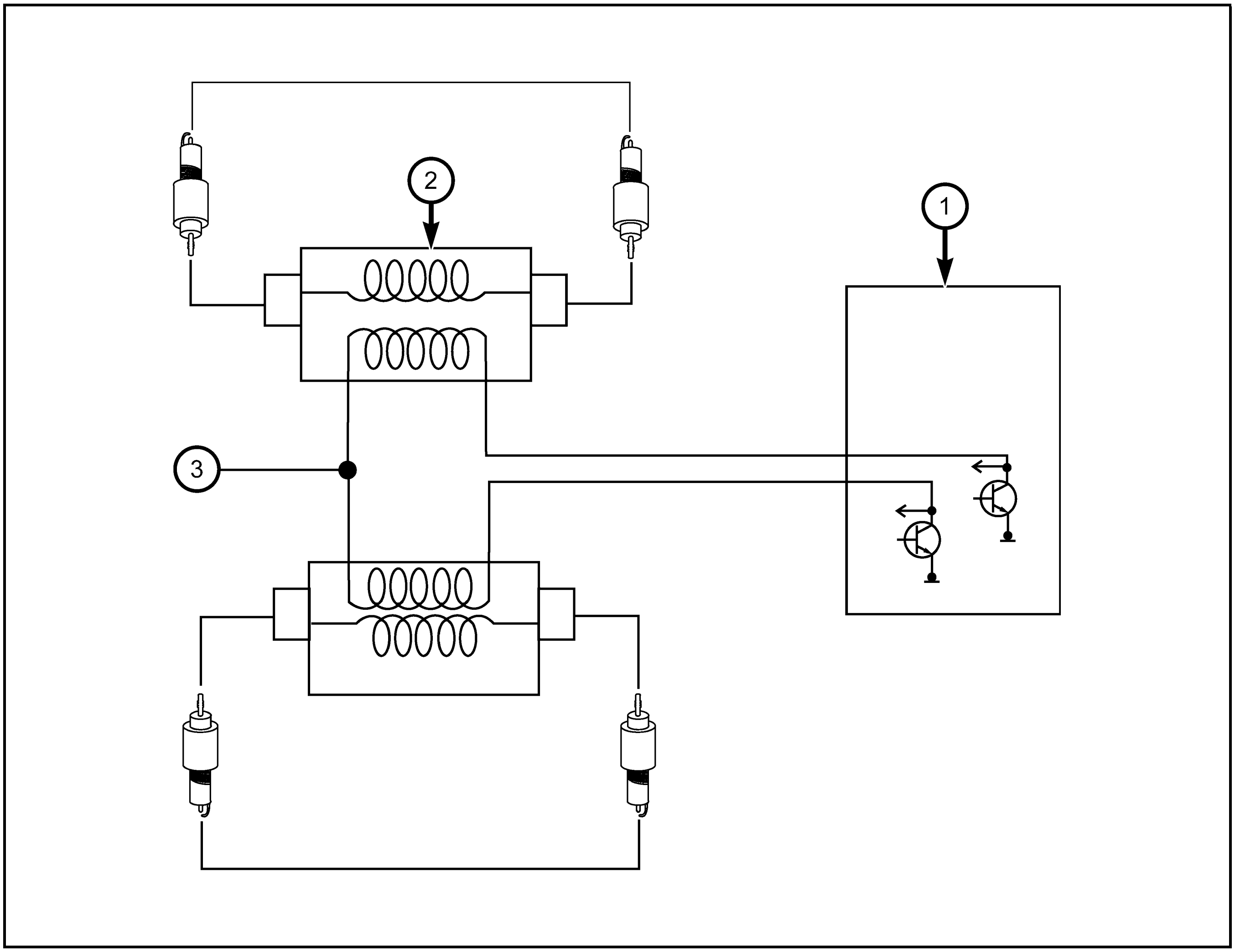

Figure 35 DIS Ignition

1	PCM	3	From ASD Relay
2	Coil Pack		

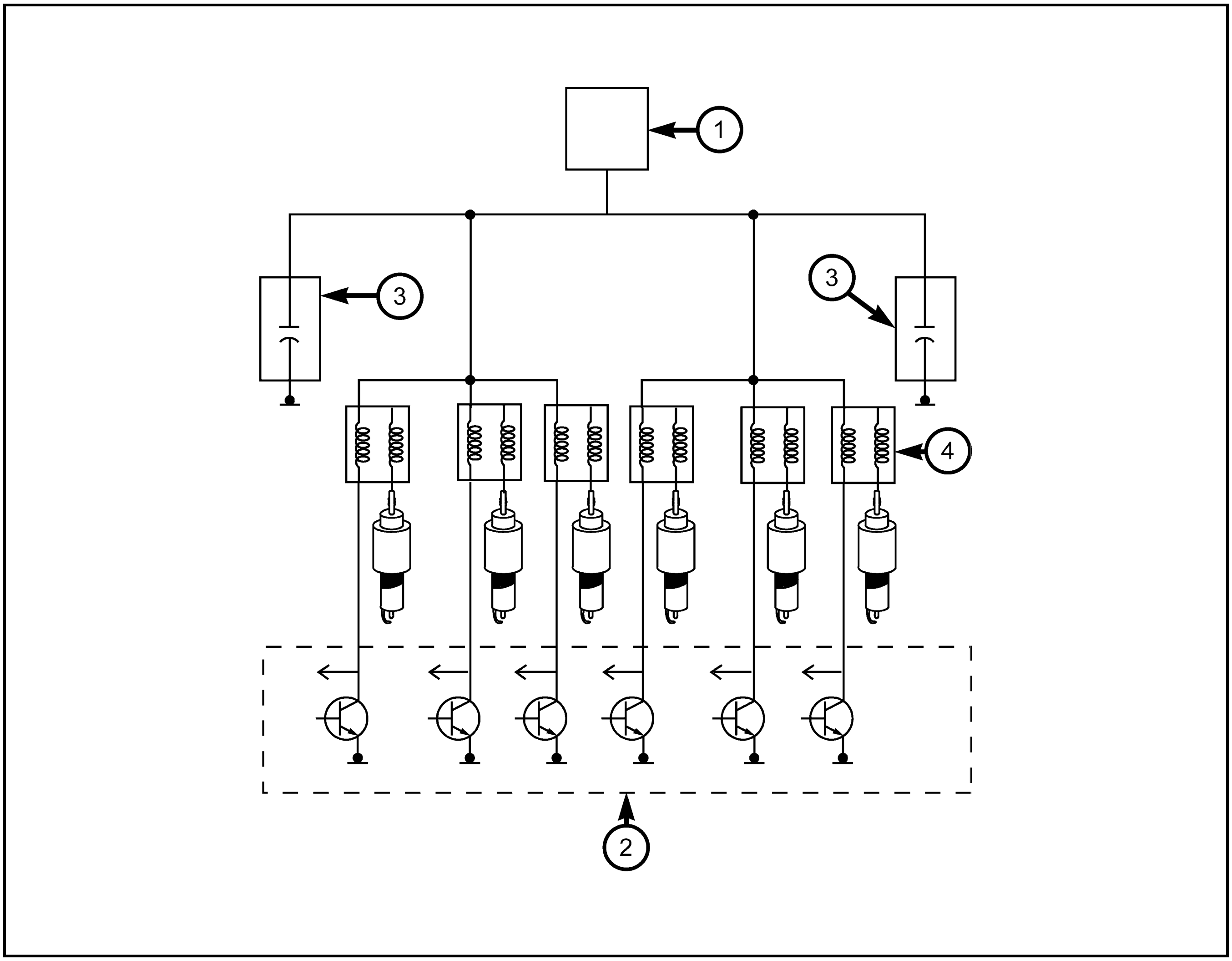

Figure 36 COP Ignition

1	ASD Relay	3	Capacitor (if applicable)
2	PCM	4	Coil-on-Plug Assemblies

IDLE AIR CONTROL (IAC) STEPPER MOTOR

Description

The PCM can control polarity of the circuit to control direction of the stepper motor (fig. 37). The IAC is called a stepper motor because it is moved in steps. The IAC motor is capable of 255 total steps from fully closed to fully open. Opening the IAC opens an air passage around the throttle blade which increases RPM.

The stepper motor has four wires. Two wires are for 12 volts and ground. The other two wires are for 12 volts and ground. The stepper motor is not really a motor at all. The pintle moves in and out and can be thought of as a "bolt" with threads. The "nut" is a permanent magnet. There are two windings by the "nut". When the PCM energizes one set of windings, this makes an electromagnet. The permanent magnet, which is allowed to rotate, is attracted to the electromagnet and rotates until the north and south poles line up. Once the poles line up the "nut" stops turning. At this time, the PCM energizes the other winding. This moves the “nut" one more step. As the "nut" turns, the pintle ("bolt") moves out or in. To make the IAC go in the opposite direction, the PCM reverses polarity on both windings. If only one wire is open, the IAC can only be moved one step in either direction.

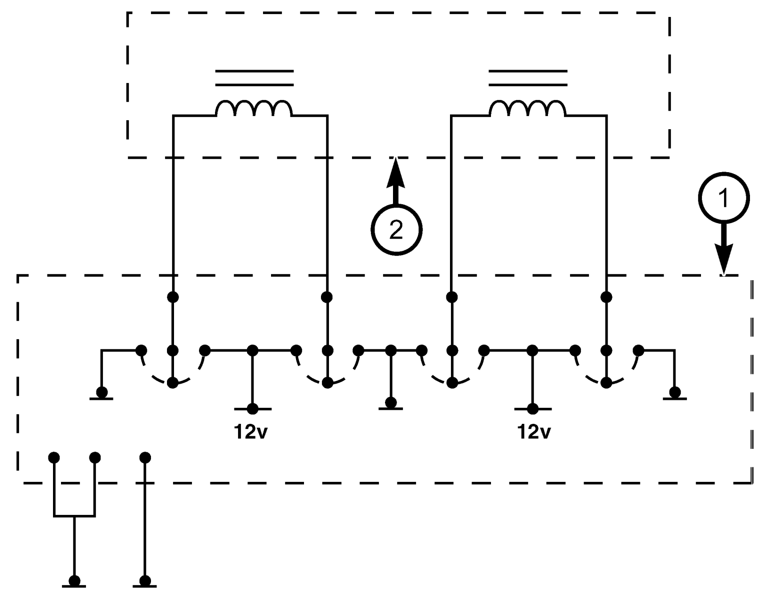

Figure 37 IAC Stepper Motor

1	PCM	2	Stepper Motor

IAC Stepper Motor Diagnostics

A DTC is set when the PCM senses a short to ground or battery voltage on any of the four driver circuits for 2.75 seconds while the IAC motor is active.

IAC Wiggle Test

A Wiggle Test can be performed to help determine proper operation of the IAC Stepper Motor. Refer to the Powertrain Diagnostic Manual for the proper test procedure.

LINEAR SOLENOID IDLE AIR CONTROL VALVE (LSIACV)

The linear solenoid idle air control valve is first used on the 2001 RS and PL. It is a two-wire solenoid operated by the PCM. The PCM provides both power and ground to move the valve. The position of the valve is determined by the PCM by the amount of current flow through the circuit, rather than “steps.” 250 ma of current flowing through the circuit indicates idle, whereas 900 ma indicates wide open. To control the position of the valve, the PCM pulse-width modulates the valve at a rate of 500 Hz. The biggest advantage of this new style idle control valve is its quick response, 20 ms from closed to full open, versus 200 ms on the older style IAC. This results in more accurate idle control and less of a tendency of idle undershoot.

RADIATOR FAN RELAYS

Single Relay Controlled

Some vehicles may have one or two radiator fans depending on how the vehicle is equipped. One relay is used and is controlled by the PCM. The PCM controls the ground circuit for the relay coil.

Dual Relay Controlled

Some vehicles may have one or two radiator fans. There are two relays, high speed fan relay and low speed fan relay. Both relays are controlled by the PCM.

Pulse-Width Modulated Control

Some vehicles have two radiator fans which are controlled by a Pulse-Width Module (PWM). The PCM controls the ground circuit of the PWM cooling module.

Some of these vehicles may also use an RFI module or a soft-start module to prevent headlamp dimming.

Hydraulic Fan

A second type of cooling system, which can replace both the electric fan and/or the engine driven fan, is the hydraulically driven fan. The same pump that provides power steering drives this hydraulic fan. The fluid used in the steering integrated fan system is the same as in the power steering system.

The advantage of this type of fan is that it provides the control of an electric fan with the power of an engine driven fan. Because the steering system and the fan system share one pump, the hydraulic fan drive receives all the flow from the pump, controls the required flow to the steering system, and uses the remainder as needed to drive the cooling fan. Because the hydraulic fan drive controls the steering flow like a typical power steering pump, the fan system is virtually invisible to the steering system. With infinite control of the fan speed, only the required air flow is provided for a given driving condition. This "Fan on Demand" strategy prevents unnecessary power draw from the engine and allows for increased tow capacity.

GENERATOR FIELD CONTROL

The PCM determines the charging rate by monitoring battery temperature. The PCM monitors battery voltage. If sensed battery voltage is 0.5 volts or lower than the target voltage, the PCM grounds the field winding until sensed battery voltage is 0.5 volts above target voltage (fig. 38). A circuit in the PCM cycles the ground side of the generator field up to 100 times per second (100 Hz), but has the capability to ground the field control wire 100% of the time full field to achieve the target voltage. If the charging rate cannot be monitored (limp-in), a duty-cycle of 25% to 50% is used by the PCM in order to have some generator output.

Diagnostics

There are three diagnostic routines concerning the generator field control:

- Generator Field Not Switching Properly – An open or shorted condition detected in the generator field control circuit
- Charging System Voltage Too High – Battery voltage sense input above target charging voltage during engine operation
- Charging System Voltage Too Low – Battery voltage sense input below target charging voltage during engine operation. Also, no significant change detected in battery voltage during active test of generator output

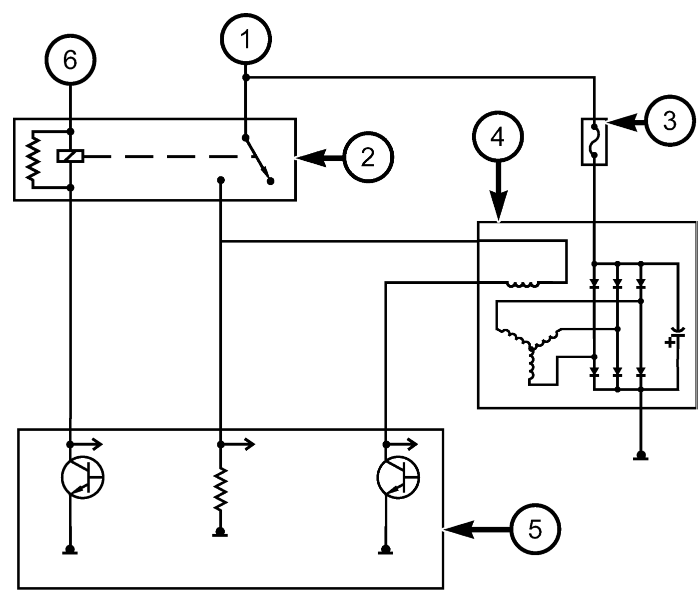

Figure 38 Generator

1	From Battery	4	Generator
2	ASD Relay	5	PCM
3	Fuse	6	From Ignition

Notes:

TORQUE CONVERTER CLUTCH SOLENOID (AUTO TRANS ONLY)

The PCM controls engagement of the clutch through the solenoid. The automatic transmission does not allow the torque converter clutch to engage if the transmission is not in at least direct drive.

GOVERNOR PRESSURE SOLENOID VALVE

JTEC-equipped vehicles may use a governor pressure solenoid valve. The solenoid valve generates the governor pressure needed for upshifts and downshifts. It is an electro-hydraulic device and is located in the governor body on the valve body transfer plate. The solenoid is pulse-width modulated by the PCM. Consult the appropriate diagnostic manual for more information.

GOVERNOR PRESSURE SENSOR

JTEC-equipped vehicles may use a governor pressure sensor. The governor pressure sensor measures the output pressure of the governor pressure solenoid valve. The sensor output signal provides the necessary feedback to the PCM. This feedback is needed to accurately control pressure. Consult the appropriate diagnostic manual for more information.

MALFUNCTION INDICATOR LAMP (MIL)

The MIL is controlled by the PCM, and illuminates for a 3 second bulb test each time the ignition is turned to ON. The MIL lamp remains continuously illuminated when an emissions component fails, or the vehicle enters a limp-in mode. Because the vehicle is equipped with OBD II diagnostic capabilities, the MIL flashes if the on-board diagnostic system detects engine misfire severe enough to damage the catalytic converter.

2001 New MIL Functionality for SBEC Vehicles (2002 on JTEC)

Unlike previous models, after the PCM performs a bulb check at key-on, the lamp stays illuminated until the vehicle is started. In addition, after the bulb check is completed, the MIL lamp flashes on and off if the CARB Readiness Indicator does not indicate that all “Once per Trip” have been successfully completed. This has been integrated into the software to address the IM240 states that require all "Once per Trip” monitors be completed prior to an IM test.

DUTY-CYCLE EVAPORATIVE PURGE SOLENOID

The evaporative purge solenoid operation is controlled by the PCM (fig. 39). The PCM duty cycles a ground path that allows the solenoid to open a varying amount. Refer to the Emission Control Systems section of this publication for more information.

Diagnostics

A DTC is set when the PCM determines that the actual state of the solenoid does not match the intended state.

The PCM monitors the Evaporative Emission System and a DTC is set under the following conditions:

- EVAP Purge Flow Monitor Failure – No air flow through the evaporative system is detected
- EVAP Purge Solenoid Circuit (Open or Shorted)

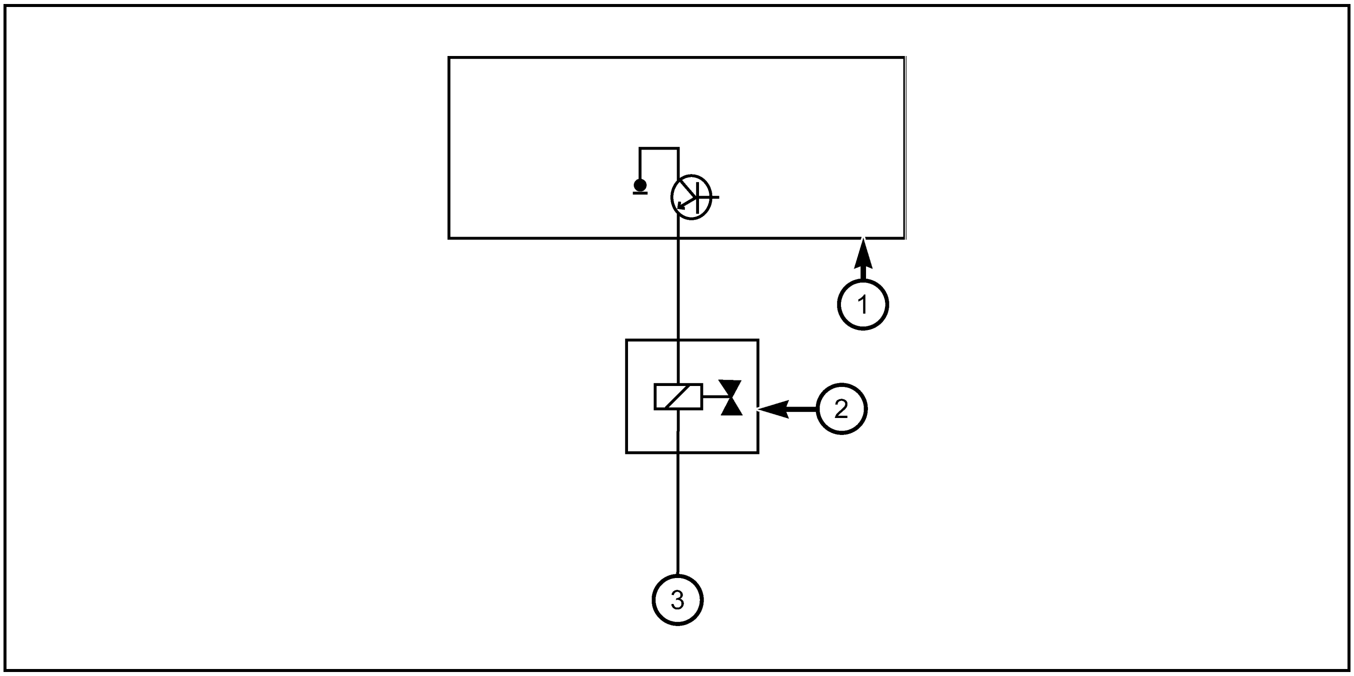

Figure 39 Duty-Cycle Purge Solenoid

1	PCM	3	From Ignition
2	Duty Purge Solenoid		

PROPORTIONAL PURGE SOLENOID

The Proportional Purge Solenoid operates at a frequency of 200 Hz and is controlled by a PCM circuit that senses the current being applied to the solenoid and then adjusts that current to achieve the desired purge flow (fig. 40). The Proportional Purge Solenoid controls the purge rate of fuel vapors from the vapor canister and fuel tank to the intake manifold.

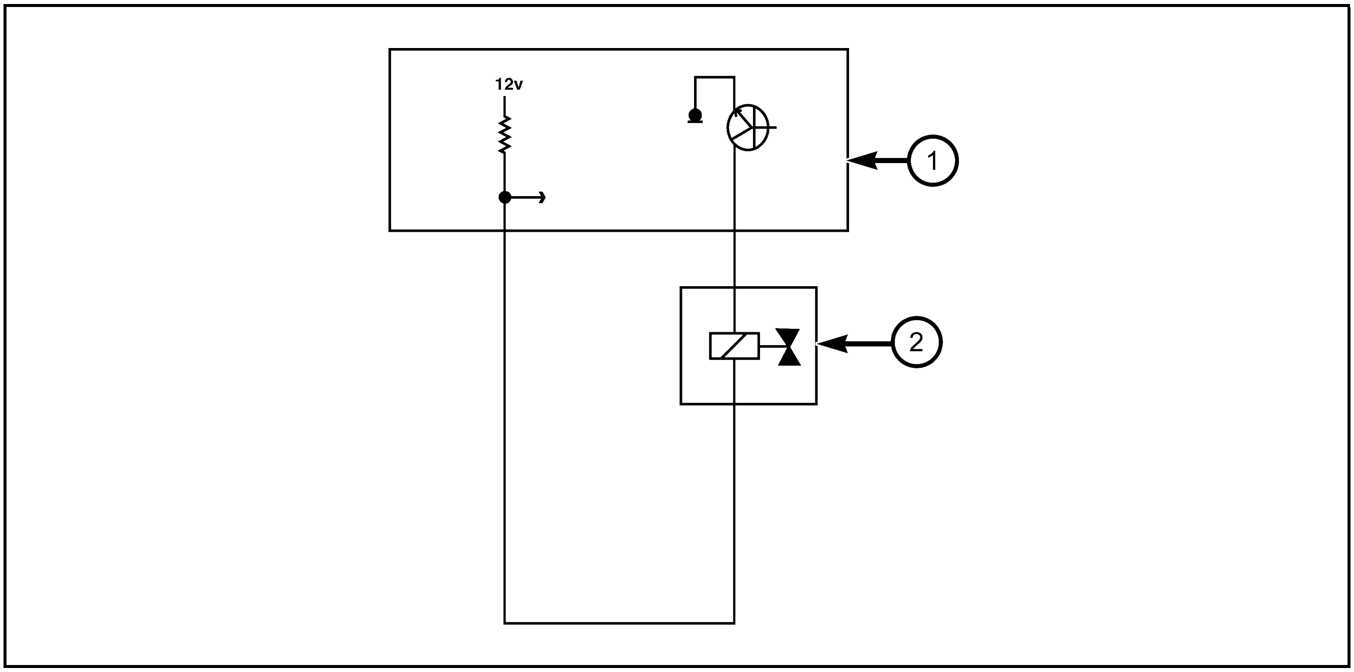

Figure 40 Proportional Purge Solenoid

1	PCM	2	Proportional Purge Solenoid

BACK-PRESSURE EGR SOLENOID

The EGR solenoid is attached to the transducer and controls the supply of vacuum to the EGR valve. The transducer is attached to the exhaust supply which aids in the control of vacuum to the EGR valve. Refer to the Emission Control System section of this publication.

LINEAR POSITION EGR SOLENOID

See 3-wire sensors for diagnostic information and the Emission Control Systems section of this publication for more information.

LEAK DETECTION PUMP SOLENOID

The PCM energizes the Leak Detection pump solenoid when specific operating conditions have been met. Refer to the Emission Control Systems section of this publication for more information.

SPEED CONTROL SERVO SOLENOIDS

The PCM on all vehicles controls the ground side of the vacuum and vent solenoids of the cruise servo. Refer to the Vehicle Speed Control System section of this publication for more information.

ACTIVITY 11

Your objective is to document the most effective process to diagnose this vehicle failure. Do not repair the vehicle unless directed to by your instructor. Your diagnosis is not as important as the process you use to come to your conclusion. Do not waste your time looking for a bug. If you really want to know what was done to the vehicle, ask your instructor. Your objective is to prove it using proven diagnostic methods.

Customer's Complaint: Slightly rough idle

Additional Information: This is the third time the customer has come back for the same complaint. The vehicle was previously found to have a misfire. The primary and secondary systems have had a repair made to them, and the engine has been overhauled. We are going to investigate whether there is a malfunction in the injector circuits.

DTCs: ____

One-Trip Failures: ____

Using the DRBIII®, access the OBD II Monitor screen called "Which Cylinder is Misfiring" and record the information:_______________________________________

To perform your diagnosis, you are going to setup the lab scope to view a known good injector signal and the injector signal on the cylinder indicating a misfire. Use the following method to setup the Lab Scope:

- On the DRBIII®, select *Lab Scope*
- Select *Live Data*
- Select *#9- Injector, Ign. Primary*
- Press *F2* to select the scope function on channel 1
- Press *F4* to add the meter display to channel 1
- Press *F3* to start

Using a back-probing tool or a "T" pin, back-probe the neighboring injector to the cylinder which indicated a misfire. The wire we want to look at is the circuit that the PCM controls, the ground side of the circuit. Attach the scope lead and start the engine.

Notice the injector pattern is jumping all over, making it very difficult to see and interpret. The next step allows us to set a trigger that appears to freeze the injector pattern on the screen.

Press *F3 Record*. Press the up cursor one time to select *Record Normal.* Notice we are going to record the signal on the *Falling Edge*. This means the DRBIII® draws the pattern every time it sees the voltage drop down from 12 volts. Press *F3* to leave the Recording setup menu.

Look at the injector pattern of the known good circuit and answer the following questions:

- Does the pattern display a consistent 12-volt feed going to the injector?___________
- What would it indicate if the 12-volt supply to the injectors did not remain in a straight line? ____
- What does the drop to zero volts indicate? _____________________________________
- Does the zero-volt line stay at zero volts, or does it drift up? ____________________
- What would it indicate if the zero-volt trace began to drift up?____________________
- What does the duration of the zero-volt trace represent? ________________________
- What happens to the trace when the PCM turns off the injector? ________________
- What is this an indication of? ____
- Would the PCM set a DTC if it did not see this? ________________ If yes, what DTC would be set? ____

Now that you have examined a known good injector circuit, switch your scope lead to the injector whose circuit indicated a problem.

Based on your knowledge of how the circuit should work, what is your preliminary diagnosis? ____

____

What further diagnostic steps would be required to verify your diagnosis? ___________

____

____

____

ACTIVITY 12

Your objective is to document the most effective process to diagnose this vehicle failure. Do not repair the vehicle unless directed to by your instructor. Your diagnosis is not as important as the process you use to come to you conclusion. Do not waste your time looking for a bug. If you really want to know what was done to the vehicle, ask your instructor. Your objective is to prove it using proven diagnostic methods.

Customer's Complaint: A/C Inop

DTCs: ____

List the steps you used to diagnose the customer's complain: __________________

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In conclusion, what is the root cause of the failure? ______________________________

____

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ACTIVITY 13

Your objective is to document the most effective process to diagnose this vehicle failure. Do not repair the vehicle unless directed to by your instructor. Your diagnosis is not as important as the process you use to come to you conclusion. Do not waste your time looking for a bug. If you really want to know what was done to the vehicle, ask your instructor. Your objective is to prove it using proven diagnostic methods.

Customer's Complaint: MIL On, battery goes dead

DTCs: ____

List the steps you used to diagnose the customer's complain: ________________

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In conclusion, what is the root cause of the failure? ____________________

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ACTIVITY 14

Your objective is to document the most effective process to diagnose this vehicle failure. Do not repair the vehicle unless directed to by your instructor. Your diagnosis is not as important as the process you use to come to you conclusion. Do not waste your time looking for a bug. If you really want to know what was done to the vehicle, ask your instructor. Your objective is to prove it using proven diagnostic methods.

Customer's Complaint: Cruise Control Inop

DTCs: ____

List the steps you used to diagnose the customer's complain: ______________

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In conclusion, what is the root cause of the failure? ____________________

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Notes:

EMISSIONS CONTROL SYSTEMS

The emissions control system is comprised of two major segments to control the output of hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NO_x.). The two major segments are evaporative emissions and exhaust emissions.

EGR SYSTEMS

There are two different EGR systems currently being used on SBEC and JTEC, the backpressure EGR or the Linear Solenoid EGR. The Exhaust Gas Recirculation (EGR) valve is used to prevent excessive combustion temperatures and reduce the formation of NOx (Oxides of Nitrogen) by reducing the volume in the combustion chamber. With the chamber's reduced volume, there is less room for the air/fuel mixture and combustion chamber temperature is reduced. A side benefit of EGR is a slight increase in fuel economy due to less fuel being burned.

Back-pressure EGR

The electronic EGR transducer contains an electrically controlled solenoid and a back–pressure transducer. The EGR Solenoid is a normally open solenoid that allows the free passage of vacuum to the EGR. If there is no exhaust backpressure reaching the transducer, the vacuum is bled off. As the backpressure starts to rise, the vacuum bleed begins to close, allowing vacuum to reach the EGR diaphragm. The more backpressure, the more EGR flow. The PCM energizes the EGR solenoid when it does not desire EGR flow, like during cold operation, or wide-open throttle. Under both of these conditions, EGR could reduce vehicle performance, but under either of these two conditions, EGR is also not needed due to the richer fuel mixtures.

Linear Solenoid EGR

A Linear Solenoid Exhaust Gas Recirculation (EGR) valve was first used on the 1998 LH. The Linear Solenoid EGR valve consists of three major components:

- Pintle, valve seat and housing – Contains and regulates gas flow
- Armature, return spring and solenoid coil – Provides operating force to regulate exhaust gas flow by changing the pintle position
- EGR Pintle Position Sensor – Senses pintle position

The exhaust gas recirculation flow is determined by the PCM. For a given set of conditions, the PCM knows the ideal exhaust gas recirculation flow to optimize NOx and fuel economy as a function of the pintle position. Pintle position is obtained from a linear potentiometer that is integral to the valve. The PCM adjusts the duty-cycle of 128 Hz power supplied to the solenoid coil to obtain the correct position.

EVAPORATIVE EMISSION CONTROL

The evaporative control system consists of a fuel cap, fuel tank, rollover valves, vapor lines, evaporative canister, Duty-Cycle Purge (DCP) solenoid, vapor lines and on some vehicles, an Evaporative System Leak Detection pump and On-Board Refueling Vapor Recovery hardware (fig. 41).

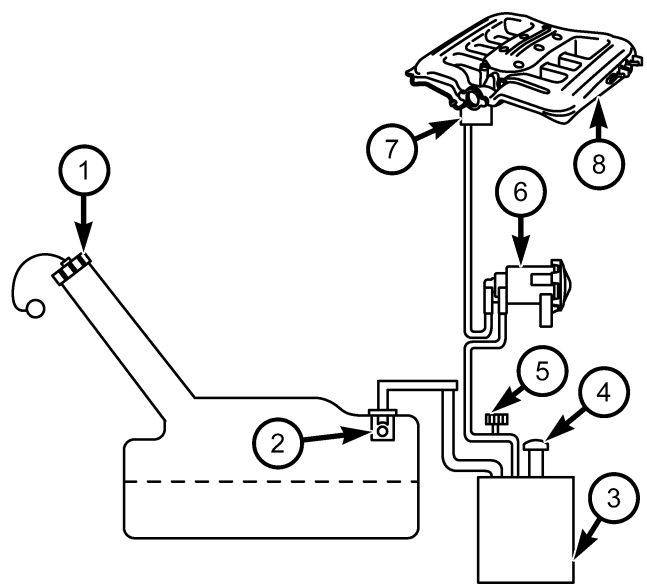

Figure 41 Evaporative Emissions

1	Fuel Filler Cap	5	Schraeder Valve (engine compartment)
2	Rollover Valve	6	Canister Purge Solenoid
3	Charcoal Canister	7	Throttle Body
4	Canister Vent	8	Intake Manifold

Fuel Filler Cap

The fuel filler cap is either a screw-on type with a ratchet mechanism added to keep the tightening force on the filler cap constant, or a quarter-turn ratchet type. Also, the cap is equipped with a valve to relieve both pressure and vacuum extremes in the fuel tank.

Rollover Valves

Attached to the top of the tank or fuel pump module is one or more rollover valves. This valve is designed to allow fuel tank vapors to be routed to the canister, to relieve fuel tank vacuum and to relieve fuel tank vacuum. In case of an accident that causes the vehicle to overturn, the valve is equipped with a check valve that prevents fuel from entering the vapor line.

Evaporative Charcoal Canister

The purpose of the evaporative charcoal canister is to vent built-up vapor pressure in the fuel tank. The activated charcoal in the canister absorbs the hydrocarbon vapors and vent fresh air to the atmosphere. The Duty-Cycle Purge solenoid is used to control the flow of vapors from the canister to the intake manifold. Operation of the solenoid is controlled by the PCM which provides a ground path that allows the solenoid to open, allowing vapor flow. When the engine reaches operating temperature, intake manifold vacuum draws the stored hydrocarbons into the combustion chamber. After the vehicle starts to cool, fuel tank vacuum is relieved by air being drawn into the fuel tank via the canister and rollover valve.

Canister Purge Solenoids

There are two different types of canister purge solenoids that have been used on passenger vehicles: the duty-cycle purge solenoid and the proportional purge solenoid.

Duty-Cycle Purge

The solenoid regulates the rate of vapor flow from the EVAP canister to the throttle body. The PCM operates the solenoid by providing a ground path that allows the solenoid to open. Power to the solenoid is provided by a switched ignition feed.

Proportional Purge Solenoid

The Proportional Purge Solenoid differs from the DCP in that the PCM supplies both power and ground. It operates at a frequency of 200 Hz and is controlled by a PCM circuit that senses the current being applied to the solenoid and then adjusts that current to achieve the desired purge flow. The Proportional Purge Solenoid controls the purge rate of fuel vapors from the vapor canister and fuel tank to the intake manifold.

Leak Detection Pump (96 through current CALIF, 2001 and current FED)

The Leak Detection Pump (LDP) is a device that pressurizes the evaporative system to determine if there are any leaks (fig. 42 and fig. 43). First required on 1996 vehicles equipped with California emissions, this system is now used on all Federal packages, starting in the 2001 model year.

The pump contains a 3–port solenoid, a pump diaphragm, two springs, a plunger, a magnetic reed switch, an atmospheric vent control valve, and two check valves.

Immediately after a cold start, if the ambient temperature is between 40°F and 90°F, engine coolant temperature is within 10° of intake air temperature and fuel level is greater than 15% but less than 85%, the 3–port solenoid is briefly energized. This initializes the pump and allows manifold vacuum to lift the diaphragm, closing the atmospheric vent. At this point, the PCM sense circuit indicates that the normally closed reed switch is now open, signaling that the diaphragm is in the up position. During the running of the LDP monitor, the PCM shallow-strokes the pump, to prevent the atmospheric vent from opening.

After the initialization tests, the PCM begins to cycle the solenoid. The diaphragm is pulled up, drawing outside air into the pump body through the inlet check valve. When the solenoid is de-energized, the spring, rated at 7.5” H_2O, forces the diaphragm down, closing the inlet check valve and opening the outlet check valve, allowing the pressure into the evaporative system.

As the evaporative system begins to pressurize, the pressure that is building in the evaporative system exerts a force on the bottom of the diaphragm and begins to oppose the spring pressure on top of the diaphragm, slowing down the pump. The PCM watches the time period from when the solenoid is de-energized, until the diaphragm drops down far enough for the reed switch to change states from open to closed. If the switch state changes too quickly, a leak in the evaporative system is indicated. The longer it takes for the switch state to change from open to closed, the tighter the evaporative system is sealed. If the system pressurizes too quickly, a restriction somewhere in the evaporative system is indicated.

There are six DTCs that can be generated by a malfunction in the LDP system:

- Small, Medium or Large Leak Detected
- Pinched Line Detected
- Switch or Mechanical Fault (the PCM does not see the switch state change)
- Solenoid continuity fault

Consult the appropriate service or diagnostic procedure manual and TSBs for detailed descriptions.

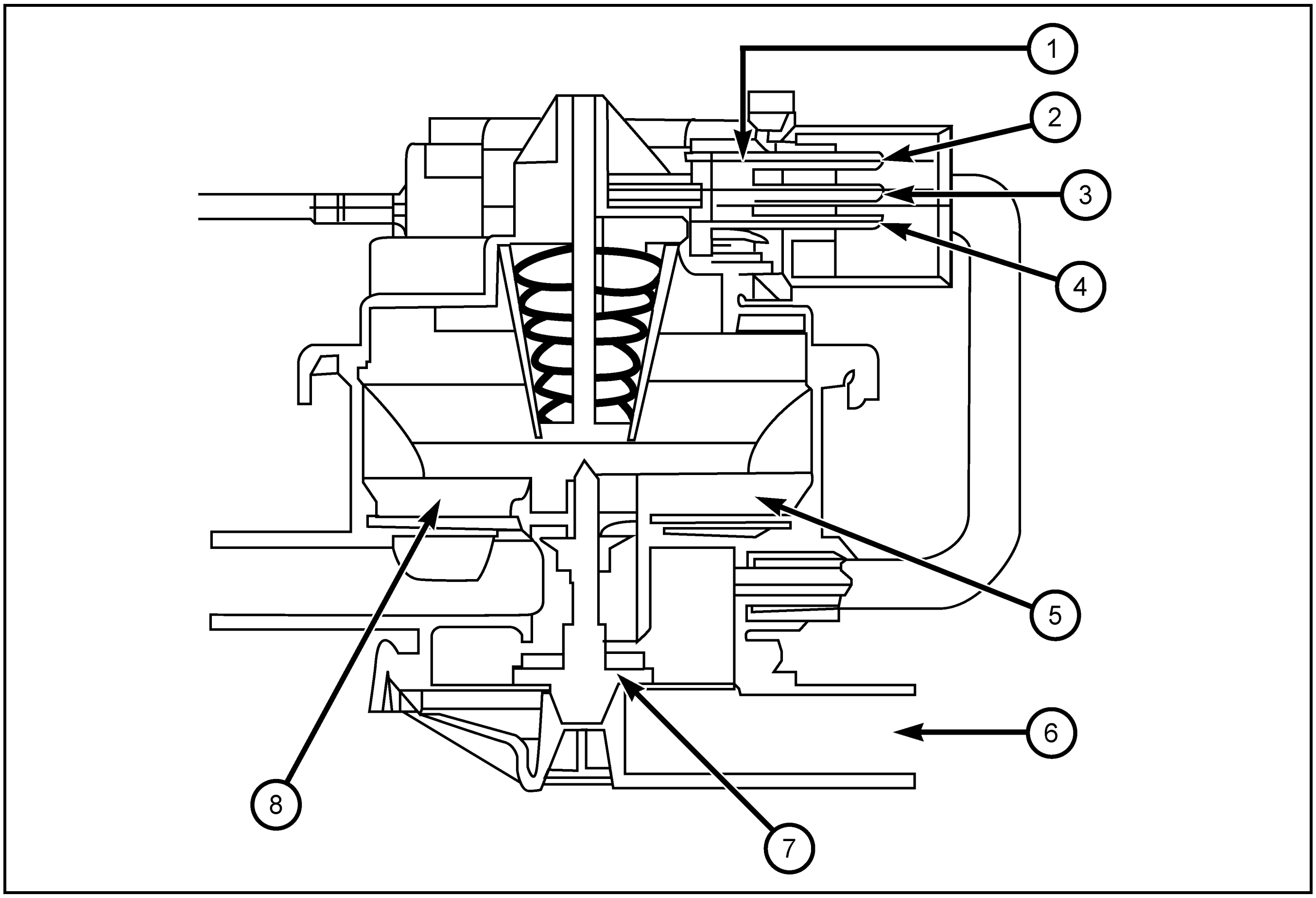

Figure 42 Leak Detection Pump

1	Normally Closed Reed Switch	5	Inlet Check Valve
2	PCM Sense Circuit	6	To Inlet Air Filter Fuel Tank Vent: Pres and Vacuum
3	Solenoid Control from PCM	7	Atmospheric Vent Valve
4	12-volt Supply (SBEC-Ignition / JTEC-ASD via the PCM)	8	Outlet Check Valve

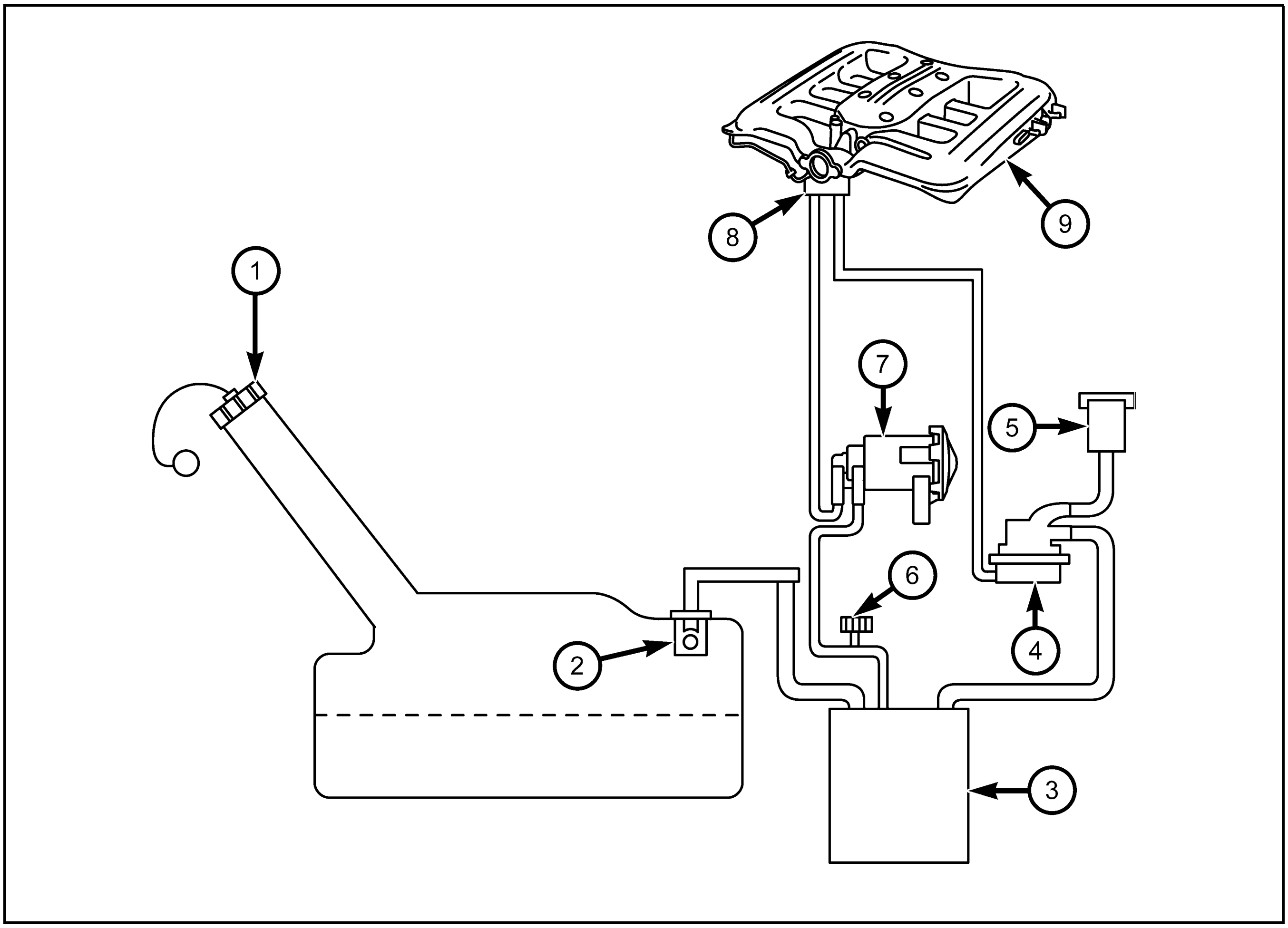

Figure 43 Evaporative Emissions with LDP

1	Fuel Filler Cap	6	Schraeder Valve (engine compartment)
2	Rollover Valve	7	Canister Purge Solenoid
3	Charcoal Canister	8	Throttle Body
4	Leak Detection Pump	9	Intake Manifold
5	Breather Element		

On-Board Refueling Vapor Recovery

The On-Board Refueling Vapor Recovery (ORVR) system was first introduced on some 1998 passenger vehicles. The purpose of the system is to draw the hydrocarbon vapors into the vehicles fuel tank during refueling. These vapors are then vented to the canister for storage. This system may be integrated with LDP (California Emissions prior to 2001) or may be standalone (fig. 44 and fig. 45). System components may vary by application.

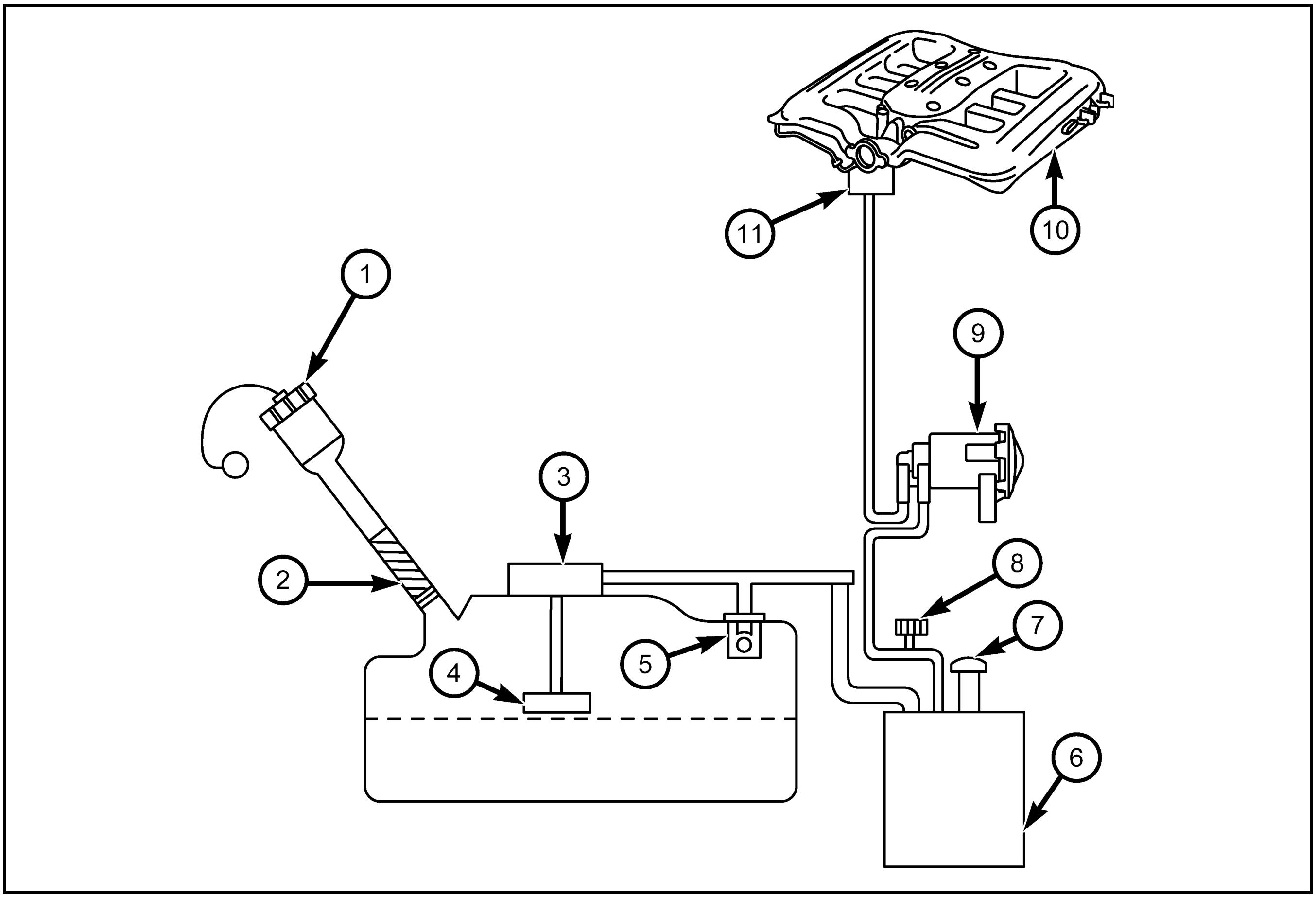

Figure 44 Evaporative Emissions with ORVR

1	Fuel Filler Cap	7	Vent
2	Filler Tube and Check Valve (anti-spit-back valve)	8	Schraeder Valve (engine compartment)
3	Liquid/Vapor Separator and Control Valve	9	Purge Solenoid
4	Control Valve Float	10	Intake Manifold
5	Rollover Valve	11	Throttle Body
6	Charcoal Canister		

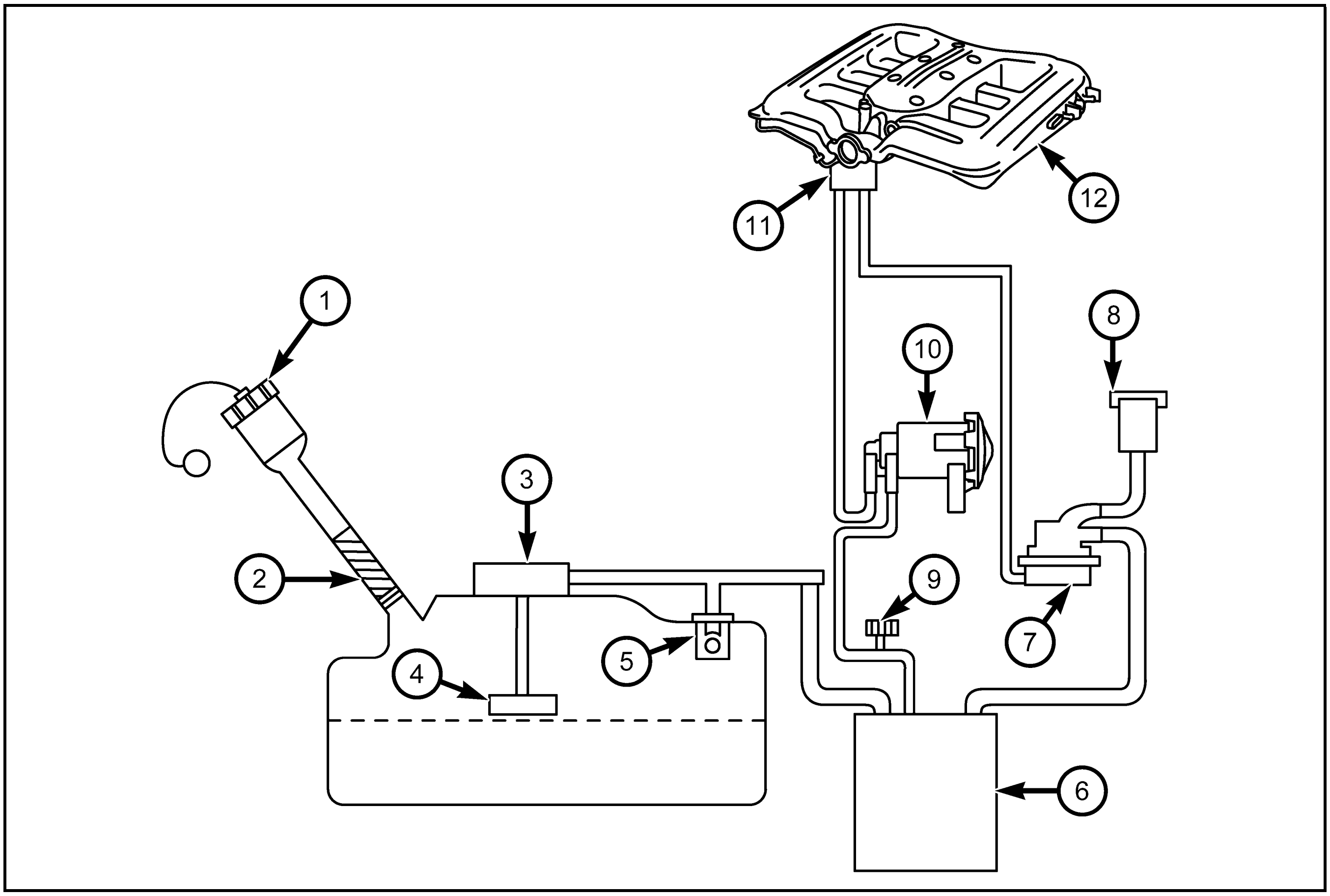

Figure 45 Evaporative Emissions with ORVR and LDP

1	Fuel Filler Cap	7	Leak Detection Pump
2	Filler Tube and Check Valve (anti-spitback valve)	8	Breather Element
3	Liquid/Vapor Separator and Control Valve	9	Schraeder Valve (engine compartment)
4	Control Valve Float	10	Purge Solenoid
5	Rollover Valve	11	Throttle Body
6	Charcoal Canister	12	Intake Manifold

ORVR OPERATION

The components of the ORVR system include a filler tube that tapers down to about 1 inch in diameter. At the base of the filler tube is a one-way check valve (anti-spitback) valve. On top of the fuel tank is a liquid/vapor separator and a vapor control valve. The vapor control valve contains a float which controls the flow of vapor to the canister, venting the tank during refueling.

During the refueling process, fuel flowing down the filler tube opens the one-way check valve, allowing fuel to enter the tank. As the fuel is flowing down the tapered filler tube, a vacuum develops that draws the hydrocarbon vapors down the tube and to the top of the tank. The vapors flow through the vapor control valve and liquid separator and into the canister for storage, thus venting the tank. As the fuel level approaches full, the control valve closes off the flow of vapors to the canister. Without a way of venting the tank, the fuel nozzle clicks off. To prevent a sudden surge of fuel up the filler tube, the one-way check valve in the base of the filler tube closes.

Note: *Diagnosing a leak on the LDP system is not recommended when the fuel level is above 75%. Besides the safety considerations, if there is an evaporative system leak on an ORVR equipped vehicle, diagnosis may be misleading. Because of the flow control valve, if the fuel level is high enough, a leak may not be detected while pressurizing the LDP system. If the system is pressurized via the Schraeder valve, a leak may not be detected from the tank back. If pressurized at the filler neck, a leak may not be detected forward of the tank.*

Note: *Some vehicles equipped with an LDP also use a vacuum-controlled vent valve that is used to relieve pressure in the evaporative system if the vehicle is shut off during the LDP monitor.*

Notes:

ACTIVITY 15

Objective: To diagnose a vehicle with a Leak Detection circuit malfunction

Customer's Complaint: ____

DTCs: ____

1 Trip Failures: ____

LDP System Diagnosis

The Leak Detection Pump is used to check the integrity of the evaporative system. The Federal EPA and CARB have determined that 95% of all Hydrocarbon emissions are not from tailpipe emissions, but are the result of evaporating gasoline. The Leak Detection Pump monitor is programmed to detect an evaporative emission leak exceeding a predetermined amount.

The following procedure is NOT to be used as a substitute for the Diagnostic Procedure Manuals, but as a supplement to enhance your understanding.

Small, Medium or Large Leaks Detected DTCs

STEP 1:

- Tighten the gas cap and run the LDP Monitor to see if it passes or fails. You can re-run the monitor by running the DRBIII® System Test/LDP Monitor Test, or if time permits, leave the vehicle sit overnight and run the natural monitor
- Be sure to read the DRBIII's® OBD II Monitors/Last Result LDP Monitor, to see how well the evaporative system sealed. Completely sealed systems show a current (or Last) Average LDP Pump Time substantially exceeding the minimum spec.
- If the monitor now passes, the gas cap was the cause of the leak, or the cause is no longer present.
- If the Average Pump Time is not SUBSTANTIALLY more than the spec, you still have a leak, even though it passed the LDP monitor. This vehicle may fail the LDP monitor at a later date. If the LDP monitor fails (or passes with less than a substantial amount of average pump time, then perform the steps in Step 2.

Note: *The Average Pump Period for the Large (0.040") Test used to read 25 Seconds on a perfectly sealed system. The New Quick Pass Test stops averaging the Pump Periods as soon as it gets a pass. So you may see 6 to 11 seconds (for SBEC) or 14 seconds (for JTEC) for the 0.040"/Large Leak Last LDP Average Pump Period. In the past this indicated a leak below the failure threshold. This is no longer true. In the past (prior to 2000 SBEC software) SBECs would* *have 25.5 seconds on a perfectly sealed systems and JTECs would have up to 55 seconds on a perfectly sealed EVAP System. On SBECs, now you must look at the 0.020" Last Test Result (when valid), or run the DRBIII® System Test for Leak Detection Pump Monitor, this causes the LDP to continue averaging the Pump Period for the Large/0.040" test. This gives you an indication of how well the system is sealed.*

STEP 2:

- Apply a constant source of vacuum to the LDP solenoid by applying vacuum to the SVST Valve (black tee with a green cap- 96/97 models only) or to the plastic line going down to the Leak Detection Pump Solenoid. The SVST valve was eliminated for 1998 because of On-Board Refueling Vapor Recovery.
- A constant source of vacuum is the preferred method, for example an A/C evacuation pump. A hand-held vacuum pump may leak down if used for this test. If you chose to use the vehicle's own engine vacuum, be sure to disconnect the purge solenoid to avoid purging while the monitor runs or else it may fail. Be aware that DTCs may have to be cleared, also erasing ALL OBD II data as well!

STEP 3:

- Using the DRBIII®, go to Engine/System Tests, and select Leak Detect Pump Test and select option 3 (Hold psi). This energizes the LDP solenoid and allows the vacuum from the constant vacuum source to apply vacuum to the LDP pump diaphragm. This lifts the diaphragm up and seals the atmospheric vent at the bottom of the Leak Detection Pump. The evaporative system is **NOW** ready to be pressurized.

STEP 4:

- Evaporative Emissions Leak Detector (EELD) Hookup:
  1. Connect the red power lead to a 12V DC power supply.
  2. Connect the black lead to a chassis ground.

STEP 5:

<u>Phase One</u>

1. Connect shop air to the 8404 Evaporative Emissions Leak Detector (EELD)

2. Set the control knob to AIR

3. Insert the tester's AIR supply tip (clear hose) into the appropriate calibration orifice on the tester's control panel (based on the DTC)

4. Press the remote start button

5. Position the red flag on the flow meter so it is aligned with the indicator ball. When calibration is complete, release the remote button. This calibrates the flow meter in liters per minute to the size leak (based on the DTC) you are looking for.

6. Install the service port adapter (no. 8404-14) on the vehicles service port, or to the service port on the fuel tank adapter No. 6922 or No. 8382.

7. Connect the AIR supply hose from the EELD to the service port or fuel tank adapter.

8. Press the remote button to activate AIR flow. **NOTE:** Larger volume fuel tanks, and/or those with lower fuel levels, may require 4 or 5 minutes to completely fill the system with air.

9. **NOTE:** If the fuel level is over 85% on vehicles with ORVR, it may be necessary to perform this procedure from the service valve AND tank adapter, due to closure of the ORVR flow control valve.

   - Compare the flow meter indicator ball reading to the red flag:
   - ABOVE the red flag is an UNACCEPTABLE leak (vehicle failed: go to Phase Two)
   - BELOW the red flag is ACCEPTABLE (vehicle passed: Test Complete)

Phase Two

1. Remove the AIR supply hose from the service port of fuel tank adapter

2. Connect the SMOKE supply tip (black hose) to the service port or fuel tank adapter.

3. Set the control switch to SMOKE

4. Press the remote start button

   - If inputting the smoke through the service port adapter, verify that smoke has filled the evaporative system by removing the fuel cap until smoke begins to escape. Reinstall the cap.
   - If inputting smoke through the fuel tank adapter, verify that smoke has filled the evaporative system, by depressing the Schraeder valve on the service port adapter until smoke begins to escape from the adapter.

5. Once smoke is observed, close the EVAP system by either reinstalling the fuel cap, or releasing the Schraeder valve.

6. For optimal performance, introduce smoke into the system for an additional 60 seconds; continue introducing smoke at 15-second intervals as necessary.

7. Using the white light, follow the evaporative system path and look for the source of the leak (exiting smoke). Make sure to check that the normally-closed purge solenoid is not leaking into the intake manifold.

8. If the leak is in a concealed area, stop the smoke and use the ultraviolet black light, while wearing the supplied yellow glasses, to locate the residual ultraviolet dye left behind by the escaping smoke. The leak deposits a residual fluid that is either bright green or yellow in color when viewed with a UV light source.

9. Repair the leak, and then retest by performing Phase 1 testing again, to verify your repair.

STEP 6:

- Re-run the LDP Monitor and check the Last Result Monitor as in Step 1 to ensure that your fix fully seals the evaporative system.

Switch or Mechanical Fault DTCs:

The fault code “Switch or Mechanical Fault”, indicates that the PCM does not see the reed valve switch in the LDP toggling as it cycles the LDP solenoid on and off. To verify proper operation, start the engine and using the DRBIII®, go to Engine/System Tests and select Leak Detect Pump Test. Select option 1 and IMMEDIATELY press the down arrow on the DRBIII®. This puts the LDP in the Slow Pumping or Switch Test mode. If the system is working correctly, the Leak Detect Pump Switch toggles back and forth between Closed (Down) and Open (Up). If the switch is toggling, the condition does not presently exist that set the DTC. If the switch does not toggle, check the following items:

Switch Stays in Closed/Down Position

- Is there a good source of vacuum at the Leak Detection Pump?
- Is there any physical damage to the LDP? Have there been any collision repairs performed to the vehicle?
- If the DRBIII® switch state indicates Closed/Down, unplug the LDP pump. Does the status change to Open/Up? If so, the wiring and the PCM logic as OK and the pump is suspect.

Switch Stays in Open/Up Position

- Unplug the LDP connector and inspect the connector terminals and LDP pins. Jumper the connector from the 12-volt feed to the PCM sense circuit (consult wiring diagrams). If the DRBIII® now toggles to Closed/Down, the LDP pump is suspect.
- If there is no change in state: Is there 12 volts getting to the pump? If not, trace the circuit back. Once the voltage source has been eliminated: Is there an open between the PCM sense circuit at the connector and the PCM itself?

APPENDIX

TYPICAL SCOPE PATTERNS

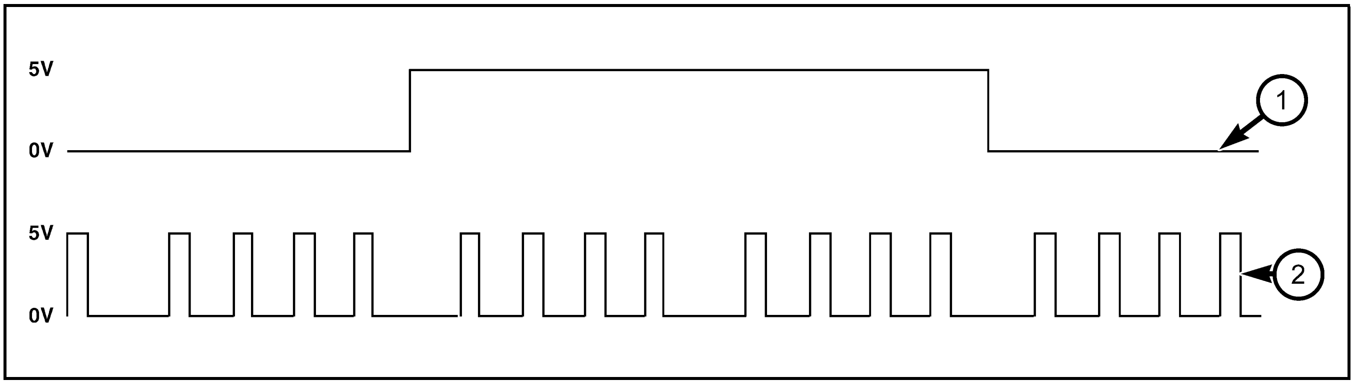

Figure 46 2.5L and 4.0L Engines

1	CMP Signal	2	CKP Signal

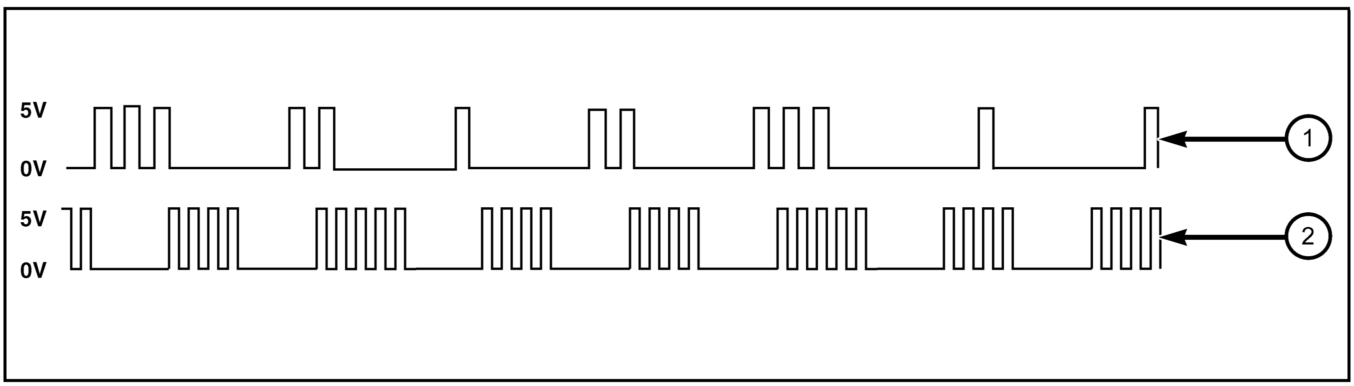

Figure 47 2.7L, 3.2L, and 3.5L Engines

1	CMP Signal	2	CKP Signal

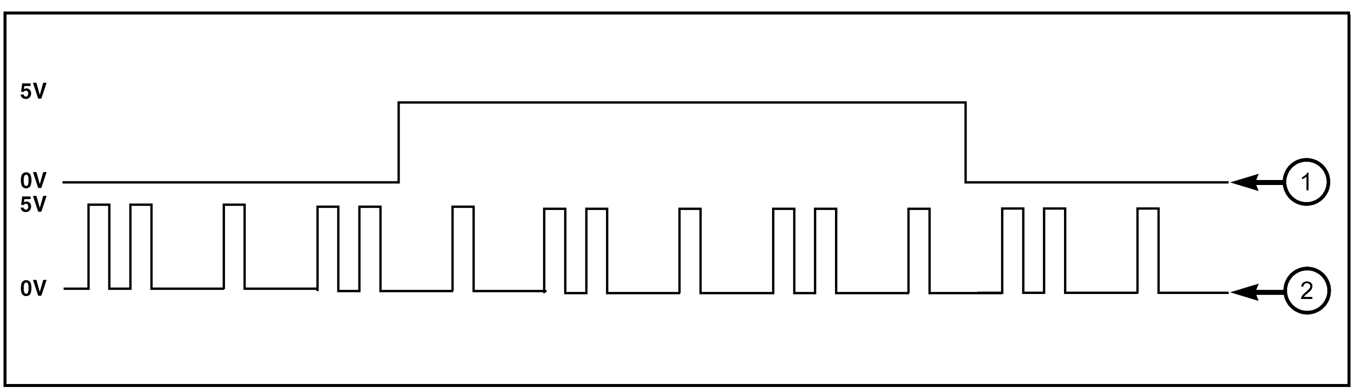

Figure 48 3.9L Engines

1	CMP Signal	2	CKP Signal

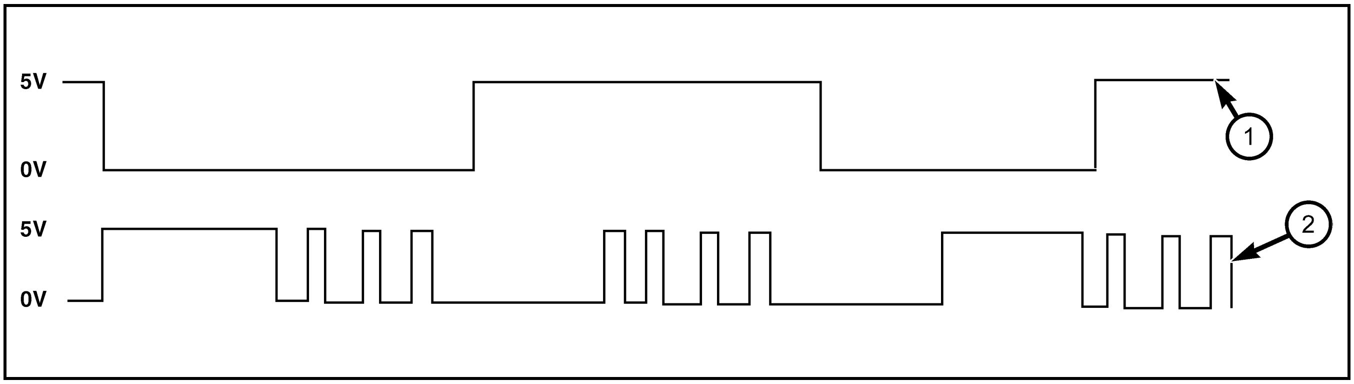

Figure 49 2.0L and 2.4L Engines

1	CMP Signal	2	CKP Signal

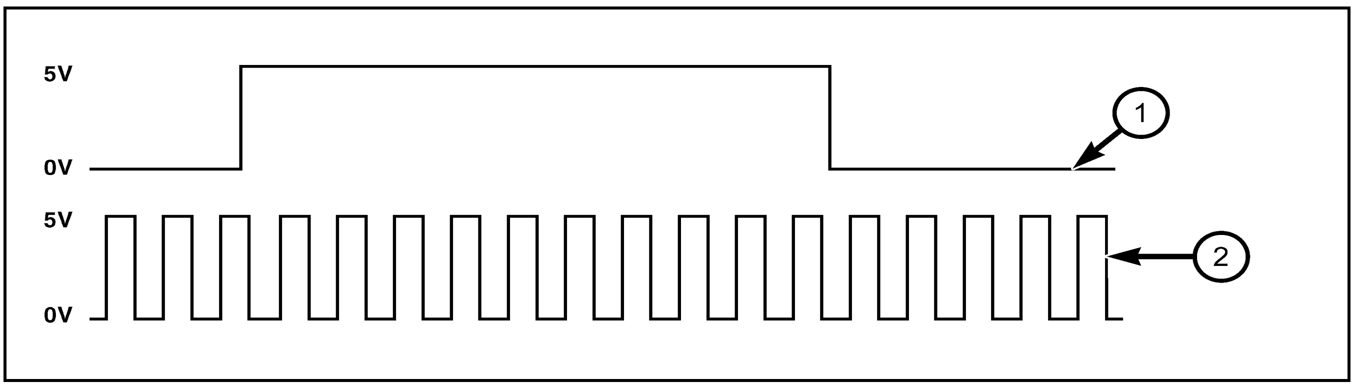

Figure 50 5.2L and 5.9L Engines

1	CMP Signal	2	CKP Signal

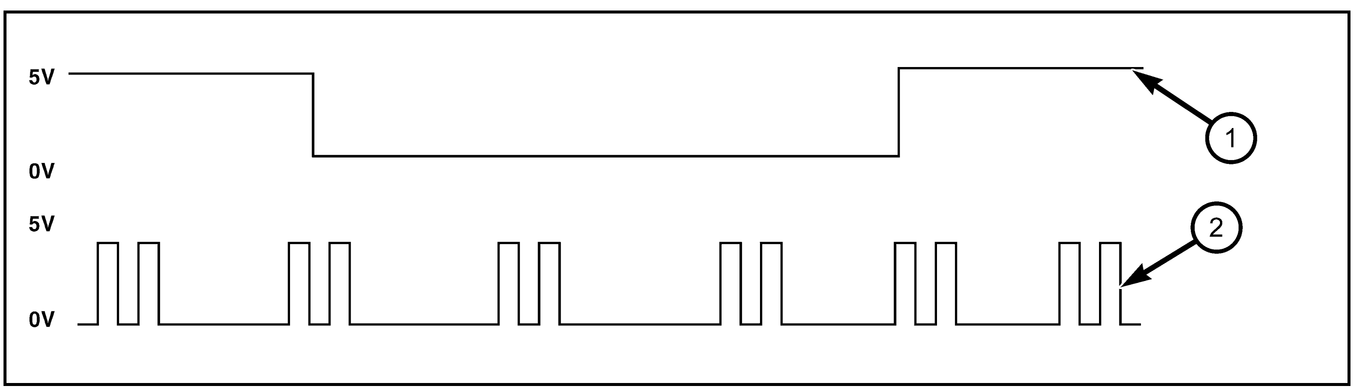

Figure 51 8.0L Engines

1	CMP Signal	2	CKP Signal

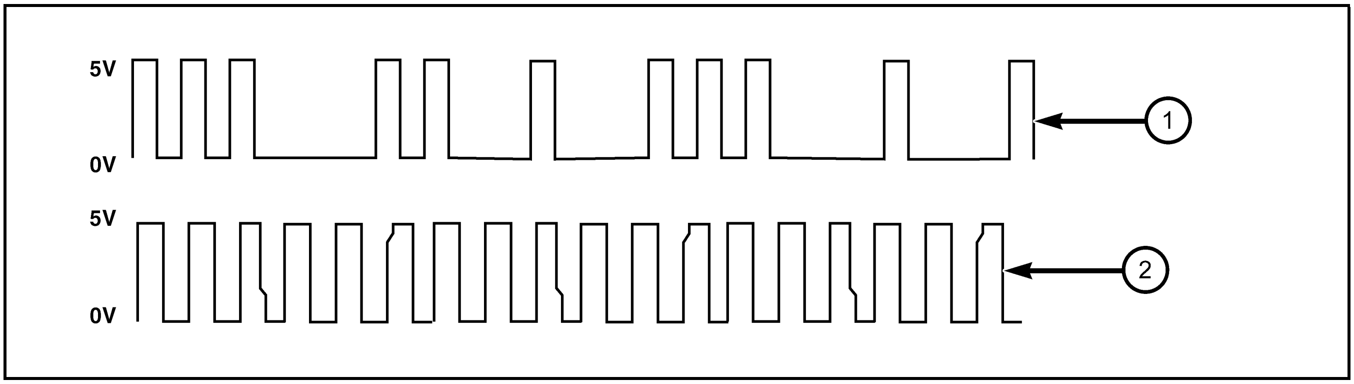

Figure 52 4.7L Engines

1	CMP Signal	2	CKP Signal

Notes: