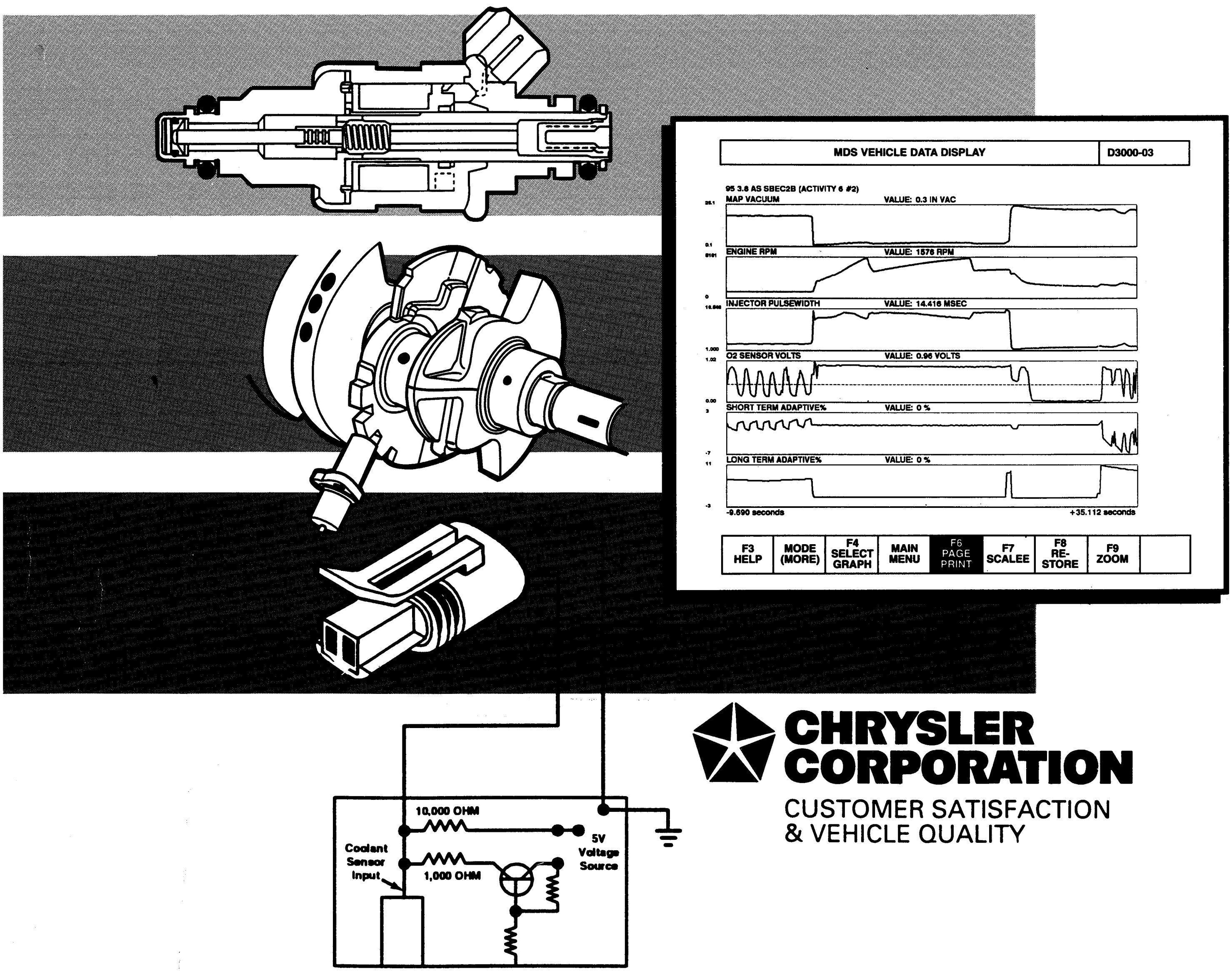
FWD 4-Cyl Fuel Injection



CHRYSLER CORPORATION

CUSTOMER SATISFACTION
& VEHICLE QUALITY

SAFETY NOTICE

This publications purpose is to provide Technical training information to individuals in the automotive trade. All test and repair procedures must be performed in accordance with manufacturers service and diagnostic manuals. All ***warnings, cautions,*** and ***notes*** must be observed for safety reasons. The following is a list of general guidelines:

- Proper service and repair is critical to the safe, reliable operation of all motor vehicles.
- The information in this publication has been developed for service personnel, and can help when diagnosing and performing vehicle repairs.
- Some service procedures require the use of special tools. These special tools must be used as recommended throughout this Technical Training Publication, the diagnostic Manual, and the Service Manual.
- Special attention should be exercised when working with spring-or tension-loaded fasteners and devices such as E-Clips, Cir-clips, Snap rings, etc., careless removal may cause personal injury.
- Always wear safety goggles when working on vehicles or vehicle components.
- Improper service methods may damage the vehicle or render it unsafe.
- Observe all *warnings* to avoid the risk of personal injury.
- Observe all *cautions* to avoid damage to equipment and vehicle.
- *Notes* are intended to add clarity and should help make your job easier.

Cautions and *Warnings* cover only the situations and procedures Chrysler Corporation has encountered and recommended. Chrysler Corporation cannot know, evaluate, and advise the service trade of all conceivable ways in which service may be performed, or of the possible hazards or each. Consequently, Chrysler Corporation has not undertaken any such broad service review. Accordingly, anyone who used a service procedure or tool that is not recommended in this publication, must be certain that neither personal safety, nor vehicle safety, is jeopardized by the service methods they select.

TECHNICAL TRAINING

CustomerOne™

MASTER TECH

FWD 4-Cyl Fuel Injection

TABLE OF CONTENTS

NOTES

LESSON 1

INTRODUCTION

STUDENT LEARNING OBJECTIVES

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

- Use a DRB III and/or MDS to interpret the signals generated by the various input sensors as displayed on these tools.
- Use the service manual procedure to properly de-pressurize the fuel system, attach the appropriate test equipment, and test fuel system pressure.
- Given a vehicle equipped with either a 2.0L or 2.4L engine, the appropriate Service Manual and Powertrain Diagnostics manual, the technician will be able to properly diagnose electrical and mechanical malfunctions of inputs and outputs to the Powertrain Control Module.
- Use a DVOM on-vehicle to measure, record, and interpret the voltage/ resistance of various PCM-related system inputs and outputs.

FWD 4-Cyl Fuel Injection

GENERAL DESCRIPTION

This publication contains information regarding the systems controlled by the Powertrain Control Module (PCM). These include the fuel, emissions, speed control, charging, radiator fan and PCM-related A/C control functions on all the 1996 vehicles equipped with either a 2.0L or 2.4L Chrysler engine. Table 1 shows the various vehicles and engine combinations that this publication applies to.

	2.0L SOHC	**2.0L DOHC Rear Exhaust**	**2.0L DOHC Front Exhaust**	**2.4L DOHC**
NS				X
JA	X			X
JX				X
PL	X	X		
FJ22			X	
F24S			X	

The body code FJ22 refers to the Sebring/Avenger. F24S refers to the Talon, made by Diamond Star Motors.

Table 1 Model/Engine Combinations

The fuel system for all these engines utilizes a speed density sequential multiport fuel injection system to deliver precise amounts of fuel to the intake manifold. Fuel for all vehicles is delivered by an in-tank pump module. On everything except FJ22/F24S, the fuel level sending unit is integral with the pump. The FJ22/F24S vehicles use a separate fuel level sending unit.

All 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.

All vehicles equipped with either the 2.0L or 2.4L engine are fully OBD II compliant in accordance with the phase-in plan. Any Talon equipped with the MMC 2.0L engine will also have OBD II diagnostics (with MMC's ECM).

ACRONYM LIST

- Air Bag Control Module - ACM
- Air Conditioning - A/C
- Auto Shutdown Relay - ASD relay
- Barometric Pressure - Baro
- Battery Temperature Sensor - BTS
- Body Control Module - BCM
- Camshaft Position Sensor - CMP sensor
- Chrysler Collision Detection Bus - C^2D
- Crankshaft Position Sensor - CKP sensor
- Data Link Connector - DLC
- Diagnostic Trouble Code - DTC
- Digital Multimeter - DMM
- Duty Cycle Purge Solenoid - DCP solenoid
- Electrically Erasable Programmable Read-Only Memory - EEPROM
- Engine Coolant Temperature Sensor - ECT sensor
- Engine Position Pulse - EPP
- Idle Air Control Motor - IAC motor
- Intake Air Temperature Sensor - IAT sensor
- Malfunction Indicator Light - MIL
- Manifold Absolute Pressure Sensor - MAP sensor
- Mopar Diagnostic System - MDS
- Mechanical Instrument Cluster - MIC
- Negative Temperature Co-efficient - NTC
- Oxygen Sensor - O2 sensor
- Park/Neutral - P/N
- Positive Temperature Co-efficient - PTC
- Power Distribution Center - PDC
- Powertrain Control Module - PCM
- Serial Peripheral Interface Output - SPIO
- Single Board Engine Controller, third generation - SBEC III
- Throttle Position Sensor - TPS
- Transitional Low Emission Vehicle - TLEV
- Transmission Control Module - TCM
- Vehicle Speed Sensor - VSS
- Vehicle Theft Security System - VTSS

POWERTRAIN CONTROL MODULE (PCM)

Introduced in 1995, the SBEC III (Single Board Engine Controller, third generation) does not require air to flow through the controller for cooling. The changes to the PCM from previous Chrysler controllers include:

- Increased memory
- Increased speed at which the processor runs:
  - Clock speed - 8 MHz
  - Bit processing - 16 bit
- Increased number of drivers to control outputs from 22 to 30
- Increased number of terminals in the connector from 60 to two 40-way connectors (80 total)
- Gold plated, low insertion force terminals (new tool #6932 required for servicing the terminals)
- Uses an Electrically Erasable Programmable Read-Only Memory (EEPROM) on all PCM's (flashable)

The PCM controls operation of the fuel, emissions, charging, idle, radiator fan, air conditioning, and speed control systems. It receives information from input sensors and switches that monitor specific operating conditions. After processing the information, the PCM operates outputs that regulate the engine performance, the ignition components, the generator field, the air conditioning compressor, the radiator fans, and the speed control servo. This cycle of input/processing/output ensures that the engine meets emissions, performance, fuel economy, driveability, and customer expectations.

SPEED DENSITY

A speed density system measures the engine RPM, as well as the intake manifold absolute pressure. Coolant temperature and throttle position are necessary inputs also. On the 4 cylinder speed density system **BOTH** the crankshaft and camshaft position inputs are needed to start and run the engine. The engine cannot run without them. The RPM signal tells the PCM <u>how often</u> to add fuel while the Manifold Absolute Pressure (MAP) sensor input determines <u>how much</u> fuel the engine receives (fig. 1).

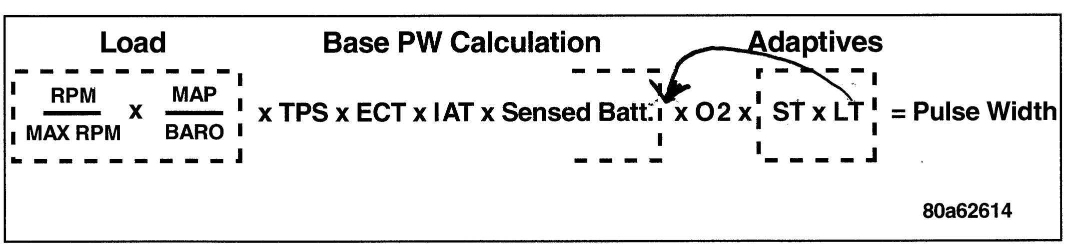


Figure 1 Speed Density Engine Management Strategy

FWD 4-Cyl Fuel Injection

For a speed density system to operate the first and most important piece of information that must be determined is the amount of air that is 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 instance, if RPM was low and vacuum nearly matched baro (WOT) then the PCM would know that 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 and is also used as a modifier. If the TPS increases rapidly then extra injectors will be fired to increase fuel flow. If the TPS is closed and the vehicle is moving then the PCM will limit and/or close off injectors during coast down. Because this formula must have a value in every position, 0 times any value = 0, the PCM will use 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. If the engine is cold the fuel will not atomize easily. To overcome this problem the PCM will add extra fuel depending on the value from the ECT. Conversely, if the engine is very hot, fuel will be limited. ECT is also used for engine cooling control. If ECT becomes too high the PCM will automatically turn on cooling fans. If the ECT signal is lost the PCM will substitute a preset (limp-in) value and turn cooling fans on.

Intake Air Temperature (IAT) is also used to modify the amount of fuel delivered, although it is not as big a modifier as ECT. If ECT is high and IAT shows cold (dense air) then the PCM will add extra fuel. Another feature of IAT is that spark advance is limited if the air is hot (thin). If the IAT signal is lost the PCM will substitute a value based on ECT.

Sensed battery voltage is needed as a modifier because the injectors are rated for specific flow at a specific voltage. If the voltage is lower than what the injector was rated at, it will take longer for the injector to open and it may not open as far. So the PCM needs to know the voltage so that it can compensate by changing the pulse width on time.

Up to this point it is not necessary that any fuel was burned and/or the PCM is in an open loop operating condition.

After the fuel is delivered the PCM looks at the O2 signal to determine how well it did on the initial calculation. The O2S provides the PCM with the raw input as to how much oxygen was left over after the combustion process.

The adaptive memories allow the PCM to do two things. First, it gives it the capability to change the pulse width to bring the O2S to its mid range of operation (short term). Second, it allows to store in memory corrections required for specific operating conditions (long term).

Based upon 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.

FUEL DELIVERY SYSTEM

The fuel system is provided fuel pressure by an in-tank pump module. 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

NOTE: *The PCM calculates engine speed from the inputs of the CMP and CKP sensors.*

EMISSION SYSTEMS

The emissions system has several components all 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 emissions that might be escaping into the atmosphere from the fuel system and engine. The emissions system includes:

- Evaporative control system
- Engine crankcase pressure control system (positive crankcase pressure)
- Exhaust emissions

The PCM controls the evaporative emissions by the operation of a Duty-Cycle Purge (DCP) solenoid. The inputs required to control the DCP solenoid include:

- ECT sensor
- O2 sensor
- TPS
- Engine speed
- MAP sensor
- Ambient/battery temperature sensor

The engine crankcase is ventilated by a Positive Crankcase Ventilation (PCV) valve that is not controlled by the PCM. The Exhaust emissions are controlled by the use of a catalytic converter, EGR valve, and almost every input and output of the PCM. The only inputs and outputs that DO NOT control emissions are:

- Speed-control switches, relay (Avenger/Sebring only), and servo
- Tachometer
- Air Conditioning (A/C) request circuit, A/C relay, and the A/C pressure sensor used on the Cirrus and Stratus only
- ASD and fuel pump relays
- Bulb check circuit (Sebring and Avenger Brake Warning lamp and Low Washer Fluid lamp)

IDLE CONTROL SYSTEMS

The PCM maintains a quality idle by controlling the Idle Air Control (IAC) motor. Inputs to the PCM required to operate the IAC motor include:

- TPS
- MAP sensor
- ECT sensor
- VSS
- Spark scatter (output)
- Power steering pressure switch
- Park/Neutral switch
- A/C switch
- Chrysler Collision Detection (C^2D) system
- Ambient/Battery Temperature sensor

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 required to maintain the proper battery voltage are:

- Battery voltage
- BTS (FJ22/F24S/PL) or ambient temperature sensor (JA/JX/NS)
- 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 on everything except the FJ22 and F24S. On the FJ22/F24S, a speed control relay provides battery voltage to the speed control servo. 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. Refer to the Vehicle Speed Control section of this publication for more information.

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. The PCM controls the ground side of the radiator fan relay's coil. The following inputs to the PCM are used to operate the radiator fan's relays:

- ECT sensor
- VSS
- A/C switch
- BTS or ambient temperature sensor

A/C CONTROL SYSTEMS

Finally, 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 sensor (JA/JX/NS only)
- ECT sensor (Sebring/Avenger only)

NOTE: The following pages of this student reference book describe each section in detail. The function and operation of the inputs and outputs are explained the first time each input or output is introduced. Subsequent sections will elaborate on any input or output not previously described.

NOTES

LESSON 2

FUEL DELIVERY SYSTEM

FUEL TANK

Fuel Tank — Avenger/Sebring/Talon

The fuel tank for these vehicles is located at the rear of the vehicle (fig. 2), between the frame rails, under the rear seat floor. The tank is made of stamped steel. The tank contains two pressure relief/rollover valves, one at the top of the tank and the other in the fuel filler tube. These valves prevent fuel flow through the vent valve hose serving the evaporative canister. The tank uses a fuel pump module that is bolted to the top of the tank. Access to the fuel pump module is through a service port underneath the rear seat cushion. The fuel pump module contains an electrically operated pump.

Fuel Tank — Cirrus/Stratus/Neon

The fuel tank for these vehicles is located at the rear of the vehicle, between the frame rails, under the rear seat floor. The tank is made from High density Polyethylene (HDPE) material. The tank contains two or three pressure relief/rollover valves, one or two at the top of the tank and the other in the fuel filler tube. These valves prevent fuel flow through the vent valve hose serving the evaporative canister. The JA/JX fuel tank incorporates a drain valve to remove the fuel before removing the tank. The Neon fuel tank has a separate fuel drain port with a quick-release cap.

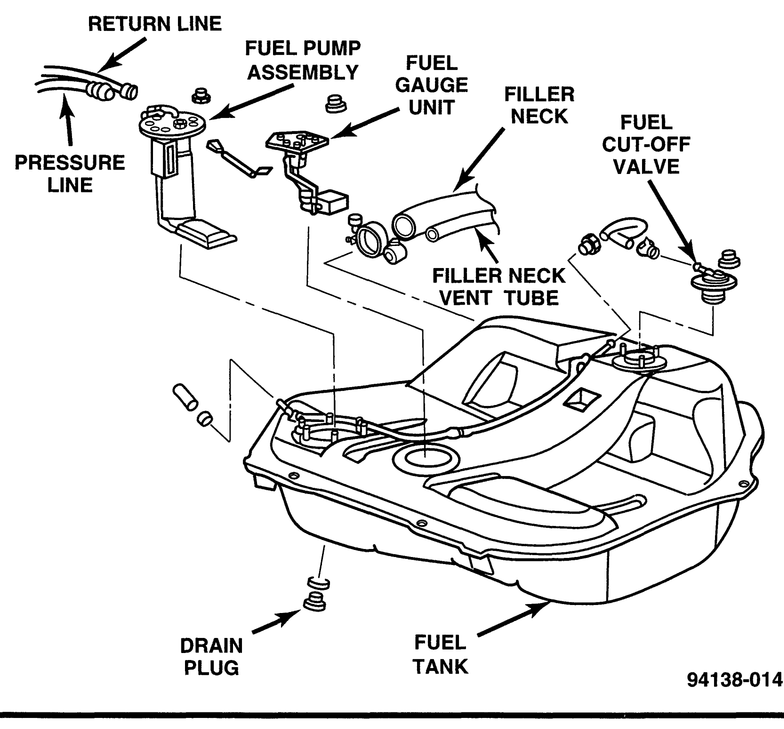


Figure 2 Avenger and Sebring Fuel Tank and Components

Fuel Tank — Minivan

The fuel tank for these vehicles is located on the driver's side of the vehicle, under the middle of the vehicle. The tank is made from High density Polyethylene (HDPE) material. There is a pressure relief/rollover valve located on the fuel tank filler neck. This valve prevents fuel flow through the vent valve hose serving the evaporative canister. The fuel tank incorporates a drain valve to remove fuel before removing the tank. All minivans use the same fuel tank, including AWD.

FUEL PUMP MODULE

The Chrysler fuel pump module is an in-tank unit with an integral fuel level sensor and pressure regulator. The pump is driven by a 12 volt DC motor any time the fuel pump relay is energized. Serviceable components on the module include:

- Inlet strainer
- Fuel level sensor
- Fuel filter/Pressure regulator

The pump draws fuel through a strainer and pushes it through the motor to the outlet. The pump contains two check valves. One valve relieves internal fuel pump pressure and regulates maximum pump output. The second valve, in the pump outlet, maintains pump pressure during engine off conditions.

The fuel systems use a positive displacement, gerotor, (JA/JX, fig. 3; PL, fig. 4) immersible pump with a permanent magnet electric motor.

This fuel system does not contain the traditional fuel return lines. The regulator contains a calibrated spring which forces a diaphragm against the fuel filter return port. When pressure exceeds the calibrated amount, the diaphragm retracts, allowing excess pressure and fuel to vent into the tank.

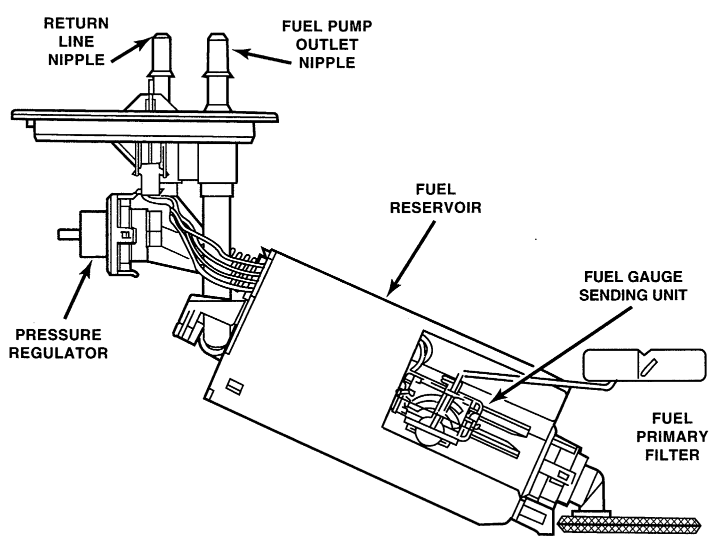


Figure 3 Cirrus and Stratus Fuel Pump Module

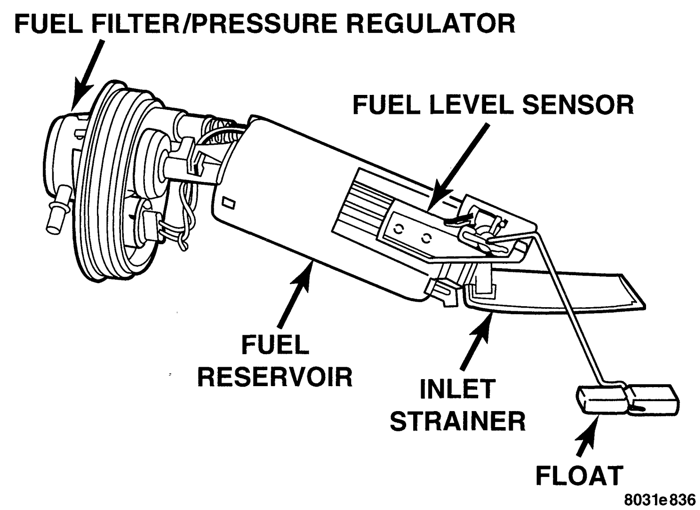


Figure 4 Neon Fuel Pump Module

If the fuel delivery system becomes blocked between the fuel pump and the regulator, the maximum deadhead pressure is approximately 880 kPa (130 psi). The regulator adjusts fuel system pressure to approximately 338 kPa (48 psi).

A fuel gauge level sending unit is attached to the fuel pump module. The fuel level input is used as an input for OBD II. If the fuel level is below 15%, or above 85% on LDP-equipped vehicles, of total tank capacity several monitors are disabled. There are diagnostics for the fuel level circuit open and shorted (Table 2).

Diagnostic	**DTC**	**MIL**
OBD II Major Monitors	Disabled	Disabled
Front O2S Voltage Checks	Active	Active
Rear O2S Voltage Checks faults	Active	Active
Front/Rear O2 Heater	Active	Active
VSS Rationality	Disabled	Disabled
P/N Switch Rationality	Disabled	Disabled
Power Steering Switch Rationality	Disabled	Disabled

Table 2 Fuel Level Diagnostics

WARNING: Use care when removing the fuel pump module from the fuel tank as gasoline remaining in the module reservoir will spill.

NOTE: On Cirrus and Stratus, the fuel pump module connector is accessed behind the left rear lower seat back cushion. Disconnect the fuel pump module connector prior to fuel tank removal. This will prevent additional required procedures during the removal process.

FUEL PRESSURE REGULATOR

Fuel Pressure Regulator — Chrysler

All vehicles use a returnless fuel system. On a return system, all fuel is routed through the hot environment of the engine compartment. Without a return line, the fuel remains in the tank and is cooler. This reduces evaporative emissions, resulting in less evaporative canister purging.

Returnless fuel systems do not have a return line routed from the fuel rail to the fuel tank. The pressure regulator is part of the fuel pump module (figs. 5 and 6).

The pressure regulator is a mechanical device that is not controlled by the PCM. The regulator contains a calibrated spring and a diaphragm that actuates the regulator valve. Fuel pressure operates on one side of the diaphragm, while spring pressure operates on the other side. The diaphragm of the regulator opens the valve to the return port, allowing fuel to be dumped back into the fuel tank. System fuel pressure reflects the amount of fuel pressure required to open the port. The spring on the opposite side of the diaphragm attempts to close the valve, causing an increase of pressure on the fuel as it travels to the fuel rail. The spring is not adjustable and is calibrated to maintain approximately 338 kPa (48 psi) of fuel pressure.

In the past the regulator was mounted on the fuel rail so that as the manifold vacuum at the tip of the injector changed, fuel pressure was modified to maintain a constant injector flow volume. With the regulator mounted at the tank, a constant fuel pressure is always supplied to the injectors. The PCM uses a special formula that calculates the pressure differential across the injector and then adjusts injector pulse width.

Fuel Flow

Depending upon the vehicle, the fuel flow is as follows:

- Remote mounted filter (3 hoses):
  Fuel flows from the pump to the filter. From the filter it flows to the regulator, mounted inside the tank, and to the fuel rail through two separate hoses. The regulator in the tank maintains the 48 psi in the filter and lines.
- Integral filter:
  Fuel flows from the pump, through the regulator, through the filter to the fuel rail.

Fuel Pressure Regulator — Mitsubishi

System pressure is maintained by the fuel pressure regulator which is mounted to the fuel filter near the tank. The regulator contains a calibrated spring and a diaphragm that actuates the regulator valve. Fuel pressure operates on one side of the valve while spring pressure and atmospheric pressure operate on the other side. When the pump delivers fuel to the fuel rail, the diaphragm of the regulator opens the valve to the return line, allowing fuel to return to the fuel tank. The spring on the opposite side of the diaphragm attempts to close the valve, causing an increase of pressure on the fuel rail. The spring is calibrated to maintain 48 psi of fuel pressure at the rail.

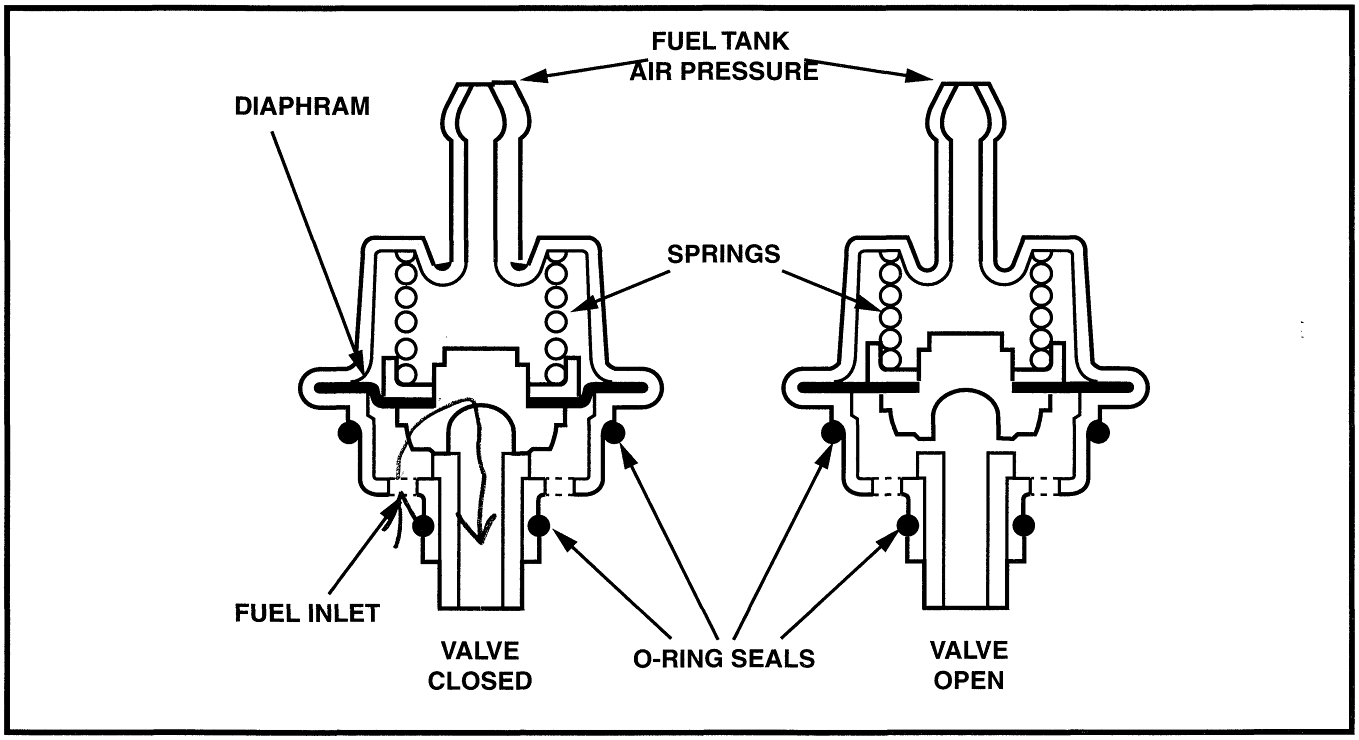


Figure 5 Fuel Pressure Regulator Operation

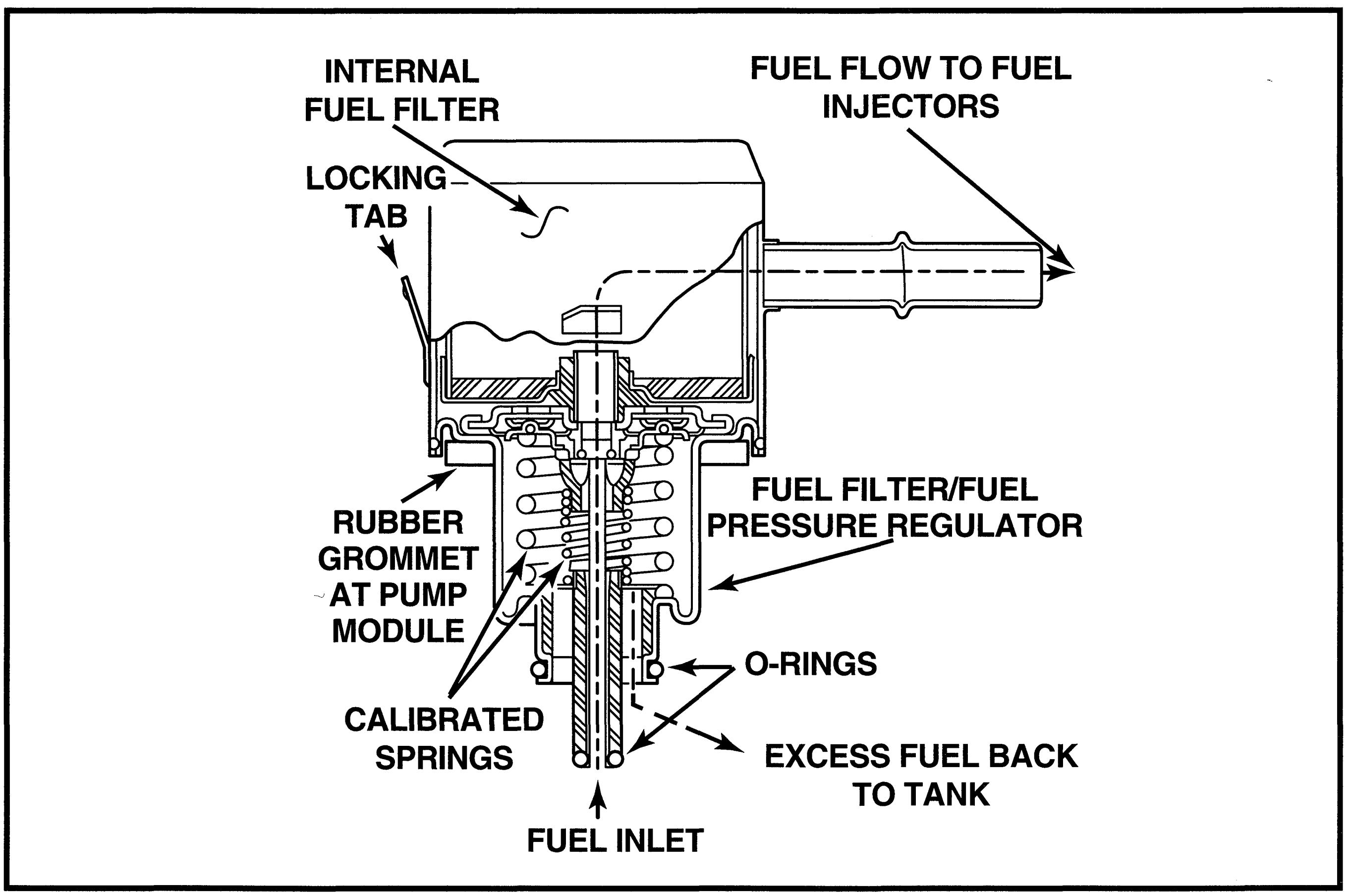


Figure 6 Side View–Filter/Regulator

FUEL PUMP RELAY

The fuel pump relay is located inside the Power Distribution Center (PDC) on JA/JX/NS and PL. On FJ22 and F24S, it is located on left side bulkhead. The fuel pump relay is energized under the following conditions to provide power to operate the fuel pump:

- For approximately 0.7 -1.5 seconds during the initial key-on cycle depending on temperature
- While the CKP sensor is providing an RPM signal that exceeds a predetermined value

Ignition voltage is provided to the fuel pump relay's coil anytime the key is in the RUN/START position (fig. 7). The PCM provides the ground control to energize the relay. Unlike previous Chrysler systems (non-OBDII), the fuel pump relay does not provide power to operate the O2 sensor heater.

The relay is energized when the key is cycled to RUN in order to prime the fuel rail with liquid fuel, allowing for a quick start-up. Any time the CKP sensor indicates that there is an RPM signal that exceeds a predetermined value, the relay is energized to ensure proper fuel pressure and volume during engine cranking and running conditions. Any time the CKP sensor signal is lost (engine has been shut off or the sensor indicates no RPM), the fuel pump relay is de-energized.

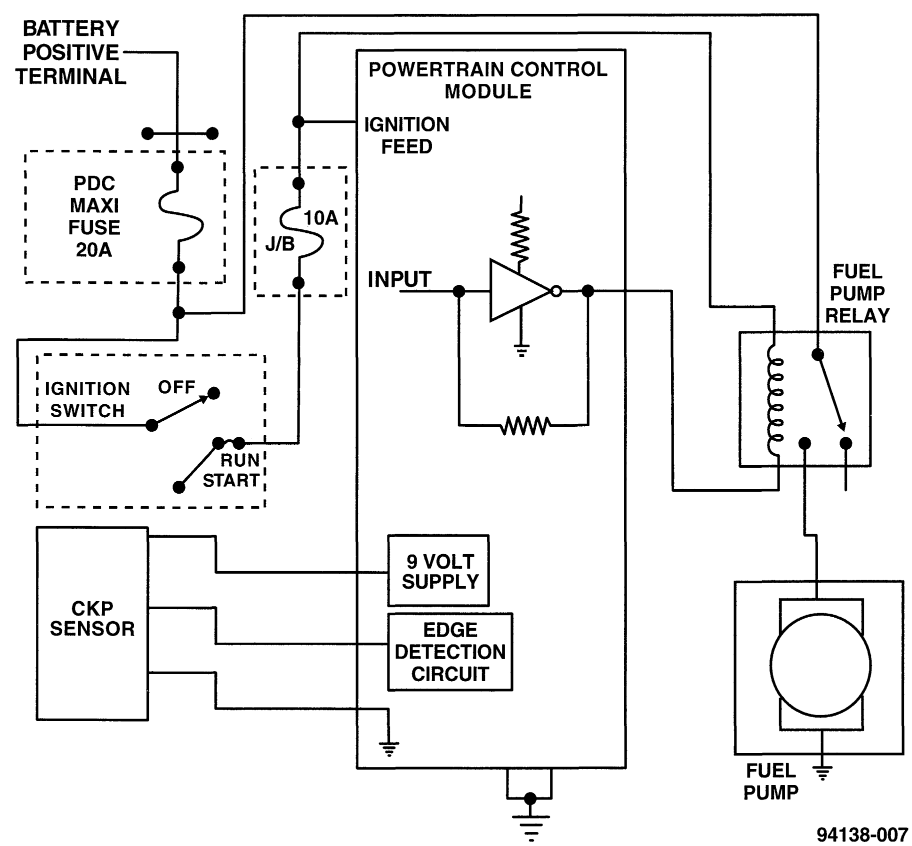


Figure 7 Fuel Pump Relay Circuit

FUEL INJECTORS

WARNING: Release fuel system pressure before servicing fuel system components. The procedure is described in the Service Manual. Service vehicles and fuel systems components in well-ventilated areas and avoid sparks, flames and other ignition sources. Never smoke while servicing the vehicle's fuel system.

The four cylinder engines use top-feed fuel injectors. The injectors mount to the fuel rail with push-on retaining clips, and use O-rings to prevent leakage between the injectors and the fuel rail.

The fuel injectors are 12 ohm electrical solenoids. The injector contains a needle valve that closes off an orifice at the nozzle end. When electrical current is supplied to the injector, the armature and needle move a short distance against a spring, allowing fuel to flow out the orifice. Because the fuel is under high pressure, a fine spray is developed in the shape of a hollow cone. The spraying action atomizes the fuel, adding it to the air entering the combustion chamber.

The fuel injectors are positioned in the intake manifold with the nozzle ends directly above the intake valve port for the corresponding cylinder.

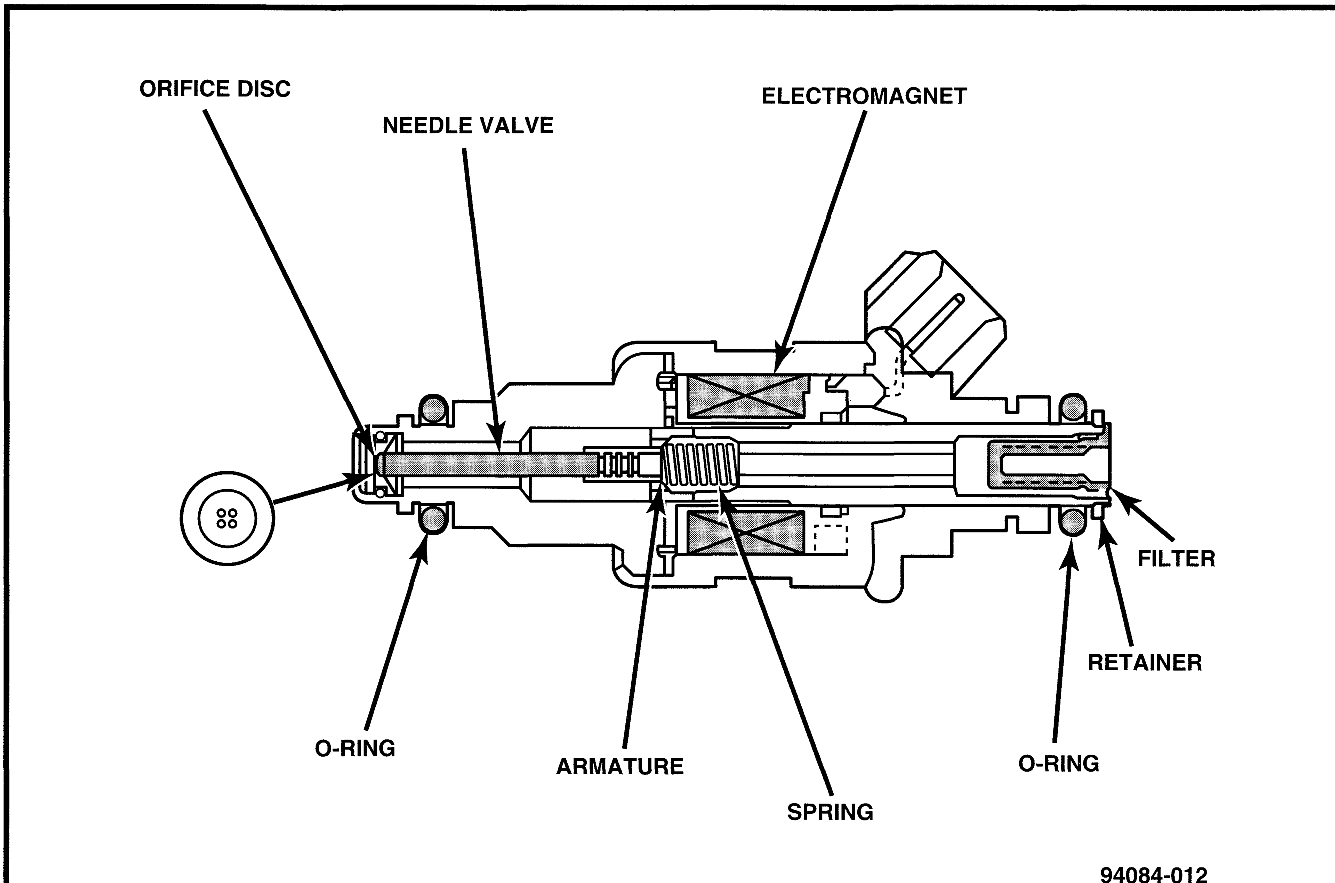


Figure 8 Fuel Injector (Multi-valve version shown)

FWD 4-Cyl Fuel Injection

Fuel is dispersed through four openings at the bottom of each injector (fig. 8). This design allows for an atomized spray, similar to a pintle injector, but with the low cost and easy serviceability of a pencil-stream injector.

FUEL FILTER

There are two different types of fuel filters. One is integral with the fuel pressure regulator and attaches to the fuel pump module. The other is mounted just outside the tank. The remote filter has three lines attached to it. Both filters are life of the vehicle items. Replacement is necessary only if something has caused the filter to become plugged, such as contaminents in the fuel. Regular maintenance is no longer required due to the fact that only the fuel actually being used by the engine is filtered.

NOTE: Always lube the O-rings inside the quick connect fittings with engine oil before reassembly of the fuel line connections at the fuel pump module, fuel filter fuel lines, and the fuel rail.

FUEL LINES AND RAIL

Fuel Lines

FJ22/F243 — The high-pressure line from the tank to the filter is made of steel, except for a high-pressure flexible hose from the pump to the steel line. A high-pressure flexible rubber hose is used from the filter to the fuel rail. The filter side of this hose is fitted with a banjo fitting. The fuel rail side of this hose is fitted with a hose union. The union is attached to the fuel rail by two attaching bolts, and is sealed by a single O-ring.

CAUTION: When installing the high-pressure fuel line to the fuel rail, apply engine oil to the O-ring, then re-torque the union bolts to 4 ft. lbs.

JA/JX/NS/PL — The high-pressure line from the tank to the filter is made of plastic. From the filter, a plastic line connects to a steel line. This line is routed from the tank to the rear of the engine compartment. From the steel line, a plastic line is connected to the fuel rail.

NOTE: If the o-rings at the quick-connect fittings become damaged, the line must be replaced.

Fuel Rail

The fuel rail is mounted on the intake manifold (fig. 9). It is attached to the fuel line with a quick connect fitting. If the O-rings at the quick connect fittings become damaged, the line must be replaced.

A fuel pressure test port is provided at the center of the fuel rail to enable fuel pressure testing. Always follow the procedures in the Service Manual when removing fuel system components.

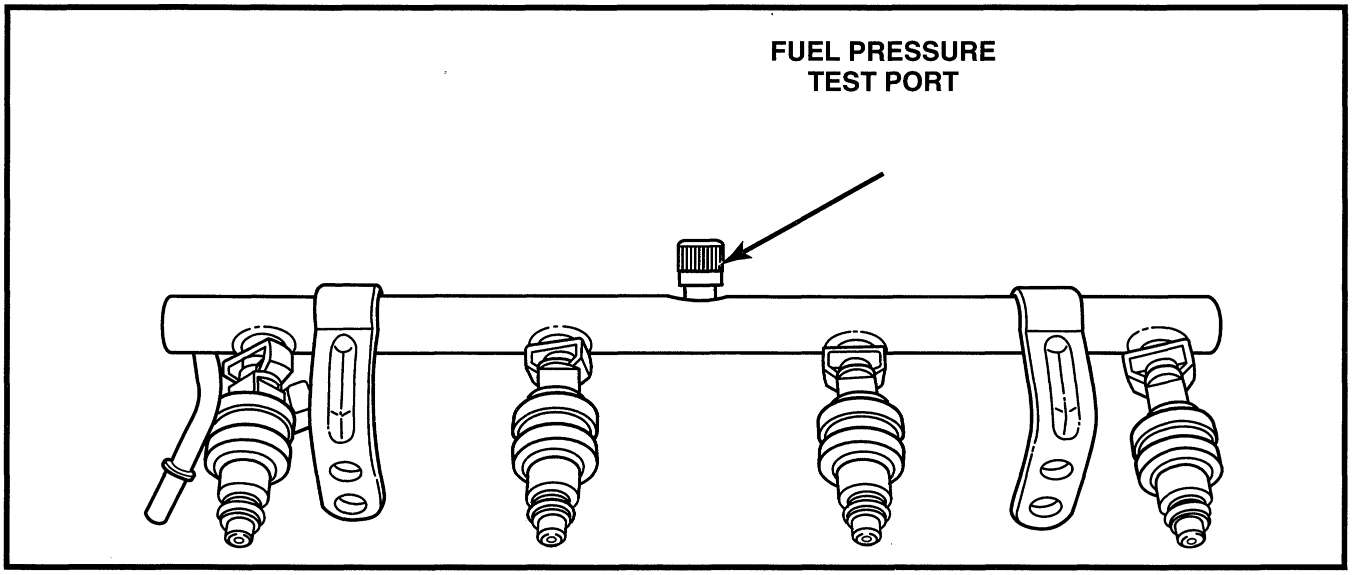


Figure 9 Fuel Rail

WARNING: The clips used to hold the injectors to the fuel rail are for assembly only. The clips are not designed to hold the injectors on with 48 psi of fuel pressure.

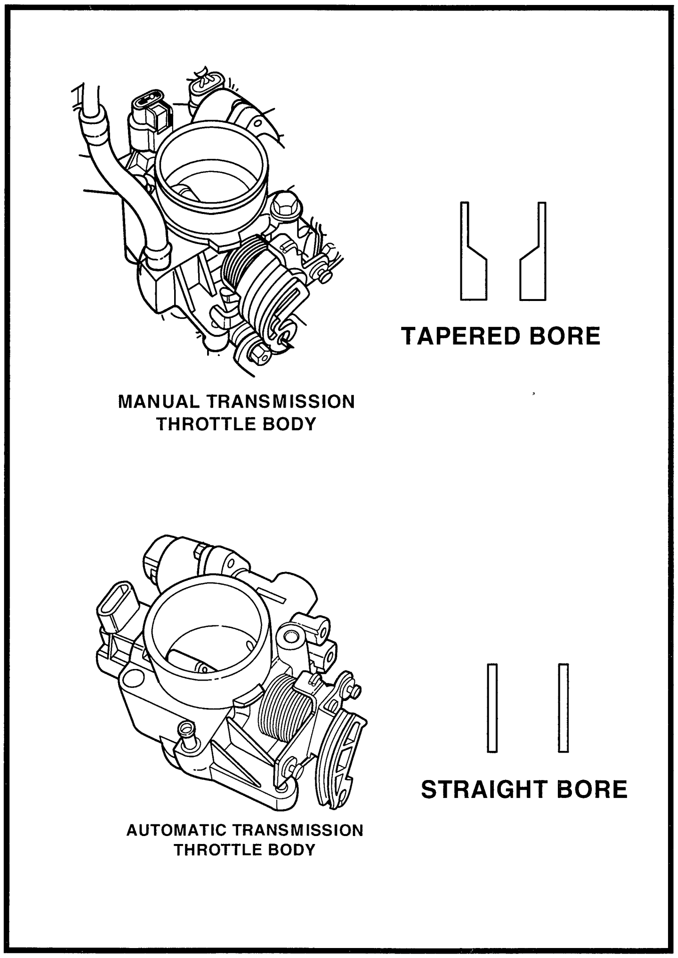


Figure 10 Throttle Bodies

THROTTLE BODY

The throttle body mounts to the intake manifold. These models use two different throttle bodies, depending on transmission application (fig. 10). A straight bore is used on models with an automatic transmission and manual transmission models use a contoured throttle body. The contoured throttle body changes air velocity slightly with moderate pedal movement: the first 1/3 of opening takes a lot of throttle movement, then opening occurs much faster. This helps reduce buck and bobble at light throttle positions.

NOTE: *The TLEV ATX also uses a contoured bore throttle body.*

The manual transmission throttle body uses an off-center (progressive) cam to provide graduated operation of the throttle blade with moderate pedal movement at tip-in. A straight throttle cam is used with automatic transmissions.

Regardless of the design, the Throttle Position Sensor (TPS) and Idle Air Control (IAC) motor are attached to the throttle body (fig. 11).

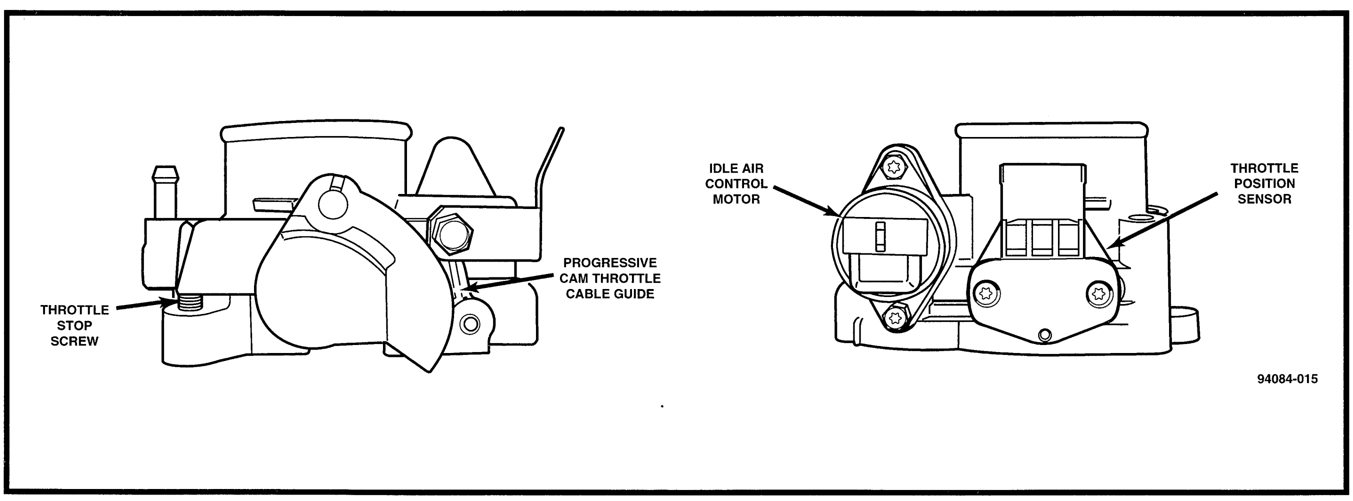


Figure 11 TPS and IAC

FUEL CUTOFF VALVE

The fuel tank is equipped with a fuel cutoff valve (fig. 12) to prevent fuel from entering the evaporative canister when the vehicle fuel tank is overfilled or when the vehicle moves around sharp corners and the fuel sloshes up to the valve. The valve also prevents fuel from leaving the fuel tank through the evaporative canister hose if the vehicle overturns.

During normal operation, the weight of the valve overpowers the force of the spring, opening the passage for fuel vapor. When the fuel level is high or when driving around sharp corners, the liquid fuel causes the float to rise, closing the port and preventing liquid fuel from entering the evaporative canister line.

If the vehicle overturns, gravitational pull on the float is great enough to overcome spring pressure and close the port, preventing any fuel spillage through the evaporative canister line. In addition, if the float sticks, causing the valve to remain closed, there is a relief valve that provides a means through which fuel vapor can be routed to the evaporative canister.

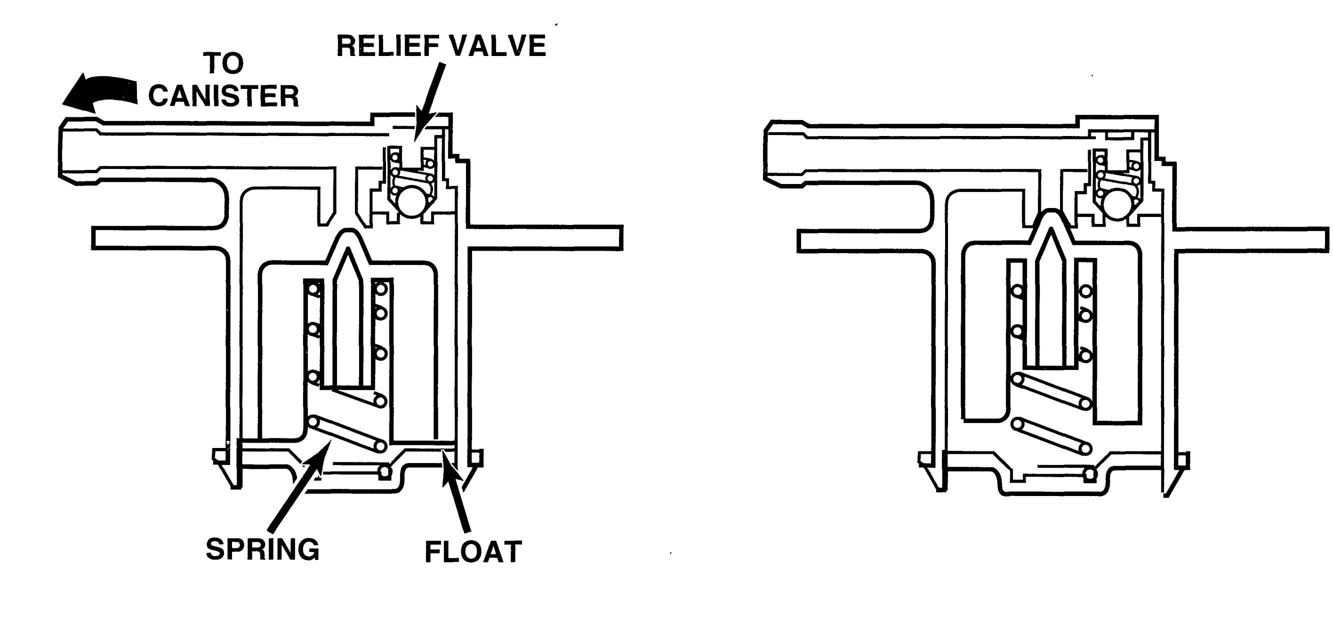


Figure 12 Fuel Cutoff Valve

FWD 4-Cyl Fuel Injection

ACTIVITY 1 — CIRRUS/STRATUS FUEL SYSTEM TEST

Instructions
Have the instructor assign you to a vehicle equipped with either a 2.0L or 2.4L engine. Use the Service Manual and DRB III to assist in answering the following questions:

1. In which section of the Service Manual will you find the fuel system test procedures? ______________________________

2. According to the Service Manual, what is the fuel pressure specification for the 2.0L/2.4L? ______________________________

3. The following questions pertain to releasing the fuel system pressure on 4 cylinder engines.

   What could happen if the gas cap is not removed from the fuel tank before starting this procedure? ______________________________

   The procedure in the Service Manual identifies the first step in releasing fuel system pressure as "removing the fuel pump relay." Where is relay located? ___

   ____

4. List the appropriate tools required to de-pressurize and test the fuel system.

   ____

   ____

5. According to the procedure listed in the Service Manual, de-pressurize the fuel system on the vehicle that you were assigned and connect the appropriate tools. Using the DRB; access the Actuator Test for Fuel System Test. Perform the fuel pressure test. What is the fuel system pressure of the vehicle? ______________

   What is the DRB doing to accomplish this test? ______________________

After completing this task, return the vehicle to its original state.

LESSON 3

POWERTRAIN CONTROL MODULE

POWER SUPPLIES AND GROUNDS

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 upon 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 DRB III scan tool.

The PCM monitors the direct battery feed input to determine charging rate, control the injector initial opening point, and back-up the RAM used to store DTC's (fig. 13). 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 will be discussed later.

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. Voltage is supplied to this circuit to power the 9-volt regulator and to allow the PCM to perform fuel, ignition, and emissions control functions. This ignition input acts as "wake up" signal to the PCM. The battery voltage on this line is supplied to the 9 volt regulator which then passes on a power up supply to the 5 volt regulator. Voltage on the ignition input can be as low as 6 volts and the PCM will still function.

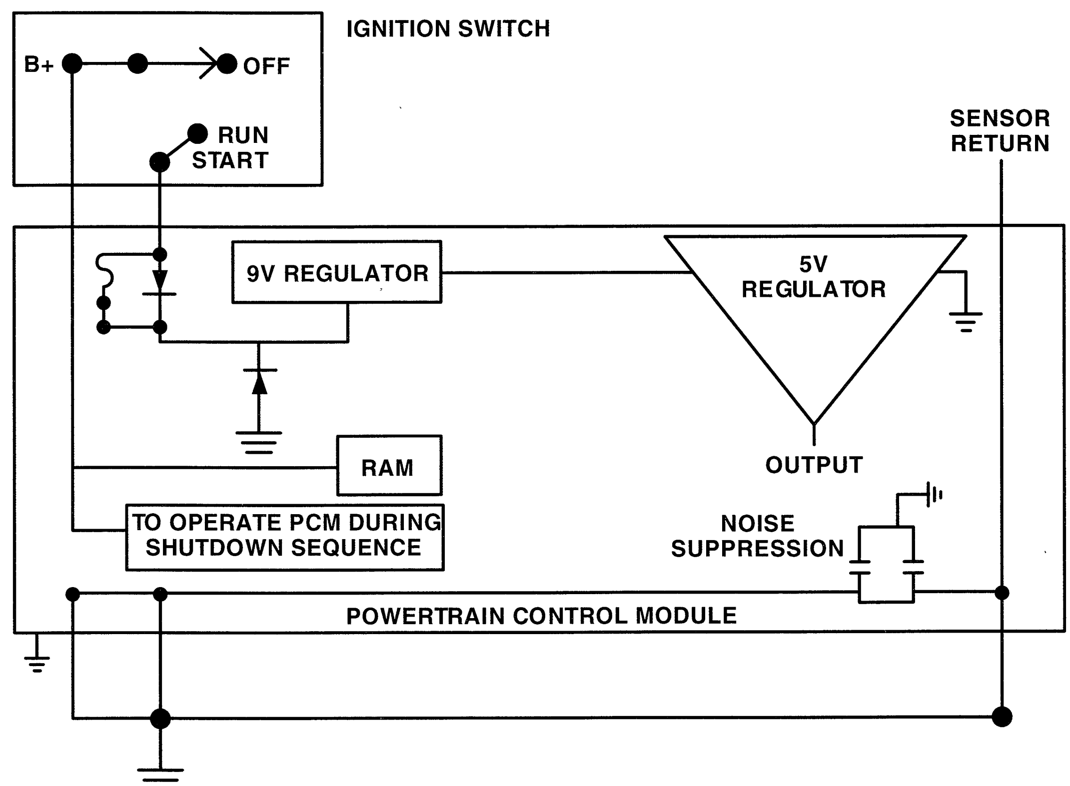


Figure 13 PCM Battery Feed

	Direct Batt.	Ign.	2.4L Grounds	2.0L SOHC Grounds	2.0L DOHC Grounds
NS	46	20	50/10		
JA	46	20	50/10	50/10	
JX	46	20			
PL	46	20		50/10/47	50/10/47
FJ	46	20		50/10/47	50/10/47
F24S	46	20		50/10/47	50/10/47

Table 3 PCM Power and Grounds (Pin)

The SBEC III case is shielded to prevent EMI and RFI. The PCM case is grounded and must be firmly attached to a good, clean body ground.

Ground is provided through multiple pins (Table 3). Depending on the vehicle there may be as many as three different ground pins. There may be either a power ground or sensor ground.

The power grounds are used to control the ground side of any relay, solenoid, ignition coil, or injector. The signal ground is used for any input that uses sensor return as a ground, and as the ground side of any internal processing component.

Internally all the ground pins are connected together, however there is noise suppression on the sensor ground. For Electro Magnetic Interference (EMI) and Radio Frequency Interference (RFI) protection the case is also grounded separately from the ground pins.

A nine-volt power supply is provided to supply the VSS, CKP and CMP sensors with a regulated voltage. The same power supply also provides the five-volt regulator with power. The nine-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 five-volt regulator.

A five-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, for the first time, a circuit in the regulator allows the five-volt signal to be sent to other inputs if the five-volt power supply were shorted to ground at the MAP sensor, TPS, or the A/C pressure sensor (JA/NS only).

Previously, shorting the five-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 five-volt power supply, the engine still shuts down, but at least diagnostics can be performed. Also, for the first time, there is a new Diagnostic Trouble Code (DTC) if the five-volt power supply becomes shorted to ground. Refer to the Diagnostic Test Procedures book or the diagnostic trouble code section in this book for more details on any on-board diagnostic information.

CCD Bused Messages

All Chrysler 4 cylinder equipped vehicles use a data bus called the "Chrysler Collision Detection" (C2D, CCD) system (figs. 14a-14c). However, different vehicles bus different messages. All 4 cylinder vehicles equipped with an 41TE (F4AC1) automatic transaxle use information collected by the PCM. This information is then delivered to the Transmission Control Module (TCM) over the bus. The TCM uses several pieces of information that the PCM already has available. Instead of having both controllers receive the same inputs, the PCM receives the input, and then sends the information to the TCM. The following is a list of bused messages that are sent to the TCM:

- Engine RPM
- Manifold pressure
- Barometric pressure
- Throttle position
- Vehicle speed
- Engine temperature
- Battery temperature
- Target idle
- Engine model
- Cumulative mileage (used to identify when the DRB III is used for diagnostics)
- Engine coolant temperature and battery temperature limp-in status
- Vehicle identification number
- Speed control status
- Park/Neutral position
- Check engine light operation
- Charge indicator light

This information is used by the TCM to ensure quality shift points during all operation modes. For more information pertaining to the 41TE (F4AC1) automatic transaxle, refer to the course offered by Technical Training.

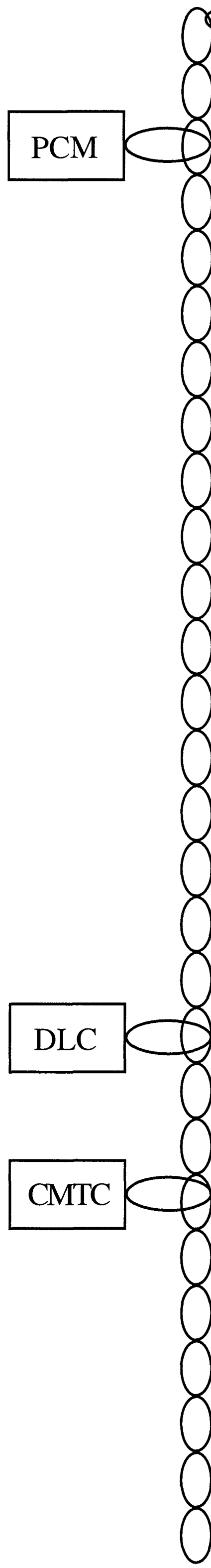
The Powertrain Control Modules (PCM) on Cirrus/Stratus (JA/JX) and Minivans (NS) also use information, such as fuel level collected by the Body Control Module (BCM). This input is used by the PCM Task manager for On Board Diagnostics II or OBD II. If a vehicle is equipped with Theft Alarm, an OK to start message is bused from the BCM to the PCM.

The PCM also delivers fault code information to the BCM which is then delivered to the instrument cluster. This information is used for MIL illumination and DTC retrieval.

On the Avenger/Sebring and Talon, the only control modules on the bus are the PCM and TCM.

Data Link Connector

The PCM maintains communication with scan tools through the vehicle's Data Link Connector (DLC). A special "Y" connector must be used in conjunction with the DRB III on the FJ22/F24S. The DLC connectors are located under the instrument panel, to the right of the steering column bracket.



PCM - MESSAGES TRANSMITTED

BMC -

- VEHICLE IDENTIFICATION NUMBER
- ENGINE TEMPERATURE
- THROTTLE POSITION
- CHARGING SYSTEM FAILURE
- PCM TRANSMISSION
- ENGINE RPM & MAP
- INJECTOR ON TIME & DISTANCE PULSES
- VEHICLE SPEED
- UPSHIFT INDICATOR
- BRAKE PEDAL
- SERVICE ENGINE SOON MIL (CHECK ENGINE)
- ENGINE SIZE
- ENGINE TYPE
- BODY STYLE

TCM -

- VEHICLE IDENTIFICATION NUMBER

CMTC -

- VEHICLE IDENTIFICATION NUMBER

DLC - MESSAGES TRANSMITTED

- DIAGNOSTIC REQUEST INFO TO DRB III

CMTC - MESSAGES TRANSMITTED

BCM -

- DATA REQUEST
- FUNCTION RESET
- CURRENT OUTSIDE TEMPERATURE

PCM - MESSAGES RECEIVED

BMC -

- POWER UP ON ENTRY
- ACCESSORY POWER CONTROL
- VTSS ARMED/DISARMED
- IGNITION STATUS
- ACCESSORY POWER
- A/C REQUEST
- VTSS STATUS

DLC - MESSAGES RECEIVED

- DIAGNOSTIC INFORMATION REQUEST TO CCD AND NON-CCD SYSTEMS

CMTC - MESSAGES RECEIVED

BCM -

- VF DIMMING
- IGNITION OFF DURATION
- LAST OUTSIDE AIR TEMPERATURE
- CURRENT FUEL ECONOMY
- FUEL ECONOMY
- DISTANCE TO EMPTY
- TRIP IGNITION TIME
- TRIP ODOMETER

PCM -

- VEHICLE IDENTIFICATION NUMBER (VIN)

Figure 14a Shared Sensor Information

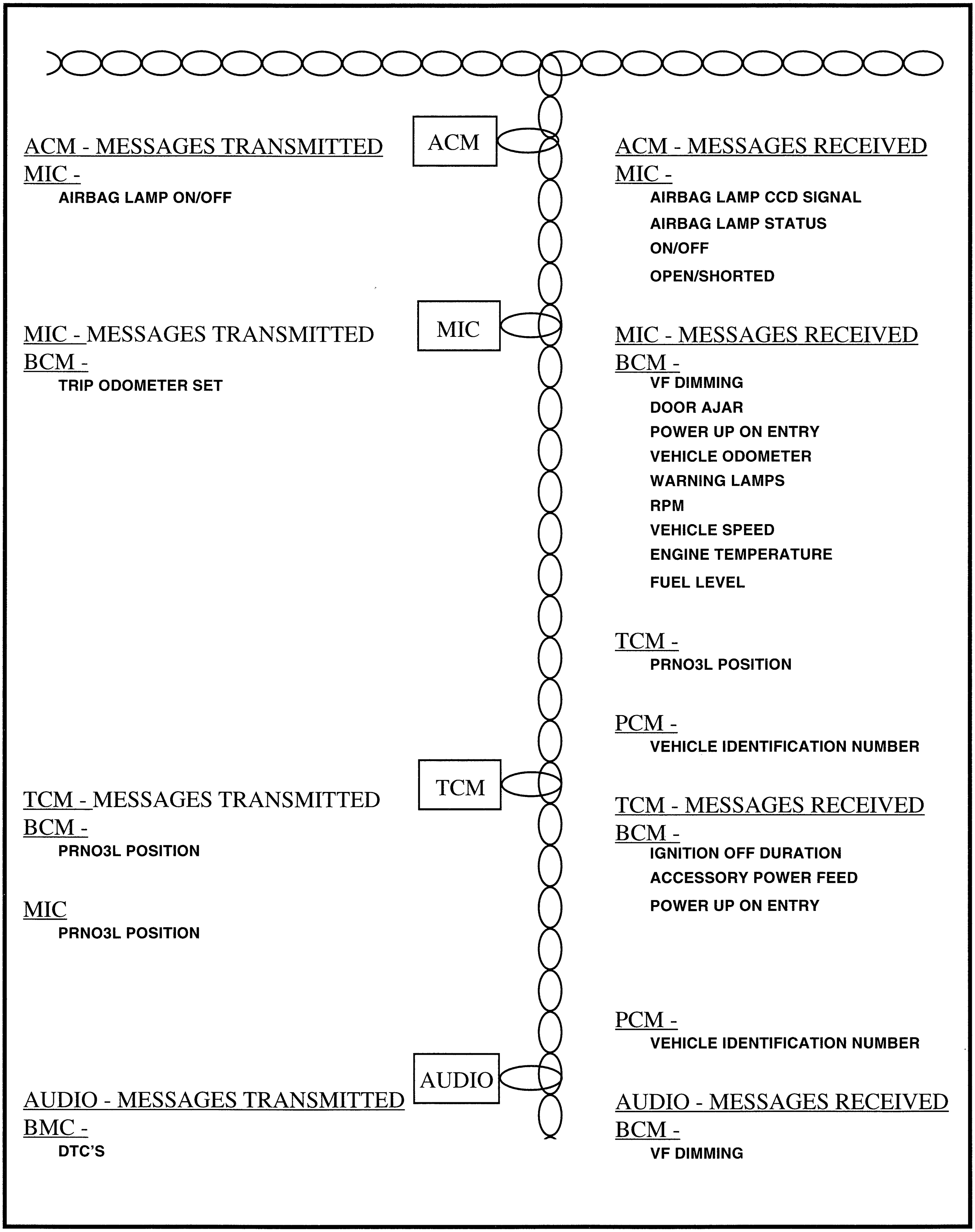
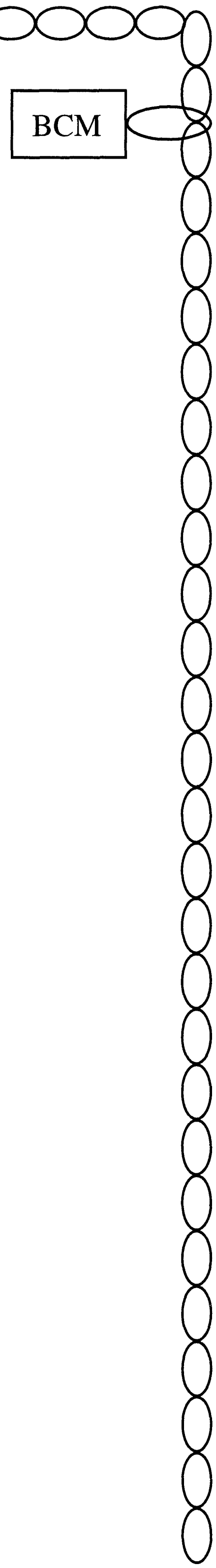


Figure 14b Shared Sensor Information (cont.)



PMC -MESSAGES TRANSMITTED

MIC -

POWER UPON ENTRY
ACCESSORY POWER FEED
VTSS SYSTEM ARMED/DISARMED
PCM RECEIVED VTSS (20 CYCLES)
IGNITION STATUS

TCM -

IGNITION OFF
POWER UP ON ENTRY

MIC -

VF DIMMING
DOOR AJAR
POWER UP ON ENTRY
ACCESSORY POWER FEED
SPEED MESSAGE
VEHICLE ODOMETER
WARNING LAMPS
RPM
VEHICLE SPEED
ENGINE TEMPERATURE
FUEL LEVEL

CMTC -

IGNITION OFF
VF DIMMING
OUTSIDE AIR TEMPERATURE
DOOR AJAR
SOME LAMP SWITCH STATUS
DISTANCE TO EMPTY
CURRENT FUEL ECONOMY
TRIP IGNITION TIME
TRIP ODOMETER 1 & 2

RADIO

VF DIMMING

BCM - MESSAGES RECEIVED

PMC -

VEHICLE IDENTIFICATION NUMBER
ENGINE TEMPERATURE
THROTTLE POSITION
CHARGING SYSTEM VOLTAGE TOO HIGH
VTSS OF/NOT OK TO START
EMISSION APPLICATION
ENGINE RPM & MAP
INJECTOR ON TIME & DISTANCE PULSES
VEHICLE SPEED
ENGINE TEMPERATURE
OK TO LOCK DOORS
SPEED CONTROL
UPSHIFT INDICATOR
BRAKE PEDAL
AC/CLUTCH DISABLE
CHECK ENGINE LIGHT
ENGINE SIZE
ENGINE TYPE
BODY STYLE

TMC -

PRNO3L POSITION

CMTC -

DATA REQUEST
FUNCTION REQUEST
CURRENT OUTSIDE TEMPERATURE

RADIO

DTC'S

Figure 14c Shared Sensor Information (cont.)

ACTIVITY 2 - PCM POWER AND GROUNDS

Instructions

Have the instructor assign you to a vehicle equipped with either a 2.0L or 2.4L engine. Use the Service Manual and the Powertrain Diagnostic Procedures manual to assist in answering the following questions.

1. Can the connectors be interchanged? ______________________

2. Are the connectors numbered? ______________________

3. Using the Driveability book, what are the pins for power? ______________________

4. Using a voltmeter, and with key off, what is sensed battery ignition? __________

5. Turn the key on. What is sensed battery voltage? ______________________

6. Reverse the leads on the voltmeter. Identify the ground pins and probe them for voltage. What are the voltage readings? ______________________

LESSON 4

FUEL INJECTION SYSTEM-PCM INPUTS

CRANKSHAFT POSITION SENSOR

The four cylinder engines use a Hall-effect Crankshaft Position (CKP) sensor as a PCM input. Previous four-cylinder engines used the distributor mounted pick-up for this task. The second crankshaft counterweight is machined with two sets of four timing notches. These notches are the trigger points for the CKP sensor.

The PCM uses the Crankshaft Position sensor to calculate the following:

- Engine RPM
- TDC number 1 and 4
- Ignition coil synchronization
- Injector synchronization
- Camshaft-to-crankshaft misalignment where applicable (Timing belt skipped 1 tooth or more diagnostic trouble code)

The PCM sends approximately 9 volts to the Hall-effect sensor (fig. 15). 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 return circuit.

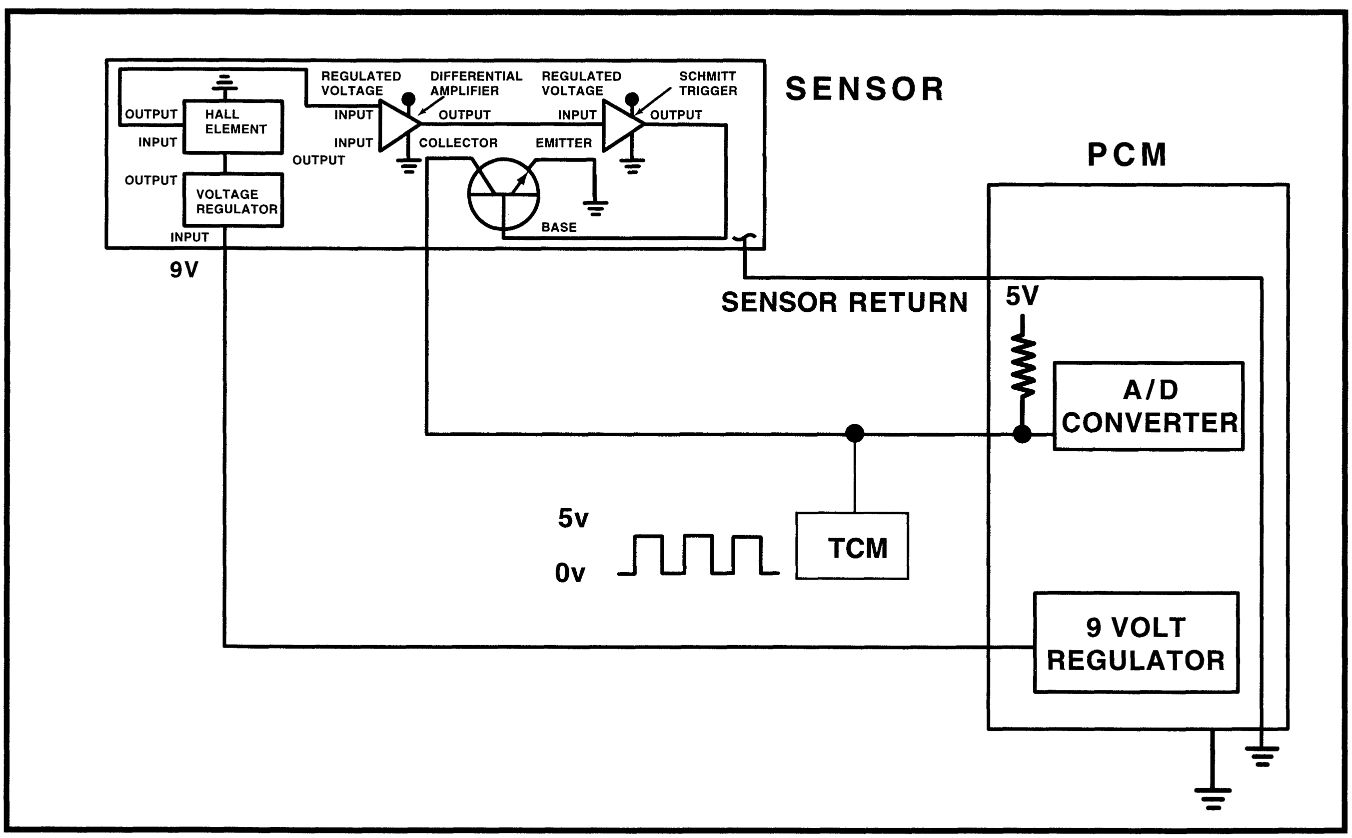


Figure 15 Crankshaft Position Sensor Circuit

The input to the PCM occurs on a 5 volt output reference circuit that operates as follows: The Hall-effect sensor contains a powerful magnet. As the magnetic field passes over the dense portion of the counterweight, the 5-volt signal is pulled to ground (.3 volts) through a transistor in the sensor. When the magnetic field passes over the notches in the crankshaft counterweight, the magnetic field turns off the transistor in the sensor, causing the PCM to register the 5-volt signal. The PCM identifies crankshaft position by registering the change from 5 to 0 volts, as signaled from the Crankshaft Position sensor.

The two sets of machined crankshaft counterweight notches are spaced 180^0 apart. The four timing notches in each set are placed 20^0 apart. One of the sets of machined counterweight notches contains a wider (60^0) notch used to indicate crankshaft position. As these notches pass the pole of the sensor, output voltage alternates between a high of 5 volts and low of 0.3 volt (fig. 16). Low output occurs when the high side of the counterweight (metal) passes the sensor. High output occurs when the machined notches (airgap) pass under the sensor.

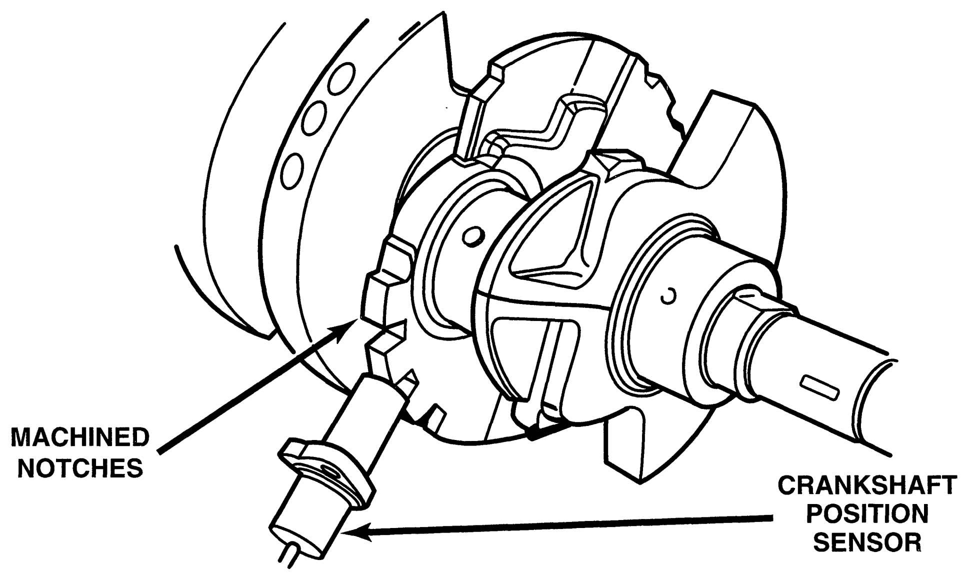


Figure 16 Crankshaft Counterweight

RPM is calculated every time the 49° to 9° slots pass the sensor. This timing is also used to determine if the crankshaft is accelerating or decelerating. This information is used to determine if misfire is occurring.
Sensor output voltage pulse width is dependent on crank rotational speed. The faster the crank turns, the shorter the time between the individual high/low pulses produced by the sensor. It is these changes of direction, or edges, that the PCM uses to make its calculations.

In order to start the vehicle, the PCM compares the crankshaft position to the camshaft position to determine which cylinder should be firing.* If the camshaft sensor switches from low to high before the crankshaft 69° edge is seen, then the PCM will fire the coil for cylinders 1 and 4 at the 9° edge (fig. 17). Or, if the cam sensor changes from high to low before the 69° edge is seen, then the PCM will fire the coil for cylinders 2 and 3.

The PCM also compares the signals sent by the CMP sensor to the signals sent by the CKP sensor to calculate whether or not the camshaft is in time with the crankshaft (Timing belt skipped 1 tooth or more DTC).

On vehicles equipped with a 41TE transmission, it is necessary for the TCM to calculate engine RPM. To do this the TCM also sends out a 5 volt reference signal. When diagnosing a suspect CKP sensor, ensure that the circuit between TCM and PCM is complete.

Crankshaft Position Sensor Service

The sensor's powerful magnet is susceptible to damage. Do not drop the sensor on a metal table or store sensors face-to-face. The clearance between the sensor and the counterweight is non-adjustable. Though the clearance is critical, manufacturing tolerances allow for some differences in clearance.

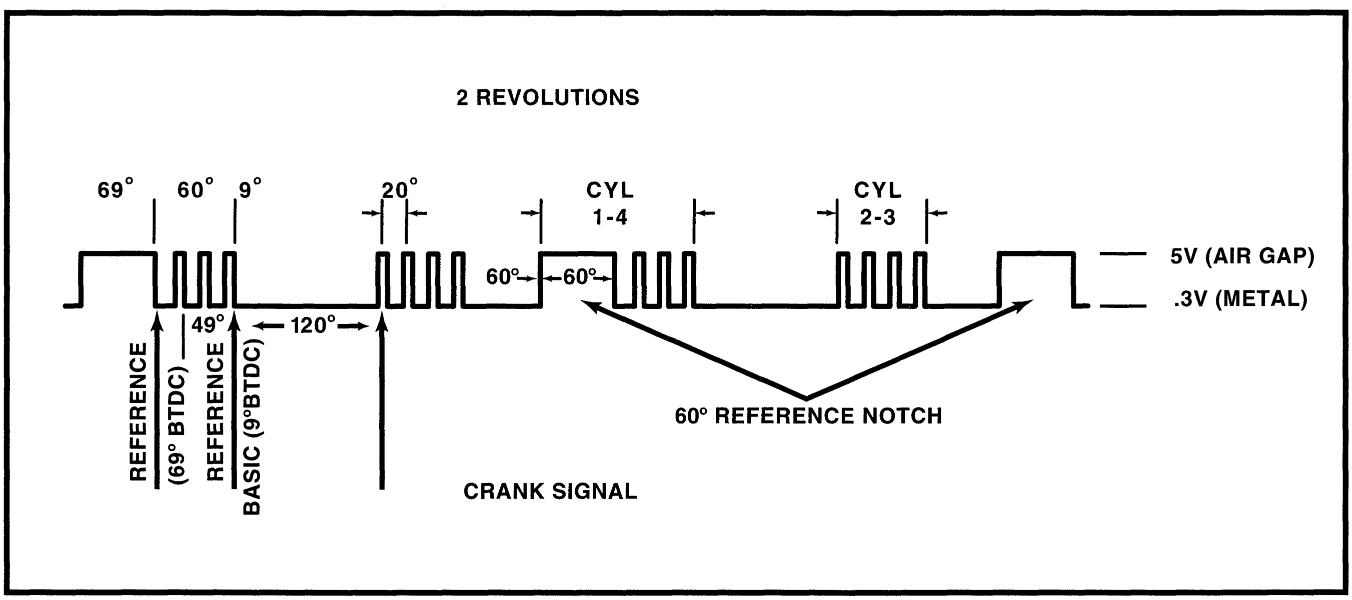


Figure 17 Crankshaft Position Sensor Signal

* In the 1996 model year, both the crank and cam signals were necessary to start the vehicle. In the prior and later model years, only the crank signal is required for startup.

CAMSHAFT POSITION SENSOR

The PCM sends approximately 9 volts to the Hall-effect sensor (fig. 18). 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 return circuit. The input to the PCM occurs on a 5 volt output reference circuit. The CMP sensor operates the CKP sensor except that there is no magnet in the CMP sensor. This magnet is attached to the rear of the camshaft. The PCM identifies camshaft position by registering the change from 5 to 0 volts, as signaled from the Camshaft Position sensor (fig. 19).

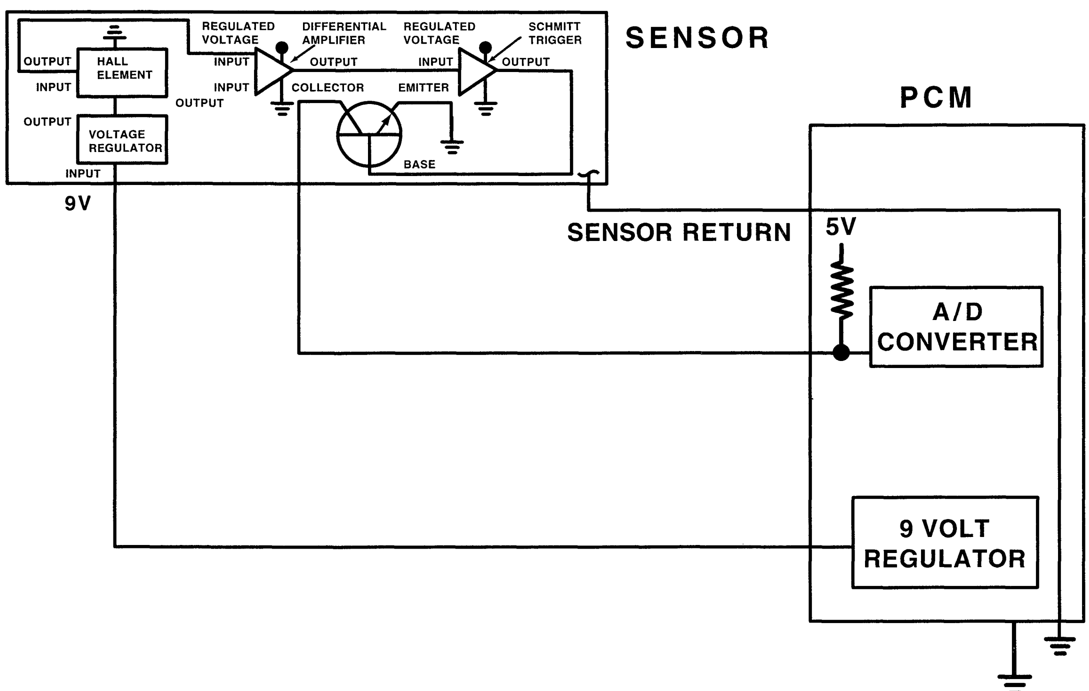


Figure 18 Camshaft Position Sensor Circuit

The PCM determines fuel injection synchronization and cylinder identification from inputs provided by the camshaft position sensor and crankshaft position sensor. From the two inputs, the PCM determines crankshaft position. This information can also be used to determine camshaft-to-crankshaft misalignment (timing belt skipped 1 tooth or more DTC, Hex 85).

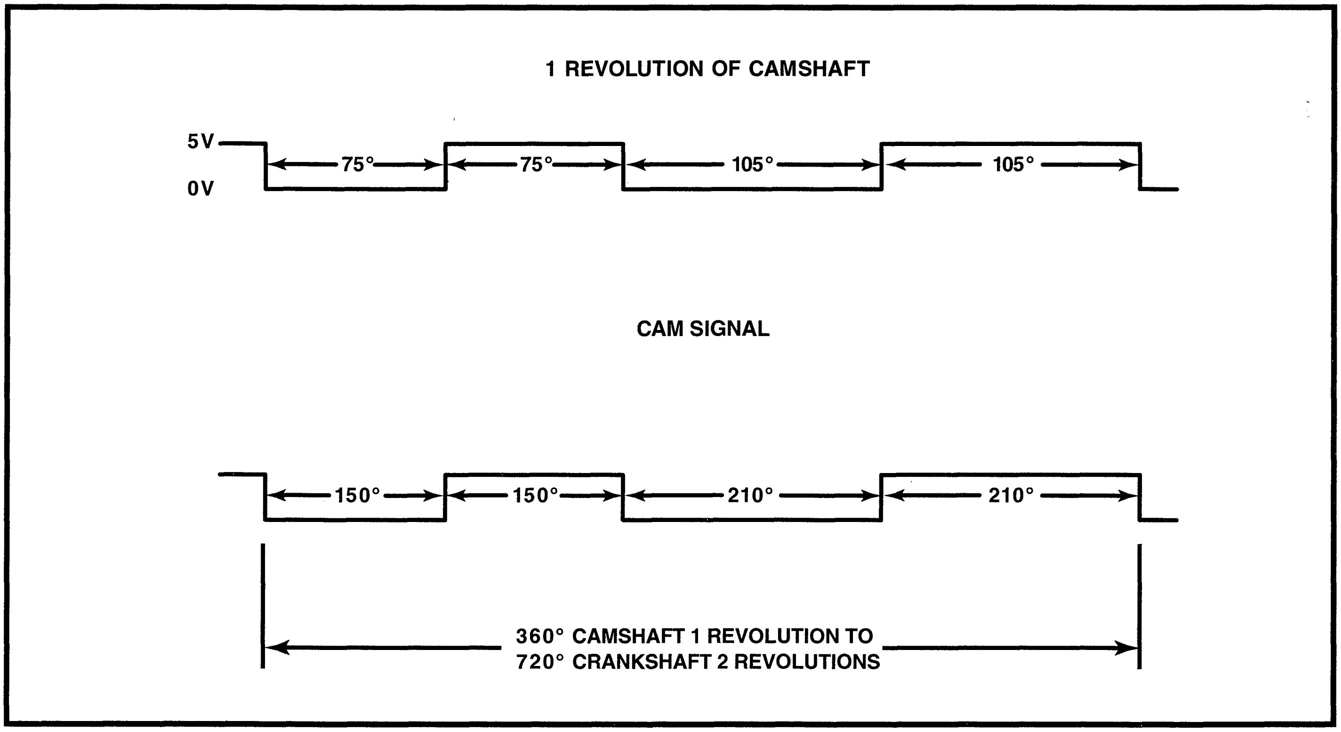


Figure 19 Camshaft Position Sensor Signal

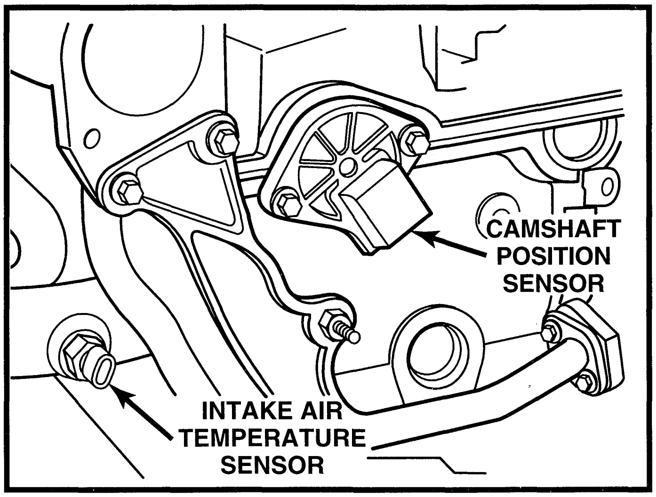


Figure 20 Camshaft Position Sensor

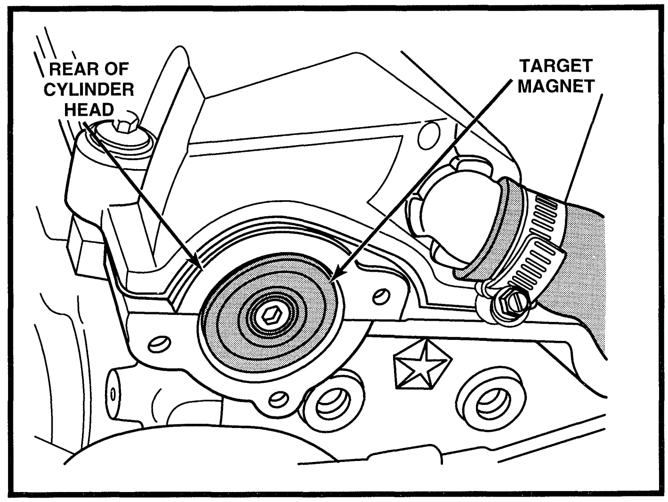


Figure 21 Target Magnet

The camshaft position sensor attaches to the rear of the cylinder head (fig. 20). A target magnet attaches to the rear of the camshaft and indexes to the correct position. The target magnet has four different poles arranged in an asymmetrical pattern, two north and two south pole pieces. As the camshaft rotates, the target magnet rotates, causing the camshaft position sensor to sense the change in polarity. As the north pole of the target magnet passes under the sensor, the transistor is turned off, which allows the PCM to register 5 volts.

The transistor turns back on when the south pole of the magnet passes under the sensor, causing the 5 volt signal to be pulled to a ground. The sensor output switch switches from high (5.0 volts) to low (0.30 volts) as the target magnet rotates.

The target magnet is attached to the camshaft with one Allen screw. The magnet is indexed by two locating pins that are offset (fig. 21) to ensure proper positioning of the target magnet.

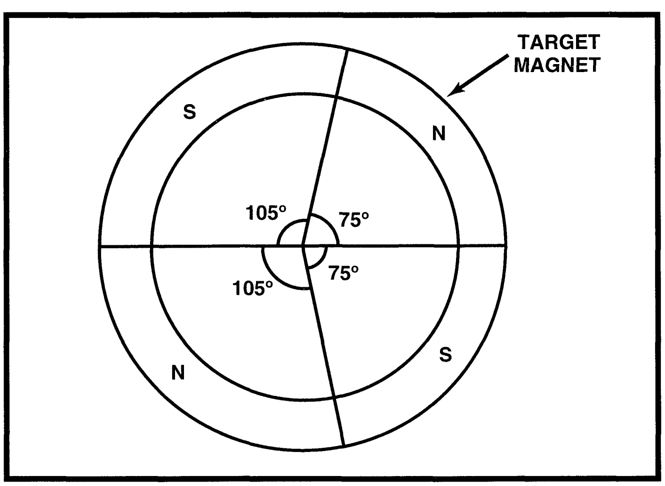


Figure 22 Target Magnet Polarity

The target magnet's polarity is unevenly spaced (fig. 22). One north pole piece is attached so that as the camshaft rotates, the signal recorded by the PCM lasts a total of 75^0 of camshaft rotation. The other north pole magnet's signal lasts a total of 105^0. The south pole piece is spaced in the same manner, 75^0 and 105°. In one revolution of the camshaft, the PCM recognizes four signals spaced as shown in Figure 20. The crankshaft rotates twice the speed of the camshaft. When comparing the angles of rotation of the crankshaft, the angles of the camshaft double.

The PCM can synchronize the CMP and CKP sensors watching one revolution of the crankshaft (fig. 23). When the PCM recognizes the 60° notch, it determines that both pistons 1 and 4 are approaching TDC. The PCM can determine which piston approaching TDC compression is by the Camshaft position. If, when the CKP sensor indicates 5 volts because it is in front of the 60° notch and the camshaft position sensor indicated a switch from 5 to 0 volts, the PCM knows that piston 1 is approaching TDC compression. If the CMP sensor switches from 5 to 0 volts before the CKP sensor indicates the 60° notch, then the PCM knows that piston 4 is approaching TDC compression.

The following is the sequence of operation at start up:

1. At key-on, the fuel pump relay is energized for approximately .7 to 1.5 seconds to provide power to operate the fuel pump. This is done to charge the fuel lines and fuel rail with enough fuel pressure to start the engine quickly.
2. As soon as the CKP sensor indicates the engine is being cranked, the ASD relay is energized providing power to the ignition coil pack and the injectors. The fuel pump relay is also energized. At the first 69° edge, the PCM pulses all four injectors simultaneously. (This system does not pulse the injectors at key-on for a primer feature.)
3. During the next two groups of signals from the CKP sensor, the PCM attempts to synchronize the CKP and CMP sensors. During this time, no injectors are pulsed, but the ignition coil is fired in the appropriate order.
4. After synchronization, the PCM pulses the injectors sequentially in the ignition firing order, however, this occurs one revolution before TDC compression.
5. When the engine speed exceeds approximately 600 RPM, the PCM switches from a cranking mode to a running mode.

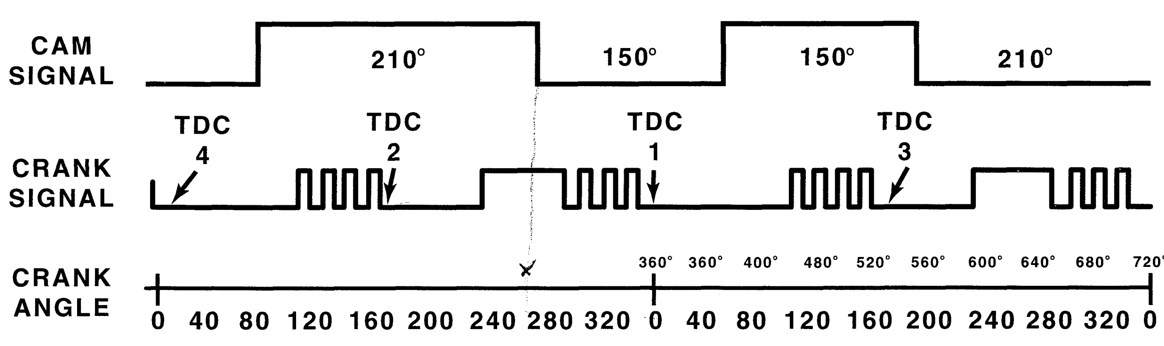


Figure 23 Crankshaft and Camshaft Sequence Chart

CAM/CRANK DIAGNOSIS

In order for the PCM to diagnose either the CAM or CRANK sensor signals, one of them must be present.

CAM/CRANK SERVICE

When the engine is running under specific conditions, the PCM stores the angle between the Crankshaft Position sensor and the Camshaft Position sensor in a designed Electronically Erasable Programmable Read Only Memory (EEPROM). This angle can be read by the technician using the DRB III scan tool in a screen labeled "Cam Timing Position." The screen gives information on the angle differences between the camshaft and the crankshaft. Zero means that there is no difference between the recorded angle stored in the EEPROM and the angle determined by comparing the Camshaft Position sensor with the Crankshaft Position sensor. A Diagnostic Trouble Code is stored in memory when the angle difference exceeds 13°. If the timing belt skips one tooth, the angle will exceed 17°. The 2.0L SOHC and DOHC engine is not a broken timing belt valve clearance engine, which means that if the belt skips more than three teeth, the valves will hit the top of the pistons.

The purpose of the DTC is to warn technicians when the belt is loosening, or has skipped one tooth or more. Under most circumstances, this means that it is time to service the timing belt or its related components. Refer to the Diagnostic Test Procedure Manual when performing any service related to the ignition or emissions systems.

Chrysler has built-in tolerances during manufacturing of the 2.0L SOHC and DOHC engine and its components. Certain components, when replaced, may change the angle between the CMP and CKP sensor readings, yet no problems will exist. The following list of components, when replaced, require the use of the DRB III scan tool to reset "Cam/Crank" angles.

- Camshaft
- Camshaft position sensor
- Camshaft position sensor target magnet
- Camshaft sprocket
- Crankshaft
- Crankshaft sprocket
- Cylinder head
- Cylinder block
- Head gasket
- PCM
- Tensioner
- Timing belt
- Water pump

Anytime the PCM is replaced, the new PCM learns the cam/crank angle.

Caution: If the timing belt has been installed incorrectly, and the PCM has had its EEPROM erased, the PCM learns an incorrect angle and cannot identify the camshaft being out of synchronization with the crankshaft.

ACTIVITY 3 — CAMSHAFT POSITION SENSOR ACTIVITY

2.0L SOHC-PL/JA

The camshaft position sensor attaches to the rear of the cylinder head.

Activities

1. Find the sensor and unplug the connector. Using voltmeter, what is voltage at 32 and 33? ____________________

2. Connect DRB and select monitors. What is the reading of voltmeter pin 44? ____
____

3. Crank engine. What does the DRB indicate for CMP state? ____________________
____

4. Using a voltmeter, measure the voltage on the three wires of the harness side connector. What are the voltages? ____________________

5. Plug the connector together and change the DRB to read DTC's. What DTC is present and why? ____________________

   If the CMP sensor wire was shorted to ground, what DTC would be present?____________________

6. Crank engine. What does the DRB indicate for CMP State? ____________________

7. Short the 9 volts to ground. What does voltmeter read? ____________________

   Remove the grounded circuit.

8. Turn key off and wait about 5 seconds. Turn key on. What does voltmeter read?
____

2.0L DOHC-PL/22/F24S

The camshaft position sensor attaches to the rear of the cylinder head.

Activities

1. Find the sensor and unplug the connector.

2. Connect DRB and select input/outputs.

3. Crank engine. What does the DRB indicate for CMP State? ____________________

4. Using a voltmeter, measure the voltage on the three wires of the harness side connector. What are the voltages? ____________________

5. Plug the connector together and change the DRB to read DTC's. What DTC is present and why? ____________________

6. Crank engine. What does the DRB indicate for CMP State? ____________________

7. Short the 9 volts to ground. What does voltmeter read? ____________________

   Remove the grounded circuit.

8. Turn key off and wait about 5 seconds. Turn key on. What does voltmeter read?

   ____

2.4L DOHC-JA/JX/NS Component Locations

The camshaft position sensor attaches to the rear of the cylinder head.

Activities

1. Find the sensor and unplug the connector.

2. Connect DRB and select input/outputs.

3. Crank engine. What does the DRB indicate for CMP State? ____________

4. Using a voltmeter, measure the voltage on the three wires of the harness side connector. What are the voltages? ____________

5. Plug the connector together and change the DRB to read DTC's. What DTC is present and why? ____________

   If the CMP sensor wire was shorted to ground, what DTC would be present? ____________

6. Crank engine. What does the DRB indicate for CMP State? ____________

7. Short the 9 volts to ground. What does voltmeter read? ____________

   Remove the grounded circuit.

8. Turn key off and wait about 5 seconds. Turn key on. What does voltmeter read?
   ____

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

The MAP serves as a PCM input, using a silicon based sensing unit, to provide data on the manifold vacuum that draws the air/fuel mixture into the combustion chamber. The PCM requires this information to determine injector pulse width and spark advance. When MAP equals Barometric pressure, the pulse width will be at maximum.

Also like the cam and crank sensors, 5 volts are supplied from the PCM and returns a voltage signal to the PCM that reflects manifold pressure (fig. 24). 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 return circuit.

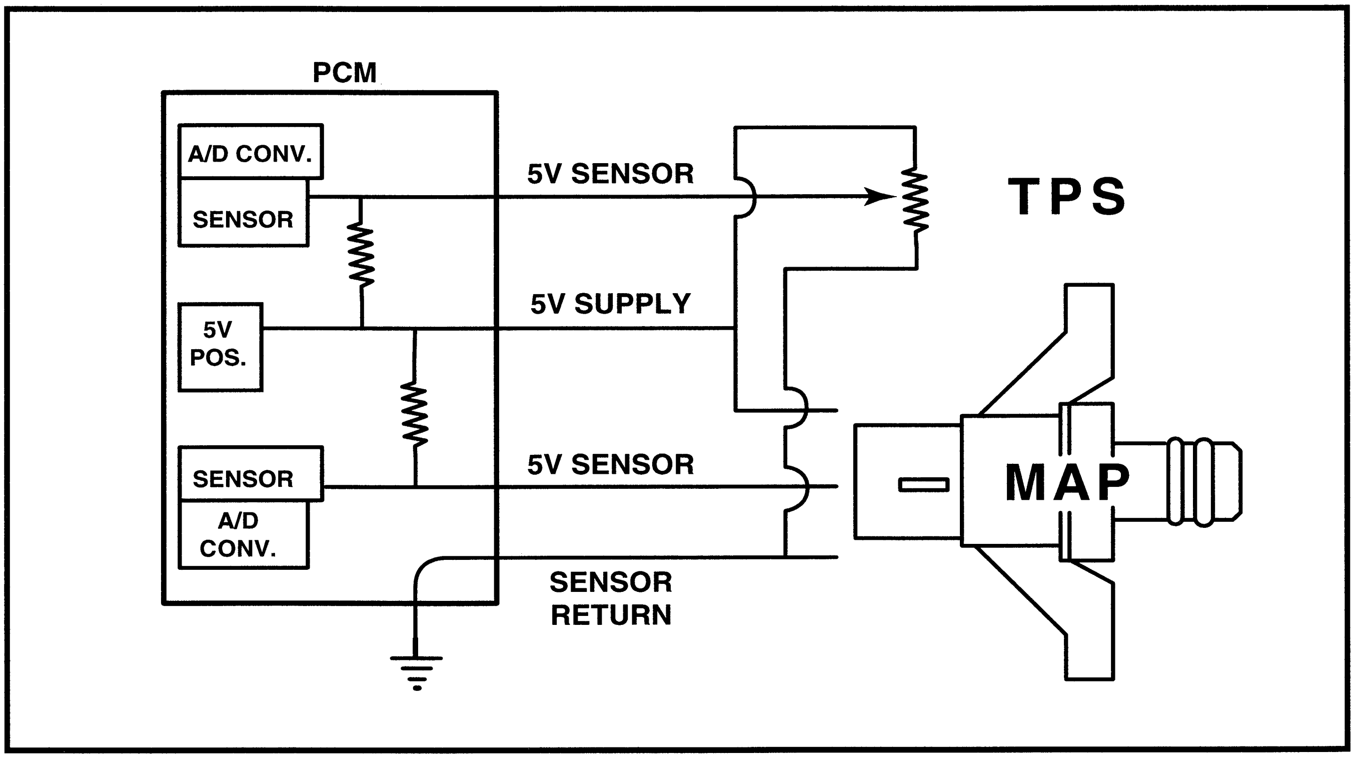


Figure 24 Manifold Absolute Pressure Sensor Circuit

The MAP sensor input is the number one contributor to pulse width. An important function of the MAP sensor is to determine barometric pressure (fig. 25). The PCM needs to know if the vehicle is at sea level or in Denver at 5000 feet above sea level, because the air density changes with altitude. It will also help to correct for varying weather conditions. This is important because as air pressure changes the barometric pressure changes. Barometric pressure and altitude have a direct inverse correlation: as altitude goes up barometric goes down. The first thing that happens as the key is rolled on, before reaching the crank position, the PCM powers up, comes around and looks at the MAP voltage, and based upon the voltage it sees, it knows the current barometric pressure relative to altitude.

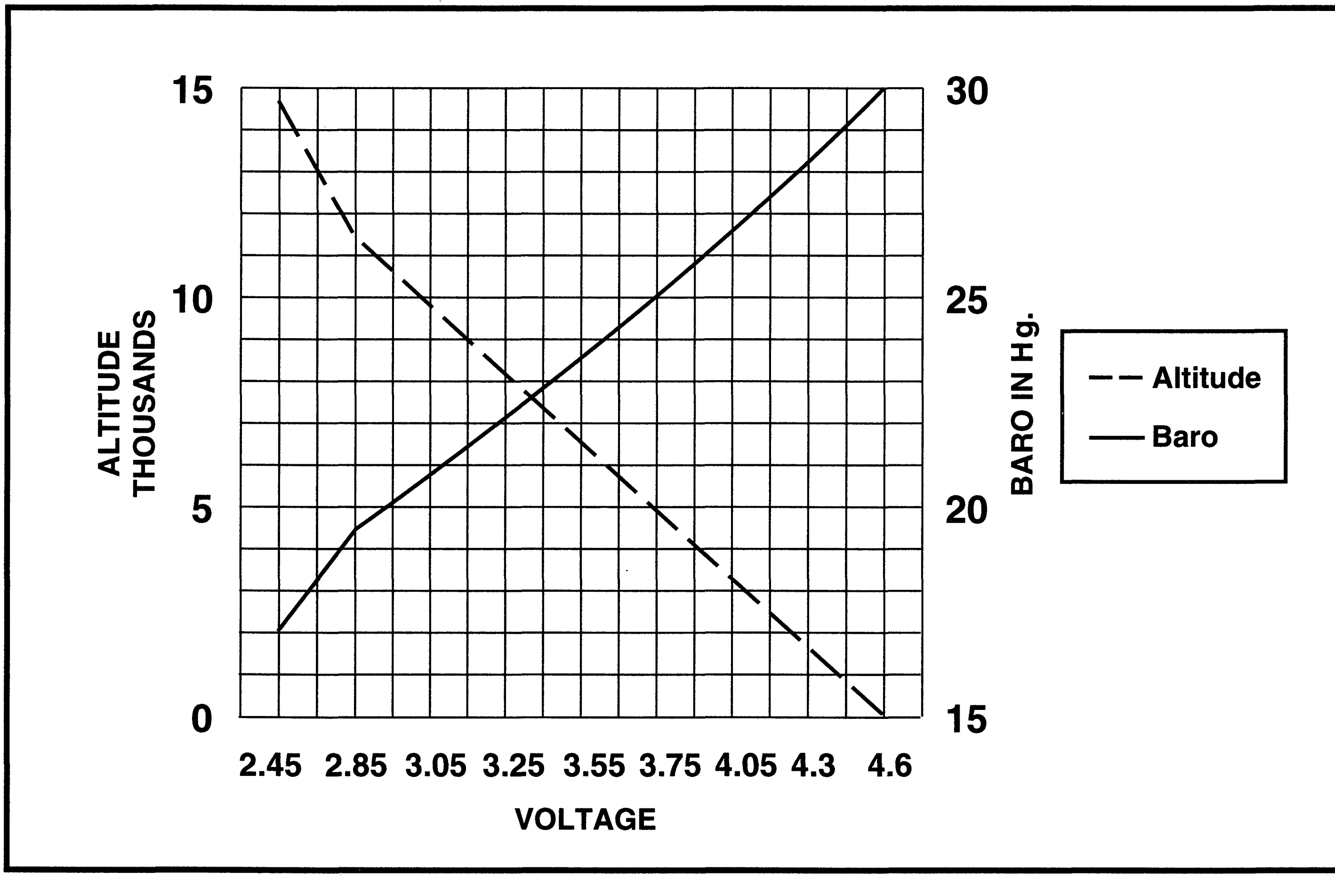


Figure 25 MAP Sensor Voltage Values

Once the engine starts, the PCM looks at the voltage again, at each 69° and 9° edge. It then averages these signals and compares the current voltage to what it was at key ON. The difference between current and what it was at key ON is manifold vacuum (fig. 26).

During key ON (engine not running) the sensor reads (updates) barometric (Baro) pressure. A normal range can be obtained by monitoring a known good sensor in your work area.

As the altitude increases the air becomes thinner (less oxygen). If a vehicle is started and driven to a very different altitude than where it was at key ON the barometric pressure needs to be updated. Any time the PCM sees at least 1.8 volts above min TPS, and based upon RPM it will update barometric pressure in the MAP memory cell. With periodic updates, the PCM can make its calculations more effectively. Also, if MAP is ever greater than Baro, Baro automatically updates.

The PCM uses the MAP sensor to aid in calculating the following:

- Barometric pressure
- Engine load
- Manifold pressure
- Injector pulse-width
- Spark-advance programs
- Shift-point strategies 41TE (F4AC1) transmissions only, via the CCD bus
- IAC position
- Decel fuel shutoff

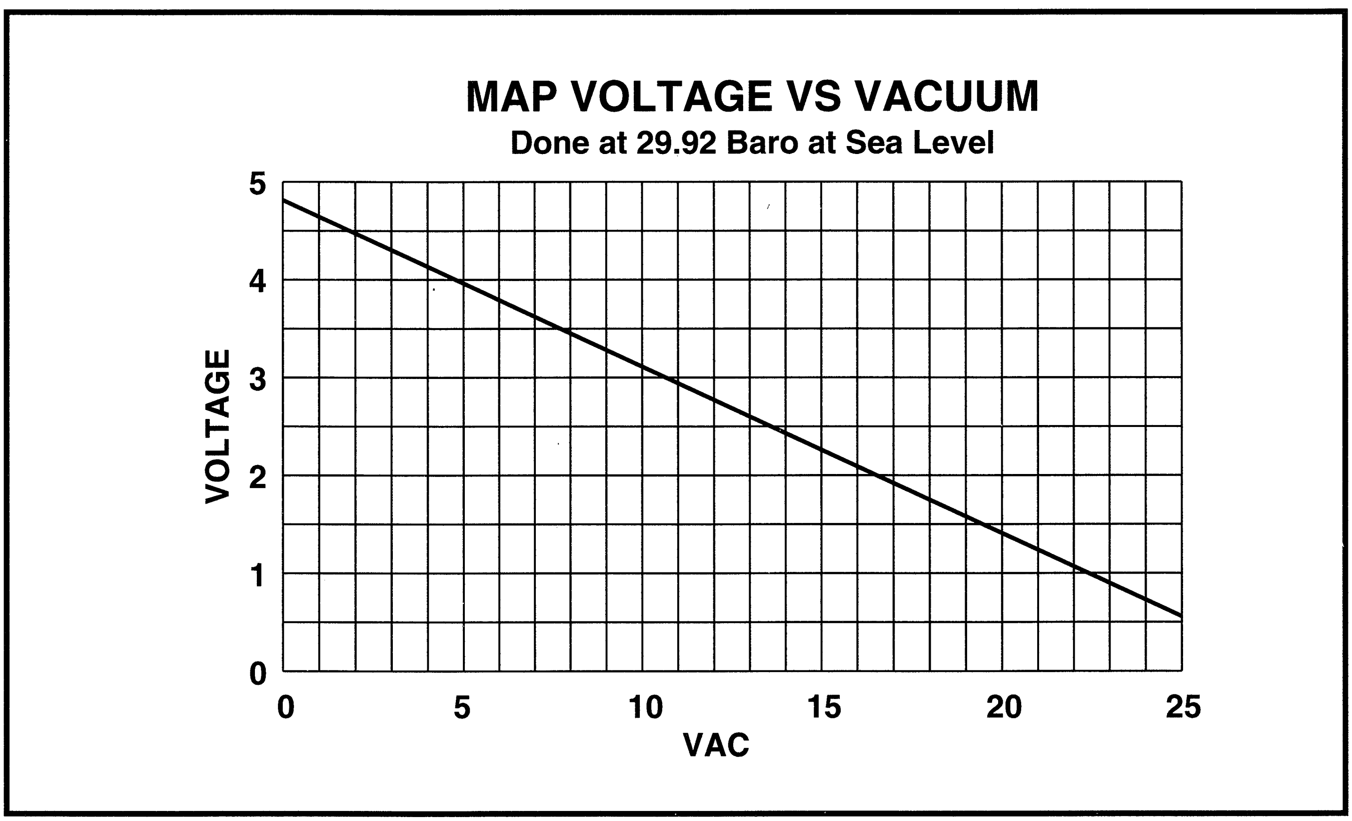


Figure 26 MAP Voltage Vs. Vacuum

The MAP sensor signal is provided from a single piezoresistive element located in the center of a diaphragm. The element and diaphragm are both made of silicone. As the pressures changes the diaphragm moves causing the element to deflect which stresses the silicone. When silicone is exposed to stress its resistance changes. As manifold vacuum increases, the MAP sensor input voltage decreases proportionally. The sensor also contains electronics that condition the signal and provide temperature compensation.

The PCM recognizes a decrease in manifold pressure by monitoring a decrease in voltage from the reading stored in the barometric pressure memory cell. The MAP sensor is a linear sensor; as pressure changes, voltage changes proportionately. The range of voltage output from the sensor is usually between 4.6 volts at sea level to as low as 0.3 volts at 26 in. of Hg (Table 4). Barometric pressure is the pressure exerted by the atmosphere upon an object. At sea level on a standard day, no storm, barometric pressure is 29.92 in Hg. For every 100 feet of altitude barometric pressure drops .10 in. Hg. If a storm goes through it can either add (high pressure) or decrease (low pressure) from what should be present for that altitude. You should make a habit of knowing what the average pressure and corresponding barometric pressure is for your area. Always use the Diagnostic Test Procedures Manual for MAP sensor testing.

INCHES OF MERCURY ABSOLUTE	INCHES OF MERCURY VACUUM	MAP SENSOR SIGNAL VOLTAGE (VOLTS)
31.0	0.5 psi	4.8
29.92	0.00	4.6
27.00	2.92	4.1
25.00	4.92	3.8
23.00	6.92	3.45
20.00	9.92	2.92
15.00	14.92	2.09
10.00	19.92	1.24
5.00	24.92	0.45

Table 4 MAP Sensor Values

MAP Sensor Diagnostics

There are three MAP sensor diagnostic routines:

- MAP voltage high
- MAP voltage low
- No change in MAP voltage at start to run transfer

With the engine running between 400 to 1500 RPM*, near closed throttle, if MAP voltage is above 4.6 volts, the voltage high fault is set.

There are two different ways to set the voltage low fault. If MAP voltage is below 1.2 volts at startup, the fault will be set. The other is MAP voltage below .02 volts while the engine is running.

To set the rationality fault, no change in MAP from start to run, the PCM must see too small a difference between engine MAP voltage running and baro at key on. This is checked at all times. If RPM becomes close to idle speed and the throttle is closed, vacuum should be greater than a calibrated amount. If vacuum is not high, then a fault will be set.

MAP voltage is only looked at when the vehicle is near closed throttle and RPM between approximately 400 to 1500 RPM*. This means that if a MAP sensor is faulty at an RPM above 1500, the PCM will believe whatever reading it gets from the MAP sensor as real.

MAP Sensor Limp-in

The PCM stores a DTC when the MAP sensor malfunctions. When the PCM sets a DTC, the MAP sensor's information is considered inaccurate. At this point, the PCM moves into "limp-in" mode. Limp-in for the MAP sensor allows the engine to continue to function, without input to the PCM from the MAP. The PCM must calculate the amount of air being consumed by the engine, which is accomplished by calculating MAP values based upon readings from the CKP sensor (RPM) and the Throttle Position Sensor (TPS). Any time the PCM sets a DTC for MAP, the Malfunction Indicator Light (MIL) is illuminated.

When the MAP sensor is in limp-in, the PCM limits the engine speed as a function of TPS to between 1500 and 4000 rpm. If the MAP sensor sends realistic signals once again, the PCM moves out of limp-in, and resumes using the MAP values.

MAP Sensor Service

There are two fluorosilicone O-rings on the MAP nipple that are susceptible to damage from shipping or careless installation. Be careful when removing or installing the MAP sensor.

* Beginning with the 1997 model year, the MAP diagnostic range is 600 to 3500 RPM.

Component Locations

The MAP sensor on four cylinder engines is located on the engine's intake manifold (figs. 27-31). On previous four cylinder engines it was located on the bulkhead. Moving the sensor to the manifold eliminates the need for a hose connecting the MAP sensor to the engine, and reduces the possibility of moisture contamination.

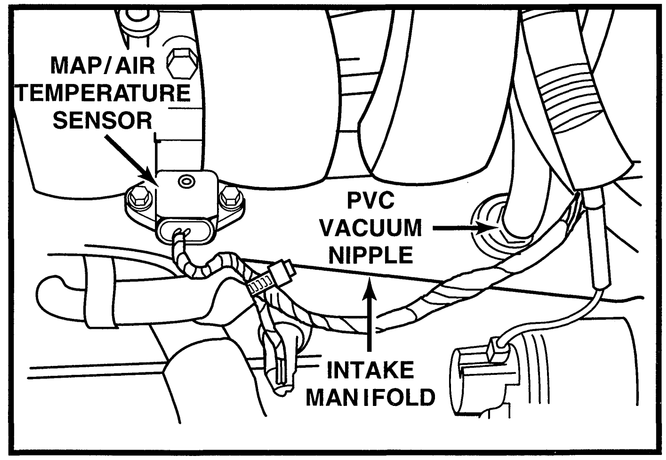


Figure 27 MAP Sensor (2.0L SOHC-PL/JA)

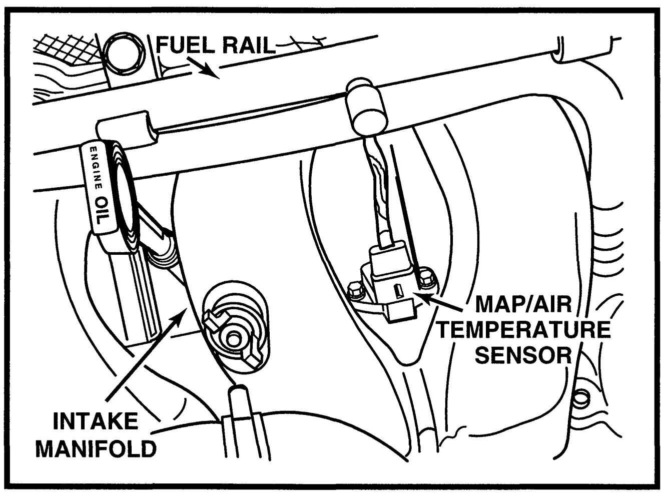


Figure 28 MAP Sensor (2.0L DOHC-PL/JA)

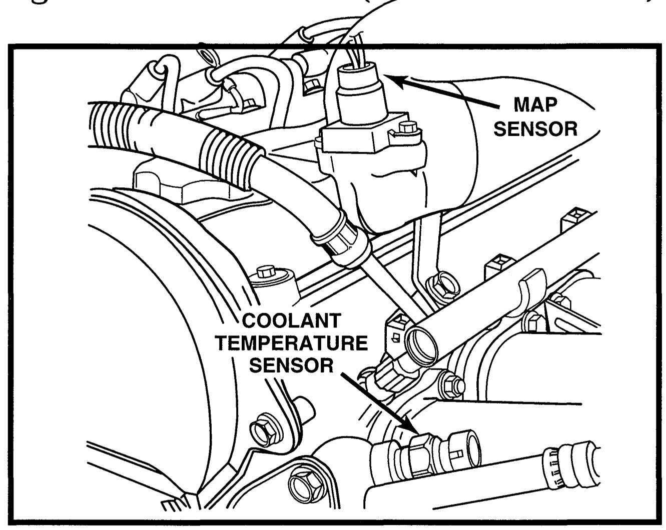


Figure 29 MAP Sensor (2.4L DOHC-NS)

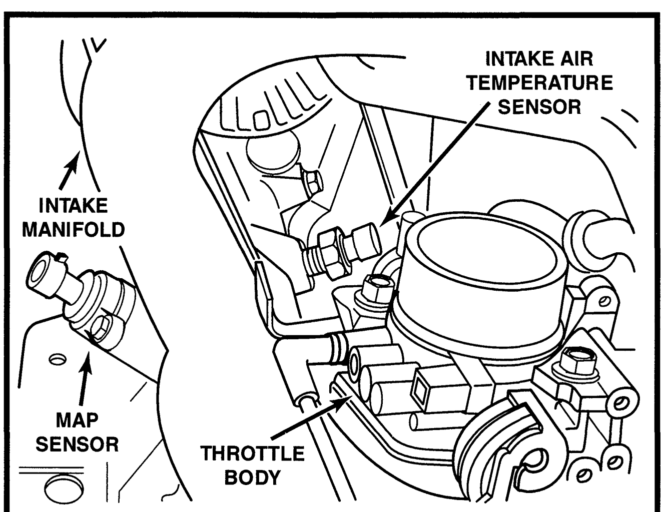


Figure 30 MAP Sensor (2.4L DOHC-JA/JX)

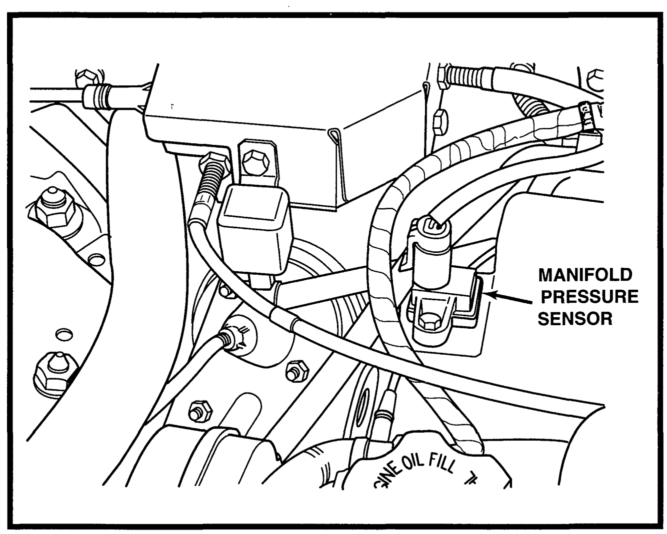


Figure 31 MAP Sensor (2.0L DOHC-FJ22/F24S)

ACTIVITY 4 — MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

2.0L SOHC-PL/JA

Activities

1. Find the sensor on the vehicle and unplug the connector. How many wires does it have? ____________ What does the DRB indicate for baro, vacuum and voltage?
   ____

2. Using a voltmeter, measure the voltage on the three or four wires. What are the voltages? ____

3. Start the engine. Using the DRBIII, what is vacuum? ____________________
   What is MAP? ____

4. Change the DRB to read DTC's. What DTC is present and why? ____________

5. Plug the connector together.

6. Change the DRB to read Sensors. Now what does the DRB indicate for baro, vacuum and voltage? ____
   If the MAP sensor wire was shorted to ground, what DTC would be present? ___
   ____

7. Turn key OFF and back ON. What does DRB show? ______________________
   Why? ____

8. Go to DTC's. What DTC is present and why? ____________________________

FWD 4-Cyl Fuel Injection

2.0L DOHC-PL/JA

Activities

1. Find the sensor on the vehicle and unplug the connector. How many wires does it have? ___________ What does the DRB indicate for baro, vacuum and voltage?
   ____

2. Using a voltmeter, measure the voltage on the three or four wires. What are the voltages? ____

3. Start the engine.

4. Change the DRB to Read DTC's. What DTC is present and why? ______________

5. Plug the connector together.

6. Change the DRB to read Sensors. Now what does the DRB indicate for baro, vacuum and voltage? ____
   If the MAP sensor wire was shorted to ground, what DTC would be present? ___
   ____

7. Using the simulator and DRB, change the MAP output to read 17" of Hg. What happened to IAC, target idle and injector pulse width? ______________________
   Why? ____

8. Slowly decrease the MAP signal toward low vacuum. As you decreased the voltage what happened to the vacuum? ____
   Why? ____

FWD 4-Cyl Fuel Injection

2.0L DOHC-F22/F24S

Activities

1. Find the sensor on the vehicle and unplug the connector. How many wires does it have? ____________ What does the DRB indicate for baro, vacuum and voltage?

2. Using a voltmeter, measure the voltage on the three or four wires. What are the voltages? ____

3. Start the engine.

4. Change the DRB to Read DTC's. What DTC is present and why? ______________
____

5. Plug the connector together.

6. Change the DRB to read Sensors. Now what does the DRB indicate for baro, vacuum and voltage? ______________________________ If the MAP sensor wire was shorted to ground, what DTC would be present? ______________________________

7. Using the simulator and DRB, change the MAP output to read 17" of Hg. What happened to IAC, target idle and injector pulse width? ______________________
Why? ____

8. Slowly decrease the MAP signal toward low vacuum. As you decreased the voltage what happened to the vacuum? ____________________________________
Why? ____

2.4L DOHC-JA/JX

Activities

1. Find the sensor on the vehicle and unplug the connector. How many wires does it have? ________________________ What does the DRB indicate for baro, vacuum and voltage? ____

2. Using a voltmeter, measure the voltage on the three or four wires. What are the voltages? ____

3. Start the engine.

4. Change the DRB to Read DTC's. What DTC is present and why? _______________

5. Plug the connector together.

6. Change the DRB to read Sensors. Now what does the DRB indicate for baro, vacuum and voltage? _____________________________ If the MAP sensor wire was shorted to ground, what DTC would be present? _____________________________

7. Using the simulator and DRB, change the MAP output to read 17" of Hg. What happened to IAC, target idle and injector pulse width? _______________________ Why? ____

8. Slowly decrease the MAP signal toward low vacuum. As you decreased the voltage what happened to the vacuum? ____ Why? ____

2.4L DOHC-NS

Activities

(1) Find the sensor on the vehicle and unplug the connector. How many wires does it have? ____________________ What does the DRB indicate for baro, vacuum and voltage? ____________________

(2) Using a voltmeter, measure the voltage on the three or four wires. What are the voltages? ____________________

(3) Start the engine.

(4) Change the DRB to Read DTC's. What DTC is present and why? ____________________

____

(5) Plug the connector together.

(6) Change the DRB to read Sensors. Now what does the DRB indicate for baro, vacuum and voltage? ____________________
If the MAP sensor wire was shorted to ground, what DTC would be present? ___

____

(7) Using the simulator and DRB, change the MAP output to read 17" of Hg. What happened to IAC, target idle and injector pulse width? ____________________
Why? ____________________

(8) Slowly decrease the MAP signal toward low vacuum. As you decreased the voltage what happened to the vacuum? ____________________

____

Why? ____________________

THROTTLE POSITION SENSOR (TPS)

The throttle position sensor is mounted to the side of the throttle body. The PCM needs to identify the actions of the throttle blade at all times to assist in performing the following calculations:

- Ignition timing advance
- Fuel injection pulse-width
- Idle (learned value or Min TPS)
- Off-Idle (0.06 volts above Min TPS)
- Wide Open Throttle (WOT) open loop (2.608 volts above learned idle voltage)
- Deceleration fuel lean out
- Fuel Cutoff during cranking at WOT (2.608 volts above learned idle voltage)
- A/C WOT Cutoff
- A/C part throttle cutoff (less than 12 mph and 3000 RPM)
- Cooling fan cutoff (low speed high throttle acceleration)

The TPS is supplied with a regulated voltage that ranges from 4.8 to 5.1 volts from the PCM (fig. 32). This output regulated voltage is the same regulated voltage that 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.

CAV	FUNCTION
1	5-VOLT SUPPLY
2	TP SENSOR SIGNAL
3	SENSOR GROUND

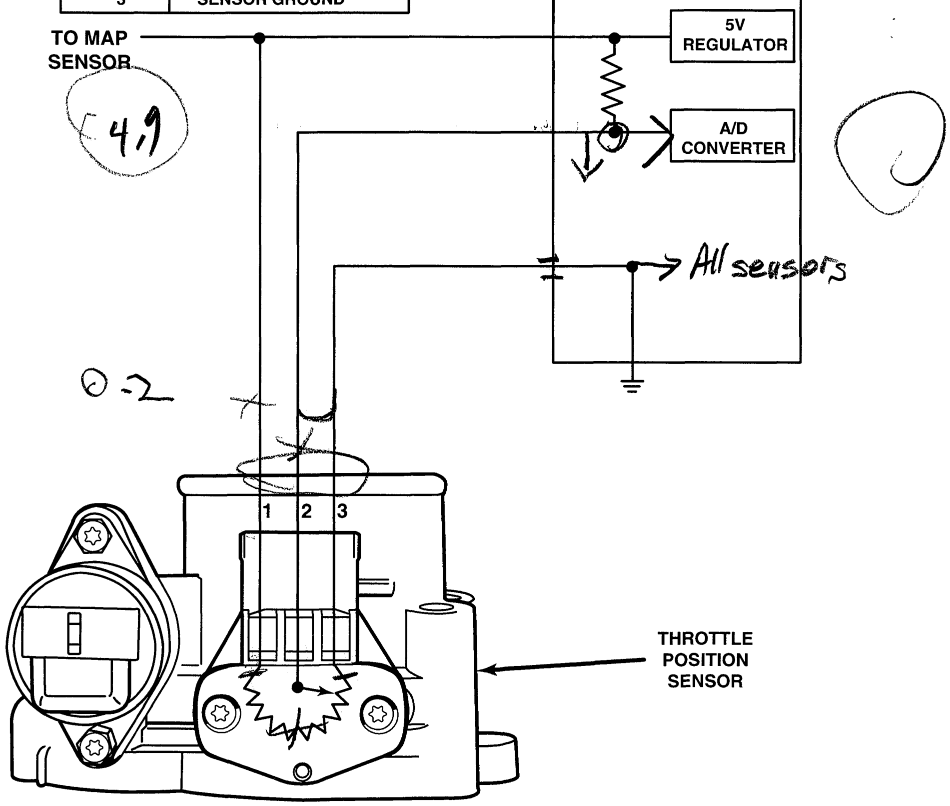


Figure 32 Throttle Position Sensor Circuit

TPS PROGRAMS

Idle

As with other Chrysler fuel-injection systems, the PCM is able to recognize an idle command based upon inputs from the TPS. Also, like other Chrysler systems, the PCM is programmed to monitor the TPS signal whenever the key is ON. While the key is on and the engine is running, the PCM assumes that the lowest voltage it can receive, above the fault threshold, must be where the throttle blade lever hits the idle stop. Normally this voltage range is approximately 0.5-1.0 volt. At the low voltage position, the PCM records the signal as "idle," better known as "minimum TPS."

The PCM's memory is updated any time the sensed voltage is less than the recorded value in the memory cell. The PCM uses voltage change to determine when the throttle has returned to the previously learned value. At key ON, the PCM will raise the target voltage value in the TPS Min idle memory cell by approximately 0.06 of a volt. This new value becomes the new Min. TPS. When the engine is started, if the actual TPS voltage is lower than the new memory value, the PCM will store actual as Min. TPS.

If the key is cycled ON without starting the engine (start to run transfer) the value in target memory will increase. So, if the key is cycled enough times without starting the engine, the Min. TPS target may become high enough that when the throttle is held physically open (WOT fuel cutoff during cranking) there is not enough actual voltage increase to allow this function to operate.

Any time the PCM receives the idle voltage signal, the PCM is programmed to maintain idle, using timing and the Idle Air Control (IAC) motor. Idle speed may vary based on ECT.

Spark advance curves and injection pulse-width programs are unique in that they are specifically calibrated for idle conditions. If equipped with an automatic transmission, the PCM also has separate programs for idle neutral and idle drive.

Off-Idle

Once the throttle is opened, the PCM moves into its off-idle program at approximately 0.06 volts above Min. TPS. At this point spark advace is no longer being used to control idle speed. The IAC motor has been repositioned to act like a dashpot. The dashpot function operates the IAC motor to prevent the possibility of the engine dying out during a sudden deceleration. So, if the throttle blade is actually closed but the TPS voltage did not drop to Min TPS (dirty throttle body) idle quality will be poor: Min. TPS with engine running cannot be learned upward (higher voltage). Only a lower voltage can be learned.

Acceleration

A rapid rise in TPS voltage within a specified time frame causes the injector pulse width to increase. The amount of pulse width increase is determined by the rate of voltage rise. For maximum response, the PCM will momentarily open 3 injectors; the injector that just closed, the one being opened and the one to be opened next.

Wide Open Throttle (WOT)

With the engine running, the PCM spark-advance and fuel pulse-width programs are affected during WOT conditions. The PCM enriches the air/fuel ratio at WOT to allow the combustion chamber to run a little cooler. To enrich the air/fuel ratio at WOT, the PCM is programmed to go into open loop any time the TPS voltage exceeds 2.608 volts above minimum idle. Also, at WOT the A/C compressor relay is de-energized to remove the A/C compressor load from the engine for a programmed amount of time.

Deceleration

Under deceleration, the PCM is programmed to “lean out” the air/fuel ratio since engine power is not needed. One of the main components involved with the deceleration program is the TPS. If, while the vehicle is in motion (based on the Vehicle Speed Sensor), the TPS is closed, and manifold vacuum is high, the PCM narrows the pulse width so that the air/fuel ratio becomes leaner. In some instances, the pulse width goes to 0.0 msec., at which time no fuel is supplied to the engine. This action causes extremely low vehicle emissions. During deceleration, the adaptive numerator is updated as there is no load on the crankshaft. The adaptive numerator is explained in detail in the On Board Diagnostics II Student Reference Book.

Wide Open Throttle Fuel Cutoff During Cranking

One last function that the PCM performs from inputs delivered by the TPS is the WOT fuel cutoff while cranking. To ensure short cranking times, the PCM fires all four injectors simultaneously, once, during cranking. After that, the PCM waits 2 revolutions, then fires the injectors sequentially. If the programmed pulse-width allows too much fuel into the combustion chamber, or if circumstances do not allow the engine to start up with the programmed quantity of fuel, the driver can operate the accelerator pedal to WOT so that the PCM de-energizes all injectors. This program occurs only during cranking and when the TPS voltage exceeds 2.608 volts above minimum TPS.

TPS Diagnostics

There are three TPS diagnostic routines:

- TPS voltage high
- TPS voltage low
- TPS voltage does not agree with MAP

The TPS voltage does not agree with MAP fault is set when the PCM interprets the MAP indication as a load condition that does not agree with what it sees from the TPS. Basically, if the voltage gets too low (.2 volts or if road speed is above 20 mph with RPM greater than 1500 and vacuum less than 2") the PCM sets the short to ground (voltage low) fault. If the voltage gets too high (4.5 volts) it sets the short to voltage (voltage high) fault.

TPS Limp-in

When the TPS indicates a voltage that is too low, too high, or not believable, the PCM sets a DTC. When the DTC is set, the MIL is illuminated and the PCM moves into limp-in mode. Limp-in for the TPS is divided into three categories: Idle, Part-throttle, and WOT. These limp-in values are mainly RPM based, although the MAP sensor has an input to the program. Refer to the Diagnostic Test Procedures Manual for complete diagnostic information.

ACTIVITY 5 — THROTTLE POSITION SENSOR

If available, hook up a 1995 TPS to a '96 vehicle and look at voltage on DRB III.

1. Turn key ON and OFF several times. What happened to MIN TPS? Will clear flood occur? ______________________

2. Start engine. Move throttle. What happened to MIN TPS? ______________________

3. With key On, engine OFF and DRB at sensors, move throttle. What happened to TPS and Inj. Pulse Width? ______________________

4. Connect fuel simulator (preset potentiometer). Raise TPS value at simulator. What happened? ______________________

5. Create a custom display on the DRB III:
   - TPS voltage
   - TPS Calculated
   - Min. TPS
   - TPS %
   - Eng. RPM
   - MAP
   - Upstream O2 voltage
   - Inj. Pulse Width

6. Increase TPS value until open loop (upstream O2) snap (rotate quickly) TPS and watch Pulse Width and listen to injectors. What did you see and hear? ______________________

   ____

7. Rotate potentiometer downward then raise it up. What did you notice TPS learning? ______________________

8. Rotate way down and move accelerator linkage. What mode is the PCM in? ____

   ____

ENGINE COOLANT TEMPERATURE (ECT) SENSOR

The PCM uses inputs from the ECT sensor for the following calculations:

- Injector pulse-width
- Spark-advance curves
- Fuel pump relay latch times
- Idle Air Control (IAC) motor key-on steps
- Initial fuel injection
- O2 sensor closed loop times (30° and above)
- Purge solenoid on/off times
- EGR solenoid on/off times
- Radiator fan relay on/off points
- Target idle speed

The ECT input is the second most powerful modifier of injector pulse width. The ECT sensor is a two wire Negative Thermal Coefficient (NTC) sensor. The PCM sends 5 volts to the sensor and is grounded through the sensor return line (fig. 33). As temperature increases, resistance in the sensor decreases.

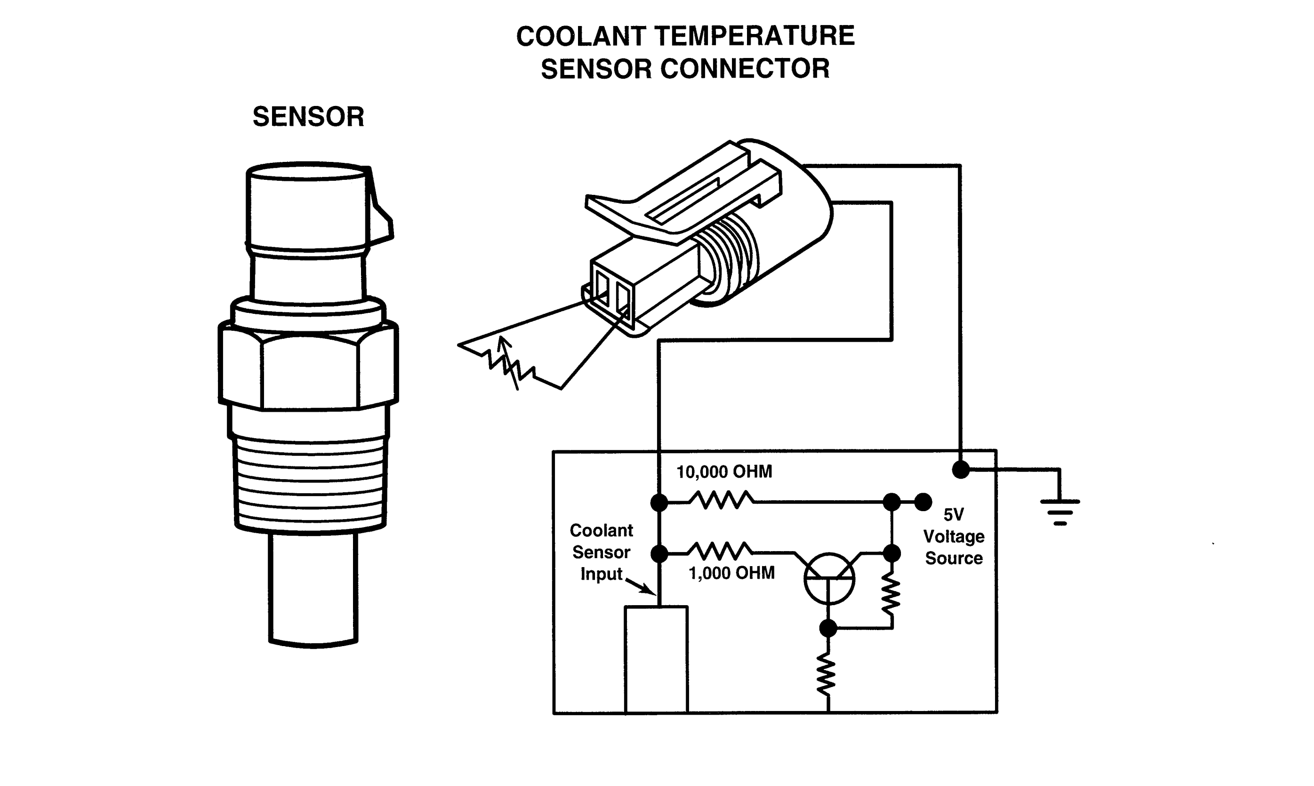


Figure 33 Engine Coolant Temperature Sensor Circuit

The resistance of the ECT sensor is as follows (fig. 34):

- 32^0 F = 29,330 - 35,990 ohms
- 77^0 F = 9,120 - 10,880 ohms
- 212^0 F = 640 - 720 ohms

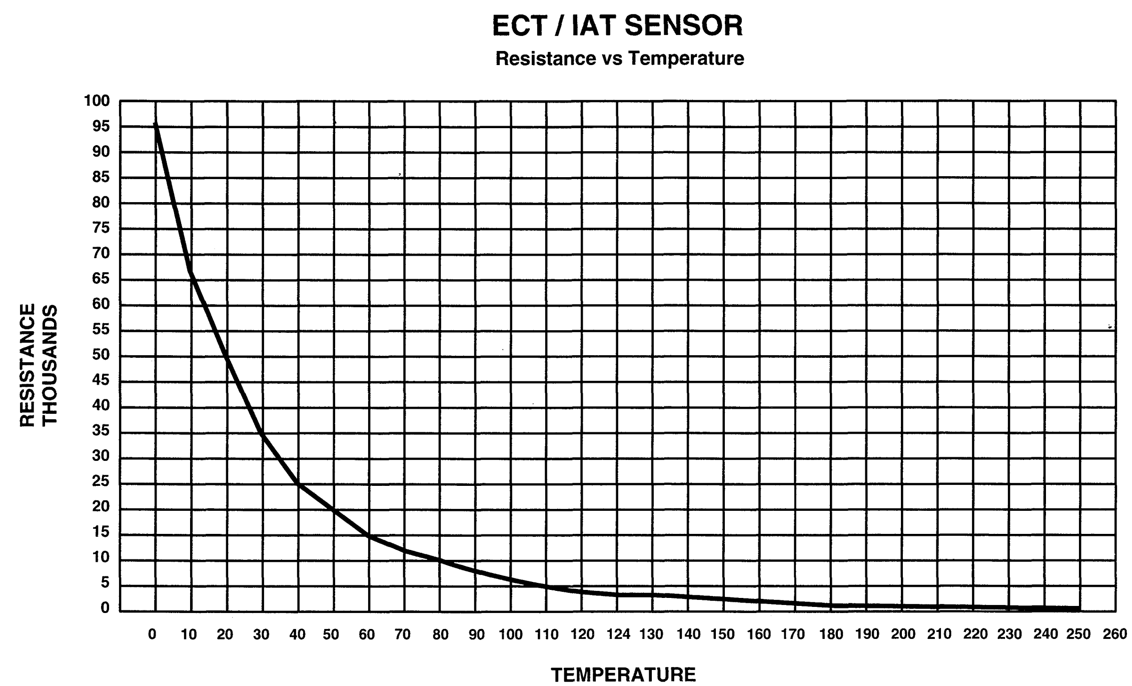


Figure 34 ECT/IAT Sensor Values

The PCM has a dual temperature-range program for better sensor accuracy at cold temperatures. At key ON, the PCM sends a regulated 5 volt signal through a 10,000 ohm resistor to the ECT sensor. The A/D converter monitors this voltage signal as it passes through the ECT sensor to ground. The A/D converter registers the voltage drop across the ECT sensor and then converts the signal into a binary code. When the voltage drop reaches approximately 1.25 volts, the PCM turns on a transistor. The transistor connects a 1,000 ohm resistor in parallel with the 10,000 ohm resistor. With this drop in resistance, the A/D converter recognizes an increase in voltage on the input circuit (fig. 35). The program allows the PCM to have a full binary control at cold temperatures up to approximately 120° F, and a second full binary control at temperatures over 120° F.

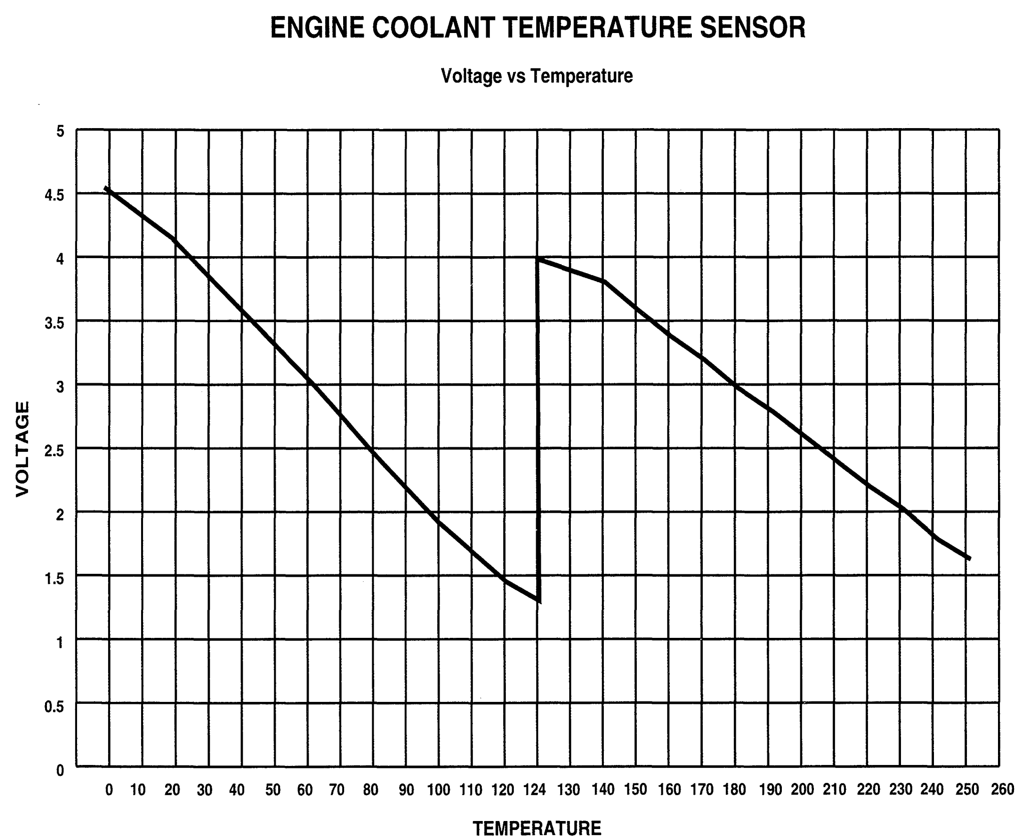


Figure 35 ECT/IAT Sensor Dual Range

At key ON, the PCM assumes a cold engine. Five volts is sent through the 10K resistor out to the sensor element to ground. If the engine is cold the resistance of the element is high and thus there is very little voltage drop through the thermistor and the corresponding sensed voltage is high. If the sensed voltage at key ON is low, this indicates it could either be a warm engine or a short in the circuit. A transistor is turned on adding a 1k resistor in parallel to the 10K resistor. Using ohms law for parallel circuits gives us a new total resistance of 909 ohms. By changing the known resistance and checking sensed voltage, if the voltage increases then the sensor is hot, if the voltage fails to increase then there is a short and the PCM will set a fault.

This dual-ranging is done because the sensor covers a range of 300° F. The PCM requires an accuracy that cannot be achieved using a 5 volt signal with one sensor for this great a range. Therefore this dual curve programming allows us to get the necessary resolution using one sensor.

ECT Sensor Diagnostics

There are four ECT diagnostic routines:

- ECT too high
- ECT too low
- ECT too cold too long.
- Closed loop temperature not reached

The ECT too cold too long fault is set when the ECT is between 19°–212°F at start up and the engine runs for 14 minutes under any condition then runs another 14 minutes above 28 mph and ECT does not reach 160°F.

The closed loop temperature not reached fault is set when the engine does not reach a calibrated (approximately 50°F) temperature within approximately 5 minutes.

ECT Sensor Limp-in

When the ECT sensor indicates a voltage that is too high (4.9 volts for 3 sec.) or too low (.5 volts for 3 sec.), the PCM sets a DTC. When a DTC is set, the MIL is illuminated and the PCM moves into limp-in mode. Limp-in mode for the ECT sensor is a preset value and the radiator fans operate at high speed.

CCD Bus

On NS/JA/JX vehicles the engine coolant temperature information is bused from the PCM to the Body Control Module (BCM). From the BCM it is bused to the instrument cluster.

ACTIVITY 6 - ENGINE COOLANT TEMPERATURE SENSOR

2.0L SOHC-PL/JA

Activities

1. Using a voltmeter, measure the voltage on the two wires. What is the voltage?
   ____

2. Plug the connector together and change the DRB to Read DTC's. What DTC is present and why? ____________________
   If the ECT sensor wire was shorted to ground, what DTC would be present?____

Hook up ECT on stimulator. Rotate potentiometer and watch values on custom display. Note RPM increase at high temp. Do it again with engine on. Then, short the circuit to ground.

3. Connect BOB and DRB III. Build a custom display:
   - Coolant Temp Degrees
   - Coolant Temp Voltage
   - Engine RPM
   - Target Idle
   - Inj. Pulse Width
   - Upstream O2 Voltage
   - Closed Loop Timer
   - IAC Steps
   - Spark Advance

   Find the sensor on the vehicle and unplug the connector. What does the DRB indicate for temperature and voltage? ____________________

4. Using the simulator and DRB, change the ECT output to read 0^0 F. What happened to IAC, target idle and injector pulse width? ____________________
   Why? ____________________

5. Slowly increase the temperature toward hot. As you increased the temperature what happened to the voltage? ____________________
   Why? ____________________

6. Using the simulator and DRB, change the ECT output to read 240^0 F. What happened to IAC, target idle and injector pulse width? ____________________
   Why? ____________________

2.0L DOHC-PL/JA

Activities

1. Using a voltmeter, measure the voltage on the two wires. What is the voltage?
   ____

2. Plug the connector together and change the DRB to Read DTC's. What DTC is present and why? ______________________________
   If the ECT sensor wire was shorted to ground, what DTC would be present? ____

Hook up ECT on stimulator. Rotate potentiometer and watch values on custom display. Note RPM increase at high temp. Do it again with engine on. Then, short the circuit to ground.

3. Connect BOB and DRB III. Build a custom display:
   - Coolant Temp Degrees
   - Upstream O2 Voltage
   - Engine RPM
   - Target Idle
   - Inj. Pulse Width
   - Upstream O2 Voltage
   - Closed Loop Timer
   - IAC Steps
   - Spark Advance

   Find the sensor on the vehicle and unplug the connector. What does the DRB indicate for temperature and voltage? ______________________

4. Using the simulator and DRB, change the ECT output to read 0° F. What happened to IAC, target idle and injector pulse width? ______________
   Why? ______________________________________

5. Slowly increase the temperature toward hot. As you increased the temperature what happened to the voltage? ______________________
   Why? ______________________________________

6. Using the simulator and DRB, change the ECT output to read 240° F. What happened to IAC, target idle and injector pulse width? ______________
   Why? ______________________________________

2.0L DOHC-F22/F24S

Activities

1. Using a voltmeter, measure the voltage on the two wires. What is the voltage?
   ____

2. Plug the connector together and change the DRB to Read DTC's. What DTC is present and why? ______________________
   If the ECT sensor wire was shorted to ground, what DTC would be present?____

Hook up ECT on stimulator. Rotate potentiometer and watch values on custom display. Note RPM increase at high temp. Do it again with engine on. Then, short the circuit to ground.

3. Connect BOB and DRB III. Build a custom display:
   - Coolant Temp Degrees
   - Upstream O2 Voltage
   - Engine RPM
   - Target Idle
   - Inj. Pulse Width
   - Upstream O2 Voltage
   - Closed Loop Timer
   - IAC Steps
   - Spark Advance

   Find the sensor on the vehicle and unplug the connector. What does the DRB indicate for temperature and voltage? ______________________

4. Using the simulator and DRB, change the ECT output to read 0° F. What happened to IAC, target idle and injector pulse width? ______________________
   Why? ____

5. Slowly increase the temperature toward hot. As you increased the temperature what happened to the voltage? ______________________
   Why? ____

6. Using the simulator and DRB, change the ECT output to read 240° F. What happened to IAC, target idle and injector pulse width? ______________________
   Why? ____

2.4L DOHC-JA/JX/NS

Activities

1. Using a voltmeter, measure the voltage on the two wires. What is the voltage?
   ____

2. Plug the connector together and change the DRB to Read DTC's. What DTC is present and why? ____________________
   If the ECT sensor wire was shorted to ground, what DTC would be present? ____

Hook up ECT on stimulator. Rotate potentiometer and watch values on custom display. Note RPM increase at high temp. Do it again with engine on. Then, short the circuit to ground.

3. Connect BOB and DRB III. Build a custom display:
   - Coolant Temp Degrees
   - Upstream O2 Voltage
   - Engine RPM
   - Target Idle
   - Inj. Pulse Width
   - Upstream O2 Voltage
   - Closed Loop Timer
   - IAC Steps
   - Spark Advance

   Find the sensor on the vehicle and unplug the connector. What does the DRB indicate for temperature and voltage? ____________________

4. Using the simulator and DRB, change the ECT output to read 0^{0} F. What happened to IAC, target idle and injector pulse width? ____________________
   Why? ____________________

5. Slowly increase the temperature toward hot. As you increased the temperature what happened to the voltage? ____________________
   Why? ____________________

6. Using the simulator and DRB, change the ECT output to read 240^{0} F. What happened to IAC, target idle and injector pulse width? ____________________
   Why? ____________________

Intake Air Temperature (IAT) Sensor

The IAT sensor sends information to the PCM on the density of the air entering the manifold, based upon temperature. The PCM uses this input to calculate the following:

- Injector pulse-width
- Adjustment of spark timing (to prevent knock with high-intake air temperatures)

The IAT sensor has the most authority at cold temperatures and during Wide Open Throttle (high RPM, low manifold vacuum). At a temperature of -20° F and Wide Open Throttle, the PCM can increase fuel injector pulse-width by as much as 37%, based upon input from the IAT sensor.

The PCM sends 5 volts to the sensor and is grounded through the sensor return line (fig 36). As temperature increases, resistance in the sensor decreases. The resistance of the IAT sensor is the same as for the ECT sensor. The differences between the IAT sensor and the ECT sensor are as follows:

- Connectors are indexed differently
- IAT sensor thread diameter is smaller
- IAT sensor material is exposed through a plastic cage (to quicken response time)

The IAT sensor and its circuit function exactly the same as the ECT sensor and its circuit.

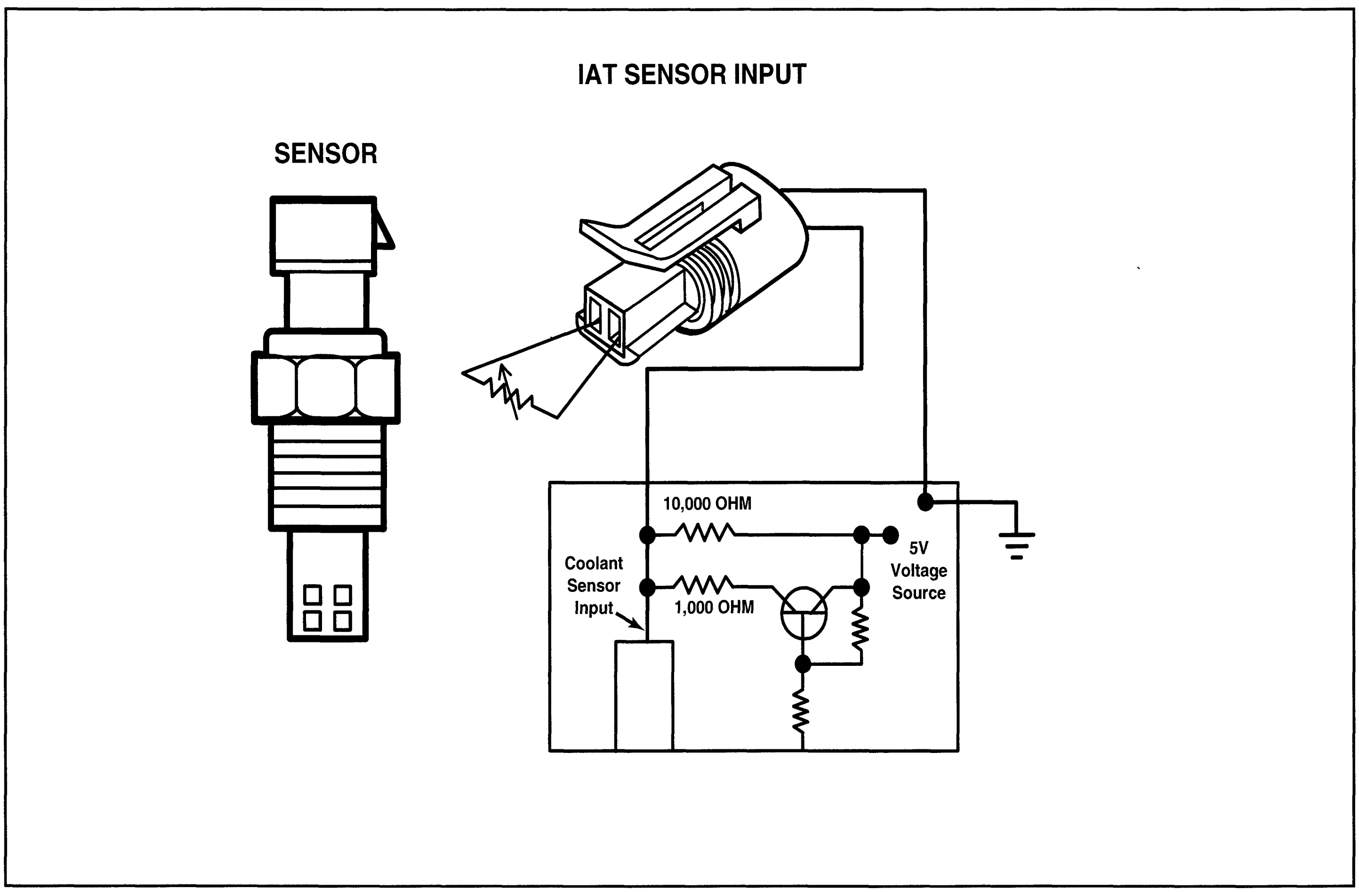


Figure 36 Intake Air Temperature Sensor Circuit

The PCM has a dual temperature-range program for better sensor accuracy at cold temperatures. At key-ON, the PCM sends a regulated 5 volt signal through a 10,000 ohm resistor to the IAT sensor. The A/D converter monitors this voltage signal as it passes through the IAT sensor to ground. The A/D converter registers the voltage drop across the IAT sensor and then converts the signal into a binary code. When the voltage drop reaches approximately 1.25 volts, the PCM turns on a transistor. The transistor connects a 1,000 ohm resistor in parallel with the 10,000 ohm resistor. With this drop in resistance, the A/D converter recognizes an increase in voltage (fig. 36, on page 58) on the input circuit. The program allows the PCM to have a full binary control at cold temperatures up to approximately 120^{0} F, and a second full binary control at temperatures over 120^{0} F.

At key ON the PCM assumes a cold engine. Five volts is sent through the 10K resistor out to the sensor element to ground. If the engine is cold the resistance of the element is high and thus there is very little voltage drop through the thermistor and the corresponding sensed voltage is high. If the sensed voltage at key ON is low, this indicates it could either be a warm engine or a short in the circuit. A transistor is turned on adding a 1k resistor in parallel to the 10k resistor. Using ohms law for parallel circuits gives us a new total resistance of 909 ohms. By changing the known resistance and checking sensed voltage, if the voltage increases then the sensor is hot, if it fail to increase then there is a short and the PCM will set a fault.

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.

IAT Sensor Limp-in

When the IAT sensor indicates a voltage that is too high or too low, the PCM sets a DTC. When the DTC is set, the MIL is illuminated and the PCM moves into limp-in mode. The IAT sensor uses the ECT sensor's information, as long as the information is believed to be accurate. If the ECT is already in limp-in, the PCM uses a temperature that has very little effect on fuel and spark programming.

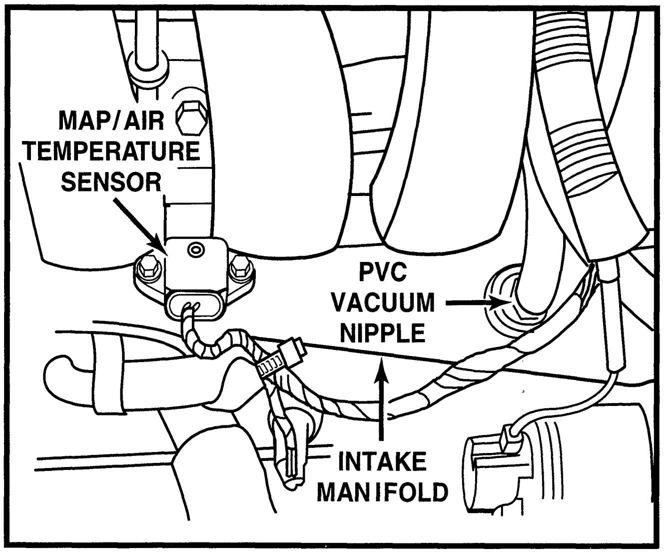


Figure 37 Intake Air Temperature Sensor-2.0L SOHC

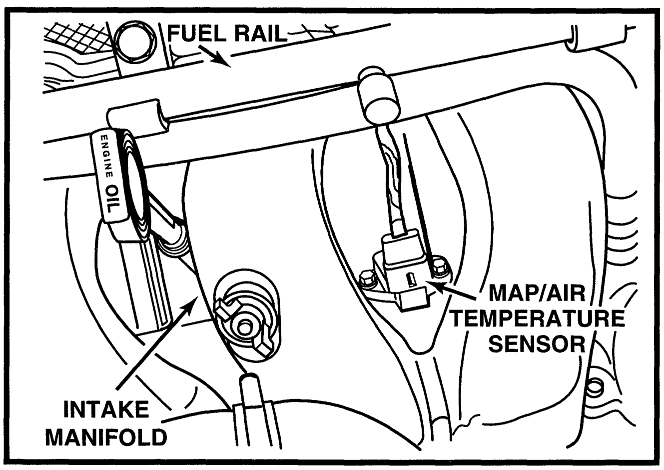


Figure 38 Intake Air Temperature Sensor-2.0L DOHC

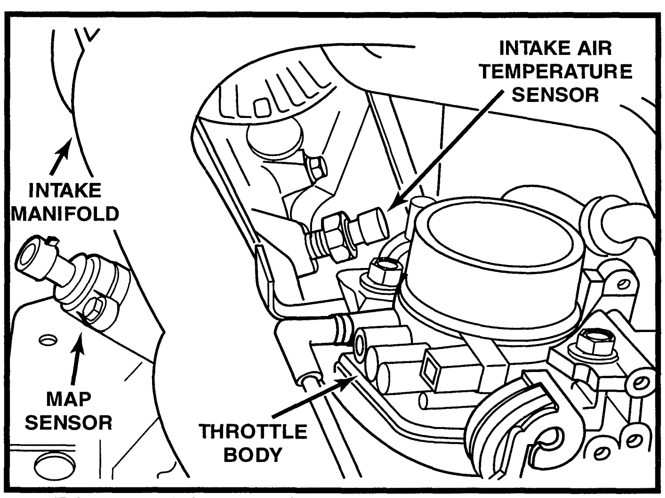


Figure 39 Intake Air Temperature Sensor-2.4L DOHC

Component Locations

2.0L SOHC-PL/JA

The IAT and Manifold Absolute Pressure (MAP) sensors are combined into a single sensor that attaches to the intake manifold (fig. 37).

2.0L DOHC-PL/JA

The IAT and Manifold Absolute Pressure (MAP) sensors are combined into a single sensor that attaches to the intake manifold (fig. 38).

2.0L DOHC-F22/F24S

The IAT sensor is threaded into the intake manifold, on the back side of the manifold.

2.4L DOHC-JA/JX/NS

The intake air temperature sensor threads into the intake manifold plenum. New sensors have sealant applied to the threads (fig. 39).

ACTIVITY 7 — INTAKE AIR TEMPERATURE SENSOR

Activities

1. Using a voltmeter, measure the voltage on the two wires. What is the voltage?
   ____

2. Plug the connector together and change the DRB to Read DTC's. What DTC is present and why? ______________________________
   If the IAT sensor wire was shorted to ground, what DTC would be present? ____

Hook up IAT on stimulator. Rotate potentiometer and watch values on custom display. Note RPM increase at high temp. Do it again with engine on. Then, short the circuit to ground.

3. Connect BOB and DRB III. Build a custom display:
   - Coolant Temp Degrees
   - Upstream O2 Voltage
   - Engine RPM
   - Target Idle
   - Inj. Pulse Width
   - Upstream O2 Voltage
   - Closed Loop Timer
   - IAC Steps
   - Spark Advance

   Find the sensor on the vehicle and unplug the connector. What does the DRB indicate for temperature and voltage? ______________________________

4. Using the simulator and DRB, change the IAT output to read 0^0 F. What happened to IAC, target idle and injector pulse width? ______________________________
   Why? ______________________________

5. Slowly increase the temperature toward hot. As you increased the temperature what happened to the voltage? ______________________________
   Why? ______________________________

6. Using the simulator and DRB, change the IAT output to read 240^0 F. What happened to IAC, target idle and injector pulse width? ______________________________
   Why? ______________________________

SENSED BATTERY VOLTAGE

The direct battery circuit to the PCM is also used as a reference point to sense battery voltage.

Fuel Injectors

Fuel injectors are rated for operation at a specific voltage. If the voltage increases, the plunger will open faster and further (more efficient) and conversely, if voltage is low the injector will be slow to open and will not open as far. So, if sensed battery voltage drops, the PCM will increase 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 Temperature Sensor) is being reached. To maintain the target charging voltage, the PCM will full field the generator to .5 volts above target then turn off to .5 volts below target. This will continue to occur up to a 100Hz frequency, 100 times per second.

OXYGEN (O2) SENSORS

General Information

In 1996, all vehicles use two O2 sensors. An O2 sensor provides the PCM with a voltage signal (0-1 volt) inversely proportional to the amount of oxygen in the exhaust. In other words, 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.

An O2 sensor must have a source of oxygen from outside of the exhaust stream for comparison. Current O2 sensors receive their fresh oxygen supply through the wire harness. This is why it is important to never solder an O2 sensor connector or pack the connector with grease (fig. 40).

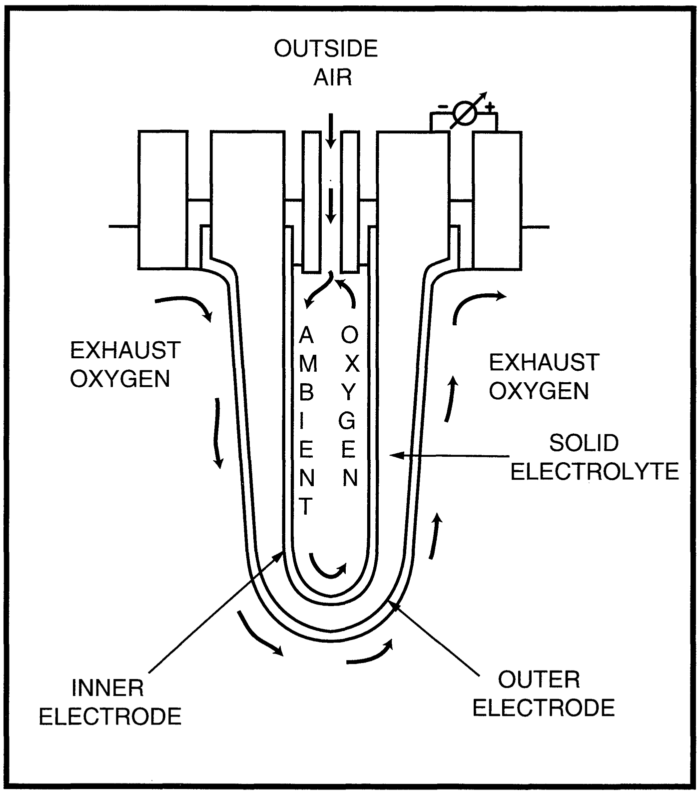


Figure 40 Oxygen Sensor Internal Operation

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

Both O2 sensors are zirconium dioxide, 4-wire, and heated. The heaters on both sensors are fed battery voltage from the ASD relay which is also controlled by the PCM (refer to ASD relay for more information). Both sensor heaters uses a common ground. One of the other two wires is the input to the PCM and the last wire is the sensor ground. Both circuits are isolated from each other and the sensor housing.

The O2 sensor uses a Positive Thermal Co-efficient (PTC) heater element. As temperature increases, resistance increases. At ambient temperatures around 70^0 F, the resistance of the heating element is approximately 6 ohms. As the sensor's temperature increases, resistance in the heater element increases. Even though these are heating elements, current flow is low. At 70°F current flow is approximately 600 milliamps. As it approaches operating temperature, it drops to approximately 200 milliamps. This allows the heater to maintain the optimum operating temperature of approximately 930^0-1100^0 F (500^0-600^0 C). Although both sensors operate the same there are physical differences, due to the environment that they operate in, that keep them from being interchangeable.

Stoichiometric Ratio

Engineers found they could maximize catalyst efficiency to a point that would minimize hydrocarbon, carbon monoxide and nitrous oxide emissions by controlling the air-fuel ratio. This air-fuel ratio is 14.7 to 1 (ideal for both fuel efficiency and emission control). In other words, 14.7 units of air are mixed with every unit of fuel to produce the minimum amount of emissions. This ratio is called the stoichiometriic (stoy-key-oh-met-rick) ratio (fig. 41).

However, conditions inside an engine's combustion chamber are not ideal. There just isn't enough time in the engine's operating cycle to allow complete combustion to take place. So, 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.

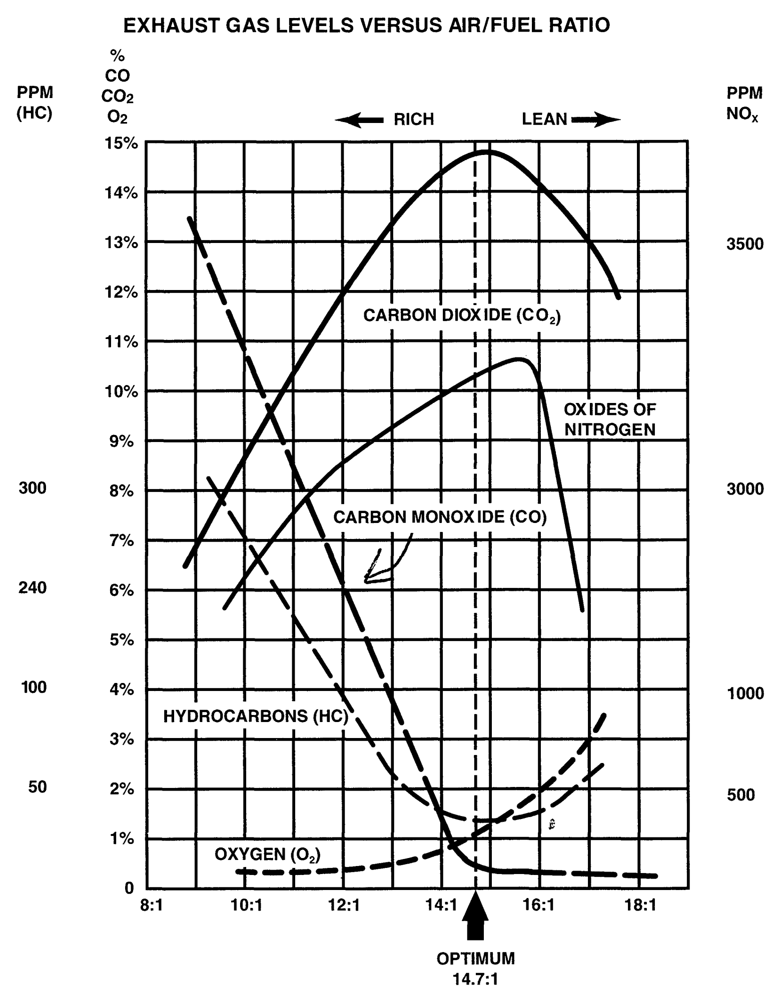


Figure 41 Exhaust Emissions vs. Air/Fuel Ratio

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 (fig. 42). 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.

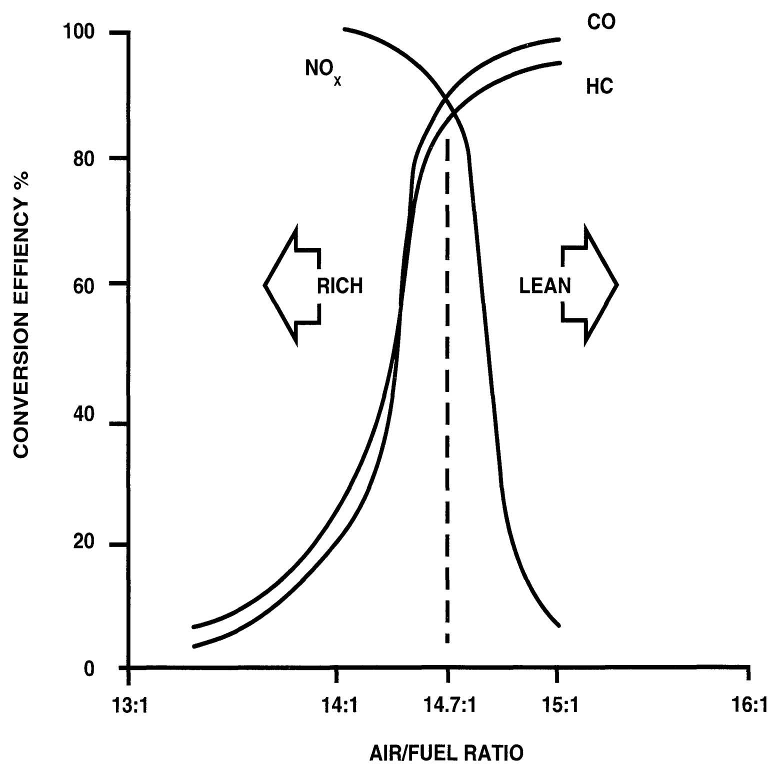


Figure 42 Conversion Efficiencies of a Three-Way Catalyst

O2S Electrical Operation

When the O2S is cold the resistance of the sensor is extremely high (infinite). As the sensor heats up two things happen. First, the resistance of the sensors drops. Second, once it heats to a certain temperature, above 660° F, the sensor becomes a galvanic battery, actually creating a voltage output.

The PCM must be able to power up the heaters, read an input voltage and diagnose the circuit and the operation of the sensors (fig. 43). To be able to do all this, the PCM uses a voltage divider circuit. A .5 volt bias is applied to the sensor as soon as the key is turn ON. This .5 volt allows the PCM to diagnose the sensor and its circuit. While the engine is heating up the PCM expects to see this .5 volt drop as the resistance of the sensor decreases. If it drops too low, this indicates a short to ground. If the voltage does not drop, there is either an open circuit or a bad sensor.

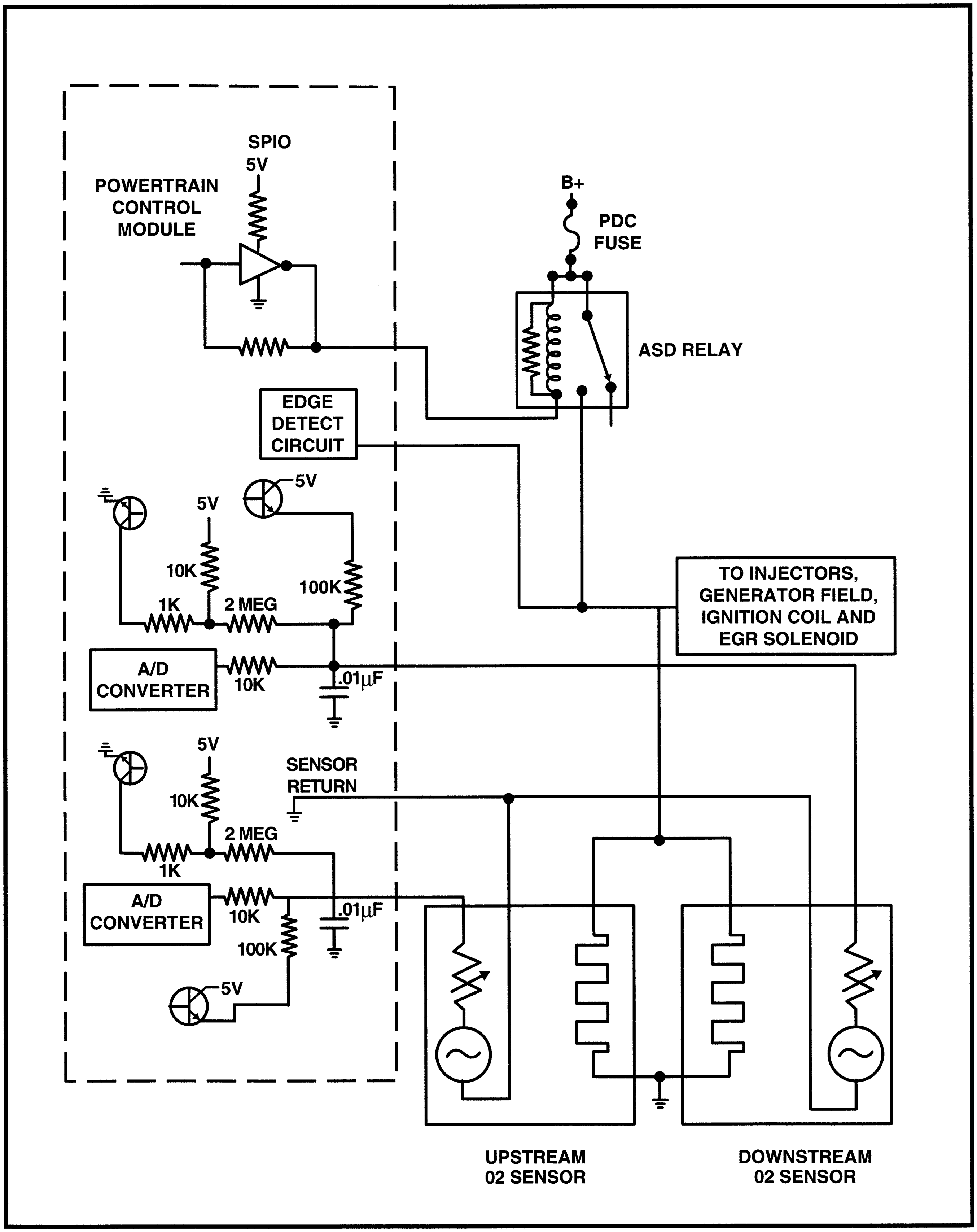


Figure 43 Dual O2 Sensor Circuit

If the voltage stays at .5 volts the PCM must determine whether the sensor is bad or if the circuit is open. To do this, 5 volts are pulsed to the sensor line for 30 seconds. Five volts is used because .5 volts could be an actual sensor voltage and the PCM has to overcome the sensor output. If the 5 volts decreases, then the sensor and circuit are good. If the 5 volts does not change then something is wrong with the sensor, sensor circuit or ground circuit. This would be displayed on the DRB III as an O2 Stays At Center fault.

When the engine is at operating temperature and input voltage from the sensor is higher than 1.2 volts, then the PCM considers the line shorted to voltage and sets a fault.

O2 Sensor Diagnostics

- O2 shorted to ground. At a cold start, ECT below 170° F, if O2S voltage is below .156 volts the fault is set.
- O2 shorted to voltage is set if the engine is running, ECT is above 176°F and voltage is above 1.2 volts.
- O2 stays at center is set if voltage stays between .39 volts and .52 volts during a trip.
- There are also tests required for OBD II. Refer to OBD II section for test descriptions.

Upstream O2 Sensor

The upstream sensor is located on the exhaust manifold and is used to maintain an Air/Fuel (A/F) ratio of approximately 14.7:1 (stoichiometric). This accomplished by the fact that an O2 sensor acts like a switch when the A/F ratio is near 14.7:1 (fig. 44). When the A/F is lean (extra oxygen) the sensor output will be very close to 0 volts. As the A/F becomes richer (less oxygen) the sensor output will change rapidly to .5 volts and can continue movement up to 1 volt if the mixture becomes too rich. Based on these operating characteristics, the PCM can be programmed with switch points to maintain the proper A/F ratio. The O2 sensor must reach a minimum of 660° F in order to effectively monitor oxygen content in the exhaust system. To provide optimum functioning of the O2 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.

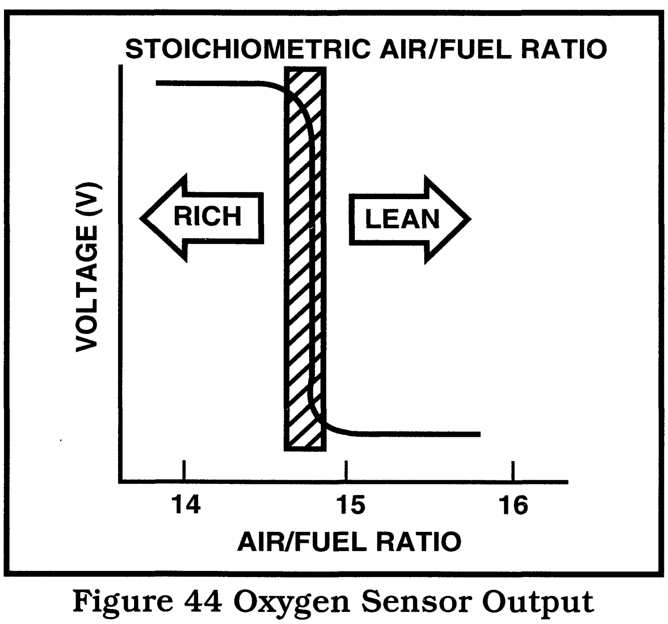


Figure 44 Oxygen Sensor Output

Closed loop parameters are as follows:

- Engine temperature exceeds 35° F
- O2 sensor is in the ready mode
- All timers have timed out, following the START to RUN transfer (the timer lengths vary, based upon engine temperature at key-on) as follows:
  - 35° F - 41 sec.
  - 50° F - 36 sec.
  - 70° F - 19 sec.
  - 167° F - 11 sec.

These times and temperatures may vary for each engine package.

During closed loop, the feedback systems begin to operate.

ACTIVITY 8 — UPSTREAM O2

Have the instructor assign you to a vehicle equipped with either a 2.0L or 2.4L engine. Use the Service Manual and DRB III to assist in answering the following questions.

1. With a cold engine, open the O2S signal switch on the breakout box. Using a DRB, what is the voltage on the PCM side of the circuit? ____________________
   What is the voltage on the O2S side? ____

2. Connect a jumper wire from the PCM side of the switch to your hand. With your other hand, touch the positive battery terminal. What voltage does the DRB indicate? ____

3. Using the DRB, perform the O2 heater test. How long did it take for the voltage to begin dropping? ____
   How long did it take for the voltage to reach single digits? __________________

Downstream O2 Sensor

As mentioned previously, the downstream O2S has two functions. One function is measuring catalyst efficiency. This is an OBD II requirement. Briefly, 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 O2S switch rates under specific operating conditions to determine if the catalyst is functioning properly. Refer to the OBD II Training Course for more information.

The other function is something new with 96 model year vehicles equipped with SBEC III PCM's. While the upstream O2S input is used to maintain the 14.7:1 A/F, 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 will fine tune the A/F ratio entering the catalyst based upon the oxygen content leaving the catalyst. This is accomplished by modifying the upstream O2S voltage goal. In the past this goal was a preprogrammed fixed value based upon where it was believed the catalyst operated most efficiently. With the new downstream O2S fuel control, the upstream O2 goal is moved up and down within the window of operation of the O2 sensor. If the oxygen content leaving the catalyst is too lean (excess oxygen) the PCM will move the upstream O2 goal up which will increase fuel in the mixture causing less oxygen to be left over. Conversely, if the oxygen content leaving the catalyst is too rich (not enough oxygen) the PCM will move the upstream O2 goal down which will remove fuel from the mixture causing more oxygen to be left over.

This function only occurs during cruise mode operation.

OBD II

There are several OBD II tests that are performed by and on the O2 sensors. A brief description of each follows.

Catalyst Monitor

The downstream O2 sensor measures the content of the O2 passing through the catalytic converter. Normally, the downstream O2 sensor's switch rate is extremely slow compared to the upstream sensor's rate. As the converter deteriorates, the O2 sensor's switch rate increases. The PCM can compare the signals produced by the upstream and the downstream O2 sensors to determine the operating efficiency of the catalyst.

O2 Monitor

Even though an O2 sensor maybe switching and not exceeding the thresholds, it must switch with a certain frequency to allow the PCM enough time to make correction before emissions are exceeded. When certain conditions are met (at idle) the PCM checks the switch rate of the O2 sensor. It looks for how fast it switches as well as how many times it switches within a calibrated time. As part of OBD II the PCM monitors the switching frequency under specific conditions and will set a fault if the sensor becomes slow or lazy. Refer to the OBD II course for more information.

O2 Heater Monitor

In order to allow the O2S to come up to operating temperature sooner after startup and due to the fact that prolonged idle conditions cannot maintain O2 sensor temperature an O2 heater is utilized. If these fail to function it could cause vehicle emissions to increase under certain conditions. OBD II requires that these heaters be monitored for proper operation. If certain conditions have been met before the key is turned off, the ASD relay is re-energized after key Off and a test is performed.

The heater element itself is not tested. The resistance in oxygen sensors output circuits is tested to determine heater operation. The resistance is normally between 100 ohms and 4.5 megaohms. When oxygen sensor temperature increases, the resistance in the internal circuit decreases. The PCM sends a 5 volt biased signal through the oxygen sensors to ground this monitoring circuit. As the temperature increases, resistance decreases and the PCM detects a lower voltage at the reference signal. Inversely, as the temperature decreases, the resistance increases and the PCM detects a higher voltage at the reference signal.

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 memory or short term correction (fig. 45). This system corrects fuel delivery in direct proportion to the readings from the upstream O2 sensor. In other words, as the Air/Fuel (AF) mixture changes the O2 sensor voltage telling the PCM that the AF ratio contains either more or less oxygen. The PCM then begins to either add or remove fuel until the O2 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 O2 sensor's output voltage indicates the switch point in the opposite direction. Short term adaptive memory will keep increasing or decreasing injector pulse width based upon the O2 sensor input. The maximum range of authority for short term memory is ±25% of base pulse width.

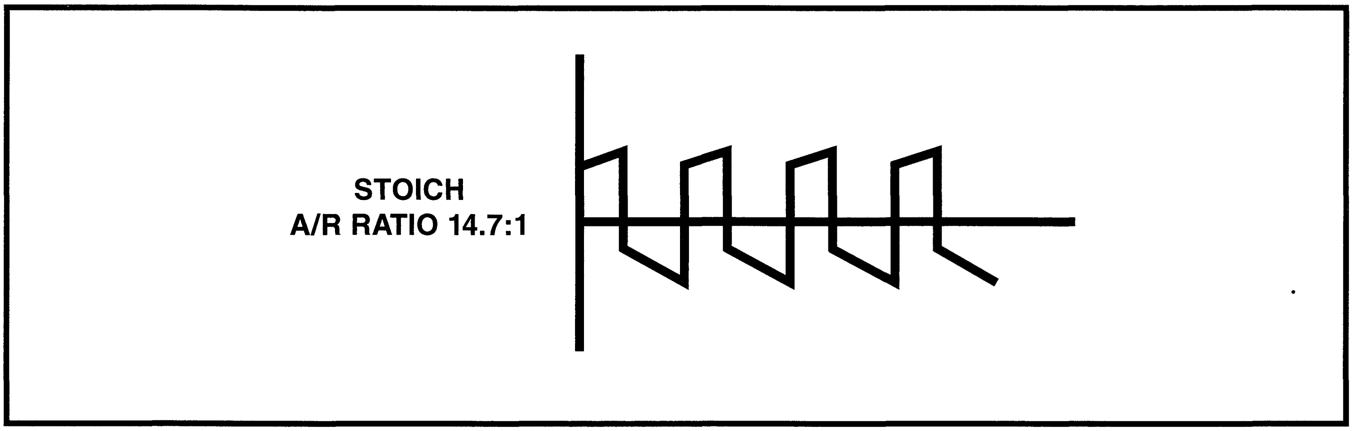


Figure 45 Short Term Fuel Compensation

For example, if there is a low fuel pressure problem, the O2 sensor will start moving toward 0 volts, lean mixture (excess oxygen). Short term fuel correction will begin to add fuel and continue to add, up to 25% of total pulse width, until the O2 sensor begins switching again.

The PCM's goal is to keep the O2 sensor switching around the goal voltage.

	Open Throttle						Idle	Decel*
Vacuum	20	17	13	9	5	0		
ABOVE ~~1984~~ RPM	1	3	5	7	9	11	13 Drive	15
BELOW ~~1984~~ RPM	0	2	4	6	8	10	12 Neutral	14
MAP Volt.	0	1.4	2.0	2.6	3.3	3.9		

* IF EQUIPPED.

Table 5 Adaptive Memory Fuel Cells

Long Term Adaptive Memory

The second system is called Long Term adaptive memory (fig. 46). In order to maintain correct emission throughout all operating ranges of the engine, it was decided that a cell structure based on engine RPM and Load (MAP) should be used (Table 5). There are up to 16 cells. 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 12 cells represent a manifold pressure and an RPM range. Six of the cells are high RPM and the other six are low RPM. Each of these cells are a specific MAP voltage range. The values shown in Table 5 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 (O2 switching at .5 volts) Long Term will update 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 will be 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 will be added because it knows there was a problem in that cell, hence the name Long Term. Long Term adaptive can change the pulse width by as much as 25%, which means it can correct for all of short term. It is possible to have a problem that would drive long term to 25% and short term to another 25% for a total change of 50% away from base pulse width calculation.

Short and Long Term is expressed as a percentage of Pulse Width change.

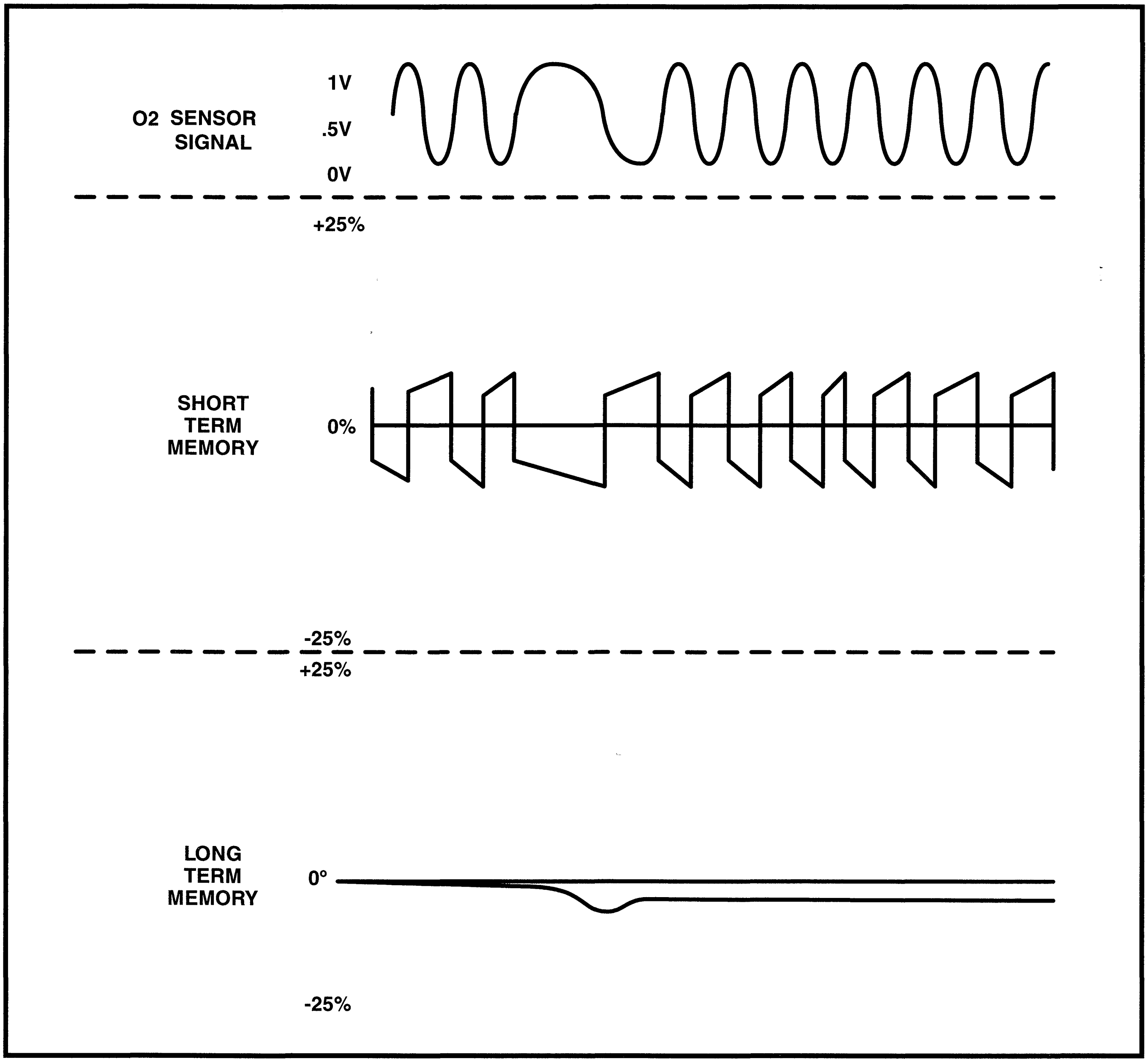


Figure 46 Long Term Fuel Compensation

Purge-Free Cells

Purge-free memory cells are used to identify the fuel vapor content of the evaporative canister. 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. For example: the 2.0L DOHC purge-free cells have the same RPM and MAP structure of cells 12, 4 and 5. The purge-free cells can be monitored by the DRB III scan tool. They are represented by "Idle Purge-free Cell, Purge-free Cell 2 and Purge-free Cell 3". The only difference between the purge-free cells and normal adaptive cells is that in purge free, the purge is completely turned off. This gives the PCM the ability to compare 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 will replace the value in long term memory with the corresponding purge-free cell value. The cells that do not have corresponding purge free will be replaced with the largest purge free value (fig. 47). If a cell is already higher than the highest purge-free it will not be changed.

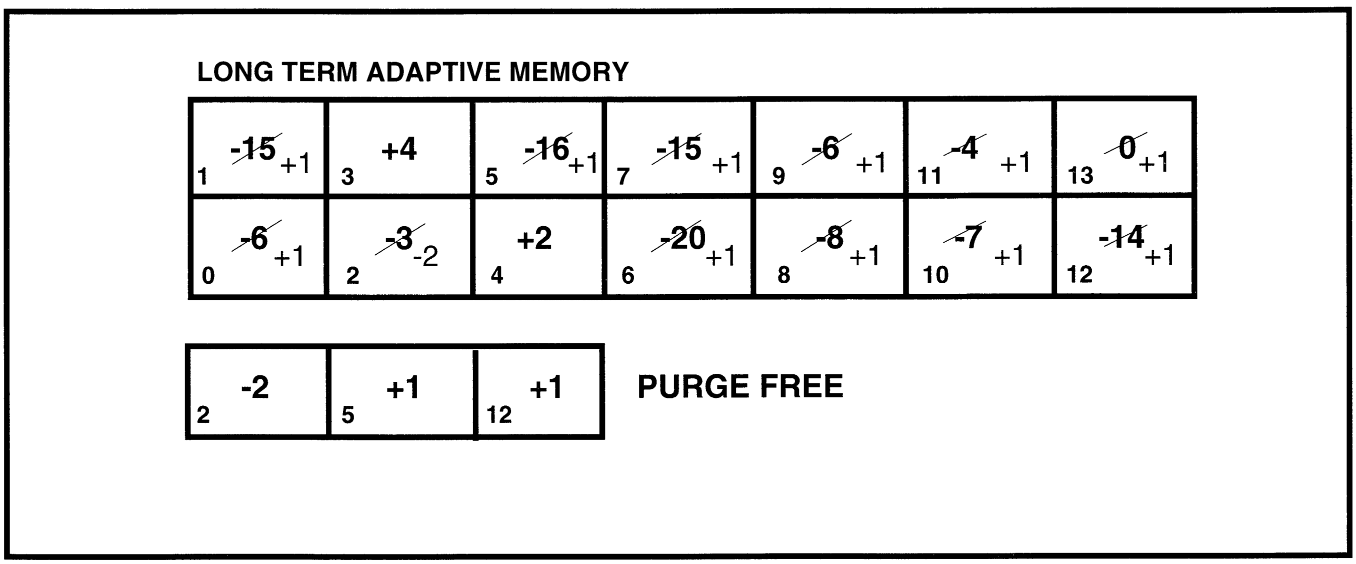


Figure 47 Purge Corruption Reset

DRB Display

The DRB can be used to display both of these systems. The Long Term memory cells are shown with the long term correction factor in each cell. The Short Term correction is always changing and is displayed above the long term memory cells. The DRB displays long term adaptive memory cells similar to Table 5.

ACTIVITY 9 — FUEL ADAPTIVE MEMORY

Instructions
Have the instructor assign you to a vehicle. Using the appropriate Service Manual or Powertrain Diagnostic Procedures Manual as reference material, answer the following questions.

1. With the engine running, reduce fuel pressure using the simulator. What happened to adaptive memories? ________________________________

Restore fuel pressure.

2. Using the simulator, change ECT both hotter and colder. What happened to adaptive memories? ________________________________
   Why? ________________________________

3. Using the simulator, change MAP both up and down. What happened to adaptive memories? ________________________________
   Why? ________________________________

4. Using the simulator, change IAT voltage both up and down. What happened to adaptive memories? ________________________________
   Why? ________________________________

5. Using the simulator, change upstream O2 voltage both up and down. What happened to adaptive memories? ________________________________
   Why? ________________________________

6. Pull off a spark plug wire. What happened to adaptive memories? ____________
   ____

7. Using the simulator, change downstream O2 voltage and watch upstream O2 goal voltage. What happened to the goal voltage? ________________________________
   Why? ________________________________

KNOCK SENSOR

The knock sensor consists of a piezoelectric material that constantly vibrates, sending an AC voltage signal to the PCM when the engine is running. The sensor is designed to produce a voltage at a specific frequency. The voltage signal produced increases with the amplitude of vibration. The PCM looks at the top half of the A/C input (half wave rectification). If the knock sensor generates a voltage that peaks beyond a predetermined threshold, the PCM will store that value in memory and retard timing.

Due to the variation in engine mounting and vehicle dynamics, knock may occur at a different frequency on the same engine. This means that knock sensors are designed for each vehicle/engine and should not be interchanged.

When the signal reaches a preset threshold, the PCM retards ignition timing to reduce engine knock.

The Knock Sensor's output is delivered to the PCM (fig. 48).

To obtain a clean signal the PCM outputs a .5 volt bias voltage. The PCM changes the .5 to .7 during the sample time. Everytime a piston reaches 9° BTDC, the PCM begins sampling for knock. The sampling continues until the piston reaches 70° ATDC. If the knock sensor voltage exceeds a preset value, timing will be retarded on all cylinders. It is not a selective cylinder retard.

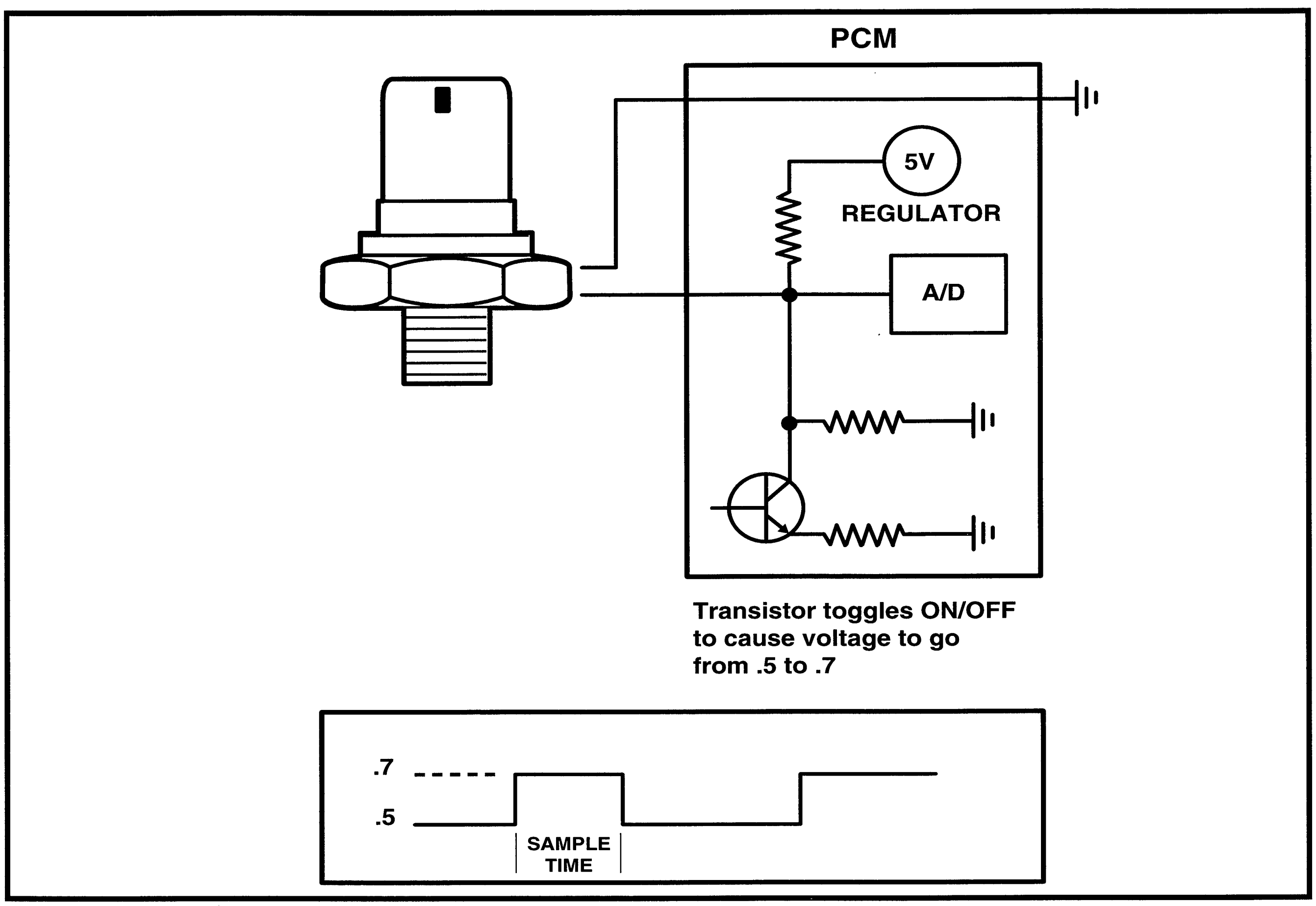


Figure 48 Knock Sensor Circuit

Knock Sensor Program

The Knock Sensor is designed to retard timing only under certain operating conditions. At idle, the PCM is programmed to disregard any Knock Sensor input. Once the engine speed exceeds a calibrated value, knock retard is allowed. Knock retard uses its own short term and long term memory program. Long term memory records previous detonation in a battery-backed RAM. The maximum authority that long term memory has over timing retard is calibrateable.

Short term memory is allowed to retard timing up to a calibrateable amount under all operating conditions (as long as RPM is above the minimum rpm) except WOT. At WOT, the PCM can retard this amount, using short term memory. The use of short term memory allows the PCM to retard timing quickly in the event of detonation, whereas long term memory builds and decays over time while the engine is running. Short term memory is lost any time the ignition key has been turned to OFF. Between short term memory and long term memory, the PCM has the authority to retard as much as 12^0 of timing.

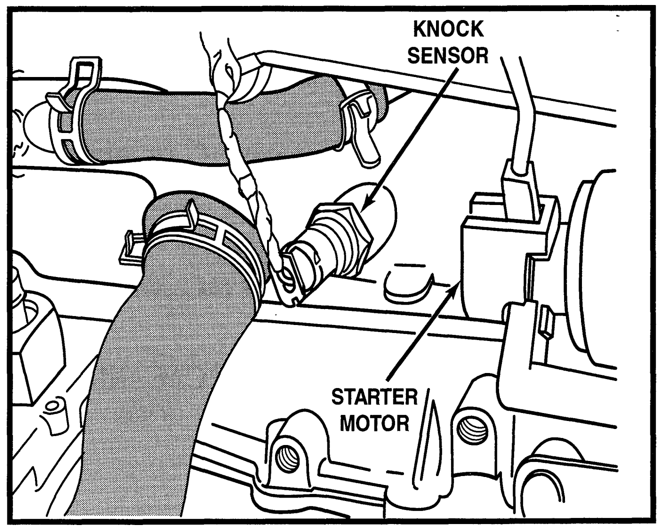


Figure 49 Knock Sensor - 2.0L SOHC/DOHC

Component Locations

2.0L SOHC/DOHC-PL/JA

The Knock Sensor is located in front of the starter motor, on the side of the engine block (fig. 49). The PL uses a two wire sensor and the JA uses a one wire sensor.

2.0L DOHC-F22/F24S

The Knock sensor is located near the Crankshaft Position sensor, on the side of the engine block.

2.4L DOHC-JA/JX/NS

The knock sensor threads into the side of the cylinder block in front of the starter (fig. 50).

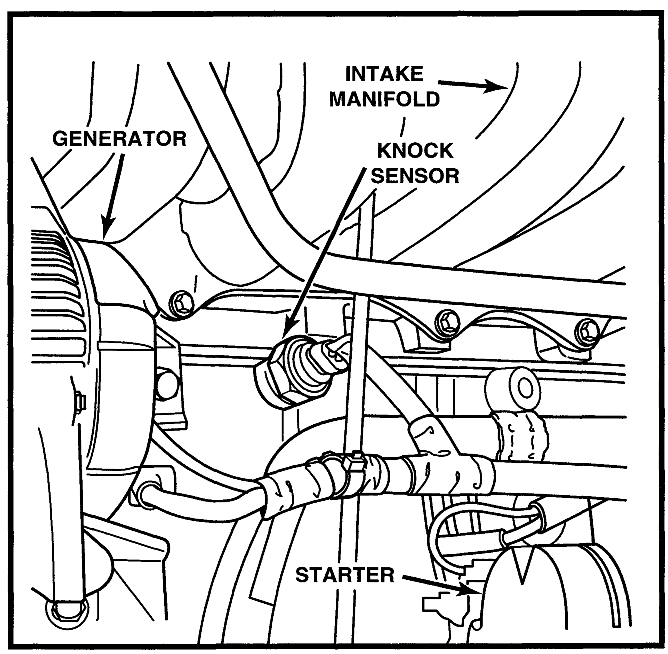


Figure 50 Sensor-2.4L DOHC

ACTIVITY 10 — KNOCK SENSOR

1. Using DRB, go to Knock Retard screen. What does it display? ________________
   - Use fluke at BOB on sensor side
   - Fluke set on A/C
   - Change fluke to D/C - should show nothing
   - Change fluke to PCM side
   - Set to D/C - should show approx. .6V
   - 2.0L shows retard 0 Degrees 2.4L doesn't

2. With the DVOM set on AC or sensor side of the harness, what kind of signal pattern does it show? ____

3. With the DVOM set on DC, what kind of signal pattern does it show? __________

4. With the DVOM on the PCM side of the harness, what voltage is shown? ______

PARK/NEUTRAL SWITCH (AUTO TRANSAXLE ONLY)

The Park/Neutral switch on vehicles with automatic transaxles is located on the transaxle housing. The Park/Neutral switch uses the same contacts as the starter relay, and provides a path to ground when the vehicle is shifted into PARK or NEUTRAL (except for NS).

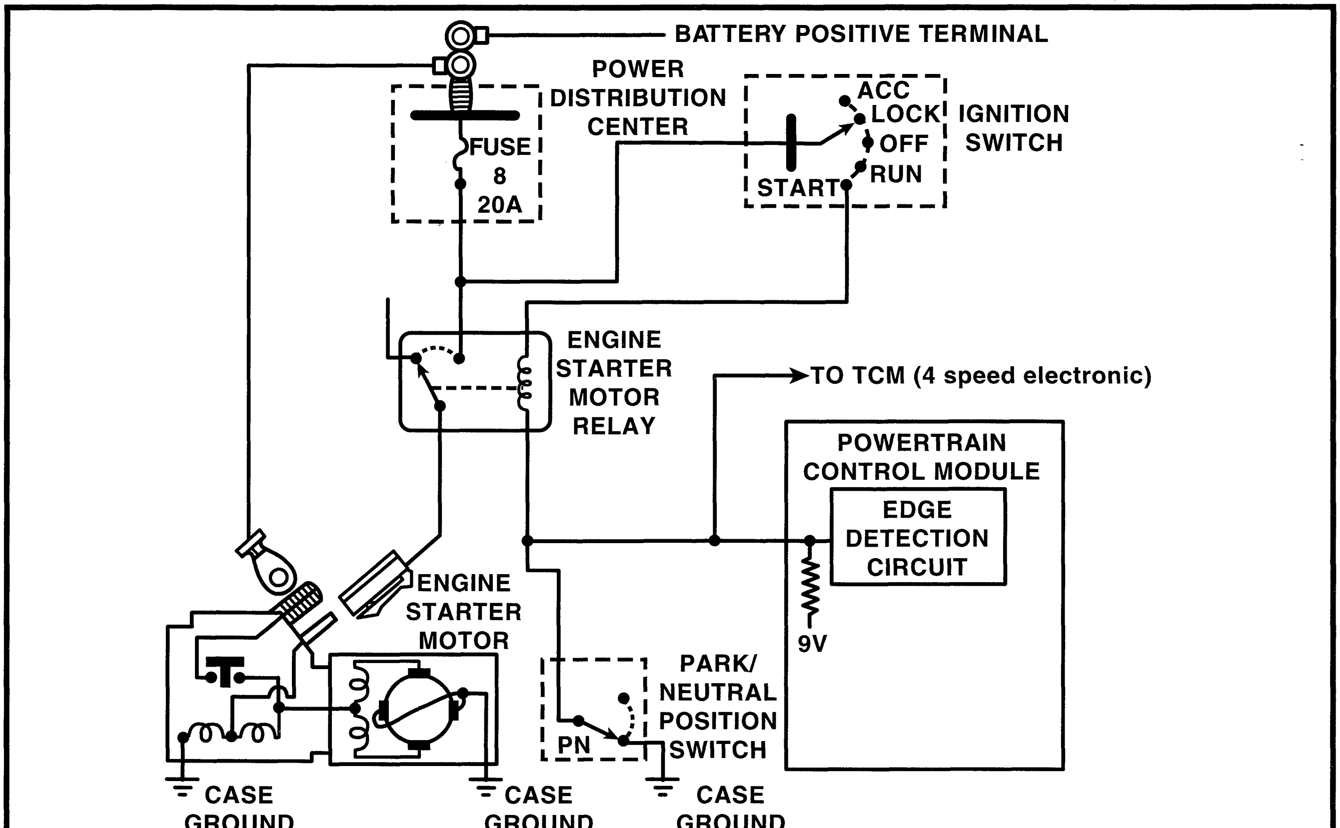


Figure 51 Park/Neutral Switch Circuit

The PCM delivers 8.5-volts to the center terminal of the Park/Neutral switch (fig. 51). 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.

The Park/Neutral switch sends a signal to both the TCM and PCM to identify gear engagement. From the time that the shift lever is moved into a forward or reverse gear until the transmission is fully engaged into a gear may be several milliseconds. When the PCM uses only the Park/Neutral switch to identify when the transmission is shifted into gear, the PCM increases the IAC steps before the transmission clutch engages, which may cause a slightly harsher engagement.

An additional feature was added to the JA vehicles' software to assist in eliminating the harsh engagement. This allows the PCM to delay the change in IAC steps until a signal is received that identifies when actual transmission engagement has occurred. This signal comes from the TCM over the CCD data bus (eminent clutch engagement). If the CCD bus has failed, the PCM will default to increasing IAC steps based strictly upon the input from the Park/Neutral position switch. Also, this function is disabled when the ECT sensor indicates that the engine temperature is 20° F or less.

The PCM uses information from the Park/Neutral switch to calculate the following:

- Spark-advance programs (idle control)
- Injector pulse-width programs (long term memory cells 12 and 13)
- Speed control disengagement
- Target idle
- Anticipation of the load increase (IAC & Timing)
- No lockup on 3 speed without P/N indication of moving to a drive gear
- There are no OBD II diagnostics in Park/Neutral
- Park/Neutral input is also used by the TCM Sense Circuit

OBD II rationality test

There is an OBD II rationality fault for the P/N switch. If the PCM sees vehicle movement, based on vehicle speed, MAP, TPS and engine RPM, and the wrong P/N state is indictated, a fault will be set. The PCM also checks for indication of P/N during start and will set a fault if the vehicle is started in Drive.

BRAKE SWITCH

The brake switch provides an input to the PCM to disengage the speed control when the brakes are applied. It is also used to influence transmission torque converter clutch disengagement, and as an indication identifying when the driver has depressed the brake pedal for some diagnostics.

On NS/JA/JX/PL, the brake switch is equipped with three sets of contacts, one normally open and the other two, normally closed (brakes disengaged) (fig. 52). On FJ22/F24S, the brake switch is equipped with two sets of contacts — one normally open and the other normally closed (brakes disengaged) (fig. 53). 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.

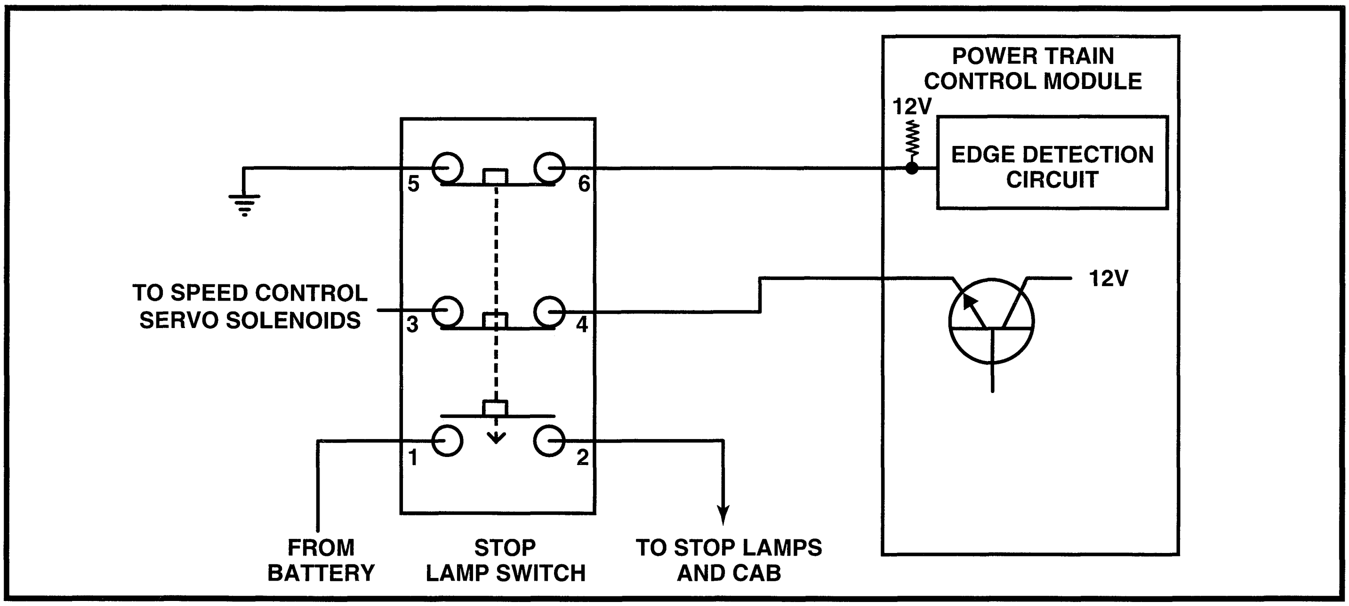


Figure 52 Brake Switch Circuit — NS/JA/JX/PL

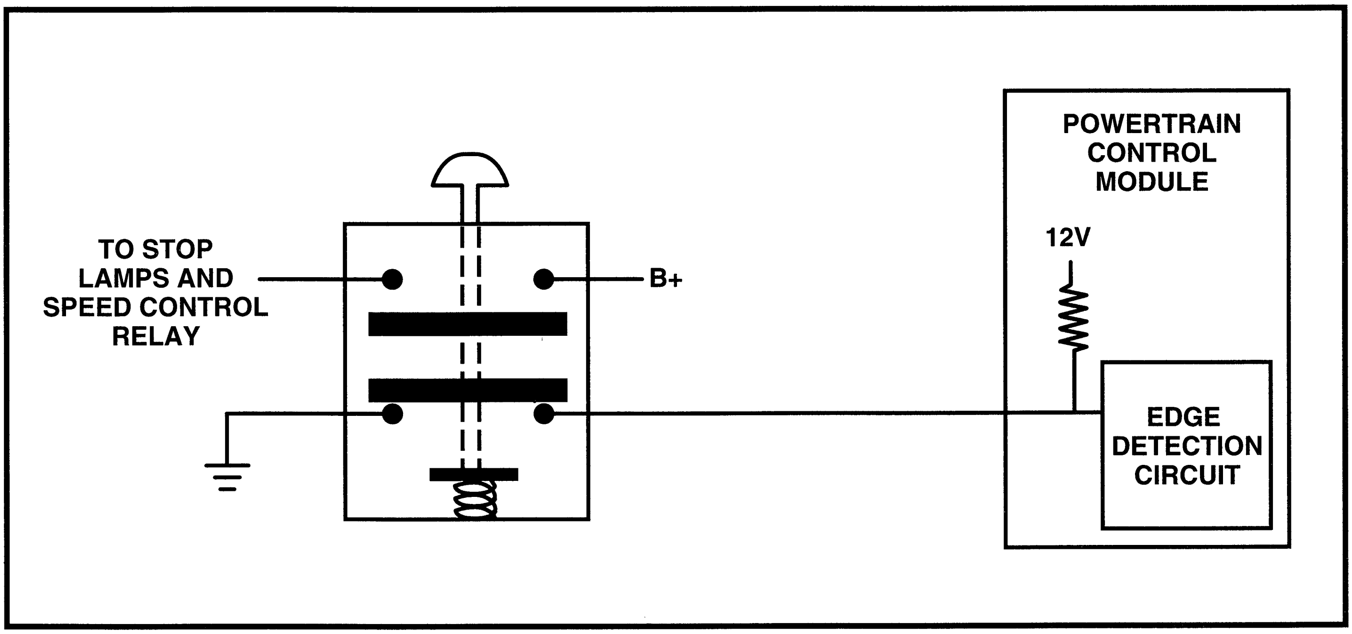


Figure 53 Brake Switch Circuit — FJ22/F24S

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

- speed control will never work
- and if the vehicle is equipped with an automatic transmission there will not be any torque converter lockup.

OBD II Rationality Test

Because a brake switch malfunction can cause all these fuel related problems it now has a rationality fault. If the PCM thinks the vehicle is moving for a calibrated amount of time with the brake pedal giving an indication of being depressed, a fault code will be set. It also sets a fault if the brake pedal is always off. Refer to the OBD II course for more information.

Component Location

The brake switch is located rearward of the brake pedal and is attached to the brake pedal sled (fig. 54).

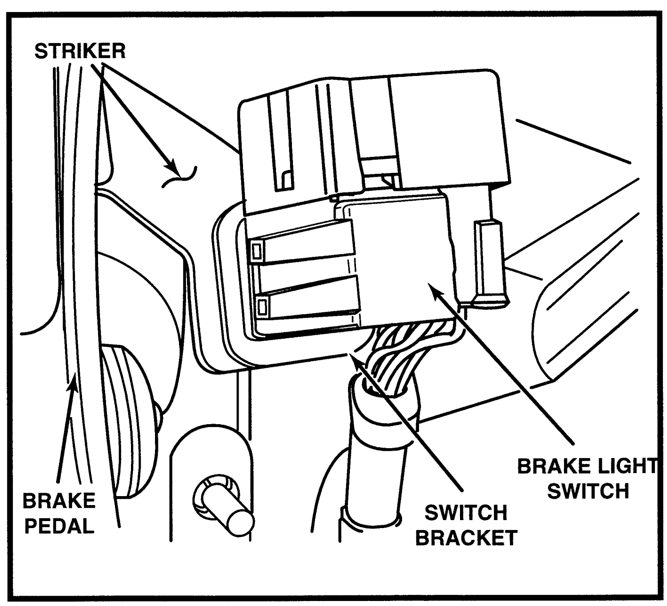


Figure 54 Brake Switch Location - JA/JX/NS/PL

VEHICLE SPEED SENSOR (VSS)

On vehicles equipped with 3 speed automatic or manual transaxles, vehicle speed is transmitted to the PCM via the Vehicle Speed Sensor, which is located in the transmission's extension housing. On vehicles equipped with 41TE automatic transaxles, the Transmission Control Module (TCM) provides the VSS signal electronically. The PCM requires the VSS to be able to control the following programs:

- Speed control
- IAC motor (during deceleration)
- Injection pulse width (during deceleration)
- OBD II diagnostics
- PCM mileage EEPROM
- Road speed Shutdown
- Speedometer/Odometer (JA/JX/NS this is bused)

NOTE: *Road Speed Shutdown is the PCM shutting off fuel injectors above a preset vehicle speed.*

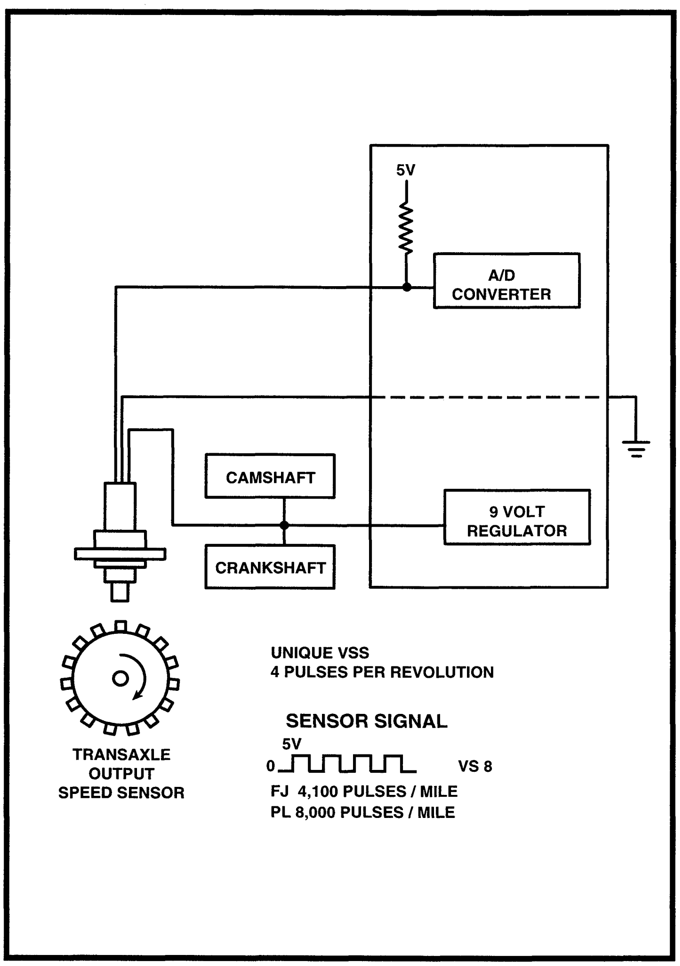


Figure 55 Vehicle Speed Sensor Circuit — Manual and 3-Speed Automatic Transaxle

Vehicle Speed Sensor Diagnostics

If P/N, ECT, MAP and engine indicate vehicle movement and there is no VSS signal, a rationality fault will be set.

3 Speed Automatic or Manual Transmissions

The VSS used on 3 speed automatic and manual transaxle vehicles is a Hall-effect sensor. This sensor is mechanically driven by a pinion gear that is in mesh with the right axle drive shaft. The Hall-effect sensor switches a 5 volt signal sent from the PCM from a ground to an open circuit at a rate of (FJ four pulses) (Chrysler eight pulses) per revolution. When the PCM counts (FJ4100) (8000 Chrysler) pulses, the PCM assumes the vehicle has traveled one mile.

Like all Hall-effect sensors, the electronics of the sensor needs a power source. This power source is provided by the PCM (fig. 55). It is the same 9 volt power supply that is used by the CKP and CMP sensors.

4 Speed Automatic

On all vehicles equipped with a 42LE transaxle (F4AC1 on FJ22/F24S) the TCM provides VSS information which has been designated "electronic pinion."

The term "electronic pinion" refers to the replacement of the pinion on the VSS with an electronic calibration programmed into the TCM. The electronic pinion is a system that allows the use of an existing VSS that is required to control shift points of the transmission.

The TCM uses an AC pulse generator to monitor transmission output-shaft speed. The 24 teeth on the output shaft are monitored by the output speed sensor. As the output shaft rotates, the output speed sensor provides an AC signal with a frequency in direct proportion to the 24 teeth on the output shaft. The TCM converts the AC sine-waves from the output speed sensor into an output shaft rpm signal. Once the TCM is programmed with information about tire size and axle ratios, the TCM delivers a signal to the PCM indicating vehicle speed.

The PCM sends a 5 volt signal to the TCM (fig. 56). The TCM switches this signal to a ground, and then opens the circuit at a rate of (FJ4100) (8000 Chrysler) pulses per mile. The PCM calculates the VSS signal on an automatic transaxle vehicle the same way it does on a manual transaxle vehicle.

Previously, when owners changed the tire size on their vehicle, the speedometer pinion gear could be changed to accommodate the change in tire size for speedometer accuracy. On vehicles equipped with a 41TE or F4AC1 automatic transaxle, the TCM can be programmed with information about tire size by using the DRB III. When programming the TCM, retrieve tire size information from the tire.

NOTE: When the TCM is replaced, the new TCM must be programmed with tire size information in order to function. The TCMs are programmed not to output the VSS signal until the technician has programmed tire size information.

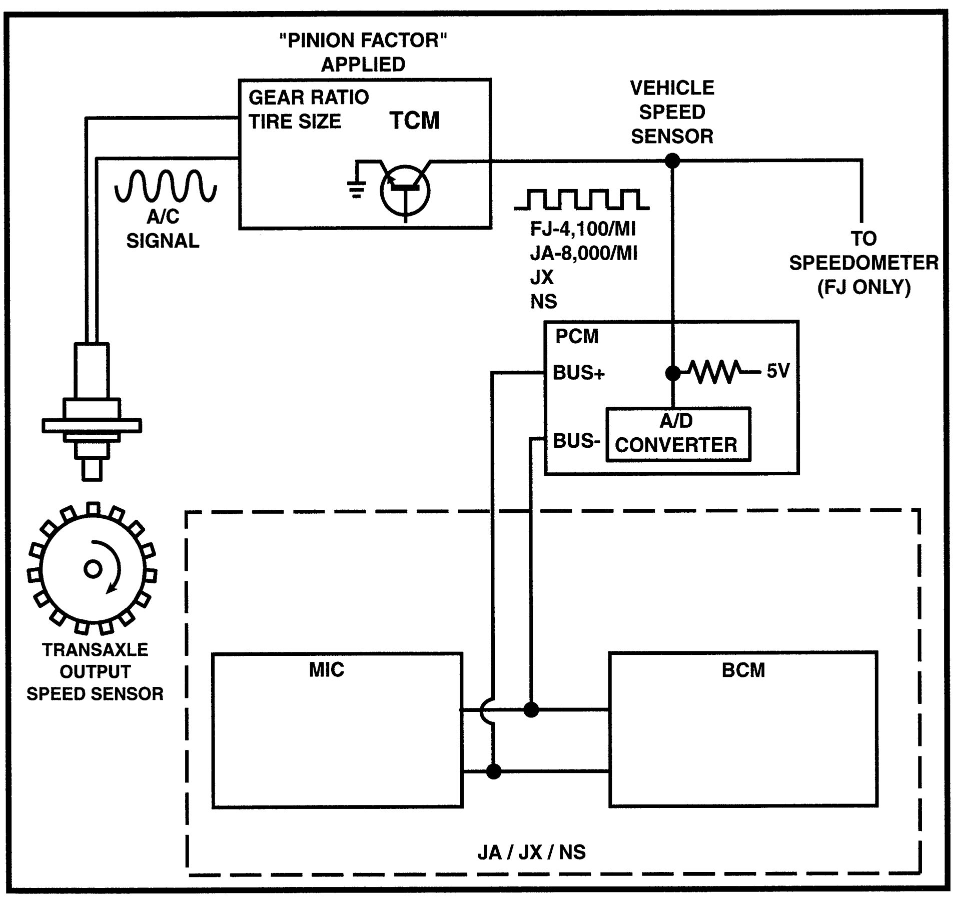


Figure 56 Vehicle Speed Sensor Circuit — 4-Speed Automatic Transaxle

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.

The PCM send 12 volts through a resistor to the sensor circuit to ground (fig. 57). On the F22/F24S, the contacts are normally open. On all other vehicles, the contacts are normally closed.

When there is a high pump load, the switch contacts open. When the contacts go open, the PCM interprets this as a reason to maintain idle speed during a higher load. The PCM modifies idle strategy by opening the IAC motor to avoid idle flutter.

The F22/F24S cars work just the opposite, although the switch strategy is the same.

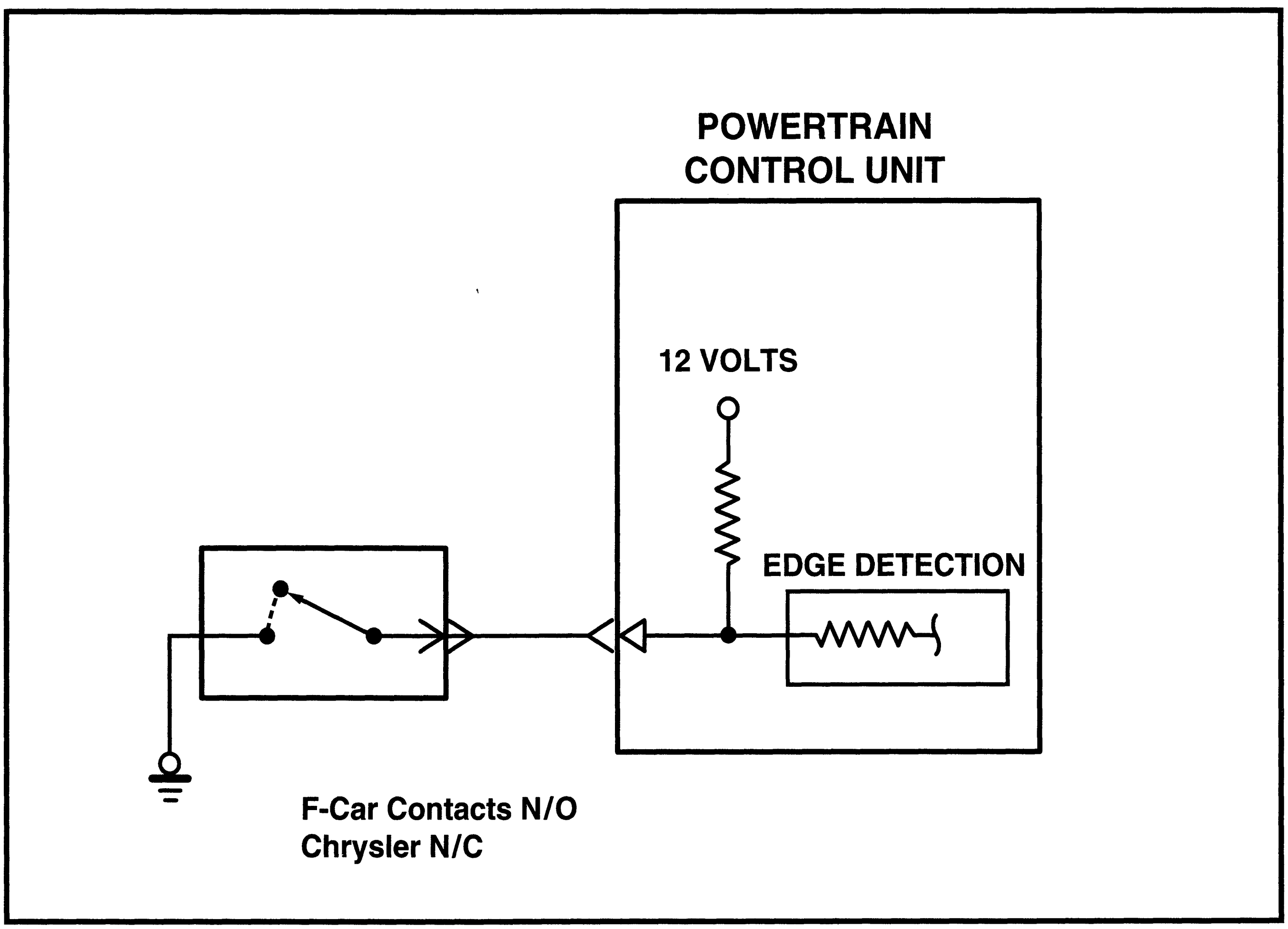


Figure 57 Power Steering Pressure Switch

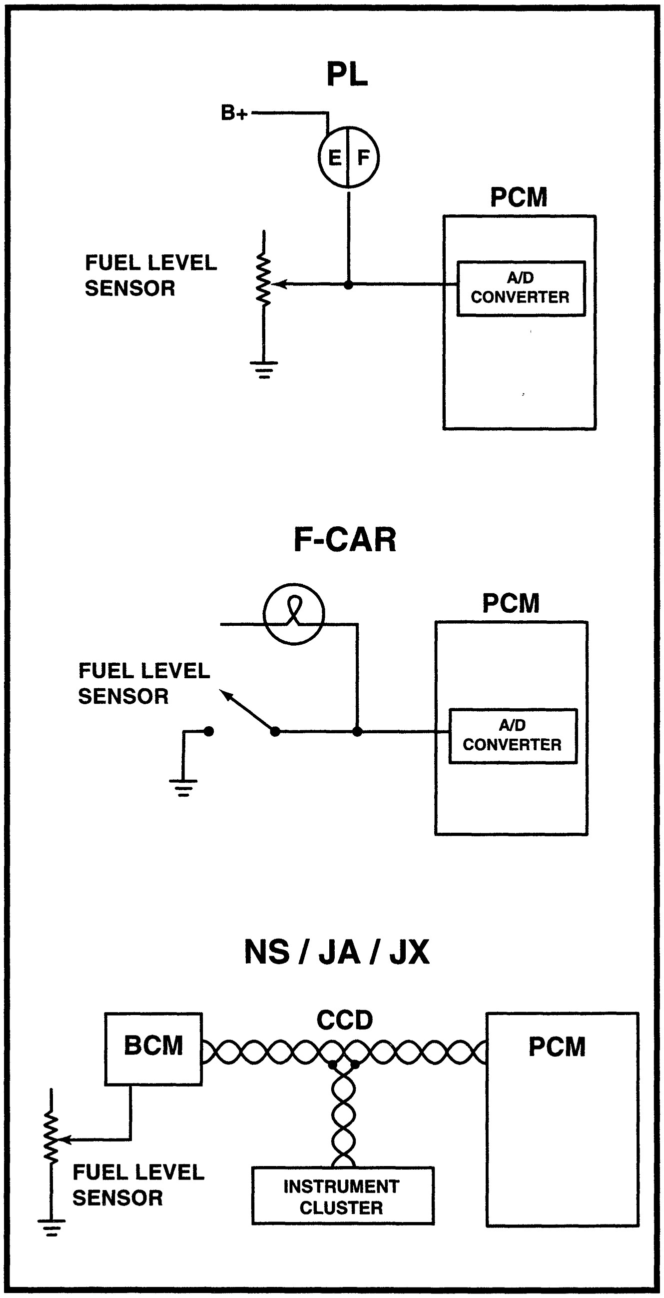


Figure 58 Fuel Level Sensor Circuits

FUEL LEVEL SENSOR INPUT

Fuel level is an input that is used as a disabler for OBD II. On FJ/F24S and PL the fuel level is input directly to the PCM (fig. 58).

PL

On these vehicles 12 volts is supplied from the fuel gauge to the fuel level sensor. The PCM measures the voltage drop across the resistor of the sensor.

FJ22/F24S

On these vehicles 12 volts is supplied from the fuel gauge to the level sensor. Twelve volts is also supplied from the low fuel lamp to the low fuel warning circuit. When the low fuel warning circuit completes a path to ground for the lamp, the PCM registers the drop in voltage on the ground side of the bulb.

JA/JX/NS

On these vehicles 12 volts is sent from the Body Control Module to the fuel level sensor. Depending on the level sensor resistance, the voltage drop changes and is converted to a fuel level. This information is then bused to the PCM.

BATTERY/AMBIENT TEMPERATURE SENSOR

The PCM incorporates a Battery/Ambient Temperature Sensor (BTS) on its circuit board (fig. 59). The function of the BTS is to enable control of the generator output based upon ambient temperature. As temperature increases, the charging rate should decrease. As temperature decreases, the charging rate should increase. The sensor functions similar to the ECT sensor with one major difference, the ambient sensor does not have a dual temperature range program. The PCM maintains the maximum output of the generator by monitoring battery voltage and controlling battery voltage to a range of 13.5-14.7 volts.

The BTS is also used for OBD II diagnostics. Certain faults and OBD II monitors are either enabled or disabled depending upon the BTS input (example: disable purge and EGR, enable LDP). Most OBD II monitors are disabled below 20°F.

If the BTS indicates a voltage that is too high or too low, the PCM sets a DTC. When the DTC is set, the MIL is illuminated and the PCM moves into limp-in mode. In Limp-in the PCM will substitute a preset value. Using this substitute temperature the PCM changing to a preset target charging system voltage. Refer to the Generator section of this publication for more information.

Battery Temperature Sensor Diagnostics

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

NS/FJ22/F24S

The battery temperature sensor is located on the circuit board of the PCM. However, the voltages are not the same between NS and the F-cars.

PL

The PL is located on the battery tray.

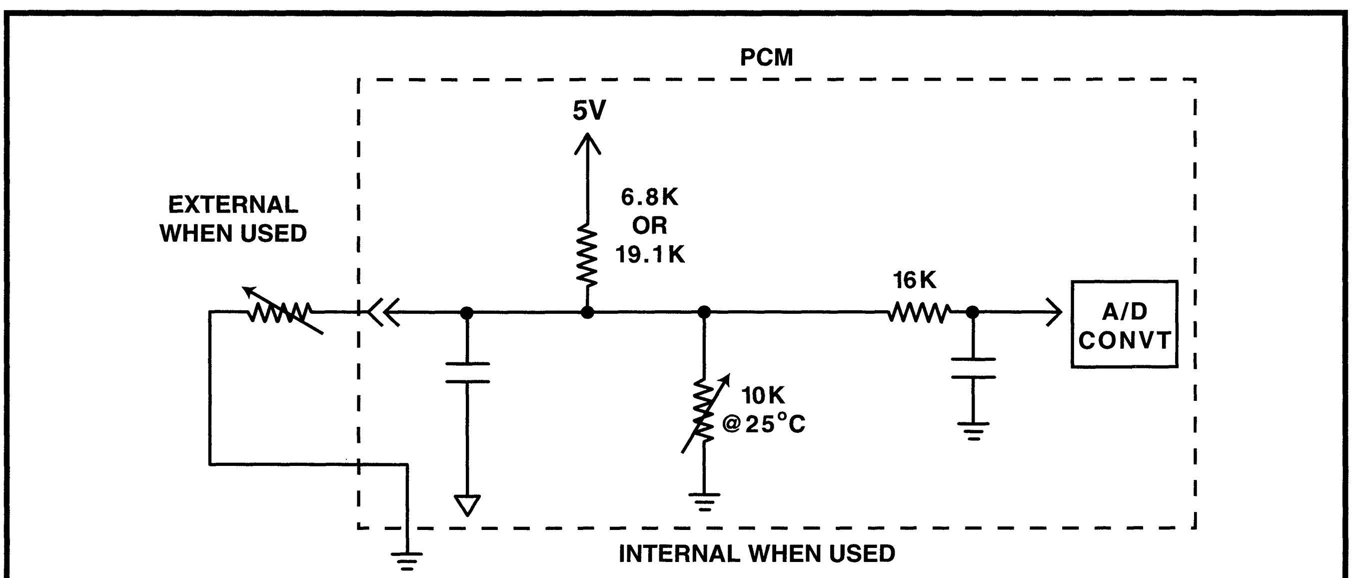


Figure 59 Ambient Temperature Sensor Circuit

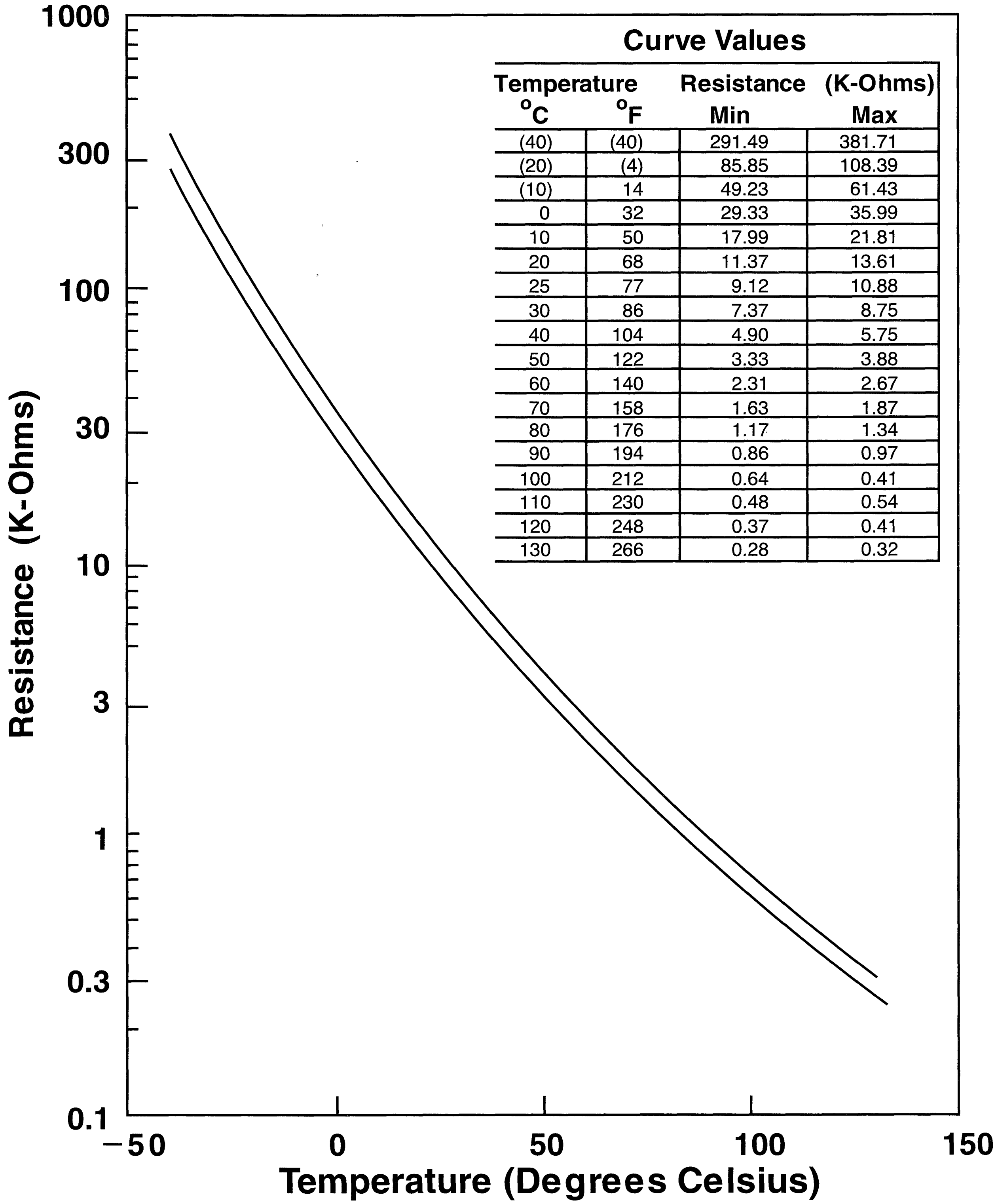
JA/JX

The BTS is located on the radiator support panel near the left bumper, and is an NTC thermistor. The PCM regulates the generator's output based upon both the ambient temperature sensor and the ECT sensor. The reason why the JA/JX use both inputs is due to the optional cold weather package. This package provides the customer with the added protection of a block heater and a battery blanket. Previous systems assumed that the temperature of the battery was fairly close to the temperature of the BTS. The PCM then controls the ground path of the generator field to maintain a target voltage based upon the BTS's information. Since the JA/JX have their batteries mounted in the left front inner fender panel, battery temperature may not be the same as underhood temperature.

When the customer plugs in their cold weather package, both the block heater and battery blanket are supplied with 120 volts. With the battery blanket operational, the battery temperature may be higher than that of the ambient temperature. In this situation, the PCM cannot use just the ambient temperature sensor to identify the battery temperature. Instead, the PCM uses both the ambient temperature sensor and the ECT sensor to calculate the battery temperature.

The PCM assumes that if the ignition has been off for a substantial amount of time, battery temperature should drop to ambient temperature, and engine coolant temperature should drop as well. If the ignition key is activated after this period of time, and engine coolant temperature is greater than ambient temperature, the PCM assumes that the battery blanket and block heater have been functioning, thus causing the battery temperature to be higher than ambient. The PCM then calculates the charging rate based upon what it assumes the battery temperature is (fig. 60).

NOTE: The PCM is programmed to assume that the battery blanket will be used only when the block heater is used.



Curve Values

Temperature °C	°F	Resistance (K-Ohms) Min	Max
(40)	(40)	291.49	381.71
(20)	(4)	85.85	108.39
(10)	14	49.23	61.43
0	32	29.33	35.99
10	50	17.99	21.81
20	68	11.37	13.61
25	77	9.12	10.88
30	86	7.37	8.75
40	104	4.90	5.75
50	122	3.33	3.88
60	140	2.31	2.67
70	158	1.63	1.87
80	176	1.17	1.34
90	194	0.86	0.97
100	212	0.64	0.41
110	230	0.48	0.54
120	248	0.37	0.41
130	266	0.28	0.32

Resistance Versus Temperature Curve

Figure 60 Battery Temperature Sensor Resistance/Temperature

If the block heater has not been activated, then after this time period, engine coolant temperature will be approximately the same as ambient temperature, and the charging rate will be the same as shown in Table 7.

Degrees F	Volts	Degrees F	Volts
-20	4.70V	110	4.20V
-10	4.57V	120	4.00V
0	4.45V	130	4.00V
10	4.30V	140	3.60V
20	4.10V	150	3.40V
30	3.90V	160	3.20V
40	3.60V	170	3.20V
50	3.30V	180	3.02V
60	3.00V	190	2.80V
70	2.75V	200	2.60V
80	2.44V	210	2.40V
90	2.15V	220	2.00V
100	1.83V	230	1.80V

Table 6 Temperature versus Voltage

Battery temperature (F)	Target Charging Rate
-4	15.19 - 14.33
32	14.82 - 13.96
68	14.51 - 13.65
104	14.08 - 13.22
144	13.77 - 13.04

Table 7 Charging Rates

AIR CONDITIONING SWITCH

When air conditioning or defrost is selected, the PCM receives an input signal that allows it to ground the A/C clutch relay (fig. 61). This provides power to the A/C clutch. In addition, the PCM adjusts the idle air controller motor to compensate for the increased engine load and maintain target idle.

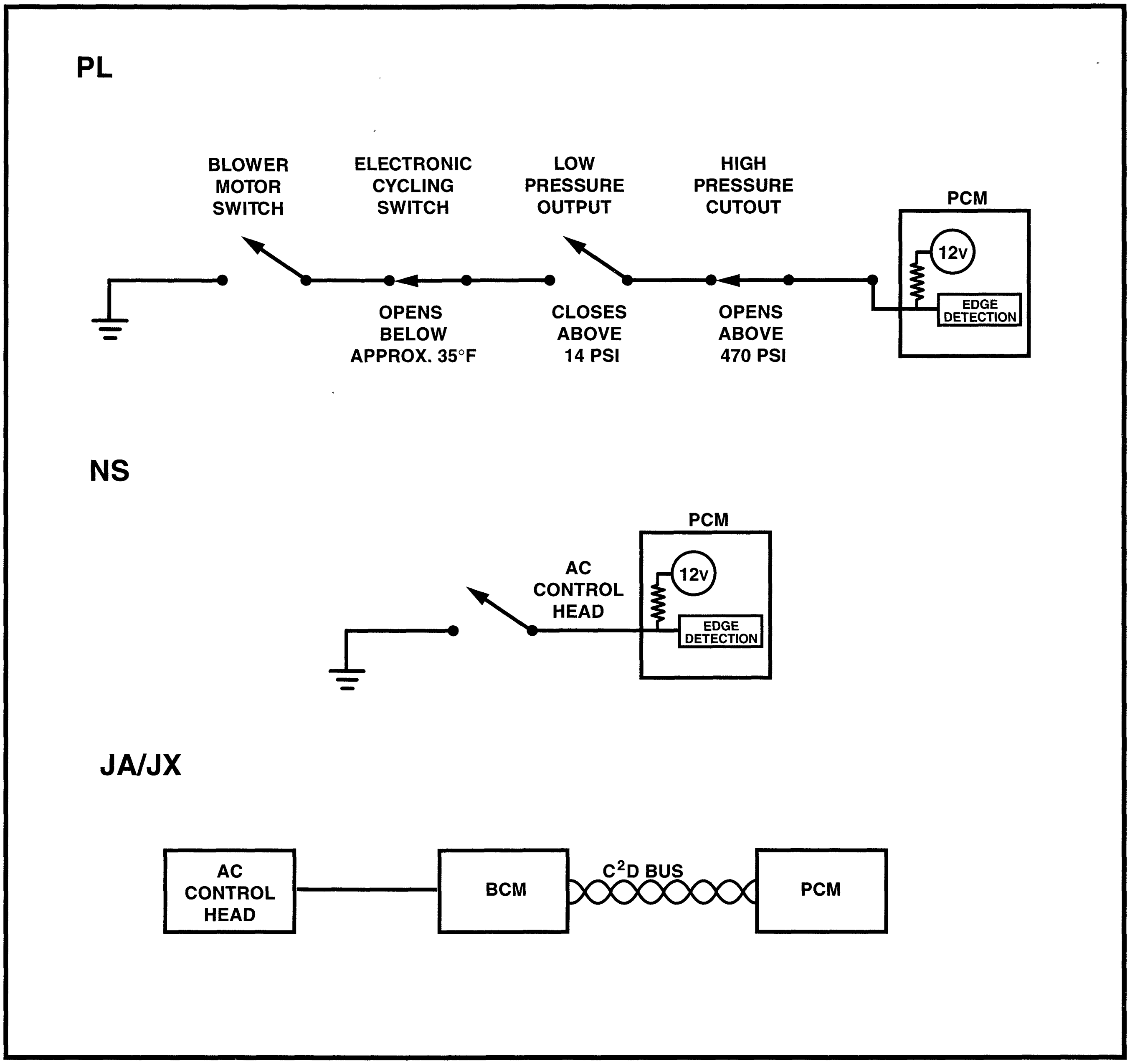


Figure 61 Air Conditioning Switch Circuits

FJ22/F24S AUTO COMPRESSOR CONTROL SYSTEM

The main output of the auto compressor control module is the A/C request signal (fig. 62). A signal is sent through terminal nine anytime that the auto compressor control module requires the compressor to be engaged. The request signal is ON as long as A/C has been selected, and the air thermo sensor and the fin thermo sensor are indicating temperatures within the parameters. Also, the compressor revolution sensor cannot be indicating that the belt is slipping.

When the auto compressor control module sends the request signal ON, system voltage passes through terminal nine to the A/C condenser fan relay. With the request signal ON, the A/C condenser fan relay should be energized.

With the request signal ON, terminal nine also provides system voltage to the dual pressure switch. The dual pressure switch is located on the receiver/drier assembly, and is used to protect the compressor from high or low pressure conditions. The LOW switch is ON (closed) at 32 psi (220 kpa) or higher, and OFF (open) at 29 psi (200 kpa) or lower. The HIGH switch turns OFF (open) at 456 psi (3,140 kpa) or higher, which removes power supplied to the compressor clutch relay. The HIGH switch turns ON (closed) at 370 psi (2,550 kpa) which re-engages the compressor clutch.

With both the LOW and HIGH pressure switch contacts closed, system voltage is supplied to the A/C compressor relay electromagnet and the PCM. Once the PCM recognizes the request signal and the PCM's other monitored inputs indicate that the A/C compressor should be engaged, the PCM provides a ground for the A/C relay's electromagnet. With the relay energized, battery voltage is supplied to the compressor clutch coil and also to terminal one of the auto compressor control module.

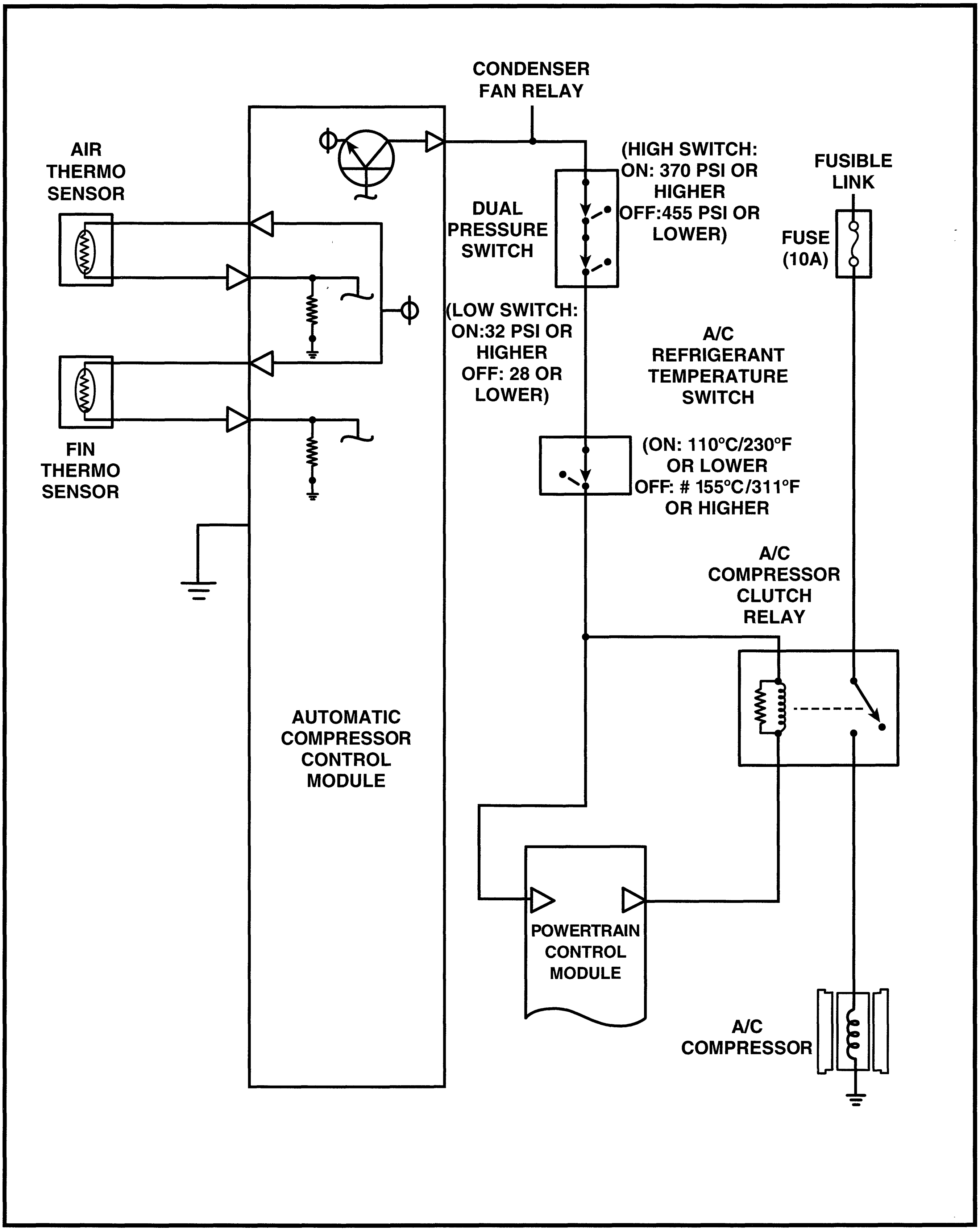


Figure 62 F-Car A/C Request Signal

A/C Pressure Transducer - NS/JA/JX

When the PCM recognizes the A/C request signal, it energizes the A/C compressor relay. While the compressor is functioning, the pressure in the A/C high-side line will increase. To decrease the pressure in the high-side line, the radiator fans may need to be operated. Since the fans need to operate only when pressures in the A/C high-side line is excessive, the PCM monitors A/C pressures from a A/C pressure sensor.

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 psig sensor that changes the resistance of its circuit based upon pressure. The PCM sends a 5-volt signal to operate the sensor's circuit (fig. 63). The PCM also sends a 5-volt monitoring circuit to the sensor. The resistance of the sensor is directly proportional to that of the pressure on the transducer. As pressure increases on the transducer, the monitoring voltage decreases. The PCM monitors the A/C pressure sensor to perform the following tasks:

- Deactivate the compressor clutch relay when discharge-line pressure exceed 430 psig
- Deactivate the compressor clutch relay when discharge-line pressure is less than 32 psi
- Identify to the PCM when the radiator fans need to be engaged
- Modifies IAC compensation based upon A/C pressures
- Control cooling fans

NOTE: The transducer uses the same 5 volt regulator as the MAP and TPS sensors.

A/C Pressure Transducer Diagnostics

- A/C Pressure Sensor Volts Too Low is set when sensor voltage goes below 0.5 volts.
- A/C Pressure Sensor Volts Too High is set when sensor voltage goes above 4.9 volts.

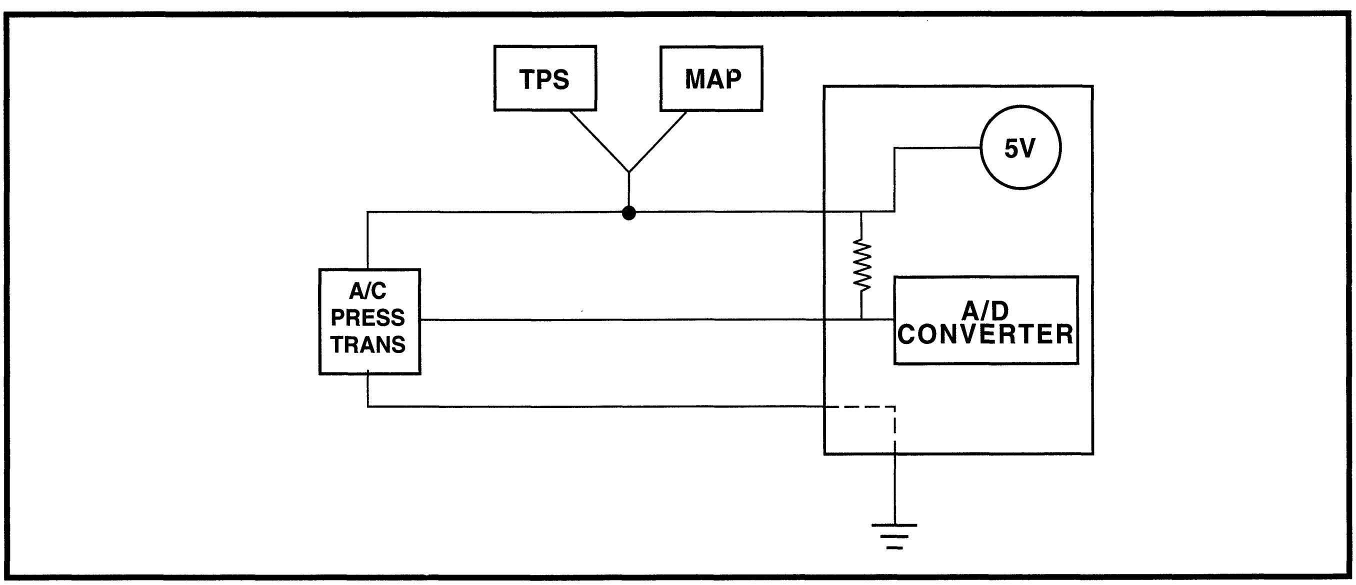


Figure 63 Air Conditioning Switch Circuit

TORQUE REDUCTION (TORQUE MANAGEMENT)

Torque reduction is a function of the TCM commanding the PCM to momentarily decrease fuel injection pulse-width while the transmission is performing high torque, high speed shifts (1-2, 2-3, 4-2, 3-1). This function happens so rapidly that the driver is never aware that the narrowing of the injection pulse-width occurred (fig. 65). The reason for "Torque reduction" is that when the transmission is shifting from one gear to the next, one clutch in the transmission must release before the next gear's clutch is applied. A fraction of a second goes by while the transmission is actually not in any gear. If, during a shift sequence, the driver has the engine at WOT, the transmission will be under the most adverse conditions. To help eliminate the abrupt torque transfer on the clutch discs, the PCM will not fire the next three injectors.

The PCM sends a 9 volt signal to the TCM (fig. 64). The TCM requests torque reduction, by momentarily grounding the 9 volt circuit, commanding the PCM to decrease injection pulse-width. When the TCM detects that 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.

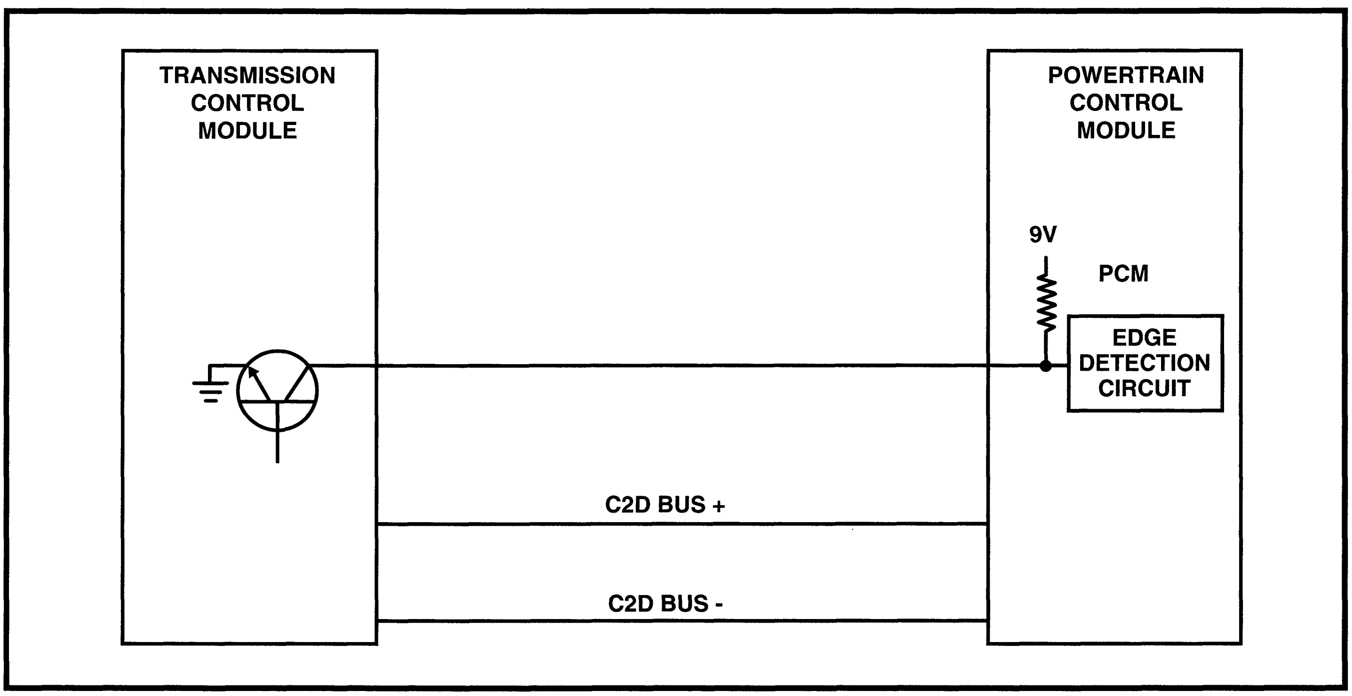


Figure 64 Torque Management Circuit

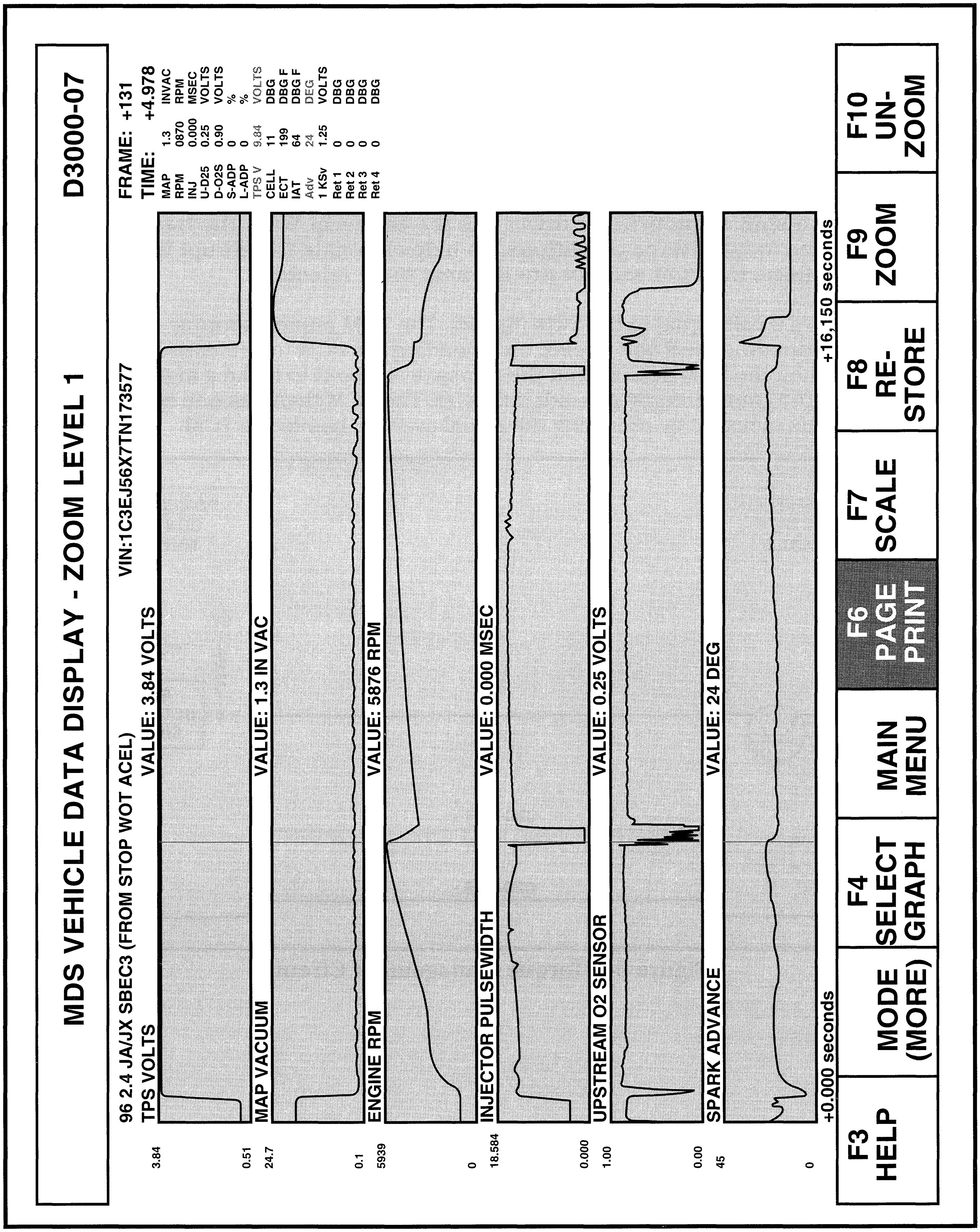


Figure 65 Torque Management Data Recording

VEHICLE SPEED CONTROL

The inputs required by the PCM to operate the speed control system include:

- Speed control switches
- Brake switch
- Park/Neutral switch
- Vehicle speed sensor
- Engine speed
- CCD bused message from TCM

Refer to the Vehicle Speed Control section in this publication for more information.

LEAK DETECTION PUMP

There is a reed switch attached to the vacuum driven pump. The switch is wired to the PCM. The PCM monitors the change in switch state to determine how long the pump has operated. This input is then used to calculate whether there is a leak in the evaporative system. Refer to the Emission Control Systems section of this publication for more informaiton.

ASD SENSE CIRCUIT

The PCM receives a battery voltage signal at pin 42, indicating that the Automatic Shut Down (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.

ACTIVITY 11 — PCM INPUTS

VSS

1. Change DRB to find vehicle speed. With engine running at idle, closed throttle, slowly increase road speed to 60 mph. What happened to engine speed? _______ Why? ____________________

2. Open throttle to 1500-2000 RPM. Slowly increase road speed. What speed did the road speed shutdown occur at? ____________________

3. With vehicle in road speed shutdown, what does injector pulse width display? ____________________

4. With road speed at closed throttle 30 mph, what does VSS display on Lab Scope? ____________________

5. Change road speed. What happened to display?____________________

6. Disconnect simulator. Open VSS switch. What does voltage read on both sides of the switch?____________________

Engine off.

7. Change DRB to read fuel level. What level is shown? ____________________

8. Change DRB to read Batt/Ambient Temp Senor. What does it show for voltage? _ And temperature?____________________

9. Open switch on BOB. What does DRB display for voltage? ____________________ And temperature?____________________

10. Measure voltage on both sides of switch. What are the readings? ______________ And sensor? ____________________

11. Change DRB to A/C Press Transducer. What does DRB indicate for voltage? ____ And pressure? ____________________

12. Open switch on BOB. What is voltage on PCM side of switch?____________________

13. Jump PCM side of switch to ground. What does DRB indicate for voltage? _____
And Pressure? ____________________

Torque Management

14. Open switch on BOB. What is voltage on PCM side? ____________________
TCM side? ____________________

15. Change DRB to read DTC's. What DTC's are shown? ____________________
Why? ____________________

Erase codes when done.

NOTES

LESSON 5

FUEL INJECTION SYSTEM — PCM OUTPUTS

SOLENOID AND RELAY CONTROL

Most of the output relays and solenoids are controlled by a serial peripheral interface/output (SPIO) circuit. 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.

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

CAUTION: Both diode and resistor suppressed relays have been used. If an incorrect relay is used, damage may occur to the relay, circuit or PCM.

AUTOMATIC SHUTDOWN RELAY (ASD)

When energized, the ASD relay provides power to operate the injectors, ignition coil, generator field, O2 sensor heaters (both upstream and downstream), EGR solenoid on JA/JX, and also provides a sense circuit to the PCM for diagnostic purposes. The PCM energizes the ASD:

- Any time there is a Crankshaft Position sensor signal that exceeds a predetermined value.
- For approximately .7–1.5 seconds during the initial key-on cycle. The determining factor for the latch time is ECT. A cold engine will allow a longer latch time to overcome slower cranking speed.
- After the engine has been turned off to perform an O2 sensor heater test.

With SBEC III, the ASD relay's electromagnet is fed battery voltage, not ignition voltage (fig. 66). The PCM still provides the ground. As mentioned earlier, the PCM energizes the ASD relay during an O2 sensor heater test. This test is performed only after the engine has been shut off. The PCM still operates internally to perform several checks, including monitoring the O2 sensor heaters. This and other DTC tests are explained in detail in the On-Board Diagnostic II Student Reference Book.

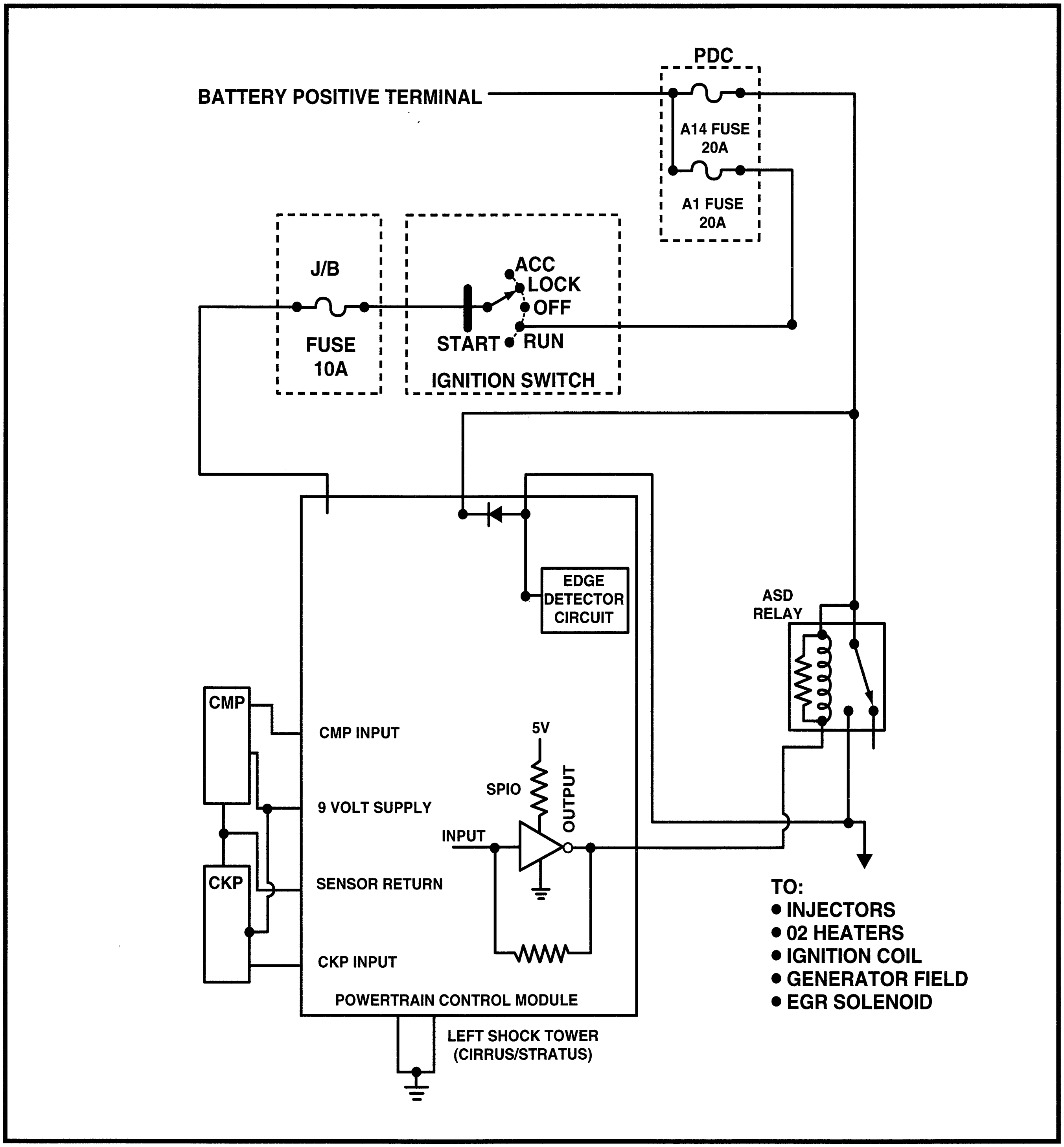


Figure 66 ASD Relay Circuit

FUEL PUMP RELAY

The fuel pump relay is energized under the following conditions to provide power to operate the fuel pump:

- For approximately 0.7 -1.5 seconds during the initial key-on cycle. The determining factor for the latch time is ECT. A cold engine will allow a longer latch time to overcome slower cranking speed.
- While the CKP sensor is providing an RPM signal that exceeds a predetermined value.

Ignition voltage is provided to the fuel pump relay's electromagnet any time the key is in the RUN position (fig. 67). The PCM provides the ground control to energize the relay. Unlike previous Chrysler systems, the fuel pump relay does not provide power to operate the O2 sensor heaters.

The relay is energized when the key is cycled to RUN in order to prime the fuel rail with liquid fuel, allowing for a quick start-up. Anytime the Crankshaft Position sensor indicates that there is an RPM signal that exceeds a predetermined value, the relay is energized to ensure proper fuel pressure and volume during engine cranking and running conditions. Any time the Crankshaft Position sensor signal is lost (engine has been shut off or the sensor indicates no RPM), the fuel pump relay is de-energized.

On Talon the fuel pump relay is located in the engine compartment, on the left side, attached to the bulkhead. On all other Chrysler vehicles the relay is located in the Power Distribution Center (PDC). Refer to the label on the underside of the PDC cover.

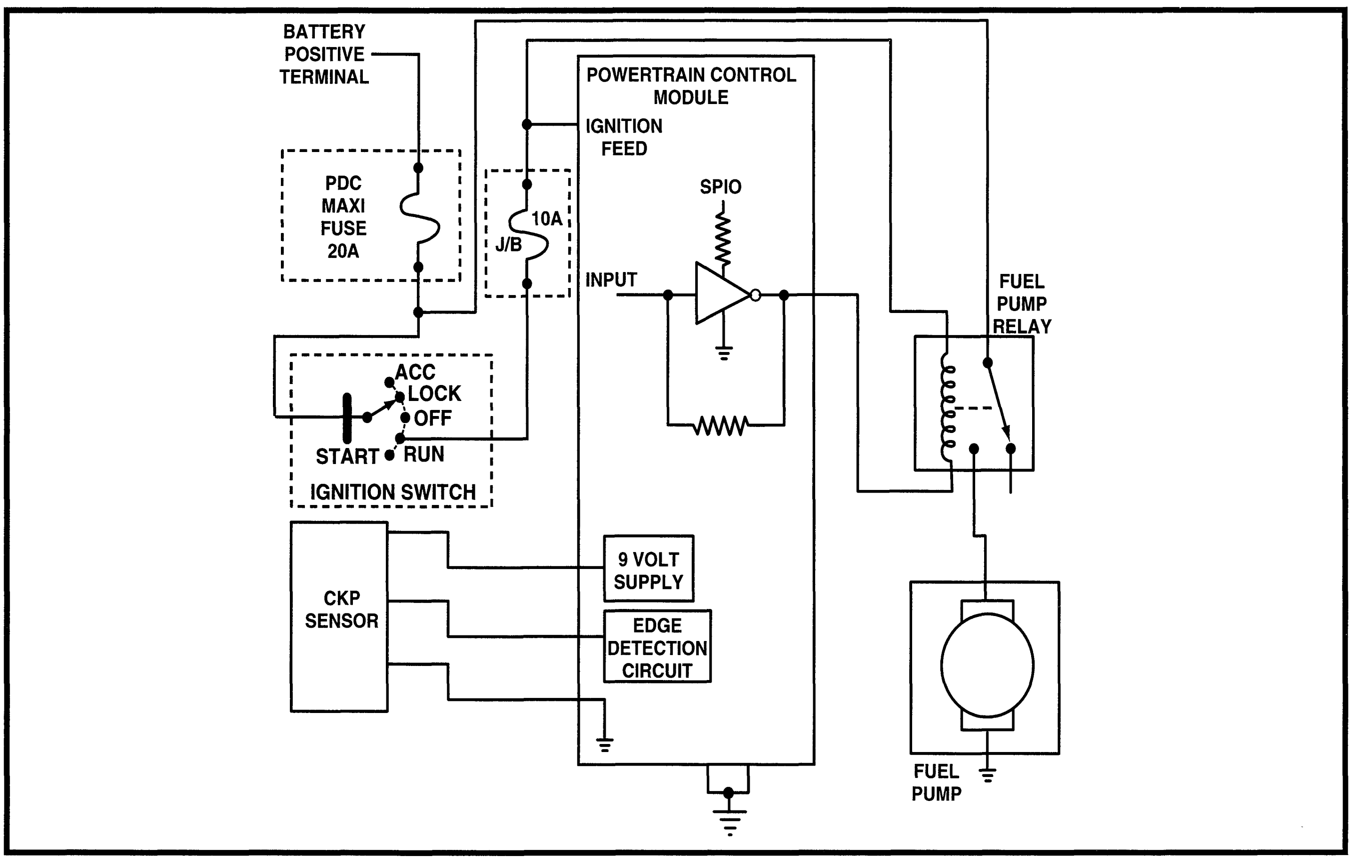


Figure 67 Fuel Pump Relay Circuit

STARTER RELAY (DOUBLE START OVERRIDE)

On NS vehicles, the starter relay ground is provided by the PCM (fig. 68). When the park/neutral switch contacts are closed, indicating Park or Neutral, the PCM will supply the ground path for the starter relay at key ON. This will occur if the engine RPM is below a predetermined value.

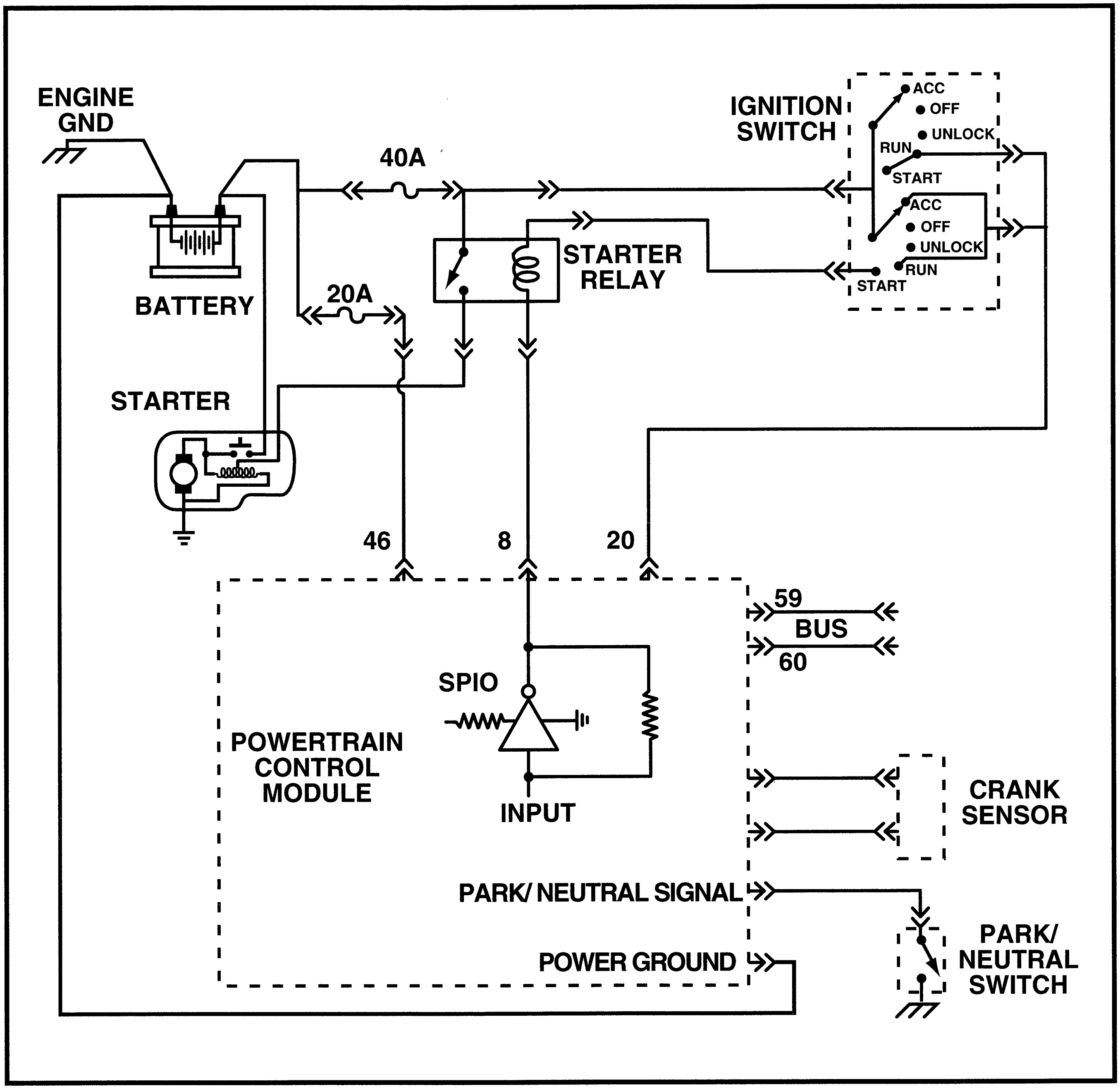


Figure 68 Starter Relay Control

FUEL INJECTORS

The PCM provides battery voltage to each injector through the ASD relay (fig. 69). 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.

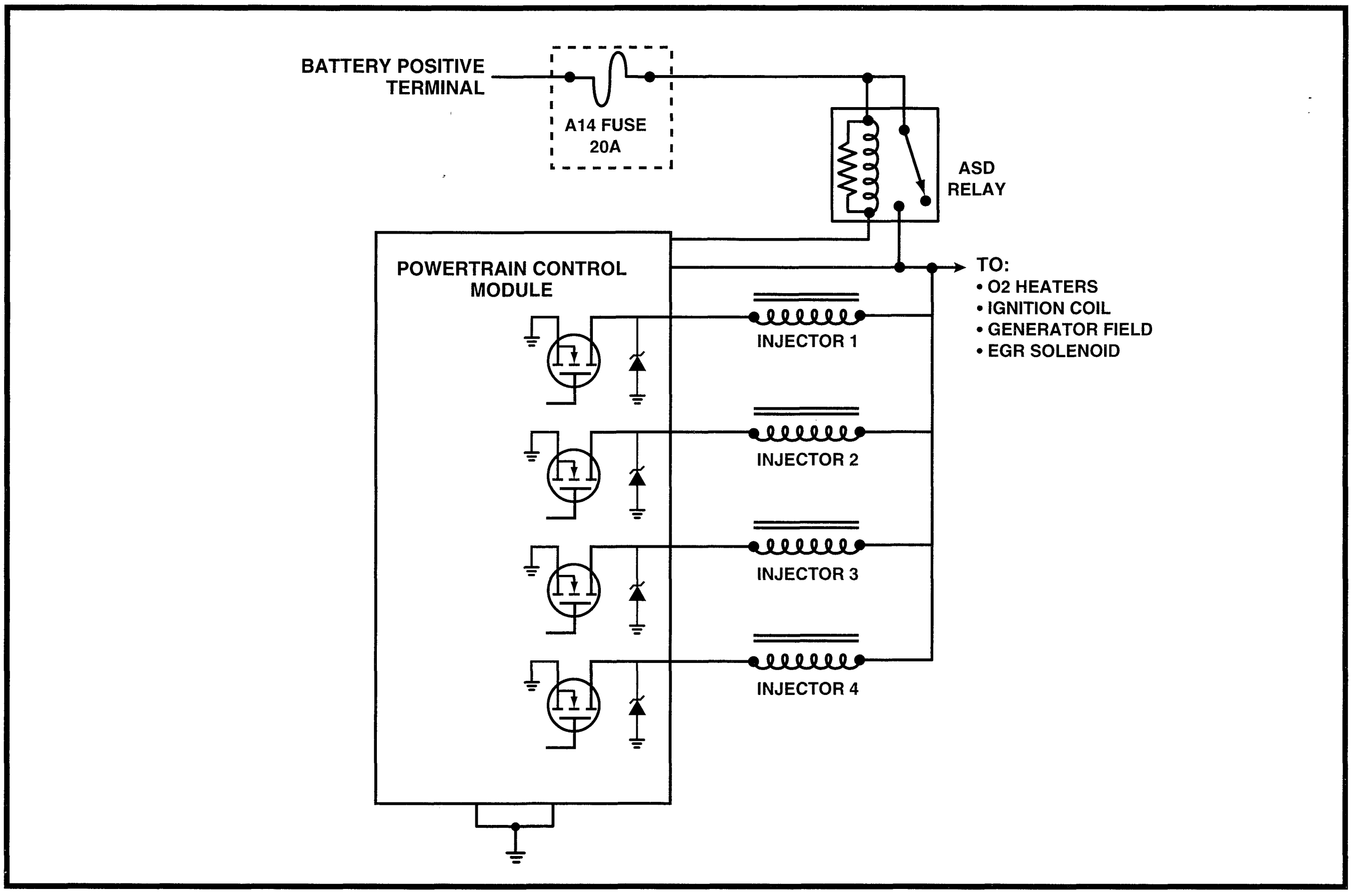


Figure 69 Fuel Injection Circuit

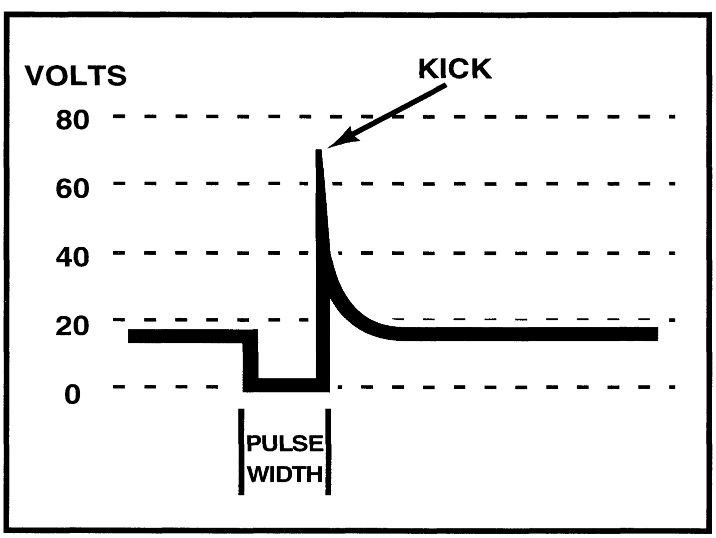


Figure 70 Injector Spike

Fuel Injector Diagnostics

To diagnose an injector the PCM monitors the voltage spike created by the collapse of the magnetic field through the injector coil. The inductive kick is typically above 60 volts (fig. 70). Any condition that restricts maximum current flow would not allow the kick to occur, resulting in an injector fault.

See the description of fuel injectors in the Fuel System Components Section of this reference guide for further information.

ACTIVITY 12 – FUEL PUMP

Activities

Have the instructor assign you to a vehicle equipped with either a 2.0L or 2.4L engine. Use the DRB III and PEP module to assist in answering the following questions:

1. Connect a DRB to the vehicle and actuate the ASD relay test. What happends? _
____
2. Actuate the fuel pump relay test. What happens? ______________________
3. Change the DRB to a Lab Scope. How much voltage is generated by either relay when the coil field collapses? ______________________
4. Go to sensors on the DRB and display pulse width. How much time is shown? _
____
5. Change the DRB back to a Lab Scope. How much voltage is generated when the injector coil collapses? ______________________
6. Open the ground path to an injector. What does the scope display? __________
____

IGNITION COILS

The PCM provides battery voltage to the ignition coil through the ASD relay (fig. 71). Coil operation is controlled by a ground path provided to each coil by the PCM. The ignition coil fires two spark plugs every power stroke. One plug fires for the cylinder under compression, and the second plug fires for the cylinder on the exhaust stroke.

The PCM determines which coils to fire and when, based on camshaft and crankshaft sensor inputs. Each ignition coil primary is joined to the power wire from the ASD relay. The ASD relay provides battery feed to the ignition coil, while the PCM provides a ground contact for energizing the coil. When the PCM breaks the ground contact, power transfers from the primary to the secondary, causing the spark.

Resistance on the primary side of the coil should be between 0.51 and 0.61 ohms. The resistance of the secondary side is between 11,500 and 13,500 ohms. The coil pack has the ability to provide up to 40,000 volts, if needed.

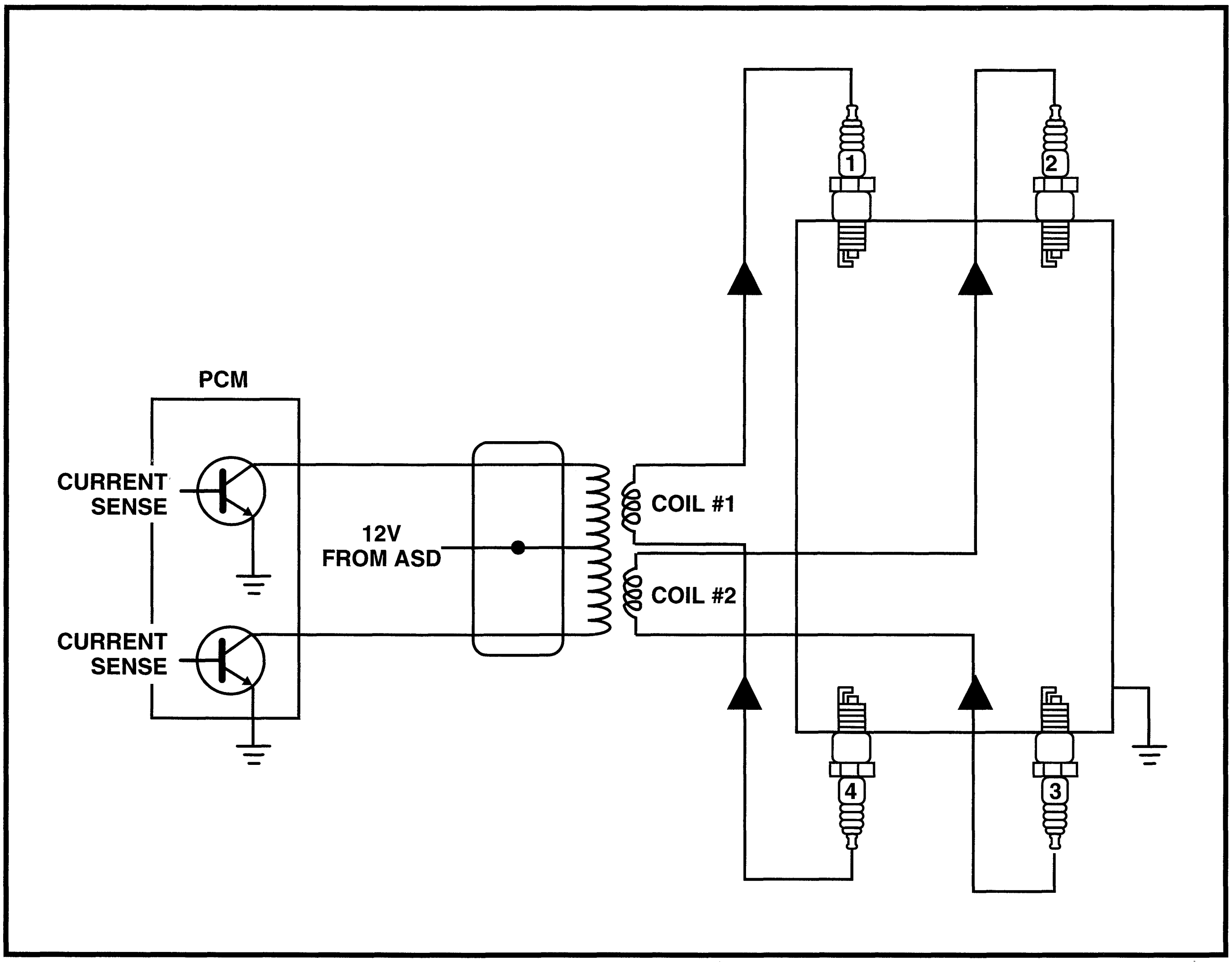


Figure 71 Ignition Control Circuit

Coil Operation

When a conductor is formed into a coil, the magnetic field is many times stronger than that of a single straight connector. To increase the strength of the magnetic field, you must either increase the number of loops in the coil, increase the amount of current flowing in the coil, or use a low reluctance material for the core of the coil.

If one coil is placed near another coil, and the first coil is connected to a current, the expanding magnetic field induces a current into the second coil. The current induced into a coil is much higher than a current induced into a straight conductor. The coil which carries current into this type of induction system is the primary winding of the coil, and the coil into which electromotive force is induced is the secondary winding of the coil. This mutual induction is the principle behind automotive ignition coils.

The magnetic field must be moving in order to induce a current. Once the magnetic field has stabilized and is not expanding through the secondary conductor, there is no current induced in the secondary conductor. As the field collapses, the lines of force pass through the secondary winding, which now induces a current in the opposite direction. When the field has completely collapsed, current flow in the secondary conductor stops.

The amount of secondary voltage generated depends on the amount of flux, the number of turns in the secondary coil, and the speed at which the primary current is interrupted. "Flux" refers to the lines of force in motion which create a magnetic field. The amount of flux depends on the primary circuit. More current in this circuit means more flux. The flux moves through the windings of the secondary coil, so more turns in the secondary coil result in more voltage. Flux collapses through the secondary coil when the primary current is interrupted. A quick interruption causes the flux to cut through the secondary windings faster. A quicker interruption results in more secondary voltage than a slow interruption.

DIS coils can be arranged in various alternations of polarity. It really does not matter if a spark fires positive or negative, as long as there is enough charge to jump the spark plug gap. The coil's polarity is: coil serving cylinders 1 and 4, 1 is positive and 4 is negative; coil serving cylinders 2 and 3, 2 is positive and 3 is negative.

The spark from a DIS coil moves from tower to tower using the block as a piece of wire to complete the circuit. This means that if any part of the circuit opens, both spark plugs will not fire. A spark will jump across the tip of the spark plug still connected to a coil tower. However, this spark is created by a capacitance effect and will not support a load on the engine

PCM Operation

The PCM toggles the ignition coil current driver ON, and then at some point before the CKP sensor indicates TDC, toggles it off. The amount of ON time (dwell), and the point at which the PCM toggles the driver OFF is determined by several inputs to the PCM. The following inputs are used by the PCM to calculate when to energize and de-energize the ignition coil to achieve the best spark advance program:

- CKP sensor
- CMP sensor
- MAP sensor
- ECT sensor
- IAT sensor
- TPS
- Engine rpm
- Knock sensor
- Battery voltage
- EGR flow
- Park/Neutral position switch

Base timing is non-adjustable, but is set from the factory at approximately 10^0 BTDC when the engine is warm and idling.

There is an adaptive dwell strategy that runs dwell from 4 to 6 msec when RPM is below 3000 and battery voltage is 12-14 volts. During cranking, dwell can be as much as 200 msec. The adaptive dwell is driven by the sensed current flow through the injector drivers. Current flow is limited to 8 amps.

As mentioned previously, the resistance of the coil primaries have a resistance of only .5 ohms. These are known as low impedance coils. Because of the low resistance the coils can allow significant current flow in excess of 15 amps. A rapid high current flow means a faster moving magnetic field which means a quicker coil saturation. To protect the PCM from damage due to high current flow there is a current sensing device in the coil output circuit. As dwell time starts the PCM allows full current flow. When the sensing device registers 8 amps the PCM begins to regulate current flow to maintain and not exceed 8 amps for the remainder of the dwell time.

For example: A technician observes that the dwell time on the 2 coils does not match; one is at 4 msec. and one is at 6 msec. This could indicate a high resistance to the primary circuit of the 6 msec. coil, i.e. longer dwell to build coil saturation due to lack of current flow.

IDLE AIR CONTROL (IAC) STEPPER MOTOR

Description

The IAC stepper motor is mounted to the throttle body, and regulates the amount of air bypassing the control of the throttle plate. As engine loads and ambient temperatures change, engine RPM changes. A pintle on the IAC stepper motor protrudes into a passage in the throttle body, controlling air flow through the passage. The IAC is controlled by the PCM to maintain the target engine idle speed.

At idle, engine speed can be increased by retracting the pintle and allowing more air to pass through the port, or can be decreased by restricting the passage with the pintle and diminishing the amount of air bypassing the throttle plate.

When engine RPM is above idle speed, the IAC is used for the functions listed below:

- Off-idle dashpot
- Deceleration air flow control
- A/C compressor load control (also opens the passage slightly before the compressor is engaged so that the engine RPM does not dip down when the compressor engages)
- Power steering load control

The PCM can control polarity of the circuit to control direction of the stepper motor.

Operation

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 PCM uses the IAC motor to control idle speed (along with timing) and to reach a desired MAP during decel (keep engine from stalling).

The stepper motor has 4 wires (fig. 72). Two wires are for 12 volts and ground. The other 2 wires are for 12 volts and ground. The stepper motor is not really a motor at all. The pintle that moves in and out can be thought of as a “bolt” with threads (fig. 73). The “nut” is a permanent magnet. There are 2 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 will energize 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 just reverses polarity on both windings. If only 1 wire is open, the IAC can only be moved 1 step in either direction.

NOTE: *To keep the IAC motor in position when no movement is needed, the PCM will energize both windings at the same time. This locks the IAC motor in place.*

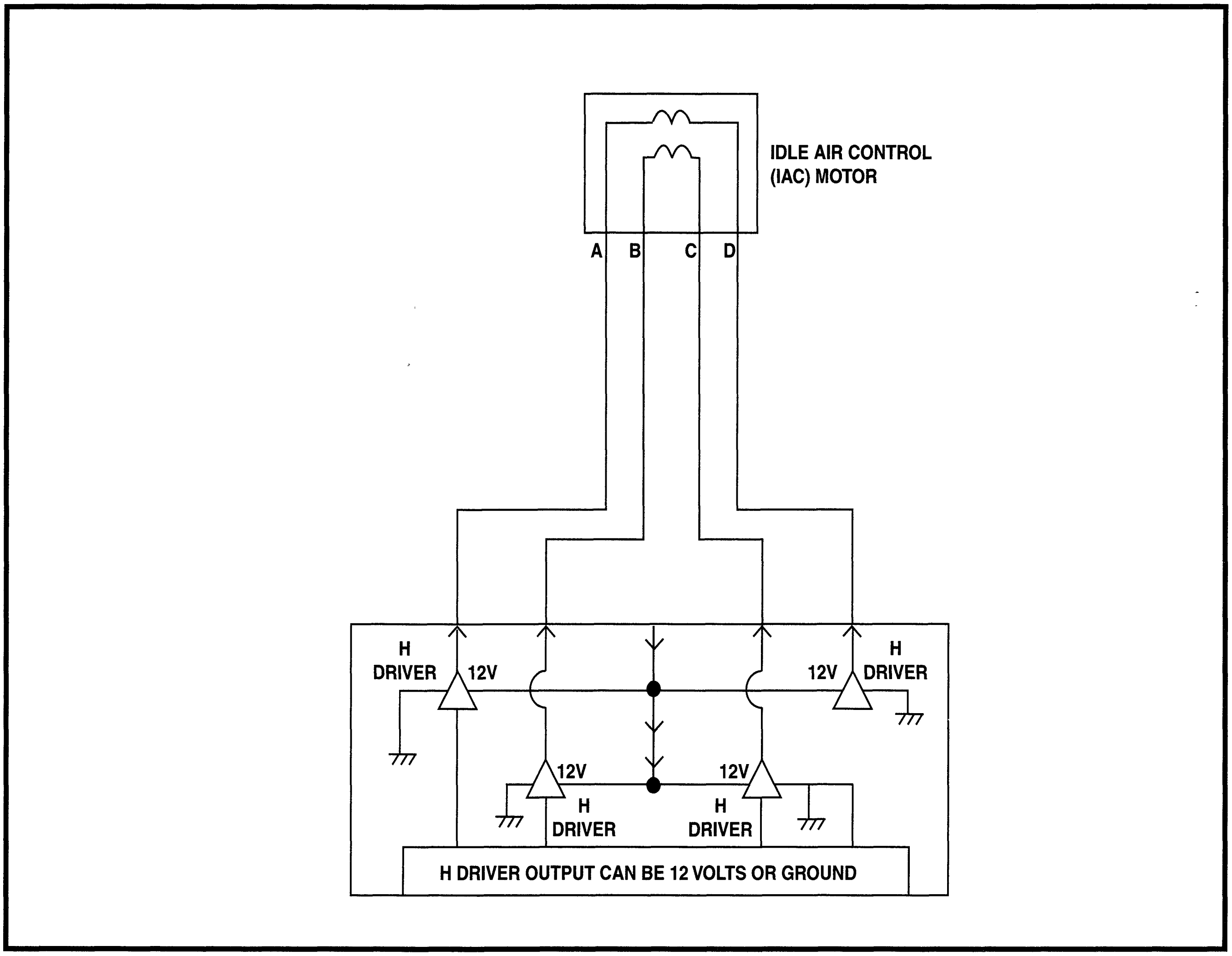


Figure 72 IAC Motor Control Circuit

In the IAC motor system, the PCM will count every step that the motor is moved. This allows the PCM to "know" the motor pintle position. If the memory is cleared, the PCM no longer "knows" the position of the pintle. So at the first key ON, the PCM drives the IAC motor closed, regardless of where it was before. This "zeros" the counter. From this point the PCM will back out the IAC motor and keep track of its position again.

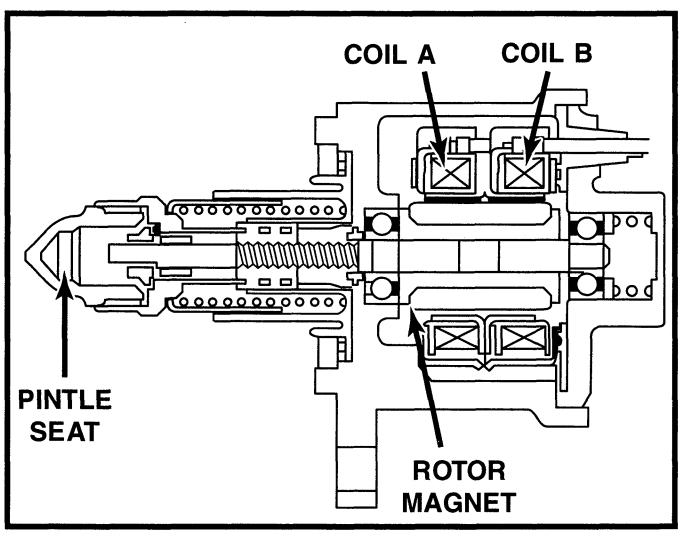


Figure 73 IAC Internal View

IAC Stepper Motor Program

When the pintle has completely blocked the air passage, the IAC stepper motor is at step 0 (fig. 74). The PCM has the authority to increase the opening by approximately 170 steps. The IAC stepper motor cannot identify in exactly which position the pintle is, so the PCM has a program that enables it to learn the position of the IAC pintle.

The program begins by learning step 0. This is accomplished by the PCM's driving the IAC stepper motor closed for several seconds when the key is first turned to the RUN position after a battery disconnect. The PCM assumes that, at the end of the cycle, the IAC stepper motor should be at step 0. Once the stepper motor finds step 0, the PCM backs the motor to the open position. The number of steps needed to arrive at the open position is based upon information delivered by the ECT sensor. The program can be updated by the DRB III or by disconnecting battery voltage from the PCM and then reconnecting it.

The PCM is also equipped with a memory program that records the number of steps the IAC stepper motor most recently advanced to during a certain set of parameters. For example: The PCM was attempting to maintain a 750 RPM target during a hot start-up cycle. The last recorded number of steps for that may have been 27. That value would be recorded in the memory cell so that the next time the PCM recognizes the identical conditions, the PCM recalls that 27 steps were required to maintain the target. This program allows for greater customer satisfaction due to greater control of engine idle.

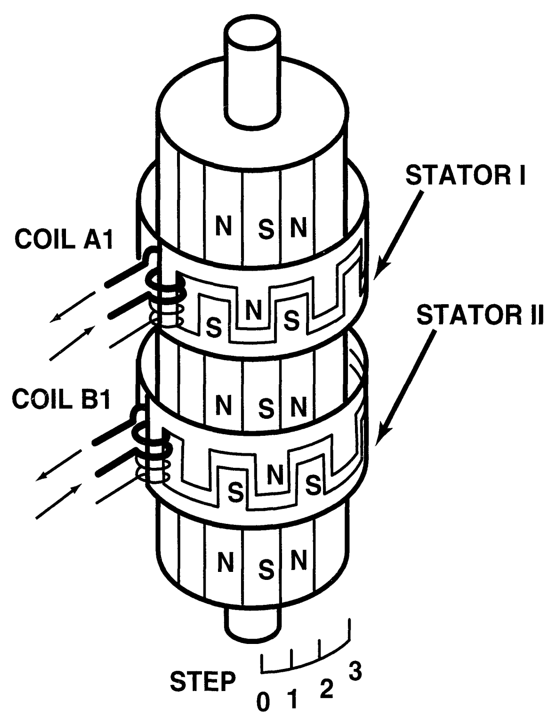


Figure 74 IAC Motor

Another function of the memory program during that key cycle, which occurs when the power steering switch or the A/C request circuit requires that the IAC stepper motor control engine RPM, is the recording of the last targeted steps. As mentioned earlier, the PCM can "anticipate" compressor loads. This is accomplished by delaying compressor operation for approximately 0.5 seconds until the PCM moves the IAC stepper motor to the recorded steps that were loaded into the memory cell. Using this program helps eliminate idle-quality changes as loads change. Finally, the PCM incorporates a "No-Load" engine speed limiter of 1800 - 2000 RPM, when it recognizes that the TPS is indicating an idle signal and IAC motor cannot maintain engine idle if MAP is high.

Target Idle

Target idle is determined by the following inputs:

- Engine Coolant Temperature sensor
- Battery Voltage
- Ambient/Battery Temperature sensor
- Vehicle Speed (VSS)
- Throttle angle (TPS)
- MAP

IAC Stepper Motor Service

Any time the IAC stepper motor or its circuit is serviced, the IAC memory cell must be updated. Use the DRB III to "Reset IAC." This ensures that the PCM can identify step 0. Also, be sure that when the IAC stepper motor is installed into the throttle body, make sure the passage is clear of debris and that the pintle does not protrude too much. Measure the distance between the motor base and the pintle tip to ensure that the distance does not exceed 1 inch.

Minimum Air Flow

Minimum air flow 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.

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 air flow. 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 air flow check, all accessories should be off. The test is performed with Tool 6457 (Metering Orifice) (fig. 75) and the DRB III scan tool. The tool is simply a 0.125 in. orifice, and the DRB III 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 air flow. The minimum air flow specifications are as follows:

- Less than 1000 miles on the engine: 550–1300 RPM.
- Over 1000 miles on the engine: 600–1300 RPM

Refer to the service manual for proper installation procedures.

If idle speed is too high, check for a vacuum leak or 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.

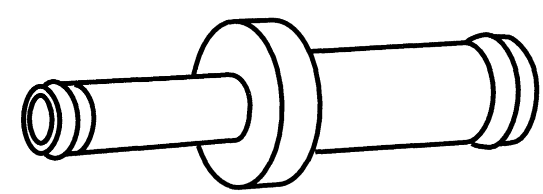


Figure 75 Metering Orifice

ACTIVITY 13 — IAC MOTOR

Use DRB and create custom display:

- MAP vacuum
- Eng. RPM
- Target idle
- IAC STEPS
- Target IAC STEPS
- Spark advance
- Min TPS
- Actual TPS volts

1. Using hand, restrict air flow (dirty air cleaner). What did you observe?
   ____
2. Make a vacuum leak. What did you observe? ______________________________
3. Open the circuit at all four IAC circuits. What did you observe?
   ____
4. Close the vacuum leak. Note timing, RPM and IAC steps. What did you observe?
   ____
5. Turn the engine OFF then ON. Where are the steps now?
   ____

Was there an idle flare? ______________________________

Should there have been one? ______________________________

6. Move P/N to drive gear (open BOB).

Systems Test

7. Perform the IAC wiggle test. Open one circuit one BOB. What happened to IAC steps? ______________________________

Miscellaneous

8. Reset memory and IAC counter. Go back to custom display. Start the engine. What did you observe? ______________________________
9. Hook up a second IAC. Go to Misc. reset IAC. What did pintle do? ____________
   ____

RADIATOR FAN RELAYS

PL (Neon)

The Neon may have one or two radiator fans depending on how the vehicle is equipped. However, there is only one relay controlling the fans regardless of the number of fans. That relay is controlled by the PCM (fig. 76). The PCM controls the ground circuit for the relay coil. A Neon may have either single or dual fans. Regardless of the number, they are turned on by engine temperature and A/C select. The relay is energized for both A/C operation and engine cooling by the PCM. The relay turn on and off points are road speed dependent:

- less than 36 mph relay is ON > 210°F, turns OFF at 201°F.
- greater than 44 mph relay is ON > 219°F, turns OFF at 210°F.

There is also an anti-steam feature. With key on, if ECT is less than 100°F and ambient/BATT is less than 90°F, and the vehicle has been above 3 mph a 3 minute timer starts if the vehicle returns to below 3 mph, when ECT reaches 180°F the fan(s) will turn on.

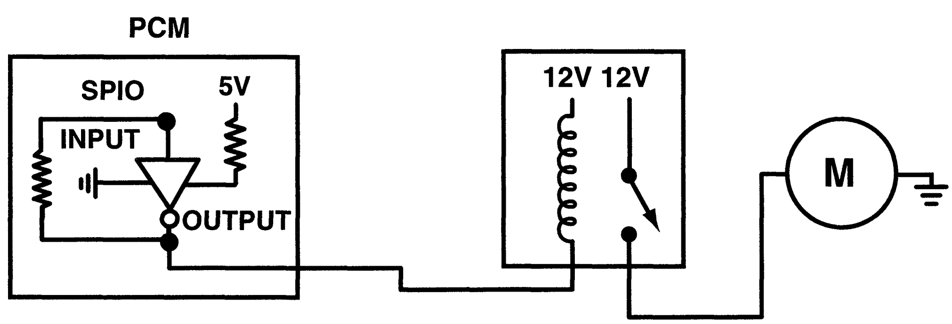


Figure 76 Radiator Fan Relay Control Circuit (PL)

Beginning with the 1997 model year, the PL uses a PWM fan module as found on NS (see page 125). The PL strategy is to ramp up, rather than ramp down as done on NS.

COOLING FANS

JA/JX

The Cirrus/Stratus/Breeze have two radiator fans. The Sebring Convertible has only one radiator fan. However, both systems operate the same. There are 2 relays, High speed fan relay and Low speed fan relay. Both relays are controlled by the PCM.

The PCM controls the radiator fan relays by providing a ground (fig. 77). The PCM monitors inputs from the A/C request, A/C pressure sensor, Transmission fluid temperature and the ECT sensor to determine when to activate the relays. With the low-speed fan relay energized, current flows across the contacts of the relay to the brushes of the low-speed fan motor. The high-speed fan motor is also engaged but at a reduced speed. To reduce the speed of the high-speed fan motor, current through the brushes must decrease. The task of reducing current flow to the high-speed motor is provided by the low-speed motor. Current flows into the low-speed motor's positive brush. Then, current flows through the negative brush and also back through the windings of the low-speed motor's high-speed brush. Due to the resistance of the high-speed siding, current is decreased and routed to the high-speed fan motors positive brush. This allows both fan motors to operate at a low speed.

When the PCM identifies the need to increase the air flow through the radiator and condenser, the PCM energizes the high-speed relay (low-speed relay is de-energized). With the high-speed fan relay energized, current flow across the relay's contacts to both high- and low- speed motors providing a high-speed fan operation. Refer to Radiator Fan and A/C Compressor Operation table for when the relays are energized.

Connected in series with the radiator fans is a Radio Frequency Induction (RFI) module. Most electric motors produce voltage spikes that may have a negative effect on some electronic components. This module is designed to reduce the tendency of voltage spikes from the radiator fan motors circuits.

NOTE: Since this module is in series with fan motors, it is important to remember that this module can affect the operation of the fan motors.

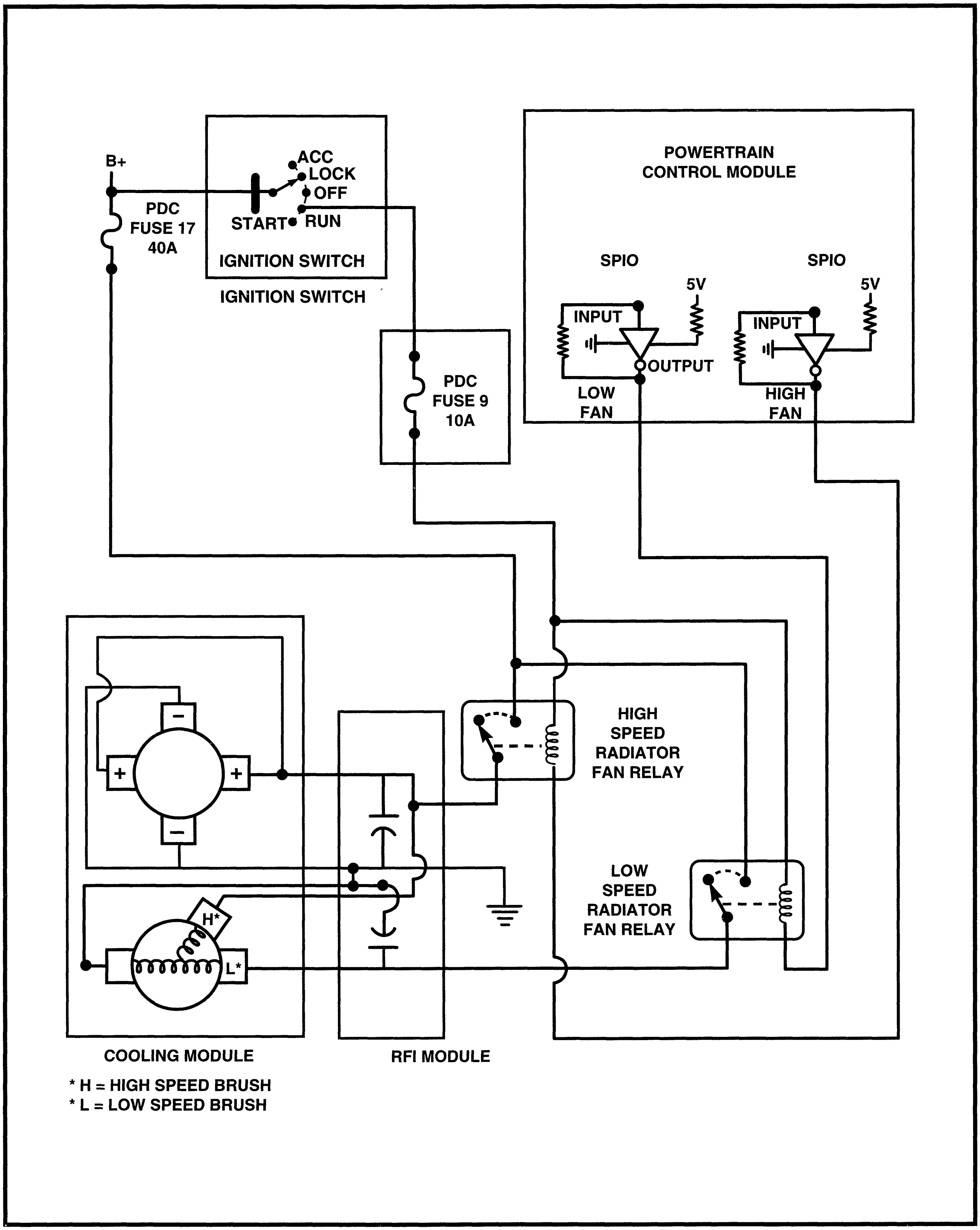


Figure 77 Radiator Fan Circuit (JA/JX)

NS

Minivans have 2 radiator fans. Both of these fans are controlled by a Pulse Width Module (PWM). The PCM controls the ground circuit of the PWM (fig. 78). The PCM decides how much fan on time is required, based on A/C pressure, ECT and road speed*. The PCM duty cycles (turns on/off rapidly) the ground circuit of the PWM. The PWM duty cycles the voltage and current supply to the fan motors. This allows for a continuously variable fan speed. To start the blade spinning, the PCM momentarily fully grounds the circuit and then begins to ramp in the duty cycle based on determined demand.

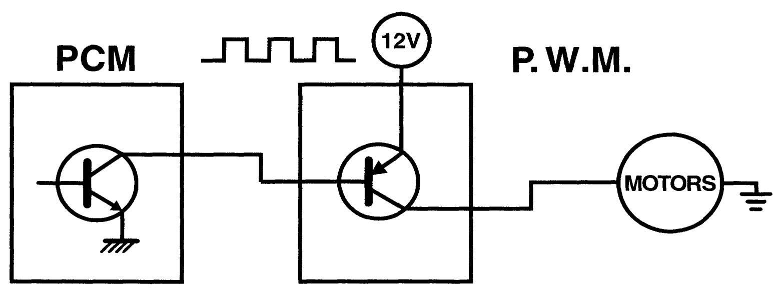


Figure 78 Radiator Fan Circuit (NS)

* Transmission fluid temperature is also an input beginning with the 1997 model year.

FJ22/F24S

Radiator Fan Relays

The PCM supplies the ground circuit for both high-speed radiator fan relays' coils. The high-speed condenser fan relay's coil is controlled through pin 69. The low-speed radiator fan relay's coil is controlled by the A/C sense circuit (fig. 79).

An Avenger/Sebring or Talon with a manual transmission has two radiator fan motors. One motor is for the radiator, the other is for the A/C condenser. The radiator fan is a single speed and the condenser fan is a 2 speed fan.

An Avenger/Sebring or Talon with an automatic transmission also has two radiator fan motors. One motor is for the radiator and the other is for the condenser. However, both motors are 2 speed.

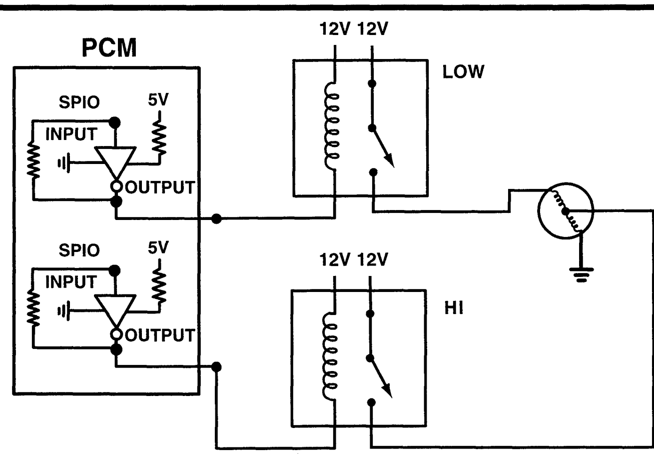


Figure 79 Radiator Fan Circuit (F-Car)

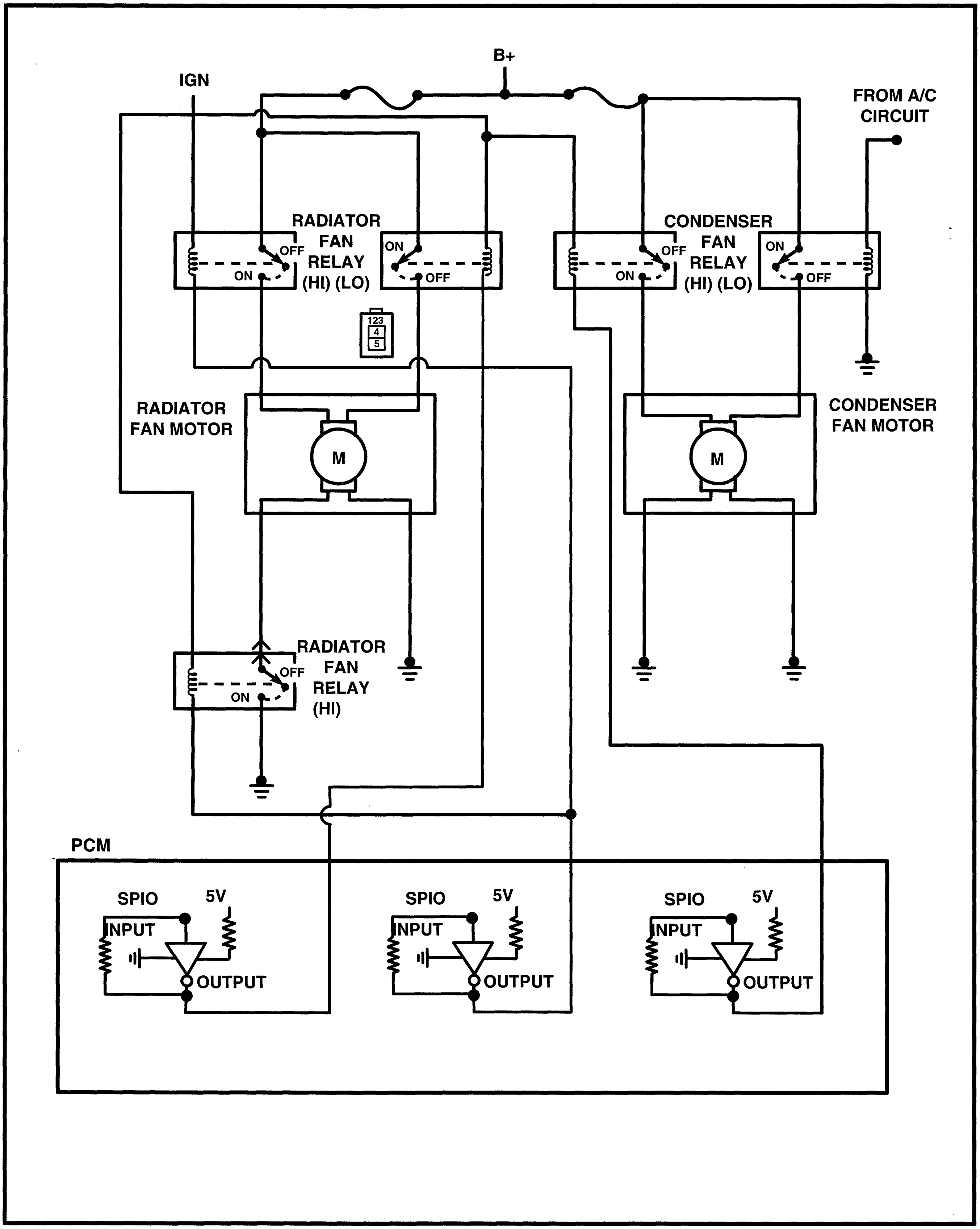


Figure 80 Avenger and Sebring Radiator Fan and Condenser Relay Circuits

All F Cars use 4 relays, 2 for each motor, to control fan speed (fig. 80). Each motor has a low speed fan relay and a high speed fan relay. The PCM controls the ground for the radiator relays and the high speed condenser relay. The low speed condenser relay is hard wired to ground. The power for the low speed condenser relay coil is supplied by the A/C ECM. Condenser fan operation is explained in the A/C section of the book.

The two-speed radiator fan motor is equipped with four fan-motor brushes; two positive and two negative. One positive brush is fed battery voltage from the low-speed fan relay and the other positive brush is fed battery voltage from one of the high-speed fan relays. The two remaining brushes (negative) are connected to a chassis ground. One brush is connected directly to ground and the other is a controlled ground through the second high-speed radiator fan relay.

Battery voltage is provided to the positive brushes fan relay's contacts through a fuse located in the PDC. When the PCM energizes the low-speed fan relay, current flows through the contacts of the relay to the fan motor's low-speed brushes, providing low-speed operation of the fan motor. High speed is accomplished by the PCM energizing all three radiator fan relays (one low-speed and two high-speed). When this occurs, current flows to both low-speed and high-speed fan motor brushes.

Condenser Fan Relays

The condenser fan motor operates very similar to the radiator fan motor. The low-speed relay's coil is provided battery voltage by the A/C switch and is grounded continuously. When all of the appropriate inputs to the automatic A/C control module indicate that the A/C compressor should be functioning, battery voltage is supplied to the condenser fan motor's low-speed relay. The high-speed fan motor relay's coil is fed battery voltage through a fuse, and the ground side is controlled by the PCM.

Battery voltage is provided to both of the relay contacts through a fuse located in the PDC. When the low-speed fan relay is energized, current flows through the relay contacts to the condenser fan motor's low-speed brushes. If high speed is called for by the PCM, the PCM energizes the high-speed fan relay. As long as the low-speed relay is supplying battery voltage to the fan motor's low-speed brushes, the energized high-speed relay supplies voltage to the high-speed brushes, which allows the condenser fan to operate at high speed.

NOTE: If the PCM energizes the condenser's high-speed relay and the low-speed relay is not energized, the condenser fan motor operates at low speed.

Table 8 represents the values at which the radiator/condenser fans and A/C compressor relays are energized and de-energized.

A/C SWITCH POSITION	VEHICLE SPEED	ENGINE COOL. TEMP. (F)	LOW FAN RELAY	HI FAN RELAY	A/C COMP.	RAD. FAN SPEED	COND. FAN SPEED
OFF	0-28 mph	Under 203	OFF	OFF	OFF	OFF	OFF
		203 to 212	ON	OFF	OFF	LOW	OFF
		Over 212	ON	ON	OFF	HI	LOW
	28-50 mph	Under 203	OFF	OFF	OFF	OFF	OFF
		203 to 212	ON	OFF	OFF	LOW	OFF
		Over 212	ON	ON	OFF	HI	LOW
	Over 50 mph	Under 212	OFF	OFF	OFF	OFF	OFF
		Over 212	ON	ON	OFF	HI	LOW
ON	0-12 mph	Under 212	ON	OFF	ON	LOW	LOW
		212 to 239	ON	ON	ON	HI	HI
		Over 239	ON	ON	Disabled	HI	HI
ON	12-28mph	Under 212	ON	OFF	ON	LOW	LOW
		212 to 239	ON	ON	ON	HI	HI
		Over 239	ON	ON	Disabled	HI	HI
	Over 50 mph	Under 212	OFF	OFF	ON	OFF	LOW
		212 to 239	ON	ON	ON	HI	HI
		Over 239	ON	ON	Disabled	HI	HI

Table 8 Radiator/Condenser Fan and A/C Compressor Relay Operation

Generator Field Control

The PCM is responsible for regulating the charging system's voltage. The voltage determined by the PCM as the final goal for the charging system is called "target charging voltage." On the FJ22/F24S/NS/PL, the target charging voltage is controlled mainly by the battery temperature sensor, which is located in the PCM (except PL which is near the battery tray). On the JA/JX, the ambient temperature sensor and the ECT sensor are the PCM's inputs that have the greatest effect on target charging voltage. The ambient temperature sensor is located on the radiator closure panel.

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 (fig. 81) until sensed battery voltage is 0.5 volts above target voltage. A circuit in the PCM cycles the ground side of the generator field up to 100 times per second (100Hz), 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% is used by the PCM in order to have some generator output.

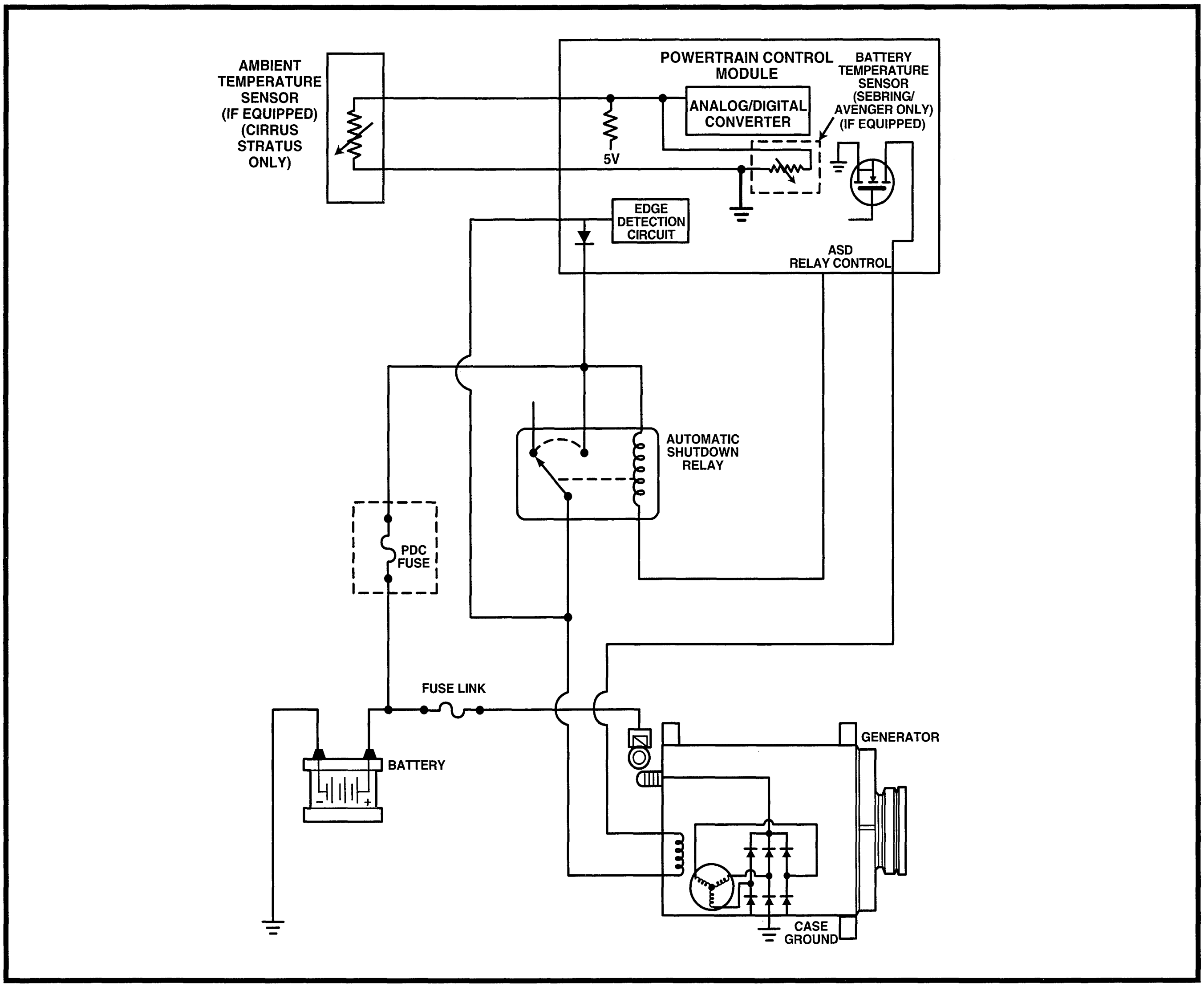


Figure 81 Generator Field Control Circuit

CHARGING SYSTEM INDICATOR LIGHT (GEN. LAMP)

The PCM controls the operation of the charging system indicator light, located in the vehicle's instrument cluster. On the Avenger and Sebring, and Neon the PCM provides a ground to complete the lamp circuit if the charging output falls below a specified threshold (fig. 82). The JA/JX/NS Cirrus and Stratus bus the charging system indicator light signal over the C^2D to the instrument cluster. Also, the lamp is illuminated if the ambient temperature sensor fails.

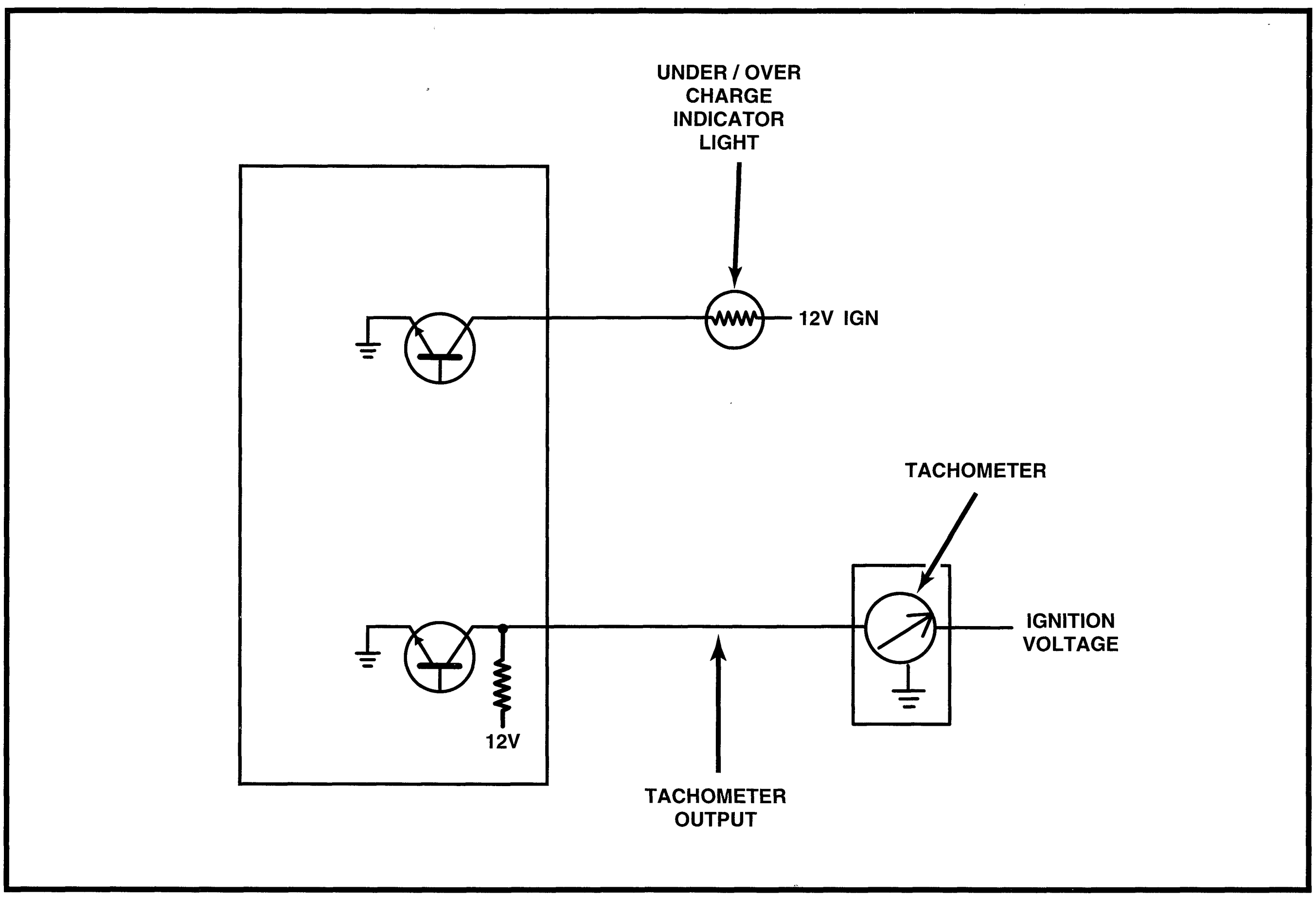


Figure 82 Generator Lamp Control Circuit

TACHOMETER

On FJ22/F24S and Neon, the PCM operates the tachometer located in the instrument panel. The PCM provides duty-cycle output voltage to the tachometer (fig. 81). The frequency of the duty cycle is based upon engine speed which is calculated from inputs from the CKP and CMP sensors.

TORQUE CONVERTER CLUTCH SOLENOID (AUTO TRANS ONLY)

Vehicles equipped with the three speed automatic transmission contain a PCM input to verify operation of the torque converter clutch solenoid. The PCM controls engagement of the clutch through the solenoid. The automatic transmission will not allow the torque converter clutch to engage if the transmission is not in direct drive.

MALFUNCTION INDICATOR LAMP (MIL)

The MIL (CHECK ENGINE) lamp is located in the instrument cluster. The MIL can illuminate under a greater number of conditions than on previous models.

The MIL is operated by the PCM, and illuminates for a three-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. In a limp-in mode, the PCM provides programmed inputs to keep the vehicle operational.

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. The vehicle should not be driven if this occurs.

Any time the MIL is illuminated, a DTC is stored. Once the MIL illuminates, the PCM must meet certain criteria to extinguish the lamp. Previously, on vehicles equipped with OBD I diagnostics, the MIL extinguishes only after the problem that caused the MIL to illuminate is repaired, and the key has been cycled from OFF to ON one time. On vehicles equipped with OBD II diagnostics, three consecutive good trips must occur to extinguish the MIL.

If a problem occurred with one of the main monitors, the PCM must pass the test of the monitor that failed three consecutive times before the MIL is extinguished.

DTCs that were stored can be automatically erased only after the MIL has been extinguished and 40 warm-up cycles have occurred.

Trip Definition

The term "Trip" has different meanings depending on what the circumstances are. If the MIL (Malfunction Indicator Lamp) is OFF, a Trip is defined as when the Oxygen Sensor Monitor and the Catalyst Monitor have been completed in the same drive cycle.

When any Emission DTC is set, the MIL on the dash is turned ON. When the MIL is ON, it takes 3 good trips to turn the MIL OFF. In this case, it depends on what type of DTC is set to know what a "Trip" is.

For the Fuel Monitor or Mis-Fire Monitor (continuous monitor), the vehicle must be operated in the "Similar Condition Window" for a specified amount of time to be considered a Good Trip.

If a Non-Continuous OBD II Monitor, such as:

- Oxygen Sensor
- Catalyst Monitor
- Purge Flow Monitor
- Leak Detection Pump Monitor (if equipped)
- EGR Monitor (if equipped)
- Oxygen Sensor Heater Monitor

fails twice in a row and turns ON the MIL, re-running that monitor which previously failed, on the next start-up and passing the monitor is considered to be a Good Trip.

If any other Emission DTC is set (not an OBD II Monitor), a Good Trip is considered to be when the Oxygen Sensor Monitor and Catalyst Monitor have been completed; or 2 minutes of engine run time if the Oxygen Sensor Monitor or Catalyst Monitor have been stopped from running.

It can take up to 2 failures in a row to turn on the MIL. After the MIL is ON, it takes 3 Good Trips to turn the MIL OFF. After the MIL is OFF, the PCM will self-erase the DTC after 40 Warm-up cycles. A Warm-up cycle is counted when the ECT (Engine Coolant Temperature Sensor) has crossed 160^{0}F and has risen by at least 40^{0}F since the engine has been started.

Refer to the OBD II course for a complete explanation.

EVAPORATIVE PURGE SOLENOID

The Evaporative purge solenoid operation is controlled by the PCM. The PCM provides a ground path that allows the solenoid to open. Refer to the Emission Control Systems section of this publication for more information.

EGR SOLENOID

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

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 operates the ground side of the vacuum and vent solenoids of the servo. Refer to the Vehicle Speed Control System section of this publication for more information.

LESSON 6

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. The evaporative emissions control for the NS/JA/JX/PL are slightly different than that of the FJ22/F24S. The exhaust emissions control are very similar in the way the PCM monitors the inputs and controls fuel and ignition systems. All 2.0/2.4L engines use an EGR valve, back pressure transducer, and a three-way catalyst.

EVAPORATIVE EMISSION CONTROL — NS/JA/JX/PL

The evaporative control system consists of a fuel cap, rollover valves, vapor lines, evaporative canister, Duty Cycle Purge (DCP) solenoid, orifice, PCV valve, and vapor lines. On some vehicles there is also an Evaporative System Leak Detection pump (fig. 83).

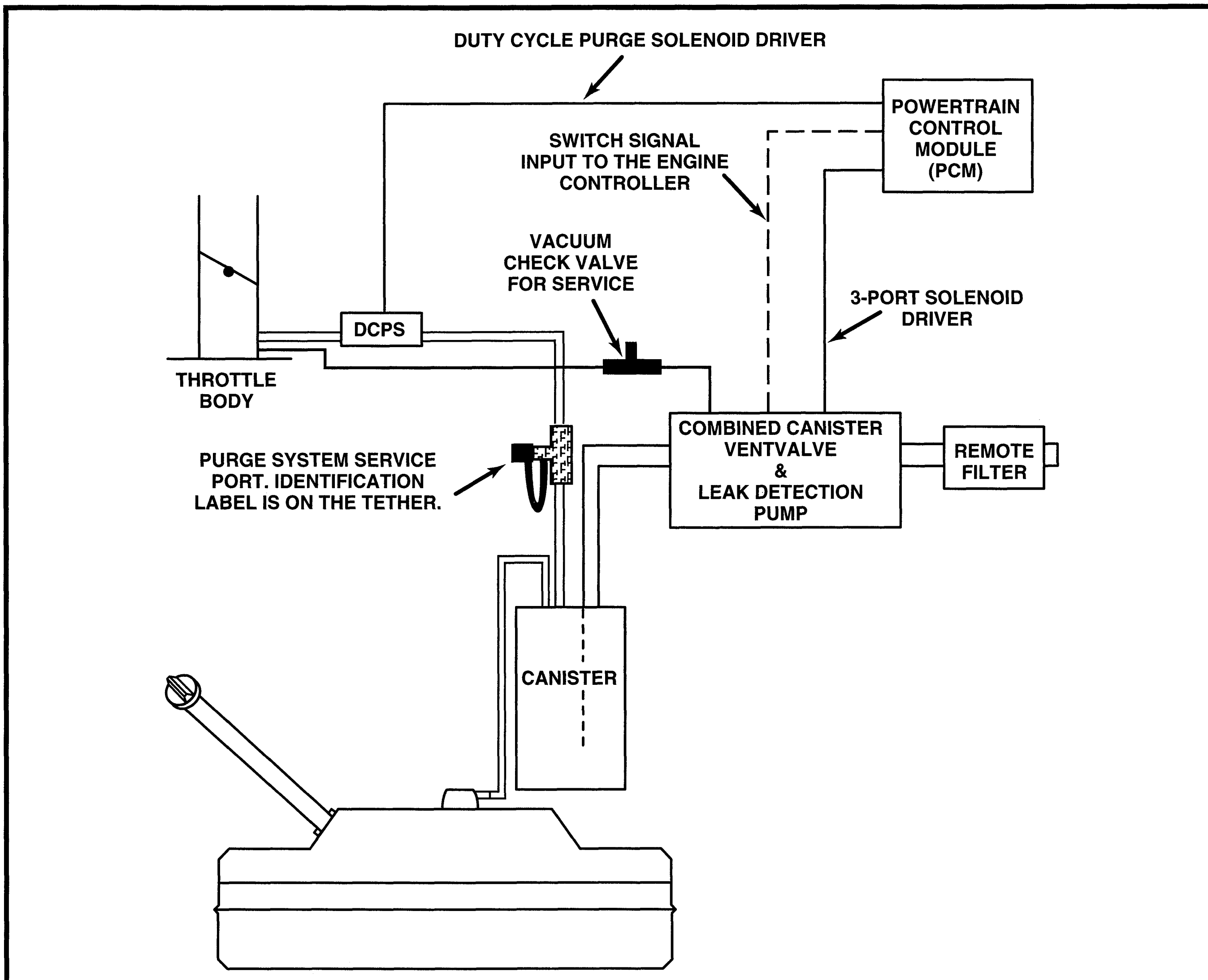


Figure 83 EVAP LDP System

Fuel Filler Cap

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

Rollover Valves

Attached to the filler neck is a replaceable rollover valve. This valve is designed to allow fuel tank vapors to be routed to the canister. 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. A second valve is attached to the top of the fuel tank on a vapor dome (fig. 84). The construction of this valve is similar to the one attached to the filler neck, except that it is not replaceable. A third rollover valve is located on the top of the fuel tank at the front. Like the previous valve, this valve is not replaceable.

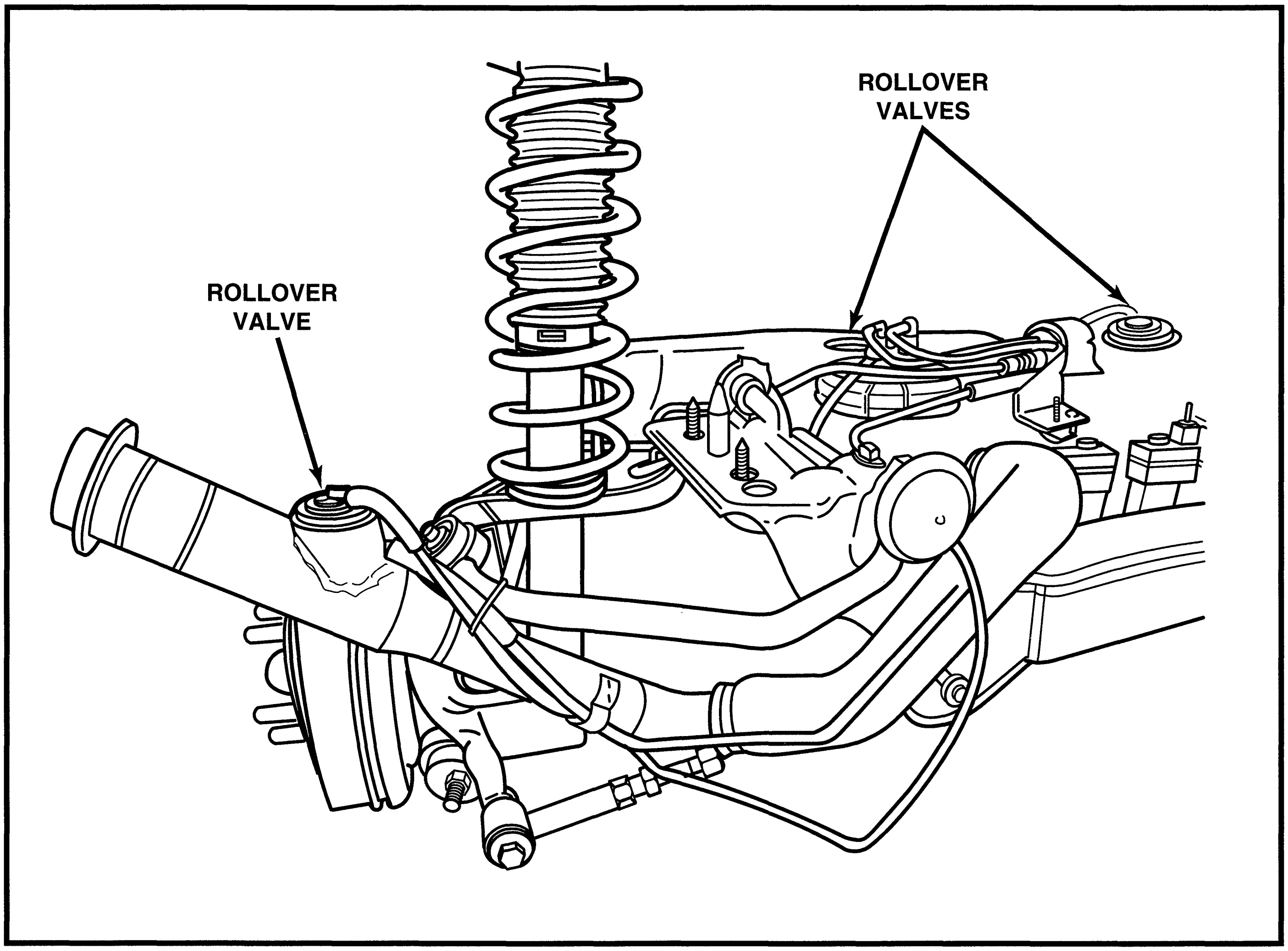


Figure 84 Rollover Valve

Evaporative Charcoal Canister

The evaporative charcoal canister temporarily stores fuel vapors until intake manifold vacuum draws them into the combustion chamber.

The Duty Cycle Purge solenoid is used to control the flow of vapors to the intake manifold (fig. 85). Operation of the solenoid is controlled by the PCM which provides a ground path that allows the solenoid to open, allowing vapor flow.

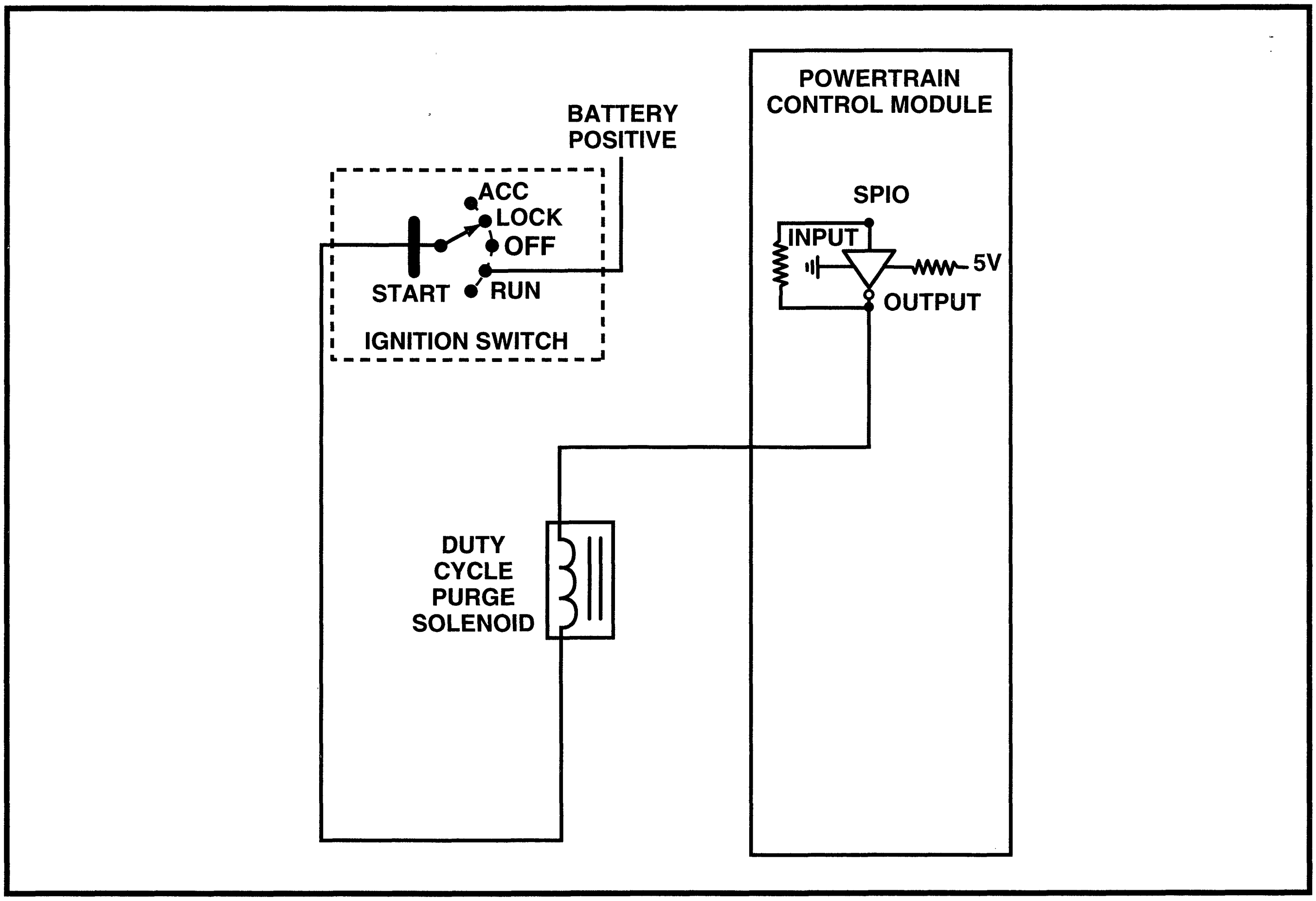


Figure 85 Duty Cycle Purge Solenoid Control Circuit

The PCM does not energize the solenoid during the cold-start warm-up period or during the hot-restart time delay. Once the vehicle enters closed-loop operation and delay times have elapsed, the PCM energizes the solenoid approximately five to ten times per second, depending upon the throttle position and vehicle speed. The PCM varies the pulse-width signal to the solenoid to control the amount of vapor flow.

EVAPORATIVE EMISSION CONTROL - FJ22/F24S

The evaporative control system consists of a fuel cap, fuel cutoff valve, vapor line, fuel tank pressure relief valve, evaporative canister, DCP solenoid, orifice, PCV valve, and an intake manifold vacuum line (refer to fig. 83 on page 135). On some vehicles there is also an Evaporative System Leak Detection Pump.

EVAPORATIVE CHARCOAL CANISTER

The evaporative charcoal canister temporarily stores fuel vapors until intake manifold vacuum draws them into the combustion chamber. Between the fuel cutoff valve and the evaporative canister is a fuel tank pressure relief valve. This valve incorporates a one-way check valve and an orifice. A restriction is applied only in the direction of flow from the fuel tank to the evaporative canister. The check valve allows the unrestricted flow of vapors in the opposite direction.

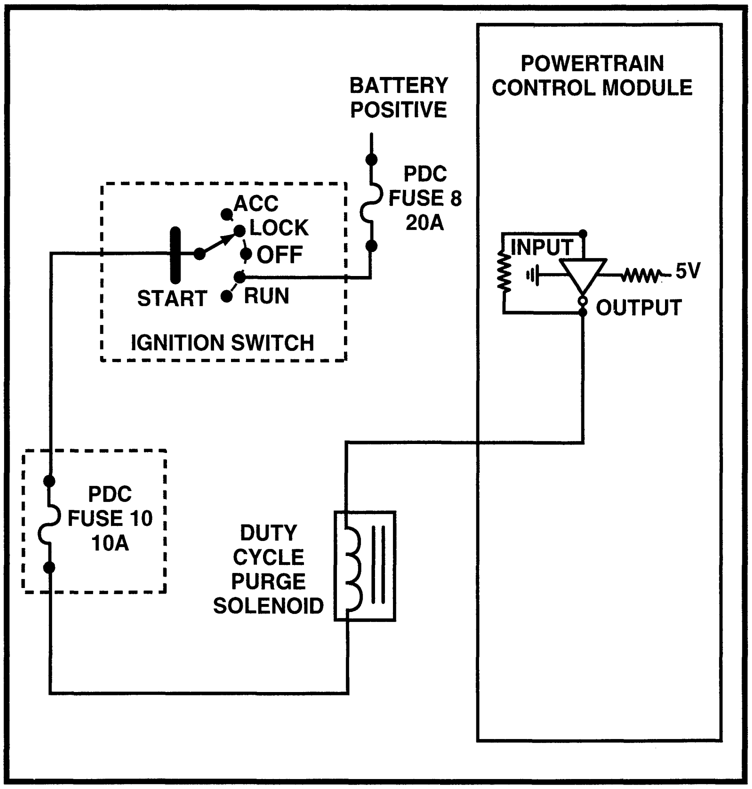


Figure 86 Duty Cycle Purge Solenoid Control Circuit

The DCP solenoid is used to control the flow of vapors to the intake manifold. Operation of the solenoid is controlled by the PCM providing a ground path that allows the solenoid to open, allowing vapor flow (fig. 86).

The PCM does not energize the solenoid during the cold-start warm-up period or during the hot-restart time delay. Once the vehicle enters closed-loop operation and delay times have elapsed, the PCM energizes the solenoid approximately five to ten times per second, depending upon the throttle position, engine speed, and engine load. The PCM varies the pulse-width signal to the solenoid to control the amount of vapor flow.

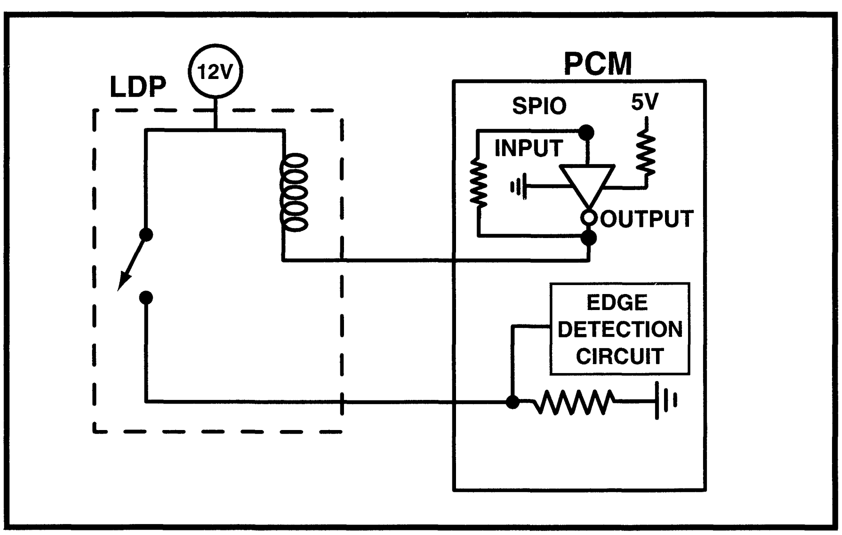


Figure 87 Leak Detection Pump Control Circuit

Leak Detection Pump

The leak detection pump is a device that pressurizes the evaporative system to determine if there are any leaks. When certain conditions are met the PCM will activate the pump and start counting pump strokes (fig. 87). If the pump stops within a calibrated number of strokes the system is determined to be leak free. If the pump does not stop, a DTC will be set. Refer to the OBD II course for more information.

POSITIVE CRANKCASE VENTILATION (PCV) VALVE

Crankcase vapors and piston ring blow-by are removed from the engine by manifold vacuum through the Positive Crankcase Ventilation (PCV) valve (fig. 88). The vapors pass through the PCV valve into the intake manifold where they become part of the calibrated air-fuel mixture and are burned and expelled with the exhaust gases.

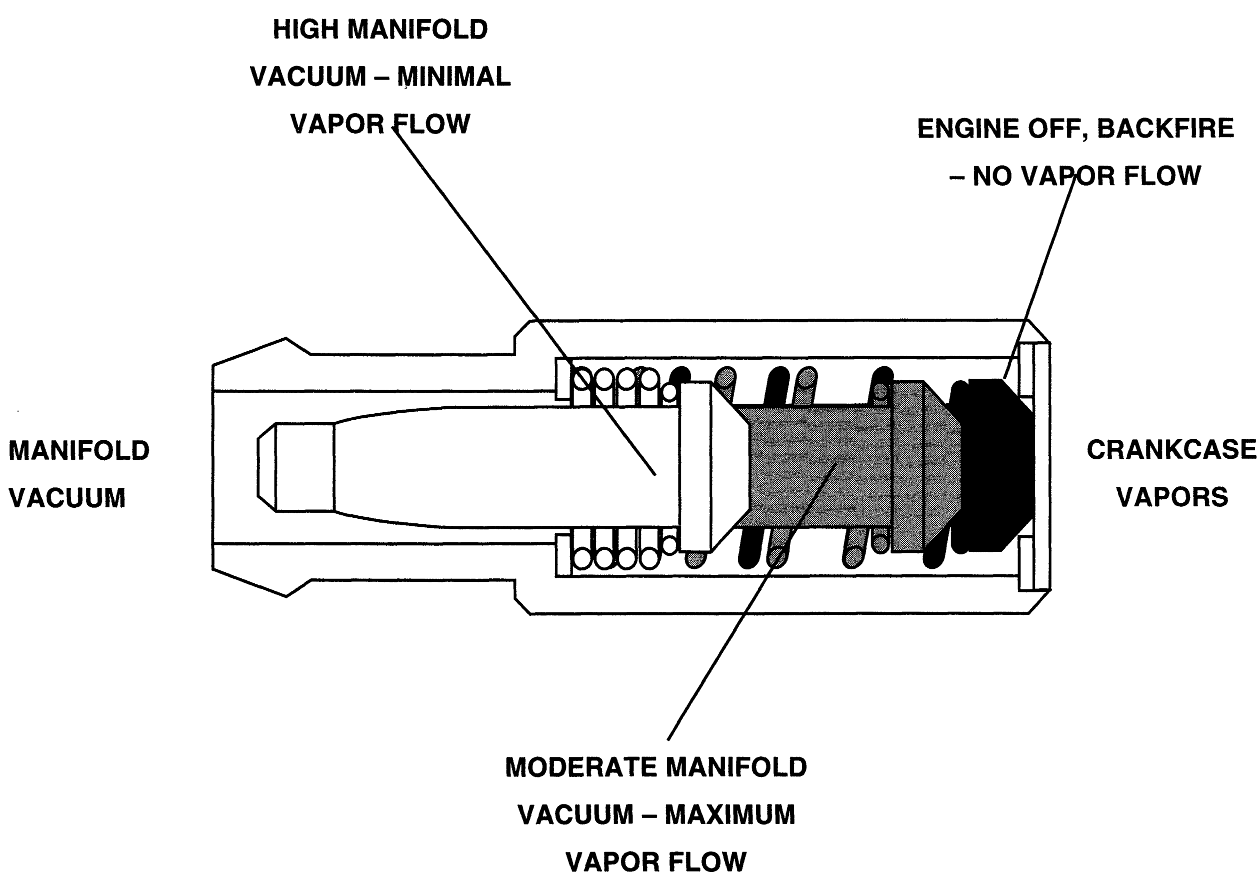


Figure 88 Positive Crankcase Ventilation Valve

EXHAUST EMISSIONS CONTROL

Exhaust emissions control start with the PCM maintaining the appropriate air/fuel ratio and ignition timing, which were explained in previous sections. Exhaust Gas Recirculation (EGR) systems used on the 2.0L/2.4L engines incorporate an EGR valve and back pressure transducer. A three-way catalyst is used to help minimize HC, CO, and NO_x exhaust emissions.

Exhaust Gas Recirculation (EGR) Transducer

EGR is used to displace oxygen and fuel in the combustion chamber. This results in a lower peak combustion temperature which aids in reduction of NO_x. It has the added benefit of increasing fuel economy.

The EGR valve and back-pressure transducer are located at the rear of the cylinder head, near the CMP sensor. The EGR solenoid is attached to the transducer, and controls the supply of vacuum to the EGR transducer. The transducer is attached to the exhaust supply, and controls the supply of vacuum to the EGR valce. The valve is fed exhaust gases from the exhaust manifold, and routes the gases to the intake manifold.

The PCM provides a ground path that operates the solenoid on the EGR transducer (fig. 89). When the solenoid is energized, manifold vacuum is not allowed to reach the transducer. De-energizing the solenoid allows vacuum to flow to the transducer, and with appropriate back pressure, the transducer vent closes. This allows vacuum to reach, and open, the EGR valve.

This EGR back-pressure transducer may contain a light spring-load (2 inches of water) to assist in the opening of the transducer valve (fig. 90). This means that the valve must have a slight amount of back-pressure to close off the vent to allow vacuum to reach the EGR valve. For proper EGR valve operation, the position of the valve is critical. The transducer hose that attaches it to the exhaust supply should always be facing down. This allows gravity to assist in opening the valve when appropriate.

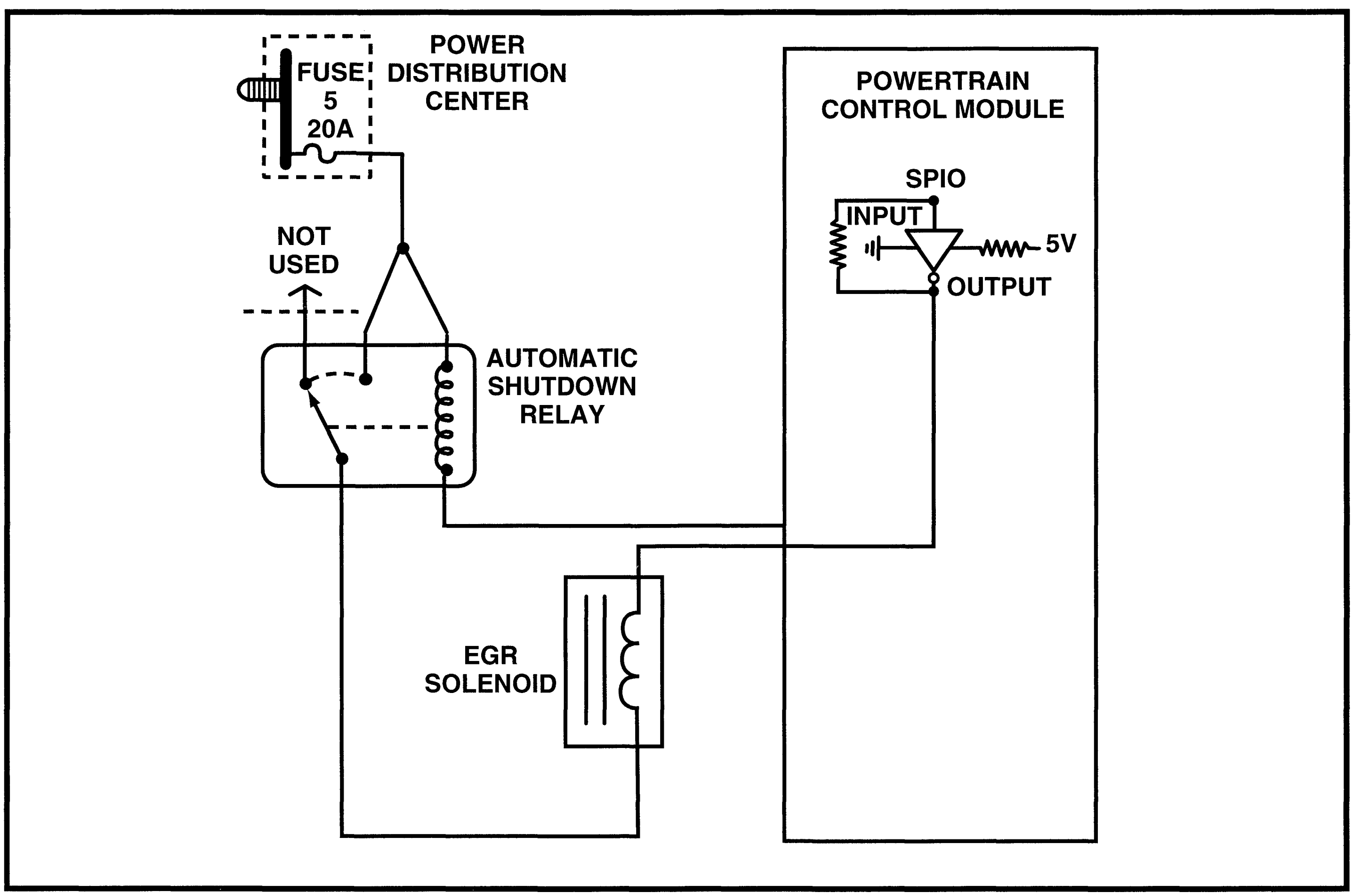


Figure 89 EGR Control Circuit

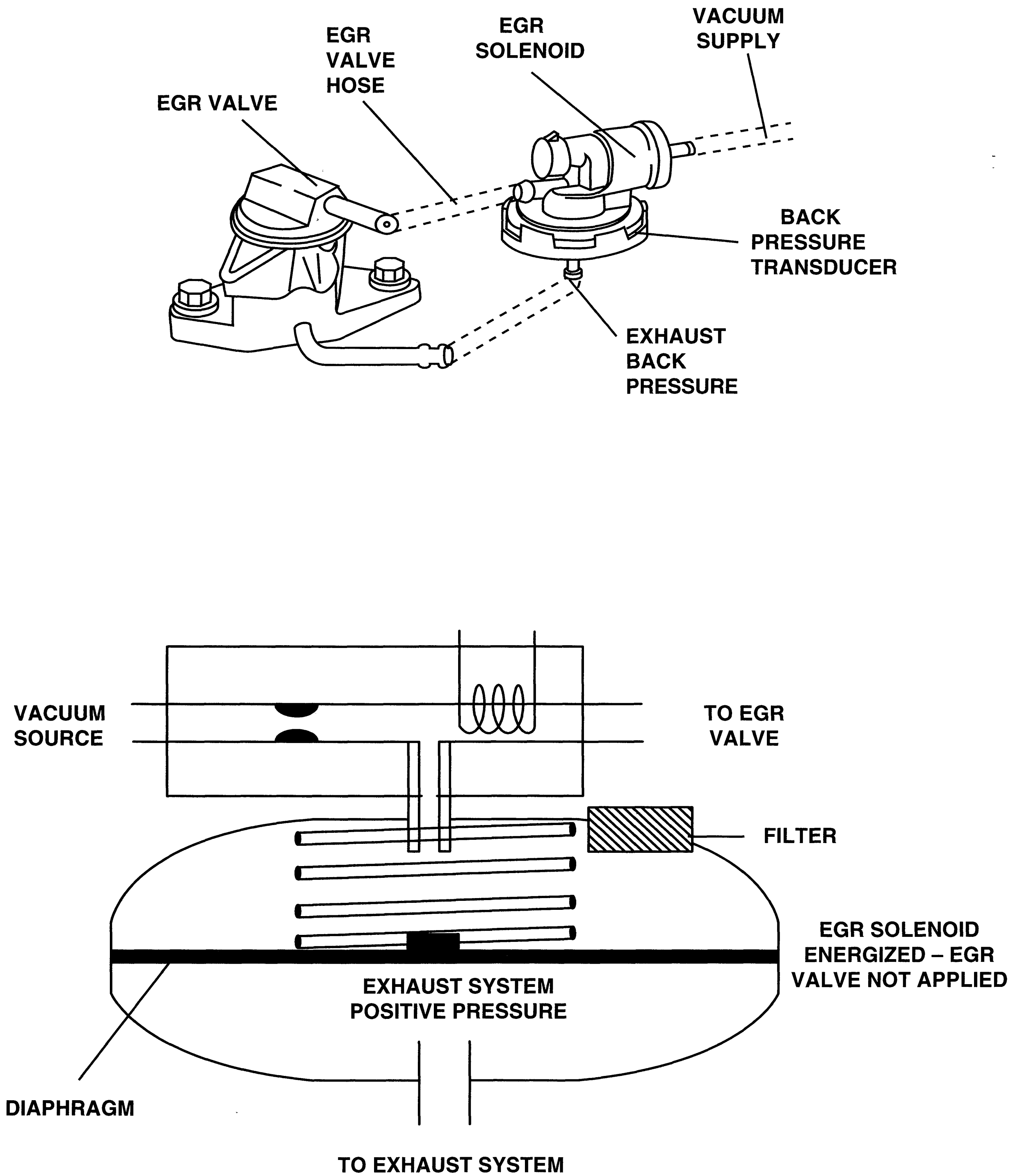


Figure 90 Back-Pressure Transducer

NOTES

LESSON 7

VEHICLE SPEED CONTROL SYSTEM

NS/JA/JX/PL VEHICLE SPEED CONTROL SYSTEM

System Operation

Vehicle speed control is accomplished through the PCM. The various speed control switches are a multiplex design, hard wired to the PCM. A vacuum operated speed control servo contains solenoids that are also controlled by the PCM.

The speed control switches provide inputs to the PCM to indicate the speed control modes: On, Off, Set, Resume, Cancel, Accelerate, Coast.

There are two separate switch assemblies that operate the speed control system. The steering-column-mounted switches use multiplexed circuits to provide inputs to the PCM for ON/OFF, Resume/ Accelerate, Set/Coast and Cancel modes.

When speed control is selected by depressing the ON/OFF switch, the PCM allows a set speed to be stored in RAM for speed control. To store a set speed, depress the COAST/SET switch while the vehicle is moving at a speed between 30 and 85 mph. In order for the speed control to engage, the brakes cannot be applied, nor can the gear selector be indicating the transmission is in Park or Neutral; if equipped with a manual transmission the transmission must be in either 3rd, 4th, or 5th gear and engine RPM must be below 6000 RPM.

The speed control can be disengaged manually by:

- Stepping on the brake pedal
- Selecting the OFF position
- Depressing the CANCEL switch
- Allowing vehicle to decelerate (coast) to below 25 mph
- Depressing the clutch

The speed control can be disengaged also by any of the following conditions:

- An indication of Park or Neutral
- An RPM increase without a VSS signal increase (indicates that the clutch has been disengaged)
- Excessive engine RPM (indicates that the transmission may be in a low gear)

The previous disengagement conditions are programmed for added safety.

Once the speed control has been disengaged, depressing the RES/ACCEL switch restores the vehicle to the target speed that was stored in the PCM's RAM.

Speed Control Switch Operation

When the ON switch is depressed, the indicator lamp comes on (if equipped) and the PCM sends 12 volts to the speed control servo through a set of contacts in the brake switch that are closed with the pedal at rest (fig. 91).

Depressing the ON/OFF switch will erase the set speed stored in the PCM's RAM and turn off power to the servo.

While traveling between 30 and 85 mph the SET button can be depressed causing a value to be stored in the PCM's RAM.

If, while the speed control is engaged, the driver wishes to increase vehicle speed, the PCM is programmed for an acceleration feature. With the RES/ACCEL switch held closed, the vehicle accelerates slowly to the desired speed. The new target speed is stored in the RAM when the RES/ACCEL switch is released. The PCM also has a "tap- up" feature in which vehicle speed increases at a rate of approximately 2 mph (FJ/F24S is 1 mph) for each momentary switch activation of the RES/ACCEL switch.

There are two ways to disengage the speed control system. Depressing either the brake pedal or cancel switch will disengage the speed control system without loosing the target speed in memory. When the brakes are applied two things happen:

- The PCM recognizes an input that the brakes are applied. This causes the PCM to disengage speed control operation and retain the target speed in memory.
- Interrupts the power supply to the speed control servo.

The PCM also provides a means to decelerate without disengaging speed control. To decelerate from an existing recorded target speed, depress and hold the SET/COAST switch until the desired speed is reached. Releasing the switch causes a new target speed to be stored in RAM.

Speed Control Servo

The speed control servo consists of three solenoids:

- Vacuum
- Vent
- Dump

There is also a diaphragm with a cable attached to control the throttle linkage.

As mentioned earlier, power is supplied to the servo's by the PCM through the brake switch. The PCM also controls the ground path for the vacuum and vent solenoids.

The dump solenoid is energized anytime it receives power. If power to the dump solenoid is interrupted, the solenoid dumps vacuum in the servo. This provides a safety backup to the vent and vacuum solenoids.

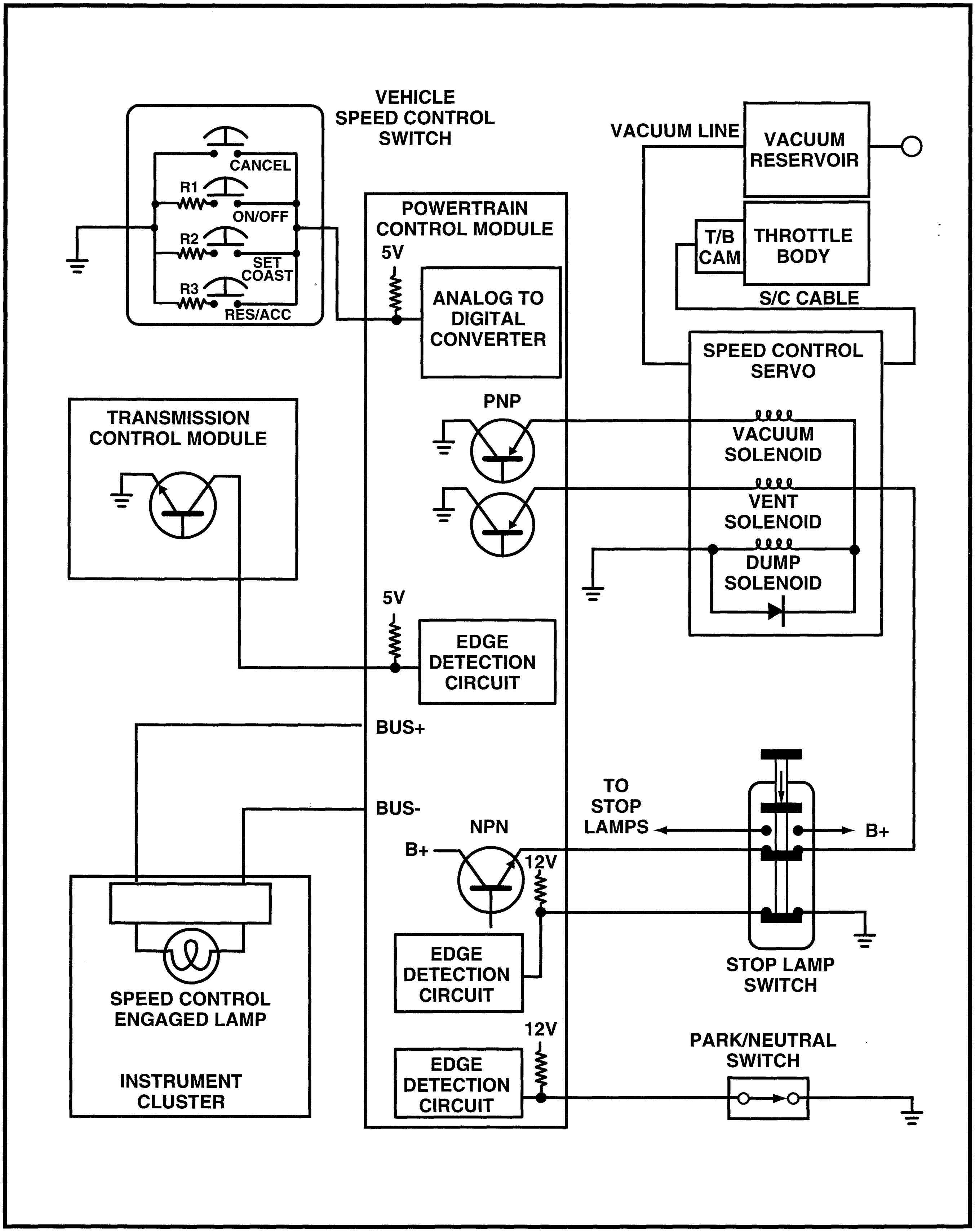


Figure 91 Typical Speed Control Circuit

The vacuum and vent solenoids must be grounded at the PCM to operate. When the PCM grounds the vacuum servo solenoid, the solenoid allows vacuum to enter the servo and pull open the throttle plate through a cable. When the PCM breaks the ground, the solenoid closes and no more vacuum is allowed to enter the servo. The PCM also operates the vent solenoid via ground. The vent solenoid opens and closes a passage to bleed or hold vacuum in the servo as required.

The PCM duty cycles the vacuum and vent solenoids to maintain the set speed, or to accelerate and decelerate the vehicle. To increase throttle opening, the PCM grounds the vacuum and vent solenoids. To decrease throttle opening, the PCM removes the grounds from the vacuum and vent solenoids. When the brake is released, if vehicle speed exceeds 25 mph to resume, 30 mph to set, and the RES/ACCEL switch has been depressed, ground for the vent and vacuum circuits is restored.

Speed Control Switch Input

This is accomplished by multiplexing. Multiplexing allows the PCM to identify more than one signal from a single wire. To accomplish this, the speed control switch uses resistors that cause different voltage signals at the PCM.

	ON	OFF	COAST	SET	RES/ ACCEL	CANCEL	CRUISE INDICATOR
NS	ON/ OFF Grd.		2.94K	6.65K	15.4K	909Ω	LED in switch when ON
JA	ON/ OFF 4.47K			SET/ COAST 9.23K	14.27K	Grd.	Instr.Cluster lamp when ON
PL/JX	15.39K	Grd.		SET/ COAST 2.94K	6.66K	912Ω	PL-none JX-Instr. Cluster when ON
FJ22 F24S	12 volts to PCM	0 volts to PCM		SET/ COAST 11.68K	5.42K	Grd.	LED in Switch when ON Instr. Cluster when engaged

Table 9 Speed Control Switch Inputs

Table 9 displays the switch variables on 4 cylinder SBEC III applications. All these different applications apply to the same basic messages begin sent to the same engine controller. It should be noted that the engine controller is not changed (wired differently) for each of these, however it does require a programmer to write a different program for each vehicle and different flash software at the plant for each engine controller.

Multiplexing

The PCM sends out 5 volts through a fixed resistor and monitors the voltage change between the fixed resistor and the switches (see fig. 91 on page 145). If none of the switches are depressed, the PCM will measure 5 volts at the sensor point (open circuit). If a switch with no resistor is closed, the PCM will measure 0 volts (grounded circuit). Now, if a resistor is added to a switch, then the PCM will measure some voltage proportional to the size of the resistor. By adding a different resistor to each switch, the PCM will see a different voltage depending on which switch is pushed.

On some vehicles another resistor has been added to the at rest circuit causing the PCM to never see 5 volts. This was done for diagnostic purposes. If the switch circuit should open (bad connection) then the PCM will see the 5 volts and know the circuit is bad. The PCM will then set an open circuit fault.

Brake Switch

The brake switch provides an input to the PCM to disengage the speed control when the brakes are applied (fig. 92). It is used also to influence transmission torque converter clutch disengagement, and as an indication identifying when the driver has depressed the brake pedal. Some OBD II diagnostics are turned on or off depending on brakes pedal position. The brake switch 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 also grounding the dump solenoid.

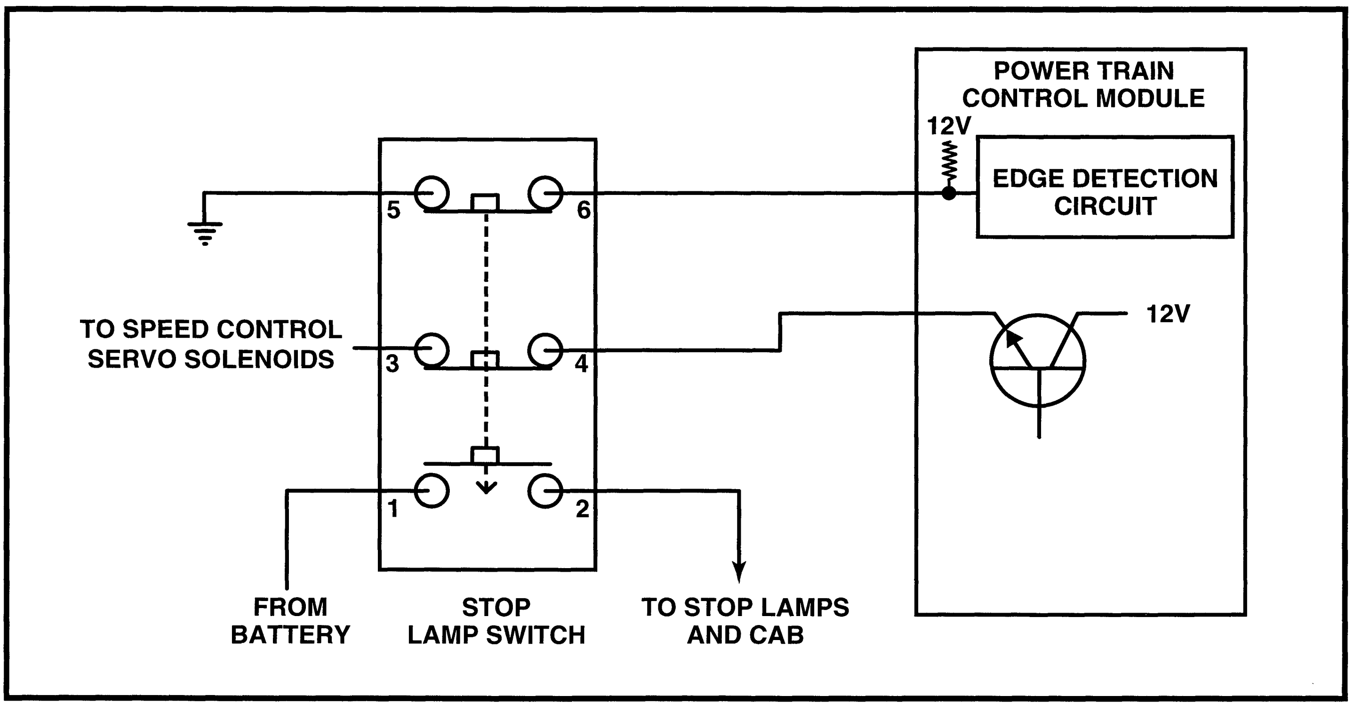


Figure 92 Brake Switch Circuit

The second set of normally closed contacts is supplied battery voltage any time speed control is selected. From the brake switch, current is routed to the speed control servo solenoids. The speed control solenoids (vacuum, vent, and dump) are provided this current any time the speed control is ON and the brakes are disengaged. When the driver applies the brakes, the contacts open and current is interrupted to the solenoids. The normally open contacts are fed battery voltage. When the brakes are applied, battery voltage is supplied to the stop lamps and the speed control relay, if so equipped. Refer to Brake Switch in the PCM inputs section of this publication for more information.

Adaptive Learning Strategy

The Speed Control has an adaptive strategy that compensates for vehicle-to-vehicle variations in speed control cable lengths. When the speed control is set with the vehicle operator's foot off of the accelerator pedal, the speed control thinks there is excessive speed control cable slack and adapts. If the lift foot sets are continually used, the speed control overshoot/undershoot condition will develop.

To "unlearn" the overshoot/undershoot condition, the vehicle operator has to press and release the set button while maintaining the desired set speed with the accelerator pedal (not decelerating or accelerating), and then turn the cruise control switch to the OFF position (or press the CANCEL button if equipped) after waiting 10 seconds. This procedure must be performed approximately 10-15 times to completely unlearn the overshoot/undershoot condition.

Interactive Speed Control

Interactive (meaning communication between the PCM and the TCM is taking place) speed control avoids unnecessary shifting for smoother, quieter operation and, when downshifts are required, makes the shifts smoother.

When Climbing A Grade

The interactive speed control will try to maintain the set speed by increasing the throttle opening. If opening the throttle alone cannot maintain the set speed and the vehicle speed drops more than 3 mph below the set speed, the transaxle will downshift to 3rd gear. If the vehicle continues to lose speed, the transaxle will downshift further until a gear that can maintain the set speed is selected. After the vehicle encounters a less steep grade or has crested the grade (reduced the load on the powertrain) and can maintain the set speed at a reduced throttle position, the transmission will upshift as appropriate until the set speed can be maintained in Overdrive.

Downshift Delay

To reduce the number and frequency of downshifts when operating in hilly/ mountainous country, downshift delay features have been added. While operating, interactive speed control delays or avoids downshifts by applying up to early wide open throttle without the TCM scheduling a downshift. If the interactive speed control is not engaged or the throttle is manually overridden by the driver while interactive speed control is engaged, the downshift delay feature is not activated.

Torque converter lock and unlock shifts are not affected by the downshift delay feature and will occur at the same throttle angle at a given speed regardless of whether interactive speed control

Grade Hunting

All vehicles equipped with a four speed automatic transmission have a grade hunting feature for the 3rd to Overdrive upshift. The TCM identifies the powertrain loading conditions and selects the proper gear to maintain the current vehicle speed. Under moderate loading conditions the transaxle will stay in 3rd gear until the top of the grade is reached or the powertrain loading is reduced. If conditions are more severe, hunting between 2nd and 3rd could occur.

Beginning with 1996, all vehicles equipped with a four speed automatic transmission also have a grade hunting feature for the 2nd to 3rd gear upshift. If powertrain loading is severe, the transaxle may shift into 2nd gear and remain there until powertrain loading is reduced, then a 2nd to 3rd gear upshift will be scheduled. Grade hunting features always operate regardless of whether or not the interactive speed control is engaged. **If the interactive speed control is not engaged and powertrain loading is not reduced, the driver may have to completely lift off of the throttle before an upshift will occur.** If the driver does lift off the throttle to induce an upshift under these conditions, vehicle speed will reduce and the Overdrive to 3rd and 3rd to 2nd gear downshifts will reoccur when the throttle is reapplied. If grade hunting is repeatedly induced by the driver, transaxle damage may result.

When Descending A Grade (Overspeed Reduction)

The overspeed reduction feature helps maintain the interactive speed control set speed when descending a grade.

The TCM must sense that the interactive speed control is set. Then the interactive speed control will try to maintain the set speed by reducing or closing the throttle opening. If closing the throttle (a TPS signal of 2 degrees or less is considered closed throttle) is not enough to keep the vehicle within 3 mph over the set speed, the transaxle will downshift to 3rd gear. The transaxle will **not** downshift to 3rd gear to try to maintain the set speed. After the downshift to 3rd gear, the interactive speed control continues its normal operation. Conditions leading to a return to Overdrive are monitored by the TCM. Once conditions are identified that grade hunting between 3rd and Overdrive is unlikely, the transaxle will shift into Overdrive and resume normal operation.

If the downshift to 3rd gear has taken place, pushing the brake pedal will disengage the interactive speed control but the transaxle will stay in 3rd gear. The transaxle will upshift to Overdrive when the TCM receives a TPS signal of approximately 5 degrees or more.

If the downshift to 3rd gear has taken place and the interactive speed control is still engaged, the transaxle will upshift to Overdrive when the TCM receives a TPS signal of approximately 8 degrees or more for approximately 3 seconds or more with the vehicle at the set speed or greater.

If the downshift to 3rd gear has taken place and the interactive speed control is disengaged using the ON/OFF button or the CANCEL button, the transaxle will upshift to Overdrive after an approximate 2 second delay.

AVENGER AND SEBRING VEHICLE SPEED CONTROL

Speed Control Switches

The speed control switches provide inputs to the PCM to indicate the speed control modes: On, Off, Set, Resume, Cancel, Accelerate, Decelerate. There are two separate switches that operate the speed control. A steering-column-mounted switch uses a multiplexed circuit to provide inputs to the PCM for Resume, Accelerate, Set, Decelerate, and Cancel modes. An ON/OFF switch, mounted on the left side of the instrument panel, provides battery voltage to the PCM to indicate ON and OFF. It also provides power to operate the speed-control servo and the speed-control light.

When speed control is selected by depressing the ON/OFF switch, the PCM allows a set speed to be stored in the RAM for vehicle speed control. To store a set speed, depress the COAST/SET switch while the vehicle is moving at a speed between 30 and 85 mph. In order for the speed control to engage, the brakes cannot be applied, nor can the gear selector be indicating the transmission is in Park or Neutral.

The speed control can be disengaged manually by:

- Stepping on the brake pedal
- Depressing the ON/OFF switch
- Depressing the CANCEL switch

The speed control can be disengaged also by any of the following conditions:

- An indication that the transmission is in Park or Neutral
- An RPM increase without a VSS signal increase (indicates that a clutch has been disengaged)
- Excessive engine RPM (indicates that the transmission may be in a low gear)

The previous disengagement conditions are programmed for added safety.

Once the speed control has been disengaged, depressing the ACCEL/RES switch restores the vehicle to the target speed that was stored in the PCM's RAM.

NOTE: *Depressing the ON/OFF switch will erase the set speed stored in the PCM's RAM.*

If, while the speed control is engaged, the driver wishes to increase vehicle speed, the PCM is programmed for an acceleration feature. With the ACCEL/RES switch held closed, the vehicle accelerates slowly to the desired speed. The new target speed is stored in the RAM when the ACCEL/RES switch is released. The PCM also has a "tap-up" feature in which vehicle speed increases at a rate of approximately 2 mph for each momentary switch activation of the ACCEL/RES switch. A "tap-down" feature is also available. If the driver taps the COAST/SET switch, the PCM will decrement the stored set speed at a rate of 1 mph. The PCM also provides a means to decelerate without disengaging speed control. To decelerate from an existing recorded target speed, depress and hold the COAST/SET switch until the desired speed is reached. Then release the switch.

The ON/OFF switch operates three components: the PCM's ON/OFF input, the speed control ON/OFF light (located on the ON/OFF switch), and the battery voltage to the speed control relay, which operates the speed control servo.

When the ON/OFF switch contacts are closed, battery voltage is supplied to PCM pin 5, which indicates that speed control is desired. At the same time, battery voltage is supplied to the speed control relay and to the speed control light, which is illuminated any time the ON/OFF switch contacts are closed. The relay contacts are normally closed, so when the ON/OFF switch is engaged, battery voltage is supplied to the speed control servo. When the brakes are applied, the relay is energized, causing the contacts to open, removing battery voltage from the servo.

The speed control switch mounted on the steering column contains three switches and two resistors. The PCM sends 5 volts to the speed control switch, which is grounded through the PCM. The input on the 5 volt reference line is responsible for identifying the following: Resume, Set, Accelerate, Decelerate, and Cancel. This is accomplished by multiplexing. Multiplexing allows the PCM to identify more than one signal from a single wire. To accomplish this, the speed control switch uses resistors that cause different voltage signals at pin 41.

The 5-volt signal has no path to ground when no contacts are closed. If the COAST/SET switch is depressed, a momentary contact closes a path to ground through a 2,700 ohm resistor. This causes a voltage change of approximately 2.58 - 3.02 volts, indicating that the COAST/SET switch has been depressed. When the ACCEL/RES switch is depressed, a momentary contact closes to ground through an 820 ohm resistor. The 5-volt signal then passes through a lower resistance than that of the COAST/SET switch, causing the voltage to be approximately 1.27 - 1.53 volts. When the CANCEL switch is depressed, the contacts close directly to ground, causing the 5-volt signal to drop to 0 volts.

Brake Switch

The brake switch provides an input to the PCM to disengage the speed control when the brakes are applied. It is used also to influence transmission torque converter clutch disengagement, and as an indication identifying when the driver has depressed the brake pedal. Also, certain programs do not run if the brakes are applied.

The brake switch is equipped with two sets of contacts, one normally open and the other normally closed (brakes disengaged). The PCM sends a 12-volt signal to the normally closed switch, which is connected to a ground. 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.

The normally open contacts are fed battery voltage. When the brakes are applied, battery voltage is supplied to the stop lamps and the speed control relay, if so equipped.

Speed-Control Servo

The speed-control servo and relay are located in the engine compartment, and are attached to the right side bulkhead. The speed-control vacuum and vent solenoids, located inside the servo, are operated by the PCM. Also located inside the speed control servo is the dump solenoid. The dump solenoid is provided an external ground. The PCM provides a ground path for the vent and vacuum solenoids during speed control operation. Any time the brakes are applied, power and ground for the solenoids are removed. When the brakes are released, the vehicle speed is greater than 30 mph, and the ACCEL/RES switch has been depressed, ground for the vent and vacuum circuits are restored.

The brake switch energizes the speed control relay causing the contacts to open when the brakes are applied. The ON/OFF switch in the ON position supplies power to the relay's contacts. Power is removed when the OFF button is depressed or the brakes are applied.

Intermediate Link

The intermediate link is used to operate the throttle from both the accelerator pedal and the speed control servo. The mechanism is designed so that when speed control is activated, the throttle can be opened or closed by the servo without moving the accelerator pedal, or when the speed control is off, moving the accelerator pedal does not cause the cable at the servo to move (fig. 93).

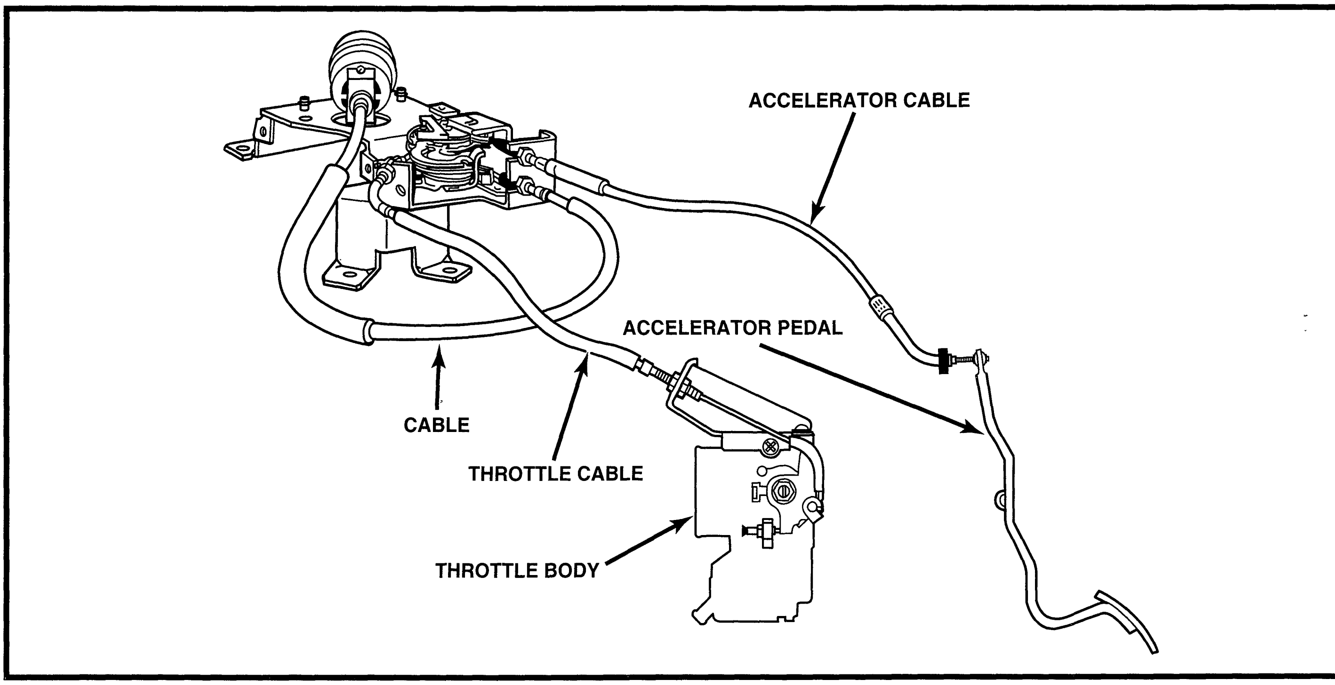


Figure 93 Intermediate Link

During driving with the vehicle speed control engaged, the speed control servo cable pulls on link C (fig. 94). As link C rotates, a tab pushes against link B, causing the throttle cable to move. This action not only opens the throttle plate, but also relieves tension on the accelerator cable so that the accelerator pedal does not move.

With the speed control disengaged, the accelerator cable pulls on link A (fig. 95). A tab on link A contacts a tab on link B when the cable is pulled. This allows the throttle cable to open the throttle plate, but causes no tension on the speed control servo cable.

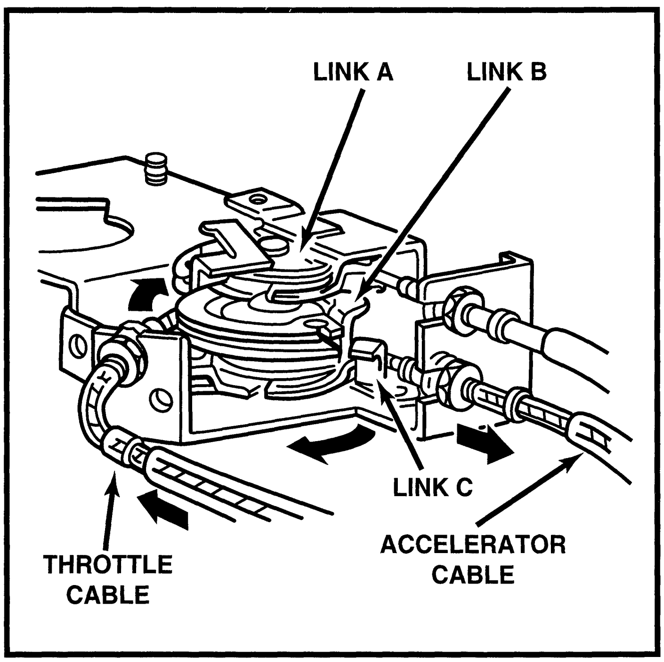


Figure 94 Speed Control Engaged

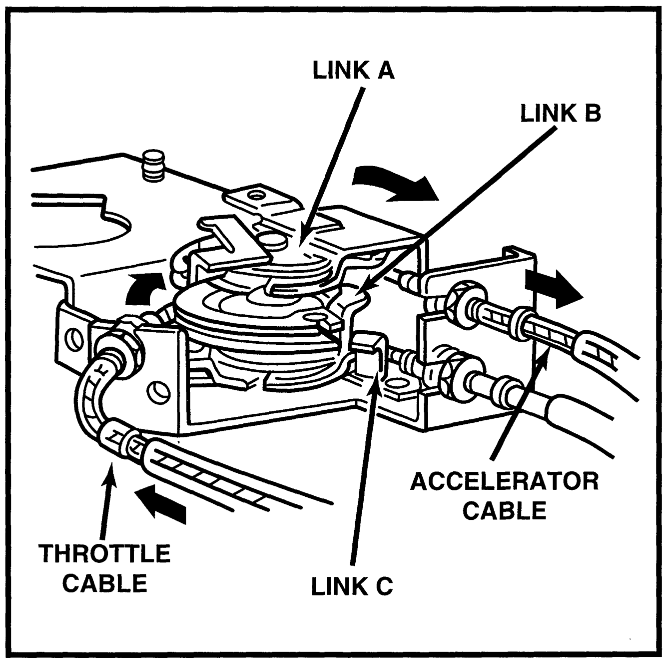


Figure 95 Speed Control Dis-engaged

NOTES

LESSON 8

AIR CONDITIONING CONTROLS

NS/JA/JX/PL

The A/C compressor clutch is operated by the A/C relay, which is located in the PDC. The A/C compressor clutch relay is controlled by the PCM based upon inputs from the A/C request signal, engine speed, A/C pressure sensor, TPS, and several timers inside the PCM.

A/C Compressor Clutch Relay

The PCM energizes the A/C compressor clutch relay by providing a ground for the relay's coil (fig. 96). The PCM will not energize the relay until the following conditions have been met:

- Engine speed is greater than 500 RPM
- Approximately six seconds have elapsed since the start-to-run transfer occurred
- A/C compressor must operate for a minimum time that changes with vehicle speed and throttle position
- Pressure on the discharge line is between 35 psig and 343 psig
- TPS voltage has not exceeded 2.6 volts above minimum TPS
- Engine speed is less than 4500 RPM

Once all of the above conditions have been met and the A/C request signal indicates that A/C compressor operation is desired, the PCM energizes the A/C compressor relay.

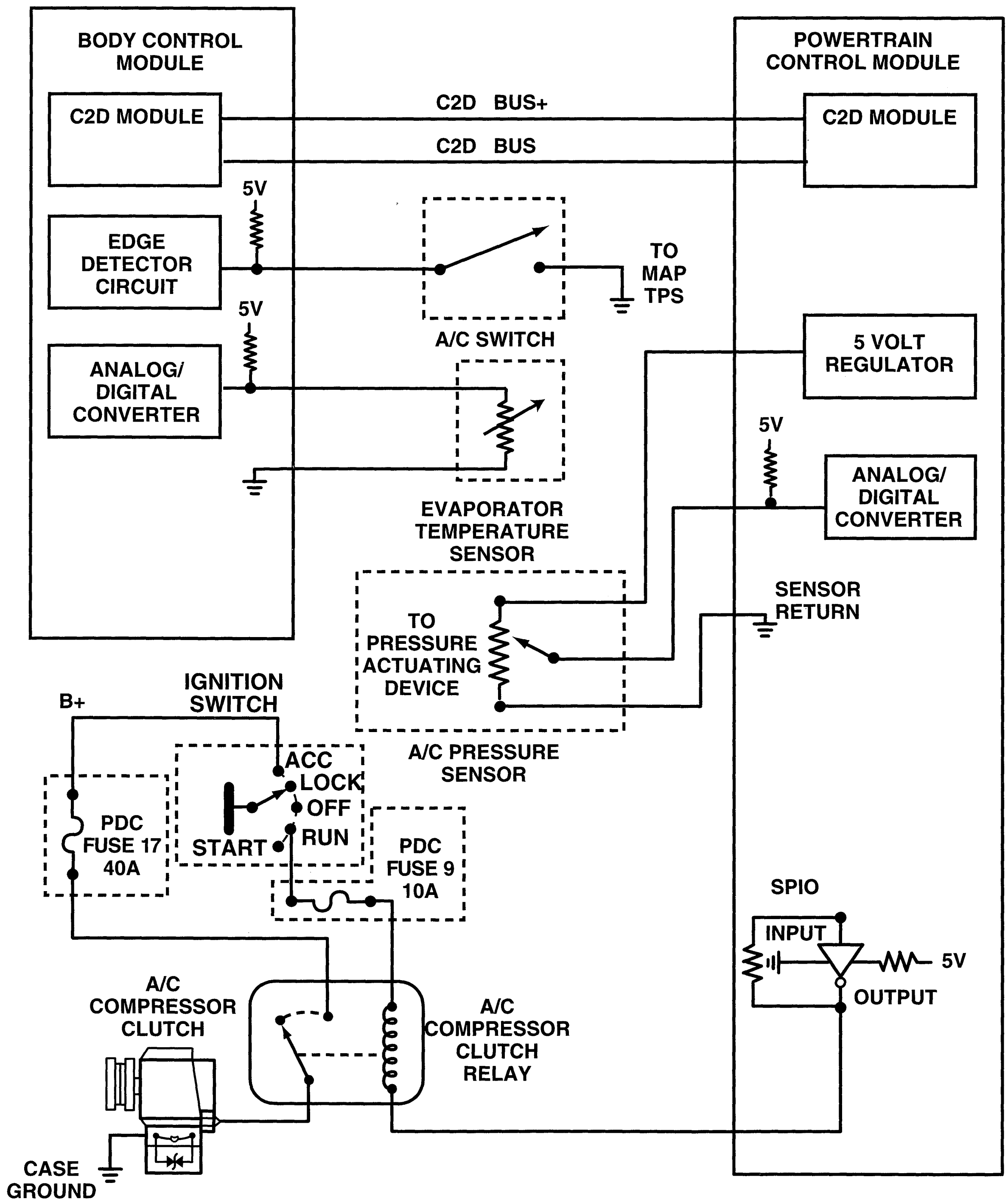


Figure 96 Cirrus and Stratus A/C Circuit

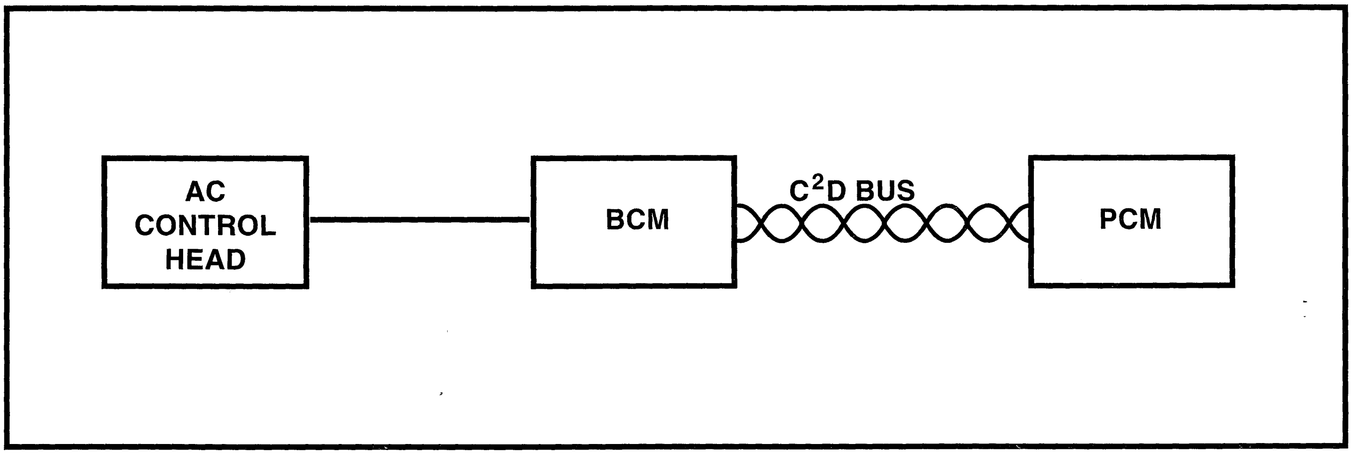


Figure 97 A/C Request (JA/JX)

A/C Request - JA/JX

The Body Control Module (BCM) identifies the operation of the A/C switch by supplying a 5-volt signal to the climate control panel (fig. 97). When A/C or defrost is selected, the 5-volt signal is pulled through the control panel's switch to a ground.

The BCM also identifies the temperature of the evaporator by monitoring the evaporator temperature sensor. At the tip of the sensor's probe is a NTC element. The BCM sends a 5-volt signal to the sensor, and the sensor is grounded at the BCM. The BCM identifies evaporator temperature by monitoring the voltage at the sensor supple pin. As temperature increases, voltage decreases.

The BCM is programmed to send an A/C request signal to the PCM via the C^2D bus when either A/C or defrost is selected, and the evaporator temperature has exceeded 37°F. At that time, the PCM is prompted to engage the A/C compressor clutch relay. While the A/C compressor is functioning, the temperature of the evaporator will decrease. The BCM discontinues sending the A/C request signal when either A/C or defrost is deactivated, or when the evaporator temperature decrease to 33°F.

NOTE: Previous Chrysler products required to have the blower fan on to be able to request A/C. On the Cirrus and Stratus, when defrost or defrost/heat (mix) mode is selected, the request signal could be delivered without the blower fan on.

A/C Request - PL

The PCM sends out 12 volts on the A/C Select pin to a series control circuit. This circuit includes the High Pressure Cut Out Switch, the Compressor, the Low Pressure Cut Out Switch on the High Side H valve, the Electronic Cycling Switch, and the Blower Motor (A/C Side) Switch which provides the ground for the series circuit.

A/C Request - NS

A/C Select Button is hard wired to the PCM (fig. 98). The PCM sends out 12 volts that latches to ground at the control head.

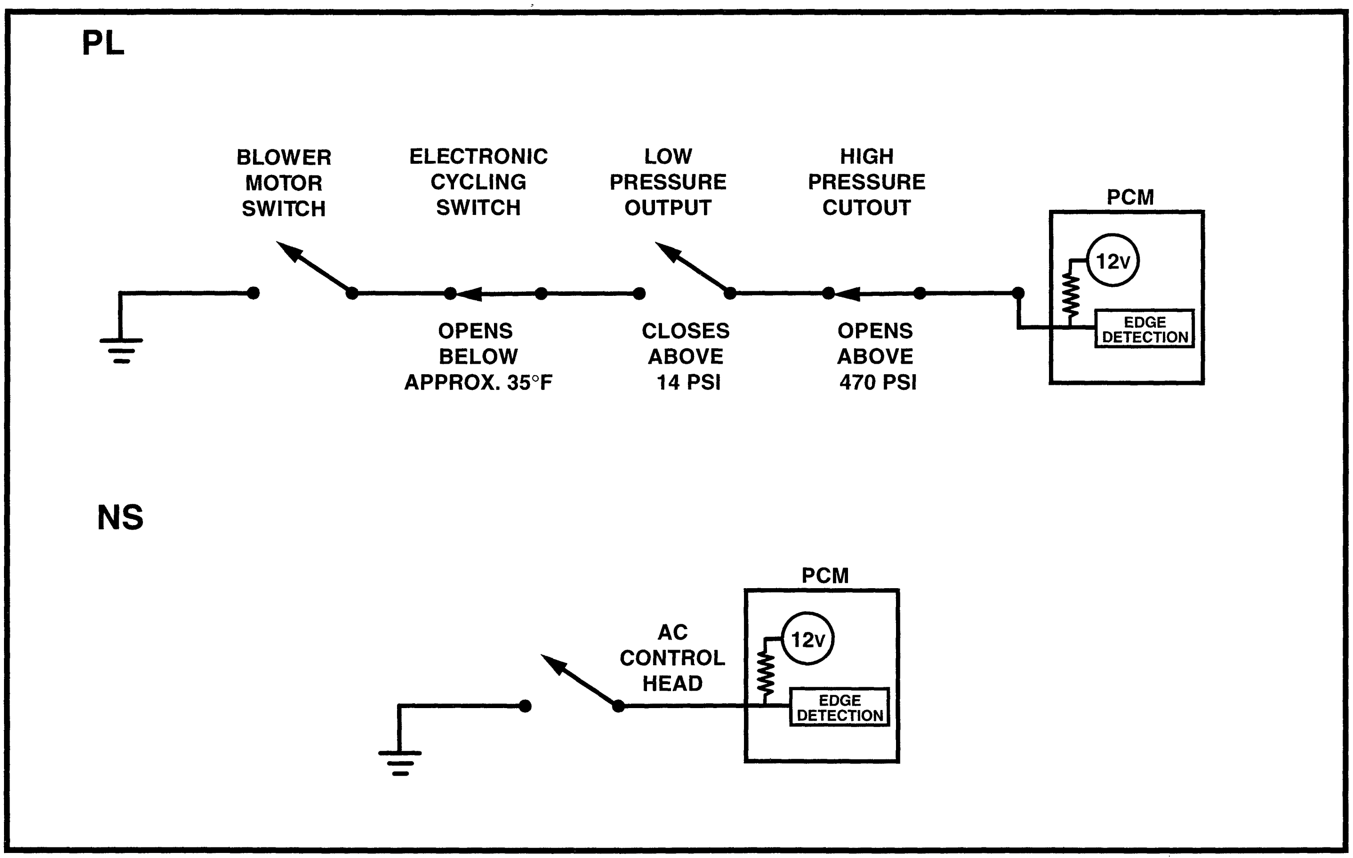


Figure 98 A/C Request (NS/PL)

FJ22/F24S A/C Control System

Several components are involved with allowing the A/C compressor to function. The PCM controls the A/C relay by monitoring the A/C request circuit. The request circuit involves the components listed in Table 10.

COMPONENT	LOCATION
Blower switch	Instrument panel
A/C switch	Instrument panel
A/C automatic compressor controller	Right side of the evaporator housing
Evaporator fin thermal sensor	Evaporator housing
Air inlet thermal sensor	Evaporator housing
Dual pressure switch	Engine compartment on the right side
A/C refrigerant temperature switch	Mounted on the compressor delivery port
Powertrain Control Module	Engine compartment on the left side

Table 10 F-Car A/C Component Locations

Blower Switch

The blower switch (fig. 99) has four possible motor speed selections: OFF, LO, MED 1, MED 2, and HI. In order to use the defrost or A/C functions, the blower must be in one of the four speed positions. The blower motor electrical circuit also includes a resistor and two relays (one for HI speed and one for the other three speeds).

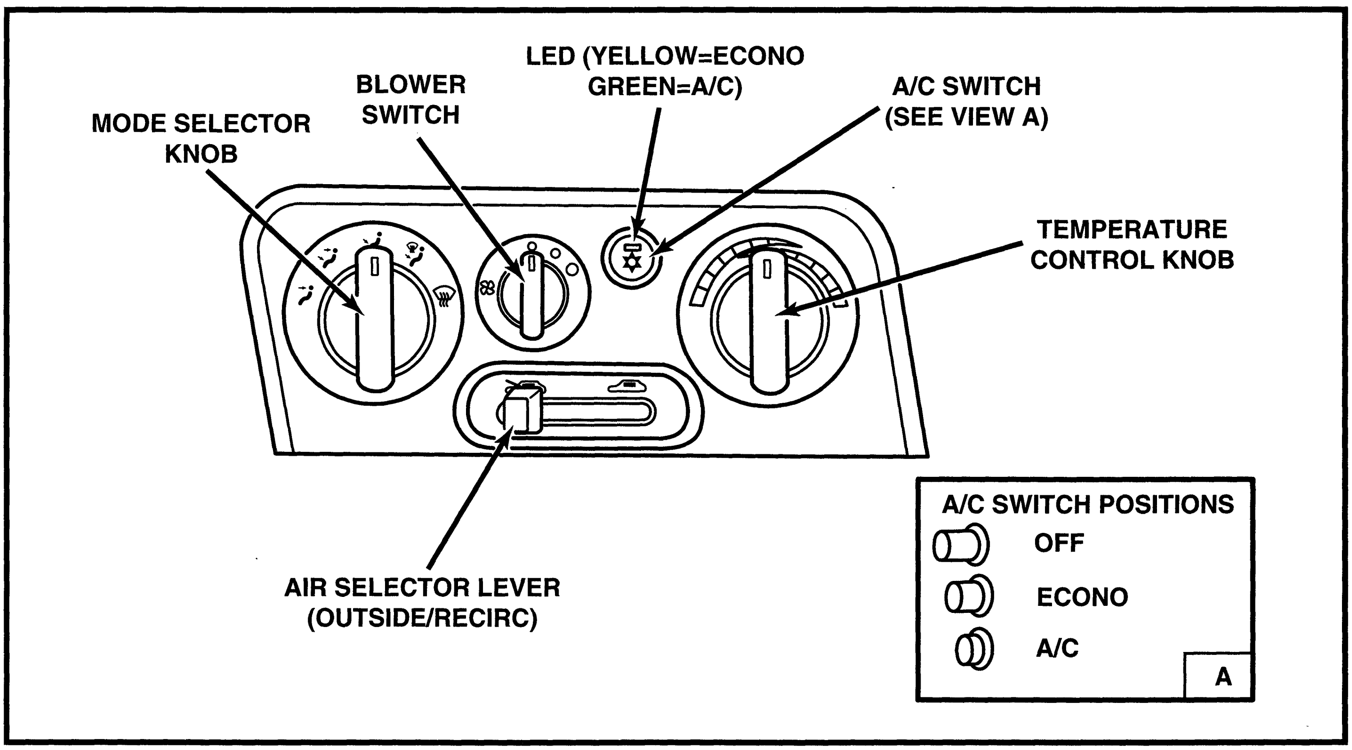


Figure 99 A/C and Blower Fan Controls

A/C Switch

The A/C switch must be pushed to the ECONO (halfway in) or A/C position (all the way in) for the air conditioning system to operate (compressor engaged). An LED in the switch illuminates yellow when the ECONO position is selected, or green when the A/C position is selected. The A/C switch is part of the auto compressor control system. Pushing the A/C switch to ECONO position raises the temperature point at which the compressor clutch cycles on and off when ambient temperatures are low. Because the compressor is engaged only when necessary, use of the ECONO position could cause the compressor to operate less frequently.

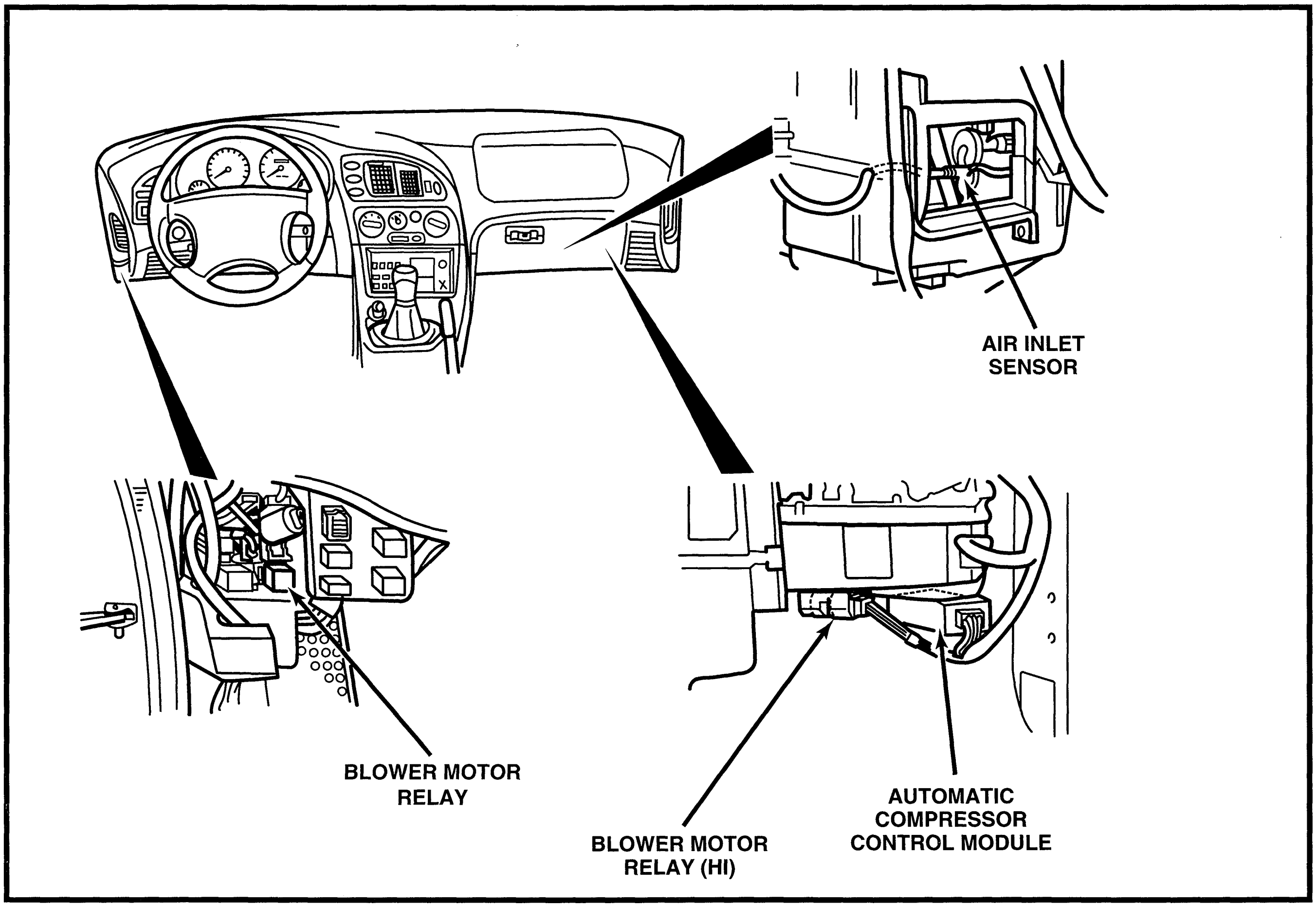


Figure 100 Passenger Compartment Components

Auto Compressor Control System

The auto compressor control system is controlled by the auto compressor control module, which is located under the blower motor assembly. Input signals from the air inlet thermo sensor and fin thermo sensor (fig. 100) are used to control the ON/OFF functions of the compressor's magnetic clutch. The air inlet thermo sensor measures the temperature of the air entering the evaporator, while the fin thermo sensor measures the temperature of the evaporator. These signals, plus operator inputs from the A/C control head, are used by the auto compressor control module to determine when the compressor's magnetic clutch should be engaged. The purpose of this system is to engage the compressor clutch only when necessary to keep interior temperatures at the desired operator-setting during A/C operation.

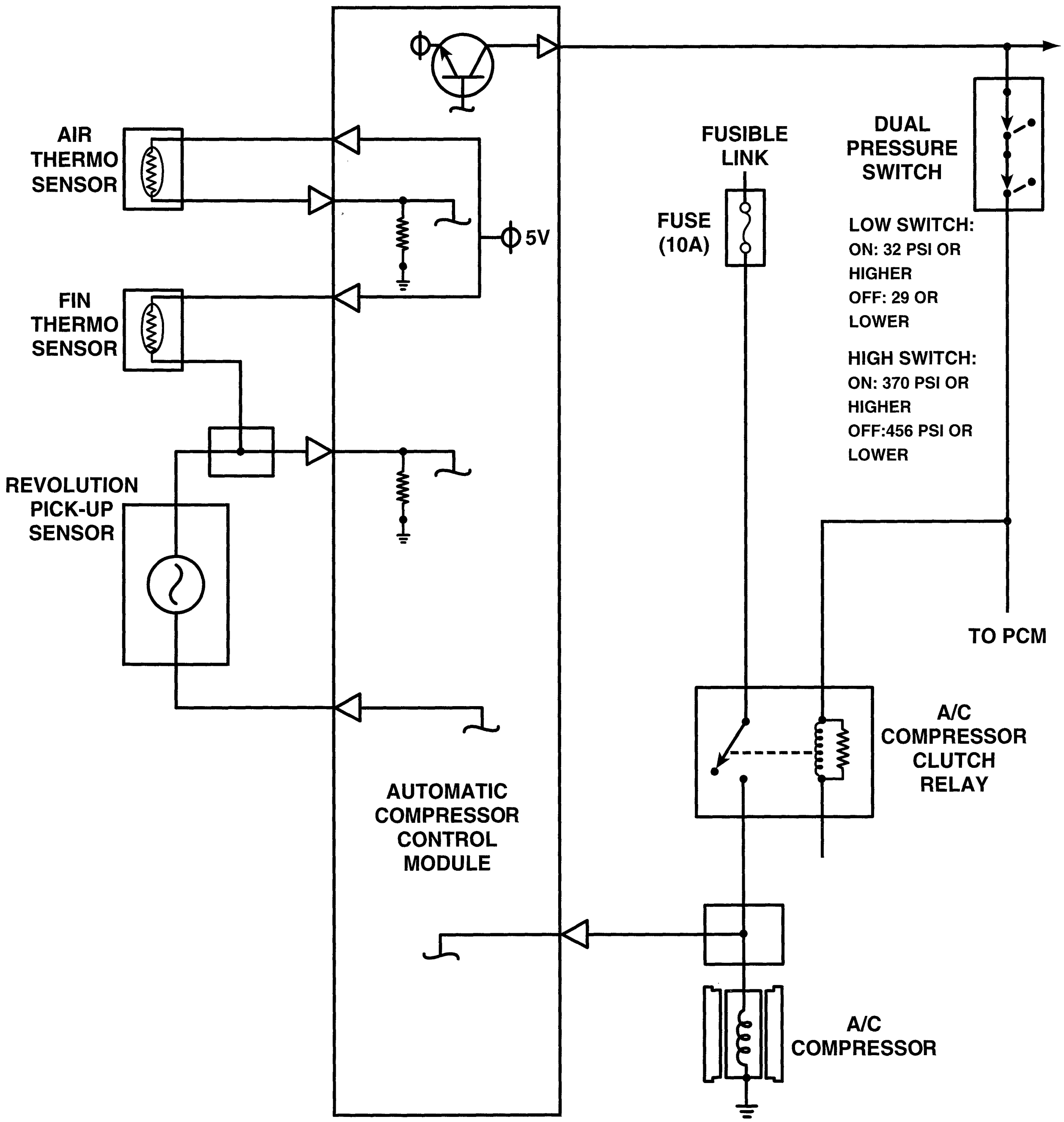


Figure 101 A/C Switch Circuit - FJ22/F24S

Auto Compressor Control Module Inputs

The inputs for the auto compressor control module are as follows (fig. 101):

- Power Supply and Ground - Battery voltage is provided to the auto compressor control module through terminal 1 any time the ignition switch is in the RUN position and a ground is provided through terminal 8.

- A/C Switch - The A/C switch is fed battery voltage anytime the blower switch signal is positioned in any of the four blower fan speeds. When ECONO is selected from the A/C switch, battery voltage is applied to terminal 2 of the auto compressor control module. When FULL A/C is selected, battery voltage is applied to terminal 7. These inputs are used by the auto compressor control module to initialize A/C operation.

- Air Inlet Thermo Sensor - The air thermo sensor is used as an ambient-temperature input to the auto compressor control module. This input is used in conjunction with the fin thermo sensor to engage the compressor clutch at the appropriate temperature ranges. The auto compressor control module sends a 5-volt reference signal through terminal 23 to the air inlet thermo sensor. The sensor return is sent through terminal 21 of the auto compressor control module. The sensor's resistance changes with the temperature of the air, thus causing a change in voltage as the temperature changes.

- Fin Thermo Sensor - The fin thermo sensor is used to identify the temperature of the evaporator. It is used in conjunction with the air inlet thermo sensor to engage the compressor clutch at the appropriate temperature ranges. The auto compressor control module sends a 5-volt reference signal to the fin thermo sensor through terminal 26. The sensor return is sent through terminal 22 of the auto compressor control module. As the temperature of the evaporator changes, the resistance of the sensor changes, thus causing a change in voltage at the signal input to the auto compressor control module.

Auto Compressor Control Module Outputs

The main output of the auto compressor control module is the A/C request signal. A signal is sent through terminal 6 anytime that the auto compressor control module requires the compressor to be engaged. The request signal is ON as long as A/C has been selected, and the air inlet thermo sensor and the fin thermo sensor indicate temperatures are within parameters.

When the auto compressor control module sends the request signal ON, system voltage passes through terminal 6 to the A/C condenser fan relay. With the request signal ON, the A/C condenser fan relay should be energized.

With the request signal ON, terminal 6 also provides system voltage to the dual pressure switch. The dual pressure switch is located on the receiver/drier assembly, and is used to protect the compressor from high- or low-pressure conditions. The LOW switch is ON (closed) at 32 psi (220 kpa) or higher, and OFF (open) at 28 psi (200 kpa) or lower. The HIGH switch turns OFF (open) at 455 psi (3,140 kpa) or higher, which removes power supplied to the compressor clutch relay. The HIGH switch turns ON (closed) at 370 psi (2,550 kpa) which re-engages the compressor clutch.

The compressor is equipped with an A/C refrigerant temperature switch that interrupts current flow to the A/C compressor clutch relay and the PCM if the compressor temperatures are excessive. The contacts are closed at A/C compressor temperatures below 230°F (110°C). The contacts open if the temperature of the compressor increases to 311°F (155°C) or higher. This aids in the prevention of A/C system damage due to high temperatures.

With both the LOW and HIGH pressure switch contacts closed, and the A/C refrigerant temperature switch closed, system voltage is supplied to the A/C compressor relay coil and the PCM. Once the PCM recognizes the request signal and the PCM's other monitored inputs indicate that the A/C compressor should be engaged, the PCM provides a ground for the A/C relay's coil. With the relay energized, battery voltage is supplied to the compressor clutch coil.

NOTES

NOTES

NOTES

NOTES

NOTES

NOTES

NOTES

TRAINING CENTERS

Technical Service Training is offered year-round, tuition-free, at these Chrysler Corporation Training Centers. The Centers are designed to advance the technical knowledge of Chrysler Corporation authorized Dealers and their personnel. Employees from Fleet Accounts, Municipal and Government Agencies are invited also.

All technical courses are conducted by professional Automotive Service Training instructors using the latest training methods. Courses cover disassembly, assembly, diagnosis, and problem-solving techniques on each subject.

All Chrysler Corporation Dealers are furnished schedules, available through the DIAL system, showing courses offered at the Training Centers. For more information, use the list below for the Training Center nearest you.

EASTERN REGION

NEW YORK
(Regional Training Center)
500 Route #303
Tappan, NY 10983-1508

ATLANTA
(Zone Training Center)
Bailey Park at Barrett, Bldg. 300
1000 Cobb Place Blvd., Suite 370
Kennesaw, GA 30144-3685

BOSTON
(Zone Training Center)
550 Forbes Blvd.
Mansfield, MA 02048-2038

CHARLOTTE
(Zone Training Center)
5009-C West W.T. Harris Blvd.
Charlotte, NC 28269-1861

ORLANDO
(Zone Training Center)
8351 Parkline Blvd., Suite 500
Orlando, FL 32809-7866

PHILADELPHIA
(Zone Training Center)
42 Lee Blvd.
Malvern, PA 19355-1235

PITTSBURGH
(Zone Training Center)
203 Overlook Dr.
Sewickley, PA 15143-2305

RICHMOND
(Zone Training Center)
1011 Technology Park Drive
Virginia Center
Glen Allen, VA 23060-4500

ROCHESTER
(Zone Training Center)
245 Summit Point Dr., Suite 1
Henrietta, NY 14467-9606

CENTRAL REGION

DETROIT
(Regional Training Center)
26001 Lawrence Ave.
Center Line, MI 48015-0612

CHICAGO
(Zone Training Center)
1980 Highgrove Lane
Naperville, IL 60540-3934

CINCINNATI
(Zone Training Center)
Enterprise Business Park
2828 E. Kemper Road
Cincinnati, OH 45241-1820

KANSAS CITY
(Zone Training Center)
Lenexa Industrial Park
13253 West 98th Street
Lenexa, KS 66215-1360

MINNEAPOLIS
(Zone Training Center)
Plymouth Oak Park
12800 Highway 55
Minneapolis, MN 55441-3840

ST. LOUIS
(Zone Training Center)
5790 Campus Drive
Hazelwood, MO 63042-2386

NEW ORLEANS
(Zone Training Center)
114 North Park Blvd., Suite 11
Covington, LA 70433-7077

MEMPHIS
(Zone Training Center)
1680 Century Center, Suite 8
Memphis, TN 38134-8849

MILWAUKEE
(Zone Training Center)
700 Walnut Ridge Drive, Suite 100
Hartland, WI 53029-9385

WESTERN REGION

LOS ANGELES
(Regional Training Center)
5141 Santa Ana Street, Suite B
Ontario, CA 91761-8633

DALLAS
(Zone Training Center)
8304 Esters Road, Suite 810
Irving, TX 75063-2234

DENVER
(Zone Training Center)
7022 S. Revere Parkway
Englewood, CO 80112-3932

HOUSTON
(Zone Training Center)
500 Century Plaza Dr., Suite 110
Houston, TX 77073-6027

PHOENIX
(Zone Training Center)
3421 East Harbour Dr. - Suite 300
Phoenix, AZ 85034-7229

PORTLAND
(Zone Training Center)
16145 S.W. 72nd Ave.
Portland, OR 97224-7743

SAN FRANCISCO
(Zone Training Center)
5720 Stoneridge Dr., Suite 1
Pleasanton, CA 94588

5/6/96

WE ENCOURAGE PROFESSIONALISM

ASE CERTIFIED ®

THROUGH TECHNICIAN CERTIFICATION

DEALER TECHNICAL OPERATIONS

CHRYSLER CORPORATION

CUSTOMER SATISFACTION
& VEHICLE QUALITY

81-699-96106 15M696 LITHO IN U.S.A.