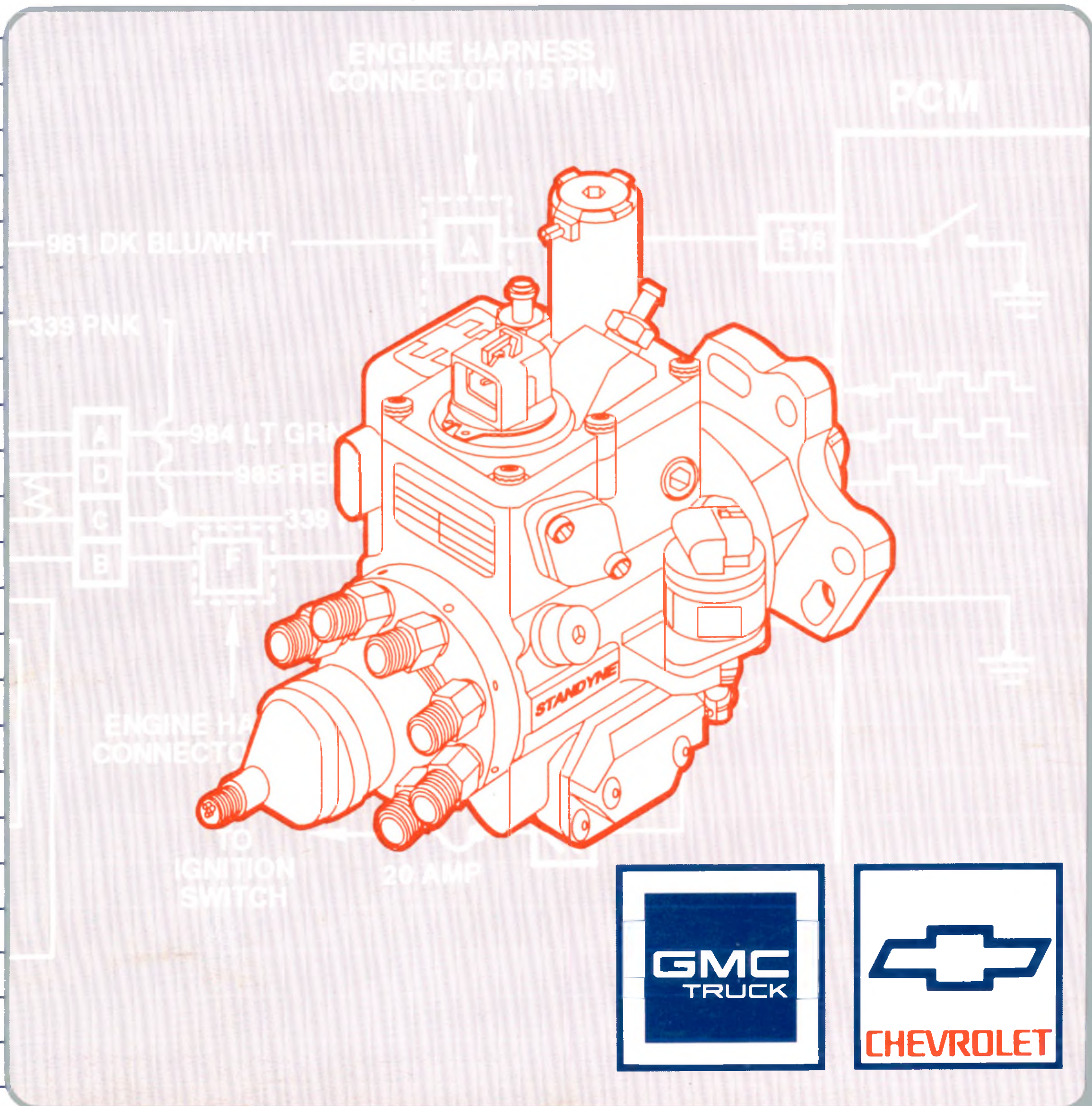
6.5L Diesel Electronic Fuel Injection



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16015.15-2

6.5L Diesel Electronic Fuel Injection

Foreword

While this booklet will serve as an excellent review of the extensive program presented in the training center sessions, it is not intended to substitute for the various service manuals normally used on the job. The range of specifications and variations in procedures between divisions require that the division service publications be referred to, as necessary, when performing these operations.

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1. General Information

COURSE OVERVIEW

The focus of this booklet and its related two-day course is electronic fuel system operation and diagnosis on the 6.5L EFI V8 diesel engine (figure 1-1). This course is intended for technicians who have diesel engine mechanical experience, but who may be less familiar with electronic engine management systems and "Scan" tool diagnostics.

Because the Powertrain Control Module (PCM) is such an integral part of fuel system management, and because it is new to diesel applications, a great deal of time will be devoted to PCM operation and diagnostics. Every attempt will be made to present this new information within the context of existing 6.5L V8 knowledge and experience.

This course also includes numerous studies intended to provide hands-on implementation of the diagnostic strategies, especially "Scan" tool usage.

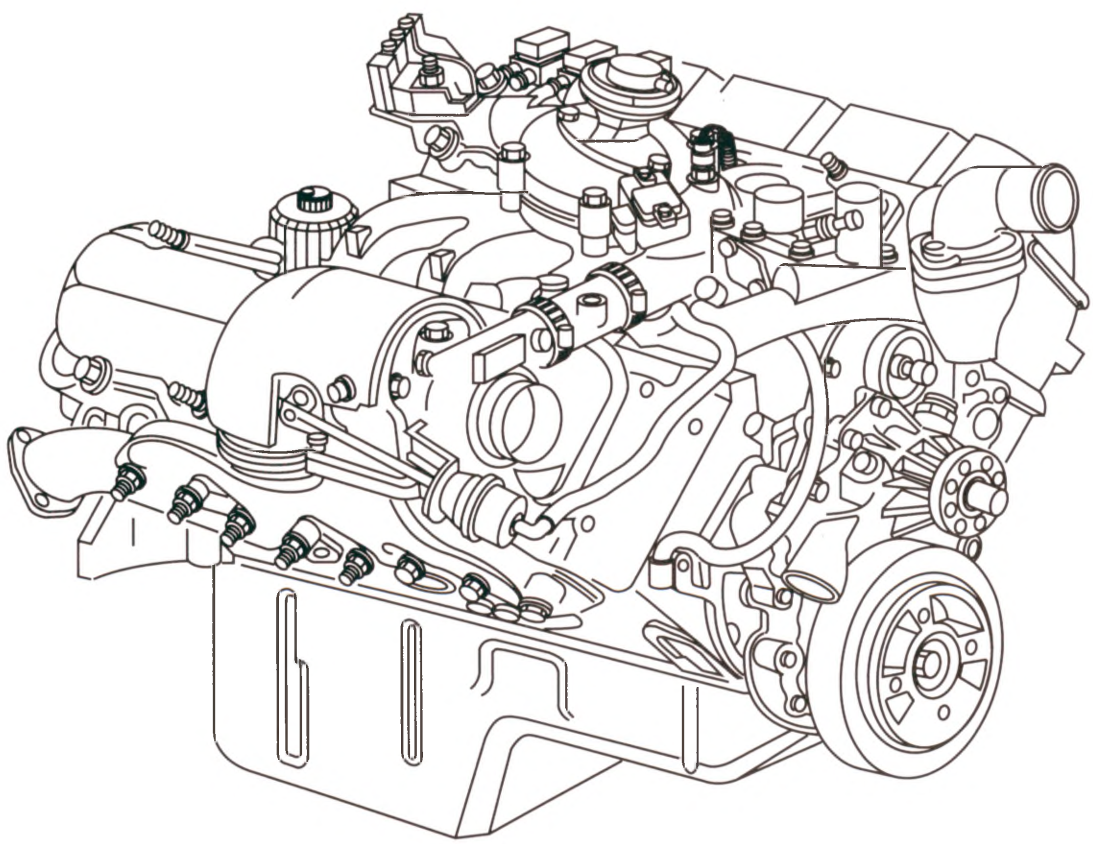


Figure 1-1, 6.5L EFI V8 Diesel Engine

6.5L EFI APPLICATIONS

In the 1992 model year, General Motors introduced a 6.5-Liter V8 diesel engine, RPO code L65, for light-duty trucks with Gross Vehicle Weight Ratings (GVWR) between 8,500 and 15,000 pounds. Among its many features, this engine was outfitted with a camshaft-driven mechanical fuel pump that delivered metered fuel to the engine's eight injection nozzles.

For the 1994 model year, an electronically fuel injected version of the 6.5L V8 diesel engine becomes available. This engine can be teamed with either a manual or electronic automatic transmission, and is also available with heavy-duty and light-duty emissions packages. The following chart identifies RPO and VIN numbers for the various 6.5L V8 diesel engine applications.

RPO	VIN	Controller	Trans	GVWR	Fuel Inj. Pump	Cat Conv?	Turbo?	EGR?
C/K Pickup								
L49	P	PCM	4L60E	<8600	Electr.	No	No	Yes
L49	P	PCM	Manual	<8600	Electr.	Yes	No	Yes
L56	S	PCM	4L80E	<8600	Electr.	Yes	Yes	Yes
L65	F	PCM	4L80E	>8600	Electr.	Yes	Yes	No
L65	F	PCM	Manual	>8600	Electr.	Yes	Yes	No
K Utility								
L56	S	PCM	4L80E	<8600	Electr.	Yes	Yes	Yes
C/K Suburban								
L65	F	PCM	4L80E	<8600	Electr.	Yes	Yes	Yes
L65	F	PCM	4L80E	>8600	Electr.	Yes	Yes	No
C/K Crew								
L65	F	PCM	4L80E	>8600	Electr.	Yes	Yes	No
L65	F	PCM	Manual	>8600	Electr.	Yes	Yes	No
G Van								
L49	P	PCM	4L60E	<8600	Electr.	No	No	Yes
L57	Y	TCM	4L80E	>8600	Mech.	No	No	No
P Truck								
L57	Y	TCM	4L80E	>8600	Mech.	No	No	No
L57	Y	N/A	Manual	>8600	Mech.	No	No	No
P Motor Home								
L65	F	PCM	4L80E	>8600	Electr.	Yes	Yes	No

IDENTIFICATION

The 6.5L EFI V8 diesel engine has a seven-character identification code stamped on the upper surface of the cylinder case near the #1 cylinder intake manifold runner (figure 1-2). The stamping contains a broadcast code that describes the engine configuration of the vehicle and a digital code that describes vehicle manufacturing information.

The fuel injection pump also has an identification code. It is contained on a metal plate riveted to the back end of its housing. The model and serial numbers are stamped on the plate (figure 1-2).

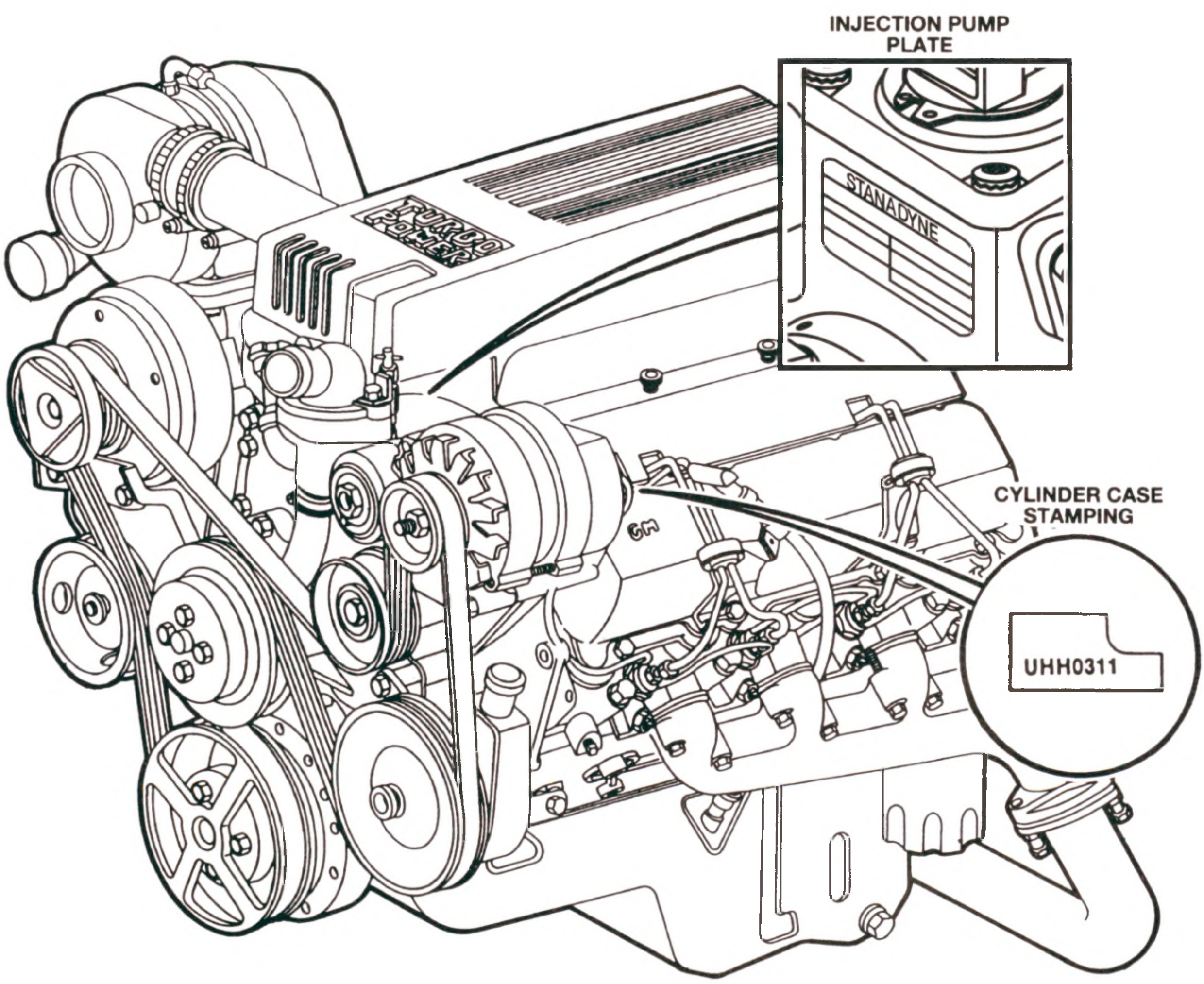


Figure 1-2, **Engine and Fuel Injection Pump Identification**

DESIGN FEATURES

The 6.5L EFI V8 diesel is derived from the same block as the non-EFI 6.5L engine. All 6.5L engines share the following attributes:

- a four-stroke cycle
- a compression ratio of 21.3:1
- eight cylinders, each with a bore measurement of 103 mm (4.055 in) and piston stroke of 97 mm (3.818 in)
- high-swirl pre-combustion chambers to mix fuel and air efficiently, resulting in low exhaust emissions
- controlled turbocharged air intake pressure of between 2 and 8 psi at peak torque, based on engine speed, load, and other conditions
- the following power ratings

RPO	VIN	Controller	Trans	GVWR	Horsepower (@ RPM)	Torque (lbs. ft. @ RPM)
C/K Pickup						
L49	P	PCM	4L60E	<8600	155 @ 3600	275 @ 1700
L49	P	PCM	Manual	<8600	155 @ 3600	275 @ 1700
L56	S	PCM	4L80E	<8600	180 @ 3400	360 @ 1700
L65	F	PCM	4L80E	>8600	190 @ 3400	385 @ 1700
L65	F	PCM	Manual	>8600	190 @ 3400	385 @ 1700
K Utility						
L56	S	PCM	4L80E	<8600	180 @ 3400	360 @ 1700
C/K Suburban						
L56	S	PCM	4L80E	<8600	180 @ 3400	360 @ 1700
L65	F	PCM	4L80E	>8600	190 @ 3400	385 @ 1700
C/K Crew						
L65	F	PCM	4L80E	>8600	190 @ 3400	385 @ 1700
L65	F	PCM	Manual	>8600	190 @ 3400	385 @ 1700
G Van						
L49	P	PCM	4L60E	<8600	155 @ 3600	275 @ 1700
L57	Y	TCM	4L80E	>8600	160 @ 3400	290 @ 1700
P Truck						
L57	Y	TCM	4L80E	>8600	160 @ 3400	290 @ 1700
L57	Y	N/A	Manual	>8600	160 @ 3400	290 @ 1700
P Motor Home						
L65	F	PCM	4L80E	>8600	190 @ 3400	385 @ 1700

MAJOR COMPONENT GROUPS

The 6.5L V8 diesel engine consists of the following major component groups (figure 1-3):

- Mechanical System
- Lubrication System
- Cooling System
- Accessory Drive System
- Air Induction/Exhaust Systems
- Fuel System
- Electrical System

Each of these systems was covered in detail in the prerequisite "6.5 Liter V8 Turbo Diesel Engine" training center course. Most of these systems remain unchanged and will not be covered here. Some are reviewed briefly, as updates warrant. You should consult the turbo diesel mechanical student handout #16015.12-1 for detailed information about systems not covered in this EFI course.

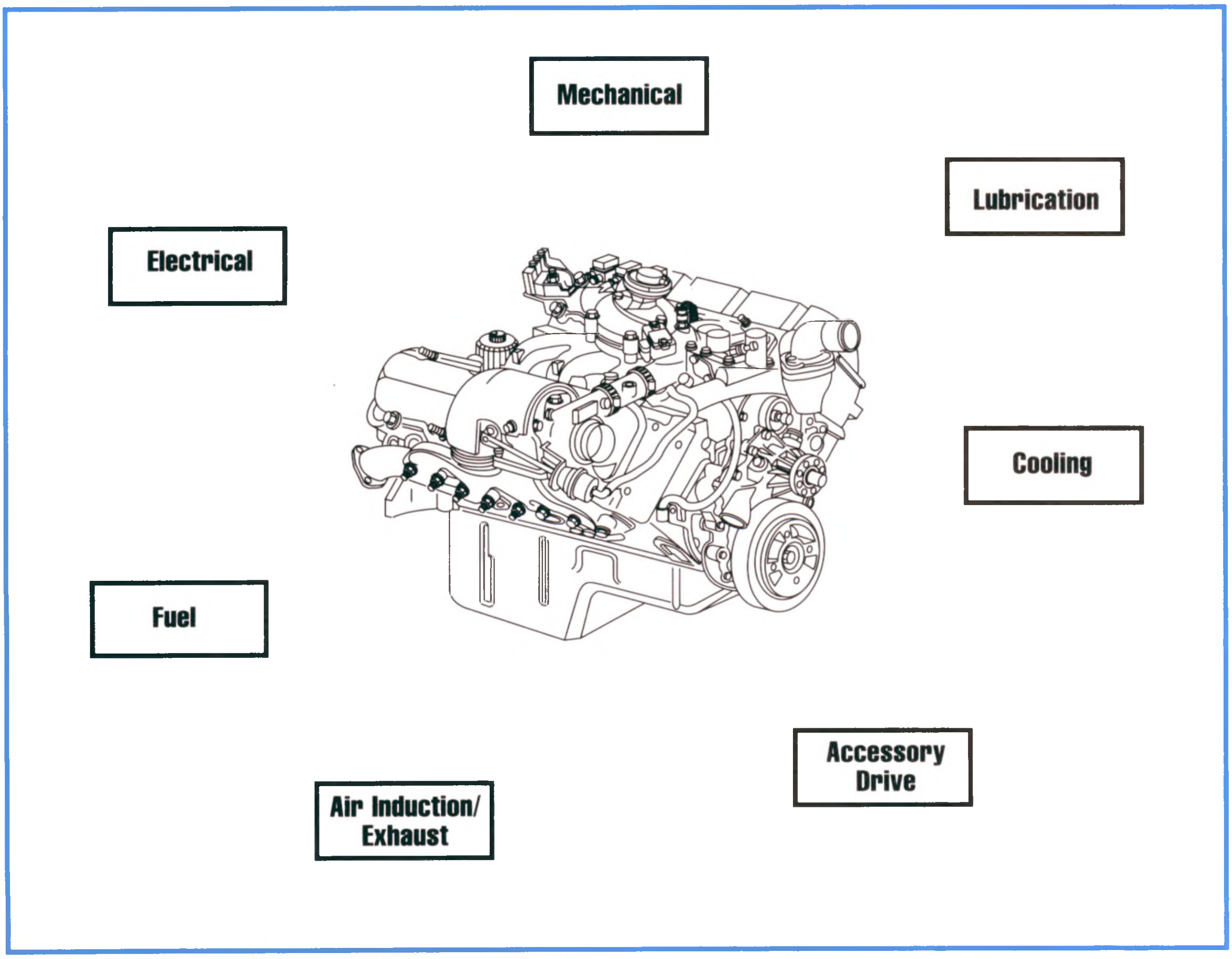


Figure 1-3, **6.5L EFI Engine Component Systems**

STARTING PROCEDURE

Use the following starting procedures on electronic fuel injection 6.5L diesel engines.

— CAUTION —
Do not leave the vehicle while the engine is running.

— NOTICE —
Do not use starting aids such as ether when starting a diesel engine.

— IMPORTANT —
During cold weather starting, the engine may temporarily run with a slight increase in noise and exhaust smoke.

— IMPORTANT —
RPO code L57 6.5L diesel engines use a mechanical injection pump. The starting procedure on vehicles with L57 engines is the same diesel starting procedure used previously and involves stepping on the accelerator pedal before turning the ignition key to the CRANK position.

1. Have all passengers fasten their seat belts.
2. Apply the parking brake.
3. For automatic transmissions, do the following:
   - Shift the transmission to P range (vehicle not moving) or N range (vehicle moving).

   For manual transmissions:
   - Shift the transmission to Neutral.
   - Press the clutch pedal fully.
4. Turn the ignition switch to the RUN position and wait until the "GLOW PLUGS" lamp in the instrument panel is "OFF."
5. Once the light turns "OFF", immediately turn the ignition switch to the CRANK position until the engine starts or 15 seconds elapse.
6. Turn the ignition switch to RUN and do the following:
   - If the engine runs, press the brake pedal and shift the transmission into gear.
   - If the engine does not run, wait 15 seconds and repeat step 4 above.
7. Wait a few seconds before moving the vehicle, especially in cold weather.
8. Release the parking brake and move the vehicle. If the vehicle fails to start, do the following:
   - Check the state of charge for the batteries.
   - Check for proper operation of the glow plug system:
     - During cranking, the "GLOW PLUGS" lamp may be on.
     - After starting, the "GLOW PLUGS" could continue cycling for up to 4 cycles.
     - If the above items check good, perform further diagnosis as defined in the Service Manual.

2. Mechanical System

OVERVIEW

The mechanical system of the 6.5L EFI V8 diesel engine includes the following component groups (figure 2-1):

- Cylinder case assembly
- Cylinder head assemblies
- Valve train
- Front cover
- Injection pump drive
- Intake manifold
- Exhaust manifolds

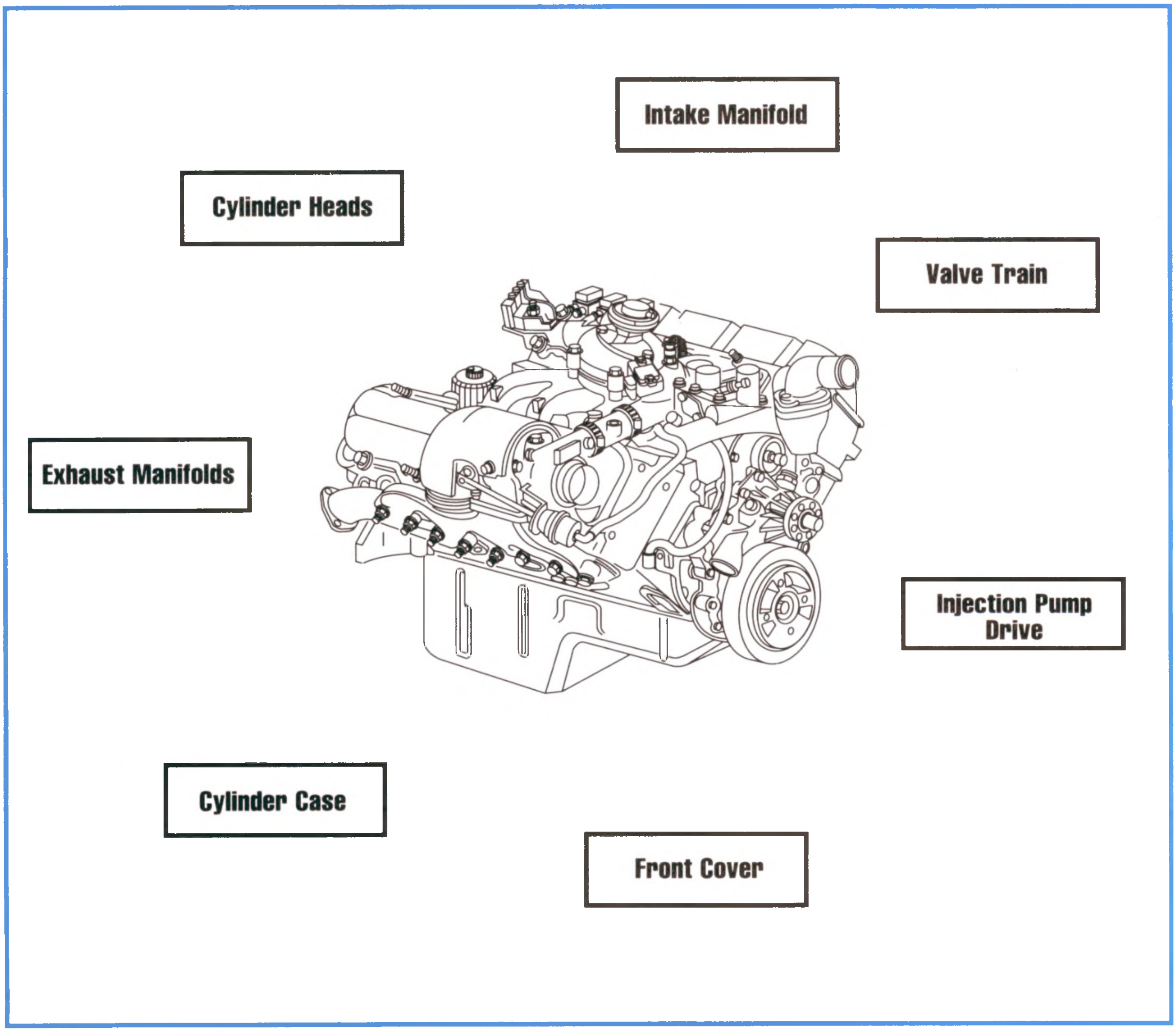


Figure 2-1, 6.5L EFI Mechanical System Component Groups

FRONT COVER

The front cover is made of cast aluminum and has several features (figure 2-2):

- Mounting surfaces for the crankshaft front seal, water pump assembly, injection pump, and accessory supports
- Sealing surfaces at the cylinder case and oil pan
- Cooling system passages
- A timing bracket for service purposes
- A hole for the crankshaft sensor machined into the cover
- A reluctor ring mounted on the end of the crankshaft sprocket
- A shorter-length collar on the balancer to accommodate the reluctor ring (figure 2-2)

— IMPORTANT —
TDC offset must be programmed into the ECM when the cover is replaced.

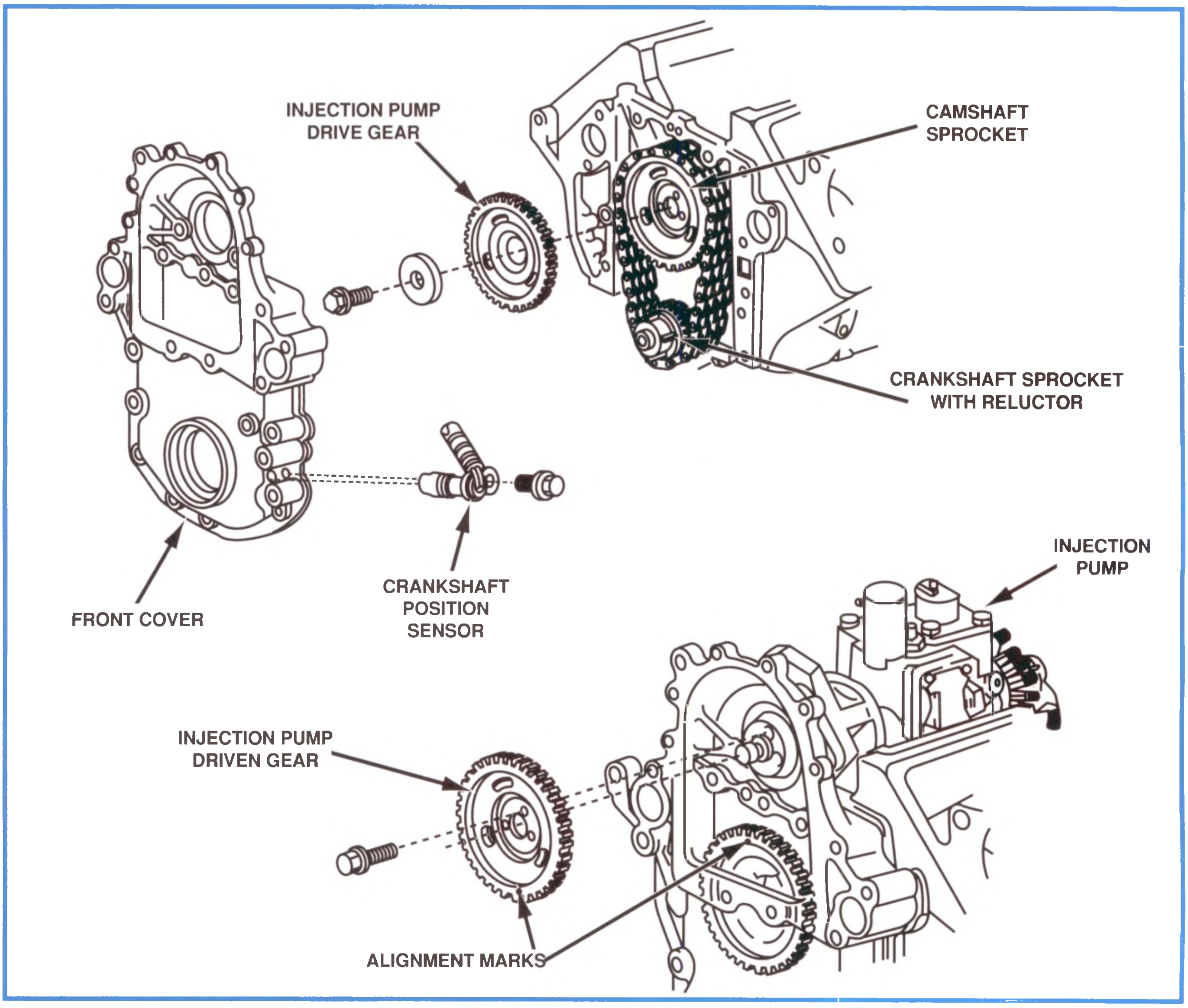


Figure 2-2, Front Cover

INTAKE MANIFOLD

The cast aluminum intake manifold connects the air induction system inlet duct to the intake ports of each cylinder head (figure 2-3). Features of the intake manifold include:

- Mounting of the air inlet duct with bolts and a paper gasket
- Mounting to each cylinder head with bolts and studs, as well as a special composite gasket
- Support for eight fuel injection lines, using brackets and rubber isolators
- Support for the turbocharger oil supply line, using a bracket
- Support for the fuel filter assembly
- Port for the Intake Air Temperature (IAT) sensor and boost sensor
- Port and gasket for the EGR valve
- Mounting for two turbocharger support brackets

— IMPORTANT —
A gasket is used to seal the EGR passage. When servicing the EGR valve, verify that this gasket is in place. Otherwise, an internal exhaust leak would occur, resulting in full-time EGR.

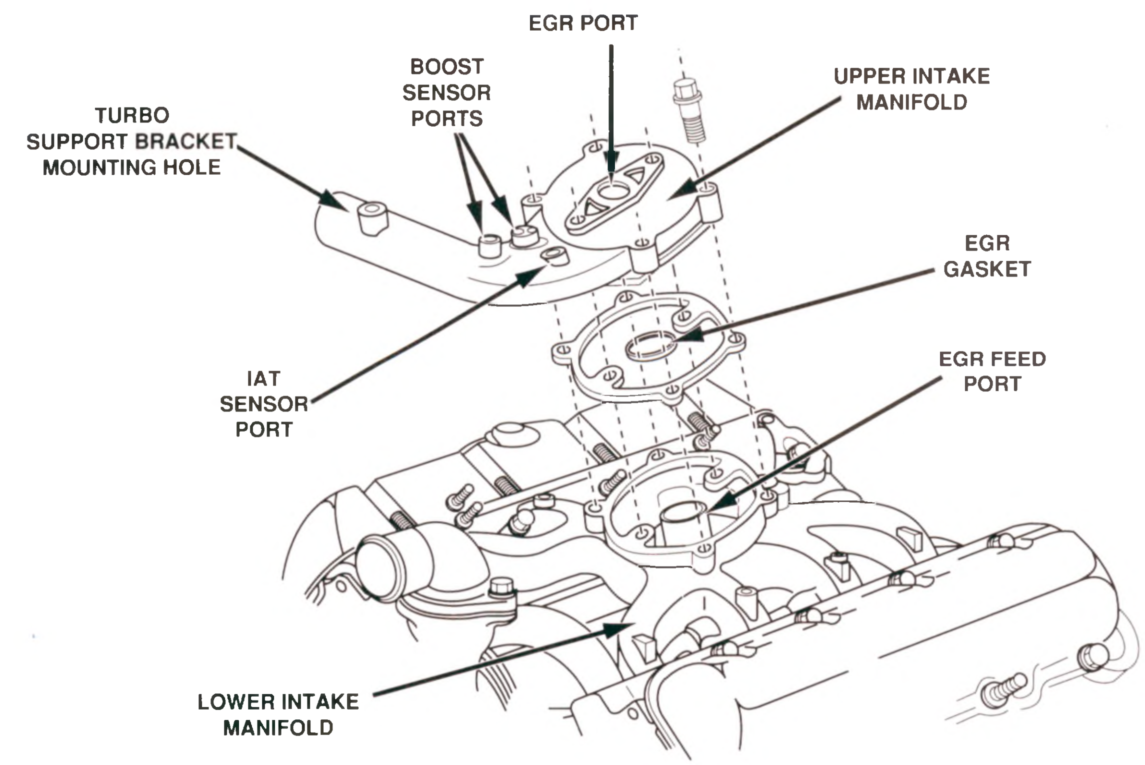


Figure 2-3, **Intake Manifold**

Notes:

3. Air Induction/Exhaust Systems

OVERVIEW

The air induction and exhaust systems of the 6.5L EFI V8 diesel engine include the following parts (figure 3-1):

- Outside air intake duct and air filter assembly
- Turbocharger assembly
- Air inlet duct
- Crankcase ventilation system
- Exhaust pipes and muffler

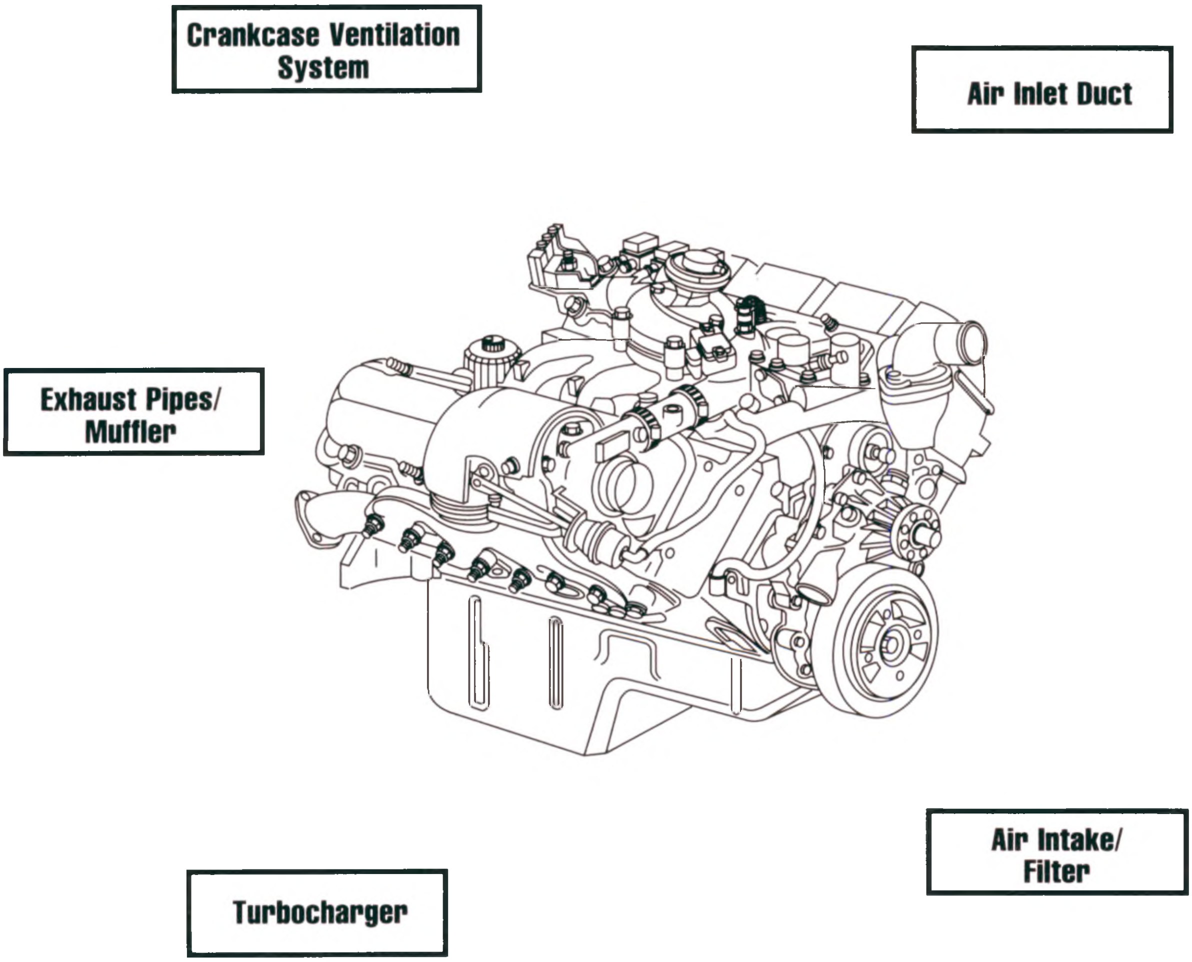


Figure 3-1, 6.5L EFI Air Induction and Exhaust System Component Groups

TURBOCHARGER ASSEMBLY

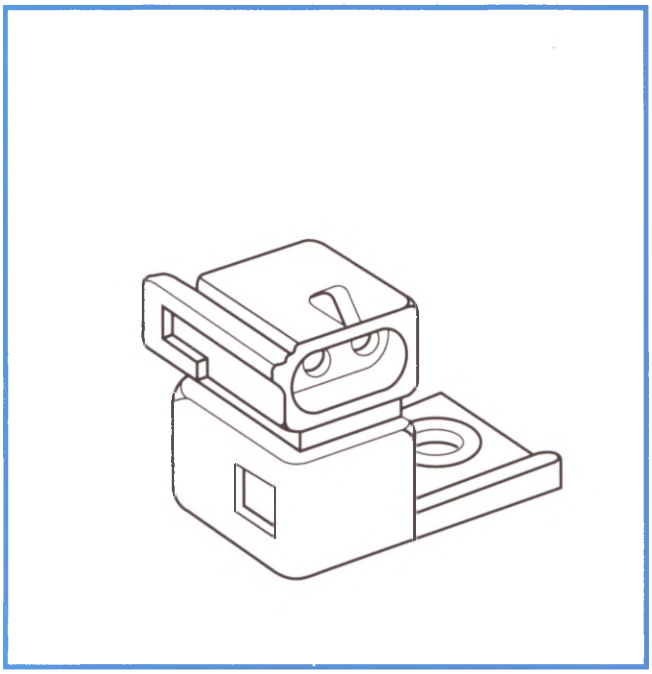


Figure 3-2, **Turbocharger Wastegate Solenoid**

The 6.5L EFI diesel turbocharger provides a variety of benefits. It increases engine response time and power, while also reducing exhaust emissions.

When the pressure of exhaust gases entering the turbocharger exceeds specified levels, these gases are bypassed directly to the exhaust pipe. The turbocharger uses a solenoid-controlled wastegate valve (figure 3-2) to accomplish this. The valve acts like a turbine wheel speed governor to limit the maximum amount of turbo boost pressure to between 2 and 8 psi.

As part of PCM engine management on the 6.5L EFI diesel engine, the wastegate valve is controlled by a solenoid. The solenoid is located on a bracket at the rear of the left head.

CATALYTIC CONVERTER

As part of its emission controls, some 6.5L EFI engine uses a palladium-oxidation catalytic converter (see chart on page 1-2 for 6.5L catalytic converter applications). The converter differs somewhat from traditional gasoline converters. Its primary function is to oxidize the organic elements of exhaust gas before it is passed to the exhaust system. It is not intended to oxidize hydrocarbons or carbon monoxide, or reduces nitrous oxides. The converter operates at normal diesel engine exhaust temperatures and requires low-sulphur diesel fuel, which all diesel fuel in the U.S. will be beginning in 1994.

4. Fuel System

OVERVIEW

The fuel control system delivers fuel from the fuel tank to the injectors via a series of pumps, filters, passageways, and ports. Accumulators and regulators help maintain pressure throughout the system for optimum fuel delivery and performance.

The 6.5L EFI delivers fuel using the same basic components as the non-electronic version. System components include (figure 4-1):

- Fuel Tank Assembly
- Lift Pump Assembly
- Fuel Filter Assembly
- Fuel Injection Pump Assembly
- Fuel Injection Lines
- Fuel Injection Nozzles
- Fuel Return System

The PCM-controlled injection pump is mounted on top of the engine, under the intake manifold. The pump is driven by the camshaft through two gears (refer to figure 2-2). One attaches to the front of the camshaft, the other attaches to the end of the pump shaft. Because these gears are the same size and have the same number of teeth, the injection pump shaft turns at the same speed as the camshaft.

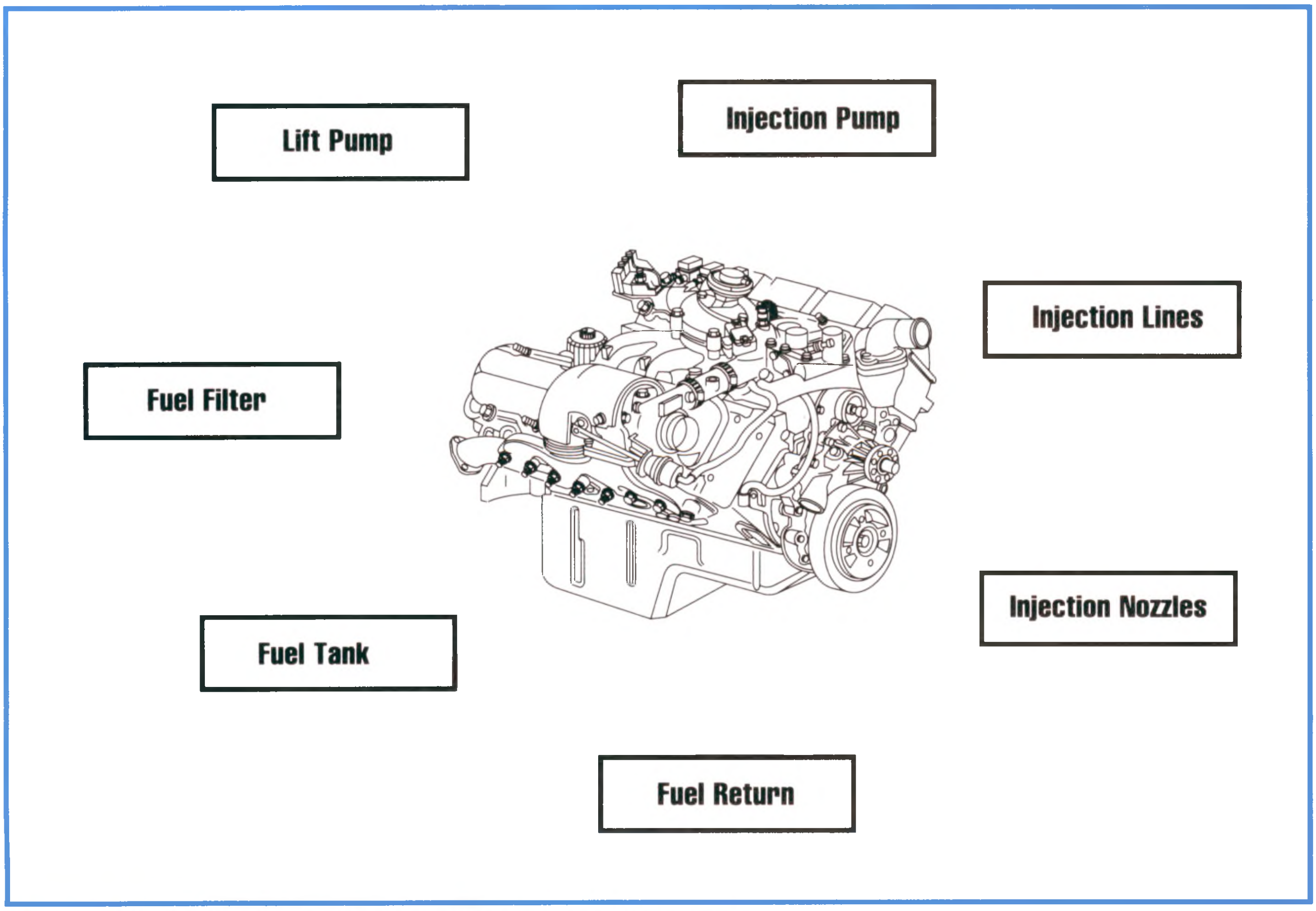


Figure 4-1, **6.5L EFI Fuel System Component Groups**

LIFT PUMP

The inlet fitting of the lift pump connects to the fuel tank pick-up/sending unit fuel supply fitting, using a pipe/hose assembly with o-rings. The outlet fitting of the lift pump connects to the inlet fitting of the fuel filter assembly on the engine, using another pipe/hose assembly.

The electric lift pump has a hollow plunger that slides in a bore located in the center passage between the inlet and outlet ports (figure 4-2). An inlet valve is mounted on one end of the hollow plunger, and an outlet valve is positioned at the outlet end of the center passage. Both valves are closed by spring force.

The lift pump is designed to move fuel under a low (suction) pressure from the fuel tank and deliver it through the filter to the transfer pump inside the fuel injection pump. To operate correctly, the injection pump must have fuel at the correct pressure and without air bubbles.

The lift pump is checked as part of the fuel supply system diagnosis. The lift pump should deliver fuel with a minimum volume of 0.24 liter (1/2 pint) in 15 seconds and tee-d in running pressure of 40 to 60 kPa (5.8 to 8.7 psi) for 1988–1993 pumps or, on 1994 and later pumps, a minimum of 3 psi with the line from the filter to the injection pump open to an approved canister and the engine cranking (i.e. not running). The lift pump suction line from the fuel tank must be air tight for correct operation of the injection pump.

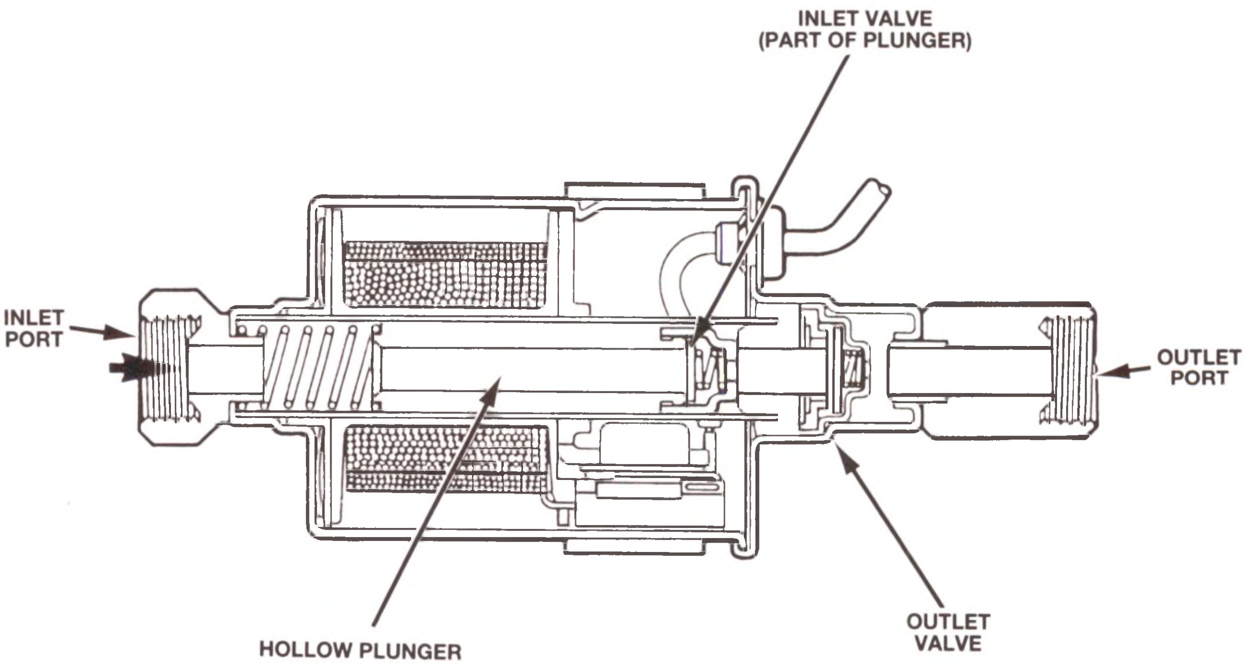


Figure 4-2, Lift Pump Construction

The electrical circuit for the lift pump involves several main components (figure 4-3):

- The oil pressure switch/sending unit, threaded into a lubrication system passage at the rear of the cylinder case
- A relay mounted near the junction block on the vehicle cowl
- An in-line fuse mounted near the battery junction block on the passenger side of the cowl
- The lift pump itself, mounted under the vehicle on the inside of the left frame rail
- Terminal G of the Data Link Connector (DLC)

When the driver moves the ignition switch to the CRANK position, the lift pump circuit is completed through the relay contacts. During this time, oil pressure is building to the point of closing the contacts of the pressure switch/sending unit. A minimum of 28 kPa (4 psi) is required to close the switch contacts.

When the ignition switch is returned to the RUN position, the oil pressure of the running engine maintains electrical power to the lift pump. If engine oil pressure drops below 28 kPa (4 psi), the engine may run poorly or stall when the lift pump circuit opens.

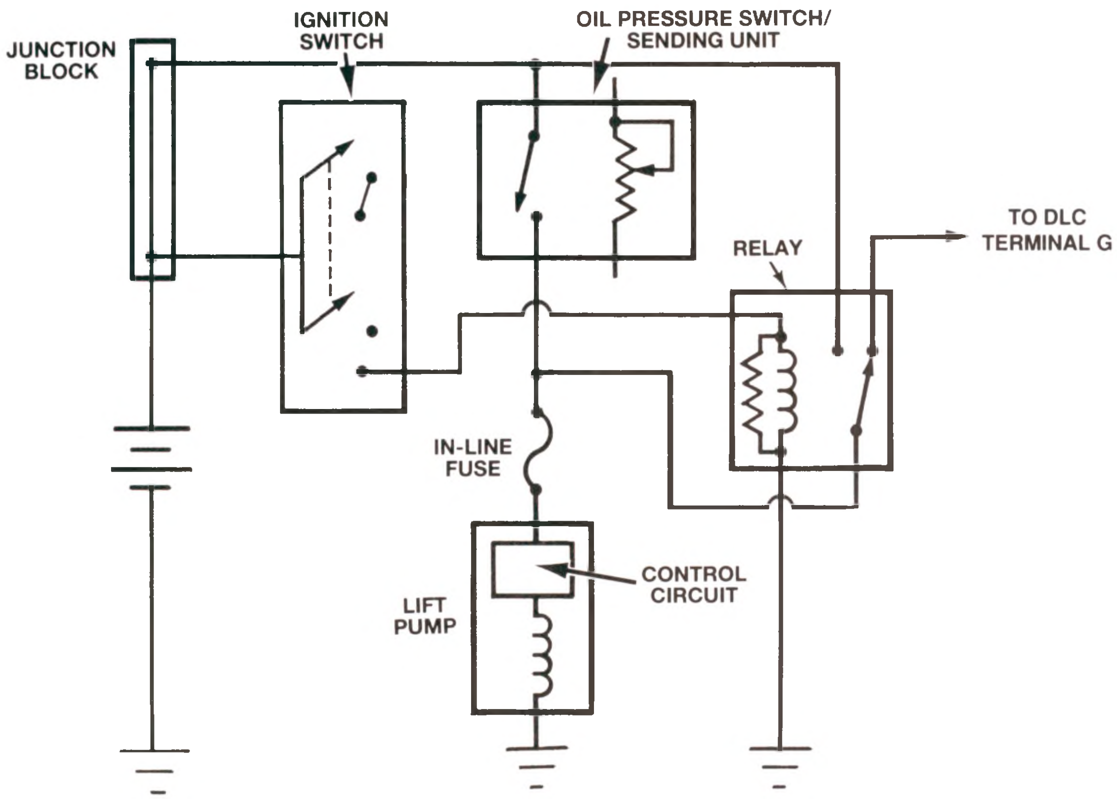


Figure 4-3, **Lift Pump Circuit Components**

FUEL FILTER

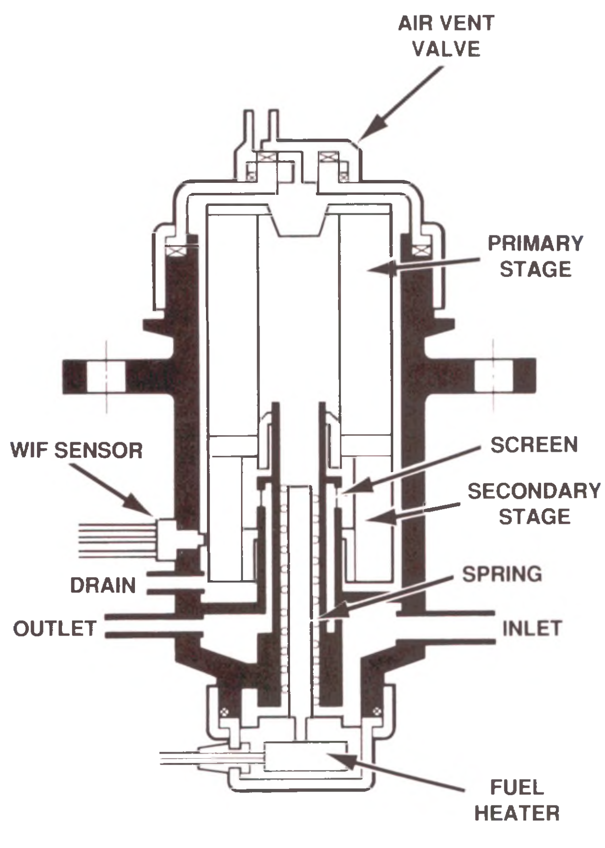


Figure 4-4, Fuel Filter Section View

The fuel filter assembly (figure 4-4) mounts on the rear of the intake manifold. Two bolts hold the assembly in place. The filter housing has two primary fittings:

- an inlet fitting connecting to the pipe/hose from the lift pump
- an outlet fitting connecting to the fuel injection pump with a hose

A third fitting connects through a hose to a drain valve mounted on the water crossover/thermostat.

The filter assembly is a two-stage replaceable element with integral seals. A threaded nut retains the element in the housing. The element has an air vent valve on its top surface that is used during a filter element replacement procedure. Filter and housing are keyed to fit one way only.

The fuel filter assembly has a fuel heater mounted to its bottom end that is retained with a threaded nut and seal ring. Another part of the fuel filter assembly is a Water In Fuel (WIF) sensor. The WIF sensor has an o-ring seal and two mounting screws. Three wires connect the WIF sensor to a power supply circuit, as well as to an instrument cluster-mounted amber warning lamp.

INJECTION PUMP

The 6.5L diesel engine uses the Stanadyne model DS rotary distributor fuel pump consisting of the following components (figure 4-5):

- A fuel solenoid driver that determines fuel metering by controlling the fuel solenoid
- An optical/fuel temperature sensor that supplies the PCM with pump speed, rotor position, cam ring position and fuel temperature information
- An engine shutoff (ESO) solenoid located on top of the pump
- An injection timing stepper (ITS) motor that controls injection timing advance and retard
- A fuel solenoid that opens and closes a control valve for pump fill and spill activity
- Inlet and outlet ports for fuel to and from the pump

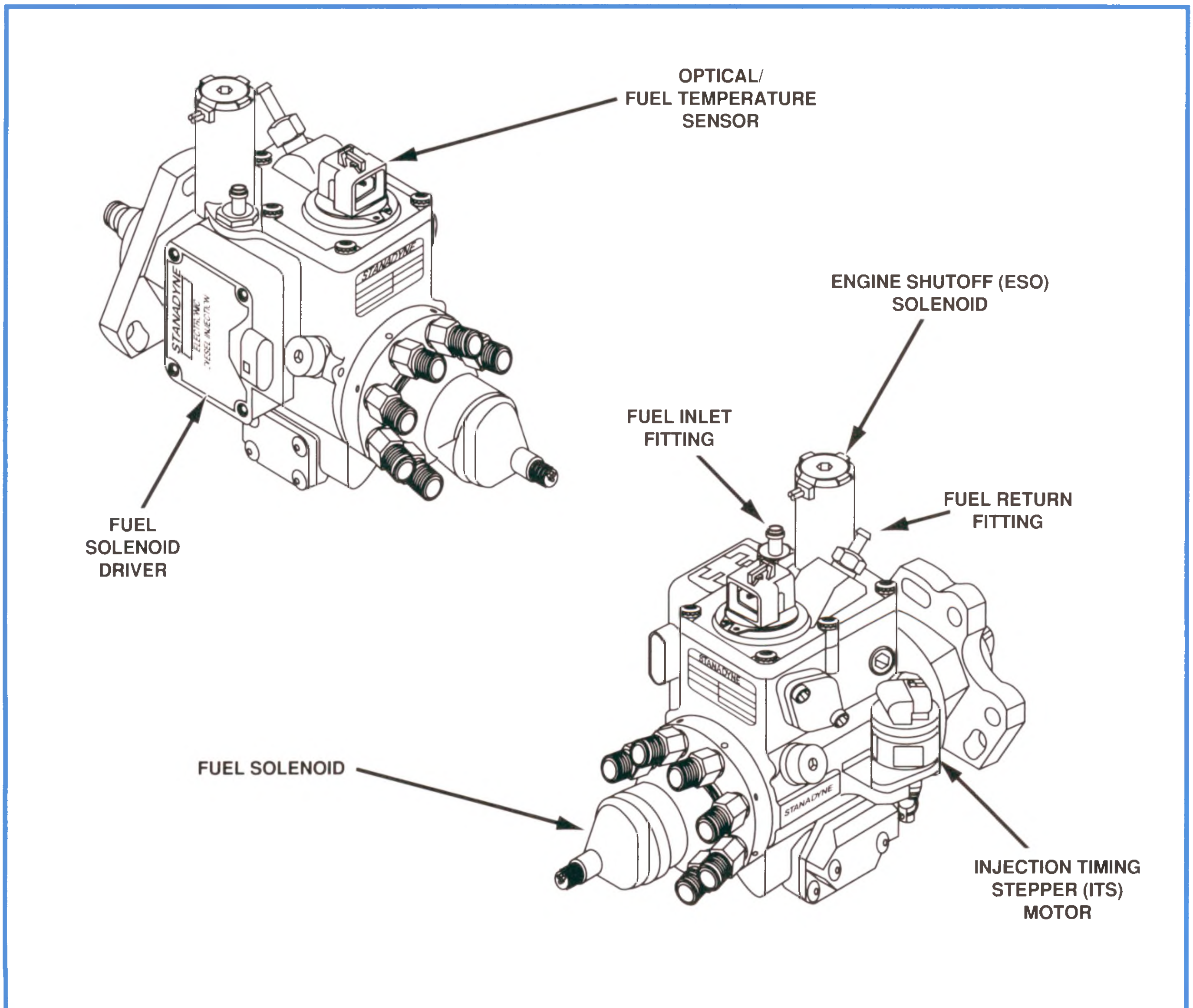


Figure 4-5, **Stanadyne Model DS Electronic Fuel Pump**

INJECTION LINES

The high-pressure discharge fittings on the head of the injection pump connect to the injection nozzles with steel lines of equal length and interior volume (figure 4-6). The ends of the injection lines have special fittings and nuts.

When the engine is not running, fuel is contained in the injection lines. During operation, a residual pressure of approximately 500 psi is maintained in each injection line. As injection occurs in each line, a small amount of fuel enters the line. This creates a pressure wave that pushes a similar amount of fuel into the nozzle at the other end of the line.

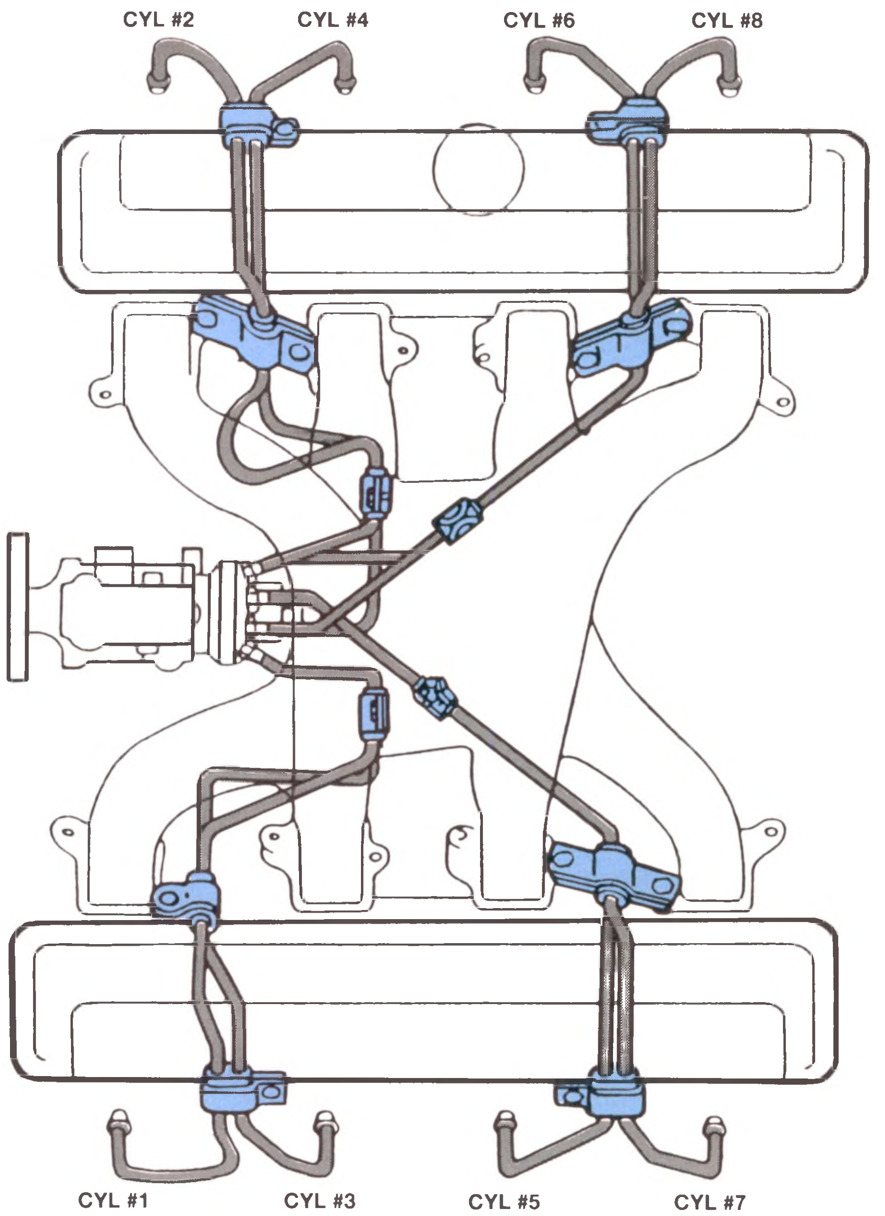


Figure 4-6, **Injection Lines**

INJECTION NOZZLES

Each cylinder has an identical fuel injection nozzle mounted in the pre-combustion chamber. The nozzles are secured with threads and copper sealing gaskets to ensure long-term seating and durability under high-pressure operation.

Each nozzle consists of a two-piece body. The upper body element includes the high-pressure inlet and a pair of leak-off ports. The lower body element consists of the nozzle nut. Each nozzle body houses the following components (figure 4-7):

- a selective-thickness shim
- a pressure spring
- a pressure spindle
- an intermediate plate
- a pintle nozzle
- a heat shield

As the pressure wave of injection reaches a nozzle, the needle valve is lifted against spring force and fuel exits into the pre-combustion chamber of the cylinder as a highly atomized spray. A small amount of fuel also travels between the needle valve and pintle nozzle to provide lubrication.

Two passages inside the upper half of the nozzle body allow fuel that has lubricated the needle valve to exit into the fuel return system. Fittings on the nozzle connect with hoses and clamps to the return system pipes.

During service, nozzles are serviced by replacement. Installation involves the use of a new compression gasket, anti-seize compound (GM P/N 1052771) on the cylinder head threads and a tightening torque of 60 to 80 N•m (44 to 59 lb-ft), using a special socket.

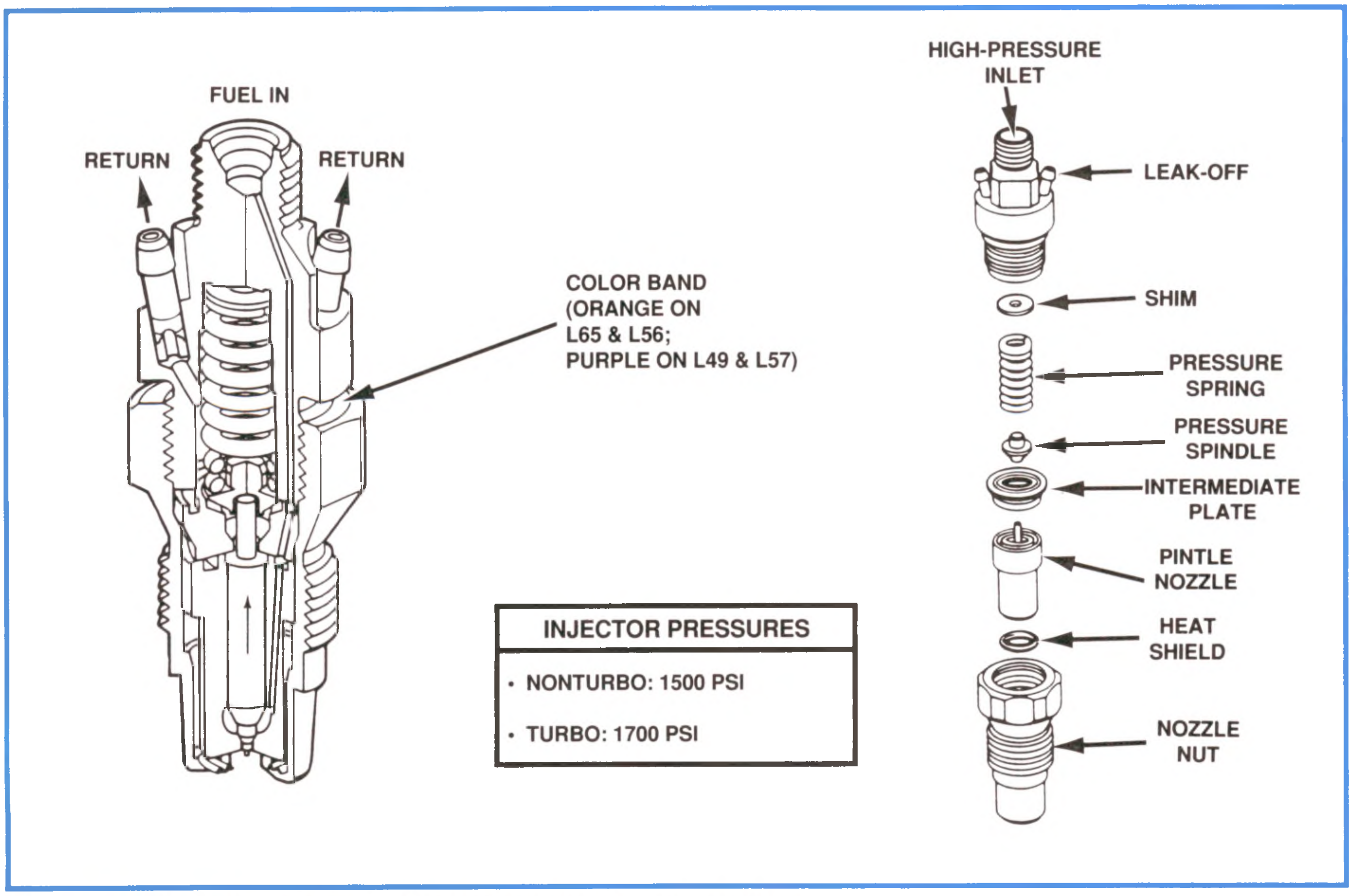


Figure 4-7, Injection Nozzle Operation and Components

FUEL RETURN SYSTEM

The fuel return system uses the following hoses and pipes (figure 4-8):

- The housing pressure regulator is connected to the return system by a hose and two clamps (view A).
- Injection nozzles are individually connected to a return pipe by short lengths of hose (view B)
- The rear fittings of nozzles for cylinder 7 and 8 have caps and clamps (view C).
- The return hoses for cylinders 1 and 2 connect to a center pipe (view D).
- The injection pump return hose connects to the same center pipe as cylinders 1 and 2. The injection return hose also connects to a pipe mounted under the right underside of the intake manifold (view E).
- At the rear of the engine, the return system pipe under the intake manifold connects to a series of hoses and pipes that send fuel back to the fuel tank (view F).

During diagnosis of the injection pump, the return system is checked for restrictions. Any blockage in the path of fuel leaving the injection pump will greatly affect the performance of the engine.

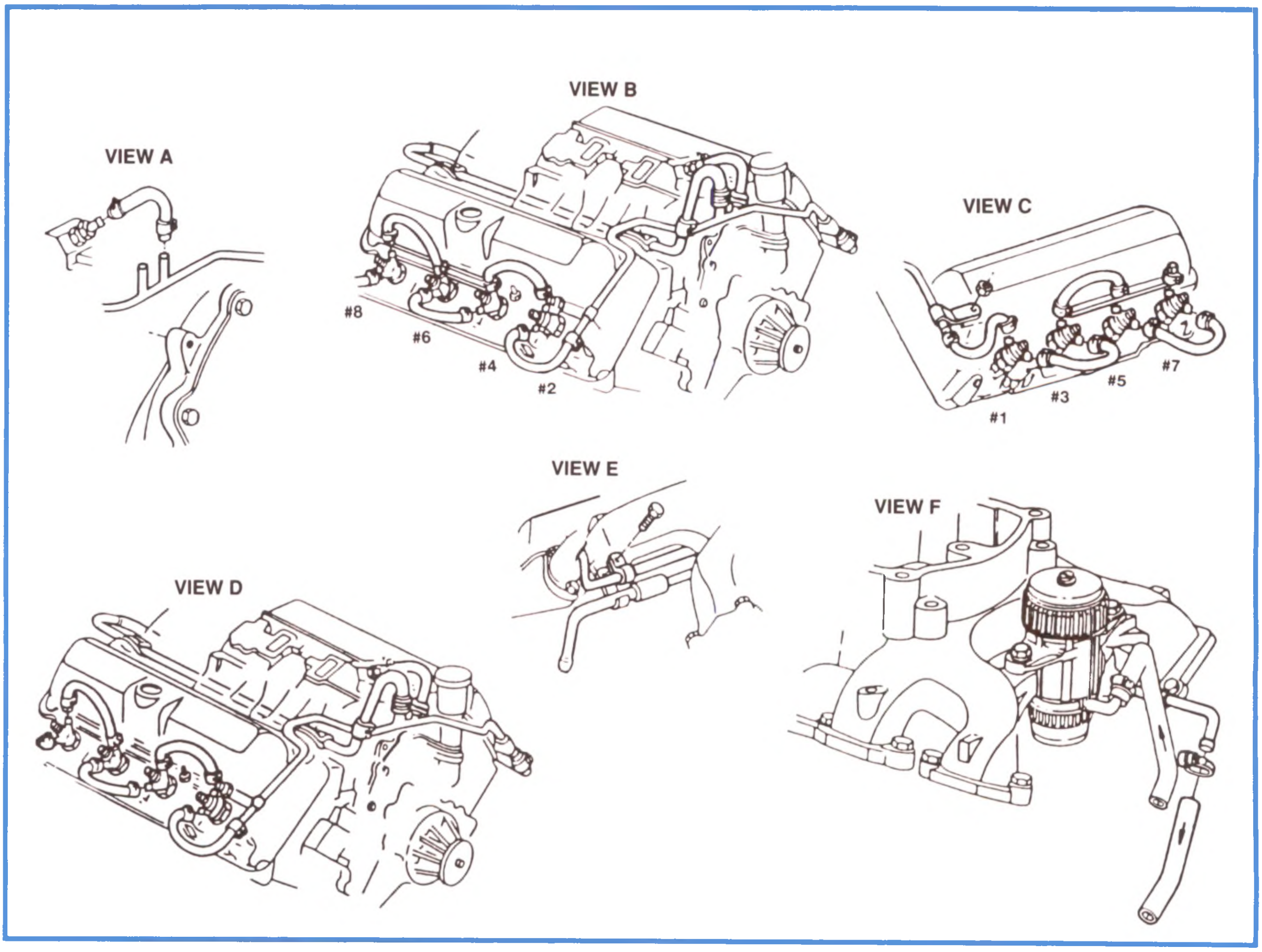


Figure 4-8, Fuel Return System

RELATED DIAGNOSIS/SERVICE PROCEDURES

Fuel Injection System Diagnosis

Diagnosis of the fuel injection system includes the following diagnostic steps.

INJECTION PUMP

To check the fuel supply to the injection pump (figure 4-9):

1. Check that the output of the lift pump is correct:
    - 1988–1993 Model Year Pumps (p/n 25115224):
        - Volume of at least 0.24 liter (1/2 pint) in 15 seconds
        - Pressure of 40 to 60 kPa (5.8 to 8.7 psi) (Tee in after filter at pump inlet, running at idle)
    - 1994 Model Year Pumps (p/n 25117340):
        - Volume of at least 0.24 liter (1/2 pint) in 15 seconds
        - Pressure of 3 psi minimum with the engine cranking, the ESO disconnected, and the fuel line open after the filter to an approved canister.
2. Check that the restriction of the fuel filter is not excessive:
    - Lift pump volume and pressure should be present at the inlet of the injection pump.
3. Check the fuel entering the injection pump for the presence of air, using a transparent hose:
    - If air bubbles appear, check the lift pump suction line for air leakage under a vacuum.
4. Check the quality of the fuel:
    - If necessary, use a fuel with a known cetane rating.

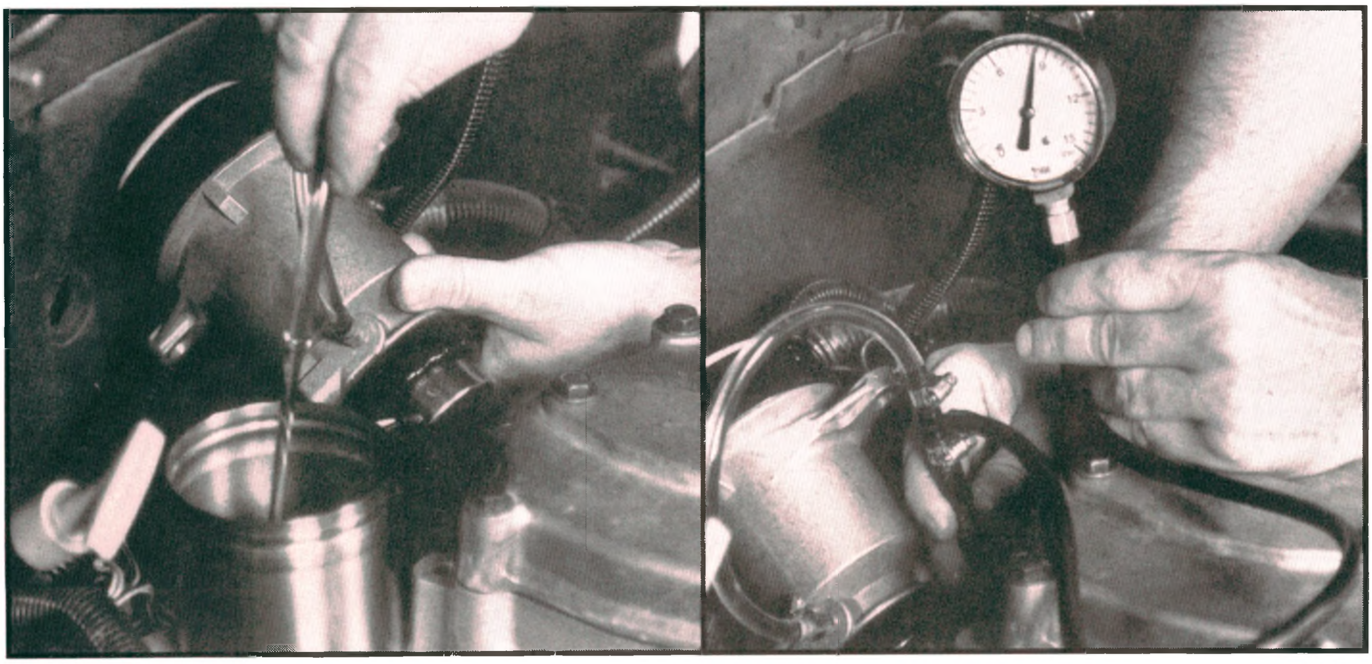


Figure 4-9, **Injection Pump Fuel Supply Checks**

INJECTION LINES AND NOZZLES

To check the operation of the injection lines and nozzles (figure 4-10):

1. Inspect the injection lines for external damage and evidence of fuel leakage.
2. Replace any damaged injection line.
3. Remove and test each injection nozzle for correct opening pressure, chatter, leakage and spray pattern.
    - Refer to the Driveability and Emissions Service Manual section 4 for nozzle opening pressure.
4. Replace any faulty nozzle and install the nozzles with new compression gaskets.

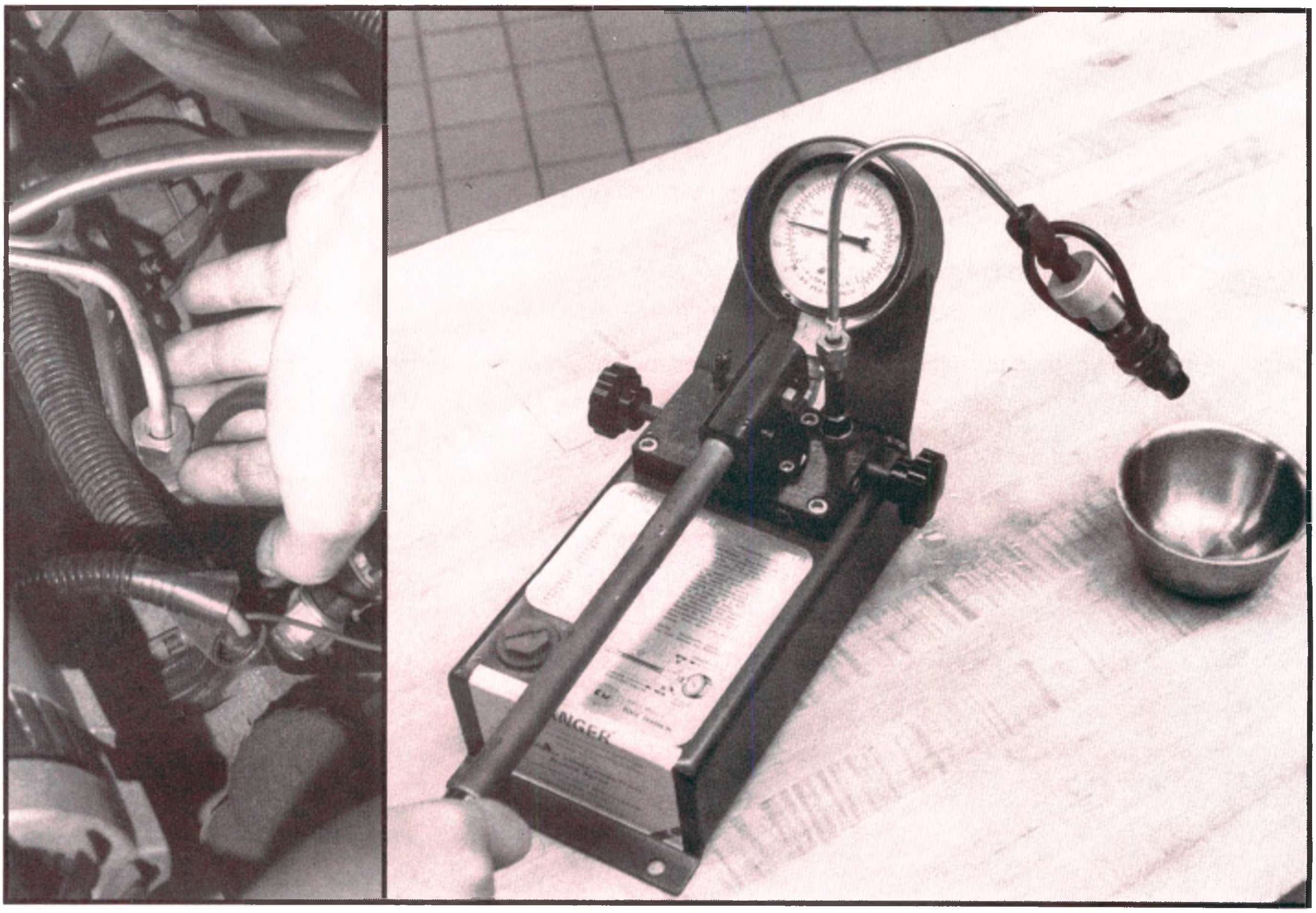


Figure 4-10, Injection Line and Nozzle Checks

Fuel Contamination Inspection and Cleaning

— IMPORTANT —
The following procedure checks for the presence of water and gasoline in diesel fuel that may cause injection pump and nozzle damage.

1. Remove the fuel filter element and inspect it:
   - If water, gasoline or fungi/bacteria are not present, end the inspection.
   - If water or fungi/bacteria are present, go to step 2.
   - If gasoline is present, go to step 3.
2. Clean water from the fuel system in these steps:
   A. Disconnect the batteries.
   B. Drain the fuel tank.
   C. Remove the fuel tank.
   D. Remove the fuel sender unit.
   E. Inspect the fuel tank and fuel sender for rust, fungi or bacteria:
      - If no rust is present, clean the inside of the fuel tank and fuel sender with hot water, then dry them with compressed air.
      - If rust is present, replace affected parts.
   F. Disconnect the ends of the following lines:
      - Lift pump suction
      - Lift pump feed
      - Fuel filter outlet
      - Fuel filter drain
      - Fuel return
   G. Inspect each of the lines and replace any rusted pipes.
   H. Dry the inside of each line with low-pressure air.
   I. Clean the inside of the fuel filter housing and dry it with compressed air.
   J. On EFI pumps, disconnect the electrical connector for the engine shutoff (ESO) solenoid.
      - On mechanical pumps, disconnect the pink wire from the fuel shut off solenoid.
   K. Install a new fuel filter element.
   L. Install the fuel pick-up/sending unit and fuel tank (add clean diesel fuel to one-quarter full).

— CAUTION —
The 6.5L EFI diesel engine could start momentarily even with the ESO solenoid disconnected.

2. *Cleaning water from the fuel system, continued...*

M. Connect the following lines:

- Lift pump suction (both ends)
- Lift pump feed (both ends)
- Fuel filter drain
- Fuel return (at injection pump)

N. Connect the fuel filter outlet and the fuel return line at the pick-up/sending unit to hoses that flow to metal containers.

O. Connect the batteries and crank the engine until clean fuel flows from the fuel filter outlet into a metal container (figure 4-11):

- Allow a maximum of 15 seconds cranking time, followed by 1 minute of cranking motor cooling time.

P. Connect the hose from the fuel filter outlet to the injection pump inlet.

Q. Open each injection line at its nozzle end and crank the engine until clean fuel flows from it:

- Use two wrenches when loosening the injection line fittings.
- Allow a maximum of 15 seconds cranking time, followed by 1 minute of cranking motor cooling time.

R. Tighten each injection line fitting at its nozzle:

- Use two wrenches when tightening the injection line fittings.

S. Connect the electrical connector for the ESO solenoid in the injection pump (electric pump) or the pink wire (mechanical pump).

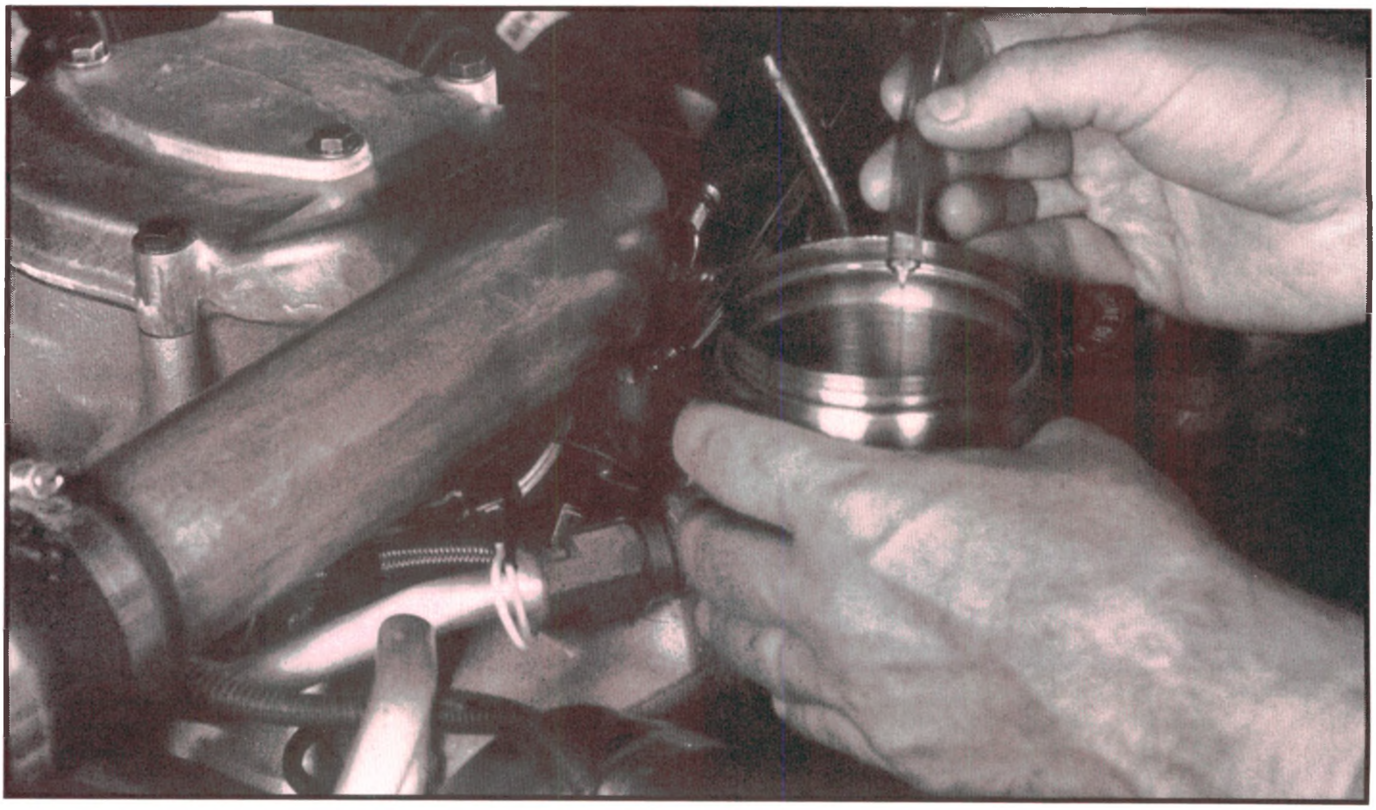


Figure 4-11, **Fuel System Cleaning (1 of 2)**

2. Cleaning water from the fuel system, continued...

T. Start and run the engine for 15 minutes while fuel flows from the fuel return line into a metal container (figure 4-11).

U. Stop the engine.

V. Connect the fuel return hose to the fuel sender.

W. Clean the engine of fuel spillage.

X. Fill the fuel tank and add a biocide, if needed.

3. Clean gasoline from the fuel system in these steps:

A. Determine a procedure:

- If the engine runs, follow steps B, C, and I.
- If the engine does not run, begin at step B.

B. Drain the fuel tank.

C. Fill the fuel tank.

D. On electric pumps, disconnect the electrical connector for the engine shutoff (ESO) solenoid in the injection pump.

- On mechanical pumps, disconnect the pink wire.

E. Remove the fuel filter outlet and connect it to a hose that flows to a metal container.

F. Crank the engine until clean fuel flows from the fuel filter outlet into a metal container:

- Allow a maximum of 15 seconds cranking time, followed by 1 minute of cranking motor cooling time.

G. Connect the hose from the fuel filter outlet to the injection pump inlet.

H. Connect the electrical connector for the ESO solenoid in the injection pump (electric pump) or the pink wire (mechanical pump).

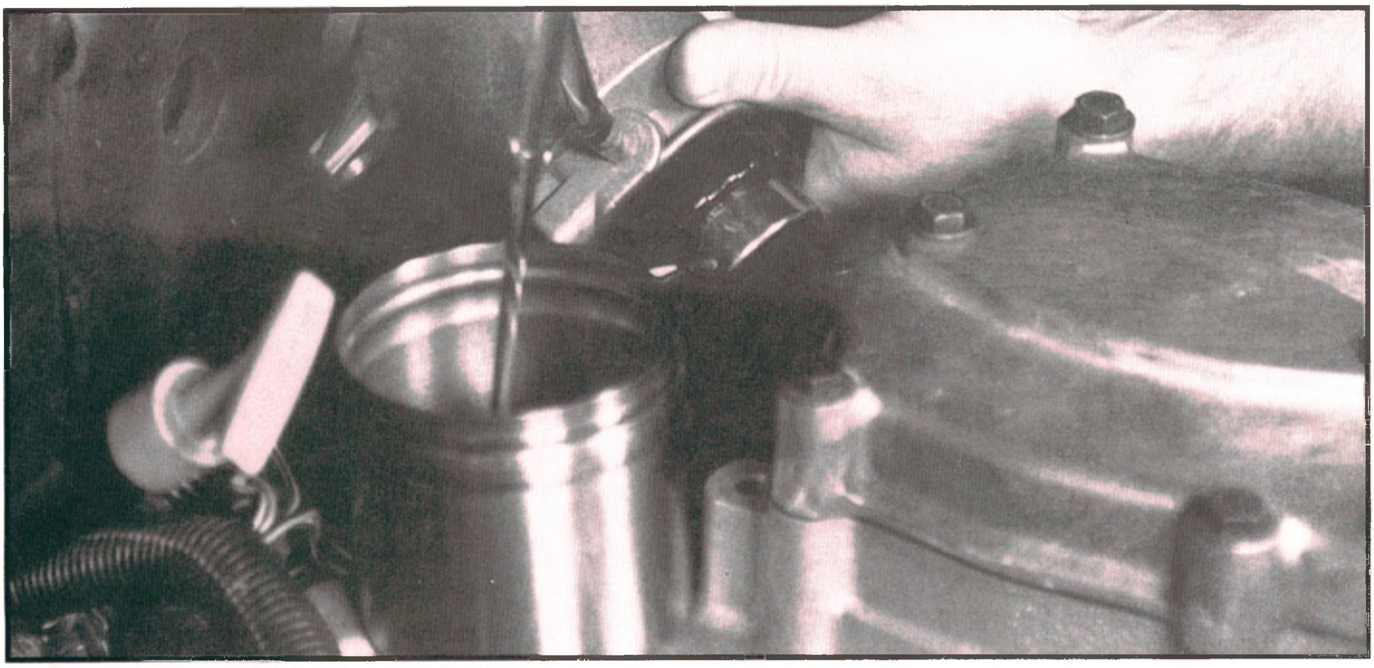


Figure 4-12, Fuel System Cleaning (2 of 2)

Fuel Specific Gravity Check

> **— IMPORTANT —**
> **The hydrometer fuel quality tester provides a general indication of fuel quality and should not be considered scientifically accurate.**

1. Drain the fuel filter housing by doing these things:
   - Stop the engine and place a container under the drain valve exit hose at the left front side of the engine.
   - Open the drain valve.
   - Start the engine and idle until clear fuel appears at the drain valve exit hose.
   - Fill a 1-liter (0.946-quart) container with a sample of clean fuel.
   - Close the drain valve and stop the engine.
   - Bring the fuel sample to 60°F (16°C).

2. Obtain a fuel quality hydrometer (special tool J 34352).

3. Fill the hydrometer with the fuel sample by doing these things:
   - Squeeze the hydrometer bulb and submerse the hydrometer tip into the sample.
   - Release the bulb, allowing fuel to enter the glass tube until it floats the glass bulb inside the tube.
   - Gently spin the hydrometer to relieve the surface tension of the fuel sample.

4. Read the scale on the glass bulb at the point where the top of the fuel sample contacts it (figure 4-13):
   - If the top of the fuel sample is in the yellow part of the glass bulb scale (above the green part), suspect diluted fuel.
   - If the top of the fuel sample is in the green part of the glass bulb scale, the fuel has high quality (approximate cetane rating of 46 to 50).
   - If the top of the fuel sample is in the yellow part of the glass bulb scale (below the green part), the fuel has moderate quality (approximate cetane rating of 41 to 45).
   - If the top of the fuel sample is in the red part of the glass bulb scale, the fuel has low quality (approximate cetane rating of 38 to 40).

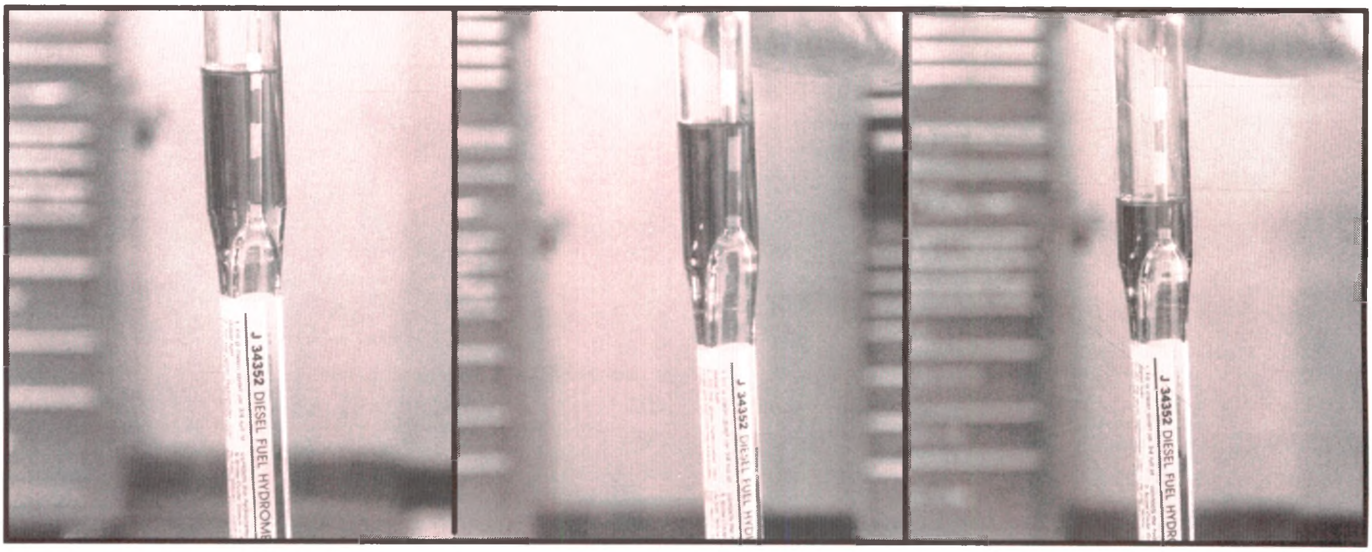


Figure 4-13, Fuel Specific Gravity Check

5. Engine Management

POWERTRAIN CONTROL MODULE (PCM) OVERVIEW

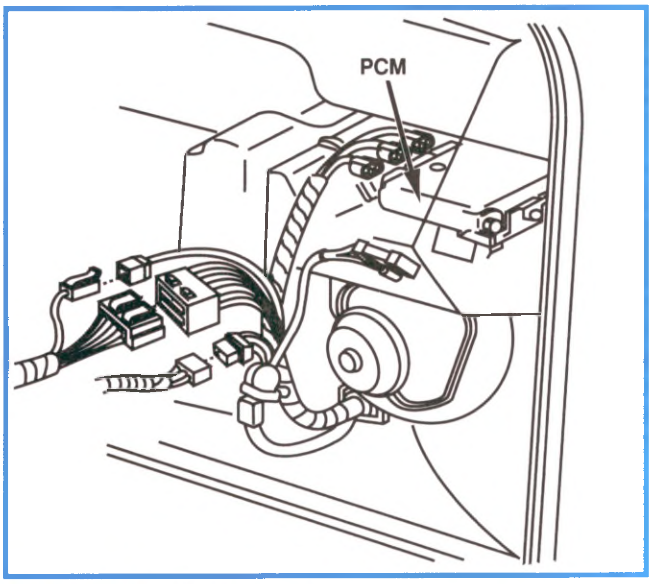


Figure 5-1, **PCM Location**

The Powertrain Control Module (PCM), located in the passenger compartment (figure 5-1), controls the EFI system.

Internally, the PCM is programmed with calibration information specific to the vehicle. This program tells the PCM what the normal operating parameters are for fuel delivery, timing, emissions control, and transmission control.

Externally, the PCM is hard-wired to numerous sensors, known as "inputs," as well as to solenoids, relays and indicator lamps, known as "outputs." The full roster of 6.5L EFI V8 PCM inputs and outputs are shown in figure 5-2.

The PCM constantly receives and interprets information from the inputs. It processes this information and compares it to the nominal, or normal, values with which it is programmed. The PCM then either sends or inhibits electrical responses to output devices in order to control fuel delivery, timing, and other emission control systems.

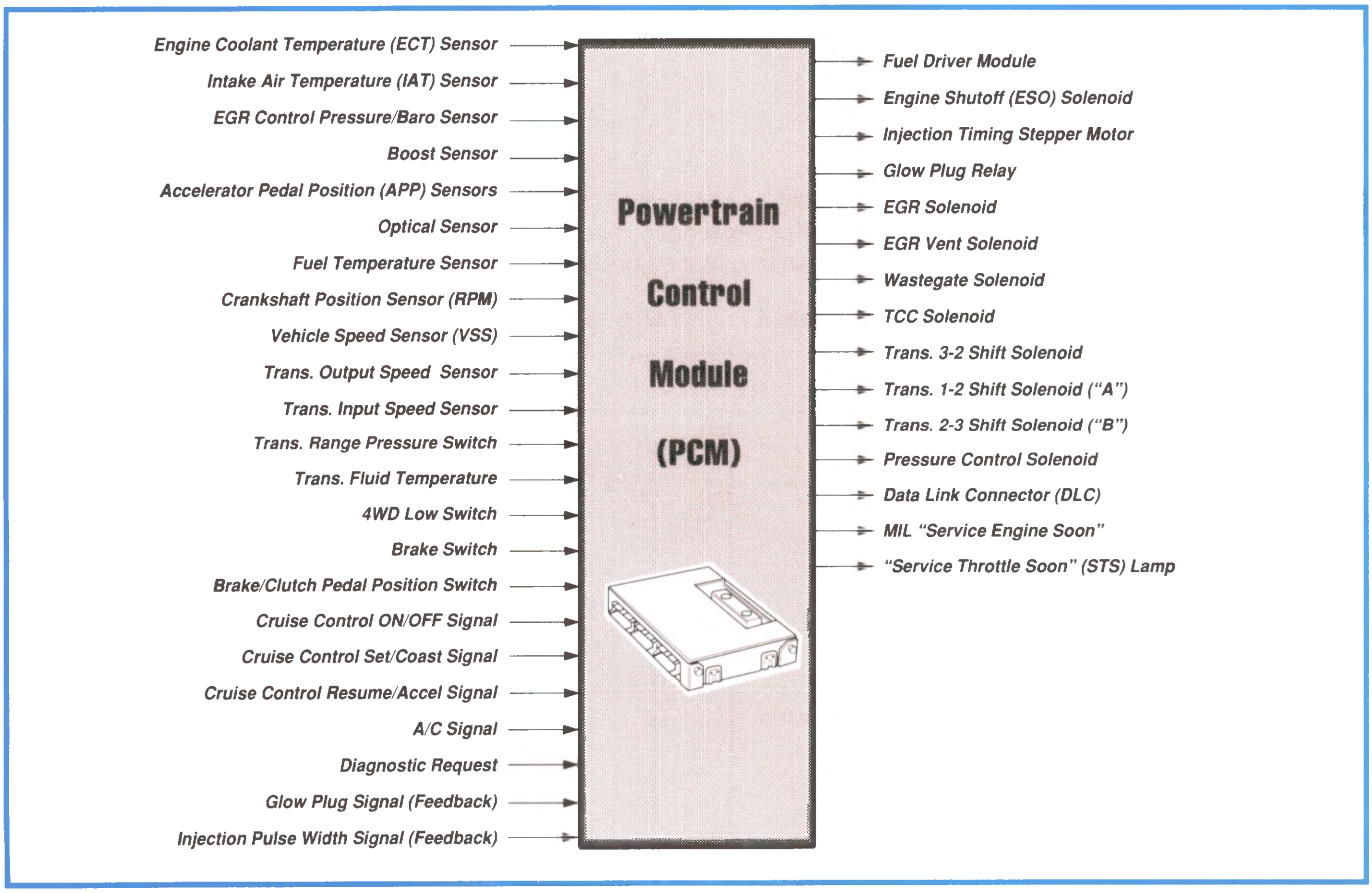


Figure 5-2, **6.5L EFI V8 Diesel PCM Inputs and Outputs**

5. Engine Management

When input data doesn't correspond to PCM parameters, or when output devices don't respond as they should, one or more Diagnostic Trouble Codes (DTC) can be set. These codes are stored in the PCM memory. Under many code conditions, the PCM will substitute default values that provide the driver with vehicle operation.

Using either the on-vehicle Data Link Connector (DLC) or a "Scan" tool, a technician can access stored codes in order to determine the causes of a driveability condition. Codes are designed so that each one relates to a specific component or system. By using the a code's corresponding diagnostic trouble-tree chart located in Section 3 of the diesel Driveability and Emissions Service Manual, a technician can systematically pinpoint and correct the condition. "Scan" tool usage and code reading are addressed in detail in section 6 of this book.

— IMPORTANT —

The PCM has a learning ability that allows it to make corrections for minor variations in the fuel system to improve driveability. If the battery is disconnected for repairs, the learning process resets and begins again. A change may be noted in the vehicle's performance. To "teach" the PCM, ensure that the engine is at operating temperature. The vehicle should be driven at part throttle, with moderate acceleration and idle conditions, until normal performance returns.

PCM CONTROL

PCM control can be divided into eight subsystems:

- Fuel Control
- Timing Control
- Glow Plug Control
- Boost Control
- EGR Control
- Cruise Control
- Transmission Control
- Diagnostic Request

The input-output relationship within the PCM isn't one-to-one. The information from a particular input might be used as part of the PCM's decision making for several outputs. For this reason, if one input fails, it can affect the operation of more than one system. Understanding these relationships can improve diagnostics.

Figures 5-3 through 5-10 show the PCM input/output relationship for the individual subsystems of the 6.5L EFI diesel engine.

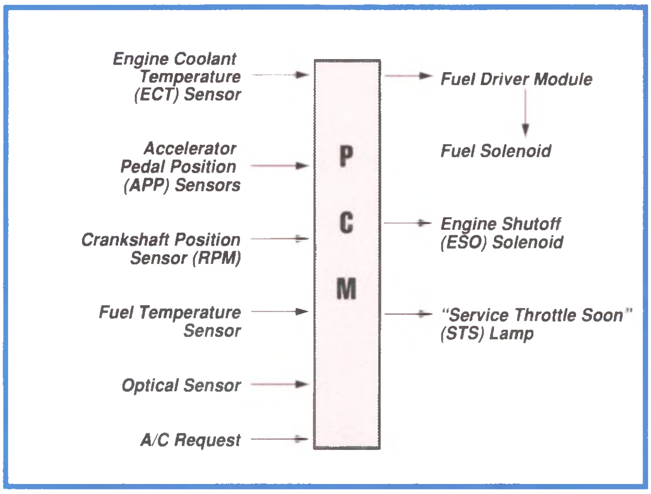


Figure 5-3, Fuel Control Inputs/Outputs

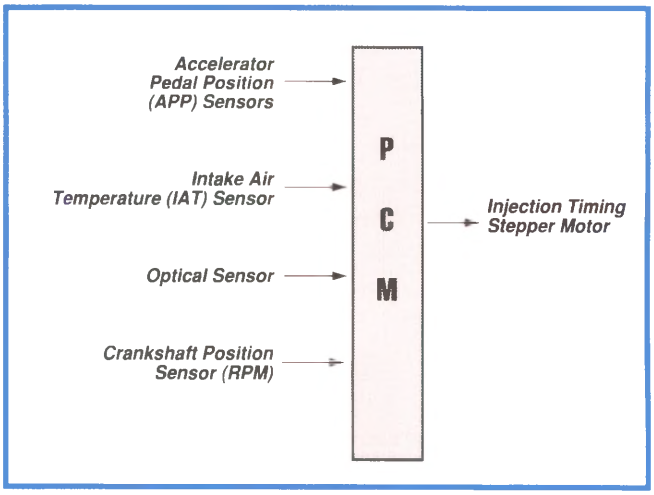


Figure 5-4, Timing Control Inputs/Outputs

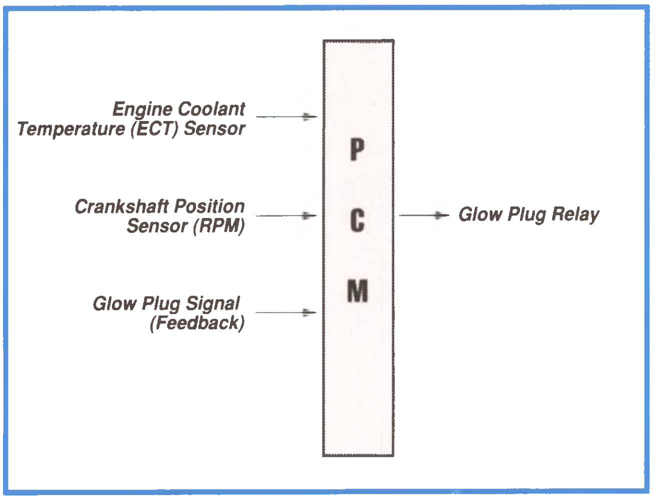


Figure 5-5, Glow Plug Control Inputs/Outputs

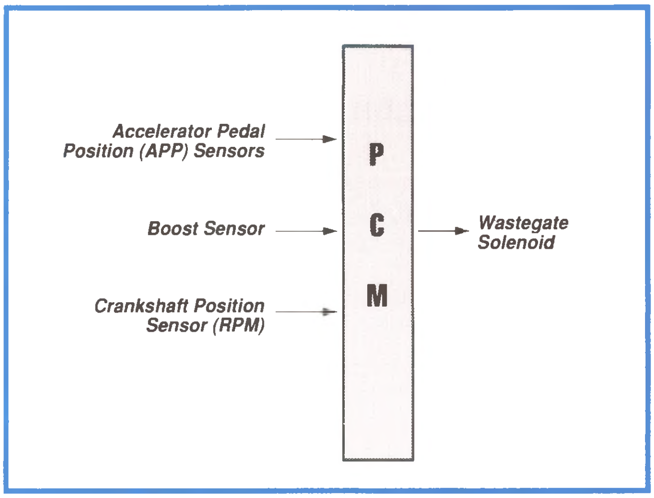


Figure 5-6, Boost Control Inputs/Outputs

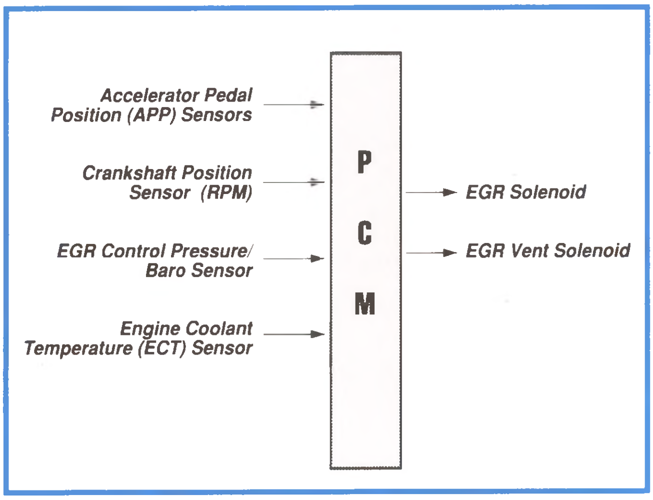


Figure 5-7, EGR Control Inputs/Outputs

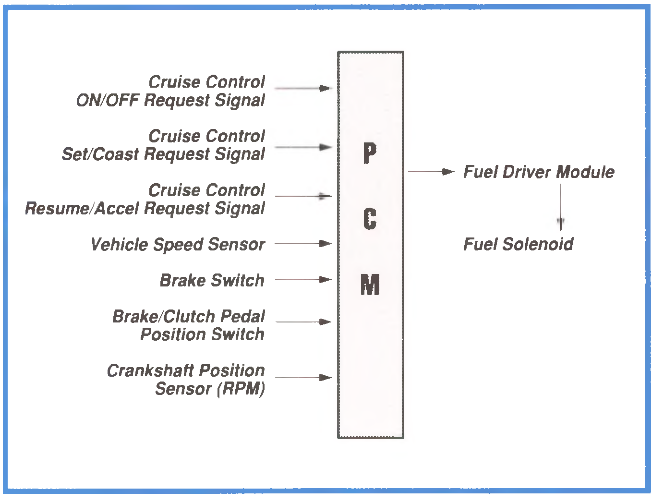


Figure 5-8, Cruise Control Inputs/Outputs

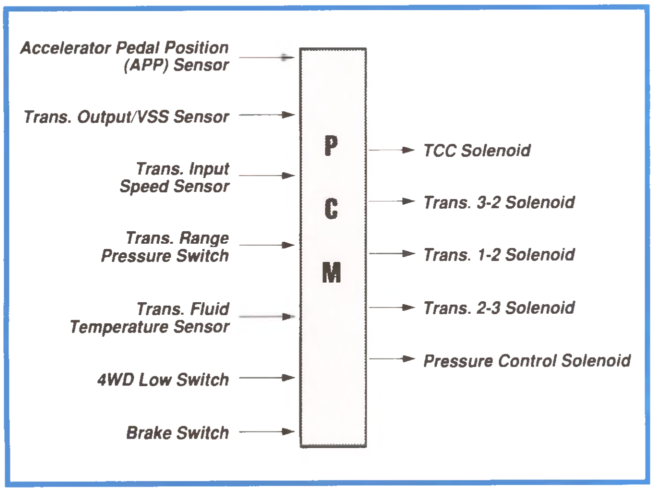


Figure 5-9, Transmission Control Inputs/ Outputs

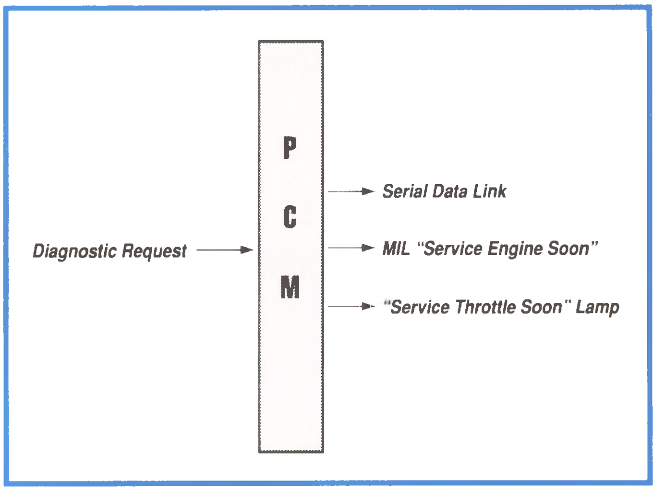


Figure 5-10, Diagnostic Request Inputs/ Outputs

FUEL CONTROL

System Operation

The electronic injection pump is the heart of the fuel control system. The rotary distributor pump uses an electromagnetic control valve to regulate fuel flow inside the pump. Four plungers in the pump pressurize fuel for distribution to the injectors. A PCM-controlled electronic stepper motor controls plunger timing via an advance piston.

The PCM uses information regarding engine coolant temperature, engine speed, accelerator position, fuel temperature, the optical sensor, and air conditioning status to calculate when to energize the fuel solenoid driver (figure 5-11). The PCM also illuminates the "Service Throttle Soon" lamp and/or Malfunction Indicator Lamp (MIL) in the instrument panel to alert the driver to conditions requiring service.

The PCM also has the capability to interrupt fuel supply when conditions warrant. It does this by de-energizing the normally closed engine shutoff (ESO) solenoid. When de-energized, the solenoid plunger prevents fuel from entering the charging passages in the pump.

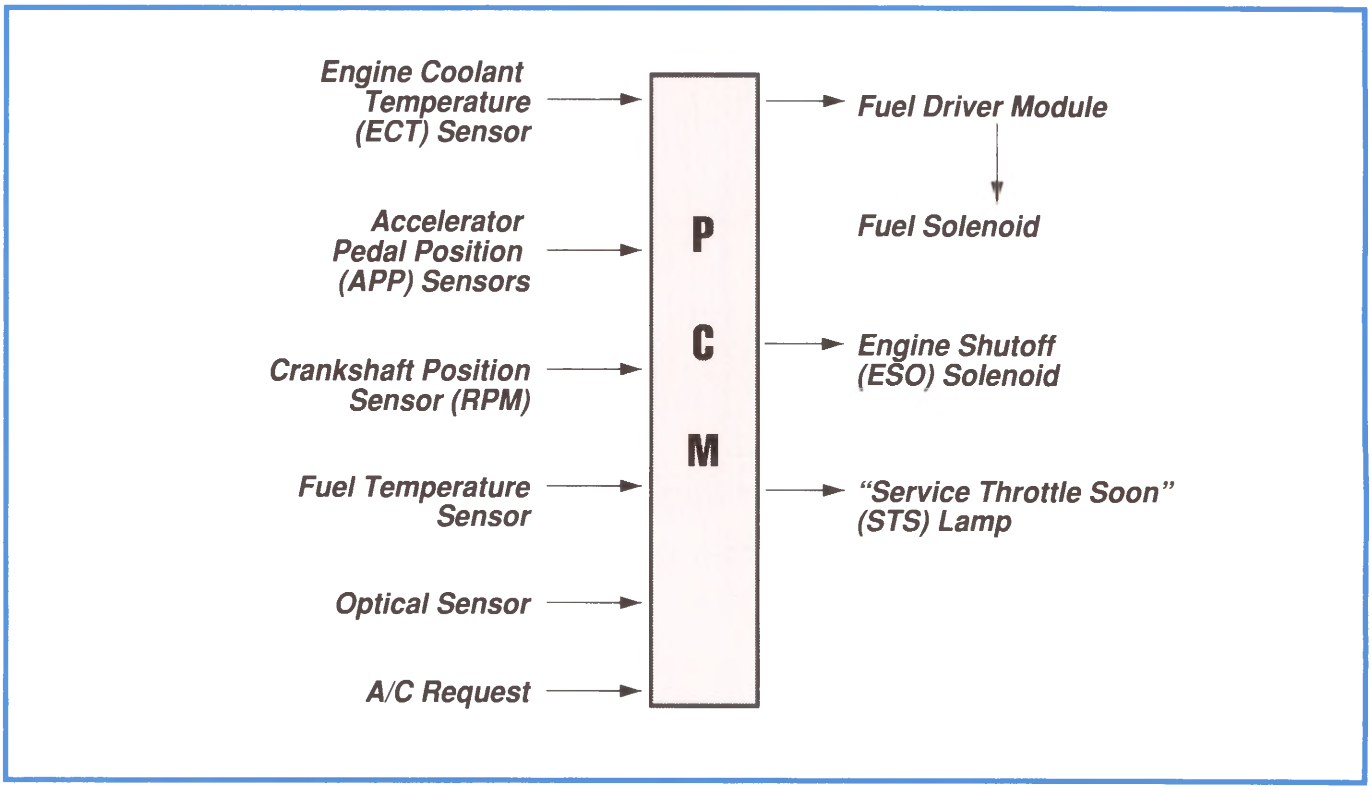


Figure 5-11, **PCM Fuel Control Inputs and Outputs**

Fuel Flow

Similar to other fuel delivery systems on diesel engines, fuel delivery on the 6.5L EFI powerplant consists of four stages:

- Pressurization
- Distribution and Metering
- Lubrication
- Timing

PRESSURIZATION

Fuel is drawn from the tank by a lift pump (figure 5-12) mounted on the inside of the left frame rail. The lift pump pressurizes the fuel at a rate of approximately .24 liter (1/2 pint) in 15 seconds (15 GPH). Pressurization rates are as follows:

- On model year 1988-1993 pumps (p/n 25115224), fuel is pressurized to between 40 and 60 kPa (5.8 to 8.7 psi, tee in running at idle)
- On model year 1994 and later pumps (p/n 25117340), fuel is pressurized to a 3 psi minimum with the line open (after the filter) to an approved canister and the engine cranking.

From the lift pump, fuel is carried to the transfer pump. The vane-type transfer pump varies the pressure of the fuel, depending on the speed of the engine. At idle, the transfer pump outlet pressure is approximately 20 to 30 psi. At full engine speed, the transfer pump outlet pressure may be over 100 psi, with a maximum of 125 psi.

A regulator valve controls transfer pump outlet pressure. The valve uses a viscosity-compensating orifice. This regulator valve is at the end of the hydraulic circuit, rather than directly at the transfer pump. As with other previous 6.5L diesel regulators, however, it spills fuel back to the transfer pump inlet.

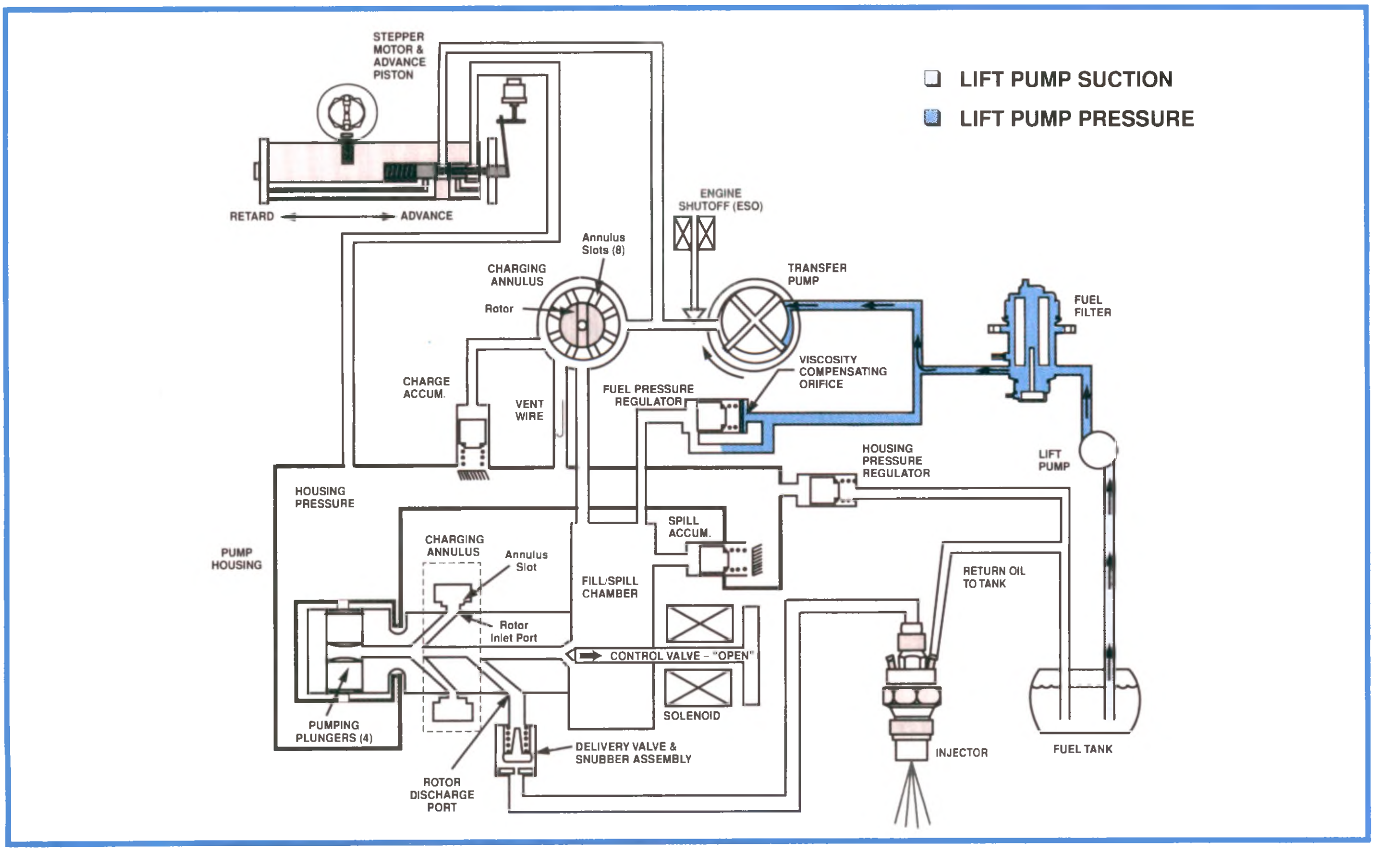


Figure 5-12, Fuel System Diagram — *Pressurization*

DISTRIBUTION AND METERING

Fuel pressurized at the transfer pump travels to the charging annulus. The annulus has eight slots. From the charging annulus, fuel is distributed to two places (figure 5-13):

- the pump housing
- the pumping plungers of the rotor

Fuel delivery to the plungers is most important for the understanding injection pump operation. Fuel reaches the plungers from two sources.

The first is through two inlet ports in the rotor. As the rotor spins, these ports align with two of the eight annulus slots. Pressurized fuel passes from the slots through the rotor inlet ports. Passages in the rotor carry fuel from the ports to the plungers.

The second source of fuel distribution to the plungers occurs at the front of the rotor, in the fill/spill chamber. Fuel enters through the open control valve. The valve's movement is controlled by the fuel solenoid. When the solenoid is off, the spool-type control valve unseats to allow fuel to pass through.

Fuel in the rotor is metered for delivery to the injection nozzles.

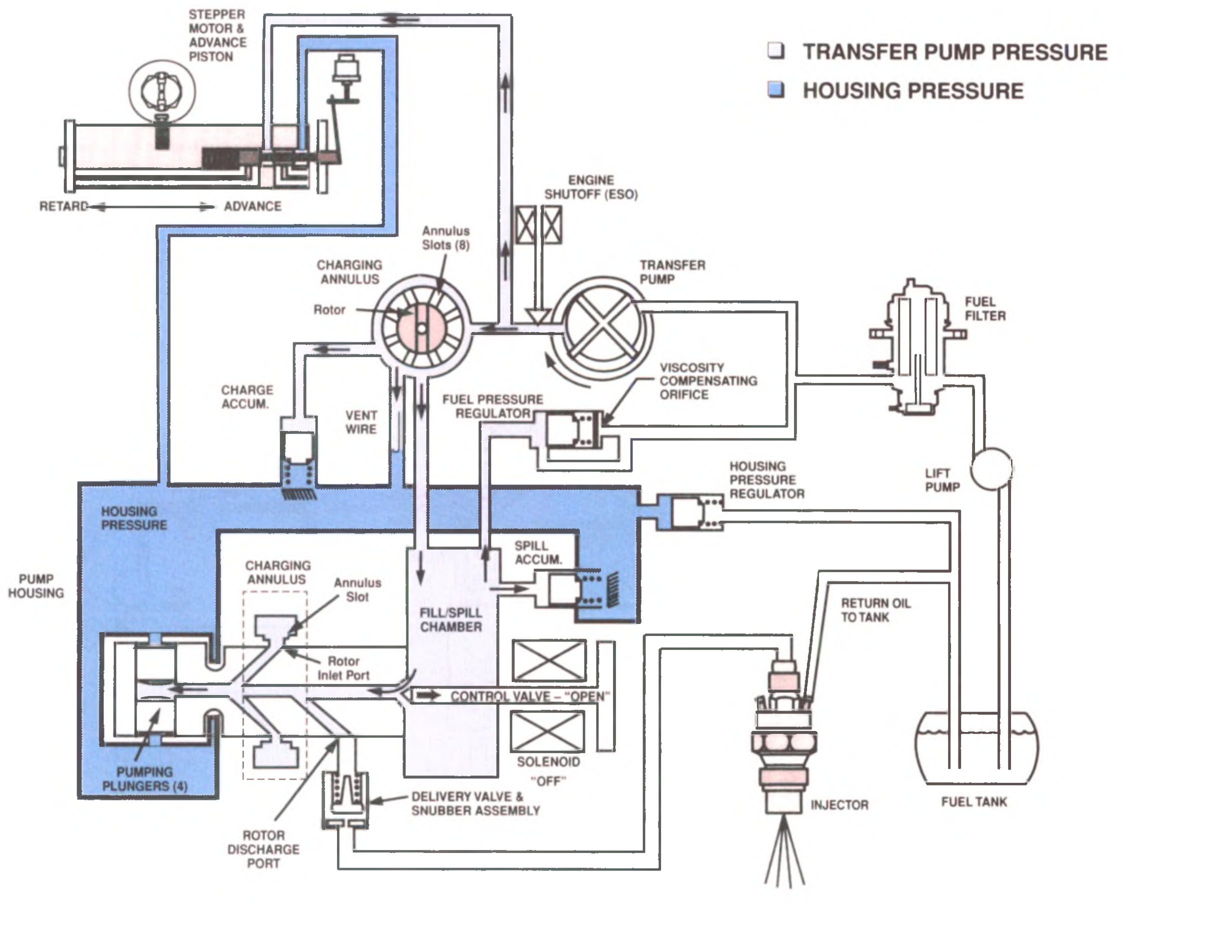


Figure 5-13, Fuel System Diagram — *Distribution and Metering*

Metering

Metering is a four-stage process consisting of:

1. Fill
2. End of fill
3. Pumping
4. Spill

These stages are the result of changes in cam ring, plunger, and control valve positions (figure 5-14). The plungers are housed in the rotor. A cam ring surrounds the plunger area of the rotor. The inner surface of the cam has eight lobes (high points) and valleys (low points).

The plungers don't directly contact the cam. Instead, there are four shoe/roller assemblies that ride on the cam's inner surface. The flat shoe surfaces contact the plungers. As the rotor spins, the shoe/roller assemblies rise and fall on the cam surface. When they do, the plungers move inward and outward. The in-and-out movement of the plungers pushes fuel to the injectors.

Metering occurs eight times in one revolution of the rotor. Each pair of inlet ports goes through the complete metering process once per revolution. The pumping chamber is always completely filled with fuel. Injection quantity is controlled by fuel spill at the end of injection.

Cam ring, plunger, and control valve activity at each metering stage are described on the following pages.

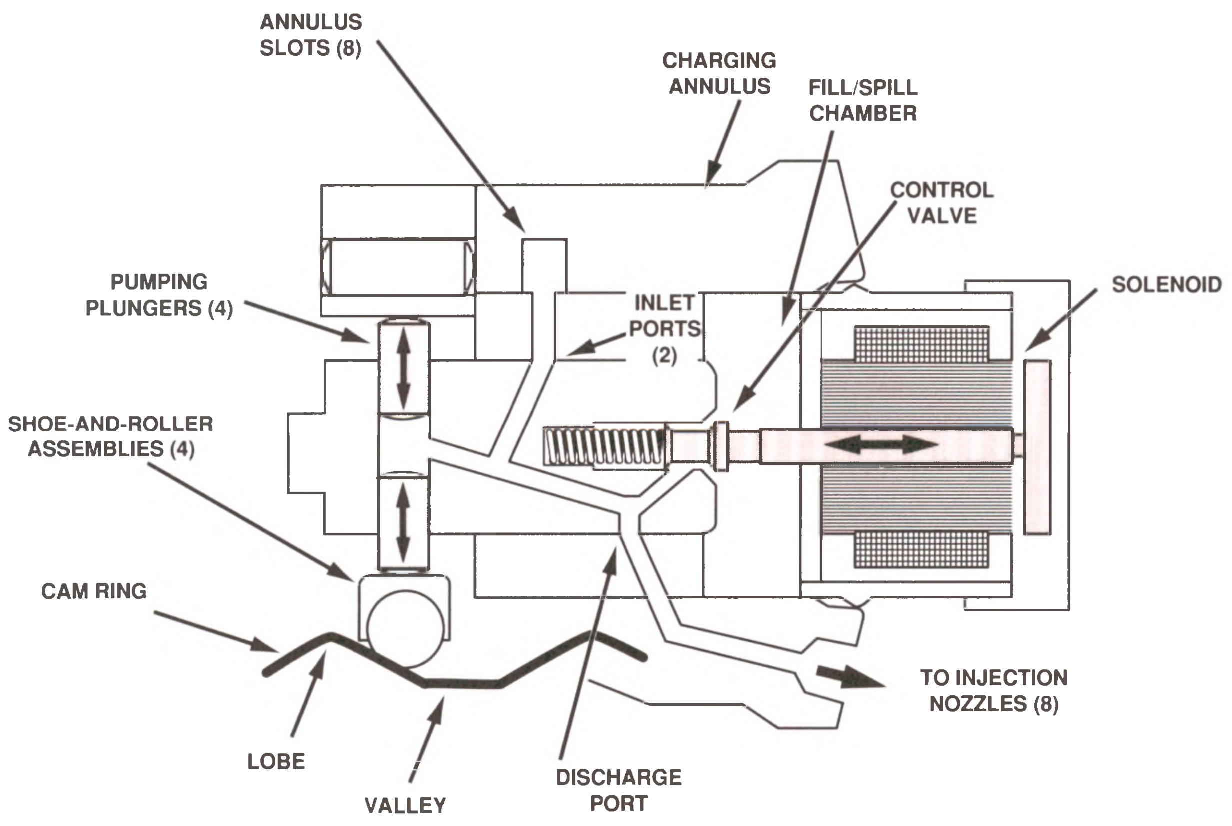


Figure 5-14, Pumping Chamber Components

Fill

During fill (figure 5-15):

- the two rotor inlet ports align with the charging annulus slots. This allows transfer pump pressure into the rotor passages.
- the fuel solenoid is off, releasing the control valve. Fuel passes around the valve head.
- the shoe/roller assemblies are entering the valleys of the cam, causing the plungers to move outward.

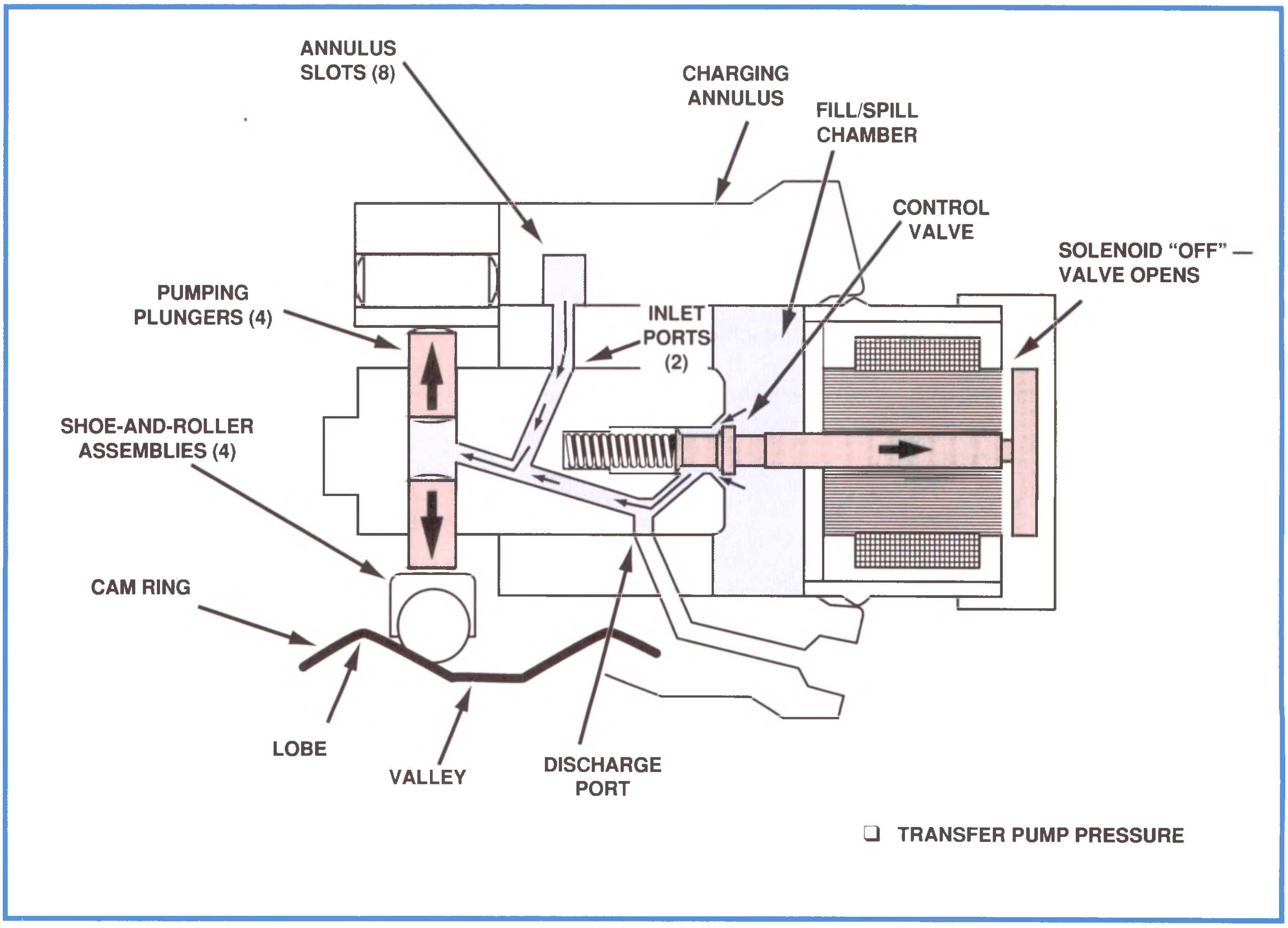


Figure 5-15, Fuel Metering — *Fill*

End of Fill

During end of fill (figure 5-16):

- the rotor inlet ports are out of alignment with the annulus slots. Fuel is prevented from entering the rotor.
- the fuel solenoid energizes to close the control valve. Fuel cannot enter around the control valve.
- the shoe/roller assemblies are in the valleys of the cam. As a result, the plungers are in the maximum outward position.

At the end of this stage, pressurized fuel is trapped in the rotor, waiting to be sent to the injection nozzles.

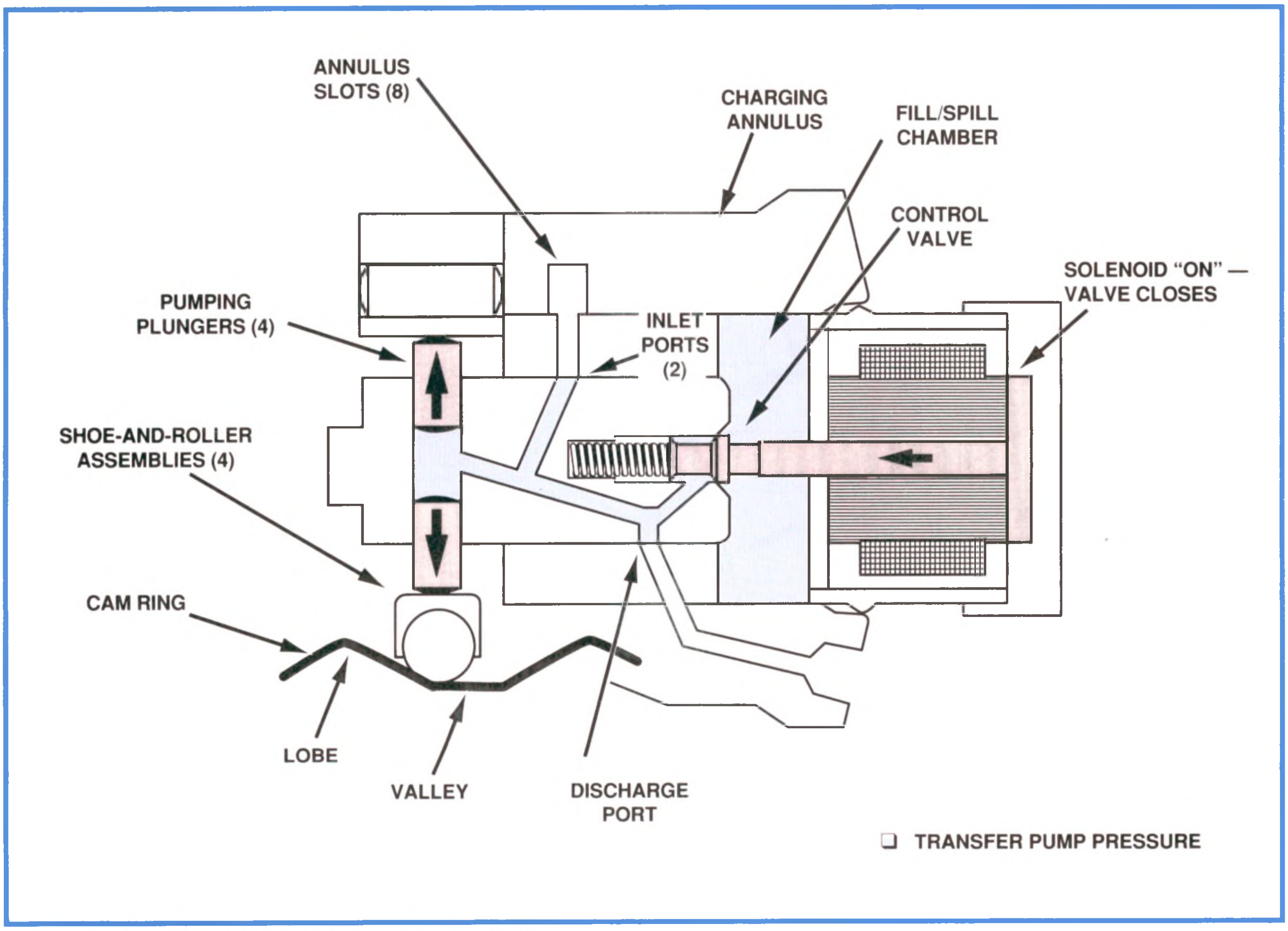


Figure 5-16, **Fuel Metering — *End of Fill***

Pumping

During pumping (figure 5-17):

- the shoe/roller assemblies begin up the next cam lobe ramp. This pushes the plungers inward, creating high-injection pressure that flows to the discharge ports.
- the solenoid remains energized to prevent fuel from escaping at the control valve opening

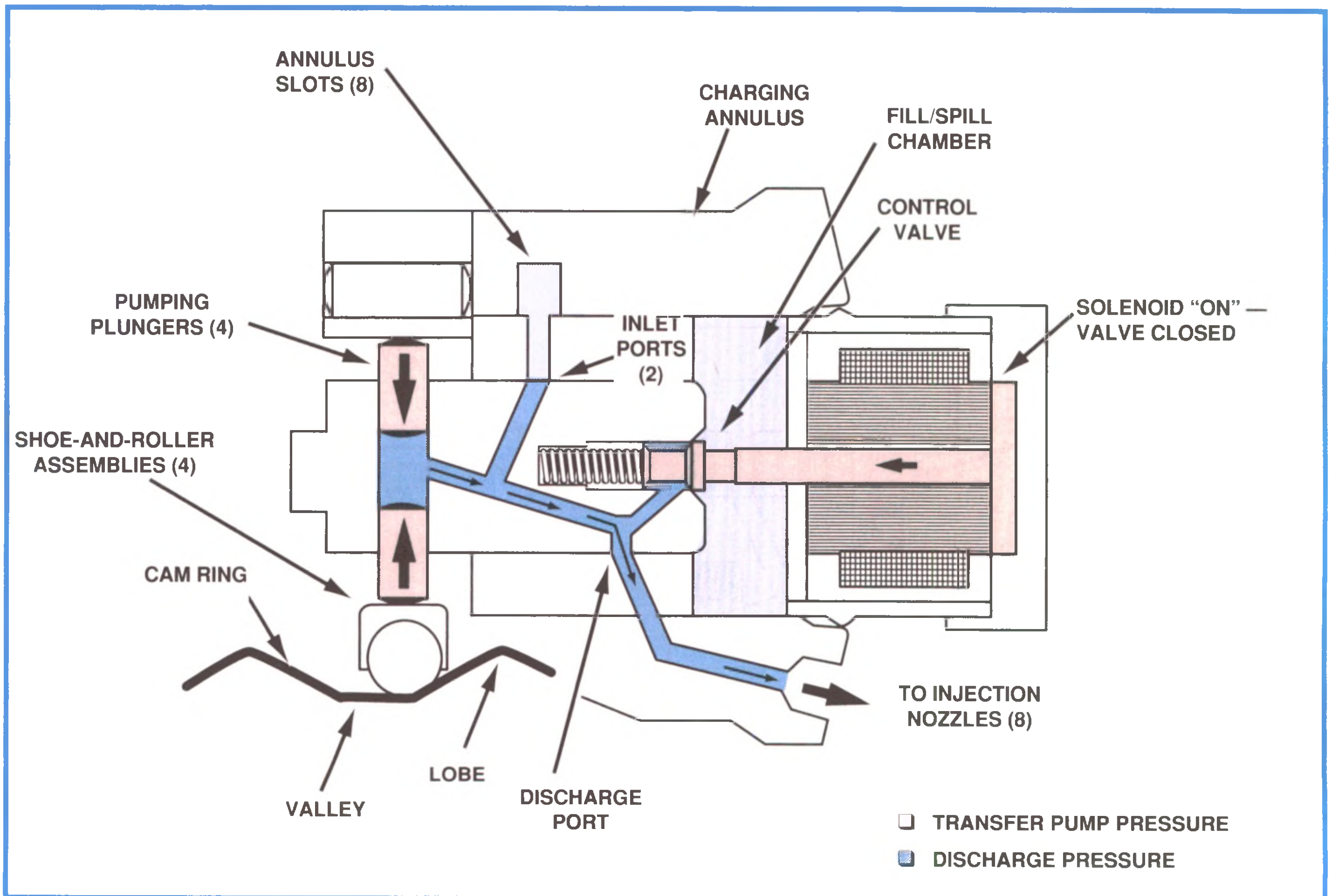


Figure 5-17, Fuel Metering — *Pumping*

Spill

Spill (figure 5-18) signals the end of injection:

- the fuel solenoid, as commanded by the PCM, de-energizes. This opens the control valve. Fuel spills out the control valve opening and returns to the fill/spill chamber.
- fuel from the injection lines spills back into the rotor through the discharge ports. Near the end of the spill cycle, the rotor spins to close the discharge ports.
- the shoe/roller assemblies are at the top of the cam lobe, putting the plungers in the maximum inward position

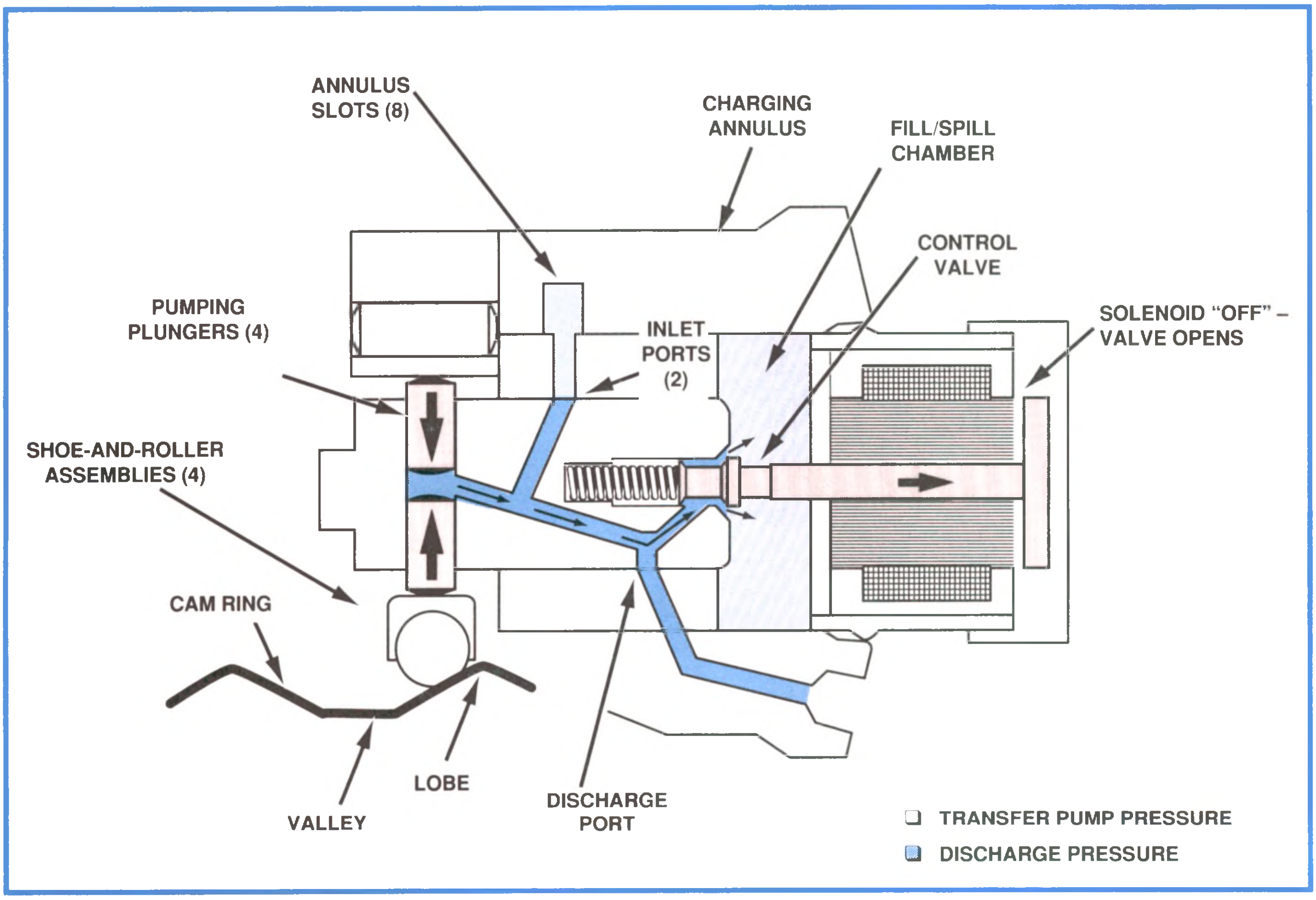


Figure 5-18, Fuel Metering — *Spill*

TIMING

Timing on the electronic pump is managed by the injection timing stepper motor. It uses a sliding piston that connects to the cam ring with a pin. As the piston slides in its housing bore, it causes the pin to rotate the cam ring to change injection timing.

There is an outlet passage from the charging annulus to the advance piston (figure 5-19). The pressurized fuel in this passage is used to move the advance piston. There are also drain passages in the piston housing.

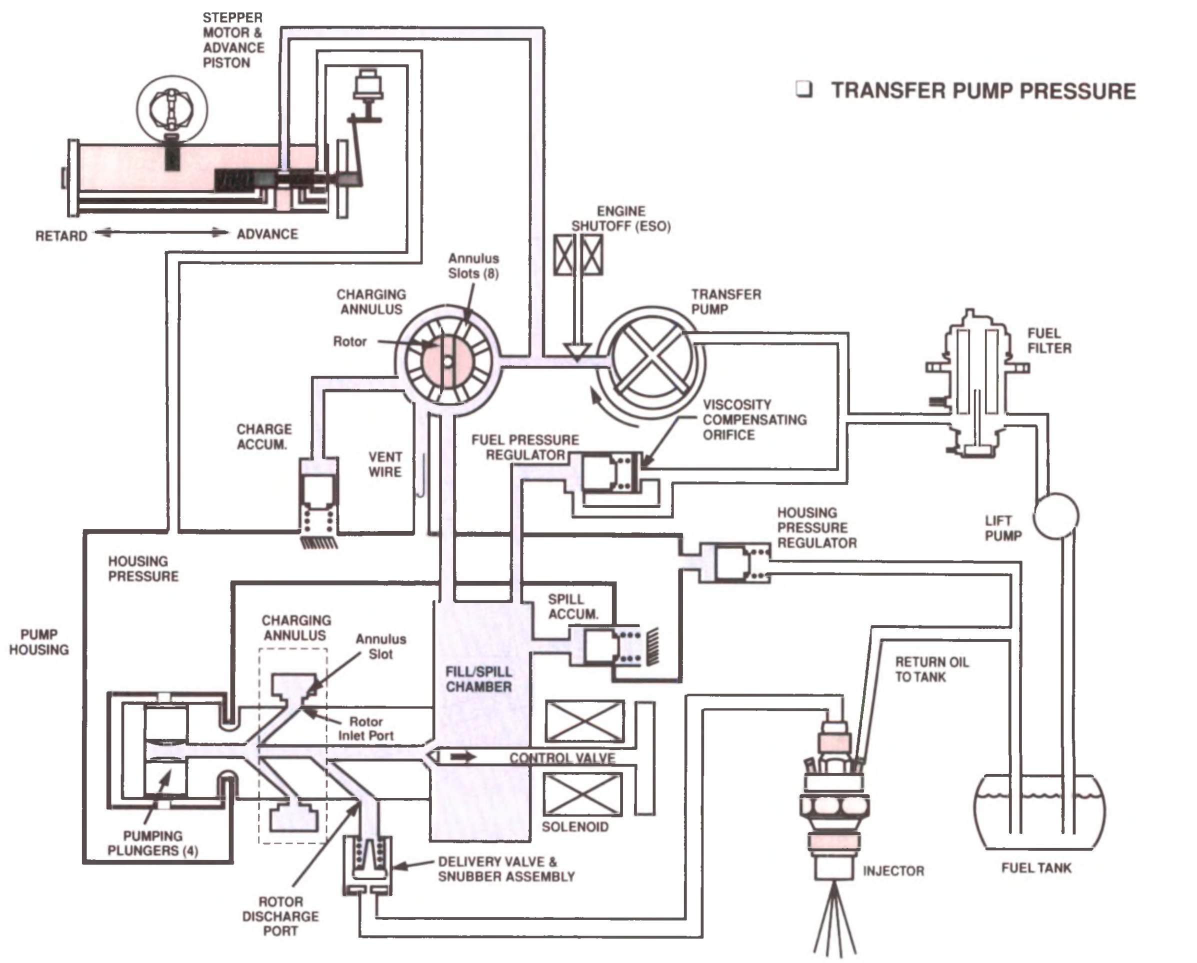


Figure 5-19, **Fuel System Diagram — *Timing***

Stepper Motor/Advance Piston Components

The mechanical advance/retard components of the stepper motor and piston assembly include (figure 5-20):

- Lever Spring
- Pivot Shaft
- Control Lever
- Servo Valve
- Cam Pin
- Advance Piston
- Servo Valve Return Spring

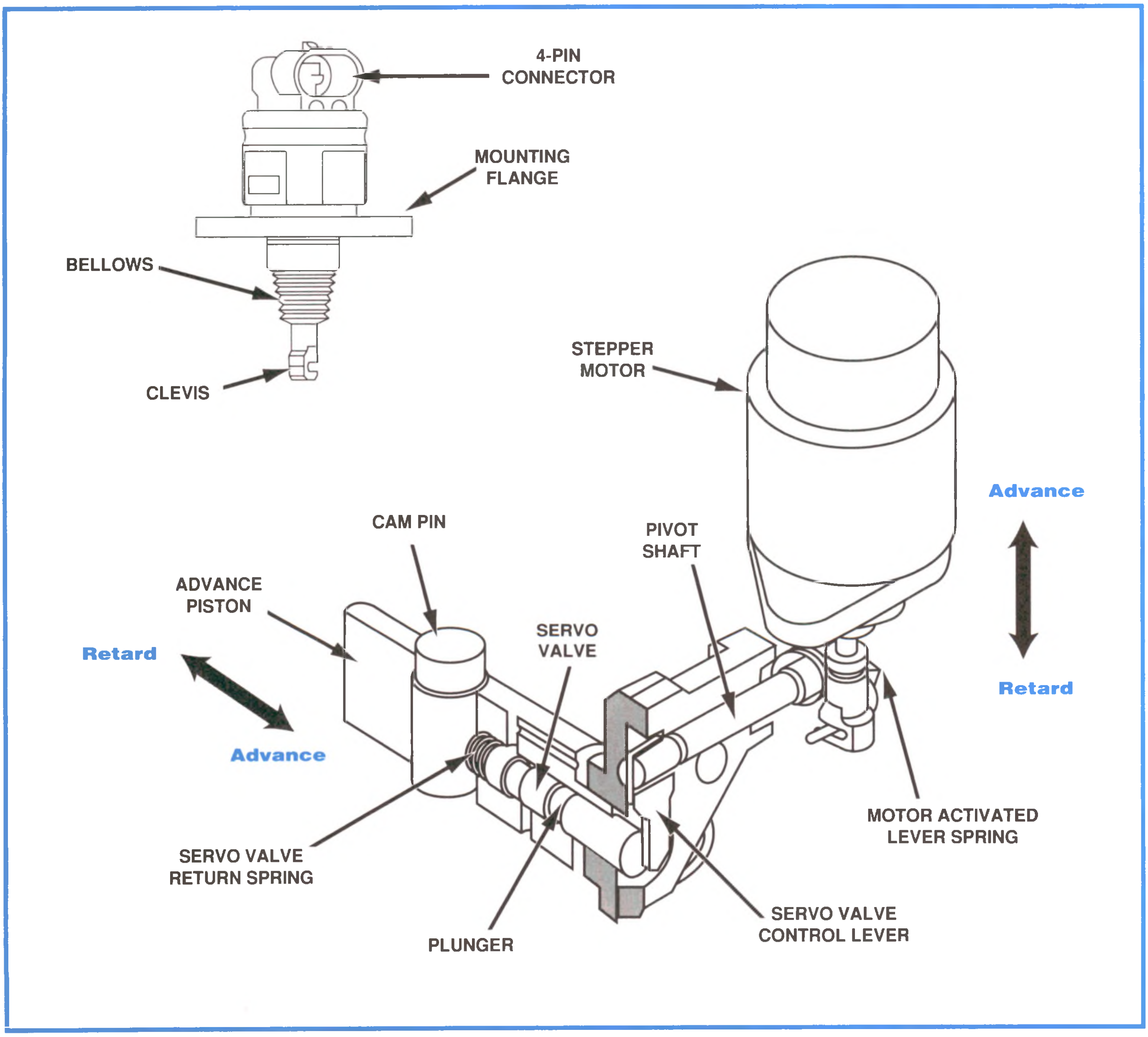


Figure 5-20, Injection Timing Stepper Motor/Advance Piston Components

Advance Piston Operation

Advance and retard are accomplished in the following ways (figure 5-21).

- In advance mode, the stepper motor arm retracts in steps. This causes the pivot shaft to rotate. As it does, it swings the paddle-like control lever away from the servo valve. Spring pressure pushes the valve off the advance passage. Pressurized fuel enters the advance passage and pushes the advance piston in the advance direction.
- In retard mode, the stepper motor arm extends downward. This rotates the pivot shaft in the other direction, causing the control lever to press on the servo valve to overcome spring pressure. The valve opens the drain passages, but blocks the advance passage. The lack of pressure at the piston causes it to move in the retard position direction.

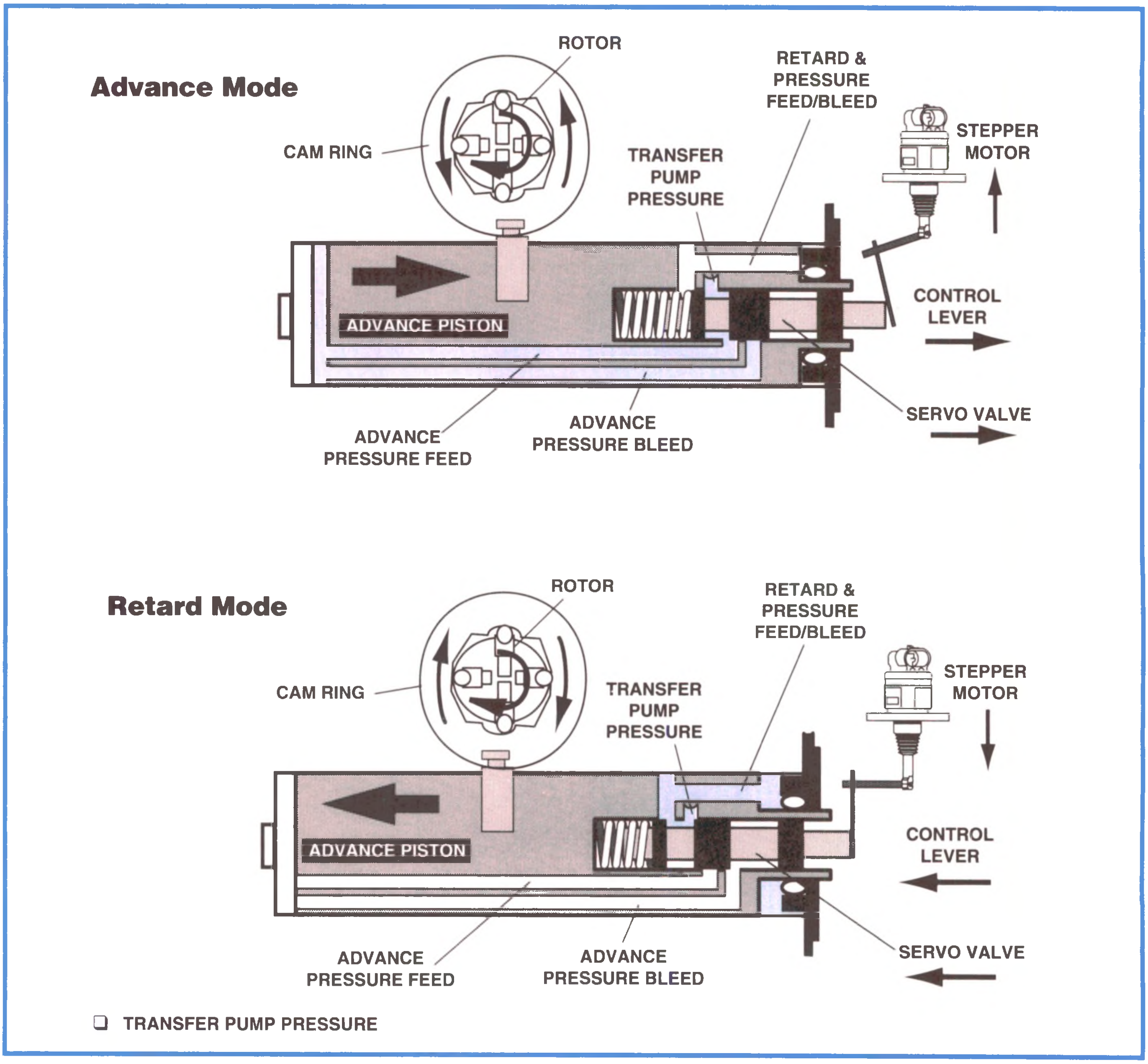


Figure 5-21, Advance Piston Operation (viewed from rear of engine)

LUBRICATION

The outlet of the transfer pump connects to a threaded restrictor known as the vent wire assembly (figure 5-22). The assembly includes a wire with hooked ends. The vent wire assembly causes fuel under transfer pump pressure to undergo a volume decrease. It also vents the pump of air.

Fuel passing through the vent wire assembly flows inside the pump housing to cool and lubricate most of the injection pump internal components, similar to non-EFI pumps.

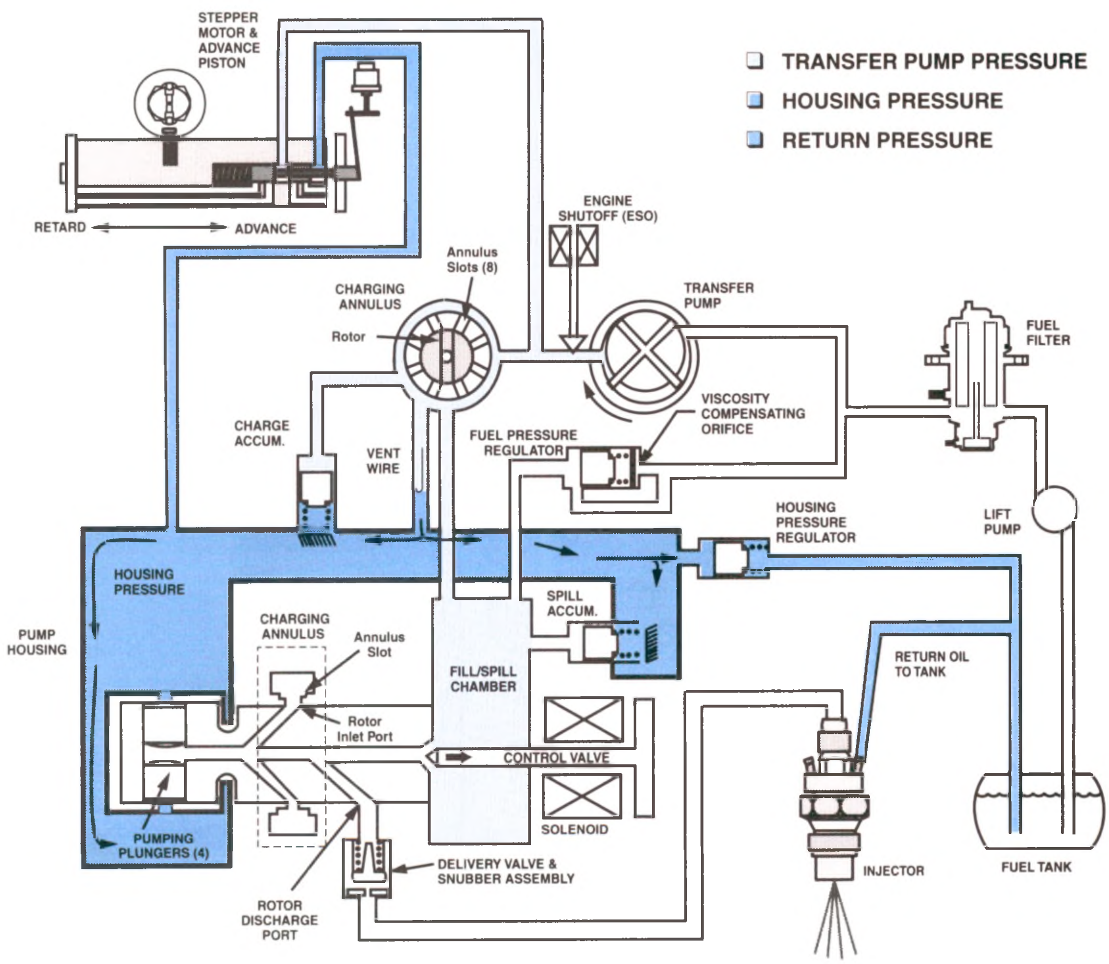


Figure 5-22, **Fuel System Diagram — *Lubrication***

Component Operation

ENGINE COOLANT TEMPERATURE (ECT) SENSOR

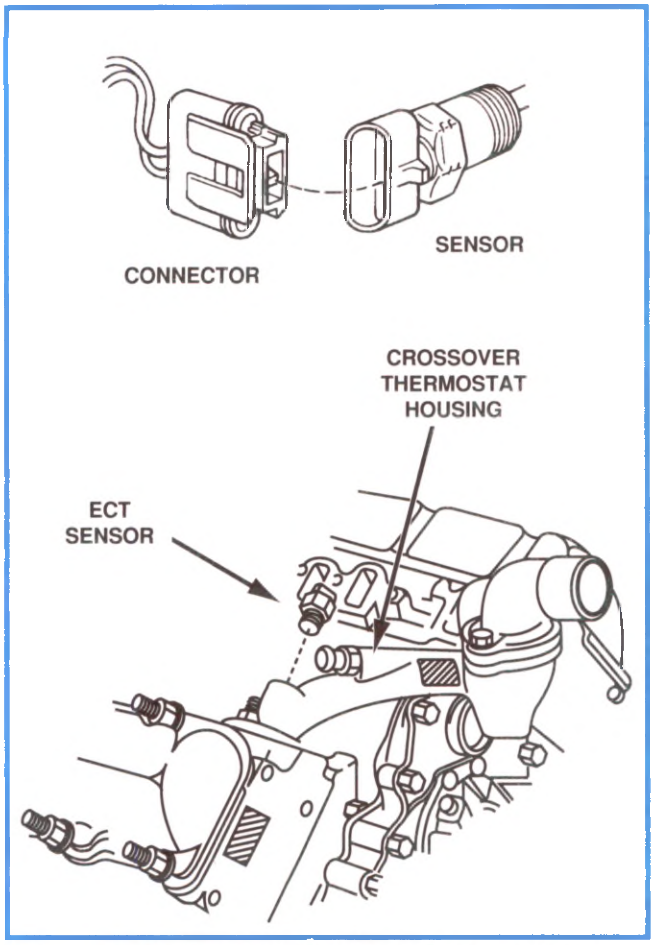


Figure 5-23, **Engine Coolant Temperature (ECT) Sensor**

Description

The Engine Coolant Temperature (ECT) sensor is mounted in the engine coolant stream (figure 5-23). The PCM uses coolant temperature as an indicator of engine operating temperature.

The sensor is a thermistor that changes value based on temperature. Low coolant temperature produces high resistance; high coolant temperature produces low resistance.

The chart below shows sensor resistance values, as well as sensor voltage signals as read by the PCM, at various temperatures.

Engine Coolant Temperature (ECT) Sensor Temp. vs. Resistance (Approximate)

°C	°F	Resis. (Ω)	Voltage
100	212	177	1.70
90	194	241	2.05
80	176	332	2.44
70	158	467	2.87
60	140	667	3.27
50	122	973	3.69
45	113	1,188	1.16
40	104	1,459	1.40
35	95	1,802	1.58
30	86	2,238	1.86
25	77	2,796	2.06
20	68	3,520	2.41
15	59	4,450	2.68
10	50	5,670	2.98
5	41	7,280	3.27
0	32	9,420	3.56
-5	23	12,300	3.80
-10	14	16,180	4.01
-15	5	21,450	4.24
-20	-4	28,680	4.41
-30	-22	52,700	4.67
-40	-40	100,700	5.00

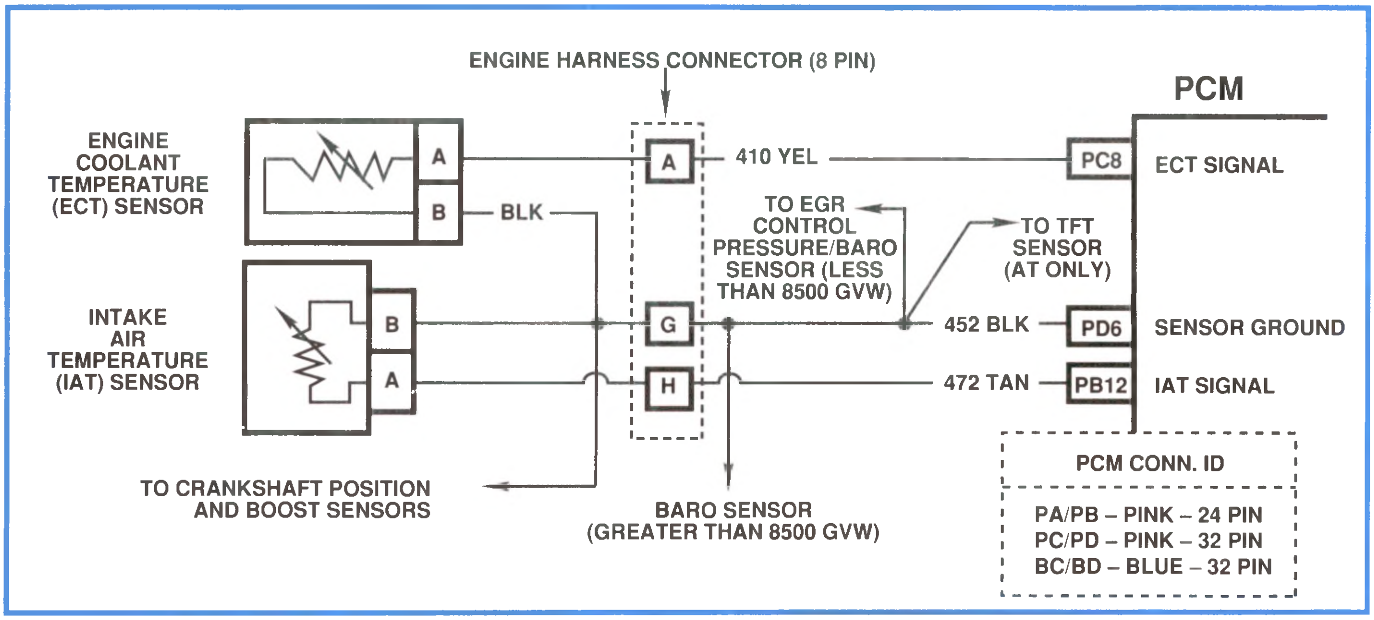


Figure 5-24, Engine Coolant Temperature (ECT) Sensor Circuit Operation

ECT Sensor Circuit Operation

The Engine Coolant Temperature (ECT) sensor receives a 5 volt signal on PCM CKT 410 (figure 5-24). As coolant temperature rises or falls, ECT sensor resistance changes inversely. When the engine is cold, sensor resistance is high. Conversely, when the engine is hot, sensor resistance is low.

As ECT sensor resistance changes, it affects the strength of the voltage signal on CKT 410. The PCM monitors this signal and uses it to determine coolant temperature. Voltage on the circuit will range from almost 5 volts at low temperatures to less than 1 volt at high temperatures.

The ECT sensor shares a common ground with the intake air temperature sensor, crankshaft position sensor, and boost sensor on CKT 452.

Engine coolant temperature affects most systems controlled by the PCM.

DTC 14 — "Engine Coolant Temperature (ECT) Sensor Circuit Low (High Temperature Indicated)"

DTC 14 sets when coolant temperature is greater than 151°C (304°F) for longer than 2 seconds. This high temperature would cause low voltage on the circuit as read by the PCM. If a DTC 14 condition is detected, the PCM substitutes an ECT default value of 77°C (171°F) and fast idle.

DTC 14 could also be caused by a short in CKT 410 to ground.

DTC 15 — "Engine Coolant Temperature (ECT) Sensor Circuit High (Low Temperature Indicated)"

DTC 15 sets when coolant temperature is less than -36°C (-33°F) and the engine has been running for at least 8 minutes. This condition would cause excessive high voltage on the circuit as read by the PCM. The PCM default value for this code is 18°C (64°F).

INTAKE AIR TEMPERATURE (IAT) SENSOR

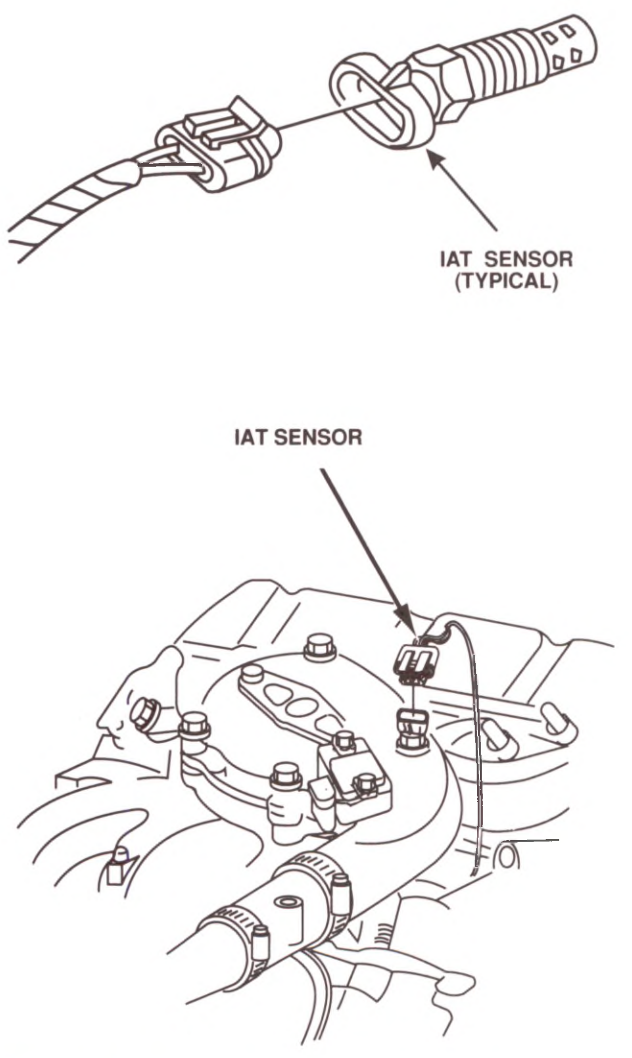


Figure 5-25, Intake Air Temperature (IAT) Sensor

Description

The Intake Air Temperature (IAT) sensor is mounted in the intake manifold (figure 5-25). Like the ECT sensor, the IAT is a thermistor that changes value based on temperature. IAT resistance values are approximately the same as for the ECT sensor and are given below.

Intake Air Temperature (IAT) Sensor Temp. vs. Resistance (Approximate)

°C	°F	Resis. (Ω)
100	212	177
90	194	241
80	176	332
70	158	467
60	140	667
50	122	973
45	113	1,188
40	104	1,459
35	95	1,802
30	86	2,238
25	77	2,796
20	68	3,520
15	59	4,450
10	50	5,670
5	41	7,280
0	32	9,420
-5	23	12,300
-10	14	16,180
-15	5	21,450
-20	-4	28,680
-30	-22	52,700
-40	-40	100,700

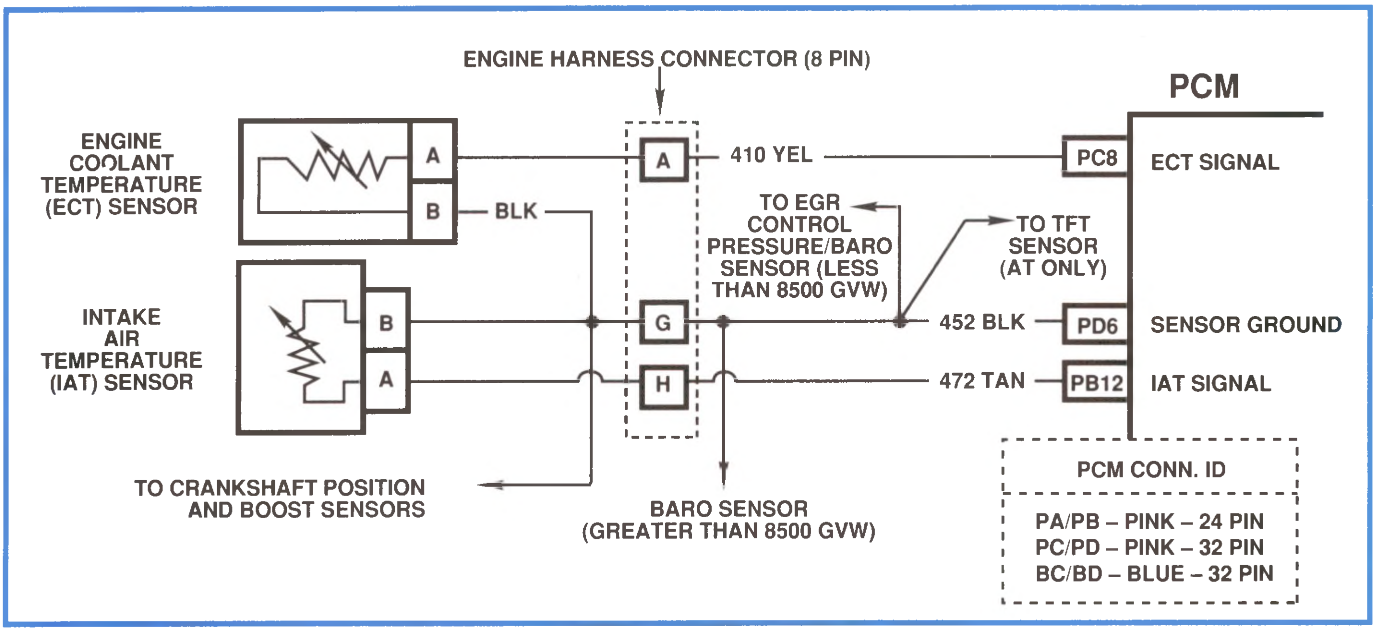


Figure 5-26, Intake Air Temperature (IAT) Sensor Circuit Operation

IAT Sensor Circuit Operation

The Intake Air Temperature (IAT) sensor receives a 5 volt signal from the PCM on CKT 472 (figure 5-26). IAT sensor resistance changes inversely according to temperature. Low intake air temperatures cause high sensor resistance, which results in higher voltage as seen by the PCM. High intake air temperatures cause low resistance and low voltage. Circuit voltage ranges from almost 5 volts at low temperatures to less than 1 volt at high temperatures.

The PCM uses the IAT sensor signal to adjust fuel delivery according to incoming air temperature.

The IAT sensor shares a common ground with the ECT sensor, crankshaft position sensor, and boost sensor on CKT 452.

DTC 47 — "Intake Air Temperature (IAT) Circuit Low (High Temperature Indicated)"

DTC 47 sets when engine coolant temperature is below 38°C (100°F) and intake air temperature is above 96°C (205°F) for 2 seconds of more. This would cause voltage on the circuit to be lower than normal.

DTC 48 — "Intake Air Temperature (IAT) Circuit High (Low Temperature Indicated)"

DTC 48 sets when intake air temperature falls below -38°C (-39°F) for 2 minutes. This causes a higher-than-normal voltage signal on the circuit back to the PCM.

ACCELERATOR PEDAL POSITION (APP) MODULE

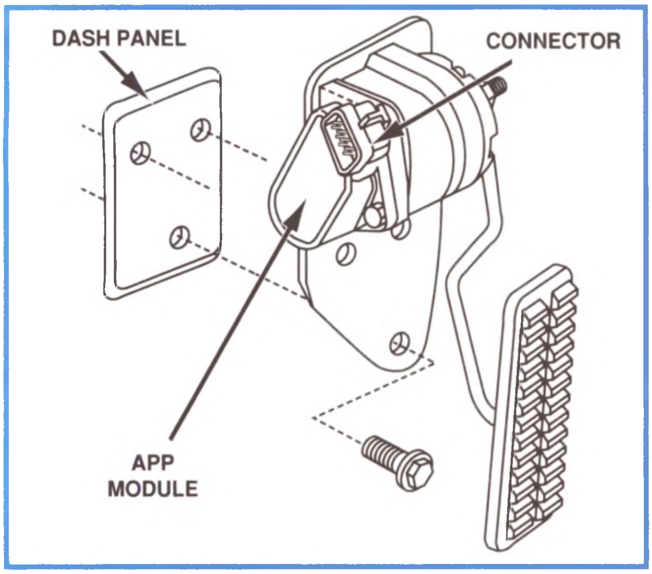


Figure 5-27, APP Module

Description

The 6.5L EFI PCM uses Accelerator Pedal Position (APP) sensors to control fuel delivery as requested by driver demands at the accelerator pedal. Three APP sensors are located in a module at the base of the accelerator pedal (figure 5-27).

The APP module replaces the throttle linkage found on non-EFI 6.5L diesel engines. While it is new to GM diesel engines, similar "drive by wire" technology has been in use for several years on diesel engines from other manufacturers.

APP Module Circuit Operation

The APP sensors are each variable-resistor type. Each sensor receives its own 5 volt reference signal from the PCM. The PCM provides a ground for each sensor to complete the circuit.

As the accelerator pedal is depressed, resistance in each sensor changes. By monitoring the output voltage from the module, the PCM can calculate proper fuel delivery as required by acceleration needs.

The PCM provides each of the three Accelerator Pedal Position (APP) sensors with independent 5 volt reference signals on the following circuits: CKT 997 to APP 1 sensor; CKT 996 to APP 2 sensor; CKT 995 to APP 3 sensor (figure 5-28).The sensors provide voltage signals back to the PCM on the following circuits: CKT 992 from APP 1 sensor; CKT 993 from APP 2 sensor; CKT 994 from APP 3 sensor.

Three sensors are used to ensure reliability in the system. Each is scaled differently. The PCM compares signal voltage of the three to determine proper operation. The PCM only requires information from one sensor; the other two serve as fail safes. Failure modes for the APP system are as follows:

- If only one sensor fails, the vehicle will operate normally. The PCM will store a DTC, but will not illuminate the "Service Throttle Soon" lamp in the instrument cluster.
- If two sensors fail, the engine will operate at reduced power. The PCM will store a DTC and will illuminate the "Service Throttle Soon" lamp.
- If all three sensors fail, the PCM will store a DTC and illuminate the "Service Throttle Soon" lamp. The PCM will also reduce engine power to idle.

APP DTCs

The following Diagnostic Trouble Codes relate to Accelerator Pedal Position (APP) sensor circuit operation.

APP 1 Sensor

- DTC 21 "Accelerator Pedal Position (APP) 1 Circuit High" sets when the voltage signal from APP 1 sensor reads greater than 4.75 volts for 2 seconds.
- DTC 22 "Accelerator Pedal Position (APP) 1 Circuit Low" sets when the voltage signal from APP 1 sensor reads less than .25 volts for 2 seconds.
- DTC 23 "Accelerator Pedal Position (APP) 1 Circuit Range Fault" sets when the PCM recognizes a skewed or misscaled sensor. The PCM compares all three sensors to each other. DTC 23 sets when APP 1 sensor voltage differs from APP 2 voltage by 6 percent or more ***and*** APP 1 voltage differs from APP 3 voltage by 10 percent or more. Both of these differences must be present for DTC 23 to set.

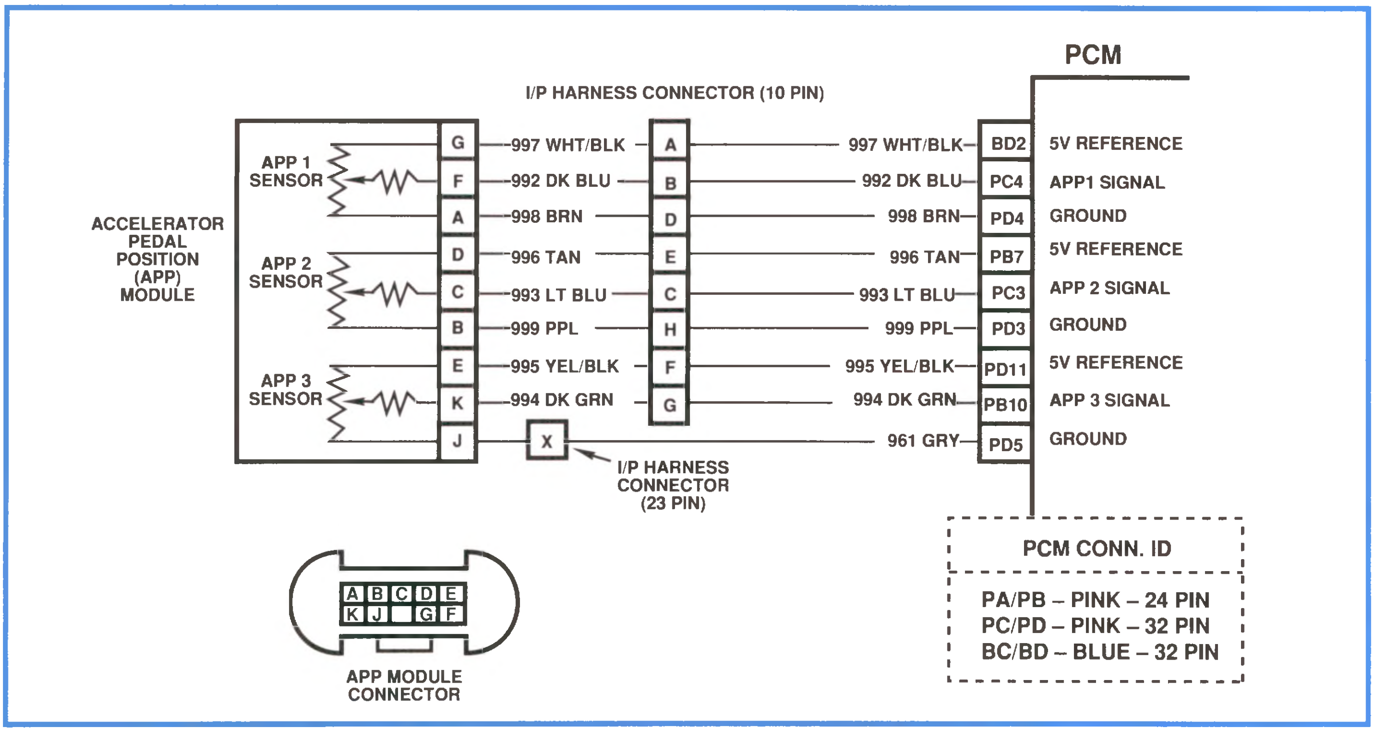


Figure 5-28, Accelerator Pedal Position (APP) Module Circuit Operation

APP 2 Sensor

- DTC 25 "Accelerator Pedal Position (APP) 2 Circuit High" sets when the voltage signal from APP 2 sensor reads greater than 4.75 volts for 2 seconds.
- DTC 26 "Accelerator Pedal Position (APP) 2 Circuit Low" sets when the voltage signal from APP 2 sensor reads less than .25 volts for 2 seconds.
- DTC 27 "Accelerator Pedal Position (APP) 2 Circuit Range Fault" sets when the PCM recognizes a skewed or misscaled sensor. The PCM compares all three sensors to each other. DTC 27 sets when APP 2 sensor voltage differs from APP 1 voltage by 6 percent or more ***and*** APP 2 voltage differs from APP 3 voltage by 10 percent or more. Both of these differences must be present for DTC 27 to set.

APP 3 Sensor

- DTC 63 "Accelerator Pedal Position (APP) 3 Circuit High" sets when the voltage signal from APP 3 sensor reads greater than 4.75 volts for 2 seconds.
- DTC 64 "Accelerator Pedal Position (APP) 3 Circuit Low" sets when the voltage signal from APP 3 sensor reads less than .25 volts for 2 seconds.
- DTC 65 "Accelerator Pedal Position (APP) 3 Circuit Range Fault" sets when the PCM recognizes a skewed or misscaled sensor. The PCM compares all three sensors to each other. DTC 65 sets when APP 3 sensor voltage differs from APP 1 voltage and APP 2 voltage each by more than 10 percent.

Other App DTCs

- DTC 84 "Accelerator Pedal Position (APP) Circuit Fault" identifies an intermittent APP fault. It sets if there are no other current APP codes stored. DTC 84 will store as a current and history code, but will not illuminate the "Service Throttle Soon" lamp. The vehicle will have limited power.
- DTC 99 "Accelerator Pedal Position (APP) 2 5-Volt Reference Fault" identifies reference voltage on APP sensor 2 below 4.8 volts for 2 seconds. DTC 99 will illuminate the STS lamp. The vehicle will have limited power.

FUEL SOLENOID DRIVER

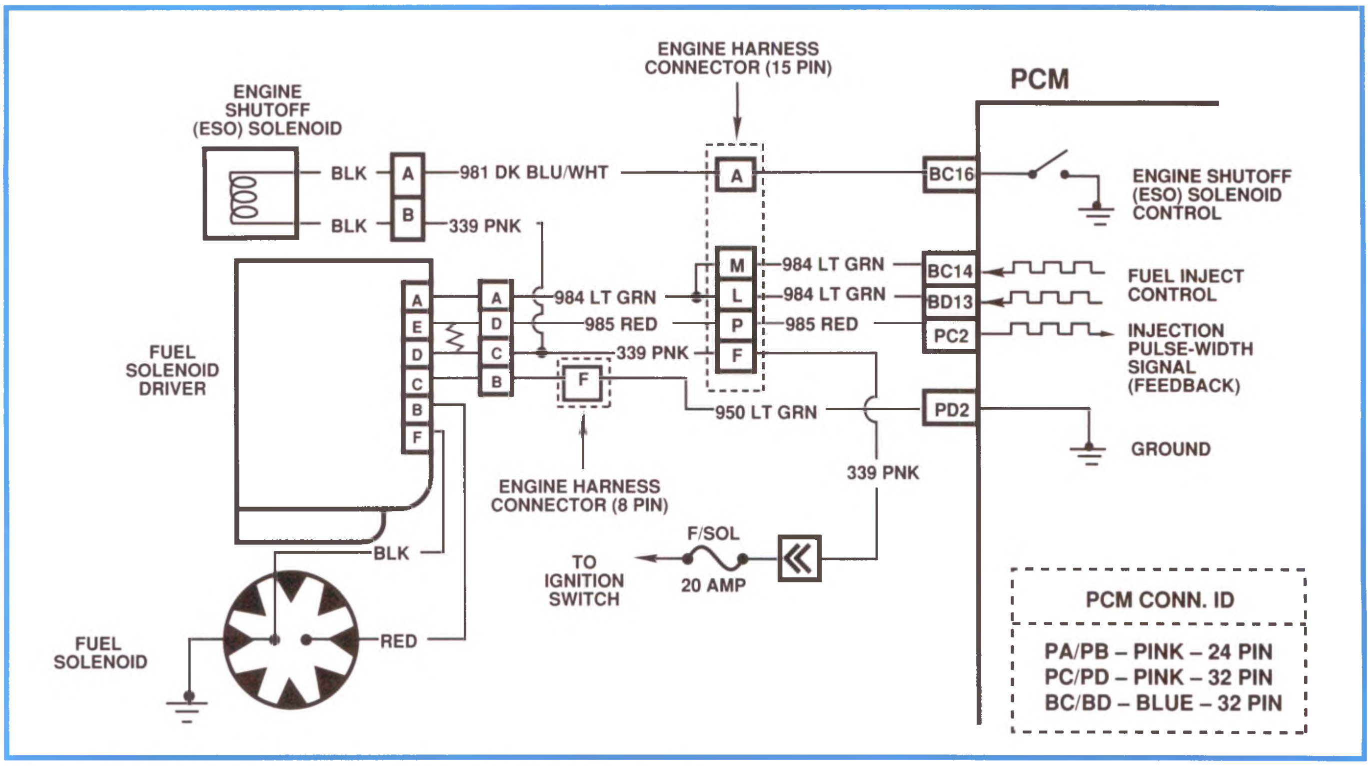


Figure 5-29, **Fuel Solenoid Driver Circuit Operation**

Fuel Solenoid Driver Circuit Operation

The fuel solenoid driver receives an inject-command signal from the PCM on CKT 984 (figure 5-29). The driver provides current-regulated output to the fuel solenoid that controls fuel pump metering injection. The driver also returns an injection pulse-width modulated (PWM) signal back to the PCM on CKT 985. This signal tells the PCM when the fuel solenoid plunger seats. The PCM uses a calibrated injection pump-mounted resistor to determine fuel rates. The resistor value of the pump is stored in PCM memory. If PCM memory has been disturbed or the PCM has been replaced, the PCM will relearn the resistor value on the next ignition cycle and store this value.

DTC 35 — "Injection Pulse Width Error (Response Time Short)"

DTC 35 sets when battery voltage is greater than 10 volts, coolant temperature is at or above 20°C (68°F), and response time of the fuel injection solenoid is less than 1.2 milliseconds as indicated by the voltage signal on CKT 985.

DTC 36 — "Injection Pulse Width Error (Response Time Long)"

DTC 36 sets when battery voltage is greater than 10 volts, coolant temperature is at or above 20°C (68°F), and response time of the fuel injection solenoid is greater than 2.5 milliseconds as indicated by the voltage signal on CKT 985.

DTC 56 — "Injection Pump Calibration Resistor Error"

DTC 56 sets when the injection pump resistor value is not present. This could be caused by the PCM having lost its memory or the PCM being unable to read a resistor value on CKT 985 on the next ignition cycle. When DTC 56 is set, a current and history DTC will store and the "Service Engine Soon" malfunction indicator lamp will illuminate. The PCM will default to the lowest fuel table, and possible poor engine performance will be noticed.The current DTC 56 will clear on the next ignition cycle. However, the history DTC 56 will remain in the PCM.

ADAPTIVE CYLINDER BALANCE

The PCM has the ability to increase and decrease the amount of fuel to each cylinder to provide smooth idle operation. If the fuel correction amount exceeds defined limits, a code is set. The following codes identify cylinder balance faults:

- DTC 91 — "Cylinder Balance Fault—#7 Cylinder"
- DTC 92 — "Cylinder Balance Fault—#2 Cylinder"
- DTC 93 — "Cylinder Balance Fault—#6 Cylinder"
- DTC 94 — "Cylinder Balance Fault—#5 Cylinder"
- DTC 95 — "Cylinder Balance Fault—#4 Cylinder"
- DTC 96 — "Cylinder Balance Fault—#3 Cylinder"
- DTC 97 — "Cylinder Balance Fault—#1 Cylinder"
- DTC 98 — "Cylinder Balance Fault—#8 Cylinder"

In order for one or more of these codes to set, the following conditions must be met:

- Engine at idle
- Coolant at normal temperature
- Cylinder fault must be continuous (i.e. constant)
- Fault must be out of limit for more than 2 seconds

— IMPORTANT —
If more than one cylinder is out of limit, as may be the case with a head gasket failure, multiple cylinder balance fault codes can set.

— IMPORTANT —
The calibration resistor in the fuel driver module is matched to the injection pump. Because of this, you should not switch modules on a pump.

ENGINE SHUTOFF (ESO) SOLENOID

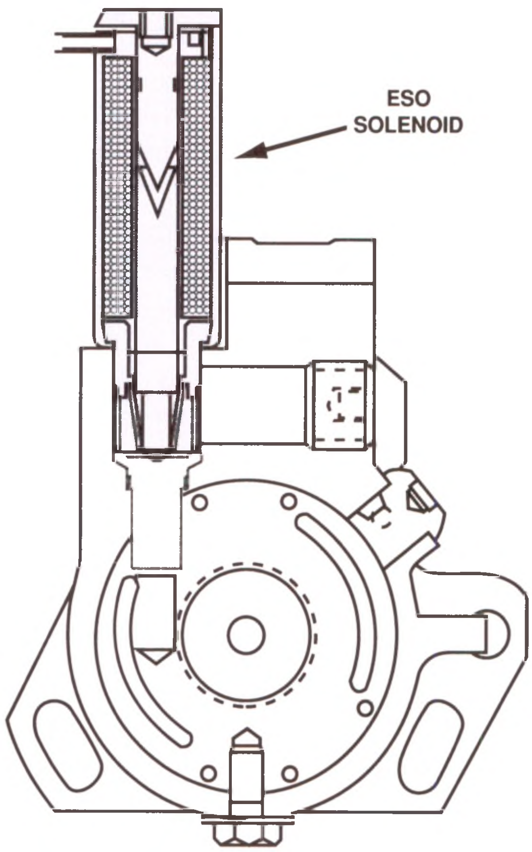


Figure 5-30, **Engine Shutoff (ESO) Solenoid**

Description

The Engine Shutoff (ESO) solenoid is located on the injection pump (figure 5-30). When the ignition switch is "OFF," the ESO solenoid is in the "No Fuel" position. It prevents fuel from entering the injection pump.

At ignition startup, the PCM provides a ground for the solenoid. This pulls the ESO pintle upward, allowing fuel into the pump.

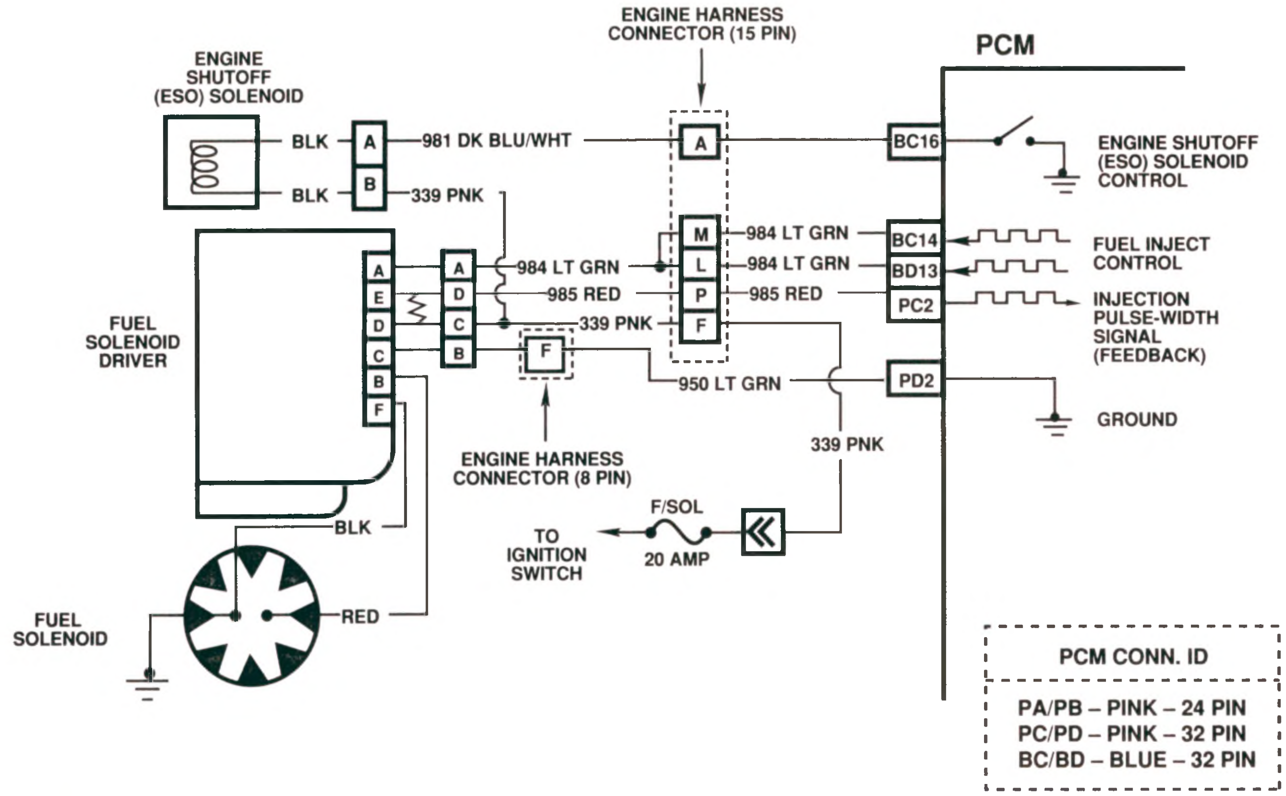


Figure 5-31, **Engine Shutoff (ESO) Solenoid Circuit Operation**

ESO Solenoid Circuit Operation

The Engine Shutoff (ESO) solenoid receives power from the ignition switch on CKT 339 (figure 5-31). By providing a ground path on CKT 981, the PCM energizes the solenoid, which then allows fuel to pass into the injection pump.

DTC 13 — "Engine Shutoff (ESO) Solenoid Circuit Fault"

DTC 13 sets when the PCM commands the engine shutoff solenoid "ON" (i.e. fuel flow to the pump), but doesn't see ignition voltage on terminal E16. DTC 13 will result in a no start condition as a result of the deenergized ESO solenoid preventing fuel from entering the injection pump.

DTC 13 could also identify a possible open in CKT 981 from the ESO to the PCM or an open in CKT 339 from the ignition switch to the solenoid.

FUEL TEMPERATURE SENSOR

Description

The fuel temperature sensor is part of the optical sensor (see figure 5-36). It is a thermistor that controls signal voltage to the PCM. Voltage from the sensor will vary inversely to fuel temperature (i.e. high temperature equals low voltage; low temperature equals high voltage). Resistance values for the sensor at various temperatures are the same as those for other temperature sensors given earlier in this book (see ECT and IAT sensor discussions).

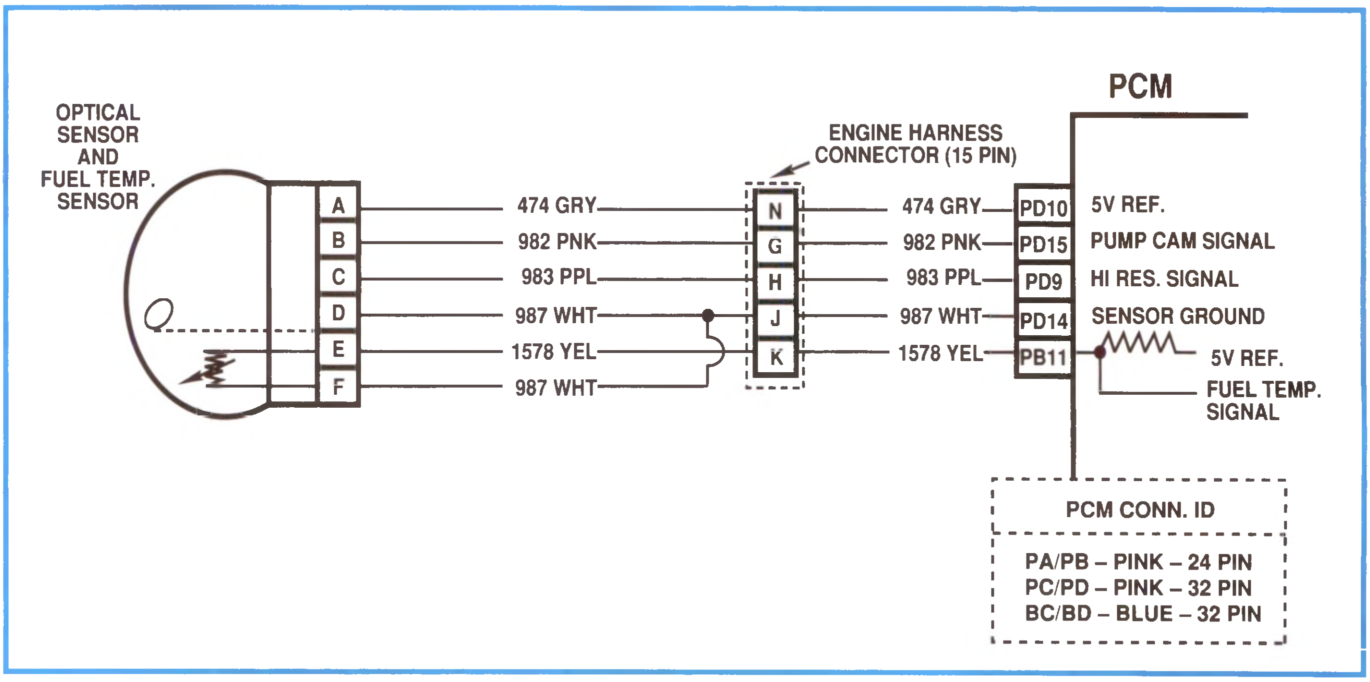


Figure 5-32, **Fuel Temperature Sensor Circuit Operation**

Fuel Temperature Sensor Circuit Operation

The PCM provides a reference signal to the fuel temperature sensor on CKT 1578 (figure 5-32). As fuel temperature changes, the sensor will alter the strength of the voltage. By monitoring CKT 1578, the PCM knows fuel temperature and can take this into consideration when determining fuel delivery rates.

Ground for the sensor is provided on CKT 987, which is shared with the optical sensor.

DTC 42 — "Fuel Temperature Circuit Low (High Temperature Indicated)"

DTC 42 sets when the PCM detects lower-than-normal voltage on CKT 1578. The code will set when fuel temperature is greater than 102°C (215°F) for more than 2 seconds.

In addition to being caused by high fuel temperatures, DTC 42 could be caused by a short to ground in CKT 1578.

DTC 43 — "Fuel Temperature Circuit High (Low Temperature Indicated)"

DTC 43 sets when CKT 1578 voltage is higher than normal. The condition for this code to set is fuel temperature less than -14°C (6°F) when the engine has been running for longer than 2 minutes. DTC 43 could also be caused by opens in CKTs 1578 or 987, or a faulty connection at the sensor or PCM.

A/C SIGNAL

Description

The A/C signal comes from the A/C-heater control head in the vehicle and informs the PCM that the driver has turned the air conditioner "ON." The PCM uses this information to adjust idle speed to compensate for A/C compressor load.

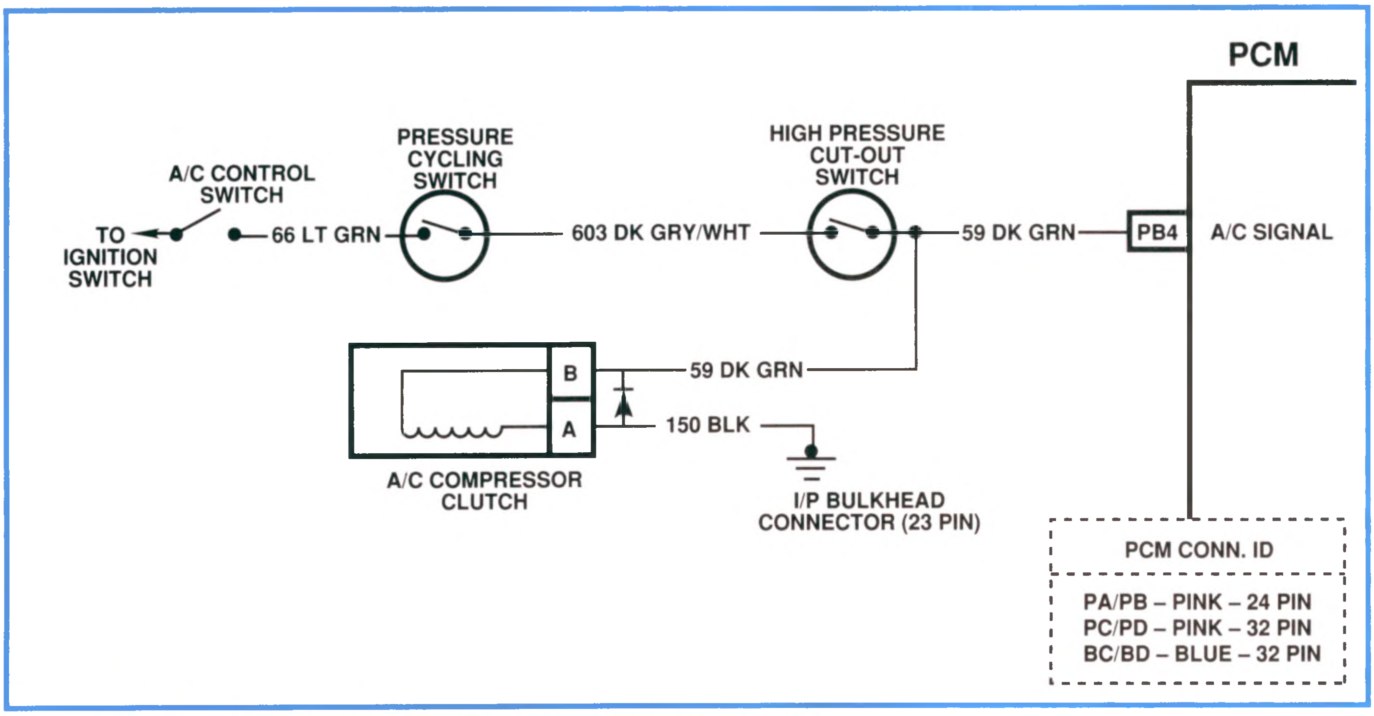


Figure 5-33, **A/C Signal Circuit Operation (general circuit)**

A/C Signal Circuit Operation

The A/C request signal is sent to the PCM on CKT 59 (figure 5-33). This circuit is spliced to the A/C compressor clutch and the A/C control switch, which receives power from the ignition switch. The high-pressure cut-out switch and the pressure cycling switch are also part of the circuit.

If A/C is operating properly and engine idle speed dips too low when the A/C compressor turns "ON" or flares too high when the compressor turns "OFF," the cause could be an open in CKT 59 to the PCM. This, along with connector terminal B4 at the PCM, should be checked under these conditions.

"SERVICE THROTTLE SOON" (STS) LAMP

Description

The "Service Throttle Soon" (STS) in the instrument panel alerts the driver to conditions in the accelerator pedal position (APP) circuit that require attention.

Under normal operation, the STS lamp illuminates when the ignition is "ON" and the engine is "OFF." The lamp comes "ON" for approximately 2 seconds at key "ON" and turns "OFF" when the engine is started. If the light remains illuminated after the engine has started, a problem may exist in the STS or APP circuits. The appropriate diagnostics should be followed as directed by the OBD System Check.

> **— IMPORTANT —**
> **The STS lamp will not display diagnostic trouble codes. DTCs are only displayed at the MIL malfunction indicator lamp.**

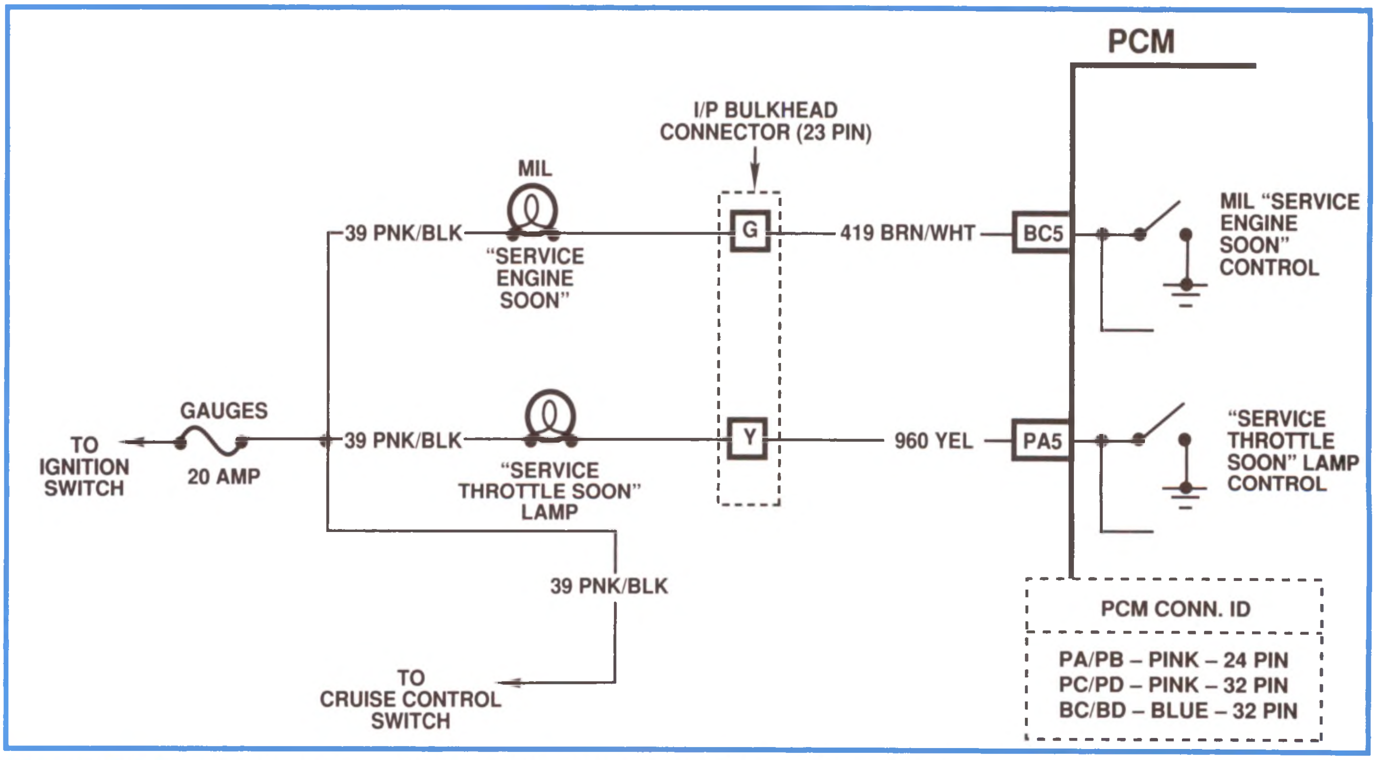


Figure 5-34, "Service Throttle Soon" (STS) Lamp Circuit Operation

STS Circuit Operation

The PCM illuminates the "Service Throttle Soon" lamp by providing a ground on CKT 960 at the module (figure 5-34). The "Service Throttle Soon" lamp receives battery power through the ignition switch on CKT 39.

DTC 49 — "'Service Throttle Soon' Lamp Circuit Fault"

DTC 49 sets when the PCM sees incorrect voltage at terminal A5. DTC 49 could also be caused by an open or short to ground in CKT 960 to the PCM or an open in CKT 39 from the ignition switch, or by a faulty bulb or fuse.

TIMING CONTROL

System Operation

PCM timing control uses input data from the Accelerator Pedal Position (APP) sensors, intake air temperature sensor, optical sensor, and crankshaft position sensor (engine speed) to energize the injection timing stepper motor (figure 5-35).

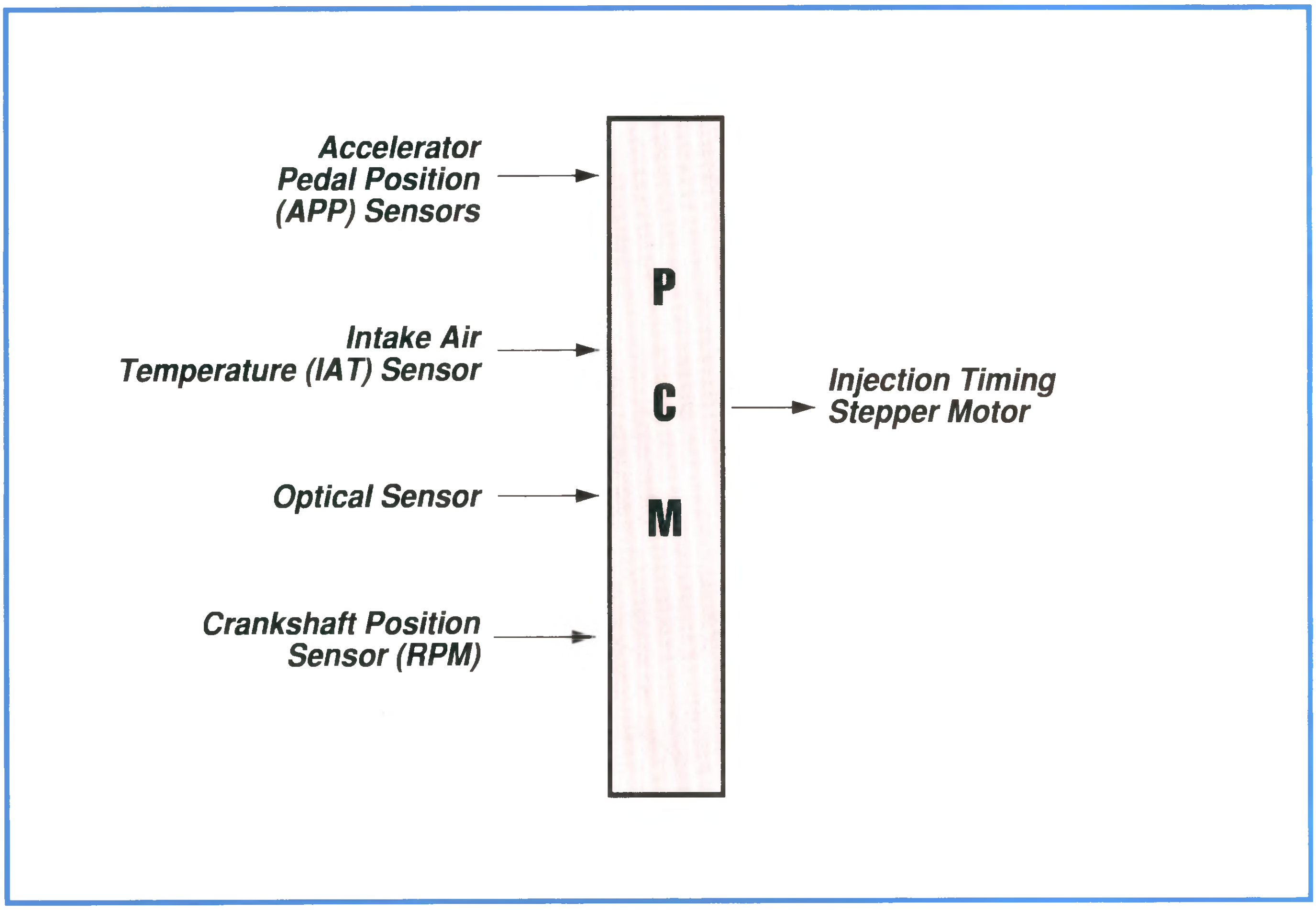


Figure 5-35, **PCM Timing Control Inputs and Outputs**

Component Operation

OPTICAL SENSOR

Description

The optical sensor is located in the fuel injection pump (figure 5-36) and includes the fuel temperature sensor. The optical sensor counts the pulses emitted by a disc in the injection pump. The disc is a silver-colored, film-like ring notched with two sets of notches.

- The outer diameters consists of 512 notches that provide the PCM with pump speed information.
- The inner diameter uses eight notches, one for each cylinder, to send pump cam reference information.

The optical sensor transmits pulses from these notches to the PCM as a voltage signal known as the high resolution signal (small notches) or pump cam signal (large notches). The PCM relies on the optical sensor to identify pump position. The high resolution signal is one of the most important PCM inputs for determining fuel control and timing.

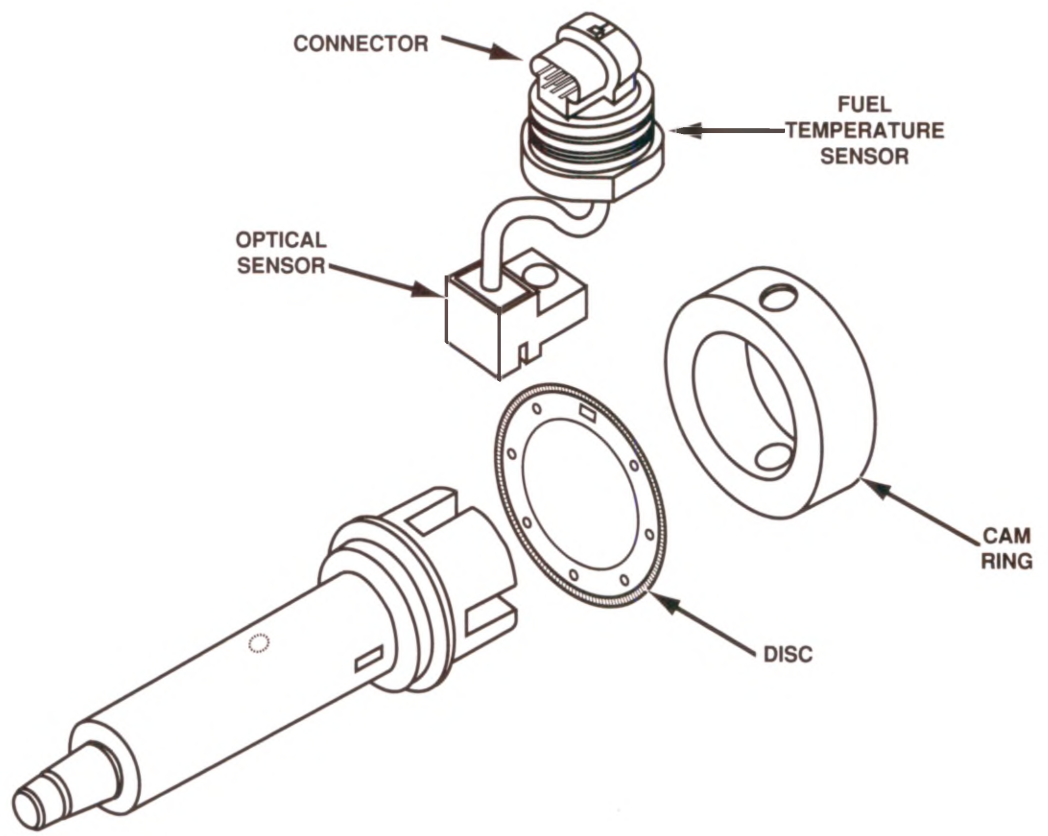


Figure 5-36, **Optical/Fuel Temperature Sensor and Disc**

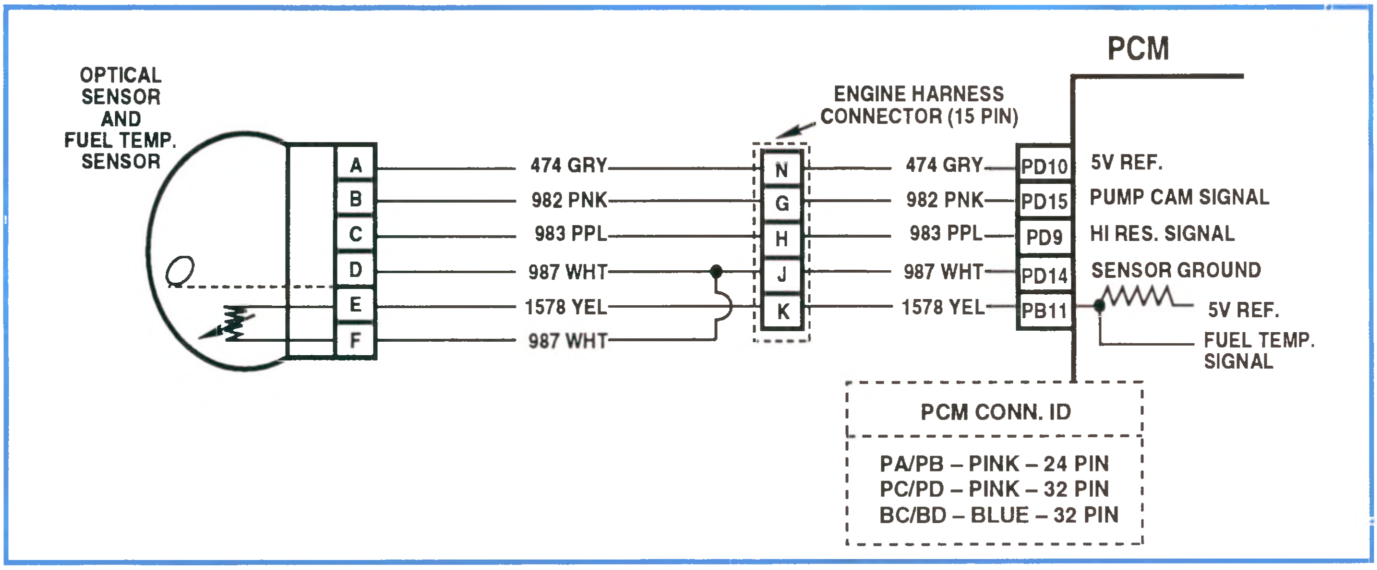


Figure 5-37, Optical Sensor Circuit Operation

Optical Sensor Circuit Operation

The PCM sends a 5 volt reference signal to the optical sensor on CKT 474 (figure 5-37). The sensor returns two signals to the PCM: a high resolution signal on CKT 983 and a cam signal on CKT 982. Both are regulated-current signals read by the PCM. The high resolution signal pulses 512 times per one revolution of the injection pump. The cam signal pulses 8 times per one revolution of the pump.

When the signal on either circuit to the PCM is out of calibration, the PCM sets a Diagnostic Trouble Code (DTC).

DTC 17 — "High Resolution Circuit Fault"

DTC 17 identifies a missing high resolution signal. It sets when the PCM receives 8 cam pulses on CKT 982 without receiving a corresponding high resolution signal on CKT 983.

DTC 18 — "Cam Reference Pulse Error"

DTC 18 identifies a missing cam pulse. It sets when the PCM detects 8 missing cam pulses on CKT 982 for every crankshaft position pulse received on CKT 643 (see crankshaft position sensor/DTC 19). If DTC 17 and 18 are both stored, it could indicate a problem with CKTs 474 or 987.

CRANKSHAFT POSITION SENSOR

Description

The crankshaft sensor is located in the front cover. The sensor is positioned over the crankshaft sprocket and consists of a Hall-effect device and a magnet (figure 5-38). The crankshaft sprocket has four teeth at 90° intervals. As the sprocket rotates, its teeth pass the sensor.

- When no teeth of the sprocket are in alignment with the sensor, the sensor's magnetic field passes through the Hall-effect device. This causes the device to turn "ON," which pulls the sensor signal line low (0 volts).
- As a tooth of the crankshaft sprocket comes into alignment with the sensor, the magnetic field passes through the lower reluctance of the tooth instead of the Hall-effect device. This causes the device to turn "OFF," allowing the sensor signal line to the PCM to go high (5 volts).

The sensor high/low digital signal is monitored by the PCM to determine crankshaft/engine speed and crankshaft position. If the crank signal is lost while the engine is running, the fuel injection system will shift to a calculated fuel injection mode based on the last fuel injection pulse, and the engine will continue to run.

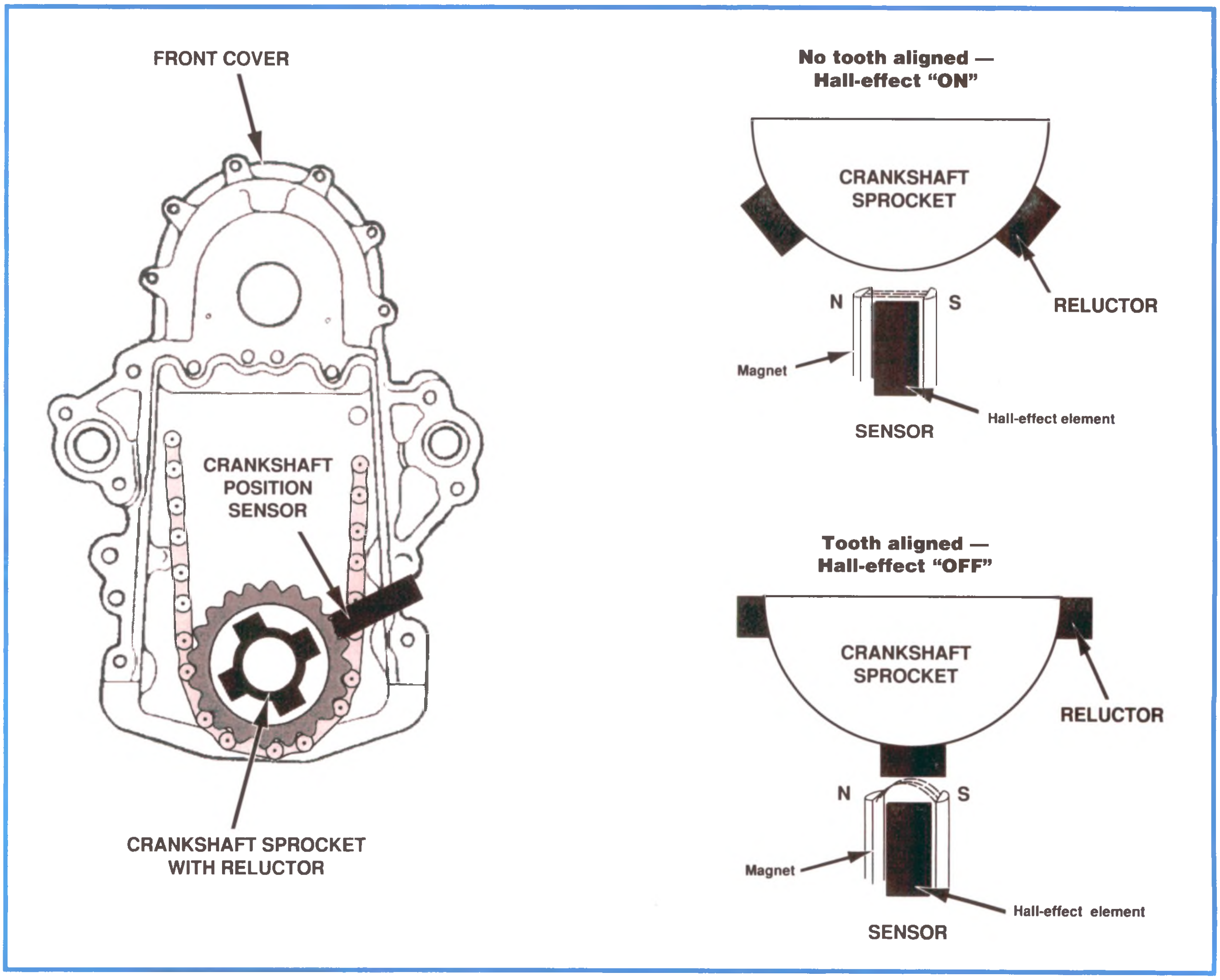


Figure 5-38, **Crankshaft Position Sensor and Hall-effect Operation**

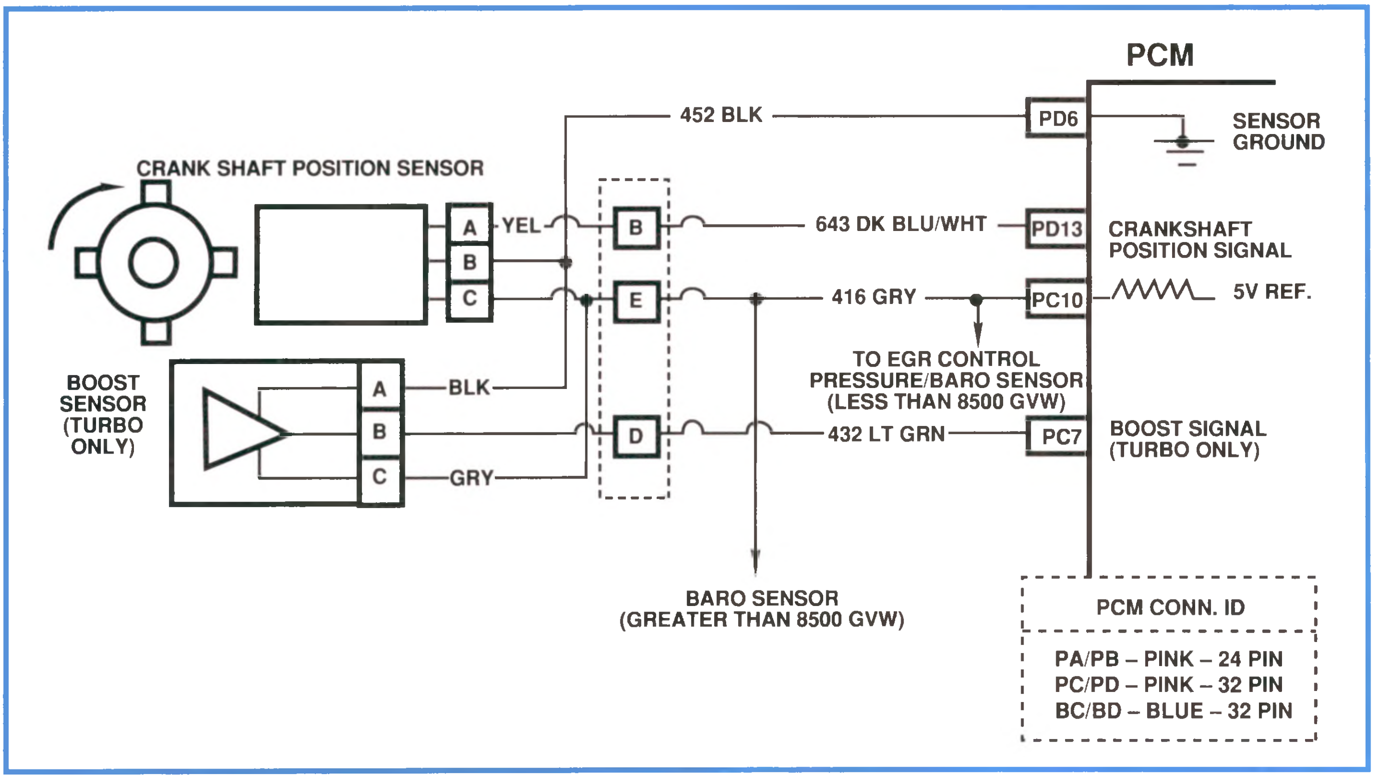


Figure 5-39, Crankshaft Position Sensor Circuit Operation

Crankshaft Position Sensor Circuit Operation

The crankshaft position sensor is a Hall-effect device that receives a 5 volt reference signal from the PCM on CKT 416, which it shares with the boost sensor on turbo models (figure 5-39). The sensor converts its changing magnetic field to digital electrical signal and sends it to the PCM on CKT 643.

The sensor shares a ground with the boost sensor, ECT sensor, and IAT sensor on CKT 452. It also shares a 5-volt reference signal with the EGR control pressure/baro sensor and boost sensor.

DTC 19 — "Crankshaft Position Reference Error"

DTC 19 identifies missing crank pulses. It sets when the PCM detects 8 missing crankshaft position pulses on CKT 643 for every cam pulse received.

DTC 57 — "PCM 5 Volt Shorted"

DTC 57 detects when the the 5 volt reference signal on CKT 416 is less than 1 volt. DTC 57 will result in no engine operation.

INJECTION TIMING STEPPER (ITS) MOTOR

Description

The injection timing stepper motor is located on the right side of the injection pump. The motor housing contains two coils that are controlled by voltage from the PCM. (See the "Fuel Control" section for a description of stepper motor mechanical and hydraulic operation.)

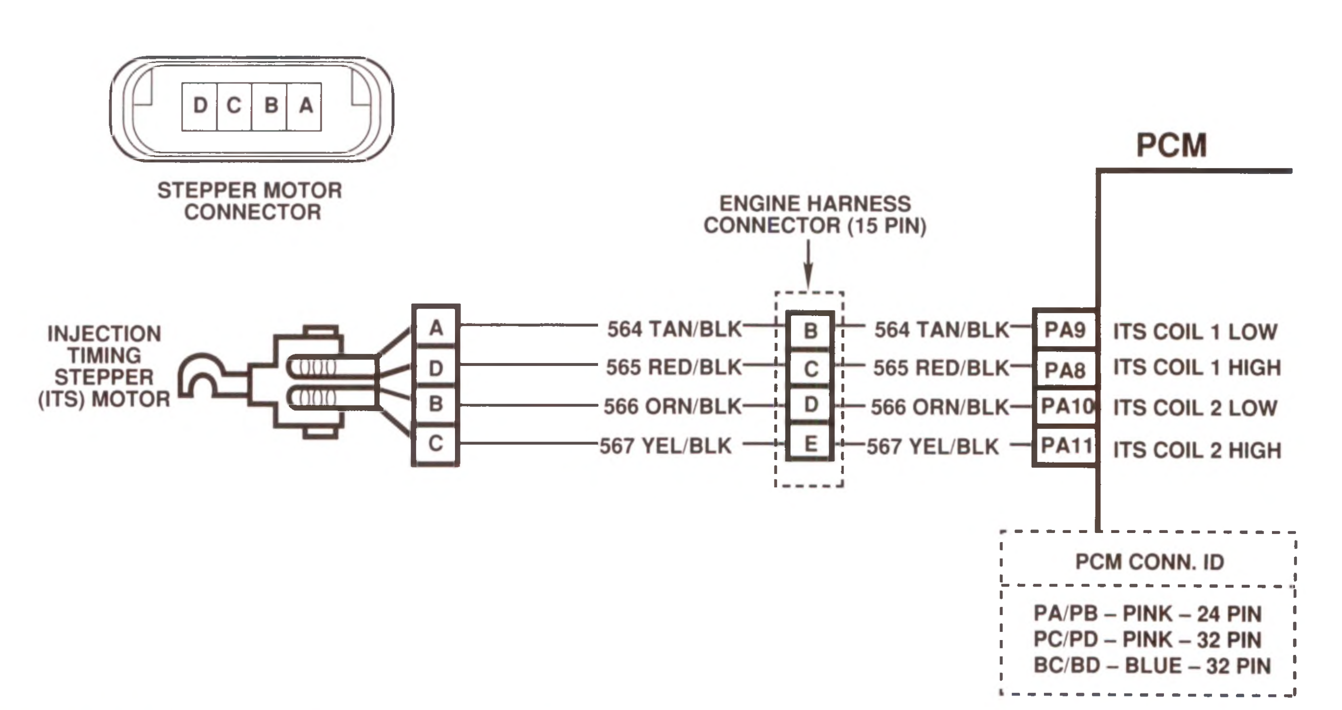


Figure 5-40, **Injection Timing Stepper Motor Circuit Operation**

ITS Circuit Operation

The injection timing stepper motor contains two coils that control injection pump timing. The PCM controls these coils through four circuits (figure 5-40):

- CKT 564 for coil 1 low position
- CKT 565 for coil 1 high position
- CKT 566 for coil 2 low position
- CKT 567 for coil 2 high position

DTC 34 — "Injection Timing Stepper (ITS) Motor Circuit Fault"

DTC 34 sets when engine RPM is steady and the PCM detects injection timing that is a 5-degree difference between "Desired Injection" and "Measured Injection" timing.

TIMING ADJUSTMENT PROCEDURES

Timing on the 6.5L EFI diesel is dependent on three variables:

1. Injection pump position, as indicated by the cam sensor and disc
2. TDC Offset (i.e. crankshaft position sensor)
3. The PCM's learned values for injection pump timing and TDC Offset

Adjusting Injection Timing

When a new injection pump is installed, pump timing must be set. Original factory timing is marked with a dynamic timing mark, which is a circle scribed across both the pump flange and front housing. For engine timing service procedures, a Tech 1 scan tool must be used — not the timing marks.

— CAUTION —
The engine must be "OFF" when the injection pump is loosened and being moved. Severe engine/pump and personal injury could result from adjusting the pump with the engine running.

To adjust injection pump timing:

1. Install the injection pump and tighten the 15mm pump retaining nuts.
2. Run the engine to operating temperature.
3. Connect the Tech 1 and perform "TDC Time Set":
   a. Enter vehicle information necessary to get to the MODE menu.
   b. Select F4: MISC TESTS from the MODE menu.
   c. Select F0: OUTPUT TESTS
   d. Select F0: INJ PUMP
   e. Select F1: TDC TIME SET. This option will drive the stepper motor to the maximum retard position. Use the Up Arrow key to initiate stepper motor action; use the Down Arrow key to stop action.
   f. Note the timing as indicated on the Tech 1 screen ("Measured Injection Timing"). It should be within Service Manual specifications (see section 4 of Driveability and Emissions manual). If timing is not within specfications:
      - turn the engine "OFF"
      - loosen the pump retaining nuts
      - adjust the pump position. Move the top of the pump, using tool J 29872, toward the driver's side to advance timing or toward the passenger's side to retard timing.
      - tighten the pump retaining nuts and restart the engine
      - perform the "TDC Time Set" procedure as described in step 3 above, as necessary, until timing is within specifications

Failure to properly set pump timing within specifications will result in DTC 88, "TDC Offset Error."

— IMPORTANT —
When installing a new injection pump, do not perform the "Offset Learn" procedure set timing only.

Programming TDC Offset

If the PCM is replaced, or if a new front cover, timing gears, timing chain, crankshaft position sensor, crankshaft or other component(s) affecting timing are removed or replaced, TDC Offset must be reprogrammed into the PCM.

To reprogram TDC Offset into the PCM:

1. Make sure the vehicle battery is fully charged.
2. The engine must be at idle.
3. The vehicle must be at operating temperature.
4. Connect the Tech 1 scan tool.
5. Select F0: OUTPUT TESTS from the Miscellaneous Tests menu.
6. Select F0: INJ PUMP.
7. Select TDC LEARN.
8. Start the engine and push the Up Arrow key. The PCM will learn the engine's top dead center offset value. This takes about 20 seconds.

Failure to correctly program TDC Offset will result in DTC 88.

DTC 88 — "TDC Offset Error"

DTC 88 sets when TDC Offset is greater than ±2.0°. This code also sets when a new PCM is installed.

GLOW PLUG CONTROL

System Operation

The glow plug system assists in providing the heat required to begin combustion during engine starting at cold ambient temperatures. The glow plugs are heated before and during cranking, as well as during initial engine operation.

There are three components of the glow plug system: a relay, an instrument panel-mounted lamp, and the glow plugs.

The PCM uses input information about engine coolant temperature and engine speed, as well as feedback information from the glow plug circuit, to control glow plug relay and lamp operation (figure 5-41).

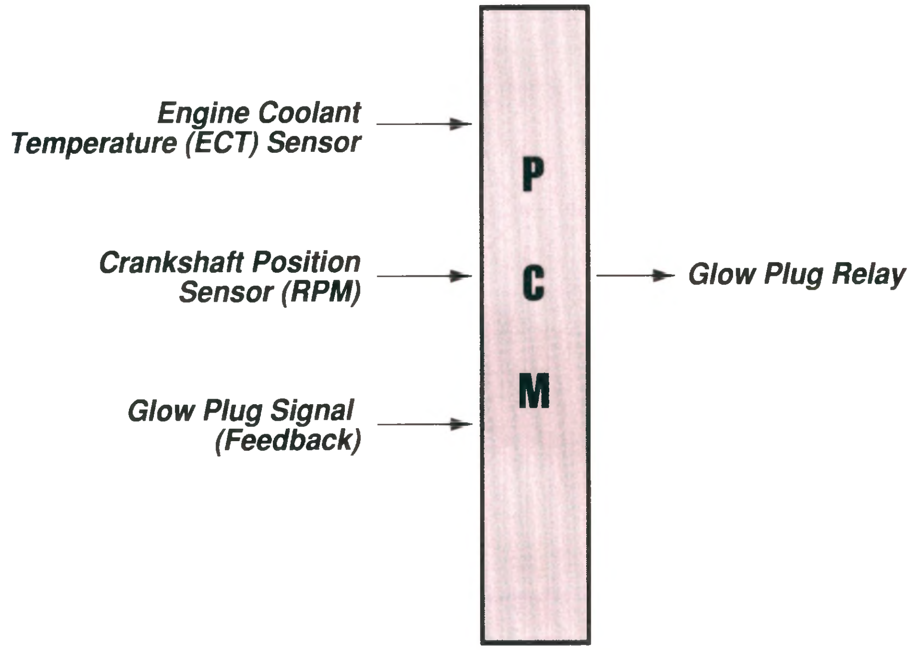


Figure 5-41, Glow Plug Control Inputs and Outputs

— IMPORTANT —
System glow plug operation is different than on L57. There is no cycling on the 6.5L EFI.
The 6.5L EFI must start immediately after glow plug light goes out.

Component Operation

GLOW PLUG RELAY AND LAMP

The glow plug relay is located at the rear of the left cylinder head. When commanded by the PCM, the relay contacts close, *allowing* ignition voltage to reach the two sets of glow plugs. The PCM uses a B+ signal to control the solid state circuitry of the glow plug relay. The glow plug lamp in the instrument cluster alerts the driver to faults in the glow plug system.

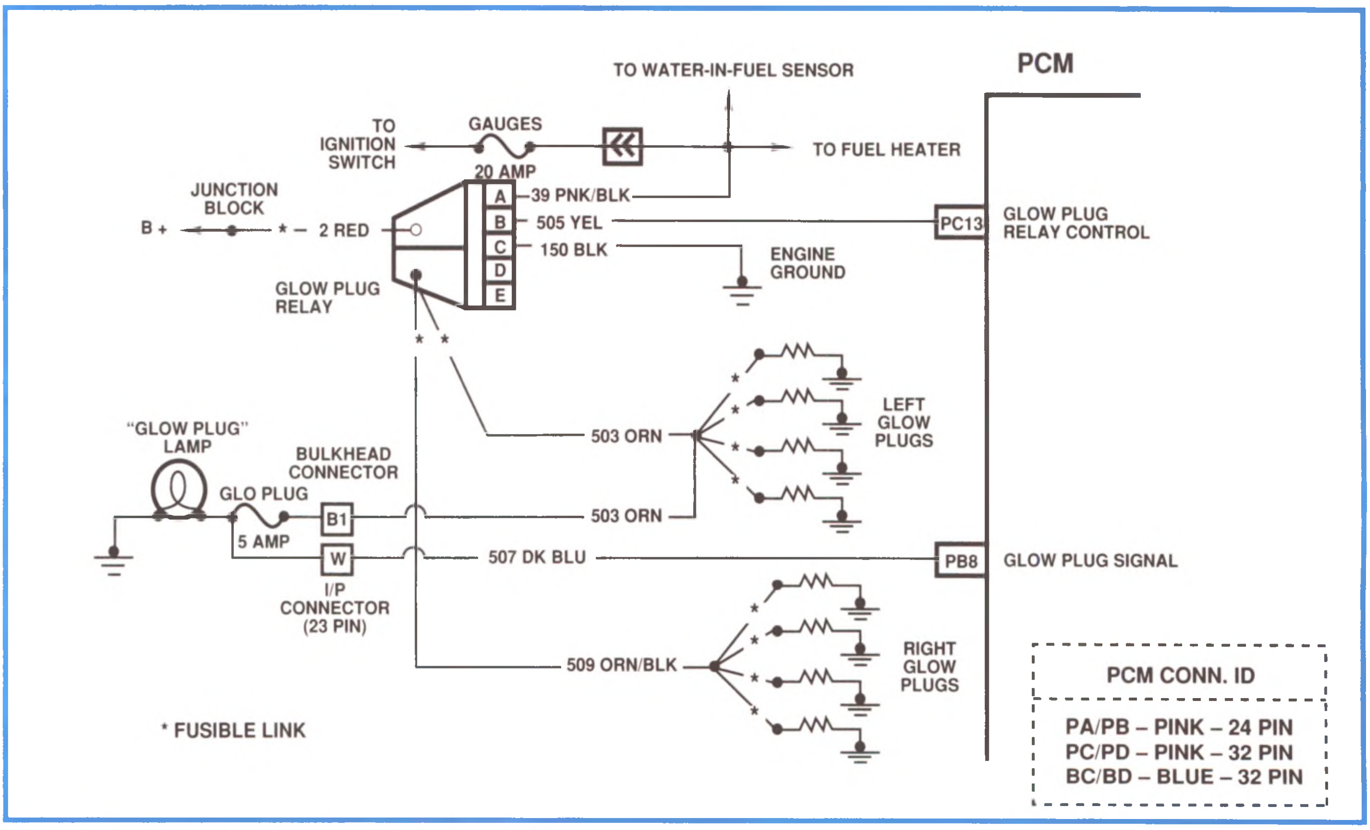


Figure 5-42, Glow Plug Circuit Operation

Glow Plug Circuit Operation

The PCM energizes the glow plug relay on CKT 505 (figure 5-42). When energized, the relay transfers battery power, which it receives on CKT 2, to the left glow plugs on CKT 503 and the right glow plugs on CKT 509. The PCM receives glow plug signal feedback on CKT 507. The PCM uses voltage on CKT 507 to illuminate the "Glow Plug" lamp when the glow plugs are "ON." Ground for the glow plug relay is provided on CKT 150.

DTC 29 — "Glow Plug System Fault"

DTC 29 sets under any of the following conditions.

1. When voltage on the glow plug feedback circuit to the PCM (CKT 507) differs from ignition voltage by 2 volts or more
2. When feedback voltage is less than .8 volts when the glow plugs are commanded "ON"
3. When feedback voltage is greater than .8 volts when the glow plugs are commanded "OFF"

The cause of a DTC 29 could be an open or short in CKT 39 or CKT 150, a faulty fuse, or a faulty connection.

Glow Plug System Check

- ASSUMES NO DTC 14, 15 OR 29 IS STORED AND THAT ENGINE COOLANT TEMPERATURE SENSOR CIRCUIT IS OPERATING PROPERLY.
- FUEL SYSTEM "OK."
- BATTERY VOLTAGE ABOVE 12.4 VOLTS.
- CRANKING SPEED ABOVE 100 RPM.
- WITH J39200 CHECK VOLTAGE AT "BATT" TERMINAL OF GLOW PLUG RELAY. IS THERE MORE THAN 11 VOLTS?

NO

REPAIR HIGH RESISTANCE
OR
OPEN IN CKT 2 TO THE IGNITION SWITCH.

YES

- KEY "OFF."
- USING J 39200 CHECK VOLTAGE AT "GLOW PLUG" TERMINAL OF GLOW PLUG RELAY CKT 503 AND 509. IS THERE MORE THAN 1 VOLT?

YES

RELAY CONTACTS SHORTED. REPLACE GLOW PLUG RELAY AND ALL GLOW PLUGS.

NO

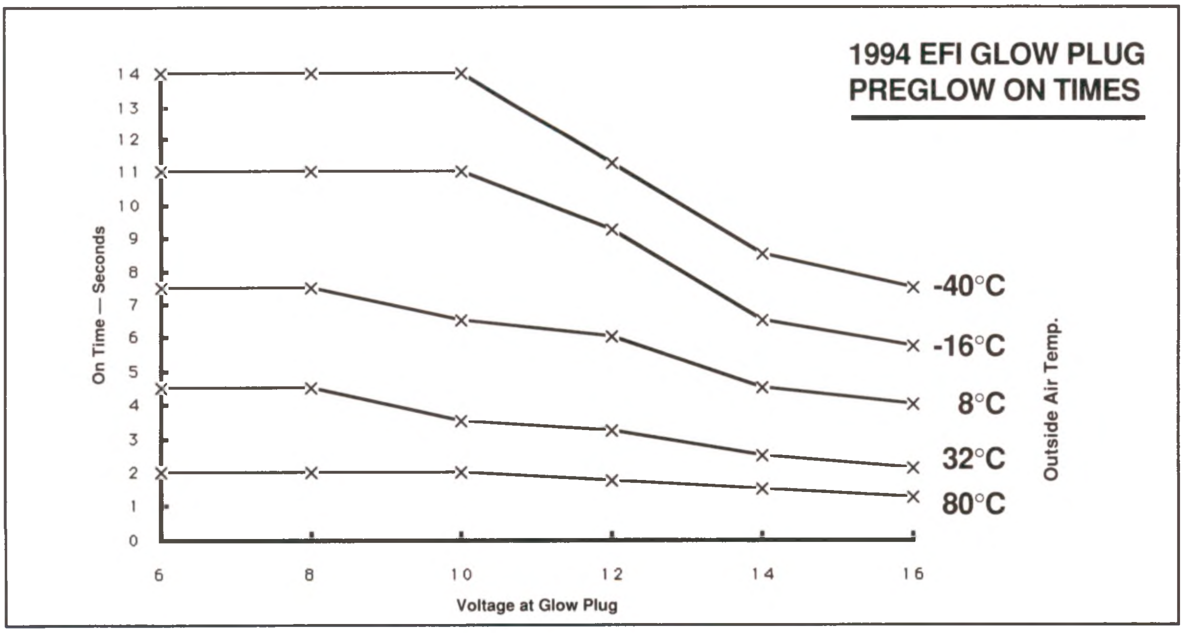
- DISCONNECT ALL GLOW PLUGS.
- USE J39200 TO MEASURE CONTINUITY BETWEEN EACH GLOW PLUG TERMINAL AND GROUND. REPLACE ANY GLOW PLUG THAT MEASURES MORE THAN 2 OHMS.
- RECONNECT ALL GLOW PLUGS.
- WITH TEST LIGHT CONNECTED TO GROUND, PROBE EACH GLOW PLUG HARNESS TERMINAL CONNECTOR.
- COMMAND GLOW PLUGS "ON." IS TEST LIGHT ON?

YES

SYSTEM OPERATING OK.

NO

REPAIR OPEN IN CKT 503.



GLOW PLUG CURRENT TEST

— NOTICE —
Never install a jumper wire between the terminal studs of the relay, since immediate damage to all glow plugs may result.

— IMPORTANT —
The Tech 1 will allow the glow plugs to be commanded "ON" when the ignition key is "ON" and the engine "OFF." The Tech 1 limits glow plug "ON" time to 3 seconds to prevent overheating. The glow plugs have to be "OFF" for 15 seconds before they can be commanded "ON" again.

Primary Checks

1. Install an ammeter at the controller/relay terminal stud (glow plug side).
2. Connect the Tech 1. Using the Tech 1's "Glow Plug Output Tests," command the glow plugs "ON."
3. Move the ignition switch to the RUN position and measure the amperage of each bank of the glow plugs.
   - If both banks have a minimum of 55 amperes current flow, the system is working properly.
   - If either bank has less than 55 amperes current flow, go to step 4.
   - If both banks have a zero ampere current flow, perform the Secondary Checks as described in the "6.5L V8 Turbo Diesel" coursebook (#16015.12-2).
4. Install an ammeter in series with one glow plug wire. Move the ignition switch to RUN and measure the amperage of the glow plug.
   - If the glow plug has a current flow of 14 amperes, it is working properly.
   - If the glow plug has a current flow less than 14 amperes, go to step 5.
5. Check the continuity of the glow plug wiring harness from the relay terminal stud to the glow plug terminal.
   - If the wiring harness has continuity, go to step 6.
   - If the wiring harness has no continuity, repair it and check system operation.
6. Replace the glow plug and follow steps 4 and 5 for other glow plugs. Use an AC-type 9G glow plug.
7. When all glow plugs have 14 amperes of current flow, end the diagnosis.

BOOST CONTROL

System Operation

The PCM monitors the APP sensors, engine speed, and intake manifold boost pressure as indicated by the boost sensor to energize the solenoid that controls the turbocharger wastegate valve (figure 5-43).

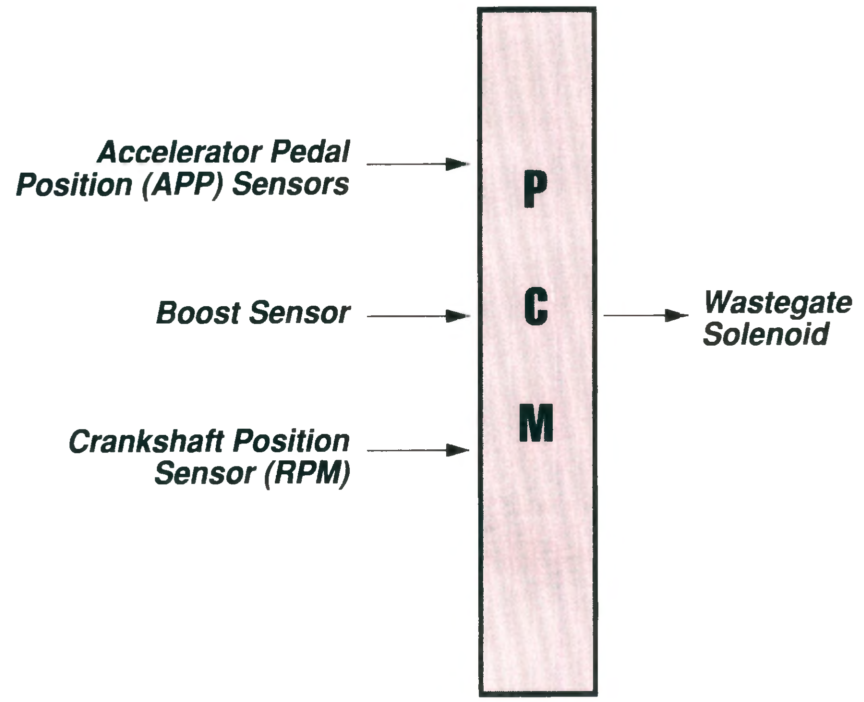


Figure 5-43, **Boost Control Inputs and Outputs**

Component Operation

BOOST SENSOR (Turbo Only)

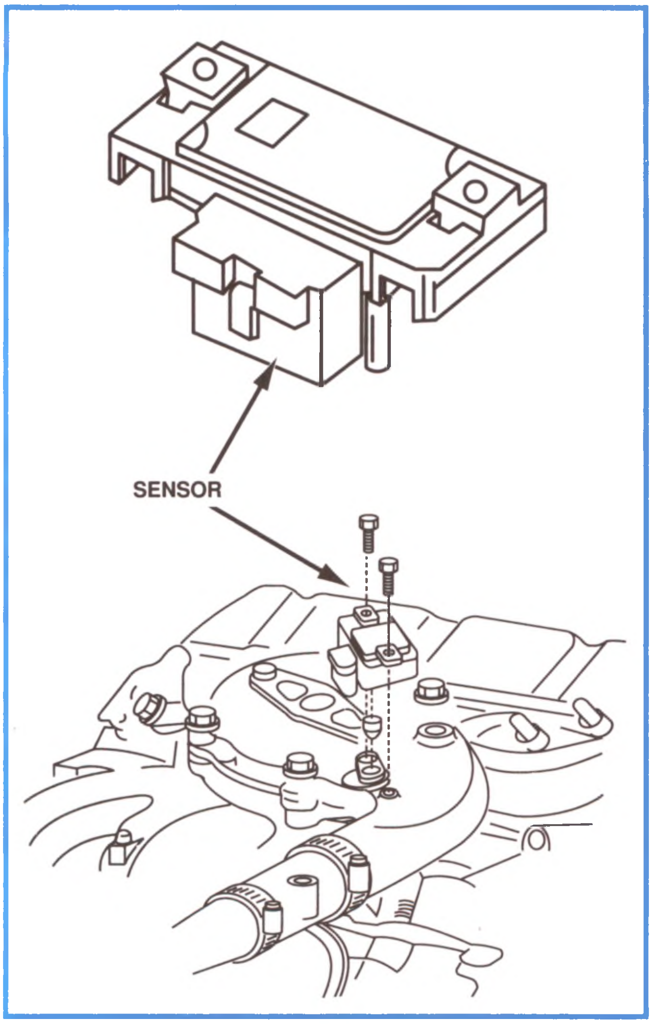


Figure 5-44, **Boost Sensor (Turbo Only)**

Description

The boost sensor (figure 5-44) on turbocharged engines measures fluctuations in intake manifold pressure and vacuum that occur as a result of changes in engine load and engine speed. The sensor is a resistor that converts manifold pressure/vacuum into electrical signals:

- At idle, the boost sensor displays approximately the same reading as barometric pressure.
- When the engine is at full load with wide open throttle (WOT), manifold pressure is high and vacuum is low. Under these conditions, boost sensor resistance is low. As a result, a high voltage signal is sent to the PCM telling it to deliver more fuel.
- Conversely, under manifold low pressure conditions, boost sensor resistance is high. This high resistance reduces the strength of the boost signal sent back to the PCM. The PCM then knows to deliver less fuel to the engine.

The PCM uses these signals to determine how much pressure is being produced by the turbocharger. Boost pressure information is used to control fuel delivery and wastegate solenoid operation.

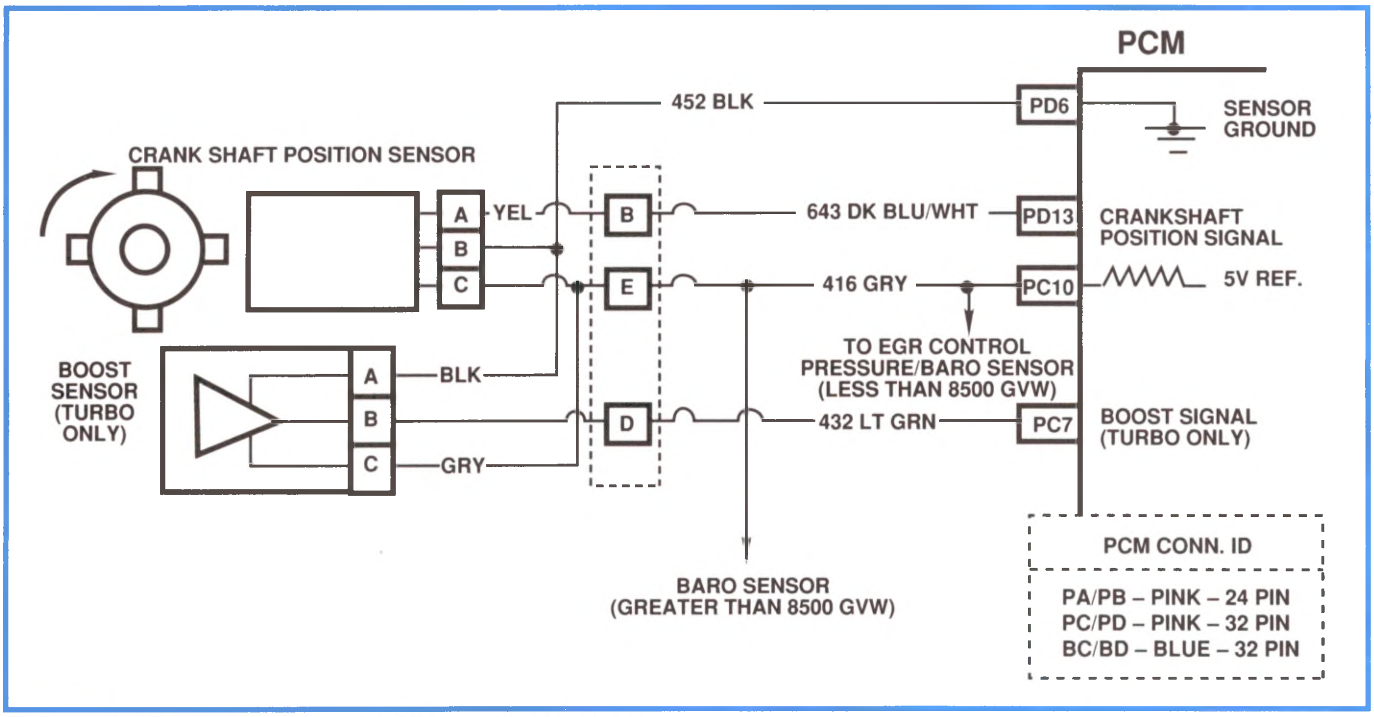


Figure 5-45, Boost Sensor Circuit Operation

Circuit Operation

The boost sensor receives a constant 5 volt reference signal from the PCM through CKT 416 (figure 5-45). The sensor signal is sent back to the PCM on CKT 432.

Ground for the sensor is provided through the PCM on CKT 452. This ground is shared with the crankshaft position sensor, the ECT sensor, and the IAT sensor.

DTC 61 — "Turbo Boost Sensor Circuit High"

DTC 61 sets when the turbo boost signal voltage is greater than 3.9 volts and engine RPM is less than 3500. A DTC 61 will result in no turbo boost and poor engine performance.

DTC 62 — "Turbo Boost Sensor Circuit Low"

DTC 62 sets when turbo boost signal voltage is less than .8 volt. DTC 62 will result in no turbo boost and limited fuel delivery.

BOOST PRESSURE TEST

1. Remove the front center mounting bolt from the air inlet and install J 39307 adapter with a 6 to 7 foot length of 3⁄16-inch I.D. rubber line. Then route the rubber line into the cab and connect J 28474 pressure gage to the end of the line.

2. Test drive the vehicle with a passenger watching the gage. Allow the vehicle to coast at engine idle speed in first gear. Then press the accelerator pedal to the floor while the passenger notes the boost pressure reading. A boost reading of 14 kPa (2 psi) or more indicates the turbocharger is operating properly.

— IMPORTANT —
The 14 kPa (2 psi) reading is for quick acceleration only. The pressure reading can climb above 14 kPa (2 psi) under heavy loads. During deceleration, the pressure reading may even go down.

WASTEGATE SOLENOID

Description

On turbocharged engines, the exhaust gases pass from the exhaust manifold through the turbocharger, turning the turbine blades. The compressor side of the turbocharger also turns, pulling air through the air filter and pushing the air into the intake manifold, pressurizing the intake manifold.

The turbocharger wastegate is normally closed when the engine is running, but it opens to bypass exhaust gas to prevent an overboost condition. The wastegate will open when vacuum is vented from the actuator, and is controlled by the pulse-width modulated wastegate solenoid.

The wastegate solenoid is pulsed "ON" and "OFF" by the PCM. Under normal driving conditions and idle, the wastegate solenoid is "ON," allowing vacuum to close the actuator to build boost pressure. A boost increase will be detected by the boost sensor. The PCM will pulse the wastegate solenoid "OFF," allowing it to vent and open the actuator to bleed off boost pressure, thereby preventing overboost.

If an overboost condition exists, the PCM will reduce fuel delivery to prevent engine damage.

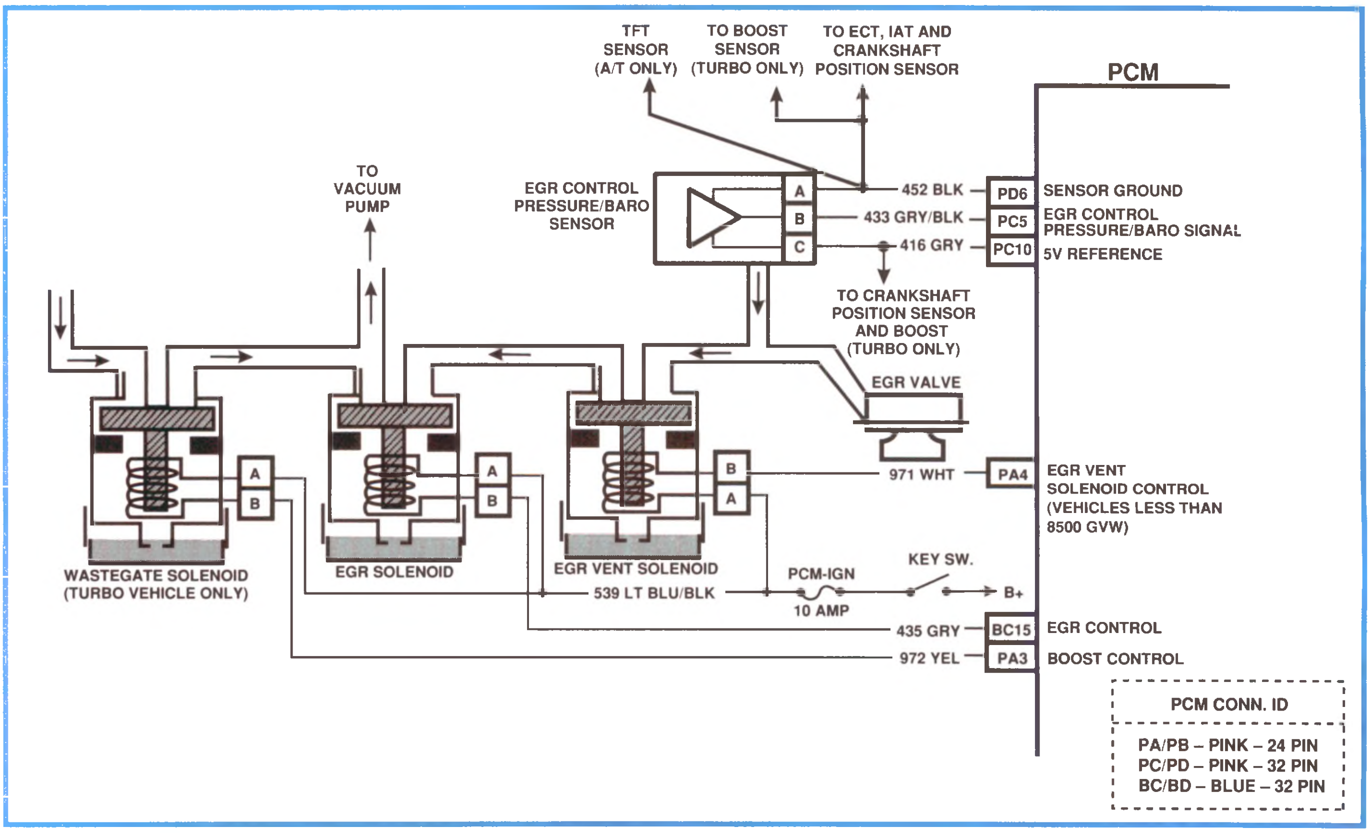


Figure 5-46, Wastegate Solenoid Circuit Operation

Wastegate Solenoid Circuit Operation

The wastegate solenoid receives power through the ignition switch on CKT 539. The PCM controls solenoid operation by providing a ground at PCM terminal A3 for CKT 972 (figure 5-46).

DTC 78 — "Wastegate Solenoid Fault"

DTC 78 sets when engine RPM is greater than 1800, fuel rate is greater than 20 cubic millimeters and boost pressure is greater or lesser than the desired amount as determined by the PCM's internal setting.

EGR CONTROL

System Operation

The PCM monitors input from the EGR control pressure/baro sensor, APP sensors, crankshaft position sensor (engine speed), and engine coolant temperature to control the amount of exhaust gas that is recirculated back into the intake manifold. Outputs for EGR control consist of the EGR solenoid, EGR vent solenoid, and EGR valve (figure 5-47).

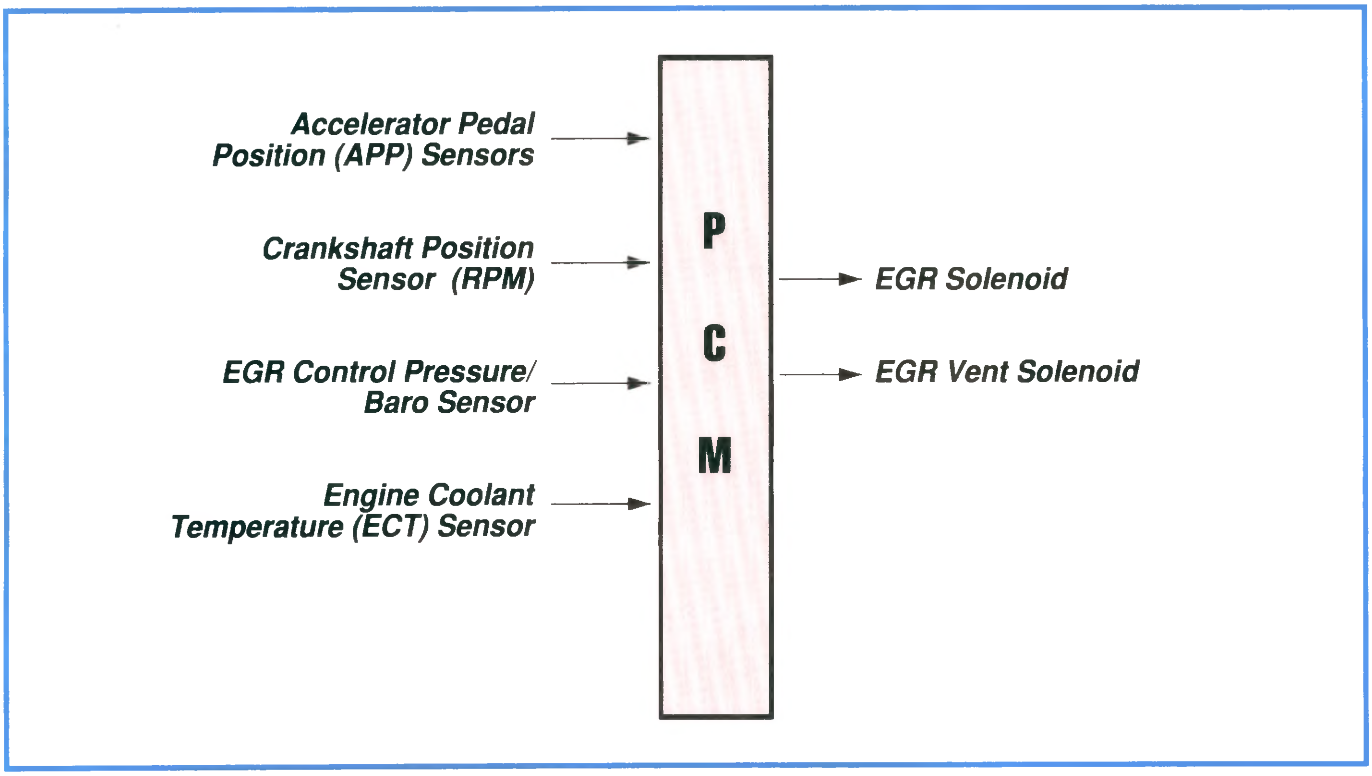


Figure 5-47, **EGR Control Inputs and Outputs**

Component Operation

EGR CONTROL PRESSURE/BARO SENSOR

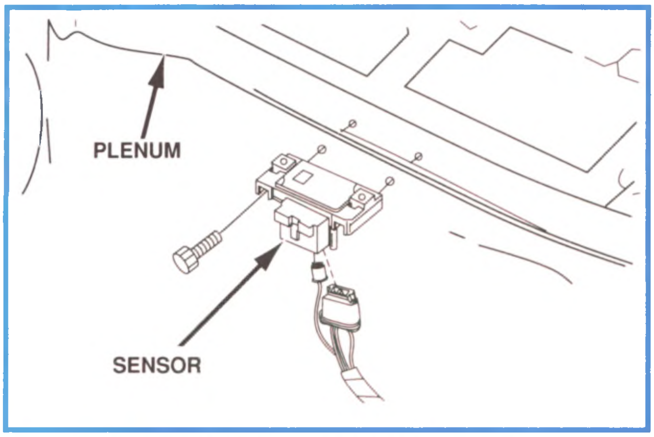


Figure 5-48, **EGR Control Pressure/Baro Sensor Location**

The EGR control pressure/baro sensor is mounted on the left side of the cowl (figure 5-48). The sensor produces a voltage signal in proportion to the amount of absolute pressure in the EGR vacuum line. The PCM compares this actual signal to the desired EGR value it has calculated and makes minor corrections in EGR solenoid operation to compensate for the difference. If the difference between actual and desired EGR is too great for the PCM to correct, a diagnostic trouble code will set. A Baro reading is taken on key up and when EGR is "OFF."

EGR Control Pressure/Baro Sensor Circuit Operation

The EGR control pressure/baro sensor receives a 5 volt reference signal from the PCM on CKT 416 (figure 5-49). This reference signal is shared with the crankshaft position sensor and boost sensor. Based upon EGR vacuum, the sensor sends a signal back to the PCM on CKT 433. Ground for the sensor is provided on CKT 452.

DTC 31 — "EGR Control Pressure/Baro Sensor Circuit Low (High Vacuum)"

DTC 31 sets when actual EGR pressure is less than 15 kPa for 2 seconds. Under these conditions, the PCM will shut down the EGR system.

DTC 33 — "EGR Control Pressure/Baro Sensor Circuit High (Low Vacuum)"

DTC 33 will set when the EGR vent is off and actual EGR pressure is more than 60 kPa higher than desired EGR.

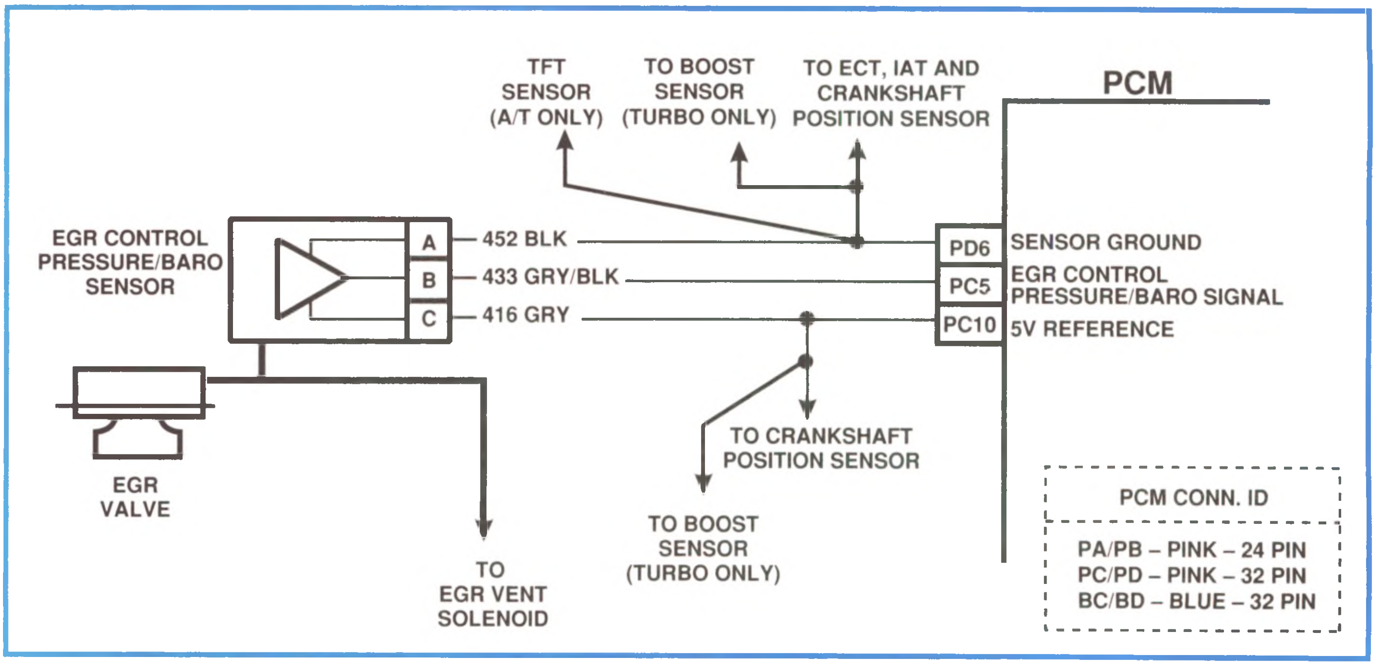


Figure 5-49, **EGR Control Pressure/Baro Sensor Circuit Operation**

EGR VALVE, EGR SOLENOID, AND EGR VENT SOLENOID

Description

The EGR valve is located atop the intake manifold in a port that is machined into the manifold (figure 5-50). A vacuum-operated pintle in the valve controls the amount of exhaust gas that is recirculated into the intake manifold. Recirculating these gases helps reduce emissions. A normally open EGR solenoid controls the EGR valve. The solenoid allows vacuum to pass to the EGR. An EGR vent solenoid is used to vent pressure from the EGR valve chamber during non-EGR conditions.

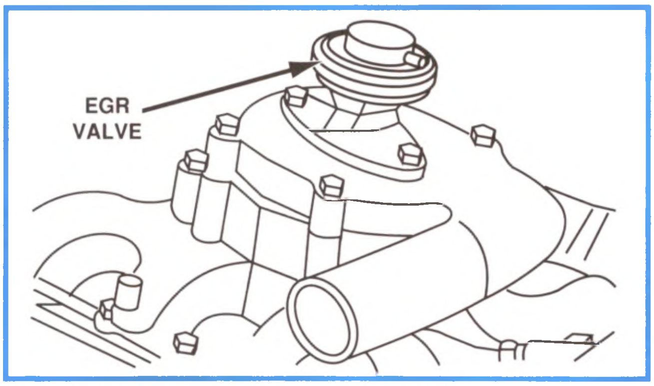


Figure 5-50, **EGR Valve (Turbo)**

EGR Circuit Operation

The PCM provides a ground path to the EGR solenoid on CKT 435 that allows the solenoid to control the EGR valve (figure 5-51). The PCM also energizes the EGR vent solenoid through CKT 971. Both solenoids receive battery power through the ignition switch on CKT 539. During normal operation, the PCM compares the EGR duty cycle command with the EGR pressure control/baro sensor signal it receives on CKT 433. If there is a difference between PCM-command EGR and actual EGR position, the PCM makes minor adjustments in the duty cycle to correct the difference. If the difference is too great for the PCM to compensate, a DTC may set.

DTC 32 — "EGR Circuit Error"

DTC 32 sets when engine RPM is greater than 506, there is a 50 kPa difference between desired EGR and actual EGR for more than 25.5 seconds, and there is no DTC 31 or 33. A DTC 32 will prompt the PCM to shut down the EGR system.

DTC 44 — "EGR Pulse Width Error"

DTC 44 sets when the PCM doesn't see ignition voltage at terminal E15 when the EGR solenoid is commanded "OFF."

DTC 45 — "EGR Vent Error"

DTC 45 sets when the PCM doesn't see ignition voltage at terminal A4 when EGR vent is commanded "OFF."

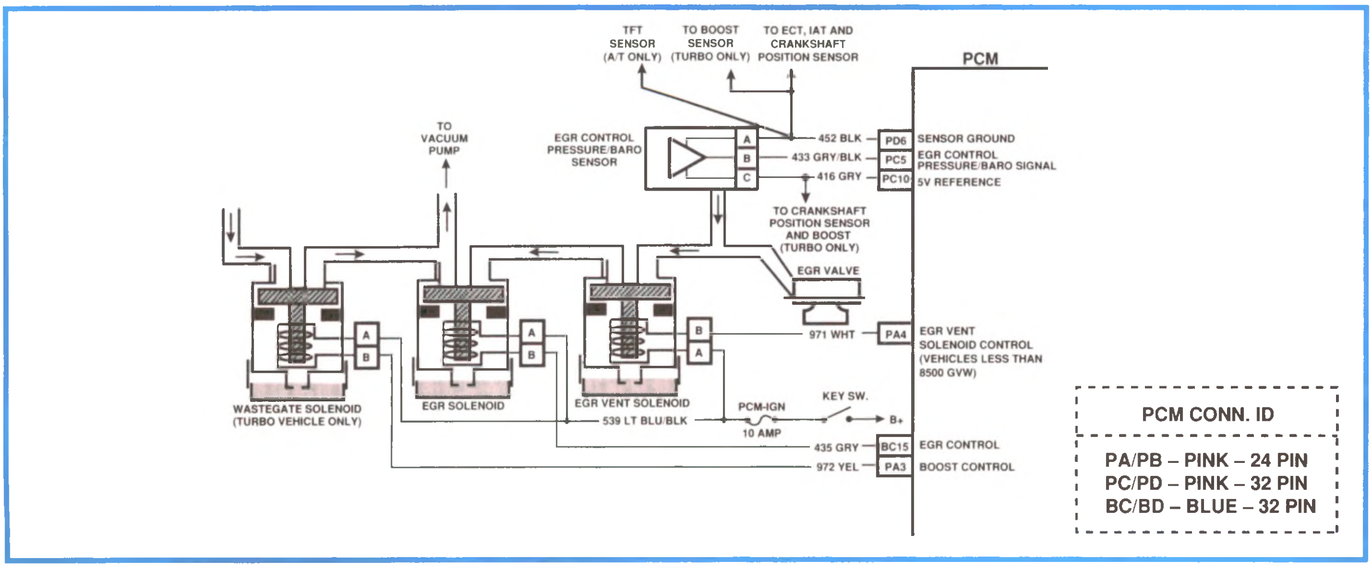


Figure 5-51, **EGR Valve Circuit Operation**

CRUISE CONTROL

System Operation

The PCM uses information about cruise control status, brake and clutch switch status, and vehicle and engine speed for fuel delivery (figure 5-52). Three cruise control modes are used by the PCM: ON/OFF request; resume/accelerate request; and set/coast request.

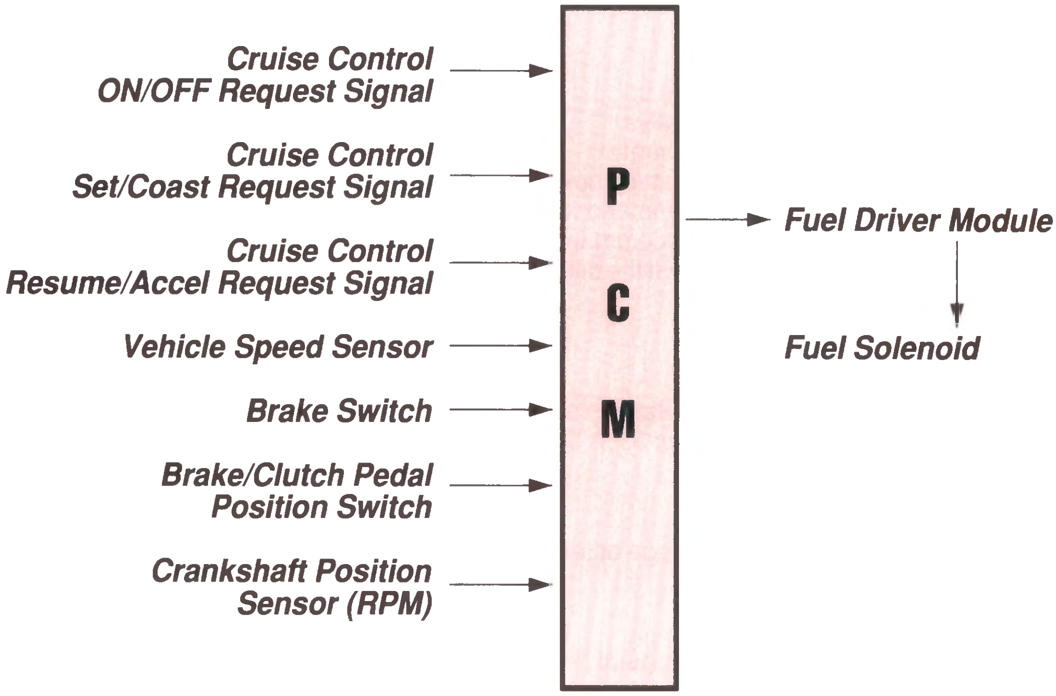


Figure 5-52, **Cruise Control Inputs and Outputs**

> **— IMPORTANT —**
> **Back-up fuel will cause cruise control to be inoperative.**

Component Description

CRUISE CONTROL SWITCH

Description

The cruise control switch assembly contains three internal discrete switches that open and close according to cruise control requests by the driver. The PCM receives inputs from these switches to control fuel delivery through the fuel driver module and solenoid.

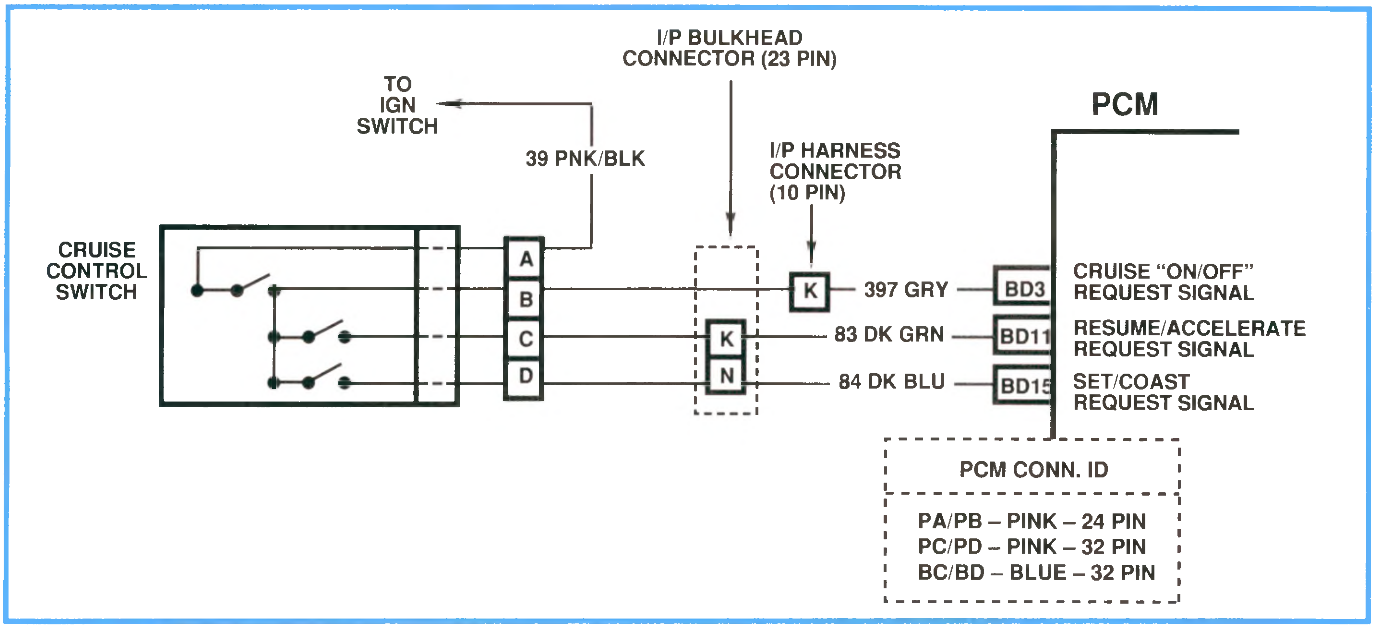


Figure 5-53, Cruise Control Switch Circuit Operation

Cruise Control Switch Circuit Operation

The cruise "ON/OFF," set/coast, and resume/accel switches are inputs to the fuel control portion of the PCM (figure 5-53). These inputs allows the PCM to control and hold a requested speed.

- "ON/OFF"status is conveyed through CKT 397
- resume/accel status is conveyed through CKT 83
- set/coast status is conveyed through CKT 84

DTC 71 — "Set/Coast Switch Fault"

DTC 71 sets when cruise control is "ON" and the PCM sees ignition voltage on CKT 84 for more than 20 seconds. DTC 71 could be caused by the set/coast switch being stuck in the engage position. As a failsafe, if DTC 71 sets, the PCM will disallow all cruise control inputs.

DTC 76 — "Resume/Accel Switch Fault"

DTC 76 sets when cruise control is "ON" and the PCM sees ignition voltage on CKT 83 for more than 20 seconds. A set/coast switch stuck in the engage position or an open in CKT 84 could be the cause of DTC 76. As with DTC 71, the PCM will ignore all cruise control inputs if DTC 76 sets.

BRAKE SWITCHES AND CLUTCH PEDAL POSITION SWITCH

Description

The PCM uses brake switch input information to interrupt cruise control operation when the brakes are applied. On automatic transmission vehicles, there are two brake switches: a normally open cruise control brake switch and a normally closed torque converter clutch (TCC) brake switch. Both send signals to the PCM alerting it to disengage cruise control. Both are housed in the stoplamp switch assembly located at the brake pedal. Manual transmission vehicles feature a normally closed clutch pedal position switch in place of the TCC brake switch.

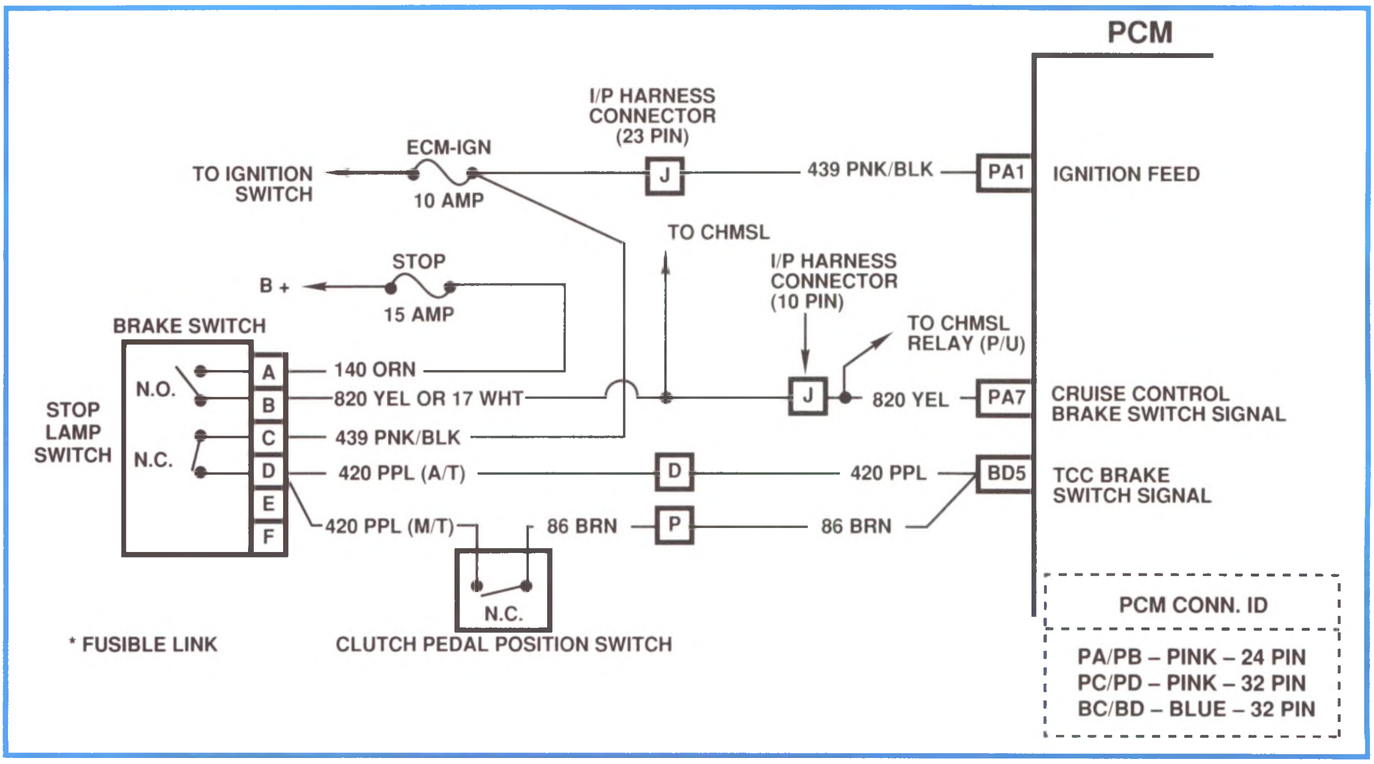


Figure 5-54, Brake Switch and Clutch Pedal Position Switch Circuit Operation

Circuit Operation

The cruise control brake switch receives battery power on CKT 140 (figure 5-54). When the brakes are applied, the switch closes, allowing a battery positive signal to travel to the PCM on CKT 820. The PCM reads this circuit to know the brakes are engaged. This information is also used to illuminate the vehicle stoplamps.

The TCC brake switch receives power from the ignition switch on CKT 439. When the brakes are applied, the TCC brake switch opens, disengaging TCC. The PCM recognizes TCC brake switch status by the absence of a voltage signal on CKT 420.

The clutch pedal position switch on manual transmissions performs the same function as the TCC brake switch. In its normally closed position, it transmits a voltage signal to the PCM on CKT 86. When the brakes are applied, the switch opens, interrupting the flow of voltage to the PCM.

DTC 41 — "Brake Switch Circuit Fault"

DTC 41 is the result of the brake inputs not toggling on moderate braking. It sets when the vehicle is decelerating and the TCC (or clutch pedal position) and cruise control brake switches are not toggling "open" and "closed" during 6 brake applications in the same ignition cycle.

TRANSMISSION CONTROL

System Operation

— IMPORTANT —
Depending upon the application, the 6.5L EFI can be teamed with either a 5-speed manual transmission or one of two automatic electronic transmissions: the 4L60E or the 4L80E. These options have slightly different impacts on PCM operation. Also, 6.5L EFI vehicles are available in 4WD or 2WD versions. These options result in slightly different PCM control functions.

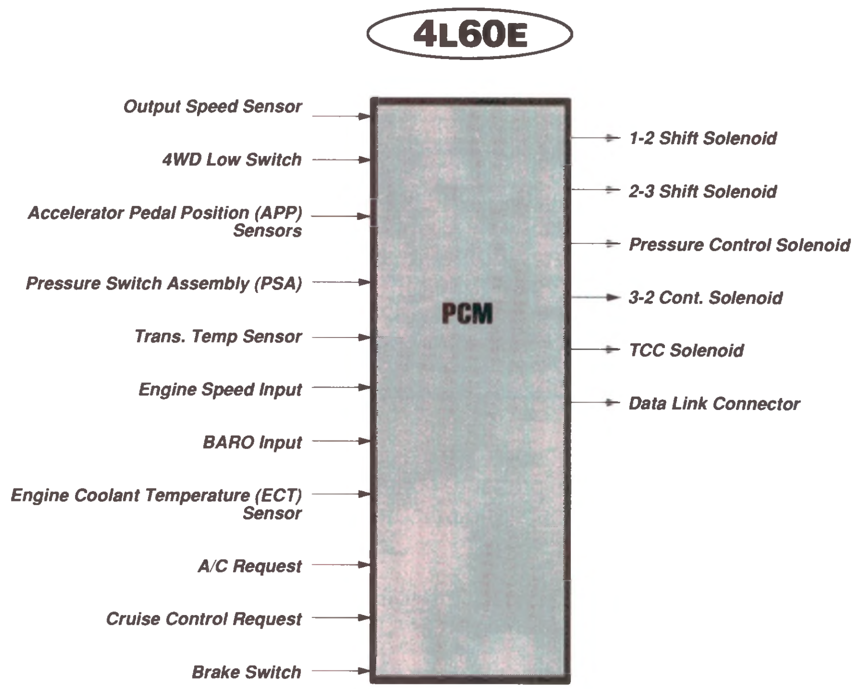
Non-EFI 6.5L diesels equipped with the 4L80E transaxle use a dedicated Transmission Control Module (TCM) to provide shift control timing, TCC apply and release, and line pressure control. The TCM has been eliminated on 6.5L EFI vehicles. Its duties are now performed by the PCM. PCM inputs and outputs for transmission control for the 4L60E and 4L80E are listed in figures 5-54 and 5-55, respectively.

The PCM also stores diagnostic trouble codes (DTCs) for the transmission. Some codes are shared by the engine and PCM, while others are dedicated transmission codes. The list of 6.5L EFI codes identifies shared as well as transmission-only codes.

Because the focus of this course is 6.5L EFI engine management, the only components of transmission control to be discussed, other than those already included in other subsystems, are the output speed sensor and the vehicle speed sensor (VSS). They have the most direct impact on engine control fuel delivery.

For complete coverage of 4L80E and 4L60E operation, diagnosis, and service procedures, refer to the following GM training center courses:

- #17001.17: Hydra-Matic 4L80E
- #17007.18: Hydra-Matic 4L60E



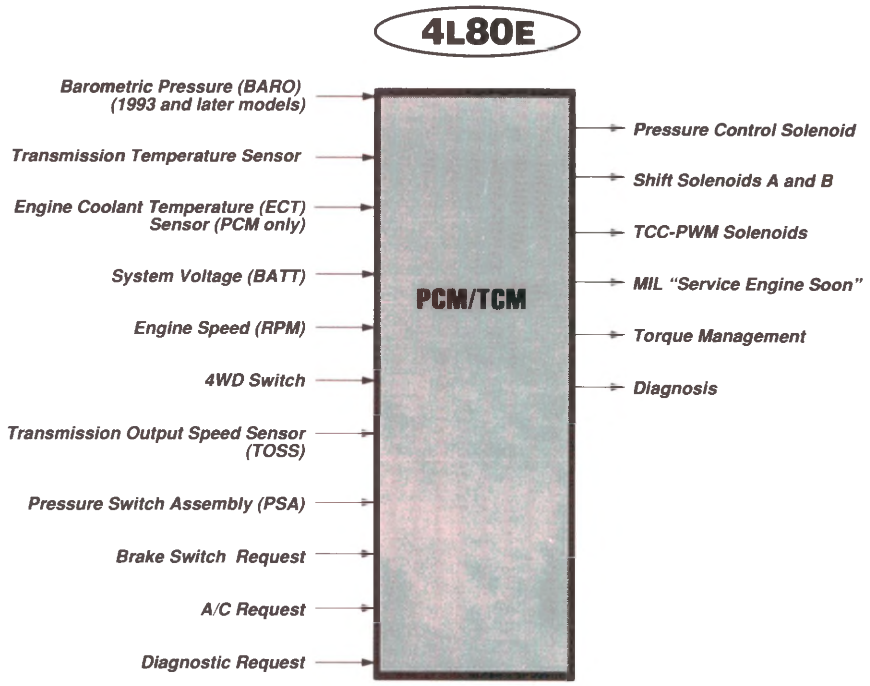


Figure 5-55, 4L60E and 4L80E Transmission Control Inputs and Outputs

Component Operation

TRANSMISSION OUTPUT SPEED SENSOR AND VEHICLE SPEED SENSOR (VSS)

Description

The transmission output speed/vehicle speed sensor is mounted on the driver's side of the transmission case, near the rear (figure 5-56). The sensor consists of a permanent magnet surrounded by a coil of wire. It reads the rotation speed of a 40-toothed ring mounted to the rear carrier assembly on 4L80E models or to the output shaft on 4L60E models.

The sensor maintains a slight air gap (.045–.109 in.) between itself and the case. The sensor produces an AC signal voltage whose frequency varies with transmission speed:

- Low speed = low voltage signal frequency (.5 volts at 100 rpm)
- High speed = high voltage signal frequency (100 volts at 8,000 rpm)

2WD/4WD Differences

The sending of vehicle speed information to the PCM differs slightly between two-wheel-drive and four-wheel-drive configurations.

- Two-wheel-drive systems use either a transmission output speed sensor or a VSS. The sensors perform essentially the same function. Each sensor's signal is used by the buffer/DRAC module to inform the PCM of vehicle speed.
- Four-wheel-drive systems use both a transmission output speed sensor and a VSS sensor. The VSS is located on the transfer case.

Information from the transmission output and/or VSS sensors is used by the PCM for TCC application and release, line pressure control, shift timing control, and torque management control.

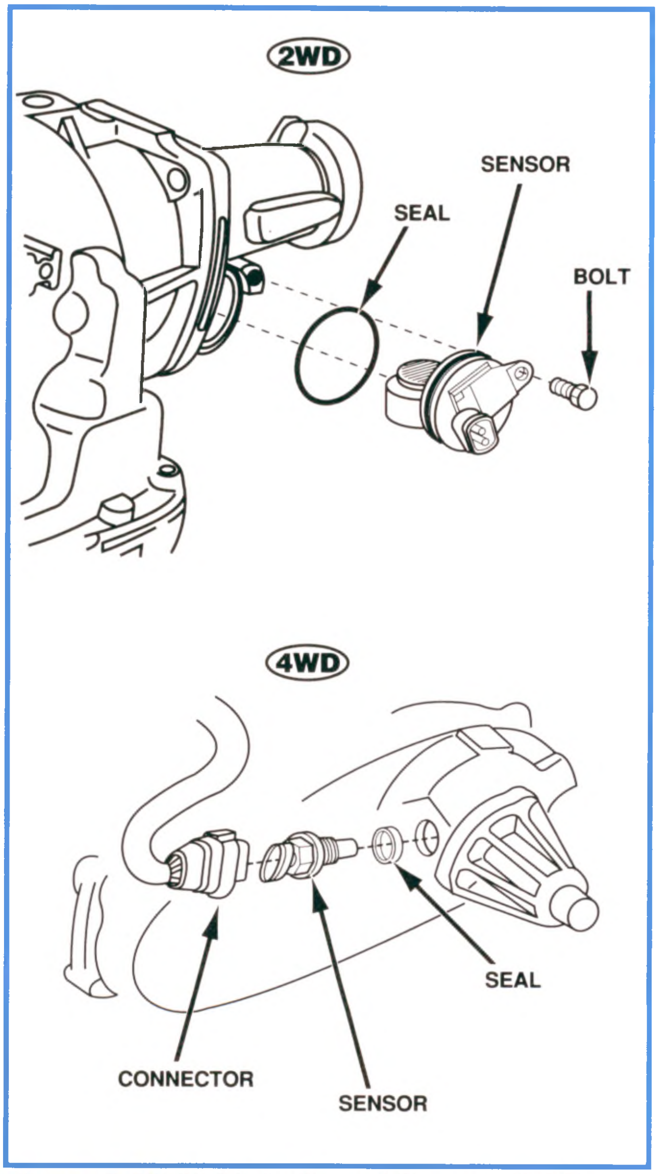


Figure 5-56, **Vehicle Speed Sensor (VSS) Locations**

VSS Buffer Module

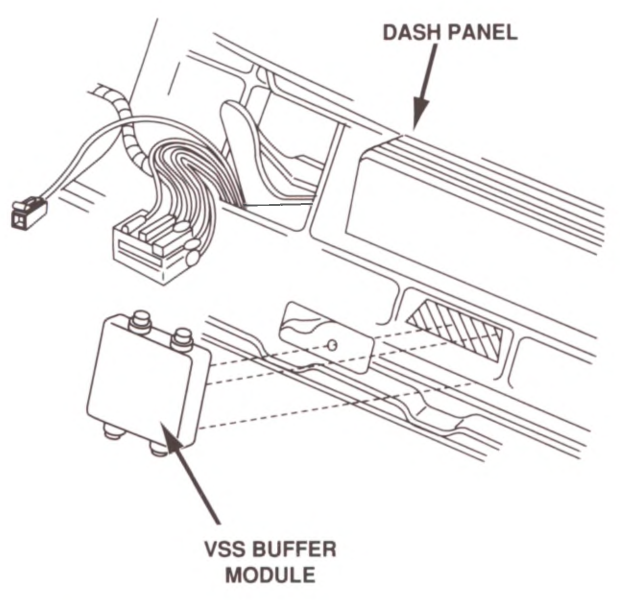


Figure 5-57, VSS Buffer Module Location

The VSS signal is sent to a Vehicle Speed Sensor (VSS) Buffer Module (figure 5-57). The module acts as a signal interpreter. It changes the AC voltage of incoming sensor signals so they can be used by the PCM. The module outputs a 4000-pulse-per-mile signal to the PCM. The buffer also emits signals used by other functions such as the Antilock Brake System (ABS) and speedometer/odometer.

The VSS buffer module is also known as a Digital Ratio Adapter Controller (DRAC) Module. The buffer/DRAC module allows for easier updating of system software if vehicle tire size and/or axle ratio are changed, which is a more common occurrence on trucks.

— IMPORTANT —
The VSS buffer is programmed with information specific to the vehicle final drive ratio and tire size. If the final drive or tire size are changed for any reason, the VSS buffer must also be changed in order to continue producing accurate speedometer/odometer readings. An incorrect buffer will also adversely affect ABS and transmission operation.

Circuit Operation

The VSS buffer/DRAC module receives a 12 volt ignition signal on CKT 250 through the ignition switch. Ground for the module is provided on CKT 450 (figure 5-58).

The module receives the output speed /vehicle speed sensor signal on CKT 821. This signal ranges from .5 volt at low transmission speeds (100 rpm) to 100 volts at high speed (8,000 rpm). The module also provides a ground for the sensor on CKT 822.The module supplies transmission output and vehicle speed information to the following components on the following circuits:

- To the PCM on CKT 437 and CKT 1586 or CKT 834
- To the speedometer on CKT 824
- To the antilock brake module on CKT 696

DTC 16 — "Vehicle Speed Signal Buffer Fault"

The VSS buffer module sends a vehicle speed signal to the PCM on CKT 834. The PCM uses this to control engine operating functions. DTC 16 identifies an open or short to ground in CKT 834. It sets when the following conditions exist for at least 2 seconds:

- Vehicle speed greater than 20 mph
- Engine speed between 1000 and 4400 rpm
- CKT 834 open or shorted to ground

DTC 16 will result in loss of cruise control or fuel cutoff.

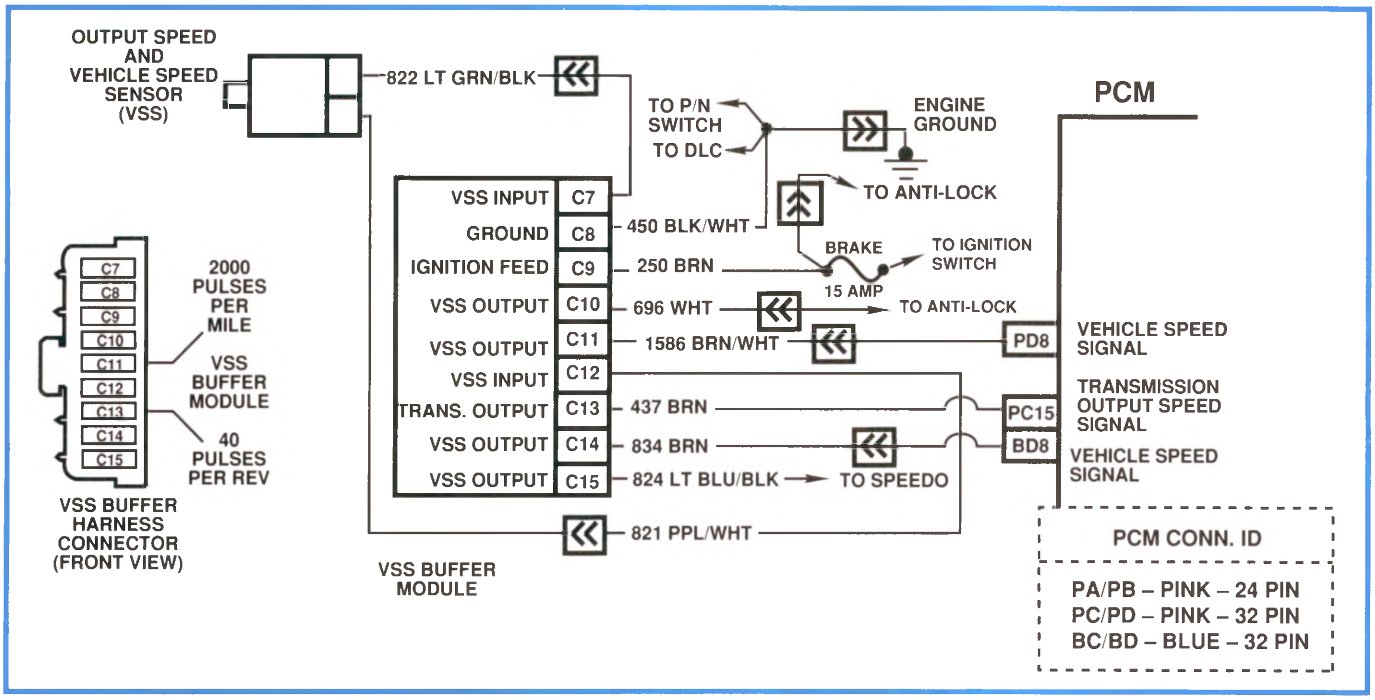


Figure 5-58, **Transmission Output Speed Sensor/Vehicle Speed Sensor (VSS) Circuit Operation**

DTC 24 — "Vehicle Speed Sensor Signal Low"

DTC 24 also when there is no vehicle speed detected by the PCM at start off. DTC 24 sets when the following conditions exist for at least 3 seconds:

- There are no stored DTCs 21 (APP 1 Circuit High), 22 (APP 1 Circuit Low), 28 (Trans. Range Pressure Switch Assembly Fault), 33 (EGR/Baro Sensor Circuit High) or 34 (Stepper Motor Circuit Fault)
- The vehicle is in any gear range other than Park or Neutral
- Voltage on CKT 437 (output speed signal to the PCM) is constant
- Transmission output speed is less than 200 RPM
- Manifold absolute pressure is greater than 40 kPa
- Throttle position is between 10% and 100%

If DTC 24 sets, the vehicle defaults to a singel gear range with no upshifts or downshifts.

DTC 72 — "Vehicle Speed Sensor (VSS) Circuit Loss (Trans. Output Speed Signal)

DTC 72 can set under two sets of conditions:

- When the vehicle is in Park or Neutral:
  - There is no DTC 28
  - Transmission output speed change is greater than 1000 rpm
  - Engine speed is greater than 200 rpm
  - All conditions exist for at least 2 seconds
- When vehicle is in a gear other than Park or Neutral:
  - There is no DTC 28 stored
  - Transmission output speed change is greater than 2050 rpm
  - Engine speed is greater than 200 rpm
  - All conditions exist for 2 seconds

DIAGNOSTIC REQUEST

System Operation

The Data Link Connector (DLC) is installed in the vehicle so a functional check of the engine's electronic control system can be made at the factory. The DLC also allows service technicians to use the PCM's self-diagnostic system to check the status of various components used in the engine's electronic control system (figure 5-59). This can be accomplished by grounding the terminals in the DLC or by using a "Scan" tool.

All voltage and resistance checks at the DLC connector must be checked with a high impedance (10 megaohm) digital volt-ohmmeter to prevent damage to the vehicle's electronic components.

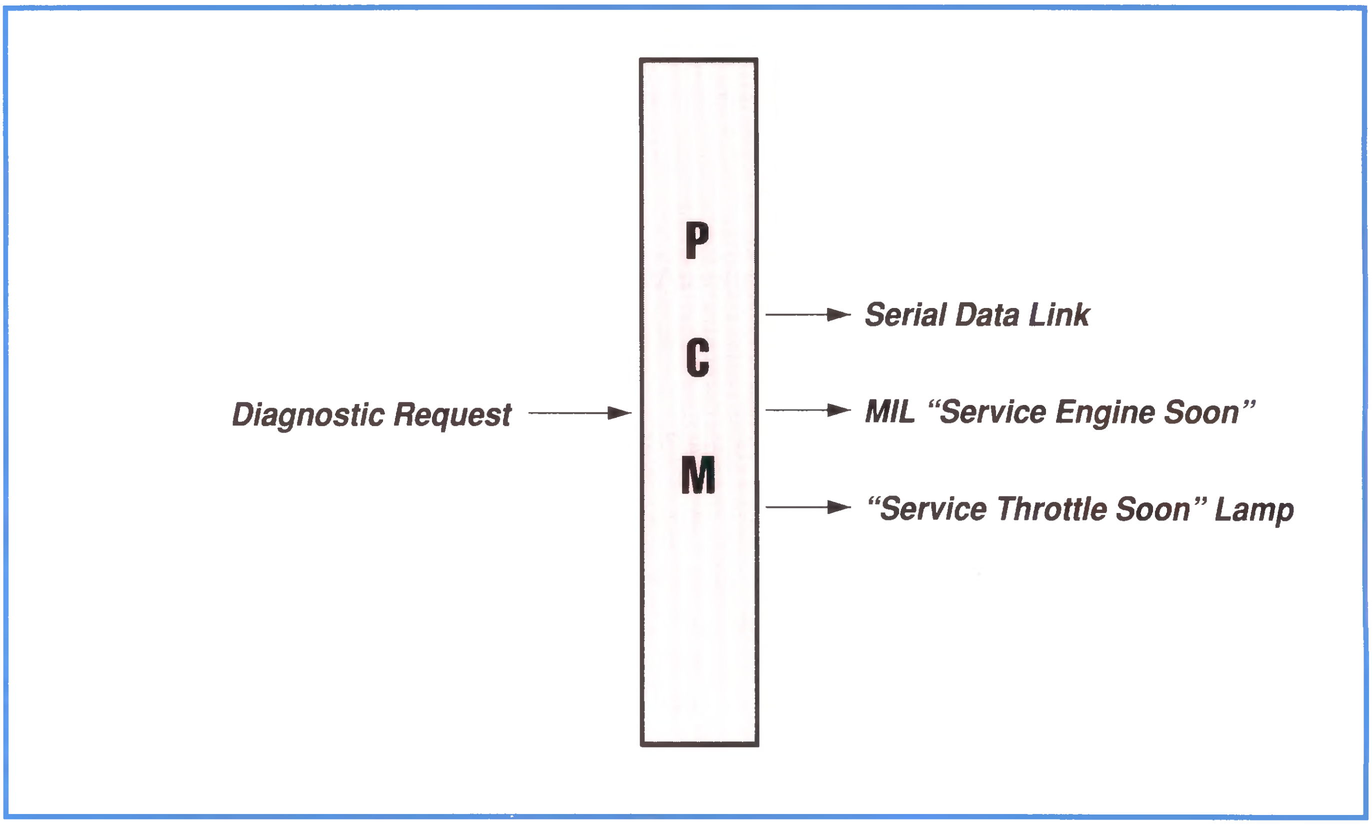


Figure 5-59, Diagnostic Request Inputs and Outputs

Component and Circuit Operation

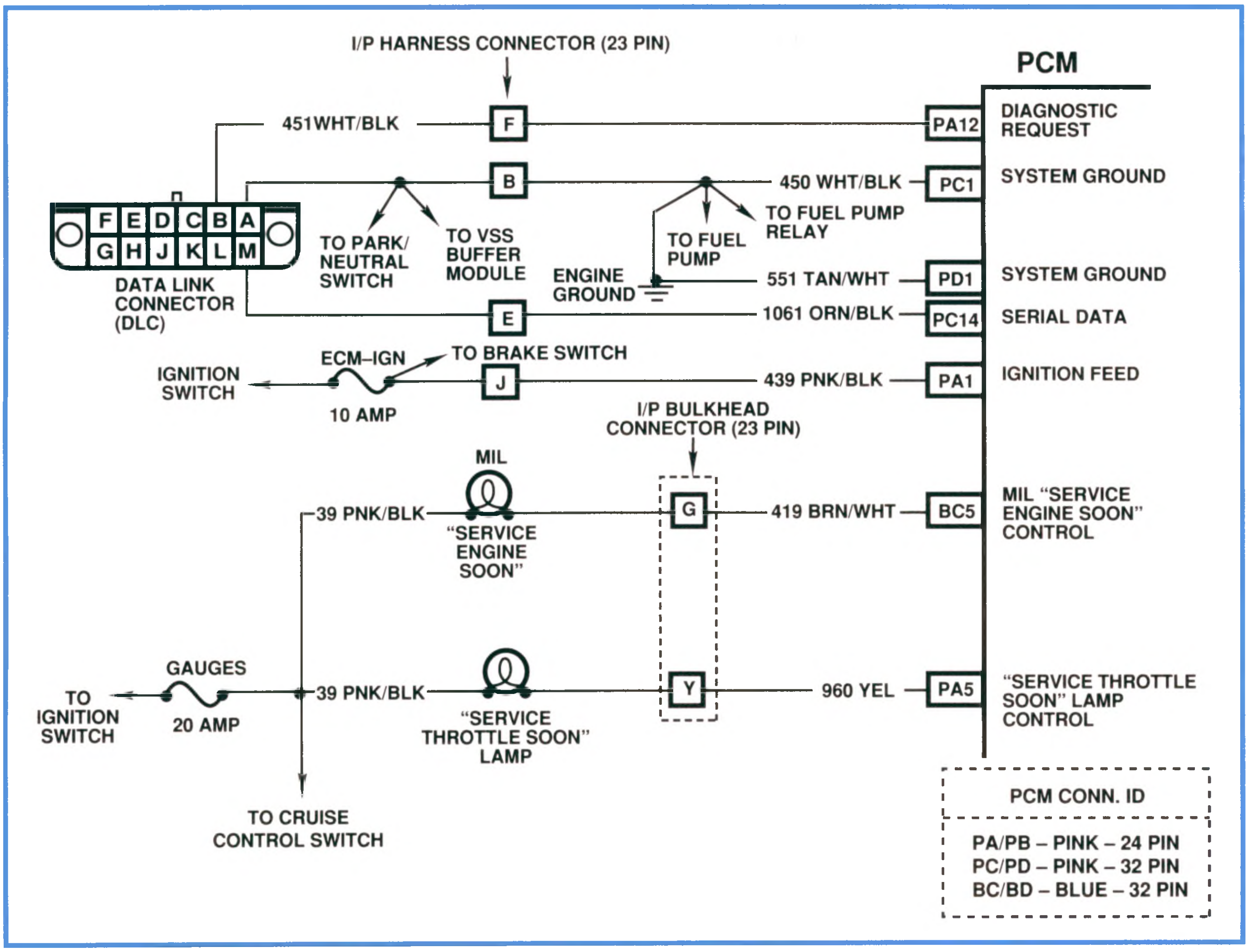


Figure 5-60, DLC Diagnostic Request Circuit Operation

DATA LINK CONNECTOR (DLC) TERMINAL "B" — DIAGNOSTIC REQUEST

When grounded to terminal "A", terminal "B" allows the MIL to flash diagnostic trouble codes.

DATA LINK CONNECTOR (DLC) TERMINAL "G" — FUEL PUMP

DLC terminal "G" allows technicians to enable the fuel pump to test for proper pump operation. CKT 490 from terminal "G" connects to fuel pump relay pin "C." Powering terminal "G" activates the fuel pump. During engine operation, voltage at terminal G should be within 1.5 volts of battery voltage. If it isn't, an oil pressure circuit problem should be suspected.

DATA LINK CONNECTOR (DLC) TERMINAL “M” — SERIAL DATA

Terminal “M” at the DLC is the serial data link for fast-baud PCMs. Serial data is a series of rapidly changing voltage signals pulsed from high to low voltage. These signals are typically 5 volts. Through terminal “M,” a “Scan” tool can read the serial data being sent between various components of the system being tested.

DTC 51 — “PROM Error (Faulty or Incorrect PROM)”

DTC 51 identifies a fault in the Programmable Read-Only Memory (PROM) portion of the PCM. PROM contains engine calibration information specific to the vehicle, model year, and emissions. The PROM also contains information used to allow fuel delivery if other parts of the PCM are damaged.

— NOTICE —

A replacement PCM used for service comes without a PROM. The PROM from the old PCM should be removed and installed in the new PCM when the PCM is replaced for reasons other than DTC 51. Consult the Service Manual for PCM on-vehicle service.

DTC 54 — “PCM Fuel Circuit Error”

DTC 54 indicates a fault in the fueling circuit fo the PCM. If a DTC 71 is also stored with DTC 54, diagnosis should begin with DTC 71.

MALFUNCTION INDICATOR LAMP (MIL)

The MIL alerts the driver to conditions requiring service. The MIL lamp receives ignition power through the ignition switch on CKT 39. The PCM turns the SES on by applying voltage on CKT 419.

DTC 46 — “MIL Circuit Fault”

DTC 46 sets when the PCM sees incorrect voltage at terminal E5.

“SERVICE THROTTLE SOON” (STS) LAMP

The “Service Throttle Soon” (STS) alerts the driver to APP module conditions requiring service. The STS does not display diagnostic trouble codes.

The STS lamp illuminates at key “ON” for 2 seconds as part of its bulb and system check. The lamp turns “OFF” at engine startup. If the STS lamp remains illuminated, the self-diagnostic system has detected a problem.

6. Diagnostics

OVERVIEW

Diagnosing electronic fuel injection systems is fairly straightforward if a sound diagnostic strategy is used. A working knowledge of the system, access to available reference materials, and the proper tools will contribute to successful diagnostics. So, too, will a logical approach.

BASIC KNOWLEDGE

Underneath its electronics, the 6.5L EFI diesel engine is a basic V8 diesel powerplant. The fuel pump, lines, and injectors still deliver fuel according to the basic rules of hydraulics. Electronics simply make them operate more precisely. Your understanding of the 6.5L mechanical systems and how they relate to each other is still indispensable for troubleshooting and repairing faults.

With the 6.5L EFI, a basic understanding of electronics is also necessary. Being able to read wiring schematics will allow you to identify components, wire colors, pin numbers, and wire routing when electrical diagnosis is required. The diagnostic trouble trees contained in Sections 3 and 10 of the Driveability and Emissions (Diesel) Service Manual are based on the schematics and require at least elementary knowledge of electrical theory.

REFERENCE MATERIALS

The most valuable reference source is the Service Manual. For 1994, light duty trucks service manuals have been reorganized to make them easier to use. The Driveability and Emissions (Diesel) Service Manual contains all the information necessary for diagnosing fuel and emissions systems.

Driveability and Emissions (Diesel) Service Manual

The Driveability and Emissions manual is organized into the following sections:

- Section 1: General Information
- Section 2: Driveability Symptoms
- Section 3: Control Module System
- Section 4: Fuel System
- Section 7: Glow Plug System
- Section 9: Exhaust Gas Recirculation (EGR) System
- Section 10: Transmission Controls
    - 10A: 4L60E Diagnostic Trouble Codes
    - 10B: 4L80E Diagnostic Trouble Codes
- Section 11: Crankcase Ventilation System
- Section 12: Air Intake System
- Section 13: Special Tools
- Section 14: Abbreviations and Glossary of Terms

6. Diagnostics

SECTION 3: CONTROL MODULE SYSTEM

Section 3 of the Driveability and Emissions Service Manual contains general as well as detailed information about the engine management system. Component descriptions provide a basic understanding of the role each sensor, switch, soienoid, and relay perform within the system. There are also descriptions of diagnostic modes and strategies.

The aspects of section 3 most vital for diagnosis are the circuit and trouble tree charts (figure 6-1). These are presented as facing-page spreads, with the circuit information on the left and the trouble tree on the right. These pages include:

- a wiring schematic for the components under discussion
- the diagnostic trouble code number and name for the circuits
- a circuit description
- a list of parameters that set the identified code
- a description of the operating mode the PCM defaults to when the code sets as well as conditions under which the code clears from PCM memory
- an explanation of steps used in the trouble tree

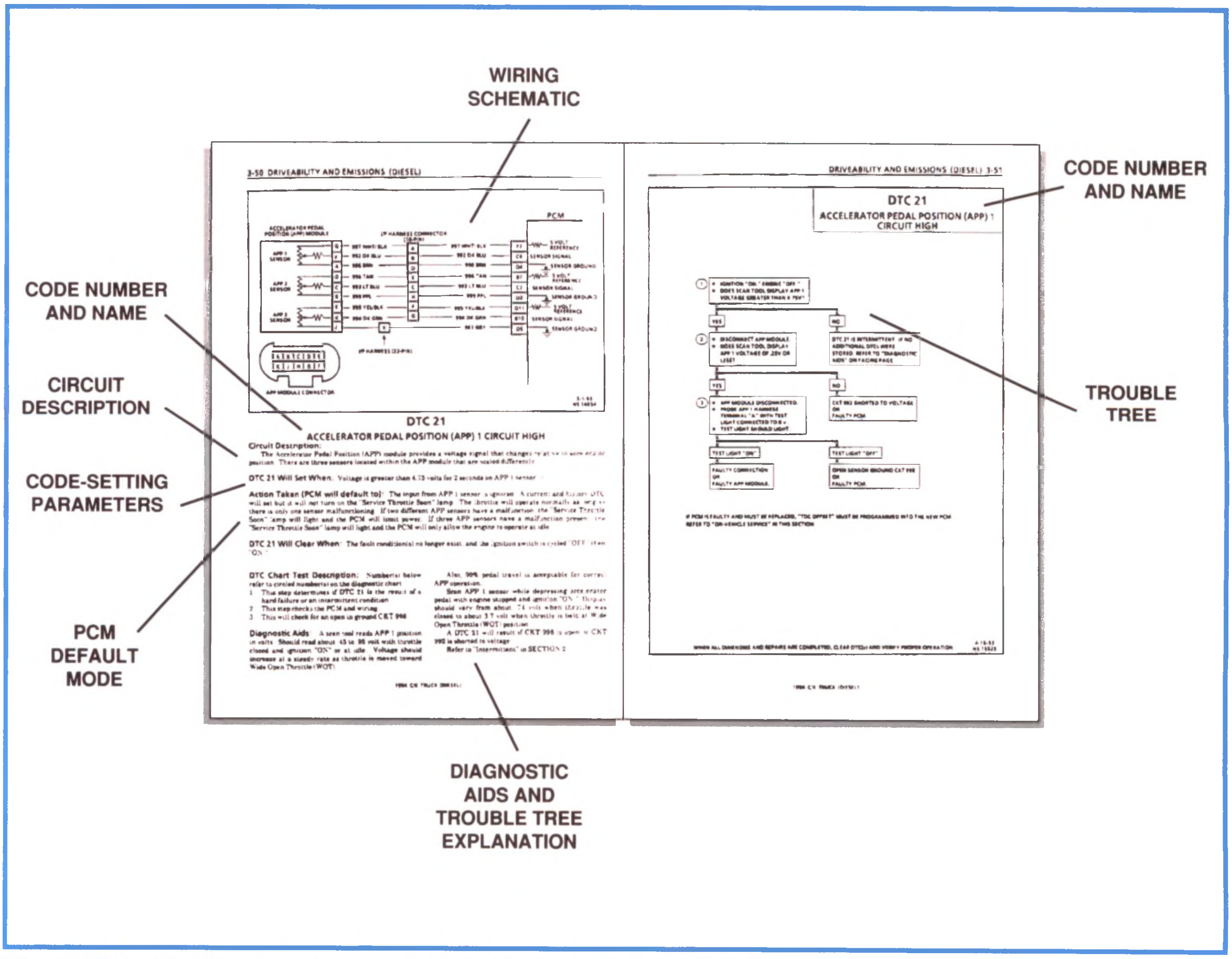


Figure 6-1, **Circuit Description and Trouble Tree Service Manual Pages**

DIAGNOSTIC TOOLS

A number of tools make diagnostics easier. They allow you to measure electrical activity on circuits and components that would otherwise be undetectable.

Digital Volt-Ohmmeter (DVOM)

A 10-megaohm digital volt-ohmmeter (DVOM) or multimeter, such as essential tool J-39200 (Fluke 87) or equivalent, is useful for testing different aspects of circuit operation. The Fluke 87 Digital Multimeter (figure 6-2) is an example of a digital multimeter.

The digital multimeter has an electronic digital readout of the value measurement being made. This type of meter has electronic circuitry for precise measurements. It is accurate to within .1 percent.

A multimeter with at least 10 megaohms input impedance is needed for use on GM vehicles. This input impedance applies to the meter only when it is used on the voltage scale. This means that the meter resists loading down the circuit being measured with a resistance of 10 million ohms. This high resistance permits measurement of very sensitive circuits without damaging or altering them.

The DVOM can function as a voltmeter to measure the magnitude of voltage. When used as an ammeter, the DVOM accurately measures extremely low current flow. When used as an ohmmeter, the DVOM measures the resistance of a circuit in ohms. These uses are described on the following pages.

6. Diagnostics

FLUKE 87 USAGE

The following terms and symbols appear on the face of the Fluke 87 Digital Mutlimeter and are used in its operation. Their meanings are explained.

Input Alert™ The meter clicks continuously if the test lead is connected to mA, mA, or A inputs on meter and the mA, mA, or A function is not selected.

Blue Button Press to toggle between AC ~ or DC ⎓ in µA, mA, or A functions. Press to toggle between Ω (ohm) and ⊣⊢ (capacitance) functions.

Hold H Press Hold and meter automatically holds each new reading; meter beeps when reading is stable (Touch Hold®). In Hz, % duty cycle, and MIN MAX, the meter stops all reading updates. Press HOLD again to exit.

Range Meter selects autoranging. Press RANGE for manual ranging (AUTO turns OFF in display). Changing ranges disables Touch Hold®, MIN MAX< and REL(ative) modes. Press RANGE for two seconds to return to autoranging.

MIN MAX Press MIN MAX to record maximum, minimum, and average readings in memory. Records true average (mean) up to 36 hours. Meter selects manual ranging. Meter beeps when a new minimum or maximum value is recorded (MIN MAX Alert™). Toggle MIN MAX to cycle through maximum, minimum average and present readings. Press MIN MAX for two seconds to exit and erase readings.

Peak MIN MAX Press MIN MAX, then ·ı)). Transients (>1ms) or sinewave (<400Hz) peak values are stored. Toggle MIN MAX to see both readings. Press ·ı)) twice to reset values without exiting MIN MAX.

Hz, % Duty Press Hz to enter frequency counter mode, press again to select % duty cycle. Press Hz again to exit. Press ·ı)) to change input trigger slope. To measure duty cycle of logic signals, select 4V DC ⎓ range.

·ı)) Select Ω and press ·ı)) for audible continuity tests (meter selects 400Z range). Threshold is –10% of each range.

REL Δ Press REL to zero display and store the reading as a relative reference. Meter selects manual ranging and zoom bar graph mode (models 83 and 85). Subsequent readings are the difference between reference and present reading. Press REL again to exit.

-▶|- Displays diode voltage drop to 3.0000V. 1mA nominal short circuit current. <3.9V open circuit test voltage. Use Touch Hold® for audible diode tests.

Ω Full scale voltage <450mV for ranges from 400Ω to 4MΩ. Full scale voltage <1.3V for 40MΩ and nS. <500µA short circuit current.

Self Test Precision 1kΩ test resistor. Select Ω, connect test lead from VΩ input to µA mA input. Display should be 1.000kΩ ± 0.005.

nS Nanosiemens. Conductance measurement for resistance >40MΩ. Select Ω and manually range until nS is displayed. To convert the reading to megaohms, divide the number displayed into 1000 (100 / nS reading = MΩ).

⊣⊢ Select Ω and press blue button. Meter autoranges to 5.00nF, .0500µF, 0.500µF, or 5.00µF range. Push-button response slows in capacitance. For capacitors <5nF, press REL to zero input or test lead capacitance. For capacitors >5µF, use an Ω range shown below and measure the analog display charge time from zero to full scale (0L):

Range =	400Ω	4kΩ	40kΩ	400kΩ	4MzΩ
µF/sec =	3000	300	30	3	0.3

[battery symbol] At least eight hours of battery life remain when symbol is first displayed.

OL 1000V rms protection in ohms, diode test, and volts. 1A, 600V fuse in µA and mA; 15A, 600V fuse in A.

[fuse symbol] To test fuses, remove test leads from any power source; select V ⎓ or V ~. Plug a test lead into MA mA input. Meter clicks if fuse is good (Input Alert™). Move test lead to A input. Meter clicks if fuse is good.

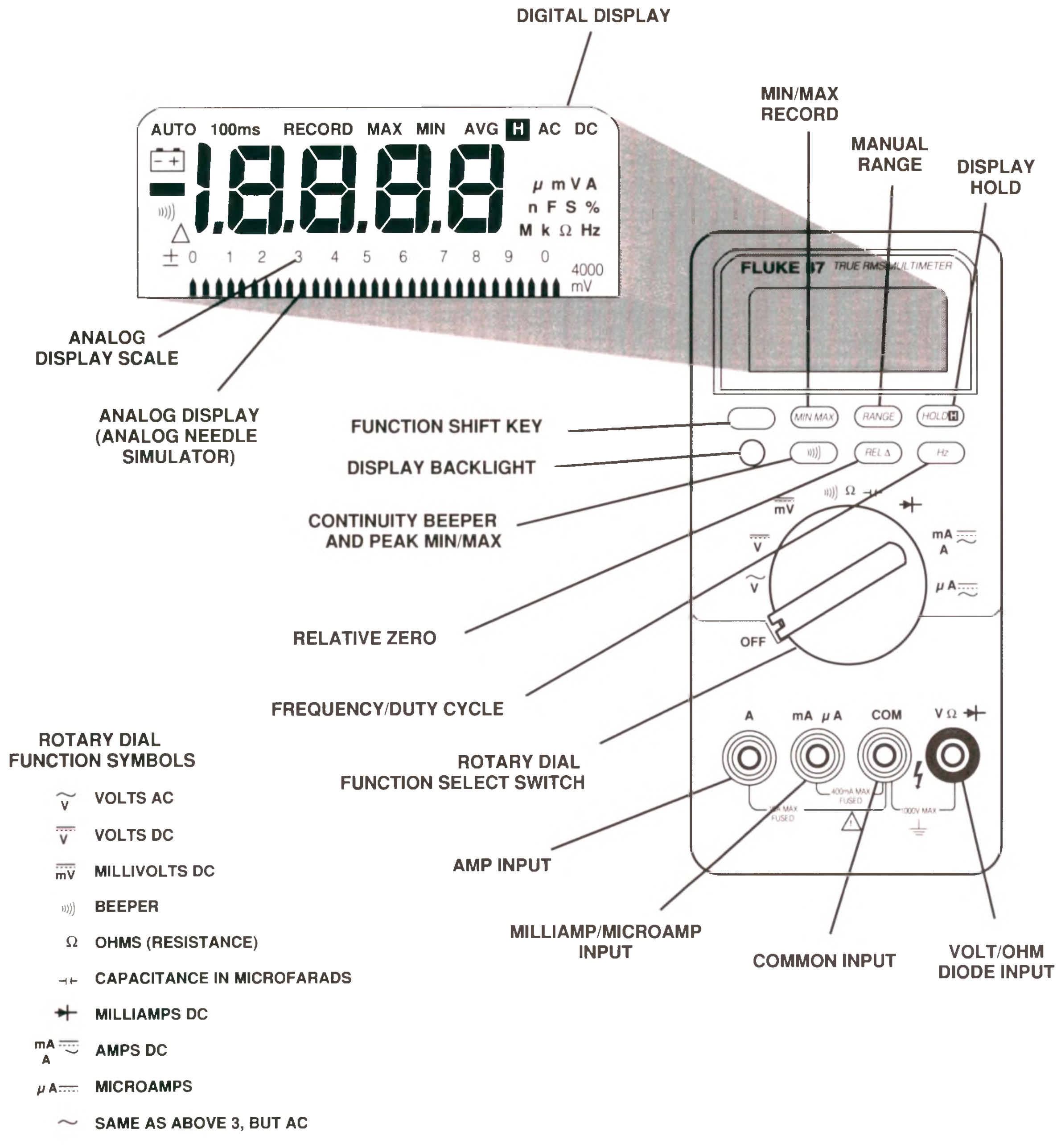


Figure 6-2, Fluke 87 Digital Multimeter

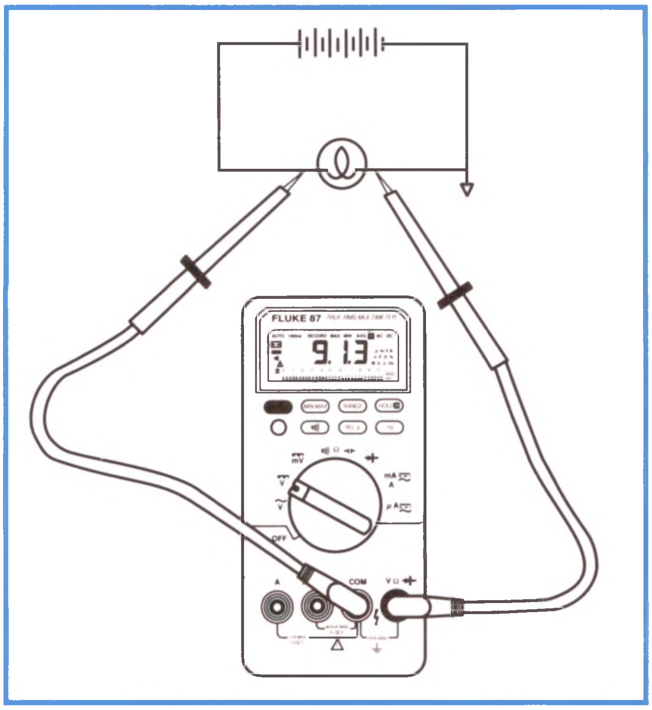


Figure 6-3, **Voltage Measurement with DVOM**

MEASURING VOLTAGE

Measuring voltage is usually the first step in testing a circuit. To test for voltage, the circuit being tested must be HOT, or receiving power. Polarity must also be observed. The negative lead of the multimeter is attached to the negative side of the circuit; the positive lead of the meter is connected to the positive side of the circuit.

Use the following procedure (figure 6-3) to test for voltage:

1. Select Volts DC or 300 mV from the selector.
2. Plug the black test probe into the "Com" input jack of the meter. Plug the red test probe into the "V" input jack.
3. Touch the probe tips to the circuit across a load or power source, as shown, in parallel to the circuit.
4. View the reading. Be sure to note the unit of measurement.

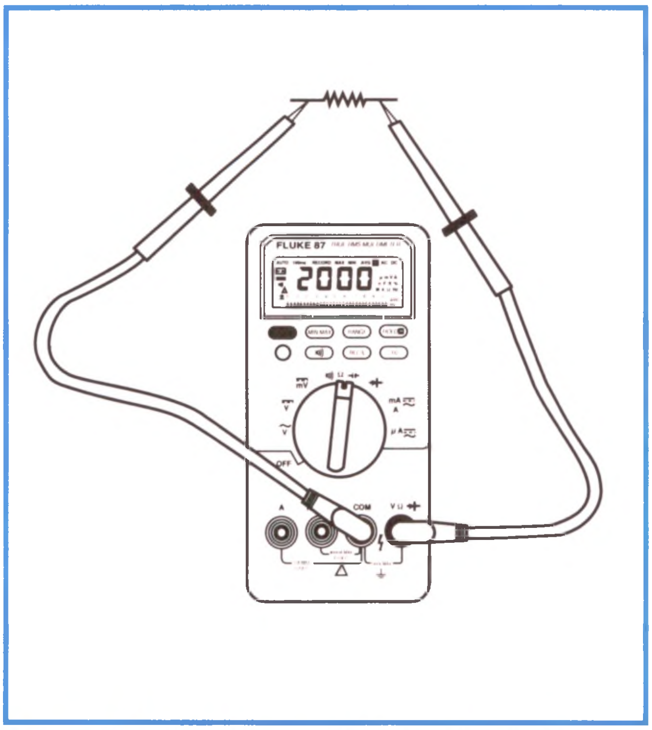


Figure 6-4, **Resistance/Continuity Testing with DVOM**

MEASURING RESISTANCE/CONTINUITY

The multimeter measures resistance by applying a test current to a circuit and measuring the voltage drop across the circuit. Resistance is measured in ohms (Ω). Resistance measurements must be made with the circuit power OFF to prevent damage to the meter and/or circuit.

The multimeter also allows continuity checking. Continuity distinguishes between an open and closed circuit. Continuity tests determine good or blown fuses, open or shorted conductors, switch operation, and circuit paths.

To perform a resistance or continuity test (figure 6-4):

1. Turn power to the circuit OFF.
2. Select resistance (Ω) from the multimeter selector.
3. Plug the black test probe of the meter into the "Com" input jack. Plug the red test probe into the "Ω" jack.
4. Connect the probe tips across the component or portion of the circuit for which you want to determine resistance.
5. View the reading. Be sure to note the unit of measurement— ohms (Ω), kilohms (kΩ), or megaohms (mΩ).

MEASURING CURRENT

Current measurements are different from the other measurements made with a DVOM. Current measurements are made in series, unlike voltage or resistance measurements, which are made in parallel. The entire circuit being measured flows through the meter. Also, the test leads must be plugged into a different set of input jacks on the meter.

To perform a current test (figure 6-5):

1. Turn power to the circuit OFF.
2. Cut or unsolder the circuit, creating a place where the meter probes can be inserted.
3. Select amps DC.
4. Plug the black test probe into the "Com" input jack. Plug the red test probe into the 10 amp or 300 milliamp input jack, depending on the expected value of the reading.
5. Connect the probe tips to the circuit across the break, as shown, so that all current will flow through the meter. This creates a series connection.
6. Turn the circuit power ON.
7. View the reading. Be sure to note the unit of measurement. If the test leads are reversed, a negative (-) sign will show in the display.

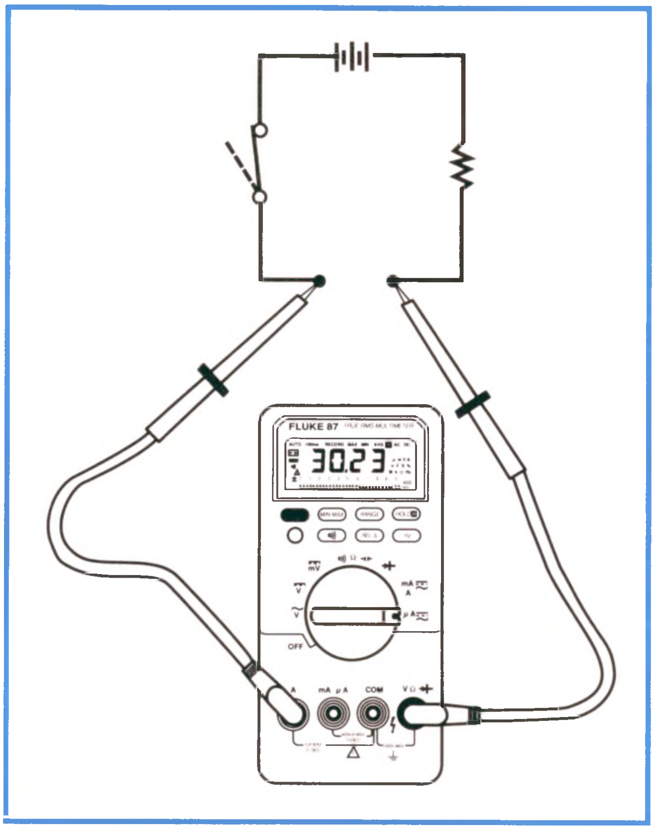


Figure 6-5, **Current Measurement with DVOM**

Circuit Testing Tools

Basic circuit testing tools such as a tachometer, a test light, and a by-pass jumper allow further circuit examination.

JUMPER WIRES

Jumper wires (figure 6-6) are simple, effective testing aids. They are used to complete a circuit by allowing current to "jump" across a suspected open or break. Thus, they are actually a test of continuity.

When a jumper wire is used, it replaces a suspected faulty portion of a circuit with a know conductor. If the circuit works properly when the jumper wire is in place, but not without it, an "open" is indicated in the area jumped. Use a jumper wire to bypass only nonresistive parts of a circuit, such as switches, connectors, and sections of wiring.

> — NOTICE —
> **Never bypass a lamp, motor, coil, or any load with a jumper wire. This reduces circuit resistance, causing very high current flow. High current could damage wiring and components.**

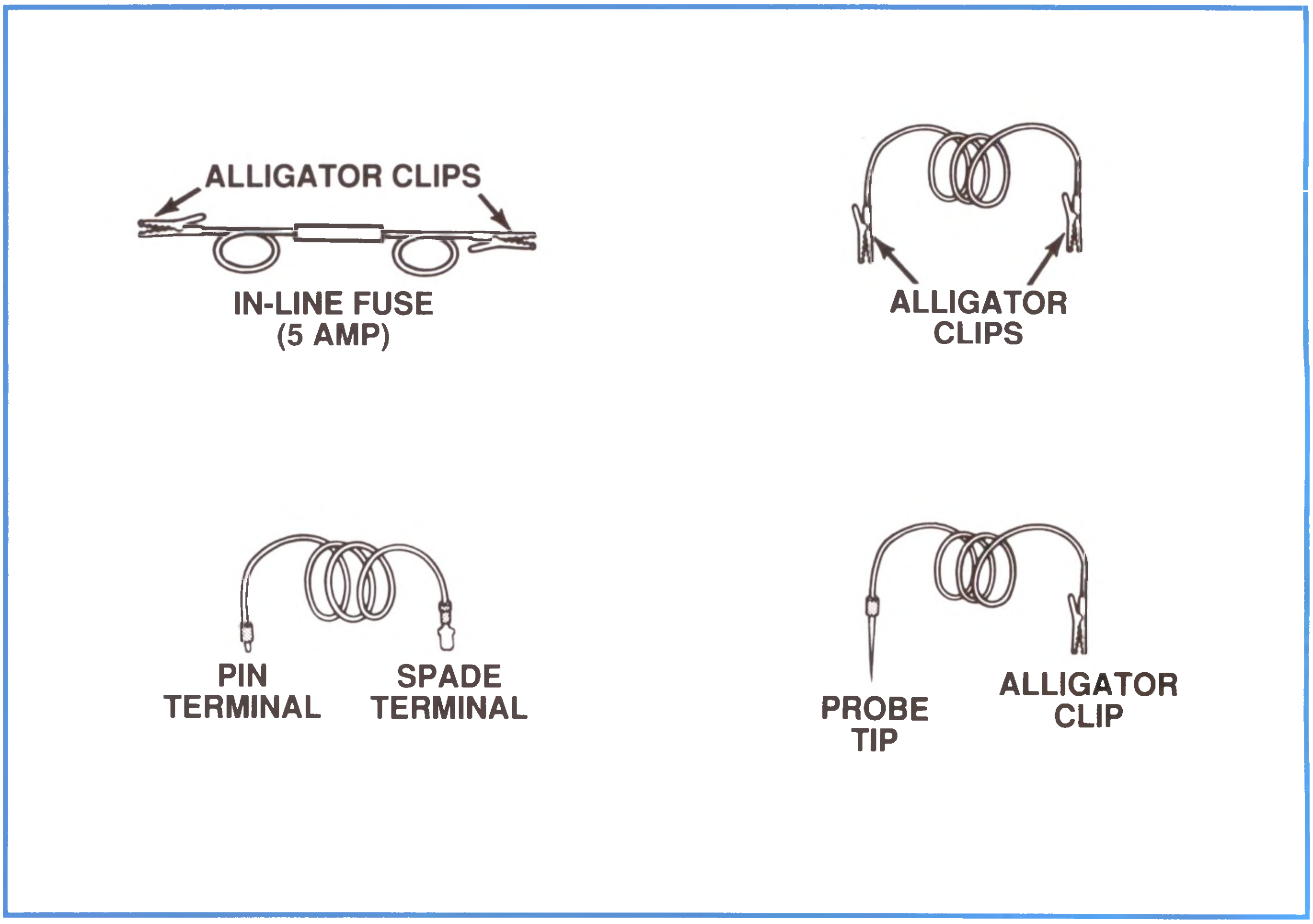


Figure 6-6, Types of Jumper Wires

TEST LIGHTS

Test lights are used to check for voltage and continuity. There are two types: self-powered and non self-powered (figure 6-7).

Self-Powered Test Light

The self-powered test light check for continuity. It consists of a light bulb, battery, and two leads (figure 6-8). If the leads are touched together, the bulb will light.

A self-powered test light is used only on an nonpowered circuit. Select two specific points along the circuit through which there should be continuity. Connect one lead of the test light to each point. If there is continuity, the test light circuit will be completed and the bulb will light.

— NOTICE —
The power to a circuit must be OFF when using a self-powered test light. If the light is connected to a "live" circuit, the circuit's high current will cause the test light's 3V lamp to burn out.

— NOTICE —
Do not use a test light on electronic circuits. Its low resistance will allow too much current to pass through the circuits, which could damage sensitive electronic parts.

Non Self-Powered Test Light

A non self-powered test light is used to check for voltage (figure 6-9). The tool is made of a 12-volt light but with a pair of leads attached. After grounding one lead, touch the other lead to various points along the circuit where voltage should be present. When the bulb goes ON, there is voltage at the point being present.

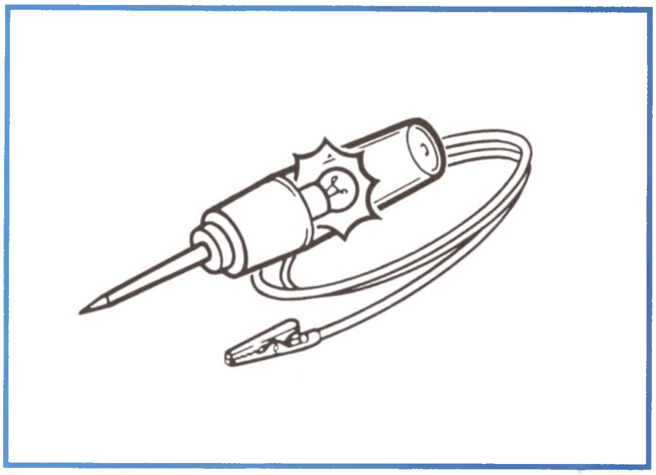


Figure 6-7, Test Light

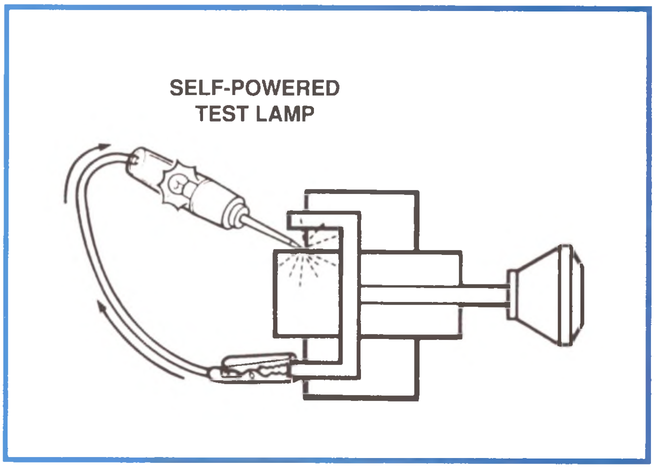


Figure 6-8, Continuity Check With Test Light

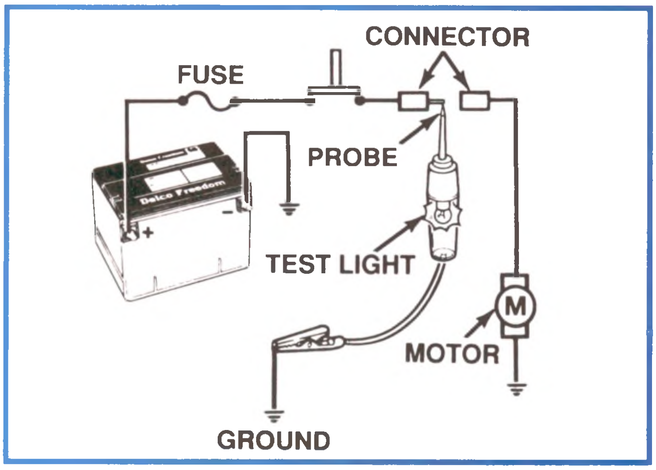


Figure 6-9, Voltage Check With Test Light

"Scan" Tools

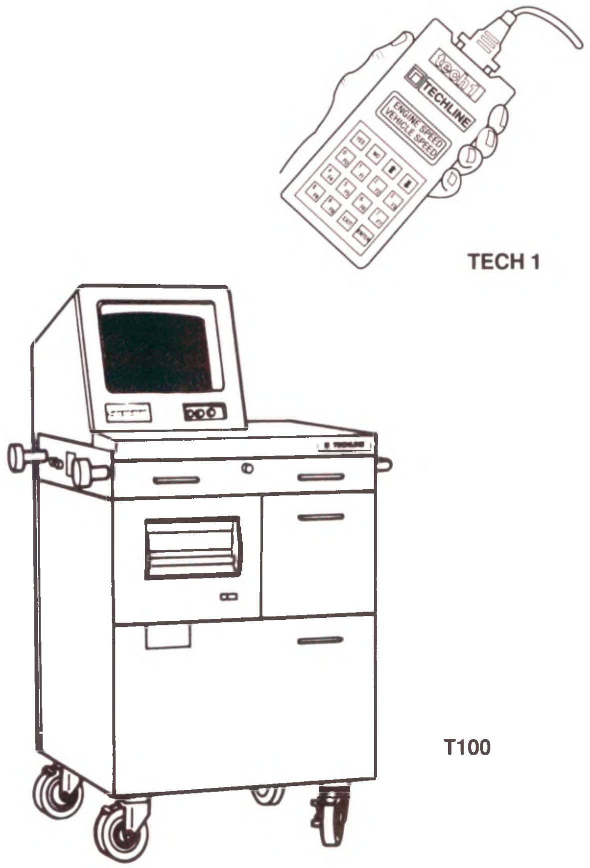


Figure 6-10, Tech 1 and T100 "Scan" Tools

Diagnostic "Scan" tools are the most versatile and effective way to isolate circuit faults, identify improper component operation, and otherwise troubleshoot the electrical circuits of the engine management system.

Two "Scan" tools are available to General Motors technicians (figure 6-10): the hand-held Tech 1 and the T100 Computerized Automotive Maintenance System (CAMS). Both systems offer Diagnostic Trouble Code (DTC) capabilities. The Tech 1, however, is more versatile. It can be used inside the vehicle and on road-tests for capturing intermittents.

Tech 1 usage is covered in detail later in this section.

OTHER DIAGNOSTIC AIDS

Several other on-vehicle items aid in diagnostics.

Data Link Connector (DLC)

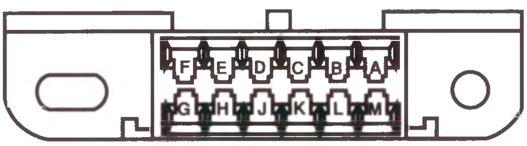


Figure 6-11, Data Link Connector (DLC)

The Data Link Connector (DLC) is located under the left side of the instrument panel (figure 6-11). It is a twelve-terminal connector wired to the PCM. By connecting a jumper wire between terminals "B" and "A" or connecting the Tech 1 adapter to the DLC, you can gain access to Diagnostic Trouble Codes (DTC).

"Service Throttle Soon" (STS) Lamp

The "Service Throttle Soon" (STS) lamp alerts the driver to problems involving the Accelerator Pedal Position (APP) sensors. If any of the sensors are inoperative or operating out of normal range, the "Service Throttle Soon" lamp will illuminate. Diagnostic Trouble Codes (DTC) may also set, depending on the degree of sensor failure.

Malfunction Indicator Lamp (MIL)

The MIL in the instrument cluster alerts the vehicle operator to driveability problems requiring service. The lamp illuminates and stays illuminated under most DTC conditions. The MIL can also be used by technicians to displays codes in the event a Tech 1 "Scan" tool is unavailable.

The lamp initially comes "ON' at ignition startup as a part of the vehicle bulb check. At engine "ON," the lamp turns "OFF." If it remains "ON," this indicates a problem with the PCM diagnostic system. If a problem goes away, the SES lamp will turn "OFF." The DTC will be stored in the PCM memory as a history code and can be retrieved using the following procedure.

— IMPORTANT —
On 6.5L EFI diesel vehicles, DTC 12 does not display at the MIL if other codes are stored. DTC 12 displays only if no other codes are stored.

READING DIAGNOSTIC TROUBLE CODES AT THE MIL

1. A jumper wire is applied across terminal "A" and "B" of the DLC.
2. The ignition key is turned to the "ON" position.
3. If no codes are stored in the PCM, the MIL will flash a DTC 12. This code indicates that the PCM diagnostic system is operating correctly. The flash sequence for DTC 12 is "flash, pause, flash-flash" followed by a long pause. This sequence appears three consecutive times.

   If DTC 12 is not indicated, there is a fault in the PCM diagnostic system, and the system should be checked using the appropriate diagnostic chart.
4. Each code is flashed three times. The first digit in the code number is indicated, followed by a pause and the second digit. For instance, DTC 35 would be indicated "flash-flash-flash, pause, flash-flash-flash-flash-flash." A long pause occurs between each sequence display.

CLEARING DIAGNOSTIC TROUBLE CODES AT THE DLC

To manually clear diagnostic trouble codes from the PCM, do the following:

1. Turn the ignition "OFF."
2. Ground DLC terminal "B" to "A."
3. Turn the ignition "ON."
4. Fully apply and hold the brake pedal.
5. Fully apply and hold the accelerator pedal.
6. Check the MIL for DTC 12.
7. Release the brake pedal.
8. Release the accelerator pedal.
9. Check the MIL for DTC 12.
10. Remove the jumper from the DLC.
11. Turn the ignition "OFF."

— IMPORTANT —
Any DTCs stored in PCM memory as history codes will be automatically cleared if the problem does not appear again within 50 ignition cycles.

DIAGNOSTIC STRATEGY

A diagnostic strategy (figure 6-12) is simply an organized process of elimination. It directs you to look for the simplest cause to a problem first, before undertaking more difficult and time-consuming procedures.

A key element of a sound diagnostic strategy is the On-Board Diagnostic Check (figure 6-13).

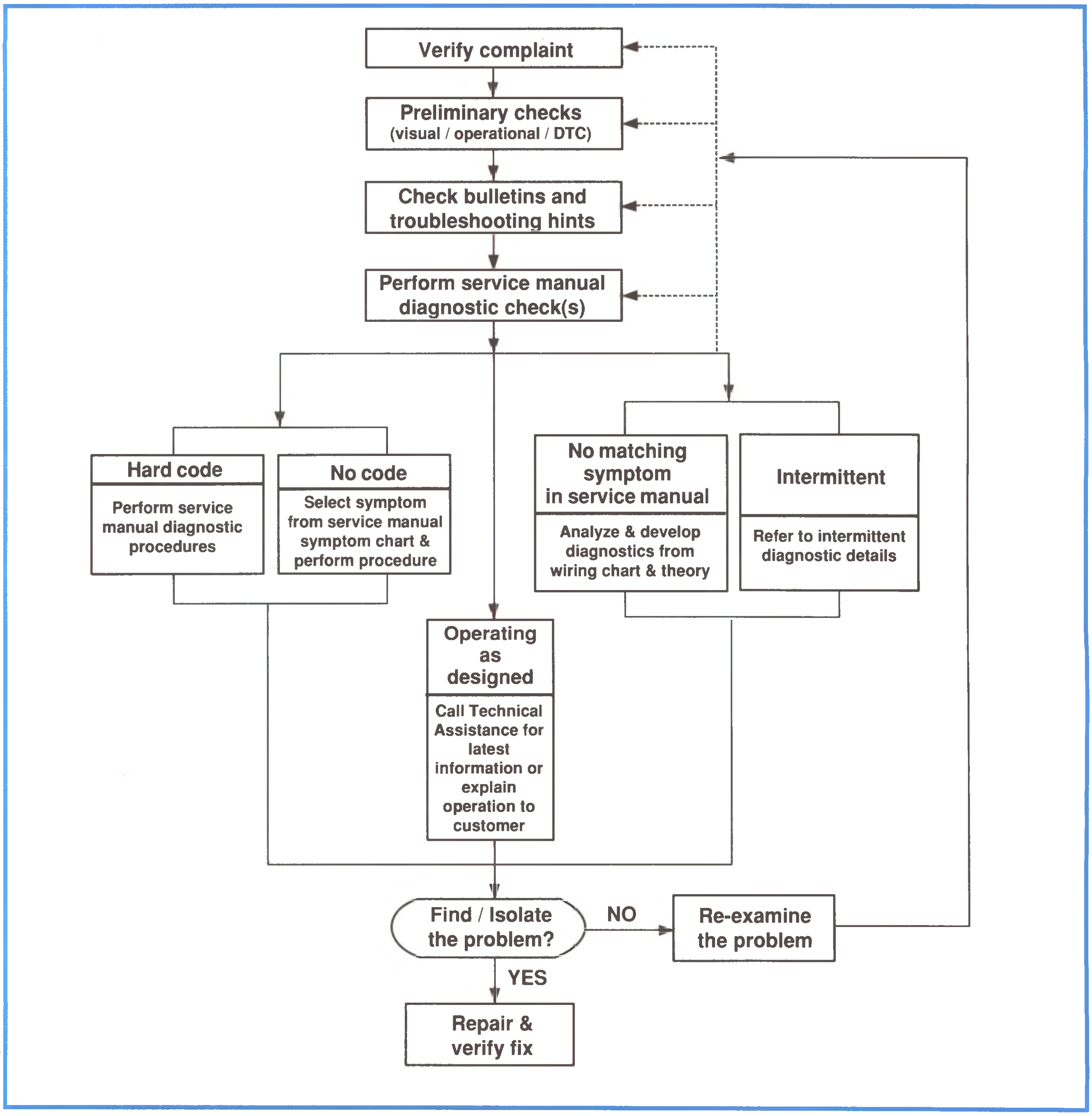


Figure 6-12, **Strategy-Based Diagnostic Approach**

ON-BOARD DIAGNOSTIC (OBD) SYSTEM CHECK

(USING TECH 1 SCAN TOOL)

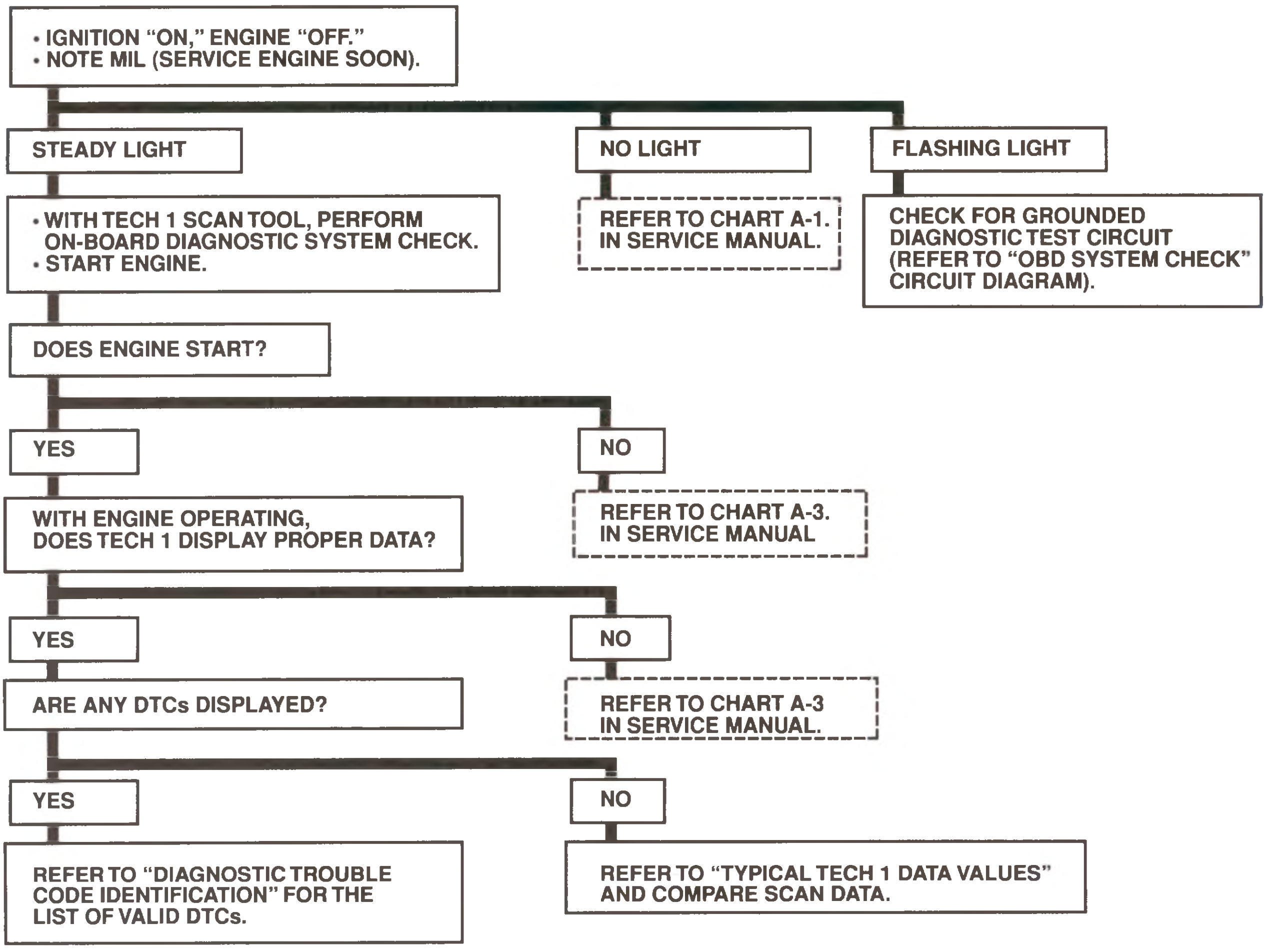


Figure 6-13, On-Board Diagnostic (OBD) Check

DIAGNOSTIC APPROACHES

Three diagnostic approaches can be used to solve driveability problems: code-based diagnostics, symptom-based diagnostics, and system-based diagnostics. Each has a specific purpose and should only be undertaken as directed by the On-Board Diagnostic (OBD) check.

Code-Based Diagnostics

Code-based diagnostics centers around the Diagnostic Trouble Codes (DTCs) stored by the PCM. These codes are systematically numbered so that each code relates to a specific fault at a specific component. Using a "Scan" tool or the Malfunction Indicator Lamp (MIL), you can identify and correct the code condition(s) by following the appropriate trouble tree.

As much as possible, code numbering consistency is used in all GM vehicles. Depending on vehicle options and equipment, code numbers may or may not apply to specific vehicles. When using code-based diagnostics, always begin with the lowest numbered code first.

A complete list of 6.5L EFI diesel DTCs is contained in section 7 of this book. The list includes the code number, name, and the page number on which the circuit description for the code is located.

Symptom-Based Diagnostics

Symptom-based diagnostics are used for conditions that don't set Diagnostic Trouble Codes but still result in driveability complaints such as sluggish performance, hard starting, or intermittents. These conditions generally produce normal "Scan" tool data values. Procedures for diagnosing driveability symptoms are found in section 2, "Driveability Symptoms," of the Driveability and Emissions manual.

Covered conditions include:

- Intermittents
- Hard Starts
- Surges and/or Chuggles
- Lack of Power, Sluggish, Spongy
- Fuel Knock/Combustion Noise
- Poor Fuel Economy
- Excessive Smoke

INTERMITTENTS

> **— IMPORTANT —**
> **Do not use the diagnostic code charts in section 3 of the Driveability and Emissions Service Manual for intermittent conditions. A fault must be present to locate the problem. If a fault is intermittent, use of diagnostic code charts may result in the replacement of good parts.**

Intermittent conditions can be especially difficult to isolate. Use the following procedure for diagnosing intermittents.

1. Most intermittent problems are caused by faulty electrical connection or wiring. Perform careful visual/physical checks as described earlier in this section and in the Service Manual. Check for:
   - Poor mating of the connector halves or terminal not fully seated in the connector body (backed out).
   - Improperly formed or damaged terminal. All connector terminals in the problem circuit should be carefully reformed or replaced to insure proper contact tension.
   - Poor terminal-to-wire connection. This requires removing the terminal from the connector body in order to check. Refer to "Wiring Harness Service" in the Service Manual.
2. If a visual/physical check does not find the cause of the problem, the vehicle can be driven with a voltmeter connected to a suspected circuit. A Tech 1 "Scan" tool can also be used to help detect intermittent conditions. An abnormal voltage or Tech 1 "Scan" tool reading when the problem occurs indicates the problem may be in that circuit. If the wiring and connectors check OK, and a diagnostic code was stored for a sensor circuit, substitute a good sensor and recheck.
3. An intermittent MIL/"Service Engine Soon" lamp with no stored diagnostic code may be caused by:
   - MIL/"Service Engine Soon" lamp wire to PCM shorted to ground.
   - "Diagnostic Request" terminal wire to PCM shorted to ground.
   - PCM power supply problems.
   - Internal PCM intermittent problems.
4. Check for electrical system interference caused by a defective relay, PCM driven solenoid, or switch. They can cause a shard electrical surge. Normally, the problem will occur when the faulty component is operated.
5. Check for improper installation of electrical options such as lights, 2 way radios, etc.
6. Check for open diode across A/C compressor clutch, and for other open diodes (refer to wiring diagrams).
7. If a problem has not been found, refer to the "PCM Connector Symptom" chart in the Driveability and Emissions Service Manual.

System-Based Diagnostics

System-based diagnostic routines are used, as directed by the OBD check, when data parameter(s) are abnormal but not so far out of range or in combination with other parameters to set a code. Covered systems include: Fuel System, Glow Plug System, Exhaust Gas Recirculation (EGR) System, Transmission Controls, Crankcase Ventilation System, and Air Intake System

TECH 1 “SCAN” TOOL

Overview

The PCM is continually monitoring and communicating with the different electronic systems of the vehicle. It monitors input data from sensors and uses this data to command solenoids, relays, switches, and indicator lamps. When the incoming data is within range and the PCM and output devices are functioning properly, the vehicle operates as it should.

But when one or more of these three variables (inputs, PCM, outputs) is out of range, a driveability problem can occur. If a Diagnostic Trouble Code is stored, identifying the problem is relatively simple. For non-code conditions, however, diagnosis requires pinpointing where the cause lies.

The Tech 1 “Scan” tool makes the search easier. It allows you to see data and activity on electrical circuits *as seen by the PCM.* This distinction is important to understand. If the PCM is not seeing data correctly, it may set a code even though nothing is actually wrong with engine operation. This is why the OBD check must be performed before beginning any diagnostics. The OBD verifies proper PCM diagnostics.

The Tech 1 accesses vehicle electronic information through the Diagnostic Link Connector (DLC). Through this capability, you can witness actual voltage signals on a particular circuit and compare them to what should be the normal signals for that circuit. The Tech 1 not only reads data, it can also send data to allow you to command various switches, solenoids, and relays “ON” and “OFF.” This two-way capability is what makes the Tech 1 “bidirectional.” When connected to the DLC, the Tech 1 allows you to:

- conduct tests to monitor input data
- retrieve diagnostic data or codes
- control output functions

— IMPORTANT —
General Motors training center course #16018.10 provides a comprehensive overview of Tech 1 operation and usage, including some of the features only mentioned in this booklet. Consult your training center schedule of classes for times and dates the Tech 1 course is offered in your area.

— IMPORTANT —
The Tech 1 and T100 diagnostic systems offers similar diagnostic capabilities. But because of its hand-held flexibility and its use as the foundation for Service Manual diagnostics, the Tech 1 is used in this course as an example of “Scan” tool operation.

Components

The Tech 1 consists of the following elements (figure 6-14):

- A display screen where information and instructions can be read. The display area is 16 characters wide and accommodates a maximum 4 lines of text.
- A keypad where information is entered. There are 16 keys
- Slots for master and auxiliary cartridges
- A power-source connector
- A power plug
- A Data Link Connector (DLC) connector

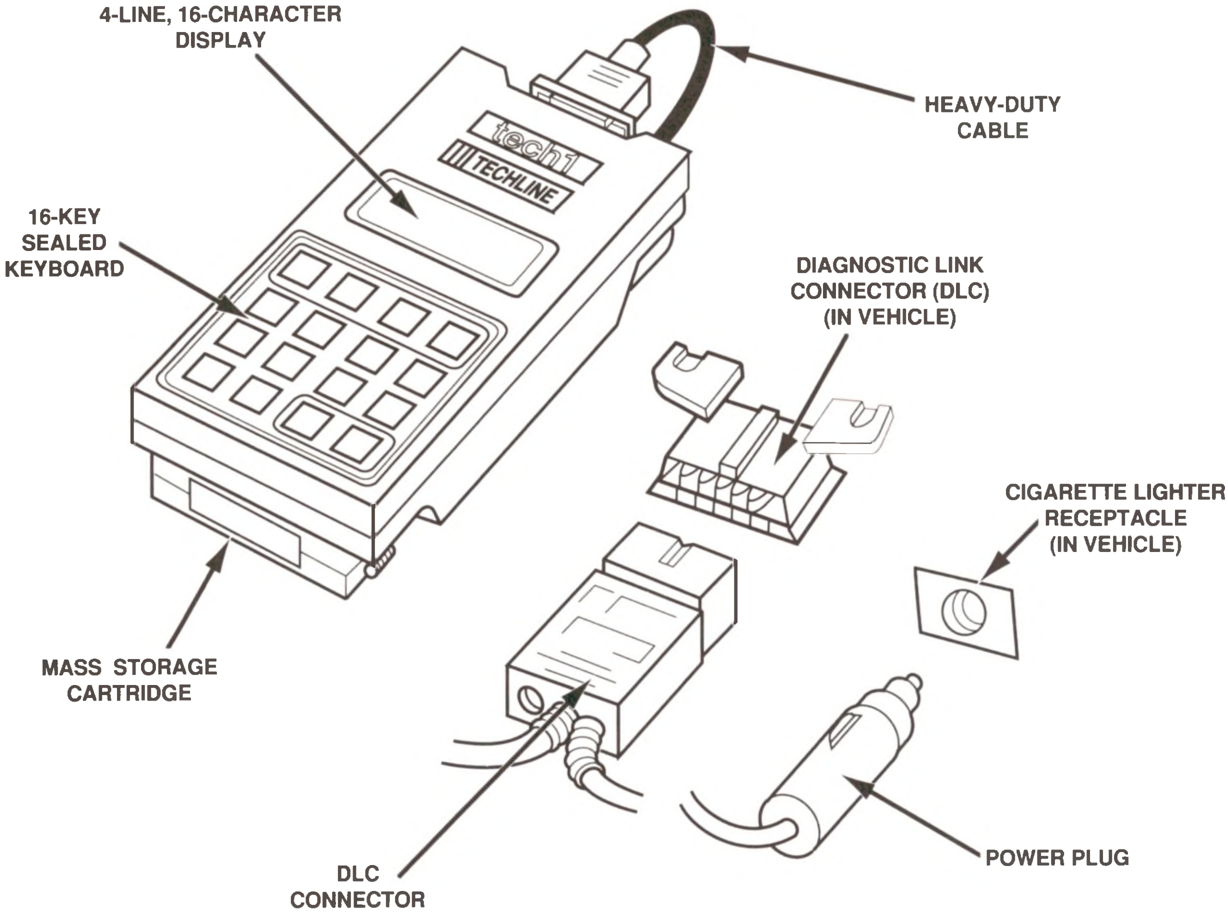


Figure 6-14, **Tech 1 Components**

KEYPAD OPERATION

The Tech 1 numeric keypad is used to enter information and navigate through the diagnostic procedures. Key functions are described below:

- **YES/NO keys.** These keys are used to answer questions posed by the Tech 1. They are also used to move to another pair of data parameters when data is being displayed.
- **UP/DOWN arrow keys.** These keys allow you to scroll up and down the display. The Tech 1 screen can only display four lines of information. Additional information beyond four lines is contained on secondary screens that are accessed using the arrow keys.
- **0–9/F0–F9 keys.** These shared-function keys are used to enter numerical data or to choose different test modes, as prompted by the display screen.
- **ENTER key.** This key is used to initiate or confirm an action when prompted by the display screen. When pressed for more than three seconds, the ENTER key will initiate the Tech 1 self-test.
- **EXIT key.** This key is used to backup to previous displays or modes. When the EXIT key is pressed for more than three seconds, the Tech 1 will return to the beginning of the program.

6. Diagnostics

MASTER AND AUXILIARY CARTRIDGES

Two slots in the Tech 1 base accommodate software cartridges. The lower slot is for the master cartridge; the upper slot is for auxiliary cartridges.

Master Cartridge

A vehicle may be equipped with several on-board microprocessors, in addition to the PCM. These could include an ABS module, a body control module, or a diagnostic energy reserve module for air bag systems. The Tech 1 can work with these different control modules by using software cartridges specific to the system in question.

Prior to 1993, master cartridges were issued that covered several model years of each separate system. In 1993, the Mass Storage Cartridge (MSC) was introduced. The MSC covers numerous systems and model years. It is also more versatile. Its information can be updated by being erased and/or written over. This is accomplishable on-site at the dealership with the proper equipment.

Auxiliary Cartridges

Auxiliary cartridges are also available. These extend the functions of the Tech 1. Special function cartridges allow you to take measurements from sources other than the DLC. Or, they allow you to connect the Tech 1 to a printer or monitor.

Tech 1 Strategy and Organization

When its use is called for by the various trouble trees in the Service Manual, the Tech 1 follows a logical, step-by-step strategy for diagnostics. Once preliminary information is entered, the Tech 1 offers a variety of options, depending on the kind of information is required. Understanding where you are within the Tech 1's hierarchy is important for understanding what kind of related testing can be done as well as what kind of information is being produced. The reference section of this book contains tree-type charts of Tech 1 screen displays.

Preparing the Tech 1

Use the following procedures to prepare the Tech 1 for use with the 6.5L EFI V8 diesel engine PCM.

1. Install the appropriate master cartridge in the bottom slot of the Tech 1 by squeezing the tabs on the cartridge and sliding it into the connector. Do not force the cartridge; it only fits one way.

2. Make sure the ignition is turned "OFF" before connecting the Tech 1 to the vehicle being tested. Plug the Tech 1 power cord into the cigarette lighter of the vehicle. The Tech 1 display will become active. The screen should display the text shown in figure 6-16.

> — NOTICE —
> **If the Tech 1 display does not become active or the display is incorrect, check the polarity of the Tech 1 plug. If you are using the battery cable adapter, be sure its polarity is correct. Incorrect polarity could damage the Tech 1.**

3. Ensure that the Tech 1 recognizes the cartridge.
   - If the Tech 1 does not recognize the cartridge, check to see that the correct cartridge has been installed for the test you want to perform.
   - If the cartridge is correct and the Tech 1 doesn't recognize it, unplug the power cord, remove the cartridge, and clean the cartridge and Tech 1 contacts with Goodwrench Circuit Board Cleaner, p/n 12345350, or equivalent. Reinstall the cartridge.

4. Insert the Tech 1 connector plug to the DLC.

5. Turn the ignition key "ON," or start the vehicle. The "Applications" screen shown in figure 6-17 should be displayed.

MASS STORAGE
CARTRIDGE
(VERSION 1.1)
<ENTER>

Figure 6-16, **Tech 1 Active Display Screen**

APPLICATIONS ↑↓
F0: POWERTRAIN
F1: POWERTRAIN
F2: CHASSIS

Figure 6-17, **Applications Screen (1 of 2)**

APPLICATIONS ↑↓
F3: BODY
F4: PROGRAMMING
F5: TRAINING

Figure 6-18, **Applications Screen (2 of 2)**

```
88-94 POWERTRAIN
(VER. 1.1)
SELECT
MODEL YEAR: 19??
```

Figure 6-18, **Powertrain Identification Screen**

```
1994 SELECT:
F0: VIN
F1: MFI    F5: CMFI
F2: TBI    F6: DIESL
```

Figure 6-19, **PCM Identification Screen**

```
SELECT 8TH DIGIT
OF VIN CODE:
4AFHKMNPSUWYZ
```

Figure 6-20, **VIN Selection Screen**

```
SELECT VIN F ENG
6.5L DIESEL
TRUCK?
94 (YES/NO)
```

Figure 6-21, **VIN Verification Screen**

Powertrain Diagnostics

1. With the "Applications" screen visible (refer to figure 6-17), press the F0 key to enter powertrain diagnostics.

2. The next screen to display (figure 6-18) asks you to identify the vehicle model year. Do this by entering the vehicle model year's last two digits. This information can be obtained from the vehicle identification number (VIN). It is the tenth character of the VIN. For instructions on identifying VIN codes, consult the General Information section of the Driveability and Emissions Service Manual.

3. After entering the model year, the Tech 1 screen prompts you for the vehicle PCM type, as shown in figure 6-19. You can identify the PCM type in one of three ways:
   a. By entering the eight digit of the VIN code, which identifies engine type
   b. By identifying the fuel delivery system of the vehicle
   c. By selecting "diesel" from the selection screen (figure 6-19).

Identifying PCM by VIN engine code:

- Select VIN by pressing the F0 key from the PCM identification screen shown in figure 6-19.
- The Tech 1 will display the screen shown in figure 6-20, asking you to enter the eighth digit of the vehicle's VIN.
  - Press the NO key to scroll through the choices until you arrive at the correct character.
  - With the correct character highlighted, press the YES key to make the selection.
- The Tech 1 will prompt you to verify the PCM/engine type, as shown in figure 6-21. Press YES if correct.

Identifying PCM by fuel delivery system:

- From the PCM selection screen (see figure 6-19), press F1 to select PFI.
- Again, select the character corresponding to the eight character of the vehicle's VIN (see figure 6-19). Use the NO key to scroll until the correct characters is highlighted, then press YES.
- The Tech 1 will display will ask you to verify the PCM according to type (figure 6-22). Press YES is this is correct.

Identifying PCM by engine type:

- From the PCM selection screen (see figure 6-19), press F6 to select diesel. A confirmation screen (figure 6-23) will appear.

4. After identifying the PCM type, perform the On-Board Diagnostic (OBD) check, as described earlier in this section or in section 3 of the Service Manual.

   The OBD verifies proper operation of the PCM's self diagnostics. These on-board diagnostics must be operating properly for the PCM to accurately monitor vehicle systems and store Diagnostic Trouble Codes. The OBD directs you to retrieve trouble codes and perform the appropriate diagnostics, or to compare Tech 1 data with the typical values for various system components. These, as well as other processes, are described on the following pages.

```
SELECT MFI ENG
6.5L (VIN=F)
DIESEL TRUCK
94 (YES/NO)
```

Figure 6-22, **MFI Verification Screen**

```
SELECT ENGINE:
6.5L (VIN=F)
DIESEL TRUCK?
94 (YES/NO)
```

Figure 6-23, **Engine Verification Screen**

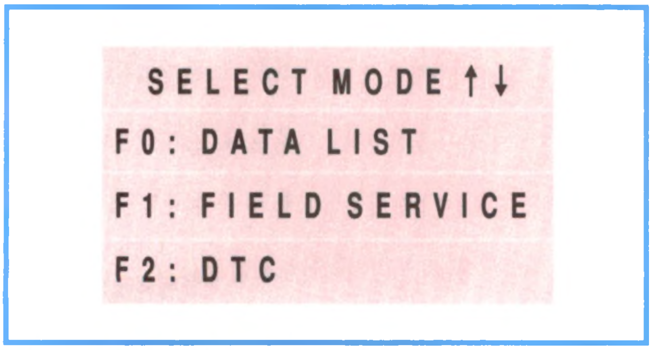


Figure 6-24, **Test Mode Menu (1 of 2)**

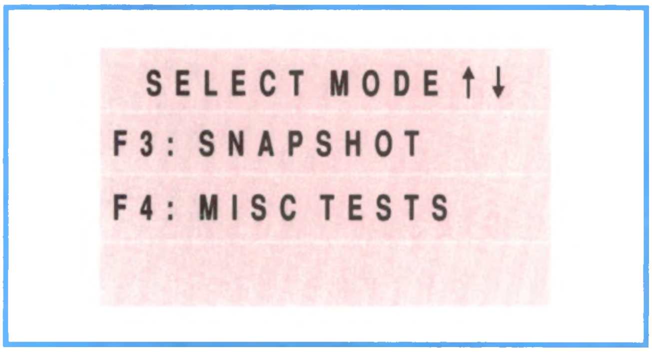


Figure 6-25, **Test Mode Menu (2 of 2)**

Test Mode

After completing the OBD, you can enter the Tech 1's "Test Mode." This mode offers a variety of testing and data compilation options, as shown in figures 6-24 and 6-25. These options are described below.

- **F0: Data List** — this option displays the data parameters for identified data pairs.
- **F1: Field Service** — this option grounds terminal "B" of the DLC. This puts the PCM in Field Service mode. The "Service Engine Soon" lamp will flash any stored codes or loop status.
- **F2: DTC** — this option displays Diagnostic Trouble Codes (DTC) stored in the PCM. Both current and history codes are displayed, from lowest to highest.
- **F3: Snapshot** — this option takes a "snapshot" of data and stores it for later retrieval. This is particularly useful for diagnosing intermittent conditions.
- **F4: Misc Test** — this option access a variety of miscellaneous tests. The number of tests varies, depending on system capabilities.

The Data List, DTC, and Snapshot options are further described on the following pages. For instructions on other Miscellaneous Tests and other Tech 1 options, consult the Tech 1 Operator's Manual.

F0:DATA LIST

The Data List mode can be used to view the data parameters for various engine functions. This data can be compared against the typical or normal data parameters. Select Data List by pressing the F0 key at the Test Mode menu (see figure 6-24).

After selecting data list, a screen allows you choose which system's data you want to view (figure 6-26). The choices are engine, transmission, or both.

Data Pairs

After you choose the data list system(s), the Tech 1 displays data list information in pairs. One scan position will appear at the top of the screen with its data value immediately underneath in the appropriate units. The second scan position will appear below the upper one, as shown in figure 6-27.

The Mass Storage Cartridge is preprogrammed with data pairs. You can scroll forward an backward through the list of predefined data pairs by using the YES and NO keys.

You can also create your own pair by locking either of the pair elements and scrolling the other entry until a new scan position is reached. To create your own data pair, use the following procedure.

1. With a data pair displayed on the Tech 1 screen, press the F0 key. An asterisk will appear to the left of the uppermost parameter's data (figure 6-28), This asterisk indicates that the parameter is locked.
2. Pressing the YES and NO keys will cause the bottom parameter to scroll.
3. To lock the bottom parameter, you must first unlock the top parameter. Do this by pressing the F1 key. The asterisk next to the top parameter data will disappear.
4. With the top parameter unlocked, press the F1 key again. An asterisk will appear next to the data of the bottom parameter (figure 6-29).
5. With the bottom parameter locked, use the YES and NO keys to scroll the top parameter until a desired position is found.
6. To unlock the bottom parameter, press the F0 key.

Only one parameter can be locked at a time. Also, the data pairs you create cannot he held permanently. If you unlock a fixed parameter and begin scrolling, you will return to the preprogrammed pairs.

```
  SELECT DATA
F0: ENGINE
F1: TRANSMISSION
F2: BOTH
```

Figure 6-26, Data List Options

```
ENGINE SPEED
  1075 RPM
DESIRED IDLE
  1037 RPM
```

Figure 6-27, Tech 1 Data Pair Screen

```
ENGINE SPEED
*  1075 RPM
DESIRED IDLE
   1037 RPM
```

Figure 6-28, Data Pair with Upper Parameter Locked

```
ENGINE SPEED
   1075 RPM
DESIRED IDLE
*  1037 RPM
```

Figure 6-29, Data Pair with Lower Parameter Locked

Typical Tech 1 "Scan" tool data is provided in the chart below.

Scan Position	Units Displayed	Typical Data Value
Engine Speed	RPM	± 100 RPM from desired
Desired Idle	RPM	PCM commanded (based on temperature)
Eng. Cool Temp.	C°/F°	85°C – 105°C (185°F – 221°F)
Intake Air Temp.	C°/F°	10°C – 90°C (50°F – 194°F)
Baro	Kpa/Volts	70 – 100 kpa / 3.5 – 4.5 v (varies with altitude)
EGR Pressure	Kpa/Volts	50 – 100 kpa / 2.8 – 3.0 v (varies with altitude)
EGR Duty Cycle	Percentage	0%
Wastegate Sol DC	Percentage	60%
Boost Presue	Kpa/Volts	99 – 160 kpa / 1.0 – 2.5 v
Fuel Temperature	C°/F°	21°C – 44°C (70°F – 110°F)
Fuel Rate	Millimeters	0 – 40 (varies with engine load)
Glow Plug Relay	Volts	12.0 – 14.5
Glow Plug Volts	Volts	12.0 – 14.5
Desired Inj Tim	# of degrees	(varies)
Measured Inj Tim	# of degrees	(varies)
Throttle Angle	Percentage	0%
Accel Ped Pos 1	Volts	0.35 – 0.95 v
Accel Ped Pos 2	Volts	4.0 – 4.5 v
Accel Ped Pos 3	Volts	3.6 – 4.0 v
Cruise Control	On/Off	off
Inj Pump Set	# of degrees	(varies)
Brake Switch 1	Open/Closed	open
Brake Switch 2	Closed/Open	closed
TDC Offset	# of degrees	0 – 2.02 (varies)
A/C Clutch	On/Off	off
System Voltage	Volts	12.0 – 14.5 v
Eng Shut Off	On/Off	on
Inj Pulse Width	Milliseconds	1.5 – 2.5 ms (may vary)
Crank Ref Missed	Counts	0
Cam Ref Missed	Counts	0
1-2 Sol/2-3 Sol	On/Off	on/on
TCC Solenoid	On/Off	off
4WD Low Switch	On/Off	off
Trans Range Sw	Invalid, Rev Drive 4, Drive 3, Drive 2, Low, Park/Neut	Park/Neut
Calibration ID	0 – 9999	internal
Time From Start	Hrs/Mins/Sec	varies

F2:DTC

Selecting F2: DTC from the Test Mode menu accesses Diagnostic Trouble Codes. The screen will prompt you for the type of codes you want to view (figure 6-30).

Codes are identified as either current (C) or history (H). Current codes indicate a present fault; history codes indicate a fault that existed at one time but is not now present.

Codes are displayed one at a time. The Tech 1 will scroll automatically through the list of codes.

> **— IMPORTANT —**
> **A current code is one which is present all the time. To check if a code is current, erase the codes and operate the vehicle. If the same code returns, the code is classified as current. If the code no longer returns after operating the vehicle within the parameters needed to set the code, the code was a history code.**

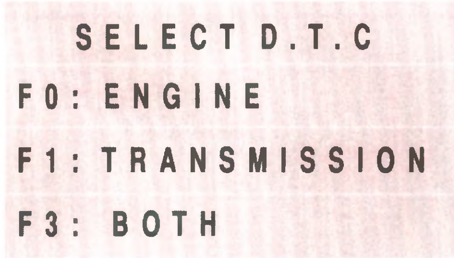


Figure 6-30, DTC Selection Screen

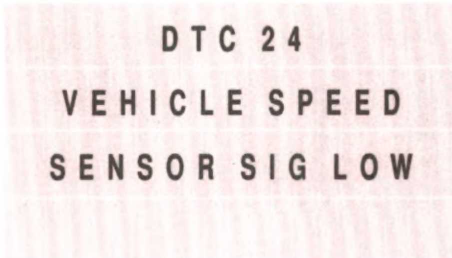


Figure 6-31, Current DTC Display

F3:SNAPSHOT

The Snapshot option is accessed by pressing F3 from the Test Mode menu. Snapshot is used to capture and store information.

Depending on the snapshot mode, you can press a key to mark a "trigger point." This trigger point serves as the reference point for the Tech 1 to analyze data. This data can be replayed and studied to help in locating current and intermittent problems.

The snapshot function provides numerous capabilities that allow you to:

- Store data parameters and trouble codes before and/or after a problem occurs
- Observe current data as it is being stored
- Store from 75 to 400 data samples, depending on the system
- Store time and position indexes for each data stream
- Save data for up to 24 hours with no external power source applied
- Select manual or automatic triggering
- Select different trigger points
- Store and/or print captured data on a variety of sources, depending on system options

SNAPSHOT OPTIONS

```
SNAPSHOT OPTIONS
F0: ANY CODE
F1: SINGLE CODE
F2: MANUAL TRIG
```

Figure 6-32, **Snapshot Options (1 of 2)**

```
SNAPSHOT OPTIONS
F3: REPLAY DATA
F4: FAST DATA
F9: TRIG. POINT
```

Figure 6-33, **Snapshot Options (2 of 2)**

```
TRIGGER POINT AT
F0: BEGINNING
F1: CENTER OR
F2: END OF DATA
```

Figure 6-34, **Trigger Point Options**

After selecting Snapshot from the Test Mode menu, a list of Snapshot options will appear on the Tech 1 display (figures 6-32 and 6-33). These options, explained below, allow you to select the conditions or circumstances that define data capture, storage, and retrieval.

- **F0: Any Code** — This option causes a snapshot to trigger any time a Diagnostic Trouble Code is detected in the data entering the Tech 1.
- **F1: Single Code** — This option allows you to identify a specific code that will trigger a snapshot. Any code other than the one identified will not cause a snapshot to occur.
- **F2: Manual Trigger** — This option allows you to manually trigger the snapshot. After selecting Manual Trigger, you can press the F9, Enter, or Exit keys to begin recording data.
- **F3: Replay Data** — This option allows you to replay snapshot data that is already stored in the Tech 1 memory.
- **F4: Fast Data** — This option allows the Tech 1 to capture the data stream at a faster rate than normal (8 samples per second versus the normal 5 samples per second). Because data is being received at a faster rate, the duration of the snapshot under Fast Data will be shorter than normal.
- **F9: Trigger Point** — This option allows you to designate when the trigger point occurs. After selecting this option, three choices are available (figure 6-34):
  - F0: Beginning — places the trigger point at the first data parameter stored. All other recorded data will have occurred after (downstream of) the trigger point.
  - F1: Center — places the trigger point in the center of total stored data. This feature requires that enough data be stored to fill the Tech 1 memory completely. This is the most common form of snapshot.
  - F2: End of Data — places the trigger point at the end of the recorded data All data occurring up to (upstream of) the trigger point will be stored in memory.

SNAPSHOT OPERATION

Capturing and Storing Data

Once a snapshot option has been chosen and the trigger point designated, the Tech 1 begins storing serial data and codes in its memory. Uninterrupted data will flow into Tech 1 memory until the memory is full or a trigger occurs. If the memory becomes full before a trigger occurs, data in the memory begins to be replaced on a "first in, first out" basis — the earliest data stored in memory will drop away as it is replaced with the latest incoming data.

During data capture, the lower right corner of the Tech 1 screen will display the following trigger information:

- A flashing "W" (figure 6-35) indicates the Tech 1 is receiving data and storing data, but waiting for a trigger.
- A fixed "T" (figure 6-36) indicates that a trigger occurred. In this mode, the Tech will continue to save data and display the "T" until its memory is full.
- A fixed "0" [zero] (figure 6-37) indicates that the Tech 1 memory is full, which causes the system to go into Data Display mode. The screen in this mode shows the data samples that were recorded at the trigger point.

```
ENGINE SPEED
1075 RPM
DESIRED IDLE
1037 RPM        W
```

Figure 6-35, **Awaiting Trigger Display (Flashing "W")**

```
ENGINE SPEED
1075 RPM
DESIRED IDLE
1037 RPM        T
```

Figure 6-36, **Trigger Occurred Display (Steady "T")**

```
ENGINE SPEED
1075 RPM
DESIRED IDLE
1037 RPM        O
```

Figure 6-37, **Memory Full/Data Display (Steady "0")**

ENGINE SPEED
1025 RPM
DESIRED IDLE
1037 RPM -1

Figure 6-38, **Data Sample with Number Index**

ENGINE SPEED
1025 RPM
DESIRED IDLE
1037 RPM -3.1

Figure 6-39, **Data Sample with Time Index**

Reviewing Data Samples

Data that is captured during snapshot operation is stored in "samples." For example, the data captured at the exact moment of the trigger point is an individual sample. (A collection of samples is called an "event.")

The Tech 1 can store between 75 and 400 data samples. These samples can have occurred before or after the trigger point sample, depending on which trigger point option was chosen.

The following keys are used to review the stored data samples.

- **YES/NO** — these keys scroll through the stored data parameter pairs.
- **UP/DOWN arrow** — these keys view data before and after the trigger point. Each data sample is identified with a number or time index. This index appears in the lower right corner of the Tech 1 display (figure 6-38).
  - A negative number indicates data that occurred before the trigger point.
  - A "0" [zero] indicates data at the exact moment of the trigger point.
  - A positive number indicates data that occurred after the trigger point.
- **ENTER** — this key toggles between the sample's number index and time index. The time index display gives the time in seconds, relative to the trigger sample, that the Tech 1 received the currently displayed data (figure 6-39).
- **F2** — this key displays any trouble codes present during the sample
- **F4** — this key brings the display to the first (earliest) sample
- **F5** — this key brings the display to the trigger point sample
- **F6** — this key brings the display to the end (last) sample
- **EXIT** — this key returns the display to the Snapshot Options menu

F4: MISC. TESTS

The Miscellaneous Tests mode is accessed by pressing F4 from the Main Menu. This mode is used to perform a variety of bi-directional checks.

After entering the Miscellaneous Tests mode, the following tests are available for the 6.5L EFI engine (figures 6-40 and 6-41)

- **F0: Output Tests** — Pressing F0 will display output test control modes that allow the Tech 1 to control PCM drivers through bi-directional communication. PCM outputs can be commanded "ON" and "OFF" to test their operation. In most cases, data parameters for the outputs can be displayed as they are being commanded.

  The following output tests can be run on 6.5L EFI vehicles (figures 6-42 and 6-43):
  - F0: Inj. Pump
  - F1: Glow Plug
  - F2: Dash Lamps
- **F2: Clear DTC** — this commands the PCM to clear any stored Diagnostic Trouble Codes (DTC), both current and history.
- **F3:RPM Control** — allows control of engine speed.
- **F5: Transmission** — allows control of transmission solenoids.
- **F7: OBD Sys Chk** — performs the On-Board Diagnostic system check.

```
SELECT MISC TEST
F0: OUTPUT TESTS
F2: CLEAR DTC
F3: RPM CONTROL
```

Figure 6-40, **Miscellaneous Tests (1 of 2)**

```
SELECT MISC TEST
F5: TRANSMISSION
F7: OBD SYS. CHK
```

Figure 6-41, **Miscellaneous Tests (2 of 2)**

```
SELECT OUTPUT
F0: INJ. PUMP
F1: GLOW PLUG
F2: DASH LAMPS
```

Figure 6-42, **Output Tests (1 of 2)**

```
SELECT OUTPUT
F7: WASTEGATE
```

Figure 6-43, **Output Tests (2 of 2)**

Notes:

7. Reference Information

PCM WIRING DIAGRAMS

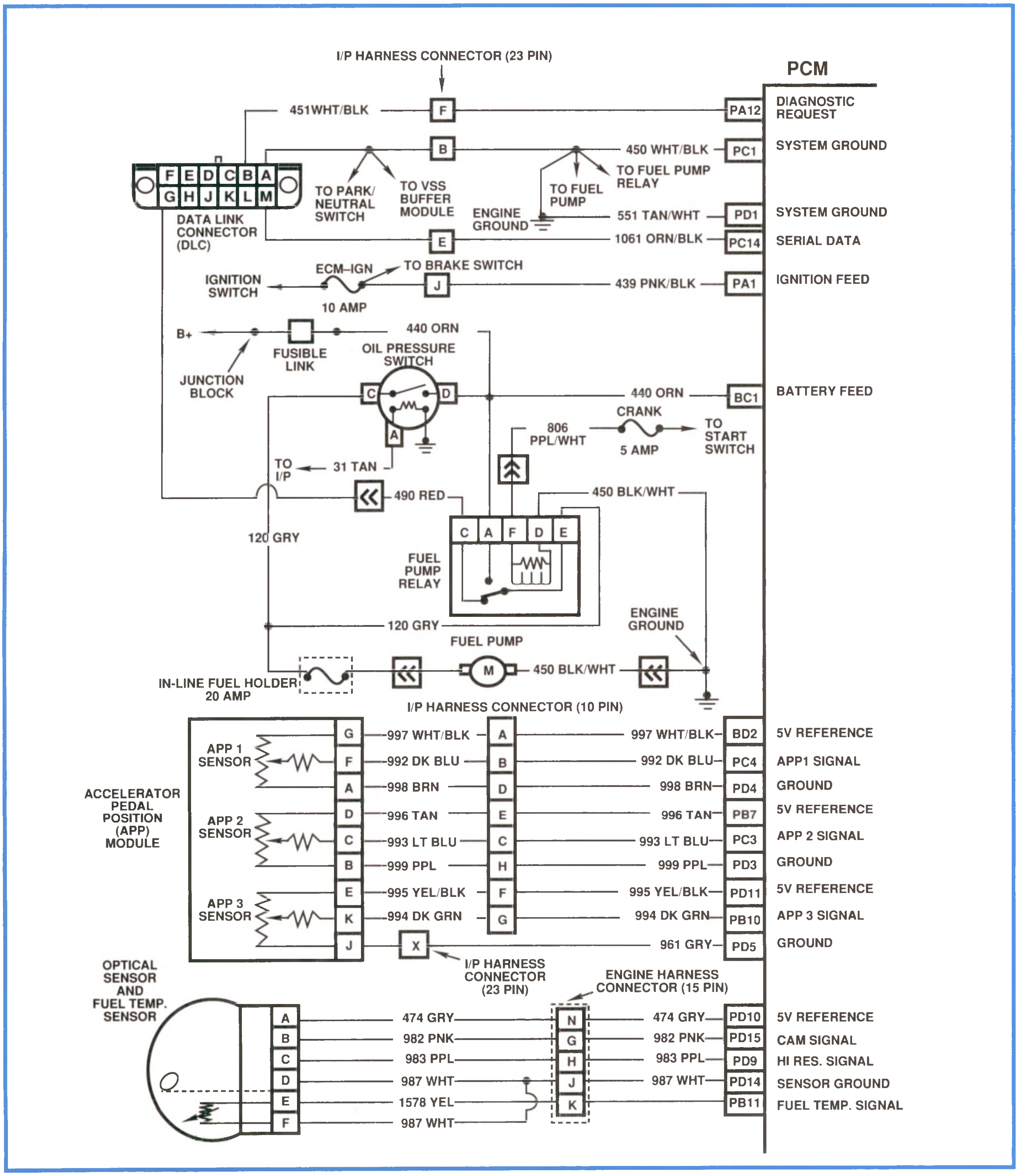


Figure 7-1, 6.5L Diesel PCM Wiring Diagram for C/K Truck (1 of 7)

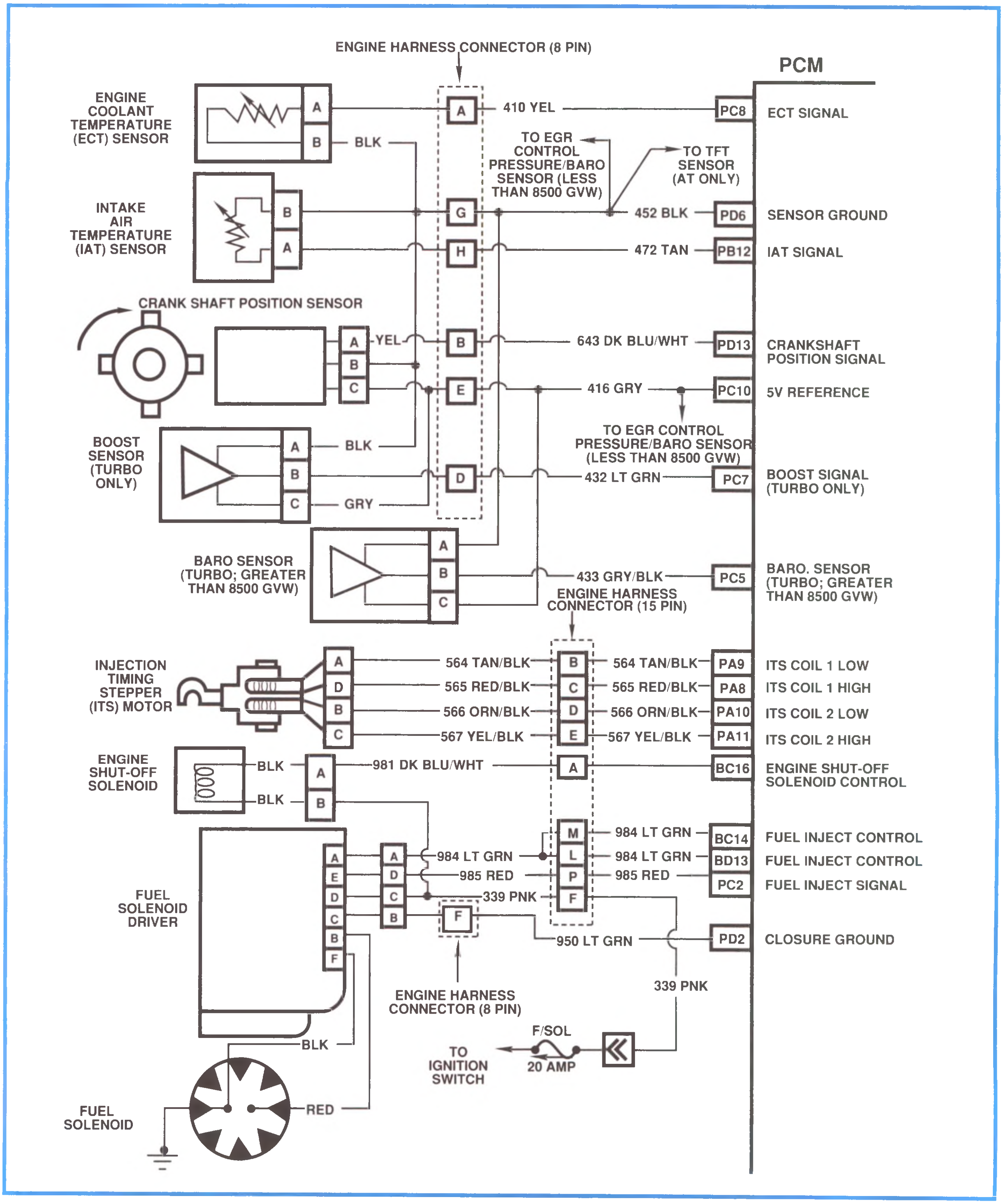


Figure 7-2, **6.5L Diesel PCM Wiring Diagram for C/K Truck (2 of 7)**

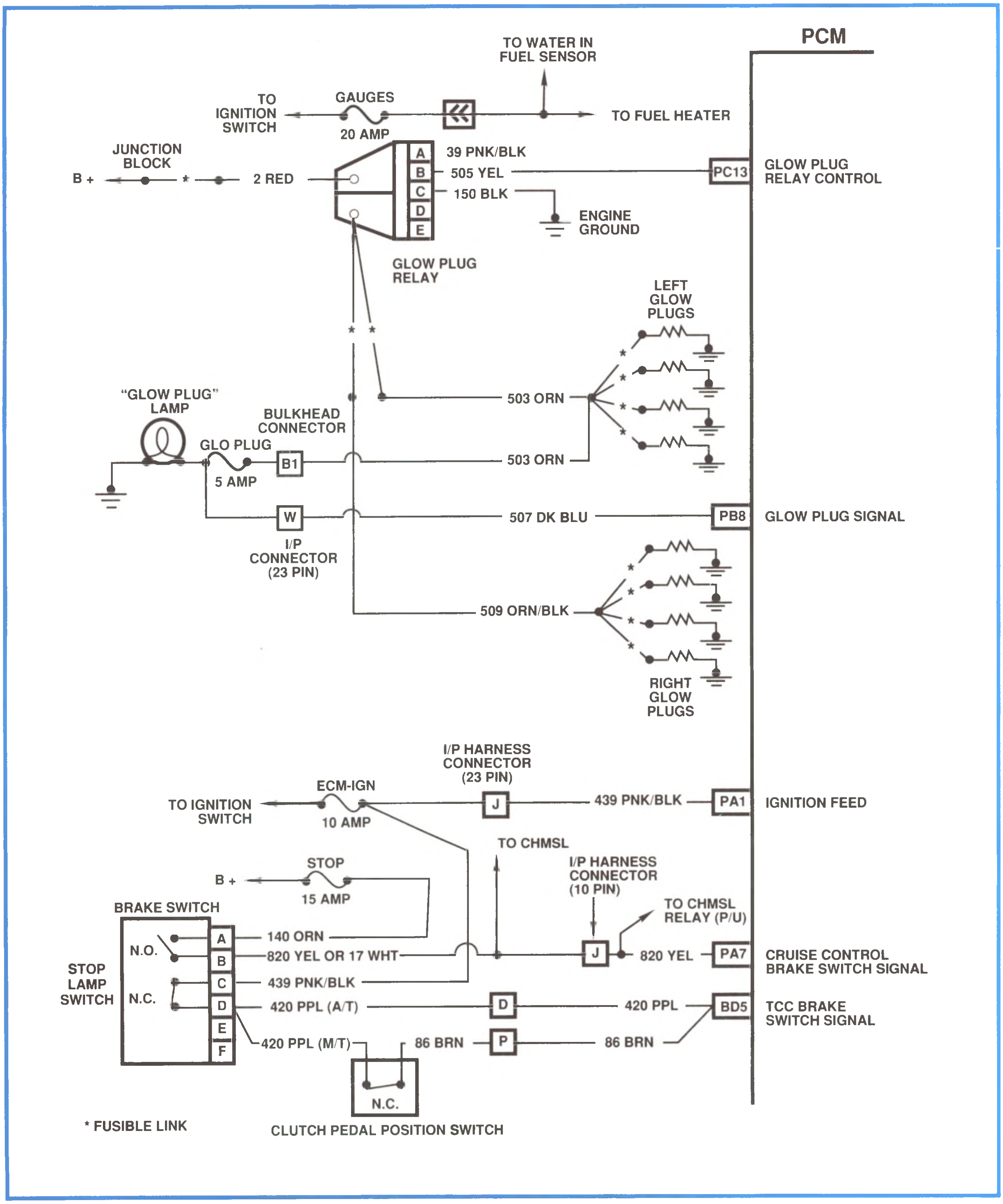


Figure 7-3, 6.5L Diesel PCM Wiring Diagram for C/K Truck (3 of 7)

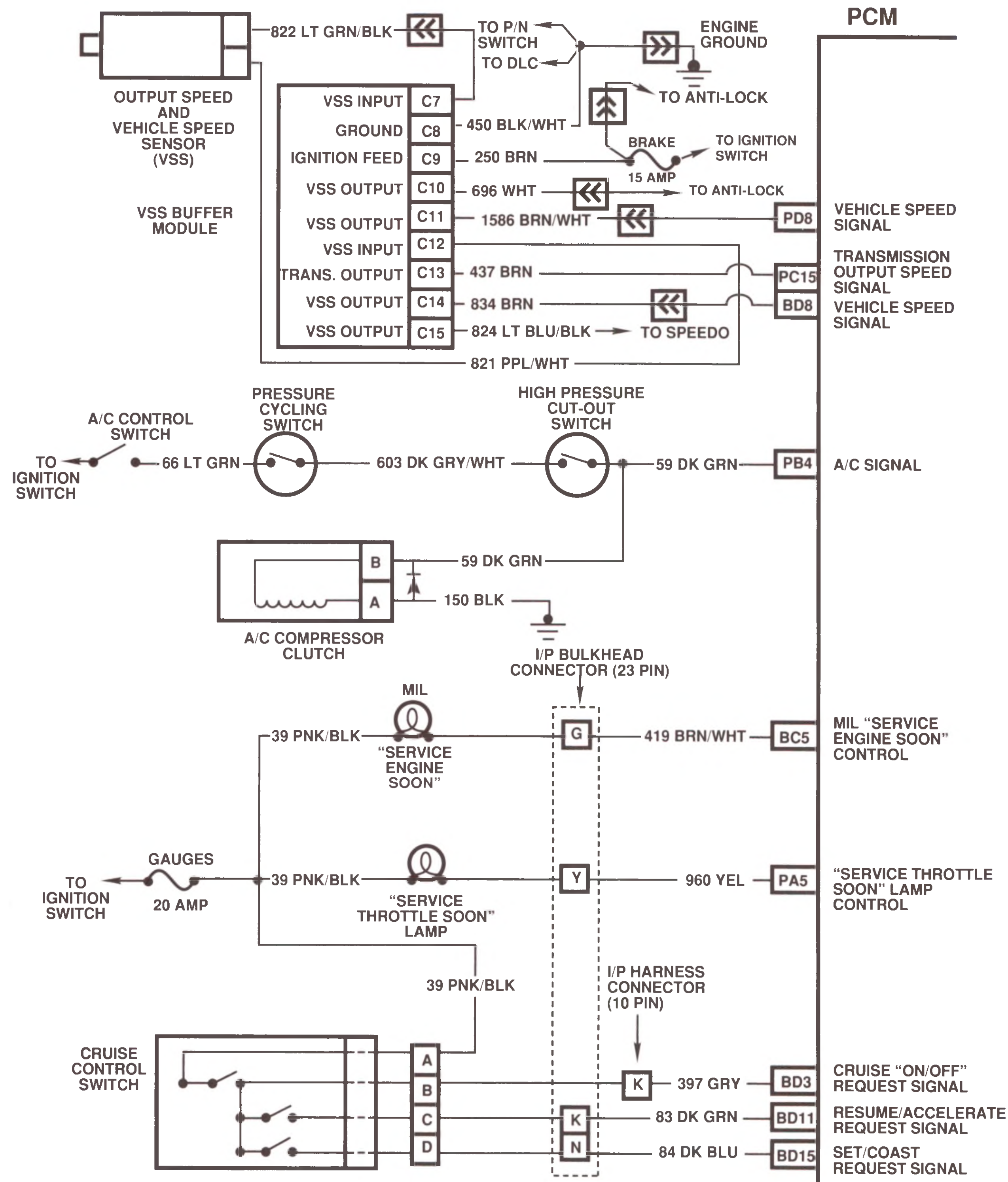


Figure 7-4, 6.5L Diesel PCM Wiring Diagram for C/K Truck (4 of 7)

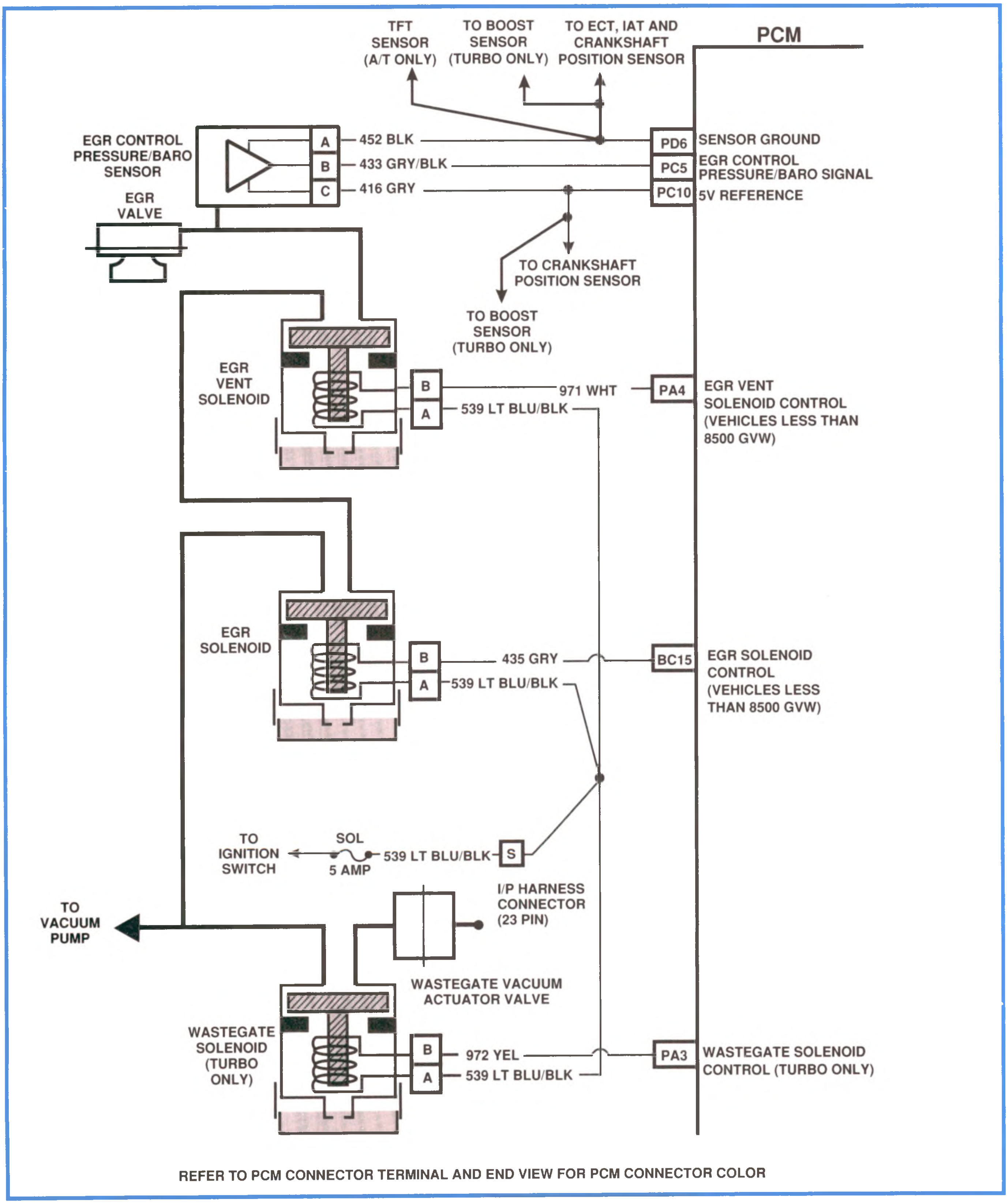


Figure 7-5, 6.5L Diesel PCM Wiring Diagram for C/K Truck (5 of 7)

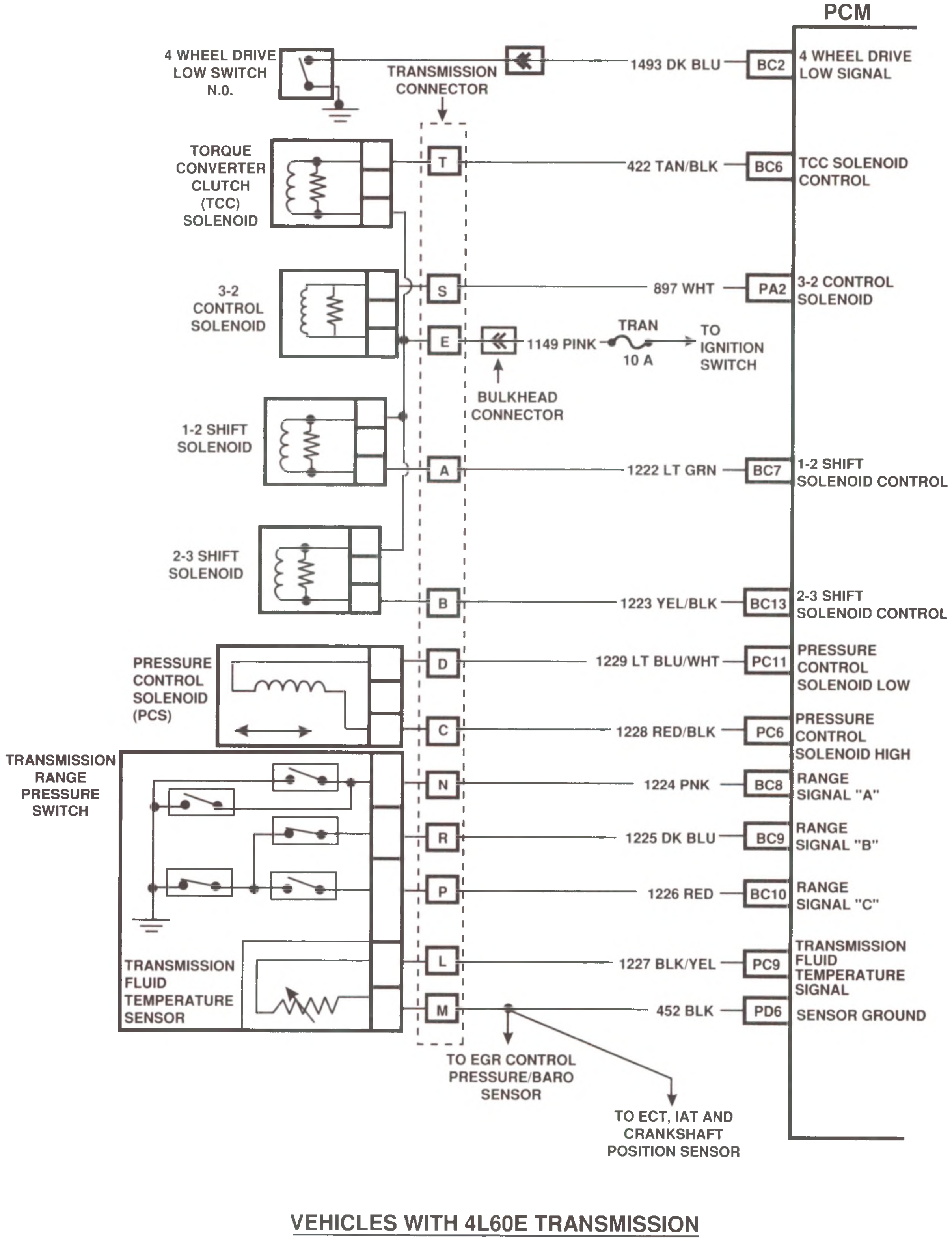


Figure 7-6, 6.5L Diesel PCM Wiring Diagram for C/K Truck (6 of 7)

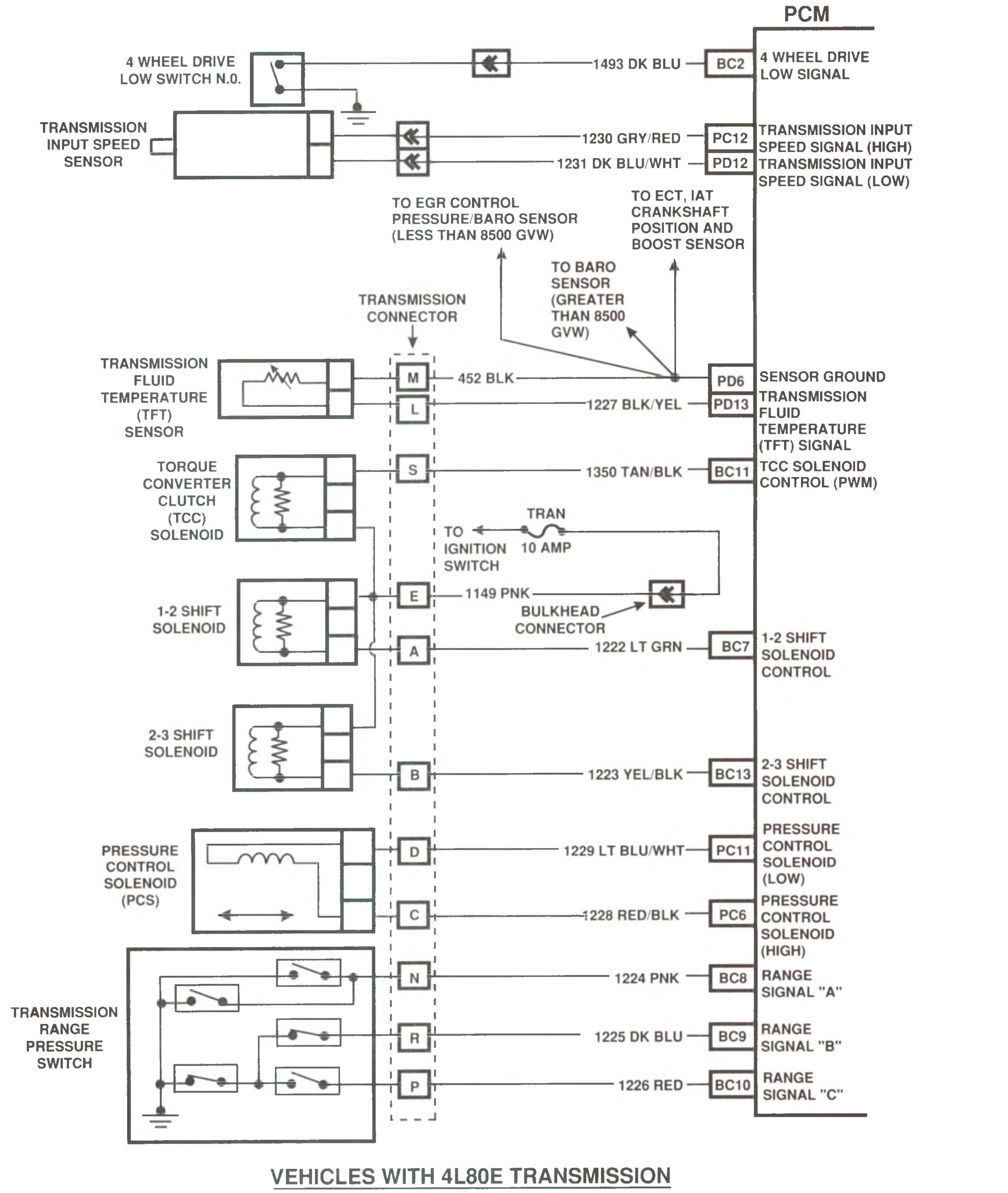


Figure 7-7, 6.5L Diesel PCM Wiring Diagram for C/K Truck (7 of 7)

PCM CONNECTOR TERMINAL IDENTIFICATION

PCM Connector and Driveability Symptoms Identification

This PCM voltage chart is for use with a J 39200 to further aid in diagnosis. These voltages were derived from a known good vehicle. The voltages you get may vary due to low battery charge or other reasons, but they should be very close.

The "B+" symbol indicates a nominal system voltage of 12-14 volts.

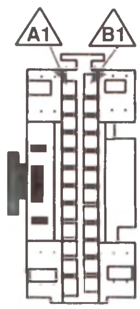
THE FOLLOWING CONDITIONS MUST BE MET BEFORE TESTING:
• Engine at operating temperature • Engine idling (for "Engine Operating" column)
• Test terminal not grounded • Scan tool not installed

PINK 24 PIN A-B CONNECTOR

PIN	PIN FUNCTION	CKT #	WIRE COLOR	NORMAL VOLTAGE KEY "ON"	ENGINE OPERATING	DTC(s) AFFECTED	POSSIBLE SYMPTOMS
PA1	IGNITION FEED	439	PNK/BLK	B+	B+	-	NO START
PA2	3-2 CONTROL SOLENOID CONTROL Δ	897	WHT	B+	B+	66	3RD GEAR ONLY
PA3	WASTEGATE SOLENOID CONTROL †	972	YEL	B+	B+	62	NO TURBO BOOST
PA4	EGR VENT SOLENOID CONTROL (VIN P, VIN S)	971	LT BLU	B+	B+	31,45	NO EGR
PA5	SERVICE THROTTLE SOON LAMP CONTROL	960	YEL	(4)	(4)	49	NO SERVICE THROTTLE SOON LAMP
PA6	NOT USED			-	-	-	-
PA7	CRUISE CONTROL BRAKE SWITCH SIGNAL	820	YEL	0	0	37,38,41	NO BRAKE LIGHTS
PA8	ITS COIL 1 HIGH	565	RED/BLK	.9V	B+	34	POOR PERFORMANCE
PA9	ITS COIL 1 LOW	564	TAN/BLK	B+	.9V	34	POOR PERFORMANCE
PA10	ITS COIL 2 LOW	566	ORN/BLK	B+	.9V	34	POOR PERFORMANCE
PA11	ITS COIL 2 HIGH	567	YEL/BLK	.9V	B+	34	POOR PERFORMANCE
PA12	DIAGNOSTIC REQUEST	451	WHT/BLK	5V	5V	NONE	-

(1) VARIES.
(2) OPEN CIRCUIT.
(3) GROUNDED CIRCUIT.
(4) OPEN/GROUNDED CIRCUIT.
(5) LESS THAN 1 VOLT.
(6) LESS THAN .5 VOLT (500mV).
Δ 4L60E.
† TURBO CHARGED.

BACK VIEW OF CONNECTOR



24 PIN A-B CONNECTOR (PINK)

VEHICLE: C/K TRUCK
ENGINE: 6.5L DIESEL VIN P (L49)
VIN S (L56)
VIN F (L65)
TRANSMISSION: 4L60E, 4L80E AND MANUAL

Figure 7-8, PCM Connector Terminal End View (1 of 6)

PCM Connector and Driveability Symptoms Identification

This PCM voltage chart is for use with a J 39200 to further aid in diagnosis. These voltages were derived from a known good vehicle. The voltages you get may vary due to low battery charge or other reasons, but they should be very close.

The "B+" symbol indicates a nominal system voltage of 12-14 volts.

THE FOLLOWING CONDITIONS MUST BE MET BEFORE TESTING:

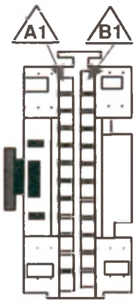
• Engine at operating temperature • Engine idling (for "Engine Operating" column)
• Test terminal not grounded • Scan tool not installed

PINK 24 PIN A-B CONNECTOR

PIN	PIN FUNCTION	CKT #	WIRE COLOR	NORMAL VOLTAGE KEY "ON"	NORMAL VOLTAGE ENGINE OPERATING	DTC(s) AFFECTED	POSSIBLE SYMPTOMS
PB1	NOT USED	-	-	-	-	-	-
PB2	NOT USED	-	-	-	-	-	-
PB3	NOT USED	-	-	-	-	-	-
PB4	A/C SIGNAL	59	DK GRN	0* Δ	0* Δ	NONE	A/C STATUS
PB5	NOT USED	-	-	-	-	-	-
PB6	NOT USED	-	-	-	-	-	-
PB7	APP 2 SENSOR 5V REFERENCE	996	TAN	5v	4.3v	25,26,27,84,99	POOR PERFORMANCE
PB8	GLOW PLUG SIGNAL	507	DK BLU	B+	0	29	HARD START
PB9	NOT USED	-	-	-	-	-	-
PB10	APP 3 SENSOR SIGNAL	994	DK GRN	4v	4v	64, 65, 84	POOR PERFORMANCE
PB11	FUEL TEMP SIGNAL	1578	YEL	(2)	1.5v (2)	42, 43	POOR PERFORMANCE IN COLD TEMPS
PB12	IAT SIGNAL	472	TAN	(2)	1.6v (2)	47, 48	POOR PERFORMANCE IN COLD TEMPS

(1) VARIES.
(2) VARIES WITH TEMPERATURE.
(3) OPEN CIRCUIT.
(4) GROUNDED CIRCUIT.
(5) OPEN/GROUNDED CIRCUIT.
(6) LESS THAN 1 VOLT.
* LESS THAN .5 VOLT (500mV).
Δ B+ WITH A/C "ON."

BACK VIEW OF CONNECTOR



24 PIN A-B CONNECTOR (PINK)

VEHICLE: C/K TRUCK
ENGINE: 6.5L DIESEL VIN P (L49)
VIN S (L56)
VIN F (L65)
TRANSMISSION: 4L60E, 4L80E AND MANUAL

Figure 7-9, PCM Connector Terminal End View (2 of 6)

PCM Connector and Driveability Symptoms Identification

This PCM voltage chart is for use with a J 39200 to further aid in diagnosis. These voltages were derived from a known good vehicle. The voltages you get may vary due to low battery charge or other reasons, but they should be very close.

The "B+" symbol indicates a nominal system voltage of 12-14 volts.

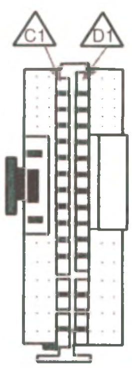
THE FOLLOWING CONDITIONS MUST BE MET BEFORE TESTING:
• Engine at operating temperature • Engine idling (for "Engine Operating" column)
• Test terminal not grounded • Scan tool not installed

PINK 32 PIN C-D CONNECTOR

PIN	PIN FUNCTION	CKT #	WIRE COLOR	NORMAL VOLTAGE KEY "ON"	NORMAL VOLTAGE ENGINE OPERATING	DTC(s) AFFECTED	POSSIBLE SYMPTOMS
PC1	SYSTEM GROUND	450	WHT/BLK	0*	0*	NONE	-
PC2	FUEL INJECT SIGNAL	985	RED	5.6V	4.0V	NONE	NONE
PC3	APP SENSOR 2 SIGNAL	993	LT BLU	4.3V	4.3V	26, 27, 84	POOR PERFORMANCE
PC4	APP SENSOR 1 SIGNAL	992	DK BLU	.5V	.5V	22, 23, 84	POOR PERFORANCE
PC5	EGR CONTROL PRESS/BARO SIGNAL (VIN P, VIN S) BARO SIGNAL (VIN F)	433	GRY/BLK	4.8V	3.2V	31, 33	NO EGR
PC6	PRESSURE CONTROL SOLENOID (HIGH) ∆ •	1228	RED/BLK	0*	6.3V	73	HARSH SHIFT
PC7	BOOST SIGNAL †	432	LT GRN	1.4V	1.4V	61, 62	NO TURBO BOOST
PC8	ECT SIGNAL	410	YEL	3.4V (3)	3.0V (3)	14, 15	EARLY TCC
PC9	TRANSMISSION FLUID TEMPERATURE (TFT) SIGNAL ∆ •	1227	BLK/YEL	3.5V	2.8V	58, 59, 79	EARLY TCC
PC10	CRANKSHAFT POSITION EGR CONTROL PRESS/BARO AND BOOST SENSOR 5 VOLT REFERENCE	416	GRY	5V	5V	19, 31	BACK UP FUEL, NO EGR
PC11	PRESSURE CONTROL SOLENOID (LOW) ∆ •	1229	LT BLU/ WHT	0*	1.5V	73	HARSH SHIFT
PC12	TRANS INPUT SPEED SIGNAL (HIGH) •	1230	GRY/RED	0*	0*	74	NO TCC APPLY NO 4TH GEAR IN HOT MODE
PC13	GLOW PLUG RELAY CONTROL	505	YEL	B+	0	29	HEAD START
PC14	SERIAL DATA	1061	ORN/BLK	5V	5V	NONE	NO SCAN TOOL DATA
PC15	TRANSMISSION OUTPUT SPEED SIGNAL	437	BRN	0*	0*	24, 72	2ND GEAR ONLY
PC16	NOT USED	-	-	-	-	-	-

(1) VARIES FROM 0 TO BATTERY VOLTAGE, DEPENDING ON POSITION OF DRIVE WHEELS.
(2) VARIES.
(2) VARIES WITH TEMPERATURE.
(4) OPEN CIRCUIT.
(5) GROUNDED CIRCUIT.
(6) OPEN/GROUNDED CIRCUIT.
(7) LESS THAN 1 VOLT.
* LESS THAN .5 VOLT (500mV).
∆ 4L60E.
• 4L80E.
† TURBO CHARGED.

BACK VIEW OF CONNECTOR



32 PIN C-D CONNECTOR (PINK)

VEHICLE: C/K TRUCK
ENGINE: 6.5L DIESEL VIN P (L49) VIN S (L56) VIN F (L65)
TRANSMISSION: 4L60E, 4L80E AND MANUAL

Figure 7-10, PCM Connector Terminal End View (3 of 6)

PCM Connector and Driveability Symptoms Identification

This PCM voltage chart is for use with a J 39200 to further aid in diagnosis. These voltages were derived from a known good vehicle. The voltages you get may vary due to low battery charge or other reasons, but they should be very close.

The "B+" symbol indicates a nominal system voltage of 12-14 volts.

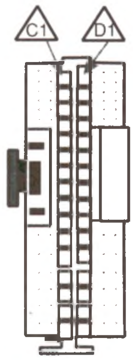
<u>THE FOLLOWING CONDITIONS MUST BE MET BEFORE TESTING:</u>
• Engine at operating temperature • Engine idling (for "Engine Operating" column)
• Test terminal not grounded • Scan tool not installed

PINK 32 PIN C-D CONNECTOR

PIN	PIN FUNCTION	CKT #	WIRE COLOR	NORMAL VOLTAGE KEY "ON"	NORMAL VOLTAGE ENGINE OPERATING	DTC(s) AFFECTED	POSSIBLE SYMPTOMS
PD1	SYSTEM GROUND	551	TAN/WHT	0*	0*	NONE	-
PD2	CLOSURE GROUND	950	LT GRN	(4)	(4)	NONE	NO START
PD3	APP 2 SENSOR GROUND	999	PPL	0	0	26, 27, 84	POOR PERFORMANCE
PD4	APP 1 SENSOR GROUND	998	BRN	0	0	22, 23, 84	POOR PERFORMANCE
PD5	APP 3 SENSOR GROUND	961	RED	0	0	64, 65, 84	POOR PERFORMANCE
PD6	ECT, IAT, CRANKSHAFT POSITION, TFT AND EGR GROUND, PRESSURE SENSOR GROUND	452	BLK	0*	0*	14, 47, 19, 58	FAST IDLE, BACK UP FUEL
PD7	NOT USED	-	-	-	-	-	-
PD8	VEHICLE SPEED SIGNAL	1586	BRN/WHT	0*	0*	16	FUEL CUTOFF
PD9	HIGH RESOLUTION SIGNAL	983	PPL	5V	2.5V	17	BACK UP FUEL
PD10	OPTICAL SENSOR 5V REFERENCE	474	GRY	5V	5V	17, 18	BACK UP FUEL,
PD11	APP 3 SENSOR 5V REFERENCE	995	YEL/BLK	5V	5V	64, 65, 84	POOR PERFORMANCE
PD12	TRANSMISSION INPUT SPEED SIGNAL (LOW) •	1231	DK BLU/ WHT	0*	0*	74	NO TCC APPLY, NO 4TH GEAR IN HOT MODE
PD13	CRANKSHAFT POSITION SIGNAL	643	BLU/WHT	5V	4.5V	19	BACK UP FUEL
PD14	OPTICAL SENSOR GROUND	987	GRN/WHT	0*	0*	17, 18	BACK UP FUEL
PD15	OPTICAL SENSOR CAM SIGNAL	442	PNK	.2V	.5V	18	BACK UP FUEL
PD16	NOT USED	-	-	-	-	-	-

(1) VARIES FROM 0 TO BATTERY VOLTAGE, DEPENDING ON POSITION OF DRIVE WHEELS.
(2) VARIES.
(3) OPEN CIRCUIT.
(4) GROUNDED CIRCUIT.
(5) OPEN/GROUNDED CIRCUIT.
(6) LESS THAN 1 VOLT.
* LESS THAN .5 VOLT (500mV).
• 4L80E.

BACK VIEW OF CONNECTOR



32 PIN C-D CONNECTOR (PINK)

VEHICLE: <u>C/K TRUCK</u>
ENGINE: <u>6.5L DIESEL</u> <u>VIN P (L49)</u>
<u>VIN S (L56)</u>
<u>VIN F (L65)</u>
TRANSMISSION: <u>4L60E, 4L80E AND MANUAL</u>

Figure 7-11, PCM Connector Terminal End View (4 of 6)

PCM Connector and Driveability Symptoms Identification

This PCM voltage chart is for use with a J 39200 to further aid in diagnosis. These voltages were derived from a known good vehicle. The voltages you get may vary due to low battery charge or other reasons, but they should be very close.

The "B+" symbol indicates a nominal system voltage of 12-14 volts.

THE FOLLOWING CONDITIONS MUST BE MET BEFORE TESTING:
• Engine at operating temperature • Engine idling (for "Engine Operating" column)
• Test terminal not grounded • Scan tool not installed

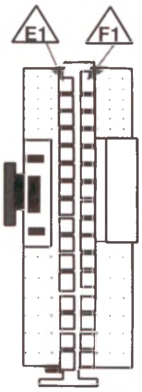
LT BLUE 32 PIN E-F CONNECTOR

PIN	PIN FUNCTION	CKT #	WIRE COLOR	NORMAL VOLTAGE KEY "ON"	NORMAL VOLTAGE ENGINE OPERATING	DTC(s) AFFECTED	POSSIBLE SYMPTOMS
BC1	BATTERY FEED	440	ORN	B+	B+	NONE	NO START
BC2	FWD LOW SWITCH Δ •	1493	DK BLU	B+	B+	NONE	POOR START
BC3	NOT USED	-	-	-	-	-	-
BC4	NOT USED	-	-	-	-	-	-
BC5	MIL "SERVICE ENGINE SOON" CONTROL	419	BRN/WHT	(5)	(5)	46	NO MIL
BC6	TCC SOLENOID CONTROL Δ	422	TAN/BLK	B+	B+	67, 69	POOR FUEL ECONOMY
BC7	1-2 SHIFT SOLENOID CONTROL Δ •	1222	LT GRN	B+	.4V	82	NO 3RD 4TH GEAR
BC8	RANGE SIGNAL "A" Δ •	1224	PNK	B+	B+	24, 28, 72	-
BC9	RANGE SIGNAL "B" Δ •	1225	DK BLU	0	0	24, 28, 72	-
BC10	RANGE SIGNAL "C" Δ •	1226	RED	B+	B+	24, 28, 72	-
BC11	TCC SOLENOID CONTROL (PWM) •	1350	TAN/BLK	B+	.4V	67 - 4L60E 8E - 4L80E	-
BC12	NOT USED	-	-	-	-	-	-
BC13	2-3 SHIFT SOLENOID CONTROL Δ •	1223	YEL/BLK	B+	.4V	81	-
BC14	FUEL INJECT CONTROL	984	LT GRN	0	1.9V	NONE	NONE
BC15	EGR SOLENOID CONTROL (VIN P AND S)	435	GRY	B+	9.5V	32, 44	NO EGR
BC16	ENGINE SHUT-OFF SOLENOID CONTROL	981	DK BLU/WHT	(5)	(5)	13	NO START

(1) VARIES.
(2) READS BATTERY VOLTAGE IN GEAR.
(3) OPEN CIRCUIT.
(4) GROUNDED CIRCUIT.
(5) OPEN/GROUNDED CIRCUIT.
(6) LESS THAN 1 VOLT.
* LESS THAN .5 VOLT (500mV).
Δ 4L60E.
• 4L80E.

VEHICLE: C/K TRUCK
ENGINE: 6.5L DIESEL VIN P (L49) VIN S (L56) VIN F (L65)
TRANSMISSION: 4L60E, 4L80E AND MANUAL

BACK VIEW OF CONNECTOR



32 PIN E-F CONNECTOR (LT BLUE)

Figure 7-12, PCM Connector Terminal End View (5 of 6)

PCM Connector and Driveability Symptoms Identification

This PCM voltage chart is for use with a J 39200 to further aid in diagnosis. These voltages were derived from a known good vehicle. The voltages you get may vary due to low battery charge or other reasons, but they should be very close.

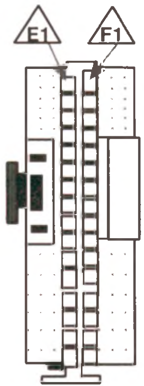
The "B+" symbol indicates a nominal system voltage of 12-14 volts.

THE FOLLOWING CONDITIONS MUST BE MET BEFORE TESTING:
• Engine at operating temperature • Engine idling (for "Engine Operating" column)
• Test terminal not grounded • Scan tool not installed

LT BLUE 32 PIN E-F CONNECTOR

PIN	PIN FUNCTION	CKT #	WIRE COLOR	NORMAL VOLTAGE KEY "ON"	NORMAL VOLTAGE ENGINE OPERATING	DTC(s) AFFECTED	POSSIBLE SYMPTOMS
BD1	NOT USED	-	-	-	-	-	-
BD2	APP 1 SENSOR 5V REFERENCE	997	WHT/BLK	5V	5V	21, 22, 23, 84	POOR PERFORMANCE
BD3	CRUISE "ON/OFF" REQUEST SIGNAL	397	GRY	(4)	(4)	NONE	NO CRUISE
BD4	NOT USED	-	-	-	-	-	-
BD5	TCC BRAKE SWITCH	420 86	PPL	B+	B+	37, 38, 41	NO TCC
BD6	NOT USED	-	-	-	-	-	-
BD7	NOT USED	-	-	-	-	-	-
BD8	VEHICLE SPEED SIGNAL	834	BRN	*	*	16	NO CRUISE
BD9	NOT USED	-	-	-	-	-	-
BD10	NOT USED	-	-	-	-	-	-
BD11	RESUME/ACCEL REQUEST SIGNAL	83	DK GRN	B+	B+	76	NO CRUISE
BD12	NOT USED	-	-	-	-	-	-
BD13	FUEL INJECT CONTROL	984	LT GRN	0	1.9V	NONE	NONE
BD14	NOT USED	-	-	-	-	-	-
BD15	SET COAST/REQUEST SIGNAL	84	DK BLU	B+	B+	71	NO CRUISE
BD16	NOT USED	-	-	-	-	-	-

BACK VIEW OF CONNECTOR



32 PIN E-F CONNECTOR (LT BLUE))

(1) VARIES.
(2) OPEN CIRCUIT.
(3) GROUNDED CIRCUIT.
(4) OPEN/GROUNDED CIRCUIT.
(5) LESS THAN 1 VOLT.
* LESS THAN .5 VOLT (500mV).
# MANUAL TRANSMISSION.
Δ 4L60E.
• 4L80E.

VEHICLE: C/K TRUCK
ENGINE: 6.5L DIESEL VIN P (L49) VIN S (L56) VIN F (L65)
TRANSMISSION: 4L60E, 4L80E AND MANUAL

Figure 7-13, PCM Connector Terminal End View (6 of 6)

TECH 1 SCREENS

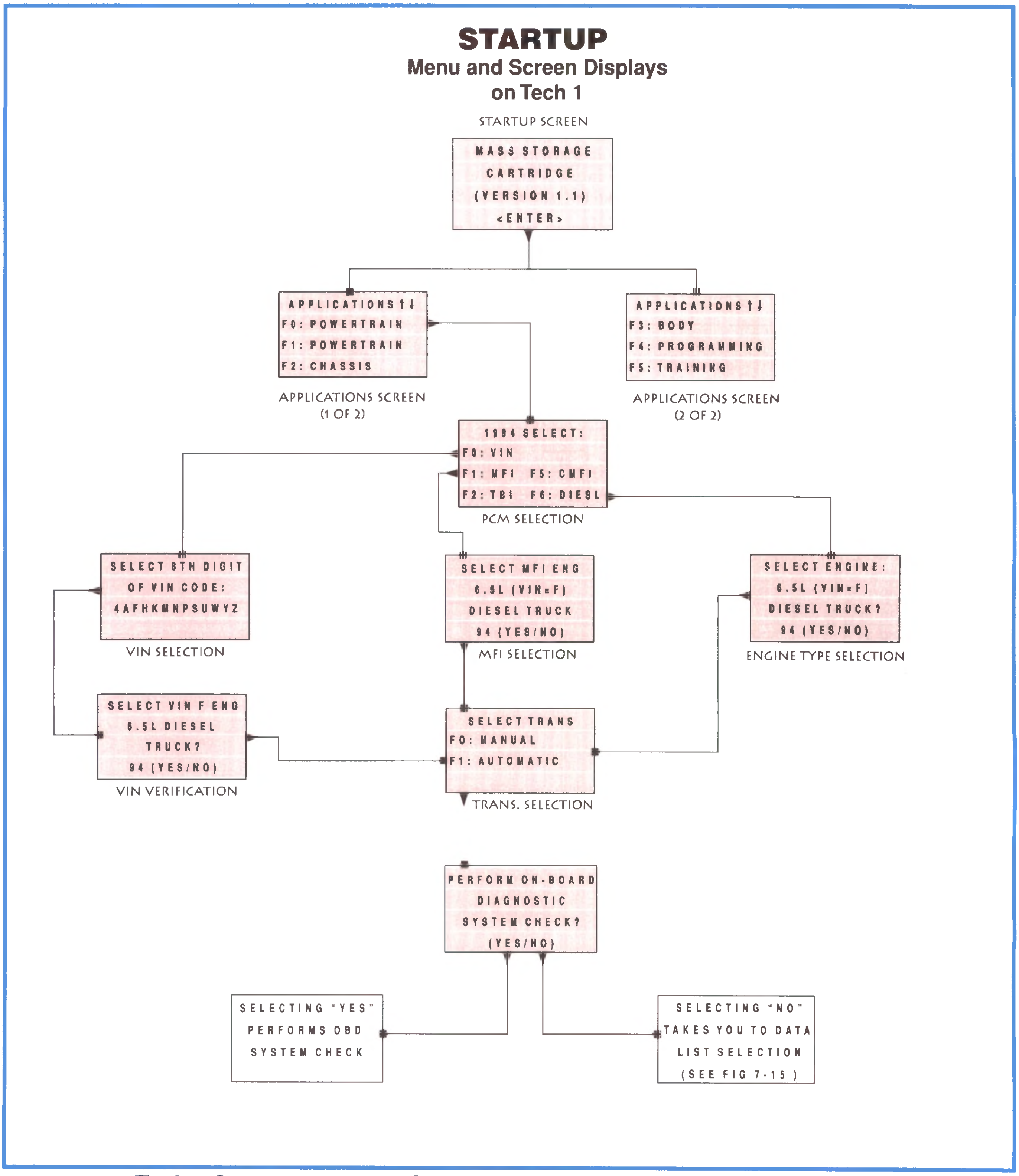


Figure 7-14, Tech 1 Startup Menu and Screen Displays

TEST MODE

Menu and Screen Displays on Tech 1

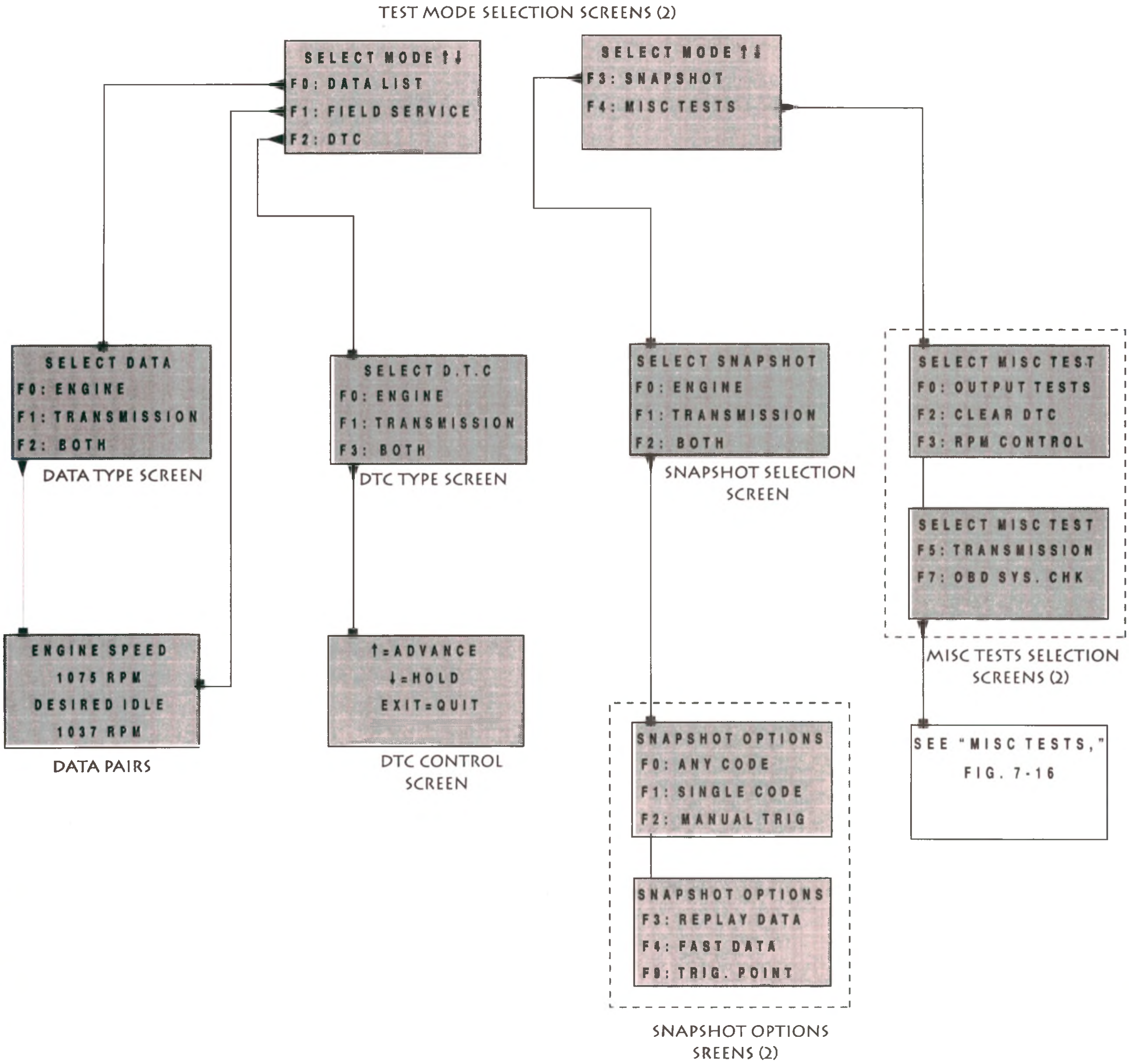


Figure 7-15, Tech 1 Test Mode Menu and Screen Displays

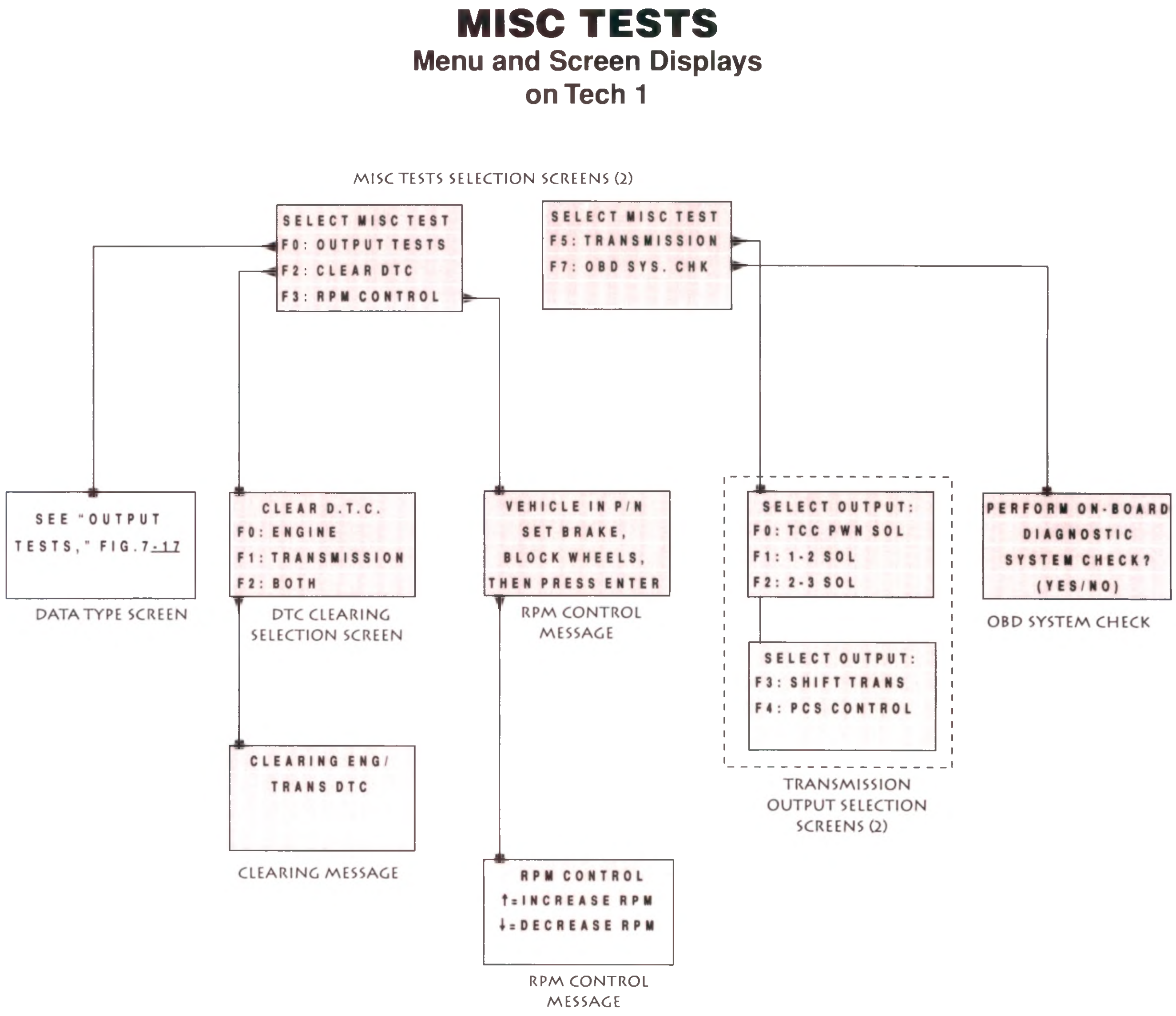


Figure 7-16, **Tech 1 Miscellaneous Tests Menu and Screen Displays**

OUTPUT TESTS

Menu and Screen Displays on Tech 1

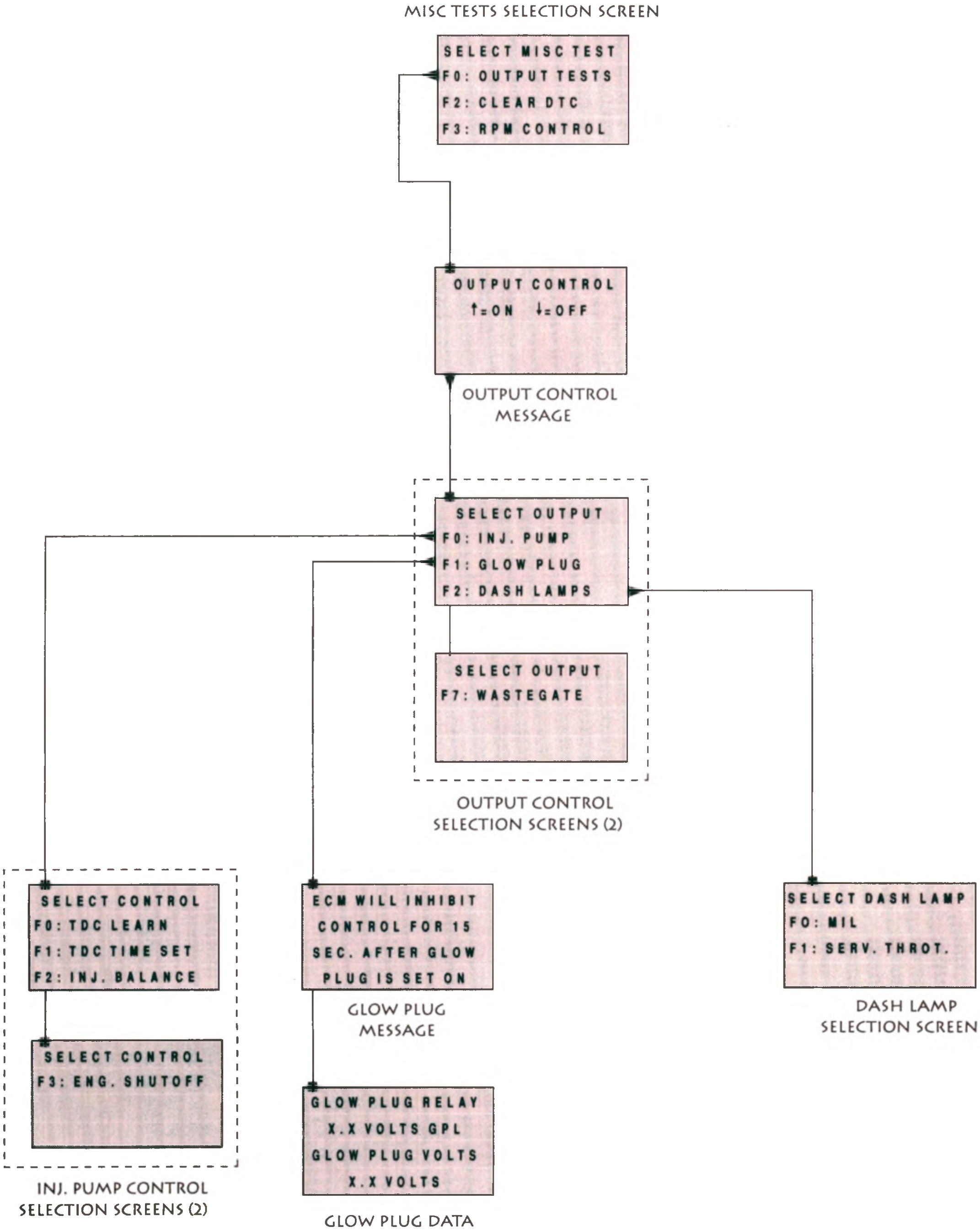
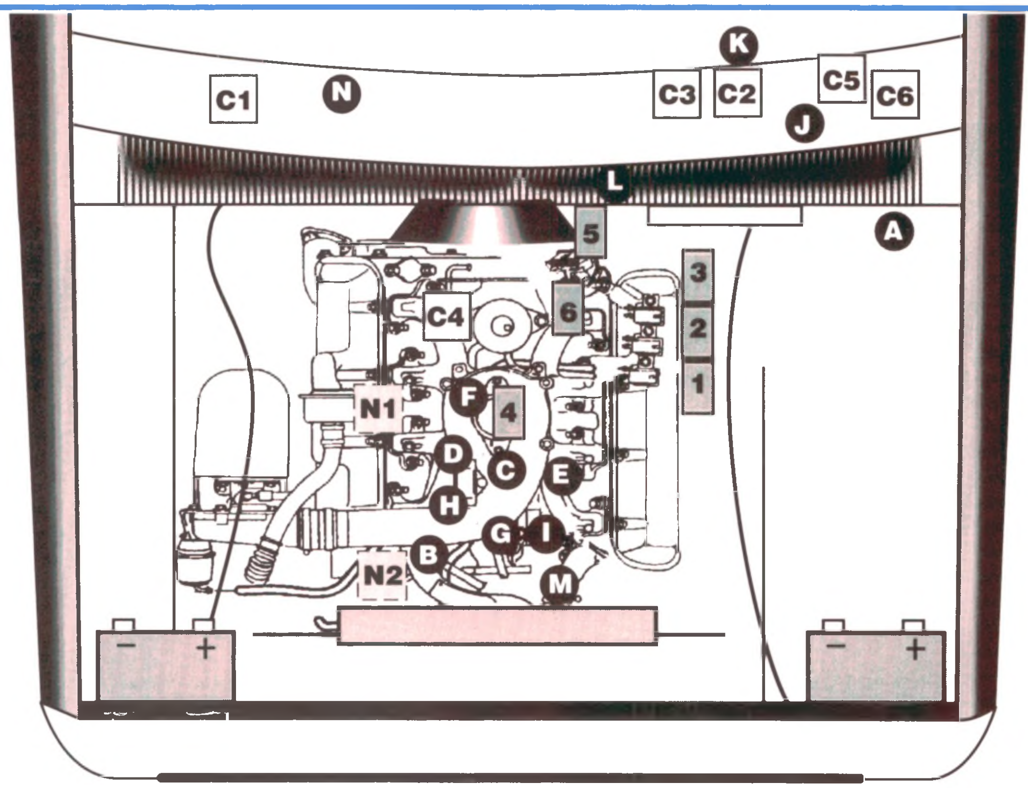


Figure 7-17, Tech 1 Output Tests Menu and Screen Displays

COMPONENT LOCATIONS



Control Module System

- C1 Powertrain Control Module (PCM)
- C2 Data Link Connector (DLC)
- C3 Malfunction Indicator Lamp (MIL) ("Service Engine Soon")
- C4 PCM Harness Ground
- C5 Fuse Block
- C6 "Service Throttle Soon" Lamp

PCM Controlled Components

1. Boost Solenoid
2. EGR Solenoid
3. EGR Vent Solenoid
4. EGR Valve
5. Trans. Connector
6. Glow Plug Relay

PCM Information Sensors

- A EGR Pressure Control/Baro Sensor
- B Engine Coolant Temp (ECT) Sensor
- C Intake Air Temp (IAT) Sensor
- D Boost Sensor
- E Fuel Solenoid Driver
- F Fuel Solenoid
- G Optical/Fuel Temp Sensor
- H Injection Timing Stepper Motor
- I Engine Shutoff (ESO) Solenoid
- J Accelerator Pedal Position (APP) Sensors
- K Cruise Control Switches
- L Output and Vehicle Speed Sensors
- M Crankshaft Position Sensor
- N VSS Buffer Module (DRAC)

Emission Components (not PCM controlled)

- N1 Crankcase Depression Regulator (CDR) Valve
- N2 Vacuum Pump

Figure 7-18, 6.5L EFI V8 Diesel Underhood Component Locations

GLOSSARY OF TERMS AND ABBREVIATIONS

The following terms and acronyms are used throughout this book and course.

Accelerator Pedal Positon (APP) Sensors — three potentiometers housed in a module at the accelerator pedal, they transmit accelerator pedal position to the PCM. Resistance for the sensors is ramped at three different rates to provide fail-safe protection.

Baro Sensor — see "EGR Control Pressure/Baro Sensor"

Boost Sensor — a sensor mounted on top of the upper intake, it measures changes in intake manifold pressure. The boost sensor reads engine load and speed changes, then converts the change in readings to voltage output.

Buffer Module, VSS — see "VSS Buffer Module"

Catalytic Converter — a device that helps reduce the level of undesirable exhaust particulates. The catalytic converter used on the 6.5L EFI diesel is a palladium-oxidation type. Unlike gasoline converters, this diesel converter does not "light off."

Cam Signal, Pump — a reference signal emitted by the 8 slots on the disk located in the injection pump. These signals are used by the PCM to calculate injection timing. The pump cam signal is one of the most important inputs to the PCM on the 6.5L EFI diesel.

Control Valve — a spool-type plunger located at the front of the injection pump rotor. The valve controls fill/spill modes. At the beginning of the injection cycle (fill), the valve allows fuel to enter the rotor. During pressuzation and metering, the valve remains closed. At the end of the cycle (spill), the valve opens to allow fuel out of the rotor.

Crankshaft Position Sensor — a Hall-effect device that reads the rotational speed of the crank-shaft sprocket. The sensor transmits this information as a digital signal to the PCM. The PCM uses the data to detemine engine speed in RPMs.

Cruise Control — a set of three switches housed in the steering column/multifunction turn signal indicator. The switches transmit information regarding cruise control ON/OFF, set/coast, and resume/accelerate status. The PCM uses this information to adjust fuel control in order to maintain vehicle speed.

Diagnostic Link Connector (DLC) — a 12-pin terminal located under the instrument panel. The DLC is used in the assembly plant to determine proper vehicle operation before it leaves the plant. The DLC is also used in service to access Diagnostic Trouble Codes (DTCs), either manually or with a "Scan" tool.

Diagnostic Trouble Codes (DTCs) — diagnostic numbers obtained at the Diagnostic Link Connec-tor (DLC) that identify specific system malfunctions. DTCs can be obtained manually by jumping DLC terminal "B" to "A" to by using the Tech 1 "Scan" tool. A complete list of DTCs is found on the following pages.

EGR Control Pressure/Baro Sensor — a sensor used to monitor the amount of vacuum in the EGR circuit. On vehicles not equipped with EGR, this sensor is used to monitor barometric pres-sure. The sensor is located on the driver's side of the cowl.

EGR Solenoid — an electrical device that opens and closes the EGR valve. The solenoid is controlled by the PCM, which determines when and what quantity of exhaust gas to recirculate into the intake system.

EGR Valve — a valve located on top of the intake manifold the allows exhaust gases to be recirculated into the intake system as a way to reduce engine emissions.

Engine Coolant Temperature (ECT) Sensor — a thermistor that translates engine coolant temperature into an electrical signal. At high coolant temperature, sensor resistance is low; at low coolant temperature, sensor resistance is high. The sensor signal is sent to the PCM, which uses it for fuel control and glow plug operation.

Engine Shutoff (ESO) Solenoid — a plunger-type electrical device that prevents fuel from entering the injection pump. The solenoid is normallly off (or closed). When commanded by the PCM, it turns on (opens) to allow fuel into the pump passages.

Fuel Solenoid — an electrical device in the injection pump that applies and releases the control valve. When it is "OFF," the solenoid allows the control valve to open. When it is "ON," the solenoid closes the control valve.

Fuel Solenoid Driver — a solid-state device located on the side of the injection pump that turns the injection solenoid "ON" and "OFF." The driver is controlled by the PCM.

Fuel Temperature Sensor — a thermistor that converts fuel temperature into electrical signals used by the PCM. The fuel temperature sensor is located in the same assembly as the optical sensor.

Glow Plugs System— a series of 6-volt heaters used to aid starting. The glow plugs come "ON" for a specified time when the ignition is "ON." There are two banks of glow plugs: three on the right side, three on the left side. The plugs are operated by the glow plug relay. The PCM turns the relay "ON" and "OFF" for glow plug operation. A lamp in the instrument panel alerts the driver to glow plug operation.

High Resolution Signal — see "Optical Sensor"

Injection Pump — a high pressure rotary type pump that is controlled by the PCM and meters, pressurizes, and distributes fuel to the eight injector nozzles. The 6.5L EFI diesel engine features a Stanadyne model DS pump.

Injection Timing — the procedure by which the PCM controls when and how much fuel is delivered to the injection pump, based on pump position, engine top dead center, and TDC Offset. The injection timing procedure on the 6.5L EFI diesel involves checking for DTC 88, "TDC Offset Error," and performing the recommended procedures.

Injection Timing Stepper Motor — a two-coil motor used to advance and retard injection pump timing. The motor is connected to the advance piston, which, in turn, is connected to the pump cam ring. When the motor arm retracts, it advances timing; when the arm extends, it retards timing.

Intake Air Temperature (IAT) Sensor — a thermistor that measures the temperature of air entering the intake system and transmits it as an electrical signal to the PCM. The sensor is located on top of the intake manifold.

Lift Pump — a pump that moves fuel under low pressure from the fuel tank to the transfer pump.

Malfunction Indicator Lamp (MIL) — a lamp in the instrument panel that alerts the driver to code-based system malfunction. Under most code conditions, the "Service Engine Soon" lamp will illuminate. During manual code reading, the lamp will flash codes in order from highest to lowest.

Offset, TDC — see "TDC Offset"

On-Board Diagnostic (OBD) System Check — an organized approach to identifying a vehicle problem that could be caused by a control module malfunction. The OBD System Check involves verifying proper PCM/MIL operation before proceding to further diagnosis.

Optical Sensor — a sensor that transmits injection pump speed information to the PCM. The sensor is mounted to the pump cam ring. It reads notches from a rotating disc and sends two signals to the PCM: a high resolution signal and a pump cam signal. These signals are used by the PCM to control fuel delivery and to determine pump position.

Powertrain Control Module (PCM) — a microprocessor-based control module that uses information from vehicle sensors (inputs) to control solenoids, relays, and other devices (outputs) responsible for vehicle operation. The PCM also performs system self diagnosis and has the ability to store Diagnostic Trouble Codes (DTCs) that aid in vehicle diagnosis.

Pump Cam Signal — see "Optical Sensor"

Pumping Plungers — four metal cylinders located in the injection pump cam ring. The plungers move in and out to pressurize fuel for delivery to the discharge ports.

"Scan" Tool — a bi-directional electronic tool that is used to diagnose system faults. When connected to the Diagnostic Link Connector (DLC), the "scan" tool can read Diagnostic Trouble Codes (DTCs). It can also control outputs to test their operation. The "scan" tool also has the ability to store information on a test drive for later viewing. The Tech 1 is a type of scan tool and is recommended for diagnosing General Motors vehicles.

"Service Throttle Soon" Lamp — an indicator lamp located in the instrument panel. It alerts the driver the malfunctions in the Accelerator Pedal Position (APP) sensor circuits.

Stepper Motor — see "Injection Timing Stepper Motor"

Tech 1 — see "'Scan Tool"

Vehicle Speed Sensor (VSS) — an electro-magnetic device attached to the output shaft housing. As the shaft rotates, its teeth pass the sensor, interrupting the sensor's magnetic field. This is sent as a signal to the PCM.

VSS Buffer Module — an electronic device that processes information from the vehicle speed sensor (VSS) and outputs it in various signals to the PCM and other components. The module is matched to the vehicle's transmission, final drive ratio, and tire size. The module is located in the instrument panel, near the PCM.

DIAGNOSTIC TROUBLE CODE (DTC) INDEX

Listed below are the DTCs for the 6.5L EFI diesel engine. Some codes are shared by the engine and transmission; these are identified with a double asterisk (**). Some codes are transmission-only codes; these are identified with a single asterisk (*). Other than DTCs 24 and 72 for the Vehicle Speed Sensor (VSS), the engine/transmission and transmission codes are not included in this book. They can be found in section 10 of the Driveability and Emissions Service Manual.

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