SECTION 1 ENGINE CONTROL SYSTEM OVERVIEW

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FUEL SYSTEM DESCRIPTION

The T 444E fuel system consists of three major sub–systems:

- Fuel Supply System.
- Injection Control Pressure System.
- Fuel Injector.

These sub–systems work together to inject pressurized fuel into the combustion chambers. The function of the fuel supply system is to deliver fuel to the injectors. The injection control pressure system supplies the injectors with high pressure lube oil.

The fuel injectors use the pressure from the lube oil to pressurize the fuel and inject the fuel into the combustion chambers.

The function of the fuel supply system is to deliver fuel from the fuel tank(s) to the injectors. The components involved in this task are:

- Fuel Lines
- Fuel Strainer
- Transfer Fuel Pump
- Fuel Filter/Water Separator
- Fuel Pressure Regulator Valve

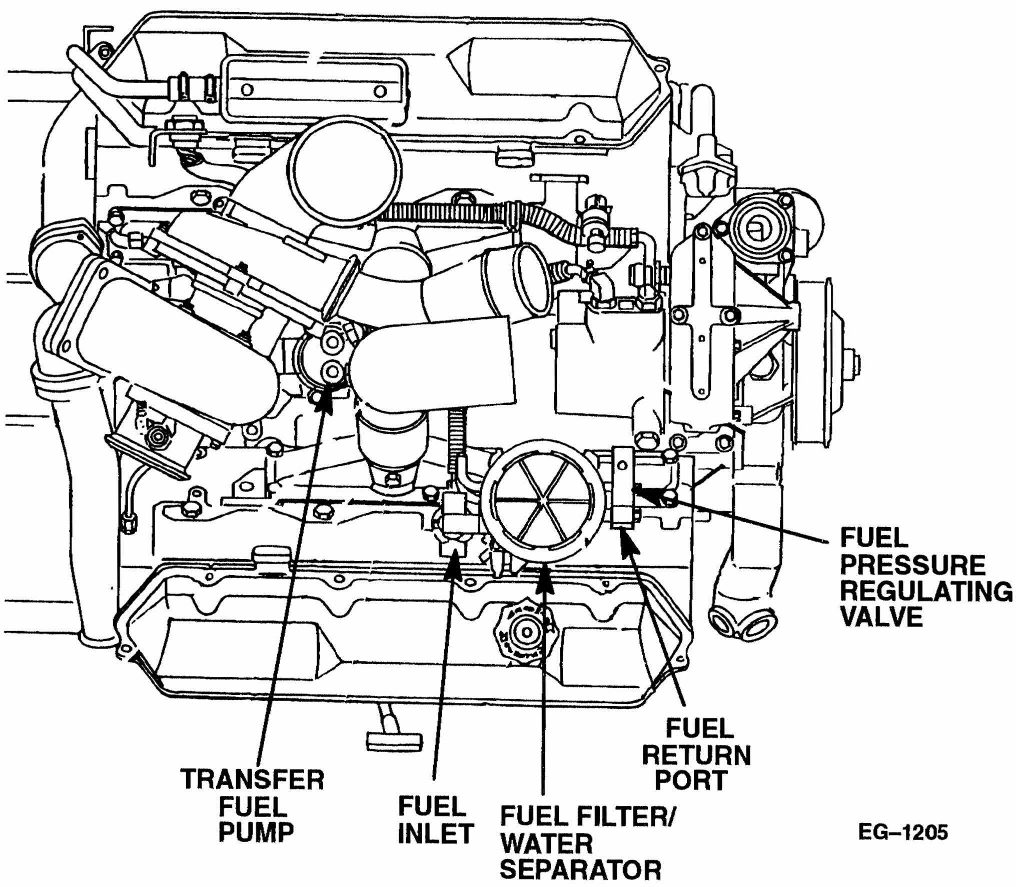

Figure 1.1–1. – Component Locations

FUEL SUPPLY SYSTEM

FUEL SYSTEM DESCRIPTION (Continued)

FUEL SUPPLY PUMP

The fuel transfer pump on the T 444E engine is a camshaft driven two stage diaphragm/piston pump mounted in the engine "V". **Refer to Figure 1.1–2.**

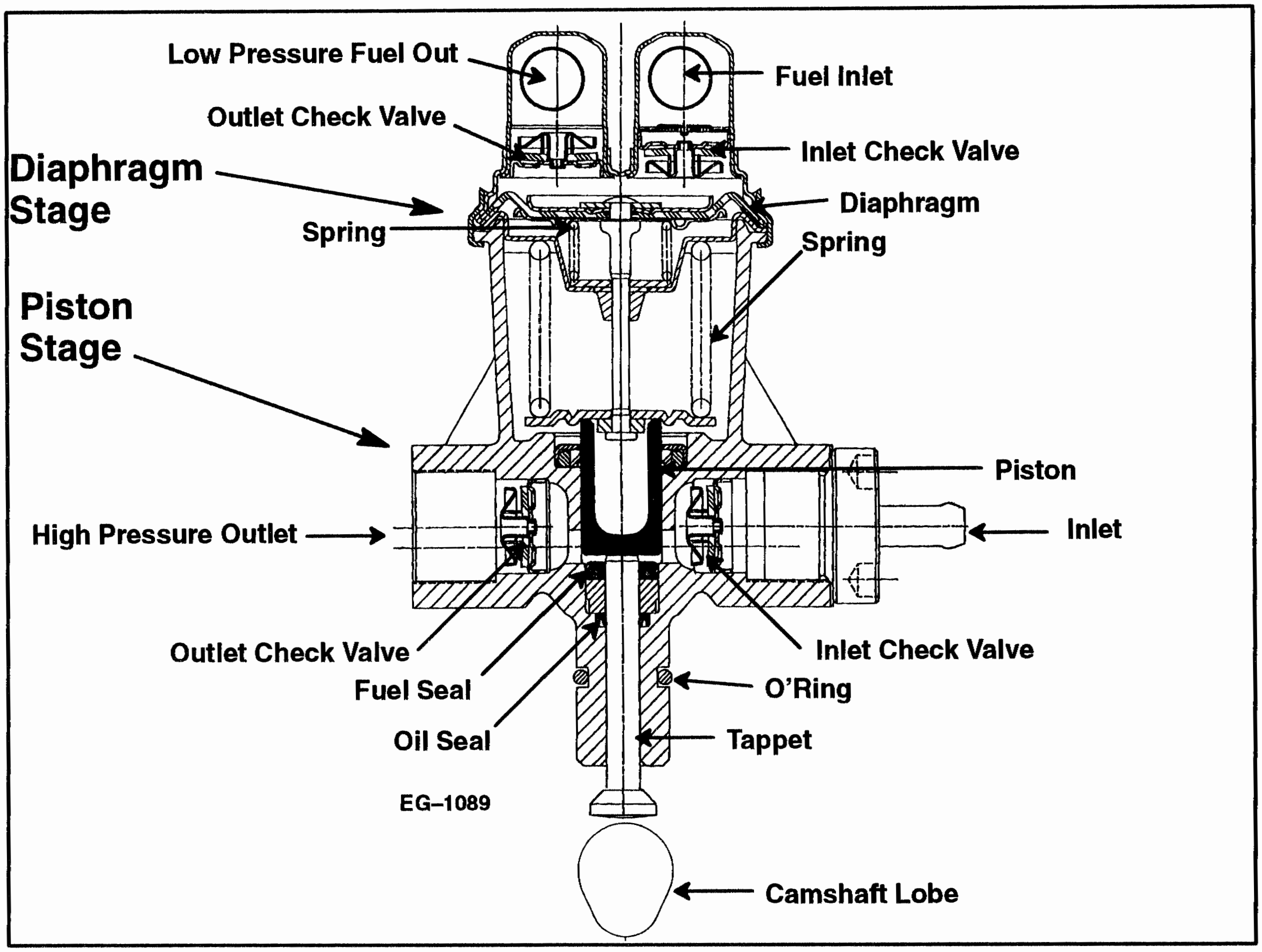

Figure 1.1–2. – Tandem Fuel Supply Pump

FUEL SYSTEM OPERATION

The diaphragm stage of the tandem lift pump draws fuel from the tank and through the fuel strainer. Pressurized fuel 4 to 6 psi (28 to 41 kPa) from the diaphragm stage is supplied to the fuel filter. Air trapped in the filter is vented back to the tank through an orifice in the regulator block mounted on the filter. The orifice is protected from plugging by a wire mesh screen located inside the filter housing.

Fuel in the filter housing passes through the filter element to a standpipe in the center of the filter assembly. Clean fuel is then routed to the inlet of the piston stage of the tandem pump.

The piston stage of the tandem pump raises fuel pressure from 4 psi to 40 psi (28 to 276 kPa) to insure proper filling of the injectors. Fuel from this stage is divided through steel lines to the back of each cylinder head. These lines supply fuel to a gallery drilled in each cylinder head which intersects each injector bore in the cylinder head. **Figure 1.1–3.**

Return fuel from the two fuel galleries is routed through hoses, of a special rubber compound, from the front of each head to the pressure regulator located on the side of the filter housing. These hoses provide flexibility in the fuel system by absorbing and smoothing pressure pulses from the piston stage of the pump.

FUEL SYSTEM DESCRIPTION (Continued)

OPERATION (Continued)

The pressure regulator contains a spring loaded valve to control pressure in the fuel galleries to 40 psi (276 kPa). Return fuel flows through the regulator and is routed to the fuel tank(s).

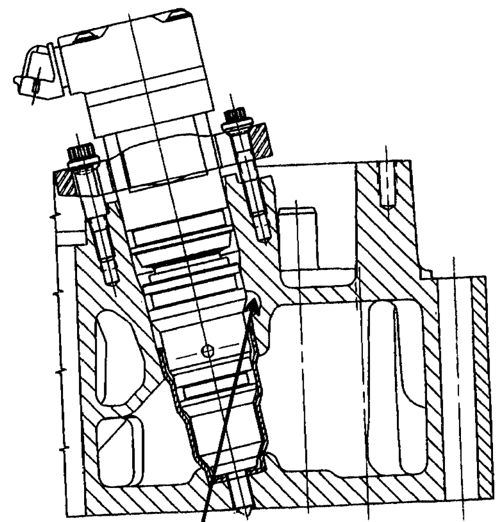

Figure 1.1–3. – Fuel Supply Passage to Injectors

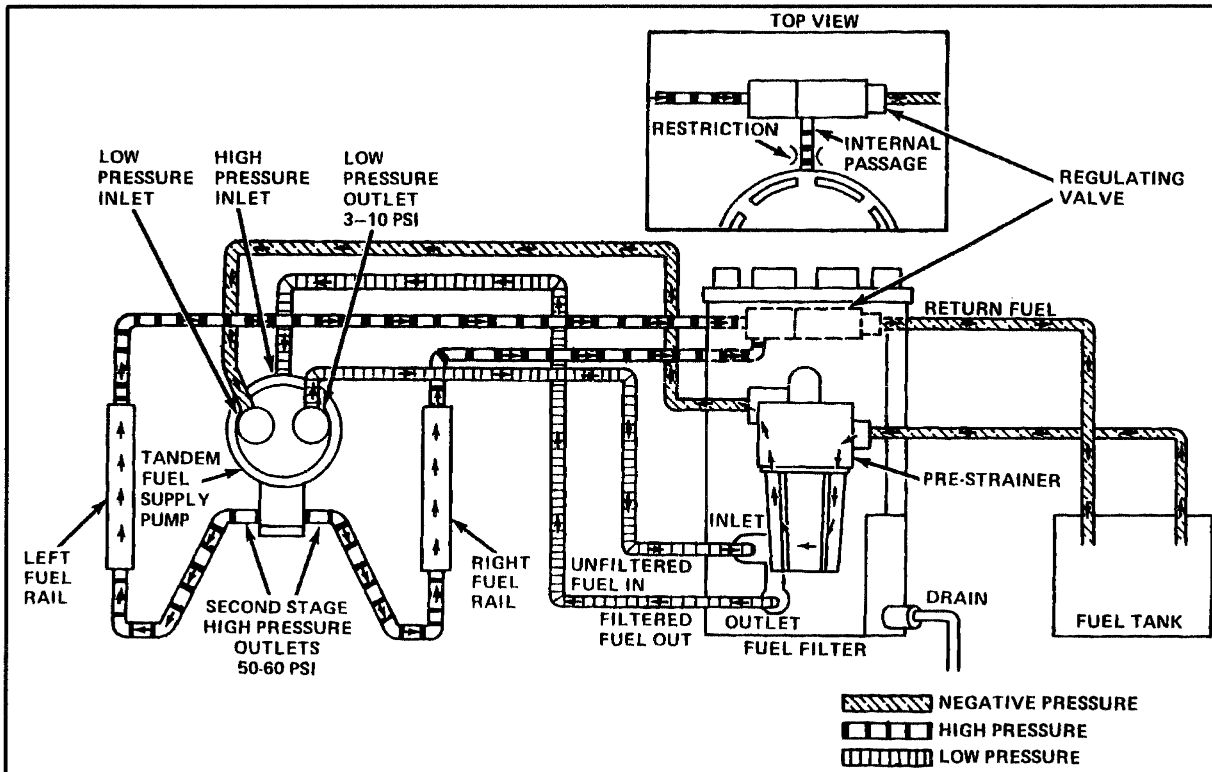

Figure 1.1–4. – Fuel Supply System

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INJECTION CONTROL SYSTEM OPERATION

(Refer to Figure 1.2–1)

The T 444E system utilizes a hydraulically actuated injector to pressurize fuel inside the injector. The hydraulic fluid used to actuate the injector is engine oil.

Oil is drawn from the oil pan thru the pickup tube by the engine oil pump. The engine oil pump is a gerotor type pump driven by the crankshaft. Oil is fed through passages in the front cover to an oil reservoir mounted on top of the front cover.

The reservoir makes available a constant supply of oil to a high pressure hydraulic pump mounted in the engine "V". The high pressure pump is a gear driven seven plunger swash plate pump. High pressure oil is delivered by the high pressure pump to oil galleries machined into the cylinder heads, drilled intersecting passages supply high pressure oil to the injector.

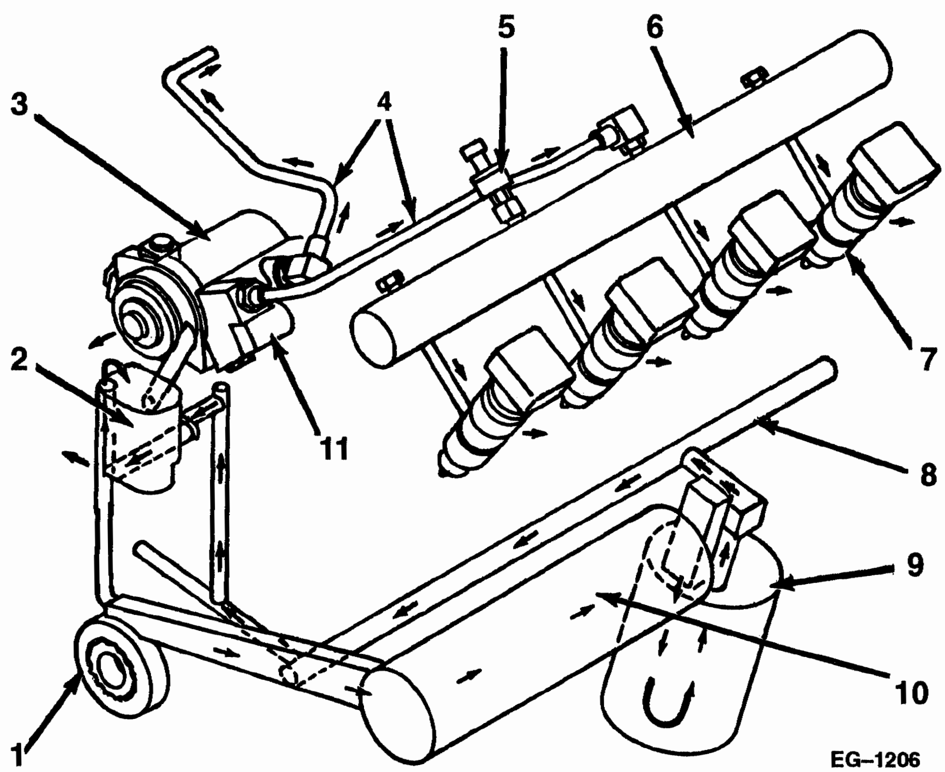

Figure 1.2–1 – Injector Oil System

1. Oil Pump
2. Reservoir (Located On Top of Front Cover)
3. High Pressure Pump
4. High Pressure Hoses
5. Injection Control Pressure Sensor
6. Cylinder Head High Pressure Rail
7. Injector (8)
8. Gallery (Crankcase)
9. Oil Filter
10. Oil Cooler
11. Injection Control Pressure Regulator

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INJECTION CONTROL PRESSURE SYSTEM

INJECTION PRESSURE CONTROL

The injection control pressure system **(Figure 1.2–2)** is a closed loop operating system. The system consists of the (ECM) Electronic Control Module, (ICP) Injection Control Pressure Sensor and the (IPR) Injection Pressure Regulator valve.

The ECM is programmed with an injection pressure control strategy which determines the correct injection control pressure at each engine operating condition. The ECM receives a 0–5 volt d.c. analog feedback signal from the ICP sensor located in the high pressure oil supply gallery on the left cylinder head that indicates Injection Control Pressure information. The ECM processes this signal and controls Injection Control Pressure by controlling the ground to the IPR regulating valve.

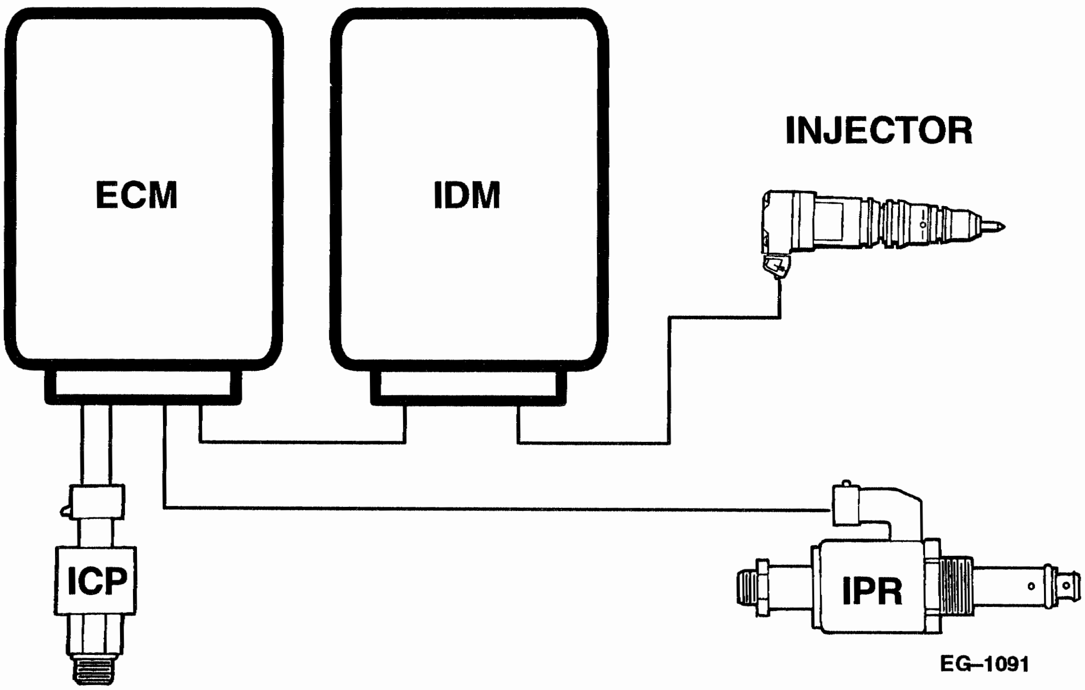

Figure 1.2–2 – Injection Control System

IPR VALVE OPERATION

The Injection Pressure Regulator valve is a pulse width modulated valve operating at 400 Hz. The pulse width is modulated from a duty cycle of 0 to 50% to control ICP pressure from 500 to 3000 psi (3.4 to 20 mPa). The regulator valve is mounted in the high pressure pump and achieves injection control pressure regulation by dumping excess oil through a (shuttle) spool valve into the front cover and back to sump.

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IPR VALVE OPERATION (Continued)

Figure 1.2–3 illustrates the IPR valve in the Engine Off state. The spool valve is held closed (to the right) by the return spring and the drain ports are closed.

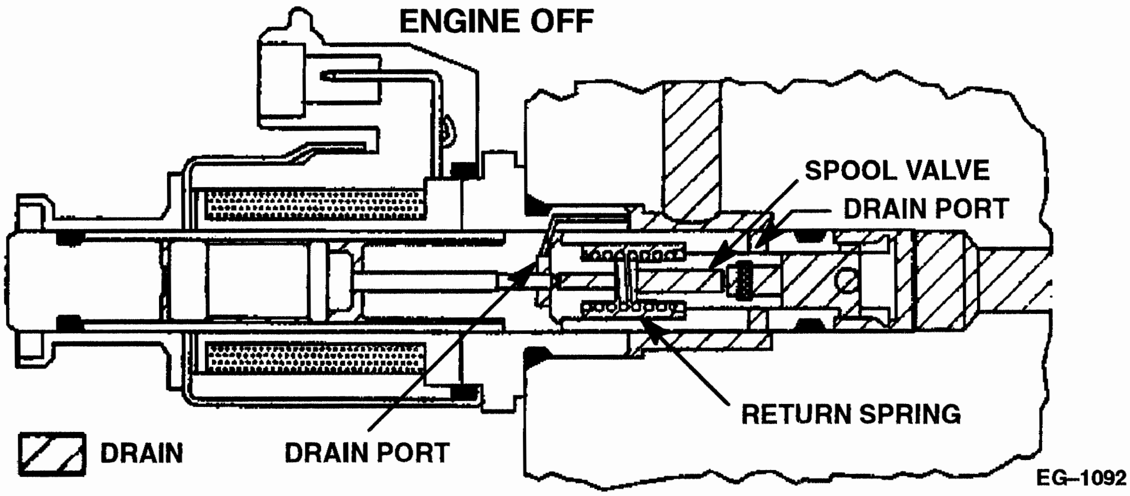

Figure 1.2–3 – Engine Off

Figure 1.2–4 illustrates the IPR valve in the Engine Cranking state. The ECM signals the IPR valve to close which directs all the oil to flow into the oil supply galleries to build oil pressure as quickly as possible to start the engine.

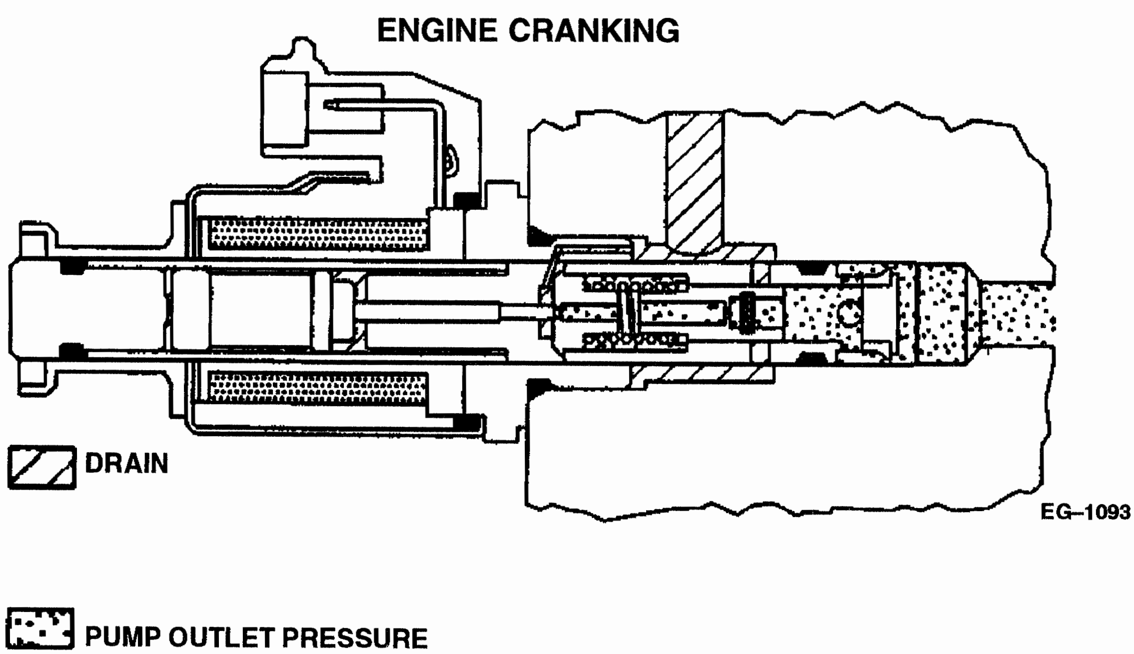

Figure 1.2–4– Engine Cranking

IPR VALVE OPERATION (Continued)

Figure 1.2–5 illustrates the IPR valve in the Engine Running state. The ECM pressure regulating signal determines the magnetic field strength of the IPR valve solenoid. The magnetic field pulls the poppet to the left as shown in **Figure 1.2–5**. This action allows the pump outlet pressure that is on the spool valve to move the spool valve to the new position of the poppet. Poppet movement allows a small amount of oil to enter the spool chamber through the spool valve control orifice and filter.

Spool chamber oil pressure is regulated by the ECM by controlling the poppet position. The spool responds to pressure changes in the spool chamber by changing position to maintain a balance of pressure on each side of the spool. Spool valve position determines the desired injection control pressure by bleeding off oil from the pump outlet to the drain port.

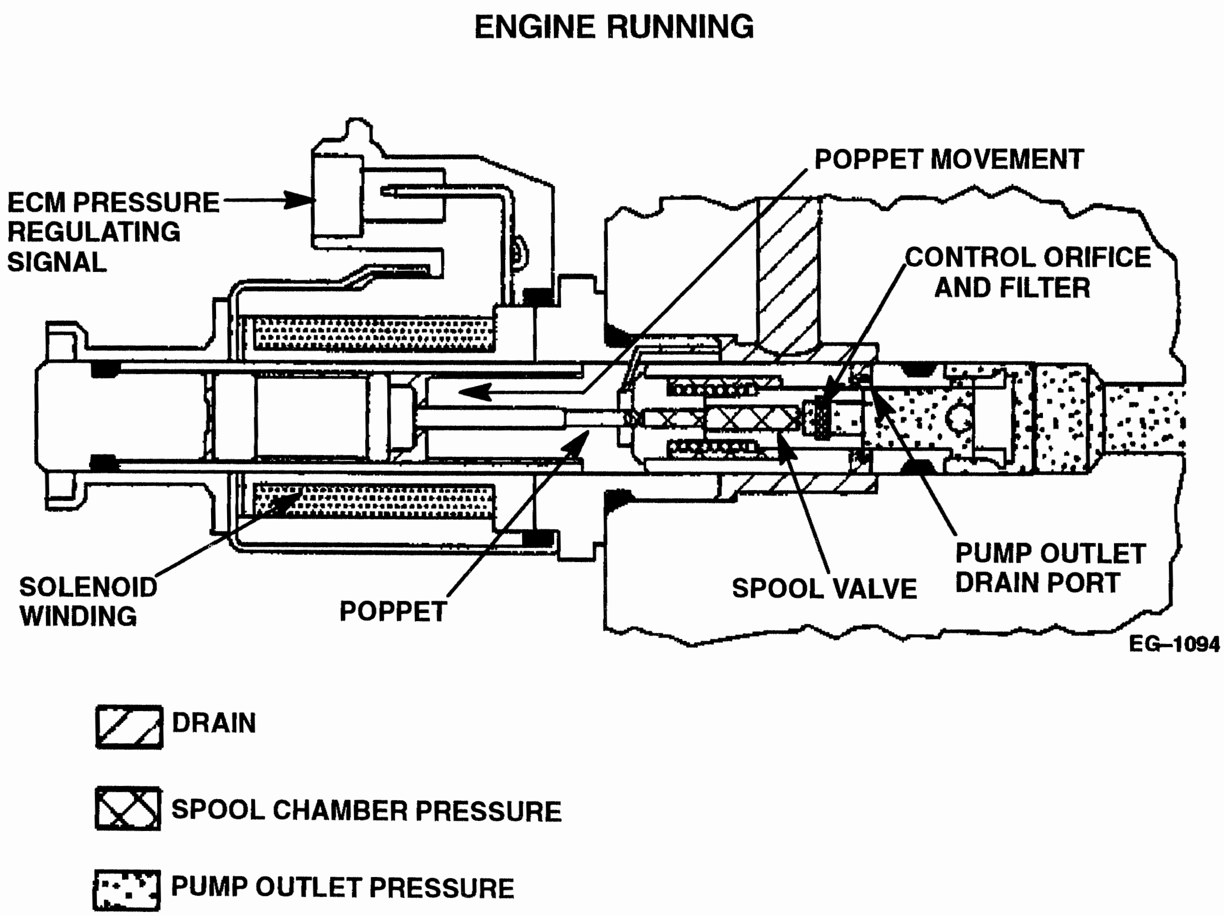

Figure 1.2–5 – Engine Running

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INJECTOR OPERATION

When an injector is energized, **(Figure 1.3–1.)** the poppet valve is opened by an electronic solenoid mounted on the injector. Oil pressure is allowed to flow into the injector and act on the amplifier piston. When injection is ended the pressure on top of the amplifier piston is vented by the poppet valve thru the top portion of the injector and directed by the oil troughs mounted on the injector to a push tube hole for return to the oil sump.

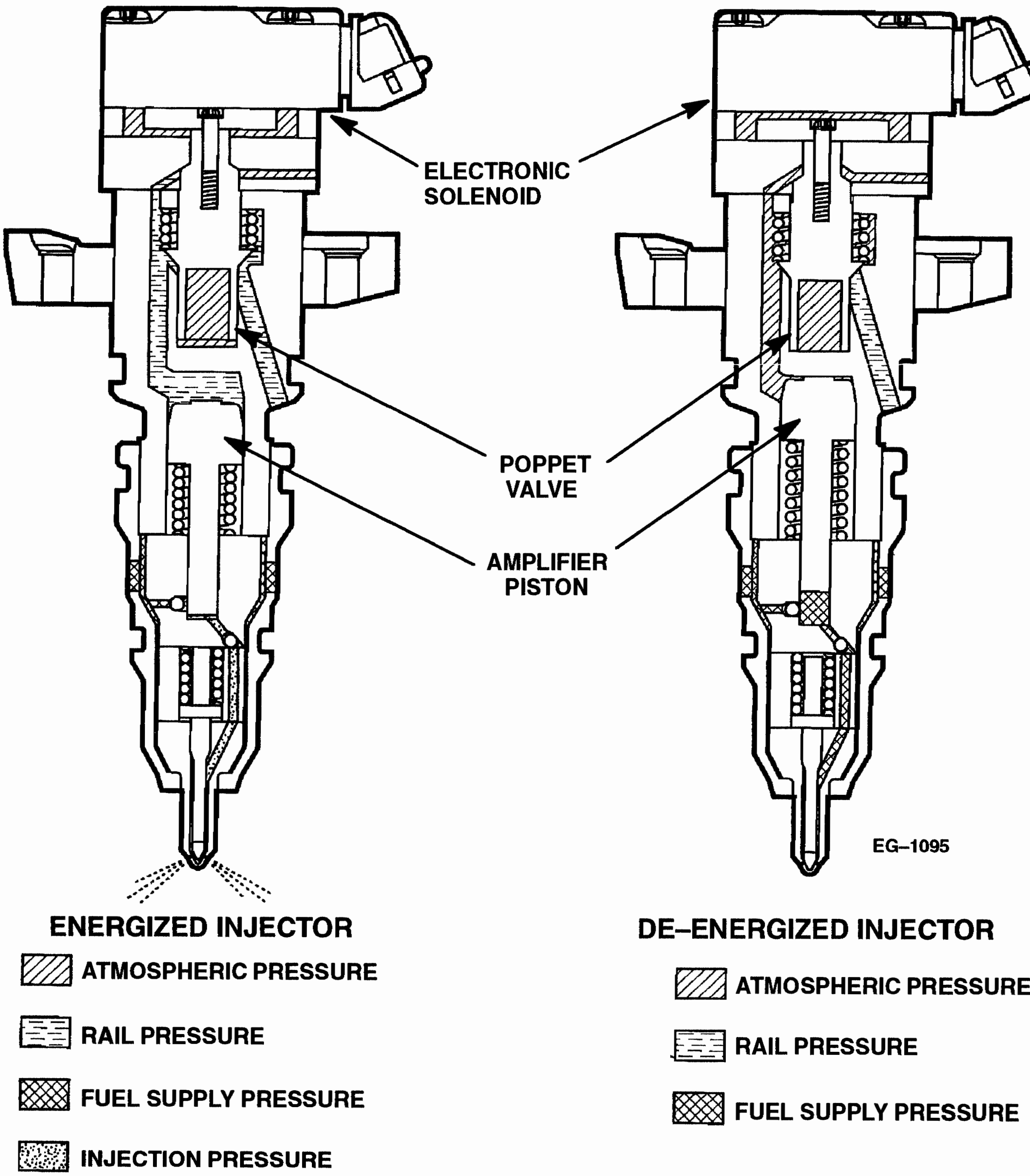

Figure 1.3–1. – Energized vs. De–energized Injector

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EXHAUST BACK PRESSURE DEVICE (Optional)

DESCRIPTION

The Exhaust Back Pressure device (**Figure 1.4–1.**) is a mechanism which applies a restriction to the flow of exhaust gas exiting the turbocharger. The increased restriction created by the closure of the butterfly valve increases exhaust back pressure and causes the engine to work harder to force the exhaust gases out of the turbocharger. This results in more heat transferred from the engine to the coolant which allows the cab in the vehicle to receive more heat in a short amount of time.

OPERATION

The exhaust back pressure device is located on the turbocharger pedestal and consists of the following components:

1. Exhaust Back Pressure Regulator (EPR).
2. Actuator Piston
3. Butterfly valve.

The Exhaust Back Pressure device is controlled by the Electronic Control Module (ECM). The ECM senses Engine Coolant Temperature and Intake Air Temperature (**Figure 1.4–2.**) to determine when the exhaust back pressure (butterfly valve closure) is required.

Engine oil pressure is present on one side of the regulator valve while the engine is running. When coolant and intake air temperatures are low, the ECM signals the regulator valve to open which allows engine oil pressure to push on the actuator piston causing the butterfly valve to close. The ECM receives exhaust back pressure information from the exhaust back pressure sensor and controls the position of the butterfly valve.

When the engine reaches operating temperature, the ECM will signal the regulator valve to fully close, cutting off engine oil pressure to the actuator piston. The actuator piston will retract due to spring pressure causing the butterfly valve to fully open and remove the exhaust restriction.

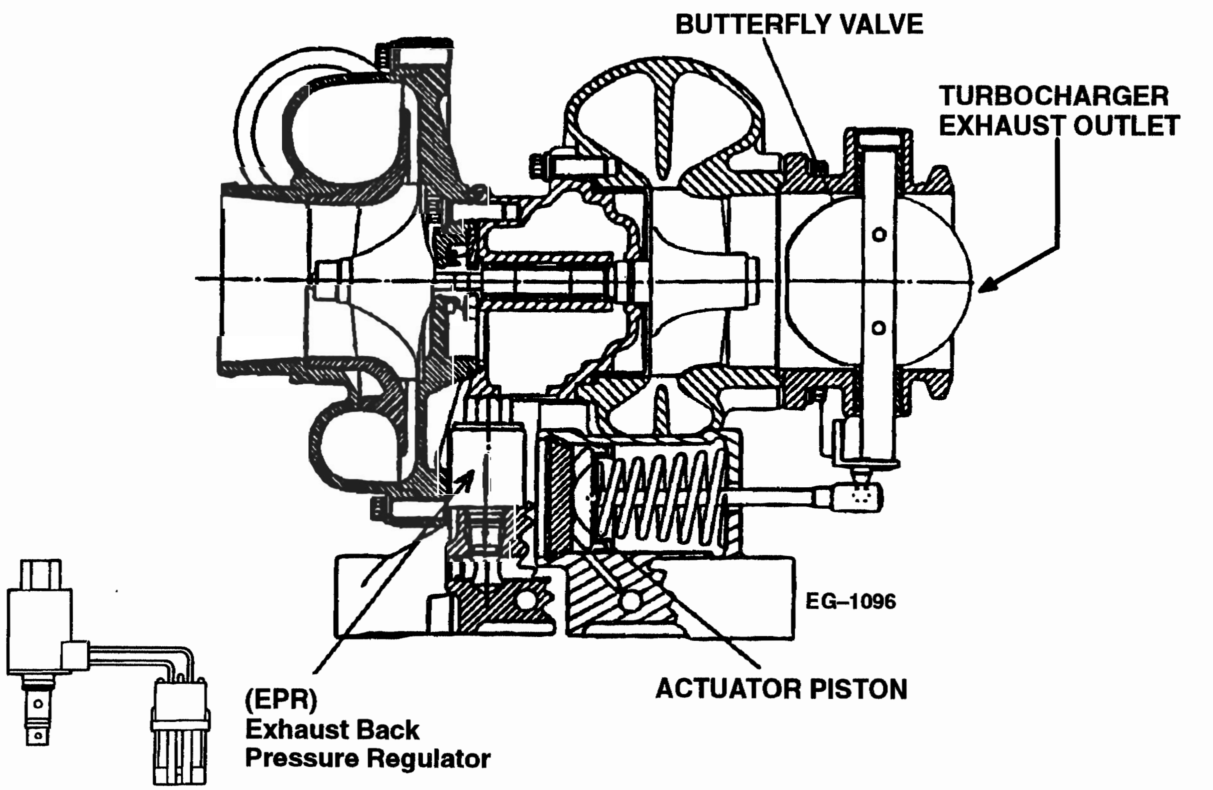

Figure 1.4–1. – Exhaust Back Pressure Device

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EXHAUST BACK PRESSURE DEVICE (Continued)

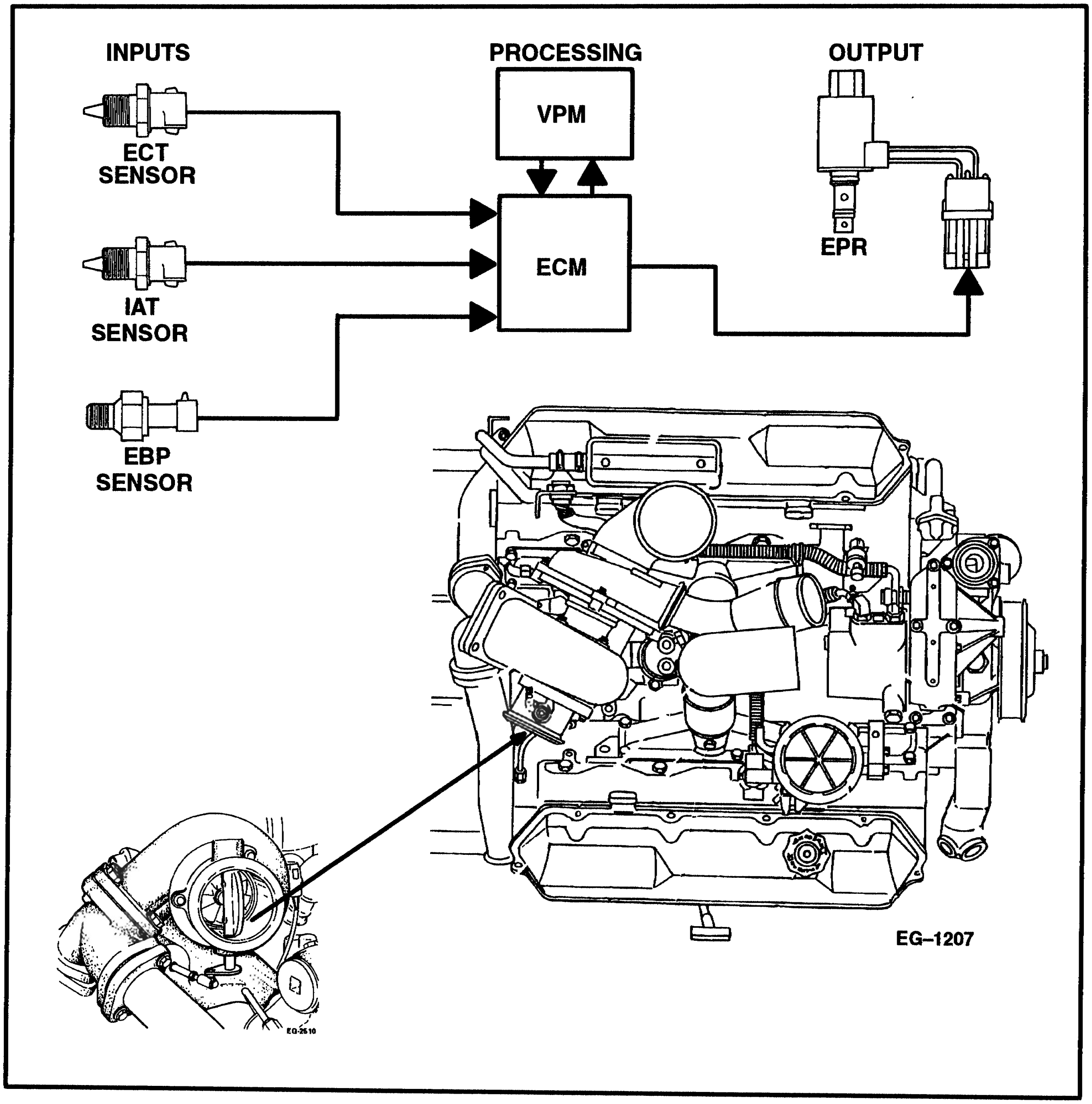

Figure 1.4–2. – Exhaust Back Pressure Device Location and Function

ELECTRONIC CONTROL MODULE

OPERATION AND FUNCTION

The Electronic Control Module (ECM) **(Figure 1.5–1.)** monitors and controls engine performance to ensure maximum performance and adherence to emissions standards. The ECM is also able to monitor and control vehicle features such as cruise control, transmission control, starter engagement etc.

To understand how the ECM functions and how it can monitor input signals and exert control over the actuators it is necessary to view the four primary functions of the ECM.

ECM Functions

- **Reference Voltage Regulator**
- **Input Conditioners**
  - **AMP**
  - **A/D Converter**
- **Microcomputer**
  - **Processor**
  - **Memory**
- **Output Drivers**
  - **Grounding Transistors**

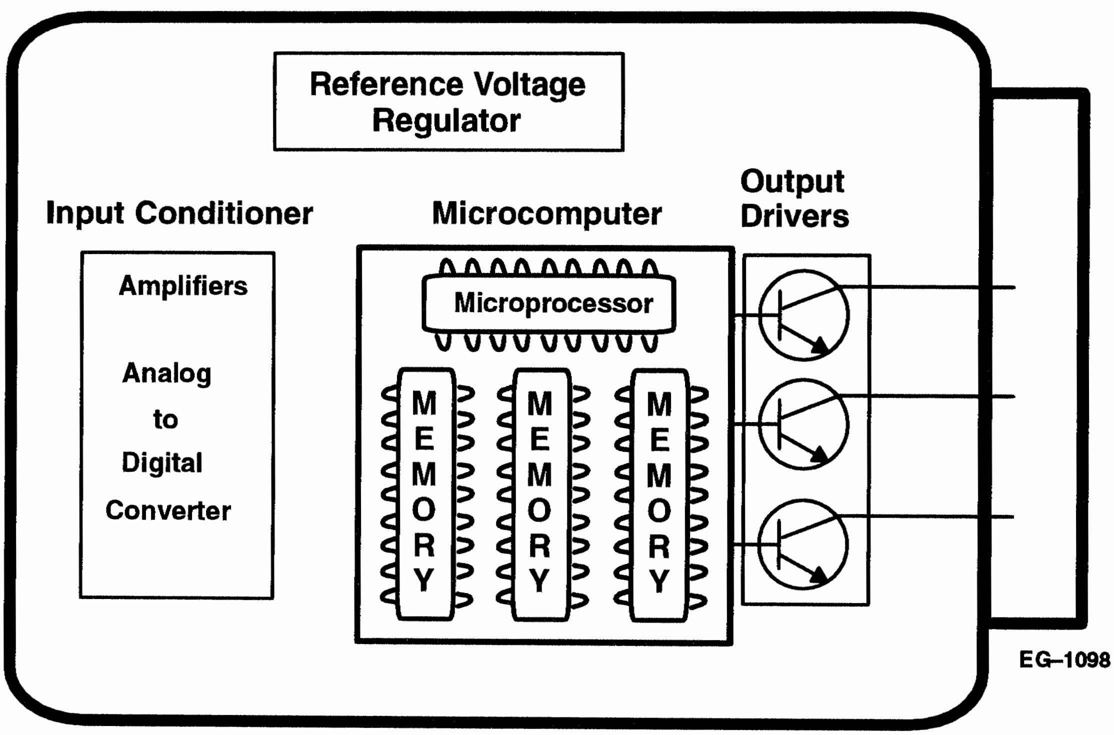

Figure 1.5–1. – Electronic Control Module

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OPERATION AND FUNCTION (Continued)

I. VOLTAGE REFERENCE

The ECM supplies a 5 volt reference signal to many of the input sensors in the control system. On most circuits the ECM compares the regulated 5 volts sent to the sensors by the modified returned signal and is able to determine temperature, pressure, speed, position and many other variables that are important to engine and vehicle functions. This 5 volt signal is current limited by a current limiting resistor in the event of an external dead short to ground.

For some sensors, like CMP (Camshaft Position), the 5 volts signal is a power source that powers up the circuitry in the sensor.

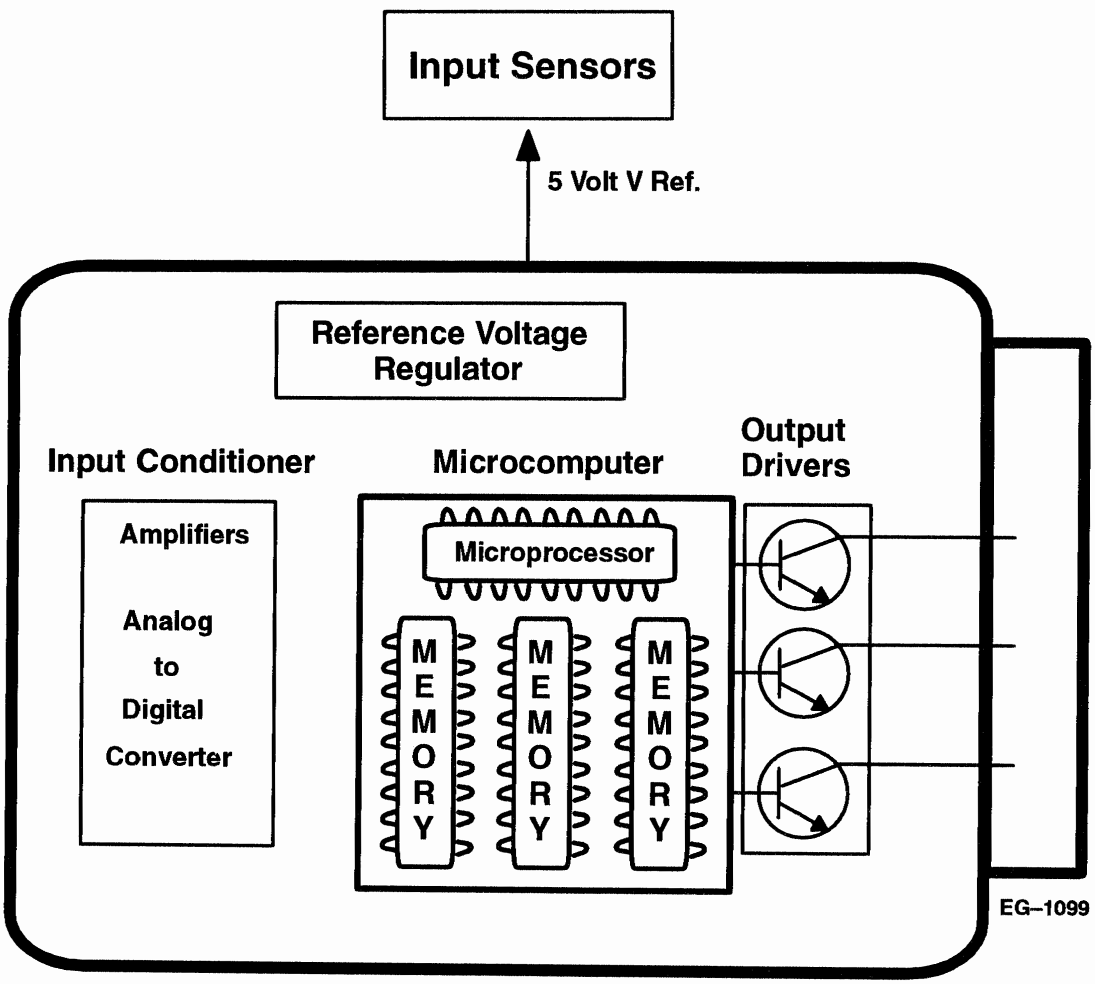

Figure 1.5–2. – Electronic Control Module 5 Volt Reference

OPERATION AND FUNCTION (Continued)

II. SIGNAL CONDITIONER

It conditions the input signals for the internal microprocessor **(Figure 1.5–3.)**. This enables the microprocessor to interpret the signals. Signal conditioning usually consists of converting analog signals to digital signals, squaring up sine wave signals or amplifying low intensity signals to a level the ECM microprocessor can process.

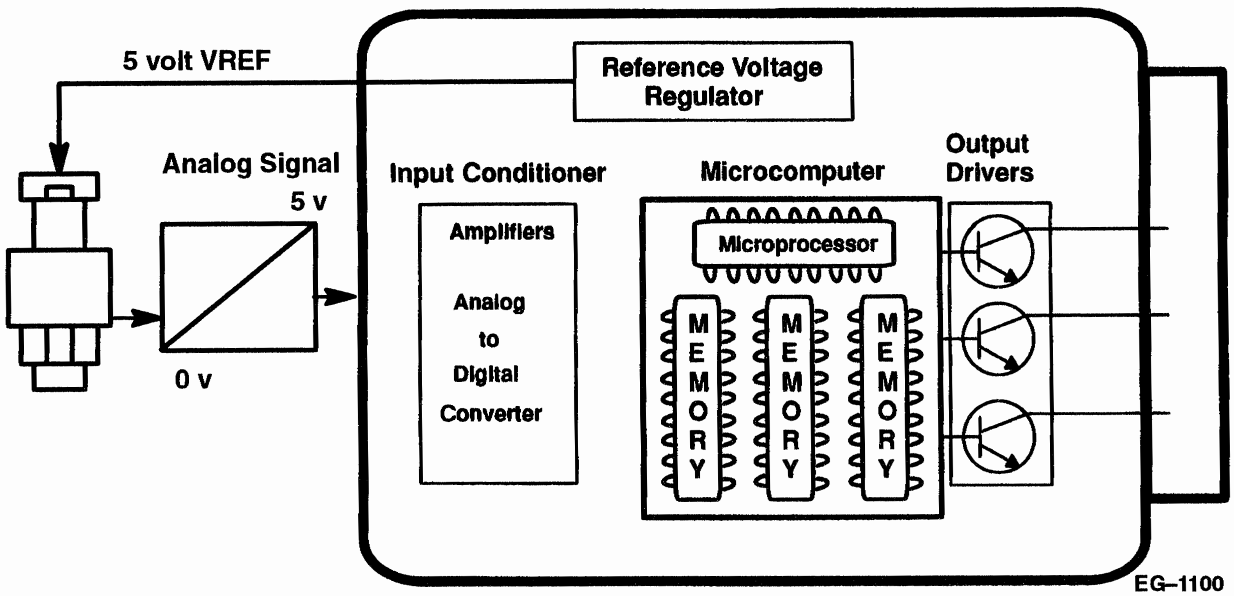

Figure 1.5–3. – Electronic Control Module Signal Conditioning

III. MICROPROCESSOR

The ECM contains an internal microprocessor. The processor stores operating instructions (control strategies) and tables of values (calibration parameters). It compares these stored instructions and values to sensed input values to determine the correct operating strategy for any given engine condition. Calculations in the ECM occur at two different levels or speeds referred to as the foreground and the background calculations. These calculations are performed on a continuous closed loop basis.

The foreground calculations occur at a much faster rate than the background calculations. These are normally the more critical functions to engine operation or they occur at a faster rate. Such as engine speed control. Background calculations are normally things that occur at a slower pace such as engine temperature.

Diagnostic strategies (instructions) are also programmed into the ECM. Some instructions cause inputs or outputs to be monitored on a continuous basis and will flag a code that will be set, other strategies will instruct the ECM to perform certain tests upon operator demand.

The ECM's microprocessor is equipped with three types of memory Random Access Memory (RAM), Read Only Memory (ROM) and Keep Alive Memory (KAM) **(Figure 1.5–4.)**. They allow the processor to store the necessary instructions, calibration tables and input values to control the engine.

OPERATION AND FUNCTION (Continued)

ROM:

Read Only Memory is the memory where calibration tables and operating strategies are stored. Information in the ROM is permanent. It can not be changed or lost by turning the engine off or disconnecting the batteries.

RAM:

Random Access Memory is a temporary storage memory for current events such as current engine temperature or current speed, pedal position etc. It is the memory to which information is temporarily stored so that it can be compared to the information in the ROM. Unlike the Rom memory, the RAM is lost every time the key is turned off or when power is interrupted to the ECM.

KAM:

Keep Alive Memory is a permanent memory. It is used to store diagnostic faults (codes). Adaptive strategies (temporary operating instructions) can also be written to it in event of a system failure or as a compensation for component wear. Uninterrupted power must be supplied from the battery to the ECM on a continuous basis to keep KAM memory alive. All information in KAM is lost if the ECM has a total power loss such as when the batteries are disconnected.

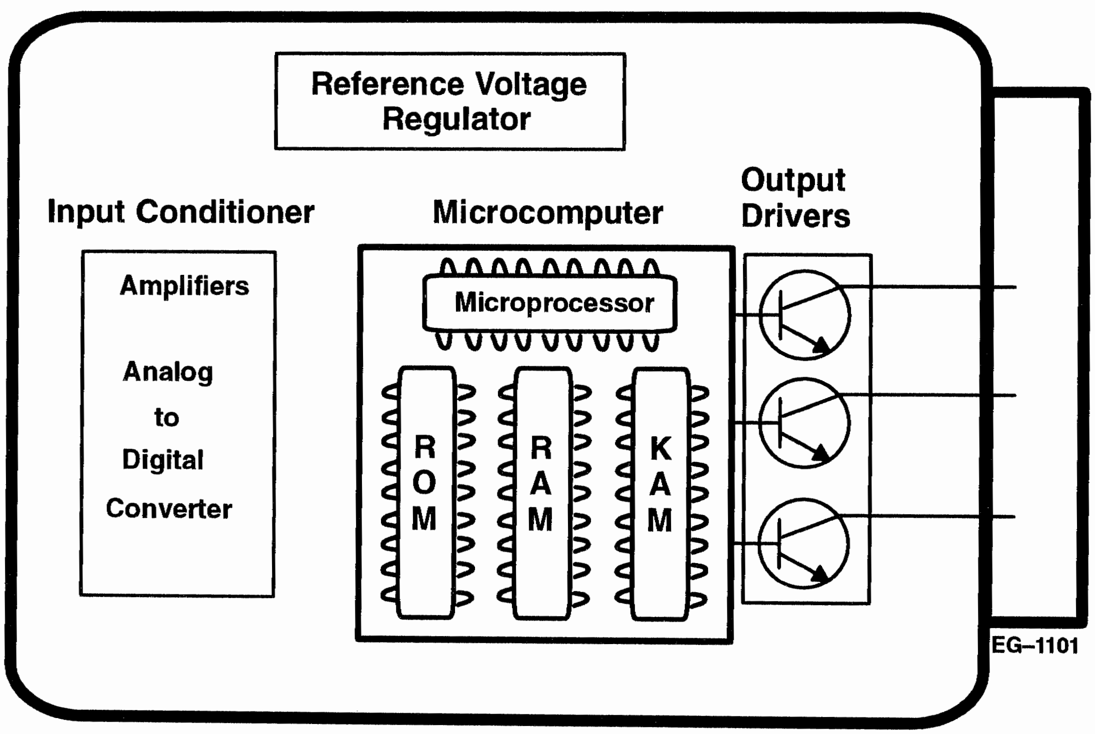

Figure 1.5–4. – Electronic Control Module Microprocessor Memory

OPERATION AND FUNCTION (Continued)

ACTUATOR CONTROL

The ECM controls the actuators by applying a (low level) signal to the base of the transistor output drivers **(Figure 1.5–5.)**. These drivers, when switched on, will complete the ground circuit of each actuator.

The actuators are controlled either thru a duty cycle (% time on/off), or controlled thru a controlled pulse width or simply just switched on or off as determined by the type of actuator being controlled.

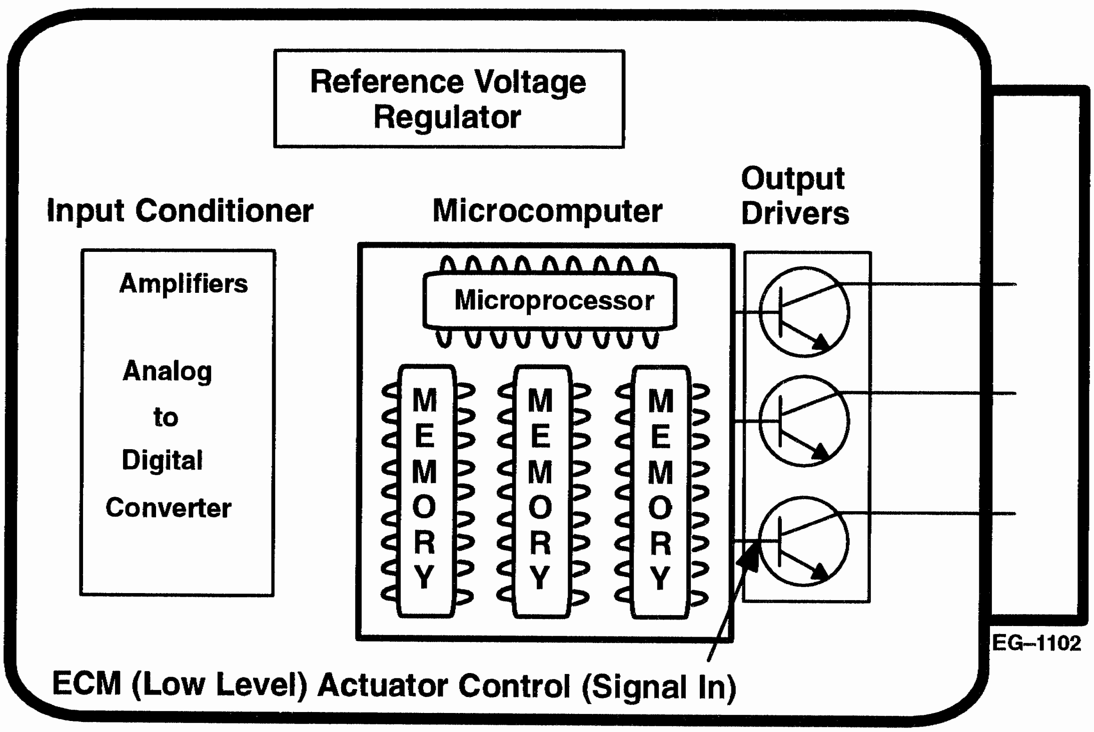

Figure 1.5–5. – Electronic Control Module Actuator Control

INJECTION DRIVER MODULE FUNCTIONS

The Injection Driver Module (IDM) is a device that performs four major functions.

I. Electronic Distributor for the injectors.
The Electronic Control Module (ECM) senses the piston position of cylinder #1 from the output signal of the Camshaft Position Sensor (CMP) which is located on the engine front cover. The CMP sensor is a Hall effect sensor which looks for a narrow vane on the timing sensor disk **(Figure 1.6–1.)**. The disk is precisely mounted and indexed on the camshaft gear in a relationship that identifies the position of #1 piston.

The ECM uses this signal to determine the correct injector firing sequence. The Cylinder Identification (CI) line carries the injector firing sequence information to the IDM.

The IDM receives a Fuel Demand Command Signal (FDCS) signal from the ECM to control injector timing and the quantity of fuel that is delivered by each injector.

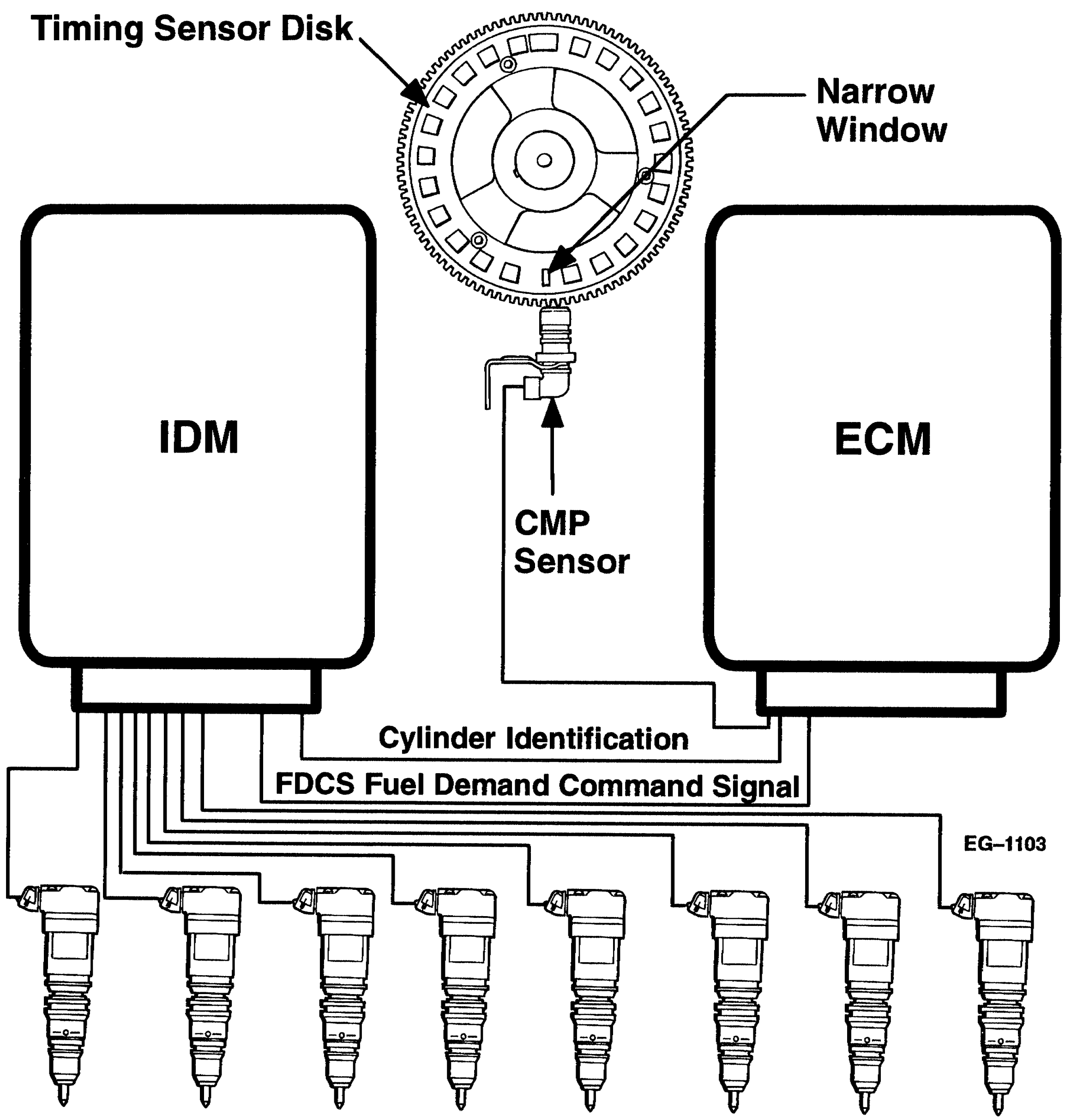

Figure 1.6–1. – Injector Driver Module (Distributor)

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INJECTOR DRIVER MODULE FUNCTIONS – (Continued)

II. Power Source for the injectors.

The IDM supplies a constant 115 + volt d.c. supply to all injectors. The 115 volt d.c. supply is created in the IDM by making and breaking a 12 volt source across a coil internal to the IDM, the same principle is used on automotive coils. The resultant 115 + volts created by the collapsed field is stored in capacitors until used by the injectors.

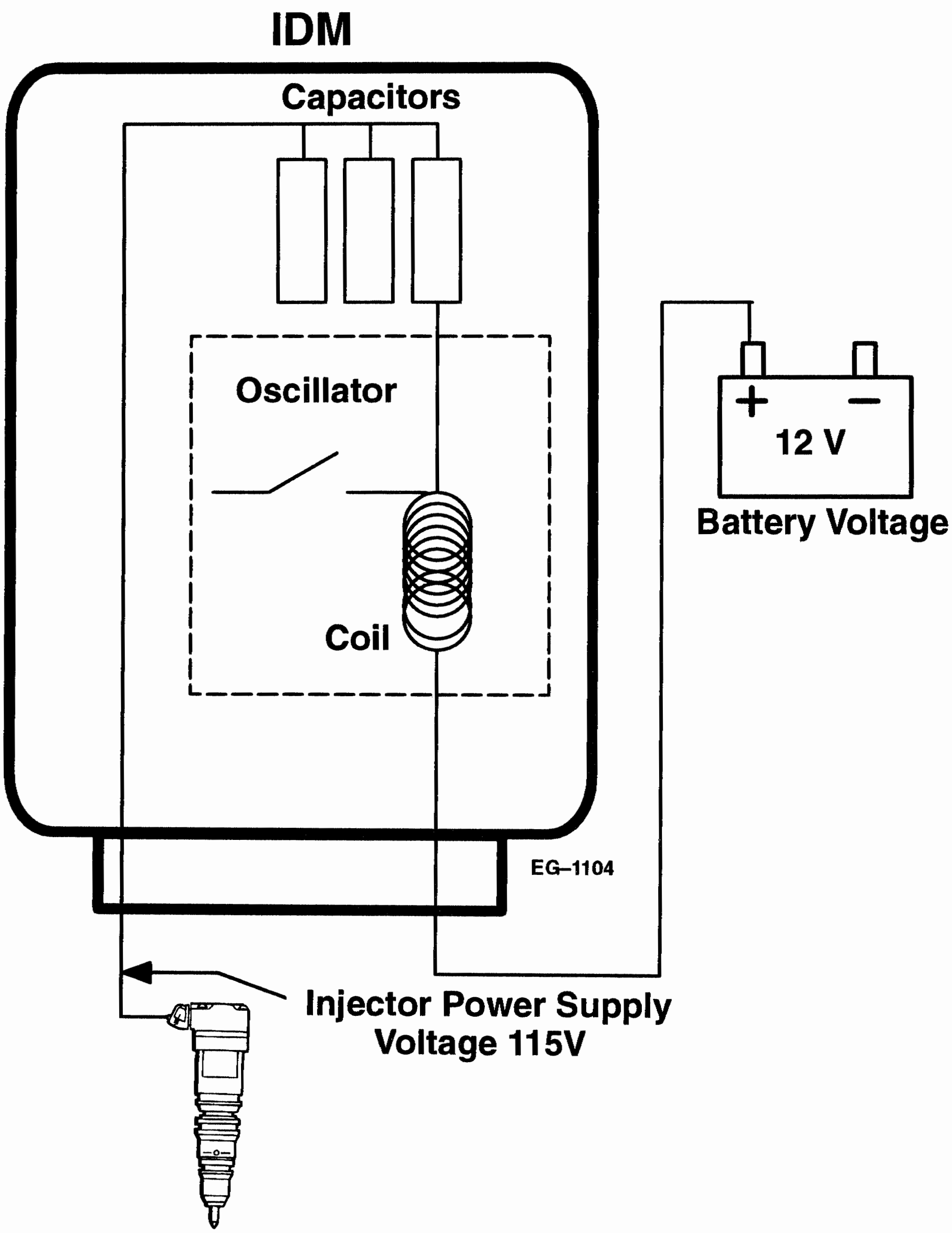

Figure 1.6–2. – Injector Driver Module (Power Source)

INJECTOR DRIVER MODULE FUNCTIONS – (Continued)

III. Output Driver for the injectors

The IDM controls when the injector is turned on and how long the injector is turned on by closing the circuit to ground by the use of output driver transistors. Each injector has an individual output driver in the IDM. The processor in the IDM selects the correct firing sequence, the ECM through the FDCS signal controls the timing of when the injection starts and the duration of how long the injector is open.

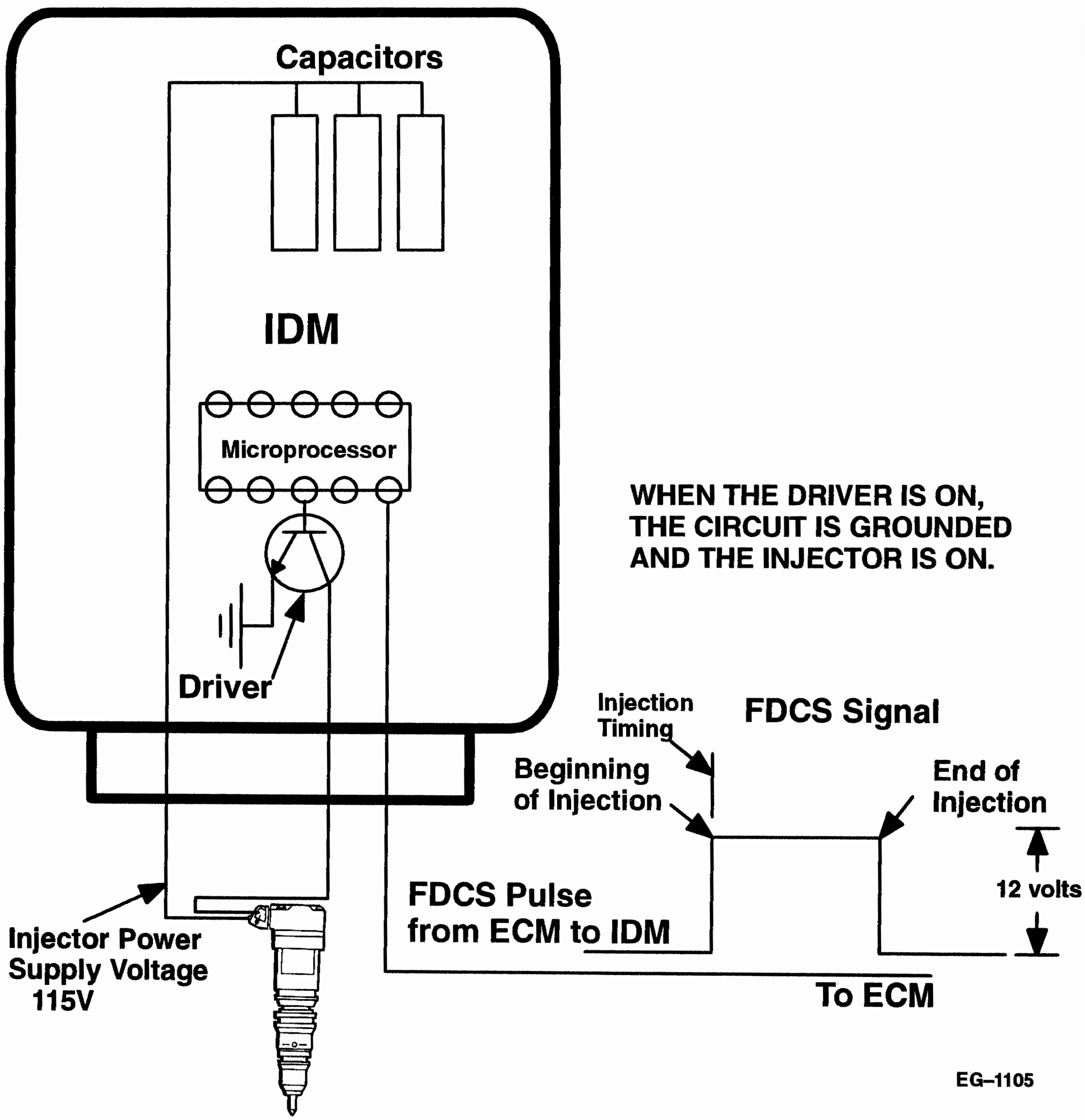

Figure 1.6–3. – Injector Driver Module (Output Driver)

INJECTOR DRIVER MODULE FUNCTIONS – (Continued)

IV **Performs diagnostics for itself and the injectors.** The IDM is capable of identifying if an injector is drawing too much current or too little current and sends a fault code to the ECM that can be accessed by the technician. This code can be used to identify potential problems in either the wiring harness or injector. The IDM also performs self diagnostic checks that can set a code to indicate that the IDM has failed and needs to be replaced.

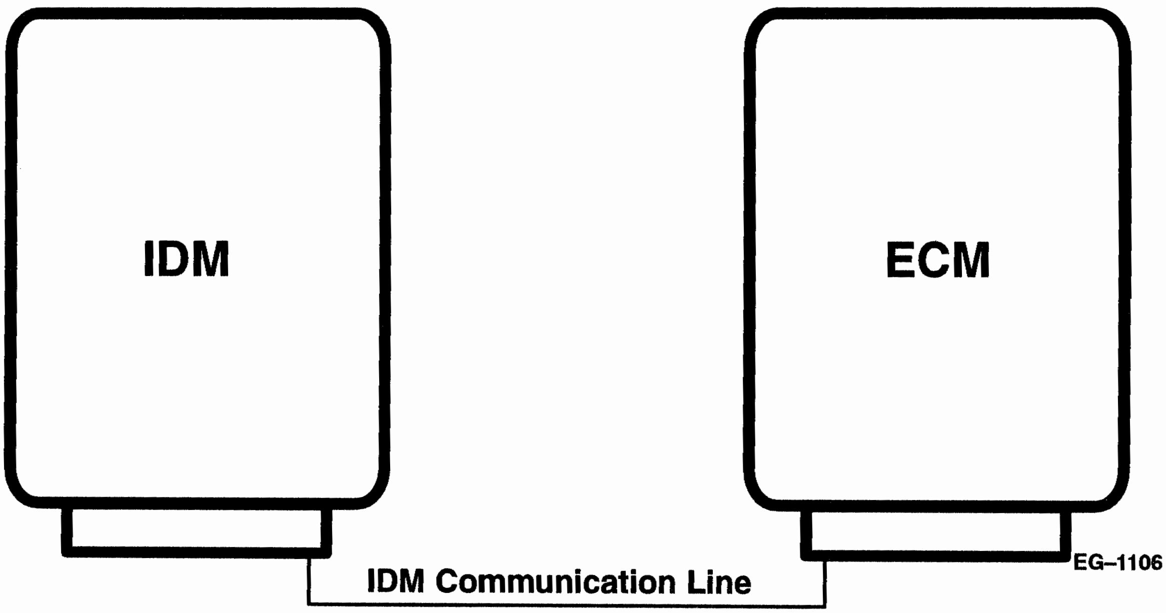

Figure 1.6–4. – Injector Driver Module Diagnostic Communication

SENSOR OPERATION

INPUT SIGNALS

Engine and vehicle sensors transmit input signals to the Electronic Control Module (ECM) **(Figure 1.7–1.)** by either:

- Controlling a reference voltage to produce an analog or digital signal.
- Generating a signal voltage.
- Switching a 12 volt signal.

REFERENCE VOLTAGE SENSORS

Reference voltage sensors are supplied with a constant 5 volts regulated supplied by the ECM. A voltage regulator supplies the reference voltage (Vref) to these sensors. This voltage is changed by the sensor and the signal is relayed back to the ECM. The ECM, by comparing the Vref to the returned signal can check it's internal programmed tables to determine the value of the variable being measured.

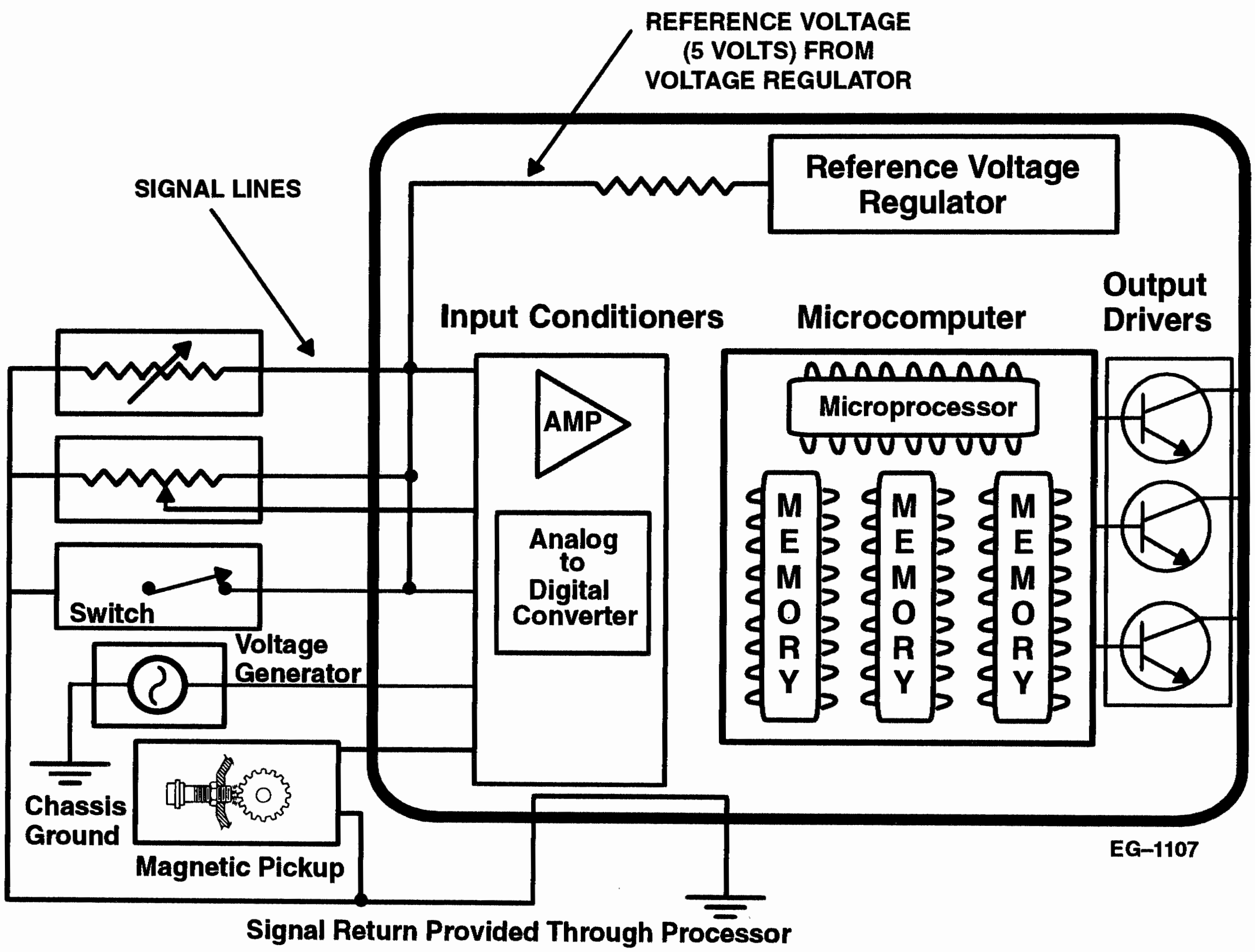

Figure 1.7–1. – Types of Input Signals

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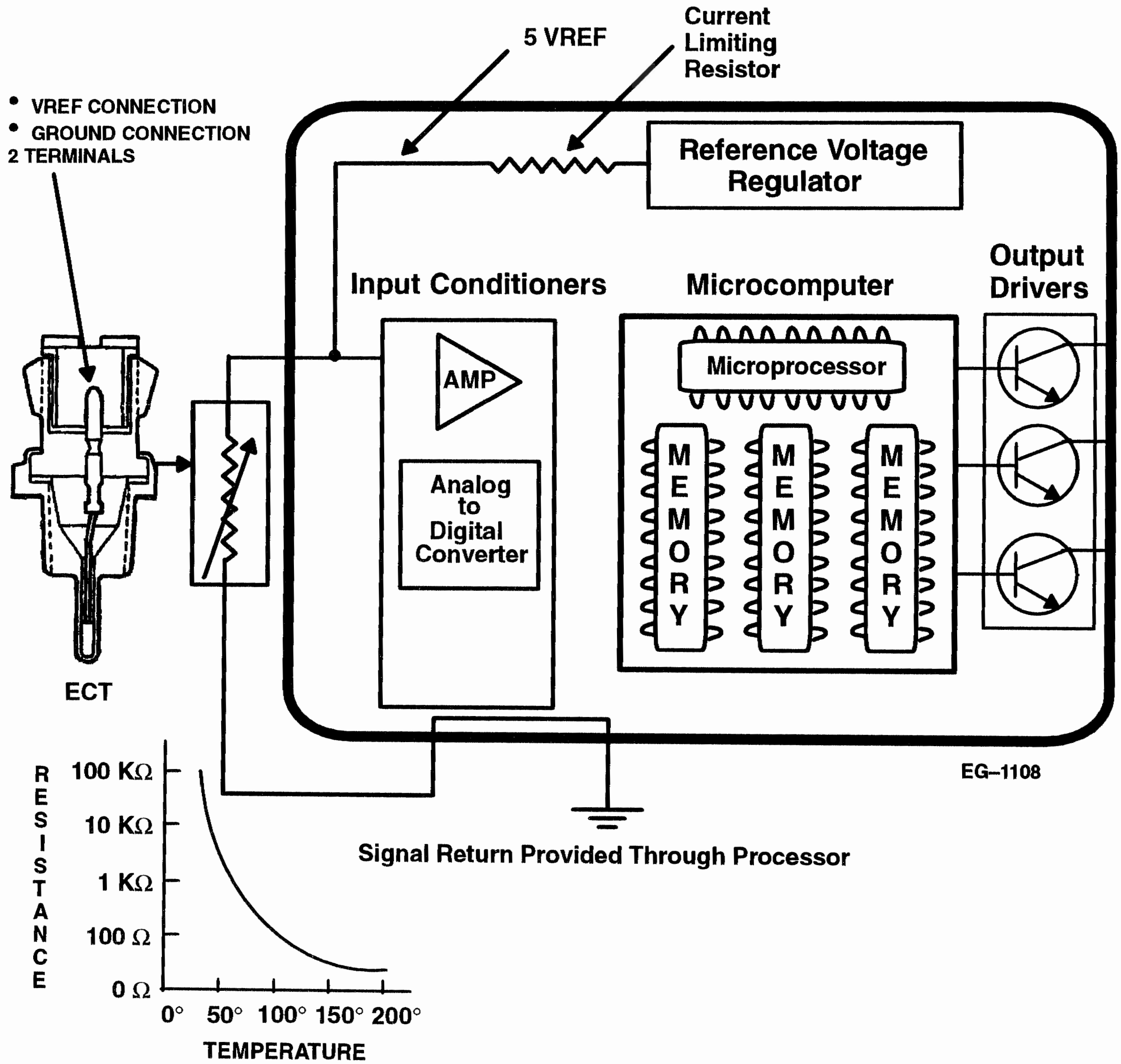
TYPES OF SENSORS

THERMISTOR

A thermistor is a type of sensor which changes it's electrical resistance with temperature. The electrical resistance of the thermistor decreases as temperature increases and increases as temperature decreases. The thermistor in conjunction with a current limiting resistor in the ECM **(Figure 1.7–2.)** forms a voltage divider network that provides a voltage signal that indicates temperature. The top half of the voltage divider is the current limiting resistor internal to the ECM. A thermistor sensor has two electrical connections, signal return and ground. The output of a thermistor sensor is not linear.

Examples:

- EOT Engine Oil Temperature
- ECT Engine Coolant Temperature Sensor
- IAT Intake Temperature Sensor



The chart indicates resistance of a thermistor decreases as temperature increases. Output of thermistor is not linear.

Figure 1.7–2. – Thermistor Engine Coolant Temperature (ECT)

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TYPES OF SENSORS (Continued)

POTENTIOMETER

A potentiometer **(Figure 1.7–3.)** is a variable voltage divider used to sense the position of a mechanical component. A reference voltage is applied to one end of the potentiometer. Mechanical motion connected to the wiper causes it to move along the resistance material in a rotary fashion. The voltage on the wiper changes at each point along the resistive material. This voltage is proportional to the amount of mechanical movement.

Example:
APS Accelerator Position Sensor

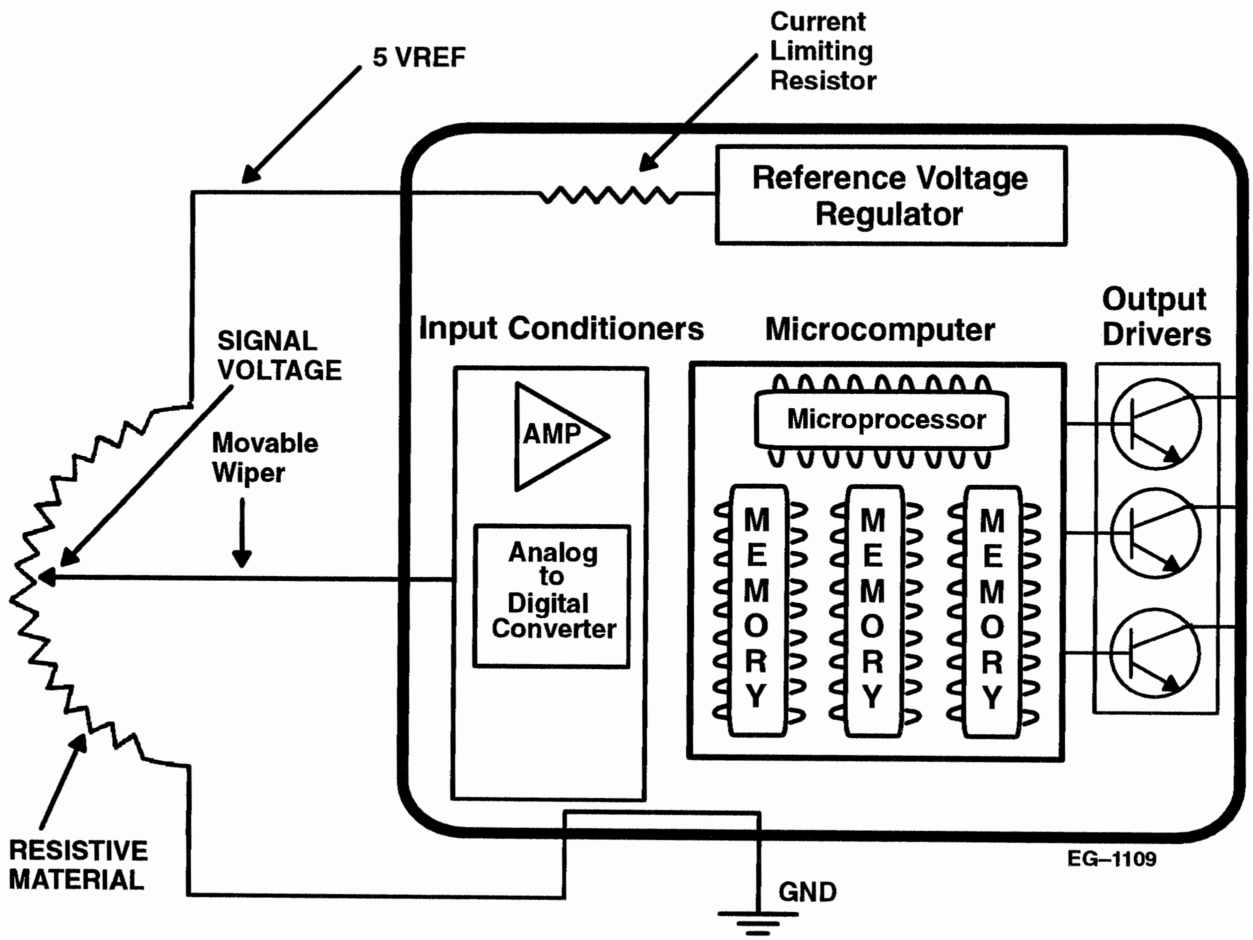

Figure 1.7–3. – Potentiometer (Variable Resistance Voltage Divider)

TYPES OF SENSORS (Continued)

VARIABLE CAPACITANCE SENSOR

Variable capacitance sensors are used to measure pressure. The pressure which is to be measured is applied to a ceramic material. The pressure forces the ceramic to move closer to a thin metal disk. This action causes the capacitance of the sensor to change which creates a frequency that corresponds to a pressure. The internal circuitry of the sensor converts that frequency into a linear analog voltage that indicates pressure. The thicker the ceramic disk the more pressure that sensor can measure. A variable capacitance sensor has three connections: Vref, signal and ground. **Refer to Figure 1.7–4.**

Examples:

EOP Engine Oil Pressure Sensor
EBP Exhaust Back Pressure Sensor
ICP Injection Control Pressure Sensor

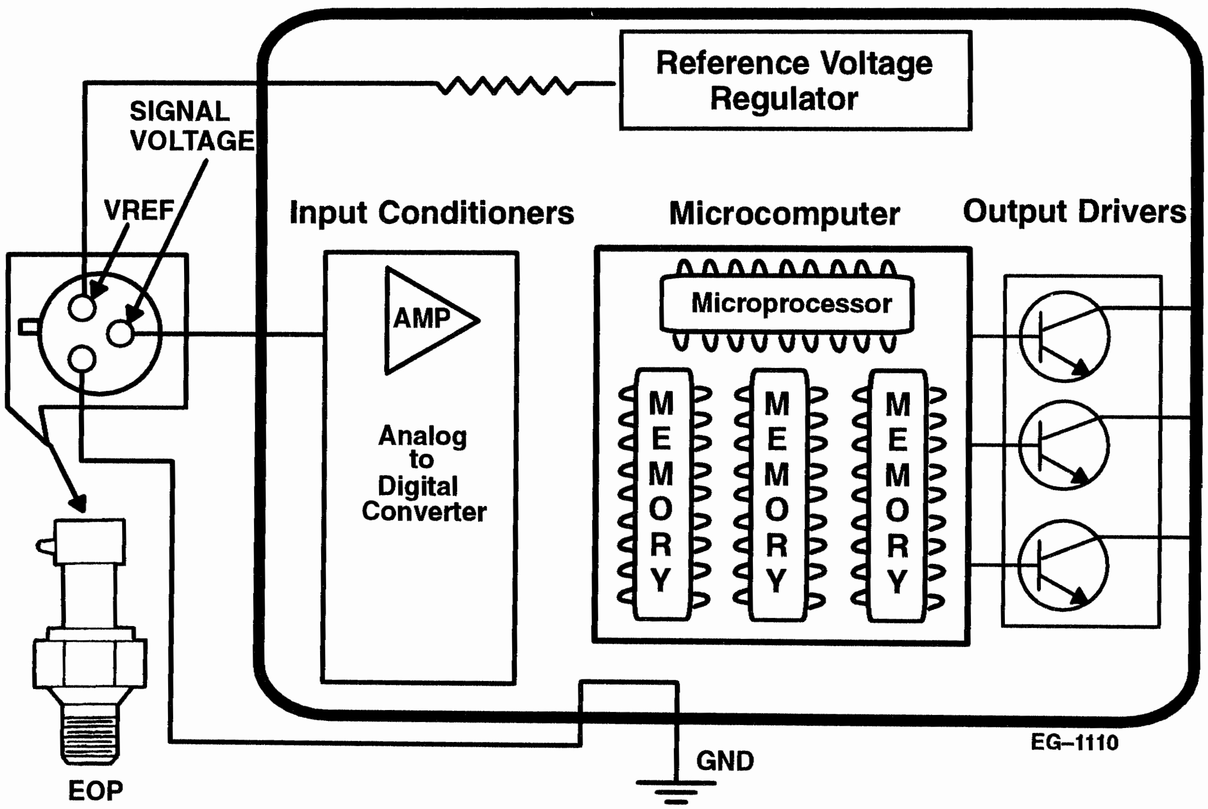

Figure 1.7–4. – Variable Capacitance Sensor (Exhaust Back Pressure Sensor)

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TYPES OF SENSORS (Continued)

HALL EFFECT SENSOR

The Hall Effect sensor is an electronic device which generates a voltage signal controlled by the presence, absence or strength of a magnetic field.

The Camshaft Position sensor is an example of a Hall Effect device. It contains a transducer, permanent magnet, signal conditioner and a switching transistor. The sensor's permanent magnet applies a magnetic field around the transducer as shown in **Figure 1.7–5.** The sensor's transducer senses the strength of the magnetic field which is controlled by the vanes and windows (located on the rotating timing sensor disk) as they pass the sensor.

A voltage signal is generated by the Hall Effect device each time a window passes the device. The signal is filtered and conditioned by the signal conditioner. The conditioned signal is applied to the switching transistor's base which causes the transistor to switch on and ground the 12 volt line from the ECM. The ECM no longer senses the 12 volt reference signal.

Each time a vane passes the Hall Effect device no signal is generated. This action causes the transistor to shut off and causes the ECM to see its 12 volt reference signal.

This switching action allows the ECM to determine crankshaft position and engine speed which is required by the ECM to control engine operating parameters such as injector timing and injection duration.

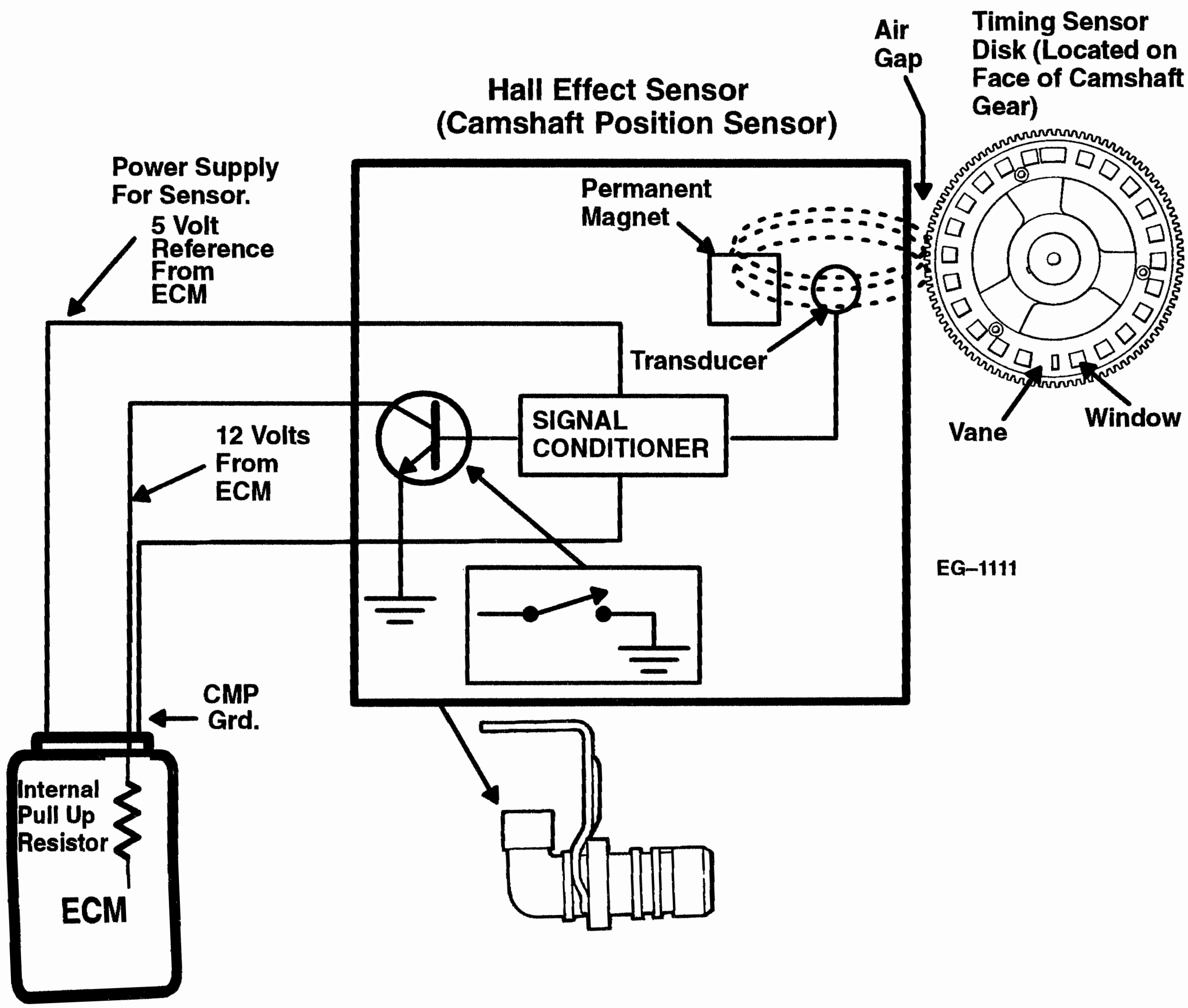

Figure 1.7–5. – Hall Effect Sensor (Camshaft Position Sensor)

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TYPES OF SENSORS (Continued)

SWITCH SENSORS

Switch sensors are used to indicate position, levels or pressures. The signal of a switch sensor is a digital signal created by either opening or closing a switch. The on or off signal can indicate position as in the case of a clutch switch, level as in the case of a coolant level switch or pressure as in the case of a low oil pressure switch. A switch sensor can be either a voltage input type switch or a grounding type switch. A voltage input style switch will supply the ECM with a voltage when closed. A grounding type switch is wired in series with a current limiting resistor in the ECM and will cause a zero voltage signal when closed (grounding the circuit). A switch sensor normally has two connectors signal return (Grd) and the signal. A switch sensor is considered a low speed digital input. **Refer to Figure 1.7–6.**

Examples:

- IVS Idle Validation Switch
- BNO Brake Normally Open
- BNC Brake Normally Closed
- CLS Coolant Level Switch
- DDS Driveline Disengagement Switch

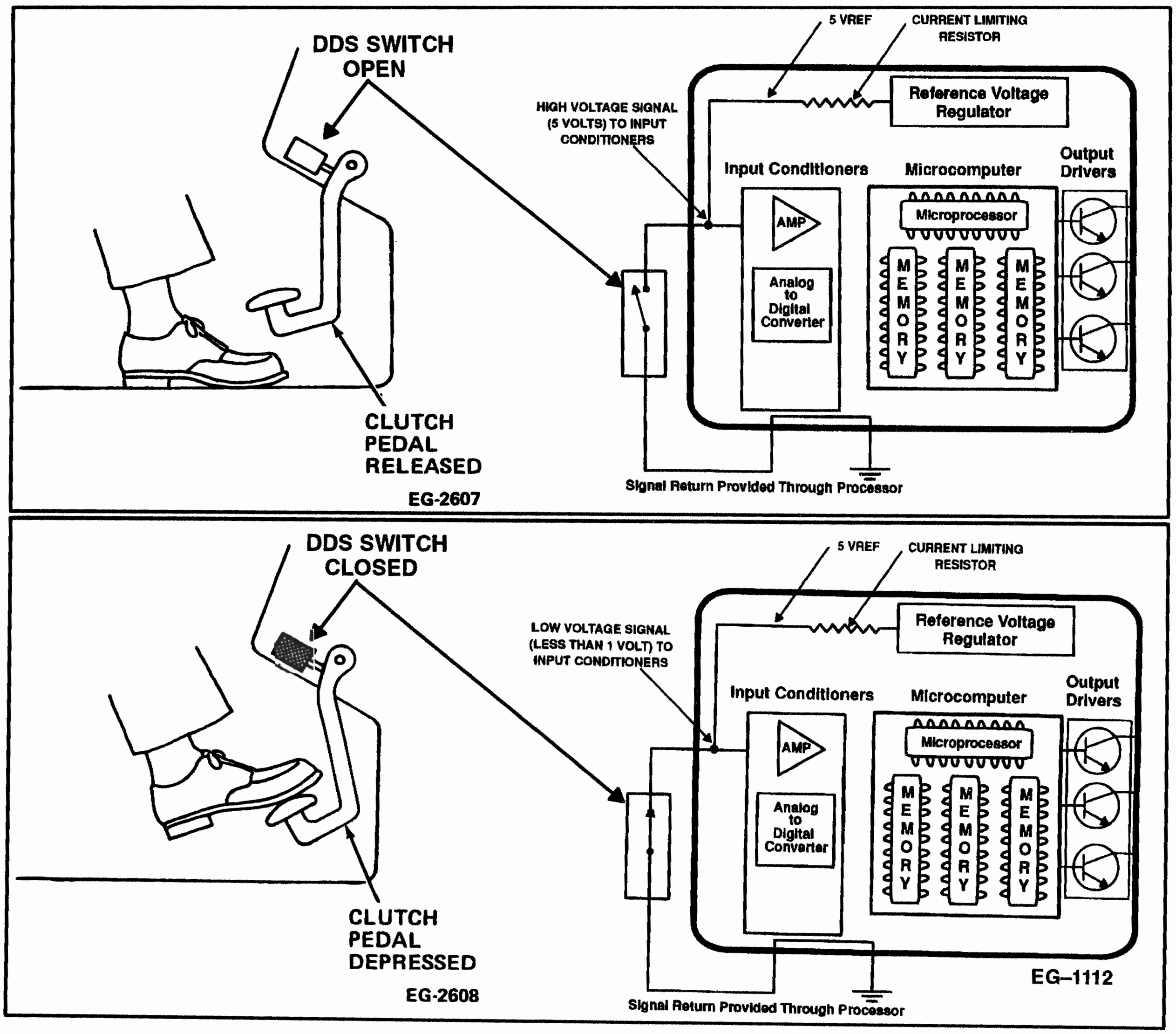

Figure 1.7–6. – Driveline Disengagement Switch (DDS)

TYPES OF SENSORS (Continued)

MAGNETIC PICKUP

A magnetic pickup is a sensor used to generate an alternating frequency that indicates speed. Magnetic pickups normally have a two wire connection for signal return and ground. A magnetic pickup is constructed with a permanent magnetic core surrounded by a wire coil. The signal frequency is generated by the rotation of gear teeth which make and break the magnetic field created by the magnet. **Refer to Figure 1.7–7.**

Examples
VSS Vehicle Speed Sensor

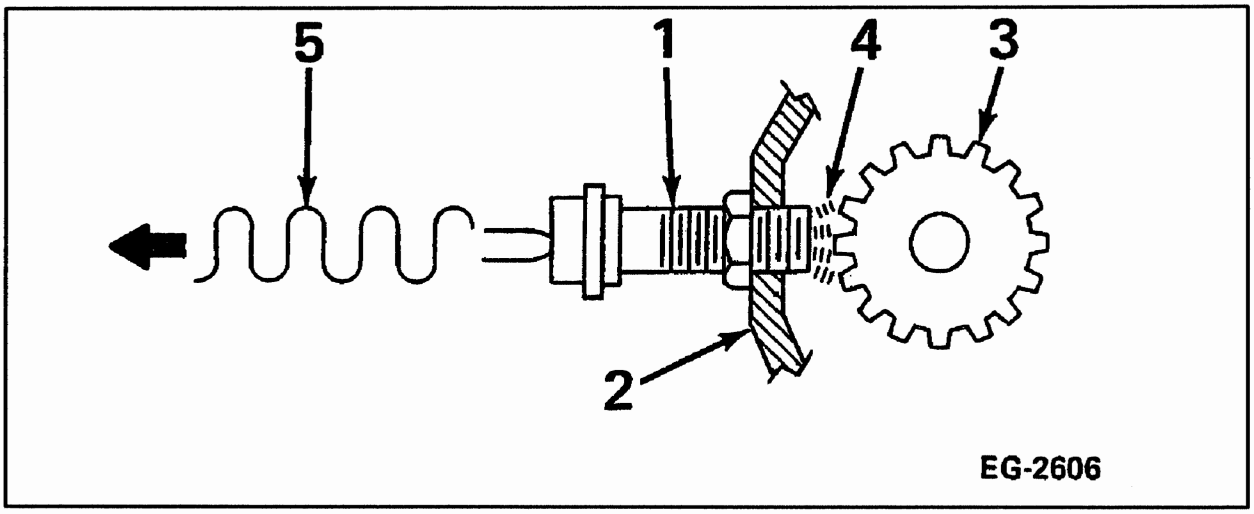

Figure 1.7–7. – Magnetic Pickup (Vehicle Speed Sensor)

1. **Magnetic Pickup Sensor**
2. **Transmission Case**
3. **16 Tooth Speedometer Gear**
4. **Permanent Magnet Field**
5. **Output Signal**

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STANDARD FEATURES

ELECTRONIC GOVERNOR CONTROL

The T 444E is fully electronically governed over all operating ranges.

COLD IDLE ADVANCE

This feature provides an increase in engine cold idle speed of up to 875 rpm (normal idle 700 rpm) for a faster warm up to nominal operating temperature. This is accomplished through the electronic control module monitoring the engine coolant temperature sensor input and adjusting injector operation as required. Low idle speed is increased proportionally when the engine's coolant temperature is below 158°F (70°C) (700rpm) to 14°F (–10°C) (875 rpm maximum).

COLD AMBIENT PROTECTION SYSTEM (CAP)

This feature is built into the engine control system software to aid engine warm up and to maintain engine temperature during extended idle periods in cold weather.

The CAP feature slowly ramps up engine idle speed (after 5 minutes of idle time) to a preset engine rpm when the intake air temperature is below 32° F (0° C) and coolant temperature is below 158 ° F (70 ° C). This system is programmed to return engine idle speed back to normal idle when the vehicle operator decides to operate the vehicle or engage the PTO.

GLOW PLUG ASSISTED START

This feature increases engine startability in cold weather. The glow plugs are controlled by the Electronic Control Module which monitors engine temperature. "A WAIT TO START" lamp is included to inform the operator when the engine is ready for cranking.

AMERICAN TRUCKING ASSOCIATION DATA LINK PROVISIONS

The T 444E is equipped with an American Trucking Association (ATA) data link connector that allows communication between the electronic engine control system and the Pro–Link 9000 Electronic Service Tool (EST).

The data link provides communication capabilities for:

- Engine parameter data transmission.
- Diagnostics and troubleshooting.
- Customer programming.
- Production line programming of vehicle features.
- Field programming.

SERVICE DIAGNOSTICS

The electronic service tool provides means for obtaining diagnostic information using the ATA data link. The recommended electronic service tool is the Pro–Link® 9000 with an International cartridge. Sensor, actuator, electronic component and engine system faults can be detected by the ECM and be diagnosed by the EST.

The engine control system also provides service diagnostic information via flash codes emitted using the engine warning lamp. The service literature is indexed according to the flash codes.

ELECTRONIC SPEEDOMETER AND TACHOMETER PROVISIONS

The engine control system calibrates vehicle speed using pulses/mile. Dip switches no longer need to be changed when components affecting speed calibration are changed. The new speed calibration information can be programmed through the Electronic Service Tool.

ENGINE OVER TEMPERATURE PROTECTION SYSTEM (COOLANT TEMPERATURE COMPENSATION)

This system reduces fuel delivery when the engine coolant temperature is above the cooling system design target value. Fueling is reduced proportionally to the extent the design limit is exceeded. The reduction is calibrated to a maximum of 20% before standard engine warning and/or optional warning/ shutdown systems engage. If this feature is activated, a fault code is stored in the Electronic Control Module's memory to explain low power complaints.

This feature may be omitted on emergency vehicle applications that require 100% power on demand.

STANDARD FEATURES (Continued)

EVENT LOGGING SYSTEM

This system records if the engine was operated beyond maximum rpm, over heated (coolant temperature), low on coolant and/or experienced low oil pressure. This information is stored in the ECM memory and may be accessed through the use of the EST.

ENGINE CRANK INHIBIT

This system will not allow the engine to crank unless the automatic transmission is in neutral and will not allow the starter to engage while the engine is running. It also facilitates the use of cruise control and Power Take–Off (PTO) options with automatic transmissions. Engine Crank Inhibit is available as an optional feature with a manual transmission and a clutch switch.

ELECTRONIC ACCELERATOR PEDAL

This feature eliminates the mechanical linkage used with conventional accelerator pedals. An accelerator position sensor within the accelerator pedal assembly provides the ECM with a signal representing the driver's demand for power.

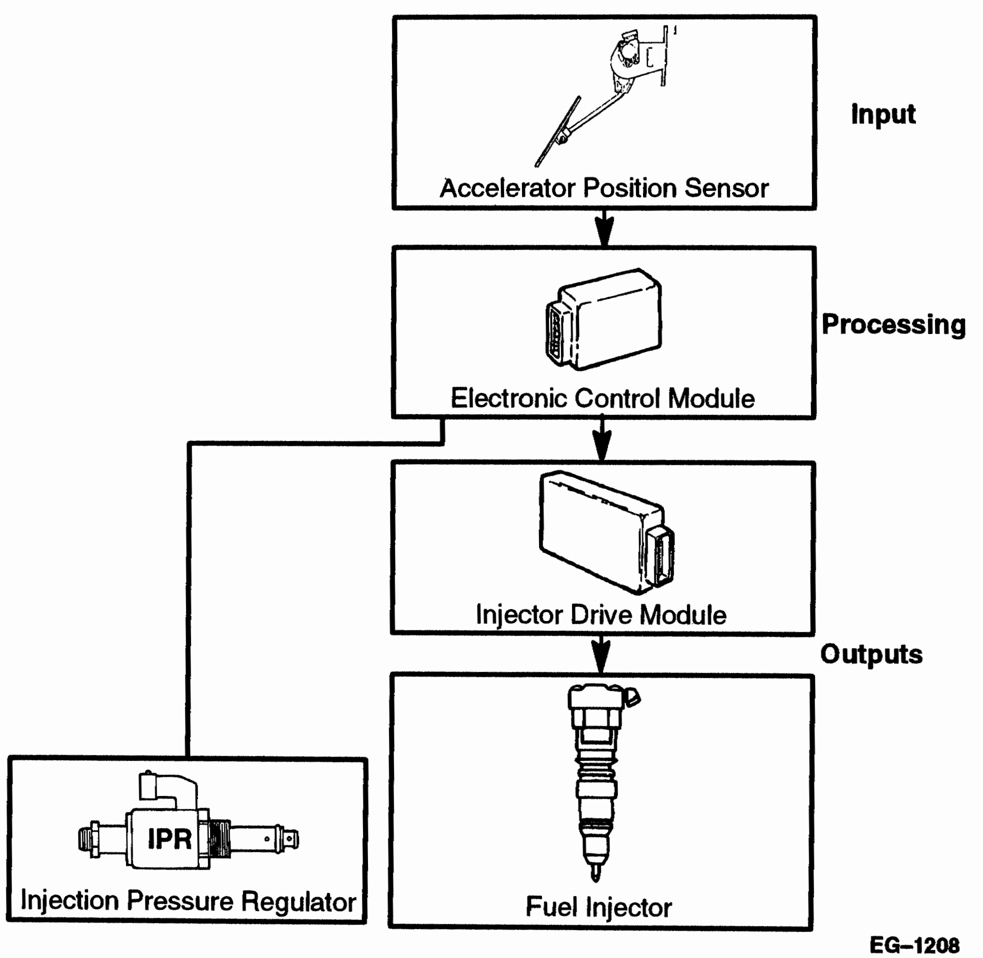

Figure 1.8–1. – Electronic Accelerator Pedal System Operation

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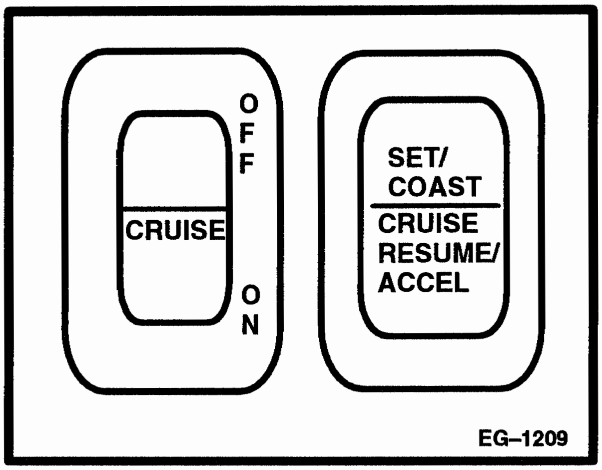
OPTIONAL FEATURES

CRUISE CONTROL

This feature provides vehicle speed using automotive style set/coast, resume/accel, on, off switches. Speed control is disabled when the brake is applied, the clutch pedal is depressed or an automatic transmission is placed in neutral. The accelerator pedal can be used to provide a speed increase from the cruise speed selected.



Cruise Control Switches.

THROTTLE CONTROL FOR PTO OPERATION

The T 444E is compatible with both stationary and mobile PTO applications. Remote and in–cab throttle control locations are available. Also, the throttle control feature can be used as an electronic hand throttle.

ROAD SPEED LIMITING/GOVERNOR

This feature limits vehicle speed to an owner/operator programmable maximum speed.

EXHAUST BACK PRESSURE ENGINE WARM–UP SYSTEM

With this feature, a butterfly valve is placed in the exhaust stream at the turbo exhaust outlet. When the ambient and engine coolant temperatures are low, the valve restricts exhaust flow. The increased engine load increases the heat transferred to the cooling system. This, in turn, increases the amount of heat available to warm the vehicle interior. The exhaust back pressure engine warm–up system is especially desirable in bus applications.

BODY EQUIPMENT MANUFACTURERS PROVISIONS

Additional circuits and connector junction blocks are provided in the cab. The circuits include provisions for:

- Remote engine speed control.
- Remote PTO (engine speed) control commands.
- Additional power and control (protection) circuits for after manufacture add–on equipment.

The standard electrical system will provide breakout connector access to the speed control circuits.

ENGINE WARNING SYSTEM

This system illuminates the red "Stop Engine" lamp and actuates a buzzer when warning thresholds for coolant temperature, engine coolant level and/or engine oil pressure (low) are exceeded.

ELECTRONIC IDLE SHUTDOWN TIMER

This is an optional feature which provides engine shutdown after a 5 minute idle time has been exceeded.

ENGINE SHUTDOWN SYSTEM (FIGURE 1.8–2.)

This system shuts down the engine after 30 seconds of operation beyond critical threshold values for coolant temperature, oil pressure and/or engine coolant level. The above mentioned warning system is included with this shutdown system. The engine may be restarted after shutdown, if it is mechanically capable of starting.

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OPTIONAL FEATURES (Continued)

ENGINE SHUTDOWN SYSTEM–(Continued)

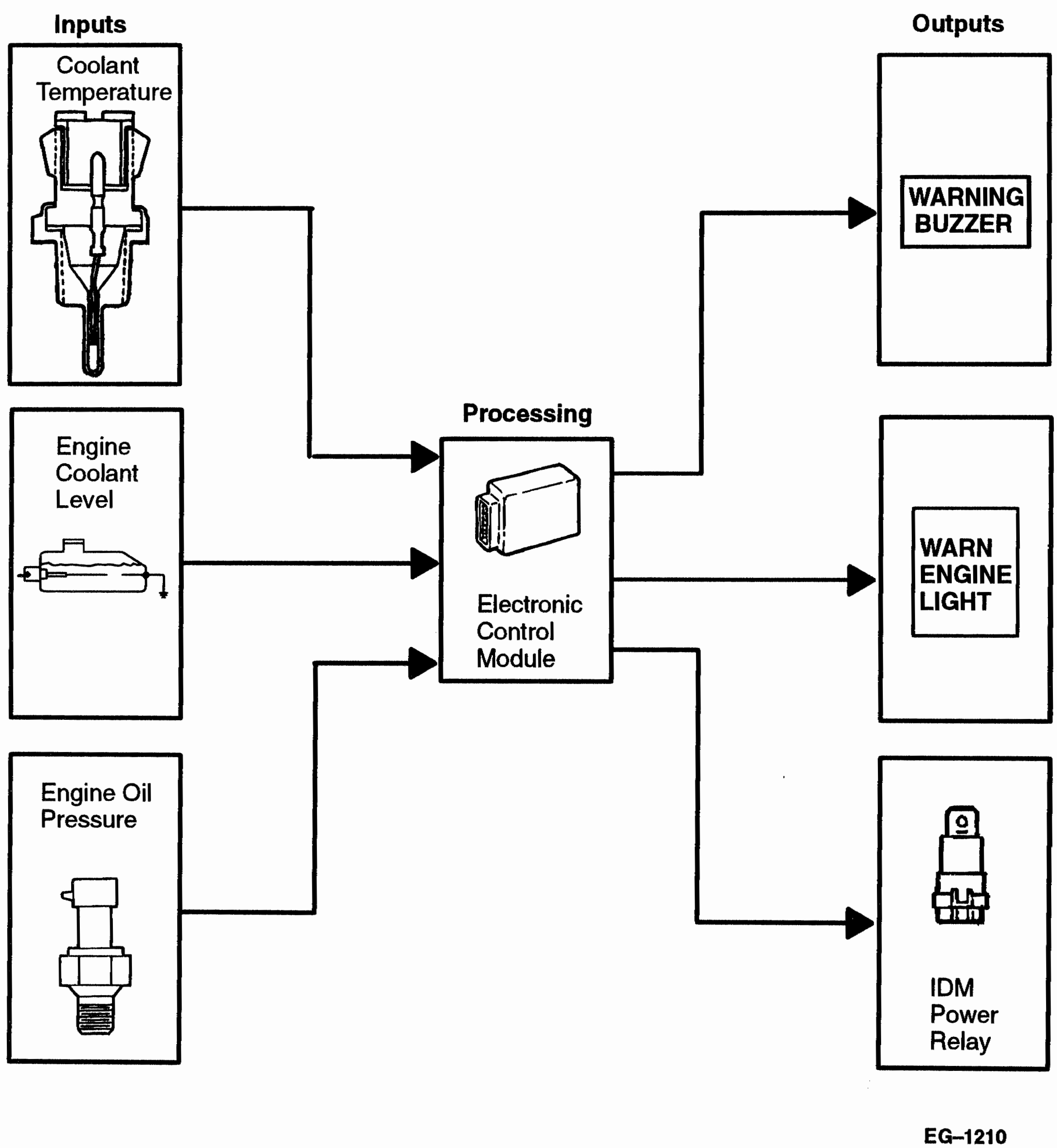

Figure 1.8–2. – Engine Shutdown System

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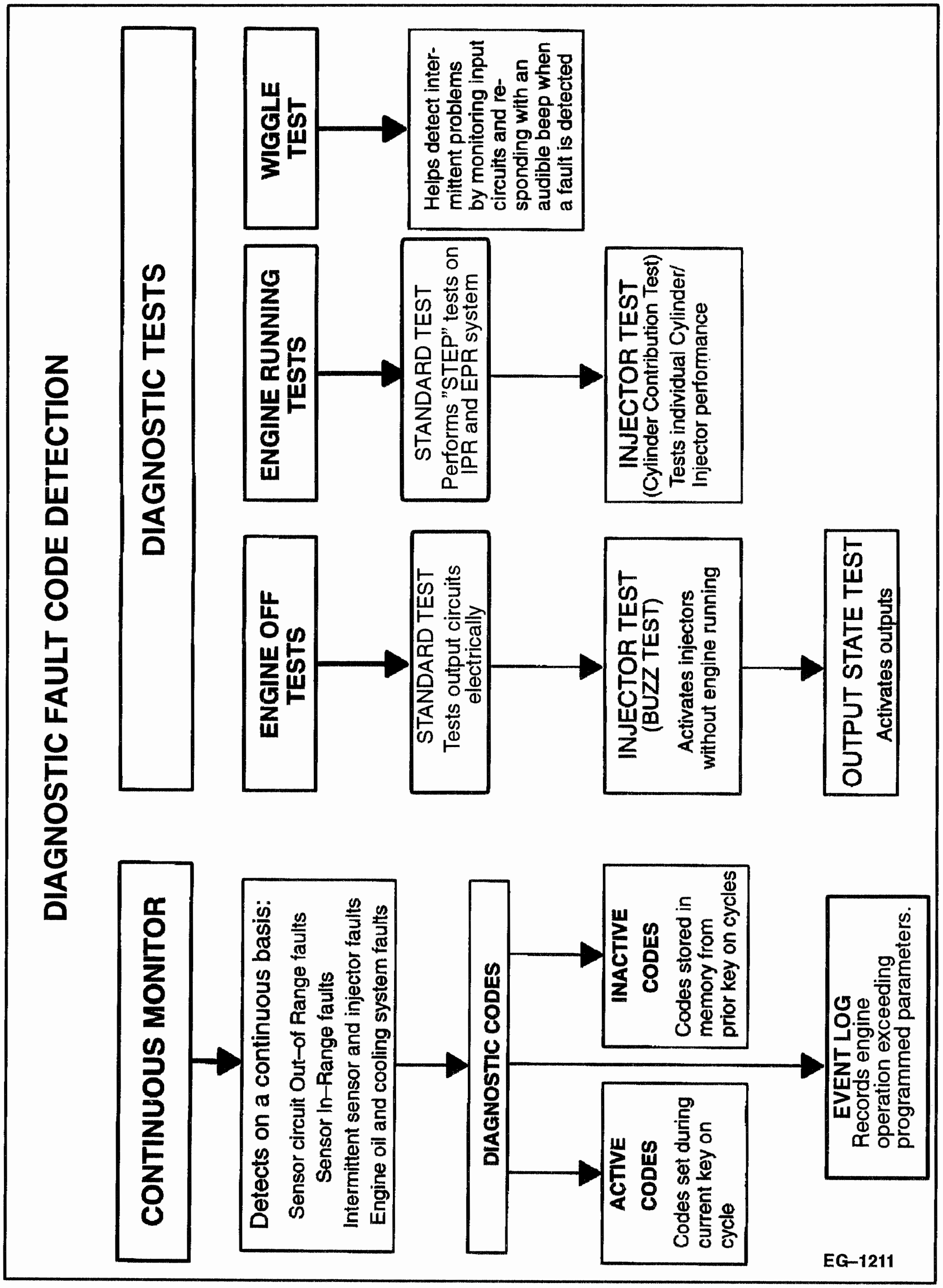
DIAGNOSTIC SOFTWARE TEST CHART



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DIAGNOSTIC SOFTWARE SELF TEST OPERATION

CONTINUOUS SELF TEST

CONTINUOUS MONITOR

Diagnostics are performed by the Electronic Control Module (ECM) continuously to detect out of range, rationality and system faults.

During the time that the key is "ON", if an input signal is "Out of Range" meaning the signal is either greater or lesser than what the signal range should be during normal operation, the ECM will record a "Fault". It will also monitor the operation of systems and will determine if the system is working within a normal range. If the ECM detects that a system falls outside a predetermined range, it will record and flag a fault.

During normal engine operation, the ECM automatically performs several tests to detect faults. When it has detected a fault, the ECM often invokes a fault management strategy to allow continued, though sometimes degraded, vehicle operation.

A "Fault" is an indication of a malfunction measured or monitored electronically. Sometimes "Faults" are referred to as "Codes."

"Codes" are three digit numbers assigned to Faults to indicate the source of the malfunction. Most Codes will indicate the source and the "Mode" of failure. The "Failure Mode" will indicate the signal reading, IE.; "Out of Range High", "Out of Range Low" or in Range fault.

During operation of the truck with the engine running, the Vehicle Personality Module (VPM) memory will record "EVENT ENGINE HOURS". This is the monitoring of engine operation exceeding programmed parameters. The standard Engine Event is Overspeed of the engine, referred to as Over RPM and excess coolant temperature. To retrieve information on Engine Events, it will be necessary to access them with the Electronic Service Tool.

If the engine is equipped with the optional engine warning/shutdown system, low oil pressure, and low coolant level operation, will also be monitored and recorded as "EVENT ENGINE HOURS".

OPERATOR ON DEMAND TESTS ENGINE OFF

STANDARD TEST (ENGINE OFF)

"Engine Off Tests" are "Standard Tests" performed by the ECM. These tests are commanded by the operator using the Electronic Service Tool (EST) or using the Self Test Input (STI) push–button switch. Since Injector Driver Module (IDM) faults are not stored in the ECM, it will be necessary to perform a self test to transmit faults from the IDM to the ECM.

To use the EST access the Engine menu and select Diagnostic Tests. Then select Engine Off Tests. Depressing the Enter key will initiate the test.

To use the STI diagnostic push–button switch, depress the switch and hold in, while turning the ignition switch to the "ON" position. Release the STI button after the key is in the "ON" position. **Do not start the engine.**

When the operator signals the test to begin, the ECM will perform internal tests of its processing components and internal memory.

It will automatically proceed to Output Circuit Check (OCC). This will operate the ECM output circuits. It will measure each individual circuit's response. The following circuits are checked by the ECM during the test:

1. Cylinder identification
2. Exhaust Pressure Regulator
3. Engine Crank Inhibit (relay)
4. Glow Plug Control (relay)
5. Injector Driver Module (relay)
6 Glow Plug Light
7. Fuel Demand Command Signal
8. Injection Pressure Regulator
9. Engine to Transmission Data Line (EDL relay).

The ECM will monitor the outputs and test the operation of the output signals and actuators. If a circuit fails the test, a fault code will be logged.

When the test is complete, the EST will display any faults that were found during the test. If the STI diagnostic switch was used, the faults will be transmitted as "Flash Codes," using the Oil Warning and Engine Warning lights.

The fault codes are read by counting the number of light flashes. The following sequence occurs:

1. The **"Oil/Water"** light will flash one time. This indicates the beginning of Active fault codes.
2. The **"WARN ENGINE"** light will flash repeatedly signaling the active fault codes. All codes are three digits. The number of flashes should be counted in sequence.

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OPERATOR ON DEMAND TESTS
ENGINE OFF (Continued)

STANDARD TEST (Continued)

3. At the end of each digit of the code there will be a short pause. Three flashes and a pause indicates the number 3. The code 232 will be sent as two flashes, (a pause), three flashes, (a pause), and two flashes.

If there is more than one code being sent, the **"OIL/WATER"** light will flash once indicating the beginning of another active fault code. The code 111 indicates "NO FAULTS".

If no further Active fault codes exist, the **"OIL/WATER"** light will flash twice, indicating the beginning of "INACTIVE CODES". The **"WARN ENGINE "** light will then flash the "INACTIVE CODE"(s) present. If several "INACTIVE CODES" are present, the **"OIL/WATER"** light will flash once between each of the fault codes.

When all of the stored fault codes have been sent, the **"OIL/WATER"** light will flash three times indicating "END OF MESSAGE".

If it is necessary to repeat transmission of fault codes, press the STI button and all stored codes will be retransmitted as described previously.

INJECTOR "BUZZ" TEST (ENGINE OFF)

The purpose of the Engine Off Injector "BUZZ" Test is to diagnose electrical problems with the fuel delivery components. This test can only be accessed with the EST and only after an "Engine Off Test" or Self Test has been performed.

NOTE: BEFORE RUNNING THIS TEST, FAULT CODES SHOULD BE ACCESSED, NOTED AND ERASED. THIS WILL ALLOW THE FAULTS FOUND IN THIS TEST TO BE DISPLAYED AS "ACTIVE CODES"

During the test, the ECM will signal the IDM to activate the injectors in numerical order 1 thru 8. The IDM will monitor each injector's electrical circuit operation. The IDM will send feedback signals to the ECM which indicate the status of injector performance and electrical circuit operation. If an electronic component in the fuel system fails the parameters of the test, an inactive fault code will be logged and transmitted to the EST at the end of the test.

NOTE: THE TECHNICIAN CAN MONITOR INJECTOR OPERATION BY LISTENING TO THE SOUND EACH INJECTOR PRODUCES AS IT IS ACTIVATED BY THE IDM, HOWEVER, IN A HARD START/NO START CONDITION WHERE THE OIL MAY BE VERY COLD/THICK INJECTORS MAY NOT BE AUDIBLE.

If the faults were not erased before this test, the faults found during this test will be displayed as "INACTIVE CODES".

To read these fault codes, access the "Diagnostic Codes" menu and read both Active and Inactive codes.

OUTPUT STATE TEST (ENGINE OFF)

The purpose of the Output State Test is to diagnose the operation of the output signals and actuators. This test can only be performed by using the Electronic Service Tool.

To run this test, select the Output State Test from the EST Engine Off Test menu. The test consists of two modes of operation:

1. Toggling outputs from high to low.
2. Toggling outputs from low to high.

When in the **"OUTPUTS ARE LOW"** mode the ECM will pull down the output voltage to their low state. This will actuate the output components that are controlled by the ECM grounding the circuits. During this test **"OUTPUTS ARE LOW"** will be displayed on the screen.

When in the **"OUTPUTS ARE HIGH"** mode the ECM will pull up the output voltage to their high state. This will actuate the output components that are controlled by the ECM energizing the control circuits. During this test **"OUTPUTS ARE HIGH"** will be displayed on the screen.

During this test, the output of the circuit in question can be monitored with a DVOM. The DVOM will measure a "High or Low" voltage state condition as the outputs are toggled. The actual voltage will vary with the circuit tested.

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DIAGNOSTIC SOFTWARE SELF TEST OPERATION

OPERATOR ON DEMAND TESTS
ENGINE OFF TEST (Continued)

OUTPUT STATE TEST (ENGINE OFF) (Continued)

NOTE 1: THE EST WILL ONLY DISPLAY "OUTPUTS ARE HIGH" OR "OUTPUTS ARE LOW". IT WILL NOT DISPLAY ANY VOLTAGES ETC. A DVOM IS REQUIRED TO MONITOR THE SUSPECTED PROBLEM CIRCUIT OR ACTUATOR.

NOTE 2: FAULTS WILL NOT BE SET DURING THIS TEST.

This following actuators and signals are toggled high and low during the test:

a. Injector Driver Module Enable Relay

b. Cylinder Identification

c. Fuel Demand Command Signal (FDCS)

d. Exhaust Pressure Regulator

e. Injection Pressure Regulator

f. Engine Crank Inhibit Relay

g. Engine Data Link (EDL) Relay

h. Oil Warning Light

i. Warn Engine Light

j. Glow Plug Lamp

k. Glow Plug Relay

OPERATOR ON DEMAND TESTS ENGINE RUNNING

STANDARD TEST (ENGINE RUNNING)

The Self Test (Engine Running) checks the operation of the following actuators:

1. Injection Pressure Regulator (IPR)
2. Exhaust Back Pressure Regulator (EPR)

During the test, the ECM commands the IPR and the EPR actuators through a pre–programmed testing sequence to determine if the actuators are performing as expected. The ECM monitors the feedback signal values from the injection control pressure and exhaust back pressure sensors and compares those values to the expected values. At the end of the test, the ECM will return the engine to the normal operating mode and transmit any fault codes which may have been set during the test.

This test can only be performed by using the Electronic Service Tool.

PROCEDURE

NOTE: ENGINE COOLANT TEMPERATURE MUST BE 160° F , BATTERY VOLTAGE MUST BE HIGHER THAN 12.5 VOLTS AND NO VEHICLE SPEED SENSOR (VSS) SIGNAL SHOULD BE PRESENT DURING THIS TEST. IF ACTIVE FAULT CODES ARE PRESENT, THEY MUST BE REPAIRED AND CLEARED PRIOR TO RUNNING THIS TEST.

1. Select "Engine Running Test" from the **"Diagnostic Test"** menu in the EST.
2. Press **"ENTER"** to begin test. The ECM will begin to raise the engine idle speed to a predetermined value. It will then command the IPR valve to set the injection control pressure to rated speed pressure. If the performance of the IPR is acceptable,the ECM will control the IPR valve to reduce the pressure in steps while continuing to monitor the performance of the injection control pressure system.

At the completion of the IPR test, the ECM will conduct a similar test on the EPR valve. When testing is completed, normal engine operation is restored and fault codes will be transmitted as described previously.

INJECTOR TEST "CYLINDER CONTRIBUTION" (ENGINE RUNNING)

The Injector Test is designed to detect problems with injection and combustion events. During the test the ECM will control fuel delivery and determine each cylinder's power contribution. If a cylinder is not performing satisfactorily, a fault code will be set.

This test can only be performed by using the Electronic Service Tool.

PROCEDURE

NOTE: THE ENGINE RUNNING SELF TEST MUST BE PERFORMED FIRST IN ORDER TO GAIN ACCESS TO THE INJECTOR (ENGINE RUNNING) TEST IN THE EST.

1. Select Injector Test from the Engine Running Test menu.

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OPERATOR ON DEMAND TESTS (ENGINE RUNNING)
INJECTOR TEST (ENGINE RUNNING) (Continued)

PROCEDURE (Continued)

2. The ECM will increase the normal amount of fuel delivery (overfuel) to the injector/cylinder being tested and monitor the reduction of fuel required to operate the remaining injectors to maintain engine speed. If there is no reduction in fuel delivery to the other cylinders the ECM will set a fault code identifying the non–contributing cylinder.

When testing is completed, normal engine operation is restored and fault codes will be transmitted.

OPERATOR ON DEMAND TESTS

WIGGLE TEST

The purpose of the Wiggle Test is to troubleshoot intermittent connections at sensors and actuators. It may be performed with the engine off or running. The Electronic Service Tool is used to monitor the following circuits during the Wiggle Test.

a. Accelerator Position Sensor (APS)
b. Intake Air Temperature Sensor (IAT)
c. Camshaft Position Sensor (CMP)
d. Data Communication Link
e. Exhaust Back Pressure (optional)
f. Engine Coolant Temperature
g. Engine Oil Pressure (optional)
h. Injection Control Pressure
i. Manifold Absolute Pressure
j. Remote Accelerator Pedal Sensor
k. Engine Oil Temperature
l. Barometric Pressure Sensor (BARO)

PROCEDURE

1. Select the Wiggle Test from the "Diagnostic Test" menu in the EST. Press the **"ENTER"** key to begin test.
2. The technician should wiggle connectors and wires at all suspected problem points. The EST will **"BEEP"** if circuit continuity is broken. It will display all faults found during the test.