ELECTRONIC FUEL INJECTION

Section 3A - Theory of Operation

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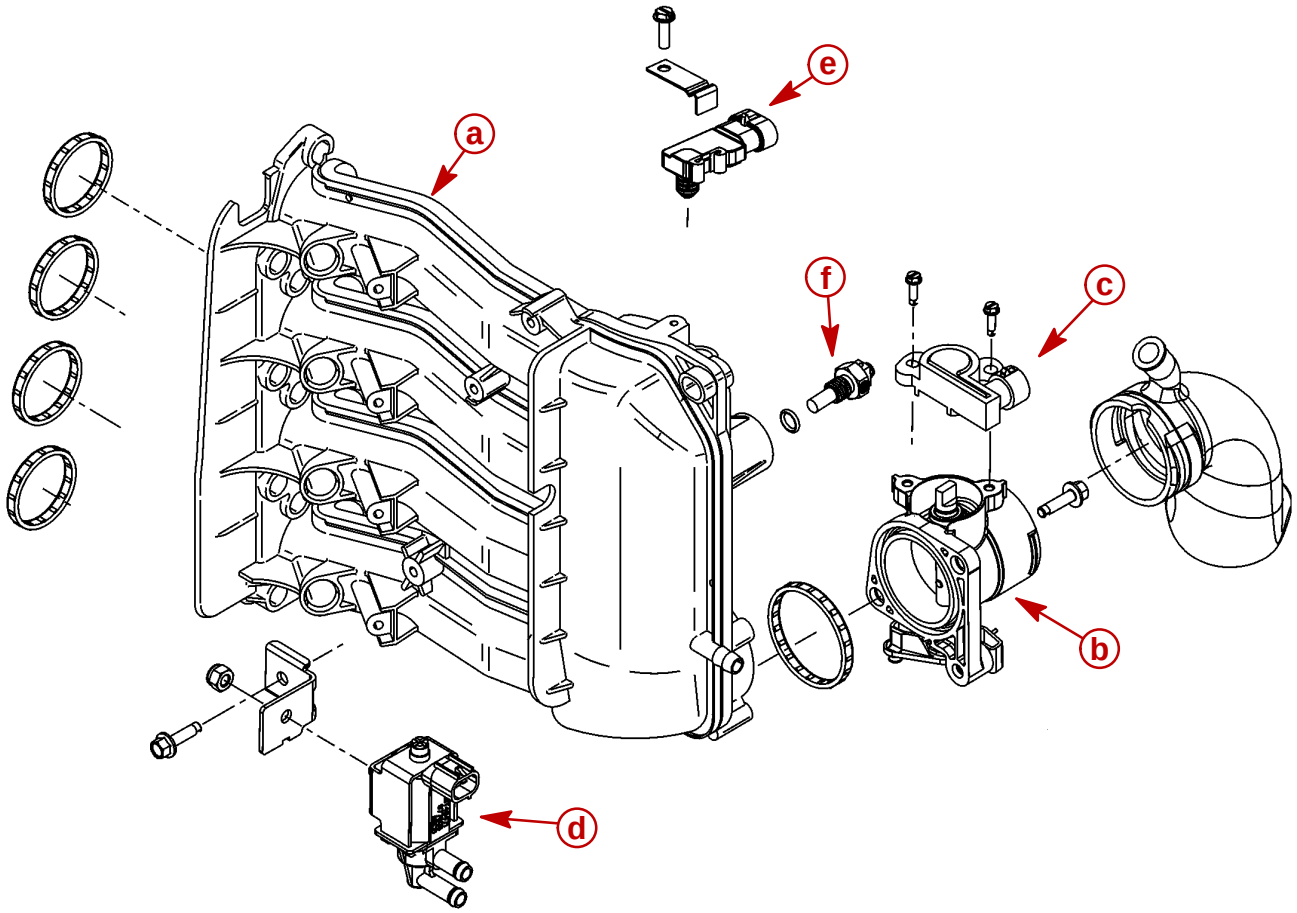
3 A

Electronic Fuel Injection System

Air Induction System

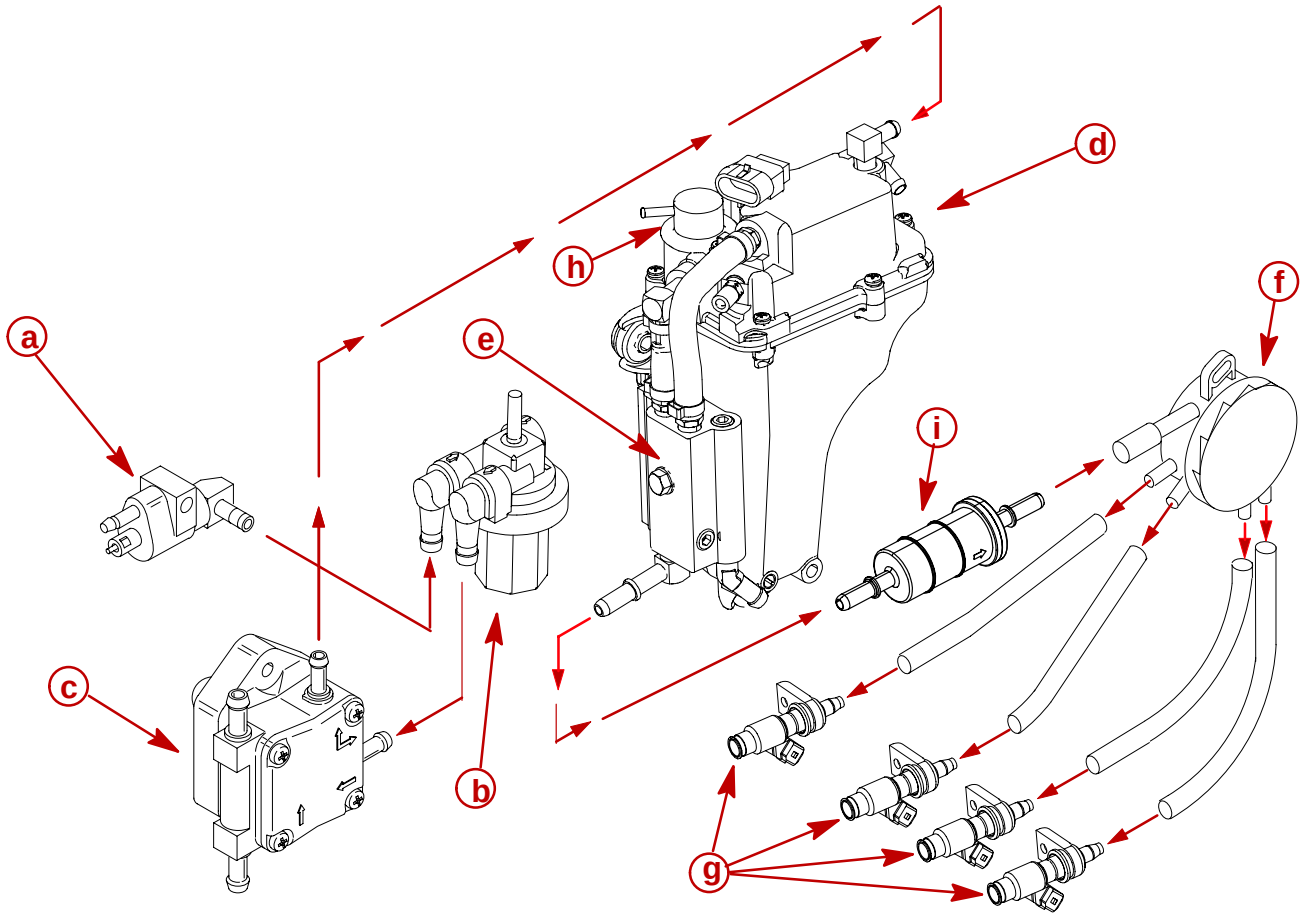
The air induction system consists of an intake manifold (an intake runner for each cylinder joined to a common air box), a single throttle body/shutter with attached Throttle Position Sensor (TPS), an Idle Air Control (IAC), a Manifold Absolute Pressure (MAP) sensor, and a Manifold Air Temperature (MAT) sensor. The intake manifold also mounts the fuel distribution manifold and the fuel injectors.



a - Intake Manifold
b - Throttle Body/Shutter
c - Throttle Position Sensor (TPS)
d - Idle Air Control (IAC)
e - Manifold Absolute Pressure (MAP) Sensor
f - Manifold Air Temperature (MAT) Sensor

Fuel System

The fuel system consists of a fuel line connector, a water separating fuel filter, a low-pressure mechanical fuel pump, a high-pressure electric fuel pump, a fuel distribution manifold, fuel injectors, a fuel cooler and a fuel pressure regulator. The low-pressure mechanical fuel pump draws fuel from the fuel tank, through the fuel line connector and fuel filter, then delivers it to the high-pressure fuel pump within the vapor separator tank. High-pressure fuel is circulated through the fuel cooler and supplied to the fuel distribution manifold and fuel injectors to be sprayed into the intake manifold. Fuel not used by the fuel injectors (fuel not entering the high-pressure fuel line to the fuel distribution manifold) circulates through the fuel cooler, then flows through pressure regulator, and returns to the vapor separator tank.



a - Fuel Line Connector
b - Water Separating Fuel Filter
c - Low-Pressure Mechanical Fuel Pump
d - Vapor Separator Tank/High Pressure Electric Fuel Pump
e - Fuel Cooler
f - Fuel Distribution Manifold
g - Fuel Injectors (4)
h - Pressure Regulator
i - High Pressure Fuel Filter

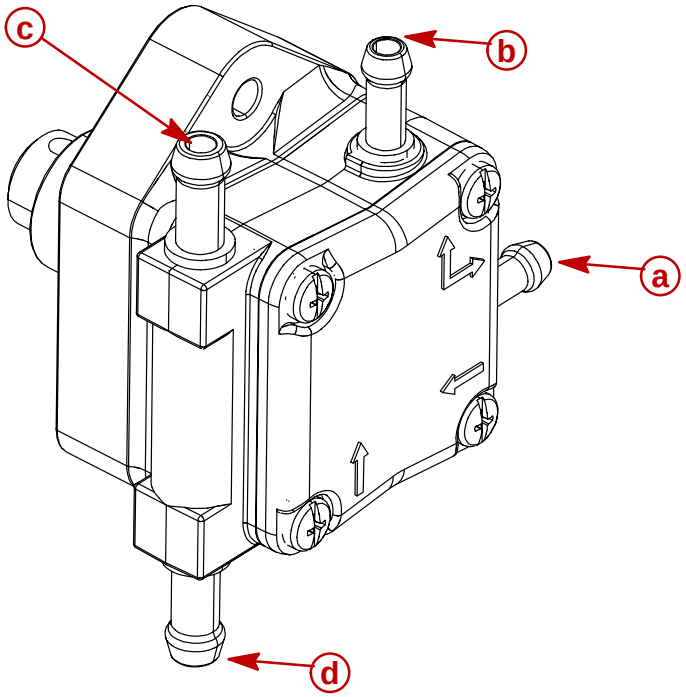
Fuel System Components

Fuel Pump

The fuel pump is a diaphragm pump which is mechanically driven off of the rocker arm.

The pump base insulates the fuel pump from the heat of the engine block. The fuel pump is water cooled to help prevent vapor lock by cooling the fuel.

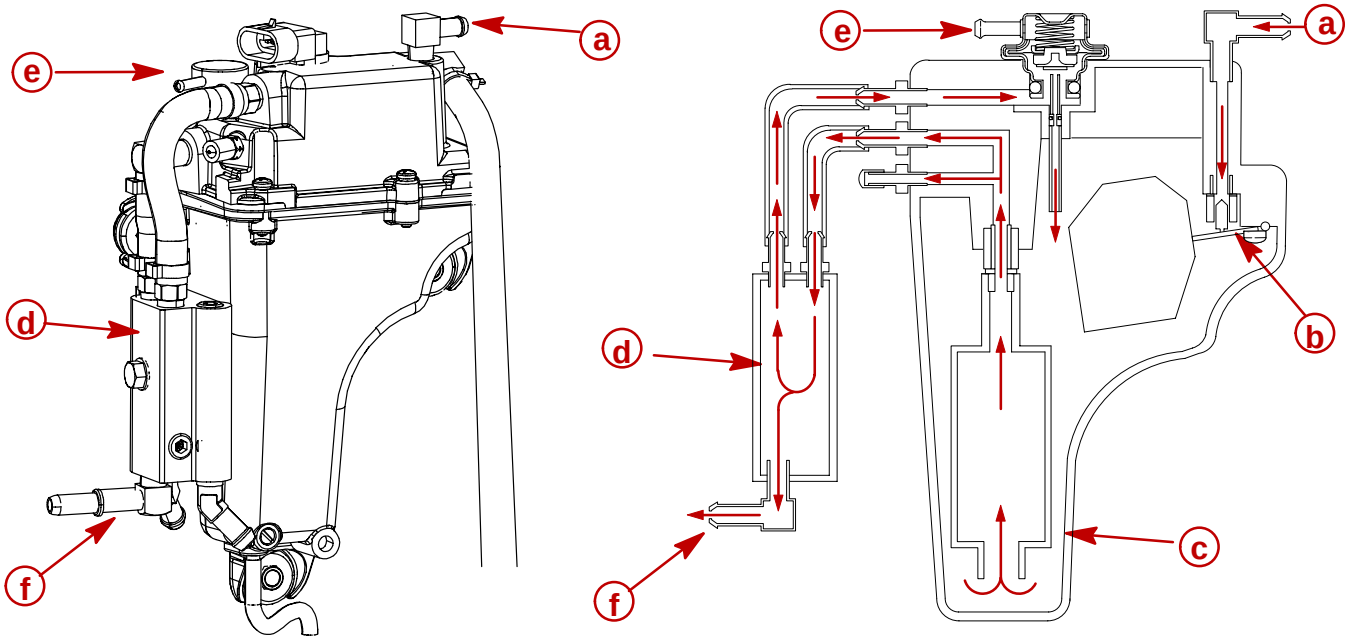
If the engine runs out of fuel, or has a restriction (on the inlet side of the pump) preventing adequate fuel flow, the pump will make a “clicking” noise.



a - Fuel From Filter/Tank
b - Fuel Outlet to VST
c - Water Inlet From VST Fuel Cooler
d - Water Outlet to Tell-tale

Vapor Separator

The vapor separator maintains a liquid fuel supply for the high pressure fuel pump located in the vapor separator tank. Fuel delivered from the mechanical low-pressure fuel pump is supplied to the top of the vapor separator and is controlled by the inlet needle/float assembly. Pressurized fuel from the high-pressure pump circulates through the fuel cooler, to the fuel distribution manifold and injectors. Excess fuel flows through the pressure regulator back to the vapor separator tank.

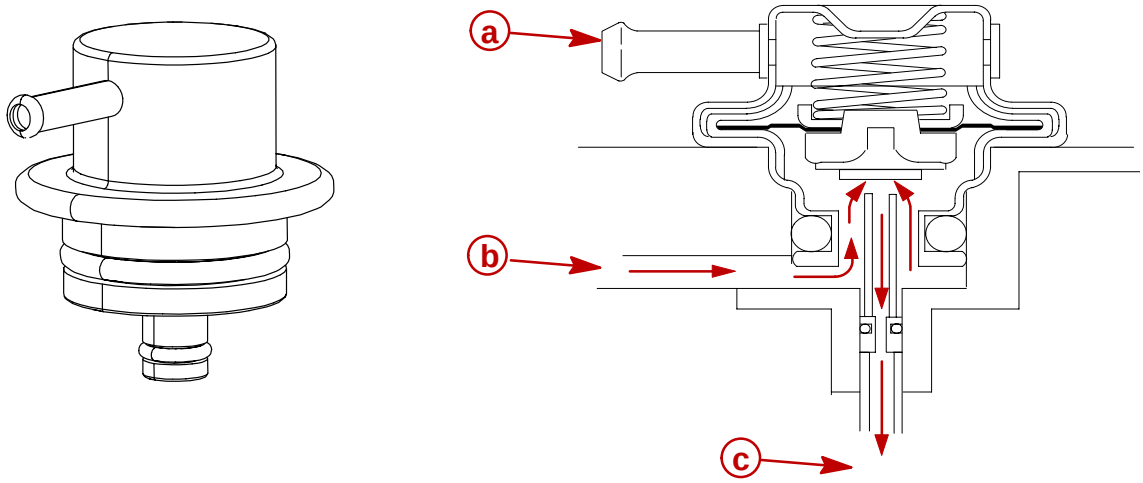


a - Fuel From Mechanical Fuel Pump
b - Inlet Needle and Float Valve
c - High Pressure Electric Fuel Pump
d - Fuel Cooler
e - Pressure Regulator
f - Fuel Outlet to Fuel Distribution Manifold

Fuel Pressure Regulator

The fuel pressure regulator mounted on top of the vapor separator maintains a stable fuel pressure between the high-pressure fuel pump and the fuel injectors. The pressure regulator consists of a spring-loaded diaphragm which actuates a valve/seat assembly. Excess fuel pressure unseats the valve returning fuel to the vapor separator tank. The excess fuel is channeled below the fuel level in the vapor separator tank through an internal pipe to prevent fuel vaporization.

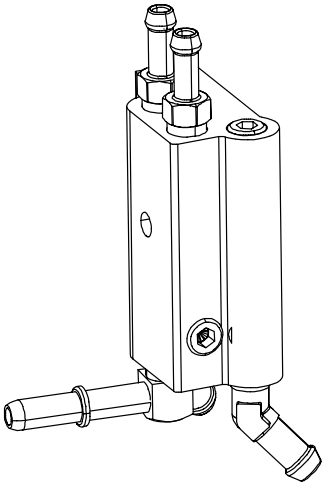
The spring side of the diaphragm is vented to atmosphere allowing barometric conditions to act on the diaphragm in addition to spring pressure.



a - Vent to Atmosphere
b - High Pressure Fuel From Fuel Cooler
c - Excess Fuel Flows to VST

Fuel Cooler

A fuel cooler (heat exchanger) is attached to the vapor separator, and uses engine cooling water to cool the high-pressure fuel supply to the fuel injectors as well as a return circuit to the VST. Removing heat from the circulating high-pressure fuel prevents the formation of fuel vapors.



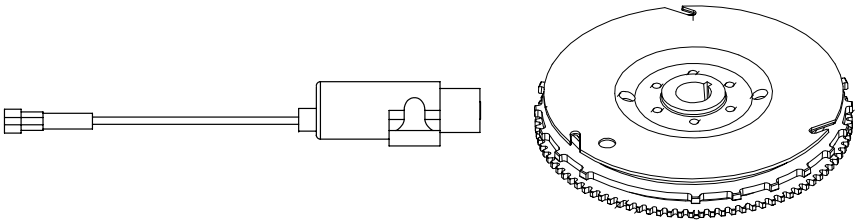
Sensors

Sensors send input signals to the ECM regarding engine operating conditions.

Crank Position Sensor (CPS)

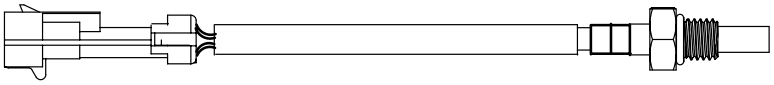
As the flywheel rotates, the CPS senses the location of the 54 teeth on the flywheel and supplies the trigger signal information to the ECM. The ECM utilizes the CPS information and determines when to trigger each ignition coil and fuel injector.

The CPS provides the ECM with crank angle position and engine speed information, which the ECM uses in determining fuel delivery and spark timing.



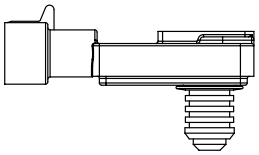
Engine Coolant Temperature (ECT) Sensor

The ETC sensor is located on the engine's exhaust cover and protrudes into the return water passage. The sensor monitors the temperature of the cooling water that has passed through the engine as controlled by the thermostat and sends signals to the ECM for processing.



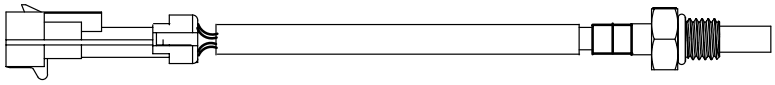
Manifold Absolute Pressure (MAP) Sensor

The MAP sensor is mounted into the intake manifold, and measures the absolute pressure within the intake manifold. This information is then used to calculate fuel delivery and spark timing.



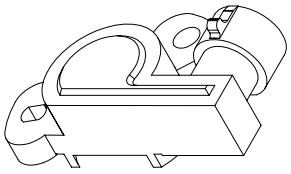
Manifold Air Temperature (MAT) Sensor

The MAT sensor is mounted into the intake manifold and measures the charge air temperature. This information is then conducted to the ECM for processing.



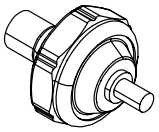
Throttle Position Sensor (TPS)

The TPS sensor is located on the throttle body and connected to the throttle shaft. It provides the ECM with throttle angle information.



Oil Pressure Switch

The oil pressure switch is located port side of the engine and protrudes into the pressurized oil galley between the oil pump and the oil filter. The sensor sends a low oil pressure signal to the ECM, which activates ignition/injection cut-off/warning horn.



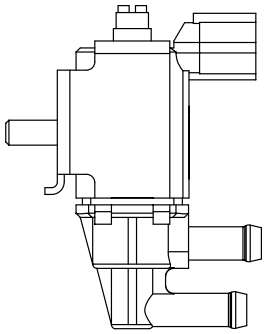
Actuators

Actuators receive input signals from the ECM and perform functions, which control air-fuel ratios, spark advance, and idle rpm.

Idle Air Control (IAC)

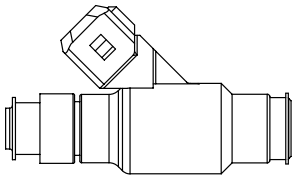
The Idle Air Control (IAC) is an electrically operated spring-loaded solenoid valve, which controls the amount of intake air that bypasses the closed throttle shutter. Signals from the ECM regulate the duty cycle that the IAC valve remains open, or (spring-loaded) closed. Duty cycle of the IAC valve ranges from 0% to 100% open. The IAC controls three operating functions:

1. Provides additional intake air (bypass) for engine start-up and allows increased idle rpm during engine warm-up.
2. Controls idle speed according to varying engine loads and running conditions.
3. Functions as an electronic dashpot by providing additional bypass air as the throttle quickly closes during a rapid deceleration, preventing engine stalling.



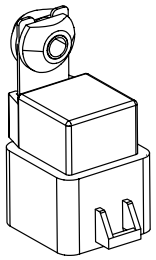
Fuel Injector

The fuel injector is an electrically operated spring-loaded solenoid, which delivers a metered amount of fuel into the intake manifold runner, just ahead of the intake valve. The injectors are electrically charged as the key switch is set to the “RUN” position. The ECM controls the injection by completing the ground circuit, lifting the solenoid, which allows high-pressure fuel to flow. The ECM then opens the ground circuit allowing the spring to close the injector and stop the fuel flow.



Main Power Relay

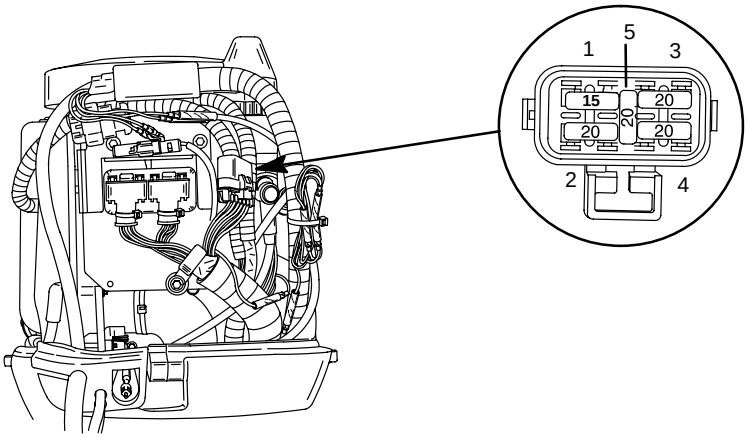
The main power relay is controlled by the ECM. It provides power to the ignition coils, idle air control, injectors, and high pressure fuel pump.



Fuse Holder Assembly

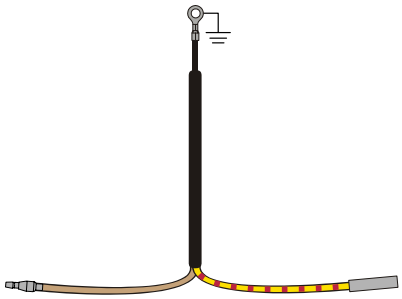
The fuse holder hold four function fuses and one spare fuse.

1. Fuse number one protects the SmartCraft wiring.
2. Fuse number two is powered by the main relay. It protects red/blue leads on the engine. This fuse provides power to the injectors, idle air control, and electric fuel pump.
3. Fuse number three protects red/purple leads on the engine, the main power relay, and key switch. When the key switch is on, the purple leads on the engine, key switch and dash gauges are also powered/protected through this fuse.
4. Fuse number four is powered by the main relay. It protects red/yellow leads on the engine. This fuse provides power to the ignition coils.
5. Fuse number 5 is a spare 20 AMP fuse.



Suppression Diode

The suppression diode is located between the brown start solenoid lead and the yellow/red key switch lead (within the engine harness), and connects to the engine ground. The purpose of the suppression diode is to eliminate the inductive spike created as the start solenoid is de-energized (key switch turned from START to RUN).



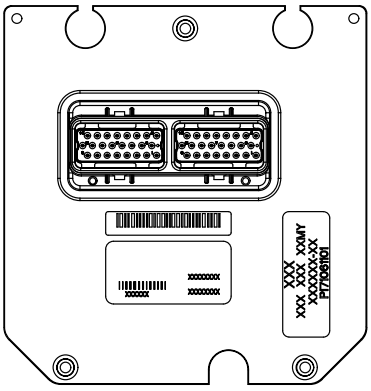
Electronic Control Module

The ECM requires 6 volts DC to operate. If the ECM should fail, the engine will stop running.

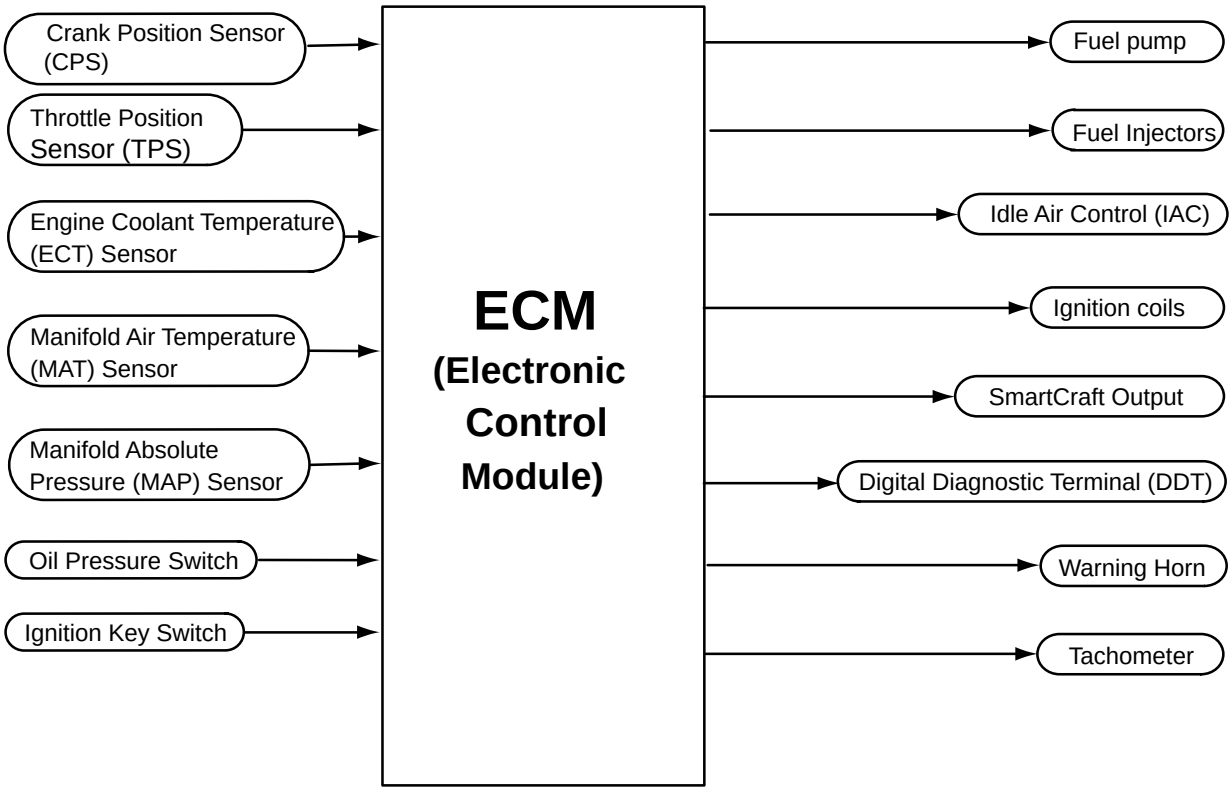
The inputs to the ECM can be monitored and tested by the Digital Diagnostic Terminal P/N 91-823686A2 and adapter harness 84-822560A5.

The ECM performs the following functions:

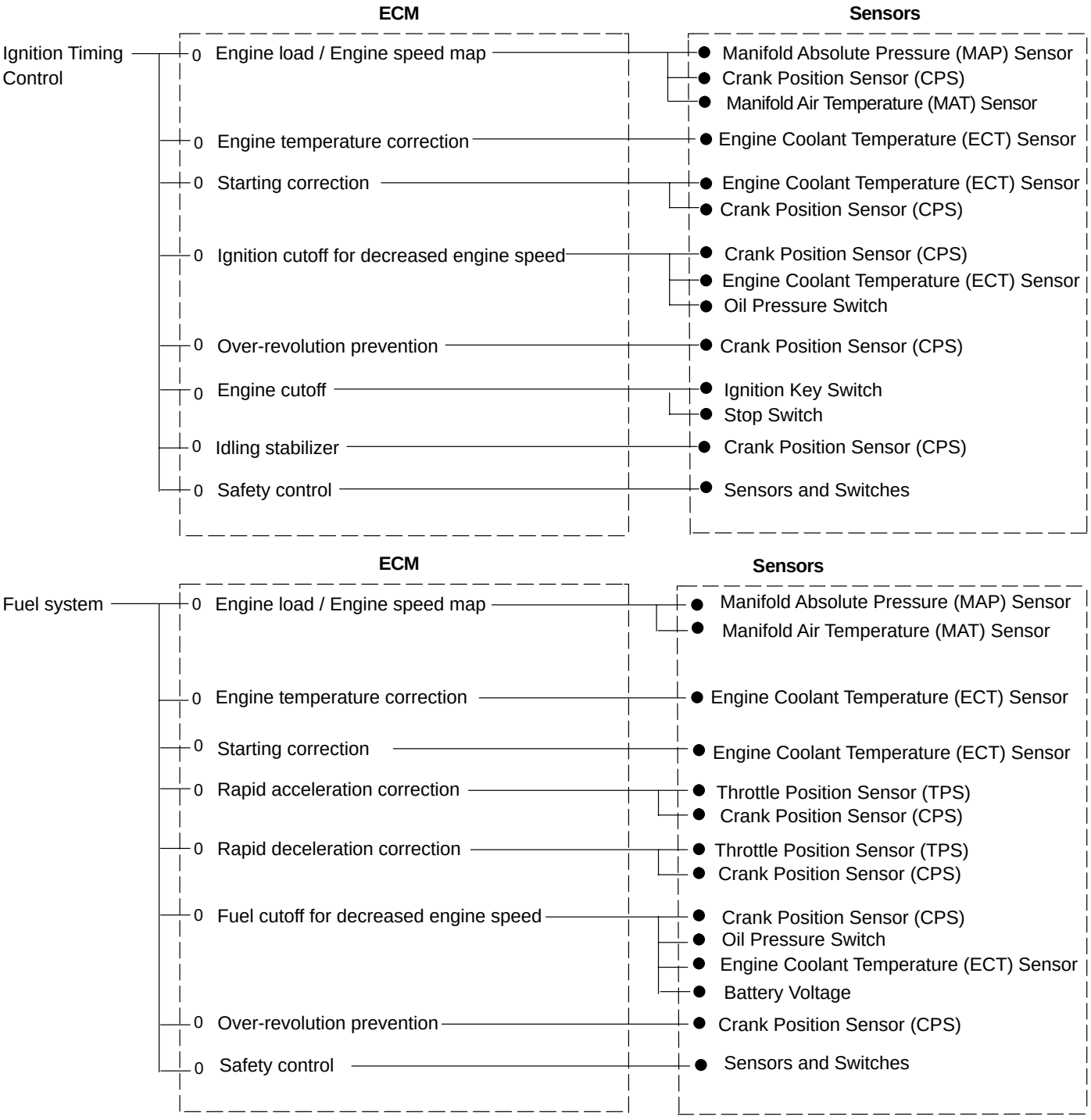
1. Calculates the precise fuel and ignition timing requirements based on engine speed, throttle position, manifold pressure, manifold air temperature and engine coolant temperature
2. Directly controls the ground circuit of fuel injectors, ignition coils, and idle air control
3. Indirectly controls the positive circuit of fuel injectors, ignition coils, and idle air control through the main relay
4. Controls alarm horn and warning functions
5. Controls RPM limit function
6. Records engine running information

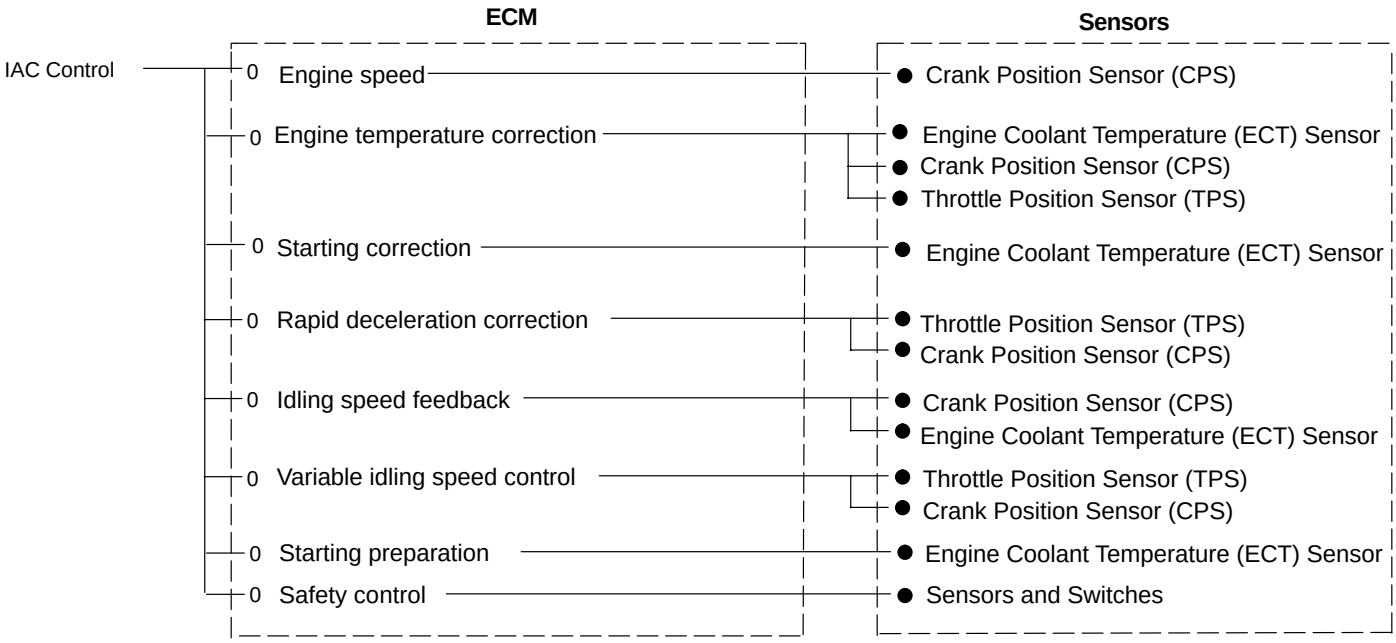


Electronic Control Module Functions



Outline of Control System





Control and Function

	Ignition	Fuel	IAC	Function
Crank Position Sensor (CPS)	○	○	○	Detects the crankshaft position and engine speed
Throttle Position Sensor (TPS)	○	○	○	Detects the open degree of the throttle valve
Engine Coolant Temperature (ECT) Sensor	○	○	○	Detects engine temperature
Manifold Absolute Pressure (MAP) Sensor	○	○		Detects intake air pressure of the intake manifold
Manifold Air Temperature (MAT) Sensor	○	○		Detects intake air temperature
Oil Pressure Switch	○	○		Detects Oil Pressure