
Fuel Systems

Overview

The fuel system supplies the fuel injectors with clean fuel at a controlled pressure. The PCM controls the fuel pump and monitors the fuel pump circuit. The PCM controls the fuel injector ON/OFF cycle duration and determines the correct timing and amount of fuel delivered. When a new fuel injector is installed it is necessary to reset the learned values contained in the keep alive memory (KAM) in the PCM. Refer to Section 2, Resetting The Keep Alive Memory (KAM).

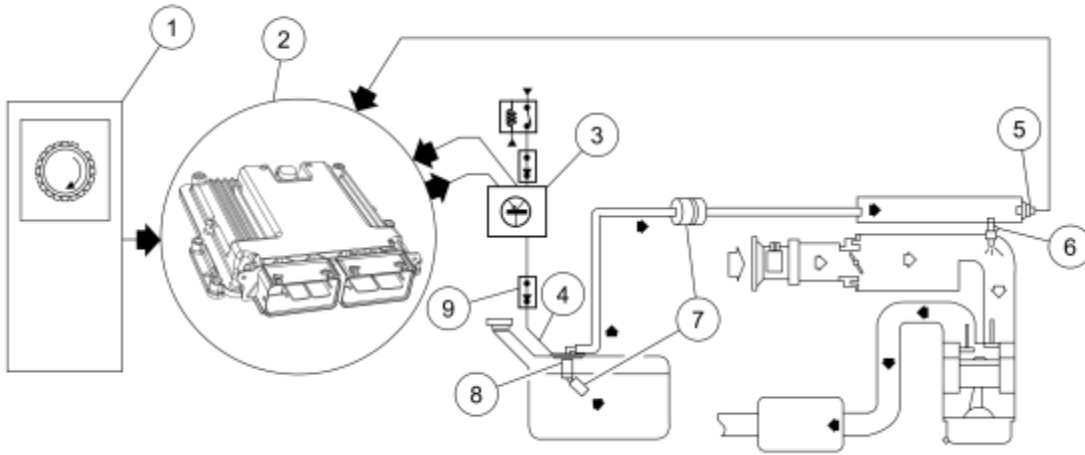
The 2 types of fuel systems used are:

- electronic returnless fuel
- mechanical returnless fuel

Electronic Returnless Fuel System (ERFS)

The ERFS consists of a fuel tank with reservoir, the fuel pump, the fuel rail pressure temperature (FRPT) sensor, the fuel filter, the fuel supply line, the fuel rail, and the fuel injectors. For additional information on the fuel system components, refer to Engine Control Components in this section. Operation of the system is as follows:

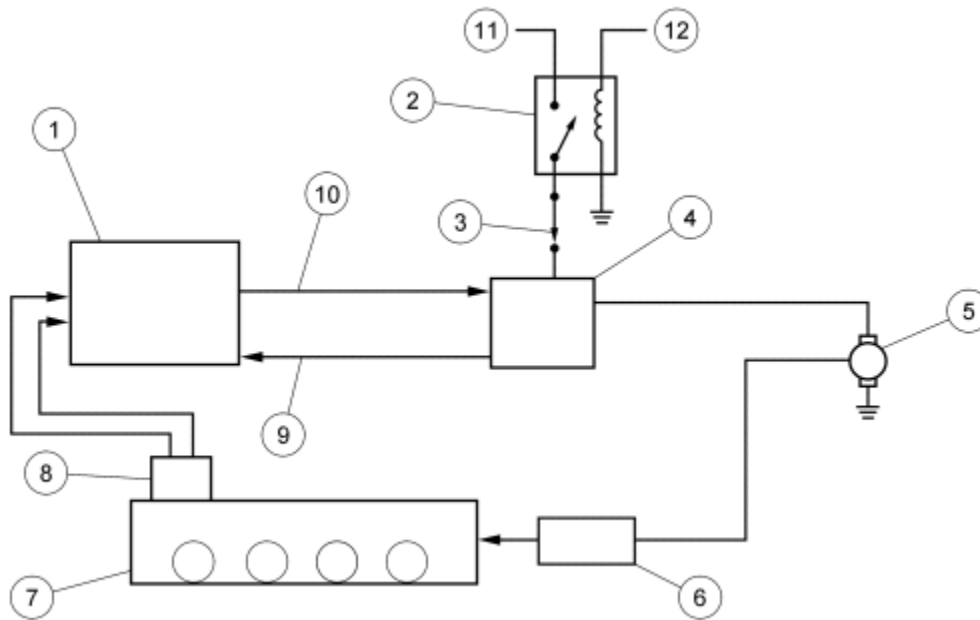
1. The fuel delivery system is enabled during ignition ON, engine OFF for 1 second (or until fuel rail pressure exceeds target) and during crank (if fuel rail pressure falls below target) or running mode once the PCM receives a crankshaft position (CKP) sensor signal. Commanded rail pressure is a function of fuel rail and engine coolant temperature, with different values commanded during crank vs. normal running.
2. The fuel pump logic is defined in the fuel system control strategy and executed by the PCM.
3. The PCM commands a duty cycle to the fuel pump control module.
4. The fuel pump control module modulates the voltage to the fuel pump (FP) required to achieve the correct fuel pressure. Voltage for the fuel pump is supplied by the power relay and fuel pump control module relay. For additional information, refer to Fuel Pump Control — ERFS and Fuel Pump Monitor (FPM) — ERFS in this section.
5. The FRPT sensor measures the pressure and temperature of the fuel in the fuel rail. The PCM uses this information to vary the duty cycle output to the fuel pump control module, which changes the fuel pressure to compensate for varying loads and to avoid fuel system vaporization.
6. The fuel injector is a solenoid operated valve that meters the fuel flow to each combustion cylinder. The fuel injector is opened and closed a constant number of times per crankshaft revolution. The amount of fuel is controlled by the length of time the fuel injector is held open. The fuel injector is normally closed, and is operated by a 12 volt source from either the PCM power relay or the fuel pump relay. The ground signal is controlled by the PCM.
7. There are 3 filtering or screening devices in the fuel delivery system. The intake filter is a fine, nylon mesh screen mounted on the intake side of the fuel pump. There is a fuel filter screen located at the fuel rail side of the fuel injector. The fuel filter assembly is located between the fuel pump and the fuel rail.
8. The FP assembly is a device that contains the fuel pump and the fuel sender assembly. The fuel pump is located inside the reservoir and supplies fuel through the fuel pump assembly manifold to the engine and the fuel pump assembly jet pump.
9. For vehicles with an inertia fuel shutoff (IFS) switch, the IFS switch de-energizes the fuel delivery secondary circuit in the event of a collision. The IFS switch is a safety device that should only be reset after a thorough inspection of the vehicle following a collision. For vehicles without an IFS switch, the fuel pump control module receives an event notification signal from the restraints control module (RCM) to disable the fuel pump in the event of a collision. The signal is sent on a dedicated circuit between the fuel pump control module and RCM.



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Electronic Returnless Fuel System (ERFS)

Typical ERFS Schematic



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Item	Number	Description
1	—	PCM
2	—	Fuel Pump Control Module Relay
3	—	IFS Switch (If Equipped)
4	—	Fuel Pump Control Module
5	—	FP Assembly
6	—	Fuel Filter
7	—	Fuel Rail And Injectors
8	—	FRPT Sensor
9	—	Diagnostic
10	—	Pulse Width Modulation
11	—	Power Source
12	—	Ignition Switch

Fuel Pump Control — ERFS

Note: The Mustang 5.8L uses 2 fuel pump control modules to control fuel for the fuel delivery system. The PCM sends one FP duty cycle on the fuel pump control (FPC) circuit. Both fuel pump control modules use this circuit.

The FP signal is a duty cycle command sent from the PCM to the fuel pump control module. The fuel pump control module uses the FP command to operate the fuel pump at the speed requested by the PCM or to turn the pump OFF. When the ignition is turned ON, the electric fuel pump runs for about 1 second and is requested OFF by the PCM if engine rotation is not detected.

Fuel Pump Duty Cycle Output From PCM (Mustang 5.8L)

FP Duty Cycle Command	PCM Status	Fuel Pump Control Module Actions
0-15%	Invalid OFF duty cycle.	The fuel pump control module sends a 20% duty cycle signal on the fuel pump monitor (FPM) circuit. The fuel pump is OFF.
5-51%	Normal operation.	The fuel pump control module operates the fuel pump at the speed requested. FP duty cycle times 2 equals pump speed % of full ON. For example, FP duty cycle equals 42%. 42 times 2 equals 84. Pump is run at 84% of full ON. The fuel pump control module sends a 60% duty cycle signal on FPM circuit.
51-67%	Invalid ON duty cycle.	The fuel pump control module sends a 20% duty cycle signal on the FPM circuit. The fuel pump is OFF.
67-83%	Valid OFF duty cycle.	The fuel pump control module sends a 60% duty cycle signal on FPM circuit. The fuel pump is OFF.
83-100%	Invalid ON duty cycle.	The fuel pump control module sends a 20% duty cycle signal on the FPM circuit. The fuel pump is OFF.

For additional information, refer to Powertrain Control Hardware , Fuel Pump Control Module.

Fuel Pump Monitor (FPM) — ERFS

Note: The Mustang 5.8L uses 2 fuel pump control modules to control fuel for the fuel delivery system. The PCM individually monitors both fuel pump control modules through the FPM and FPM2 circuits.

The fuel pump control module communicates diagnostic information to the PCM through the FPM circuit. This information is sent by the fuel pump control module as a duty cycle signal. The 3 duty cycle signals that may be sent are listed in the following table.

Fuel Pump Control Module Duty Cycle Signals

Duty Cycle	Comments
20%	This duty cycle indicates the fuel pump control module is receiving an invalid duty cycle from the PCM.
40%	This duty cycle indicates the fuel pump control module is receiving an invalid event notification signal from the RCM.
60%	This duty cycle indicates the fuel pump control module is functioning normally.
80%	This duty cycle indicates the fuel pump control module is detecting a concern with the secondary circuits.

For additional information, refer to Powertrain Control Hardware , Fuel Pump Control Module in this section.

Mechanical Returnless Fuel System (MRFS)

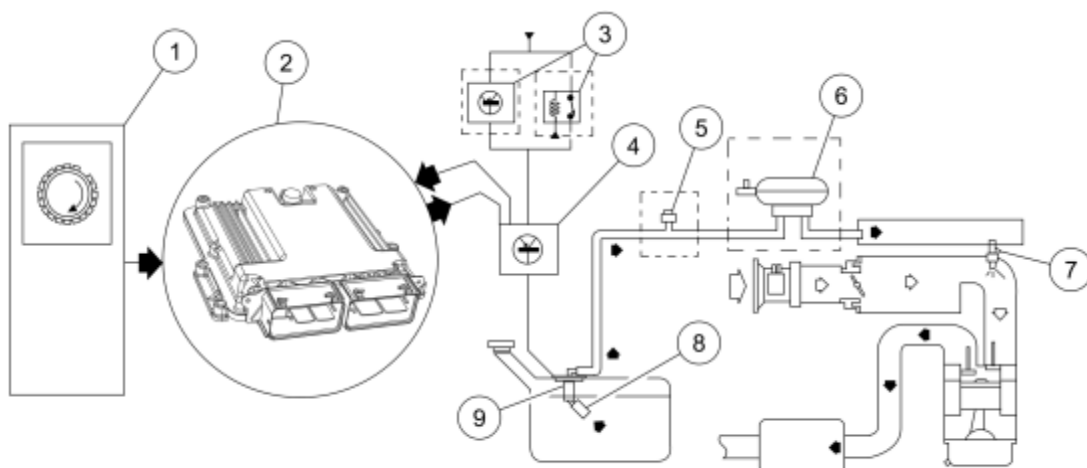
Note: The MRFS can be configured with a dual or variable speed fuel pump. The MRFS incorporates a fuel pump control module which is used to control the speed of the fuel pump. For additional information, refer to Powertrain Control Hardware in this section.

The MRFS uses a fuel tank with reservoir, the fuel pump, the fuel pump control module, the fuel pressure regulator, the fuel filter, the fuel supply line, the fuel rail, and fuel injectors.

For vehicles with gasoline direct fuel injection, a pressure accumulator is incorporated into the fuel line to prevent fuel vapor formation after several hours of cold soak and reduce crank time.

For additional information on the fuel system components, refer to Engine Control Components in this section. Operation of the system is as follows:

1. The fuel delivery system is enabled during ignition ON, engine OFF for 1 second and during crank or running mode once the PCM receives a CKP sensor signal. On vehicles with gasoline direct fuel injection, the high pressure fuel system may be under vacuum after several hours of cold soak. Fuel vapor may collect at the fuel injection pump, causing a long start condition. To prevent this, the fuel pump relay is energized for 1 or 2 seconds, depending on application, as soon as the dome light is commanded ON. This causes the fuel pump control module and the fuel pump to cycle for 1 or 2 seconds and purge any trapped air or fuel vapor from the high pressure fuel system.
2. The fuel pump logic is defined in the fuel system control strategy and executed by the PCM.
3. The fuel pump control module relay provides voltage to the fuel pump control module. Some vehicles use a replaceable relay inside the battery junction box; others use an internal relay in the body control module (BCM).
4. The PCM commands a duty cycle to the fuel pump control module. The fuel pump control module reports diagnostic information to the PCM. The fuel pump control module controls the voltage to the FP based on the duty cycle request from the PCM. Voltage for the fuel pump is supplied by the fuel pump control module relay.
5. For vehicles with gasoline direct fuel injection, a fuel pressure sensor monitors the low pressure fuel system.
6. For vehicles with gasoline direct fuel injection, the fuel injection pump raises fuel system pressure to as high as 15 MPa (2175 psi), and delivers it to the fuel rail.
7. The fuel injector is a solenoid-operated valve that meters the fuel flow to each combustion cylinder. The fuel injector is opened and closed a constant number of times per crankshaft revolution. The amount of fuel is controlled by the length of time the fuel injector is held open. The fuel injector is normally closed and is operated by the PCM.
8. There are 3 to 5 filtering or screening devices in the fuel delivery system. For additional information, refer to Fuel Systems , in this section.
9. The FP assembly contains the fuel pump, the fuel pressure regulator, lifetime fuel filter and the fuel sender assembly. The fuel pressure regulator is attached to the FP assembly and regulates the pressure of the fuel supplied to the fuel injectors. The fuel pressure regulator controls the pressure of the clean fuel as the fuel returns from the fuel filter. The fuel pressure regulator is a diaphragm-operated relief valve. Fuel pressure is established by a spring preload applied to the diaphragm. The FP assembly is located in the fuel tank.



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Typical Mechanical Returnless Fuel System (MRFS)

Fuel Pump Control — MRFS

The FP signal is a duty cycle command sent from the PCM to the fuel pump control module. The fuel pump control module uses the FP command to operate the fuel pump at the speed requested by the PCM or to turn the fuel pump OFF. A valid duty cycle to command the fuel pump ON, is in the range of 15-47%. The fuel pump control module doubles the received duty cycle and provides this voltage to the fuel pump as a percent of the battery voltage. When the ignition is turned ON, the fuel pump runs for about 1 second and is requested OFF by the PCM if engine rotation is not detected.

Fuel Pump Duty Cycle Output From PCM (Focus)

FP Duty Cycle Command	PCM Status	Fuel Pump Control Module Actions
0-4%	Valid OFF duty cycle.	The fuel pump control module sends a 60% duty cycle signal on the FPM circuit. The fuel pump is OFF.
4-18%	Invalid OFF duty cycle.	The fuel pump control module sends a 20% duty cycle signal on the FPM circuit. The fuel pump is OFF.
18-80%	Normal operation.	The fuel pump control module operates the fuel pump at the speed requested. FP duty cycle times 1.43 minus 14.29 equals pump speed % of full ON. For example, FP duty cycle equals 42%. 42 times 1.43 minus 14.29 equals 46 (rounded). Pump is run at 46% of full ON. The fuel pump control module sends a 60% duty cycle signal on the FPM circuit.
80-86%	Normal operation.	The fuel pump control module operates the fuel pump at full ON. The fuel pump control module sends a 60% duty cycle signal on the FPM circuit.
86-95%	Invalid OFF duty cycle.	The fuel pump control module sends a 20% duty cycle signal on the FPM circuit. The fuel pump is OFF.
95-100%	Valid OFF duty cycle.	The fuel pump control module sends a 60% duty cycle signal on the FPM circuit. The fuel pump is OFF.

Fuel Pump Duty Cycle Output From PCM (Edge 2.0L, Escape 1.6L, Escape 2.0L, Explorer 2.0L, Explorer 3.5L GTDI, F-150 3.5L, Fiesta 1.0L, Fiesta 1.6L GTDI, Fusion 1.5L, Fusion 1.6L, Fusion 2.0L, MKT 2.0L, MKZ 2.0L, Taurus 2.0L, Transit Connect 1.6L)

FP Duty Cycle Command	PCM Status	Fuel Pump Control Module Actions
0-5%	Invalid OFF	The fuel pump control module sends a 20% duty cycle signal on the FPM circuit. The fuel pump

	duty cycle.	is OFF.
5-47%	Normal operation.	The fuel pump control module operates the fuel pump at the speed requested. FP duty cycle times 1.43 minus 14.29 equals pump speed % of full ON. For example, FP duty cycle equals 42%. 42 times 1.43 minus 14.29 equals 46 (rounded). Pump is run at 46% of full ON. The fuel pump control module sends a 60% duty cycle signal on the FPM circuit.
47-51%	Normal operation — full ON.	The fuel pump control module operates the fuel pump at full ON. The fuel pump control module sends a 60% duty cycle signal on the FPM circuit.
51-67%	Invalid OFF duty cycle.	The fuel pump control module sends a 20% duty cycle signal on the FPM circuit. The fuel pump is OFF.
67-83%	Valid OFF duty cycle.	The fuel pump control module sends a 60% duty cycle signal on the FPM circuit. The fuel pump is OFF.
83-100%	Invalid OFF duty cycle.	The fuel pump control module sends a 20% duty cycle signal on the FPM circuit. The fuel pump is OFF.

Fuel Pump Duty Cycle Output From PCM (All Others)

FP Duty Cycle Command	PCM Status	Fuel Pump Control Module Actions
0-15%	Invalid OFF duty cycle.	The fuel pump control module sends a 20% duty cycle signal on the FPM circuit. The fuel pump is OFF.
37%	Normal low speed operation.	The fuel pump control module operates the fuel pump at the speed requested. The fuel pump control module sends a 60% duty cycle signal on the FPM circuit.
47%	Normal high speed operation.	The fuel pump control module operates the fuel pump at the speed requested. The fuel pump control module sends a 60% duty cycle signal on the FPM circuit.
51-67%	Invalid ON duty cycle.	The fuel pump control module sends a 20% duty cycle signal on the FPM circuit. The fuel pump is OFF.
67-83%	Valid OFF duty cycle.	The fuel pump control module sends a 60% duty cycle signal on the FPM circuit. The fuel pump is OFF.
83-100%	Invalid ON duty cycle.	The fuel pump control module sends a 20% duty cycle signal on the FPM circuit. The fuel pump is OFF.

Fuel Pump Monitor (FPM) — MRFS

The fuel pump control module communicates diagnostic information to the PCM through the FPM circuit. This information is sent by the fuel pump control module as a duty cycle signal. The duty cycle signals that may be sent are listed in the following tables.

Note: The Expedition and Navigator have the event notification signal circuit and an IFS switch. The event notification signal information is calibrated off in the PCM and the IFS switch disables the voltage to the fuel pump control module in the event of a collision. Some vehicles use a fuel pump control module relay located in the body control module (BCM) that is disabled when the BCM detects a crash event. These vehicles do not use an IFS switch nor an event notification signal circuit.

Fuel Pump Control Module Duty Cycle Signals (Edge 2.0L, Escape 1.6L, Escape 2.0L, Explorer 2.0L, Explorer 3.5L GTDI, F-150 3.5L, Fiesta 1.0L, Fiesta 1.6L GTDI, Focus, Fusion 1.5L, Fusion 1.6L, Fusion 2.0L, MKT 2.0L, MKZ 2.0L, Taurus 2.0L, Transit Connect 1.6L)

Duty Cycle	Comments
20%	This duty cycle indicates the fuel pump control module is receiving an invalid duty cycle from the PCM.
60%	This duty cycle indicates the fuel pump control module is functioning normally.
80%	This duty cycle indicates the fuel pump control module is detecting a concern with the secondary circuits.

Fuel Pump Control Module Duty Cycle Signals (All Others)

Duty Cycle	Comments
20%	This duty cycle indicates the fuel pump control module is receiving an invalid duty cycle from the PCM.
40%	For vehicles with event notification signal, this duty cycle indicates the fuel pump control module is receiving an invalid event notification signal from the RCM. For vehicles without event notification signal, this duty cycle indicates the fuel pump control module is functioning normally.
60%	For vehicles with event notification signal, this duty cycle indicates the fuel pump control module is functioning normally.
80%	This duty cycle indicates the fuel pump control module is detecting a concern with the secondary circuits.

Fuel Filters

The system contains 3 to 5 filtering or screening devices. Refer to Workshop Manual Section 310-01, Fuel Tank and Lines, for the individual component locations.

1. The fuel intake filter or screen is a fine nylon mesh filter mounted on the intake side of the fuel pump. It is part of the assembly and cannot be repaired separately.
2. The filter/screen at the fuel rail port of the injectors is part of the fuel injector assembly and cannot be repaired separately.
3. The filter/screen at fuel inlet side of the fuel pressure regulator is part of the regulator assembly and cannot be repaired separately.
4. The fuel filter assembly is located between the fuel pump and injectors. This filter may be a lifetime fuel filter located in the fuel pump assembly or an external 3-port inline filter that allows clean fuel to return to the fuel tank. A new filter may be installed for the external filter.
5. The fuel filter sock is located on the fuel pump assembly between the reservoir and the fuel tank.

Fuel Pressure Sensor

On some gasoline direct fuel injection applications, there is a fuel pressure sensor located in the fuel line that allows the PCM to monitor the low pressure fuel system operation. For additional information, refer to Engine Control Components , Fuel Pressure Sensor in this section.
