Fuel Systems

Overview

The fuel system supplies the fuel injectors with clean fuel at a controlled pressure. The powertrain control module (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 and during crank or running mode once the PCM receives a crankshaft position (CKP) sensor signal.

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 driver module (FPDM).

4. The FPDM 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 or FPDM power supply relay. For additional information refer to Fuel Pump Control and Fuel Pump Monitor.

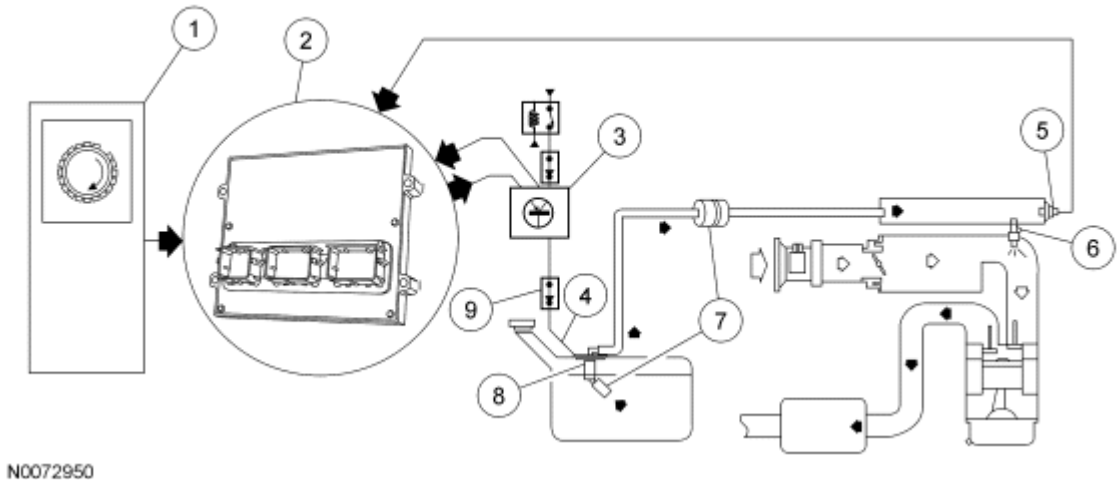
5. The FRPT sensor measures the pressure and temperature of the fuel in the fuel rail. The PCM uses this information to vary the duty cycle output to the FPDM, which changes the fuel pressure, to compensate for varying loads and to avoid fuel system vaporization.

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 electronic engine control (EEC) 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.

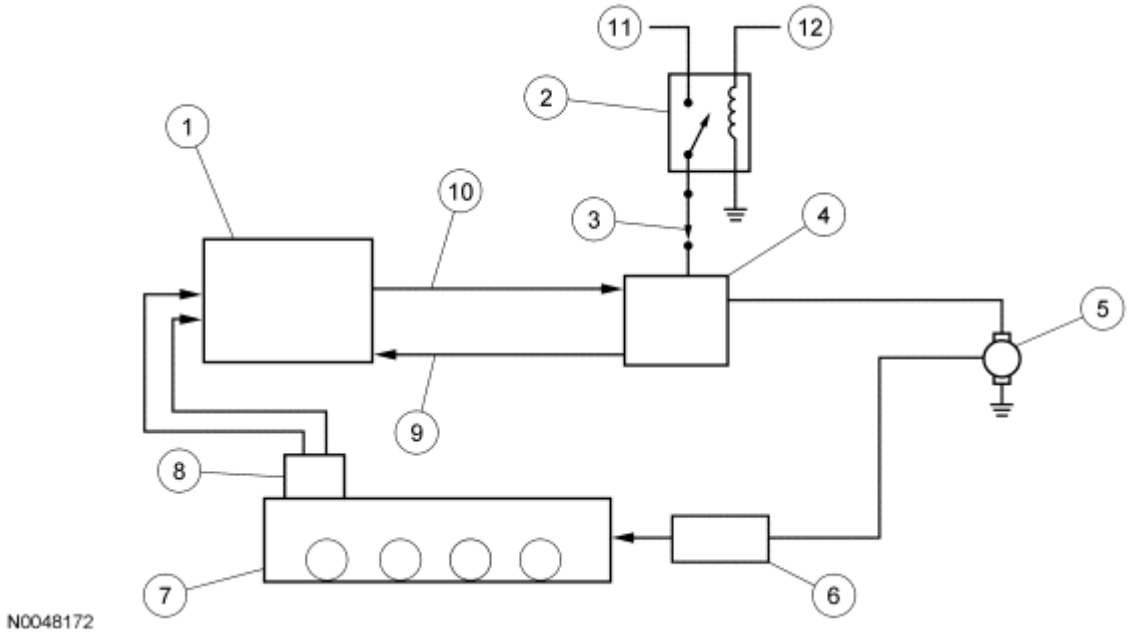
8. The FP module is a device that contains the fuel pump and the fuel sender assembly. The fuel pump is located inside the reservoir and supplies fuel through the fuel pump module manifold to the engine and the fuel pump module jet pump.

9. The inertia fuel shut-off (IFS) switch is used to de-energize 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.



Electronic Returnless Fuel System

Typical Electronic Returnless Fuel System Schematic



Item	Number	Description
1	—	PCM
2	—	FPDM Relay
3	—	IFS Switch
4	—	FPDM
5	—	FP Module
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 5.4L uses two FPDMs to control fuel for the fuel delivery system. The PCM sends one FP duty cycle on the fuel pump control (FPC) circuit. This circuit is used by both FPDMs.

The FP signal is a duty cycle command sent from the PCM to the FPDM. The FPDM 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

FP Duty Cycle Command	PCM Status	FPDM Actions
0-4%	The PCM does not output this duty cycle.	Invalid FP duty cycle. The FPDM sends 25% duty cycle signal on the fuel pump monitor (FPM) circuit. The fuel pump is off.
4-5%	Dead band range for transitions between FPDM states.	—
5-45%	Normal operation.	The FPDM operates the fuel pump at the speed requested. "FP duty cycle" x 2 equals pump speed % of full on. (for example, FP duty cycle equals 42%. 42x2 equals 84. Pump is run at 84% of full on). The FPDM sends 50% duty cycle signal on FPM circuit.
45-48%	Normal operation. An open circuit cannot be detected in this range.	The FPDM operates the fuel pump at the speed requested. "FP duty cycle" x 2 equals pump speed % of full on. The FPDM sends 50% duty cycle signal on FPM circuit.
48-51%	Normal operation.	The FPDM operates the fuel pump at full on. The FPDM sends 50% duty cycle signal on FPM circuit.
51-52%	Dead band range for transitions between FPDM states.	—
52-68%	The PCM does not output this duty cycle.	Invalid FP duty cycle. The FPDM sends 25% duty cycle signal on the FPM circuit. The fuel pump is off.
68-70%	Dead band range for transitions between FPDM states.	—
70-81%	To request the fuel pump off, the PCM outputs this duty cycle.	Valid fuel pump off command from the PCM. The FPDM does not operate the fuel pump. The FPDM sends a 50% duty cycle signal on the FPM circuit.
81-83%	Dead band range for transitions between FPDM states.	—
83-100%	The PCM does not output this duty cycle.	Invalid FP duty cycle. The FPDM sends 25% duty cycle signal on the FPM circuit. The fuel pump is off.

For additional information, refer to Powertrain Control Hardware , Fuel Pump Driver Module (FPDM).

Fuel Pump Monitor (FPM) — ERFS

Note: The Mustang 5.4L uses two FPDMs to control fuel for the fuel delivery system. The PCM individually monitors both FPDMs through the FPM and FPM2 circuits.

The FPDM communicates diagnostic information to the PCM through the FPM circuit. This information is sent by

the FPDM as a duty cycle signal. The three duty cycle signals that may be sent are listed in the following table.

FUEL PUMP DRIVER MODULE DUTY CYCLE SIGNALS

Duty Cycle	Comments	FP_M PID [a]
50%	This duty cycle indicates that the FPDM is functioning normally.	80-125%
25%	This duty cycle indicates that the FPDM either did not receive a fuel pump (FP) duty cycle command from the PCM or did not receive a valid FP duty cycle command from the PCM.	15-60%
75%	This duty cycle indicates that the FPDM detects a concern in the circuits between the fuel pump and FPDM.	250-400%

[a] Some scan tools display the FP_M PID as the duty cycle in column 1. Other scan tools display the FP_M PID as a value shown in the FP_M PID column. This value fluctuates randomly. It is OK for the value to briefly go outside this range, then return.

For additional information, refer to Powertrain Control Hardware , Fuel Pump Driver Module (FPDM).

Mechanical Returnless Fuel System (MRFS) — Single Speed

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

The single speed MRFS uses a fuel tank with reservoir, the fuel pump, the fuel pressure regulator, the fuel filter, the fuel supply line, the fuel rail, fuel injectors, and a Schrader valve/pressure test point. 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.

2. The fuel pump logic is defined in the fuel system control strategy and is carried out by the PCM.

3. The PCM grounds the fuel pump relay, which provides power to the fuel pump.

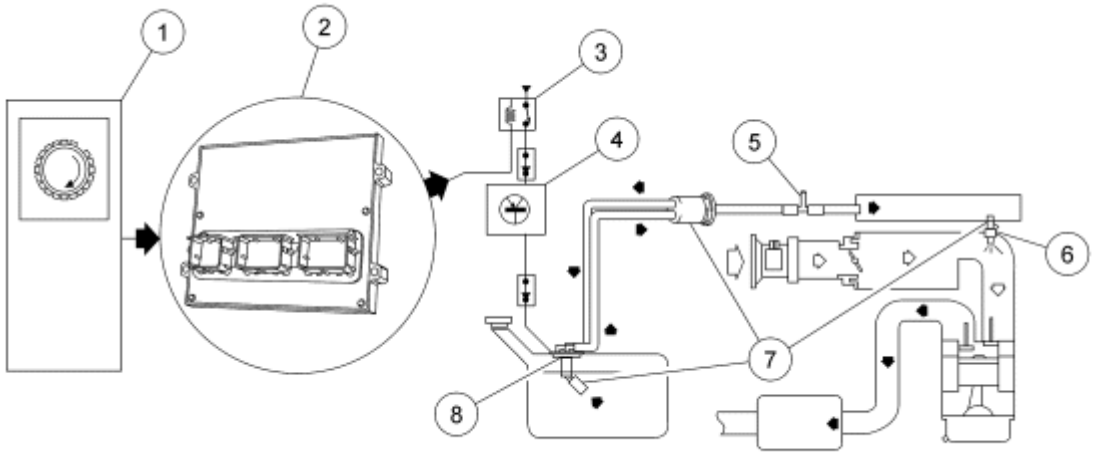
4. The IFS switch is used to de-energize the fuel delivery secondary circuit in the event of collision. The IFS switch is a safety device that should only be reset after a thorough inspection of the vehicle following a collision.

5. A pressure test point valve, Schrader valve, is located on the fuel rail and is used to measure the fuel injector supply pressure for diagnostic procedures and repairs. On vehicles not equipped with a Schrader valve, use the Rotunda Fuel Pressure Test Kit 134-R0087 or equivalent.

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 EEC power relay or the fuel pump relay. The ground signal is controlled by the PCM.

7. There are 3-5 filtering or screening devices in the fuel delivery system. For additional information refer to Fuel Filters in this section.

8. The FP module contains the fuel pump, the fuel pressure regulator, and the fuel sender assembly. The fuel pressure regulator is attached to the FP module 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 module is located in the fuel tank.



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Typical Mechanical Returnless Fuel System with External Fuel Filter

Fuel Pump Control — Single Speed MRFS

The output signal from the PCM is used to control the electric fuel pump. With the EEC power relay contacts closed, vehicle power (VPWR) is sent to the coil of the fuel pump relay. For electric fuel pump operation, the PCM grounds the FP circuit, which is connected to the coil of the fuel pump relay. This energizes the coil and closes the contacts of the relay, sending B+ through the FP PWR circuit to the electric fuel pump. When the ignition is turned on, the electric fuel pump runs for about 1 second and is turned off by the PCM if engine rotation is not detected.

Fuel Pump Monitor (FPM) — Single Speed MRFS

The FPM circuit is spliced into the fuel pump power (FP PWR) circuit and is used by the PCM for diagnostic purposes. The PCM sources a low current voltage down the FPM circuit. With the fuel pump off, this voltage is pulled low by the path to ground through the fuel pump. With the fuel pump off and the FPM circuit low, the PCM can verify the FPM and FP PWR circuits are complete from the FPM splice through the fuel pump to ground. This also confirms that the FP PWR or FPM circuits are not short to power. With the fuel pump on, voltage is now being supplied from the fuel pump relay to the FP PWR and FPM circuits. With the fuel pump on and the FPM circuit high, the PCM can verify the FP PWR circuit from the fuel pump relay to the FPM splice is complete. It can also verify the fuel pump relay contacts are closed and there is a B+ supply to the fuel pump relay.

Mechanical Returnless Fuel System (MRFS) — Dual Speed

Note: The MRFS can be configured with a single or dual speed fuel pump. The dual speed 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 dual speed 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, fuel injectors, and a Schrader valve/pressure test point (if equipped). 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.

2. The fuel pump logic is defined in the fuel system control strategy and executed by the PCM.

3. For vehicles with an IFS switch, the switch is used to disable the voltage to the fuel pump control module 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 event notification signal is sent on a dedicated circuit between the fuel pump control module and the RCM.

4. The PCM commands a duty cycle to the fuel pump control module. The fuel pump control module reports diagnostic information to the PCM.

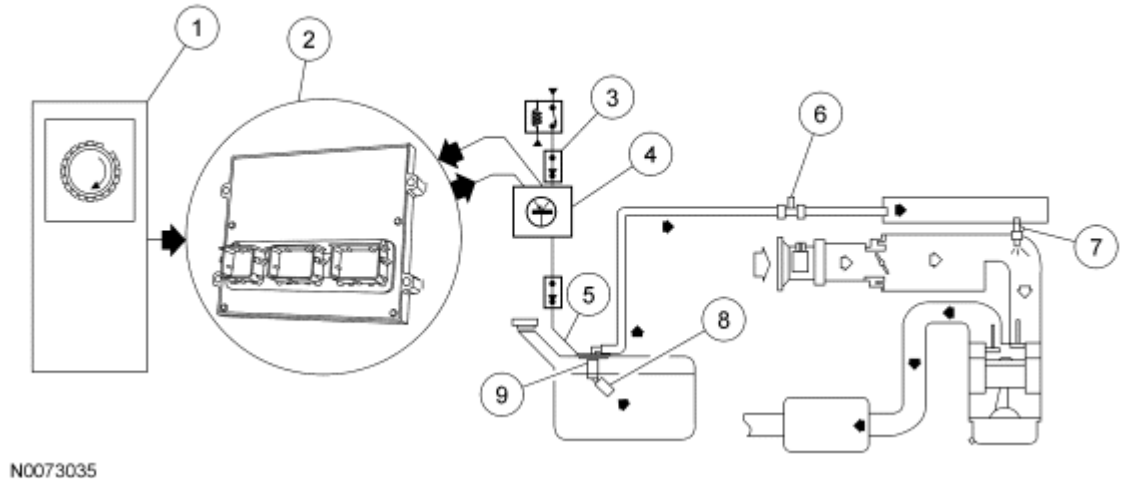
5. The fuel pump control module controls the voltage to the fuel pump (FP) based on the duty cycle request from the PCM. Voltage for the fuel pump is supplied by the fuel pump control module relay. For additional information refer to Fuel Pump Control and Fuel Pump Monitor.

6. A pressure test point valve, Schrader valve, is located on the fuel rail and is used to measure the fuel injector supply pressure for diagnostic procedures and repairs. On vehicles not equipped with a Schrader valve, use the Rotunda Fuel Pressure Test Kit 134-R0087 or equivalent.

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 a 12-volt source from the fuel pump relay. The ground signal is controlled by the PCM.

8. There are 3-5 filtering or screening devices in the fuel delivery system. For additional information refer to Fuel Filters in this section.

9. The FP module contains the fuel pump, the fuel pressure regulator, lifetime fuel filter (if equipped) and the fuel sender assembly. The fuel pressure regulator is attached to the FP module 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 module is located in the fuel tank.



Typical Dual Speed Mechanical Returnless Fuel System with Lifetime Fuel Filter

Fuel Pump Control — Dual Speed 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

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.
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 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 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.

Fuel Pump Monitor (FPM) — Dual Speed 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 four duty cycle signals that may be sent are listed in the following table.

Note: The Expedition and Navigator vehicles 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 is used to disable the voltage to the fuel pump control module in the event of a collision.

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%	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 3-5 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 the pressure test point (Schrader valve) or injectors. This filter may be a lifetime fuel filter located in the fuel pump module or an external 3-port in-line 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 module between the reservoir and the fuel tank.

Pressure Test Point

On some applications there is a pressure test point with a Schrader fitting in the fuel rail that relieves the fuel pressure and measures the fuel injector supply pressure for repair and diagnostic procedures. Before repairing or diagnosing the fuel system, read any WARNING information. On vehicles not equipped with a Schrader valve, use the Rotunda Fuel Pressure Test Kit 134-R0087 or equivalent.