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## 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 \(KAM\)](#).

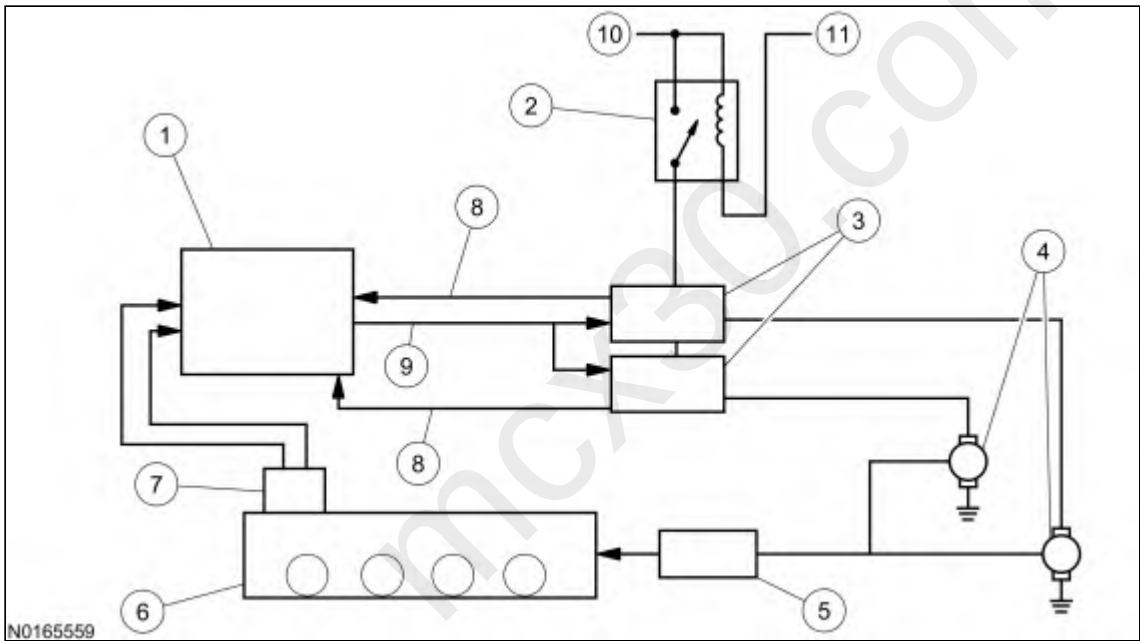
The 2 types of fuel systems used are:

- electronic returnless fuel
- mechanical returnless fuel

### Electronic Returnless Fuel System (ERFS)

The ERFS consists of a fuel tank with reservoir, the dual fuel pumps, 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 two fuel pump control modules.
4. The two fuel pump control modules modulate the voltage to the two fuel pumps (FP) required to achieve the correct fuel pressure. Voltage for the two fuel pumps 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 2 fuel pump control modules, which change 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 filters are fine, nylon mesh screens mounted on the intake side of the 2 fuel pumps. There is a fuel filter screen located at the fuel rail side of the fuel injector. The fuel filter assembly is located between the 2 fuel pumps and the fuel rail.
8. The FP assembly is a device that contains the 2 fuel pumps and the fuel sender assembly. The 2 fuel pumps are located inside the reservoir and supply fuel through the fuel pump assembly manifold to the engine and the fuel pump assembly jet pump.



## Fuel Pump Control — ERFs

**Note:** The Mustang 5.2L engines uses 2 fuel pump control modules to control fuel for the fuel delivery system. The PCM sends one FP duty cycle on the 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 modules. The fuel pump control modules use the FP command to operate the fuel pumps at the speed requested by the PCM or to turn the pumps OFF. When the ignition is turned ON, the electric fuel pumps run for about 1 second and are 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.                                                                                                                                                                                 |
| 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 5.2L engines 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 modules communicate diagnostic information to the PCM through the FPM and FPM2 circuits. This information is sent by the fuel pump control modules 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.                                        |

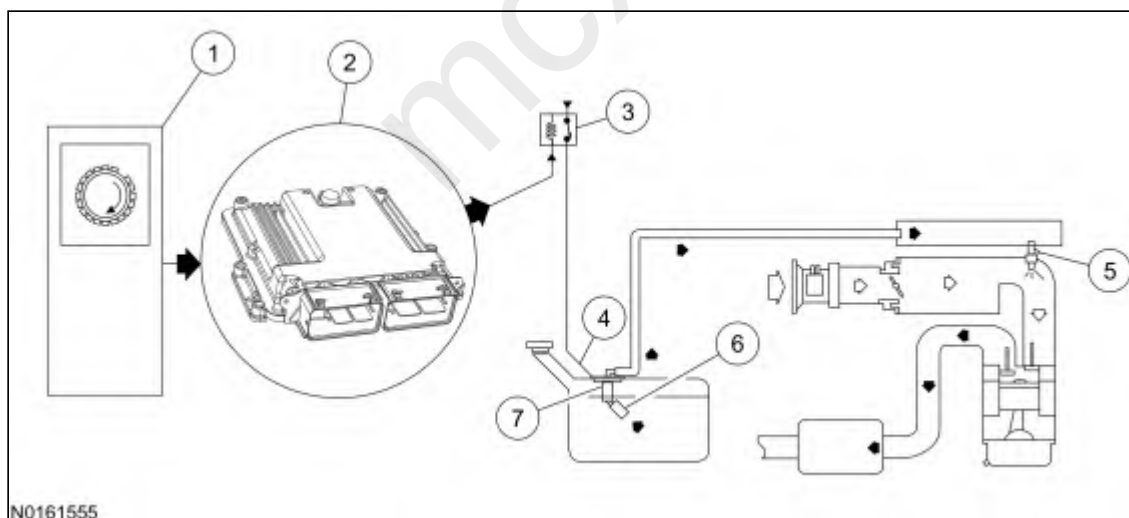
| Duty Cycle | Comments                                                                                                   |
|------------|------------------------------------------------------------------------------------------------------------|
| 80%        | This duty cycle indicates the fuel pump 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) — EcoSport 1.5L, KA

The MRFS uses a fuel tank with reservoir, the fuel pump, the fuel supply line, the fuel rail, and 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 is carried out by the PCM or the body control module (BCM).
3. The PCM or BCM grounds the fuel pump relay, which provides power to the fuel pump.
4. The PCM monitors the FPPWR circuit by way of a spliced FPM circuit.
5. 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.
6. There are 3 to 5 filtering or screening devices in the fuel delivery system. For additional information, refer to [Fuel Systems](#), in this section.
7. 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.



Typical MRFS (KA)

### Fuel Pump Control — EcoSport 1.5L, KA

The output signal from the PCM or BCM controls the electric fuel pump. With the PCM power relay contacts closed, VPWR is sent to the coil of the fuel pump relay. For electric fuel pump operation, the PCM or BCM 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 FPPWR 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 or BCM if engine rotation is not detected.

## Fuel Pump Monitor — EcoSport 1.5L, KA

The FPM circuit is spliced into the FPPWR 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 FPPWR circuits are complete from the FPM splice through the fuel pump to ground. This also confirms that the FPPWR 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 FPPWR and FPM circuits. With the fuel pump ON and the FPM circuit high, the PCM can verify the FPPWR 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) — All Others

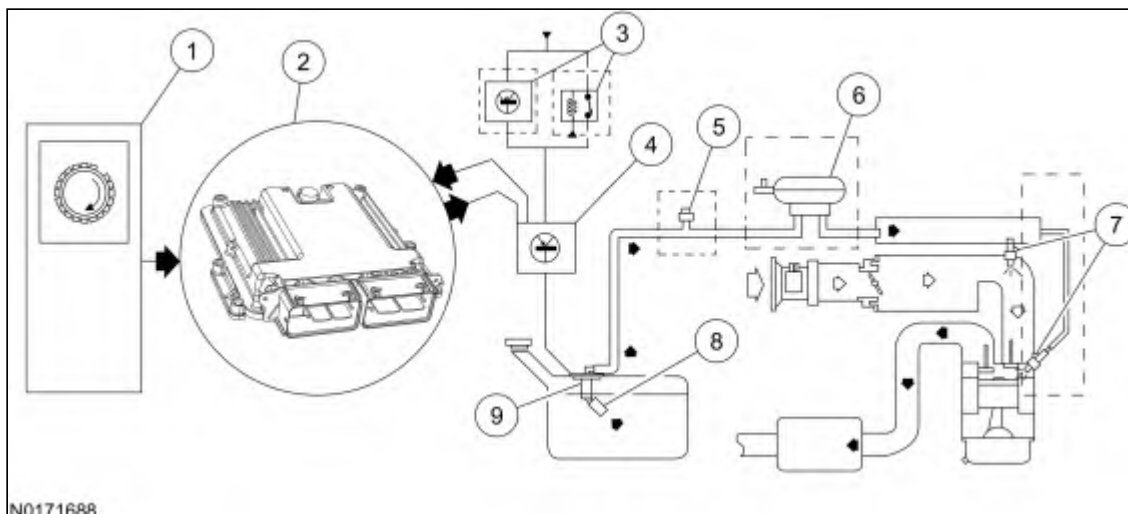
**Note:** The MRFS can be configured with a dual or variable speed fuel pump. The MRFS incorporates a fuel pump control module which is used to control the speed of the fuel pump. For additional information, refer to [Powertrain Control Hardware](#) in this section.

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. On some vehicles, both the direct fuel injection system and the port fuel injection system are used to deliver fuel to the engine.
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.



Typical Mechanical Returnless Fuel System (MRFS)

### Fuel Pump Control — All Others

**Note:** The Continental 3.0L, Ford GT and MKZ 3.0L use 2 fuel pump control modules to control fuel for the fuel delivery system. The PCM sends one FP duty cycle on the 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 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 (EcoSport 2.0L, Transit Connect 2.0L)

| 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 (Aviator, Continental 2.0L, Continental 2.7L, Continental 3.0L, Corsair, Edge, Escape/Kuga, Explorer, Expedition, F-150, Ford GT, Fusion 1.5L, Fusion 2.0L, Fusion 2.7L, MKZ, Mustang 2.3L, Mustang 5.0L, Nautilus, Navigator, Ranger 2.3L, Transit)**

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

**Note:** The Continental 3.0L, Ford GT and MKZ 3.0L use 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 duty cycle signals that may be sent are listed in the following tables.

**Fuel Pump Control Module Duty Cycle Signals (Aviator, Continental 2.0L, Continental 2.7L, Continental 3.0L, Corsair, Edge, Escape/Kuga, Explorer, Expedition, F-150, Ford GT, Fusion 1.5L, Fusion 2.0L, Fusion 2.7L, Mustang 5.0L, MKZ, Mustang 2.3L, Nautilus, Navigator, Ranger 2.3L, Transit)**

| 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.

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