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2019 Ford Flex Service and Repair Manual

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the OFF, ACC or LOCK position, the PCM (powertrain control module) stays powered up until the correct engine shutdown occurs.

The ISP-R and the INJPWRM circuits provide the ignition state input to the PCM (powertrain control module) . Based on the ISP-R and INJPWRM signals the PCM determines when to power down the PCM (powertrain control module) power relay.

Engine Off Timer Monitor

The engine off time is obtained from the PCM (powertrain control module) or the BCM (body control module) . If the engine off time is obtained from the BCM (body control module) , the PCM (powertrain control module) expects to receive a message with the engine off time from the BCM (body control module) shortly after engine start up. If the message is not available on the controller area network (CAN) or a battery disconnect has occurred, a communication DTC (diagnostic trouble code) sets.

There are two parts to this test.

The first part determines if the timer is incrementing during engine OFF. The PCM (powertrain control module) determines the timer is incrementing during engine OFF by comparing the engine coolant temperature value prior to shut down, to the engine coolant temperature value at ignition ON to determine if an engine OFF soak has occurred. For an engine OFF soak to occur, the engine coolant temperature value must be greater than 71°C (160 °F) while the engine is running. The timer starts at ignition OFF and the engine coolant temperature value must decrease by greater than 17°C (30 °F) before the next ignition ON signal. If the engine off timer indicates a value less than 30 seconds, a DTC (diagnostic trouble code) sets.

The second part checks the accuracy of the engine off timer. The PCM (powertrain control module) determines the accuracy of the engine off timer by comparing time in the BCM (body control module) with the time in the PCM (powertrain control module) . The timer in the BCM (body control module) is allowed to count up for 5 minutes and compared to a different clock in the PCM (powertrain control module) . If the two timers differ by more than 15 seconds, a DTC (diagnostic trouble code) sets.

Engine RPM Limiter

The PCM (powertrain control module) disables some or all of the fuel injectors whenever an engine RPM (revolutions per minute) over speed condition is detected. The purpose of the engine RPM (revolutions per minute) limiter is to prevent damage to the powertrain. Once the driver reduces the excessive engine speed, the engine returns to the normal operating mode. No repair is required. However, the technician should clear the DTCs and inform the customer of the reason for the DTC (diagnostic trouble code) .

Excessive wheel slippage may be caused by sand, gravel, rain, mud, snow, ice, or excessive and sudden increase in RPM (revolutions per minute) while in NEUTRAL or while driving.

Failure Mode Effects Management (FMEM)

The FMEM is an alternate system strategy in the PCM (powertrain control module) designed to maintain engine operation if one or more sensor inputs fail.

Engine Load	Road Conditions (Smooth-Bumpy)
Engine Idle/Accel/Deceleration	

Accumulating PCM Data

The PCM (powertrain control module) data can be accumulated in a number of ways. This includes circuit measurements with a DMM (digital multimeter) or scan tool PID (parameter identification) data. Acquisition of PCM (powertrain control module) PID (parameter identification) data using a scan tool is one of the easiest ways to gather information. Gather as much data as possible when the concern is occurring to prevent improper diagnosis. Data should be accumulated during different operating conditions and based on the customer description of the intermittent concern. Compare this data with the known good data values.

Peripheral Inputs

Some signals may require certain peripherals or auxiliary tools for diagnosis. In some cases, these devices can be inserted into the measurement jacks of the scan tool or DMM (digital multimeter) . For example, connecting an electronic fuel pressure gauge to monitor and record the fuel pressure voltage reading and capturing the data would help find the fault.

Comparing PCM Data

After the PCM (powertrain control module) values are acquired, it is necessary to determine the concern area. This typically requires the comparison of the actual values from the vehicle to known good data values.

Analyzing PCM Data

Look for abnormal events or values that are clearly incorrect. Inspect the signals for abrupt or unexpected changes. For example, during a steady cruise most of the sensor values should be relatively stable. Sensors such as TP (throttle position) , as well as an RPM (revolutions per minute) that changes abruptly when the vehicle is traveling at a constant speed, are clues to a possible concern area.

Look for an agreement in related signals. For example, if the APP1 or APP2 changes during acceleration, a corresponding change should occur in RPM and SPARK ADV PID (parameter identification) .

Make sure the signals act in proper sequence. An increase in RPM (revolutions per minute) after the TP1 and TP2 increases is expected. If the RPM (revolutions per minute) increases without a TP1 and TP2 change, a concern may exist.

The PID (parameter identification) values are not always captured from the same execution loop. Depending on the number of PIDs acquired, the sample rate may be 60 ms or longer. For example, the ETC_ACT reading will always lag behind the ETC_DSD reading due to the physical time to move the throttle plate. This is an expected difference between ETC_ACT and ETC_DSD during these events.

Scroll through the PID data while analyzing the information. Look for sudden drops or spikes in the values.

0010	2	1010	A
0011	3	1011	B
0100	4	1100	C
0101	5	1101	D
0110	6	1110	E
0111	7	1111	F

The first 4 bits of a DTC (diagnostic trouble code) do not convert directly into hex digits. The conversion into different types of DTCs (P, B, C and U) is defined by SAE J2012. This standard contains DTC (diagnostic trouble code) definitions and formats.

Binary Bit Pattern	SAE DTC Type	Binary Bit Pattern	SAE DTC Type
0000	P0	1000	B0
0001	P1	1001	B1
0010	P2	1010	B2
0011	P3	1011	B3
0100	C0	1100	U0
0101	C1	1101	U1
0110	C2	1110	U2
0111	C3	1111	U3

ISO 14229 sends 2 additional bytes of information with each DTC (diagnostic trouble code) , a failure type byte and a status byte.

DTC Byte 1		DTC Byte 2		Failure Type Byte		Status Byte	
0000	0100	0010	0000	0000	0000	1111	0101

Most Significant Bits				Least Significant Bits			
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

DTC Status Bit Definitions

Refer to the following status bit descriptions:

Bit 7

- 0 - The ECU (electronic control unit) is not requesting warning indicator to be active
- 1 - The ECU (electronic control unit) is requesting warning indicator to be active

Bit 6

- 0 - The DTC (diagnostic trouble code) test completed this monitoring cycle
- 1 - The DTC (diagnostic trouble code) test has not completed this monitoring cycle

Bit 5

- 0 - The DTC (diagnostic trouble code) test has not failed since last code clear
- 1 - The DTC (diagnostic trouble code) test failed at least once since last code clear

Bit 4

- 0 - The DTC (diagnostic trouble code) test completed since the last code clear
- 1 - The DTC (diagnostic trouble code) test has not completed since the last code clear

Bit 3

- 0 - The DTC (diagnostic trouble code) is not confirmed at the time of the request
- 1 - The DTC (diagnostic trouble code) is confirmed at the time of the request

Bit 2

- 0 - The DTC (diagnostic trouble code) test completed and was not failed on the current or previous monitoring cycle
- 1 - The DTC (diagnostic trouble code) test failed on the current or previous monitoring cycle

Bit 1

- 0 - The DTC (diagnostic trouble code) test has not failed on the current monitoring cycle board diagnostic) DTC (diagnostic trouble code) sets.

- The MIL (malfunction indicator lamp) is located in the IPC (instrument panel cluster) and is the international standards organization (ISO) standard engine symbol.
- The MIL (malfunction indicator lamp) is illuminated with the ignition ON, engine OFF, until the engine is cranked for starting. The MIL (malfunction indicator lamp) will turn OFF after engine start if no concerns are present.
- The MIL (malfunction indicator lamp) may flash after 17 seconds with the ignition ON, engine OFF, unless the OBD (on-board diagnostic) inspection/maintenance (I/M) readiness indicators indicate all of the OBD (on-board diagnostic) monitors have completed since the last KAM (keep alive memory) reset or since the PCM (powertrain control module) DTCs have been cleared with a reset command from the scan tool.
- The MIL (malfunction indicator lamp) will remain illuminated after engine start if a confirmed emission related concern or an OBD (on-board diagnostic) DTC (diagnostic trouble code) exists.
- If the MIL (malfunction indicator lamp) flashes at a steady rate, after engine start, a severe misfire condition may exist.
- The MIL (malfunction indicator lamp) will remain OFF with the ignition ON, engine OFF, if a MIL (malfunction indicator lamp) indicator or IPC (instrument panel cluster) concern is present.
- To turn OFF the MIL (malfunction indicator lamp) after a repair, a reset command from the scan tool must be sent, or 3 consecutive drive cycles must be completed without a concern.
- If the MIL (malfunction indicator lamp) flashes erratically, a low battery voltage concern may be present causing the PCM (powertrain control module) to reset during cranking.

On Board Diagnostic (OBD) Drive Cycle

Description of On Board Diagnostic (OBD) Drive Cycle

The following procedure is designed to execute and complete the OBD (on-board diagnostic) monitors. To complete a specific monitor for repair verification, follow steps 1 through 4, then continue with the step described by the appropriate monitor found under the OBD (on-board diagnostic) Monitor Exercised column.

Federal OBD (on-board diagnostic) requires that all vehicles comply with 0.5 mm (0.020 inch) EVAP (evaporative emission) system requirements in addition to meeting the 1.0 mm (0.040 inch) EVAP (evaporative emission) system monitoring requirements. Some vehicles will use the engine off 0.5 mm (0.020 inch) EVAP (evaporative emission) monitor rather than the 1.0 mm (0.040 inch) EVAP (evaporative emission) monitor to set I/M Readiness.

Drive Cycle Preparation	**NOTE** To bypass the EVAP (evaporative emission) soak timer (normally 6 hours), the PCM (powertrain control module) must remain powered after clearing the continuous DTC (diagnostic trouble code) s and resetting the emission monitors information in the PCM (powertrain control module) . 1. Install the scan tool. Turn the ignition ON with the engine OFF. Cycle the ignition OFF, then ON. If needed, select the appropriate vehicle and engine qualifier. Clear the continuous DTC (diagnostic trouble code) s and reset the emission monitors information in the PCM (powertrain control module) .	Bypasses the engine soak timer. Resets the OBD (on-board diagnostic) monitor status.
	2. Begin to monitor the following PID (parameter identification) s (if available): AAT, ECT, EVAPDC, FLI, IAT and TP MODE. Start the vehicle without returning the ignition to the OFF position.	
	3. Idle the vehicle for 15 seconds. Drive at 77 to 104 km/h (48 to 65 mph) until the engine coolant temperature is at least 76.7°C (170°F).	
Prep for Monitor Entry	4. Is the ambient air temperature between 4.4 and 37.8°C (40 and 100°F)? If AAT is not available, IAT is used. If not, complete the following steps, but note that step 16 is required to bypass the EVAP (evaporative emission) monitor and complete the OBD (on-board diagnostic) drive cycle.	Engine warm-up and provides ambient air temperature input to the PCM (powertrain control module) . If AAT is not available, IAT is used.
HO2S (heated oxygen sensor)	5. Cruise at 77 to 104 km/h (48 to 65 mph) for greater than 5 minutes.	Executes the HO2S (heated oxygen sensor) monitor.
EVAP (evaporative emission)	6. Cruise at 77 to 104 km/h (48 to 65 mph) for 10 minutes (avoid sharp turns and hills). NOTE: To initiate the monitor, the throttle should be at part throttle, EVAPDC must be greater than 75%, and FLI must be	Executes the EVAP (evaporative emission) purge flow monitor if the ambient air temperature

	except the EVAP (evaporative emission) monitor have completed. If not, go to step 15.	
EVAP (evaporative emission)	13. Turn the ignition OFF for 1 hour to allow the engine off 0.508 mm (0.020 inch) leak check to run.	Executes the 0.508 mm (0.020 inch) EVAP (evaporative emission) monitor.
Readiness Check	14. Turn the ignition ON. Access the On-Board System Readiness (OBD (on-board diagnostic) II monitor status) function on the scan tool. Determine whether all non-continuous monitors including the EVAP (evaporative emission) monitor have completed. If not, go to step 15.	Determine if any monitor has not completed.
Pending Code Check And EVAP (evaporative emission) Monitor Bypass Check	15. With the scan tool, check for pending codes. Conduct the normal repair procedures for any pending code concern. Otherwise, repeat any incomplete monitor. If the EVAP (evaporative emission) monitor is not complete and the ambient air temperature was out of the 4.4 to 37.8°C (40 to 100°F) temperature range in step 4, or the altitude is over 2438 m (8000 ft.), the EVAP (evaporative emission) bypass procedure must be followed. Go to Step 16.	Determines if a pending code is preventing the completion of the OBD (on-board diagnostic) drive cycle.
EVAP (evaporative emission) Monitor Bypass	16. Park the vehicle for a minimum of 8 hours. Repeat steps 2 through 14. Do not repeat step 1.	Allows the bypass counter to increment to 2.

On Board Diagnostics (OBD) Monitors

The California Air Resources Board (CARB) began regulating OBD (on-board diagnostic) systems for vehicles sold in California beginning with the 1988 model year. The initial requirements, known as OBD (on-board diagnostic) I, required identifying the likely area of concern with regard to the fuel metering system, EGR (exhaust gas recirculation) system, emission related components and the PCM (powertrain control module) . A MIL (malfunction indicator lamp) was required to illuminate and alert the driver of the concern and the need to repair the emission control system. A DTC (diagnostic trouble code) was required to assist in identifying the system or component associated with the concern.

Starting with the 1994 model year, both CARB and the Environmental Protection Agency (EPA) mandated enhanced OBD (on-board diagnostic) systems, commonly known as OBD (on-board diagnostic) II. The carry out an OBD (on-board diagnostic) check in order to renew a vehicle registration. The I/M readiness indicators must show that all monitors have been completed prior to the OBD (on-board diagnostic) check.

Starting in the 1996 model year, OBD (on-board diagnostic) II was required on all California and California State gasoline engine vehicles up to 14,000 lbs. GVWR. Starting in the 1997 model year, diesel engine vehicles up to 14,000 lbs. GVWR required OBD II.

California states are ones that have adopted California emission regulations, starting in the 1998 model year. For example, Delaware, Connecticut, Maine, Massachusetts, New Mexico, New Jersey, New York, Oregon, Pennsylvania, Rhode Island, Vermont and Washington have adopted California's emission regulations. These states receive California certified vehicles for passenger cars, light trucks, and medium duty vehicles up to 14,000 lbs GVWR.

Starting in the 1996 model year, OBD (on-board diagnostic) II was also required on all Federal gasoline engine vehicles up to 8,500 lbs. GVWR. Starting in the 1997 model year, diesel engine vehicles up to 8,500 lbs. GVWR required OBD (on-board diagnostic) II.

Starting in the 2004 model year, Federal vehicles over 8,500 lbs. are required to phase in OBD (on-board diagnostic) II. Starting in the 2004 model year, gasoline fueled medium duty passenger vehicles (MDPVs) are required to have OBD (on-board diagnostic) II. By the 2006 model year, all Federal vehicles from 8,500 to 14,000 lbs. GVWR will have been phased into OBD (on-board diagnostic) II.

Permanent Diagnostic Trouble Code (DTC)

The software stores a permanent DTC (diagnostic trouble code) in non volatile random access memory (NVRAM) whenever a DTC (diagnostic trouble code) is set and the MIL (malfunction indicator lamp) has been illuminated. Permanent DTCs can only be cleared by the module strategy itself. After a permanent DTC (diagnostic trouble code) is stored, 3 consecutive test passed monitoring cycles must complete before the permanent DTC (diagnostic trouble code) can be erased. At that time, both the permanent DTC (diagnostic trouble code) is erased and the MIL (malfunction indicator lamp) is extinguished. The PCM (powertrain control module) clears permanent DTCs after one monitoring cycle if a request to clear DTCs is sent by the scan tool, and the test subsequently runs and passes (test must continue to pass for the entire driving cycle for continuous monitors) and a Permanent DTC (diagnostic trouble code) Driving Cycle has been completed. A Permanent DTC (diagnostic trouble code) Driving Cycle requires a total of 10 minutes of engine run time, consisting of 5 minutes of vehicle operation above 40 km/h (25 MPH) and 30 continuous seconds of vehicle operation at idle. After clearing DTCs, running the OBD (on-board diagnostic) Drive Cycle ensures that all monitors complete, the Permanent DTC (diagnostic trouble code) Driving Cycle completes, inspection/maintenance (I/M) readiness codes are set to a ready status and any permanent DTCs are erased. A permanent DTC (diagnostic trouble code) cannot be erased by clearing the KAM (keep alive memory) . The intended use of the permanent DTC (diagnostic trouble code) is to prevent vehicles from passing an in use inspection simply by disconnecting the battery or clearing the DTCs with a scan tool prior to the inspection. The presence of permanent DTCs at an inspection without the MIL (malfunction indicator lamp) illuminated is an indication that a correct repair was not verified by the on board monitoring system.

Vehicle Reference Voltage (VREF)

There are 2 different types of reference voltages supplied by the PCM (powertrain control module) for use with engine related sensors. One source would be Voltage Reference (VREF) which is a 5-volt source. Another is Vehicle Buffered Power (VBPWR) which is a regulated 12-volt source. These sources are supplied to the sensor to provide more stable and accurate input to the PCM since the voltage is consistent. The PCM (powertrain control module) can have up to 3 internal sources of VREF and one source of VBPWR (if equipped). Each of these sources can be connected to multiple external circuits, with separate PCM (powertrain control module) terminals for each circuit. These circuits can then be connected to one or more sensors as needed.

Due to variations that occur over the different vehicle lines and engines used in each line, there are a variety of different sensor layouts used. Reference voltages are supplied to the sensors that require it for proper operation. In some cases, reference voltage faults can be indicated by multiple sensor faults relating to circuit high, circuit low, or sensor performance despite no external shared connections due to these internal BUS connections that are shared between the affected sensors.

Although a steady 5 volts to VREF sensors is desired, this voltage can vary between 4.5 – 5.5 volts. The VREF PID (parameter identification) within the PCM (powertrain control module) does not display the actual output voltage the PCM (powertrain control module) is supplying to these sensors. This PID (parameter identification) only reflects an internal module VREF that is unrelated to the VREF output BUS's.

Variable Camshaft Timing (VCT) Monitor

The VCT (variable camshaft timing) output driver in the PCM (powertrain control module) is checked electrically for opens or shorts. The VCT (variable camshaft timing) system is checked functionally by monitoring the closed loop camshaft position error correction. If the correct camshaft position cannot be maintained and the system has an advance or retard error greater than the calibrated threshold, a VCT (variable camshaft timing) control concern is indicated.

Variable Camshaft Timing (VCT) System

The VCT (variable camshaft timing) system enables rotation of the camshaft relative to the crankshaft rotation as a function of engine operating conditions.

The VCT (variable camshaft timing) system has 4 operational modes: idle, part throttle, wide open throttle (WOT), and default mode. At idle and low engine speeds with closed throttle, the PCM (powertrain control module) determines the phase angle based on airflow, engine oil temperature and engine coolant temperature. At part and wide open throttle the PCM (powertrain control module) determines the phase angle based on engine RPM (revolutions per minute) , load, and throttle position. The VCT (variable camshaft timing) system provides reduced emissions and enhanced engine power, fuel economy and idle quality. In addition, some VCT (variable camshaft timing) system applications can eliminate the need for an external EGR (exhaust gas recirculation) system. The elimination of the EGR (exhaust gas recirculation) system is accomplished by controlling the overlap time between the intake valve opening and exhaust valve closing.