EFI SYSTEM-ELECTRONIC THROTTLE BODY (ETB) ECH

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Do not fill fuel tank while engine is hot or running.

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.

Typical electronic fuel injection (EFI) system and related components include:

- Fuel pump module and lift pump.
- Fuel filter.
- High pressure fuel line.
- Fuel line(s).
- Fuel injectors.
- Electronic throttle body (ETB)/intake manifold.
- Electronic control unit (ECU).
- Ignition coils.
- Engine temperature sensor.
- Throttle position sensor (TPS) is contactless and not serviceable.
- Crankshaft position sensor.
- Oxygen sensor.
- Temperature/manifold absolute pressure (TMAP) sensor.
- Malfunction indicator light (MIL)-optional.
- 30 Amp fuse (charging system).
- Kohler 60 Amp fuse (high output charging system).
- 10 Amp fuse (ignition switch).
- 10 Amp fuse (battery power).
- Wire harness assembly & affiliated wiring.

FUEL RECOMMENDATIONS

Refer to Maintenance.

FUEL LINE

Low permeation fuel line must be installed on all Kohler Co. engines to maintain EPA and CARB regulatory compliance.

OPERATION

NOTE: When performing voltage or continuity tests, avoid putting excessive pressure on or against connector pins. Flat pin probes are recommended for testing to avoid spreading or bending terminals.

EFI system is designed to provide peak engine performance with optimum fuel efficiency and lowest possible emissions. Ignition and injection functions are electronically controlled, monitored and continually corrected during operation to maintain ideal air/fuel ratio.

Central component of system is Electronic Control Unit (ECU) which manages system operation, determining best combination of fuel mixture, ignition timing, throttle opening and/or engine RPM for current operating conditions.

ETB engines feature an ECU that uses CAN BUS/ J1939 communication protocols and may be linked to other electronic control modules installed on application. Please refer to equipment manufacturer's manual to determine if equipped and operational detail. Native fault codes are in line with J1939 protocol. We continue to reference P Codes for consistency.

A lift fuel pump is used to move fuel from tank through an in-line fuel filter and fuel line. Fuel is then pumped to fuel pump module. Fuel pump module regulates fuel pressure to a system operating pressure of 39 psi. Fuel is delivered from fuel pump module through high pressure fuel line into injectors, which inject fuel into intake ports. ECU controls amount of fuel by varying length of time that injectors are on. This can range from 2 to over 12 milliseconds depending on fuel requirements. Controlled injection of fuel occurs every other crankshaft revolution, or once for each 4-stroke cycle. When intake valve opens, air/fuel mixture is drawn into combustion chamber, compressed, ignited, and burned.

ECU controls amount of fuel being injected and ignition timing by monitoring primary sensor signals for engine temperature, operator requested engine speed (RPM), and throttle position (load). These primary signals are compared to preprogrammed maps in ECU computer chip, and ECU adjusts fuel delivery to match mapped values. After engine reaches operating temperature, an exhaust gas oxygen sensor provides feedback to ECU based upon amount of unused oxygen in exhaust, indicating whether fuel mixture being delivered is rich or lean. Based upon this feedback, ECU further adjusts fuel input to re-establish ideal air/fuel ratio. This operating mode is referred to as closed loop operation. EFI system operates closed loop when all three of following conditions are met:

- Engine temperature is greater than 50-60°C (122-140°F).
- Oxygen sensor has warmed sufficiently to provide a signal (minimum 400°C, 752°F).
- Engine operation is at a steady state (not starting, warming up, accelerating, etc.).

During closed loop operation ECU has ability to readjust and learn adaptive controls, providing compensation for changes in overall engine condition and operating environment, so it will be able to maintain ideal air/ fuel ratio. This system requires a minimum engine temperature greater than 50-60°C (122-140°F) to properly adapt. These adaptive values are maintained as long as ECU is not reset.

During certain operating periods such as cold starts, warm up, acceleration, high load, etc., a richer air/fuel ratio is required and system operates in an open loop mode. In open loop operation oxygen sensor output is used to ensure engine is running rich, and controlling adjustments are based on primary sensor signals and programmed maps only. This system operates open loop whenever three conditions for closed loop operation (above) are not being met.

ECU is brain or central processing computer of entire EFI and ETB/electronic governor system. During operation, sensors continuously gather data which is relayed through wiring harness to input circuits within ECU. Signals to ECU include: ignition (on/off), crankshaft position and speed (RPM), throttle position, requested customer speed input, oil temperature, intake air temperature, exhaust oxygen levels, manifold absolute pressure, and battery voltage.

ECU compares input signals to programmed maps in its memory to determine appropriate fuel and spark requirements for immediate operating conditions. ECU then sends output signals to set injector duration, ignition timing, and ETB throttle opening.

ECU continually performs a diagnostic check of itself, each sensor, and system performance. If a fault is detected, ECU can turn on a Malfunction Indicator Light (MIL) (if equipped) on equipment control panel, store fault code in its fault memory, and go into a default operating mode. Depending on significance or severity of fault, normal operation may continue. A technician can access stored fault code using a blink code diagnosis flashed out through MIL or use KOHLER® Diagnostic System (KDS) Gen 2, see Tools and Aids.

ECU requires a minimum of 6.0 volts to operate.

To prevent engine over-speed and possible failure, a rev-limiting feature is programmed into ECU. If maximum RPM limit (4500) is exceeded, ECU suppresses injection signals, cutting off fuel flow. This process repeats itself in rapid succession, limiting operation to preset maximum.

Wiring harness used in EFI system connects electrical components, providing current and ground paths for system to operate. All input and output signaling occurs through two special all weather connectors that attach and lock to ECU. Connectors are Black and Grey and keyed differently to prevent being attached to ECU incorrectly.

Condition of wiring, connectors, and terminal connections is essential to system function and performance. Corrosion, moisture, and poor connections are as likely cause of operating problems and system errors as an actual component. Refer to Electrical System for additional information.

EFI system is a 12 VDC negative ground system, designed to operate down to a minimum of 6.0 volts. If system voltage drops below this level, operation of voltage sensitive components such as ECU, fuel pump, ignition coils, and injectors will be intermittent or disrupted, causing erratic operation or hard starting. A fully charged, 12 volt battery with a minimum of 350 cold cranking amps is important in maintaining steady and reliable system operation. Battery condition and state of charge should always be checked first when troubleshooting an operational problem.

Keep in mind that EFI-related problems are often caused by wiring harness or connections. Even small amounts of corrosion or oxidation on terminals can interfere with milliamp currents used in system operation.

Cleaning connectors and grounds will solve problems in many cases. In an emergency situation, simply disconnecting and reconnecting connectors may clean up contacts enough to restore operation, at least temporarily.

If a fault code indicates a problem with an electrical component, disconnect ECU connector and test for continuity between component connector terminals and corresponding terminals in ECU connector using an ohmmeter. Little or no resistance should be measured, indicating that wiring of that particular circuit is OK.

Crankshaft position sensor is essential to engine operation; constantly monitoring rotation and speed (RPM) of crankshaft. There are 23 consecutive teeth cast into flywheel. One tooth is missing and is used to reference crankshaft position for ECU.

During rotation, an AC voltage pulse is created within sensor for each passing tooth. ECU calculates engine speed from time interval between consecutive pulses. Gap from missing tooth creates an interrupted input signal, corresponding to specific crankshaft position near BDC for cylinder #1. This signal serves as a reference for control of ignition timing by ECU. Synchronization of inductive speed pickup and crankshaft position takes place during first two revolutions each time engine is started. Sensor must be properly connected at all times. If sensor becomes disconnected for any reason, engine will quit running.

Throttle position sensor (TPS) is used to indicate throttle plate angle to ECU. Since throttle (by way of governor or customer speed input/ETB throttle opening) reacts to engine load, angle of throttle plate is directly related to load on engine.

TPS is sealed and not serviced separately. Mounted on electronic throttle body and operated directly off end of throttle shaft, TPS works as a potentiometer, varying voltage signal to ECU in direct correlation to angle of throttle plate. This signal, along with other sensor signals, is processed by ECU and compared to internal preprogrammed maps to determine required fuel and ignition settings for amount of load.

TPS auto-learn is an automated process. No adjustment is required.

Engine temperature sensor is used by system to help determine fuel requirements for starting (a cold engine needs more fuel than one at or near operating temperature).

Mounted in breather cover, it has a temperature-sensitive resistor that extends into oil flow. Resistance changes with oil temperature, altering voltage sent to ECU. Using a table stored in its memory, ECU correlates voltage drop to a specific temperature. Using fuel delivery maps, ECU then knows how much fuel is required for starting at that temperature.

Temperature/Manifold Absolute Pressure (TMAP) sensor is an integrated sensor that checks both intake air temperature and manifold absolute pressure.

Intake Air Temperature control is a thermally sensitive resistor that exhibits a change in electrical resistance with a change in its temperature. When sensor is cold, resistance of sensor is high. As sensor warms up, resistance drops and voltage signal increases. From voltage signal, ECU can determine temperature of intake air.

Purpose of sensing air temperature is to help ECU calculate air density. Higher air temperature less dense air becomes. As air becomes less dense ECU knows that it needs to lessen fuel flow to achieve correct air/fuel ratio. If fuel ratio was not changed engine would become rich, possibly losing power and consuming more fuel.

Manifold Absolute Pressure check provides immediate manifold pressure information to ECU. TMAP sensor measures difference in pressure between outside atmosphere and vacuum level inside intake manifold and monitors pressure in manifold as primary means of detecting load. Data is used to calculate air density and determine engine's mass air flow rate, which in turn determines required ideal fueling. MAP also stores instant barometric pressure reading when key is turned ON.

Oxygen sensor functions like a small battery, generating a voltage signal to ECU based upon difference in oxygen content between exhaust gas and ambient air.

Tip of sensor protruds into exhaust gas. When oxygen concentration on one side of tip is different than that of other side, a voltage signal up to 0.98 volt is generated and sent to ECU. Voltage signal tells ECU if engine is straying from ideal fuel mixture, and ECU then adjusts injector pulse accordingly.

Oxygen sensor functions after being heated to a minimum of 400°C (752°F). A heater inside sensor heats electrode to optimum temperature in about 10 seconds. Oxygen sensor receives ground through wire, eliminating need for proper grounding through muffler. If problems indicate a bad oxygen sensor, check all connections and wire harness. Oxygen sensor can also be contaminated by leaded fuel, certain RTV and/or other silicone compounds, fuel injector cleaners, etc. Use only those products indicated as O2 Sensor Safe.

Fuel injectors mount into intake manifold, and high pressure fuel line attaches to them at top end. Replaceable O-rings on both ends of injector prevent external fuel leakage and also insulate it from heat and vibration. A special clip connects each injector to high pressure fuel line and holds it in place. O-rings and retaining clip must be replaced any time fuel injector is separated from its normal mounting position.

When key switch is on, fuel pump module will pressurize high pressure fuel line to 39 psi, and voltage is present at injector. At proper instant, ECU completes ground circuit, energizing injector. Valve needle in injector is opened electromagnetically, and pressure in high pressure fuel line forces fuel down through inside. Director plate at tip of injector contains a series of calibrated openings which directs fuel into manifold in a cone-shaped spray pattern.

Injectors have sequential fueling that open and close once every other crankshaft revolution. Amount of fuel injected is controlled by ECU and determined by length of time valve needle is held open, also referred to as injection duration or pulse width. Time injector is open (milliseconds) may vary in duration depending on speed and load requirements of engine.

A high-voltage, solid-state, battery ignition system is used with EFI system. ECU controls ignition output and timing through transistorized control of primary current delivered to coils. Based on input from crankshaft position sensor, ECU determines correct firing point for speed at which engine is running. At proper instant, it interrupts flow of primary current in coil, causing electromagnetic flux field to collapse. Flux collapse induces an instantaneous high voltage in coil secondary which is strong enough to bridge gap on spark plug. Each coil fires every other revolution (during normal running).

ETB EFI engines are equipped with either a 20 amp or high output charging system to accommodate combined electrical demands of ignition system and specific application. Charging system troubleshooting information is provided in Electrical System.

An electric fuel pump module and a lift pump are used to transfer fuel in EFI system. Types of lift pumps are: a pulse fuel pump, a mechanical fuel pump, or a low pressure electric fuel pump. Pumping action is created by either oscillation of positive and negative pressures within crankcase through a hose, or by direct lever/pump actuation off rocker arm movement. Pumping action causes diaphragm on inside of pump to pull fuel in on its downward stroke and to push it into fuel pump module on its upward stroke. Internal check valves prevent fuel from going backward through pump. Fuel pump module receives fuel from lift pump, increases and regulates pressure for fuel injectors.

Fuel pump module is rated for a minimum output of 13.5 liters (3.51 gallons) per hour and regulated at 270 kilopascals (39 psi).

When key switch is turned ON and all safety switch requirements are met, ECU activates fuel pump module for about six seconds, which pressurizes system for start-up. If key switch is not promptly turned to start position, engine fails to start, or engine is stopped with key switch ON (as in case of an accident), ECU switches off pump preventing continued delivery of fuel. In this situation, MIL will go on, but it will go back off after 4 cranking revolutions if system function is OK. Once engine is running, fuel pump remains on.

Precision components inside fuel pump module are not serviceable. DO NOT attempt to open fuel pump module. Damage to components will result and warranty will be void. Because fuel pump module is not serviceable, engines are equipped with a special 10-micron EFI fuel filter to prevent harmful contamination from entering module.

If there are two filters in system, one before lift pump will be a standard 51-75 micron filter, and one after lift pump will be special 10-micron filter. Be sure to use an approved 10-micron filter for replacement.

High pressure fuel line is an assembly of hoses, injector caps and a fuel connector to fuel pump module. High pressure fuel line feeds fuel to top of injectors through injector caps. Caps are fastened to intake manifold and injectors are locked into place. A small retaining clip provides a secondary lock.

High pressure fuel line is serviced as a complete assembly to prevent tampering and safety hazards. Components are not individually serviceable.

Vent hose assembly is intended to vent fuel vapor out of fuel pump module and direct fuel vapor into electronic throttle body. Most EFI engines are equipped with an engine mounted purge port on #2 cylinder barrel baffle. This capped purge port can be used by OEM to vent fuel tanks or used in conjunction with a carbon canister kit for evaporative emissions compliance. Purge port connects to vent hose assembly and directs all fuel vapor into electronic throttle body. If purge port remains unused, port must remain capped to prevent dirt from entering engine.

EFI engines have no carburetor, so throttle function (regulate incoming combustion airflow) is achieved with a throttle valve in a separate electronic throttle body (ETB) attached to intake manifold. ETB is an assembly of three functional components: 1) A mechanical throttle body to control air flow to engine. 2) A DC electric motor and gear reduction to drive and position throttle blade. 3) A non-contact throttle position sensor to measure throttle position. This technology is common on many modern automobiles, including a return spring feature. Return spring will mechanically return throttle blade to a home position if power is lost or interrupted to drive motor. Home position is above normal low idle position, but typically is low RPM and very low load.

ETB (Electronic throttle body)/intake manifold provides mounting for fuel injectors, throttle position sensor, TMAP sensor, high pressure fuel line, and air cleaner assembly.

ETB Engine idle speed is not adjustable and is preset and controlled by ECU. Standard idle speed setting for EFI engines is 1500 RPM, but certain applications might require a different setting.

For starting and warm up, ECU will adjust fuel and ignition timing, based upon ambient temperature, engine temperature, and loads present. In cold conditions, idle speed will be different than normal for a few moments. Idle speed typically starts higher than normal, but gradually decreases to established setting as operation continues. Engine must be completely warmed up, in closed loop operating mode for accurate idle check.

IMPORTANT NOTES!

- Cleanliness is essential and must be maintained at all times when servicing or working on EFI system. Dirt, even in small quantities, can cause significant problems.
- Clean any joint or fitting with parts cleaning solvent before opening to prevent dirt from entering system.
- Always depressurize fuel system through fuel connector on fuel pump module before disconnecting or servicing any fuel system components.
- Never attempt to service any fuel system component while engine is running or ignition switch is ON.
- Do not use compressed air if system is open. Cover any parts removed and wrap any open joints with plastic if they will remain open for any length of time. New parts should be removed from their protective packaging just prior to installation.
- Avoid direct water or spray contact with system components.
- Do not disconnect or reconnect ECU wiring harness connector or any individual components with ignition on. This can send a damaging voltage spike through ECU.
- Do not allow battery cables to touch opposing terminals. When connecting battery cables attach positive (+) cable to positive (+) battery terminal first, followed by negative (-) cable to negative (-) battery terminal.
- Never start engine when cables are loose or poorly connected to battery terminals.
- Never disconnect battery while engine is running.
- Never use a quick battery charger to start engine.
- Do not charge battery with key switch ON.
- Always disconnect negative (-) battery cable before charging battery, and also unplug harness from ECU before performing any welding on equipment.

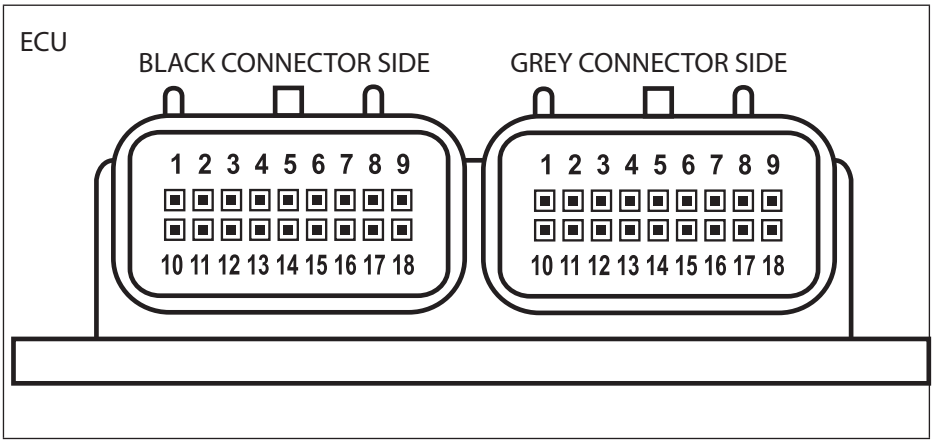
ELECTRICAL COMPONENTS

Electronic Control Unit (ECU)

Pinout of ECU

Black Connector Side	
Pin #	**Description**
1	Ignition Coil #1 Ground
2	Battery Ground
3	Not Used
4	Crankshaft Position Sensor Input High
5	Fuel Injector Output #1 Ground
6	Fuel Injector Output #2 Ground
7	Oxygen Sensor Heater
8	Intake Air Temperature (TMAP) Sensor Input
9	Fuel Pump Ground
10	Ground for TPS, TMAP, O2, and Temp sensors
11	Manifold Absolute Pressure (TMAP) sensor input
12	Throttle Position Sensor (TPS) input
13	Crankshaft Position Sensor Low
14	Engine Temperature Sensor input
15	Ignition Switch (Switched +12V)
16	Power for TPS and TMAP sensor (+5V)
17	Oxygen Sensor (O2) input
18	Battery Power (Permanent +12V)

Grey Connector Side	
Pin #	**Description**
1	Not Used
2	Not Used
3	Malfunction Indicator Light (MIL) Ground
4	Not Used
5	Not Used
6	Not Used
7	CAN Low
8	CAN High
9	Battery Ground
10	Ignition Coil #2 Ground
11	ETB Motor High
12	ETB Motor Low
13	Desired Engine Speed Input (0-5V)
14	Safety Switch Ground
15	Not Used
16	ECU Reset
17	Fuel Pump Control (+12V)
18	Not Used



Pinout of ECU

Never attempt to disassemble ECU. It is sealed to prevent damage to internal components. Warranty is void if case is opened or tampered with in any way.

All operating and control functions within ECU are preset. No internal servicing or readjustment may be performed. If a problem is encountered, and you determine ECU to be faulty, contact your source of supply.

ECU pins are coated at factory with a thin layer of electrical grease to prevent fretting and corrosion. Do not attempt to remove grease from ECU pins.

Relationship between ECU and throttle position sensor (TPS) is very critical to proper system operation. TPS to throttle shaft positioning is an automated process performed at key cycle and cannot be altered.

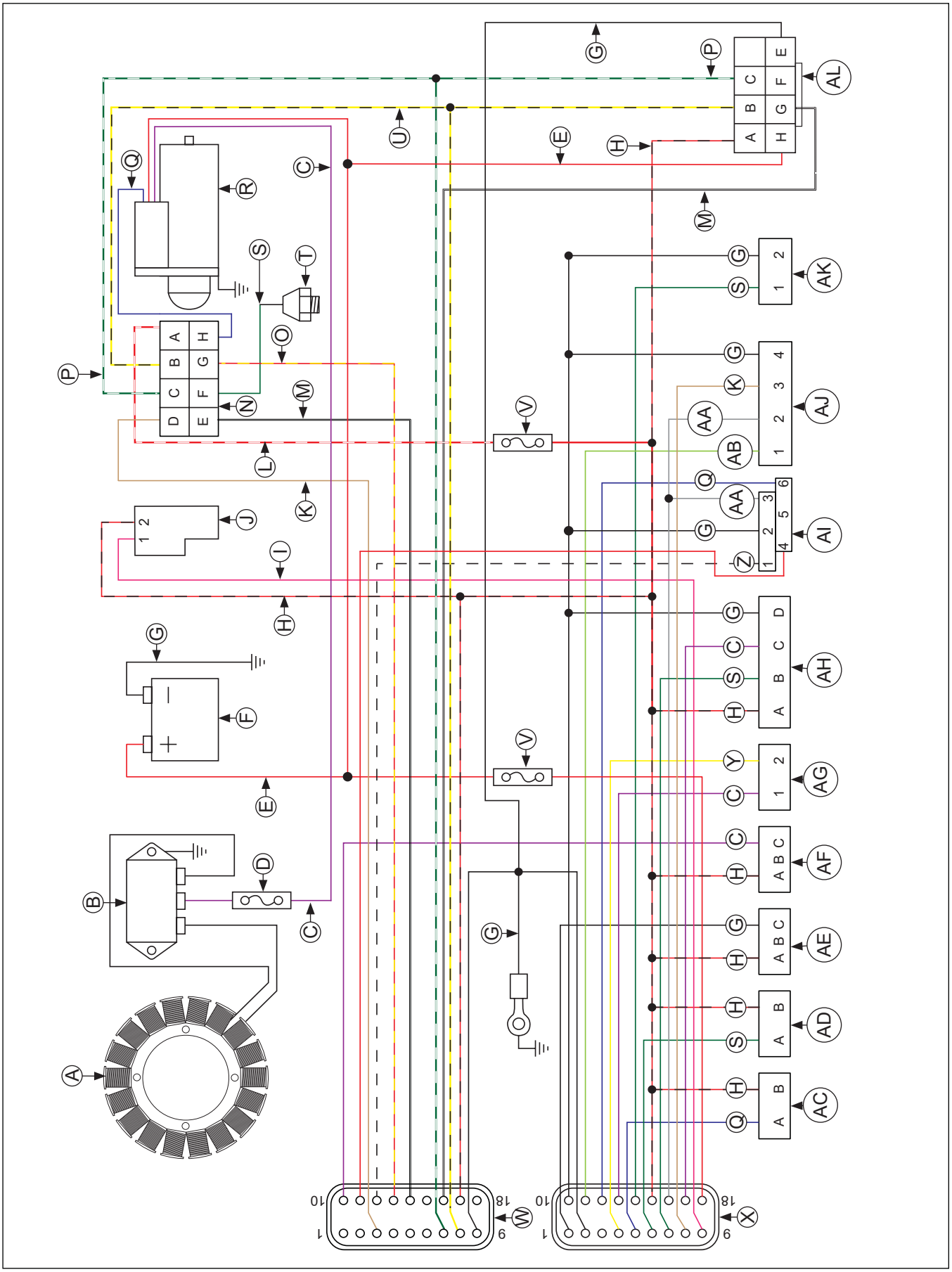
Any service to ECU, TPS/Electronic Throttle Body, or fuel pump module replacement should include ECU Reset.

This will clear all trouble codes, all closed loop learned offsets, all max values, and all timers besides permanent hour meter.

This system will NOT reset when battery is disconnected!

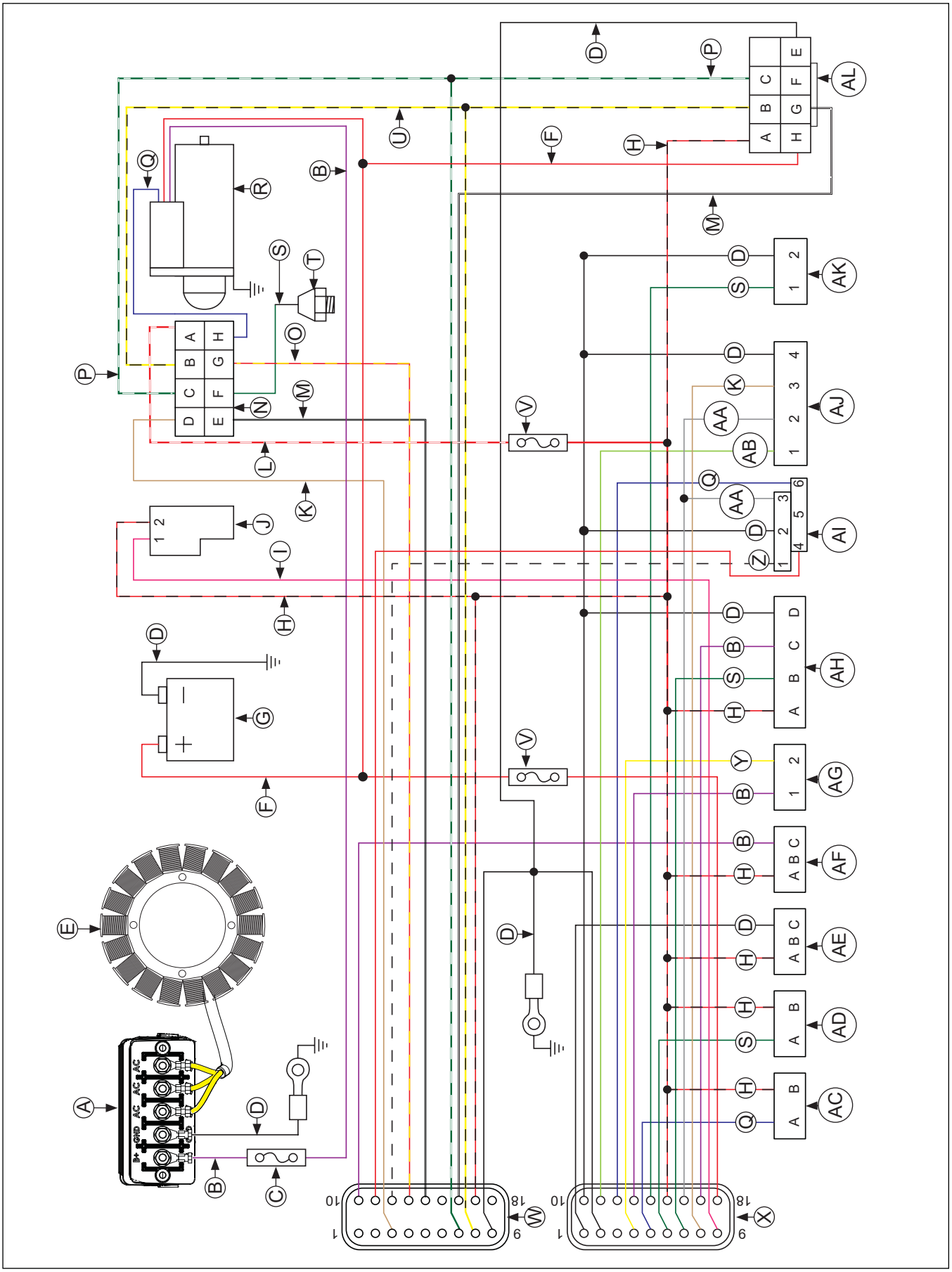
ECU Reset Procedure

1. Turn key/ignition OFF.
2. Install Green colored wire jumper from Kohler EFI service kit on to diagnostic port (or connect white wire to black wire (terminals G and E) in diagnostic port).
3. Turn key/ignition ON, then OFF and count 10 seconds.
4. Turn key/ignition ON, then OFF and count to 10 seconds a second time.
5. Remove Green colored wire jumper. Turn key/ignition ON, then OFF and count to 10 seconds a third time. ECU is reset.



ETB EFI Wiring Harness 20 Amp

ETB EFI Wiring Harness 20 Amp Detail							
A	Stator	**B**	Rectifier-Regulator	**C**	Purple	**D**	30A Fuse
E	Red	**F**	Battery	**G**	Black	**H**	Red/Black
I	Pink	**J**	Fuel Pump Module	**K**	Tan	**L**	Red/White
M	White	**N**	8-Terminal Connector	**O**	Red/Yellow	**P**	Green/White
Q	Dark Blue	**R**	Starter Motor	**S**	Dark Green	**T**	Oil Pressure Switch
U	Yellow/Black	**V**	10A Fuse	**W**	Grey Connector	**X**	Black Connector
Y	Yellow	**Z**	Black/White	**AA**	Grey	**AB**	Light Green
AC	Fuel Injector #1	**AD**	Fuel Injector #2	**AE**	Ignition Coil #1	**AF**	Ignition Coil #2
AG	Crankshaft Position Sensor	**AH**	Oxygen Sensor	**AI**	Electronic Throttle Control	**AJ**	TMAP Sensor
AK	Engine Temperature Sensor	**AL**	Diagnostic Connector (8 Bay, 7 Pin)				



ETB EFI Wiring Harness High Output Charging System

ETB EFI Wiring Harness High Output Charging System Detail							
A	Rectifier-Regulator	**B**	Purple	**C**	Kohler 60A Fuse*	**D**	Black
E	Stator	**F**	Red	**G**	Battery	**H**	Red/Black
I	Pink	**J**	Fuel Pump Module	**K**	Tan	**L**	Red/White
M	White	**N**	8-Terminal Connector	**O**	Red/Yellow	**P**	Green/White
Q	Dark Blue	**R**	Starter Motor	**S**	Dark Green	**T**	Oil Pressure Switch
U	Yellow/Black	**V**	10A Fuse	**W**	Grey Connector	**X**	Black Connector
Y	Yellow	**Z**	Black/White	**AA**	Grey	**AB**	Light Green
AC	Fuel Injector #1	**AD**	Fuel Injector #2	**AE**	Ignition Coil #1	**AF**	Ignition Coil #2
AG	Crankshaft Position Sensor	**AH**	Oxygen Sensor	**AI**	Electronic Throttle Control	**AJ**	TMAP Sensor
AK	Engine Temperature Sensor	**AL**	Diagnostic Connector (8 Bay, 7 Pin)				

*Main engine harness has 30A fuse, but this fuse is nonfunctional in High Output Charging System, as 30A charging circuit has been disabled.

Crankshaft Position Sensor

A sealed, non-serviceable assembly. If fault code P0337 is present and engine does not start/run, proceed to step 1. If P0337 is present and engine operates, clear codes and retest. If Fault Code diagnosis indicates a problem within this area, test and correct as follows.

1. Inspect wiring and connections for damage or problems.
2. Make sure engine has resistor type spark plugs.
3. Disconnect Black connector from ECU.
4. Connect an ohmmeter between #4 and #13 pin terminals. A resistance value of 325-395 Ω at room temperature (20°C, 68°F) should be obtained.
5. If resistance is correct, remove blower housing.
6. Disconnect crankshaft position sensor connector from wiring harness. Test resistance between terminals. A reading of 325-395 Ω should again be obtained.
   a. If resistance is incorrect, remove screws securing sensor to mounting bracket and replace sensor.
   b. If resistance in step 4 was incorrect, but resistance of sensor alone was correct, test wire harness circuits between sensor connector terminals and corresponding pin terminals (#4 and #13) in main connector. Correct any observed problem, reconnect sensor, and perform step 4 again.
7. If resistance in step 4 is correct, check mounting, flywheel teeth (damage, run-out, etc.), and flywheel key.
8. When fault is corrected and engine starts, clear fault codes following ECU Reset procedure.

Throttle Position Sensor (TPS)

TPS is a sealed, non-serviceable internal part of electronic throttle body assembly. If diagnosis indicates a bad sensor, complete electronic throttle body replacement is necessary. If a blink code indicates a problem with TPS, it can be tested as follows:

Diagnostics of sensor: ECU will still have electrical faults captured in fault codes: P0122 & P0123. These electrical faults still have same meaning as with prior sensor, P0122 detecting low voltage, open circuit, and P0123 for high voltage conditions between ECU, wire harness, and sensor. Tip: when working with any electrical connection, remember to keep connections clean & dry. This is best accomplished by cleaning connection thoroughly prior to disassembly. Contaminated sensor connections can cause premature engine faults. Functionally testing sensor can no longer be done with simple resistance checks. If either of these two faults is present or a TPS fault is suspected, recommended diagnostic test is as follows:

If KOHLER® Diagnostic System (KDS) Gen 2 is available (see Tools and Aids)

Observe throttle percent and raw TPS values through KDS tool. With KDS tool communicating to ECU and key ON engine not running, these values can be observed using Throttle Position test within KDS tool test options. Select Throttle Position Test, select desired percent of throttle opening. (For example, 50% requested opening will yield 50% TPS opening +/- 5%.) It is recommended to perform multiple tests in different throttle opening positions. (For example, 10%, 50%, and 100%.) If any of these tests are found to be outside of specified range, it is recommended to power engine down, wait 15 seconds, turn engine key switch power to ON position, and using KDS tool, repeat Throttle Opening Test. If values again are found to be outside of specified range, it is recommended to replace electronic throttle body assembly. If no results are found while performing this test, a small load or gentle back and forth motion can be applied to connectors or wires just outside connectors to detect a faulty connection.

If only a volt meter is available

Measure voltage supply to sensor from ECU. This voltage should be 5.00 +/- 0.20 volts. This can be measured by gently probing terminals 2 & 3 on harness side with TPS connector removed from TPS and key ON. This will generate a P0122 fault that can be cleared with an ECU reset. If voltage is low, battery, harness and ECU should be investigated. If supply voltage is good, plug sensor back into harness. Probe sensor signal wire with volt meter, terminal 6 at TPS or pin Black 12 at ECU. This signal should be 0.6-1.2 volts at idle. Since there is no longer any wear elements inside sensor, most likely faults will be in electrical connections between sensor and wire harness and wire harness to ECU.

Engine Temperature Sensor

A sealed, non-serviceable assembly. A faulty sensor must be replaced. If a blink code indicates a problem with temperature sensor, it can be tested as follows:

1. Remove temperature sensor from breather cover and cap or block sensor hole.
2. Wipe sensor clean and allow it to reach room temperature (25°C, 77°F).
3. Unplug Black connector from ECU.
4. With sensor still connected, check temperature sensor circuit resistance between Black pin 10 and 14 terminals. Value should be 9000-11000 Ω.
5. Unplug sensor from wire harness and check sensor resistance separately across two pins. Resistance value should again be 9000-11000 Ω.
   a. If resistance is out of specifications, replace temperature sensor.
   b. If it is within specifications, proceed to Step 6.
6. Check circuits (input, ground), from wire harness connector to sensor plug for continuity, damage, etc. Connect one ohmmeter lead to Black pin 14 in wire harness connector (as in step 4). Connect other lead to terminal #1 in sensor plug. Continuity should be indicated. Repeat test between Black pin 10 and terminal #2 in sensor plug.

Temperature/Manifold Absolute Pressure (TMAP) Sensor

A sealed non-serviceable integrated sensor that checks both intake air temperature and manifold absolute pressure. Complete replacement is required if it is faulty. Sensor and wiring harness can be checked as follows.

If a blink code indicates a problem with Intake Air Temperature (TMAP) Sensor Circuit (P0112 or P0113), it can be tested as follows:

1. Remove TMAP sensor from intake manifold.
2. Allow it to reach room temperature (20°C, 68°F).
3. Unplug Black connector from ECU.
4. With sensor still connected, check temperature sensor circuit resistance between Black pin 10 and 8 pin terminals. Value should be 1850-2450 Ω.
5. Unplug sensor from wire harness and check sensor resistance separately across pin. Resistance value should again be 1850-2450 Ω.
   a. If resistance is out of specifications, check local temperature. Sensor resistance will go down as temperature is higher. Replace TMAP sensor if determined to be faulty.
   b. If it is within specifications, proceed to Step 6.
6. Check circuits (input, ground), from main harness connector to sensor plug for continuity, damage, etc. Connect one ohmmeter lead to Black pin 8 in main harness connector (as in step 4). Connect other lead to terminal #3 in sensor plug. Continuity should be indicated. Repeat test between Black pin 10 and terminal #4 in sensor plug.
7. Reinstall sensor.

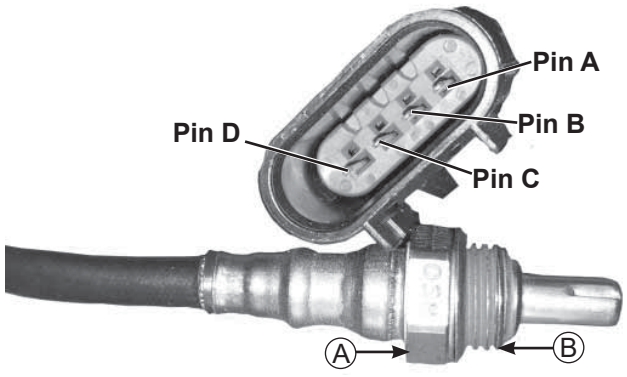
If a blink code indicates a problem with Manifold Absolute Pressure (TMAP) Sensor Circuit (P0107 or P0108), it can be tested as follows:

1. Make sure all connections are making proper contact and are free of dirt and debris. Slide locking tab out and pull off TMAP connector. Turn key switch to ON and check with a volt meter by contacting red lead to pin 1 and black lead to pin 2. There should be 5 volts present, indicating ECU and wiring harness are functioning.
2. Check continuity in wire harness. Ohms between Pin 3 at sensor connector and Black pin 11 connector at ECU should be near zero ohms. If no continuity is measured or very high resistance, replace wire harness.
3. Check to make sure intake manifold is not loose and TMAP sensor is not loose. Loose parts would allow a vacuum leak, making TMAP sensor report misleading information to ECU.
   a. Tighten all hardware and perform an ECU Reset Procedure to see if MIL will display a fault with sensor again. If MIL finds a fault with TMAP sensor, replace it.

Oxygen Sensor (O2)

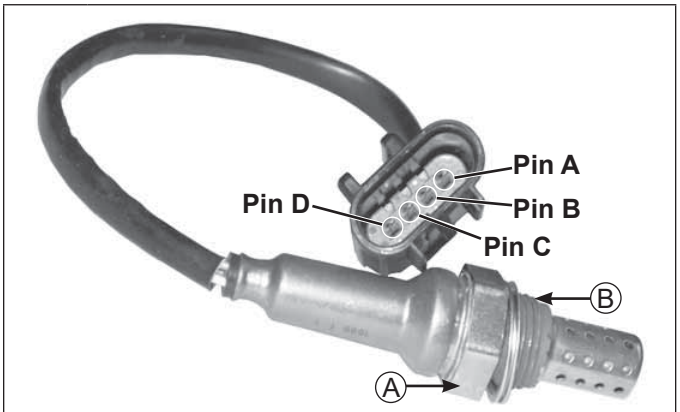
Identify style of sensor to ensure proper testing and installation torque.

Style 1 (Smaller Sensor)



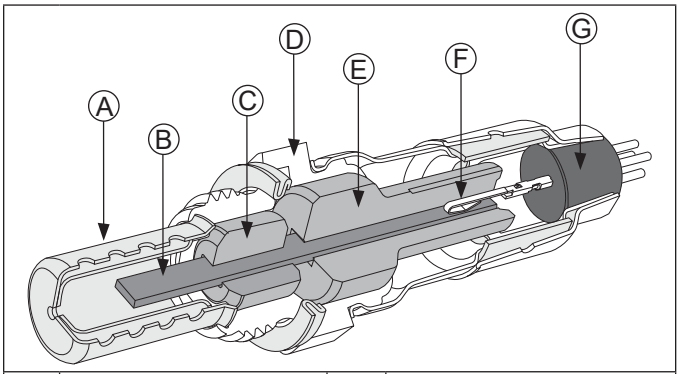
Pin A	Heater +	**Pin B**	Heater -
Pin C	Sensor Output	**Pin D**	Sensor Ground
A	14 mm or 9/16 in. Wrench Size	**B**	12 mm x 1.25 Thread Size
Installation Torque 18 N·m (159 in. lb.)			

Style 2 (Larger Sensor)



Pin A	Heater +	**Pin B**	Heater -
Pin C	Sensor Output	**Pin D**	Sensor Ground
A	22 mm or 7/8 in. Wrench Size	**B**	18 mm x 1.5 Thread Size
Installation Torque 50.1 N·m (37 ft. lb.)			

Cutaway Oxygen Sensor Components (O2)



A	Protection Shield	**B**	Planar Element and Heater
C	Lower Insulator	**D**	Stainless Steel Housing
E	Upper Insulator	**F**	Terminal Connection to Element
G	High Temp Water Seal		

Temperature must be controlled very accurately and gas constituents measured to a high degree of accuracy for absolute sensor measurements. This requires laboratory equipment to determine a good or bad sensor in field. Furthermore, as with most devices, intermittent problems are difficult to diagnose. Still, with a good understanding of system and sensor, it is possible to diagnose many sensor problems in field.

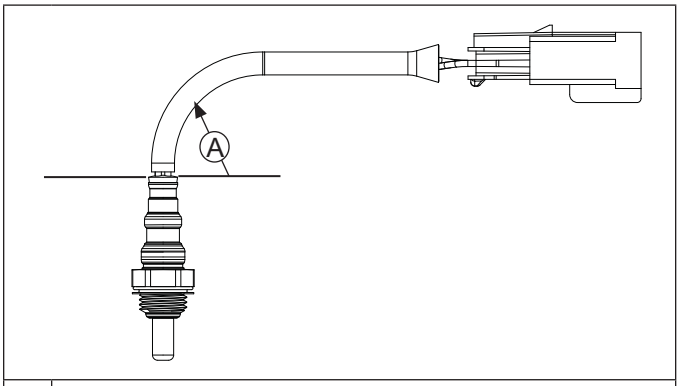
Using KOHLER® Diagnostic System (KDS) Gen 2, see Tools and Aids, connected to ECU is a useful technique for observing sensor performance. However, user must understand that such software reads a signal generated by ECU. If there is an ECU or wiring problem, readings could be misinterpreted as a sensor problem. Digital nature of signal to KDS tool means that it is not reading continuous output of sensor. A voltmeter can also be used as an effective tool in diagnosing sensors.

Using injector timing test within KDS tool will aid in testing operation of O2 sensor. See instructions within help (?) area of injector timing test.

It is advisable to use an electronic meter such as a digital voltmeter. Simple mechanical meters may place a heavy electrical load on sensor and cause inaccurate readings. Since resistance of sensor is highest at low temperatures, such meters will cause largest inaccuracies when sensor is in a cool exhaust.

Visual Inspection

Sensor Wire Detail



A	Keep a minimum of 25 mm (1.0 in.) radius at grommet.

NOTE: Always route harness away from hot exhaust and away from moving parts.

NOTE: **Do not attempt to clean sensor.** Replace as needed.

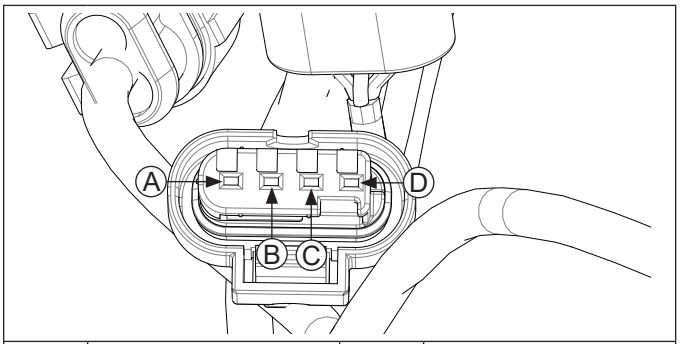
1. Look for a damaged or disconnected sensor-to-engine harness connection.
2. Look for damage to sensor lead wire or associated engine wiring due to cutting, chaffing or melting on a hot surface.
3. Disconnect sensor connector and look for corrosion in connector.
4. Try reconnecting sensor and observe if problem has cleared.
5. Correct any problems found during visual check.
6. Inspect for any exhaust system leaks upstream or downstream of oxygen sensor. Confirm oxygen sensor is secured to exhaust with appropriate torque.

   Style 1 (Smaller Sensor) 18 N·m (159 in. lb.).

   Style 2 (Larger Sensor) 50.1 N·m (37 ft. lb.).

   All leaks must be repaired and an ECU reset must be performed before proceeding with sensor testing.
7. Using KDS tool, document any trouble codes. Determine if historic trouble codes are logically related to current fault experienced. If uncertain, clear codes and retest.

Sensor Signal Observation
Engine Harness O2 Sensor Connector Plug Detail



A	Red w/Black Stripe	**B**	Dark Green
C	Purple	**D**	Black

NOTE: **Do not cut into or pierce sensor or engine wiring to make this connection.** Sensor produces a very small signal. Corrosion or damage to wiring could lead to an incorrect signal because of repairs or contamination to sensor.

1. With sensor connected and using KOHLER® Diagnostic System (KDS) Gen 2, see Tools and Aids, start engine to observe O2 sensor activity. Run engine at sufficient speed to bring sensor and engine up to operating temperature (engine temperature of 150°F (66°C) or more displayed by KDS tool).

   Maintained throttle openings of less than 20% typically display closed loop operation where sensor output voltage should cycle between 0.05 to 0.95 Volts.

   Maintained throttle openings of 30-40% and above typically display open loop operation where sensor should have above 0.500 Volt. Occasional spikes outside these values is normal. Lack of continuous fluctuation is not an indication of a defective sensor.

2. With key ON and engine OFF, sensor connected, using diagnostic software, O2 volts displayed should be more than 1.0 volt. This voltage is generated by ECU. If not present, there may be a power and/or ground supply fault to engine harness or ECU, a fault of engine harness itself (refer to Visual Inspection), or a fault of ECU.

   With key ON and sensor unplugged, using a digital voltmeter, observe voltage between Pin socket C and Pin socket D of engine wiring harness (refer to engine harness connector plug detail at top of page). Voltage should read approximately 5.0 volts.

3. Using a digital voltmeter, observe system sensor voltage between Pin socket A and negative (-) battery ground. Battery voltage should be seen. If battery voltage is not seen, inspect engine wiring, fuses, and/or electrical connections.

Sensor Removal Inspection

NOTE: Apply anti-seize compound only to threads. **Anti-seize compound will affect sensor performance if it gets into lower shield of sensor.**

1. If sensor has heavy deposits on lower shield, engine, oil, or fuel may be source.
2. If heavy carbon deposits are observed, incorrect engine fuel control may be occurring.
3. With sensor at room temperature measure heater circuit resistance, Heater + (Pin A) and Heater - (Pin B).

   Style 1 (Smaller Sensor) resistance should be 16.5-19.5 Ω.

   Style 2 (Larger Sensor) resistance should be 8.1-11.1 Ω.

4. If a damaged sensor is found, identify root cause, which may be elsewhere in application. Refer to Troubleshooting-Oxygen (O2) Sensor table.
5. A special "dry to touch" anti-seize compound is applied to all new oxygen sensors at factory. If recommended mounting thread sizes are used, this material provides excellent anti-seize capabilities and no additional anti-seize is needed. If sensor is removed from engine and reinstalled, anti-seize compound should be reapplied. Use an oxygen sensor safe type anti-seize compound. It should be applied according to directions on label. Torque sensor to appropriate torque.

   Style 1 (Smaller Sensor) 18 N·m (159 in. lb.).

   Style 2 (Larger Sensor) 50.1 N·m (37 ft. lb.).

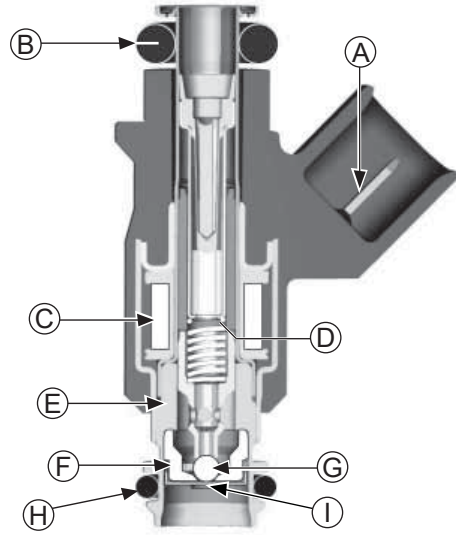
Troubleshooting-Oxygen (O2) Sensor

Condition	Possible Cause	Conclusion
Continuous low voltage output (less than 400mV) observed with throttle openings of 40% or more (lean biased condition). Fault codes P0131, P0171, or P0174 may set.	Shorted sensor or sensor circuit. Shorted lead wire. Wiring shorted to ground.	Replace sensor or replace and properly route wiring.
	Upstream or downstream exhaust leaks observed. Air leak at sensor.	Repair all exhaust leaks and torque sensor to appropriate torque. Style 1 (Smaller Sensor) 18 N·m (159 in. lb.). Style 2 (Larger Sensor) 50.1 N·m (37 ft. lb.).
	Restricted fuel supply.	Resolve fuel supply issues from tank to engine. Test fuel pressure. Perform repairs necessary.
	Misfire	A misfire causing incomplete combustion will result in lean (low voltage) values.
	Lean biased sensor failure.	Replace sensor.
Continuous high voltage output (600mV or more) observed with throttle openings of 40% or less (rich biased condition). Fault codes P0172 or P0132 may set.	Silica poisoning.	Replace sensor. Identify and resolve root cause.
	Contaminated gasoline.	Purge fuel system and retest.
	Wiring shorted to voltage.	Replace damaged harness.
	Overly rich condition due to unmetered fuel entering combustion chamber.	Test fuel pressure. Inspect fuel pump vent and evaporative emissions hoses for raw fuel flow. Inspect engine oil for fuel contamination; drain and refill if suspect. Perform repairs as necessary.
	Cold engine. Engine temperature below 150°F (66°C) as displayed by KOHLER® Diagnostic System (KDS) Gen 2, see Tools and Aids.	Normal operation, or engine operated in an excessively cold environment.
	Rich biased sensor failure.	Replace sensor.
No activity from sensor. KDS tool displays 1.015 Volts continuously. Fault codes P0031 or P0032 may set.	Heater circuit open or shorted.	Replace sensor.
	Engine keyed ON with sensor disconnected. Historic codes.	Secure and/or confirm sensor connection and clear codes.
	Contaminated gasoline.	Purge fuel system and retest.

Fuel Injectors

	⚠ WARNING
	Explosive Fuel can cause fires and severe burns. Fuel system ALWAYS remains under HIGH PRESSURE.
Wrap a shop towel completely around fuel pump module connector. Press release button(s) and slowly pull connector away from fuel pump module allowing shop towel to absorb any residual fuel in high pressure fuel line. Any spilled fuel must be completely wiped up immediately.	

Details



A	Electrical Connection	**B**	Upper O-ring
C	Solenoid Winding	**D**	Armature
E	Valve Housing	**F**	Valve Seat
G	Valve End	**H**	Lower O-ring
I	Director Plate		

NOTE: Do not apply voltage to fuel injector(s). Excessive voltage will burn out injector(s). Do not ground injector(s) with ignition ON. Injector(s) will open/turn on if relay is energized.

NOTE: When cranking engine with injectors disconnected, fault codes will be registered in ECU and will need to be cleared using software fault clear or an ECU Reset Procedure.

Injector problems typically fall into three general categories: electrical, dirty/clogged, or leakage. An electrical problem usually causes one or both of injectors to stop functioning. Several methods may be used to check if injectors are operating.

1. With engine running at idle, listen for a buzzing or clicking sound.
2. Disconnect electrical connector from an injector and listen for a change in idle performance (only running on one cylinder) or a change in injector noise or vibration.
3. Using KOHLER® Diagnostic System (KDS) Gen 2, see Tools and Aids, perform Adjust Injector Timing test or Injector #1 or #2 test as found in test section of tool. See instructions within help (?) area of each test.

If an injector is not operating, it can indicate either a bad injector, or a wiring/electrical connection problem. Check as follows:

1. Disconnect electrical connector from both injectors. Plug a 12 volt noid light into one connector.
2. Make sure all safety switch requirements are met. Crank engine and check for flashing of test light. Turn key OFF for at least 10 seconds between tests to allow ECU to go to sleep and reawake. Repeat test at other connector.
   a. If flashing occurs, use an ohmmeter (Rx1 scale) and check resistance of each injector across two terminals. Proper resistance is 11-13 Ω. If injector resistance is correct, check whether connector and injector terminals are making a good connection. If resistance is not correct, replace injector.

Check all electrical connections, connectors, and wiring harness leads if resistance is incorrect.

Injector leakage is very unlikely, but in those rare instances it can be internal (past tip of valve needle), or external (weeping around injector O-rings). Loss of system pressure from leakage can cause hot restart problems and longer cranking times. To check for leakage it will be necessary to loosen or remove blower housing which may involve removing engine from unit. Refer to Disassembly for removal of injector.

1. Remove manifold mounting bolts and separate throttle body/manifold from engine leaving TPS, high pressure fuel line, injectors and fuel line connections intact. Discard old gaskets.
2. Position manifold assembly over an appropriate container to capture fuel and turn key switch ON to activate fuel pump and pressurize system. Do not turn switch to START position.
3. If either injector exhibits leakage of more than two to four drops per minute from tip, or shows any sign of leakage around outer shell, turn ignition switch OFF and replace injector as follows.
4. Depressurize fuel system.
5. Clean any dirt accumulation from sealing/mounting area of faulty injector(s) and disconnect electrical connector(s).
6. Pull retaining clip off top of injector(s). Remove screw holding injector(s) from manifold.
7. Reverse appropriate procedures to install new injector(s) and reassemble engine. Use new O-rings and retaining clips any time an injector is removed (new replacement injectors include new O-rings and retaining clips). Lubricate O-rings lightly with clean engine oil. Use installation tool provided with O-rings to install new upper O-ring. Place tool into fuel injector inlet. Place one side of O-ring into O-ring groove and roll O-ring over tool onto fuel injector. Torque screw securing fuel injector caps and blower housing mounting screws to 7.3 N·m (65 in. lb.), and intake manifold and air cleaner mounting screws to 10.5 N·m (93 in. lb.). An ECU Reset will need to be completed.

Injector problems due to dirt or clogging are generally unlikely due to design of injectors, high fuel pressure, and detergent additives in gasoline. Symptoms that could be caused by dirty/clogged injectors include rough idle, hesitation/stumbling during acceleration, or triggering of fault codes related to fuel delivery. Injector clogging is usually caused by a buildup of deposits on director plate, restricting flow of fuel, resulting in a poor spray pattern. Some contributing factors to injector clogging include higher than normal operating temperatures, short operating intervals, and dirty, incorrect, or poor quality fuel. Cleaning of clogged injectors is not recommended; they should be replaced. Additives and higher grades of fuel can be used as a preventative measure if clogging has been a problem.

Ignition Coil

If a coil is determined to be faulty, replacement is necessary. An ohmmeter may be used to test wiring and coil windings.

NOTE: Do not ground primary coil with ignition ON as they may overheat or spark.

NOTE: Always disconnect spark plug lead from spark plug before performing following tests.

NOTE: **If ignition coil(s) are disabled and an ignition fault is registered, system will automatically disable corresponding fuel injector drive signal.** Fault must be corrected to ignition coil and ECU power (switch) must be turned OFF for 10 seconds for injector signal to return. This is a safety measure to prevent bore washing and oil dilution.

Testing

Using an ohmmeter set on Rx1 scale, check resistance in circuits as follows:

1. To check cylinder coil 1 (starter side), disconnect Black connector from ECU and test between Black pins 1 and 15. To check cylinder coil 2 (oil filter side), disconnect Grey connector from ECU and test between Grey pins 10 and 17. Wiring and coil primary circuits are OK if readings are 0.5-0.8 Ω.
2. If reading(s) are not within specified range, check and clean connections and retest.
3. If reading(s) are still not within specified range, test coils separately from main harness as follows:
   a. Remove screw retaining coil to housing and disconnect primary leads connector.
   b. Connect an ohmmeter set on Rx1 scale to primary terminals of coil. Primary resistance should be 0.5-0.8 Ω.
   c. Connect an ohmmeter set on Rx10K scale between spark plug boot terminal and B+ primary terminal. Secondary resistance should be 6400-7800 Ω.
   d. If secondary resistance is not within specified range, coil is faulty and needs to be replaced.

Ignition coils can be tested using KOHLER® Diagnostic System (KDS) Gen 2, see Tools and Aids. Select Ignition Coil test #1 or #2 and follow instructions in help (?) area of test.

FUEL COMPONENTS

	⚠ WARNING
	Explosive Fuel can cause fires and severe burns. Fuel system ALWAYS remains under HIGH PRESSURE.
Wrap a shop towel completely around fuel pump module connector. Press release button(s) and slowly pull connector away from fuel pump module allowing shop towel to absorb any residual fuel in high pressure fuel line. Any spilled fuel must be completely wiped up immediately.	

Fuel Pump Module (FPM)

FPM is not serviceable and must be replaced if determined to be faulty. If a FPM problem is suspected, make certain pump is being activated, all electrical connections are properly secured, fuses are good. If required, testing of fuel pump may be conducted.

FPM can be tested using KOHLER® Diagnostic System (KDS) Gen 2, see Tools and Aids. Select Fuel Pump Test and follow instructions in help (?) area of test.

NOTE: Fuel pump module pins are coated with a thin layer of electrical grease to prevent fretting and corrosion. Do not attempt to remove electrical grease from fuel pump module pins.

1. Relieve fuel pressure at FPM. FPM may need to be loosened or pulled away from engine. Press release button(s) and slowly pull connector away from FPM allowing shop towel to absorb any residual fuel in high pressure fuel line. Insert pressure test jumper (from Kohler EFI Service Kit) between high pressure fuel line and FPM.
2. Connect black hose of Pressure Tester. Route clear hose into a portable gasoline container or equipment fuel tank.
3. Turn on key switch to activate pump and check system pressure on gauge. It may take several key/power down cycles to compress air introduced into system and reach regulated pressure. System pressure of 39 psi ± 3 should be present. Turn key switch OFF and depress valve button on tester to relieve system pressure.
   a. If pressure is too high or too low, proceed to troubleshooting.
4. If pump did not activate (step 3), confirm that safety system on equipment is not active. One potential cause of unnecessary FPM replacement may involve measuring voltage at FPM electrical connector. Using a Digital Volt Ohm Meter (DVOM) will provide a reading near battery voltage, even when ECU is not grounding FPM circuit.
   a. Connect a DVOM across terminals in plug, turn on key switch and confirm battery voltage is present during six second prime process.

b. Test light confirmation: Turn key off. Disconnect DVOM. Connect 12 volt test light across terminals in plug. Key needs to remain off for a minimum of 30 seconds before proceeding. Turn key on. Confirm test light illuminates for approximately 6 seconds. After approximately 6 seconds, test light will remain off unless another prime cycle is initiated.

5. If battery voltage is not present and/or test light does not illuminate, connect red lead of DVOM to red wire of plug and black lead to a battery ground while key is still ON.
6. If battery voltage is present, turn key switch OFF and connect an ohmmeter between terminals on FPM to check for continuity. If battery voltage at plug was confirmed, and there was continuity across FPM terminals, reconnect plug to FPM, making sure you have a good connection. Turn on key switch and listen for FPM to activate.
   a. If FPM starts, repeat steps 2 and 3 to verify correct pressure.
   b. If FPM still does not operate, replace it.
7. If battery voltage was not present at connector inspect fuse and wiring harness.

High Pressure Fuel Line

High pressure fuel line is mounted to intake manifold. No specific servicing is required unless operating conditions indicate that it needs replacement. Thoroughly clean area around all joints and relieve any pressure before starting any disassembly. Detach by removing two mounting screws, wire ties, and injector retaining clips.

Purge Port and Vent Hose Assembly

No specific servicing is required for vent hose assembly or purge port unless operating conditions indicate replacement is required. All components are serviced individually. Abrasion sleeves on hoses should be reused or replaced when servicing vent hoses. Please note vent hose routing and replicate after service or component replacement to prevent pinching or abrasion of vent hoses. Only Kohler replacement parts can be used because fitting is specific to system and must be maintained. Visit KohlerEngines.com for recommended Kohler replacement parts.

Electronic Throttle Body (ETB)/Intake Manifold Assembly

NOTE: ECU Reset is required if electronic throttle body is replaced.

Electronic throttle body (ETB) is serviced as an assembly, with throttle shaft, TPS, and throttle plate installed. Throttle shaft rotates on needle bearings (non-serviceable), capped with seals to prevent air leaks.

ETB can be tested using KOHLER® Diagnostic System (KDS) Gen 2, see Tools and Aids,. Select Throttle Position Test and follow instructions in help (?) area of test.

TROUBLESHOOTING

Troubleshooting Guide

Condition	Possible Cause
Engine Starts Hard or Fails to Start When Cold.	Fuel pump not running.
	Faulty spark plugs.
	Old/stale fuel.
	Incorrect fuel pressure.
	Crankshaft position sensor loose or faulty.
	TPS set incorrect (ECU Reset).
	TPS faulty.
	Engine temp sensor faulty.
	Faulty coils.
	Low system voltage.
	Faulty injectors.
	Faulty battery.
	Loose or corroded connections.

Troubleshooting Guide

Condition	Possible Cause
Engine Starts Hard or Fails to Start When Hot.	Faulty spark plugs.
	Fuel pump not running.
	Fuel pressure low.
	Insufficient fuel delivery.
	TPS set incorrect (ECU Reset).
	Crankshaft position sensor loose or faulty.
	TPS faulty.
	Engine temp sensor faulty.
	Faulty injectors.
	Vapor lock.
Engine Stalls or Idles Roughly (cold or warm).	Faulty spark plugs.
	Insufficient fuel delivery.
	TPS set incorrect.
	TPS faulty.
	Faulty engine temperature sensor.
	Faulty injectors.
Engine Misses, Hesitates, or Stalls Under Load.	Fuel injector(s), fuel filter, fuel line, or fuel pick-up dirty/restricted.
	Dirty air cleaner.
	Insufficient fuel pressure or fuel delivery.
	Vacuum (intake air) leak.
	Improper governor operation.
	TPS faulty.
	Bad coil(s), spark plug(s), or wires.
Low Power	Faulty/malfunctioning ignition system.
	Dirty air filter.
	Insufficient fuel delivery.
	Plugged/restricted exhaust.
	One injector not working.
	Basic engine problem exists.
	TPS faulty.
	Throttle plate in electronic throttle body not fully opening to WOT.

Function Test

⚠ WARNING

High Pressure Fluids can puncture skin and cause severe injury or death.

Do not work on fuel system without proper training or safety equipment.

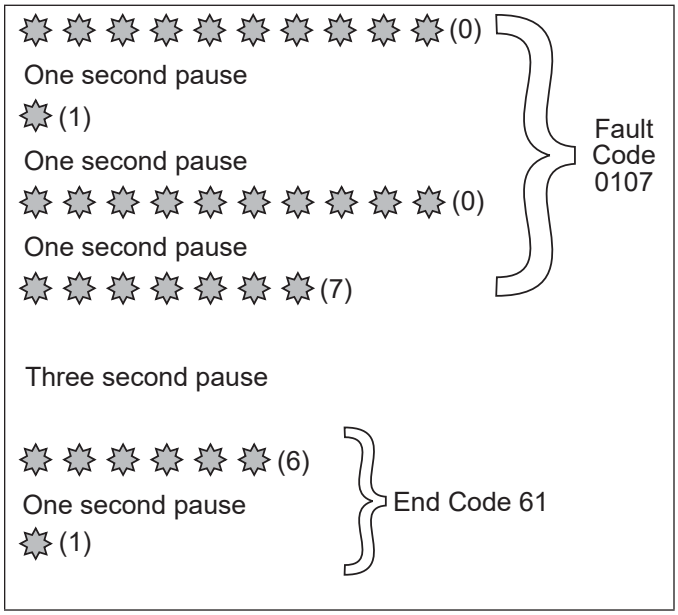
Fluid puncture injuries are highly toxic and hazardous. If an injury occurs, seek immediate medical attention.

Function of fuel system is to provide sufficient delivery of fuel at system operating pressure of 39 psi ± 3. If an engine starts hard, or turns over but will not start, it may indicate a problem with EFI fuel system. A quick test will verify if system is operating.

1. Disconnect and ground spark plug leads.
2. Complete all safety interlock requirements and crank engine for approximately 3 seconds.
3. Remove spark plugs and check for fuel at tips.
   a. If there is fuel at tips of spark plugs fuel pump and injectors are operating.
   b. If there is no fuel at tips of spark plugs, check following:
      1. Make sure fuel tank contains clean, fresh, proper fuel.
      2. Make sure that vent in fuel tank is open.
      3. Make sure fuel tank valve (if equipped) is fully opened.
      4. Make sure battery is supplying proper voltage.
      5. Check that fuses are good, and that no electrical or fuel line connections are damaged or broken.
      6. Test fuel pump module operation as described earlier under Fuel Pump Module.

Fault Codes

Example of Diagnostic Display



Fault Code Summary

Fault Code	MIL Blinks	Connection or Failure Description	SAE J1939 Fault Codes	
			SPN	FMI
P2119	**1/5/2/11**	Throttle Actuator Stuck	**5419**	**7**
P2100	**1/5/2/11**	Throttle Actuator Control Motor Circuit Open (Low Current Fault)	**5419**	**5**
P0171	**1/10/8/13**	Maximum Adaptation Limit Exceeded	**4237**	**0**
P0172	**1/10/8/13**	Minimum Adaptation Limit Exceeded	**4237**	**1**
P0174	**1/10/8/13**	Lean Fuel Condition at High Load (Open Loop)	**4237**	**31**
P0336	**10/2/7/12**	Crankshaft Position Sensor Noisy Signal	**636**	**2**
P0337	**10/2/7/12**	False Start Detected/CKP Sensor Signal	**636**	**8**
P0201	**10/2/8/11**	Injector 1 Circuit Malfunction	**651**	**31**
P0202	**10/2/8/12**	Injector 2 Circuit Malfunction	**652**	**31**
P0351	**10/4/15/4**	Cylinder 1 Ignition Coil Malfunction	**1268**	**31**
P0352	**10/4/15/5**	Cylinder 2 Ignition Coil Malfunction	**1269**	**31**
P0232	**10/5/4/3**	Fuel Pump Module Circuit High Voltage	**1347**	**6**
P0230	**10/5/4/3**	Fuel Pump Module Circuit Low Voltage or Open	**1347**	**5**
P0123	**10/10/3/3**	Throttle Position Sensor Circuit High Voltage	**51**	**3**
P0122	**10/10/3/3**	Throttle Position Sensor Circuit Low Voltage or Open	**51**	**4**
P0108	**10/10/6/6**	Manifold Absolute Pressure Sensor Circuit High Voltage	**102**	**3**
P0107	**10/10/6/6**	Manifold Absolute Pressure Sensor Circuit Low Voltage or Open	**102**	**4**
P0113	**10/10/6/9**	Intake Air Temperature Sensor Circuit High Voltage or Open	**105**	**3**
P0112	**10/10/6/9**	Intake Air Temperature Sensor Circuit Low Voltage	**105**	**4**
P0118	**10/10/6/14**	Engine Temperature Sensor Circuit High Voltage or Open	**110**	**3**
P0117	**10/10/6/14**	Engine Temperature Sensor Circuit Low Voltage	**110**	**4**
P0217	**10/10/6/14**	Overheat	**110**	**0**
P0563	**10/10/6/8**	System Voltage High	**168**	**3**
P0562	**10/10/6/8**	System Voltage Low	**168**	**4**
P0132	**10/11/15/10**	Oxygen Sensor 1 Circuit High Voltage	**3056**	**3**
P0131	**10/11/15/10**	Oxygen Sensor 1 Circuit Low Voltage, or Open	**3056**	**4**
P0031	**10/11/15/10**	Oxygen Sensor Heater Circuit Low Voltage	**3056**	**5**
P0032	**10/11/15/10**	Oxygen Sensor Heater Circuit High Voltage	**3056**	**6**
61	-	End of Code Transmission	**-**	**-**

ECU continuously monitors engine operation against preset performance limits. If operation is outside limits, ECU activates MIL, if equipped, and stores a diagnostic code in its fault memory. If component or system returns to proper function, ECU will turn off MIL. If MIL stays illuminated, it warns customer a fault is currently happening, and dealer service is required. Upon receipt, dealer technician can access fault code(s) to help determine what portion of system is malfunctioning.

Codes are accessed through key switch and displayed as blinks or flashes of MIL. Access codes as follows:

1. Check that battery voltage is above 11 volts.
2. Start with key switch OFF.
3. Turn key switch to ON and OFF, then ON and OFF, then ON, leaving it on in third sequence. Do not start engine. Time between sequences must be less than 2.5 seconds.
4. MIL will blink a series of times. Number of times MIL blinks represents a number in blink code.
5. A sequence of four MIL blinks make up a fault code. There is a one (1) second pause between blinks of a fault code. There is a three (3) second pause between separate fault codes. After fault code(s) are blinked a two digit 61 is blinked to indicate program has completed.
   a. It's a good idea to write down codes as they appear, as they may not be in numerical sequence.
   b. Code 61 will always be last code displayed, indicating end of code transmission. If code 61 appears immediately, no other fault codes are present.

After problem has been corrected, fault codes may be cleared by following ECU Reset Procedure.

Fault Code Summary lists fault codes, and what they correspond to. Diagnostic Code Summary is a list of individual codes with an explanation of what triggers them, what symptoms might be expected, and probable causes.

EFI SYSTEM-ELECTRONIC THROTTLE BODY (ETB) ECH

MIL may not be provided with engine. If equipment manufacturer has not added a MIL to equipment, one can be added easily for quick diagnostics. Main engine to vehicle connection will have a tan wire which is ground for MIL. Either incandescent or LED type bulbs can be used for MIL as long as they do not draw more than 0.1 amps. Bulb needs to be rated at 1.4 Watts or less, or needs to have a total resistance of 140 Ω or more. LEDs typically draw less than 0.03 amps. Attach +12 volts to positive terminal of bulb and attach ground terminal of bulb to tan wire.

ECU circuit will flow small amount of current. This may dimly illuminate LED type bulb. On is bright. Resistor can be added in series if LED type bulb is used to eliminate glow.

Diagnostic Code Summary

Fault Code	MIL Blinks	SPN	FMI
Code P0031	**10/11/15/10**	**3056**	**5**

NOTE: Codes P0031 and P0032 may have been mistakenly activated by turning key ON with oxygen sensor disconnected. If either code status is inactive, that code may have set during assembly or a previous repair and may not be related to current event. Clear codes and retest to confirm. If code status is active, refer to Oxygen Sensor (O2) earlier in this section, to test and troubleshoot.

Component:	Oxygen Sensor Heater
Fault:	O2S Heater Circuit Low Voltage
Condition:	System voltage too low, open connection or faulty sensor.
Conclusion:	Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU Black pin 7 or broken wire. Oxygen Sensor Related ● Sensor connector or wiring problem. Poor system ground from ECU to engine or battery to engine.

Fault Code	MIL Blinks	SPN	FMI
Code P0032	**10/11/15/10**	**3056**	**6**

NOTE: Codes P0031 and P0032 may have been mistakenly activated by turning key ON with oxygen sensor disconnected. If either code status is inactive, that code may have set during assembly or a previous repair and may not be related to current event. Clear codes and retest to confirm. If code status is active, refer to Oxygen Sensor (O2) earlier in this section, to test and troubleshoot.

Component:	Oxygen Sensor Heater
Fault:	O2S Heater Circuit High Voltage
Condition:	System voltage too high, shorted connection or faulty sensor.
Conclusion:	Oxygen Sensor Related ● Sensor connector or wiring problem. ● Sensor damaged. ● Pin circuit wiring or connectors at Black 7. ECU Related ● ECU-to-harness connection problem.

Fault Code	MIL Blinks	SPN	FMI
Code P0107	**10/10/6/6**	**102**	**4**

Component:	Manifold Absolute Pressure (TMAP)
Fault:	MAP Circuit Low Voltage or Open
Condition:	Intake manifold leak, open connection or faulty sensor.
Conclusion:	TMAP Sensor Related ● Sensor malfunction. ● Vacuum leaks from loose manifold or sensor. Wire Harness Related ● Poor grounding or open circuit. ● Wire harness and connectors loose, damaged or corroded. ● Pin circuit wiring or connectors at Black 10, 11 and 16.

Fault Code	MIL Blinks	SPN	FMI
Code P0108	**10/10/6/6**	**102**	**3**

Component:	Manifold Absolute Pressure (TMAP)
Fault:	MAP Circuit High Voltage
Condition:	Intake manifold leak, shorted connection or faulty sensor.
Conclusion:	TMAP Sensor Related ● Sensor malfunction. ● Vacuum leaks from loose manifold or sensor. Wire Harness Related ● Poor grounding. ● Pin circuit wiring or connectors at Black 11.

Fault Code	MIL Blinks	SPN	FMI
Code P0112	**10/10/6/9**	**105**	**4**

Component:	Intake Air Temperature (TMAP)
Fault:	Intake Air Temperature Sensor Circuit Low Voltage
Condition:	Shorted connection, faulty sensor or shorted wire.
Conclusion:	TMAP Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits ECU Black pin 10 and Black 8 may be damaged or routed near noisy signal (coils, stator, etc.). ● ECU-to-harness connection problem.

Fault Code	MIL Blinks	SPN	FMI
Code P0113	**10/10/6/9**	**105**	**3**

Component:	Intake Air Temperature (TMAP)
Fault:	Intake Air Temperature Sensor Circuit High Voltage or Open
Condition:	Shorted connection, faulty sensor, broken wire or connection.
Conclusion:	TMAP Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits ECU Black pin 10 and 8 may be damaged. ● ECU-to-harness connection problem or broken wire.

Fault Code	MIL Blinks	SPN	FMI
Code P0117	**10/10/6/14**	**110**	**4**

Component:	Engine Temperature Sensor
Fault:	Engine Temperature Sensor Circuit Low Voltage
Condition:	Shorted connection, faulty sensor or shorted wire.
Conclusion:	Temperature Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits ECU Black pin 10 and Black 14 may be damaged or routed near noisy signal (coils, stator, etc.). ● ECU-to-harness connection problem.

Fault Code	MIL Blinks	SPN	FMI
Code P0118	**10/10/6/14**	**110**	**3**

Component:	Engine Temperature Sensor
Fault:	Engine Temperature Sensor Circuit High Voltage or Open
Condition:	Shorted connection, faulty sensor, open connection or broken wire.
Conclusion:	Temperature Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits ECU Black pin 10 and 14 may be damaged. ● ECU-to-harness connection problem or broken wire. System Related ● Engine is operating above 176°C (350°F) temperature sensor limit.

Fault Code	MIL Blinks	SPN	FMI
Code P0122	**10/10/3/3**	**51**	**4**

Component:	Throttle Position Sensor (TPS)
Fault:	TPS Circuit Low Voltage or Open
Condition:	Open connection, broken wire or faulty sensor.
Conclusion:	TPS Related ● TPS bad or worn internally. Engine Wiring Harness Related ● Broken or shorted wire in harness. ECU Black pin 10 to TPS pin 1. ECU Black pin 12 to TPS pin 3. ECU Black pin 16 to TPS pin 2. Throttle Body Related ● Throttle shaft inside TPS worn, broken, or damaged. ● Throttle plate loose or misaligned. ● Throttle plate bent or damaged allowing extra airflow past, or restricting movement. ECU Related ● Circuit providing voltage or ground to TPS damaged. ● TPS signal input circuit damaged.

Fault Code	MIL Blinks	SPN	FMI
Code P0123	**10/10/3/3**	**51**	**3**

Component:	Throttle Position Sensor (TPS)
Fault:	TPS Circuit High Voltage
Condition:	Shorted connection or faulty sensor.
Conclusion:	TPS Sensor Related ● Sensor connector or wiring. Throttle Body Related ● Throttle shaft or bearings worn/ damaged. Engine Wiring Harness Related ● ECU pins Black 10, 12 and 16 damaged (wiring, connectors). ● ECU pins Black 10, 12 and 16 routed near noisy electrical signal (coils, stator). ● Intermittent 5 volt source from ECU (pin Black 16). ● ECU-to-harness connection problem.

Fault Code	MIL Blinks	SPN	FMI
Code P0131	**10/11/15/10**	**3056**	**4**

Component:	Oxygen Sensor
Fault:	O2S 1 Circuit Low Voltage
Condition:	Open connection, broken wire or faulty sensor.
Conclusion:	Oxygen Sensor Related ● Sensor connector or wiring problem. ● Sensor contaminated, corroded or damaged. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or 17. TPS Auto-Learn Incorrect ● Lean condition (check oxygen sensor signal with VOA and see Oxygen Sensor). Engine wiring harness related such as a cut wire, broken or pinched.

Fault Code	MIL Blinks	SPN	FMI
Code P0132	**10/11/15/10**	**3056**	**3**

Component:	Oxygen Sensor
Fault:	O2S 1 Circuit High Voltage
Condition:	Shorted connection or faulty sensor.
Conclusion:	Oxygen Sensor Related ● Sensor connector or wiring problem. ● Sensor contaminated or damaged. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or Black pin 17. Engine Wiring Harness Related ● Difference in voltage between sensed voltage and actual sensor voltage. ● Short in wire harness.

Fault Code	MIL Blinks	SPN	FMI
Code P0171	1/10/8/13	4237	0

Component:	Fuel System
Fault:	Maximum adaptation limit exceeded
Condition:	Fuel inlet screen/filter plugged, low pressure at high pressure fuel line, TPS malfunction, shorted connection, faulty O2 sensor, low fuel or wrong fuel type.
Conclusion:	Oxygen Sensor Related ● Corrosion or poor connection. ● Sensor contaminated or damaged. ● Air leak into exhaust. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or Black pin 17. TPS Sensor Related ● Throttle plate position incorrect during Auto-Learn. ● TPS problem or malfunction. Engine Wiring Harness Related ● Difference in voltage between sensed voltage and actual sensor voltage. ● Problem in wiring harness. ● ECU-to-harness connection problem. Systems Related ● Ignition (spark plug, plug wire, ignition coil). ● Fuel (fuel type/quality, injector, fuel pressure too low, fuel pump module or lift pump). ● Combustion air (air cleaner dirty/ restricted, intake leak, throttle bore). ● Base engine problem (rings, valves). ● Exhaust system leak (muffler, flange, oxygen sensor mounting boss, etc.). ● Fuel in crankcase oil.

Fault Code	MIL Blinks	SPN	FMI
Code P0172	1/10/8/13	4237	1

Component:	Fuel System
Fault:	Minimum adaptation limit exceeded
Condition:	Too high pressure at high pressure fuel line, TPS malfunction, shorted connection, faulty O2 sensor or fuel pump module failure.
Conclusion:	Oxygen Sensor Related ● Sensor connector or wiring. ● Sensor contaminated or damaged. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or Black pin 17. TPS Sensor Related ● Throttle plate position incorrect during Auto-Learn. ● TPS problem or malfunction. Engine Wiring Harness Related ● Difference in voltage between sensed voltage and actual sensor voltage. ● Problem in wiring harness. ● ECU-to-harness connection problem. Systems Related ● Ignition (spark plug, plug wire, ignition coil). ● Fuel (fuel type/quality, injector, fuel pressure too high, fuel pump module or lift pump). ● Combustion air (air cleaner dirty/ restricted). ● Base engine problem (rings, valves). ● Fuel in crankcase oil. ● Fuel pump module is over filled. ● Lift pump diaphragm is ruptured.

EFI SYSTEM-ELECTRONIC THROTTLE BODY (ETB) ECH

Fault Code	MIL Blinks	SPN	FMI
Code P0174	**1/10/8/13**	**4237**	**31**

Component:	Fuel System
Fault:	Lean fuel condition
Condition:	Fuel inlet screen/filter plugged, low pressure at high pressure fuel line, TPS malfunction, shorted connection or faulty sensor.
Conclusion:	TPS Auto-Learn Incorrect ● Lean condition (check oxygen sensor signal with VOA and see Oxygen Sensor). Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU pin Black 10, 12, 16 and 17. Low Fuel Pressure ● Plugged filters. ● Bad lift pump. ● Vapor lock. Oxygen Sensor Related ● Sensor connector or wiring problem. ● Exhaust leak. ● Poor ground. ● Contaminated sensor. Poor system ground from ECU to engine, causing rich running while indicating lean. Fuel pump module connection. See Fuel Components.

Fault Code	MIL Blinks	SPN	FMI
Code P0201	**10/2/8/11**	**651**	**31**

Component:	Fuel Injector
Fault:	Injector 1 Circuit Malfunction
Condition:	Injector damaged or faulty, shorted or open connection.
Conclusion:	Injector Related ● Injector coil shorted or opened. Engine Wiring Harness Related ● Broken or shorted wire in harness. ECU pin Black 5. ● Wiring from Ignition. ECU Related ● Circuit controlling injector #1 damaged.

Fault Code	MIL Blinks	SPN	FMI
Code P0202	**10/2/8/11**	**652**	**31**

Component:	Fuel Injector
Fault:	Injector 2 Circuit Malfunction
Condition:	Injector damaged or faulty, shorted or open connection.
Conclusion:	Injector Related ● Injector coil shorted or opened. Engine Wiring Harness Related ● Broken or shorted wire in harness. ECU pin Black 6. ● Wiring from Ignition. ECU Related ● Circuit controlling injector #2 damaged.

Fault Code	MIL Blinks	SPN	FMI
Code P0217	**10/10/6/14**	**110**	**0**

Component:	Engine Overheat Warning
Fault:	Overheat
Condition:	Engine operating at or above recommended temperature limit.
Conclusion:	Throttle opening is limited, value varies by engine model. ● Ramps in and out of limit. Provides an alert to operator of a condition that may cause damage to engine. ● Typically this is remedied by clearing debris blocking engine cooling air flow.

Fault Code	MIL Blinks	SPN	FMI
Code P0230	**10/5/4/3**	**1347**	**5**

Component:	Fuel Pump
Fault:	Circuit Low Voltage or Open
Condition:	Shorted or open connection.
Conclusion:	Fuel Pump Related ● Fuel pump module open or shorted internally. Engine Wiring Harness related ● Broken or shorted wire in harness. ECU pin Black 9 or Grey 17. ECU Related ● ECU is damaged.

Fault Code	MIL Blinks	SPN	FMI
Code P0232	**10/5/4/3**	**1347**	**6**

Component:	Fuel Pump
Fault:	Circuit High Voltage
Condition:	Shorted connection.
Conclusion:	Fuel Pump Related ● Fuel pump module damaged internally. Charging Output System Too High.

Fault Code	MIL Blinks	SPN	FMI
Code P0336	**10/2/7/12**	**636**	**2**

Component:	Crankshaft Position Sensor
Fault:	Crankshaft Position Sensor Noisy Signal
Condition:	Loose sensor, faulty/bad battery, shorted or faulty connection, faulty sensor or faulty sensor grounding.
Conclusion:	Crankshaft Position Sensor Related ● Sensor connector or wiring. ● Sensor loose. Crankshaft Position Sensor Wheel Related ● Damaged teeth. ● Gap section not registering. Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU pin Black 4 and Black 13 may be routed near noisy signal (coils, stator, etc.). ● ECU-to-harness connection problem. Ignition System Related ● Non-resistor spark plug(s) used. ● Faulty or disconnected ignition coil or secondary lead.

Fault Code	MIL Blinks	SPN	FMI
Code P0337	**10/2/7/12**	**636**	**8**

NOTE: If fault code P0337 is present and engine does not start/run, proceed to step 1 of Crankshaft Position Sensor earlier in this section. If P0337 is present and engine operates, clear codes and retest.

Component:	Crankshaft Position Sensor
Fault:	Crankshaft Position Sensor No Signal
Condition:	Loose sensor, open or shorted connection (sensor connector or battery connections) or faulty sensor.
Conclusion:	Crankshaft Position Sensor Related ● A false fault code P0337 is triggered by a voltage drop with key ON and engine off. Voltage drop may be caused by a poor/inadequate battery connection, battery charger connected or disconnected, or any event that may interrupt voltage signal to ECU like a power interruption or heavy load from equipment that results in a recordable voltage drop. ● Sensor connector or wiring. ● Sensor loose. Crankshaft Position Sensor Wheel Related ● Damaged teeth. Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU pin Black 4 or Black 13. ● ECU-to-harness connection problem. If code is stored in fault history and starts normally. Clear code, no other service required.

Fault Code	MIL Blinks	SPN	FMI
Code P0351	**10/4/15/4**	**1268**	**31**

Component:	Ignition Coil
Fault:	Cylinder 1 Ignition Coil Malfunction
Condition:	Broken/shorted wire in harness (may not be visible), shorted connection or faulty sensor.
Conclusion:	Engine Wiring Harness Related ● Connection to ignition or fuse. ● Pin circuit wiring or connectors. ● ECU pin Black 1. ● ECU-to-harness connection problem. Ignition System Related ● Incorrect spark plug(s) used. ● Poor connection to spark plug.

Fault Code	MIL Blinks	SPN	FMI
Code P0352	**10/4/15/4**	**1269**	**31**

Component:	Ignition Coil
Fault:	Cylinder 2 Ignition Coil Malfunction
Condition:	Broken/shorted wire in harness (may not be visible), shorted connection or faulty sensor.
Conclusion:	Engine Wiring Harness Related ● Connection to ignition or fuse. ● Pin circuit wiring or connectors. ECU pin Grey 10. ● ECU-to-harness connection problem. Ignition System Related ● Incorrect spark plug(s) used. ● Poor connection to spark plug.

Fault Code	MIL Blinks	SPN	FMI
Code P0562	**10/10/6/8**	**168**	**4**

Component:	System Voltage
Fault:	System Voltage Low
Condition:	Faulty voltage regulator, bad fuse or shorted connection.
Conclusion:	Corroded Connections Bad Stator Bad Battery ● Low output charging system. ● Poor magnet in flywheel. ● Bad or missing fuse.

Fault Code	MIL Blinks	SPN	FMI
Code P0563	**10/10/6/8**	**168**	**3**

Component:	System Voltage
Fault:	System Voltage High
Condition:	Faulty voltage regulator or shorted connection.
Conclusion:	Faulty Rectifier-Regulator Bad Stator. Bad Battery.

Fault Code	MIL Blinks	SPN	FMI
Code P2100	**1/5/2/11**	**5419**	**5**

Component:	Throttle Actuator Control Motor Circuit Open
Fault:	Low Current
Condition:	Throttle drive motor open circuit.
Conclusion:	Engine will only run at fixed low speed.

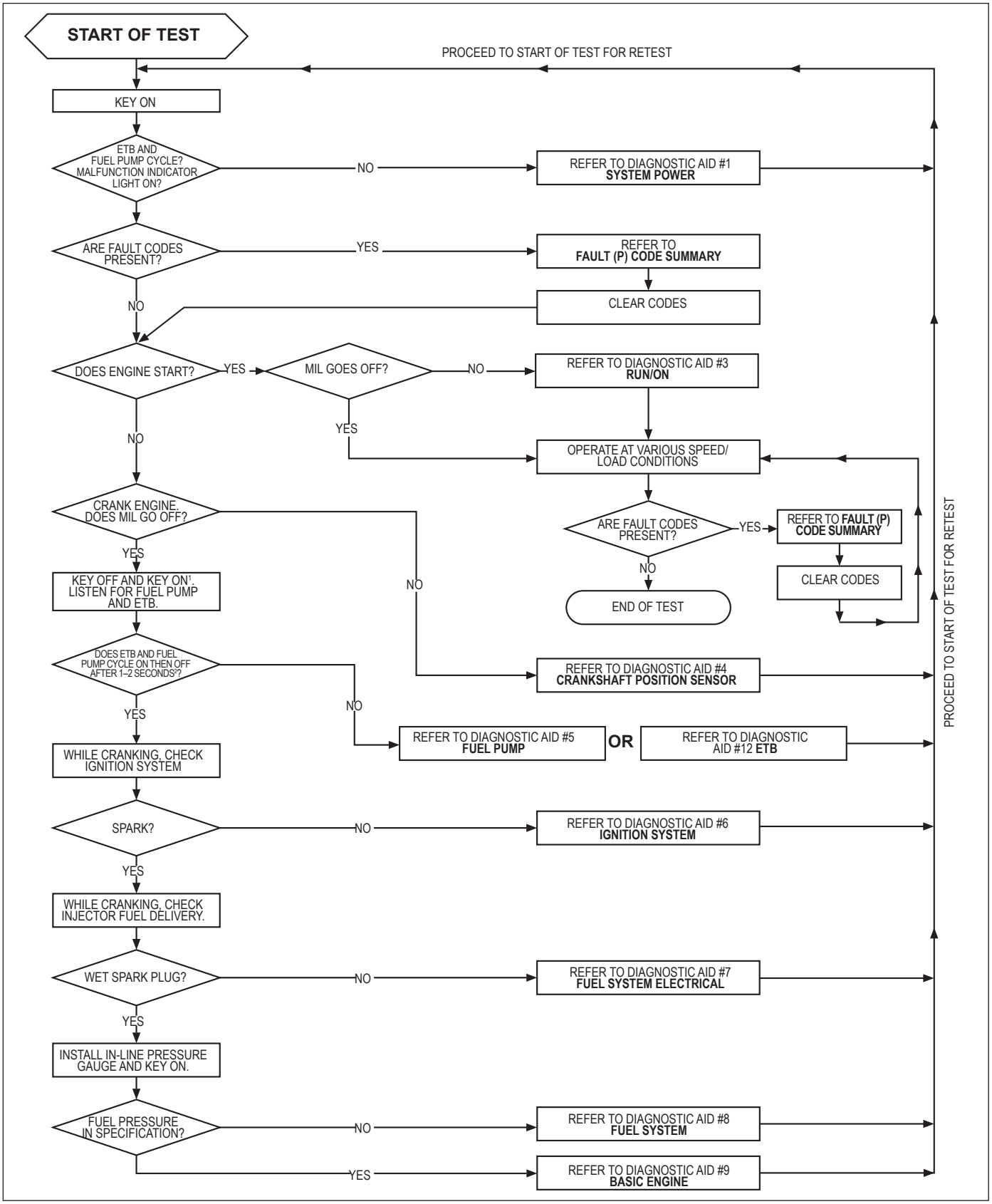
Fault Code	MIL Blinks	SPN	FMI
Code P2119	**1/5/2/11**	**5419**	**7**

Component:	Throttle Actuator
Fault:	Sticking/sticky/binding
Condition:	Throttle performance-binding
Conclusion:	Movement of throttle blade is restricted.

Code 61

Component:	End of Code Transmission

EFI Diagnostic Flow Diagram



1. After turning key to OFF, wait 10 seconds before turning to ON to allow ECU to go to sleep.
2. Fuel pump module can be heard or a vibration can be felt to establish pump cycle. Fuel pump module will run for one 4-6 second cycle when ECU wakes up after being asleep.

Troubleshooting Flow Chart

Following flow chart provides an alternative method of troubleshooting EFI system. Chart will enable you to review entire system in about 10-15 minutes. Using chart, accompanying diagnostic aids (listed after chart), and any signaled fault codes, you should be able to quickly locate any problems within system.

Flow Chart Diagnostic Aids

Diagnostic Aid #1 SYSTEM POWER
(MIL does not illuminate when key is turned ON)

NOTE: MIL is installed by vehicle OEM. Twelve volt supply to bulb will be part of vehicle wire harness. Kohler key switch model will have MIL on engine with 12V supply to bulb.

Conclusion
- Battery
- Main system fuse
- MIL light bulb burned out
- MIL electrical circuit problem
  Pin circuits Grey 3.
- Ignition switch
- Permanent ECU power circuit problem
  Pin circuit Black 18.
- Switched ECU power circuit problem
  Pin circuit Black 15.
- ECU grounds
- ECU

Diagnostic Aid #2 FAULT CODES
Refer to Diagnostic Fault Code Summary.

Diagnostic Aid #3 RUN/ON
(MIL remains ON while engine is running)*

Condition
NOTE: Either incandescent or LED type bulbs can be used for MIL as long as they do not draw more than 0.1 amps. Bulb needs to be rated at 1.4 Watts or less, or needs to have a total resistance of 140 Ω or more. LEDs typically draw less than 0.03 amps.

*All current fault codes will turn on MIL when engine is running.

Diagnostic Aid #4 CRANKSHAFT POSITION SENSOR
(MIL does not turn off during cranking)

Condition
- Crankshaft position sensor
- Crankshaft position sensor circuit problem, pin circuits Black 4 and Black 13.
- Crankshaft position sensor/toothed wheel air gap
- Toothed wheel
- Flywheel key sheared
- ECU

Diagnostic Aid #5 FUEL PUMP
(fuel pump not turning on)

Condition
- Main fuse
- Fuel pump circuit problem, pin circuits Black 9 and Grey 17.
- Fuel pump module

Diagnostic Aid #6 IGNITION SYSTEM
(no spark)

Condition
- Spark plug
- Plug wire
- Coil
- Coil circuit(s), pin circuits Grey 10 and Black 1.
- ECU grounds
- ECU
- Vehicle safety interlocks, ground signal on safety wire.

Diagnostic Aid #7 FUEL SYSTEM ELECTRICAL
(no fuel delivery)

Condition
- No fuel
- Air in high pressure fuel line
- Fuel valve shut OFF
- Fuel filter/line plugged
- Injector circuit(s), pin circuits Black 5 and Black 6
- Injector
- ECU grounds
- ECU
- Lift pump not working

Diagnostic Aid #8 FUEL SYSTEM
(fuel pressure)

Low Fuel Pressure-Condition
- Low fuel
- Fuel filter plugged
- Fuel supply line plugged
- Lift fuel pump - insufficient fuel supply
- Fuel pump (lift or module) - internally plugged
- Pressure regulator not functioning properly inside fuel pump module.

Diagnostic Aid #9 BASIC ENGINE
(cranks but will not run)

Condition
- Refer to basic engine troubleshooting charts within Troubleshooting.

Diagnostic Aid #10 SPEED CONTROL-Analog (0-5V input)
(engine speed does not change when requested)

Condition
- Speed request voltage from OEM controller is not being received by engine. Consult OEM service information for OEM diagnostics.
- Bad connection in speed input circuit (terminal G in engine connector, red w/yellow tracer).
- Bad connection in engine connectors (ETB/equipment connector).
- Stuck/damaged ETB assembly.

Diagnostic Aid #11 SPEED CONTROL-CAN Communications
(engine speed does not change when requested)

Condition
- Speed request from OEM CAN controller is not being received by engine. Consult OEM service information for OEM diagnostics.
- Bad connection in engine connectors (ETB/equipment connector).
- Stuck/damaged ETB assembly.

Diagnostic Aid #12 ETB
(ETB does not cycle when key is switched from off to on)

Condition
- Blown power fuse
- Bad electrical connection
- Stuck throttle plate
- Defective throttle

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Do not fill fuel tank while engine is hot or running.

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.

Typical electronic fuel injection (EFI) system and related components include:

- Fuel pump module and lift pump.
- Fuel filter.
- High pressure fuel line.
- Fuel line(s).
- Fuel injectors.
- Throttle body/intake manifold.
- Electronic control unit (ECU).
- Ignition coils.
- Engine (oil) temperature sensor.
- Throttle position sensor (TPS). Earlier engines have a contacting (brushes) TPS. Later engines have a contactless (magnetic) TPS.
- Crankshaft position sensor.
- Oxygen sensor.
- Earlier engines have a separate manifold absolute pressure sensor (MAP) and an intake air temperature (IAT) sensor (located in throttle body).
- Later engines have a combined temperature/manifold absolute pressure (TMAP) sensor.
- Malfunction indicator light (MIL) - optional.
- Wire harness assembly & affiliated wiring.

FUEL RECOMMENDATIONS

Refer to Maintenance.

FUEL LINE

Low permeation fuel line must be installed on all Kohler Co. engines to maintain EPA and CARB regulatory compliance.

OPERATION

NOTE: When performing voltage or continuity tests, avoid putting excessive pressure on or against connector pins. Flat pin probes are recommended for testing to avoid spreading or bending terminals.

EFI system is designed to provide peak engine performance with optimum fuel efficiency and lowest possible emissions. Ignition and injection functions are electronically controlled, monitored and continually corrected during operation to maintain ideal air/fuel ratio.

Central component of system is Electronic Control Unit (ECU) which manages system operation, determining best combination of fuel mixture and ignition timing for current operating conditions.

A lift fuel pump is used to move fuel from tank through an in-line fuel filter and fuel line. Fuel is then pumped to fuel pump module. Fuel pump module regulates fuel pressure to a system operating pressure of 39 psi. Fuel is delivered from fuel pump module through high pressure fuel line into injectors, which inject fuel into intake ports. ECU controls amount of fuel by varying length of time that injectors are on. This can range from 2 to over 12 milliseconds depending on fuel requirements. Controlled injection of fuel occurs every other crankshaft revolution, or once for each 4-stroke cycle. When intake valve opens, air/fuel mixture is drawn into combustion chamber,compressed, ignited, and burned.

ECU controls amount of fuel being injected and ignition timing by monitoring primary sensor signals for engine temperature, speed (RPM), and throttle position (load). These primary signals are compared to preprogrammed maps in ECU computer chip, and ECU adjusts fuel delivery to match mapped values. After engine reaches operating temperature, an exhaust gas oxygen sensor provides feedback to ECU based upon amount of unused oxygen in exhaust, indicating whether fuel mixture being delivered is rich or lean. Based upon this feedback, ECU further adjusts fuel input to re-establish ideal air/fuel ratio. This operating mode is referred to as closed loop operation. EFI system operates closed loop when all three of following conditions are met:

- Oil temperature is greater than 50-60°C (122-140°F).
- Oxygen sensor has warmed sufficiently to provide a signal (minimum 400°C, 752°F).
- Engine operation is at a steady state (not starting, warming up, accelerating, etc.).

During closed loop operation ECU has ability to readjust and learn adaptive controls, providing compensation for changes in overall engine condition and operating environment, so it will be able to maintain ideal air/fuel ratio. This system requires a minimum engine oil temperature greater than 60-70°C (140-158°F) to properly adapt. These adaptive values are maintained as long as ECU is not reset.

During certain operating periods such as cold starts, warm up, acceleration, high load, etc., a richer air/fuel ratio is required and system operates in an open loop mode. In open loop operation oxygen sensor output is used to ensure engine is running rich, and controlling adjustments are based on primary sensor signals and programmed maps only. This system operates open loop whenever three conditions for closed loop operation (above) are not being met.

ECU is brain or central processing computer of entire EFI system. During operation, sensors continuously gather data which is relayed through wiring harness to input circuits within ECU. Signals to ECU include: ignition (on/off), crankshaft position and speed (RPM), throttle position, oil temperature, intake air temperature, exhaust oxygen levels, manifold absolute pressure, and battery voltage.

ECU compares input signals to programmed maps in its memory to determine appropriate fuel and spark requirements for immediate operating conditions. ECU then sends output signals to set injector duration and ignition timing.

ECU continually performs a diagnostic check of itself, each of sensors, and system performance. If a fault is detected, ECU can turn on a Malfunction Indicator Light (MIL) (if equipped) on equipment control panel, store fault code in its fault memory, and go into a default operating mode. Depending on significance or severity of fault, normal operation may continue. A technician can access stored fault code using a blink code diagnosis flashed out through MIL. An optional computer software diagnostic program is also available, see Tools and Aids.

ECU requires a minimum of 6.0 volts to operate.

To prevent engine over-speed and possible failure, a rev-limiting feature is programmed into ECU. If maximum RPM limit (4500) is exceeded, ECU suppresses injection signals, cutting off fuel flow. This process repeats itself in rapid succession, limiting operation to preset maximum.

Wiring harness used in EFI system connects electrical components, providing current and ground paths for system to operate. All input and output signaling occurs through two special all weather connectors that attach and lock to ECU. Connectors are Black and Grey and keyed differently to prevent being attached to ECU incorrectly.

Condition of wiring, connectors, and terminal connections is essential to system function and performance. Corrosion, moisture, and poor connections are as likely cause of operating problems and system errors as an actual component. Refer to Electrical System for additional information.

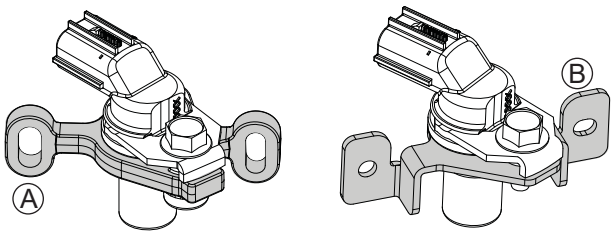
EFI system is a 12 VDC negative ground system, designed to operate down to a minimum of 6.0 volts. If system voltage drops below this level, operation of voltage sensitive components such as ECU, fuel pump, ignition coils, and injectors will be intermittent or disrupted, causing erratic operation or hard starting. A fully charged, 12 volt battery with a minimum of 350 cold cranking amps is important in maintaining steady and reliable system operation. Battery condition and state of charge should always be checked first when troubleshooting an operational problem.

Keep in mind that EFI-related problems are often caused by wiring harness or connections. Even small amounts of corrosion or oxidation on terminals can interfere with milliamp currents used in system operation.

Cleaning connectors and grounds will solve problems in many cases. In an emergency situation, simply disconnecting and reconnecting connectors may clean up contacts enough to restore operation, at least temporarily.

If a fault code indicates a problem with an electrical component, disconnect ECU connector and test for continuity between component connector terminals and corresponding terminals in ECU connector using an ohmmeter. Little or no resistance should be measured, indicating that wiring of that particular circuit is OK.

Crankshaft Position Sensor Bracket



A	Earlier Design Bracket	**B**	Later Design Bracket

Crankshaft position sensor is essential to engine operation; constantly monitoring rotation and speed (RPM) of crankshaft. There are 23 consecutive teeth cast into flywheel. One tooth is missing and is used to reference crankshaft position for ECU. Inductive crankshaft position sensor with earlier design bracket is mounted 0.20-0.70 mm (0.008-0.027 in.) from flywheel. Later design bracket requires no adjustment.

During rotation, an AC voltage pulse is created within sensor for each passing tooth. ECU calculates engine speed from time interval between consecutive pulses. Gap from missing tooth creates an interrupted input signal, corresponding to specific crankshaft position near BDC for cylinder #1. This signal serves as a reference for control of ignition timing by ECU. Synchronization of inductive speed pickup and crankshaft position takes place during first two revolutions each time engine is started. Sensor must be properly connected at all times. If sensor becomes disconnected for any reason, engine will quit running.

Throttle position sensor (TPS) is used to indicate throttle plate angle to ECU. Since throttle (by way of governor) reacts to engine load, angle of throttle plate is directly related to load on engine.

Mounted on throttle body and operated directly off end of throttle shaft, TPS works as a potentiometer, varying voltage signal to ECU in direct correlation to angle of throttle plate. This signal, along with other sensor signals, is processed by ECU and compared to internal preprogrammed maps to determine required fuel and ignition settings for amount of load.

Correct position of TPS is established and set at factory. Do not loosen TPS or alter mounting position unless absolutely required by fault code diagnosis. If TPS is loosened or repositioned, appropriate TPS Learn Procedure must be performed to re-establish baseline relationship between ECU and TPS.

Engine (oil) temperature sensor is used by system to help determine fuel requirements for starting (a cold engine needs more fuel than one at or near operating temperature).

Mounted in breather cover, it has a temperature-sensitive resistor that extends into oil flow. Resistance changes with oil temperature, altering voltage sent to ECU. Using a table stored in its memory, ECU correlates voltage drop to a specific temperature. Using fuel delivery maps, ECU then knows how much fuel is required for starting at that temperature.

Earlier engines have a separate intake air temperature (IAT) sensor (located in throttle body) and a manifold absolute pressure (MAP) sensor. Later engines have a combined temperature/manifold absolute pressure (TMAP) sensor.

Intake Air Temperature (IAT) sensor is a thermally sensitive resistor that exhibits a change in electrical resistance with a change in its temperature. When sensor is cold, resistance of sensor is high. As sensor warms up, resistance drops and voltage signal increases. From voltage signal, ECU can determine temperature of intake air.

Purpose of an air temperature sensor is to help ECU calculate air density. Higher air temperature less dense air becomes. As air becomes less dense ECU knows that it needs to lessen fuel flow to achieve correct air/fuel ratio. If fuel ratio was not changed engine would become rich, possibly losing power and consuming more fuel.

Manifold absolute pressure (MAP) sensor provides immediate manifold pressure information to ECU. MAP measures difference in pressure between outside atmosphere and vacuum level inside intake manifold and monitors pressure in manifold as primary means of detecting load. Data is used to calculate air density and determine engine's mass air flow rate, which in turn determines required ideal fueling. MAP also stores instant barometric pressure reading when key is turned ON.

Later engines have a Temperature/Manifold Absolute Pressure (TMAP) sensor. This is an integrated sensor that checks both intake air temperature and manifold absolute pressure. This combined sensor is located in intake manifold.

Oxygen sensor functions like a small battery, generating a voltage signal to ECU based upon difference in oxygen content between exhaust gas and ambient air.

Tip of sensor, protruding into exhaust gas, is hollow. Outer portion of tip is surrounded by exhaust gas, with inner portion exposed to ambient air. When oxygen concentration on one side of tip is different than that of other side, a voltage signal up to 1.0 volt is generated and sent to ECU. Voltage signal tells ECU if engine is straying from ideal fuel mixture, and ECU then adjusts injector pulse accordingly.

Oxygen sensor functions after being heated to a minimum of 400°C (752°F). A heater inside sensor heats electrode to optimum temperature in about 10 seconds. Oxygen sensor receives ground through wire, eliminating need for proper grounding through muffler. If problems indicate a bad oxygen sensor, check all connections and wire harness. Oxygen sensor can also be contaminated by leaded fuel, certain RTV and/or other silicone compounds, fuel injector cleaners, etc. Use only those products indicated as O2 Sensor Safe.

Fuel injectors mount into intake manifold, and high pressure fuel line attaches to them at top end. Replaceable O-rings on both ends of injector prevent external fuel leakage and also insulate it from heat and vibration. A special clip connects each injector to high pressure fuel line and holds it in place. O-rings and retaining clip must be replaced any time fuel injector is separated from its normal mounting position.

When key switch is on, fuel pump module will pressurize high pressure fuel line to 39 psi, and voltage is present at injector. At proper instant, ECU completes ground circuit, energizing injector. Valve needle in injector is opened electromagnetically, and pressure in high pressure fuel line forces fuel down through inside. Director plate at tip of injector contains a series of calibrated openings which directs fuel into manifold in a cone-shaped spray pattern.

Injectors have sequential fueling that open and close once every other crankshaft revolution. Amount of fuel injected is controlled by ECU and determined by length of time valve needle is held open, also referred to as injection duration or pulse width. Time injector is open (milliseconds) may vary in duration depending on speed and load requirements of engine.

A high-voltage, solid-state, battery ignition system is used with EFI system. ECU controls ignition output and timing through transistorized control of primary current delivered to coils. Based on input from crankshaft position sensor, ECU determines correct firing point for speed at which engine is running. At proper instant, it interrupts flow of primary current in coil, causing electromagnetic flux field to collapse. Flux collapse induces an instantaneous high voltage in coil secondary which is strong enough to bridge gap on spark plug. Each coil fires every other revolution.

EFI engines are equipped with either a 20 or 25 amp charging system to accommodate combined electrical demands of ignition system and specific application. Charging system troubleshooting information is provided in Electrical System.

An electric fuel pump module and a lift pump (two types) are used to transfer fuel in EFI system. Types of lift pumps are: a pulse fuel pump, a mechanical fuel pump, or a low pressure electric fuel pump. Pumping action is created by either oscillation of positive and negative pressures within crankcase through a hose, or by direct lever/pump actuation off rocker arm movement. Pumping action causes diaphragm on inside of pump to pull fuel in on its downward stroke and to push it into fuel pump module on its upward stroke. Internal check valves prevent fuel from going backward through pump. Fuel pump module receives fuel from lift pump, increases and regulates pressure for fuel injectors.

Fuel pump module is rated for a minimum output of 13.5 liters per hour and regulated at 270 kilopascals (39 psi).

When key switch is turned ON and all safety switch requirements are met, ECU activates fuel pump module for about six seconds, which pressurizes system for start-up. If key switch is not promptly turned to start position, engine fails to start, or engine is stopped with key switch ON (as in case of an accident), ECU switches off pump preventing continued delivery of fuel. In this situation, MIL will go on, but it will go back off after 4 cranking revolutions if system function is OK. Once engine is running, fuel pump remains on.

Precision components inside fuel pump module are not serviceable. DO NOT attempt to open fuel pump module. Damage to components will result and warranty will be void. Because fuel pump module is not serviceable, engines are equipped with a special 10-micron EFI fuel filter to prevent harmful contamination from entering module.

If there are two filters in system, one before lift pump will be a standard 51-75 micron filter, and one after lift pump will be special 10-micron filter. Be sure to use an approved 10-micron filter for replacement.

High pressure fuel line is an assembly of hoses, injector caps and a fuel connector to fuel pump module. High pressure fuel line feeds fuel to top of injectors through injector caps. Caps are fastened to intake manifold and injectors are locked into place. A small retaining clip provides a secondary lock.

High pressure fuel line is serviced as a complete assembly to prevent tampering and safety hazards. Components are not individually serviceable.

Vent hose assembly is intended to vent fuel vapor out of fuel pump module and direct fuel vapor into throttle body. Most EFI engines are equipped with an engine mounted purge port on #2 cylinder barrel baffle. This capped purge port can be used by OEM to vent fuel tanks or used in conjunction with a carbon canister kit for Tier III evaporative emissions compliance. Purge port connects to vent hose assembly and directs all fuel vapor into throttle body. If purge port remains unused, port must remain capped to prevent dirt from entering engine.

EFI engines have no carburetor, so throttle function (regulate incoming combustion airflow) is achieved with a throttle valve in a separate throttle body attached to intake manifold. Throttle body/intake manifold provides mounting for fuel injectors, throttle position sensor, either a separate MAP sensor and an intake air temperature (IAT) sensor, or a TMAP sensor, high pressure fuel line, idle speed screw, and air cleaner assembly.

Idle speed is only adjustment that may be performed on EFI system. Standard idle speed setting for EFI engines is 1500 RPM, but certain applications might require a different setting. Check equipment manufacturer's recommendation.

For starting and warm up, ECU will adjust fuel and ignition timing, based upon ambient temperature, engine temperature, and loads present. In cold conditions, idle speed will probably be different than normal for a few moments. Under other conditions, idle speed may actually start lower than normal, but gradually increase to established setting as operation continues. Do not attempt to circumvent this warm up period, or readjust idle speed during this time. Engine must be completely warmed up, in closed loop operating mode for accurate idle adjustment.

IMPORTANT NOTES!

- Cleanliness is essential and must be maintained at all times when servicing or working on EFI system. Dirt, even in small quantities, can cause significant problems.
- Clean any joint or fitting with parts cleaning solvent before opening to prevent dirt from entering system.
- Always depressurize fuel system through fuel connector on fuel pump module before disconnecting or servicing any fuel system components.
- Never attempt to service any fuel system component while engine is running or ignition switch is ON.
- Do not use compressed air if system is open. Cover any parts removed and wrap any open joints with plastic if they will remain open for any length of time. New parts should be removed from their protective packaging just prior to installation.
- Avoid direct water or spray contact with system components.
- Do not disconnect or reconnect ECU wiring harness connector or any individual components with ignition on. This can send a damaging voltage spike through ECU.
- Do not allow battery cables to touch opposing terminals. When connecting battery cables attach positive (+) cable to positive (+) battery terminal first, followed by negative (-) cable to negative (-) battery terminal.
- Never start engine when cables are loose or poorly connected to battery terminals.
- Never disconnect battery while engine is running.
- Never use a quick battery charger to start engine.
- Do not charge battery with key switch ON.
- Always disconnect negative (-) battery cable before charging battery, and also unplug harness from ECU before performing any welding on equipment.

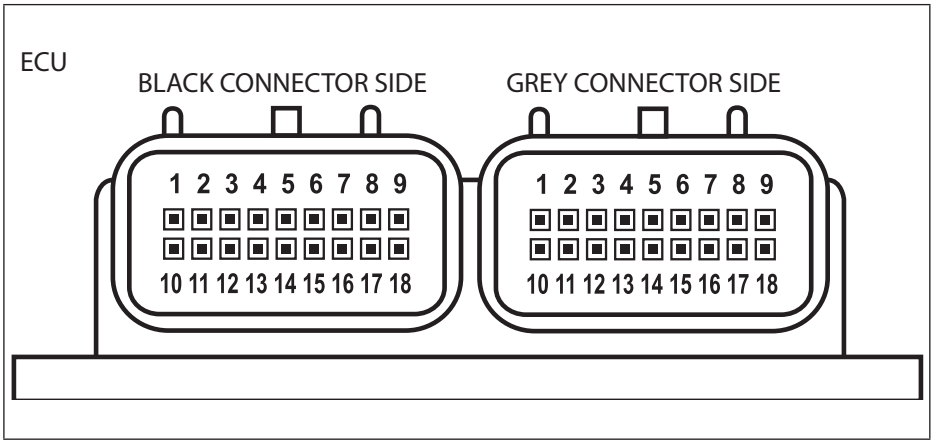
ELECTRICAL COMPONENTS

Electronic Control Unit (ECU)

Pinout of ECU

Black Connector Side	
Pin #	**Function**
1	Ignition Coil #1 Ground
2	Battery Ground
3	Diagnostic Communication Line
4	Speed Sensor input
5	Fuel Injector Output #1 Ground
6	Fuel Injector Output #2 Ground
7	Oxygen Sensor Heater
8	Intake Air Temperature (IAT) sensor or TMAP sensor input
9	Fuel Pump Ground
10	Ground for TPS, IAT and MAP sensors or TMAP sensor, O2 and Oil sensors
11	MAP sensor or TMAP sensor input
12	Throttle Position Sensor (TPS) input
13	Speed Sensor Ground
14	Oil Temperature Sensor input
15	Ignition Switch (Switched +12V)
16	Power for TPS sensor, MAP sensor or TMAP sensor (+5V)
17	Oxygen Sensor (O2) input
18	Battery Power (Permanent +12V)

Grey Connector Side	
Pin #	**Description**
1	Not Used
2	Not Used
3	Malfunction Indicator Light (MIL) Ground
4	Not Used
5	Not Used
6	Not Used
7	Not Used
8	Not Used
9	Battery Ground
10	Ignition Coil #2 Ground
11	Not Used
12	Not Used
13	Not Used
14	Safety Switch Ground
15	Not Used
16	ECU
17	Fuel Pump Control (+12V)
18	Not Used



Pinout of ECU

Never attempt to disassemble ECU. It is sealed to prevent damage to internal components. Warranty is void if case is opened or tampered with in any way.

All operating and control functions within ECU are preset. No internal servicing or readjustment may be performed. If a problem is encountered, and you determine ECU to be faulty, contact your source of supply.

ECU pins are coated at factory with a thin layer of electrical grease to prevent fretting and corrosion. Do not attempt to remove grease from ECU pins.

Relationship between ECU and throttle position sensor (TPS) is very critical to proper system operation. If TPS or ECU is changed, or mounting position of TPS is altered, appropriate TPS Learn Procedure must be performed to restore synchronization.

Any service to ECU, TPS/Throttle Body (including idle speed increase over 300 RPM), or fuel pump module replacement should include ECU Reset.

This will clear all trouble codes, all closed loop learned offsets, all max values, and all timers besides permanent hour meter.

This system will NOT reset when battery is disconnected!

ECU Reset Procedure

1. Turn key/ignition OFF.
2. Install Red wire jumper from Kohler EFI service kit on to service port (connect white wire to black wire in 4 way diagnostic port).
3. Turn key/ignition ON, then OFF and count 10 seconds.
4. Turn key/ignition ON, then OFF and count to 10 seconds a second time.
5. Remove Red wire jumper. Turn key/ignition ON, then OFF and count to 10 seconds a third time. ECU is reset.

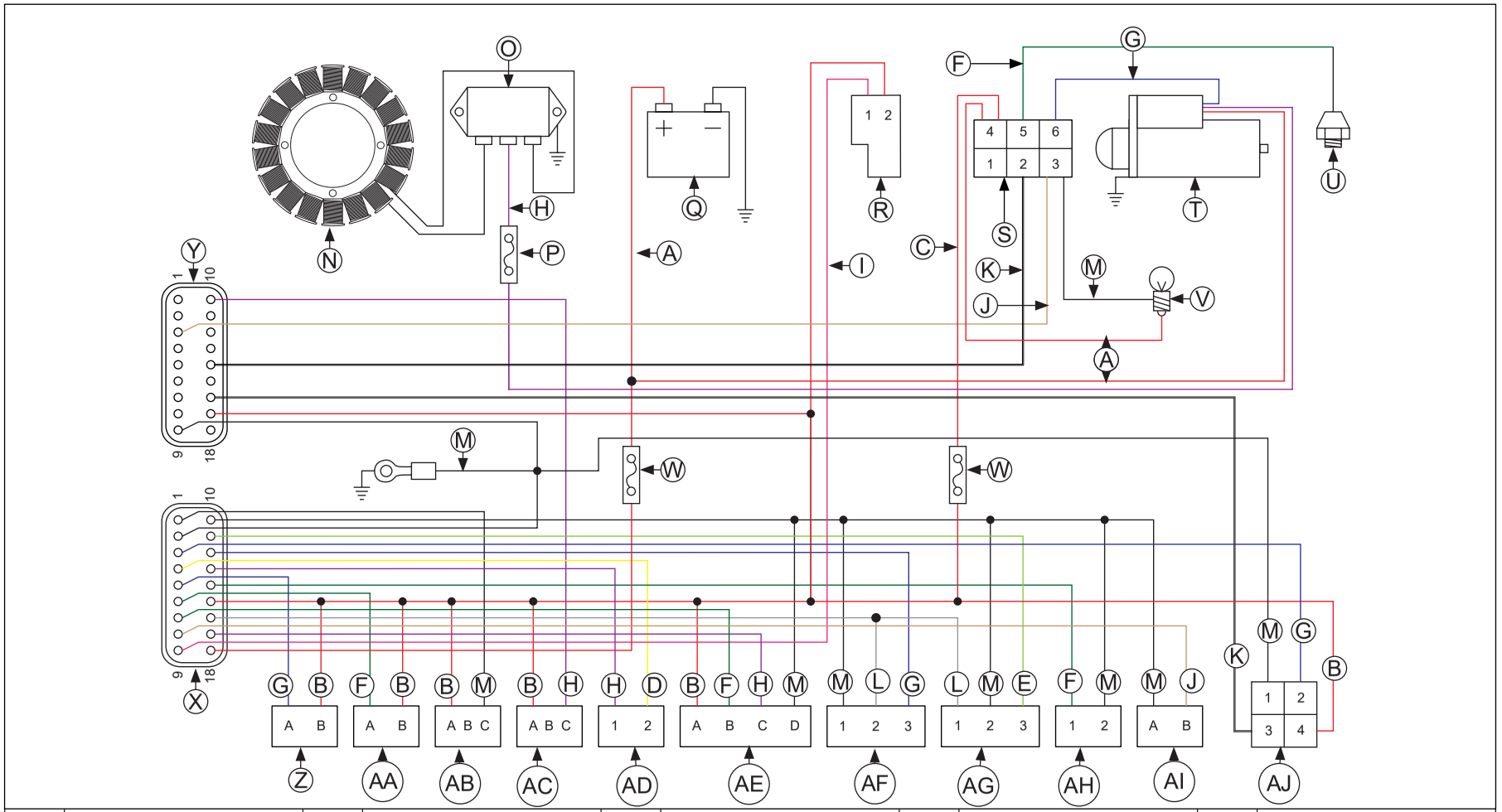
A TPS Learn Procedure **must** be performed after ECU Reset.

TPS Learn Procedure

1. Turn idle screw clockwise one full turn prior to key/ignition ON after ECU Reset.
2. Start engine, run at low idle until engine is warm.
3. Idle speed must be above 1500 RPM. If below 1500 RPM, turn idle screw up to 1700 RPM and then shut down engine and perform ECU Reset again.
4. Adjust idle speed down to 1500 RPM. Allow engine to dwell at 1500 RPM for about 3 seconds.
5. After this, adjust idle speed to final specified speed setting.
6. Turn key/ignition OFF and count to 10 seconds.

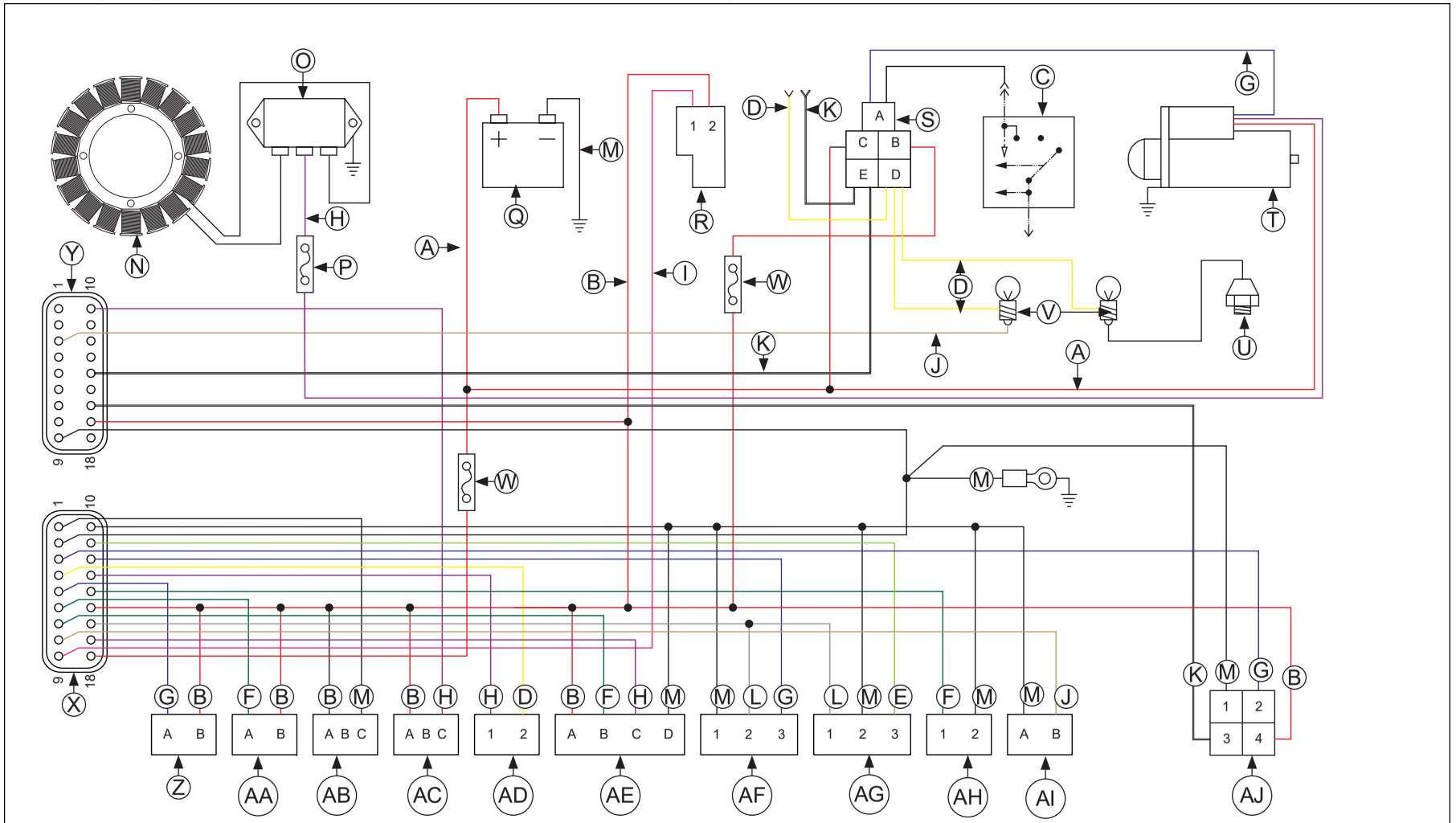
Learn procedure is complete.

EFI Wiring Diagram 6-Terminal Connector (engines with separate MAP sensor and intake air temperature sensor)



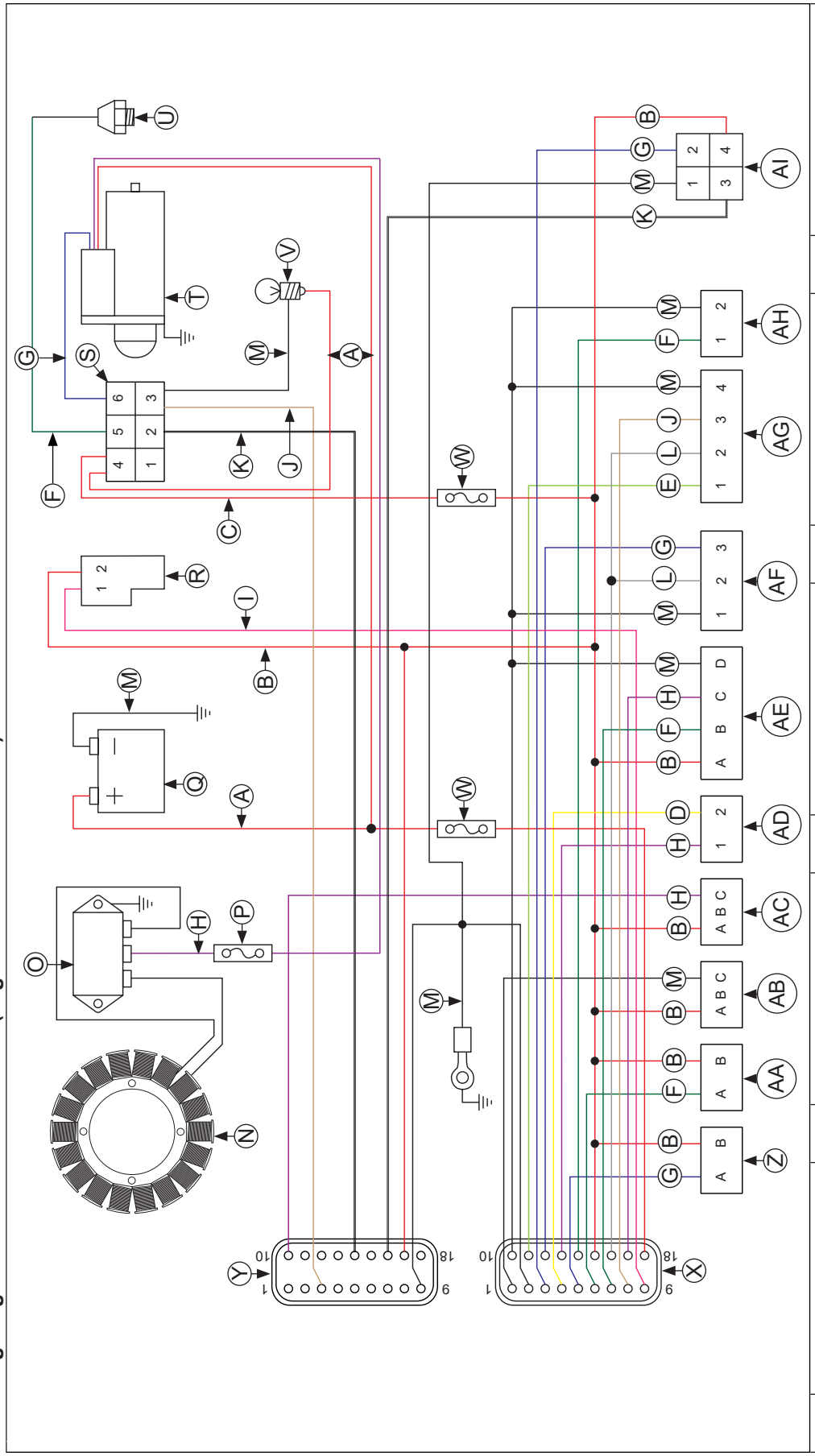
A	Red	**B**	Red/Black	**C**	Red/White	**D**	Yellow	**E**	Light Green
F	Dark Green	**G**	Dark Blue	**H**	Purple	**I**	Pink	**J**	Tan
K	White	**L**	Grey	**M**	Black	**N**	Stator	**O**	Rectifier-Regulator
P	30A Fuse	**Q**	Battery	**R**	Fuel Pump	**S**	6-Terminal Connector	**T**	Starter Motor
U	Oil Pressure Switch	**V**	MIL	**W**	10A Fuse	**X**	Black Connector	**Y**	Grey Connector
Z	Fuel Injector #1	**AA**	Fuel Injector #2	**AB**	Ignition Coil #1	**AC**	Ignition Coil #2	**AD**	Crankshaft Position Sensor
AE	Oxygen Sensor	**AF**	Throttle Position Sensor	**AG**	Manifold Absolute Pressure Sensor	**AH**	Oil Temperature Sensor	**AI**	Intake Air Temperature Sensor
AJ	Diagnostic Connector								

EFI Wiring Diagram 5-Terminal Connector and Optional Key Switch (engines with separate MAP sensor and intake air temperature sensor)



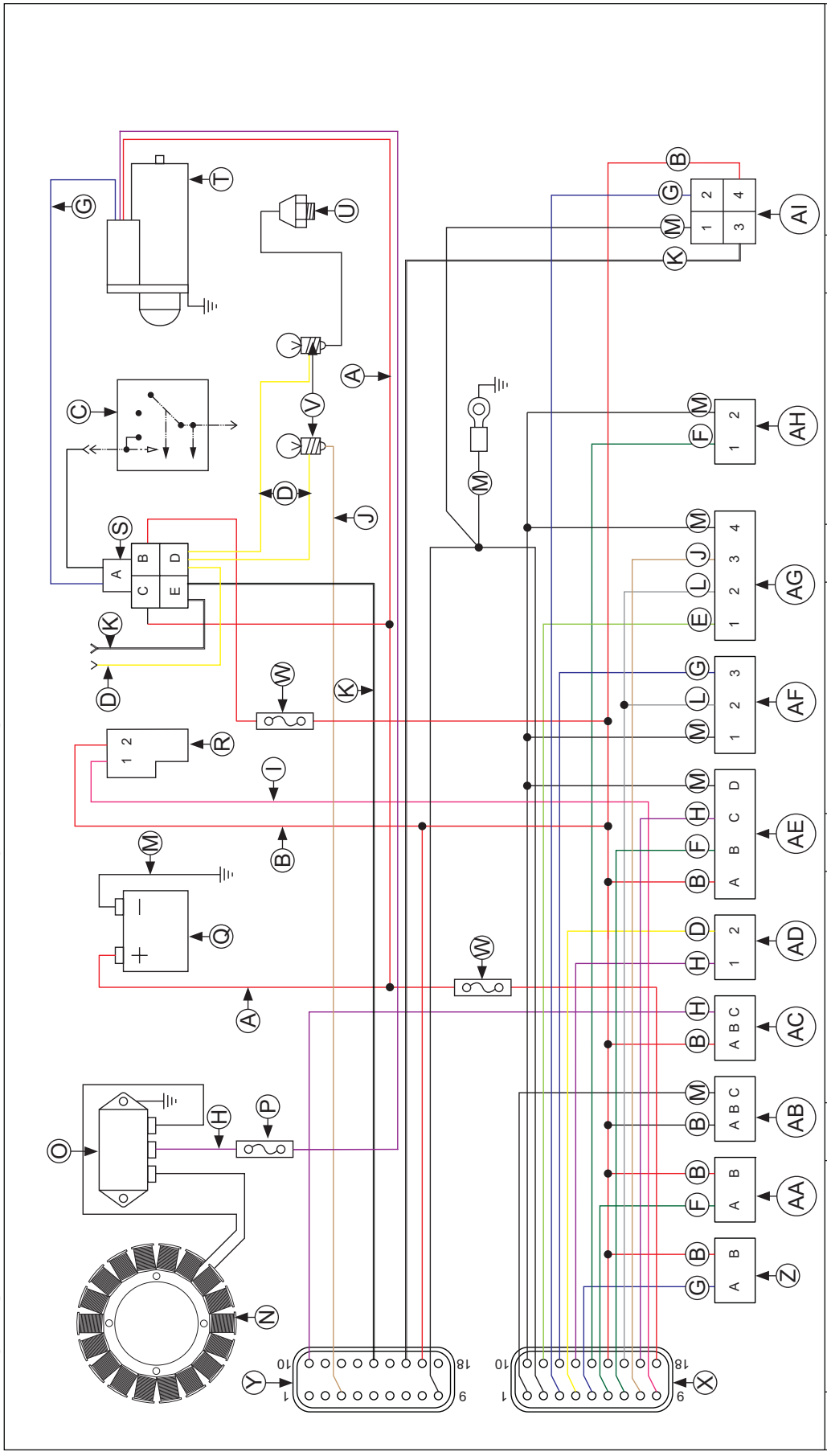
A	Red	**B**	Red/Black	**C**	Red/White	**D**	Yellow	**E**	Light Green
F	Dark Green	**G**	Dark Blue	**H**	Purple	**I**	Pink	**J**	Tan
K	White	**L**	Grey	**M**	Black	**N**	Stator	**O**	Rectifier-Regulator
P	30A Fuse	**Q**	Battery	**R**	Fuel Pump	**S**	5-Terminal Connector	**T**	Starter Motor
U	Oil Pressure Switch	**V**	MIL	**W**	10A Fuse	**X**	Black Connector	**Y**	Grey Connector
Z	Fuel Injector #1	**AA**	Fuel Injector #2	**AB**	Ignition Coil #1	**AC**	Ignition Coil #2	**AD**	Crankshaft Position Sensor
AE	Oxygen Sensor	**AF**	Throttle Position Sensor	**AG**	Manifold Absolute Pressure Sensor	**AH**	Oil Temperature Sensor	**AI**	Intake Air Temperature Sensor
AJ	Diagnostic Connector								

EFI Wiring Diagram 6-Terminal Connector (engines with TMAP sensor)



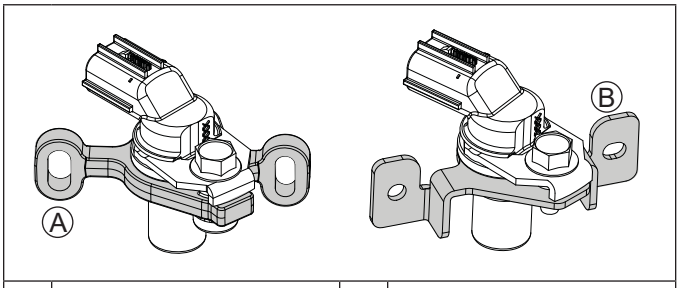
A	Red	B	Red/Black	C	Red/White	D	Yellow	E	Light Green		
F	Dark Green	G	Dark Blue	H	Purple	I	Pink	J	Tan		
K	White	L	Grey	M	Black	N	Stator	O	Rectifier-Regulator		
P	30A Fuse	Q	Battery	R	Fuel Pump	S	6-Terminal Connector	T	Starter Motor		
U	Oil Pressure Switch	V	MIL (Optional)	W	10A Fuse	X	Black Connector	Y	Grey Connector		
Z	Fuel Injector #1	AA	Fuel Injector #2	AB	Ignition Coil #1	AC	Ignition Coil #2	AD	Crankshaft Position Sensor		
AE	Oxygen Sensor	AF	Throttle Position Sensor	AG	TMAP Sensor	AH	Oil Temperature Sensor	AI	Diagnostic Connector		

EFI Wiring Diagram 5-Terminal Connector and Optional Key Switch (engines with TMAP sensor)



A	Red	**B**	Red/Black	**C**	Red/White	**D**	Yellow	**E**	Light Green
F	Dark Green	**G**	Dark Blue	**H**	Purple	**I**	Pink	**J**	Tan
K	White	**L**	Grey	**M**	Black	**N**	Stator	**O**	Rectifier-Regulator
P	30A Fuse	**Q**	Battery	**R**	Fuel Pump	**S**	5-Terminal Connector	**T**	Starter Motor
U	Oil Pressure Switch	**V**	MIL (Optional)	**W**	10A Fuse	**X**	Black Connector	**Y**	Grey Connector
Z	Fuel Injector #1	**AA**	Fuel Injector #2	**AB**	Ignition Coil #1	**AC**	Ignition Coil #2	**AD**	Crankshaft Position Sensor
AE	Oxygen Sensor	**AF**	Throttle Position Sensor	**AG**	TMAP Sensor	**AH**	Oil Temperature Sensor	**AI**	Diagnostic Connector

Crankshaft Position Sensor



A	Earlier Design Bracket	B	Later Design Bracket

A sealed, non-serviceable assembly. If Fault Code diagnosis indicates a problem within this area, test and correct as follows.

1. Check mounting and air gap of crankshaft position sensor.

   Earlier design bracket has slots to set air gap of 0.20-0.70 mm (0.008-0.027 in.).

   Later design bracket is not adjustable, but if gap is greater than 2.794 mm (0.110 in.) check bracket or sensor for damage.
2. Inspect wiring and connections for damage or problems.
3. Make sure engine has resistor type spark plugs.
4. Disconnect Black connector from ECU.
5. Connect an ohmmeter between #4 and #13 pin terminals. A resistance value of 325-395 Ω at room temperature (20°C, 68°F) should be obtained. If resistance is correct, check mounting, air gap, flywheel teeth (damage, run-out, etc.), and flywheel key.
6. Disconnect crankshaft position sensor connector from wiring harness. Test resistance between terminals. A reading of 325-395 Ω should again be obtained.
   a. If resistance is incorrect, remove screws securing sensor to mounting bracket and replace sensor.
   b. If resistance in step 5 was incorrect, but resistance of sensor alone was correct, test wire harness circuits between sensor connector terminals and corresponding pin terminals (#4 and #13) in main connector. Correct any observed problem, reconnect sensor, and perform step 5 again.
7. When fault is corrected and engine starts, clear fault codes following ECU Reset procedure.

Throttle Position Sensor (TPS)

Earlier engines were built with a contacting (brush) type TPS. Later engines are built with a contactless (magnet) type TPS. Both designs have same three wires attached; a 5 volt supply, a ground, and a signal wire. However, these designs are not interchangeable. Follow proper testing information based on sensor type.

Contacting (Brush) Type TPS Resistance Table

Throttle Position	Between Terminal	Resistance Value (Ω)	Continuity
Closed	A & C	1400-1800	Yes
Full with Stop Pin	A & C	3200-4100	Yes
Full without Stop Pin	A & C	4600-5200	Yes
Any	A & B	3000-7000	Yes

TPS is a sealed, non-serviceable assembly. If diagnosis indicates a bad sensor, complete replacement is necessary. If a blink code indicates a problem with TPS, it can be tested as follows:

1. Counting number of turns, back out idle speed adjusting screw (counterclockwise) until throttle plates can be closed completely. Write this number down for reference later.
2. Disconnect Black connector from ECU, but leave TPS mounted to throttle body.
3. a. Use an ohmmeter and connect red (positive) ohmmeter lead to Black pin 12 terminal and black (negative) ohmmeter lead to Black pin 10 terminal to test.
   b. Hold throttle closed and check resistance. It should be 1400-1800 Ω.
4. Leave leads connected to pin terminals as described in step 3. Rotate throttle shaft slowly to full throttle position. Monitor dial during rotation for indication of any momentary short or open circuits. Note resistance at full throttle position. It should be 4600-5200 Ω without a stop pin, or 3200-4100 Ω with a stop pin.
5. Disconnect main wiring harness connector from TPS, leaving TPS assembled to throttle body. Refer to Resistance Table and perform resistance checks indicated between terminals in TPS switch, with throttle in positions specified.

   If resistance values in steps 3, 4, and 5 are within specifications, go to step 6.

   If resistance values are not within specifications, or a momentary short or open circuit was detected during rotation (step 4), TPS needs to be replaced, go to step 7.
6. Check TPS circuits (input, ground) between TPS plug and main harness connector for continuity, damage, etc. Input pin is 12 and ground is pin 10.
   a. Repair or replace as required.
   b. Turn idle speed screw back in to its original setting.
   c. Reconnect connector plugs, start engine and retest system operation.

7. Remove two mounting screws from TPS. Save screws for reuse. Remove and discard faulty TPS. Install replacement TPS and secure with original mounting screws.
   a. Reconnect Black and TPS connector plugs.
   b. Perform TPS Learn Procedure integrating new sensor to ECU.

Contactless (Magnet) Type TPS

TPS is a sealed, non-serviceable assembly. If diagnosis indicates a bad sensor, complete replacement is necessary. Magnet that sensor detects is separate, and can be replaced or reused. If a blink code indicates a problem with TPS, it can be tested as follows:

Diagnostics of sensor: ECU will still have electrical faults captured in fault codes: P0122 & P0123. These electrical faults still have same meaning as with prior sensor, P0122 detecting low voltage, open circuit, and P0123 for high voltage conditions between ECU, wire harness, and sensor. Tip: when working with any electrical connection, remember to keep connections clean & dry. This is best accomplished by cleaning connection thoroughly prior to disassembly. Contaminated sensor connections can cause premature engine faults. Functionally testing sensor can no longer be done with simple resistance checks. If either of these two faults is present or a TPS fault is suspected, recommended diagnostic test is as follows:

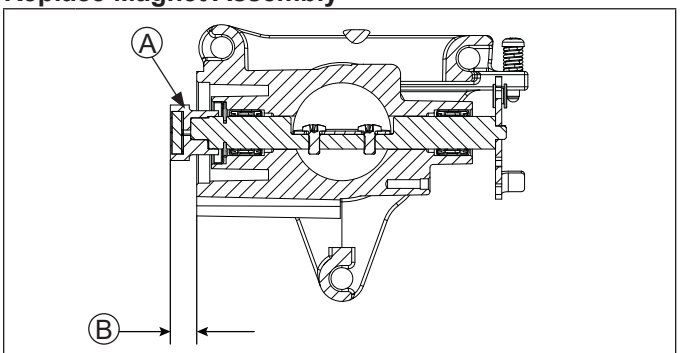
If a computer with diagnostic software is available

Observe throttle percent and raw TPS values through diagnostic software. With diagnostic software communicating to ECU and key ON engine not running, these values can be observed while throttle is moved from closed to full open position. There should be a smooth and repeatable throttle percent value starting at closed position reading between 0 (about 6.5%) to WOT position reading 93 (100%). If one of these values is outside of specified range and output transitions in a smooth manner, reset ECU and run test again. Since there is no longer any wear elements inside sensor, most likely faults will be in electrical connections between sensor and wire harness and wire harness to ECU. With service software communicating to ECU and engine not running, a small load or gentle back and forth motion can be applied to connectors or wires just outside connectors to detect a faulty connection.

If only a volt meter is available

Measure voltage supply to sensor from ECU. This voltage should be 5.00 +/- 0.20 volts. This can be measured by gently probing terminals B & C on harness side with TPS connector removed from TPS and key ON. This will generate a P0122 fault that can be cleared with an ECU reset. If voltage is low, battery, harness and ECU should be investigated. If supply voltage is good, plug sensor back into harness. Probe sensor signal wire with volt meter, terminal A at TPS or pin Black 12 at ECU. This signal should start between 0.6-1.2 volts at low idle and grow smoothly as throttle is opened to 4.3-4.8 volts at full open (WOT). Since there is no longer any wear elements inside sensor, most likely faults will be in electrical connections between sensor and wire harness and wire harness to ECU.

Replace Magnet Assembly



A	Magnet Assembly	**B**	Magnet Installation Depth

Magnet assembly is captured in a small plastic housing that is press fit to end of throttle shaft. This generally does not need replacement. If replacement is required, can be replaced as follows:

1. Remove sensor from throttle body, exposing round magnet assembly.
2. A pair of flat blade screw drivers or a spanner tool can be used to pry this off shaft. Caution should be used to avoid damage to machined flat surface that sensor seals against. Also, make sure throttle blade is in full open position to avoid driving throttle blade into throttle bore causing damage to blade and/or bore.
3. When replacing magnet assembly, alignment is critical. There is a D-shaped drive feature on end of shaft and a matching pocket in magnet assembly. On outer diameter of magnet assembly is a notch that aligns with center of flat feature of D. Align this notch and flat of D feature in shaft and preassemble parts.
4. With throttle blade in full open position (WOT), press magnet assembly fully on to throttle shaft. Full insertion can be checked by measuring height from throttle body sensor mounting face to end of magnet assembly. This should be no more than 8.6 mm (0.338 in.). Installation process requires significant force, so take care that all parts are aligned. Tapping magnet assembly on can fracture/damage brittle magnet within assembly and throttle body assembly and is NOT RECOMMENDED.

Engine (Oil) Temperature Sensor

A sealed, non-serviceable assembly. A faulty sensor must be replaced. If a blink code indicates a problem with temperature sensor, it can be tested as follows:

1. Remove temperature sensor from breather cover and cap or block sensor hole.
2. Wipe sensor clean and allow it to reach room temperature (25°C, 77°F).
3. Unplug Black connector from ECU.
4. With sensor still connected, check temperature sensor circuit resistance between Black pin 10 and 14 terminals. Value should be 9000-11000 Ω.
5. Unplug sensor from wire harness and check sensor resistance separately across two pins. Resistance value should again be 9000-11000 Ω.
   a. If resistance is out of specifications, replace temperature sensor.
   b. If it is within specifications, proceed to Step 6.
6. Check circuits (input, ground), from wire harness connector to sensor plug for continuity, damage, etc. Connect one ohmmeter lead to Black pin 14 in wire harness connector (as in step 4). Connect other lead to terminal #1 in sensor plug. Continuity should be indicated. Repeat test between Black pin 10 and terminal #2 in sensor plug.

Earlier engines have a separate intake air temperature (IAT) sensor (located in throttle body) and a manifold absolute pressure (MAP) sensor (located in intake manifold).

Intake Air Temperature Sensor

A non-serviceable component. Complete replacement is required if it is faulty. Sensor and wiring harness can be checked as follows.

1. Remove temperature sensor from throttle body.
2. Allow it to reach room temperature (20°C, 68°F).
3. Unplug Black connector from ECU.
4. With sensor still connected, check temperature sensor circuit resistance between Black pin 10 and 8 pin terminals. Value should be 3100-3900 Ω.
5. Unplug sensor from wire harness and check sensor resistance separately across two pins. Resistance value should again be 3100-3900 Ω.
   a. If resistance is out of specifications, replace temperature sensor.
   b. If it is within specifications, proceed to Step 6.
6. Check circuits (input, ground), from main harness connector to sensor plug for continuity, damage, etc. Connect one ohmmeter lead to Black pin 8 in main harness connector (as in step 4). Connect other lead to terminal #1 in sensor plug. Continuity should be indicated. Repeat test between Black pin 10 and terminal #2 in sensor plug.

Manifold Absolute Pressure Sensor (MAP)

A sealed, non-serviceable assembly. A faulty sensor must be replaced. If a blink code indicates a problem with manifold absolute pressure sensor, it can be tested as follows:

1. Make sure all connections are making proper contact and are free of dirt and debris. Remove blower housing. Slide locking tab out and pull off manifold absolute pressure connector. Turn key switch to ON and check with a volt meter by contacting red lead to pin 1 and black lead to pin 2. There should be 5 volts present, indicating ECU and wiring harness are functioning.
2. Check continuity in wire harness. Ohms between Pin 3 at sensor connector and Black pin 11 connector at ECU should be near zero ohms. If no continuity is measured or very high resistance, replace wire harness.
3. Check to make sure intake manifold is not loose and MAP sensor is not loose. Loose parts would allow a vacuum leak, making MAP sensor report misleading information to ECU.
   a. Tighten all hardware and perform an ECU Reset and a TPS Learn Procedure to see if MIL will display a fault with MAP sensor again. If MIL finds a fault with MAP sensor, replace it.

Later engines have a combined temperature/ manifold absolute pressure (TMAP) sensor (located in intake manifold).

Temperature/Manifold Absolute Pressure (TMAP) Sensor

A sealed non-serviceable integrated sensor that checks both intake air temperature and manifold absolute pressure. Complete replacement is required if it is faulty. Sensor and wiring harness can be checked as follows.

If a blink code indicates a problem with Intake Air Temperature (TMAP) Sensor Circuit (P0112 or P0113), it can be tested as follows:

1. Remove TMAP sensor from intake manifold.
2. Allow it to reach room temperature (20°C, 68°F).
3. Unplug Black connector from ECU.
4. With sensor still connected, check temperature sensor circuit resistance between Black pin 10 and 8 pin terminals. Value should be 1850-2450 Ω.
5. Unplug sensor from wire harness and check sensor resistance separately across pin. Resistance value should again be 1850-2450 Ω.
   a. If resistance is out of specifications, check local temperature. Sensor resistance will go down as temperature is higher. Replace TMAP sensor if determined to be faulty.
   b. If it is within specifications, proceed to Step 6.

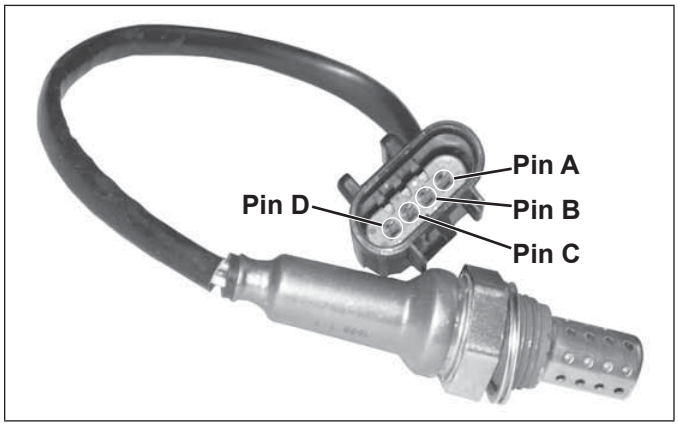
6. Check circuits (input, ground), from main harness connector to sensor plug for continuity, damage, etc. Connect one ohmmeter lead to Black pin 8 in main harness connector (as in step 4). Connect other lead to terminal #3 in sensor plug. Continuity should be indicated. Repeat test between Black pin 10 and terminal #4 in sensor plug.
7. Reinstall sensor.

If a blink code indicates a problem with Manifold Absolute Pressure (TMAP) Sensor Circuit (P0107 or P0108), it can be tested as follows:

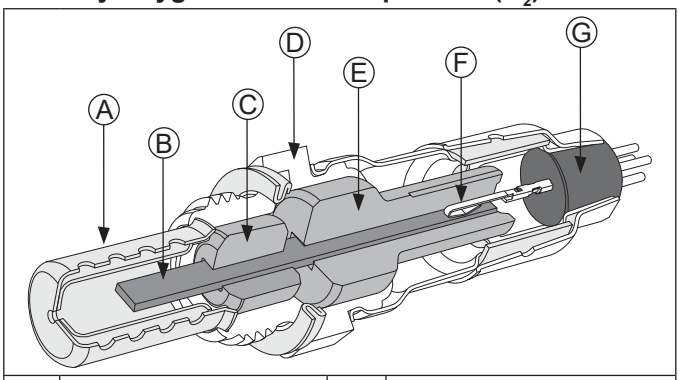
1. Make sure all connections are making proper contact and are free of dirt and debris. Slide locking tab out and pull off TMAP connector. Turn key switch to ON and check with a volt meter by contacting red lead to pin 1 and black lead to pin 2. There should be 5 volts present, indicating ECU and wiring harness are functioning.
2. Check continuity in wire harness. Ohms between Pin 3 at sensor connector and Black pin 11 connector at ECU should be near zero ohms. If no continuity is measured or very high resistance, replace wire harness.
3. Check to make sure intake manifold is not loose and TMAP sensor is not loose. Loose parts would allow a vacuum leak, making TMAP sensor report misleading information to ECU.
   a. Tighten all hardware and perform an ECU Reset and a TPS Learn Procedure to see if MIL will display a fault with sensor again. If MIL finds a fault with TMAP sensor, replace it.

Oxygen Sensor (O_2)

Components



Cutaway Oxygen Sensor Components (O_2)



A	Protection Shield	**B**	Planar Element and Heater
C	Lower Insulator	**D**	Stainless Steel Housing
E	Upper Insulator	**F**	Terminal Connection to Element
G	High Temp Water Seal		

Temperature must be controlled very accurately and gas constituents measured to a high degree of accuracy for absolute sensor measurements. This requires laboratory equipment to determine a good or bad sensor in field. Furthermore, as with most devices, intermittent problems are difficult to diagnose. Still, with a good understanding of system and sensor, it is possible to diagnose many sensor problems in field.

Using diagnostic software connected to ECU is a useful technique for observing sensor performance. However, user must understand that such software reads a signal generated by ECU. If there is an ECU or wiring problem, readings could be misinterpreted as a sensor problem. Digital nature of signal to software means that it is not reading continuous output of sensor. A voltmeter can also be used as an effective tool in diagnosing sensors. It is advisable to use an electronic meter such as a digital voltmeter. Simple mechanical meters may place a heavy electrical load on sensor and cause inaccurate readings. Since resistance of sensor is highest at low temperatures, such meters will cause largest inaccuracies when sensor is in a cool exhaust.

Visual Inspection

1. Look for a damaged or disconnected sensor-to-engine harness connection.
2. Look for damage to sensor lead wire or associated engine wiring due to cutting, chaffing or melting on a hot surface.
3. Disconnect sensor connector and look for corrosion in connector.
4. Try reconnecting sensor and observe if problem has cleared.
5. Correct any problems found during visual check.

Sensor Signal Observation

NOTE: **Do not cut into or pierce sensor or engine wiring to make this connection.** Sensor produces a very small signal. Corrosion or damage to wiring could lead to an incorrect signal because of repairs or contamination to sensor.

1. Using a voltmeter, observe voltage between Pin C and Pin D before engine is started. With key ON, and sensor unplugged, voltage should read about 5.0 volts. With sensor attached, using diagnostic software, voltage should read about 1.0 volt. This voltage is generated by ECU. If it is not present, there is a short in associated wiring and corrective action should be taken. If voltage still is not present, there is a problem with ECU or engine harness.
2. Reconnect sensor and start engine. Run engine at sufficient speed to bring sensor up to operating temperature. Maintain for 1 to 2 minutes to ensure that engine has gone closed loop. Once in closed loop, sensor voltage should cycle between about 100 to 250 mv (low speed idle) and 700 to 900 mv (high speed no load). If this cycling is not observed, a determination must be made, if problem is with engine or sensor.
3. Check engine harness for battery voltage on heater circuit.

Removal Inspection

NOTE: Apply anti-seize compound only to threads. **Anti-seize compound will affect sensor performance if it gets into lower shield of sensor.**

1. If sensor has heavy deposits on lower shield, engine, oil, or fuel may be source.
2. If heavy carbon deposits are observed, incorrect engine fuel control may be occurring.
3. If sensor is at room temperature, measure between signal leads, black wire (Pin C) and grey wire (Pin D) attached to sensor. If resistance is less than one megohm, sensor has an internal short.
4. With sensor at room temperature measure heater circuit resistance, purple wire (Pin A) and white wire (Pin B), resistance should be 8.1-11.1 Ω.
5. If a damaged sensor is found, identify root cause, which may be elsewhere in application. Refer to Troubleshooting-Oxygen Sensor (O_2) table.
6. A special "dry to touch" anti-seize compound is applied to all new oxygen sensors at factory. If recommended mounting thread sizes are used, this material provides excellent anti-seize capabilities and no additional anti-seize is needed. If sensor is removed from engine and reinstalled, anti-seize compound should be reapplied. Use an oxygen sensor safe type anti-seize compound. It should be applied according to directions on label.

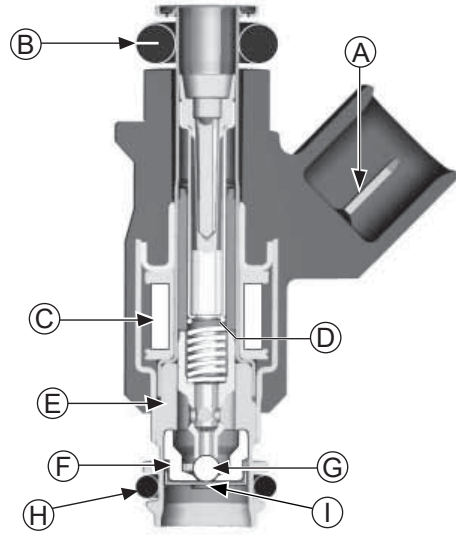
Troubleshooting-Oxygen Sensor (O_2)

Condition	Possible Cause	Conclusion
Low voltage output.	Shorted sensor or sensor circuit. Shorted lead wire. Wiring shorted to ground.	Replace sensor or repair wiring.
	Contamination of air reference.	Remove source of external contamination, protect air reference area.
	Air leak at sensor or gasket, sensor upper shield damage.	Use recommended torque at installation, replace gasket or sensor. Revise application exhaust. Shield sensor from damage.
High voltage output.	Silica poisoning.	Replace sensor.
	Contaminated gasoline.	Use high quality fuel.
	Engine problem; misfire.	Correct cause of misfire.
	Excessive rich air/fuel ratio.	Check for high fuel pressure. Leaking injector. Liquid fuel in vent line.
	Wiring shorted to voltage.	Repair wiring.
Open circuit, no activity from sensor.	Broken element. Sensor dropped. Hard blow to engine or exhaust system. Defective sensor. Thermal shock.	Replace sensor.
Slow time response.	Open heater circuit. Improper handling. Carbon deposits.	Replace sensor.
	Improper fueling.	Correct fueling.
	Incorrect or contaminated fuel.	Use high quality fuel.
	Excessive engine oil consumption causing exhaust contamination or other exhaust side contamination.	Correct engine condition.
	Heater circuit open/shorted or out of specification.	Repair short in harness wires, replace sensor.

Fuel Injectors

	WARNING
	Explosive Fuel can cause fires and severe burns. Fuel system ALWAYS remains under HIGH PRESSURE.
Wrap a shop towel completely around fuel pump module connector. Press release button(s) and slowly pull connector away from fuel pump module allowing shop towel to absorb any residual fuel in high pressure fuel line. Any spilled fuel must be completely wiped up immediately.	

Details



A	Electrical Connection	**B**	Upper O-ring
C	Solenoid Winding	**D**	Armature
E	Valve Housing	**F**	Valve Seat
G	Valve End	**H**	Lower O-ring
I	Director Plate		

NOTE: Do not apply voltage to fuel injector(s). Excessive voltage will burn out injector(s). Do not ground injector(s) with ignition ON. Injector(s) will open/turn on if relay is energized.

NOTE: When cranking engine with injectors disconnected, fault codes will be registered in ECU and will need to be cleared using software fault clear or an ECU Reset and TPS Learn Procedure.

Injector problems typically fall into three general categories: electrical, dirty/clogged, or leakage. An electrical problem usually causes one or both of injectors to stop functioning. Several methods may be used to check if injectors are operating.

1. With engine running at idle, listen for a buzzing or clicking sound.
2. Disconnect electrical connector from an injector and listen for a change in idle performance (only running on one cylinder) or a change in injector noise or vibration.

If an injector is not operating, it can indicate either a bad injector, or a wiring/electrical connection problem. Check as follows:

1. Disconnect electrical connector from both injectors. Plug a 12 volt noid light into one connector.
2. Make sure all safety switch requirements are met. Crank engine and check for flashing of test light. Turn key OFF for at least 10 seconds between tests to allow ECU to go to sleep and reawake. Repeat test at other connector.
   a. If flashing occurs, use an ohmmeter (Rx1 scale) and check resistance of each injector across two terminals. Proper resistance is 11-13 Ω. If injector resistance is correct, check whether connector and injector terminals are making a good connection. If resistance is not correct, replace injector.

Check all electrical connections, connectors, and wiring harness leads if resistance is incorrect.

Injector leakage is very unlikely, but in those rare instances it can be internal (past tip of valve needle), or external (weeping around injector O-rings). Loss of system pressure from leakage can cause hot restart problems and longer cranking times. To check for leakage it will be necessary to loosen or remove blower housing which may involve removing engine from unit. Refer to Disassembly for removal of injector.

1. Remove manifold mounting bolts and separate throttle body/manifold from engine leaving TPS, high pressure fuel line, injectors and fuel line connections intact. Discard old gaskets.
2. Position manifold assembly over an appropriate container to capture fuel and turn key switch ON to activate fuel pump and pressurize system. Do not turn switch to START position.

NOTE: Fuel pump module pins are coated with a thin layer of electrical grease to prevent fretting and corrosion. Do not attempt to remove electrical grease from fuel pump module pins.

3. If either injector exhibits leakage of more than two to four drops per minute from tip, or shows any sign of leakage around outer shell, turn ignition switch OFF and replace injector as follows.
4. Depressurize fuel system.
5. Clean any dirt accumulation from sealing/mounting area of faulty injector(s) and disconnect electrical connector(s).
6. Pull retaining clip off top of injector(s). Remove screw holding injector(s) from manifold.

7. Reverse appropriate procedures to install new injector(s) and reassemble engine. Use new O-rings and retaining clips any time an injector is removed (new replacement injectors include new O-rings and retaining clips). Lubricate O-rings lightly with clean engine oil. Use installation tool provided with O-rings to install new upper O-ring. Place tool into fuel injector inlet. Place one side of O-ring into O-ring groove and roll O-ring over tool onto fuel injector. Torque screw securing fuel injector caps and blower housing mounting screws to 7.3 N·m (65 in. lb.), and intake manifold and air cleaner mounting screws to 10.5 N·m (93 in. lb.). An ECU Reset will need to be completed.

Injector problems due to dirt or clogging are generally unlikely due to design of injectors, high fuel pressure, and detergent additives in gasoline. Symptoms that could be caused by dirty/clogged injectors include rough idle, hesitation/stumbling during acceleration, or triggering of fault codes related to fuel delivery. Injector clogging is usually caused by a buildup of deposits on director plate, restricting flow of fuel, resulting in a poor spray pattern. Some contributing factors to injector clogging include higher than normal operating temperatures, short operating intervals, and dirty, incorrect, or poor quality fuel. Cleaning of clogged injectors is not recommended; they should be replaced. Additives and higher grades of fuel can be used as a preventative measure if clogging has been a problem.

Ignition Coil

If a coil is determined to be faulty, replacement is necessary. An ohmmeter may be used to test wiring and coil windings.

NOTE: Do not ground primary coil with ignition ON as they may overheat or spark.

NOTE: Always disconnect spark plug lead from spark plug before performing following tests.

NOTE: **If ignition coil(s) are disabled and an ignition fault is registered, system will automatically disable corresponding fuel injector drive signal.** Fault must be corrected to ignition coil and ECU power (switch) must be turned OFF for 10 seconds for injector signal to return. This is a safety measure to prevent bore washing and oil dilution.

Testing
Using an ohmmeter set on Rx1 scale, check resistance in circuits as follows:

1. To check cylinder coil 1 (starter side), disconnect Black connector from ECU and test between Black pins 1 and 15. To check cylinder coil 2 (oil filter side), disconnect Grey connector from ECU and test between Grey pins 10 and 17. Wiring and coil primary circuits are OK if readings are 0.5-0.8 Ω.
2. If reading(s) are not within specified range, check and clean connections and retest.
3. If reading(s) are still not within specified range, test coils separately from main harness as follows:
   a. Remove screw retaining coil to housing and disconnect primary leads connector.
   b. Connect an ohmmeter set on Rx1 scale to primary terminals of coil. Primary resistance should be 0.5-0.8 Ω.
   c. Connect an ohmmeter set on Rx10K scale between spark plug boot terminal and B+ primary terminal. Secondary resistance should be 6400-7800 Ω.
   d. If secondary resistance is not within specified range, coil is faulty and needs to be replaced.

FUEL COMPONENTS

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Fuel system ALWAYS remains under HIGH PRESSURE.

Wrap a shop towel completely around fuel pump module connector. Press release button(s) and slowly pull connector away from fuel pump module allowing shop towel to absorb any residual fuel in high pressure fuel line. Any spilled fuel must be completely wiped up immediately.

Fuel Pump Module (FPM)

Fuel pump module is not serviceable and must be replaced if determined to be faulty. If a fuel pump problem is suspected, make certain pump is being activated, all electrical connections are properly secured, fuses are good, and a minimum of 7.0 volts is being supplied. If during cranking, voltage drops below 7.0 volts, a reduction of fuel pressure may occur resulting in a lean starting condition. If required, testing of fuel pump may be conducted.

1. Relieve fuel pressure at fuel pump module. Fuel pump module may need to be loosened or pulled away from engine. Disconnect fuel coupler from fuel pump module and insert pressure test jumper (from Kohler EFI Service Kit) between high pressure fuel line and fuel pump module.
2. Connect black hose of Pressure Tester. Route clear hose into a portable gasoline container or equipment fuel tank.
3. Turn on key switch to activate pump and check system pressure on gauge. It may take several key cycles to compress air introduced into system and reach regulated pressure. If system pressure of 39 psi ± 3 is observed, wiring, fuel pump, and regulator are working properly. Turn key switch OFF and depress valve button on tester to relieve system pressure.
   a. If pressure is too high or too low, replace fuel pump module.
4. If pump did not activate (step 3), disconnect plug from fuel pump. Connect a DC voltmeter across terminals in plug, turn on key switch and observe if a minimum of 7 volts is present during six second prime process.
5. If no voltage is observed, connect red lead of meter to red wire of plug and black lead to a good ground while key is still ON.

6. If voltage is between 7 and 14, turn key switch OFF and connect an ohmmeter between terminals on pump to check for continuity.
   a. If there was no continuity between pump terminals, replace fuel pump.
   b. If voltage was below 7, test wiring harness.
7. If voltage at plug was good, and there was continuity across pump terminals, reconnect plug to pump, making sure you have a good connection. Turn on key switch and listen for pump to activate.
   a. If pump starts, repeat steps 2 and 3 to verify correct pressure.
   b. If pump still does not operate, replace it.

High Pressure Fuel Line

High pressure fuel line is mounted to intake manifold. No specific servicing is required unless operating conditions indicate that it needs replacement. Thoroughly clean area around all joints and relieve any pressure before starting any disassembly. Detach by removing two mounting screws, wire ties, and injector retaining clips.

Purge Port and Vent Hose Assembly

No specific servicing is required for vent hose assembly or purge port unless operating conditions indicate replacement is required. All components are serviced individually. Abrasion sleeves on hoses should be reused or replaced when servicing vent hoses. Please note vent hose routing and replicate after service or component replacement to prevent pinching or abrasion of vent hoses. Only Kohler replacement parts can be used because fitting is specific to system and must be maintained. Visit KohlerEngines.com for recommended Kohler replacement parts.

Throttle Body/Intake Manifold Assembly

NOTE: ECU Reset is required if throttle body is replaced.

Throttle body is serviced as an assembly, with throttle shaft, TPS, throttle plate, and idle speed adjusting screw installed. Throttle shaft rotates on needle bearings (non-serviceable), capped with seals to prevent air leaks.

TROUBLESHOOTING

Troubleshooting Guide

Condition	Possible Cause
Engine Starts Hard or Fails to Start When Cold.	Fuel pump not running.
	Faulty spark plugs.
	Old/stale fuel.
	Incorrect fuel pressure.
	Crankshaft position sensor loose or faulty.
	TPS set incorrect (ECU Reset and TPS Learn).
	TPS faulty.
	Engine temp sensor faulty.
	Faulty coils.
	Low system voltage.
	Faulty injectors.
	Faulty battery.
	Loose or corroded connections.

Troubleshooting Guide

Condition	Possible Cause
Engine Starts Hard or Fails to Start When Hot.	Faulty spark plugs.
	Fuel pump not running.
	Fuel pressure low.
	Insufficient fuel delivery.
	TPS set incorrect (ECU Reset and TPS Initialization).
	Crankshaft position sensor loose or faulty.
	TPS faulty.
	Engine temp sensor faulty.
	Faulty injectors.
Engine Stalls or Idles Roughly (cold or warm).	Faulty spark plugs.
	Insufficient fuel delivery.
	TPS set incorrect.
	TPS faulty.
	Faulty engine temperature sensor.
	Faulty injectors.
Engine Misses, Hesitates, or Stalls Under Load.	Fuel injector(s), fuel filter, fuel line, or fuel pick-up dirty/restricted.
	Dirty air cleaner.
	Insufficient fuel pressure or fuel delivery.
	Vacuum (intake air) leak.
	Improper governor setting, adjustment or operation.
	TPS faulty, mounting problem or TPS Initialization Procedure incorrect.
	Bad coil(s), spark plug(s), or wires.
Low Power	Faulty/malfunctioning ignition system.
	Dirty air filter.
	Insufficient fuel delivery.
	Improper governor adjustment.
	Plugged/restricted exhaust.
	One injector not working.
	Basic engine problem exists.
	TPS faulty or mounting exists.
	Throttle plate in throttle body not fully opening to WOT stop (if equipped).

Function Test

⚠ WARNING

High Pressure Fluids can puncture skin and cause severe injury or death.

Do not work on fuel system without proper training or safety equipment.

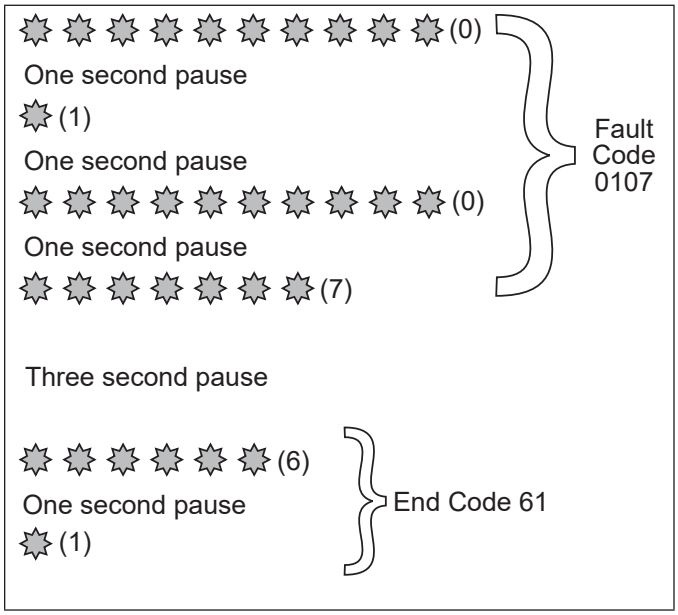
Fluid puncture injuries are highly toxic and hazardous. If an injury occurs, seek immediate medical attention.

Function of fuel system is to provide sufficient delivery of fuel at system operating pressure of 39 psi ± 3. If an engine starts hard, or turns over but will not start, it may indicate a problem with EFI fuel system. A quick test will verify if system is operating.

1. Disconnect and ground spark plug leads.
2. Complete all safety interlock requirements and crank engine for approximately 3 seconds.
3. Remove spark plugs and check for fuel at tips.
   a. If there is fuel at tips of spark plugs fuel pump and injectors are operating.
   b. If there is no fuel at tips of spark plugs, check following:
      1. Make sure fuel tank contains clean, fresh, proper fuel.
      2. Make sure that vent in fuel tank is open.
      3. Make sure fuel tank valve (if equipped) is fully opened.
      4. Make sure battery is supplying proper voltage.
      5. Check that fuses are good, and that no electrical or fuel line connections are damaged or broken.
      6. Test fuel pump module operation as described earlier under Fuel Pump.

Fault Codes

Example of Diagnostic Display



Diagnostic Fault Code Summary

Fault Code	Connection or Failure Description
0031	Oxygen Sensor Heater Circuit Low Voltage
0032	Oxygen Sensor Heater Circuit High Voltage
0107	Manifold Absolute Pressure (MAP or TMAP) Sensor Circuit Low Voltage or Open
0108	Manifold Absolute Pressure (MAP or TMAP) Sensor Circuit High Voltage
0112	Intake Air Temperature (IAT or TMAP) Sensor Circuit Low Voltage
0113	Intake Air Temperature (IAT or TMAP) Sensor Circuit High Voltage or Open
0117	Coolant/Oil Temperature Sensor Circuit Low Voltage
0118	Coolant/Oil Temperature Sensor Circuit High Voltage or Open
0122	Throttle Position Sensor Circuit Low Voltage or Open
0123	Throttle Position Sensor Circuit High Voltage
0131	Oxygen Sensor 1 Circuit Low Voltage, or Open
0132	Oxygen Sensor 1 Circuit High Voltage
0171	Maximum Adaptation Limit Exceeded
0172	Minimum Adaptation Limit Exceeded
0174	Lean Fuel Condition at High Load (Open Loop)
0201	Injector 1 Circuit Malfunction
0202	Injector 2 Circuit Malfunction

0230	Fuel Pump Module Circuit Low Voltage or Open
0232	Fuel Pump Module Circuit High Voltage
0336	Crankshaft Position Sensor Noisy Signal
0337	Crankshaft Position Sensor No Signal
0351	Cylinder 1 Ignition Coil Malfunction
0352	Cylinder 2 Ignition Coil Malfunction
0562	System Voltage Low
0563	System Voltage High
61	End of Code Transmission

ECU continuously monitors engine operation against preset performance limits. If operation is outside limits, ECU activates MIL, if equipped, and stores a diagnostic code in its fault memory. If component or system returns to proper function, ECU will turn off MIL. If MIL stays illuminated, it warns customer a fault is currently happening, and dealer service is required. Upon receipt, dealer technician can access fault code(s) to help determine what portion of system is malfunctioning.

Codes are accessed through key switch and displayed as blinks or flashes of MIL. Access codes as follows:

1. Check that battery voltage is above 11 volts.
2. Start with key switch OFF.
3. Turn key switch to ON and OFF, then ON and OFF, then ON, leaving it on in third sequence. Do not start engine. Time between sequences must be less than 2.5 seconds.
4. MIL will blink a series of times. Number of times MIL blinks represents a number in blink code.
5. A sequence of four digits make up a fault code. There is a one (1) second pause between blinks of a fault code. There is a three (3) second pause between separate fault codes. After fault code(s) are blinked a two digit 61 is blinked to indicate program has completed.
   a. It's a good idea to write down codes as they appear, as they may not be in numerical sequence.
   b. Code 61 will always be last code displayed, indicating end of code transmission. If code 61 appears immediately, no other fault codes are present.

After problem has been corrected, fault codes may be cleared by following ECU Reset and TPS Learn Procedures.

Diagnostic Fault Code Summary lists fault codes, and what they correspond to. Diagnostic Code Summary is a list of individual codes with an explanation of what triggers them, what symptoms might be expected, and probable causes.

A MIL may not be provided with engine. If equipment manufacturer has not added a MIL to equipment, one can be added easily for quick diagnostics. Main engine to vehicle connection will have a tan wire which is ground for MIL. Either incandescent or LED type bulbs can be used for MIL as long as they do not draw more than 0.1 amps. Bulb needs to be rated at 1.4 Watts or less, or needs to have a total resistance of 140 Ω or more. LEDs typically draw less than 0.03 amps. Attach +12 volts to positive terminal of bulb and attach ground terminal of bulb to tan wire.

Diagnostic Code Summary

Code 0031

Component:	Oxygen Sensor Heater
Fault:	O2S Heater Circuit Low Voltage
Condition:	System voltage too low, open connection or faulty sensor.
Conclusion:	Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU black pin 7 or broken wire. Oxygen Sensor Related ● Sensor connector or wiring problem. Poor system ground from ECU to engine or battery to engine.

Code 0032

Component:	Oxygen Sensor Heater
Fault:	O2S Heater Circuit High Voltage
Condition:	System voltage too high, shorted connection or faulty sensor.
Conclusion:	Oxygen Sensor Related ● Sensor connector or wiring problem. ● Sensor damaged. ● Pin circuit wiring or connectors at Black 7. ECU Related ● ECU-to-harness connection problem.

Code 0107

Component:	Manifold Absolute Pressure (MAP or TMAP) Sensor
Fault:	MAP or TMAP Circuit Low Voltage or Open
Condition:	Intake manifold leak, open connection or faulty sensor.
Conclusion:	MAP or TMAP Sensor Related ● Sensor malfunction. ● Vacuum leaks from loose manifold or sensor. Wire Harness Related ● Poor grounding or open circuit. ● Wire harness and connectors loose, damaged or corroded. ● Pin circuit wiring or connectors at Black 10, 11 and 16. Bad TPS Learn.

Code 0108

Component:	Manifold Absolute Pressure (MAP or TMAP) Sensor
Fault:	MAP or TMAP Circuit High Voltage
Condition:	Intake manifold leak, shorted connection or faulty sensor.
Conclusion:	MAP or TMAP Sensor Related ● Sensor malfunction. ● Vacuum leaks from loose manifold or sensor. Wire Harness Related ● Poor grounding. ● Pin circuit wiring or connectors at Black 11. Bad TPS Learn.

Code 0112

Component:	Intake Air Temperature (IAT or TMAP) Sensor
Fault:	Intake Air Temperature (IAT or TMAP) Sensor Circuit Low Voltage
Condition:	Shorted connection, faulty sensor or shorted wire.
Conclusion:	Temperature (IAT or TMAP) Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits Black 10 and Black 8 may be damaged or routed near noisy signal (coils, alternator, etc.). ● ECU-to-harness connection problem.

Code 0113

Component:	Intake Air Temperature (IAT or TMAP) Sensor
Fault:	Intake Air Temperature (IAT or TMAP) Sensor Circuit High Voltage or Open
Condition:	Shorted connection, faulty sensor, broken wire or connection.
Conclusion:	Temperature (IAT or TMAP) Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits ECU Black pin 10 and 8 may be damaged. ● ECU-to-harness connection problem or broken wire.

Code 0117

Component:	Coolant/Oil Sensor
Fault:	Coolant/Oil Temperature Sensor Circuit Low Voltage
Condition:	Shorted connection, faulty sensor or shorted wire.
Conclusion:	Temperature Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits Black 10 and Black 14 maybe damaged or routed near noisy signal (coils, stator, etc.). ● ECU-to-harness connection problem.

Code 0118

Component:	Coolant/Oil Sensor
Fault:	Coolant/Oil Temperature Sensor Circuit High Voltage or Open
Condition:	Shorted connection, faulty sensor, open connection or broken wire.
Conclusion:	Temperature Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits ECU Black pin 10 and 14 may be damaged. ● ECU-to-harness connection problem or broken wire. System Related ● Engine is operating above 176°C (350°F) temperature sensor limit.

Code 0122

Component:	Throttle Position Sensor (TPS)
Fault:	TPS Circuit Low Voltage or Open
Condition:	Open connection, broken wire or faulty sensor.
Conclusion:	TPS Related ● TPS bad or worn internally. Engine Wiring Harness Related ● Broken or shorted wire in harness. ECU Black pin 10 to TPS pin 1. ECU Black pin 12 to TPS pin 3. ECU Black pin 16 to TPS pin 2. Throttle Body Related ● Throttle shaft inside TPS worn, broken, or damaged. ● Throttle plate loose or misaligned. ● Throttle plate bent or damaged allowing extra airflow past, or restricting movement. ECU Related ● Circuit providing voltage or ground to TPS damaged. ● TPS signal input circuit damaged.

Code 0123

Component:	Throttle Position Sensor (TPS)
Fault:	TPS Circuit High Voltage
Condition:	Shorted connection or faulty sensor.
Conclusion:	TPS Sensor Related ● Sensor connector or wiring. ● Sensor output affected or disrupted by dirt, grease, oil, wear. ● Sensor loose on throttle body manifold. Throttle Body Related ● Throttle shaft or bearings worn/ damaged. Engine Wiring Harness Related ● ECU pins Black 10, 12 and 16 damaged (wiring, connectors). ● ECU pins Black 10, 12 and 16 routed near noisy electrical signal (coils, alternator). ● Intermittent 5 volt source from ECU (pin Black 16). ● ECU-to-harness connection problem.

Code 0131

Component:	Oxygen Sensor
Fault:	O2S 1 Circuit Low Voltage
Condition:	Open connection, broken wire or faulty sensor.
Conclusion:	Oxygen Sensor Related ● Sensor connector or wiring problem. ● Sensor contaminated, corroded or damaged. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or 17. TPS Learn Procedure Incorrect ● Lean condition (check oxygen sensor signal with VOA and see Oxygen Sensor). Engine wiring harness related such as a cut wire, broken or pinched.

Code 0132

Component:	Oxygen Sensor
Fault:	O2S 1 Circuit High Voltage
Condition:	Shorted connection or faulty sensor.
Conclusion:	Oxygen Sensor Related ● Sensor connector or wiring problem. ● Sensor contaminated or damaged. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or Black pin 17. Engine Wiring Harness Related ● Difference in voltage between sensed voltage and actual sensor voltage. ● Short in wire harness.

Code 0171

Component:	Fuel System
Fault:	Maximum adaptation limit exceeded
Condition:	Fuel inlet screen/filter plugged, low pressure at high pressure fuel line, TPS malfunction, shorted connection, faulty sensor, low fuel or wrong fuel type.
Conclusion:	Oxygen Sensor Related ● Corrosion or poor connection. ● Sensor contaminated or damaged. ● Air leak into exhaust. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or Black pin 17. TPS Sensor Related ● Throttle plate position incorrect during Learn procedure. ● TPS problem or malfunction. Engine Wiring Harness Related ● Difference in voltage between sensed voltage and actual sensor voltage. ● Problem in wiring harness. ● ECU-to-harness connection problem. Systems Related ● Ignition (spark plug, plug wire, ignition coil). ● Fuel (fuel type/quality, injector, fuel pressure too low, fuel pump module or lift pump). ● Combustion air (air cleaner dirty/ restricted, intake leak, throttle bores). ● Base engine problem (rings, valves). ● Exhaust system leak (muffler, flange, oxygen sensor mounting boss, etc.). ● Fuel in crankcase oil.

Code 0172

Component:	Fuel System
Fault:	Minimum adaptation limit exceeded
Condition:	Too high pressure at high pressure fuel line, TPS malfunction, shorted connection, faulty sensor or fuel pump module failure.
Conclusion:	Oxygen Sensor Related ● Sensor connector or wiring. ● Sensor contaminated or damaged. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or 17. TPS Sensor Related ● Throttle plate position incorrect during Learn procedure. ● TPS problem or malfunction. Engine Wiring Harness Related ● Difference in voltage between sensed voltage and actual sensor voltage. ● Problem in wiring harness. ● ECU-to-harness connection problem. Systems Related ● Ignition (spark plug, plug wire, ignition coil). ● Fuel (fuel type/quality, injector, fuel pressure too high, fuel pump module or lift pump). ● Combustion air (air cleaner dirty/ restricted). ● Base engine problem (rings, valves). ● Fuel in crankcase oil. ● Fuel pump module is over filled. ● Lift pump diaphragm is ruptured.

Code 0174

Component:	Fuel System
Fault:	Lean fuel condition
Condition:	Fuel inlet screen/filter plugged, low pressure at high pressure fuel line, TPS malfunction, shorted connection or faulty sensor.
Conclusion:	TPS Learn Incorrect ● Lean condition (check oxygen sensor signal with VOA and see Oxygen Sensor). Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU pin Black 10, 12, 16 and 17. Low Fuel Pressure ● Plugged filters. ● Bad lift pump. Oxygen Sensor Related ● Sensor connector or wiring problem. ● Exhaust leak. ● Poor ground. Poor system ground from ECU to engine, causing rich running while indicating lean. Fuel pump module connection. See Fuel Components.

Code 0201

Component:	Fuel Injector
Fault:	Injector 1 Circuit Malfunction
Condition:	Injector damaged or faulty, shorted or open connection.
Conclusion:	Injector Related ● Injector coil shorted or opened. Engine Wiring Harness Related ● Broken or shorted wire in harness. ECU pin Black 5. ● Wiring from Ignition. ECU Related ● Circuit controlling injector #1 damaged.

Code 0202

Component:	Fuel Injector
Fault:	Injector 2 Circuit Malfunction
Condition:	Injector damaged or faulty, shorted or open connection.
Conclusion:	Injector Related ● Injector coil shorted or opened. Engine Wiring Harness Related ● Broken or shorted wire in harness. ECU pin Black 6. ● Wiring from Ignition. ECU Related ● Circuit controlling injector #2 damaged.

Code 0230

Component:	Fuel Pump
Fault:	Circuit Low Voltage or Open
Condition:	Shorted or open connection.
Conclusion:	Fuel Pump Related ● Fuel pump module open or shorted internally. Engine Wiring Harness related ● Broken or shorted wire in harness. ECU pin Black 9 or Grey 17. ECU Related ● ECU is damaged.

Code 0232

Component:	Fuel Pump
Fault:	Circuit High Voltage
Condition:	Shorted connection.
Conclusion:	Fuel Pump Related ● Fuel pump module damaged internally. Charging Output System Too High.

Code 0336

Component:	Crankshaft Position Sensor
Fault:	Crankshaft Position Sensor Noisy Signal
Condition:	Air gap incorrect, loose sensor, faulty/bad battery, shorted or faulty connection, faulty sensor or faulty sensor grounding.
Conclusion:	Crankshaft Position Sensor Related ● Sensor connector or wiring. ● Sensor loose or air gap incorrect. Crankshaft Position Sensor Wheel Related ● Damaged teeth. ● Gap section not registering. Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU pin Black 4 and Black 13. ● ECU-to-harness connection problem. Ignition System Related ● Non-resistor spark plug(s) used. ● Faulty or disconnected ignition coil or secondary lead.

Code 0337

Component:	Crankshaft Position Sensor
Fault:	Crankshaft Position Sensor No Signal
Condition:	Air gap incorrect, loose sensor, open or shorted connection or faulty sensor.
Conclusion:	Crankshaft Position Sensor Related ● Sensor connector or wiring. ● Sensor loose or air gap incorrect. Crankshaft Position Sensor Wheel Related ● Damaged teeth. Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU pin Black 4 or Black 13. ● ECU-to-harness connection problem. If code is stored in fault history and starts normally. Clear code, no other service required.

Code 0351

Component:	Ignition Coil
Fault:	Cylinder 1 Ignition Coil Malfunction
Condition:	Broken wire in harness (may not be visible), shorted connection or faulty sensor.
Conclusion:	Engine Wiring Harness Related ● Connection to ignition or fuse. ● Pin circuit wiring or connectors. ● ECU pin Black 1. ● ECU-to-harness connection problem. Ignition System Related ● Incorrect spark plug(s) used. ● Poor connection to spark plug.

Code 0352

Component:	Ignition Coil
Fault:	Cylinder 2 Ignition Coil Malfunction
Condition:	Broken wire in harness (may not be visible), shorted connection or faulty sensor.
Conclusion:	Engine Wiring Harness Related ● Connection to ignition or fuse. ● Pin circuit wiring or connectors. ECU pin Grey 10. ● ECU-to-harness connection problem. Ignition System Related ● Incorrect spark plug(s) used. ● Poor connection to spark plug.

Code 0562

Component:	System Voltage
Fault:	System Voltage Low
Condition:	Faulty voltage regulator, bad fuse or shorted connection.
Conclusion:	Corroded Connections Bad Stator Bad Battery ● Low output charging system. ● Poor magnet in flywheel. ● Bad or missing fuse.

Code 0563

Component:	System Voltage
Fault:	System Voltage High
Condition:	Faulty voltage regulator or shorted connection.
Conclusion:	Faulty Rectifier-Regulator Bad Stator. Bad Battery.

Code 61

Component:	End of Code Transmission

Troubleshooting Flow Chart

Following flow chart provides an alternative method of troubleshooting EFI system. Chart will enable you to review entire system in about 10-15 minutes. Using chart, accompanying diagnostic aids (listed after chart), and any signaled fault codes, you should be able to quickly locate any problems within system.

Flow Chart Diagnostic Aids

Diagnostic Aid #1 SYSTEM POWER
(MIL does not illuminate when key is turned ON)

NOTE: MIL is installed by vehicle OEM. Twelve volt supply to bulb will be part of vehicle wire harness. Kohler key switch model will have MIL on engine with 12V supply to bulb.

Conclusion
- Battery
- Main system fuse
- MIL light bulb burned out
- MIL electrical circuit problem
  Pin circuits Grey 3.
- Ignition switch
- Permanent ECU power circuit problem
  Pin circuit Black 18.
- Switched ECU power circuit problem
  Pin circuit Black 15.
- ECU grounds
- ECU

Diagnostic Aid #2 FAULT CODES
Refer to Diagnostic Fault Code Summary.

Diagnostic Aid #3 RUN/ON
(MIL remains ON while engine is running)*

Condition
NOTE: Either incandescent or LED type bulbs can be used for MIL as long as they do not draw more than 0.1 amps. Bulb needs to be rated at 1.4 Watts or less, or needs to have a total resistance of 140 Ω or more. LEDs typically draw less than 0.03 amps.

*All current fault codes will turn on MIL when engine is running.

Diagnostic Aid #4 CRANKSHAFT POSITION SENSOR
(MIL does not turn off during cranking)

Condition
- Crankshaft position sensor
- Crankshaft position sensor circuit problem, pin circuits Black 4 and Black 13.
- Crankshaft position sensor/toothed wheel air gap
- Toothed wheel
- Flywheel key sheared
- ECU

Diagnostic Aid #5 FUEL PUMP
(fuel pump not turning on)

Condition
- Main fuse
- Fuel pump circuit problem, pin circuits Black 9 and Grey 17.
- Fuel pump module

Diagnostic Aid #6 IGNITION SYSTEM
(no spark)

Condition
- Spark plug
- Plug wire
- Coil
- Coil circuit(s), pin circuits Grey 10 and Black 1.
- ECU grounds
- ECU
- Vehicle safety interlocks, ground signal on safety wire.

Diagnostic Aid #7 FUEL SYSTEM ELECTRICAL
(no fuel delivery)

Condition
- No fuel
- Air in high pressure fuel line
- Fuel valve shut OFF
- Fuel filter/line plugged
- Injector circuit(s), pin circuits Black 5 and Black 6
- Injector
- ECU grounds
- ECU
- Lift pump not working

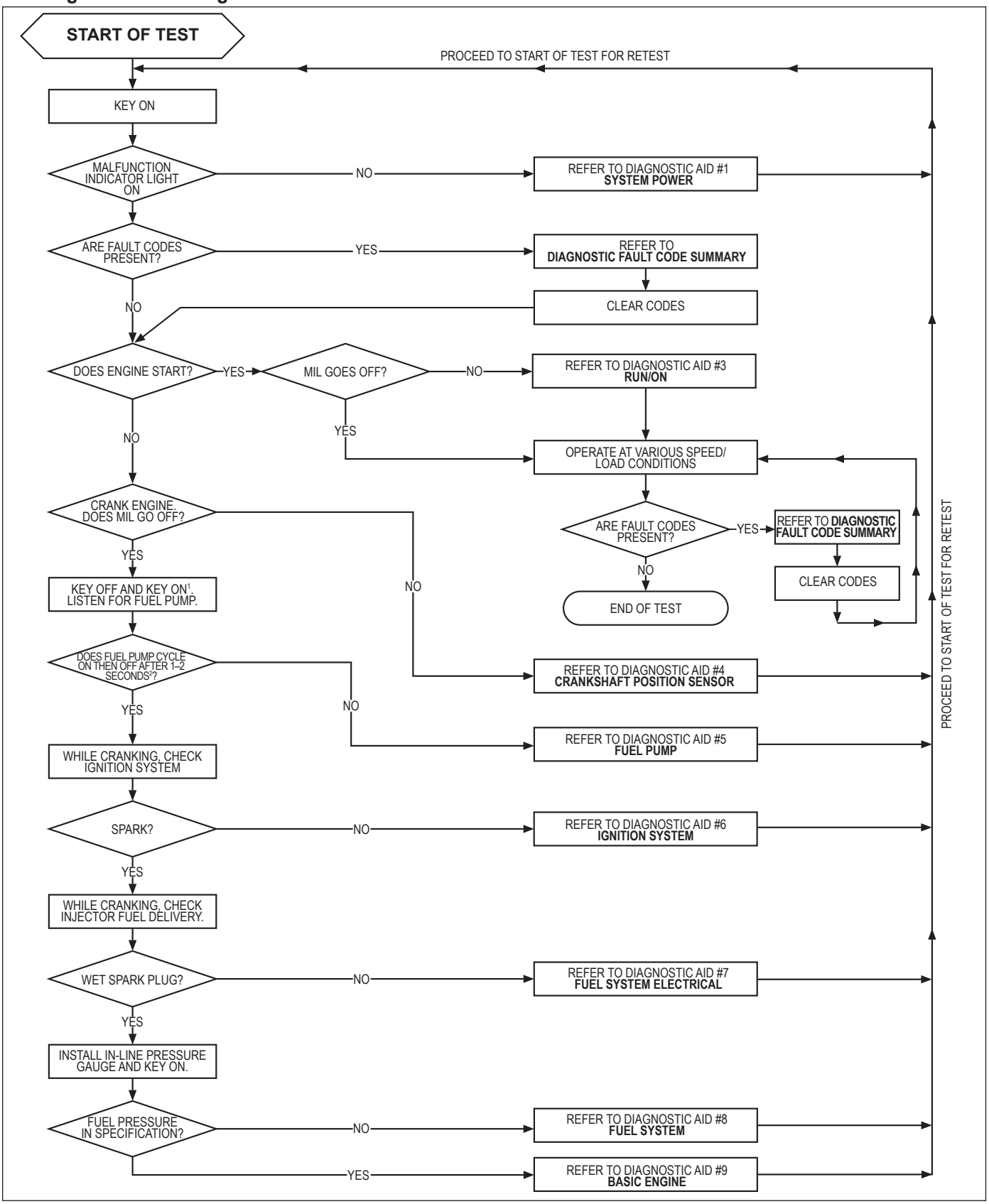
Diagnostic Aid #8 FUEL SYSTEM
(fuel pressure)

Low Fuel Pressure-Condition
- Low fuel
- Fuel filter plugged
- Fuel supply line plugged
- Lift fuel pump - insufficient fuel supply
- Fuel pump (lift or module) - internally plugged
- Pressure regulator not functioning properly inside fuel pump module.

Diagnostic Aid #9 BASIC ENGINE
(cranks but will not run)

Condition
- Refer to basic engine troubleshooting charts within Troubleshooting.

EFI Diagnostic Flow Diagram



1. After turning key to OFF, wait 10 seconds before turning to ON to allow ECU to go to sleep.
2. Fuel pump module can be heard or a vibration can be felt to establish pump cycle. Fuel pump module will run for one 4-6 second cycle when ECU wakes up after being asleep.