SECTION 0A

GENERAL INFORMATION

Notes, Cautions, And Warnings

Notes, Cautions, and Warnings are used in this manual to emphasize important and critical instructions. They are used for the following conditions:

NOTE

Denotes situations which could influence safety or proper performance of the vehicle or component and to highlight an essential operating procedure or condition.

⚠ CAUTION

Operating procedures or practices that will result in damage to or destruction of the engine if not strictly observed.

⚠ WARNING

Operating procedures or practices that will result in serious injury or loss of life if not correctly followed.

Fuel Systems Cautions

⚠ WARNING

Do not smoke, carry lighted tobacco, or use a lighted flame of any type when working on or near any fuel related component. Highly flammable air-fuel mixtures may be present and can be ignited causing personal injury.

⚠ WARNING

Do not allow propane to contact the skin. Propane is stored in the fuel tank as a liquid. When propane contacts the atmosphere, it immediately expands into a gas, resulting in refrigeration that can cause severe burns.

⚠ WARNING

Do not allow propane to accumulate in areas below ground level such as in a service pit or underground ventilation systems. Propane is heavier than air and can displace oxygen, creating a dangerous condition.

It is important to note that this manual contains various Warnings, Cautions and Notes that must be carefully observed in order to reduce the risk of personal injury during service or repair. Improper service or repair may damage the engine or render it unsafe or fail to make the engine emissions compliant. It is also important to warn of all hazardous consequences that might result from careless treatment of the engine. Failure to observe these items could influence terms of the warranty.

To reduce the chance of personal injury and/or property damage, the following instructions must be carefully observed.

Proper service and repair are important to the safety of the service technician and the safe reliable operation of all engines. The service procedures recommended and described in this service manual are effective methods of performing service and repair. Some of these procedures require the use of tools specially designed for the purpose.

If part replacement is necessary, the replacement part must be of the same part number or equivalent part. Do not use a replacement part of lesser quality. In the case of replacement parts for the emission control system use only genuine OEM replacement parts.

Before using a replacement part, service procedure, or a tool which is not recommended by the engine manufacturer, it must first be determined that neither personal safety nor the safe operation of the engine will be jeopardized by the replacement part, service procedure or the tool selected.

Special service tools shown in this service manaual that have tool product numbers beginning with “J” or “BT” are available for world wide distribution from:

- Kent-Moore Tools
- 28635 Mound Road
- Warren, MI. 48092
- 1-800-345-2233

Special Tools which are required to service the LPG fuel system are listed below:

- o Hand held diagnostic scanner
- o ITK-1 Fuel pressure test kit

The tools are available from:

IMPCO Engine System Division
7100 East 15 Mile Road
Sterling ‘Heights, MI. 48312
1-586-276-4333

English And Metric Fasteners

⚠ CAUTION

Late model engines use a combination of English and Metric fasteners. The components affected are the starter motor, engine mounts, and flywheel housing mounting. Other components may also have a combination of fasteners, always verify that the proper fasteners are used whenever removing or replacing any components.

Handling Electrostatic Discharge (ESD) Sensitive Parts

Many solid state electrical components can be damaged by electrostatic discharge (ESD). Some will display a label, but many will not.

In order to avoid possibly damaging any components, observe the following:

1. Body movement produces an electrostatic charge. To discharge personal static electricity, touch a ground point (metal) on the vehicle. This should be done any time you:
   - Slide across the vehicle seat.
   - Sit down or get up.
   - Do any walking.
2. Do not touch exposed electric terminals on components with your finger or any tools. Remember, the connector that you are checking might be tied into .a circuit that could be damaged ‘by electrostatic discharge.
3. When using a screwdriver or similar tool to disconnect a connector, never let the tool come in contact with or come between the exposed terminals.
4. Never jumper, ground, or use test equipment probes on any components or connectors unless specified in diagnosis. When using test equipment, always connect the ground lead first.
5. Do not remove the solid state component from its protective packaging until you are ready to install the part.
6. Always touch the solid state components package to a ground before opening. Solid state components can also be damaged if:
   - They are bumped or dropped.
   - They are laid on any metal work benches or components that operate electrically, such as a TV, radio, or oscilloscope.

GLOSSARY OF TERMS

Air Valve Vacuum (AVV): The vacuum signal taken from below the air valve assembly and above the throttle butterfly.

ADP: Adaptive Digital Processor.

Air/Fuel Ratio: The amount of air and fuel in the air fuel mixture, which enters the engine, shown in a ratio.

Analog Voltmeter: A meter that uses a needle to point to a value on a scale of numbers usually of the low impedance type; used to measure voltage and resistance.

Aromatics: Pertaining to or containing the six-carbon ring characteristic of the benzene series. Found in many crude oils.

Backfire: Combustion of the air/fuel mixture in the intake or exhaust manifolds. A backfire can occur if the intake or exhaust valves are open when there is a mis-timed ignition spark.

Benzene: An aromatic (C6H6). Sometimes blended with gasoline to improve antiknock value. Benzene is toxic and suspected of causing cancer.

Bi-Fueled: A vehicle equipped to run on two fuels at the same time such as a fumigated diesel.

Blow-By: Gases formed by the combustion of fuel and air, which ordinarily should exert pressure only against the piston crown and first compression ring. When rings do not seal, these gases (blowby) escape down the side of the piston into the crankcase.

BTU: British Thermal Unit. A measurement of the amount of heat required to raise the temperature of 1lb. of water 1 degree F.

Butane: An odorless, colorless gas, C4H10 found in natural gas and petroleum. One of the five LP gases.

CAFE: Corporate Average Fuel Economy.

CARB: California Air Resources Board.

Carbon Monoxide (CO): A chemical compound of a highly toxic gas that is both odorless and colorless.

Carburetor: An apparatus for supplying an internal-combustion engine a mixture of vaporized fuel and air.

Cathode Ray Tube: A vacuum tube in which cathode rays usually in the form of a slender beam are projected on a fluorescent screen and produce a luminous spot.

Circuit: A path of conductors through which electricity flows before it returns to its source.

Closed Loop Operation: Applies to systems utilizing an oxygen sensor. In this mode of operation, the system uses oxygen sensor information to determine air/fuel ratio. Adjustments are made accordingly and checked by comparing the new oxygen sensor to previous signals. No stored information is used.

CNG: Compressed Natural Gas.

CKP: Crankshaft Position Sensor

CMP: Camshaft Position Sensor

Conductor: A material, normally metallic, that permits easy passage of electricity.

Contaminants: Impurities or foreign material present in fuel.

Control Module: One of several names for a solid state microcomputer which monitors engine conditions and controls certain engine functions; i.e. air/fuel ratio, injection and ignition time, etc.

Converter: A LPG fuel system component containing varying stages of fuel pressure regulation combined with a vaporizer.

Cryogen: A refrigerant used to obtain very low temperatures.

Current: The directed flow of electrons through a conductor. Measured in amps.

Dedicated Fuel System: A motor fuel system designed to operate on only one fuel type.

Diaphragm: A thin, flexible membrane that separates two chambers. When the pressure in one chamber is lower than in the other chamber, the diaphragm will move toward the side with the low pressure.

Diaphragm Port: The external port located at the fuel inlet assembly and connected to the vacuum chamber above the air valve diaphragm.

Digital Volt/Ohm Meter (DVOM): A meter that uses a numerical display in place of a gauge and is usually of the high impedance type.

DTC: Diagnostic Trouble Code

DST: Diagnostic Scan Tool.

DVOM: Digital volt/ohmmeter.

ECT: Engine Coolant Temperature.

ECM : Electronic Control module

EFI: Electronic Fuel Injection. A fuel injection system, which uses a microcomputer to determine and control the amount of fuel, required by, and injected into, a particular engine.

EGR: Exhaust gas recirculation.

EPA: Environmental Protection Agency: A regulating agency of the Federal government which, among other duties, establishes and enforces automotive emissions standards.

Ethanol: Grain alcohol (C2H5OH), generally produced by fermenting starch or sugar crops.

Evaporative Emissions Controls: An automotive emission control system designed to reduce hydrocarbon emissions by trapping evaporated fuel vapors from the fuel system.

Excess Flow Valve: A check valve that is caused to close by the fuel when the flow exceeds a predetermined rate.

Forced Idle: ECM commands electronic throttle controller to an idle position.

FTV: Fuel Trim Valve.

FFV: Flexible Fuel Vehicle.

Firing Line: The portion of an oscilloscope pattern that represents the total amount of voltage being expended through the secondary circuit.

FMVSS: Federal Motor Vehicle Safety Standards.

FPP: Foot Pedal Position Sensor

Fuel Injector:, a spring loaded, electromagnetic valve which delivers fuel into the intake manifold, in response to electrical from the control module.

Fuel Lock: A solenoid-controlled valve located in the fuel line to stop the flow when the engine stops or the ignition switch is off.

Gasohol: 10 percent ethanol, 90 percent gasoline. Often referred to as E-10.

Gasoline: A motor vehicle fuel that is a complex blend of hydrocarbons and additives. Typical octane level is 89.

Greenhouse Effect: A scientific theory that suggests that excessive levels of carbon dioxide from the burning of fossil fuels is causing the atmosphere to trap heat and cause global warming.

HD 10: A fuel of not less than 80% liquid volume propane and not more than 10% liquid volume propylene.

HD 5: A fuel of not less than 90% liquid volume propane and not more than 5% liquid volume propylene.

HDV: Heavy Duty Vehicle.

Hg: Chemical symbol for mercury. Used in reference to vacuum (in. of Hg).

Hydrocarbon: A chemical compound made up of hydrogen and carbon (HC). A major pollution emission of the internal combustion engine. Gasoline and almost all other fuels are hydrocarbons.

Hydrostatic Relief Valve: A pressure relief device installed in the liquid propane hose on a propane fuel system.

IAT: Intake Air Temperature

Ideal Mixture: The air/fuel ratio at which the best compromise of engine performance to exhaust emissions is obtained. Typically 14.7:1.

Ignition Reserve: The difference between available voltage and the required voltage.

ILEV: Inherently Low Emission Vehicle.

IMPCO: Imperial Machine Products Company. IMPCO Technologies, Inc. A manufacturer of both LPG and Gasoline fuel systems.

Impedance: A form of opposition of AC current flow (resistance) measured in ohms.

Insulation: A nonconductive material used to cover wires in electrical circuits to prevent the leakage of electricity and to protect the wire from corrosion.

Intercept: An electrical term for a type of splice where the original circuit is interrupted and redirected through another circuit.

ITK: IMPCO Test Kit

Knock: Sound produced when an engine's air/fuel mixture is ignited by something other than the spark plug, such as a hot spot in the combustion chamber. Can be caused by a

fuel with an octane rating that is too low or maladjusted ignition timing. Also called detonation or ping.

Lambda Sensor: A feedback device, usually located in the exhaust manifold, which detects the amount of oxygen present in exhaust gases in relation to the surrounding atmosphere.

LDV: Light Duty Vehicle.

Lean Mixture: An air to fuel ratio above the stoichiometric ratio; too much air.

LEV: Low Emission Vehicle.

Limp-in or Limp-home: This term is used to describe the drivability characteristics of a failed computer system

Liquified Petroleum Gas (LPG): A fuel commonly known as propane consisting mostly of propane (C3H8), derived from the liquid components of natural gas stripped out before the gas enters the pipeline, and the lightest hydrocarbons produced during petroleum refining. Octane level is 107.

Low Rev Limit Secondary engine speed control, only used to limit speed when throttle positioning is not maintaining desired speed

LPG: Liquified Petroleum Gas.

M85: A blend of gasoline and methanol consisting of 85% methanol and 15% gasoline.

Measurements of Pressure: 1 PSI=2.06 Hg (mercury) = 27.72" H2O (water column). At sea level atmospheric pressure is 29.92" Hg.

Methanol: Known as wood alcohol (CH3OH), a light, volatile, flammable alcohol commonly made from natural gas.

Misfire: Failure of the air/fuel mixture to ignite during the power stroke.

Mixer: Fuel introduction device that does not include a throttle plate.

MPFI: Multi-Point Fuel injection. A fuel injection system that uses one injector per cylinder mounted on the engine to spray fuel near the intake valve area of combustion chamber.

MTBE: Methyl Tertiary Butyl Ether. Oxygenate add to gasoline to reduce harmful emissions and to improve the octane rating.

Multi-fuel System: A motor fuel system designed to operate on two different fuels, such as LPG and gasoline.

Natural Gas: A gas formed naturally from buried organic material, composed of a mixture of hydrocarbons, with methane (CH4) being the dominant component.

NGV: Natural Gas Vehicle.

Nox: See Oxides of Nitrogen.

Octane Rating: The measurement of the antiknock value of a motor fuel.

OEM: Original Equipment Manufacturer, the vehicle manufacturer.

Open-Loop: An operational mode during which control module memory information is used to determine air/fuel ratio, injection timing, etc., as opposed to actual oxygen sensor input.

Orifice: A port or passage with a calibrated opening designed to control or limit the amount of flow through it.

Oscilloscope: An instrument that converts voltage and frequency readings into traces on a-cathode ray tube (also see Cathode Ray Tube).

Oxides of Nitrogen: Chemical compounds of nitrogen bonded to various amounts of oxygen (Nox). A chief smog forming-agent.

Oxygen Sensor: An automotive fuel system that produces a signal in accordance with the oxygen content of the exhaust gas. (See Lambda Sensor).

Oxygenate: MTBE, ethanol and methanol. Oxygenates are added to gasoline to increase the oxygen content and therefore reduce exhaust emissions.

Ozone: A radical oxygen module (O3) that is found in the upper atmosphere and filters out ultraviolet radiation from the sun. Ground level ozone is formed by Nox, during the formation of photochemical smog.

Particulates: Microscopic pieces of solid or liquid substances such as lead and carbon that are discharged into the atmosphere by internal combustion engines.

Positive Crankcase Ventilation (PCV): An automotive emission control system designed to reduce hydrocarbon emissions by routing crankcase fumes into the intake manifold rather than to the atmosphere.

Power Derate Level 1 ECM has detected condition in throttle control and limits throttle blade opening to 50%

Power Derate Level 2 ECM has detected condition in throttle control and limits throttle blade opening to 20%

Pressure Differential: The differential between atmospheric pressure and intake manifold (referred to as vacuum) pressure.

Pressure Regulator: A device to control the pressure of fuel delivered to the fuel injector(s).

Primary Circuit: The low-voltage or input side of the ignition coil.

Propane: An odorless, colorless gas, C3H8, found in natural gas and petroleum.

PTV: Pressure Trim Valve

Reactivity: Refers to the tendency of an HC in the presence of Nox and sunlight to cause a smog-forming reaction. The lighter the HC, the lower reactivity tends to be.

Regulator: An assembly used to reduce and control the pressure of a liquid or vapor.

Resistance: The opposition to the flow of current in an electrical circuit. Measured in ohms.

SECTION 0B

MAINTAINENCE

Maintenance

The maintenance of the engine and its related components is critical to the life of the engine and optimum performance during its useful life. All engines require a certain amount of maintenance. The suggested maintenance requirements are contained in this section. Industrial engines operate in various environments from extremely dusty environments, to hot and cold temperature environments and clean environments. The recommended schedule is a recommended guide line for the owner and servicing agency to follow, however certain environmental operating conditions may require more frequent inspection and maintenance. In addition the owner may have installed additional equipment to the equipment which may also increase the requirements for service on certain components. Therefore the owner and servicing agent should review the operating condition of the equipment and determine if more frequent inspections and maintenance cycles maybe required.

⚠ WARNING

The engine installed in this equipment may use one or both accessory drive belt configurations. The drive belt may be incorporated to drive the water pump, alternator and addition pumps or devices. It is important to note, the drive belt is an integral part of the cooling and charging system and should be inspected at a minimum according to the maintenance schedule in this section and in extremely hot and dirty environments more often.

When inspecting the belts check for:

- Cracks,
- Chunking of the belt,
- Splits
- Material hanging loose from the belt
- Glazing, hardening

If any of these conditions exist the belt should be replaced with an OEM replacement belt.

V-Belt Systems

Check the belt tension by pressing down on the midway point of the longest stretch between two pulleys. The belt should not depress beyond 13mm (1/2 inch). If the depression is more than allowable adjust the tension. Do not over tighten the tension of the belt. Over tightening may cause overload on the bearings and pulleys of the drive belt components.

Serpentine Belt System

Serpentine belts utilize a spring-loaded tensioner which keeps the belt properly adjusted. Serpentine belts should be checked according to the maintenance schedule in this section.

NOTE

The engine manufacturer does not recommend the use of "belt dressing" or "anti slipping agents" on either belt configuration.

Cooling System

⚠ WARNING

It is important to remember that the cooling system of this engine be maintained properly to insure the longevity of the engine. Maintenance of the cooling system is critical to not only the engine but the fuel system as well. Because the LPG vaporizer is connected into the cooling system low coolant levels and restricted or plugged radiator cores can impact the performance of the fuel system. Therefore proper maintenance of the cooling system should include removing dust, dirt and debris from the radiator core on regular intervals. To properly maintain the cooling system follow the recommend maintenance schedule in this section.

Cooling system inspections should be performed as prescribed when inspecting the cooling system check for the following:

- Plugged or restricted radiator core clean with compressed air, blow dust and debris from the core and the fan shroud
- Check the radiator cap to insure proper sealing if damage replace
- Check for coolant leaks at the radiator tank seams and inlet joints repair or replace as necessary
- Check for leaks at the radiator hose connections, tighten hose clamps if necessary
    - Check Radiator hoses for swelling,

separation, cracks deterioration in the hoses, or hardening, if any of these conditions exist the hose should be replaced with the OEM replacement parts

- Check coolant level if low add with 50/50 mixture, Do not add plain water
- Replace coolant per the recommended schedule at the end of this section

CHECKING THE COOLANT LEVEL

⚠ WARNING

Do not remove the cooling system pressure cap when the engine is hot. Allow the engine to cool and then remove the cap slowly allowing pressure to vent. Hot coolant under pressure may discharge violently.

1. Check coolant level in coolant recovery tank. Add specified coolant as required.

NOTE

The engine manufacturer and the fuel system supplier do not recommend the use of “stop leak” additives to repair leaks in the cooling system. If leaks are present the radiator should be removed and repaired.

If the radiator requires repair insure that the radiator core repairs did not result in a significant reduction in the cooling capacity of the radiator.

The engine manufacturer recommends the cooling system be filled with a 50/50 mixture of ethelyene glychol anitfreeze and water.

This GM industrial engine can utilize any type of permanent antifreeze or any brand antifreeze solution that meets GM Specification 1825M or 1899M which will not damage aluminum parts.

Engine Electrical System Maintenance

The engine electrical system incorporates computers to control certain functions of the equipment. The electrical system connections and ground circuits require good connections. Follow the recommended maintenance schedule in this section to maintain optimum performance. When inspecting the electrical system check the following:

- Check battery connection clean and insure that connectors are tight.
- Check battery for cracks or damage to the case replace if necessary.
- Check Positive and Negative cables for corrosion, rubbing, chaffing and insure tight connections at both ends.
- Check engine wire harness for rubbing, chaffing, pinching, and cracks or breaks in the wiring.
- Check engine harness connectors, check to insure fitted and locked by pushing the connector together then pull on the connector halves to insure they are locked.
- Check ignition coil wire for hardening, cracking, arcing, chaffing, separation, split boot covers and proper fit.
- Check spark plug wires for hardening, cracking, chaffing, separation, split boot covers and proper fit.
- Replace spark plugs at the required intervals per the recommended maintenance schedule
- Check to insure all electrical components are securely mounted and retained to the engine or chassis.
- Check to insure any additional electrical devices installed by the owner are properly installed in the system.
- Check the MIL, charging, and oil pressure lights for operation by starting the engine and checking that the light illuminates for the prescribe period of time before turning out.

Engine Crankcase Oil

Oil Recommendation

Prior to changing the oil, select oil based on the prevailing daytime temperature in the area in which the equipment will be operated. The chart in figure 1 is a guide to selecting the proper crankcase oil.

IMPORTANT: Oils containing “solid” additives, non-detergent oils, or low quality oils are not recommended by the engine manufacturer.

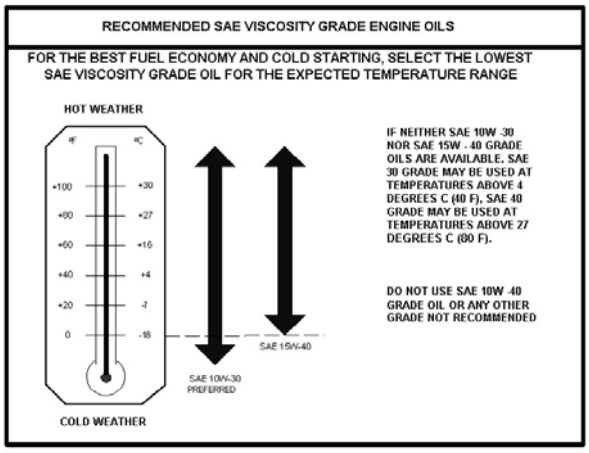


Figure 1 Engine Oil Viscosity Recommendation

Use Of Supplemental Additives

Use of the oils recommended by the engine manufacturer already contains a balanced additive treatment. The uses of supplemental additives which are added to the engine

oil by the customer are not necessary and may be harmful. The engine manufacturer, fuels system suppliers and engine distributors do not review, approve or recommend such products.

Synthetic Oils

Synthetic oils have been available for use in industrial engines for a relatively long period of time. Synthetic oils may offer advantages in cold temperature pumpability and high temperature oxidations resistance. However, synthetic oils have not proven to provide operational or economic benefits over conventional petroleum-based oils in industrial engines. Their use does not permit the extension of oil change intervals.

Checking/filling Engine Oil Level

NOTE

Care must be taken when checking engine oil level. Oil level must be maintained between the “ADD” mark and the “FULL” mark on the dipstick. To ensure that you are not getting a false reading, make sure the following steps are taken before checking the oil level.

1. Stop engine if in use
2. Allow sufficient time (approximately 5 minutes) for the oil to drain back into the oil pan
3. Remove the dipstick. Wipe with a clean cloth or paper towel and reinstall. Push the dipstick all the way into the dipstick tube.
4. Remove the dipstick and note the oil level.
5. Oil level must be between the “FULL” and “ADD” marks.

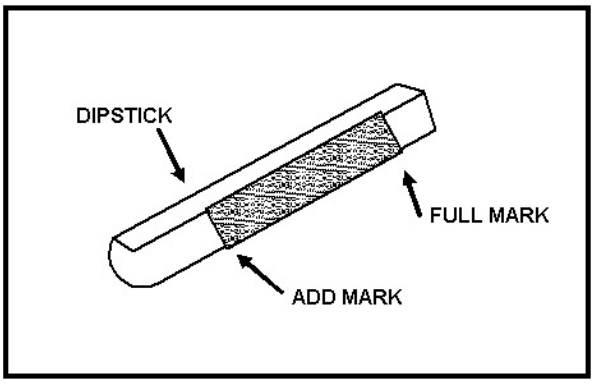


Figure 2 *Engine Oil Dip stick (Typical)*

6. If the oil level is below the “ADD” mark, proceed to Step 7 and 8, and reinstall the dipstick into the dipstick tube.
7. Remove the oil filler cap from the valve rocker arm cover
8. Add the required amount of oil to bring the level up to but not over the “FULL” mark on the dipstick
9. Reinstall the oil filler cap to the valve rocker arm cover and wipe any excess oil clean.\

Changing The Engine Oil

NOTE

When changing the oil, always change the oil filter.

1. Start the engine and run until it reaches normal operating temperature.

NOTE

Change oil when engine is warm from operation as it flows more freely, carrying away more impurities.

2. Stop engine.

⚠ WARNING

Engine oil will be hot. Use protective gloves to prevent burns. Engine oil contains chemicals which may be harmful to your health avoid skin contact.

3. Remove drain plug and allow the oil to drain.
4. Remove and discard oil filter and it sealing ring.
5. Coat sealing ring on the new filter with clean engine oil, wipe the sealing surface on the filter mounting surface to remove any dust, dirt or debris. Tighten filter securely (follow filter manufacturers instructions). Do not overtighten.
6. Check sealing ring on drain plug for any damage, replace if necessary, wipe plug with clean rag, wipe pan sealing surface with clean rag and re-install plug into the pan. Tighten to specification.
7. Fill crankcase with oil.
8. Start engine and check for oil leaks.
9. Dispose of oil and filter in a safe manner.

Fuel System Inspection And Maintenance

Propane Fuel System

The Propane fuel system installed on this industrial engine has been designed to meet the emission standard applicable for this equipment for 2004 model year. To ensure compliance to these standards follow the recommended maintenance schedule contained in this section.

Inspection And Maintenance Of The Fuel Storage Cylinder

The fuel storage cylinder should be inspected daily or at the beginning of each operational shift for any leaks, external damage, adequate fuel supply and to insure the manual service valve is open. Fuel storage cylinders should always be securely mounted, inspect the securing straps or retaining devices for damage insure that all locking devices are closed and locked. Check to insure that the fuel storage cylinder is positioned with the locating pin in the tank collar on all horizontally mounted cylinders this will insure the proper function of the cylinder relief valve.

When refueling or exchanging the fuel cylinder check the quick fill valve for thread damage. Insure the o-ring is in place, check the o-ring for cracking, chunking or separation, replace if damaged before filling. Check the service line quick coupler for any thread damage. Insure the o-ring is in place, check the o-ring for cracking, hardening, chunking or separation. Replace if damaged.

NOTE

When refueling the fuel cylinder, wipe clean both the female and male connection with a clean rag prior to filling. This will prevent dust, dirt and debris from being introduced to the fuel cylinder and prolong the life of the fuel filter.

Inspection And Replacement Of The Fuel Filter

The Propane system on this emission certified engine utilizes an in-line replaceable fuel filter element. This element should be replaced, at the intervals specified in the recommended maintenance schedule. When inspecting the fuel filter check the following:

- Check for leaks at the inlet and outlet fittings, using a soapy solution or an electronic leak detector, if leaks are detected make repairs
- Check to make sure filter is securely mounted.
- Check filter housing for external damage or distortion, if damaged replace fuel filter

To replace the filter use the following steps:

1. Move the equipment to a well ventilated area and insure all external ignition sources are not present.
2. Start the engine.
3. With the engine running close the manual valve.
4. When the engine runs out of fuel turn OFF the key when the engine stops and disconnect the battery negative cable.

⚠ WARNING

A small amount of fuel may still be present in the fuel line, use gloves to prevent burns, wear proper eye protection. If liquid fuels continues to flow from the connections when loosened check to make sure the manual valve is fully closed.

5. Slowly loosen the inlet fitting and disconnect.
6. Slowly loosen the outlet fitting and disconnect.
7. Remove the filter housing form the equipment.
8. Check for contamination.
9. Tap the opening of the filter on a clean cloth.
10. Check for debris.
11. Check canister for proper mounting direction.
12. Reinstall the filter housing to the equipment.
13. Tighten the inlet and outlet fittings to specification.
14. Open the manual valve.

NOTE

The fuel cylinder manual valve contains an "Excess Flow Check Valve" open the manual valve slowly to prevent activating the "Excess Flow Check Valve".

15. Check for leaks at the inlet and outlet fittings, and the filter housing end connection using a soapy solution or an electronic leak detector, if leaks are detected make repairs.

Low Pressure Regulator Maintenance And Inspection

NOTE

The Low Pressure Regulator (LPR) components have been specifically designed and calibrated to meet the fuel system requirements of the emission certified engine. The regulator should not be disassembled or rebuilt. If the LPR fails to operate or develops a leak the LPR should be replaced with the OEM recommended replacement parts.

When inspecting the regulator check for the following items:

- Check for any fuel leaks at the inlet and outlet fittings.
- Check for any fuel leaks in the regulator body.
- Check the inlet and outlet fittings of the coolant supply lines for water leaks.
- Check the coolant supply lines for hardening, cracking, chaffing or splits. If any of these conditions exist replace coolant lines.
- Check coolant supply hose clamp connections, ensure they are tight.
- Check the to ensure the Pressure Trim Valve (PTV) mounting bolts are secure.
- Check PTV for external amage.
- Check PTV electrical connection to ensure the connector is seated and locked.
- Check to ensure the regulator is securely mounted.

Checking/draining Oil Build-up In The Low Pressure Regulator

During the course of normal operation oil or "heavy ends" may build inside the secondary chamber of the Low Pressure Regulator (LPR). These oil and heavy ends may be a result of poor fuel quality, contamination of the fuel supply chain, or regional variation of the fuel make up. If the build up of oil becomes significant this can affect the performance of the secondary diaphragm response. The Recommended Maintenance Schedule found in this section recommends that the oil be drained periodically.

NOTE

Draining the regulator when the engine is warm will help the oils to flow freely from the regulator.

To drain the LPR use the following steps:

1. Move the equipment to a well ventilated area and ensure no external ignition sources are present.
2. Start the engine.
3. With the engine running close the manual valve.
4. When the engine runs out of fuel turn OFF the key when the engine stops and disconnect the battery negative cable.

⚠ WARNING

A small amount of fuel may still be present in the fuel line, use gloves to prevent burns, wear proper eye protection. If liquid fuels continues to flow from the connections when loosened check to make sure the manual valve is fully closed.

5. Slowly loosen the inlet fitting and disconnect.
6. Loosen the hose clamp at the outlet hose fitting and remove the hose.
7. Remove and retain the locking pin in the outlet fitting and remove the outlet fitting from the LPR
8. Disconnect PTV connection and disconnect the vacuum hose.
9. Remove the two LPR mounting bolts and retain.
10. Place a small receptacle in the engine compartment.
11. Rotate the LPR to 90° so that the outlet fitting is pointing down into the receptacle and drain the LPR.
12. Inspect the secondary chamber for any large dried particles and remove.
13. Remove the receptacle and reinstall the LPR with the two retaining bolts and tighten to specifications.
14. Reinstall the outlet fitting and secure with the previously removed locking pin.
15. Reconnect the PTV electrical connection push connector until lock “Click”, pull on the connector to ensure it is locked, connect the vacuum line.
16. Reconnect the outlet hose and secure the hose clamp.
17. Reinstall the fuel inlet line and tighten connection to specification.
18. Slowly open the manual service valve.

NOTE

The fuel cylinder manual valve contains an “Excess Flow Check Valve” open the manual valve slowly to prevent activating the “Excess Flow Check Valve”.

19. Check for leaks at the inlet and outlet fittings using a soapy solution or an electronic leak detector, if leaks are detected make repairs. Check coolant line connections to ensure no leaks are present.
20. Start engine recheck for leaks at the regulator.
21. Dispose of any drained material in safe and proper manner.

Air Fuel Mixer/throttle Control Device Maintenance And Inspection

⚠ CAUTION

The Air Fuel Mixer components have been specifically designed and calibrated to meet the fuel system requirements of the emission certified engine. The mixer should not be disassembled or rebuilt. If the mixer fails to operate or develops a leak the mixer should be replaced with the OEM recommended replacement parts.

When inspecting the mixer check for the following items:

- Check for any fuel leaks at the inlet fitting.
- Check the fuel inlet hose for cracking, splitting or chaffing, replace if any of these condition exist.
- Check to ensure the mixer is securely mounted.
- Check air inlet hose connection and insure clamp is tight, check inlet hose for cracking, splitting or chaffing, replace if any of these condition exist.
- Check air cleaner element according to the *Recommended Maintenance Schedule* found in this section.
- Check fuel line to Throttle body mounted Fuel

Trim Valve (FTV) for cracking, splitting or chaffing, replace if any of these condition exist.

- Check Throttle body return action to ensure throttle shaft is not sticking repair if necessary.
- Check FTV electrical connection to ensure connector is fully seated and locked.
- Check for leaks at the throttle body and intake manifold.

Exhaust System And Catalytic Converter Inspection And Maintenance

NOTE

The exhaust system on this emission certified engine contains an Exhaust Gas Oxygen Sensor (EGO) which provides feed back to the ECM on the amount of oxygen present in the exhaust stream after combustion. The measurement of oxygen in the exhaust stream is measured in voltage and sent to the ECM. The ECM then makes corrections to the fuel air ratio to ensure the proper fuel charge and optimum catalytic performance. Therefore it is important that the exhaust connections remain secured and air tight.

⚠ CAUTION

The EGO sensor is sensitive to silicone or silicone based products. Do not use silicone sprays or hoses which are assembled using silicone lubricants. Silicone contamination can cause severe damage to the EGO.

When inspecting the Exhaust system check the following:

- Check the exhaust manifold at the cylinder head for leaks and that all retain bolts and shields (if used) are in place.
- Check the manifold to exhaust pipe fasteners to ensure they are tight and that there are no exhaust leaks repair if necessary.
- Check EGO electrical connector to ensure connector is seated and locked, check wires to ensure there is no cracking, splits chaffing or “burn through” repair if necessary.
- Check any exhaust pipe extension connector for leaks tighten if necessary
- Visually inspect converter to insure muffler is securely mounted and tail pipe is properly aimed.
- Check for any leaks at the inlet and outlet of the converter

leaks

- Check the base of the injector for leaks
- Check the injector wire connections to ensure sure they are fully seated and locked
- Check the fuel pressure sender electrical connection to ensure they are fully seated and locked

CERTIFIED ENGINE MAINTENANCE REQUIREMENTS										
	Install	Interval Hours								
	Date	Daily	250	500	750	1000	1250	1500	1750	2000
General Maintenance Section										
Visual check for leaks		**X**								
Check engine oil level		**X**								
Check coolant level		**X**								
Change engine oil and filter	**Every 200 hours or monthly**									
Check Fuel system for leaks	**Prior to any service or maintenance activity**									
Inspect Accessory Drive belts						**X**				**X**
Inspect electrical system										**X**
Inspect all vacuum lines and fitting										**X**
Inspect all fuel lines and fitting										**X**
Engine Coolant Section										
Check coolant level		**X**								
Clean debris from radiator core	**Every 100 hours or 60 days of operation**									
Change coolant						**X**				**X**
Inspect coolant hoses for cracks, swelling or deterioration						**X**				**X**
Engine Ignition System										
Inspect Battery case for damage						**X**				**X**
Inspect battery cables						**X**				**X**
Check all electrical connectors						**X**				**X**
Check ignition timing and adjust										**X**
Replace spark plugs										**X**
Check spark plug wires										**X**
Fuel System Maintenance										
Replace fuel filter						**X**				**X**
Inspect lock off for leaks										**X**
Ensure lock off closing										**X**
Test LPG/Gas regulator pressure										**X**
Inspect LPR for oil build up	**Annually or every 2000 hours**									
Inspect LPR for coolant leaks	**Annually or every 2000 hours**									
Check air induction system for leaks										**X**
Check manifold for vacuum leaks										**X**
Check FTV electrical connection										**X**
Check throttle shaft for sticking										**X**
Check injector & rails for leaks										**X**
Inspect air cleaner	**Every 200 hours, or every 100 hours in dusty environment**									
Replace filter element	**Annually, or Bi-annually in dusty environments**									
Engine Exhaust System										
Inspect exhaust manifold for leaks										**X**
Inspect exhaust piping for leaks										**X**
Inspect catalyst inlet and outlet										**X**
Check HEGO sensor connector										**X**

The maintenance schedule represents manufacturers recommended maintenance intervals to maintain proper engine/equipment function. Specific state and federal regulations may require equipment operators to conduct comprehensive engine/equipment inspections at more periodic intervals than those specified above. This maintenance schedule has no regulatory value and should not be considered representative of any state or federal engine/equipment maintenance requirement.

SECTION 1A1

LPG FUEL SYSTEM OPERATION

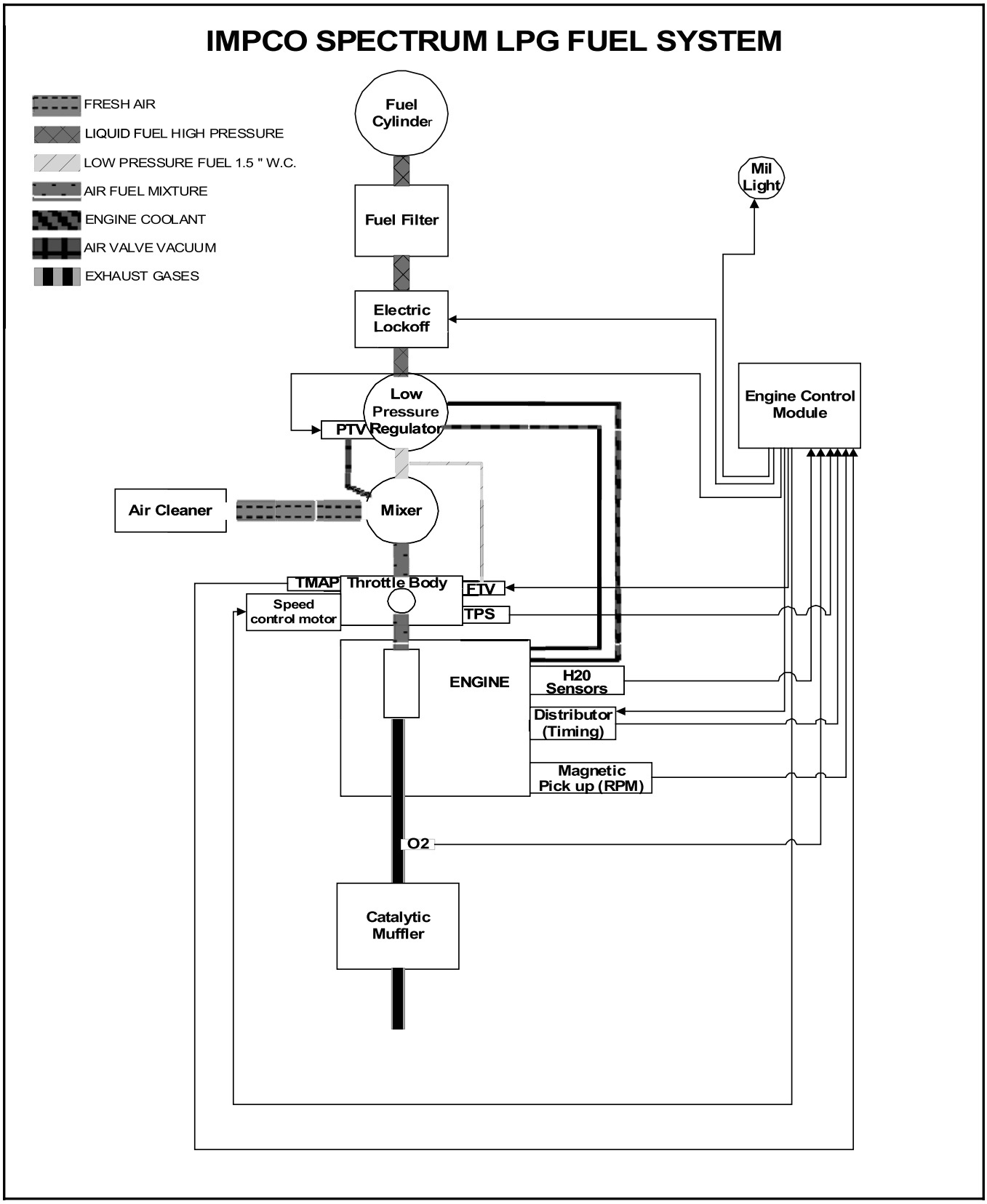


Figure 1 Typical Fuel System Schematic

Description and Operation of the Fuel Systems

Propane Fuel System

The primary components of the propane fuel system are the fuel storage tank, low pressure regulator (LPR), fuel mixer module with throttle control device, electric fuel lock-off solenoid, engine control unit (ECM) fuel trim valve (FTV) pressure trim valve (PTV) and three way catalytic (TWC) converter. The system operates at pressures which range from 355.60 mm (14.0 inches) of water column up to 21.5 BAR (312 psi).

LPG Fuel Tank

1. Liquid Outage valve w/quick disconnect coupling	11. Vapor Withdrawal Tube (when applicable)
2. Filler Valve	12. 80% Limiter Tube
3. Pressure Relief Valve	13. Fuel Level Float
4. Liquid Outage Fill Check Valve	14. Liquid Withdrawal Tube
5. Fuel Gauge	

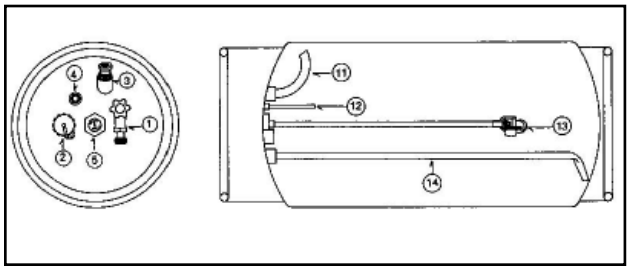


Figure 2 Typical Propane Fuel Tank

Propane is stored in the fuel tank as a liquid. The approximate pressure of the fuel in the tank is 16.5 bar (240 psi) when the tank is full at an ambient temperature of 27° C (81°F). The boiling point, (temperature at which the liquid fuel becomes vapor) is approximately -40° C (-40° F). When the fuel changes from liquid to vapor the fuel expands and creates pressure inside the tank. When the tank service valve is opened the pressure inside the tank forces the liquid fuel out though the pick up tube located near the bottom of the fuel cylinder. Because the propane is stored under pressure the tank is equipped with a safety valves which are normally set at 25.8 bar (375 psi) to prevent tank rupture due to over-pressurization of the cylinder. The service valve mounted in the end of the cylinder controls the flow of fuel from the tank. By turning the handle to its “open” position, fuel flows out of the tank and into the service line. The service valve is also equipped with a safety feature called an “excess flow check valve”. This feature reduces the flow from the service valve in the event of a rupture of the fuel line or any down stream component.

Service Line

Propane flows from the fuel tank to the electric lock via the service line. The service line is connected to the tank utilizing a quick coupler. The other end of the service line is connected to a “bulkhead connector” mounted on the equipment sheet metal. This bulkhead connector allows for a safe means of passing through the equipments engine compartment sheet metal and into the engine compartment. If a bulkhead connector is used a pressure relief device is mounted in the service line or the connector itself to prevent over pressurization of the service line. The service line is made of high pressure hose with special material or possibly tubing which is friendly to the LPG fuel and should always be replaced with an OEM supplied part.

⚠ CAUTION

The bulkhead assembly should never be removed and a service line run through the sheet metal.

Fuel Filter

Propane fuel like all other motor fuels is subject to contamination from outside sources. Refueling of the equipments tank and removal of the tank from the equipment can inadvertently introduce dirt and other foreign matter into the fuel system. It is therefore necessary to filter the fuel prior to entering the fuel system components down stream of the tank. An inline bulkhead fuel filter is utilized in the fuel system to remove the dirt and foreign matter from the fuel. The filter is replaceable. Maintenance of the filter is critical to proper operation of the fuel system and should be replaced as

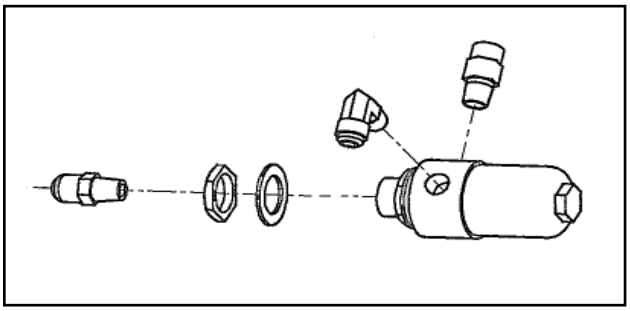


Figure 3 Inline Fuel Filter

defined in the Recommended Maintenance Schedule. In severe operating condition more frequent replacement of the filter may be necessary.

Electric Lock Off

The Electric Lock Off device is an integrated assembly. The electric lock assembly is a 12 volt normally closed valve. The solenoid is mounted to the valve body. When energized the solenoid opens the valve and allows the Propane fuel to flow through the device. The valve opens during cranking and run cycles of the engine. The lock off supply voltage is controlled by the engine module (ECM)

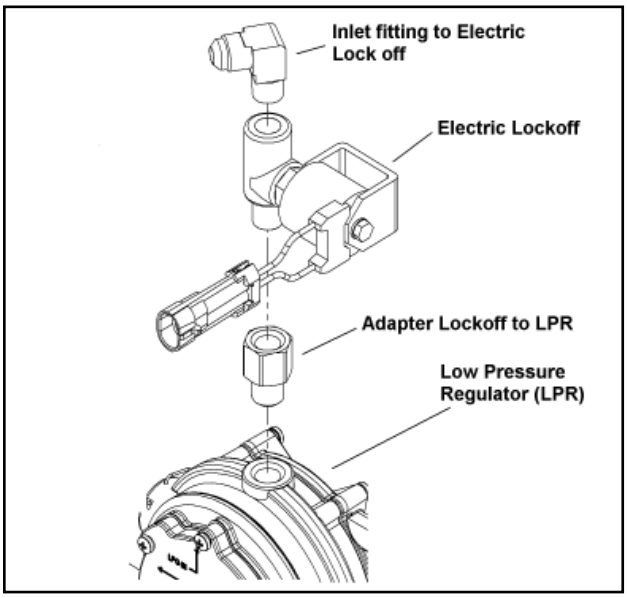


Figure 4 Electric Fuel Lock Off

Low Pressure Regulator (LPR)

The LPR is a combination vaporizer, pressure regulating device. The LPR is a negative pressure two stage regulator that is normally closed when the engine is not running. When the engine is cranking or running a partial vacuum is created in the fuel line which connects the regulator to the mixer. This partial vacuum opens the regulator permitting fuel to flow to the mixer.

Propane fuel enters the primary port of the LPR and passes through the primary jet and into the primary/exchanger chamber. As the propane passes through the heat exchanger the fuel expands and creates pressure inside the chamber. The pressure rises as the fuel expands when the pressure rises above 10.34 kpa (1.5 psi), sufficient pressure is exerted on the primary diaphragm to cause the diaphragm plate to pivot and press against the primary valve pin thus closing off the flow of fuel. This action causes the flow of fuel into the regulator to be regulated. When the engine is cranking, sufficient vacuum will be introduce into the secondary chamber from the mixer drawing the secondary diaphragm down onto the spring loaded lever and opening the secondary valve allowing vaporized fuel to pass to the mixer. Increased vacuum in the secondary chamber increases the downward action on the secondary lever causing it to open wider allowing more fuel to flow to the mixer.

The regulator utilized on this emission certified engine is equipped with a unique Pressure Trim Valve (PTV) which is directly mounted to the regulator. This solenoid is a 12 volt normally closed solenoid. The function of this solenoid is to regulate a specific amount of venture vacuum to the atmospheric side of the secondary diaphragm. By introducing vacuum to the top side of the secondary diaphragm during regulator operation the amount of fuel being delivered to the mixer can be “trimmed” or reduced to allow for correction to the air fuel ratio for closed loop fuel control. The solenoid receives a reference signal from the ECM which causes the solenoid to be pulsed fast or slow depending on the amount of fuel to be trimmed.

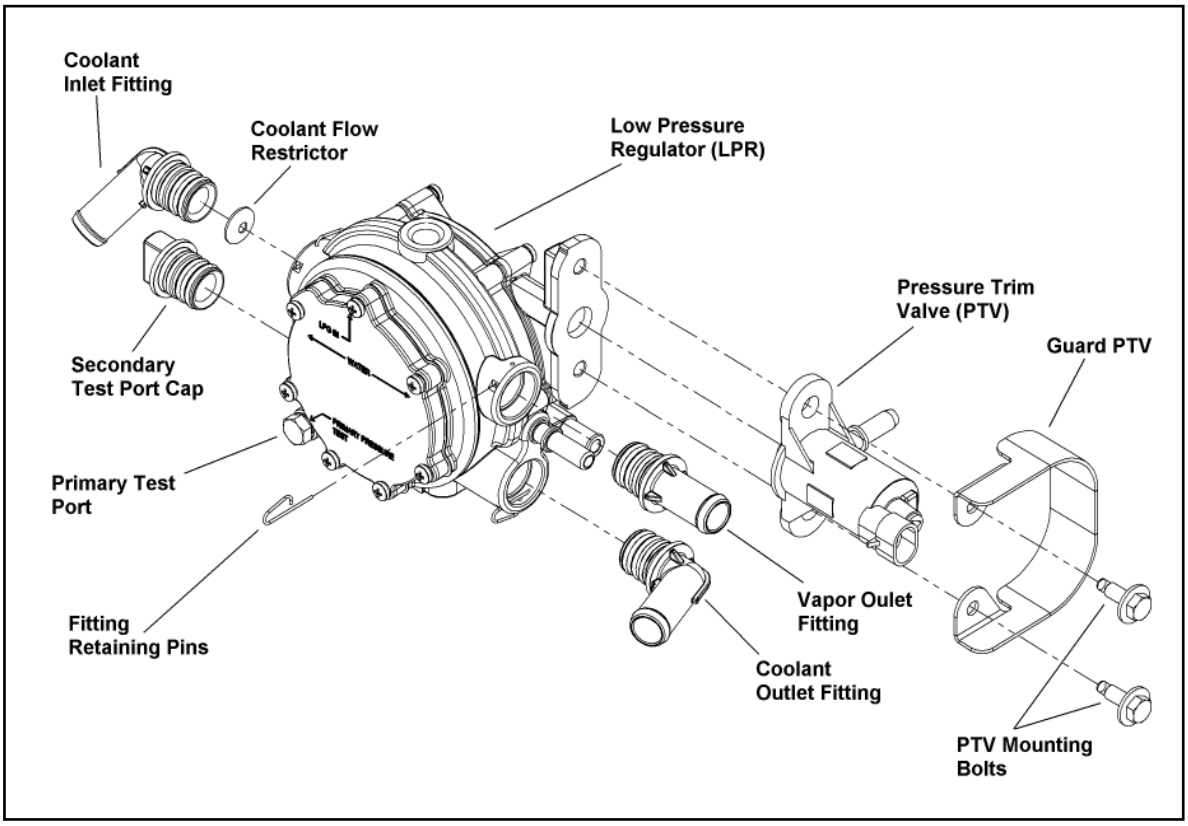


Figure 5 Low Pressure Regulator

⚠ CAUTION

The LPR is an emission control device. Components inside the regulator are specifically calibrated to meet the engine emissions requirements and should never be disassembled or rebuilt. If the LPR fails to operate, replace with an OEM replacement part.

⚠ CAUTION

When servicing the regulator use caution to insure the jet is replaced in the regulator. Failure to install the jet may cause damage to the regulator and cause fuel control and emission problems.

The process of pressure reduction within the regulator causes a refrigeration effect this requires that the regulator be heated with engine coolant to prevent the regulator from freezing and fail to function properly. The regulator is connected into the coolant system by hoses connected to the engines coolant circuit. The emission certified regulator contains an orifice or jet in the outet side of the regulator to maintain the proper amount of coolant flow during regular operation. The orifice is located between the inlet fitting and the housing of the regulator.

Air Fuel Mixer

The air valve mixer is an air-fuel metering device and is completely self-contained. The mixer is an air valve design, utilizing a relatively constant pressure drop to draw fuel into the mixer from cranking to full load. The mixer is mounted in the air stream ahead of the throttle control device.

⚠ CAUTION

The air/fuel mixer is an emission control device. Components inside the mixer are specifically calibrated to meet the engines emissions requirements and should never be disassembled or rebuilt. If the mixer fails to operate replace

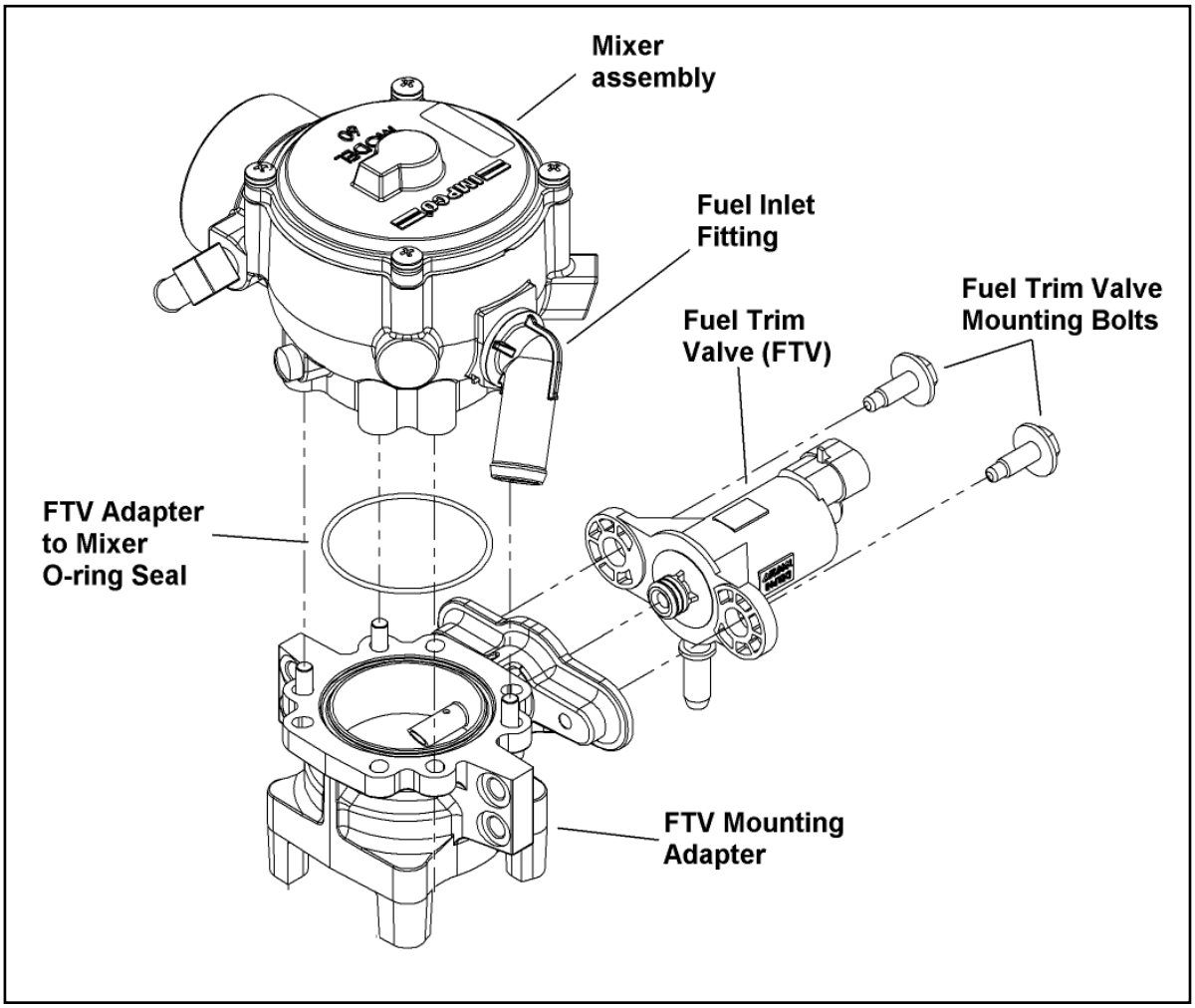


Figure 6 Air Fuel Mixer

with an OEM replacement part.

When the engine begins to crank it draws in air with the air valve covering the inlet, negative pressure begins to build. This negative pressure signal is communicated to the top of the air valve chamber through four vacuum ports in the air valve assembly. A pressure/force imbalance begins to build across the air valve diaphragm between the air valve vacuum chamber and the atmospheric pressure below the diaphragm. The air valve vacuum spring is calibrated to generate from 101.6 mm (4.0 inches) of water column at start to as high as 355.60 mm (14.0 inches) of water column at full throttle. The vacuum being created is referred to as Air Valve Vacuum (AVV). As the air valve vacuum reaches 101.6mm (4.0 inches) of water column, the air valve begins to lift against the air valve spring. The amount of AVV generated is a direct result of the throttle position. At low engine speed the air valve vacuum is low and the air valve position is low thus creating a small venturi for the fuel to flow. As the engine speed increase the AVV increases and the air valve is lifted higher thus creating a much larger venturi. This air valve vacuum is communicated from the mixer venture to the LPR secondary chamber via the low pressure fuel supply hose. As the AVV increases in the secondary chamber the secondary diaphragm is drawn further down forcing the secondary valve lever to open wider.

The mixer is equipped with a low speed mixture adjustment which is retained in a tamper proof housing. The mixer has been preset at the factory and should not require any adjustment. In the event that the idle adjustment should need to be adjusted refer to the Fuel System Repair section of this manual.

The mixer is mounted into the air stream utilizing an adapter which contains the Fuel Trim Valve (FTV). The FTV is utilized to assist with

fuel control while the engine is operating. The FTV is a 12 volt normally closed electric valve and is connected to the LPR by a fuel line. The FTV normally receives a pulse from the ECM which causes the FTV to be cycled open and closed to allow additional fuel to be supplied to the air stream above the throttle plate. During normal closed loop operating condition the ECM provides a electrical pulse to both the FTV and the PTV which controls the amount of fuel being introduced into the air stream. The PTV is connected to the Air Valve Vacuum (AVV) which reduces the amount of fuel flow to the regulator; the FTV introduces additional fuel into the air stream. By cycling the PTV more frequently and the FTV less frequently the air fuel ratio can be leaned, by decreasing the PTV duty cycles and increasing the FTV duty cycles the air fuel ratio can be increased.

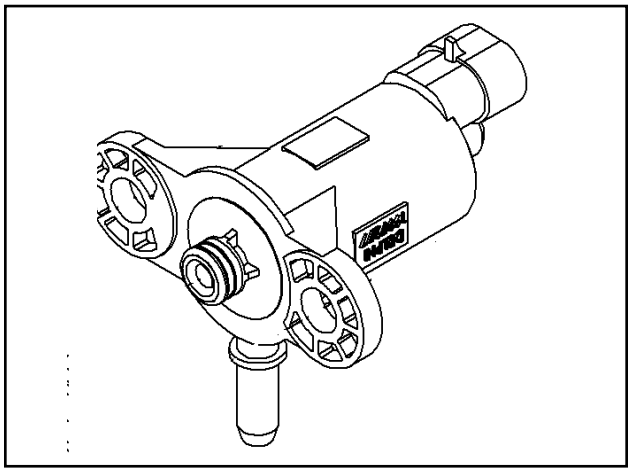


Figure 7 Pressure Trim Valve and Fuel Trim Valve

Throttle Control Device

Drive By Wire

Engine speed control is maintained by the amount of pressure applied to the foot pedal located in the engine compartment. In a Drive By Wire (DBW) application there is no direct connection between the operator pedal and the throttle shaft. Speed and load control are determined by the ECM. Defaults programmed into the ECM software and throttle position sensors allow the ECM to maintain safe operating control over the engine.

In a drive by wire application the Electronic Throttle Control device or “throttle body assembly” is connected to the intake manifold of the engine. The electronic throttle control device utilizes an electric motor connected to the throttle shaft. In addition a Foot Pedal Position sensor (FPP) is located in the operator’s compartment. When the engine is running electrical signals are sent from the foot pedal position sensor to the engine ECM when the operator depresses or release the foot pedal. The ECM then sends an electrical signal to the motor on the electronic throttle control to increase or decrease the angle of the throttle blade thus increasing or decreasing the air/fuel charge to the engine.

The electronic throttle control device incorporates two internal Throttle Position Sensors (TPS) which provide output signals to the ECM as to the location of the throttle shaft and blade. The TPS information is used by the ECM to correct for speed and load control as well as emission control.

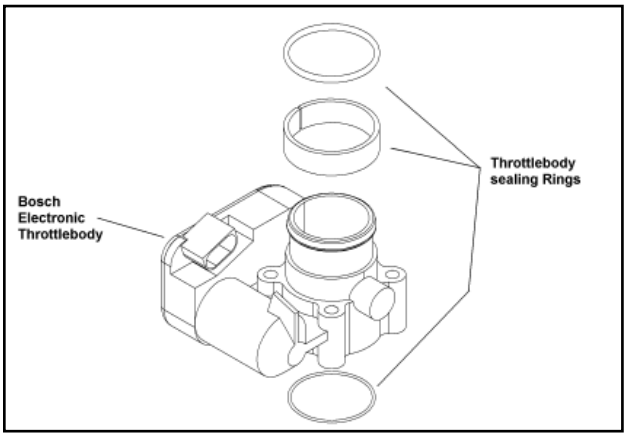


Figure 8 Electronic Throttle control device “Drive by Wire” throttle body assembly”

Three Way Catalytic Muffler

The emission certified engine has been designed and calibrated to meet the emission standards in effect for 2004. To help meet the emission requirements the vehicle has been equipped with a Three Way Catalytic (TWC) muffler. The catalyst muffler is a three way

catalyst, sound damping and spark arresting unit. Besides controlling the noise created from the combustion process, and preventing sparks from escaping from the exhaust system the most important function is treating the exhaust gases which are created from the combustion process. The three-way catalyst consists of a honeycomb coated with a mixture of platinum, palladium, and rhodium. The hot gases flow through the catalyst sections where an oxidation and reduction reactions take place. These chemical reactions reduce the amount of CO, HC and NOX in the engines exhaust. The Exhaust gas then flows through the outlet

Figure 9 Three way catalytic converter

Engine Control Module

To obtain maximum effect from the catalyst and accurate control of the air fuel ratio the emission certified engine is equipped with an onboard computer or Engine control module (ECM). The ECM is a 32 bit controller which receives in-put data from sensors fitted to the engine and fuel system and then out-puts various signals to control engine operation.

One specific function of the controller is to maintain “closed loop fuel control”. Closed loop fuel control is accomplished when the exhaust gas oxygen sensor (EGO) mounted in the exhaust system sends a voltage signal to the controller. The controller then calculates any correction that may need to be made to the air fuel ratio. The controller then out-puts signals to PTV or the FTV or both mounted in the fuel system to change the amount of fuel being delivered from the regulator or mixer or to the engine.

The controller also performs diagnostic functions on the fuel system and notifies the operator of malfunctions by turning on a Malfunction Indicator Light (MIL) mounted in the dash. Malfunctions in the system are identified by a Diagnostic Code number. In addition to notifying the operator of the malfunction in the system the controller also stores the information about the malfunction in its memory. A technician can than utilize a computerized diagnostic tool to retrieve the stored diagnostic code and by using the diagnostic charts in this manual determine the cause of the malfunction. In the event a technician does not have the computerized diagnostic tool the MIL light can be used to identify the diagnostic code. By following specific steps the technician can activate the “blink” feature and count the number of blinks to determine the diagnostic code number to locate the fault in the system.

Heated Exhaust Gas Oxygen Sensor

The Heated Exhaust Gas Oxygen Sensor (HEGO) is mounted in the exhaust system downstream of the engine. The HEGO is used to measure the amount of oxygen present in the exhaust stream and communicate that to the ECM via an electrical signal. The amount of oxygen present in the exhaust stream indicates whether the fuel air ratio is to rich or to lean. If the HEGO sensor signal indicates that the exhaust stream is to rich the ECM will decrease or lean the fuel mixture during engine operation, if the mixture is to lean the ECM will richen the mixture. The ECM continuously monitors the HEGO sensor output if a rich or lean condition is present for an extended period of time and the ECM cannot correct the condition the ECM will set a diagnostic code and turn on the MIL light in the dash.

⚠ CAUTION

The Heated Exhaust Gas Oxygen Sensor (HEGO) is an emissions control component. If the HEGO fails to operate, replace only with

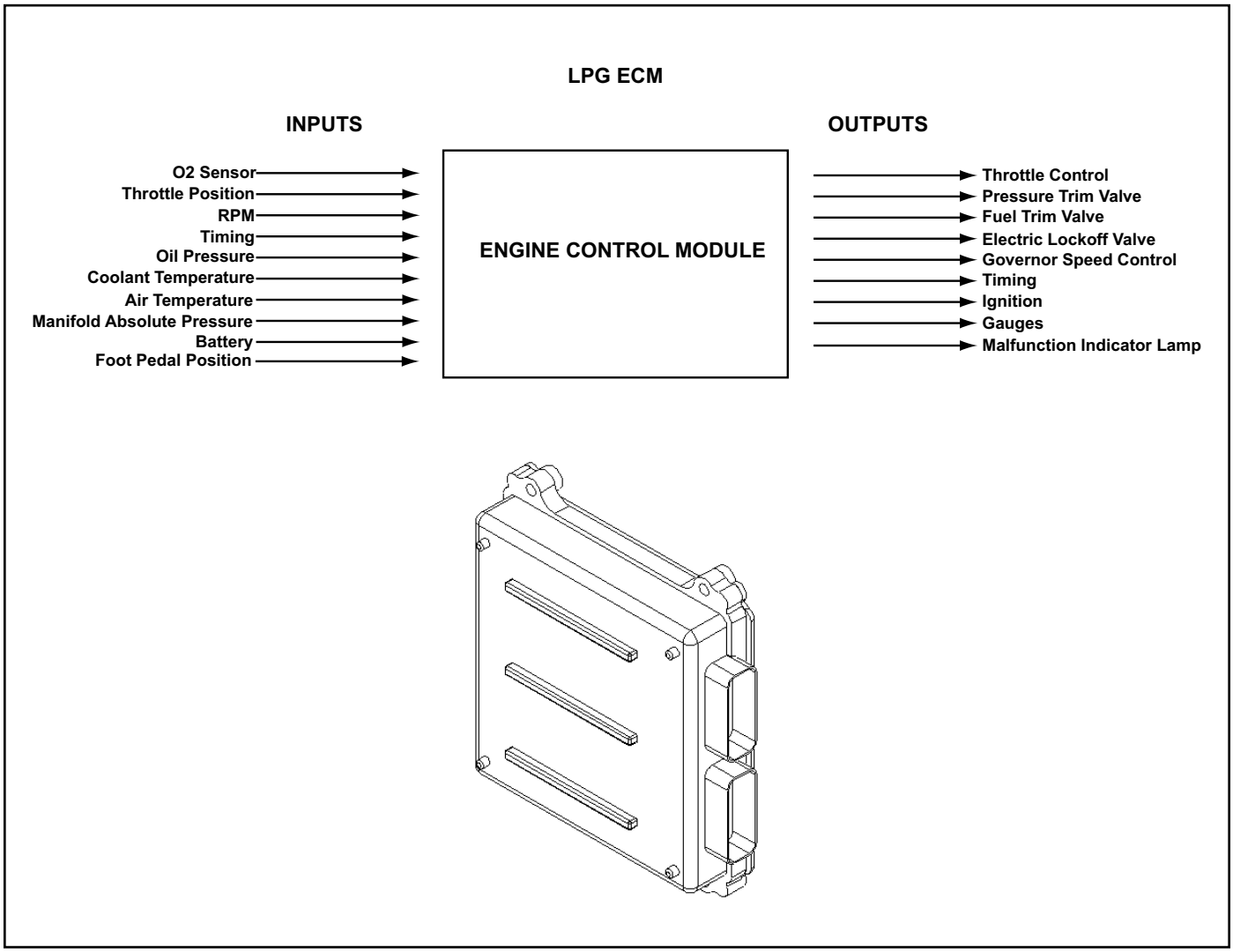


Figure 10 Engine control unit (ECM)

an OEM replacement part. The HEGO sensor is sensitive to silicone and silicone based products and can become contaminated. Avoid using silicone sealers or hoses treated with silicone lubricant in the air stream or fuel supply lines.

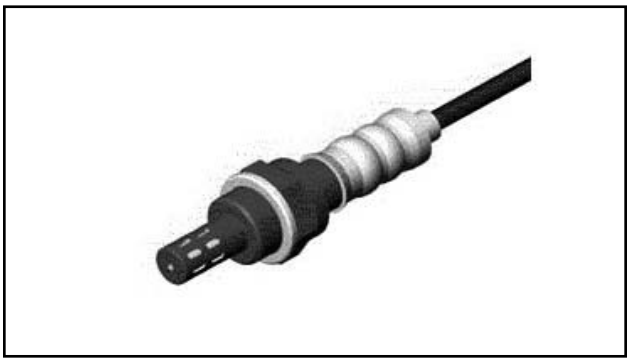


Figure 11 Exhaust Gas Oxygen Sensor (EGO)

Temperature Manifold Absolute Pressure Sensor (TMAP)

The ECM receives signal from sensors mounted to the engine and fuel system to control engine operation and emission control. The TMAP is a dual sensor mounted in the air stream of the fuel system. The TMAP provides the ECM with the temperature of the air charge entering the engine which the ECM utilizes to correct the air fuel ratio depending on the ambient air temperature the vehicle is operating in. It also provides the ECM with the Manifold Absolute Pressure (MAP) which allows to the ECM to adjust fuel air ratio based on barometric pressure as well provides the ECM with the load condition being introduce to the engine. The TMAP is mounted to the throttle body to manifold adapter.

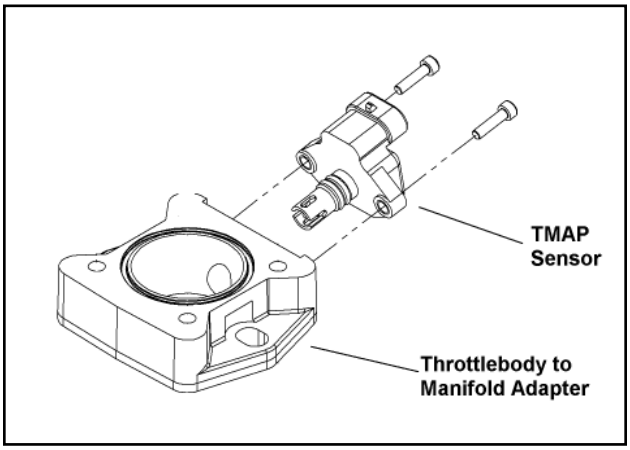


Figure 12 Temperature Manifold Absolute Pressure (TMAP) sensor

Engine RPM Sensor

The ECM relies on a Magnetic sensor to count the revolutions of the crankshaft to determine the engine speed. The Magnetic sensor is mounted to a bracket located directly above a timing whell which is machined with teeth to trip the magnetic sensor.. The timing wheel is mounted to the front pulley of the engine.

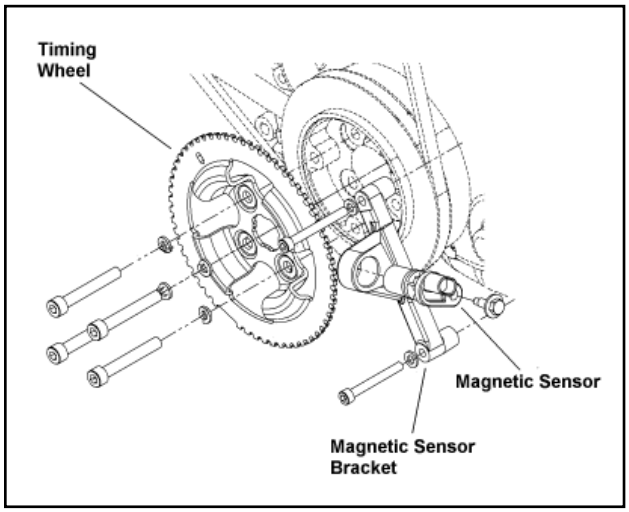


Figure 13 Magnetic Sensor & Timing Wheel

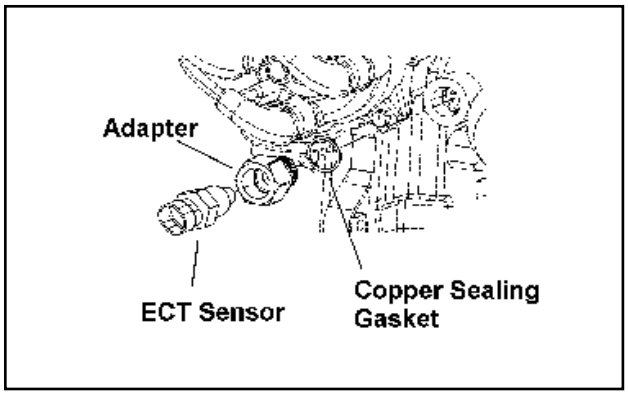


Figure 14 Engine Coolant Temperature Sensor (ECT)

Engine Coolant Tmeperature Sensor (ECT)

The ECM receives a signal from the Engine Coolant Temperature (ECT) sensor. The ECM will make correction to the air fuel ratio based on the engine operating temperature. The ECM has also been programmed with default settings which may result in a power reduction or shut down the engine in the event the engine overheats.

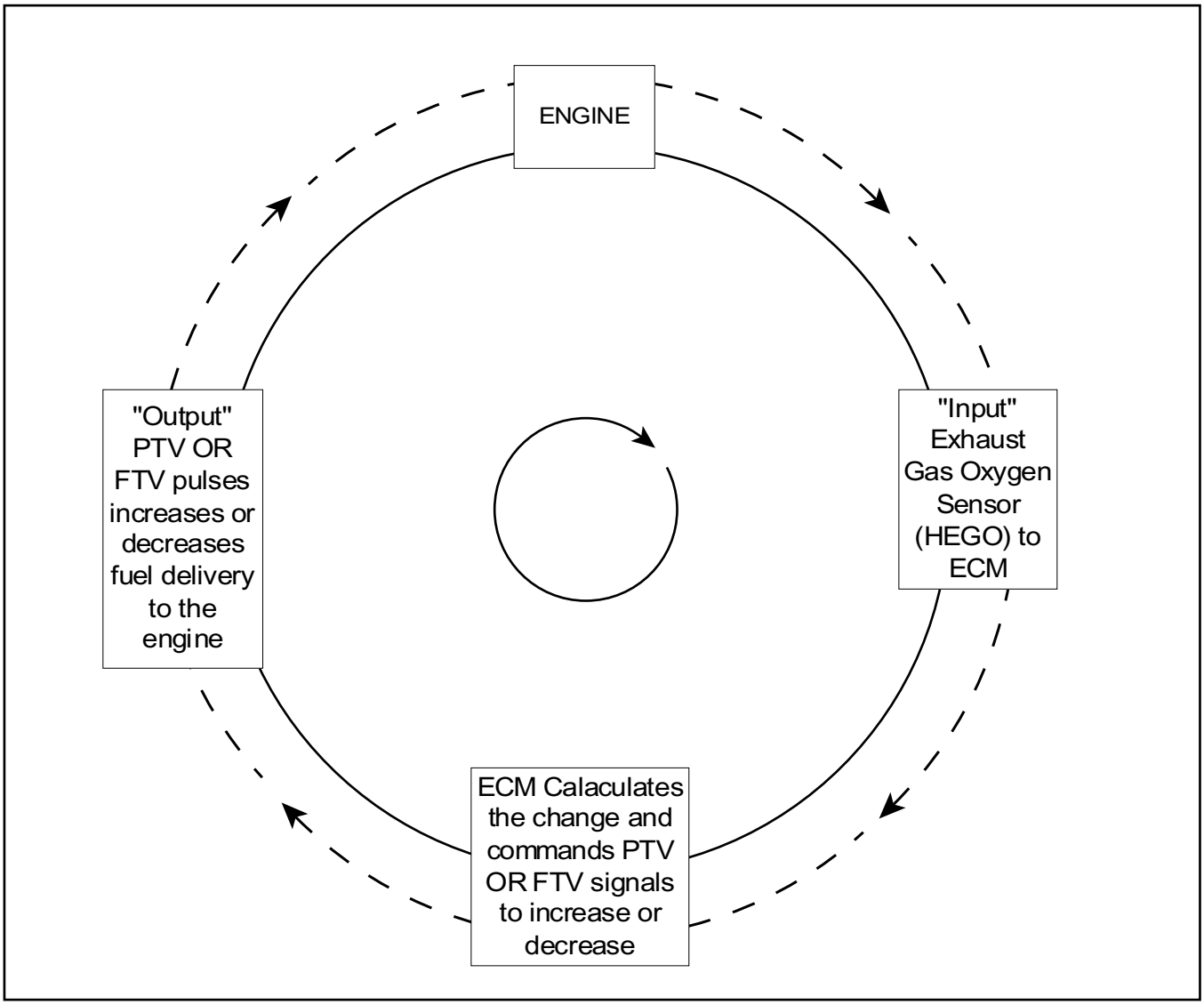


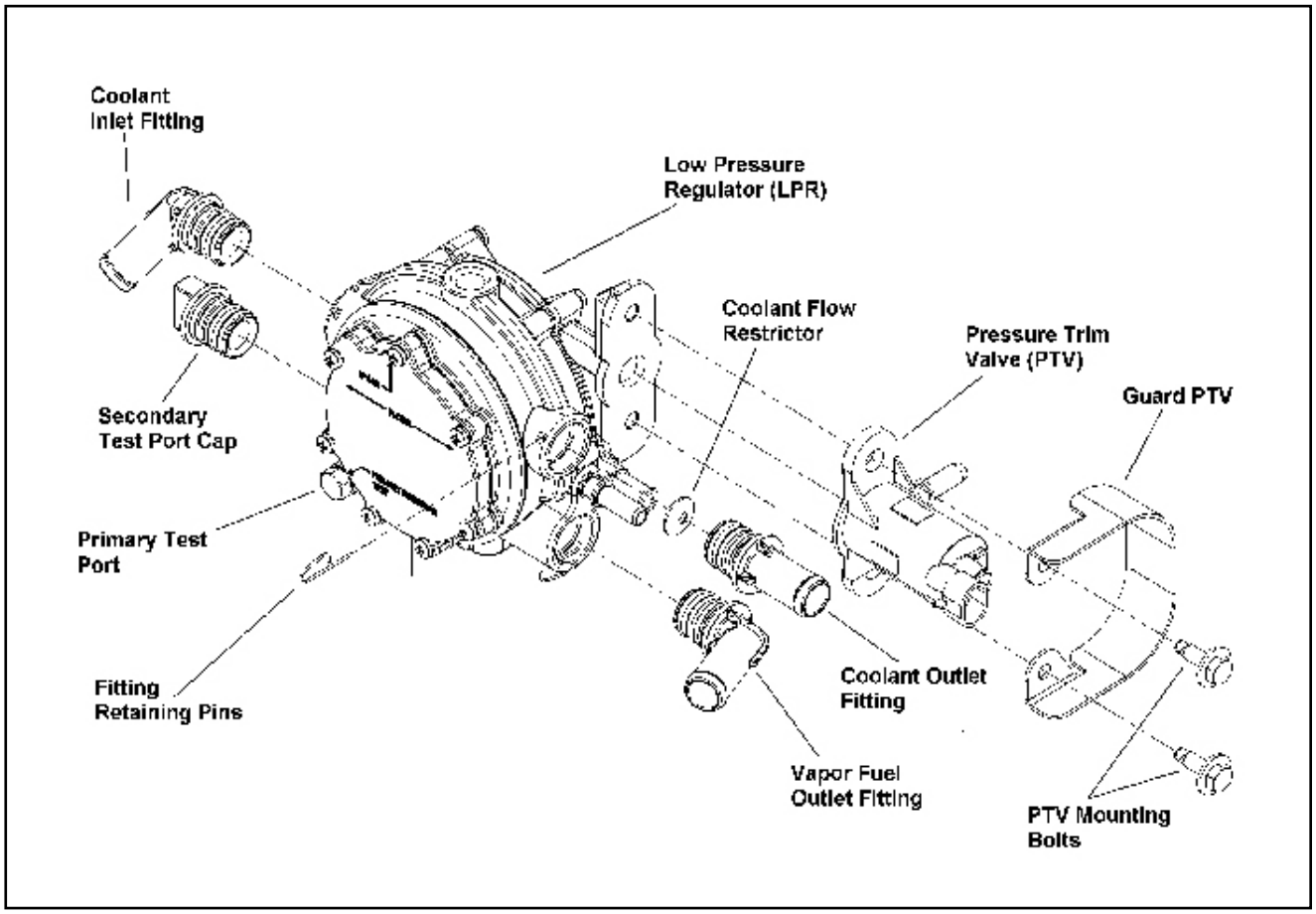
Figure 15 Propane Closed Loop Control Schematic

Closed Loop Control System

Closed Loop control is the term used to describe the strategy used by the ECM to maintain proper tail pipe emission. The ECM utilizes the input of the sensors in the system to adjust air fuel ratio. The HEGO provides a signal to the ECM which indicates the amount of oxygen present in the exhaust gases after combustion. The correct air fuel ratio is necessary to maintaining proper temperature in the catalyst for conversion of the unburned gases after combustion and supplying sufficient power for engine operation.

SECTION 1B1

LPG FUEL SYSTEM DIAGNOSTICS



LPG Fuel System Diagnosis

Fuel System Description

The Engine Control Module (ECM) receives information from various engine sensors in order to control the operation of the fuel control solenoid valves (FTV) and the low-pressure lock-off (LPL) solenoid. The LPL solenoids prevent fuel flow unless the engine is cranking or running. LPG is stored in the tank and delivered under pressure to the system as a liquid. During key on, the LPL receives a two (2) second prime pulse from the ECM which allows LPG to flow from the tank through fuel filter and fuel lines to the low pressure regulator (LPR) at pressures up to 312 psi.

In the (LPR) the fuel is vaporized and the pressure reduced in two stages. The first stage reduces the pressure to approximately 4.5 psi. The second stage reduces the pressure to approximately negative 1.5" of water column.

The fuel is then drawn from the secondary chamber of the LPR by the vacuum generated by air flowing through the mixer. This vacuum signal is also used to generate lift for the mixer air valve. This vacuum signal is most commonly referred to as air valve vacuum. In the mixer, the fuel mixes with the air entering the engine. This air/fuel mixture is then drawn into the engine for combustion.

Diagnostic Aids

This procedure is intended to diagnose a vehicle operating on LPG. If the vehicle will not continue to run on LPG, refer to Hard Start for preliminary checks. Before proceeding with this procedure, verify that the vehicle has a sufficient quantity of fuel and that liquid fuel is being delivered to the LPR. Also, ensure that the manual shut off valve on the LPG tank is fully opened and that the excess flow valve has not been activated.

Tools Required:

- 7/16 Open end wrench (for test port plugs)
- Straight Blade screw driver
- DVOM (GM J 39200, Fluke 88 or equivalent).

Duty Cycle Monitoring Tool

- IMPCO Fuel System Analyzer (FSA), or DVOM (GM J 39200, Fluke 88 or equivalent).

Diagnostic Scan Tool

- IMPCO hand held PDA or equivalent.

Pressure Gauges

- Water Column Gauge / Manometer (GM 7333-6 or equivalent).
- 0-10 PSI Gauge

Test Description

The numbers below refer to step numbers on the diagnostic table.

5. This step will determine if the fuel control solenoid (FCS) and fuel supply system are functioning properly. The vacuum on the secondary test port will be approximately –1.0 " to –2.0" w.c. If the vehicle has a hard start or poor idle, check for proper operation of the idle control solenoid (ICS).
6. This step checks the base mechanical LPR output pressure by disabling all fuel control devices.
9. This step checks for proper air valve operation.
19. This determines if fuel is available from the fuel tank supply system.

LPG Fuel System Diagnosis

Step	Action	Value(s)	Yes	No
1	Were you referred to this procedure by a DTC diagnostic chart?	—	Go to *Step 3*	Go to *Step 2*
2	Perform the On Board Diagnostic (OBD) System Check. Are any DTCs present in the ECM?	—	Go to the applicable DTC Table	Go to *Step 3*
3	Verify that the LPG fuel tank has a minimum of 1/4 tank of fuel, that the manual valve is open and the tank quick connect is fully engaged Does the vehicle have fuel?	—	Go to *Step 4*	—
4	1. Connect a water column gauge or a manometer to the secondary test port of the low pressure regulator (LPR). 2. Start the engine and allow it to reach operating temperature. Does the engine start and run?	—	Go to *Step 5*	Go to *Step 8*
5	With the engine idling, observe the pressure reading for the LPR secondary pressure. Does the fuel pressure fluctuate rhythmically **OUTSIDE** the specified range?	-1.0" to -2.0" w.c.	Go to *Step 25*	Go to *Step 6*

6	1. Disconnect the PTV electrical connectors. **Note:** This action may cause a DTC to be set by the ECM 2. With the engine idling observe the pressure reading on the secondary test port. Is the fuel pressure **WITHIN** the specified range?	-1.0” to -2.0” w.c.	Go to *Fuel Control System Diagnosis*	Go to *Step 7*
7	1. Inspect the air intake stream between the mixer assembly and the throttle body for leaks. 2. Inspect the fuel hose connection between the LPR and mixer assembly for damage or leakage. 3. Inspect the vacuum hoses to the FTV solenoid. Was a problem found and corrected?	—	Go to *Step 26*	Go to *Step 22*
8	1. Connect a water column gauge or a manometer to the secondary test port of the low pressure regulator (LPR). 2. Crank the engine and observe the pressure reading for the LPR secondary pressure. Does the fuel pressure indicate a vacuum is present?	—	Go to *Step 12*	Go to *Step 9*
9	1. Remove Air induction hose to the mixer 2. Observe the air valve for movement while the engine is cranking. **Note:** Movement of the air valve will be minimal at cranking speeds. Does the air valve move when the engine is cranked?	—	Go to *Step 11*	Go to *Step 10*

10	1. Inspect the air intake stream to the mixer assembly and the throttle body for vacuum leaks. 2. Inspect the vacuum hoses from the mixer to the PTV solenoids for proper connection and condition. Was a problem found and repaired?	—	Go to *Step 26*	Go to *Step 24*
11	Inspect the fuel hose connection between the LPR and the mixer assembly for damage or leakage. Was a problem found and repaired?	—	Go to *Step 26*	Go to *Step 12*
12	1. Connect a 0-10 psi gauge to the primary test port of the low pressure regulator (LPR). 2. Crank the engine and observe the pressure reading for the LPR primary pressure. Is the fuel pressure **ABOVE** the specified value?	2.0 – 4.0 psi	Go to *Step 22*	Go to *Step 13*
13	1. Turn OFF the ignition. 2. Disconnect the LPL connector. 3. Install a test light between the pins of the LPL connector. 4. Crank the engine. The test light should illuminate. Does the test light illuminate?	—	Go to *Step 14*	Go to *Step 16*
14	Using a DVOM, check the resistance of the low pressure lock-off (LPL). Is the resistance within the specified range?	12 - 24 Ω	Go to *Step 15*	Go to *Step 23*

15	1. Turn the ignition OFF. 2. Close the manual shut-off valve on the LPG tank. **CAUTION: When disconnecting LPG fuel lines, liquid LPG may be present. Perform this step in a well ventilated area.** 3. Loosen the fuel inlet hose fitting at the inlet of the LPL. Was fuel present when the fitting was loosened?	—	Go to *Step 23*	Go to *Step 17*
16	1. Turn OFF the ignition. 2. Connect the test light to chassis ground and probe pin A of the LPL connector. 3. Crank the engine. The test light should illuminate. Does the test light illuminate?	—	Go to *Step 20*	Go to *Step 21*
17	1. Remove the LPG fuel filter / LPL. 2. Remove the filter from the LPL. 3. Empty the contents of the inlet side of the LPG fuel filter onto a clean surface. 4. Inspect the contents of the LPG fuel filter for an excessive amount of foreign material or water. If necessary, locate and repair the source of contamination. 5. Verify the LPG fuel filter is not restricted or plugged. Was a problem found?	—	Go to *Step 19*	Go to *Step 23*
18	The fuel supply system or hoses are plugged or restricted, locate and repair the problem. Is the action complete?	—	Go to *Step 26*	—
19	Replace the fuel filter. Refer to *Fuel Filter Replacement.* Is the action complete?	—	Go to *Step 26*	—

20	Repair the open in the lock-off ground circuit. Is the action complete?	—	Go to *Step 26*	—
21	Repair the open in the lock-off power (OEM fuel pump) circuit. Is the action complete?	—	Go to *Step 26*	—
22	Replace the low pressure regulator (LPR). Refer to *Low Pressure Regulator Replacement*. Is the action complete?	—	Go to *Step 26*	—
23	Replace the lock-off. Refer to *Low Pressure Lock-off (LPL) Replacement*. Is the action complete?	—	Go to *Step 26*	—
24	Replace the mixer assembly. Refer to *Fuel Mixer Replacement*. Is the action complete?	—	Go to *Step 26*	—
25	The fuel supply system is operating normally, if a failure of the control solenoids is suspected. Refer to *Fuel Control System Diagnosis.* 1. Install the test plug in the LPR secondary chamber. 2. If you were sent to this routine by another diagnostic chart, return to the previous diagnostic procedure. Is the action complete?	—	System OK	—

26	1. Disconnect all test equipment 2. Install the primary and secondary test port plugs. 3. Start the engine. 4. Using SNOOP® or equivalent, leak check the test port plugs. Is the action complete?	—	System OK	—

SECTION 1B4

SYMPTOM DIAGNOSIS

Symptom Diagnosis

Important Preliminary Checks

Checks	Action
Before Using This Section	Before using this section, you should have performed On Board Diagnostic Check and determined that: 1. The Control Module and MIL (Malfunction Indicator Lamp) are operating correctly. 2. There are no Diagnostic Trouble Codes (DTCs) stored, or a DTC exists but without a MIL. Several of the following symptom procedures call for a careful visual and physical check. The visual and physical checks are very important. The checks can lead to correcting a problem without further checks that may save valuable time.
LPG Fuel System Check	1. Verify the customer complaint. 2. Locate the correct symptom table. 3. Check the items indicated under that symptom. 4. Operate the vehicle under the conditions the symptom occurs. Verify HEGO switching between lean and rich. **IMPORTANT!** **Normal HEGO switching indicates the LPG fuel system is in closed loop and operating correctly at that time.** 5. If a scan tool is available, **take a snapshot** under the condition that the symptom occurs. Go to *Engine Scan Tool Data* List to verify normal sensor values and parameters.

Visual and Physical Checks	• Check all ECM system fuses and circuit breakers. • Check the ECM ground for being clean, tight and in its proper location. • Check the vacuum hoses for splits, kinks and proper connections. • Check thoroughly for any type of leak or restriction. • Check for air leaks at all the mounting areas of the intake manifold sealing surfaces. • Check for proper installation of the mixer module assembly. • Check for air leaks at the mixer assembly. • Check the ignition wires for the following conditions: − Cracking − Hardness − Proper routing − Carbon tracking • Check the wiring for the following items: − Proper connections, pinches or cuts. • The following symptom tables contain groups of possible causes for each symptom. The order of these procedures is not important. If the scan tool readings do not indicate the problems, then proceed in a logical order, easiest to check or most likely to cause first.

Intermittent

Checks	Action
DEFINITION: The problem may or may not turn ON the Malfunction Indicator Lamp (MIL) or store a Diagnostic Trouble Code (DTC).	
Preliminary Checks	• Refer to *Important Preliminary Checks.* • Do not use the DTC tables. If a fault is an intermittent, the use of the DTC tables may result in the replacement of good parts.
Faulty Electrical Connections or Wiring	• Faulty electrical connections or wiring can cause most intermittent problems. • Check the suspected circuit for the following conditions: − Faulty fuse or circuit breaker − Connectors poorly mated − Terminals not fully seated in the connector (backed out) − Terminals not properly formed or damaged − Terminal to wires poorly connected − Terminal tension insufficient. • Carefully remove all the connector terminals in the problem circuit in order to ensure the proper contact tension. If necessary, replace all the connector terminals in the problem circuit in order to ensure the proper contact tension. • Checking for poor terminal to wire connections requires removing the terminal from the connector body.
Operational Test	If a visual and physical check does not locate the cause of the problem, drive the vehicle with a scan tool. When the problem occurs, an abnormal voltage or scan reading indicates the problem may be in that circuit.
Intermittent Malfunction Indicator Lamp (MIL)	The following components can cause intermittent MIL and no DTC(s): • A defective relay, Control Module driven solenoid, or a switch that can cause electrical system interference. Normally, the problem will occur when the faulty component is operating. • The improper installation of electrical devices, such as lights, 2-way radios, electric motors, etc. • The ignition secondary voltage shorted to a ground. • The Malfunction Indicator Lamp (MIL) circuit or the Diagnostic Test Terminal intermittently shorted to ground. • The Control Module grounds.

Loss of DTC Memory	To check for the loss of the DTC Memory: 1. Disconnect the TMAP sensor. 2. Idle the engine until the Malfunction Indicator Lamp illuminates. The ECM should store a TMAP DTC. The TMAP DTC should remain in the memory when the ignition is turned OFF. If the TMAP DTC does not store and remain, the ECM is faulty.
Additional Checks	.

No Start

Checks	Action
DEFINITION: The engine cranks OK but does not start.	
Preliminary Checks	• Refer to *Important Preliminary Checks*.
Control Module Checks	• If a scan tool is available: • Check for proper communication with both the ECM • Check the 3A inline fuse in the ECM battery power circuit. Refer to *Engine Controls Schematics.* • Check battery power, ignition power and ground circuits to the ECM. Refer to *Engine Control Schematics.* Verify voltage and/or continuity for each circuit.
Sensor Checks	• Check the TMAP sensor. • Check the Magnetic pickup sensor (RPM). .
Fuel System Checks	**Important**: A closed LPG manual fuel shut off valve will create a no start condition. • Check for air intake system leakage between the mixer and the throttle body. • Verify proper operation of the low pressure lock-off solenoids. • Verify proper operation of the fuel control solenoids. • Check the fuel system pressures. Refer to the *LPG Fuel System Diagnosis*. • Check for proper mixer air valve operation.

Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. • Check for the proper ignition voltage output with *J 26792* or the equivalent. • Verify that the spark plugs are correct for use with LPG (R46TS) • Check the spark plugs for the following conditions: − Wet plugs − Cracks − Wear − Improper gap − Burned electrodes − Heavy deposits • Check for bare or shorted ignition wires. • Check for loose ignition coil connections at the coil.
Engine Mechanical Checks	**Important:** The LPG Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than the gasoline fuel supply system. • Check for the following: − Vacuum leaks − Improper valve timing − Low compression − Bent pushrods − Worn rocker arms − Broken or weak valve springs − Worn camshaft lobes.
Exhaust System Checks	• Check the exhaust system for a possible restriction: − Inspect the exhaust system for damaged or collapsed pipes − Inspect the muffler for signs of heat distress or for possible internal failure. • Check for possible plugged catalytic converter. Refer to *Restricted Exhaust System Diagnosis*

Hard Start

Checks	Action
DEFINITION: The engine cranks OK, but does not start for a long time. The engine does eventually run, or may start but immediately dies.	
Preliminary Checks	• Refer to *Important Preliminary Checks*. • Make sure the vehicle's operator is using the correct starting procedure.
Sensor Checks	• Check the Engine Coolant Temperature sensor with the scan tool. Compare the engine coolant temperature with the ambient air temperature on a cold engine. IF the coolant temperature reading is more than 5 degrees greater or less than the ambient air temperature on a cold engine, check for high resistance in the coolant sensor circuit. Refer to *DTC 111* • Check the Crankshaft Position (CKP) sensor. • Check the Throttle position (TPS) sensor.
Fuel System Checks	**Important**: A closed LPG manual fuel shut off valve will create an extended crank OR no start condition. • Verify the excess flow valve in the LPG manual shut-off valve is not tripped. • Check mixer module assembly for proper installation and leakage. • Verify proper operation of the low pressure lock-off solenoids. • Verify proper operation of the PTV and FTV. • Check for air intake system leakage between the mixer and the throttle body. • Check the fuel system pressures. Refer to the *Fuel System Diagnosis*.

Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. • Check for the proper ignition voltage output with *J 26792* or the equivalent. • Verify that the spark plugs are correct for use with LPG (R46TS) • Check the spark plugs for the following conditions: − Wet plugs − Cracks − Wear − Improper gap − Burned electrodes − Heavy deposits • Check for bare or shorted ignition wires. • Check for moisture in the distributor cap if applicable. • Check for loose ignition coil connections. **Important**: 1. If the engine starts but then immediately stalls, Crankshaft Position (CKP). 2. Check for improper gap, debris or faulty connections.
Engine Mechanical Checks	**Important:** The LPF Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than the gasoline fuel supply system. • Check for the following: − Vacuum leaks − Improper valve timing − Low compression − Bent pushrods − Worn rocker arms − Broken or weak valve springs − Worn camshaft lobes. Ref • Check the intake and exhaust manifolds for casting flash.

Exhaust System Checks	• Check the exhaust system for a possible restriction: − Inspect the exhaust system for damaged or collapsed pipes − Inspect the muffler for signs of heat distress or for possible internal failure. • Check for possible plugged catalytic converter. Refer to *Restricted Exhaust System Diagnosis* or *Exhaust System* in the GM MD Service Manual.
Additional Checks	•

Cuts Out, Misses

Checks	Action
DEFINITION: A surging or jerking that follows engine speed, usually more pronounced as the engine load increases which is not normally felt above 1500 RPM. The exhaust has a steady spitting sound at idle, low speed, or hard acceleration for the fuel starvation that can cause the engine to cut-out.	
Preliminary Checks	• Refer to *Important Preliminary Checks*.
Ignition System Checks	• Start the engine. • Wet down the secondary ignition system with water from a spray bottle, and look/listen for arcing or misfiring as you apply water. • Check for proper ignition output voltage with spark tester J 26792. • Check for a cylinder misfire. • Verify that the spark plugs are correct for use with LPG (R46TS) • Remove the spark plugs in these cylinders and check for the following conditions: • Insulation cracks • Wear • Improper gap • Burned electrodes • Heavy deposits • Visually/Physically inspect the secondary ignition for the following: • Ignition wires for arcing, cross-firing and proper routing • Ignition coils for cracks or carbon tracking
Engine Mechanical Checks	• Perform a cylinder compression check. • Check the engine for the following: − Improper valve timing − Bent pushrods − Worn rocker arms − Worn camshaft lobes. − Broken or weak valve springs. • Check the intake and exhaust manifold passages for casting flash.

Fuel System Checks	• Check the fuel system - plugged fuel filter, low fuel pressure, etc. Refer to *LPG Fuel System Diagnosis*. • Check the condition of the wiring to the low pressure lock-off solenoid.
Additional Check	Check for Electromagnetic Interference (EMI). • EMI on the reference circuit can cause a missing condition. • Monitoring the engine RPM with a scan tool can detect an EMI. • A sudden increase in the RPM with little change in the actual engine RPM, indicates EMI is present. • If the problem exists, check the routing of the secondary wires and the ground circuit.

Hesitation, Sag, Stumble

Checks	Action
DEFINITION: The vehicle has a momentary lack of response when depressing the accelerator. The condition can occur at any vehicle speed. The condition may cause the engine to stall if it's severe enough.	
Preliminary Checks	Refer to *Important Preliminary Checks*.
Fuel System Checks	• Check the fuel pressure. Refer to *LPG Fuel System Diagnosis*. • Check for low fuel pressure during a moderate or full throttle acceleration. If the fuel pressure drops below specification, there is possibly a faulty low pressure regulator or a restriction in the fuel system. • Check the Manifold Absolute Pressure (MAP) sensor response and accuracy. • Check LPL electrical connection • Check the mixer air valve for sticking or binding. • Check the mixer module assembly for proper installation and leakage. • Check the PTV and FTV.
Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. If a problem is reported on LPG and not gasoline, do not discount the possibility of a LPG only ignition system failure and test the system accordingly. • Check for the proper ignition voltage output with *J 26792* or the equivalent. • Verify that the spark plugs are correct for use with LPG (R46TS) • Check for faulty spark plug wires • Check for fouled spark plugs. •
Additional Check	1. Check for manifold vacuum or air induction system leaks • Check the generator output voltage.

Backfire

Checks	Action
DEFINITION: The fuel ignites in the intake manifold, or in the exhaust system, making a loud popping noise.	
Preliminary Check	• Refer to *Important Preliminary Checks*.
Ignition System Checks	**Important!** **LPG, being a gaseous fuel, requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. The ignition system must be maintained in peak condition to prevent backfire.** • Check for the proper ignition coil output voltage using the spark tester *J26792* or the equivalent. • Check the spark plug wires by connecting an ohmmeter to the ends of each wire in question. If the meter reads over 30,000 ohms, replace the wires. • Check the connection at each ignition coil. • Check for deteriorated spark plug wire insulation. • Check the spark plugs. The correct spark plugs for LPG are (R46TS) • Remove the plugs and inspect them for the following conditions: − Wet plugs − Cracks − Wear − Improper gap − Burned electrodes − Heavy deposits

Engine Mechanical Check	**Important!** **The LPG Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than a gasoline fuel supply system.** • Check the engine for the following: − Improper valve timing − Engine compression − Manifold vacuum leaks − Intake manifold gaskets − Sticking or leaking valves − Exhaust system leakage • Check the intake and exhaust system for casting flash or other restrictions.
Fuel System Checks	• Perform a fuel system diagnosis. Refer to *LPG Fuel System Diagnosis*.

Lack of Power, Sluggishness, or Sponginess

Checks	Action
DEFINITION: The engine delivers less than expected power. There is little or no increase in speed when partially applying the accelerator pedal.	
Preliminary Checks	• Refer to *Important Preliminary Checks.* • Refer to the *LPG Fuel system OBD System Check* • Compare the customer's vehicle with a similar unit. Make sure the customer has an actual problem. *Do not compare the power output of the vehicle operating on LPG to a vehicle operating on gasoline as the fuels do have different drive feel characteristics* • Remove the air filter and check for dirt or restriction. • Check the vehicle transmission Refer to the OEM transmission diagnostics.
Fuel System Checks	• Check for a restricted fuel filter, contaminated fuel, or improper fuel pressure. Refer to *LPG Fuel System Diagnosis*. • Check for the proper ignition output voltage with the spark tester *J 26792* or the equivalent. • Check for proper installation of the mixer module assembly. • Check all air inlet ducts for condition and proper installation. • Check for fuel leaks between the LPR and the mixer. • Verify that the LPG tank manual shut-off valve is fully open. • Verify that liquid fuel (not vapor) is being delivered to the LPR.
Sensor Checks	• Check the Heated Exhaust Gas Oxygen Sensor (HEGO) for contamination and performance. Check for proper operation of the MAP sensor. • Check for proper operation of the TPS sensor.
Exhaust System Checks	• Check the exhaust system for a possible restriction: − Inspect the exhaust system for damaged or collapsed pipes − Inspect the muffler for signs of heat distress or for possible internal failure. − Check for possible plugged catalytic converter.

Engine Mechanical Check	Check the engine for the following: • Engine compression • Valve timing • Improper or worn camshaft. Refer to *Engine Mechanical* in the Service Manual.
Additional Check	• Check the ECM grounds for being clean, tight, and in their proper locations. • Check the generator output voltage. • If all procedures have been completed and no malfunction has been found, review and inspect the following items: • Visually and physically, inspect all electrical connections within the suspected circuit and/or systems. • Check the scan tool data.

Poor Fuel Economy

Checks	Action
DEFINITION: Fuel economy, as measured by refueling records, is noticeably lower than expected. Also, the economy is noticeably lower than it was on this vehicle at one time, as previously shown by an by refueling records.	
Preliminary Checks	• Refer to *Important Preliminary Checks*. • Check the air cleaner element (filter) for dirt or being plugged. • Visually (Physically) check the vacuum hoses for splits, kinks, and proper connections. • Check the operators driving habits for the following items: − Is there excessive idling or stop and go driving? − Are the tires at the correct air pressure? − Are excessively heavy loads being carried? − Is their often rapid acceleration? • Suggest to the owner to fill the fuel tank and to recheck the fuel economy. • Suggest that a different operator use the equipment and record the results.
Fuel System Checks	• Check the LPR fuel pressure. Refer to *LPG Fuel System Diagnosis*. • Check the fuel system for leakage.
Sensor Checks	• Check the Temperature Manifold Absolute Pressure (TMAP) sensor.
Ignition System Checks	• Verify that the spark plugs are correct for use with LPG (R46TS) • Check the spark plugs. Remove the plugs and inspect them for the following conditions: − Wet plugs − Cracks − Wear − Improper gap − Burned electrodes − Heavy deposits • Check the ignition wires for the following items: − Cracking − Hardness − Proper connections
Cooling System Checks	• Check the engine thermostat for always being open or for the wrong heat range

Additional Check	• Check the transmission shift pattern. Refer to the OEM Transmission Controls section the Service Manual. • Check for dragging brakes.

Rough, Unstable, or Incorrect Idle, Stalling

Checks	Action
DEFINITION: The engine runs unevenly at idle. If severe enough, the engine or vehicle may shake. The engine idle speed may vary in RPM. Either condition may be severe enough to stall the engine.	
Preliminary Check	• Refer to *Important Preliminary Checks*.
Sensor Checks	• Check for silicon contamination from fuel or improperly used sealant. The sensor will have a white powdery coating. The sensor will result in a high but false signal voltage (rich exhaust indication). The ECM will reduce the amount of fuel delivered to the engine causing a severe driveability problem. • Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance: • Check the Temperature Manifold Absolute Pressure (TMAP) sensor response and accuracy.
Fuel System Checks	• Check for rich or lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. Monitoring the oxygen sensors will help identify the problem. • Check for a sticking mixer air valve. • Verify proper operation of the PTV and FTV. • Perform a cylinder compression test. Refer to *Engine Mechanical* in the Service Manual. • Check the LPR fuel pressure. Refer to the *LPG Fuel System Diagnosis*. • Check mixer module assembly for proper installation and connection.

Ignition System Checks	• Check for the proper ignition output voltage using the spark tester *J26792* or the equivalent. • Verify that the spark plugs are correct for use with LPG (R46TS) • Check the spark plugs. Remove the plugs and inspect them for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Blistered insulators – Heavy deposits • Check the spark plug wires by connecting an ohmmeter to the ends of each wire in question. If the meter reads over 30,000 ohms, replace the wires.
Additional Checks	**Important:** The LPG Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than the gasoline fuel supply system. • Check for vacuum leaks. Vacuum leaks can cause a higher than normal idle and low throttle angle control command. • Check the ECM grounds for being clean, tight, and in their proper locations. • Check the battery cables and ground straps. They should be clean and secure. Erratic voltage may cause all sensor readings to be skewed resulting in poor idle quality..
Engine Mechanical Check	• Check the engine for the following: – Broken motor mounts – Improper valve timing – Low compression – Bent pushrods – Worn rocker arms – Broken or weak valve springs – Worn camshaft lobes

Surges/Chuggles

Checks	Action
DEFINITION: The engine has a power variation under a steady throttle or cruise. The vehicle feels as if it speeds up and slows down with no change in the accelerator pedal.	
Preliminary Checks	• Refer to *Important Preliminary Checks*. • Be sure the driver understands the Torque Converter Clutch operation.
Sensor Checks	Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance.
Fuel System Checks	• Check for Rich or Lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. Monitoring the oxygen sensors will help identify the problem. • Check the fuel pressure while the condition exists. Refer to *LPG Fuel System Diagnosis.* • Verify proper fuel control solenoid operation. • Verify that the LPG manual shut-off valve is fully open. • Check the in-line fuel filter for restrictions.
Ignition System Checks	• Check for the proper ignition output voltage using the spark tester J26792 or the equivalent. • Verify that the spark plugs are correct for use with LPG (R46TS) • Check the spark plugs. Remove the plugs and inspect them for the following conditions: − Wet plugs − Cracks − Wear − Improper gap − Burned electrodes − Heavy deposits − Check the Crankshaft Position (CKP) sensor.
Additional Check	• Check the ECM grounds for being clean, tight, and in their proper locations. • Check the generator output voltage. • Check the vacuum hoses for kinks or leaks. • Check Transmission

SECTION 1C2

WIRING SCHEMATICS

ON-VEHICLE SERVICE WIRE HARNESS REPAIR

The ECM/PCM harness electrically connects the ECM/PCM to the various solenoids, electrically and sensors in vehicle engine and passenger compartment.

Wire harnesses should be replaced with proper part number harnesses. When signal wires are spliced, into a harness, use wire with high temperature insulation only.

With the low current and voltage levels found in the system, it is important that the best possible bond at all wire splices be made by soldering the splices, as shown in Figure 1.

Molded on connectors require complete replacement of the connector. This means splicing a new connector assembly into the harness.

Refer to Figure 1 for wiring diagrams.

CONNECTORS AND TERMINALS

Use care when probing a connector or replacing terminals in them. It is possible to short between opposite terminals. If this happens to the wrong terminal pair, it is possible to damage certain components. Always use jumper wires between connectors, for circuit checking. NEVER probe through the Weather-Pack seals. Use tachometer adapter J 35812, or equivalent, which provides an easy hook up of the tach lead. The connector test adapter kit J 35616, or equivalent, contains an assortment of flexible connectors, used to probe terminals during diagnosis. Fuse remover and test tool BT 8616, or equivalent, is used for removing a fuse and to adapt fuse holder, with a meter, for diagnosis.

When diagnosing, open circuits are often difficult to locate by sight, because oxidation, or terminal misalignment are hidden by the connectors. Merely wiggling a connector on a sensor, or in the wiring harness, may correct the open circuit condition. This should always be considered, when an open circuit, or failed sensor is indicated. Intermittent problems may, also, be caused by oxidized or loose connections.

Before making a connector repair, be certain of the type of connector. Weather-Pack and Meter Pack connectors look similar, but are serviced differently.

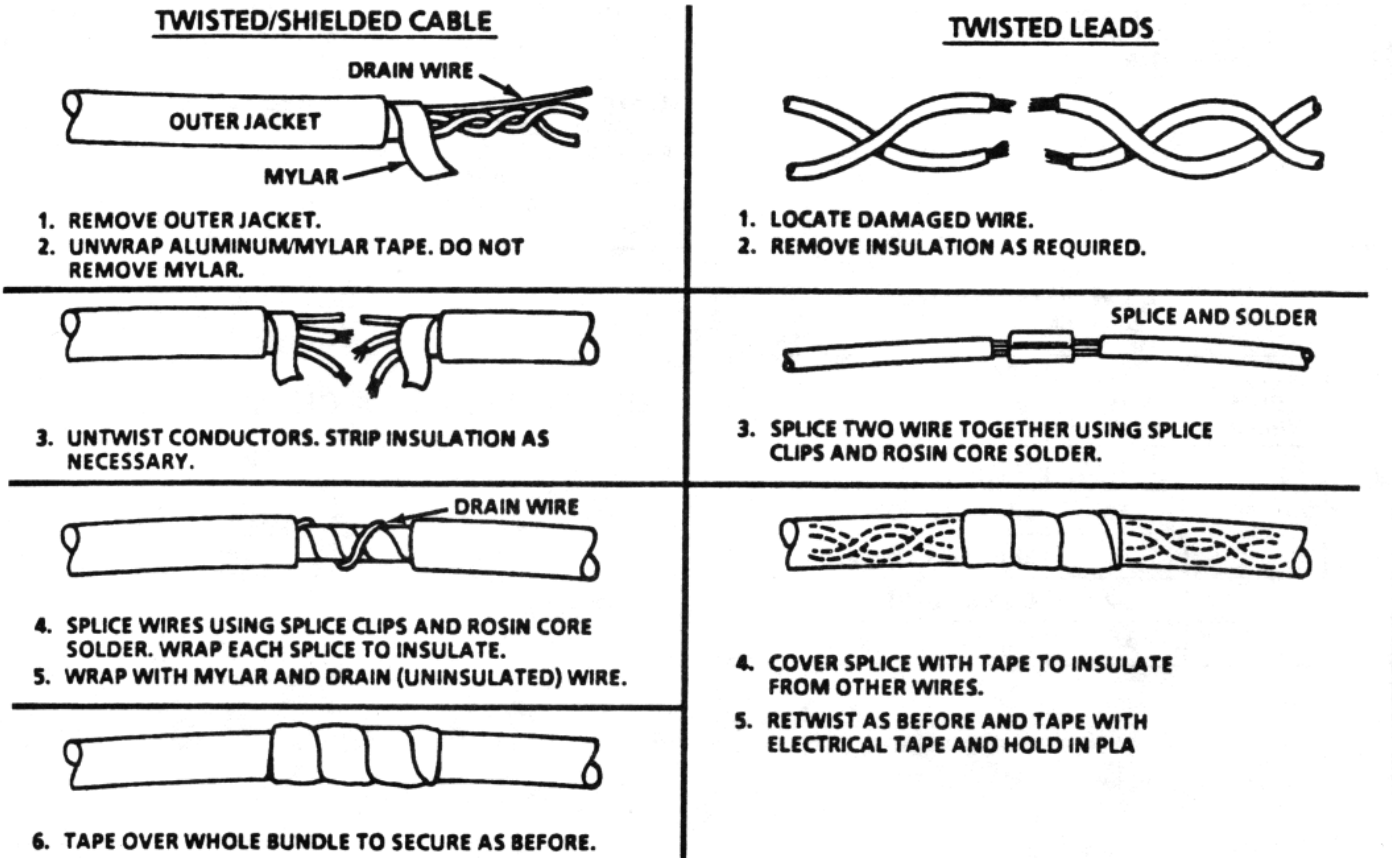


FIGURE 1 WIRE HARNESS REPAIR

Micro-Pack

Refer to Figure 2 and repair procedure for replacement of a :Micro-Pack terminal.

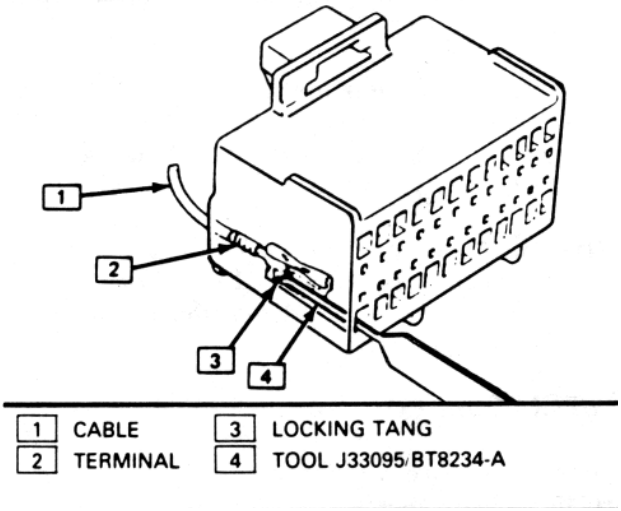


FIGURE 2 MICRO-PACK CONNECTOR

Metri-Pack

Some connectors use terminals called Metri-Pack Series 150. (Figure 3). 'These may be used at the coolant sensor, as well as TBI units.

They are also called "Pull-To-Seat" terminals, because, to install a terminal on a wire, the wire is first inserted through the seal (5) and connector (4). The terminal is then crimped on the wire and the terminal pulled back into the connector to seat it in place.

To remove a terminal:

1. Slide the seal back on the wire.
2. Insert tool (3) BT-8518, or J 35689, or equivalent, as shown in insert "A" and "B," to release the terminal locking tab (2).
3. Push the wire and terminal out through the connector.

If reusing the terminal, reshape the locking tang (2).

Weather-Pack

A Weather-Pack connector can be identified by a rubber seal, at the rear of the connector. This connector, which is used in the engine compartment, protects against moisture and dirt, which could create oxidation and deposits on the terminals. This protection is important, because of the very low voltage and current levels found in the electronic system.

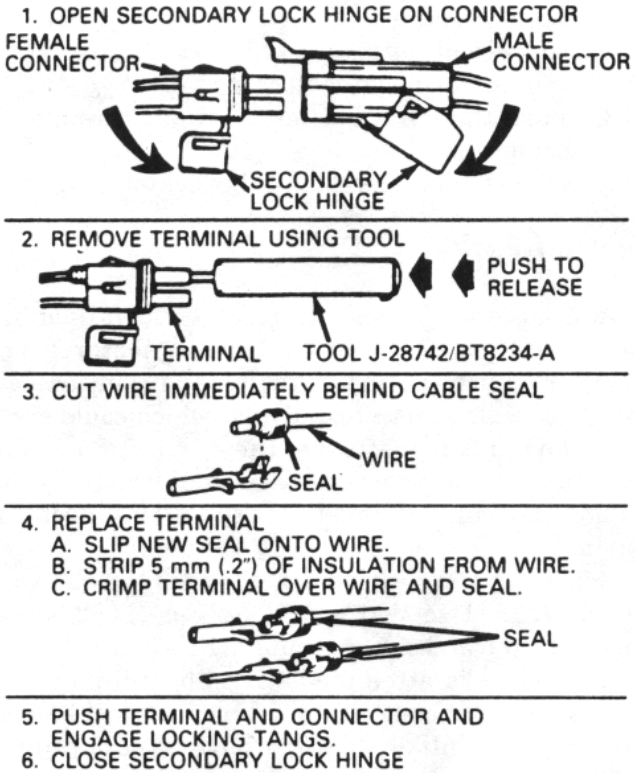
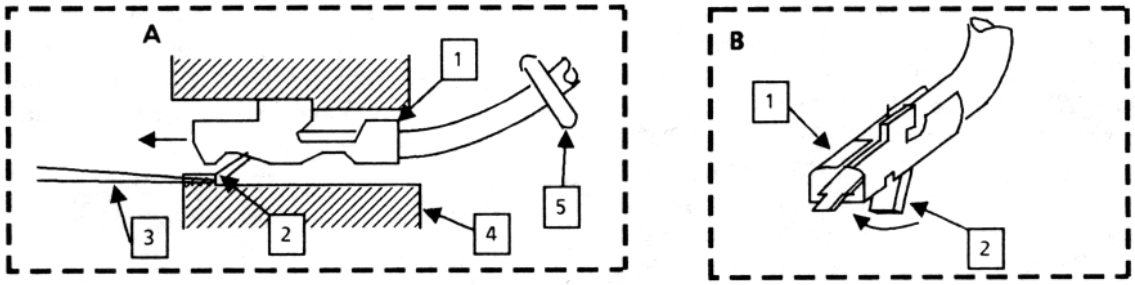


FIGURE 4 WEATHER PACK TERMINAL REPAIR



1. METRI-PACK SERIES 150 FEMALE TERMINAL
2. LOCKING TANG
3. TOOL J35689 OR BT-8446
4. CONNECTOR BODY
5. SEAL

FIGURE 3 METRI-PACK SERIES 150 TERMINAL REMOVAL

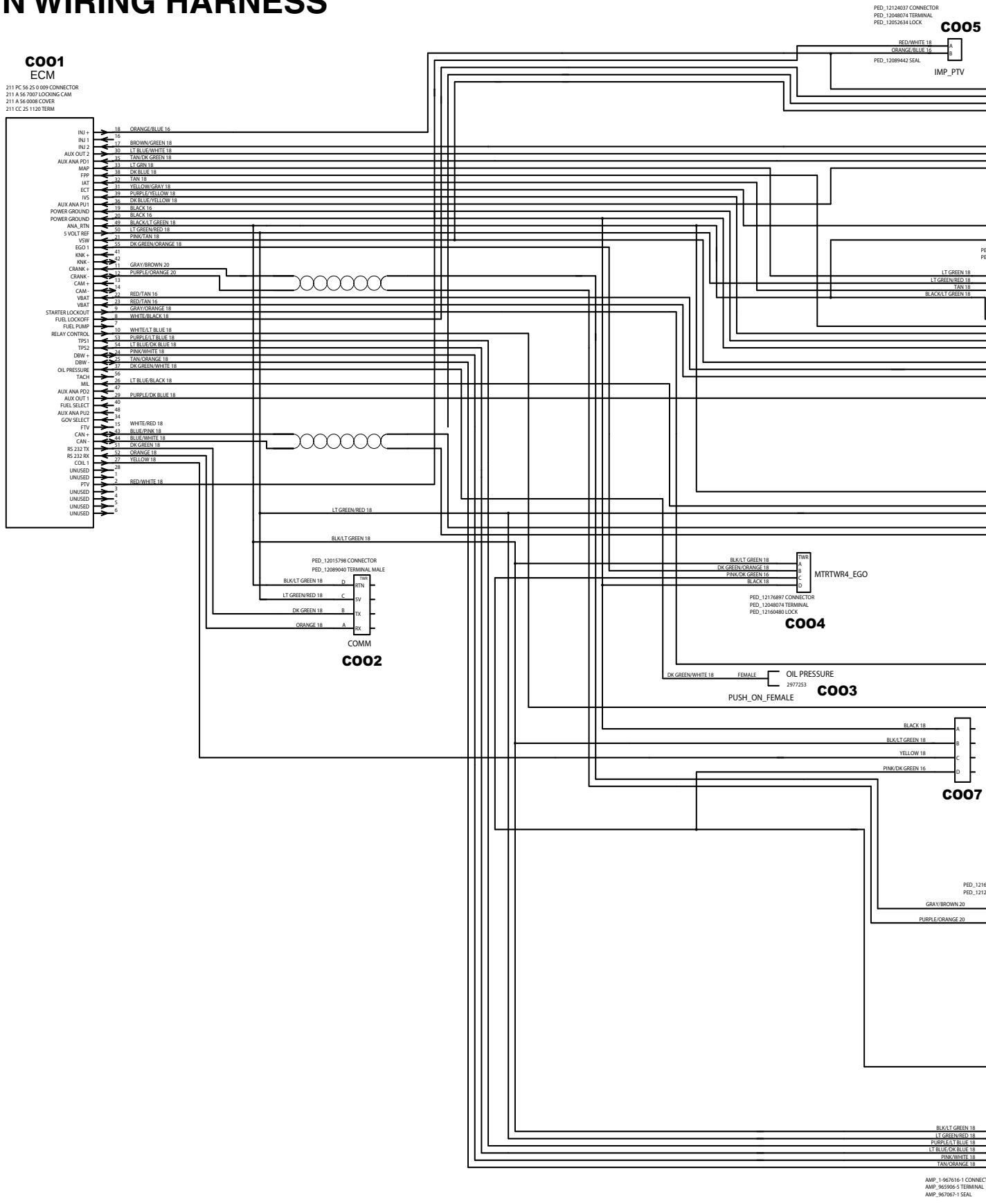
Repair of a Weather-Pack terminal is shown in Figure 3-23. Use tool J M28742, or BT8234-A to remove the pin and sleeve terminals.

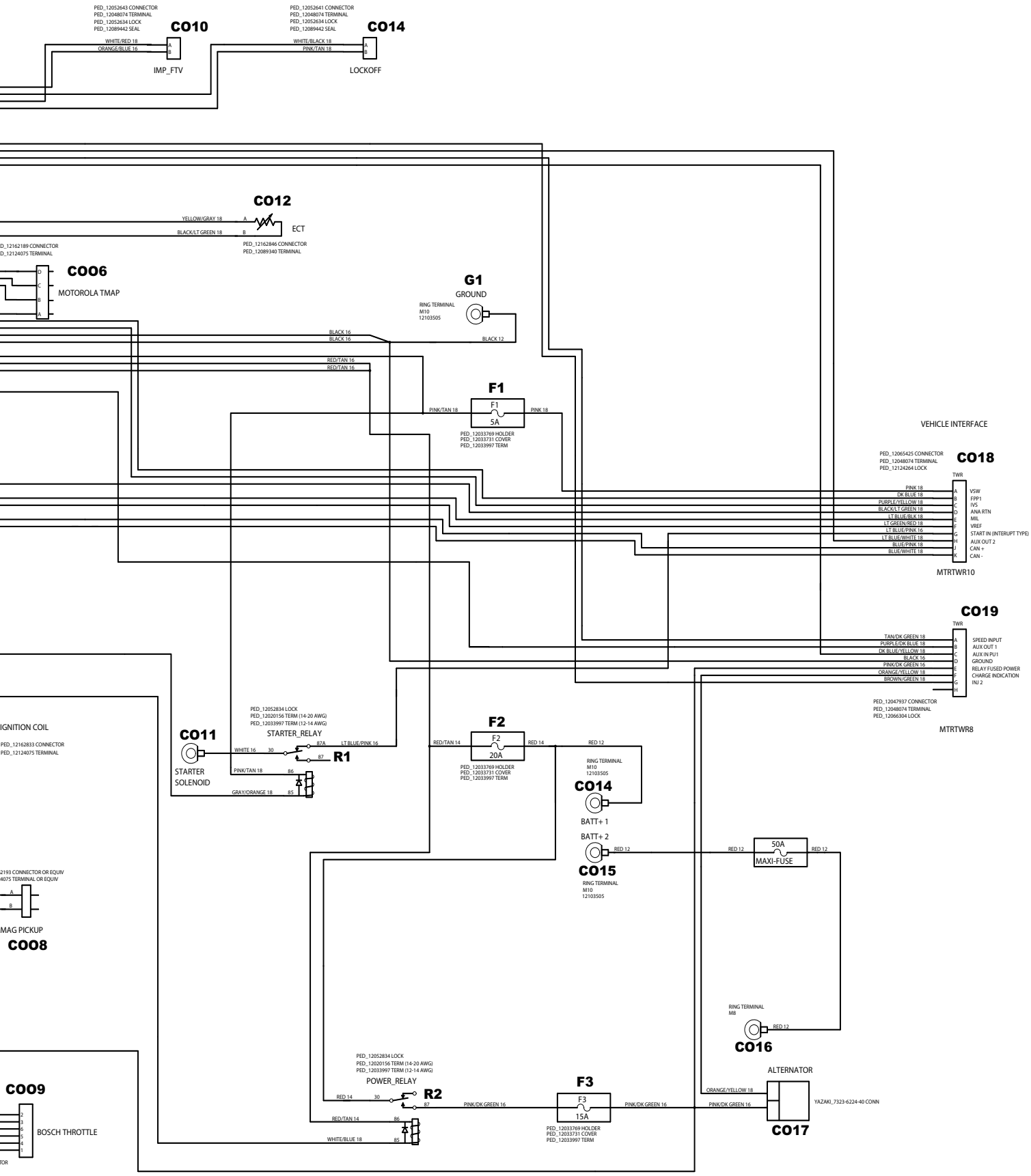
If removal is attempted with an ordinary pick, there is a good chance that the terminal will be bent, or deformed. Unlike standard blade type terminals, these terminals cannot be straightened once they are bent.

Make certain that the connectors are properly seated and all of the sealing rings in place, when connecting leads. The hinge type flap provides a backup, or secondary locking feature for the connector. They are used to improve the connector reliability by retaining the terminals, if the small terminal lock tangs are not positioned properly.

Weather-Pack connections cannot be replaced with standard connections. Instructions are provided with Weather-Pack connector and terminal packages.

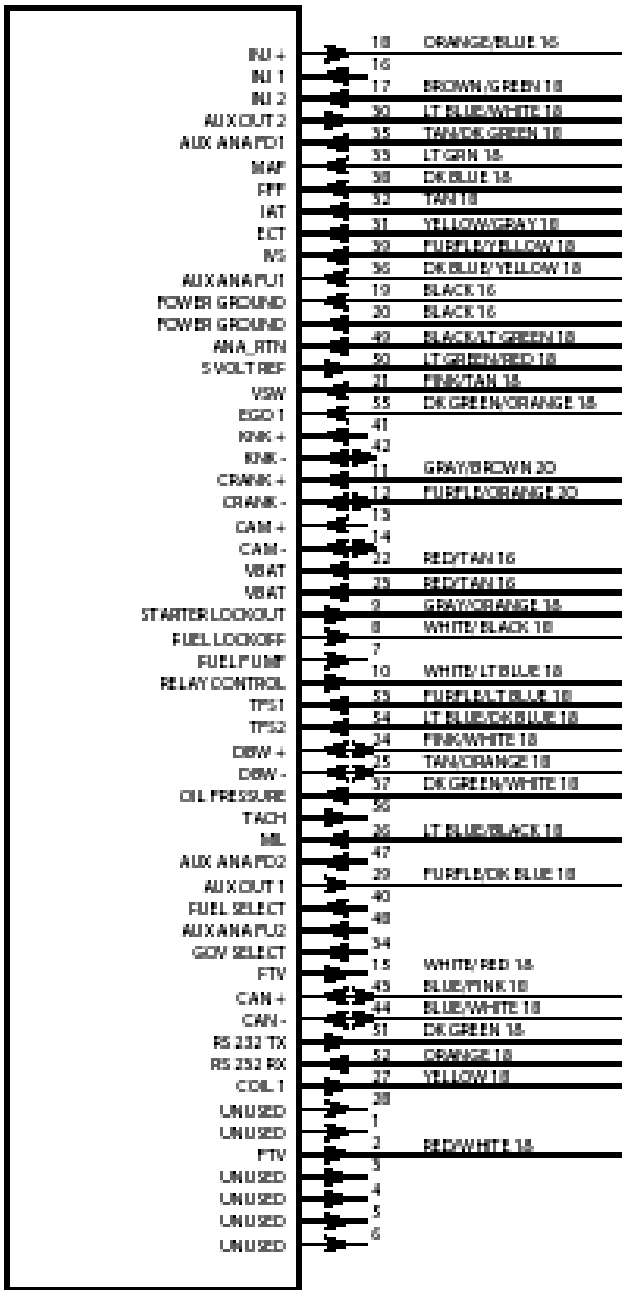
MAIN WIRING HARNESS



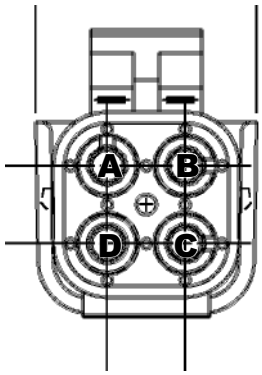

PED_12052643 CONNECTOR
PED_12048074 TERMINAL
PED_12052634 LOCK
PED_12089442 SEAL
CO10
WHITE/RED 18
ORANGE/BLUE 16
IMP_FTV
PED_12052641 CONNECTOR
PED_12048074 TERMINAL
PED_12052634 LOCK
PED_12089442 SEAL
CO14
WHITE/BLACK 18
PINK/TAN 18
LOCKOFF
CO12
YELLOW/GRAY 18
BLACK/LT GREEN 18
ECT
PED_12162846 CONNECTOR
PED_12089340 TERMINAL
D_12162189 CONNECTOR
D_12124075 TERMINAL
CO06
MOTOROLA TMAP
G1
GROUND
RING TERMINAL
M10
12103505
BLACK 16
BLACK 16
BLACK 12
RED/TAN 16
RED/TAN 16
F1
F1
5A
PINK/TAN 18
PINK 18
PED_12033769 HOLDER
PED_12033731 COVER
PED_12033997 TERM
VEHICLE INTERFACE
PED_12065425 CONNECTOR
PED_12048074 TERMINAL
PED_12124264 LOCK
CO18
TWR
PINK 18
DK BLUE 18
PURPLE/YELLOW 18
BLACK/LT GREEN 18
LT BLUE/BLK 18
LT GREEN/RED 18
LT BLUE/PINK 16
LT BLUE/WHITE 18
BLUE/PINK 18
BLUE/WHITE 18
VSW
FPP1
IVS
ANA RTN
MIL
VREF
START IN (INTERUPT TYPE)
AUX OUT 2
CAN +
CAN -
MTRTWR10
CO19
TWR
TAN/DK GREEN 18
PURPLE/DK BLUE 18
DK BLUE/YELLOW 18
BLACK 16
PINK/DK GREEN 16
ORANGE/YELLOW 18
BROWN/GREEN 18
SPEED INPUT
AUX OUT 1
AUX IN PU1
GROUND
RELAY FUSED POWER
CHARGE INDICATION
INJ 2
PED_12047937 CONNECTOR
PED_12048074 TERMINAL
PED_12066304 LOCK
MTRTWR8
IGNITION COIL
PED_12162833 CONNECTOR
PED_12124075 TERMINAL
PED_12052834 LOCK
PED_12020156 TERM (14-20 AWG)
PED_12033997 TERM (12-14 AWG)
STARTER_RELAY
CO11
STARTER
SOLENOID
WHITE 16
30
87A
LT BLUE/PINK 16
87
R1
PINK/TAN 18
86
GRAY/ORANGE 18
85
F2
F2
20A
RED/TAN 14
RED 14
RED 12
PED_12033769 HOLDER
PED_12033731 COVER
PED_12033997 TERM
RING TERMINAL
M10
12103505
CO14
BATT+ 1
BATT+ 2
RED 12
RED 12
50A
MAXI-FUSE
RED 12
CO15
RING TERMINAL
M10
12103505
2193 CONNECTOR OR EQUIV
4075 TERMINAL OR EQUIV
A
B
MAG PICKUP
CO08
RING TERMINAL
M8
RED 12
CO16
PED_12052834 LOCK
PED_12020156 TERM (14-20 AWG)
PED_12033997 TERM (12-14 AWG)
POWER_RELAY
R2
RED 14
30
87
PINK/DK GREEN 16
RED/TAN 14
86
WHITE/BLUE 18
85
F3
F3
15A
PINK/DK GREEN 16
PED_12033769 HOLDER
PED_12033731 COVER
PED_12033997 TERM
ALTERNATOR
ORANGE/YELLOW 18
PINK/DK GREEN 16
YAZAKI_7323-6224-40 CONN
CO17
CO09
BOSCH THROTTLE
TOR

ENGINE CONTROL MODULE C001

211 PC 56 25 0 009 CONNECTOR
211 A 56 7007 LOCKING CAM
211 A 56 0008 COVER
211 CC 25 1120 TERM



COMMUNICATION PORT CONNECTOR C002

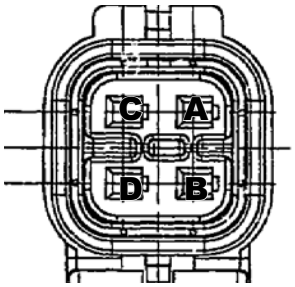


Pins	Wire Color	Function
A	Orange	RS232 RX
B	Dark Green	RS232 TX
C	Lt Green/Red	5 Volt Ref
D	Black/Lt Green	Analog Return

OIL PRESSURE CONNECTOR C003

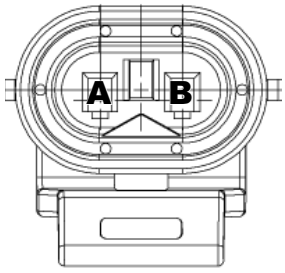
Pins	Wire Color	Function
A	Lt Green/Black	Oil Pressure Switch

HEATED OXYGEN SENSOR (HEGO) CONNECTOR C004



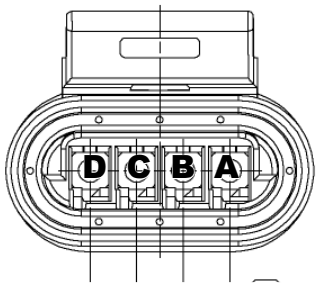
Pins	Wire Color	Function
A	Black/Lt Green	Analog Return
B	Dk Green/Orange	HEGO
C	Pink/Dk Green	Relay Fused Power
D	Black	Power Ground

FUEL TRIM VALVE (FTV) CONNECTOR C005



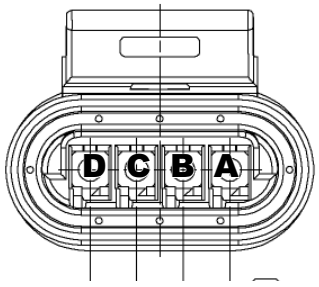
Pins	Wire Color	Function
A	Red/White	INJ 7
B	Orange/Blue	INJ +

TMAP CONNECTOR C006



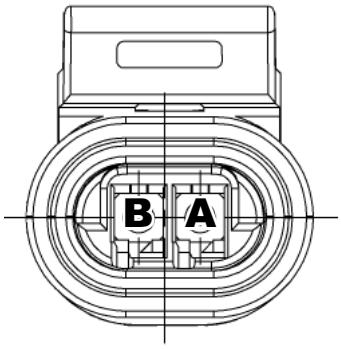
Pins	Wire Color	Function
A	Black/Lt Green	Analog Return
B	Tan	IAT
C	Lt Green/Red	5 Volt Reference
D	Lt Green	MAP

COIL CONNECTOR C007



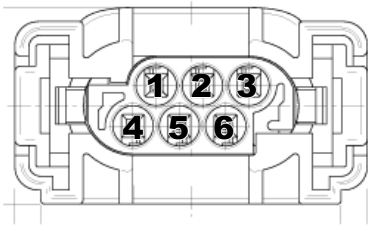
Pins	Wire Color	Function
A	Black	Power Ground
B	Black/Lt Green	Analog Return
C	Yellow	Coil 1
D	Pink/Dk Green	Relay Fused Power

MAGNETIC PICKUP CONNECTOR C008



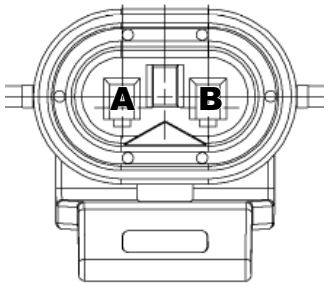
Pins	Wire Color	Function
A	Gray/Brown	Crank +
B	Purple/Orange	Crank –

THROTTLE CONNECTOR C009



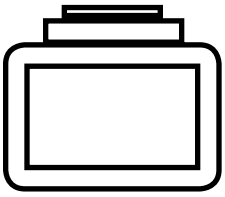
Pins	Wire Color	Function
1	Tan/Orange	DBW -
2	Black/Lt Green	Analog Return
3	Lt Green/Red	5 Volt Reference
4	Purple/Lt Blue	TPS 1
5	Lt Blue/Dk Blue	TPS 2
6	Pink/White	DBW +

PRESSURE TRIM VALVE (PTV) CONNECTOR C010



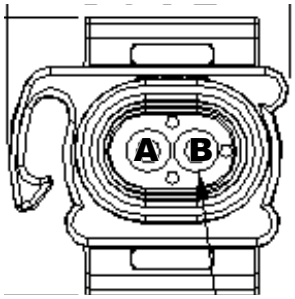
Pins	Wire Color	Function
A	White/Red	Gaseous Trim
B	Orange/Blue	INJ +

STARTER SOLENOID CONNECTOR C011



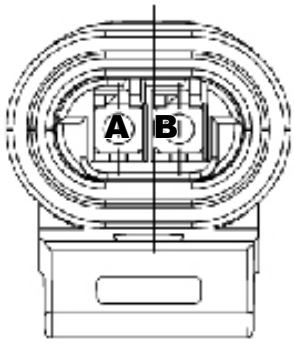
Pins	Wire Color	Function
A	White	Starter Relay R1

ENGINE COOLANT TEMPERATURE SENSOR (ECT) CONNECTOR C012



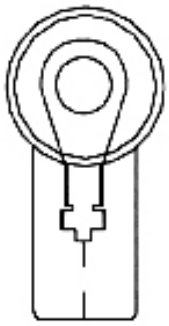
Pins	Wire Color	Function
A	Yellow/Gray	ECT
B	Black/Lt Green	Analog Return

FUEL LOCKOFF CONNECTOR CO13



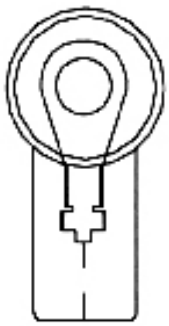
Pins	Wire Color	Function
A	White/Black	Fuel Lockoff
B	Pink/Tan	VSW

BATTERY POSITIVE CONNECTOR C014



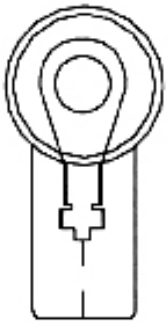
Pins	Wire Color	Function
A	Red	Power Relay R2

BATTERY POSITIVE CONNECTOR C015



Pins	Wire Color	Function
A	Red	Alternator

ALTERNATOR CONNECTOR C016

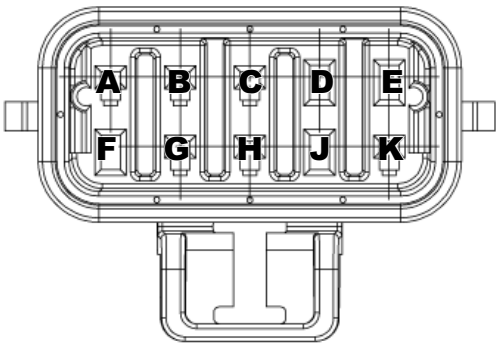


Pins	Wire Color	Function
A	Red	Battery

ALTERNATOR CONNECTOR C017

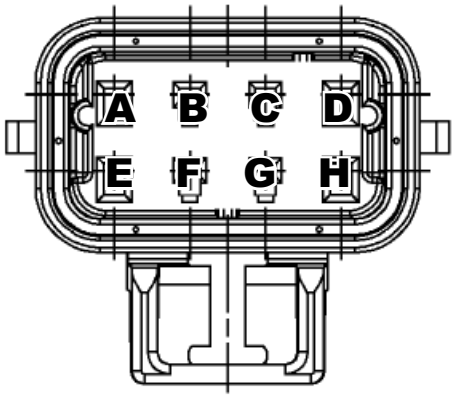
Pins	Wire Color	Function
A	Pink/Dk Green	Power Relay R2
B	Orange/Yellow	Charge Indicator

INSTRUMENT PANEL CONNECTOR C018



Pins	Wire Color	Function
A	Pink	VSW
B	Dk Blue	FPP1
C	Purple/Yellow	IVS
D	Black/Lt Green	ANA RTN
E	Lt Blue/Black	MIL
F	Lt Green/Red	VREF
G	Lt Blue/Pink	Start
H	Lt Blue/White	AUX Out 2
J	Blue/Pink	CAN +
K	Blue/White	CAN -

INSTRUMENT PANEL CONNECTOR C019



Pins	Wire Color	Function
A	Tan/Dk Green	Speed Input
B	Purple Dk Blue	AUX Out
C	Dk Blue/Yellow	AUX In
D	Black	Ground
E	Pink/Dk Green	Relay Fused Power
F	Orange/Yellow	Charge Indication
G	Brown/Green	INJ 2
H	(not used)	

SECTION 1C4

DIAGNOSTIC TROUBLE CODES

DESCRIPTION OF ECM BASED DIAGNOSTICS

DEFINITION OF TERMS

Active Gov Mode	Speed is governed by one of two modes. Isochronous, which maintains an exact speed, or Droop, which allows speed to drop a predetermined amount based on current engine load.
AL	Adaptive Learn
AL Mult	Adaptive Learn Multiplier. The adaptive learn multiplier is a correction to the fuel delivery which is expressed as a percentage (%) and stored in the ECM's RAM.
Analog	0 to 5 volt or 0 to 12 volt signals
Batt	Battery Voltage
BP	Barometric Pressure. The pressure of the outside air.
CHT	Cylinder Head Temperature
CL	Closed Loop
CL Mult	Closed Loop Multiplier. The closed loop multiplier is a fast acting adjustment to the fuel delivery based on feedback from the HEGO. The closed loop multiplier is expressed as a percentage (%) and is not stored in the ECM's memory.
Closed Loop	Fuel and timing modified based on feedback from the O2 sensor.
DBW	Drive by wire.
DTC	Diagnostic Trouble Code. A code which is stored in the ECM when an ECM initiated test fails.
ECT	Engine Coolant Temperature.
ECM	Engine Control Module. The computer, which controls the fuel and ignition system on the engine.
EGO	See HO2S
Forced Idle	ECM commands electronic throttle controller to an idle position.
FPP	Foot Pedal Position.
HO2S	Heated Oxygen Sensor
IAT	Intake Air Temperature
IVS	Idle Validation Switch
Low Rev Limit	Secondary engine speed control, only used to limit speed when throttle positioning is not maintaining desired speed
MAP	Manifold Absolute Pressure. The pressure of the air in the intake manifold.
MAT	Manifold Air Temperature. The temperature of the air in the intake manifold
MIL	Malfunction Indicator Light. A dash mounted light that illuminates when the ECM senses a system fault.
ms	Milli-seconds. 1/1000 of a second.
Open Loop	Fuel and timing based strictly on tables stored in the ECM.
Power Derate Level 1	ECM has detected condition in throttle control and limits throttle blade opening to 50%
Power Derate Level 2	ECM has detected condition in throttle control and limits throttle blade opening to 20%
PSIA	Pounds per square inch absolute. 14.7 psia = 0 psig
RAM	Random Access Memory. The portion of computer memory within the ECM, which changes as the engine is running and is stored while the engine is off.
TPS	Throttle Position Sensor. The throttle position sensor measures the opening of the throttle.

Spectrum Diagnostic Section

DIAGNOSTICS OVERVIEW OF THE SPECTRUM FUEL SYSTEM

The Spectrum Fuel system has built-in diagnostics for trouble shooting. The system has a dash mounted Malfunction Indicator Lamp (MIL) for indication of system problems.

MALFUNCTION INDICATOR LAMP (MIL)

Most engine control system related problems that affect emissions or driveability of the vehicle will set a (DTC) Diagnostic Trouble Code and illuminate the Malfunction Indicator Lamp.

The MIL has the following functions:

1. It notifies the driver of a problem with the fuel system, ignition system, or emission control system so the driver can arrange for service as soon as possible.
2. It will display DTC's that have been stored due to a system malfunction.

The lamp should come on when the key is in the ON position and the engine is not running. This feature verifies that the lamp is in proper working order. If the lamp does not come on with the vehicle key on/engine off, repair it as soon as possible. Once the engine is in start or run mode, the lamp should go off. If the lamp illuminates while the engine is in the start or run mode, there is a current Diagnostic Trouble Code.

SPECTRUM DIAGNOSTIC TROUBLE CODES (DTC)

Diagnostic Trouble Codes are set when the Spectrum ECM (Electronic Control Module) runs a diagnostic self-test and the test fails. When a DTC is set, the ECM will illuminate the Malfunction Indicator Lamp on the instrument panel and save the code in memory. The ECM will continue to run the self-test unless the DTC is an oxygen sensor lean, oxygen sensor rich, or an internal ECM related DTC. If the system continues to fail the test, the lamp will stay illuminated and the DTC is current (ACTIVE). All DTC's are stored as historical faults until they are cleared. All DTC's except the ECM related DTC's will automatically clear from memory if the DTC does not reset within 100 consecutive engine run cycles.

While a Diagnostic Trouble Code is current for a sensor, the ECM may assign a default "limp home" value and use that value in its control algorithms. All of the system diagnostic self-tests run continuously during normal vehicle operation.

The Diagnostic Trouble Codes can be read by using either the MIL lamp or a laptop computer. Refer to Using a Laptop Computer to Diagnose the Spectrum System and Using a Diagnostic Jumper to Diagnose the ECI System, located in this section. Diagnostic Trouble Codes can be cleared from memory with a laptop computer or by turning the ignition key to the OFF position and removing the system main power fuse (F3) for 15 seconds.

If more than one DTC is detected, always begin with the lowest number DTC and diagnose each problem to correction unless directed to do otherwise by the fault tree. The DTC's are numbered in order of importance. Having DTC 112 and DTC 122, both concerning the oxygen sensor, is possible. By repairing DTC 112 first, the problem causing the DTC 122 may also be corrected.

DIAGNOSTIC COMMUNICATION ERROR

The ECM 5 volt reference circuit powers the Spectrum diagnostic link cable. In the event that the 5 volt reference signal is open or shorted to ground, you will not be able to connect to the system. If you are unable to connect, follow the quick checks listed below:

Be sure you are using the correct password and latest software for the system you are connecting to.

Check the ECM system power and ground circuits. Refer to DTC 261 for the power schematic. Also check for +12 switched power at ECM pin 21 with the ignition key on.

Check for power at the DLC connector for +5 volts between pins C (LT GRN/RED) and pin D (BLK) with the ignition key in the on position.

You may still be able to retrieve a code using the blink code function if none of the above recommendations prove useful. In the event of a 5 volt reference signal malfunction, DTC 531 or 532 should set. If you find one of these codes using the blink code function, follow the DTC diagnostic chart recommendations in the DTC section of this manual.

USING A LAPTOP COMPUTER TO DIAGNOSE THE SPECTRUM SYSTEM

A laptop computer is the preferred tool for performing diagnostic testing of the Spectrum system. A laptop computer, with the system diagnostic cable and diagnostic software, is used to read and clear Diagnostic Trouble codes. It is also used to monitor sensor and actuator values. The diagnostic software also performs several special tests.

The following procedures will assist you in using a laptop computer to diagnose the Spectrum system:

INSTALLING THE SPECTRUM DIAGNOSTIC SOFTWARE

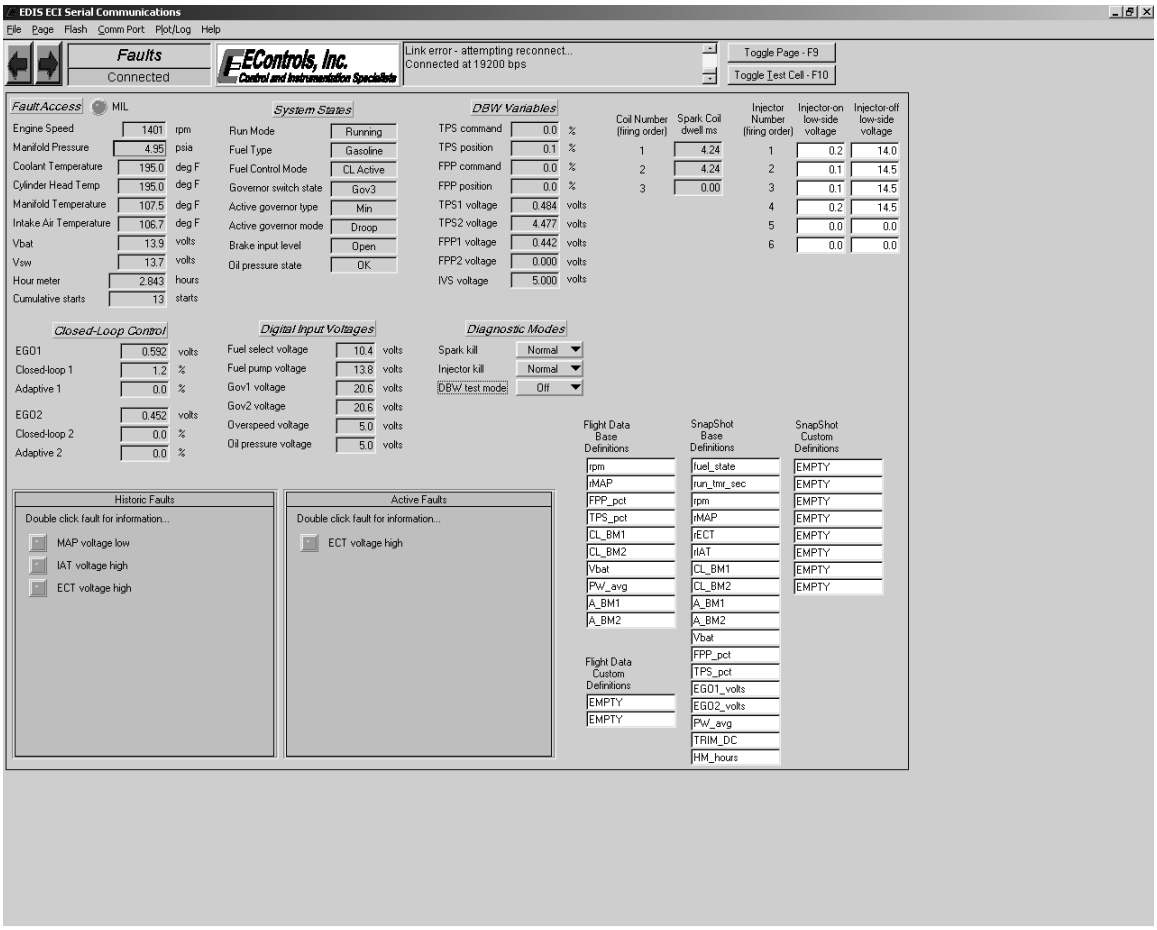
Loading Software and Connecting the Computer

- Start Windows
- Insert the Diagnostic Interface software CD.
- Click on the START button.
- From the Start menu, select RUN.
- In the command-line text box, type the letter of your CD-ROM drive, followed by: \setup (for example, e:\setup), then click OK.
- Follow the on screen instructions.

Connecting a Laptop Computer to the Spectrum System

- Connect the system diagnostic cable to the RS232 port on the back of the computer. If you do not have a RS232 port use the USB to RS232 adapter supplied in the IMPCO ITK-2 test kit.
- Connect the diagnostic cable to the diagnostic connector on the engine harness. The diagnostic connector is a square 4-pin connector located near the Spectrum system ECM.
- Turn the computer ON.
- Start Windows.
- From the Start menu select Programs.
- Select IMPCO Display.
- Place the ignition key in the ON position.
- The system Gauge screen should now appear and a green banner in the upper left hand will read “Connected”.

DIAGNOSTIC TROUBLE CODES



The System Fault screen is used to view and clear DTC's, which have been set.

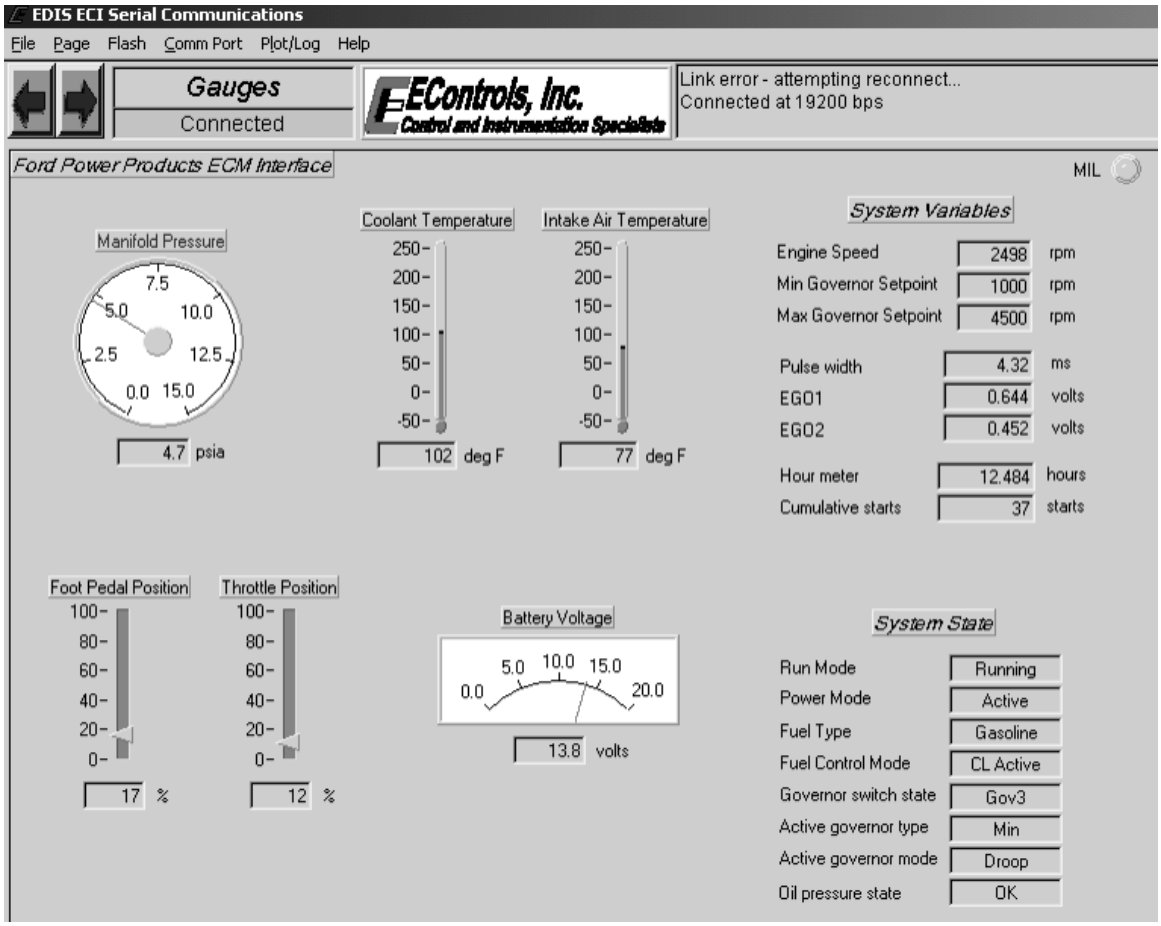
Checking Diagnostic Trouble Codes

The System Fault screen contains a listing of all of the Historic and Active DTC's set within the system. If a DTC is stored in memory, the screen will display that fault in the History column. If the fault is active it will also show up in that column.

Clearing Diagnostic Trouble Codes

To clear a DTC from memory use the arrow keys or mouse to move then Press the Enter key to clear the fault from memory. NOTE: Record faults before erasing them for reference during diagnostics.

DATA STREAM

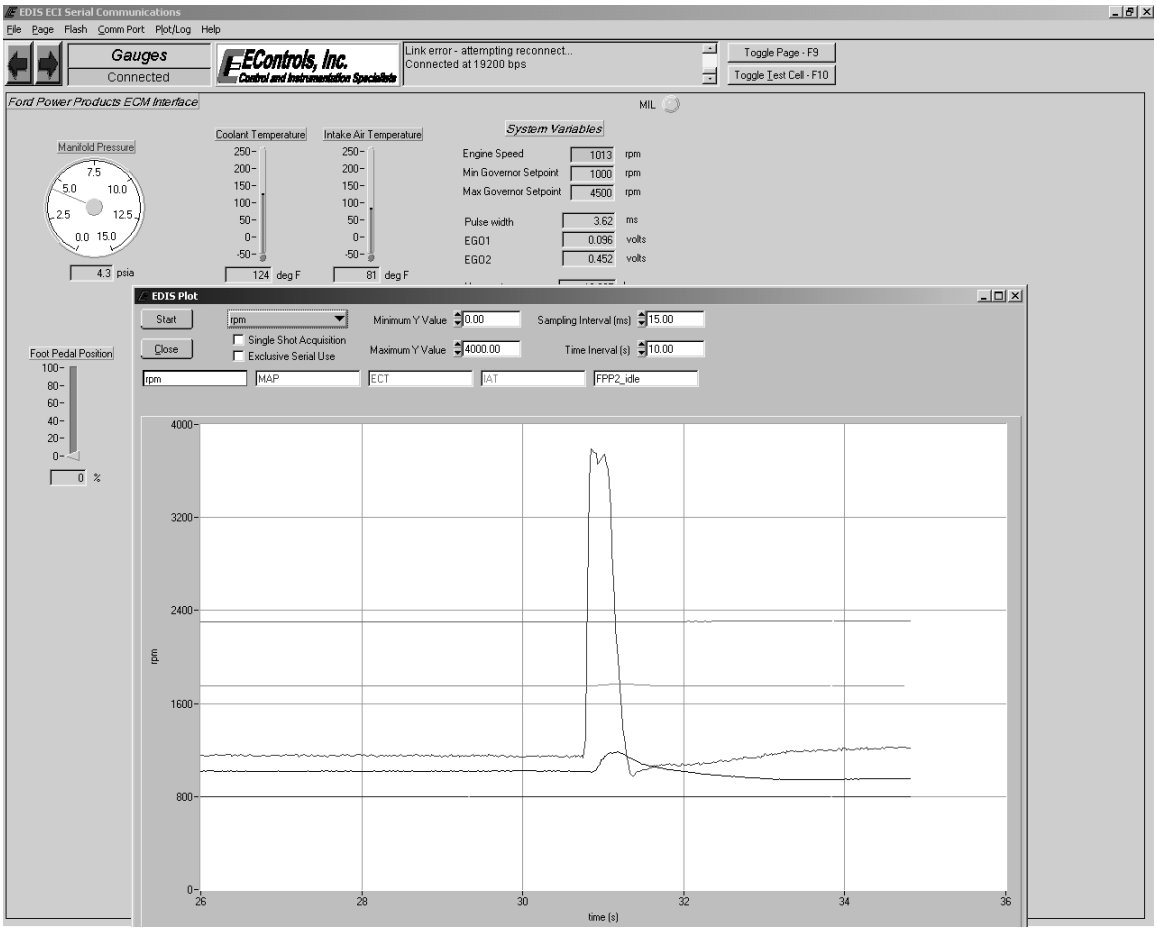


Reading Sensor and Actuator Values

Most applicable sensor and actuator values are displayed on the Gauges screen. The display shows the value for sensors, voltages and the sensor values in engineering units.

NOTE: If a DTC for a sensor is current, the engineering value for that sensor may be a default, limp home value and the voltage value will be the actual sensor voltage. Use the voltage value when performing diagnostics unless directed to do otherwise by the diagnostic chart.

GRAPHING AND DATA LOGGING



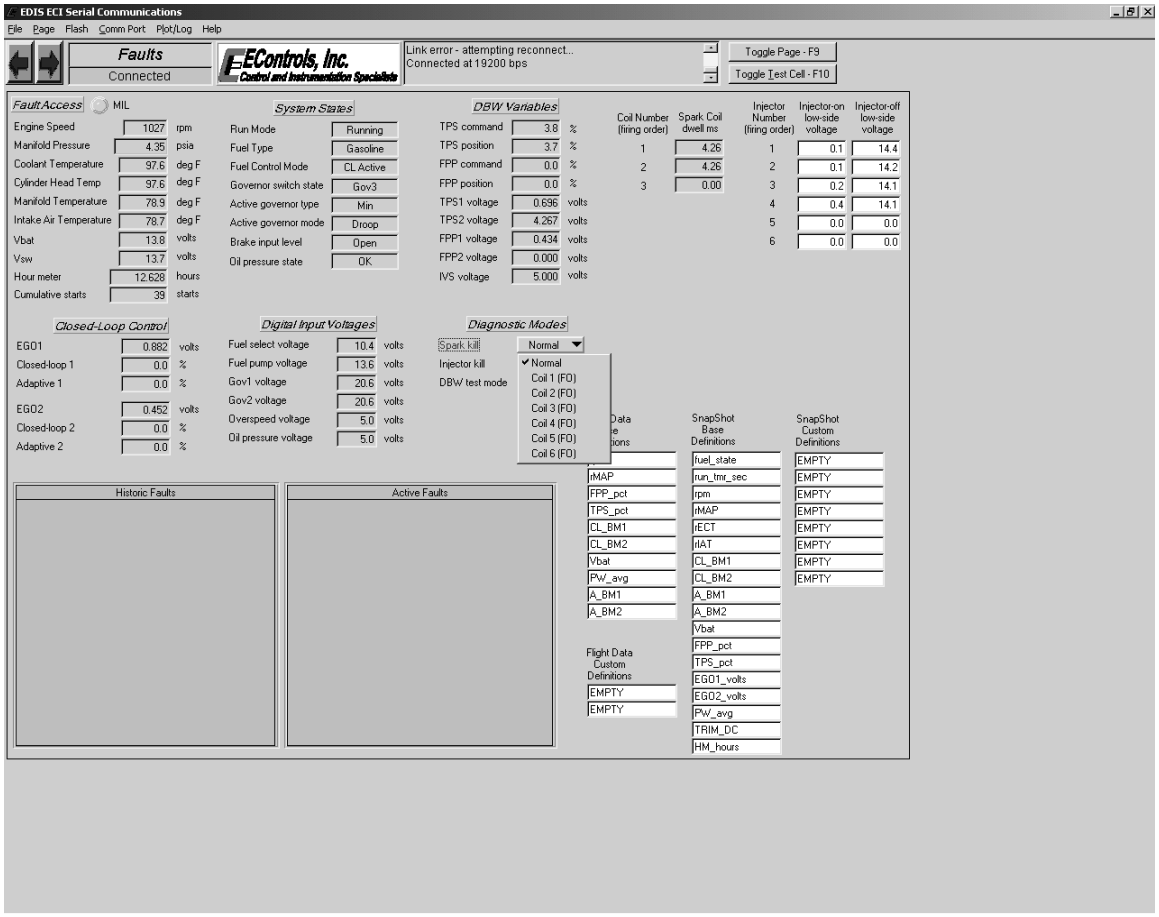
Graphing the values and voltages can be a very useful tool in doing intermittent diagnosis. The system diagnostic monitoring software includes graphing and data logging capability. These features enhance the ability to diagnose and repair possible problems with the system. The graphing feature allows sensor inputs and select control output variables to be plotted in real-time while the engine is running.

To plot a variable you must first “TAG” the variable you wish to plot. To do this, use the mouse to highlight the variable, and then right click.

Next press the “P” key or double click the Plot/Log button to invoke the plotting feature. You may change the desired time interval for each display screen. The default is 10 seconds. This can be increased or decreased as necessary to display the desired results. You can also change the sample rate.

You are now ready to plot. Simply click the “START” button to observe the plotted variables. The plot sweeps across the screen from left to right. To pause the display screen press the “SPACE BAR” at any time during plotting. To continue plotting simply press the “SPACE BAR” again. To stop the plotting feature simply click the “STOP” button. To exit the plotting screen click the “CLOSE” button. The range of each variable is listed along the left side of the display and the time is listed along the bottom of the screen.

Ignition System Test



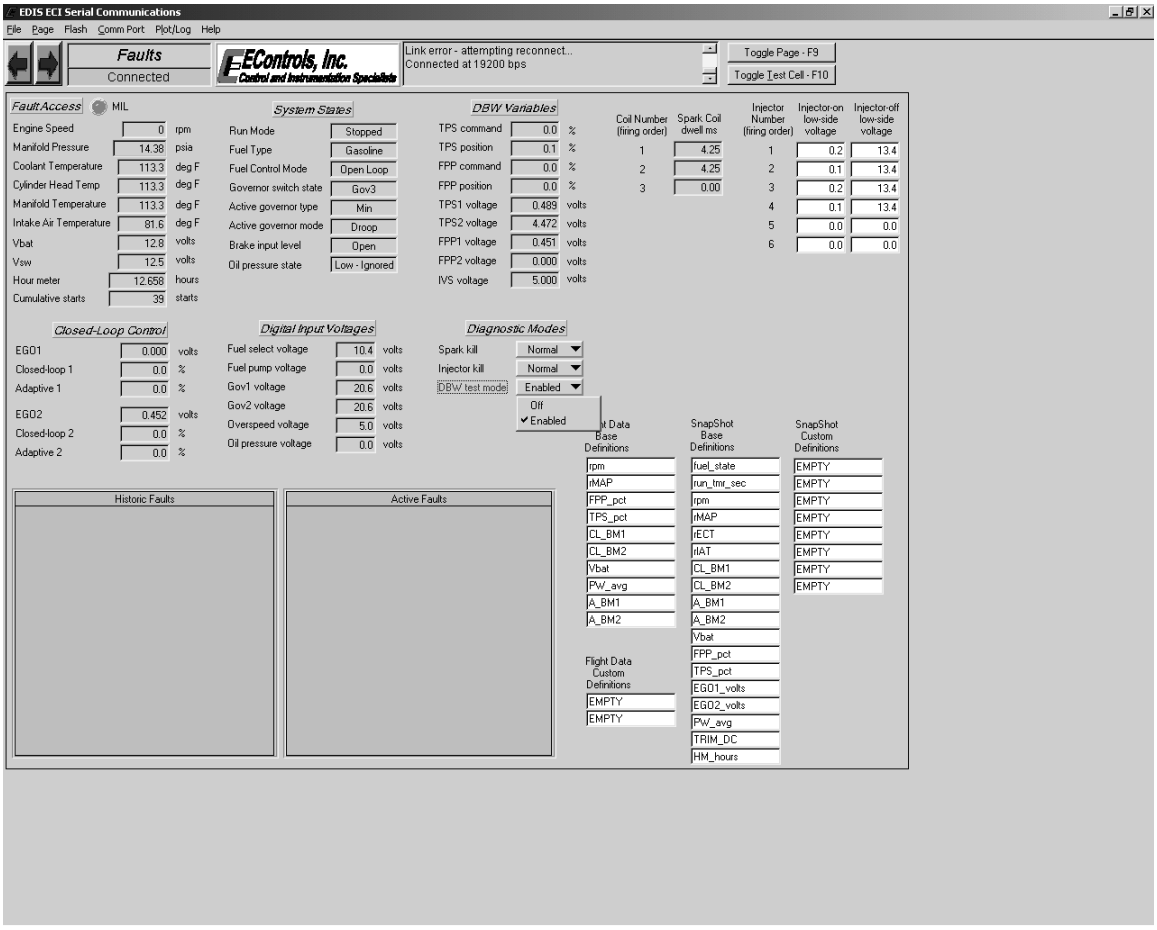
The Spark Kill diagnostic mode allows the technician to disable the ignition on individual cylinders. If the Spark Kill diagnostic mode is selected with the engine running below 1000 RPM, the minimum throttle command will lock into the position it was in when the test mode was entered. If the Spark System Test mode is selected with the engine running above 1000 RPM, the throttle will continue to operate normally.

Disabling Ignition Outputs

To disable the ignition system for an individual cylinder, use the mouse to highlight the “Spark Kill” button and select the desired coil. The spark output can be re-enabled by using the mouse to highlight the “Spark Kill” button and selecting “Normal”. If the engine is running below 1000 RPM, the spark output will stay disabled for 15 seconds and then re-set. If the engine is running above 1000 RPM, the spark output will stay disabled for 5 seconds and then re-set. This test mode has a timeout of 10 minutes. Record the rpm drop related to each spark output disabled.

The Spark outputs are arranged in the order which the engine fires, not by cylinder number.

THROTTLE TEST



To select this test mode the engine must be off but the key must be in the ON position.

The DBW (Drive By Wire) test mode allows the technician to control the throttle directly with the foot pedal or throttle input and is used during the diagnostic routines specified for FPP and TPS for Spectrum systems that use DBW.

FPP position displays the current position of the foot pedal as a percentage. FPP volts display the voltage which the ECM is reading from the FPP sensor.

TPS Command displays the commanded throttle position expressed as a percentage, which is being sent to the throttle. TPS Position is the actual percent of throttle opening being sent to the ECM from the throttle. TPS volts display the actual TPS signal voltage the ECM is receiving from the throttle.

Using a Diagnostic Jumper to Diagnose the ECI System

If you do not have access to a laptop computer, it is still possible to access the Diagnostic Trouble Codes stored in the memory of the Spectrum system ECM using a diagnostic jumper and the Malfunction Indicator Lamp. With the key off connect the diagnostic jumper to the ECI system diagnostic connector located near the ECM. Jumper diagnostic pins A and D. Turn the ignition on but do not start the vehicle. The Malfunction Indicator Lamp (MIL) will begin to flash.
The MIL displays three digit codes by flashing the first digit, pausing, then flashing the second digit, pausing, and then flashing the third digit. There will be a long pause between codes. For example, a code 143 would be

one flash followed by four flashes followed by three flashes.
The MIL will first display a 166 three times. Code 166 indicates that the ECM based diagnostic routines are functioning. Then, any Diagnostic Trouble Codes stored in memory will display three times each. The MIL will then start over with the code 166. If the vehicle is started while the diagnostic jumper is in place, the MIL will flash rapidly.
Diagnostic Trouble Codes may be cleared from the system ECM memory by moving the ignition key to the OFF position and removing the (F1) system battery fuse for at least 15 seconds. Note: This will erase all of the memory in the computer including the adaptive learn.

Diagnostic Communication Error

The ECM 5 volt reference circuit powers the Spectrum diagnostic link cable. In the event that the 5 volt reference signal is open or shorted to ground, you will not be able to connect to the system. If you are unable to connect, follow the quick checks listed below:

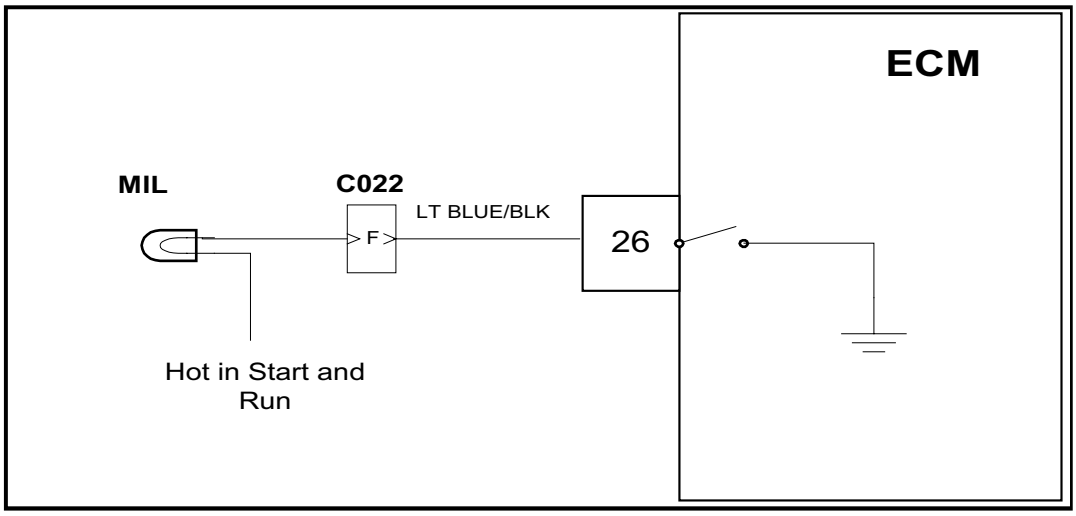
Be sure you are using the correct password and latest software for the system you are connecting to.

Check the ECM system power and ground circuits. Refer to DTC 261 for the power schematic. Also check for +12 switched power at ECM pin 21 with the ignition key on.

Check for power at the DLC connector for +5 volts between pins C (LT GRN/RED) and pin D (BLK) with the ignition key in the on position.

You may still be able to retrieve a code using the blink code function if none of the above recommendations prove useful. In the event of a 5 volt reference signal malfunction, DTC 531 or 532 should set. If you find one of these codes using the blink code function, follow the DTC diagnostic chart recommendations in the DTC section of this manual.

OBD System Check/Malfunction Indicator Lamp



Circuit Description

The Spectrum Fuel system is equipped with OBD (On-Board Diagnostics). The system has a dash mounted MIL (Malfunction Indicator Lamp) for the indication of system problems. Engine control system problems that affect emissions or driveability of the vehicle will set a DTC (Diagnostic Trouble Code). The ECM will then provide a path to ground and illuminate the MIL (Malfunction Indicator Lamp)

The MIL has the following functions:

1. It notifies the driver of a problem with the fuel system, ignition system, or emission control system so the driver can arrange for service as soon as possible.
2. It will display DTC's that have been stored due to a system malfunction.

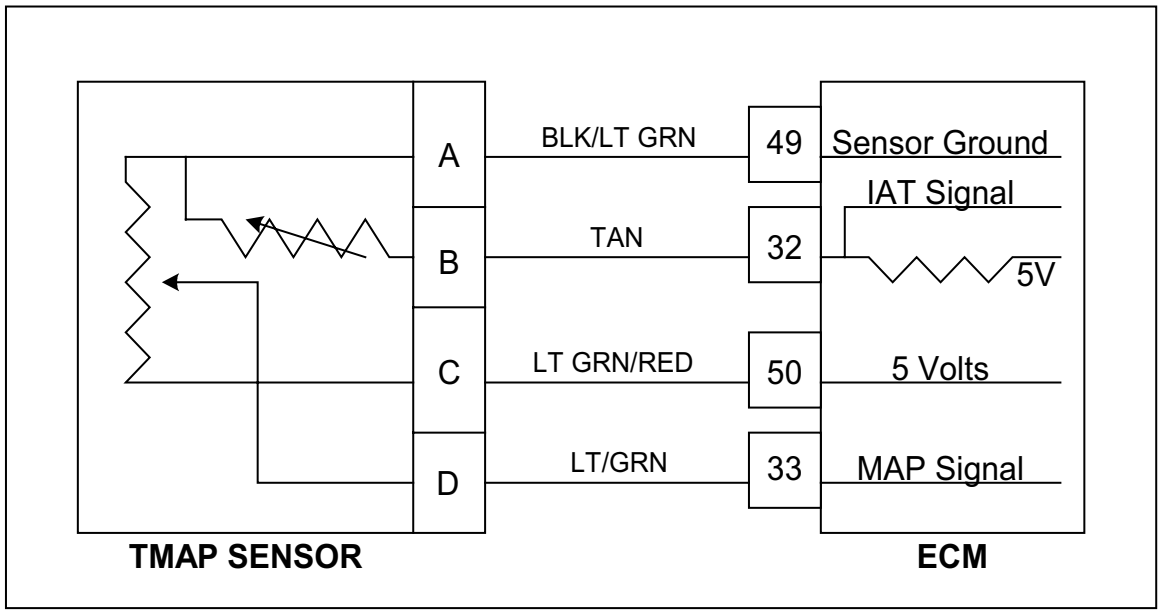
The lamp should illuminate when the key is in the ON position, and the engine is not running. This feature verifies that the lamp is in proper working order. If the lamp does not come on with the vehicle key on/engine off, repair it as soon as possible. Once the engine is in start or run mode, the lamp should go off. If the lamp illuminates while the engine is in the start or run mode, a current Diagnostic Trouble Code may be set. Always use the OBD System Check chart on the next page of this manual to verify proper MIL operation before proceeding with a DTC diagnostic code repair.

OBD System Check

Step	Action	Value(s)	Yes	No
1	• Key ON Engine OFF Does the MIL illuminate?		*Go to Step (2)*	*Go to Step (3)*
2	• Start the engine • Does the MIL lamp turn off?		*MIL is working properly. OBD System Check is complete*	Go to Step (10)
3	• Key ON engine OFF • Check for voltage between MIL power source and engine ground Do you have voltage?		*Go to Step (4)*	*Repair MIL voltage source. Refer to OEM body and chassis wiring diagrams*
4	Replace MIL lamp Did that solve the problem?		*Go to step (1)*	*Go to Step (5)*
5	• Key OFF • Disconnect ECM wire harness connector C001 • Using a DVOM check for continuity between MIL side of connector C022 and ECM terminal 26 Do you have continuity?		Go to Step (6)	*Go to Step (8)*
6	• Inspect the MIL lamp socket, connector C022 and ECM terminal 26 for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
7	• Replace ECM Is the replacement complete?		Go to Step (1)	-

8	• Back probe both MIL and ECM side of terminal F in connector C022 • Using a DVOM check for continuity through connector C022 Do you have continuity?		*Go to Step (9)*	*Repair open circuit in connector C022*
9	• Inspect the MIL lamp socket, connector C022 and ECM terminal 26 for damage, corrosion or contamination Did you find a problem?		Repair the damaged socket or terminal as required. Refer to Wiring Repairs in Engine Electrical.	Repair the wire harness open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	Active DTC (Diagnostic trouble code) is stored in memory. Proceed with DTC diagnosis. If no active DTC is found in ECM memory return to this page Step (11)		-	-
11	• Key OFF • Disconnect ECM wire harness connector C001 • Using a DVOM check for continuity between ECM terminal 26 and battery voltage • Do you have continuity?		Repair the shorted to ground circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)

DTC 111-IAT High Voltage



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition-Engine Running
- Fault Condition-IAT Sensor Voltage greater than 4.95
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled

Circuit Description

The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm.
The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow.

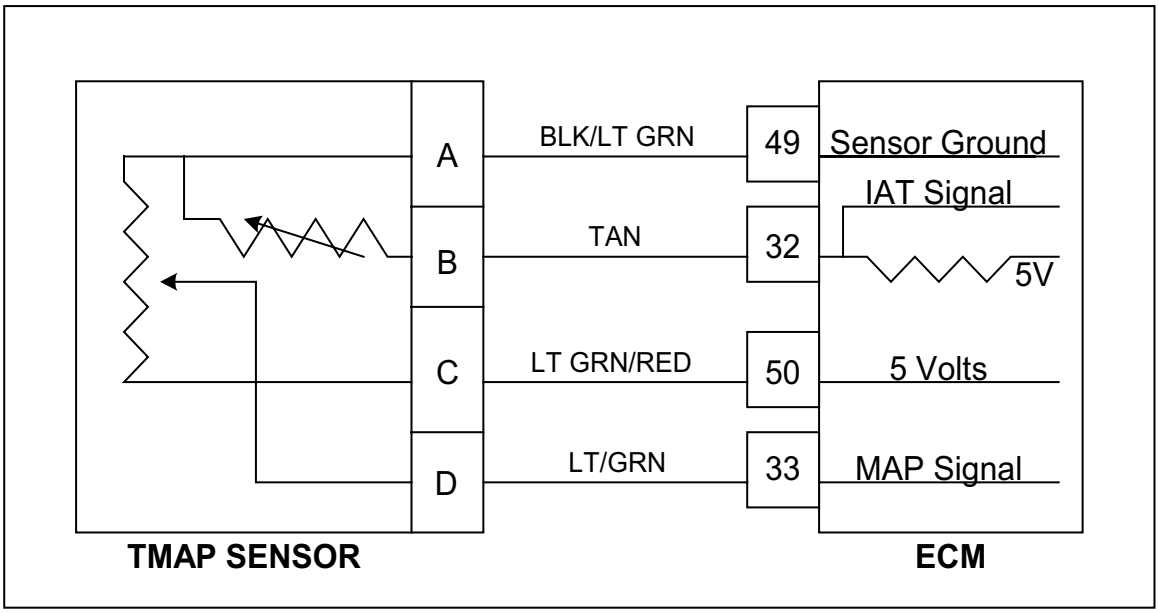
This fault will set if the signal voltage is more than 4.95 volts anytime the engine is running. The ECM will use the default value for the IAT sensor in the event of this fault.

DTC 111- IAT VOLTAGE HIGH

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display IAT voltage of 4.95 or greater?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key Off • Disconnect the TMAP sensor connector from the wiring and harness and jumper pins A and B together • Key On Does the DST display IAT voltage of 0.1 volts or less?		Go to step (9)	Go to step (4)
4	• Key OFF • Jumper TMAP sensor connector signal pin B to engine ground • Key ON • Does DST display IAT voltage of 0.1 volts or less?		Go to Step (7)	Go to Step (6)
5	Replace TMAP sensor. Is the replacement complete?		Go to Step (11)	_
6	• Key OFF • Disconnect the ECM wire harness connector. • Check for continuity between TMAP sensor connector signal pin B and ECM IAT signal pin 32. Do you have continuity between them?	__	Go to step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

7	• Check for continuity between TMAP sensor connector ground circuit pin A and ECM sensor ground circuit pin 49. Do you have continuity between them?	__	Go to step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?	_	Go to step (11)	_
9	• Re-check wire harness and TMAP sensor connectors for damage corrosion or contamination Were any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical	Go to Step (5)
10	• Re-check wire harness and TMAP sensor connectors for damage corrosion or contamination Were any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical	Go to Step (8)
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-111 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 112-IAT Low Voltage



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition Engine Cranking or Running
- Fault Condition-IAT Sensor Voltage less than 0.05
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled and allowed to stay at limit if required but will then also set the limiting fault.

Circuit Description

The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm.
The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow.

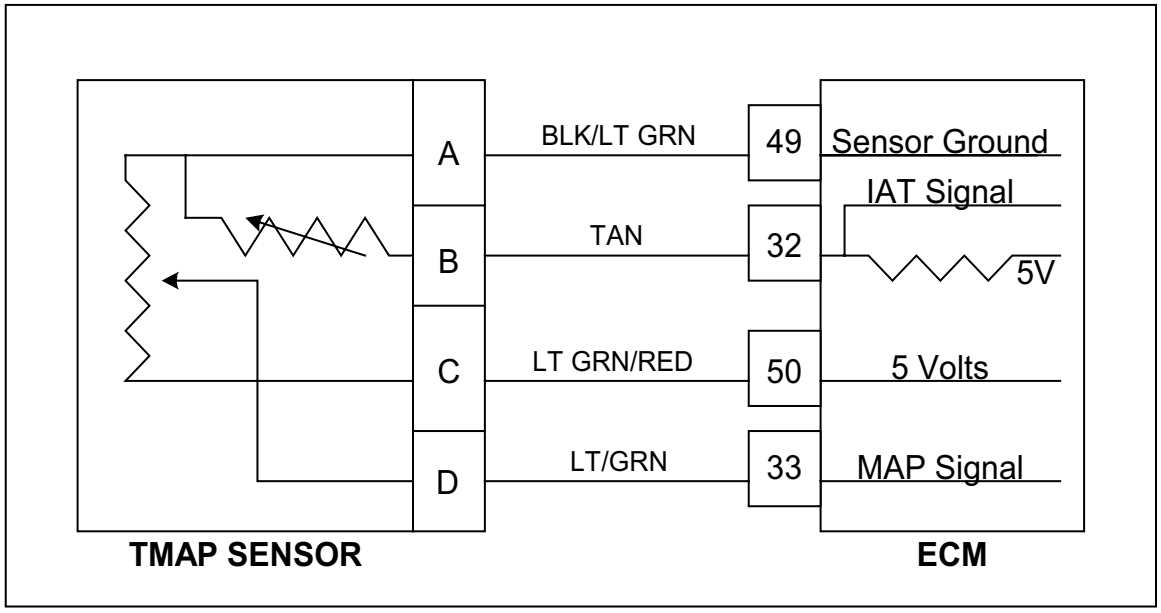
This fault will set if the signal voltage is less than 0.05 volts anytime the engine is cranking or running. The ECM will use the default value for the IAT sensor in the event of this fault.

DTC 112- IAT VOLTAGE LOW

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	_	Go to Step (2)	Go to OBD System Check Section
2	• Key On • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display IAT voltage of 0.05 or less?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key Off • Disconnect the TMAP sensor wire harness connector • Key ON Does the DST display IAT voltage of 4.9 volts or greater?		Go to step (4)	Go to step (5)
4	Replace TMAP sensor. Is the replacement complete?		Go to Step (9)	_
5	• Key OFF • Disconnect ECM wire harness connector. • Check for continuity between TMAP sensor connector ground pin A and TMAP sensor connector signal pin B Do you have continuity between them?	__	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (6)
6	• Check for continuity between TMAP sensor connector signal circuit pin B and engine ground. Do you have continuity?	__	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (7)

7	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?	_	Go to step (8)	_
8	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-112 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 113-IAT Higher Than Expected 1



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition-Engine Running
- Fault Condition-Intake Air Temperature greater than 200 degrees F. and engine RPM greater than 1000
- MIL-On for active fault and for 15 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled
- Power Derate 1

Circuit Description

The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm.
The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow.

This fault will set if the Intake Air Temperature is greater than 200 degrees F. for 60 seconds or more and engine RPM is greater than 1000. Power Derate 1 will then be enforced. During this fault, maximum throttle position is 50% and the MIL will be on.

Diagnostic Aids

* This fault will set when inlet air is much hotter than normal. The most common cause of high inlet air temperature is a problem with the inlet air system. Ensure that the air inlet is not obstructed, modified or damaged.

* Inspect the air inlet system for cracks or breaks that may allow unwanted under hood air in to the air inlet system

DTC 113-IAT Higher Than Expected 1

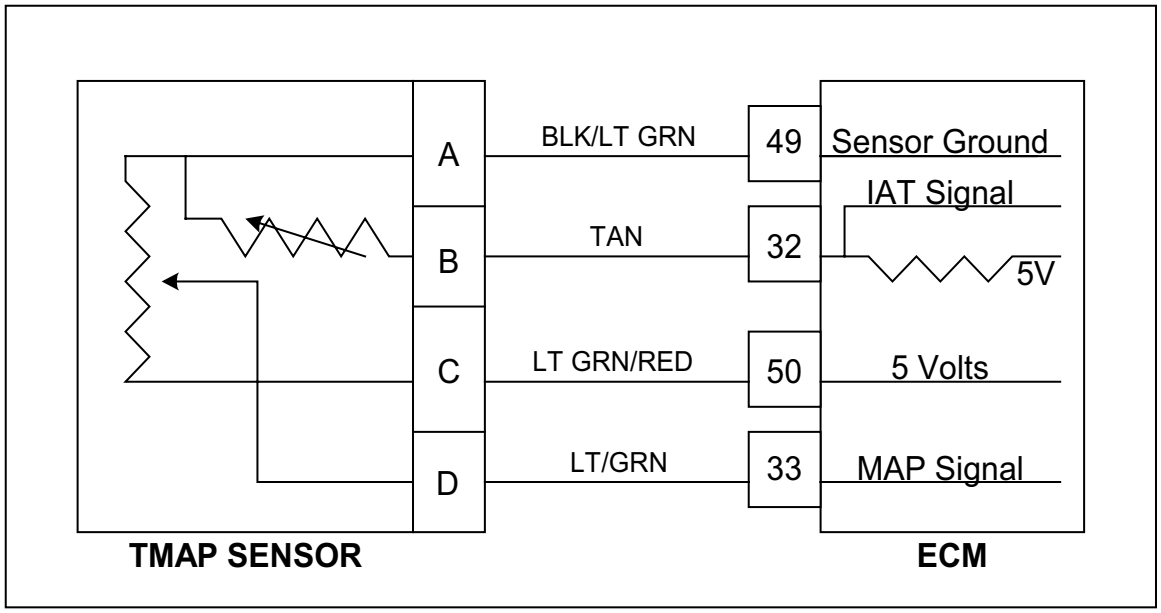
Diagnostic Aids

* This fault will set when inlet air is much hotter than normal. The most common cause of high inlet air temperature is a problem with the inlet air system. Ensure that the air inlet is not obstructed, modified or damaged.

* Inspect the air inlet system for cracks or breaks that may allow unwanted under hood air in to the air inlet system

* If none of the above can be found, Follow the diagnostic steps for DTC 112-IAT Low Voltage.

DTC 114-IAT Higher Than Expected 2



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition-Engine Running
- Fault Condition-Intake Air Temperature greater than 210 degrees F. and engine RPM greater than1000
- MIL-On for active fault and for 15 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled
- Engine Shut Down

Circuit Description

The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm.
The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow.

This fault will set if the Intake Air Temperature is greater than 210 degrees F. after 120 seconds and engine RPM is greater than 1000. The MIL light will be on during this active fault and the engine

DTC 114-IAT Higher Than Expected 2

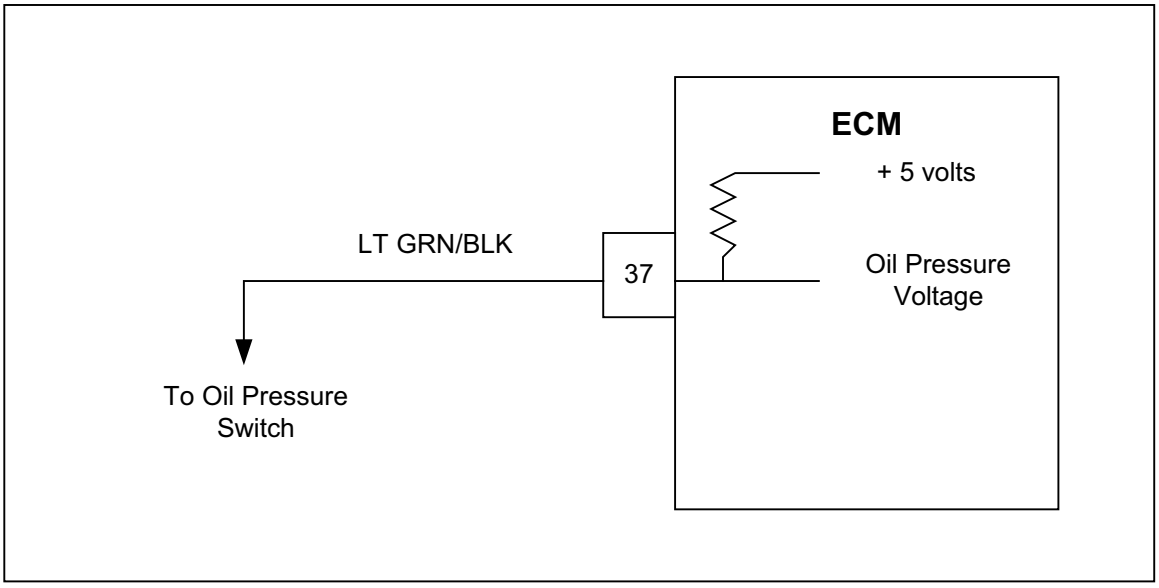
Diagnostic Aids

* This fault will set when inlet air is much hotter than normal. The most common cause of high inlet air temperature is a problem with the inlet air system. Ensure that the air inlet is not obstructed, modified or damaged.

* Inspect the air inlet system for cracks or breaks that may allow unwanted under hood air in to the air inlet system

* If none of the above can be found, Follow the diagnostic steps for DTC 112-IAT Low Voltage.

DTC 115-Oil Pressure Low



Conditions for Setting the DTC

- Engine Oil Pressure low
- Check Condition-Engine running for 15 seconds and RPM greater than 600
- Fault Condition- Open circuit/voltage high
- MIL-On during active fault and for 3 seconds after active fault
- Adaptive-Enabled
- Closed Loop-Enabled
- Engine Shut Down

Circuit Description

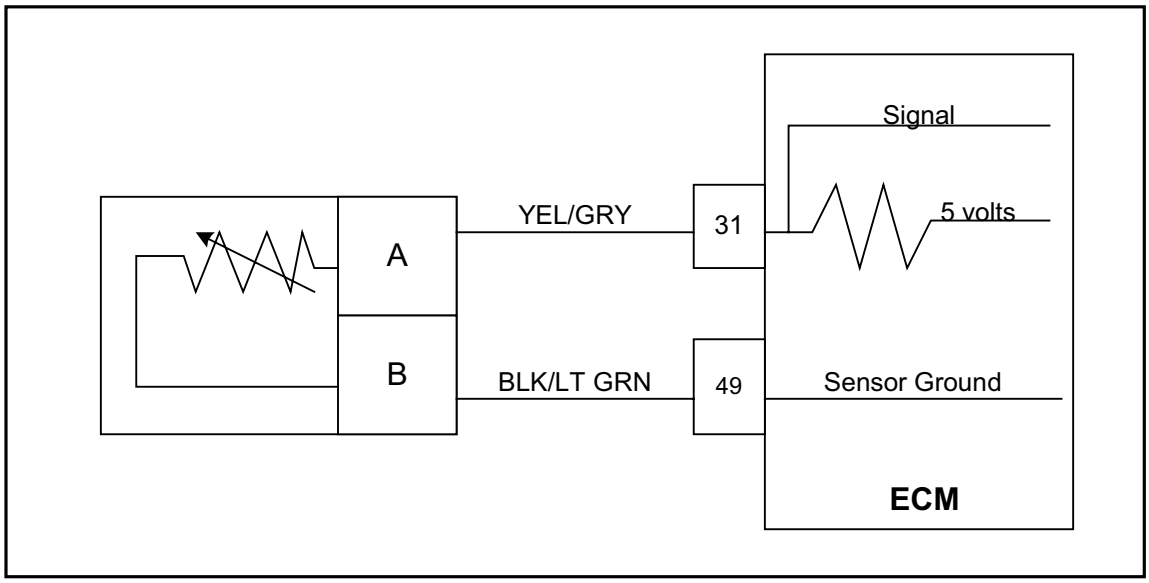
The Oil Pressure Switch is used to communicate a low oil pressure condition to the ECM. Engine damage can occur if the engine is operated with low oil pressure. The ECM uses an analog voltage input with an internal 5 volt reference. If the oil pressure circuit is grounded, the input voltage will be near zero. If it is open, the input will be near 5 volts. The switch is normally closed and the fault will set if the circuit becomes open. The engine will shut down in the event of this fault to help prevent possible damage.

DTC 115- Oil Pressure Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Verify that the engine has oil pressure using a mechanical oil pressure gauge before proceeding with this chart. See Engine Specifications Section 1F. Does the engine have oil pressure?	15 psi or greater	Go to Step (3)	Repair faulty Oiling System
3	• Key On, Engine Running DST connected in System Data Mode • Clear DTC 115 • Warm the engine by idling until the ECT temperature is above 160 degrees F. and has been running for at least one minute • Increase engine speed above 600 RPM Does DTC115 reset and cause the engine to shut down?	Greater than 600 rpm	Go to Step (4)	Intermittent problem Go to Intermittent section
4	• Key OFF • Disconnect oil pressure switch harness connector C005 • Jumper the pressure switch LG/BK wire to engine ground • Clear DTC 115 • Start engine, let idle for at least one minute with ECT over 160 degrees F. • Increase engine speed above 1300 RPM Does DTC 115 reset?		Go to Step (6)	Go to Step (5)
5	• Replace oil pressure switch Is the replacement complete?		Go to Step (9)	-
6	• Key OFF • Disconnect ECM harness connector C001 • Using a DVOM check for continuity between oil pressure switch connector LG/BK wire and ECM connector pin 37 • Do you have continuity between them?		Go to Step (7)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

7	• Inspect ECM connector pin 37 for damage corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (8)
8	• Replace ECM • Is the replacement complete?		Go to Step (9)	-
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-115 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 121-ECT / High Voltage



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Engine Running
- Fault Condition-ECT sensor voltage exceeds 4.95
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled

Circuit Description

The ECT (Engine Coolant Temperature) sensor is a temperature sensitive resistor located in the engine coolant. It is used for the engine airflow calculation, gasoline cold enrichment and to enable other temperature dependant features. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm. This fault will set if the signal voltage is greater than 4.95 volts anytime the engine is running. The ECM will use a default value for the ECT sensor in the event of this fault.

ECT Data:	
Temp (deg F)	**Ohms**
242.4	101
231.9	121
211.6	175
201.4	209
181.9	302
163.1	434
144.9	625
127.4	901
102.4	1,556
78.9	2,689
49.9	5,576
23.5	11,562
-5.7	28,770
-21.2	49,715
-30.8	71,589
-40.0	99,301

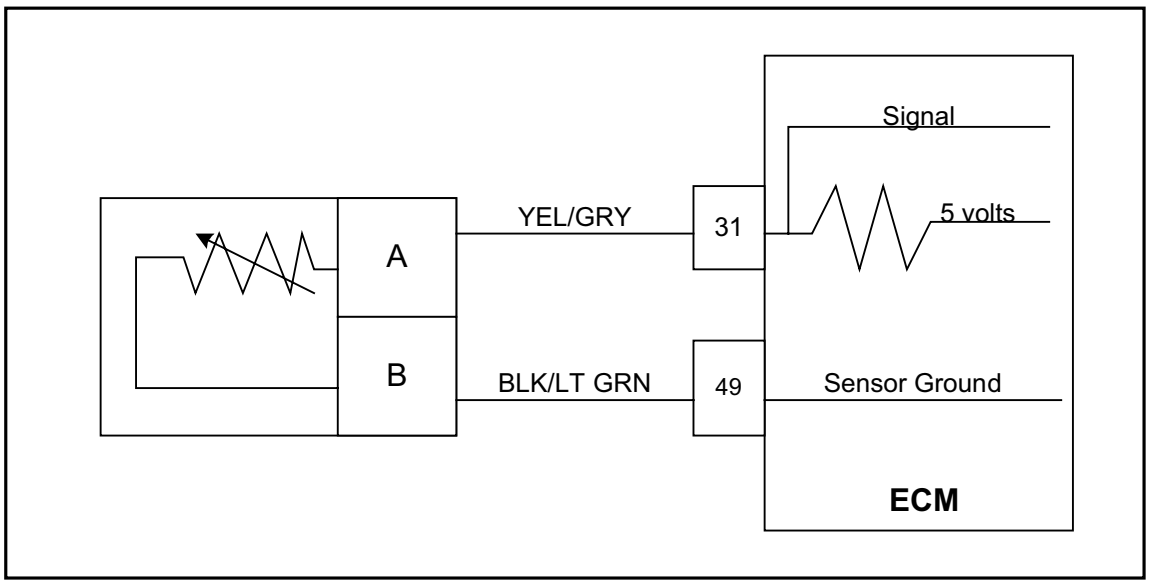
DTC 121- ECT VOLTAGE HIGH

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display ECT voltage of 4.95 or greater?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key Off • Disconnect the ECT sensor from the wiring harness and Jumper connector terminals A and B together • Key On Does the DST display ECT voltage of 0.05 volts or less?		Go to step (4)	Go to Step (8)
4	• Using a DVOM check the resistance between the two terminals of the ECT sensor and compare the resistance reading to the chart Is the resistance value correct?	See resistance chart vs. temperature in the DTC 121 circuit description	Go to Step (6)	Go to step (5)
5	• Replace ECT sensor Is the replacement complete?		Go to Step (14)	-
6	• Inspect the ECT wire harness connector terminals for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)

7	• Key OFF • Disconnect ECM wire harness connector • Inspect ECM connector pins 31 and 49 for damage corrosion or contamination • Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Intermittent problem Go to Intermittent section
8	• Jumper the ECT signal pin A at the ECT connector to engine ground Does DST display ECT voltage of 0.05 or less?		Go to Step (9)	Go to Step (12)
9	• Key OFF • Disconnect ECM wire harness connector • Using a DVOM check for continuity between ECT sensor ground pin B and ECM connector pin 49 Do you have continuity between them?		Go to Step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Inspect ECM connector pins 31 and 49 for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (11)
11	• Replace ECM Is the replacement complete?		Go to Step (14)	-
12	• Key OFF • Disconnect ECM wire harness connector • Using A DVOM check for continuity between ECT connector signal pin A and ECM connector terminal 31 Do you have continuity between them?		Go to Step (13)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
13	• Inspect ECM connector pins 31 and 49 for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (11)

14	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-121 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 122-ECT Low Voltage



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Engine Running
- Fault Condition- ECT sensor voltage less than 0.05
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled

Circuit Description

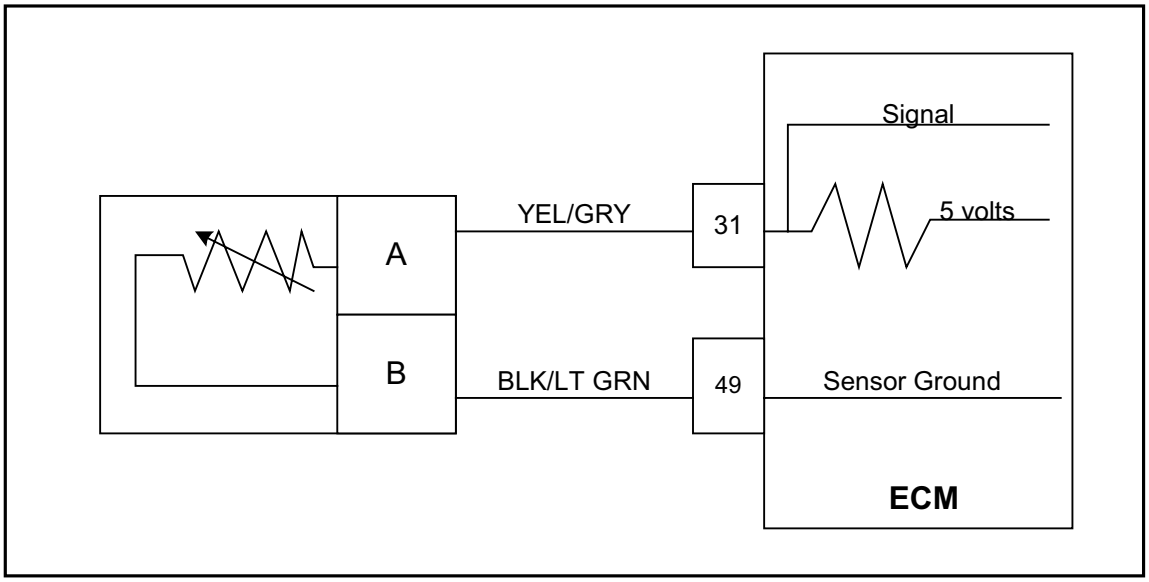
The ECT (Engine Coolant Temperature) sensor is a temperature sensitive resistor located in the engine coolant. It is used for the engine airflow calculation, gasoline cold enrichment and to enable other temperature dependant features. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm
This fault will set if the signal voltage is less than 0.05 volts anytime the engine is running. The ECM will use a default value for the ECT sensor in the event of this fault.

DTC 122- ECT VOLTAGE LOW

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	_	Go to Step (2)	Go to OBD System Check Section
2	• Key On • DST (Diagnostic Scan Tool) connected in • System Data Mode Does DST display ECT voltage of 0.05 or less?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key Off • Disconnect the ECT wire harness connector • Key ON Does the DST display ECT voltage of 4.9 volts or greater?		Go to step (4)	Go to step (5)
4	Replace ECT sensor. Is the replacement complete?		Go to Step (8)	_
5	• Key OFF • Disconnect ECM wire harness connector • Check for continuity between ECT sensor connector signal pin A and ECT sensor ground pin B Do you have continuity between them?	__	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (6)
6	• Check for continuity between ECT sensor connector signal circuit pin A and engine ground. Do you have continuity?	__	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (7)

7	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?	_	Go to step (8)	_
8	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-122 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 123-ECT Higher Than Expected 1



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Engine Running
- Fault Condition-Engine Coolant Temperature reading or estimate greater than 220 degrees F. and engine RPM greater than 500 for 60 seconds
- MIL- On during active fault and for 15 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled
- Power Derate (level 1)

Circuit Description

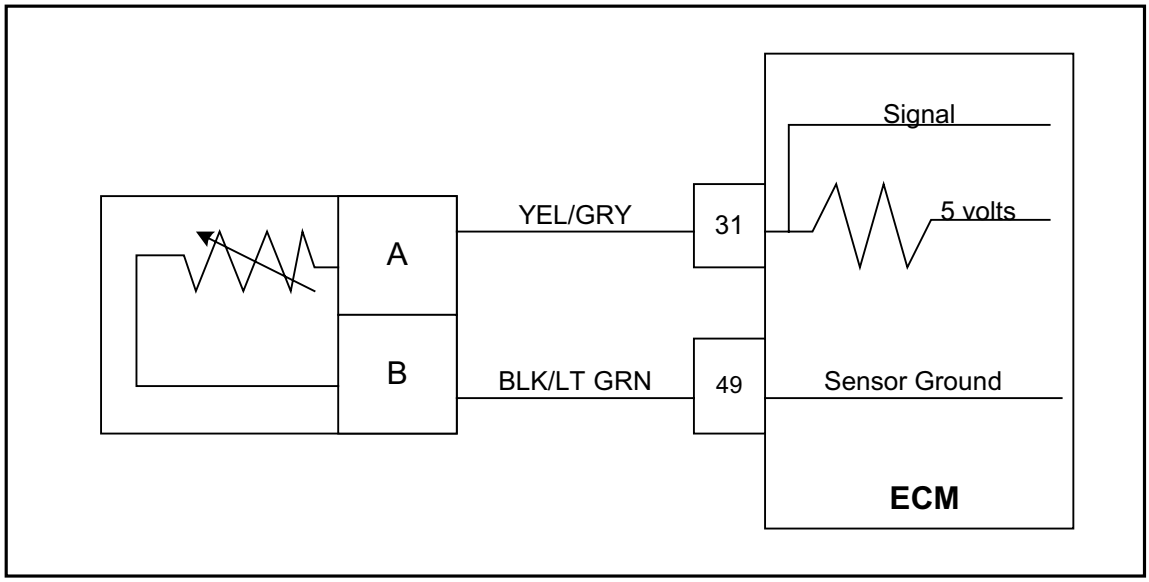
The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. The ECT (Engine Coolant Temperature) sensor that is located in the coolant near the thermostat. The ECT is used for engine airflow calculation, fuel enrichment, ignition timing control, to enable certain features, and for engine protection. The ECM provides a voltage divider circuit so when the sensor reading is cool the sensor reads higher voltage, and lower when warm.

This fault will help protect the engine in the event of over temperature. When the coolant exceeds 220 degrees F. and engine RPM exceeds 500 this fault will set and Power Derate 1 will be enforced. During this fault, maximum throttle position is 50% and the MIL light will turn on.

DTC 123- ECT Higher Than Expected 1

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On • DST (Diagnostic Scan Tool) connected in System Data Mode • Warm Engine to normal operating temperature, then run the engine above 500 rpm for 60 seconds Does DST display ECT temperature of 220 degrees F. or greater with the engine running over 500 rpm?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Verify with a temperature gauge that the engine coolant is over 220 degrees F. Does the temperature gauge indicate 220 degrees F. or greater?		Repair Cooling system.	Go to step (4)
4	Verify ECT circuit function. Follow diagnostic test procedure for DTC-122 ECT Low Voltage		-	-

DTC 124-ECT Higher Than Expected 2



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Engine Running
- Fault Condition-Engine Coolant temperature reading or estimate greater than 235 degrees F. and engine RPM greater than 500 for 60 seconds
- MIL-On for active fault and for 15 seconds after active fault
- Adaptive-Enabled
- Closed Loop-Enabled
- Engine Shut Down

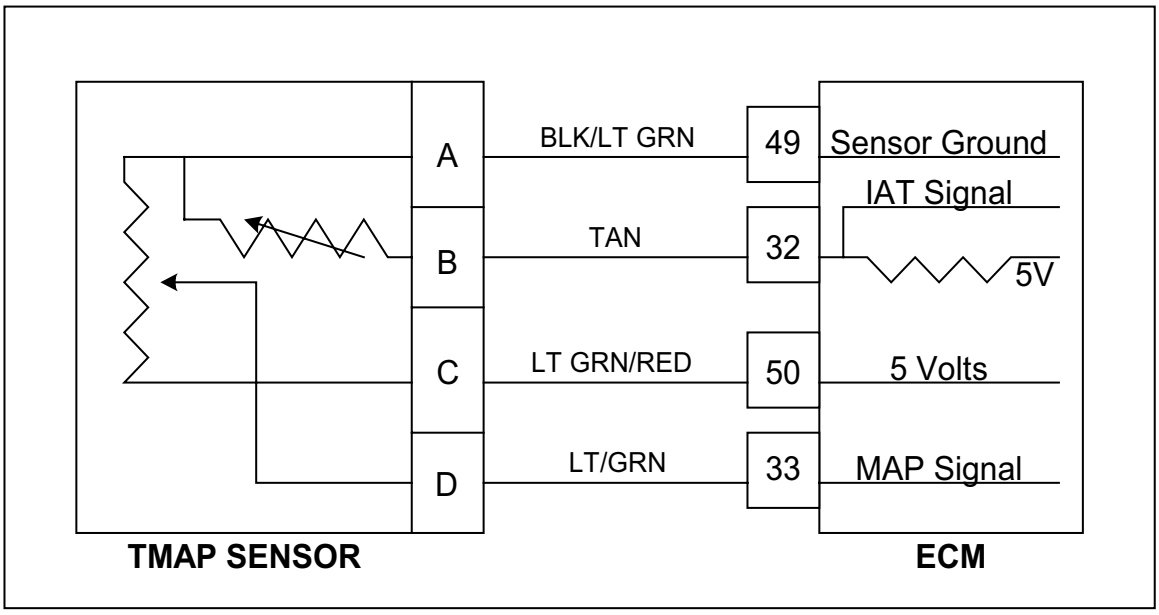
Circuit Description

The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. The ECT (Engine Coolant Temperature) sensor that is located in the coolant near the thermostat. The ECT is used for engine airflow calculation, ignition timing control, fuel enrichment, to enable certain features, and for engine protection. The ECM provides a voltage divider circuit so when the sensor reading is cool, the signal reads higher voltage, and lower when warm. This fault will set if coolant temperature reaches 235 degrees F. and engine RPM exceeds 500 rpm, then engine will shut down.

DTC 124 ECT Higher Than Expected 2

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On • DST (Diagnostic Scan Tool) connected in System Data Mode • Warm Engine to normal operating temperature, then run the engine above 500 rpm for 60 seconds • Does DST display ECT temperature of 235 degrees F. or greater with the engine running over 500 rpm?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Verify with a temperature gauge that the engine coolant is over 235 degrees F. Does the temperature gauge indicate 235 degrees F. or greater?		Repair Cooling system.	Go to step (4)
4	Verify ECT circuit function. Follow diagnostic test procedure for DTC-122 ECT Low Voltage		-	-

DTC 131-MAP High Pressure



Conditions for Setting the DTC

- Manifold Absolute Pressure
- Check Condition-RPM greater than 800, Throttle Command less than 10%, steady MAP and TPS
- Fault Condition-MAP greater than 17.8 psia, TPS less than 10% and engine RPM greater than 1800.
- MIL-On
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled and allowed to stay at limit
- Misc. Fueling is based on RPM and TPS Limp-Home Condition during this fault.

Circuit Description

The TMAP is a combined inlet manifold temperature and pressure sensor connected to the intake manifold. It is used to measure the pressure of air in the manifold prior to induction into the engine. The pressure reading is used in conjunction with other inputs to determine the airflow rate to the engine, which also determines the fuel flow rate. This fault will set when the MAP reading is higher than it should be for the given TPS, and RPM. When the fault is set, the Adaptive Learn will be disabled for the remainder of the key on cycle and the MIL will be on. The engine will operate on a default MAP during this active fault.

Diagnostic Aids

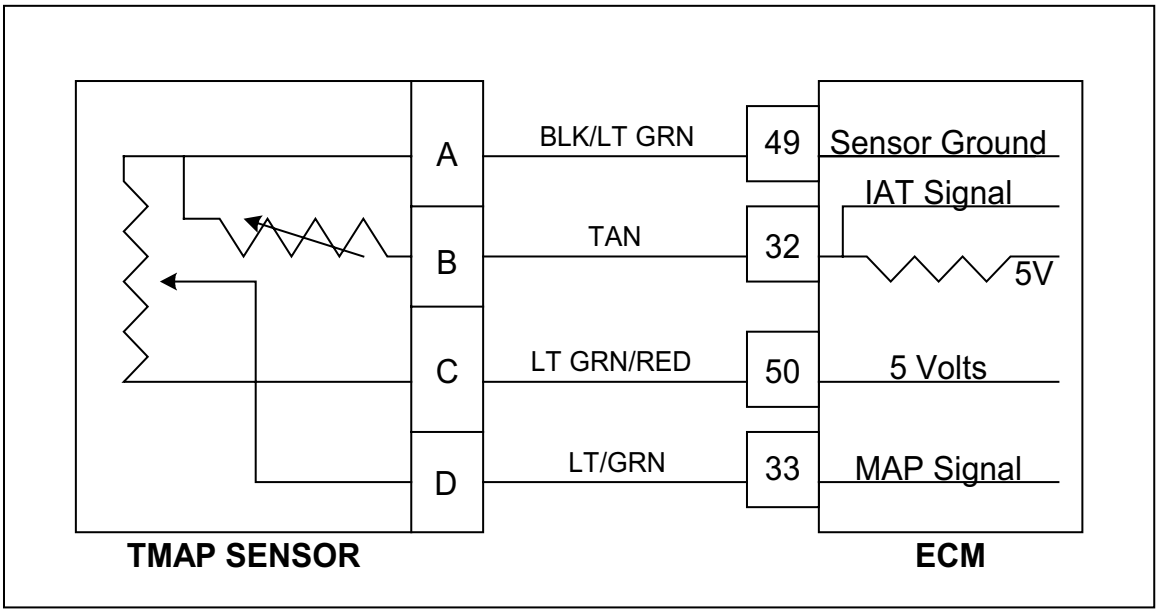
If the engine is running rough, unstable or missing due to a suspected mechanical problem, vacuum leak or other issue causing misfire these problems must be taken care before using the MAP diagnostic chart. Failure to follow this recommendation will result in a false MAP diagnostic and repair procedure.

DTC 131- MAP HIGH PRESSURE

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine running. • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display MAP pressure of 13.0 psia or greater with the engine idling?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect the TMAP sensor connector • Key ON Does the DST display MAP pressure less than 0.05 psia?		Go to step (4)	Go to step (6)
4	• Probe TMAP sensor ground circuit pin A with a test light connected to battery voltage. Does the test light come on?		Go to step (5)	Go to step (8)
5	• Check TMAP mechanical connection for correct mounting or possible damage causing leakage. Is the TMAP sensor mechanical connection Ok?		Go to step (6)	Go to Step (10)
6	• Key OFF • Disconnect ECM connector and inspect terminals for damage corrosion or contamination. Is the connection Ok?		Go to step (7)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
7	Replace TMAP sensor. Is the repair complete?	__	Go to step (11)	-

8	• Disconnect ECM connector and check for continuity between TMAP connector sensor ground pin A and ECM sensor ground PIN 49. Do you have continuity between them?		Go to step (9)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
9	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		Go to step (11)	-
10	• Correct TMAP mechanical connection Has TMAP mechanical connection been corrected?		Go to Step (11)	-
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-131 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 132-MAP Low Voltage



Conditions for Setting the DTC

- Manifold Absolute Pressure
- Check Condition-Cranking or Running
- Fault Condition-MAP voltage less than 0.05,Throttle Position greater than 2% and engine RPM less than 7000.
- MIL-On
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled
- Misc.-Fueling is based on RPM and TPS Limp-Home Condition during this fault.

Circuit Description

The Manifold Absolute Pressure sensor is a pressure transducer connected to the intake manifold. It is used to measure the pressure of air in the manifold prior to induction into the engine. The pressure reading is used in conjunction with other inputs to determine the airflow rate to the engine, which determines the fuel flow rate. This fault will set when the MAP reading is lower than the sensor should normally produce. When this fault is set the Adaptive Learn will be disabled for the remainder of the key on cycle and the MIL will be on.

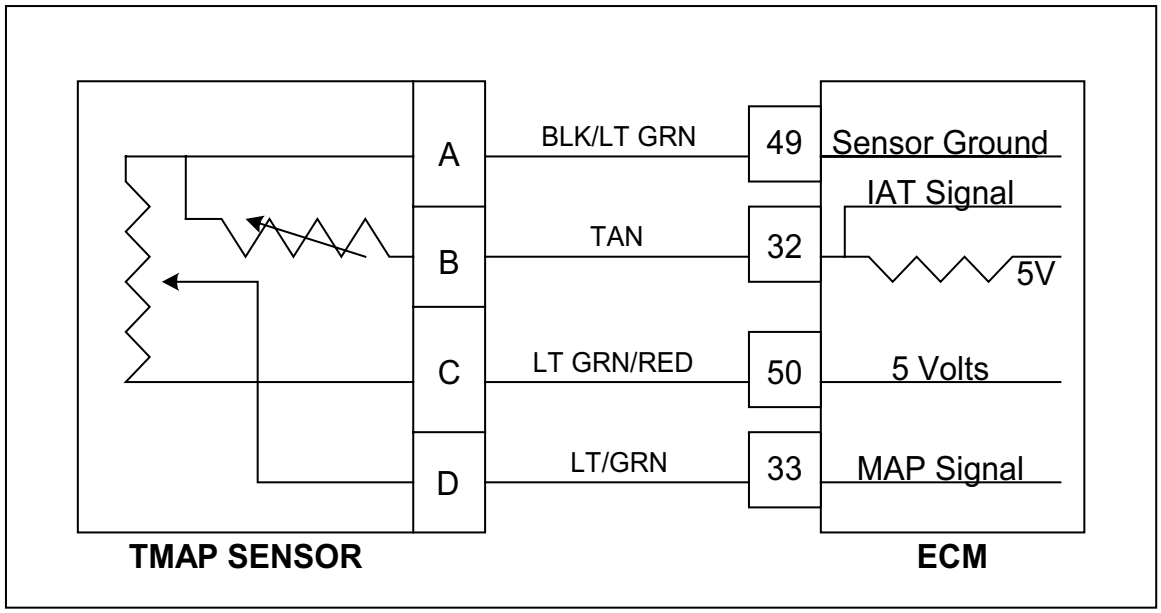
DTC 132- MAP Low Voltage

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine running. • DSC (Diagnostic Scan Tool) connected in System Data Mode Does DST display MAP voltage of 0.05 or less with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect the TMAP sensor from the wiring harness • Jumper the 5 volt reference pin C and MAP signal circuit pin D together • Key ON Does the DST display MAP voltage of 4.5 volts or greater?		Go to Step (4)	Go to step (8)
4	• Inspect TMAP connector pins for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (5)
5	• Key OFF • Disconnect ECM connector • Check for continuity between TMAP sensor connector signal pin D and ECM MAP signal pin 33. Do you have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Check for continuity between TMAP sensor connector 5 volt supply signal pin C and ECM 5 volt supply pin 50 Do you have continuity between them?		Go to step (7)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

7	• Check for continuity between TMAP sensor connector ground pin A and ECM sensor ground pin 49 Do you have continuity between them?		Go to step (17)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	• Probe MAP signal circuit with a test light connected to battery voltage Does the DST display MAP voltage of 4.0 or greater?		Go to Step (9)	Go to step (13)
9	• Key OFF • Disconnect ECM connector • Check for continuity between TMAP sensor connector and ECM 5 volt reference signal. Do you have continuity between them?		Go to step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Check for continuity between TMAP sensor connector 5 volt reference pin C signal and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (11)
11	• Inspect ECM connector and wire harness connector terminals for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (16)
12	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		Go to step (17)	-
13	• Disconnect ECM connector • Check for continuity between TMAP sensor connector signal circuit pin D and ECM signal PIN 33 Do you have continuity between them?		Go to Step (14)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

14	• Check for continuity between TMAP sensor connector signal pin D and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (15)
15	• Inspect ECM connector and wire harness connector terminals for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (16)
16	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		Go to Step (18)	-
17	Replace TMAP sensor Is the replacement complete?		Go to step (18)	-
18	• Remove all test equipment except the DSC. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-132 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 134-BP High Pressure



Conditions for Setting the DTC

- Barometric Pressure
- Check Condition-Key On
- Fault Condition-BP greater than 16 psia
- MIL-On for active fault and for 2 seconds after active fault
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled

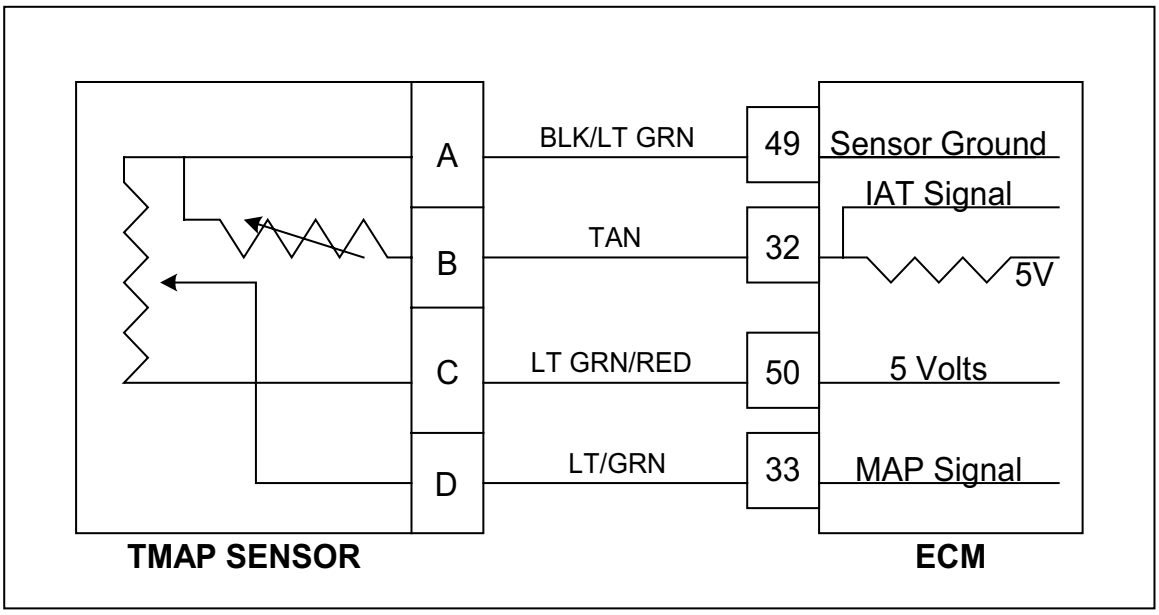
Circuit Description

The BP (Barometric Pressure) is estimated from the TMAP sensor. The barometric pressure value is used for fuel and airflow calculations. This fault sets in the event the BP value is out of the normal range.

DTC 134- BP High Pressure

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On • DST (Diagnostic Scan Tool) connected in • System Data Mode Does DST display MAP pressure of 16 psia or greater?		Go to step (3)	Intermittent problem Go to Intermittent section
3	Replace TMAP sensor. Is the repair complete?			-
	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-134 check for any stored codes. Does the engine operate normally with no stored codes?		System Ok	Go to OBD System Check

DTC 135-BP Low Pressure



Conditions for Setting the DTC

- Barometric Pressure
- Check Condition-Key On
- Fault Condition-BP less than 8.3 psia
- MIL-On for active fault and for 2 seconds after active fault
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled

Circuit Description

The BP (Barometric Pressure) is estimated from the TMAP sensor. The barometric pressure value is used for fuel and airflow calculations. This fault sets in the event the BP value is out of the normal range.

DTC 135- BP Low Pressure

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On. • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display BP pressure of 8.3 psia or less?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect the TMAP sensor from the wiring harness • Jumper the 5 volt reference pin C and MAP signal pin D together • Key ON Does the DST display BP pressure of 16.00 psia or greater?		Go to Step (4)	Go to step (8)
4	• Inspect TMAP connector and wire harness connector terminals for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (5)
5	• Key OFF • Disconnect ECM connector • Check for continuity between TMAP sensor connector pin D and ECM connector pin 33 Do you have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

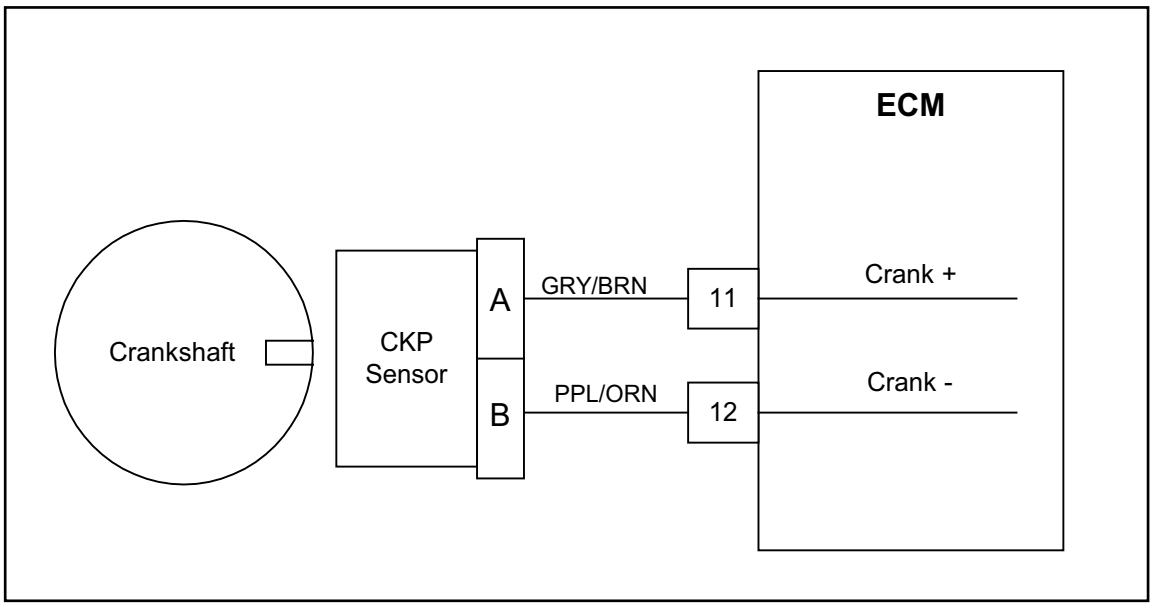
6	• Check for continuity between TMAP sensor connector 5 volt supply pin C and ECM connector pin 50 Do you have continuity between them?		Go to step (7)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
7	• Check for continuity between TMAP sensor connector ground pin A and ECM connector pin 49 Do you have continuity between them?		Go to step (17)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	• Remove Jumper that was installed during step 3 • Probe TMAP connector signal circuit D with a test light connected to battery voltage Does the DST display BP pressure of 16.00 psia or greater?		Go to Step (9)	Go to step (13)
9	• Key OFF • Disconnect ECM connector • Check for continuity between TMAP sensor connector pin C and ECM connector pin 50 Do you have continuity between them?		Go to step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Check for continuity between TMAP sensor connector 5 volt reference signal pin C and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (11)

11	• Inspect TMAP AND ECM connectors pins for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (16)
12	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		Go to step(17)	-
13	• Disconnect ECM connector • Check for continuity between TMAP sensor connector pin D and ECM pin 33 Do you have continuity between them?		Go to Step (14)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
14	• Check for continuity between TMAP sensor connector pin D and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (15)
15	• Inspect ECM connector and wire harness connector pins for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (16)
16	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		Go to Step (18)	-
17	Replace TMAP sensor Is the replacement complete?		Go to step (18)	-

18	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-135 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

v

DTC 142-Crank Sync Noise



Conditions for setting the DTC

- Crankshaft Position sensor
- Check Condition- Engine running
- Fault Condition- 1 invalid crank re-sync
- MIL- On during active fault and for 10 seconds after active fault
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled

Circuit Description

The Crankshaft Position sensor is a magnetic transducer mounted on the engine block adjacent to a pulse wheel located on the crankshaft. It determines crankshaft position by monitoring the pulse wheel. The Crankshaft Position sensor is used to measure engine RPM and its signal is used to synchronize the ignition and fuel systems. The ECM must see a valid Crankshaft position signal while running. If no signal is present for 800ms or longer, this fault will set.

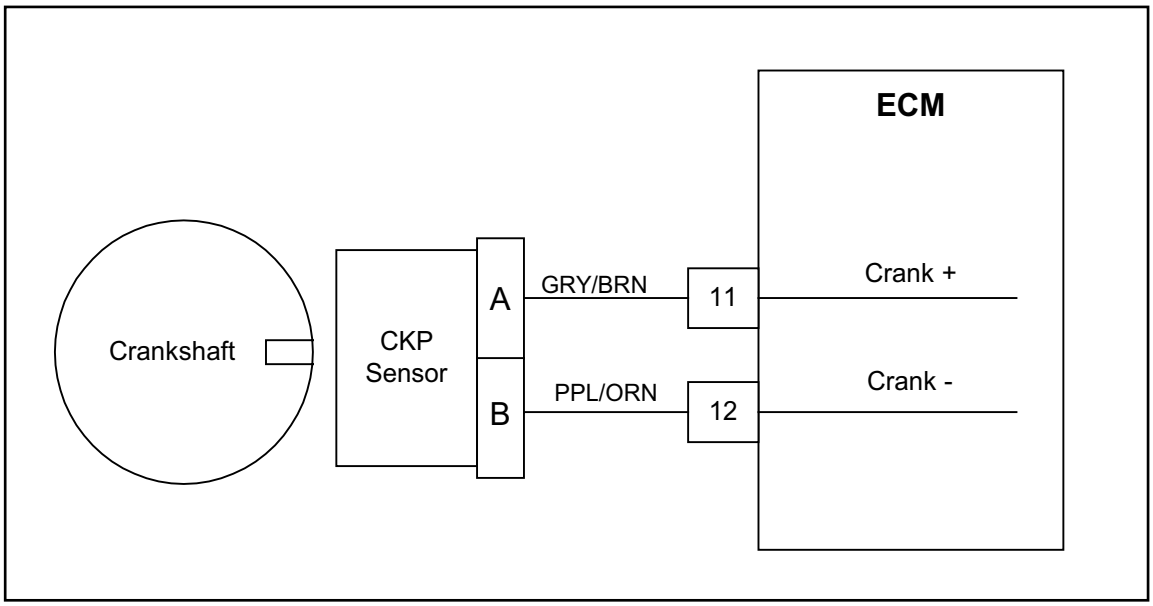
DTC 142 Crank Sync Noise

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Check to be sure that the ECM ground terminal G1 to engine ground is clean and tight. Is terminal G1 clean and tight?		Go to Step (3)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
3	• Key OFF • Disconnect the CKP sensor connector • Using a DVOM check for voltage output from the CKP sensor while cranking the engine • Do you have voltage output?	Over .5 volts	Go to Step (4)	Go to Step (11)
4	• Key OFF • Disconnect ECM connector C001 • Using a DVOM check for continuity between CKP connector pin A and ECM connector pin 11 • Do you have continuity between them?		Go to Step (5)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Using a DVOM check for continuity between CKP connector pin B and ECM connector pin 12 Do you have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Inspect the CKP connector C011 pins for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)

7	• Inspect the ECM connector C001 pins 11 and 12 for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (8)
8	• Using a DVOM check for continuity between ECM connector pins 11 and 12 to engine ground Do you have continuity?		Repair the shorted circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (10)
9	• Replace CKP sensor Is the replacement complete?		Go to Step (16)	-
10	• Replace ECM • Is the replacement complete?		Go to Step (16)	-
11	• Key OFF • Inspect the pulse wheel and CKP sensor for mechanical damage, corrosion or contamination. Did you find a problem?		Repair the distributor as necessary. Refer to Engine Repairs in Engine Section	Go to Step (12)
12	• Check the CKP pulse wheel to sensor air gap Is the air gap correct?	.030 to .040 inches	Go to step (13)	Go to Step (14)
13	• Check CKP for excessive movement or broken mounting bracket. Does the CKP show excessive movement on the bracket?		Go to Step (15)	Go to Step (9)
14	• Re set air gap to the correct specification Is the gap now set to the correct specification?	.030 to .040 inches	Go to Step (16)	-

15	• Replace CKP sensor bracket • Is the replacement complete?		Go to Step (16)	-
16	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-142 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 143-Never Crank Synced At Start



Conditions for setting the DTC

- Crankshaft Position sensor
- Check Condition- Engine running
- Fault Condition- 1 invalid crank re-sync
- MIL- On during active fault
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled

Circuit Description

The Crankshaft Position sensor is a magnetic transducer mounted on the engine block adjacent to a pulse wheel located on the crankshaft. It determines crankshaft position by monitoring the pulse wheel. The Crankshaft Position sensor is used to measure engine RPM and its signal is used to synchronize the ignition and fuel systems. The ECM must see a valid Crankshaft position signal while running. If no signal is present for 800ms or longer with rpm greater than 90, this fault will set.

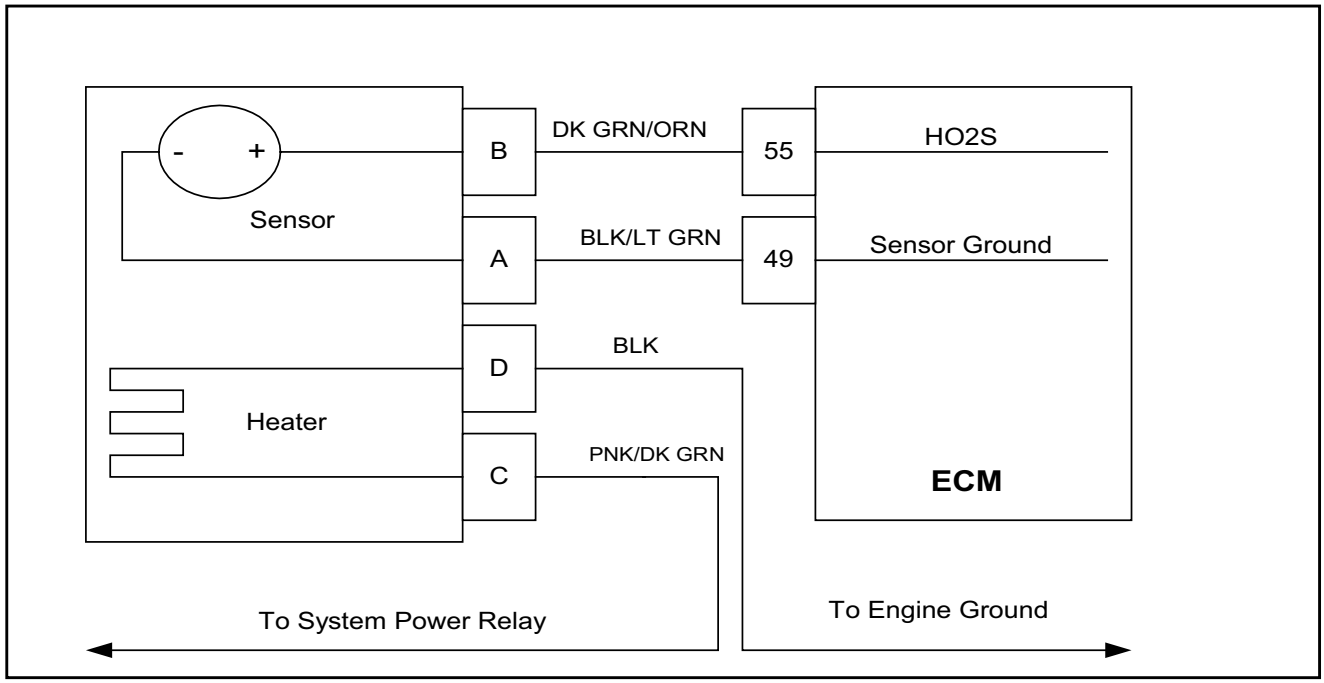
DTC 143 Never Crank Sync at Start

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Check to be sure that the ECM ground terminal G1 to engine ground is clean and tight. Is terminal G1 clean and tight?		Go to Step (3)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
3	• Key OFF • Disconnect the CKP sensor connector • Using a DVOM check for voltage output from the CKP sensor while cranking the engine • Do you have voltage output?	Over .5 volts	Go to Step (4)	Go to Step (11)
4	• Key OFF • Disconnect ECM connector C001 • Using a DVOM check for continuity between CKP connector pin A and ECM connector pin 11 • Do you have continuity between them?		Go to Step (5)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Using a DVOM check for continuity between CKP connector pin B and ECM connector pin 12 Do you have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Inspect the CKP connector C011 pins for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)

7	• Inspect the ECM connector C001 pins 11 and 12 for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (8)
8	• Using a DVOM check for continuity between ECM connector pins 11 and 12 to engine ground Do you have continuity?		Repair the shorted circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (10)
9	• Replace CKP sensor Is the replacement complete?		Go to Step (16)	-
10	• Replace ECM • Is the replacement complete?		Go to Step (16)	-
11	• Key OFF • Inspect the pulse wheel and CKP sensor for mechanical damage, corrosion or contamination. Did you find a problem?		Repair the distributor as necessary. Refer to Engine Repairs in Engine Section	Go to Step (12)
12	• Check the CKP pulse wheel to sensor air gap Is the air gap correct?	.030 to .040 inches	Go to step (13)	Go to Step (14)
13	• Check CKP for excessive movement on the bracket. Does the CKP show excessive movement on the bracket		Go to Step (15)	Go to Step (9)
14	• Re set air gap to the correct specification Is the gap now set to the correct specification?	.030 to .040 inches	Go to Step (16)	-
15	• Replace CKP sensor bracket • Is the replacement complete?		Go to Step (16)	-

16	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-143 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 211- Closed Loop Multiplier High (LPG)



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check Condition- Engine running
- Fault Condition- Closed Loop multiplier out of range (greater than 35%)
- MIL- Disabled
- Adaptive- Enabled but not updated when Closed Loop is at limit
- Closed Loop- Enabled

Circuit description

The HO2S sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The ECM uses this information to correct the fuel flow with the Closed Loop multiplier and the adaptive multiplier. This fault sets if the Closed Loop multiplier exceeds the limits of normal operation and cannot correctly modify the fuel flow within its limits.

Diagnostic Aids

Always diagnose any ECM codes that are present before beginning this diagnostic procedure.

- Heated Oxygen sensor wires may be mis-routed and contacting the exhaust manifold.
- Vacuum leaks can cause a lean exhaust condition, especially at light load and idle conditions.
- Exhaust leaks can cause a lean exhaust condition, especially at light load and idle conditions
- A poor ECU ground to the engine block or battery negative
- Problems with the fuel system causing lean fuel mixtures such as low fuel pressure, faulty mixture control solenoid or damaged fuel mixer assembly.

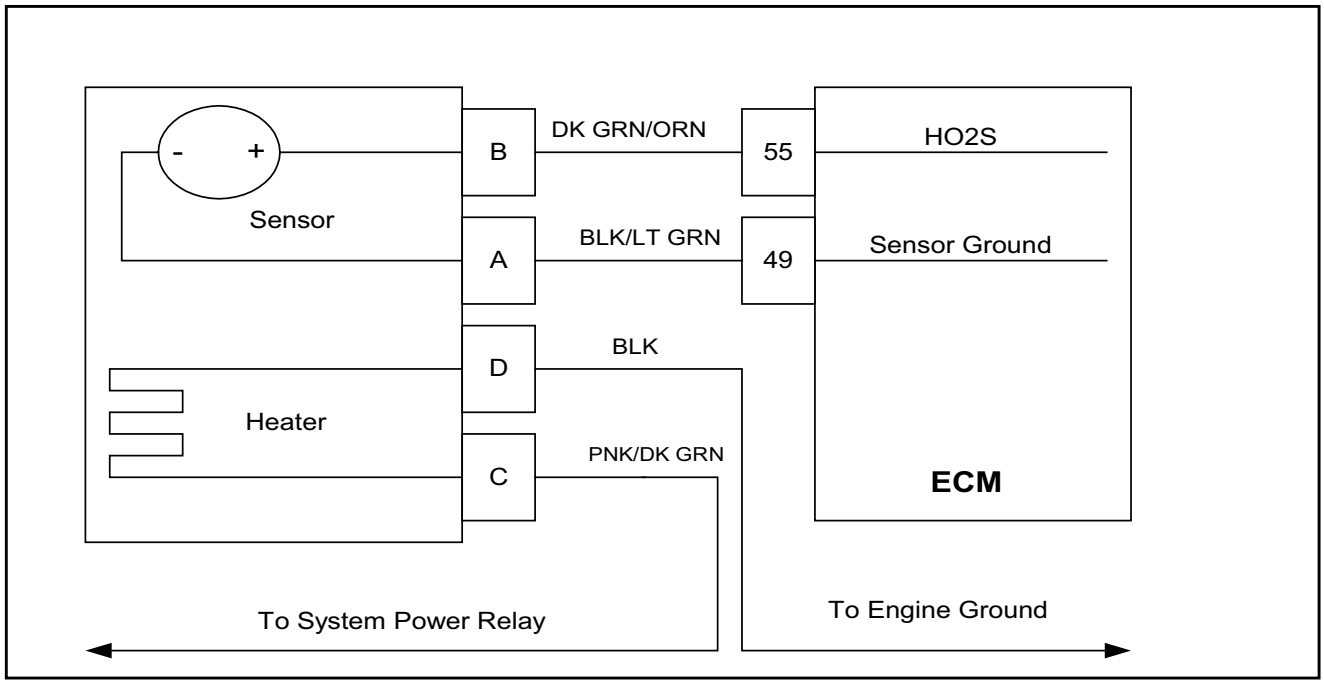
Never solder HO2S wires. For the correct repair procedure refer to Wiring Repairs in the Engine Electrical Section.

DTC 211- Closed Loop Multiplier High (LPG)

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Run engine to full operating temperature and then idle for a minimum of 2 minutes Does DST display HO2S voltage fixed below 0.35 volts after 2 minutes of idle run time?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect ECM connector • Disconnect HO2S wire harness connector • Using a high impedance DVOM check for continuity between HO2S connector signal pin B and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (4)
4	• Using a high impedance DVOM check for continuity between HO2S connector signal pin B and HO2S connector sensor ground pin A • Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (5)
5	• Refer to Diagnostic aids for DTC 211 Did you check the diagnostic Aids for DTC 211?		Go to Step (6)	
6	• Replace HO2S sensor Is the replacement complete?		Go to Step (7)	

7	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-211 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

212-HO2S Open/Inactive



Conditions for Setting the DTC

- Heated Oxygen Sensor
  - Check condition- Engine running
  - Fault condition- HO2S cold persistently more than 120 seconds
  - MIL- On during active fault and for 1 second after active fault
  - Adaptive- Disabled during active fault
  - Closed Loop- Disabled during active fault

Circuit Description

The HO2S sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The ECM uses this information to correct the fuel flow with the Closed Loop multiplier and the Adaptive multiplier.

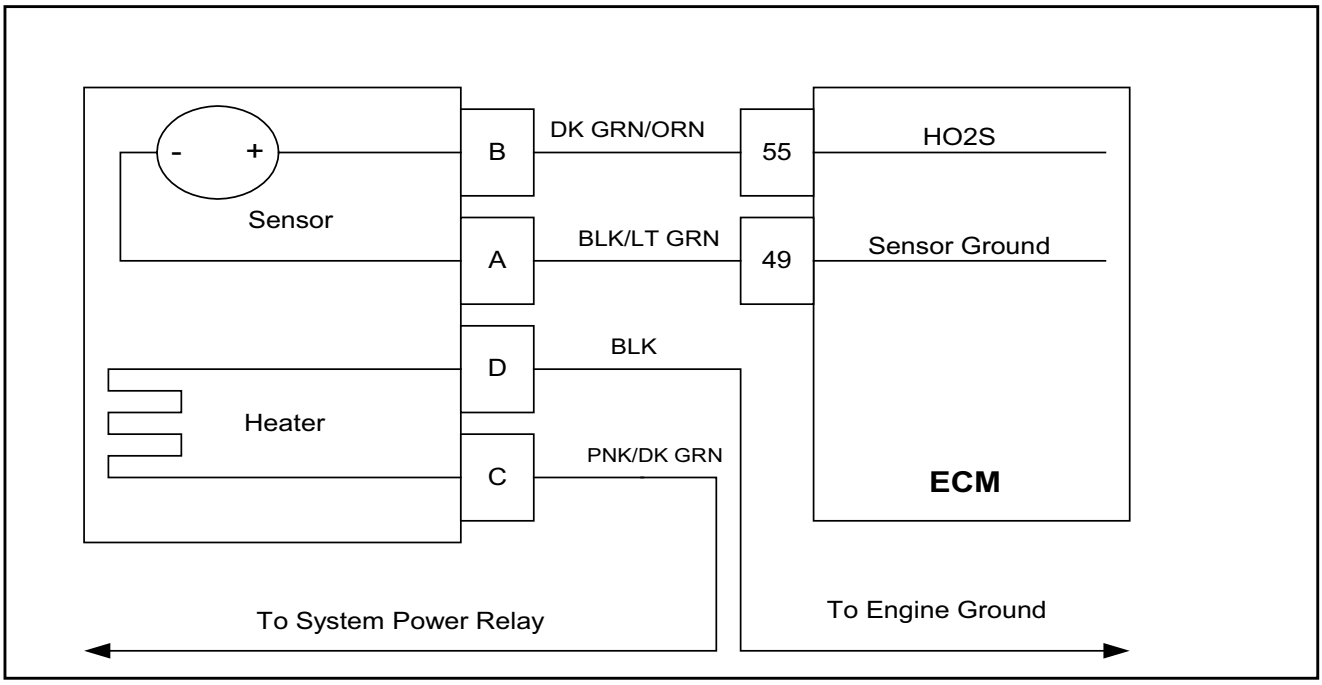
This fault will set if HO2S is cold, non-responsive, or inactive for 120 seconds or longer.

DTC 212- HO2S Open/Inactive

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Run engine to full operating temperature and then idle for a minimum of 2 minutes Does DST display HO2S voltage fixed between 0.4 and 0.5 volts after 2 minutes of idle run time?		Go to Step (5)	Go to Step (3)
3	• Back probe HO2S wire harness connector and check for voltage between HO2S connector heater ground pin D and battery voltage positive. Do you have power?		Go to step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Back probe HO2S wire harness connector and check for voltage between HO2S connector heater power pin C and engine ground. Do you have power?		Go to step (7)	Repair the circuit as necessary. **Check System Power Relay** circuit. Refer to Wiring Repairs in Engine Electrical.

5	• Key OFF • Disconnect HO2S connector and ECM connector. • Key ON • Check for continuity between HO2S sensor connector ground pin A and ECM HO2S sensor ground PIN 49. Do you have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Check for continuity between HO2S sensor connector signal pin B and ECM connector HO2S signal pin 55 Do you have continuity between them?		Go to Step (8)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
7	Replace HO2S Sensor Is the replacement complete?		Go to Step (9)	-
8	• Inspect ECM connector pins 49 and 55 for damage, corrosion or contamination • Inspect HO2S connector terminals A, B, C and D for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-212 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 224- Closed Loop Multiplier Low (LPG)



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Functional Fault-Closed Loop multiplier out of range (at limit of -35%)
- MIL- on during active fault

Circuit Description

The HO2S (Heated Oxygen Sensor) sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The ECM uses this information to correct the fuel flow with the Closed Loop multiplier and the adaptive multiplier. This fault sets if the Closed Loop multiplier exceeds the limits of normal operation. When the multiplier cannot correctly modify the fuel flow within its limits, it is limited at -35%.

Diagnostic Aids

Always diagnose any other ECM codes that are present before beginning this diagnostic procedure.

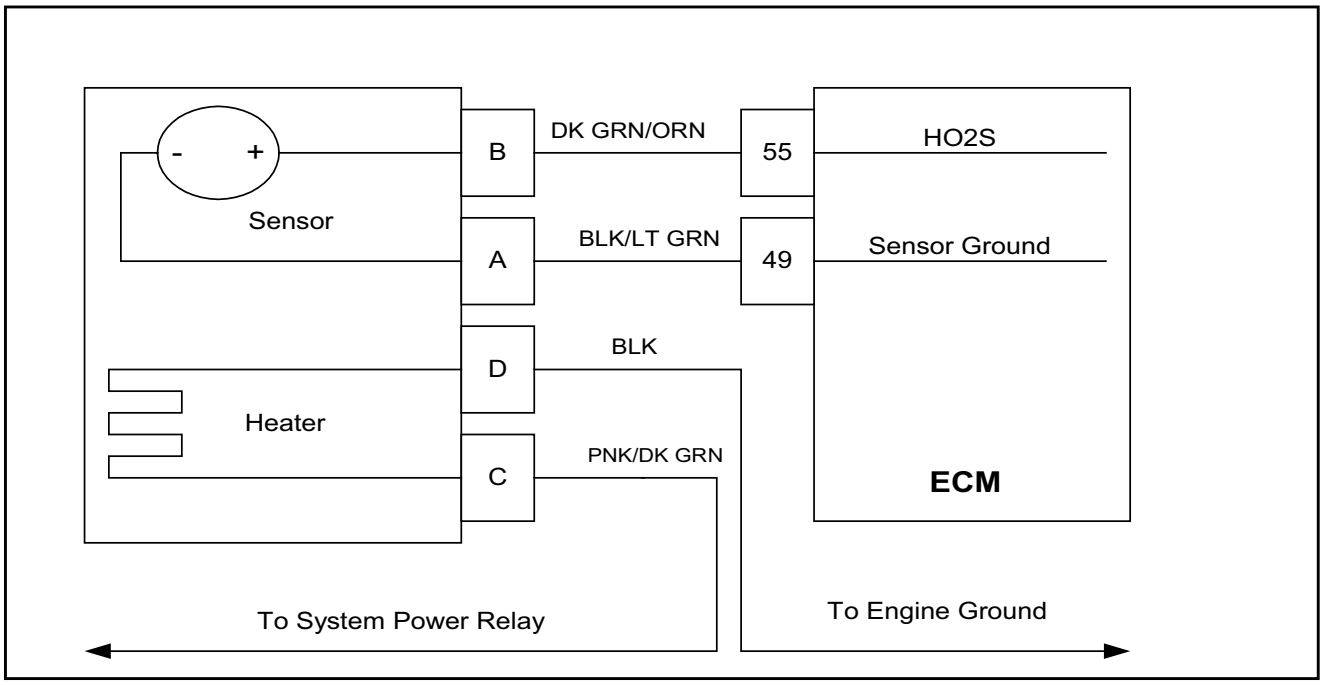
Fuel System High secondary fuel pressure can cause the system to run rich. A worn fuel mixer, faulty PTV (pressure trim valve) or FTV (fuel trim valve) can also cause the system to run rich.

Fuel Quality A drastic variation in fuel quality (very high butane content) may cause the system to run rich. Be sure that the specified HD-5 or HD-10 motor fuel grade propane is used.

DTC 224- Closed Loop Multiplier Low (LPG)

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Run engine to full operating temperature and then idle for a minimum of 2 minutes Does DST display HO2S voltage fixed above 0.7 volts after 2 minutes of idle run time?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect HO2S wire harness connector • Disconnect ECM wiring harness connector • Key ON • Using a high impedance DVOM check for voltage between HO2S connector signal pin B and engine ground Do you have voltage?		Repair wire harness shorted signal to voltage Refer to Wiring Repairs in Engine Electrical.	Refer to Diagnostic Aids for DTC 224

DTC 243-Adaptive Learn High (LPG)



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check Condition- Engine Running
- Fault Condition- Adaptive multiplier out of range (greater than +30%)
- MIL- Disabled
- Adaptive- Enabled
- Closed Loop- Enabled

Circuit Description

The HO2S sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The ECM uses this information to correct the fuel flow with the Closed Loop multiplier and Adaptive multiplier. This fault will set if the adaptive multiplier exceeds the limits of normal operation.

Diagnostic Aids

If any other DTCs are present, diagnose those first

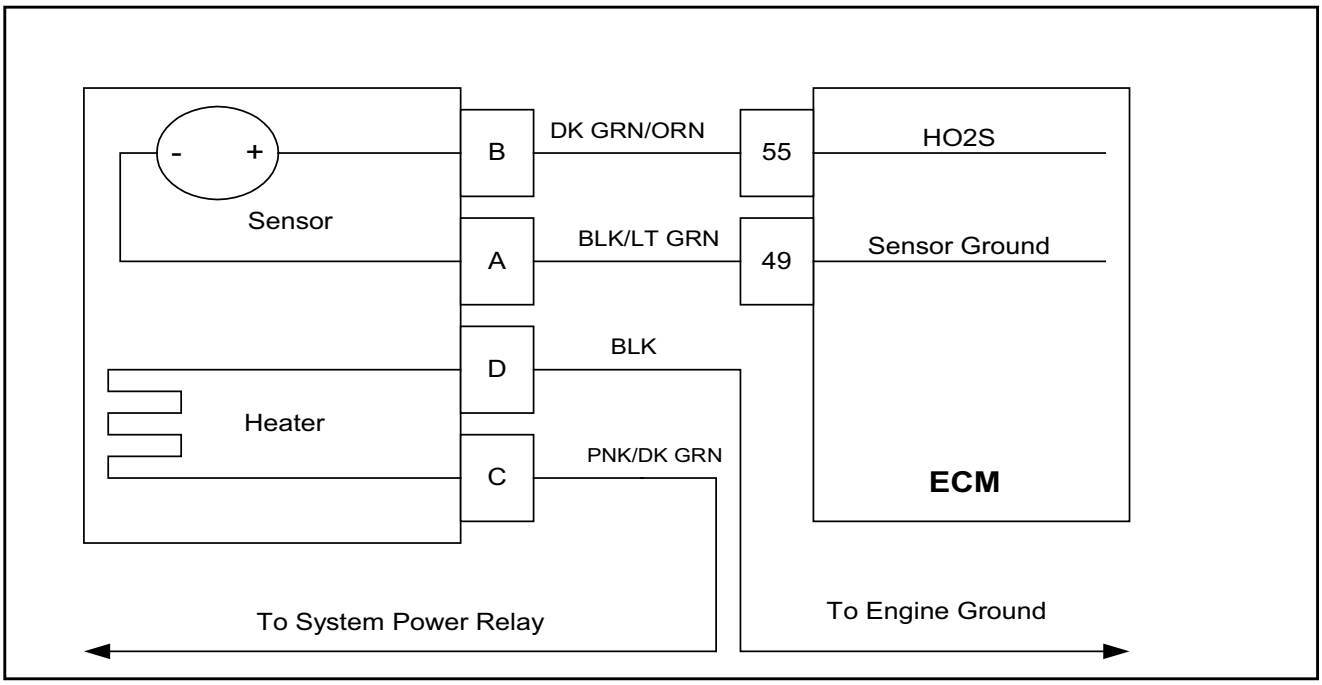
Oxygen Sensor Wire Heated Oxygen sensor wires may be mis-routed and contacting the exhaust manifold.
Vacuum Leaks Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at especially at light load.
Injectors System will be lean if an injector driver or driver circuit fails open. The system will also be lean if an injector fails in a closed manner.
Fuel Pressure Low fuel pressure, faulty fuel injector or damaged fuel pump assembly can cause fuel system to run lean
Exhaust Leaks If there is an exhaust leak, outside air can be pulled into the exhaust and past the 02 sensor causing a false lean condition.
Fuel Quality Contaminated or spoiled fuel can cause the fuel system to be lean.
Ground Problem ECM grounds must be good battery or engine ground.

DTC 243 Adaptive Learn High (LPG)

Step	Action	Value(s)	Yes	No
1	• Perform the On-Board (OBD) System Check? Are any other DTCs present?		Go to Step (3)	Go to Step (2)
2	Visually and physically check the following items: • The air intake duct for being collapsed or restricted • The air filter for being plugged • The HO2S sensor installed securely and the wire leads not contacting the exhaust manifold or ignition wires • ECM grounds for being clean and tight. Refer to Section 1C Engine Electrical Power and Ground Distribution • Fuel System Diagnostics. Refer to Section 1B Fuel System Diagnostics Was a repair made?		Go to Step (7)	Go to Step (4)
3	• Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been detected, diagnosed and repaired?		Go to Step (7)	Go to step (4)
4	• Key ON Engine running • Using a DVOM back probe the HO2S sensor connector heater circuit pin C for positive and D for negative. check for voltage • Do you have voltage?	Battery voltage	Go to Step (5)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Key OFF • Disconnect HO2S sensor wire harness connector • Disconnect ECM wire harness connector • Key ON • Using a DVOM check for voltage at HO2S connector signal pin B and engine ground Do you have voltage?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
6	• Replace HO2S sensor Is the replacement complete?		Go to Step (7)	-

7	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-243 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 244-Adaptive Learn Low (LPG)



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check Condition- Engine running
- Fault Condition- Adaptive multiplier out of range (at limit of -30%)
- MIL-Disabled
- Adaptive- Enabled
- Closed Loop- Enabled

Circuit Description

The HO2S sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The ECM uses this information to correct the fuel flow with the Closed Loop multiplier and Adaptive multiplier. This fault will set if the adaptive multiplier exceeds the limits of normal operation.

Diagnostic Aids

Always diagnose any other ECM codes that are present before beginning this diagnostic procedure.

Fuel System High secondary fuel pressure will cause the system to run rich. A worn fuel mixer, faulty PTV (pressure trim valve) or FTV (fuel trim valve) can also cause the system to run rich.

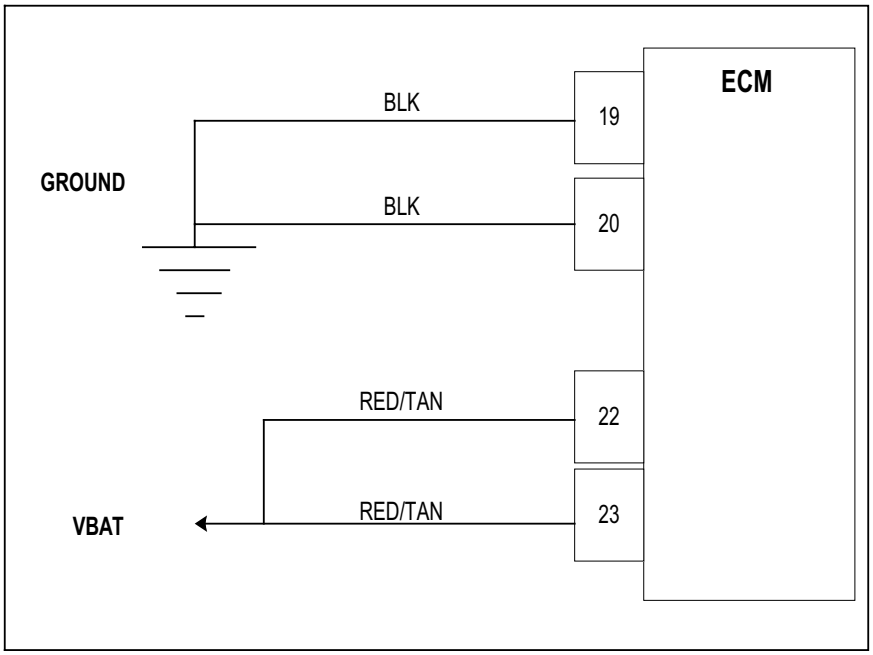
Fuel Quality A drastic variation in fuel quality (very high butane content) may cause the system to run rich. Be sure that the specified HD-5 or HD-10 motor fuel grade propane is used.

DTC 244 Adaptive Learn Low (LPG)

Step	Action	Value(s)	Yes	No
1	• Perform the On-Board (OBD) System Check? Are any other DTCs present?		Go to Step (3)	Go to Step (2)
2	Visually and physically check the following items: • The air intake duct for being collapsed or restricted • The air filter for being plugged • ECM grounds for being clean and tight. Refer to Section 1C Engine Electrical Power and Ground Distribution • Fuel System Diagnostics. Refer to Section 1B Fuel System Diagnostics Was a repair made?		Go to Step (7)	Go to Step (4)
3	• Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been detected, diagnosed and repaired?		Go to Step (7)	Go to step (4)
4	• Key OFF • Disconnect HO2S sensor wire harness connector • Disconnect ECM wire harness connector • Key ON • Using a DVOM check for voltage at HO2S connector signal pin B and engine ground Do you have voltage?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (5)
5	• Replace HO2S sensor Is the replacement complete?		Go to Step (7)	-

7	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-244 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 261-System Voltage Low



Conditions for Setting the DTC

- System Voltage to ECM
- Check Condition-Key on and RPM greater than 1500
- Fault Condition-Battery voltage at ECM less than 9.0 volts continuously for 5 seconds
- MIL-On for active fault and for 10 seconds after active fault
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled

Circuit Description

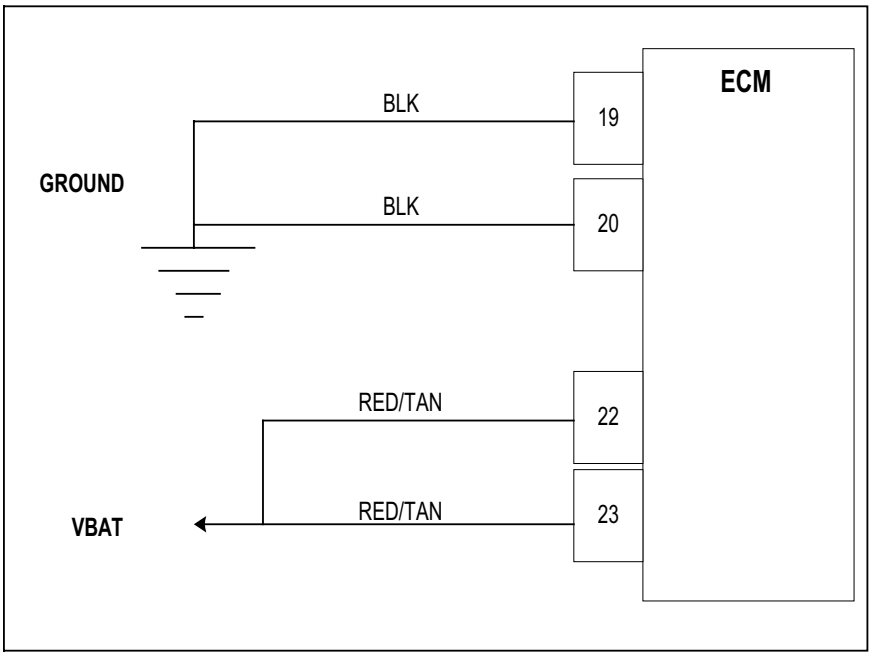
The battery voltage powers the ECM and must be measured to correctly operate injector drivers, fuel trim valves and ignition coils. This fault will set if the ECM detects system voltage less than 9.0 for 5 seconds or longer while the alternator should be charging. The adaptive learn is disabled.

DTC 261- System Voltage Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display system voltage greater than 9.0 volts?	-	Intermittent problem Go to Engine Electrical Intermittent section	Go to Step (3)
3	• Check battery condition Is it OK?	-	Go to Step (4)	Replace Battery
4	• Check charging system Is it Ok?	-	Go to Step (5)	Repair charging System
5	• Back probe ECM connector pins 22 and 23 • Measure voltage with DVOM between each pin and engine ground Is the voltage greater than 9.0 volts?	-	Repair ECM Ground circuit. Go to Power and Ground section in engine Electrical	Go to Step (6)
6	• Back probe ECM connector pins 19 and 20 • Measure voltage with DVOM between each pin and battery voltage Is the voltage greater than 9.0 volts?	-	Repair ECM power circuit. Go to Power and Ground section in engine Electrical	Go to step (7)
7	Replace ECM Is the replacement complete?	-	Go to Step (8)	-

8	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-261 check for any stored codes. Does the engine operate normally with no stored codes?	-	System OK	Go to OBD System Check

DTC 262-System Voltage High



Conditions for Setting the DTC

- System Voltage to ECM
- Check Condition-Cranking or Running
- Fault Condition-Switched battery voltage at ECM greater than 18 volts for 3 seconds
- MIL-On for active fault and for 5 seconds after active fault
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled

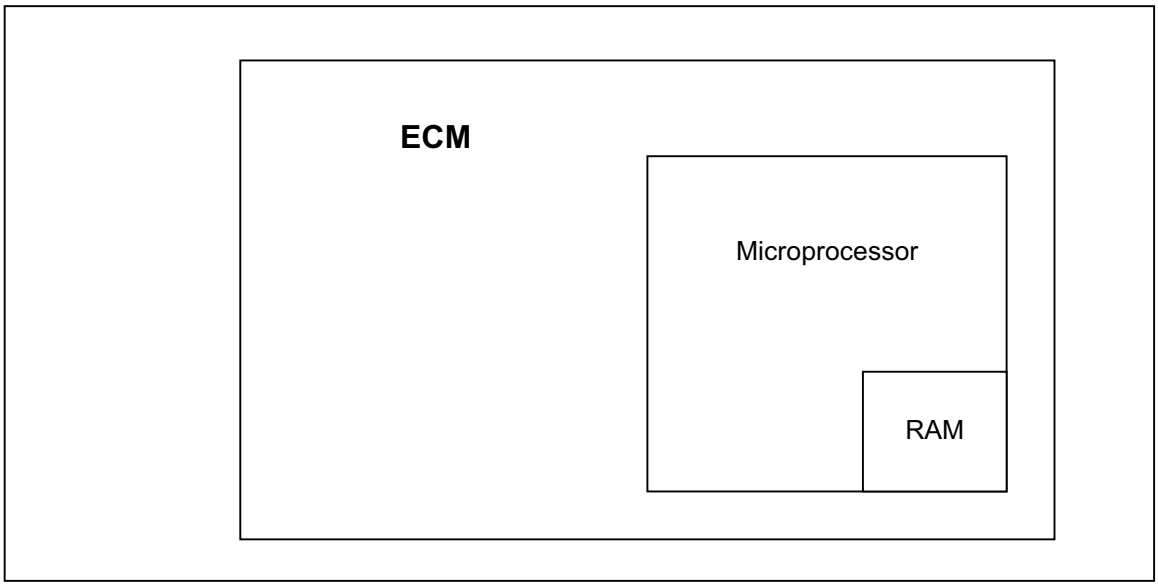
Circuit Description

The battery voltage powers the ECM and must be measured to correctly operate injector drivers, trim valves and ignition coils. This fault will set if the ECM detects voltage greater than 18 volts for 3 seconds at anytime the engine is cranking or running. The adaptive learn is disabled. The ECM will shut down with internal protection if the system voltage exceeds 26 volts.

DTC 262- System Voltage High

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Run engine greater than 1500 rpm. Does DST display system voltage less than 18 volts?	-	Intermittent problem Go to Engine Electrical Intermittent section	Go to Step (3)
3	• Check voltage at battery terminals with DVOM with engine speed greater than 1500 rpm Is it greater than 18 volts?	-	Go to Step (4)	Go to Step (5)
4	• Repair the charging system Has the charging system been repaired?	-	Go to Step (6)	-
5	• Replace ECM Is the replacement complete?		Go to Step (6)	-
6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-262 check for any stored codes. Does the engine operate normally with no stored codes?	-	System OK	Go to OBD System Check

DTC 511-COP Failure



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

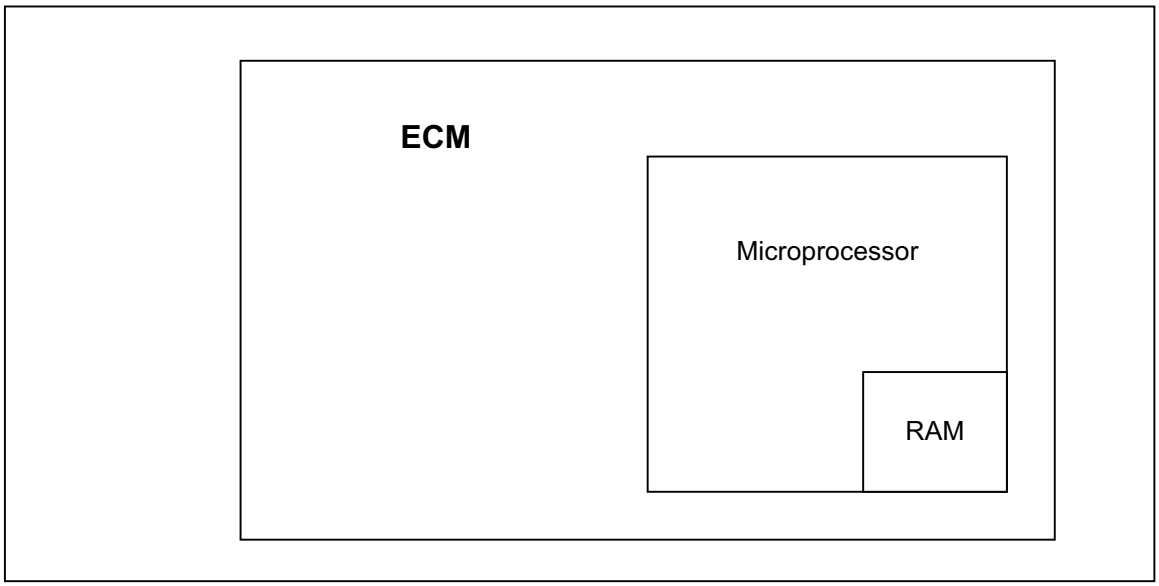
Circuit Description

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 511 COP Failure

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 511 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		Go to Step (5)	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-511 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 512-Invalid Interrupt



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

Circuit Description

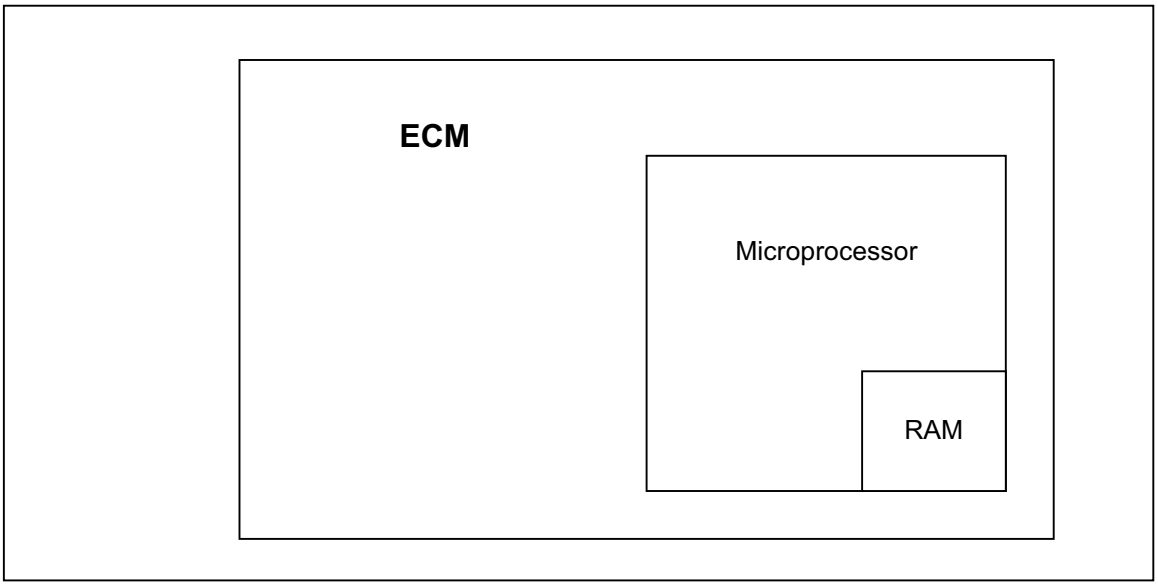
The ECM has checks that must be verified each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 512 Invalid Interrupt

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 512 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		Go to Step (5)	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-512 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 513-A/D Loss



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

Circuit Description

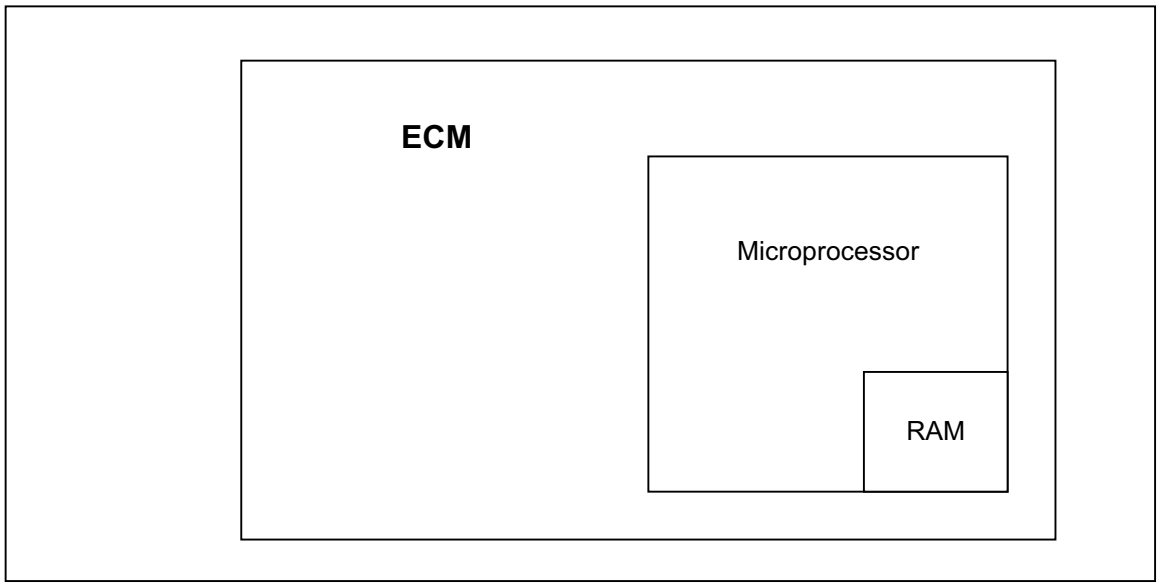
The ECM has checks that must be verified each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 513 A/D Loss

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 513 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		Go to Step (5)	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-513 check for any stored codes. Does the engine normally with no stored codes?		System OK	Go to OBD System Check

DTC 514-RTI 1 Loss



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

Circuit Description

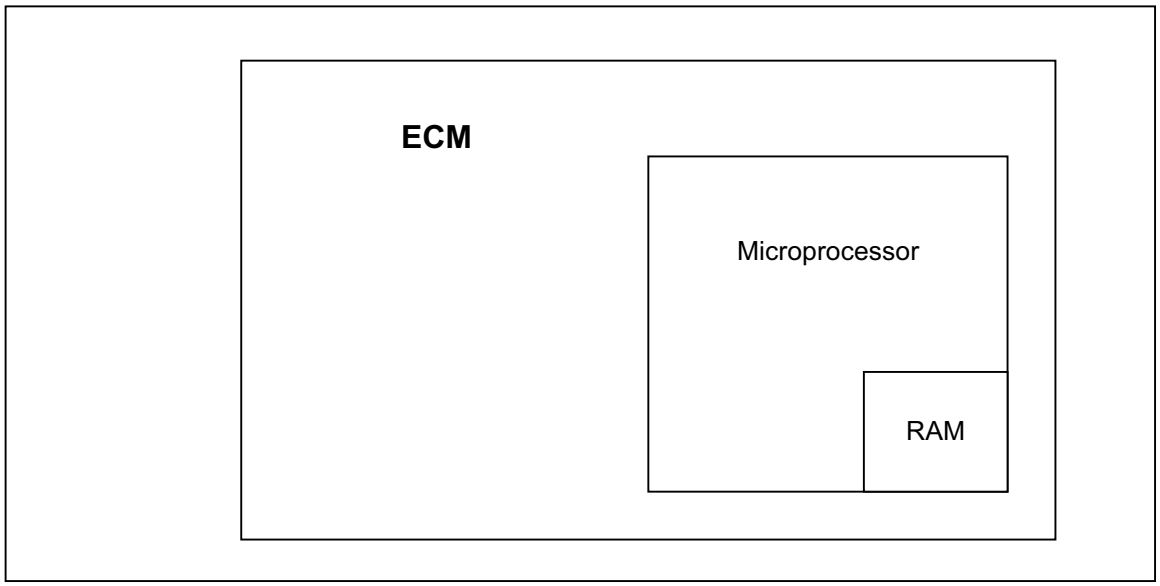
The ECM runs checks that must be verified each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 514 RTI 1 Loss

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 514 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		Go to Step (5)	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-514 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 515-Flash Checksum Invalid



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

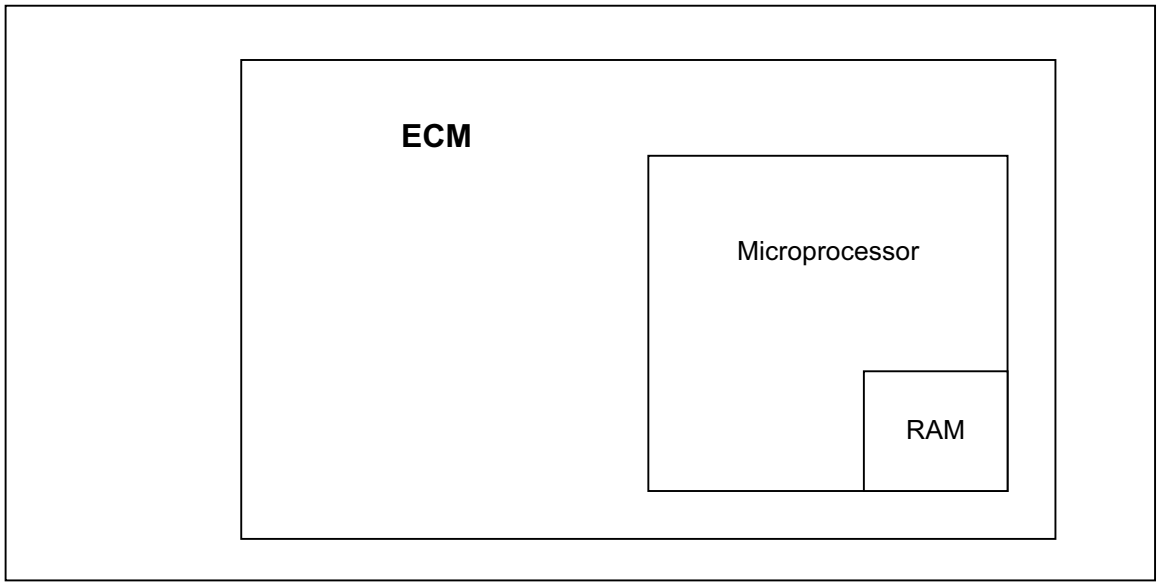
Circuit Description

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase. During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 515 Flash Checksum Invalid

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 515 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		Go to Step (5)	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-515 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 516-Ram Failure



Conditions for Setting the DTC

- Random Access Memory
- Check Condition- Key-On
- Fault Condition- Internal ECM memory access failure
- MIL- On until fault is cleared
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2) enforced

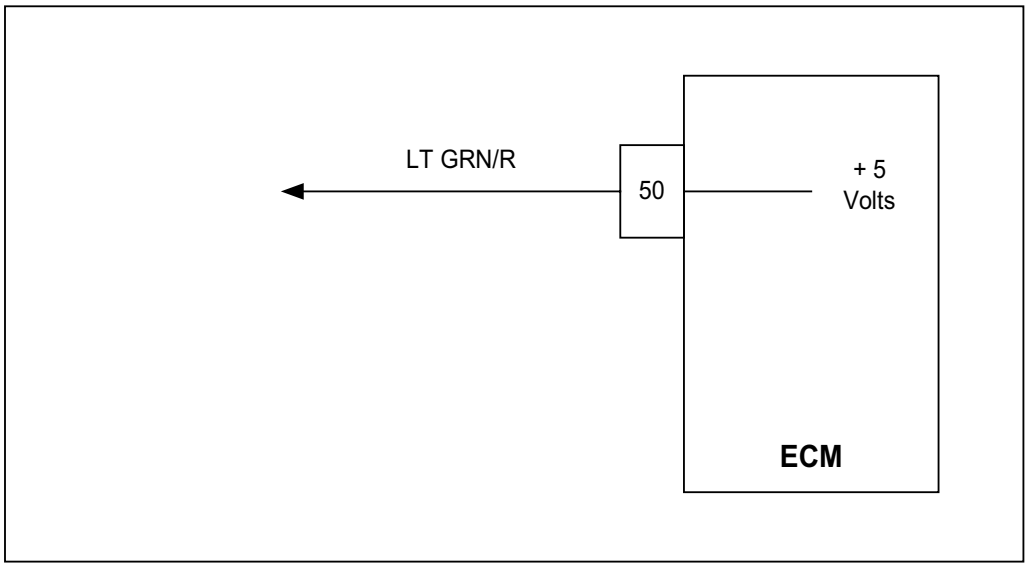
Circuit Description

Random Access Memory is located within the microprocessor that can be read from or written to at any time. The System Fault Codes and the Adaptive Learn Table are among the data stored in RAM. This fault will set if the ECM detects a problem accessing or writing information to RAM. This fault will not self erase and must be cleared manually.

DTC 516 Ram Failure

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 516 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		Go to Step (5)	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-516 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 531-External 5V Ref Lower Than Expected



Conditions for Setting the DTC

- External 5V reference
- Check Condition-Cranking with battery voltage greater than 8 volts and engine running
- Fault Condition-5V reference voltage lower than 4.6 volts
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled

Circuit Description

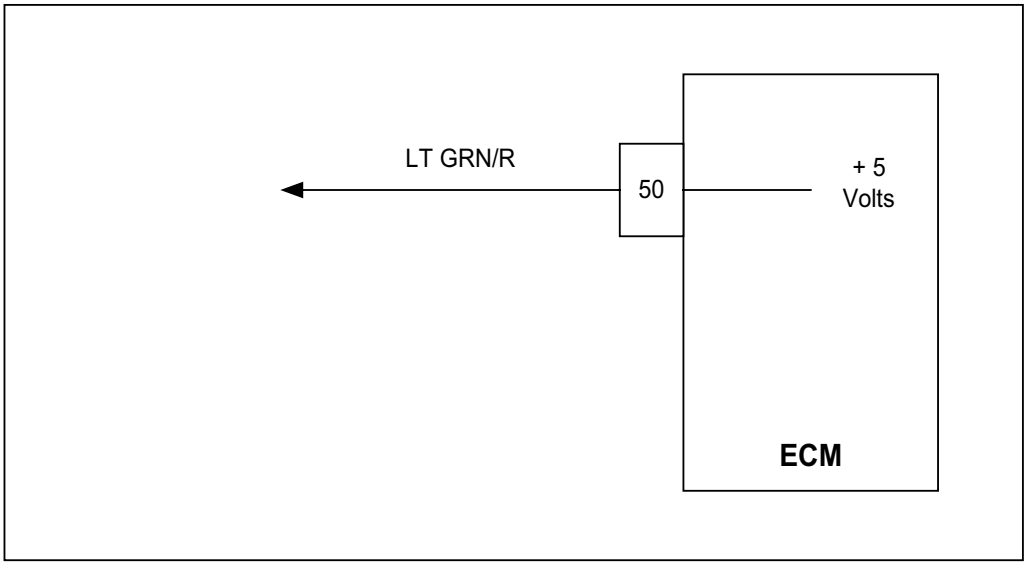
The External 5 Volt supply powers some of the sensors and other components in the system. The accuracy of the 5 Volt supply is very important to the accuracy of the sensors and therefore controlled by the ECM. The ECM monitors the 5 volt supply to determine if it is overloaded, shorted, or otherwise out of specification. This fault will set if the 5 Volt reference is below 4.6 volts.

DTC 531 External 5V Reference Lower Than Expected

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine Running • DST (Diagnostic Scan Tool) connected in System Fault Mode Does DST display DTC 531?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect ECM connector • Using DVOM check for continuity between ECM 5 volt reference LT GRN/R pin 50 and engine ground Do you have continuity?		Go to Step (5)	Go to Step (4)
4	• Replace ECM Is the replacement complete?		Go to Step (7)	-
5	• While monitoring DVOM for continuity between ECM 5 volt reference and engine ground disconnect each sensor (below) one at a time to find the shorted 5 volt reference. When continuity to ground is lost the last sensor disconnected is the area of suspicion. Inspect 5volt reference supply wire leads for shorts before replacing the sensor. • IAT • ECT/CHT • TMAP • FPP • TPS 1 • TPS 2 • Crankshaft Sensor • Camshaft Sensor While disconnecting each sensor one at a time did you loose continuity?		Go to Step (6)	-

6	• Replace Sensor Is the replacement complete?		Go to step (7)	-
7	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-531 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 532-External 5 V Ref Higher Than Expected



Conditions for Setting the DTC

- External 5V reference
- Check Condition-Cranking with battery voltage greater than 8 volts or engine running
- Fault Condition-5V reference voltage higher than 5.4 volts
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled

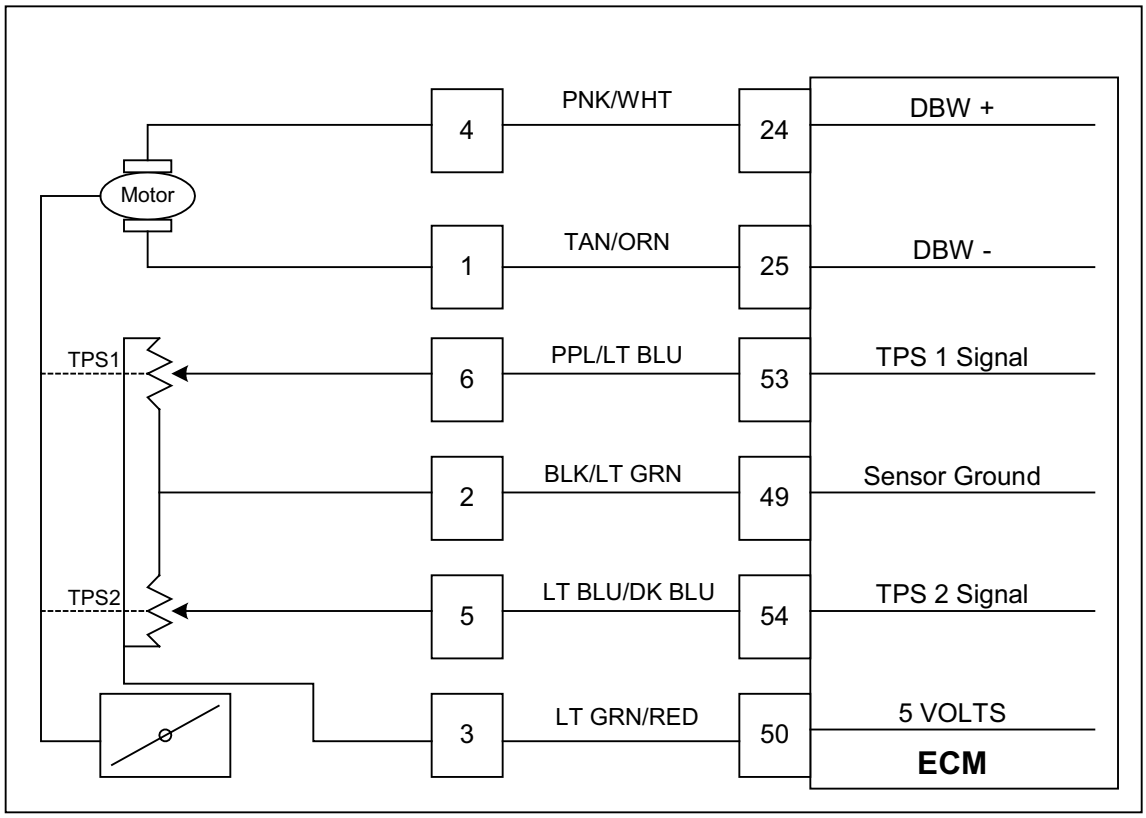
Circuit Description

The External 5 Volt supply powers some of the sensors and other components in the system. The accuracy of the 5 Volt supply is very important to the accuracy of the sensors and therefore control by the ECM. The ECM to determine if they are overloaded, shorted, or otherwise out of specification monitors the 5 Volt supply. This fault will set if the 5 Volt reference is above 5.4 volts.

DTC 532 External 5V Reference Higher Than Expected

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine running • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display DTC 532?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM ground connections Refer to Engine electrical power and ground distribution. Are the ground connections Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Key OFF • Disconnect ECM connector • Key ON • Using DVOM check for Voltage between ECM harness wire LT GRN/R pin 50 and engine ground Do you have voltage?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (5)
5	• Replace ECM Is the replacement complete?		Go to Step (6)	-
6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-532 check for any stored codes. Does the vehicle engine normally with no stored codes?		System OK	Go to OBD System Check

DTC 554-Gaseous Fuel Lo Rev Overun



Conditions for Setting the DTC

- TPS or FPP Code set
- Check Condition- Engine running in LPG mode
- Fault Condition- unable to enforce low rev limit of 1300 to 1500 rpm
- MIL- On during active fault
- Adaptive- Enabled
- Closed Loop- Enabled
- Engine Shut Down

Circuit description

This fault may set if the engine is running in the LPG fuel mode with one ore more codes relating to the throttle control system. If the ECM has been commanded to enforce low rev limit and the governor control system is unable to achieve low rev limiting the engine will shut down.

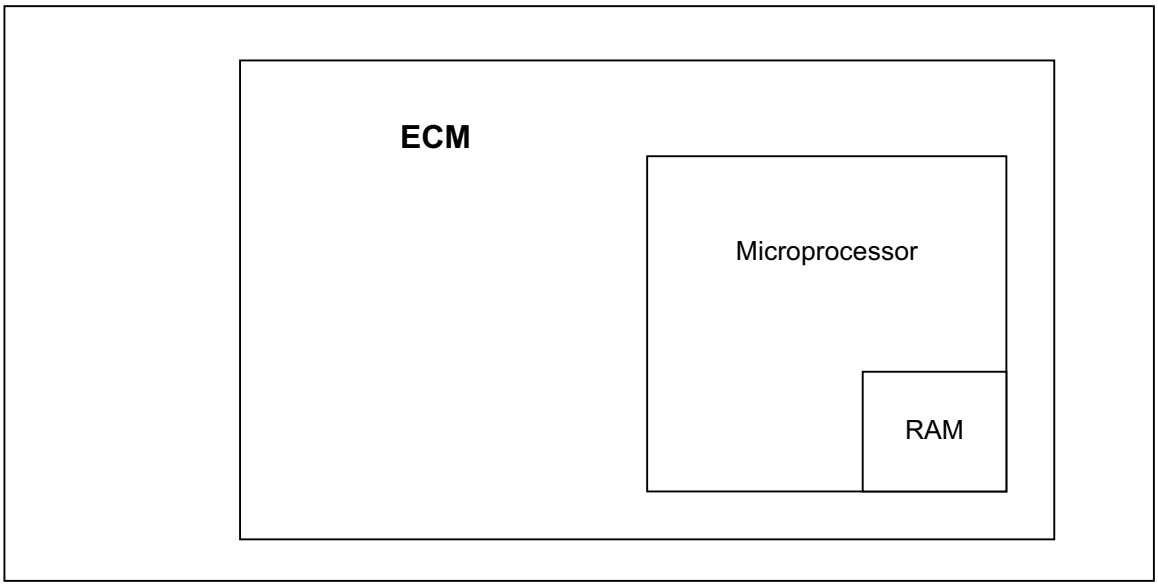
Diagnostic Aids

In the event of multiple DTC codes present in the ECM control system, always work to resolve the lowest numerical DTC code first. This code may have been set as a result of another throttle control system DTC. In the event this does

DTC 554-Gaseous Fuel Flow Rev Limit

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Check for other DTC codes that may be stored in ECM memory Did you find other DTC codes stored in the ECM memory?		Go to Step (3)	Go to Step (4)
3	• Repair DCT codes starting with the lowest code first. Have the other codes been diagnosed and repaired?		Go to Step (5)	-
4	Follow the diagnostic chart recommendations for DTC 637		-	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-554 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 555-RTI 2 Loss



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

Circuit Description

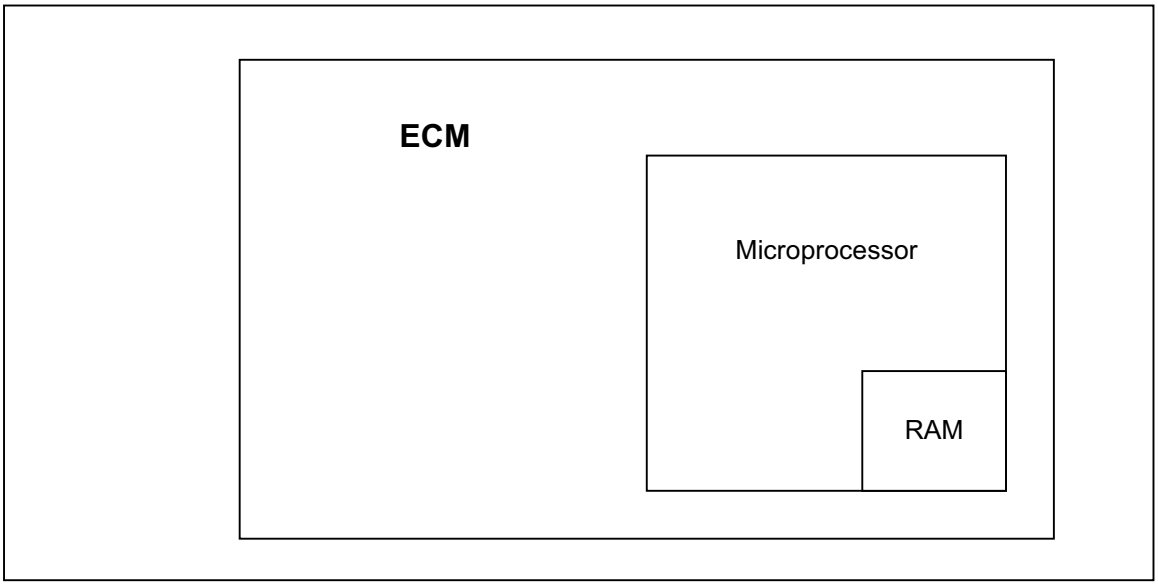
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 555 RTI 2 Loss

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 555 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		Go to Step (5)	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-555 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 556-RTI 3 Loss



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

Circuit Description

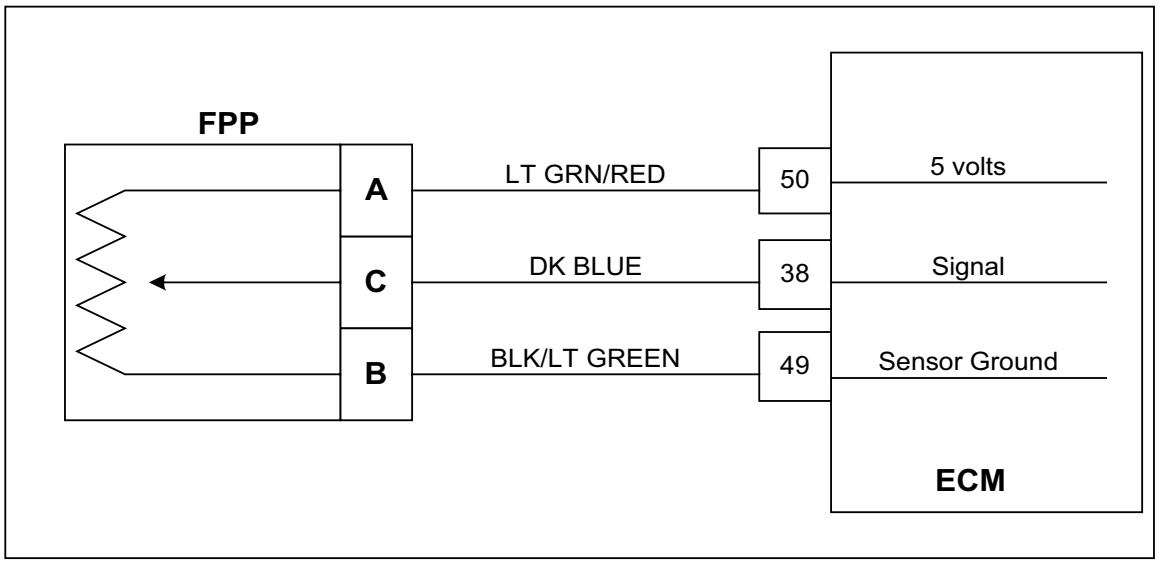
The ECM runs checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 556 RTI 3 Loss

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 555 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		Go to Step (5)	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-556 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 611-FPP High Voltage



Conditions for Setting the DTC

- Foot Pedal Position
- Check Condition-Key On
- Fault Condition-FPP1 sensor voltage exceeds 4.8
- MIL-On during active fault
- Low Rev Limit enforced 1300
- Forced Idle700 rpm
- Power Derate 1

Circuit Description

The Foot Pedal Position sensor uses a variable resistor to determine signal voltage based on pedal position. Less depression of pedal results in lower voltage, and greater depression results in higher voltage.

This fault will set if voltage is over 4.8 volts at any operating condition while the key is on. If the voltage exceeds 4.8, then FPP is considered to be out of specifications. At this point the ECM does not have a valid signal, and must therefore enforce the low rev limit and Power Derate (level 1). When these are enforced the maximum throttle position is 50% and the maximum engine speed is 1300 RPM. The Low Rev Limit is enforced for the remainder of the key-on cycle to 700 rpm. Rev limit is still enforced if the active fault is no longer present

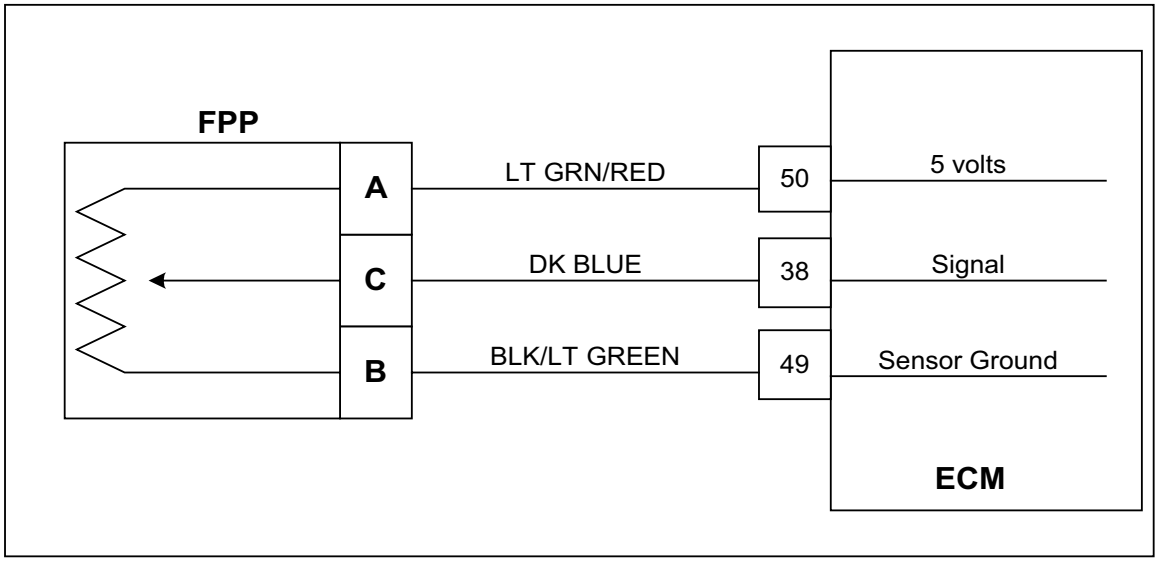
DTC 611 FPP Voltage High

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display FPP voltage of 4.8 volts or greater with the foot pedal in the idle position?		Go to Step (8)	Go to Step (3)
3	• Slowly increase FPP while observing FPP voltage Does DST FPP voltage ever exceed 4.8 volts?		Go to step (4)	Intermittent problem Go to Intermittent section
4	• Key OFF • Disconnect FPP sensor connector • Inspect connector and wire terminals for damage, corrosion or contamination Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (5)
5	• Disconnect ECM connector C001 • Check continuity between FPP sensor connector ground pin B and ECM connector FPP sensor ground pin 49 Do have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Key ON • Using a DVOM check for voltage at ECM wire harness connector FPP signal pin 38 and ECM sensor ground terminal pin 49 Do you have voltage between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)

Step	Action	Value(s)	Yes	No
7	• Using a DVOM check for voltage at ECM wire harness connector between ECM FPP signal pin 38 and engine ground Do you have voltage between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Intermittent problem Go to Intermittent section
8	• Key OFF • Disconnect FPP sensor from wire harness • Key ON Does DSC display FPP voltage less than 0.2 volts?		Go to Step (11)	Go to Step (9)
9	• Disconnect ECM wire harness connector C001 • Using a DVOM check for voltage between the ECM FPP signal pin 38 and engine ground Do you have voltage between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (10)
10	• Replace ECM Is the replacement complete?		Go to Step (15)	-
11	• Probe FPP sensor connector ground circuit pin B with a test light connected to battery voltage Does the test light come on?		Go to Step (12)	Go to Step (14)
12	• Key OFF • Disconnect ECM wire harness connector • Inspect the ECM wire harness connector terminals for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (13)
13	• Replace FPP sensor Is the replacement complete?		Go to step (15)	-

Step	Action	Value(s)	Yes	No
14	• Key OFF • Disconnect ECM connector • Check continuity between FPP sensor connector ground pin B and ECM connector FPP sensor ground pin 49 Do have continuity between them?		Go to Step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
15	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-611 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 612-FPP Low Voltage



Conditions for Setting the DTC

- Foot Pedal Position
- Check Condition-Key On
- Fault Condition-FPP sensor voltage less than 0.200
- MIL-On during active fault
- Power Derate 1
- Low rev limit 1300 rpm
- Force Idle 700 rpm

Circuit Description

The Foot Pedal Position sensor uses a variable resistor to determine signal voltage based on pedal position. Less depression of pedal results in lower voltage, and greater depression results in higher voltage.

This fault will set if voltage is less than 0.2 volts at any operating condition while the key is on. If the voltage is less than 0.2, then FPP is considered to be out of specifications. At this point the ECM does not have a valid signal, and must therefore enforce the low rev limit and Power Derate (level 1). When these are enforced the maximum throttle position is 50% and the maximum engine speed is 1300 RPM. The Low Rev Limit is enforced for the remainder of the key-on cycle to 700 rpm. Rev limit is still enforced if the active fault is no longer present

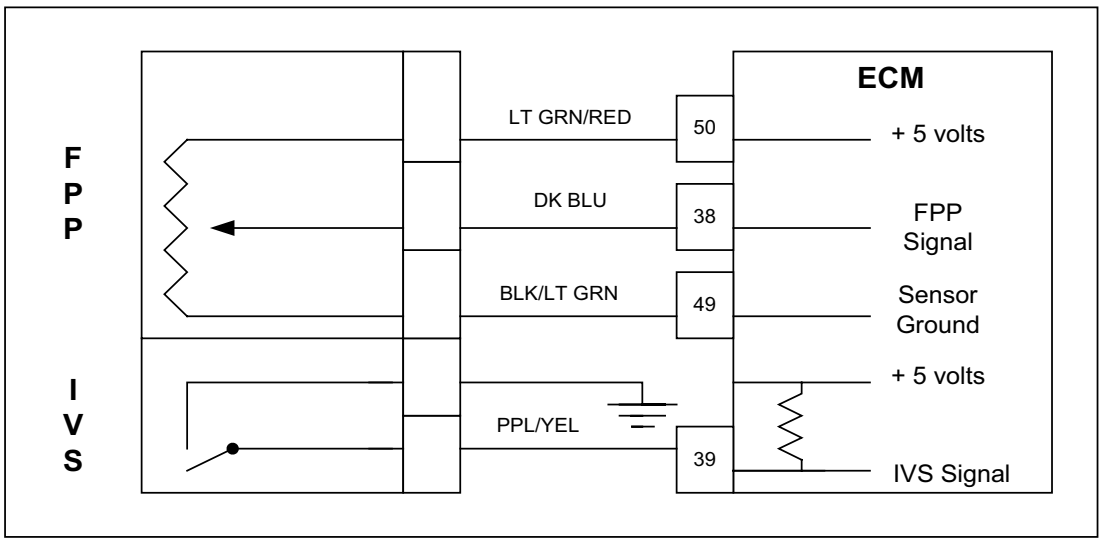
DTC 612 FPP Voltage Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display FPP voltage of 0.2 volts or less with the foot pedal in the idle position?		Go to Step (7)	Go to Step (3)
3	• Slowly depress FP while observing FPP voltage Does DST FPP voltage ever drop below 0.2 volts?		Go to step (4)	Intermittent problem Go to Intermittent section
4	• Key OFF • Disconnect FPP sensor connector • Inspect connector and wire terminals for damage, corrosion or contamination Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (5)
5	• Key ON • Using A DVOM check for voltage at the FPP sensor connector between 5 volt reference pin A and FPP sensor ground pin B Do you have voltage between them?	5.0 Volts	Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Replace FPP Sensor Is the replacement complete?		Go to Step (18)	-
7	• Key OFF • Disconnect FPP Sensor from wire harness • Jumper 5 volt reference circuit pin A and FPP signal circuit pin C together • Key ON Does DST display FPP voltage of 4.8 volts or greater?		Go to Step (8)	Go to Step (9)

8	• Check FPP connector wire terminals for damage, corrosion or contamination? Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
9	• Probe FPP connector signal circuit pin C with a test light connected to battery voltage Does the DST display FPP voltage of 4.8 volts or greater?		Go to Step (10)	Go to Step (14)
10	• Key OFF • Disconnect ECM wire harness connector • Using a DVOM check for continuity between FPP sensor connector 5 volt reference pin A and ECM connector 5 volt reference pin 50 Do you have continuity between them?		Go to Step (11)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
11	• Using A DVOM check for continuity between ECM 5 volt reference pin 50 and engine ground Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (12)
12	• Using a DVOM check for continuity between ECM connector 5 volt reference pin 50 and ECM sensor ground pin 49 Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (13)
13	• Inspect FPP and ECM connector terminal terminals for damage, corrosion or contamination Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (17)

14	• Key OFF • Disconnect ECM wire harness connector C001 • Using a DVOM check for continuity between FPP connector signal pin C and ECM connector FPP signal pin 38 Do you have continuity between them?		Go to Step (15)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
15	• Using a DVOM check for continuity between ECM connector FPP signal pin 38 and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (16)
16	• Using a DVOM check for continuity between ECM FPP signal pin 38 and ECM connector FPP sensor ground pin 49 Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (13)
17	• Replace ECM Is the replacement complete?		Go to Step (18)	-
18	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-612 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 613-FPP Higher Than IVS Limit



Conditions for Setting the DTC

- Foot Pedal Position/Idle Validation Switch
- Check Condition-Engine Cranking or Running
- MIL-On during active fault
- Fault Condition-IVS at idle and FPP voltage greater than 1.12 volts
- Power Derate 1 50% maximum throttle
- Low rev Limit 1300 rpm
- Force Idle 700 rpm

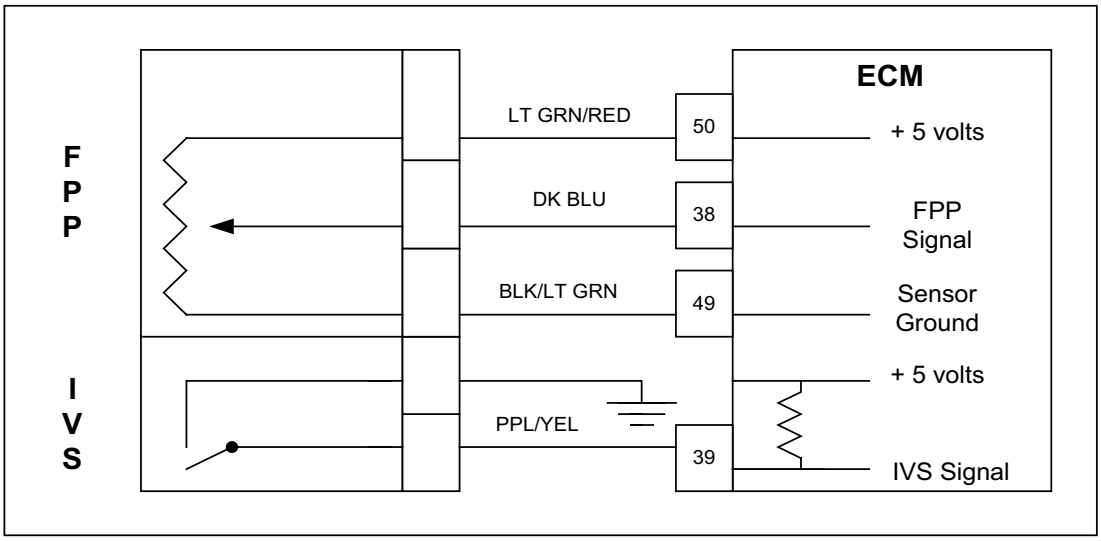
Circuit Description

The engine load command to the ECM is determined by operator depression of the electronic foot pedal. The ECM monitors the foot pedal position and controls the throttle to maintain the commanded power level. Because a problem with the foot pedal signal can result in a higher or lower power than intended by the operator, the pedal used with this control system incorporates a sensor with an idle validation switch. Checks and cross checks are constantly conducted by the ECM to determine the validity of the signals. The Idle Validation Switch (IVS) is a normally closed contact (idle) that opens the IVS circuit to the ECM when the pedal is depressed more than the idle position.

DTC 613 FPP Higher Than IVS Limit

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display IVS “idle” with the foot pedal fully depressed?		Go to Step (3)	Go to Step (7)
3	• Key OFF • Disconnect foot pedal from harness • Key ON Does DST display IVS “idle”?		Go to Step (4)	Go to Step (5)
4	• Replace foot pedal Is the replacement complete?		Go to Step (8)	-
5	• Key OFF • Disconnect ECM wire harness connector • Using a DVOM check for continuity between IVS signal and engine ground Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
6	• Replace ECM Is the replacement complete?		Go to Step (8)	-
7	• Depress foot pedal until DST reads FPP voltage between 1.1 and 1.3 volts Does DST display IVS “idle”	1.1 to 1.3 volts	Go to Step (4)	Intermittent problem Go to Intermittent section
8	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-613 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go OBD System Check

DTC 614-FPP Lower Than IVS Limit



Conditions for Setting the DTC

- Foot Pedal Position/Idle Validation Switch
- Check Condition-Engine Cranking or Running
- MIL-On during active fault
- Fault Condition-IVS off idle and FPP voltage less than .880 volts
- Power Derate 1 50% maximum throttle
- Low rev Limit 1300 rpm
- Force Idle 700 rpm

Circuit Description

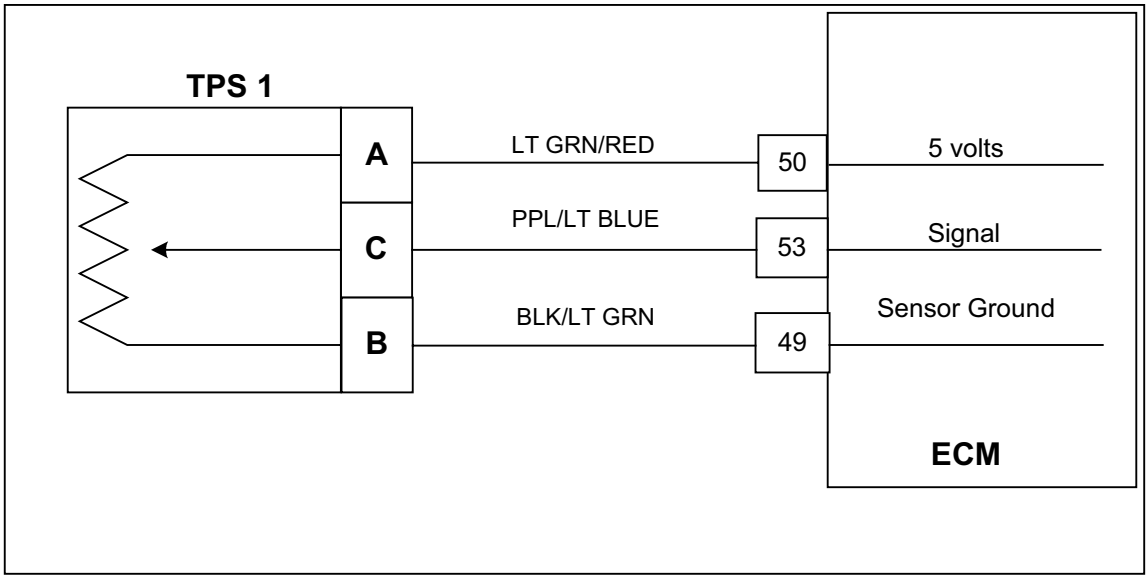
The engine load command to the ECM is determined by operator depression of the electronic foot pedal. The ECM monitors the foot pedal position and controls the throttle to maintain the commanded power level. Because a problem with the foot pedal signal can result in a higher or lower power than intended by the operator, the pedal used with this control system incorporates a sensor with an idle validation switch. Checks and cross checks are constantly conducted by the ECM to determine the validity of the signals. The Idle Validation Switch (IVS) is a normally closed contact (idle) that opens the IVS circuit to the ECM when the pedal is depressed more than the idle position.

This fault will set if the IVS is off-idle (open) and the FPP voltage is less than 0.880 volts. During this fault, Power Derate (level 2) and the Low Rev Limit are enforced. When these are enforced the maximum throttle position is 20% and the maximum engine speed is 1300 RPM. These are enforced for the remainder of the key-on cycle. If the active fault is no longer present, the MIL light will be on for the remainder of the key-on cycle. This is a reminder that the Power Derate and Low Rev Limits are still enforced.

DTC 614 FPP Lower Than IVS Limit

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display IVS “OFF IDLE” with the foot pedal in the idle position?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Jumper IVS signal and IVS ground together at wire harness connector • Key ON Does DST display IVS “ON”		Go to step (4)	Go to Step (5)
4	• Replace Foot Pedal Is the replacement complete?		Go to Step (7)	-
5	• Key OFF • Disconnect ECM wire harness connector • Using a DVOM check for continuity between IVS signal and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
6	• Replace ECM Is the replacement complete?		Go to Step (7)	-
7	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-614 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go OBD System Check

DTC 631-TPS 1 Signal Voltage High



Conditions for Setting the DTC

- Throttle Position Sensor #1
- Check Condition-Cranking or Running
- Fault Condition-TPS sensor voltage exceeds 4.8
- MIL-On during active fault
- Power Derate 1
- Low rev limit 1300 rpm
- Forced idle 700 rpm

Circuit Description

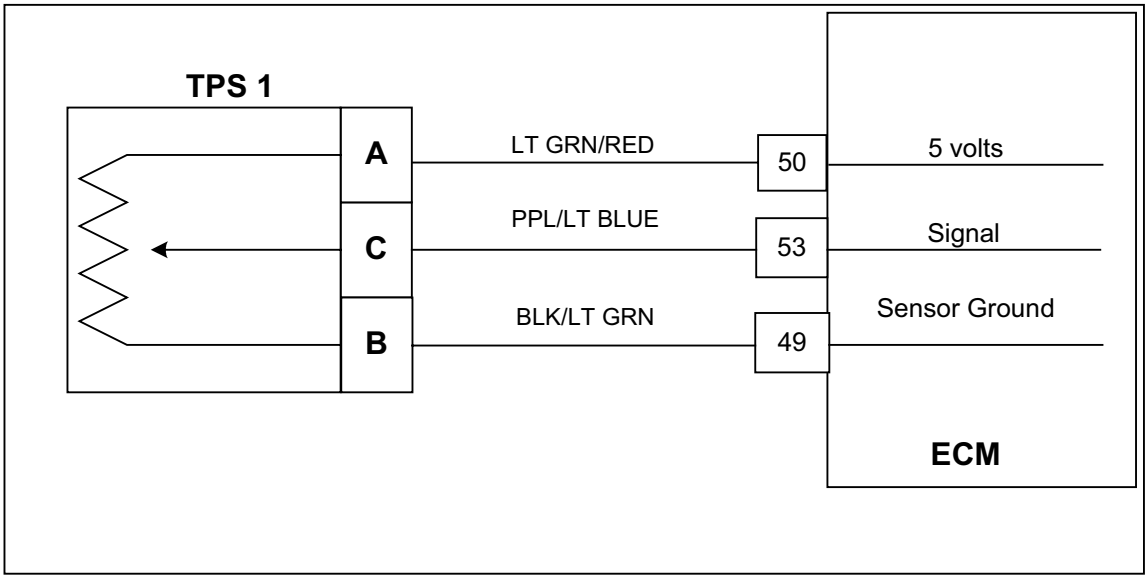
The Electronic Throttle has two counter acting Throttle Position Sensors. Two sensors are used for improved safety and redundancy. The Throttle Position sensor uses a variable resistor to determine signal voltage based on throttle plate position, and is connected to the throttle shaft. Less opening results in lower voltage, and greater opening in higher voltage. The TPS value is used by the ECM to determine if the throttle is opening as commanded. This fault will set if voltage is above 4.8 volts at any operating condition while the engine is cranking or running.
Power derate 1 will be enforced limiting the throttle to 50% maximum. Low rev limit and forced idle will also be enforced during this fault.

DTC 632 TPS 1 Signal Voltage Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in DBW (Drive by Wire) throttle test mode Does the DST display TPS 1 voltage of 0.2 volts or less with the throttle closed		Go to Step (4)	Go to Step (3)
3	• Slowly depress Foot Pedal while observing TPS 1 voltage Does TPS 1 voltage ever fall below 0.2 volts?		Go to Step (4)	Intermittent problem Go to Intermittent section
4	• Key OFF • Disconnect the TPS 1 electrical connector • Jumper the 5 volt reference circuit pin A and TPS 1 signal circuit pin C together at the throttle connector • Key ON Does DST display TPS 1voltage of 4.0 volts or greater?		Go to Step (7)	Go to Step (5)
5	• Key OFF • Disconnect ECM wire harness connector Using a DVOM check continuity between TPS 1 connector signal pin C and ECM connector TPS 1 signal pin 53 Do have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Replace ECM Is the replacement complete?		Go to Step (9)	-
7	• Inspect the throttle wire harness connector terminals for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (8)

8	• Replace the TPS 1 Is the replacement complete?		Go to Step (9)	-
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-632 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 632-TPS 1 Signal Voltage Low



Conditions for Setting the DTC

- Throttle Position Sensor #1
- Check Condition-Cranking or Running
- Fault Condition-TPS sensor voltage less than 0.2
- MIL-On during active fault
- Power Derate 1
- Low rev limit 1300 rpm
- Forced idle 700 rpm

Circuit Description

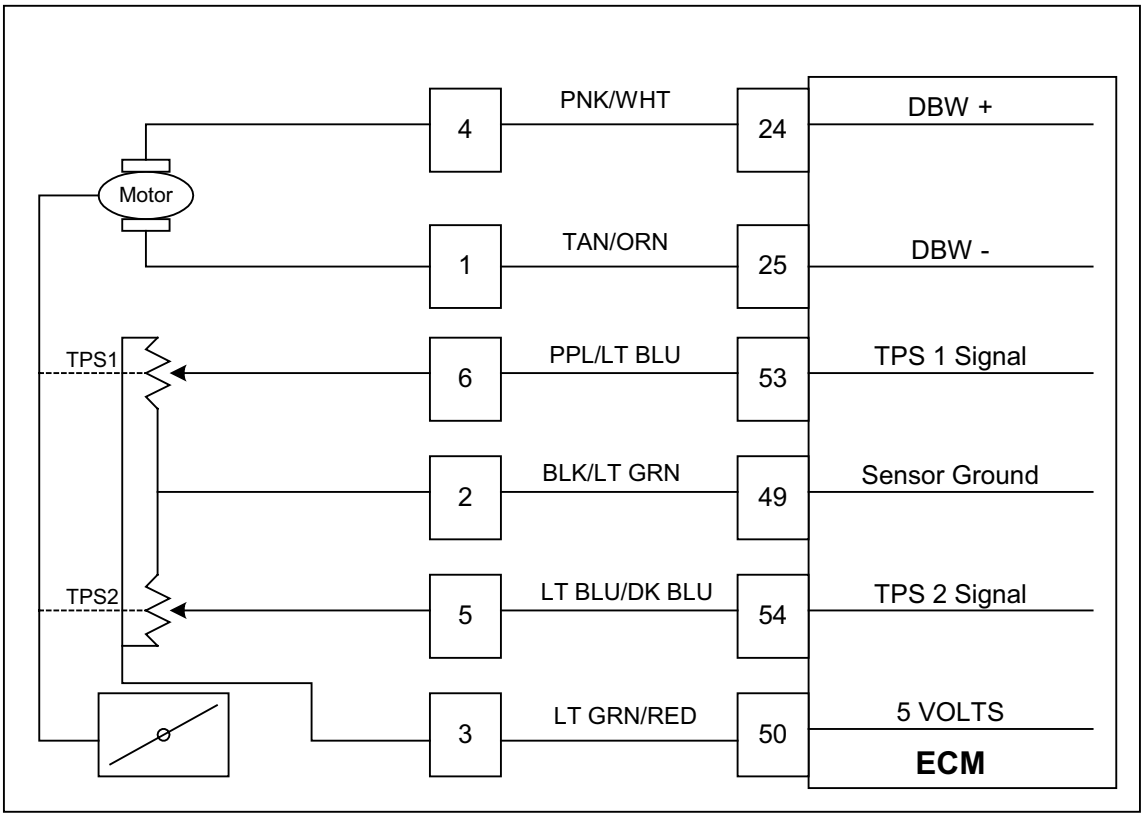
The Electronic Throttle has two counter acting Throttle Position Sensors. Two sensors are used for improved safety and redundancy. The Throttle Position sensor uses a variable resistor to determine signal voltage based on throttle plate position, and is located within the throttle. Less opening results in lower voltage, and greater opening in higher voltage. The TPS value is used by the ECM to determine if the throttle is opening as commanded. This fault will set if voltage is less than 0.2 volts at any operating condition while the engine is cranking or running. Power derate 1 will be enforced limiting the throttle to 50% maximum and low rev limit and forced idle will also be enforced during this fault.

DTC 632 TPS 1 Signal Voltage Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in DBW (Drive by Wire) throttle test mode Does the DST display TPS 1 voltage of 0.2 volts or less with the throttle closed		Go to Step (4)	Go to Step (3)
3	• Slowly depress Foot Pedal while observing TPS 1 voltage Does TPS 1 voltage ever fall below 0.2 volts?		Go to Step (4)	Intermittent problem Go to Intermittent section
4	• Key OFF • Disconnect the TPS 1 electrical connector • Jumper the 5 volt reference circuit pin A and TPS 1 signal circuit pin C together at the throttle connector • Key ON Does DST display TPS 1voltage of 4.0 volts or greater?		Go to Step (7)	Go to Step (5)
5	• Key OFF • Disconnect ECM wire harness connector Using a DVOM check continuity between TPS 1 connector signal pin C and ECM connector TPS 1 signal pin 53 Do have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Replace ECM Is the replacement complete?		Go to Step (9)	-
7	• Inspect the throttle wire harness connector terminals for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (8)
8	• Replace the TPS 1 Is the replacement complete?		Go to Step (9)	-

9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-632 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 633-TPS 2 Signal Voltage High



Conditions for Setting the DTC

- Throttle Position Sensor #2
- Check Condition-Cranking or Running
- Fault Condition-TPS 2 sensor exceeds 4.8 volts
- MIL-On during active fault
- Power Derate 1
- Low rev limit 1300 rpm
- Forced idle 700 rpm

Circuit Description

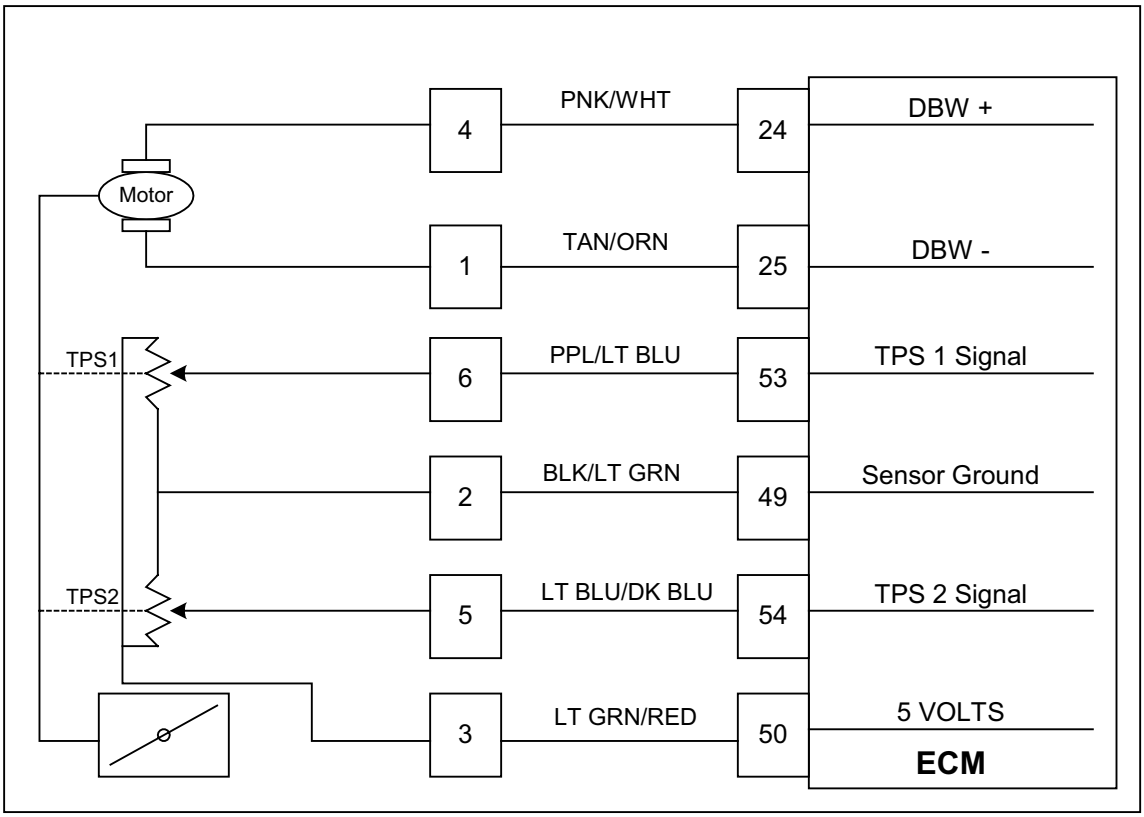
The Electronic Throttle has two counter acting Throttle position Sensors. Two sensors are used for improved safety and redundancy. The Throttle Position sensor (TPS2) uses a variable resistor to determine signal voltage based on throttle plate position, and is located within the throttle. Less opening results in higher voltage and greater opening in lower voltage. The TPS value is used by the ECM to determine if the throttle is opening as commanded. This fault will set if voltage is above 4.8 volts at any operating condition while the engine is cranking or running. Power derate 1 will be enforced limiting the throttle to 50% maximum. Low rev limit and forced idle will also be enforced during this fault.

DTC 633 TPS 2 Signal Voltage High

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in DBW (Drive by Wire) throttle test mode Does the DST display TPS 2 voltage of 4.8 volts or greater with the throttle closed		Go to Step (4)	Go to Step (3)
3	• Slowly depress Foot Pedal while observing TPS 2 voltage Does TPS 2 voltage ever exceed 4.8 volts?		Go to Step (4)	Intermittent problem Go to Intermittent section
4	• Key OFF • Disconnect electronic throttle connector • Key ON Does DST display TPS 2 voltage less than 0.2 volts?		Go to Step (7)	Go to Step (5)
5	• Key OFF • Disconnect ECM wire harness connector C001 • Key ON • Using a DVOM check for voltage between electronic throttle connector TPS 2 signal pin 5 and engine ground Do you have voltage?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
6	• Replace ECM Is the replacement complete?		Go to Step (11)	-
7	• Back probe sensor ground circuit at the ECM side of the wire harness pin 49 with a test light connected to battery voltage Does the test light come on?		Go to Step (8)	Go to Step (10)
8	• Inspect the electronic throttle wire harness connector and terminals for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (9)

9	• Replace electronic throttle Is the replacement complete?		Go to Step (11)	-
10	• Key OFF • Disconnect ECM connector • Using a DVOM check for continuity between throttle connector sensor ground pin 2 and ECM connector sensor ground pin 49 Do have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-633 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 634-TPS 2 Signal Voltage Low



Conditions for Setting the DTC

- Throttle Position Sensor #2
- Check Condition-Cranking or Running
- Fault Condition-TPS 2 sensor voltage less than 0.2
- MIL-On during active fault
- Power Derate 1
- Low rev limit 1300 rpm
- Forced idle 700 rpm

Circuit Description

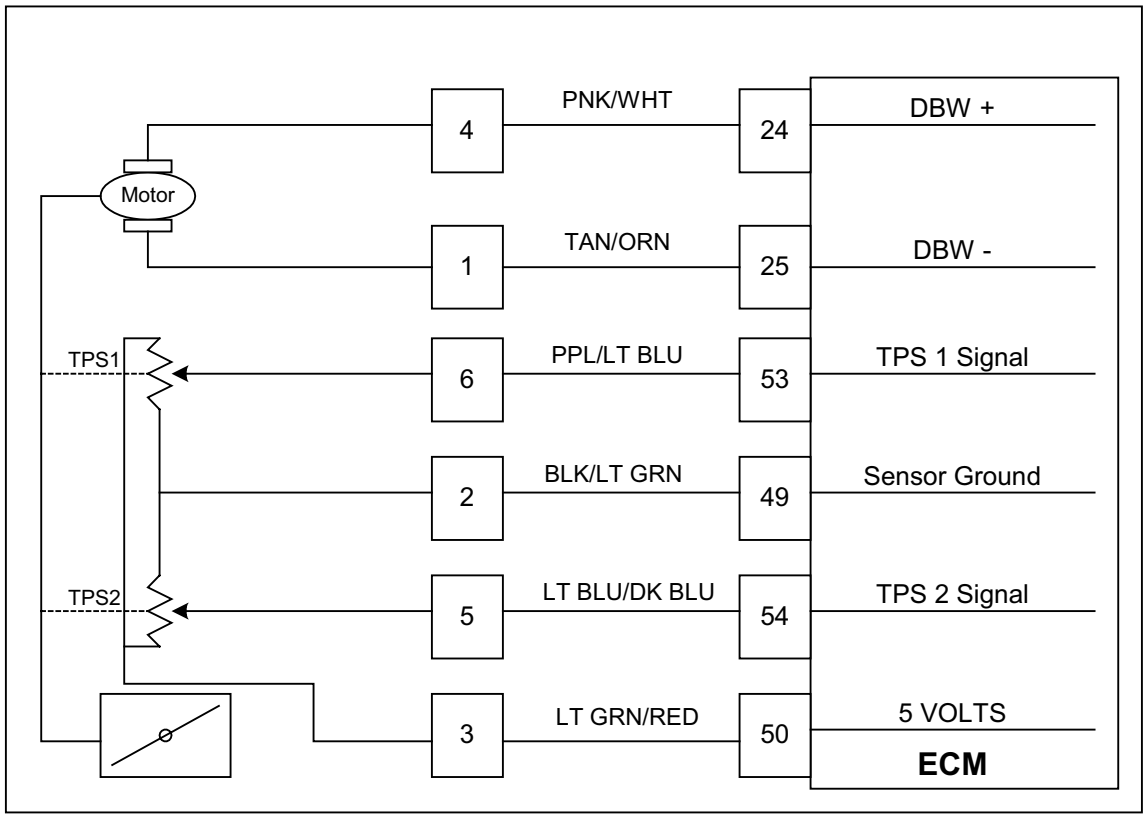
The Electronic Throttle has two counter acting Throttle Position sensors. Two sensors are used for improved safety and redundancy. The Throttle Position Sensor (TPS2) uses a variable resistor to determine signal voltage based on throttle plate position, and is located within the throttle. Less opening results in higher voltage and greater opening in lower voltage. The TPS value is used by the ECM to determine if the throttle is opening as commanded. This fault will set if voltage is below 0.2 volts at any operating condition while the engine is cranking or running. Power derate 1 will be enforced limiting the throttle to 50% maximum. Low rev limit and forced idle will also be enforced during this fault.

DTC 634 TPS 2 Signal Voltage Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in DBW (Drive by Wire) throttle test mode Does the DST display TPS 2 voltage of 0.2 volts or less with the throttle closed		Go to Step (4)	Go to Step (3)
3	• Slowly depress Foot Pedal while observing TPS 2 voltage Does TPS 2 voltage ever fall below 0.2 volts?		Go to Step (4)	Intermittent problem Go to Intermittent section
4	• Key OFF • Disconnect electronic throttle connector • Jumper the 5 volt reference circuit and TPS 2 signal circuit together at the throttle connector • Key ON Does DST display TPS 2 voltage of 4.0 volts or greater?		Go to Step (7)	Go to Step (5)
5	• Key OFF • Disconnect ECM wire harness connector Using a DVOM check continuity between TPS 2 connector signal and ECM connector TPS 2 signal terminals Do have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Replace ECM Is the replacement complete?		Go to Step (9)	-
7	• Inspect the throttle wire harness connector terminals for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (8)
8	• Replace throttle Is the replacement complete?		Go to Step (9)	-

9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-634 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 635-TPS1 Higher Than TPS 2



Conditions for Setting the DTC

- Throttle Position Sensor 1 & 2
- Check Condition-Key On
- Fault Condition-TPS1 higher than TPS2
- MIL-On for remainder of key on cycle
- Power Derate 1
- Low rev limit 1300 rpm
- Forced idle 700 rpm

Circuit Description

There are 2 Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from these voltages. Although the voltages are different, the calculated values for the throttle position percentages should be very close to the same. The TPS values are used by the ECM to determine if the throttle is opening as commanded. This fault will set if TPS1 is 20% (or more) higher than TPS2. At this point the throttle is considered to be out of specification, or there is a problem with the TPS signal circuit. Power derate 1 will be enforced limiting the throttle to 50% maximum. Low rev limit and forced idle will also be enforced during this fault.

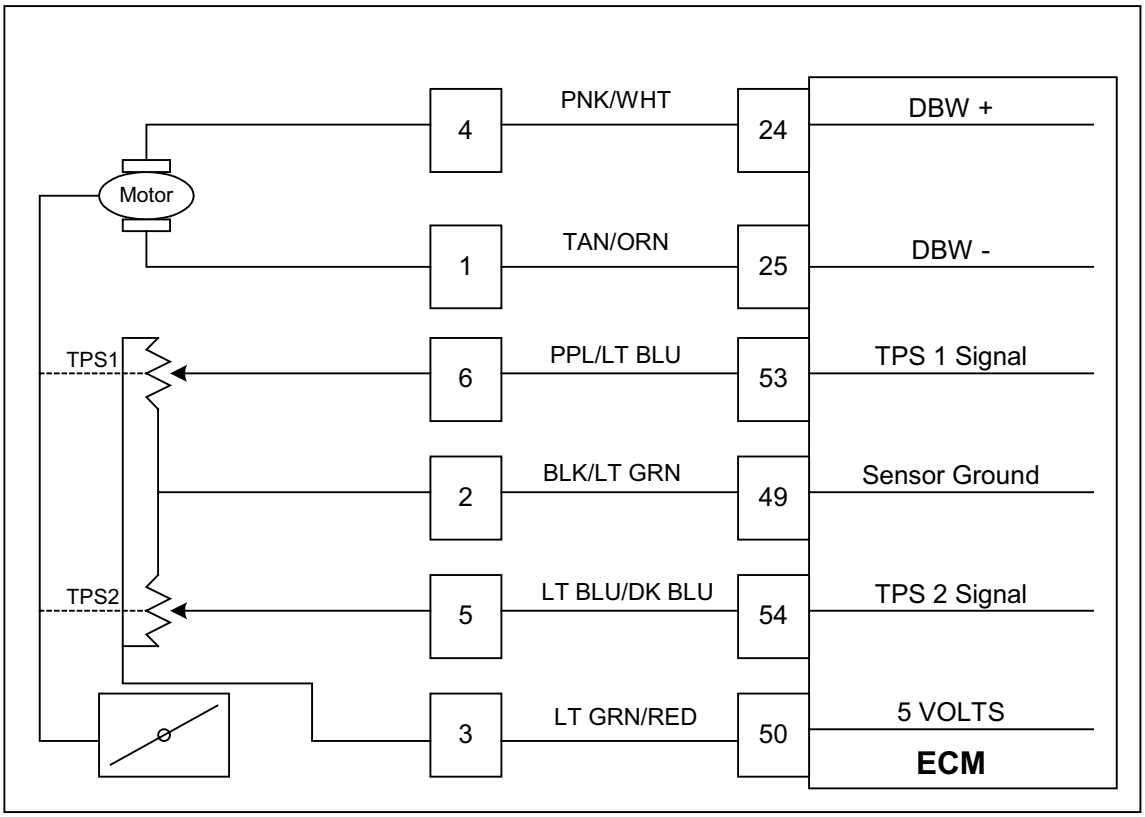
DTC 635 TPS 1 Higher Than TPS 2

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display more than a 20% difference between TPS 1 and TPS 2?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect wiring harness connector to throttle • Key ON • Change DST mode to DBW (drive by wire) test mode Is the voltage for TPS 1 and TPS 2 less than 0.1 volts?		Go to Step (5)	Go to Step (4)
4	• Key OFF • Disconnect ECM wiring harness connector • Key ON • Using a DVOM check for voltage between TPS 1 or TPS 2 (the one that is over 0.1 volts) and engine ground Do you have voltage?		Repair the TPS 1 or TPS 2 circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (13)
5	• Jumper TPS 1 and TPS 2 signal to the 5 volt reference at the throttle connector Does DST display TPS 1 and TPS 2 voltage over 4.95 volts		Go to Step (6)	Go to Step (8)
6	• Inspect wire terminals at throttle connector for damage corrosion or contamination Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
7	• Replace Throttle Is the replacement complete?		Go to Step (14)	-

8	• Key OFF • Disconnect ECM wire harness connector from ECM • Using a DVOM check for continuity between throttle connector TPS 1 signal and ECM connector TPS 1 signal terminal Do you have continuity between them?		Go to Step (9)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
9	• Using a DVOM check for continuity between throttle connector TPS 2 signal and ECM connector TPS 2 signal terminal Do you have continuity between them?		Go to Step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Using a DVOM check for continuity between throttle connector TPS 1 signal and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (11)
11	• Using a DVOM check for continuity between throttle connector TPS 2 signal and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (12)
12	• Inspect ECM connector terminals for damage corrosion or contamination. Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical	Go to Step (13)
13	• Replace ECM Is the replacement complete?		Go to Step (14)	-

14	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-635 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 636-TPS1 Lower Than TPS2



Conditions for Setting the DTC

- Throttle Position Sensor 1 & 2
- Check Condition-Key On
- Fault Condition-TPS1 lower than TPS2
- MIL-On for remainder of key on cycle
- Power Derate 1
- Low rev limit 1300 rpm
- Forced idle 700 rpm

Circuit description

There are 2 Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from these voltages. Although the voltages are different, the calculated values for the throttle position percentages should be very close to the same. The TPS values are used by the ECM to determine if the throttle is opening as commanded. This fault will set if TPS1 is 20% (or more) lower than TPS2. At this point the throttle is considered to be out of specification, or there is a problem with the TPS signal circuit. Power derate 1 will be enforced limiting the throttle to 50% maximum. Low rev limit and forced idle will also be enforced during this fault.

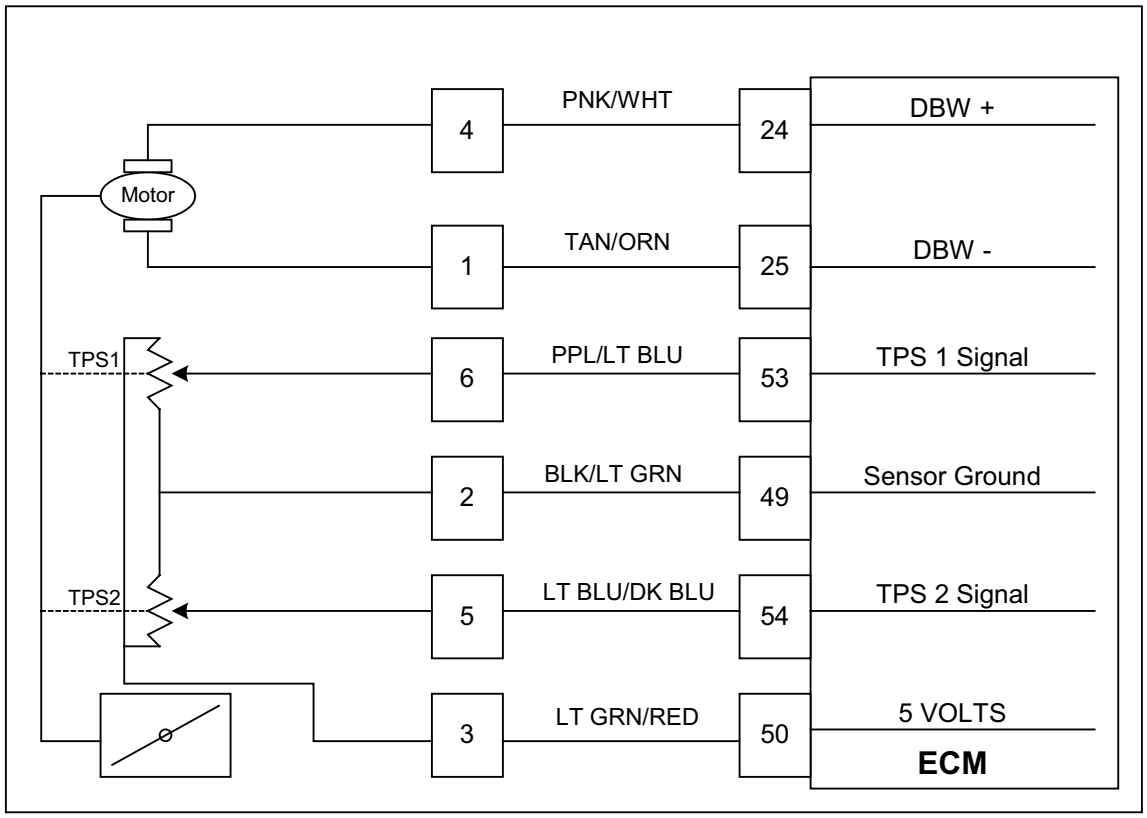
DTC 636 TPS 1 Lower Than TPS 2

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display more than a 20% difference between TPS 1 and TPS 2?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect wiring harness connector to throttle • Key ON • Change DST mode to DBW (drive by wire) test mode Is the voltage for TPS 1 and TPS 2 less than 0.1 volts?		Go to Step (5)	Go to Step (4)
4	• Key OFF • Disconnect ECM wiring harness connector • Key ON • Using a DVOM check for voltage between TPS 1 or TPS 2 (the one that is over 0.1 volts) and engine ground Do you have voltage?		Repair the TPS 1 or TPS 2 circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (13)
5	• Jumper TPS 1 and TPS 2 signal to the 5 volt reference at the throttle connector Does DST display TPS 1 and TPS 2 voltage over 4.95 volts		Go to Step (6)	Go to Step (8)
6	• Inspect wire terminals at throttle connector for damage corrosion or contamination Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
7	• Replace Throttle Is the replacement complete?		Go to Step (14)	-

8	• Key OFF • Disconnect ECM wire harness connector from ECM • Using a DVOM check for continuity between throttle connector TPS 1 signal and ECM connector TPS 1 signal terminal Do you have continuity between them?		Go to Step (9)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
9	• Using a DVOM check for continuity between throttle connector TPS 2 signal and ECM connector TPS 2 signal terminal Do you have continuity between them?		Go to Step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Using a DVOM check for continuity between throttle connector TPS 1 signal and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (11)
11	• Using a DVOM check for continuity between throttle connector TPS 2 signal and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (12)
12	• Inspect ECM connector terminals for damage corrosion or contamination. Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical	Go to Step (13)
13	• Replace ECM Is the replacement complete?		Go to Step (14)	-

14	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-636 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 637-Throttle Unable To Open



Conditions for Setting the DTC

- Throttle Position Sensor
- Check Condition-Cranking or Running
- Fault Condition-Throttle command is 20% more than throttle position
- MIL-On during active fault
- Engine Shut Down

Circuit Description

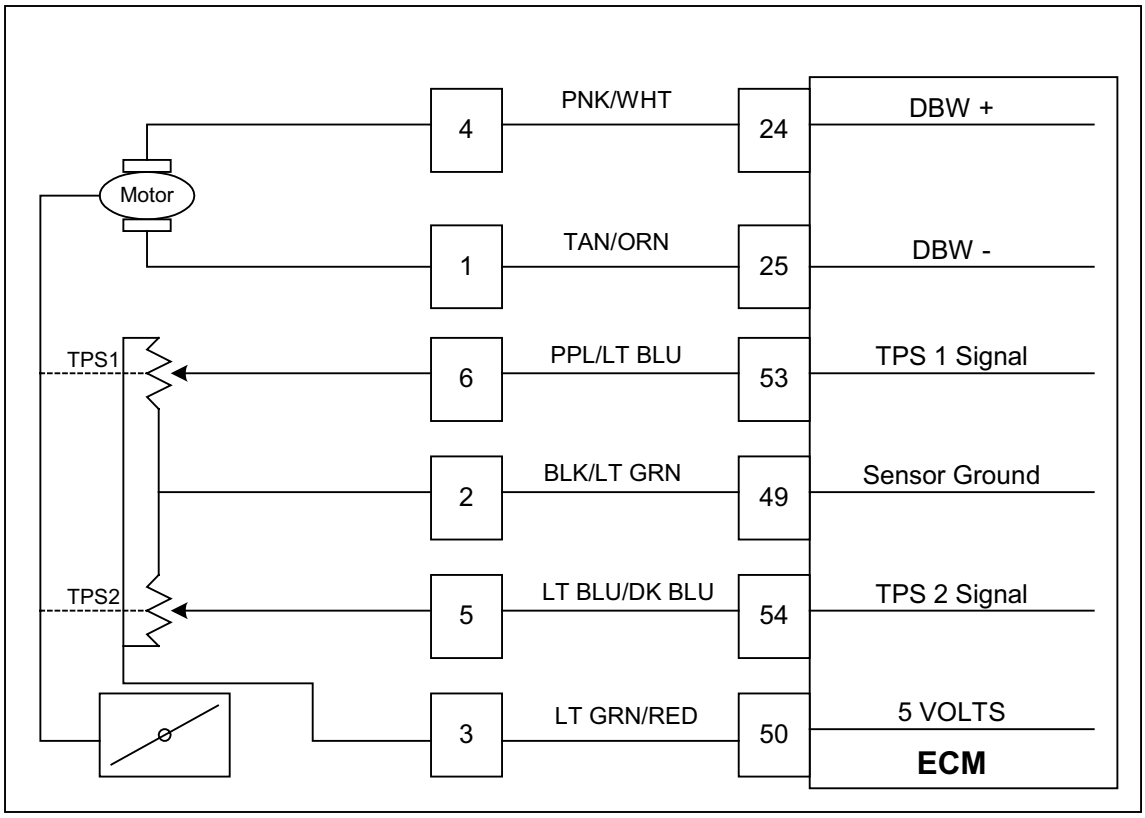
There are 2 Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from these voltages. Although the voltages are different, the calculated values for the throttle position percentages should be very close to the same. The TPS values are used by the ECM to determine if the throttle is opening as commanded. This fault will set if the throttle command is 20% or more than the actual throttle position. During this active fault the MIL light will turn on and the engine will shut down.

DTC 637 Throttle Unable to Open

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in DBW (Drive By Wire) test mode • Depress Foot Pedal until theThrottle Command is 63%-68% Is the TPS voltage less than 2.0 volts?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect wire harness connector from throttle • Probe TPS 1 signal circuit with test light connected to battery voltage • Key ON Is TPS voltage 4.0 volts or greater?		Go to Step (4)	Go to Step (8)
4	• Check throttle bore for foreign object Did you find a problem?		Go to Step (5)	Go to step (6)
5	• Remove the foreign object Has the object been removed?		Go to Step (11)	-
6	• Check throttle connector terminals for damage corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
7	• Replace throttle Is the replacement complete?		Go to Step (11)	-
8	• Key OFF • Disconnect ECM wire harness connector • Using a DVOM check for continuity between throttle connector TPS 1 signal terminal and ECM TPS 1 signal terminal Do you have continuity between them?		Go to Step (9)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

9	• Using a DVOM check for continuity between throttle connector TPS 1 signal and engine ground Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (10)
10	• Replace ECM Is the replacement complete?		Go to step (11)	-
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-637 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 638-Throttle Unable To Close



Conditions for Setting the DTC

- Throttle Position Sensor
- Check Condition-Cranking or Running
- Fault Condition-Throttle position is 20% greater than throttle command
- MIL-On during active fault
- Engine Shut Down

Circuit Description

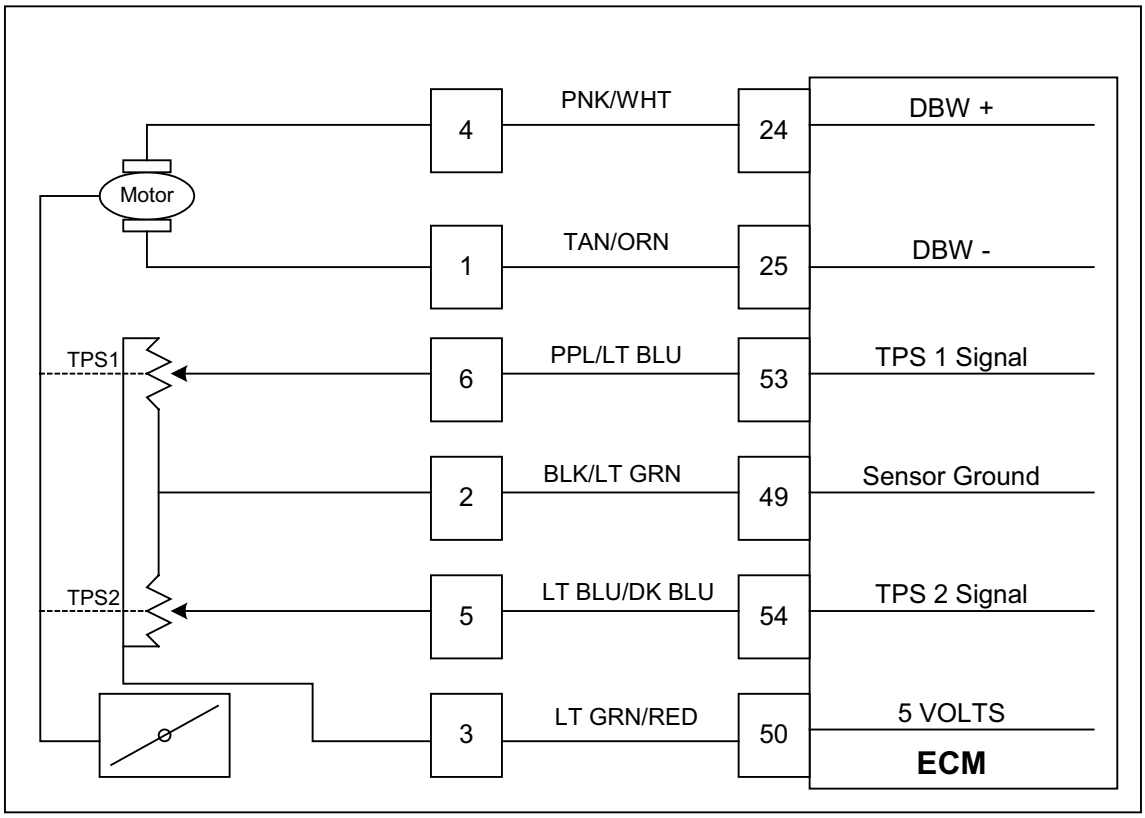
There are 2 Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from these voltages. Although the voltages are different, the calculated values for the throttle position percentages should be very close to the same. The TPS values are used by the ECM to determine if the throttle is opening as commanded. This fault will set if the throttle command is 20% less than the actual throttle position. During this active fault the MIL light will turn on and the engine will shut down.

DTC 638 Throttle Unable to Close

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in DBW (Drive By Wire) test mode • Depress Foot Pedal until theThrottle Command is between 63%-68% Is the TPS 1 voltage greater than 2.0 volts?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect wire harness connector from throttle • Probe TPS 1 signal circuit with test light connected to battery voltage • Key ON Does DST display TPS 1 voltage less than 0.2 volts		Go to Step (6)	Go to Step (4)
4	• Key OFF • Disconnect ECM wire harness connector • Key ON • Using a DVOM check for voltage between throttle connector signal terminal and engine ground Do you have voltage?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (5)
5	• Replace ECM Is the replacement complete?		Go to Step (13)	-
6	• Back probe sensor ground circuit at ECM connector with test light connected to battery voltage Does the test light come on?		Go to Step (9)	Go to Step (7)
7	• Key OFF • Disconnect ECM wire harness connector • Using a DVOM check for continuity between throttle connector signal ground and ECM signal ground circuit terminals Do you have continuity between them?		Go to Step (8)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	• Replace ECM • Is the replacement complete?		Go to Step (13)	-

9	• Check throttle for foreign object in bore Did you find a foreign object in the bore?		Go to Step (10)	Go to Step (11)
10	• Remove foreign object Is the removal complete?		Go to Step (13)	-
11	• Inspect the throttle wire harness connector terminals for damage, corrosion or contamination Did you find the problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (12)
12	• Replace throttle Is the replacement complete?		Go to Step (13)	-
13	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-638 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 651-Max Govern Speed Override



Conditions for Setting the DTC

- Max Govern Speed Override
- Check Condition- Engine Running
- Fault Condition- Engine RPM greater than 3800 for 2 seconds continuously
- MIL- On during active fault
- Adaptive- Enabled
- Closed Loop- Enabled

Circuit description

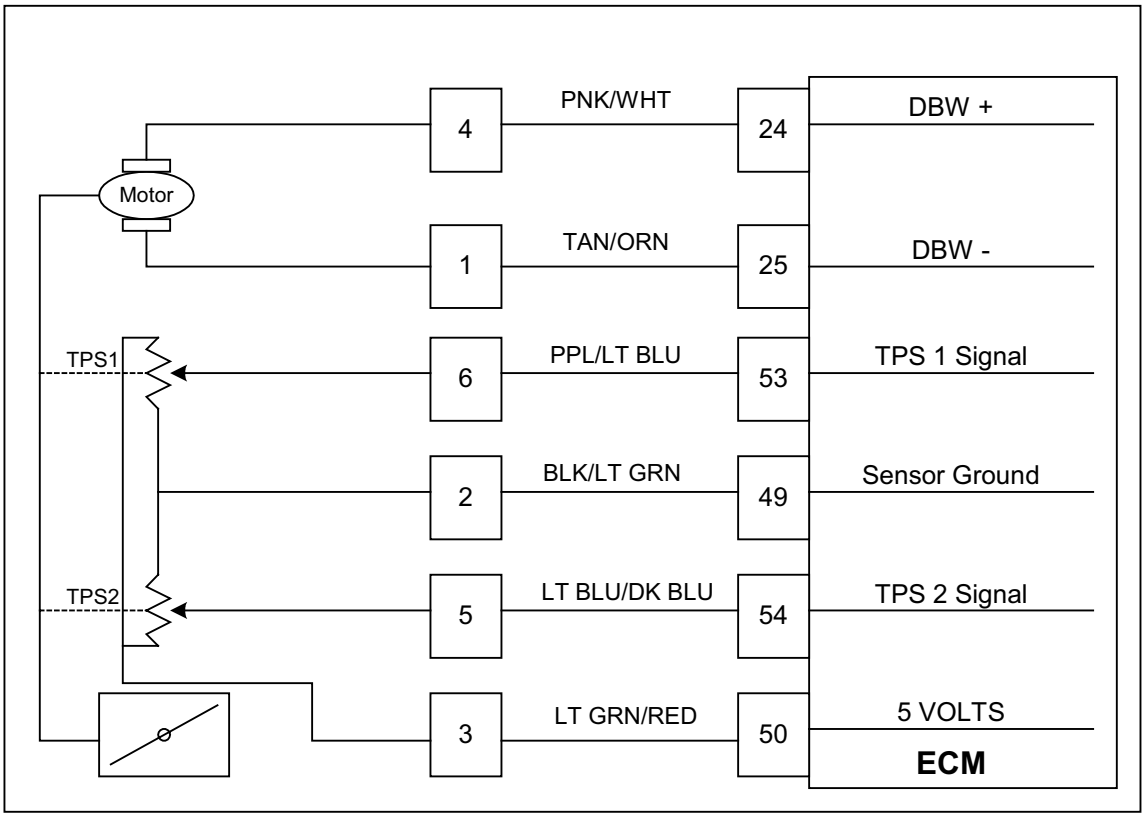
This fault will set anytime the engine RPM exceeds 3800 for 2 seconds or more continuously. This speed overrides any higher max governor speeds programmed by the user. This is to help prevent engine or equipment damage. The MIL will be on during this active fault.

DTC 651 Max Govern Speed Override

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST in Active Fault Mode Are any other DTC codes present with DTC 651?		Go to Step (3)	Go to Step (4)
3	• Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been diagnosed and repaired?		Go to step (4)	-
4	• Check the Service Part Number on the ECM to ensure correct calibration is in use Is the Service Part Number Correct?		Go to Step (6)	Go to Step 5
5	• Replace ECM with correct Service Part Number Is the replacement complete?		Go to Step (9)	-
6	• Check the mechanical operation of the throttle Is the mechanical operation of the throttle OK?		Go to Step (8)	Go to Step (7)
7	• Correct mechanical operation of the throttle. Refer to Engine & Component R&R Section 1E Has the mechanical operation of the throttle been corrected?		Go to step (9)	-
8	• Check engine for large manifold vacuum leaks. Refer to Fuel Systems Section 1B Symptom Diagnostics Did you find and correct the vacuum leak?		Go to Step (9)	Go to OBD System Check Section

9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-651 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 652-Fuel Rev Limit



Conditions for Setting the DTC

- Fuel Rev Limit
- Check Condition- Engine Running
- Fault Condition- Engine RPM greater than 4000 for 2 seconds continuously
- MIL- On during active fault
- Adaptive- Enabled
- Closed Loop- Enabled

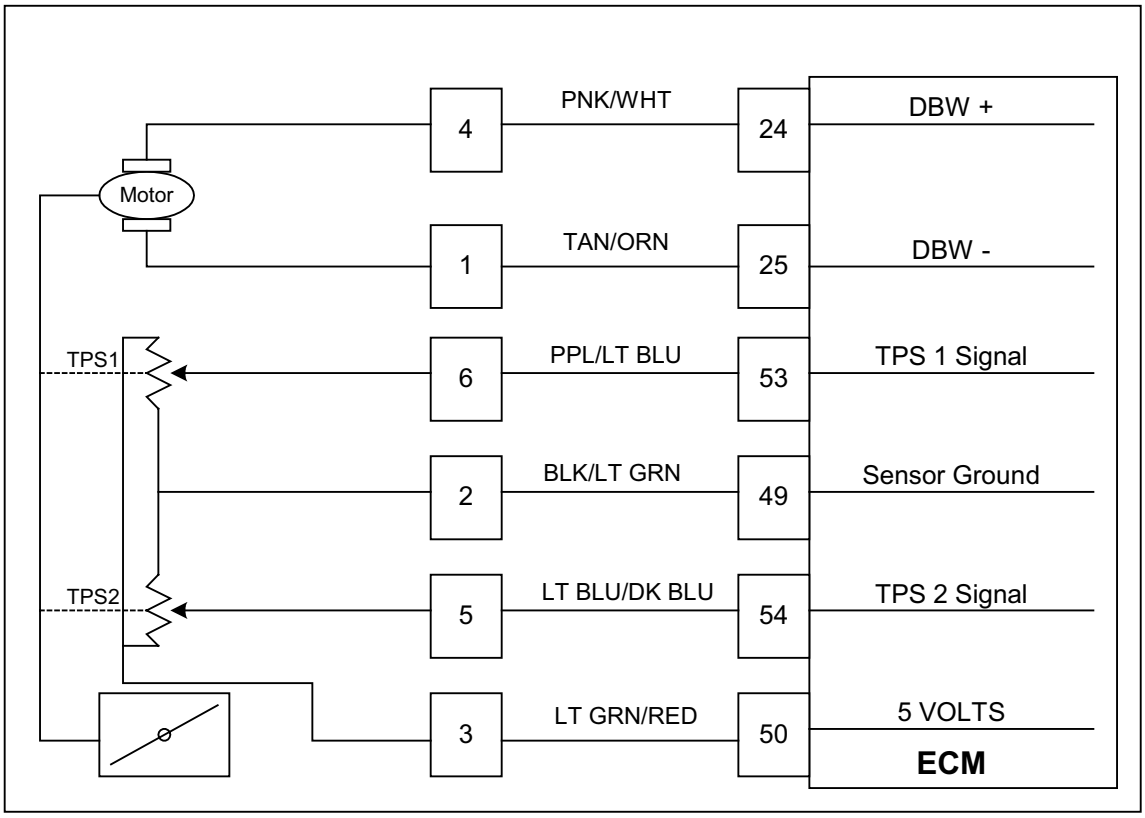
Circuit Description

This fault will set anytime engine RPM exceeds 4000 for 2 seconds or more continuously. When these conditions are met, the ECM shuts off the fuel injectors. This is to help prevent engine or equipment damage. The MIL will be on during this active fault.

DTC 652 Fuel Rev Limit

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST in Active Fault Mode Are any other DTC codes present with DTC 651?		Go to Step (3)	Go to Step (4)
3	• Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been diagnosed and repaired?		Go to step (4)	-
4	• Check the Service Part Number on the ECM to ensure correct calibration is in use Is the Service Part Number Correct?		Go to Step (6)	Go to Step 5
5	• Replace ECM with correct Service Part Number Is the replacement complete?		Go to Step (9)	-
6	• Check the mechanical operation of the throttle Is the mechanical operation of the throttle OK?		Go to Step (8)	Go to Step (7)
7	• Correct mechanical operation of the throttle. Refer to Engine & Component R&R Section 1E Has the mechanical operation of the throttle been corrected?		Go to step (9)	-
8	• Check engine for large manifold vacuum leaks. Refer to Fuel Systems Section 1B Symptom Diagnostics Did you find and correct the vacuum leak?		Go to Step (9)	Go to OBD System Check Section

DTC 653-Spark Rev Limit



Conditions for Setting the DTC

- Spark Rev Limit
- Check Condition- Engine running
- Fault Condition- Engine RPM greater than 4100
- MIL- On during active fault
- Adaptive- Enabled
- Closed Loop- Enabled
- Engine Shut Down

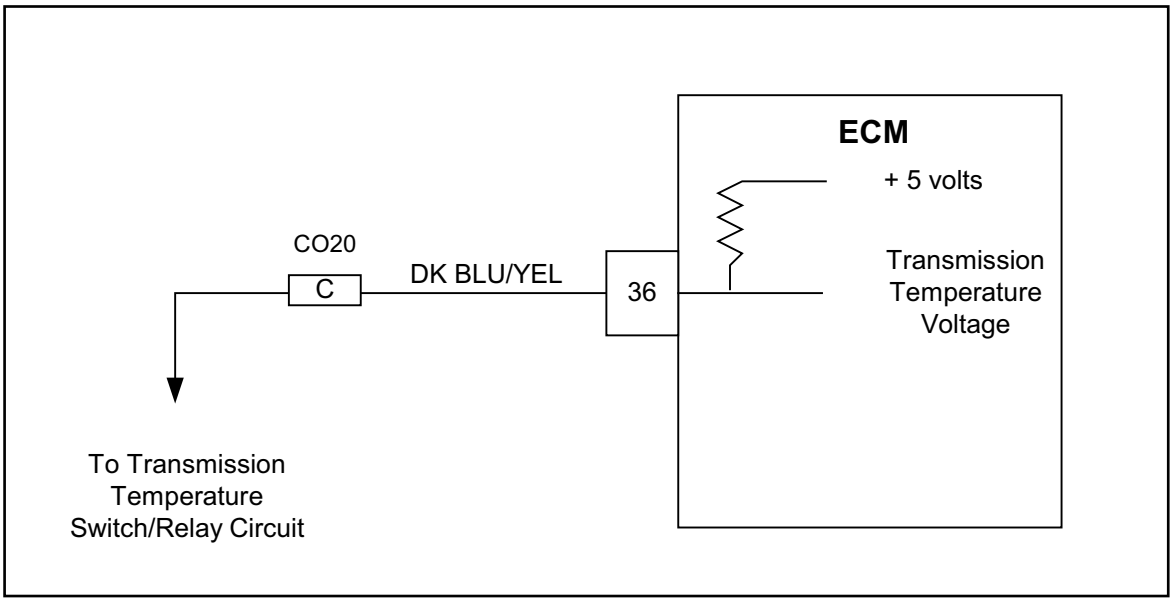
Circuit description

This fault will set anytime the engine RPM exceeds 4100 for 2 seconds or more continuously. When these conditions are met, the ECM will shut off spark to the engine. This is to help prevent engine or equipment damage. The MIL will be on during this active fault and the engine will shut down.

DTC 653 Spark Rev Limit

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST in Active Fault Mode Are any other DTC codes present with DTC 651?		Go to Step (3)	Go to Step (4)
3	• Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been diagnosed and repaired?		Go to step (4)	-
4	• Check the Service Part Number on the ECM to ensure correct calibration is in use Is the Service Part Number Correct?		Go to Step (6)	Go to Step 5
5	• Replace ECM with correct Service Part Number Is the replacement complete?		Go to Step (9)	-
6	• Check the mechanical operation of the throttle Is the mechanical operation of the throttle OK?		Go to Step (8)	Go to Step (7)
7	• Correct mechanical operation of the throttle. Refer to Engine & Component R&R Section 1E Has the mechanical operation of the throttle been corrected?		Go to step (9)	-
8	• Check engine for large manifold vacuum leaks. Refer to Fuel Systems Section 1B Symptom Diagnostics Did you find and correct the vacuum leak?		Go to Step (9)	Go to OBD System Check Section

DTC 721-Transmission Over Temperature



Conditions for Setting the DTC

- Check Condition-Engine running
- Transmission Temperature High
- Fault Condition- closed circuit/voltage low
- MIL-On during active fault
- Power Derate 2

Circuit Description

The transmission temperature switch is used to communicate a high temperature condition to the ECM. Transmission damage can occur if the transmission is operated at high temperature. The ECM uses an analog voltage input with an internal 5 volt reference. If the transmission temperature circuit is grounded, the input voltage will be near zero. If it is open the input will be near 5 volts. The temperature switch is normally open and should close at 122C and remain closed until the temperature drops to 115C. The fault will set if the switch becomes closed with the engine running for longer than 10 seconds. Power derate 2 will be enforced to a maximum throttle position of 20%.

Diagnostic Aids

Before performing any electrical diagnostics be sure to check the transmission fluid levels and cooling systems for proper operation. Also verify that the truck is being operated to the manufactures specifications in regards to load, speed and environmental conditions. Failure to follow this recommendation may result in a false DTC diagnosis.

DTC 721- Transmission Over Temperature

Step	Action	Value(s)	Yes	No
1	Did you perform the On Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	Did you perform the Diagnostic Aids check for DTC 721?		Go to step (3)	Perform the Diagnostic Aids check for DTC 721
3	• Key Off • Disconnect ECM connector C001 • Disconnect transmission temperature switch connector CO20 • Using a high impedance DVOM check for continuity between ECM pin 36 and engine ground Do you have continuity?		Repair the shorted circuit to ground as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (4)
4	• Verify transmission relay lamp circuit is in proper working order and not shorted to ground. Is the transmission relay lamp circuit ok?		Go to Step (5)	Repair the circuit as required. See chassis electrical system section.
5	• Replace transmission temperature switch Is the replacement complete?		Go to Step (6)	-

6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature, running the transmission to similar conditions where the DTC 721 previously set. • Observe the MIL • Observe engine performance and drive ability • After operating the engine within the test parameters of DTC-721 check for any stored codes. Does the engine operate normally without setting DTC 721?		System OK	Go to Step (7)
7	• Replace the ECM Is the replacement complete?		Go to Step (8)	-
8	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature, running the transmission to similar conditions where the DTC 721 previously set. • Observe the MIL • Observe engine performance and drive ability • After operating the engine within the test parameters of DTC-721 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

SECTION 1E1
FUEL SYSTEM

REPAIR INSTRUCTIONS

PROPANE FUEL SYSTEM PRESSURE RELIEF

⚠ WARNING

The propane fuel system operates at pressures up to 21.5 BAR (312 psi). To minimize the risk of fire and personal injury, relieve the propane fuel system pressure (where applicable) before servicing the propane fuel system components.

To relieve propane fuel system pressure:

1. Close the manual shut-off valve (MSV) on the propane fuel tank.
2. Start and run the vehicle until the engine stalls.
3. Turn the ignition switch OFF.

⚠ WARNING

Residual vapor pressure will be present in the fuel system. Ensure the work area is well ventilated before disconnecting any fuel line.

PROPANE FUEL SYSTEM LEAK TEST

⚠ WARNING

Never use an open flame of any type to check for propane fuel system leaks.

Always inspect the propane fuel system for leaks after performing service. Check for leaks at the fittings of the serviced or replaced component. Use a commercially available liquid leak detector or an electronic leak detector. When using both methods, use the electronic leak detector first to avoid contamination by the liquid leak detector.

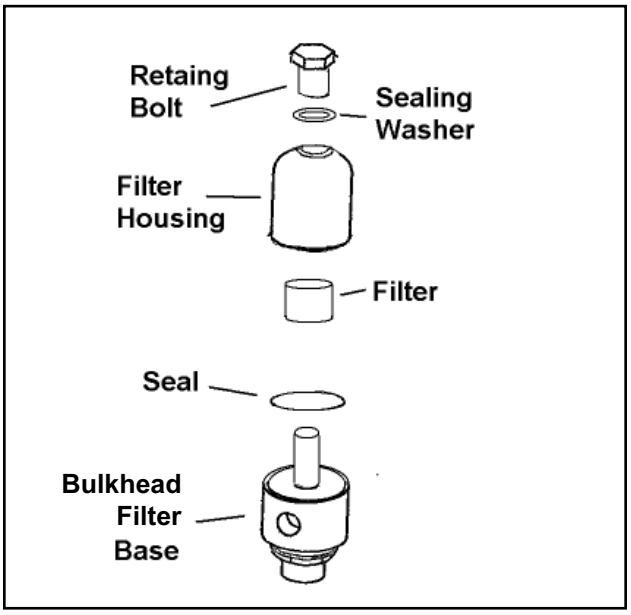


Figure 1 Fuel Filter

PROPANE FUEL FILTER REPLACEMENT (Figure 1)

Removal Procedure

1. Relieve the propane fuel system pressure. Refer to Propane Fuel System Pressure Relief.
2. Disconnect the negative battery cable.
3. Slow loosen the fuel inlet hose fitting to relieve any residual fuel pressure.
4. Remove the filter housing retaining bolt and sealing washer discard washer.
5. Remove the filter housing from the bulkhead filter base discard the filter and the sealing ring.
6. Clean and inspect the filter base for any debris.

Installation Procedure

NOTE

Be sure to install new sealing washer and seals

Do Not use Teflon tape on the pipe fittings use only a liquid pipe sealant

7. Install the housing seal to the bulkhead base.

8. Install the filter to the bulkhead base.
9. Install the filter housing to the bulkhead base.
10. Install sealing washer and retaining bolt and tighten to specification.

    Tighten
    27 Nm (20 ft lbs)
11. Tighten the fuel inlet hose fitting to specification.

    Tighten
    27 Nm (20 ft lbs)
12. Reconnect the negative battery cable.
13. Open manual shut-off valve.
14. Start the vehicle and leak check the propane fuel system at each serviced fitting Refer to *Propane Fuel System Leak Test.*

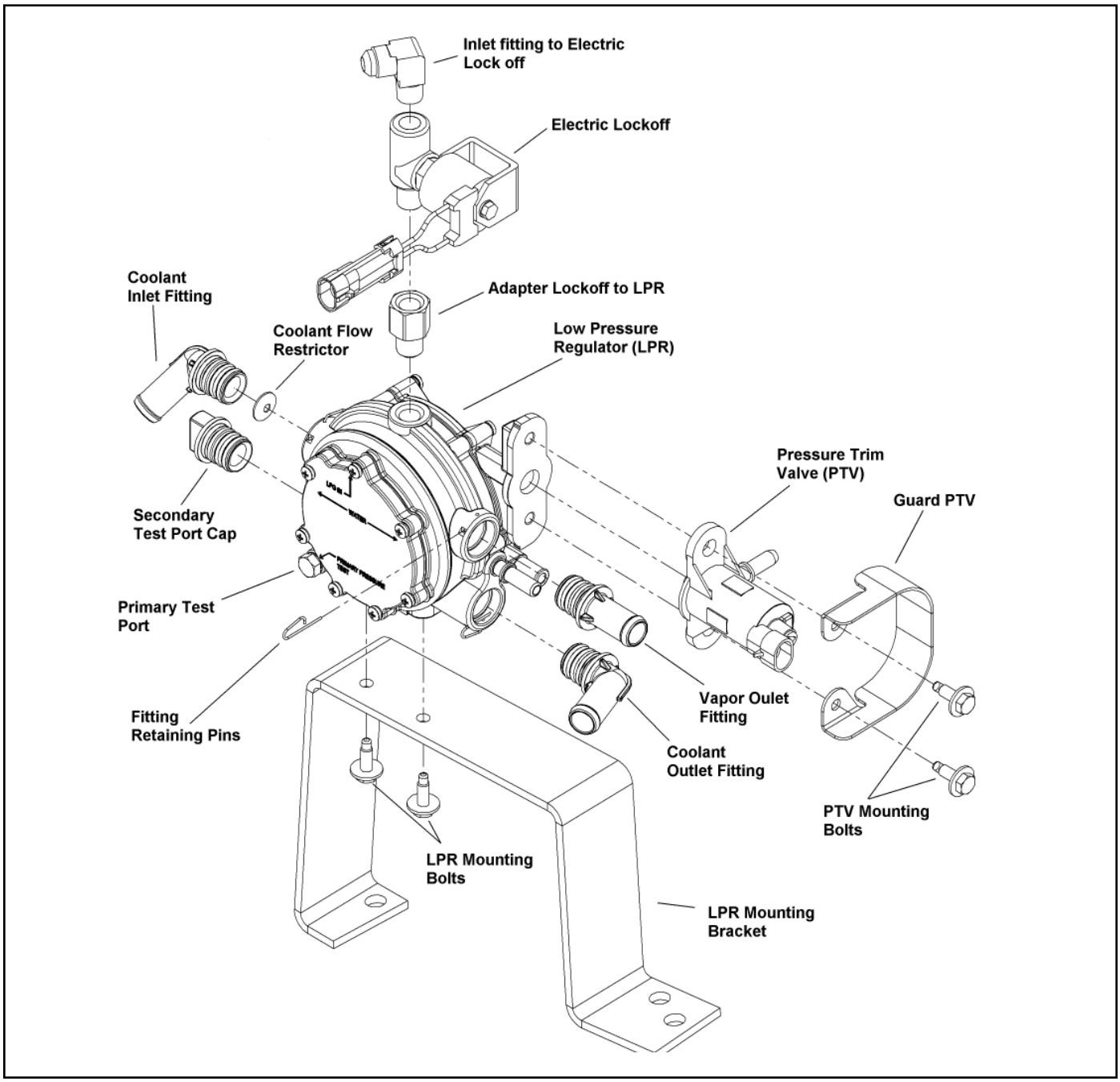


Figure 2 Low Pressure Regulator

LOW PRESSURE LOCK-OFF (LPL)

REPLACEMENT

(Figure 2)

Removal Procedure

1. Relieve the propane fuel system pressure. Refer to *Propane Fuel System Pressure Relief.*
2. Disconnect the negative battery cable.
3. Disconnect the LPL electrical connector.
4. Disconnect the LPG fuel inlet line from the LPL inlet fitting.
5. Unscrew the LPL from the LPR inlet fitting.

Installation Procedure

NOTE

Do not use Teflon tape on any fuel fitting. Use a liquid pipe thread sealant when installing fittings.

6. Apply pipe thread sealant to the LPR inlet fitting.
7. Install the LPL to the LPR. Tighten the LPL finger tight plus 1 to 2 turns and place the LPL in the correct position.
8. Install the fuel inlet line.
9. Tighten the fuel line fitting to the LPL

   Tighten
   27 Nm (20 ft lbs)

10. Connect the LPL electrical connector.
11. Connect the negative battery cable.
12. Slowly open the tank manual shut off valve.
13. Start the vehicle and leak check the propane fuel system at each serviced fitting.

PRESSURE TRIM VALVE (PTV) REPLACEMENT

(Figure 2)

1. Disconnect the PTV electrical connection.
2. Remove the vacuum hose from the PTV.
3. Remove and retain the two (2) retaining bolts and PTV guard.
4. Remove the PTV.

Installation Procedure

NOTE

Apply a small amount of O-ring lubricant to the PTV O-ring before installation

5. Install the PTV and guard using the two mounting bolts.
6. Tighten retaining bolts.

   Tighten
   9 N•m (80 lb-in)

7. Connect the PTV vacuum line.
8. Connect the PTV electrical connector.
9. Start the vehicle.
10. Connect the diagnostic service tool and verify the engine is operating in closed loop and no MIL light is present.

LOW PRESSURE REGULATOR (LPR) REPLACEMENT

(Figure 2)

Removal Procedure

1. Relieve the propane fuel system pressure. Refer to *Propane Fuel System Pressure Relief.*
2. Disconnect the negative battery cable.
3. Clamp the coolant hoses to the LPR or drain the radiator.
4. Remove the LPL. Refer to *Low Pressure Lock-off Replacement.*
5. Remove the PTV Refer to *Pressure Trim Valve Replacement.*
6. Disconnect the supply and return coolant lines from the LPR.
7. Remove the retaining pin from the water inlet and outlet fittings and retain
8. Remove the coolant inlet and outlet fitting retaining pins and retain.

9. Remove the outlet fitting locate the orifice in the housing or attached to the fitting and retain.
10. Remove the inlet fitting retain.
11. Disconnect the FTV supply line.
12. Remove the two LPR mounting bolts and retain.
13. Lift LPR assembly and remove.
14. Loosen the fuel vapor hose clamp at the LPR fuel outlet fitting.
15. Disconnect the fuel vapor hose from the LPR outlet fitting and remove the LPR.
16. Remove the retaining pin from the vapor outlet fitting and retain.
17. Remove and retain the vapor outlet fitting from the LPR.
18. Remove the LPR.

Installation Procedure

⚠ CAUTION

Do not use Teflon tape on any fuel fitting. Use a liquid pipe thread sealant when installing fittings.

Lubricate the o-ring of the PTV before installing into the LPR.

Lubricate the o-rings on each of the fitting.

Be sure to reinstall regulator coolant line orifice into the outlet side of the LPR before installing the coolant line hose fitting.

19. Install the outlet water fitting insure orifice is in place and secure with retaining pin.
20. Install the inlet water fitting and secure with retaining pin.
21. Install vapor outlet fitting and secure with retaining pin.
22. Insert the vapor hose to the fuel outlet fitting and place clamp.
23. Install the FTV supply line and secure.
24. Secure the LPR to the mounting bracket using the two (2) retaining bolts and tighten to specification.

    Tighten
    14 Nm (10 ft lbs)
25. Install the water inlet line to the fittings and place clamps.
26. Install the water outlet line to the fittings and place clamps.
27. Install LPL. Refer to *Low Pressure Lock-off Replacement.*
28. Install the PTV Refer to *Pressure Trim Valve Replacement.*
29. Tighten fuel line fitting.

    Tighten
    27 Nm (20 ft lbs)
30. Replace the drained coolant.
31. Start the vehicle and leak check the propane fuel system at each serviced fitting.
32. Connect the diagnostic service tool and verify the engine is operating in closed loop and no MIL light is present.

FUEL TRIM VALVE (FTV) SOLENOID REPLACEMENT

(Figure 3)

Removal Procedure

1. Disconnect the FTV electrical connection.
2. Remove the fuel supply hose from the FTV.
3. Remove the two (2) retaining bolts and retain.
4. Remove the FTV.

Installation Procedure

NOTE

Apply a small amount of O-ring lubricant to the PTV o-ring before installation

5. Install FTV to the throttle body
6. Install the and two bolts
7. Tighten retaining bolts

   Tighten
   9 N•m (80 lb-in)
8. Connect Fuel supply hose.

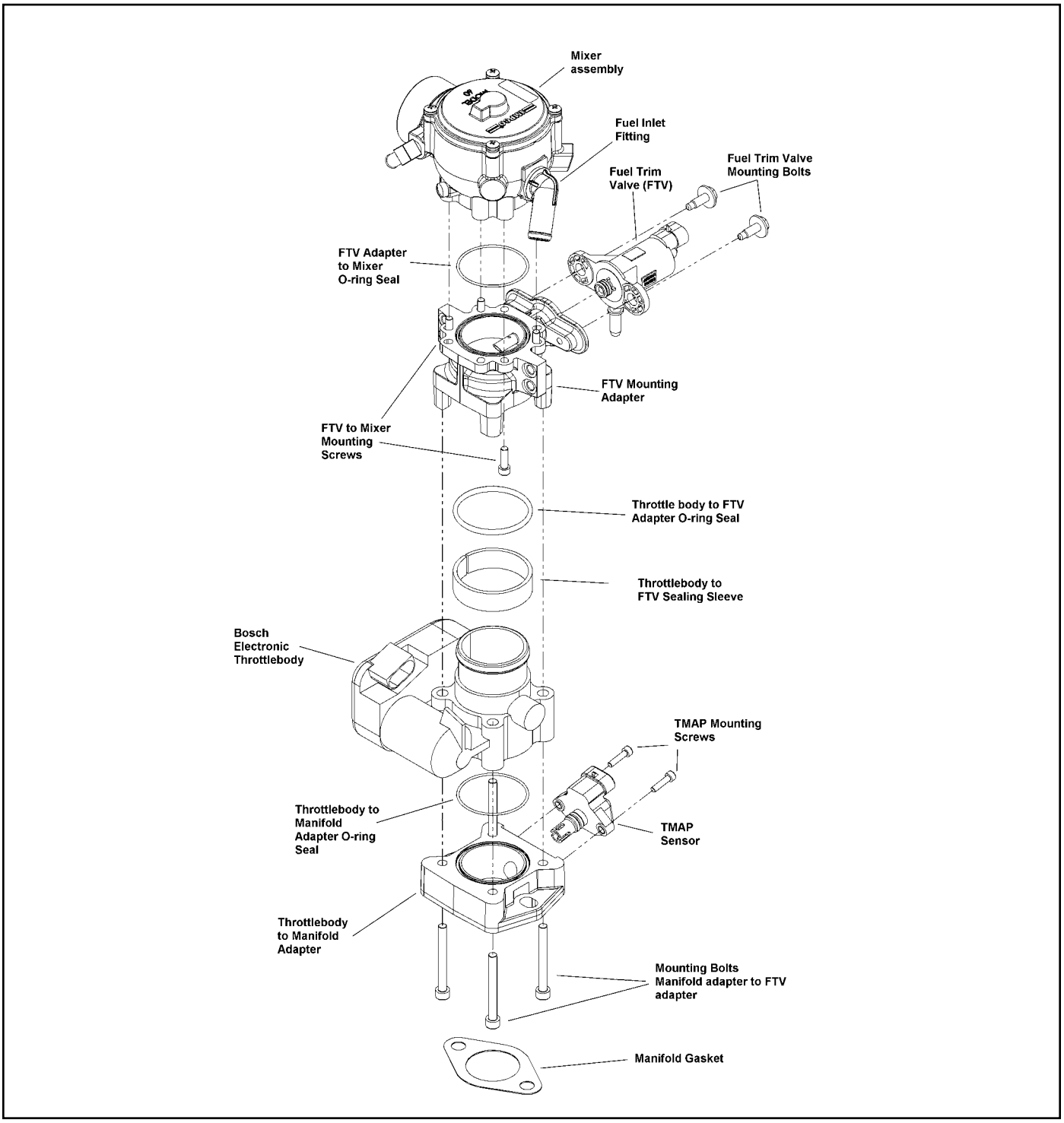


Figure 3 Mixer Assembly

9. Connect electrical connection.
10. Start the vehicle.
11. Connect the diagnostic service tool and verify the engine is operating in closed loop and no MIL light is present.

TEMPERATURE MANIFOLD ABSOLUTE PRESSURE (TMAP)
(Figure 3)

Removal Procedure

1. Disconnect the TMAP electrical connector.
2. Remove the two retaining bolts.
3. Remove the TMAP.

Installation Procedure

- Apply a small amount of O-ring lubricant to the TMAP o-ring before installation.

4. Install the TMAP.
5. Tighten retaining bolts.

   Tighten
   7 N•m (62 lb-in)

6. Connect the TMAP electrical connection.
7. Start engine.

THROTTLE BODY ASSEMBLY REPLACEMENT
(Figure 3)

Removal Procedure

1. Disconnect the negative battery cable.
2. Remove the air intake duct.
3. Disconnect the electronic throttle electrical connector.
4. Disconnect the FTV supply line.
5. Disconnect the PTV vacuum line.
6. Disconnect the balance line to the LPR.
7. Release mixer fuel inlet hose clamp and remove hose from mixer inlet.
8. Remove the two (2) manifold retaining and remove the throttle body assembly.
9. Remove gasket, and discard .
10. Remove the four (4) throttle body to adapter bolts and retain.
11. Remove the throttle body from the FTV adapter.
12. Remove the O-ring gasket and discard.

Installation Procedure

NOTE

Lightly Lubricate the both the o-rings of the electronic throttle control device to manifold adapter and FTV adapter.

Cover Throttle body adapter opening to prevent debris from entering engine until reassembly.

13. Install both the o-ring and sleeve to the throttle body.
14. Insert the throttle body to the FTV adapter.
15. Install the adapter O-ring seal.
16. Install throttle body assembly to the throttle body to manifold adapter and secure with four (4) screws.

    Tighten
    9 N•m (80 lb-in)

17. Install the manifold gasket.
18. Secure the assembly with the two (2) retaining bolts.

    Tighten
    12 N•m (106 lb-in)

19. Install balance line to the LPR.
20. Install the PTV vacuum line.
21. Install the fuel supply line to the FTV.
22. Install fuel supply line to the mixer and reset clamp.
23. Connect the FTV electrical connector.
24. Connect the electronic throttle body electrical connection.
25. Connect the air inlet duct.
26. Start engine.
27. Start the vehicle and leak check the propane fuel system at each serviced fitting.
28. Connect the diagnostic service tool and verify system is operating closed loop and no MIL light is present.

MIXER REPLACEMENT

Figure 3

Removal Procedure

1. Disconnect the negative battery cable.
2. Remove the air intake duct.
3. Remove the Throttle body assembly *Refer to Throttle Body Assembly Replacement.*
4. Remove the four (4) screws in the throttle body to FTV adapter and retain.
5. Remove and discard the mixer to FTV adapter O-ring.

Installation Procedure

NOTE

Lightly Lubricate the o-ring of the Mixer to FTV adapter before installing

Cover Throttle body adapter opening to prevent debris from entering engine until reassembly

1. Install Mixer to FTV adapter and secure with the four (4) screws.

   Tighten
   9 N•m (80 lb-in)

2. Install Throttle body Refer to Electronic Throttle Body Assembly Replacement.

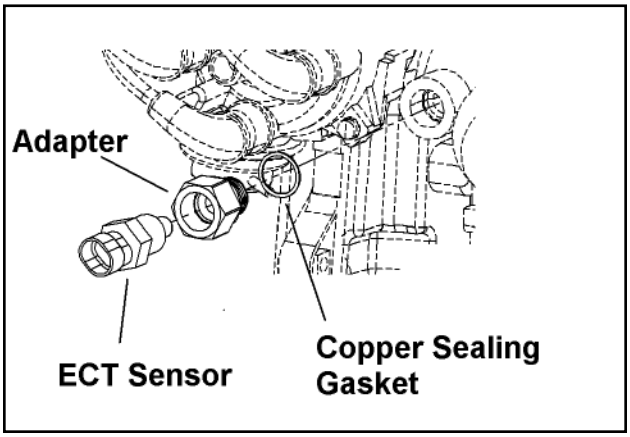


FIGURE 4
ENGINE COOLANT TEMPERATURE SENSOR REPLACEMENT

Figure 4

1. Disconnect the ECT electrical connect.
2. Remove ECT from the adapter, do not remove the adapter.
3. Remove the ECT and discard.

Installation Procedure

- If the ECT adapter to the block is removed locate the brass washer and replace.
- If the ECT adapter is replaced with a new adapter **remove the O-ring supplied with the adapter** before installing the brass sealing washer.

4. Apply liquid pipe sealant to the ECT.
5. Install the ECT to the adapter and tighten to finger tight.
6. Tighten to specification.

   Tighten
   1 to 2 turns after finger tight

COOLANT HOSE REPLACEMENT

1. Drain coolant.
2. Using a hose clamp pliers disconnect both hose clamps on each hose.
3. Remove the coolant inlet hose form each fitting.
4. Remove the coolant outlet hose.

Installation Procedure

⚠ CAUTION

Coolant hose are specifically designed, DO NOT use hose material or length other than the OEM specified parts.

DO NOT mix the inlet or outlet hoses when re-installing.

1. Install hose clamps and set back on each hose.
2. Reinstall the coolant inlet hose to each fitting.
3. Reinstall the coolant outlet hose to each fitting.

4. Reset clamps.
5. Refill with coolant.
6. Start engine and check for coolant leaks.

VAPOR HOSE REPLACEMENT

1. Using a hose clamp pliers disconnect both hose clamps.
2. Remove the vapor hose form each fitting.

Installation Procedure

NOTE

Vapor supply hose is specifically designed, DO NOT use hose material or length other than the OEM specified parts.

3. Install hose clamps and set back on each hose.
4. Reinstall the vapor hose to each fitting.
5. Reset clamps.
6. Start engine and check for leaks.

BALANCE LINE HOSE REPLACEMENT

1. Remove the clamp to the fitting at the mixer.
2. Remove small hose to check valve.
3. Remove and retain check valve.
4. Remove clamp at the LPR connection.

Installation Procedure

⚠ CAUTION

Balance line hoses are specifically designed, DO NOT use hose material or length other than the OEM specified parts.

DO NOT mix the hoses when reinstalling.

Install check valve in correct direction. (Arrow on check valve pointing toward mixer).

7. Install hose clamps and set back on each hose.
8. Reinstall the LPR hose end to the LPR fitting and set clamp.
9. Install Check valve and set clamp. (Directional part arrow pointing to mixer).
10. Reinstall the small hose section and set clamps.
11. Start engine and check for leaks.

PTV HOSE REPLACEMENT

1.Using a hose clamp pliers disconnect the clamps on the hose fitting at the mixer.

2.Using a small screw driver push locking clip back on PTV connection.

3.Remove the hose and discard.

Installation Procedure

⚠ CAUTION

PTV hoses are specifically designed, DO NOT use hose material or length other than the OEM specified parts

4. Install hose clamps and set back on the mixer hose end.
5. Reinstall hose at the PTV and push lock in place.
6. Reinstall hose at the mixer and set clamp.
7. Start engine and check for leaks.

FTV HOSE REPLACEMENT

1. Using a small screw driver push locking clips back on FTV connection at FTV and LPR.
2. Remove the hose and discard.

Installation Procedure

⚠ CAUTION

FTV hoses are specifically designed, DO NOT use hose material or length other than the OEM specified parts

3. Reinstall hose at the FTV and LPR and push locks in place.
4. Start engine and check for leaks.

ENGINE CONTROL MODULE REPLACEMENT

1. Disconnect Negative battery cable.
2. Remove controller from mounting bracket.
3. Push connector lock back to unlock connector.
4. Unplug controller and remove.

Installation Procedure

NOTE

Controller is calibrated for each engine verify you have the correct controller

.

5. Plug connector into controller.
6. Push lock into place.
7. Mount controller into mounting bracket.
8. Reconnect the battery cable.
9. Install Diagnostic service tool.
10. Start engine.
11. Check for any DTC codes and clear.
12. Verify engine is in closed loop and no MIL lights are present.

HEATED EXHAUST GAS OXYGEN SENSOR REPLACEMENT

1. Disconnect the O-2 sensor electrical connector.
2. Using a O-2 Sensor socket remove the O-2 Sensor and discard.

Installation Procedure

NOTE

Before install the O-2 sensor lubricate threads with anti-seize compound GM P/N 5613695 or equivalent. Avoid getting compound on the sensor tip.

3. Install O-2 sensor.

   Tighten
   41 N•m (30 lb-ft)
4. Start engine.
5. Check for any DTC codes and clear.
6. Verify engine is in closed loop and no MIL lights are present.

THREE WAY CATALYTIC CONVERTER MUFFLER REPLACEMENT

1. Remove the TWC muffler using the OEM end product processes.

Installation Procedure

NOTE

The Three Way Catalytic converter is specifically designed to meet the emission control of the certified engine. Use only the OEM specified parts.

2. Install the TWC muffler using the OEM end product processes.
3. Start engine.
4. Check for any DTC codes and clear
5. Verify engine is in closed loop and no MIL lights are present.

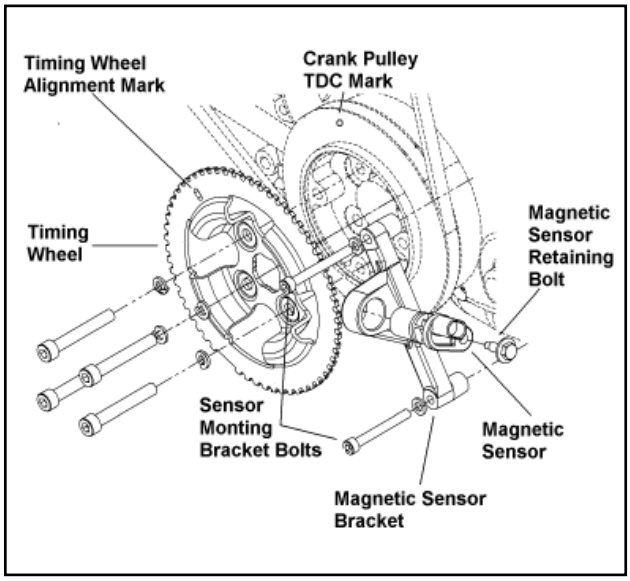


Figure 5 Timing Wheel

MAGNETIC SENSOR REPLACEMENT
Figure 5

1. Disconnect the Magnetic Pickup sensor electrical connector.
2. Remove the one (1) retaining bolt and retain.
3. Remove sensor.

Installation Procedure

NOTE

Remove any debris from the timing wheel.

4. Install the Magnetic pickup into the bracket.
5. Secure using one retaining bolt and tighten to specification.

   Tighten
   9 N•m (80 lb-in)

6. Adjust air gap of Magnetic Pickup, Refer to *Magnetic Pickup Air Gap Adjustment.*
7. Start engine.
8. Check for any DTC codes and clear.
9. Verify engine is in closed loop and no MIL lights are present.

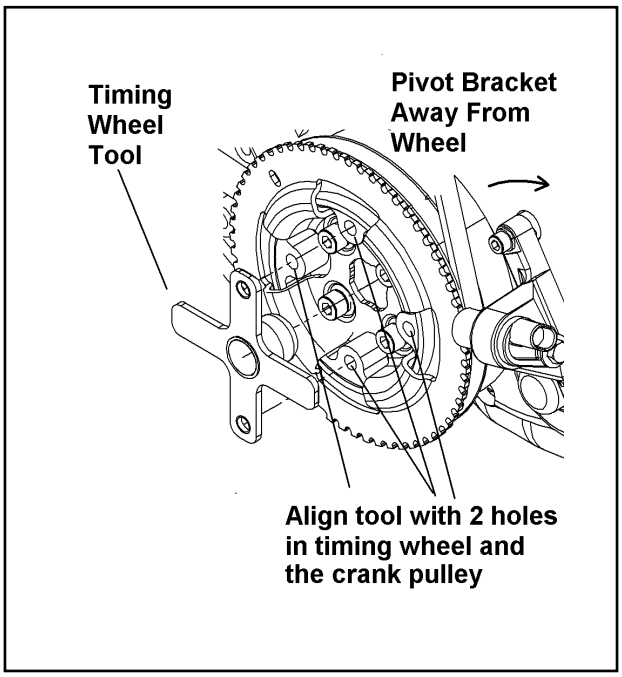


Figure 6 Removing Timing Wheel

TIMING WHEEL REPLACEMENT
Figure 6

1. Remove the four retaining bolts and lock washer and retain.
2. Remove the timing wheel.

Installation Procedure

NOTE

Remove any debris from the magnetic sensor.

3. Loosen the top and bottom Sensor Bracket bolts slightly and pivot the bracket away from the timing wheel.
4. Locate the timing wheel to the pulley by aligning the slot in the timing wheel with the TDC mark on the crankshaft pulley.
5. Re-install the 4 retaining bolt and lockwashers. Install hand tight only.
6. Insert the timing wheel installation tool into the timing wheel. Hold tool against the face of the crank pulley. Bolts can be used to

hold the tool in place if necessary. Center the timing wheel to the pulley.

7. Timing wheel should have very little.
8. Install the four (4) bolts and tighten to specification.

   Tighten
   9 N•m (80 lb-in)
9. Remove the timing wheel tool.
10. Adjust air gap of Magnetic Pickup, Refer to *Magnetic Pickup Air Gap Adjustment.*
11. Start engine.
12. Check for any DTC codes and clear.
13. Verify engine is in closed loop and no MIL lights are present.

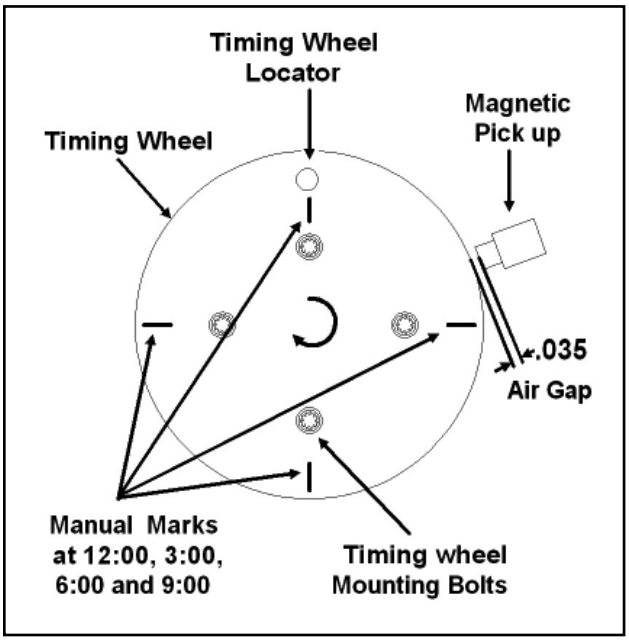


Figure 7 Installing Timing Wheel

TIMING WHEEL REPLACEMENT WITHOUT SPECIAL TOOL

Figure 6

1. Remove the four retaining bolts and lock washer and retain.
2. Remove the timing wheel.

Installation Procedure

NOTE

Remove any debris from the magnetic sensor.

3. Rotate crankshaft to position the TDC mark at 12:00.
4. Align the locator mark on the timing wheel with the TDC mark on the crankshaft pulley.
5. Install the four securing bolts and hand tighten.
6. Using a marker mark the timing wheel at 12:00, 3:00, 6:00, and 9:00 positions.
7. Place a .035 Brass feeler gauge between the sensor and the timing wheel with the crankshaft at 12:00 and insure feeler gauge moves in and out freely.
8. Rotate the crankshaft to each of the marked positions and insure feeler gauge moves in out freely.
9. If the gauge does not move freely at each of four marks loosen the four timing wheel retaining bolts and reposition the timing wheel and re secure hand tight and re-check air gap.
10. Recheck air gap at all mark positions and tighten the four (4) retaining bolts to specification.

    Tighten
    9 N•m (80 lb-in)

MAGNETIC PICKUP SENSOR AIR GAP ADJUSTMENT

Figure 7

1. Loosen the top and bottom Sensor Bracket bolts slightly and pivot the bracket away from the timing wheel

Installation Procedure

NOTE

Remove any debris from the magnetic sensor

2. Place a .035 Brass feeler gauge between the Magnetic pickup and the timing wheel and pivot the bracket to the timing wheel.
3. Secure the two bracket bolts and tighten to specification.

   Tighten
   9 N•m (80 lb-in)
4. Remove the feeler gauge.
5. Start engine.
6. Check for any DTC codes and clear.
7. Verify engine is in closed loop and no MIL lights are present.