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MS41.1/MS41.2

Models: E36/E39/Z3 - MS41.1 with M52 Engine
E36 M3 - MS41.2 with S50B32 Engine

Production Date: 1996-1999

Manufacturer: Siemens

Pin Connector: 88 Pins

Objectives of the Module

After completing this module, you will be able to:

- Understand Secondary Air Injection
- Describe Running Losses Fuel Supply System
- Understand Evaporative Emissions Leak Detection
- Describe the Knock Sensor Function
- Name Two Types of Emissions the ECM Controls
- Describe What is required to Illuminate the “CHECK ENGINE” Light
- Describe How the Secondary Ignition is Monitored for Misfire Detection
- Understand A/C Compressor Control

MS41.1/MS41.2

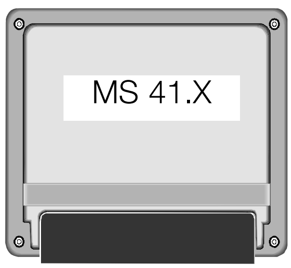
Purpose of the System

The MS41.X system manages the following functions:

Air:
- **Idle Speed Valve**
- **Throttle Position**
- **Hot Film Air Mass Meter**

Fuel:
- **Fuel Supply**
- **Running Losses (Introduced on E39 9/97)**
- **Fuel Injection**

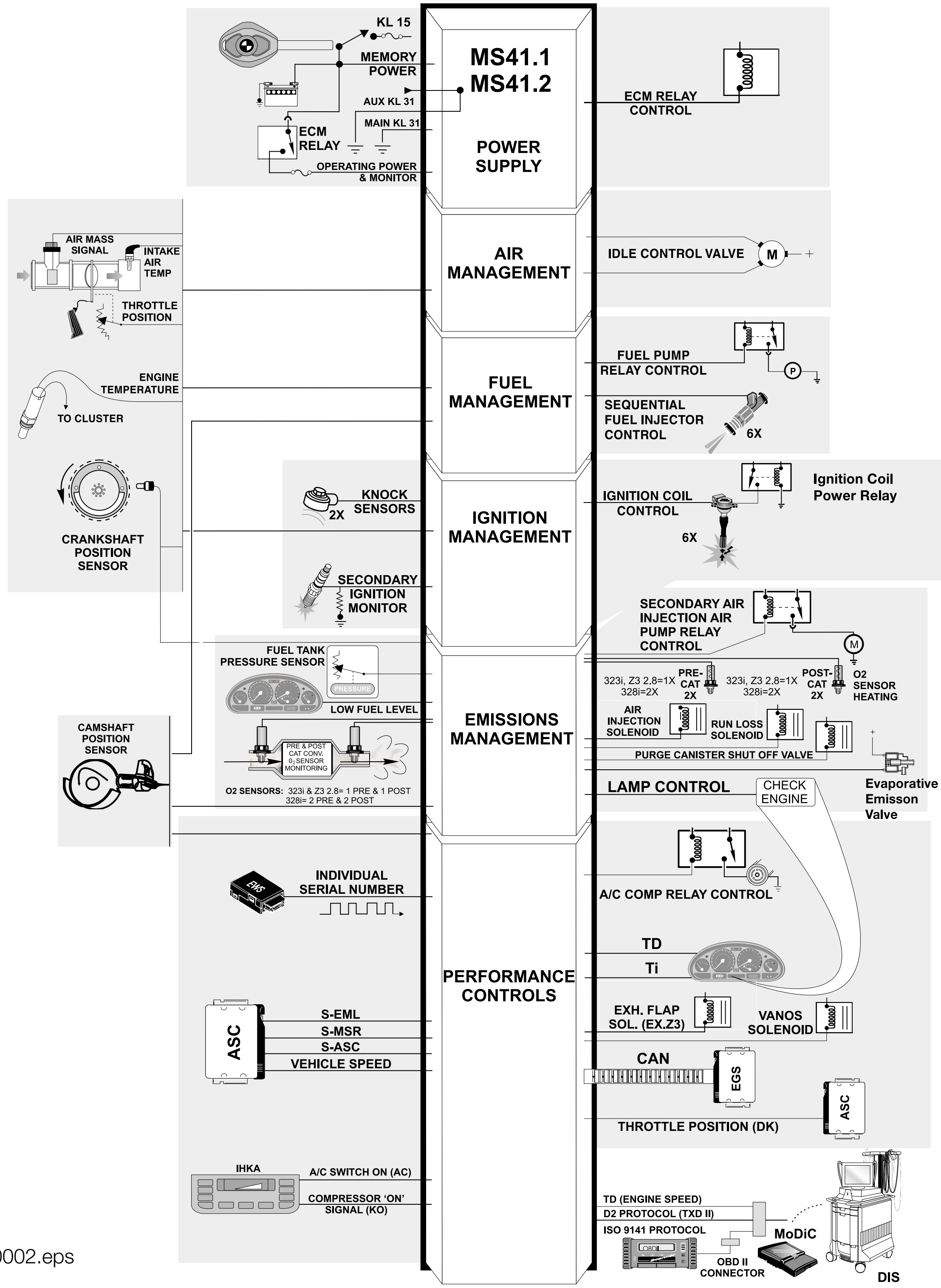
Ignition:
- **Direct Ignition**
- **Knock Control**
- **Primary/Secondary Ignition Monitoring**



Emissions:
- **OBD II Compliant**
- **Secondary Air Injection**
- **Pre and Post Oxygen Sensors**
- **Oxygen Sensor Heating**
- **Misfire Detection**
- **Evaporative Emission Control and Leak Detection**
- **Barometric Pressure Sensing (E39 9/97)**
- **CHECK ENGINE Light**

Performance Controls:
- **VANOS Control**
- **Output of Injection Signal (Ti) for MPG Gage**
- **Output of Engine RPM (TD) for Tachometer**
- **A/C Compressor Control**
- **CAN Bus Communication**
- **ASC Interfacing**
- **EWS II**
- **Exhaust Flap Control**
- **ECM Programming**

System Components: INPUTS - PROCESSING - OUTPUTS



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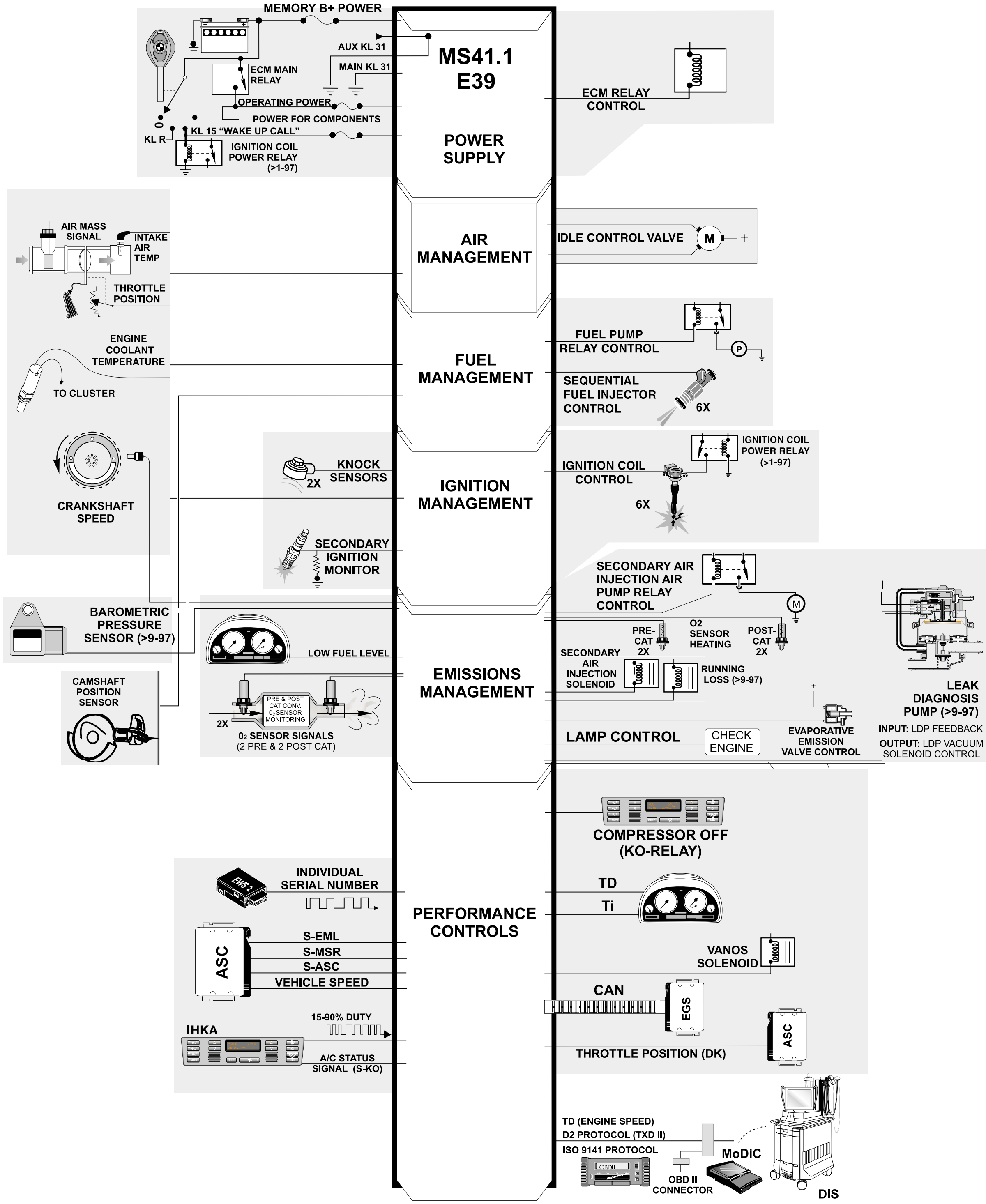
System Components: INPUTS - PROCESSING - OUTPUTS



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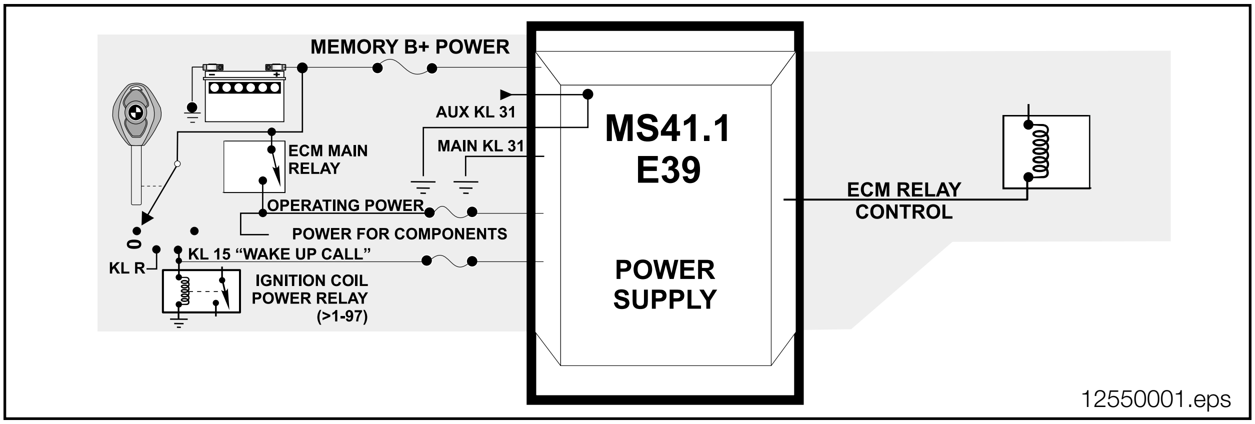
Power Supply



KL30 - Battery Voltage: It supplies the operating voltage to the ECM. The ECM contains a "EEPROM" that will store data in the event of power loss (battery disconnected).

KL15 - Ignition Switch: When the ignition is switched "on" the ECM is informed that the engine is about to be started. KL15 also supplies voltage to the Engine Control Module Relay. Switching KL15 "off" removes the ECM operating voltage.

Engine Control Module Relay: It provides the operating voltage for:

• ECM	• Fuel Pump Relay
• Fuel Injectors	• Oxygen Sensor Heating
• Idle Speed Valve	• EGS (and ASC on E39)
• Evaporative Emission Valve/Air Inlet Shut Off Valve	• Hot Film Air Mass Sensor
• Exhaust Flap Solenoid	• Secondary Air Pump Relay
• VANOS Solenoid	• Secondary Air Injection Solenoid
• Running Losses Solenoid	

Ground: Multiple ground paths are necessary to complete current flow through the ECM. The ECM ground pin numbers and functions are:

Pin#	Ground
04, 28, 32, 34, 56	ECM
07	Hot Film Air Mass Sensor
38	Knock Sensor Shielding
39	Temperature Sensors
40	Crankshaft Position/RPM sensor and Fuel Tank Pressure Sensor
41, 64	Camshaft Position Sensors Shielding
42	Throttle Position Sensor

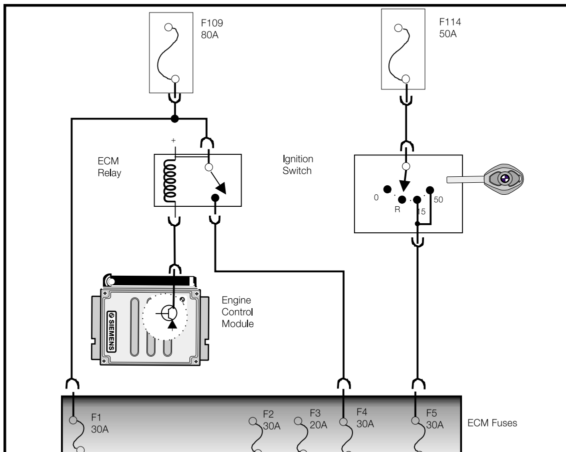
Principle of Operation

Battery Voltage is monitored by the ECM for fluctuations. It will adjust the output functions to compensate for a lower (11.7v) and higher (14v) voltage value. For example, the ECM will:

• Modify Pulse Width Duration of Fuel Injection
• Modify Dwell Time of Ignition

The E39 Power Supplies (KL15 and ECM Relay) are fused to the MS41.1 ECM.

The fuses are housed in the Engine Fuse Block located in the Electronics Box.



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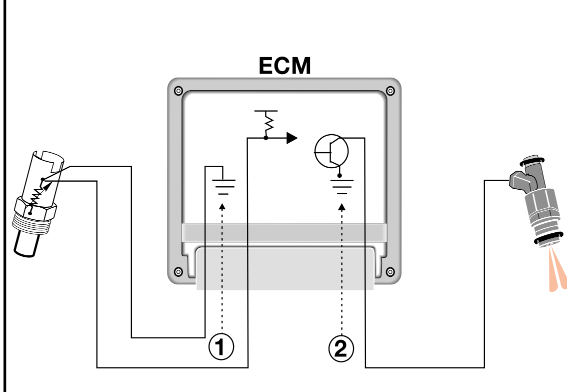
When **KL15** is switched “on” the ECM is ready for engine management. The ECM will activate ground to energize the Engine Control Module Relay. The Engine Control Module Relay supplies operating voltage to the ECM and the previously mentioned operating components.

When **KL15** is switched “off” the ECM operating voltage is removed. The ECM will maintain a ground to the Engine Control Module Relay for a few seconds.

Ground is required to complete the current path through the ECM. The ECM also:

• Internally links a constant ground (1) to the engine sensors.
• Switches gound (2) to activate components.



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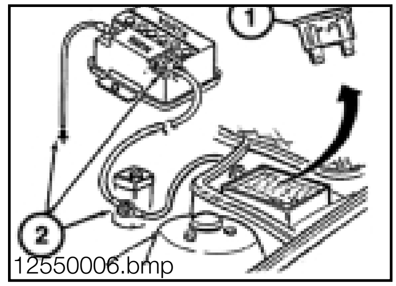
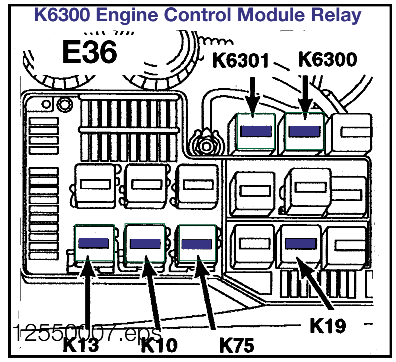
Workshop Hints



Power Supply - Testing

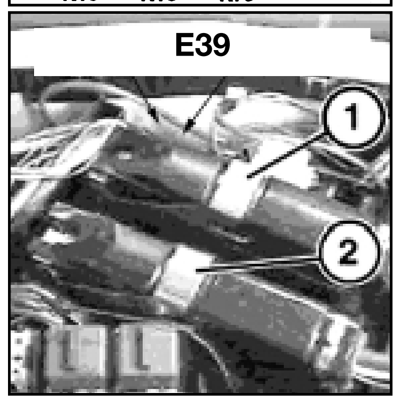
Inadequate power and ground supply can result in:

• No Start
• Hard Starting (Long Crank Times)
• Inaccurate Diagnostic Status or ECM Not Found
• Intermittant/Constant "CHECK ENGINE" Light
• Intermittant/Constant Driveability Problems

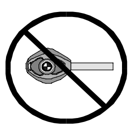


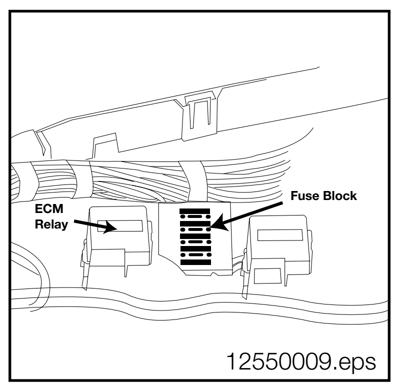
Power supply including fuses should be tested for:

• Visual (1) Blown Fuse
• Available Voltage 2
• Voltage Drop (Dynamic Resistance) (2)
• Resistance of Cables and Wires (2)



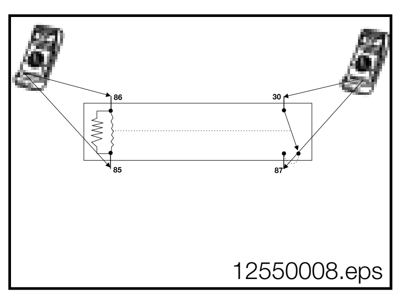
The ignition (KL15) must be switched off when removing or installing the ECM connector to prevent voltage spikes (arcing) that can damage the Control Module!





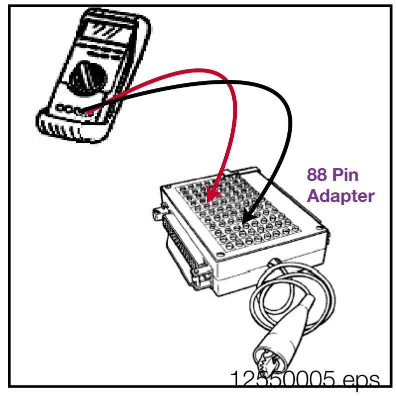
The Engine Control Module Relay (E36 located in the fuse box, Z3/E39 in the Electronics Box) should be tested for:

• Battery Voltage and Switch Ground (1)
• Resistance (1)
• Battery Voltage and Voltage Drop (2)



Tools and Equipment

Power Supply



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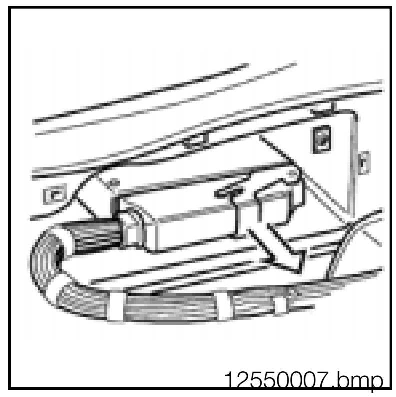
When testing power supply to an ECM, the DIS/MoDIC multimeter function as well as a reputable hand held multimeter can be used.

It is best to make the checks at the ECM connection, this method includes testing the wiring harness.

E36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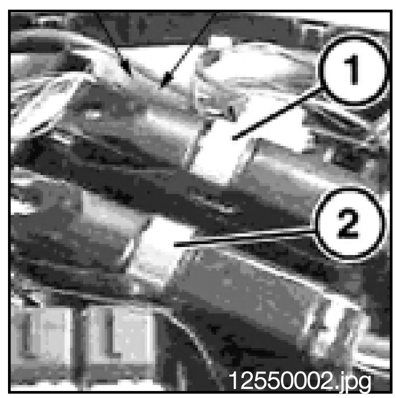
The correct Universal Adapter for the MS41.X application should be used (#88 88 6 614 410). This will ensure the pin connectors and the harness will not be damaged.

The interior of this Universal Adapter is shielded, therefore it is vital that the ground cable is connected to the vehicle chassis whenever the adapter is used.

The adapter uses a Printed Circuit board inside keeping the capacitive and inductive load to a minimum.

E39 (1)= ECM



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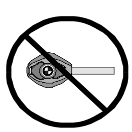
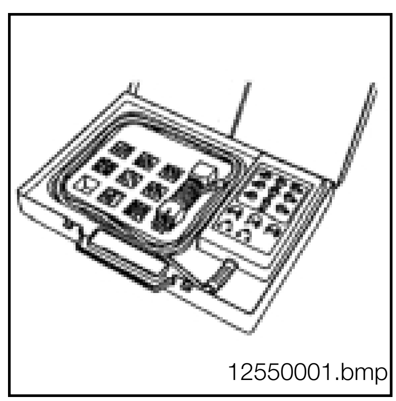
When installing the Universal Adapter to the ECM (E36 located below the windshield on the passenger side of the engine compartment, Z3/E39 in the Electronics Box), make sure the ignition is switched off.



The Engine Control Module **Relay** should be tested using the relay test kit (P/N 88 88 6 613 010) shown on the right.

This kit allows testing of relays from a remote position.

Always consult the ETM for proper relay connections.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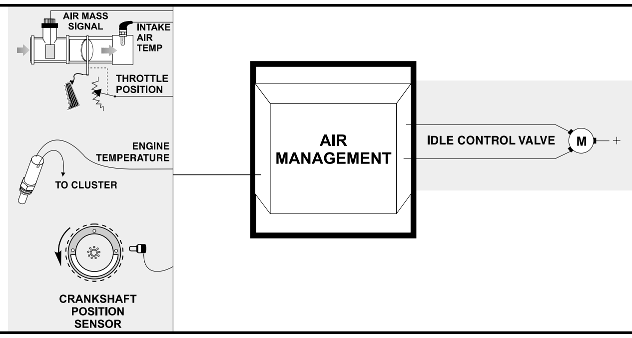
Air Management



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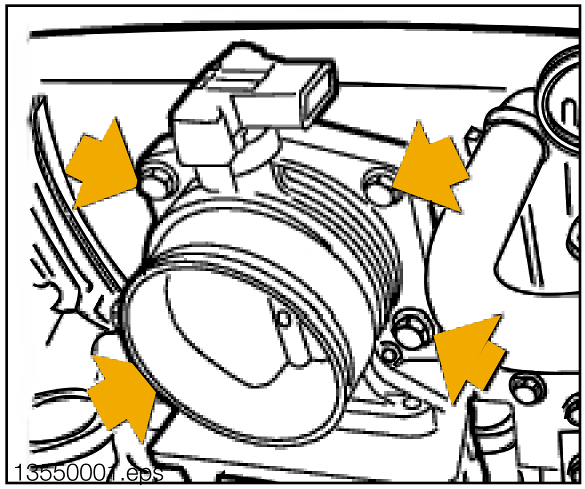
Throttle Valve: The mechanical throttle valve regulates the intake air flow and it is linked by a cable to the accelerator pedal.

The throttle housing is secured to the intake manifold by four bolts (arrows).

The throttle valve is heated by engine coolant to prevent condensation from “icing”. The throttle valve is “preset” and should not be adjusted.



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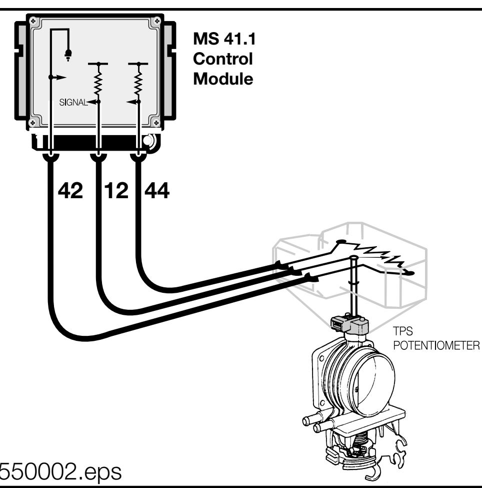
Throttle Position Sensor: A potentiometer is mounted on the throttle housing which provides the ECM with a voltage value (0-5v) that represents throttle angle position and rate of movement. The sensor receives its power supply from the ECM.

The Potentiometer is non-adjustable because the ECM “learns” the throttle angle voltage at idle speed. If the throttle position sensor is replaced, the adaptations must be cleared using the DIS/MoDIC.



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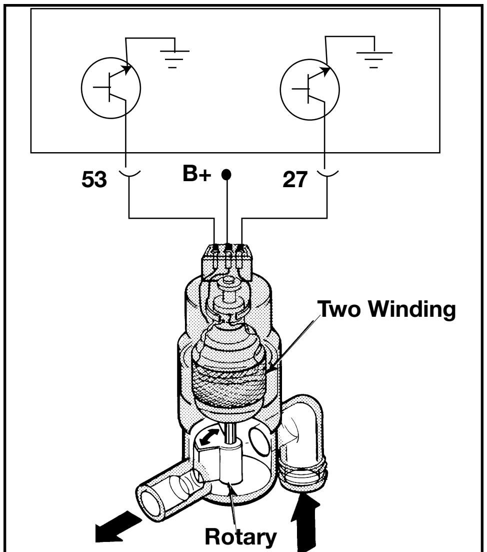
If this input is defective, a fault code will be stored and the “CHECK ENGINE” Light will be illuminated when the OBD II criteria is achieved. The ECM will still operate the engine using the Hot-Film Air Mass Meter and Engine RPM inputs.

Idle Speed Control Valve: This valve regulates air by-passing the throttle valve to control the engine idle speed.



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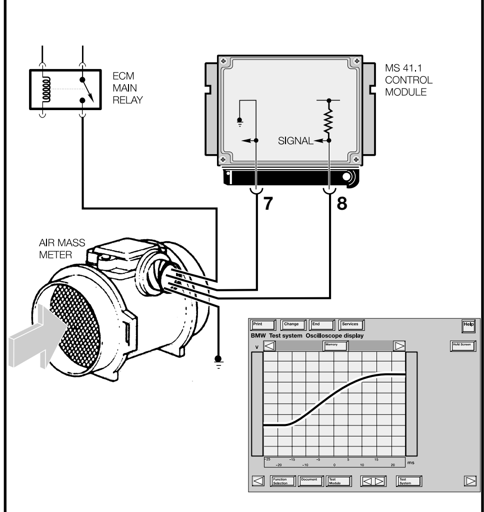
The valve is supplied with battery voltage from the ECM Relay. The Idle Air Actuator is a two-coil rotary actuator. The ECM is equipped with two final stage transistors which will alternate positioning of the actuator.

The final stages are "pulsed" simultaneously by the ECM which provides ground paths for the actuator. The duty cycle of each circuit is varied to achieve the required idle RPM.

If this component/circuits are defective, a fault code will be set and the “CHECK ENGINE” Light will be illuminated when the OBD II criteria is achieved.

Hot-Film Air Mass Meter (HFM): The air volume input signal is produced electronically by the HFM which uses a heated metal film (180º C above intake air temperature) in the air flow stream.



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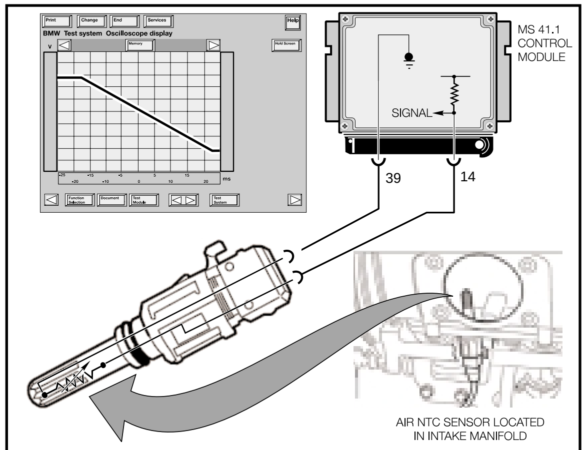
The ECM Relay provides the operating voltage. As air flows through the HFM, the film is cooled changing the resistance which affects current flow through the circuit. The sensor produces a 1-5 volt varying signal. Based on this change the ECM monitors and regulates the amount of fuel injected.

If this input is defective, a fault code will be set and the “CHECK ENGINE” Light will be illuminated when the OBD II criteria is achieved. The ECM will operate the engine using the Throttle Position and Engine RPM inputs.

NOTE: The HFM is non-adjustable.

Air Temperature Signal: This signal is needed by the ECM to correct the air volume input for changes in the intake air temperature. The sensor is located in the intake manifold behind the throttle housing.



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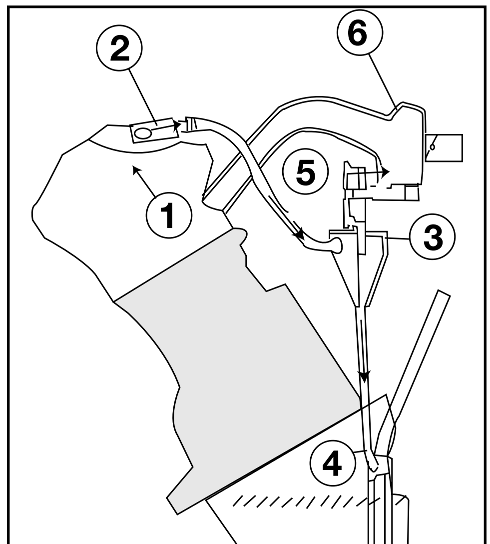
The ECM provides the power supply to this component. The sensor decreases in resistance as the temperature rises and vice versa (NTC). The ECM monitors the applied voltage (5v), as air temperature changes the resistance value the voltage signal will vary (0-5v).

If this input is defective, a fault code will be set and the "CHECK ENGINE" Light will be illuminated when the OBD II criteria is achieved. The ECM will operate the engine using the Engine Coolant Sensor input.



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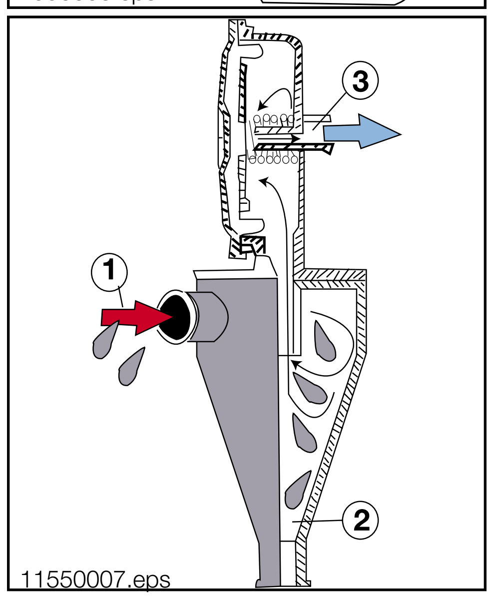
Pressure Control Valve: The pressure control valve varies the vacuum applied to the crankcase ventilation depending on engine load. The valve is balanced between spring pressure and the amount of manifold vacuum.

The oil vapors exit the separator labyrinth (2) in the cylinder head cover (1). The oil vapors are drawn into the cyclone type liquid/vapor separator (3) regulated by the pressure control valve (5). The collected oil will drain back into the oil pan (4).

At idle when the intake manifold vacuum is high, the vacuum reduces the valve opening allowing a small amount of crankcase vapors to be drawn into the intake manifold. At part to full load conditions when intake manifold vacuum is lower, the spring opens the valve and additional crankcase vapors are drawn into the intake manifold.



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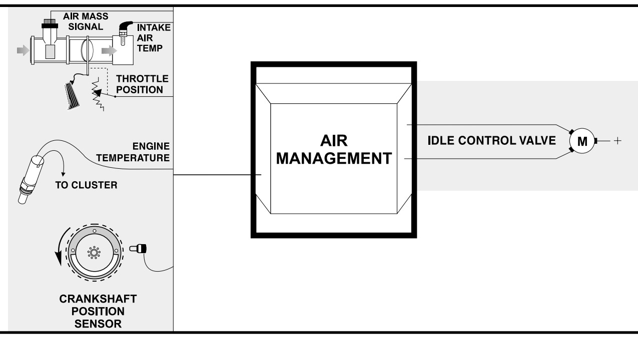
1. Engine Oil Vapors
2. Collective Drain Back Oil
3. Oil Vapors to the Intake Manifold

Principle of Operation

Air flow into the engine is regulated by the Throttle Valve or the Idle Speed Control Valve. Both of these air "passages" are necessary for smooth engine operation from idle to full load. On the MS41.X system, the Throttle Valve is **mechanically controlled** and the Idle Speed Control Valve is **electrically controlled**. All of the ECM monitoring, processing and output functions are a result of regulated air flow.



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The Throttle Position Sensor is monitored by the ECM for throttle angle position and rate of movement. As the throttle plate is opened, a rising voltage signal (up to 5v) requests acceleration and at what rate. The ECM will increase the volume of fuel injected into the engine, advance the ignition timing and decrease the Idle Speed Valve opening (air is now going by the throttle plate). The "full throttle" position indicates maximum acceleration to the ECM and in addition to the functions just mentioned, this will have an effect on the airconditioning compressor (covered in Performance Controls).

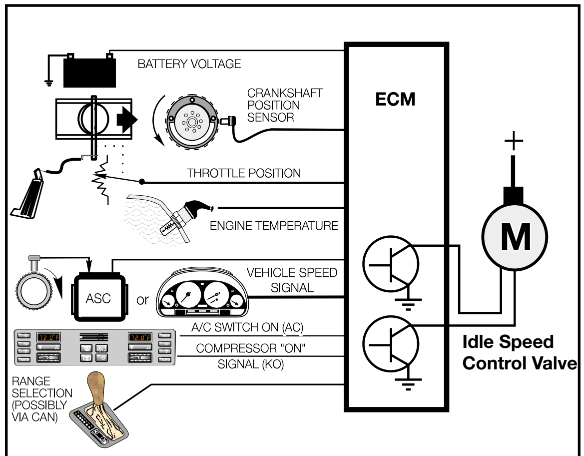
As the throttle plate is closed (integral springs), a decrease in voltage signals the ECM to activate fuel shut off if the rpm is above idle speed (coasting). The Idle Speed Control Valve will then be opened to maintain idle speed.

The ECM monitors the engine idle speed in addition the Throttle Position Sensor voltage. The voltage value is "learned" at the correct idle speed and if the voltage value has changed (mechanical wear of throttle plate or linkage), the ECM will adjust the Idle Speed Control Valve to maintain the correct idle speed based on the "new" voltage (the adaptations must be cleared using the DIS/MoDIC). If the Throttle Position input is defective, a fault code will be set and the "CHECK ENGINE" Light will illuminate when the OBD II criteria is achieved. The ECM will maintain engine operation based on the Hot-Film Air Mass Sensor and the Engine RPM Sensor.

The Idle Speed Control Valve is controlled by the ECM modulating the ground circuits to the two windings for opening and closing. By varying the duty cycle applied to the windings, the valve can be progressively opened or held steady to maintain the idle speed. If the Idle Speed Control Valve circuit is defective, a fault code will be set and the "CHECK ENGINE" Light will illuminate when the OBD II criteria is achieved.

There are additional factors that influence the ECM in regulating idle speed:

- **The Rpm sensor input allows the ECM to monitor engine speed because of loads that cause idle fluctuations due to drag on the engine: power steering, thick oil (friction forces), etc.**
- **Cold engine temperature (coolant NTC) provides higher idle speed to raise temperature sooner.**
- **Vehicle speed informs ECM when the vehicle is stationary and requires idle maintenance.**
- **A/C on request from the climate control system (arming the ECM) and compressor engage (stabilize idle speed) acknowledgment.**
- **Range selector provides a Park/Neutral input to the ECM identifying when the vehicle is in a drive gear. This signal allows idle stabilizaton for the increased load on the engine.**



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The Hot-Film Air Mass Sensor sends a varying voltage (0-5v) to the ECM representing the measured amount of intake air volume. This input is used by the ECM to determine the amount of fuel to be injected. If this input is defective, a fault code will be set and the “CHECK ENGINE” Light will illuminate when the OBD II criteria is achieved. The ECM will maintain engine operation based on the Throttle Position Sensor and Engine Speed Sensor.

The Air Temperature Signal allows the ECM to make a calculation of intake air temperature. The varying voltage input from the NTC sensor indicates the larger proportion of oxygen found in cold air, as compared to less oxygen found in warmer air. The ECM will adjust the amount of injected fuel because the quality of combustion depends on oxygen sensing ratio.

The ignition timing is also affected by air temperature. If the intake air is hot the ECM retards the base ignition timing to reduce the risk of detonation. If the intake air is cooler, the base ignition timing will be advanced. If this input is defective, a fault code will be set and the “CHECK ENGINE” Light will illuminate when the OBD II criteria is achieved.

Workshop Hints

Air Management

Unmetered air leaks can be misleading when diagnosing faults causing Check Engine Light/driveability complaints. Refer to S.I. #11 03 92 (3500) for testing intake vacuum leaks.

Crankcase Ventilation System

A fault in this system can often "mislead" diagnosis. This type of fault can produce:

• Mixture/Misfire Defect Codes
• Whistling Noises
• Performance/Driveabiltity Complaints

Please refer to the following Service Information Bulletins for details on the Crankcase Ventilation System:

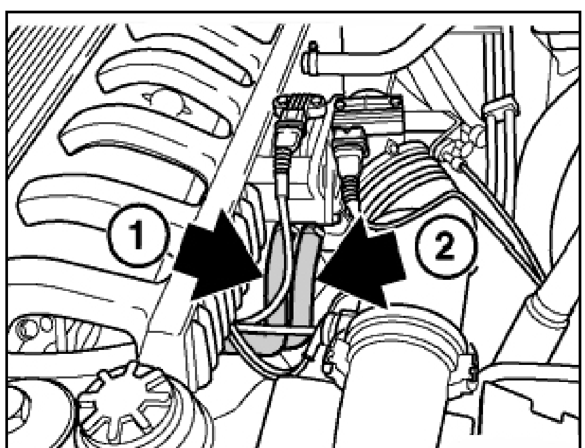
• Crankcase Ventilation System Check S.I. #11 05 98

Throttle Valve and Throttle Position Sensor

These components are non-adjustable and tampering is not permitted. However, the attaching throttle and cruise control cables should be adjusted (refer to Repair Instructions).

Please refer to the following Service Information Bulletins for details on the Throttle Valve Housing:

• Service Action = Throttle Body Heater - Coolant Hose SI #13 02 97



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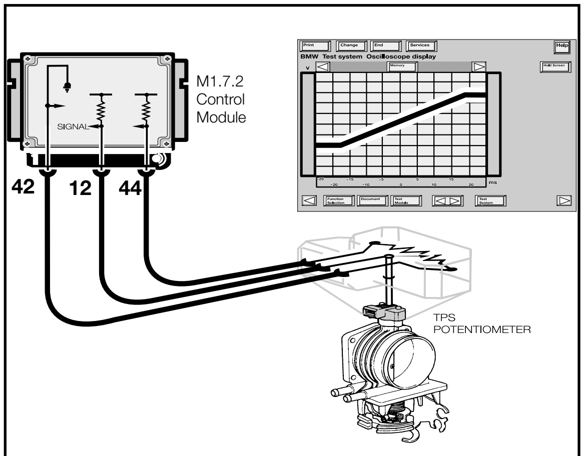
Throttle Position Sensor - Testing

The Throttle Position Sensor (potetiometer) can be tested with the following methods:

- **DIS Status Page (approx. 0.6v idle to 4.2v full throttle)**
- **DIS Oscilloscope - Select from the Preset Measurements which requires taking the measurements with the ECM and Universal Adapter with the ECM disconnected. (approx. 1-4 k ohms).**
- **Resistance check of the entire circuit, using the Universal Adapter with the ECM disconnected (approx. 1-4 k ohms).**



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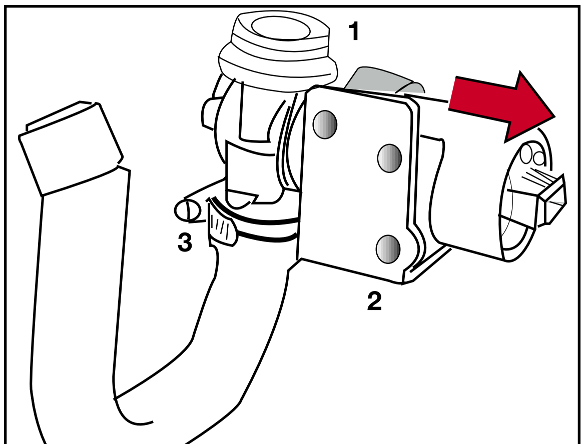
Idle Speed Control Valve - Testing

- **The Idle Speed Control Valve and idle air circuit (passage ways) should be checked for physical obstructions. Visually inspect the sealing gasket (1), mounting (2) and air hose clamps (3).**
- **The resistance of the valve winding should be checked.**
- **The ECM output and Idle Speed Control Valve operation can be tested by "Component Activation" on the DIS/MoDIC.**
- **The Pulse Width Modulated ground outputs from the ECM can be tested using the DIS/ MoDIC Oscilloscope.**
- **Consult Technical Data for specified idle speed.**



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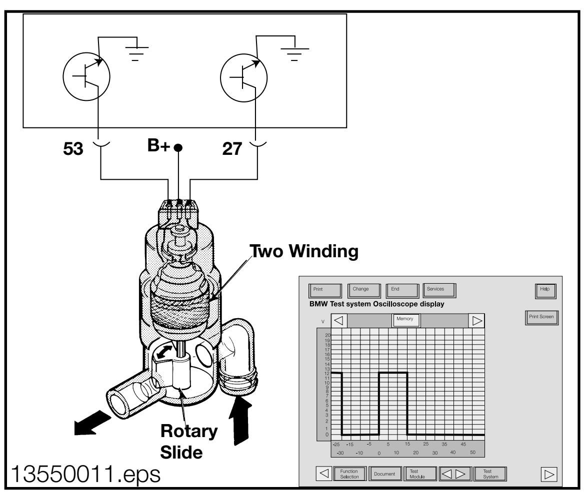

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NOTE: If the valve is blocked or contaminated, An HFM fault code will also be present!

Hot-Film Air Mass Sensor

This component is non-adjustable and tampering is not permitted.

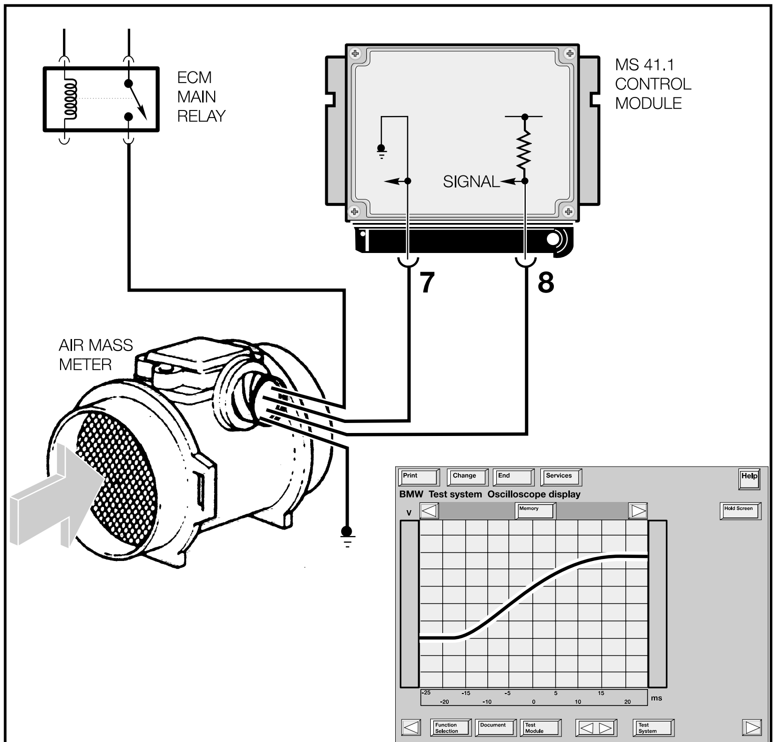
A faulty Hot-Film Air Mass Sensor can produce the following complaints:

• Difficult To Restart When Engine Is Hot
• Engine Starts Then Stalls
• "CHECK ENGINE" Light Illuminated
• Engine Starts And Runs Only With Accelerator Pedal Depressed

Testing:

The Hot-Film Air Mass Sensor can be tested with the following methods:

• DIS/MoDIC Fault Code and Component Testing.
• DIS Status Page
• DIS Oscilloscope - which requires taking the measurement with the ECM and the Universal Adapter connected to the circuit (engine running).



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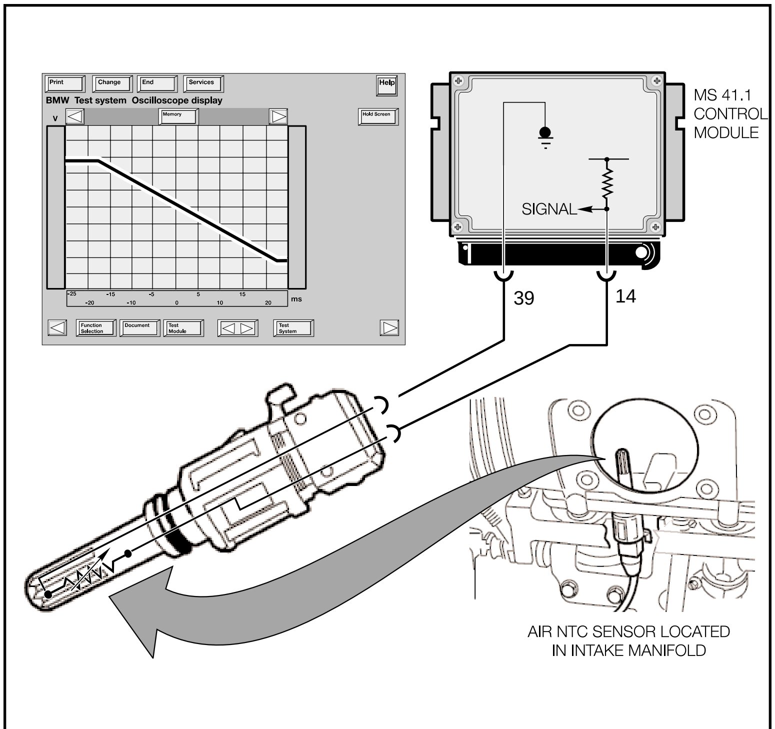
NOTE: Visually inspect the sensor for damaged, missing or blocked screens. The screens affect air flow calibration. Also inspect the sealing rings where the sensor inserts in the air filter housing and intake boot. Ensure the pin connections are tight.

Air Temperature Signal - Testing

NTC sensors decrease in resistance as the temperature rises and vice versa. The ECM monitors the sensor voltage which varies as temperature changes the resistance value. For example, as temperature rises:

• Resistance through the sensor decreases.
• Voltage drop across the sensor decreases.
• Input signal voltage also decreases (5 - 0v)



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This Sensor should be tested using:

• DIS/Modic Status page
• DIS/Modic Multimeter 2.2 - 2.7 k ohms at 20º C

Tools and Equipment

The DIS/Modic as well as a reputable hand held multimeter can be used when testing inputs/ components.

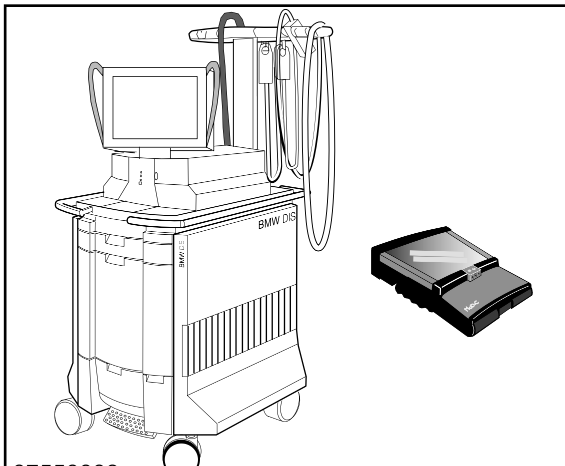
It is best to make the checks at the ECM connection, this method includes testing the wiring harness.

The correct Universal Adapter for the MS41.X application should be used (#88 88 6 614 410). This will ensure the pin connectors and the harness will not be damaged.

The interior of this Universal Adapter is shielded, therefore it is vital that the ground cable is connected to the vehicle chassis whenever the adapter is used.

The adapter uses a Printed Circuit board inside keeping the capacitive and inductive load to a minimum.

When installing the Universal Adapter to the ECM (E36 located below the windshield on the passenger side of the engine compartment, Z3/E39 in the Electronics Box), make sure the ignition is switched off.



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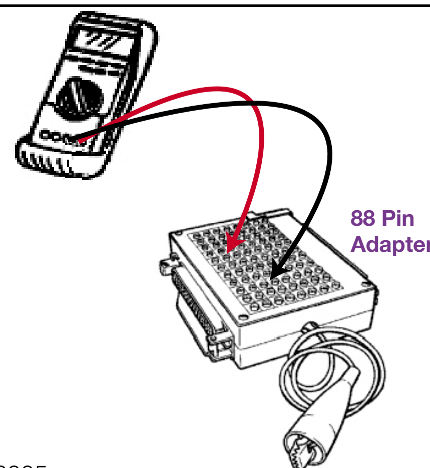

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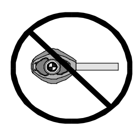
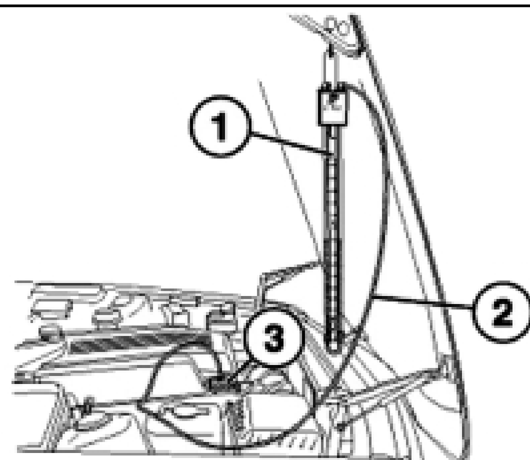


The Slack Tube Manometer Test Tool (#99 00 0 001 410) should be used to troubleshoot crankcase ventilation valves.



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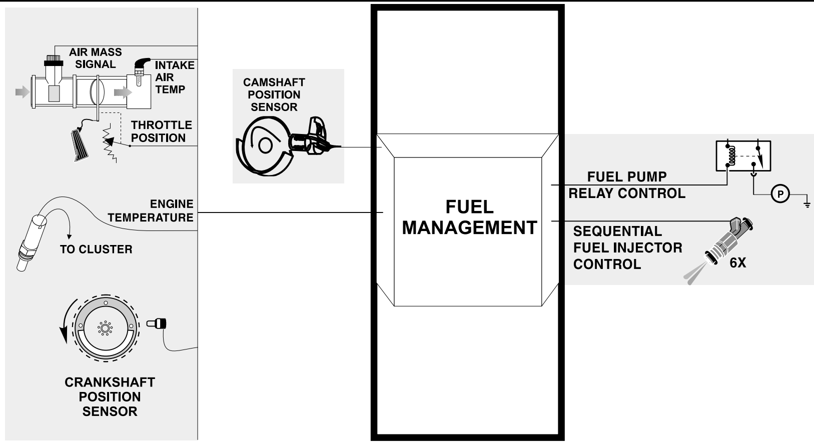
Fuel Management



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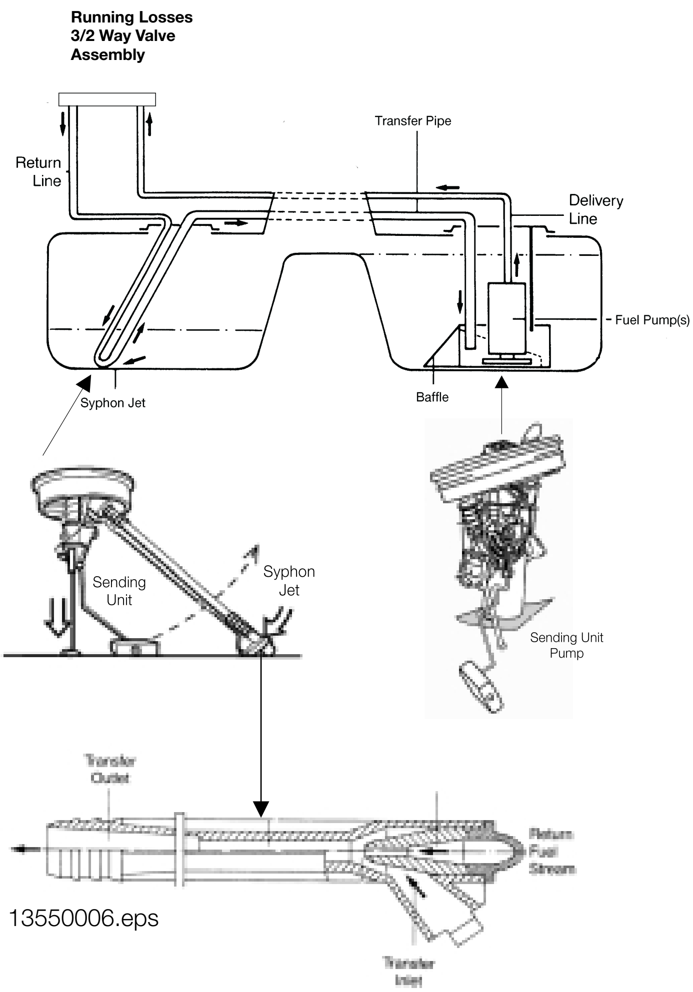
Fuel Tank: The fuel tank is made of high density polyethylene (reduced weight) which is manufactured to meet safety requirements.

A mid-chassis mounted "saddle" type tank is used (E36/ E39) which provides a tunnel for the driveshaft but creates two separate low spots in the tank.

A Syphon jet is required with this type of tank to transfer fuel from the left side, linked to the fuel return line.

As fuel moves through the return, the siphon jet creates a low pressure (suction) to pick up fuel from the left side of the tank and transfer it to the right side at the fuel pick up.



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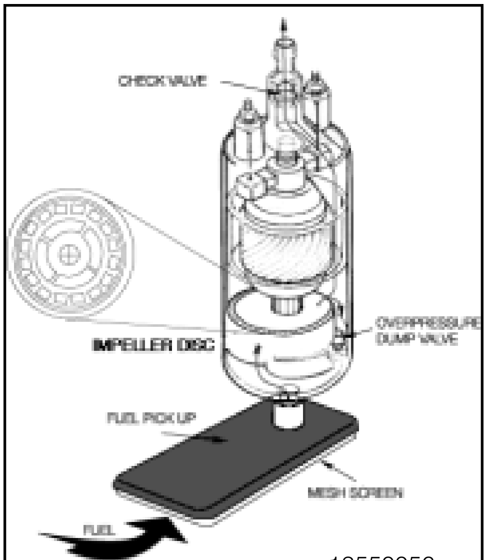
The Z3 uses a conventional type fuel tank that is mounted between the seats and the luggage compartment. The Z3 has a single sending unit that (with the fuel pump) is accessed from behind the passenger seat.

Fuel Pump: The electric fuel pump supplies constant fuel volume to the injection system. This system uses a single submersable (in the fuel tank) pump. The inlet is protected by a mesh screen.



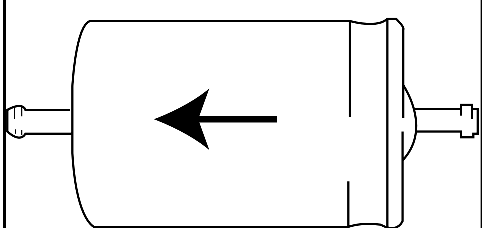
13550056.eps

When the fuel pump is powered, the armature will rotate the impeller disc creating low pressure at the inlet. The fuel will be drawn into the inlet and passed through the fuel pump housing (around the armature). The fuel lubricates and cools the internals of the pump motor.

The fuel will exit through a non-return check valve to supply the injection system. The non-return check valve is opened by fuel exiting the pump and will close when the pump is deactivated. This maintains a "prime" of fuel in the filter, lines, hoses and fuel rail.

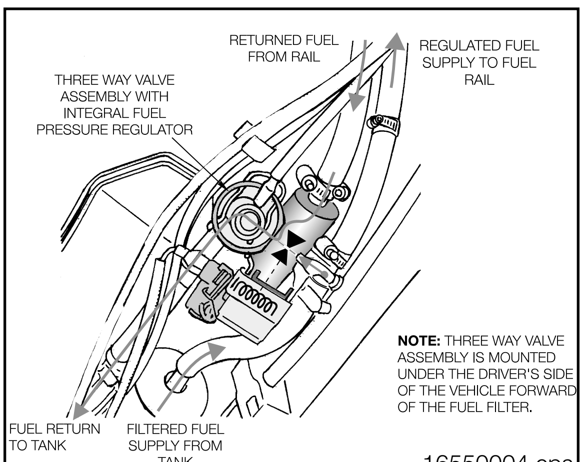
The pump contains an internal overpressure relief valve that will open (reducing roller cell pressure) if there is a restriction in the fuel supply hardware.

Fuel Supply Components: The fuel is transfered from the fuel pump to the fuel filter. The fuel filter "traps" contaminents before they reach the fuel injectors and should be replaced at the specified interval. The arrow on the filter denotes the installation direction (under the driver side floor). The large filter size also serves as a volume reservoir for pressurized fuel (dampening fuel pump pulsations).


16550005.eps

Running Losses refers to the fuel vapors that can escape to the atmosphere during vehicle operation. The fuel pump delivers more volume than the injection system requires. The unused fuel is routed through a return line to the tank at the fuel pressure regulator integrated in the Running Losses 3/2 Way Valve under the driver side floor. The fuel is constantly circulated in this manner.

Using the by-pass type regulator reduces the returned fuel temperature to the tank.



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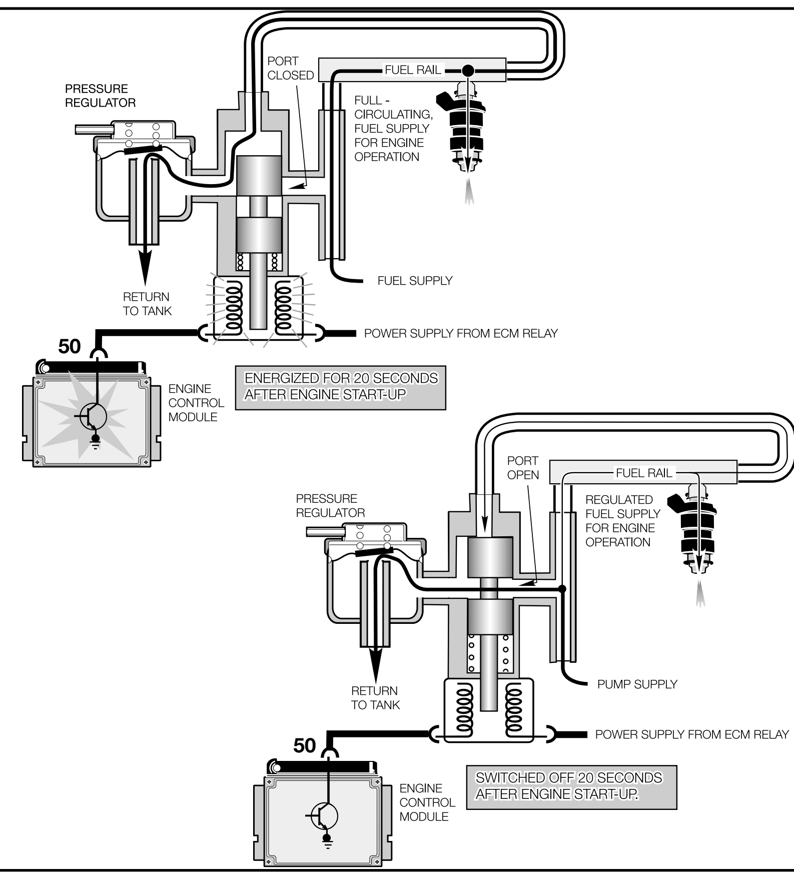
Running Losses Fuel Supply: The ECM controls the operation of the Running Losses Fuel Circuit by activating the by-pass solenoid. The solenoid is energized for 20 seconds on engine start up to supply full fuel volume to the fuel rail. After 20 seconds, the solenoid is deactivated and sprung closed (the by-pass is opened). This reduces the amount of fuel circulating through the fuel rail and diverts the excess to return through the fuel pressure regulator.

The fuel injectors are provided with regulated fuel for injection but the returned fuel by-passes the engine compartment fuel rail thus lowering the temperature and amount of vaporization that takes place in the fuel tank.

The solenoid is also activated momentarily if an engine misfire is detected. This function provides full fuel flow through the fuel rail to determine if the misfire was caused by a lean fuel condition. The solenoid is monitored by the ECM for faults.



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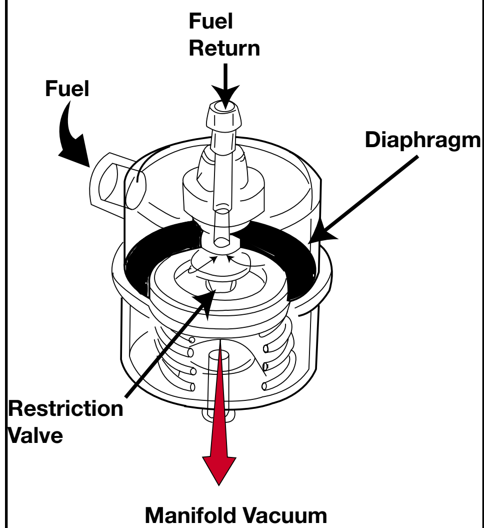
Fuel Pressure Regulator: The Fuel Pressure Regulator maintains a constant “pressure differential" for the fuel injectors.

The fuel pressure is set to 3.5 bar (+/- 0.2) by internal spring tension on the restriction valve.

The vacuum chamber is sealed off by a diaphragm which is connected by a hose to the intake manifold. Intake manifold vacuum regulates the fuel pressure by assisting to compress the spring (lowering fuel pressure).

When the restriction valve opens, unused fuel returns back to the fuel tank.



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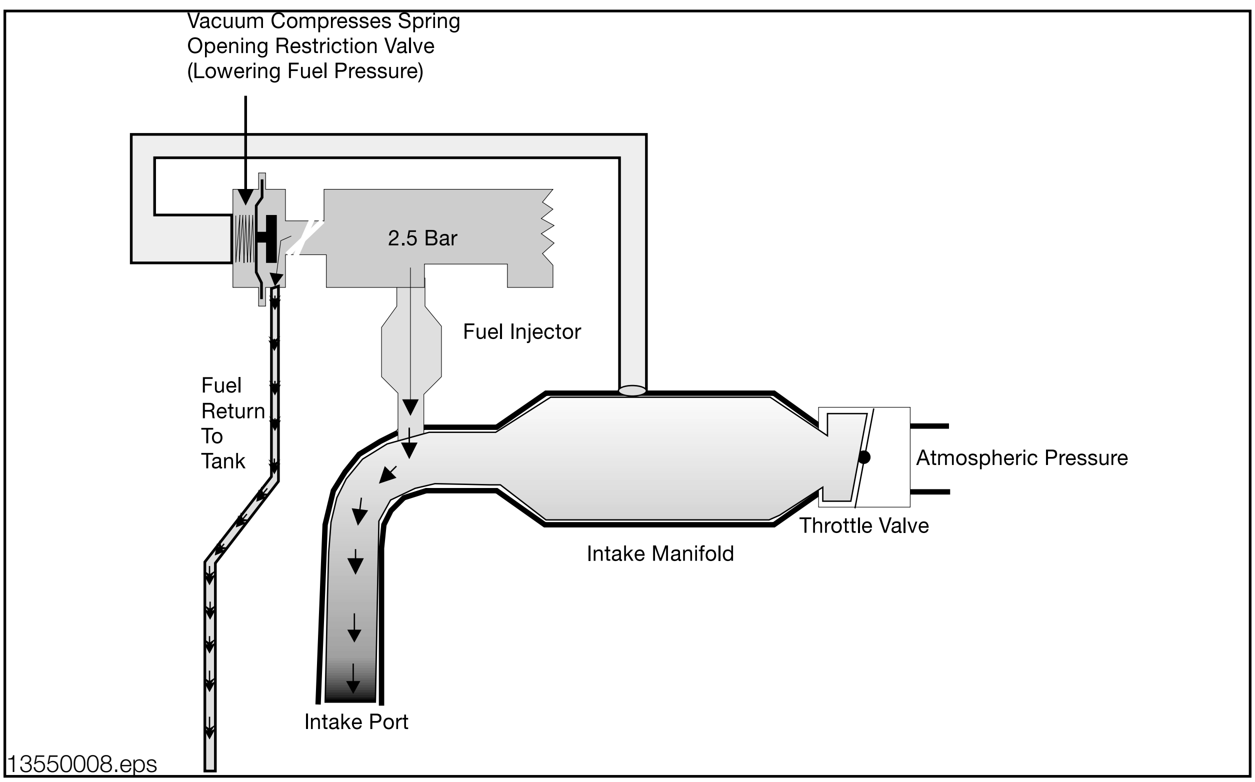
Examples of “pressure differential” are:

- At low to part throttle, intake manifold vacuum is available at the tip of the fuel injectors to enhance fuel “flow through”. Vacuum is also applied to the fuel pressure regulator vacuum chamber, causing the diaphragm to compress the spring which opens the restriction valve. This lowers the fuel pressure available to the fuel injectors.



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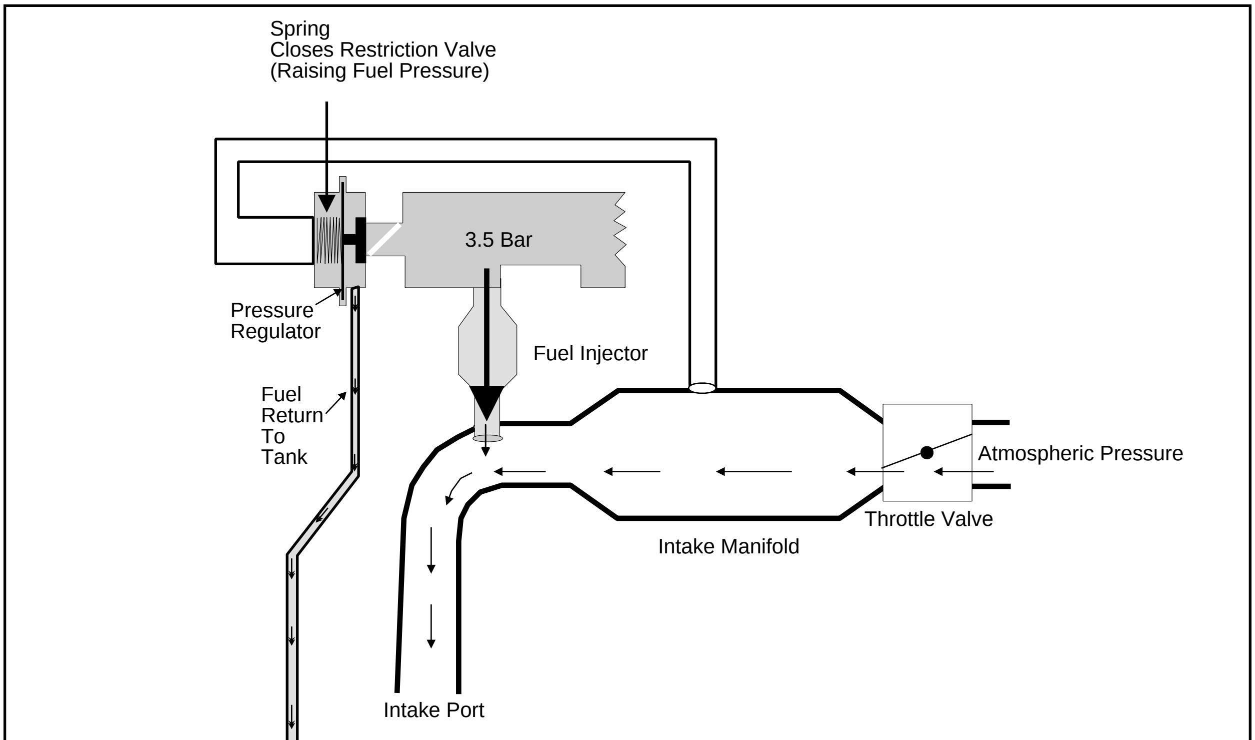
• Wide open throttle depletes intake manifold vacuum at the tip of the fuel injectors and in the fuel pressure regulator vacuum chamber. The spring closes the restriction valve to raise fuel pressure available to the fuel injectors. This maintains pressure differential (fuel flow through) for the fuel injectors.



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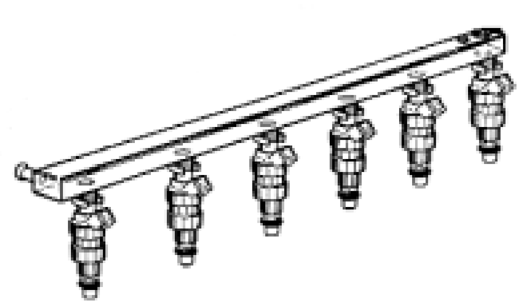
By maintaining constant Fuel Pressure Differential through vacuum sensing (engine load), the ECM can then regulate volume and mixture by the length of time the injectors are open (duration).

The fuel rail distributes an even supply of fuel to all of the injectors, and also serves as a volume reservoir. The fuel rail is secured by bolts to the intake manifold.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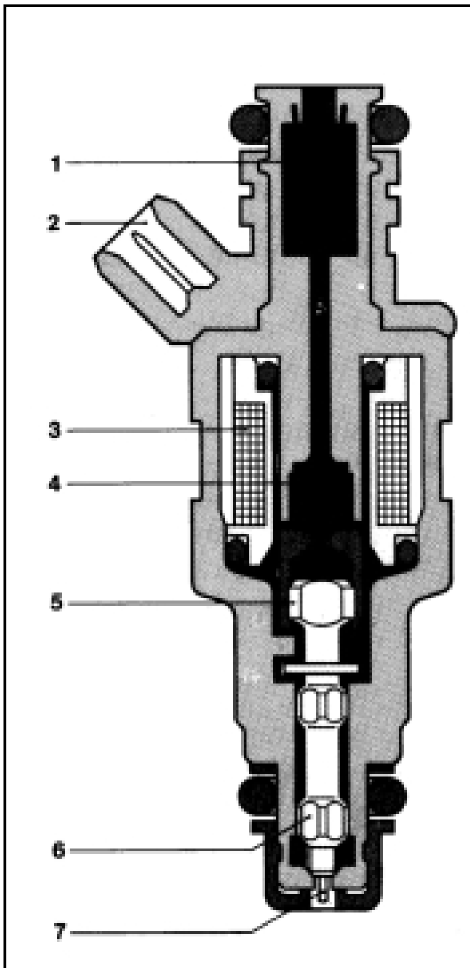
Bosch Fuel Injectors: The Fuel Injectors are electronically controlled solenoid valves that provide precise metered and atomized fuel into the engine intake ports. The Fuel Injector Valve consists of:

1.	**Fuel Strainer**
2.	**Electrical Connector**
3.	**Solenoid Winding**
4.	**Closing Spring**
5.	**Solenoid Armature**
6.	**Needle Valve**
7.	**Pintle**



13550075.jpg

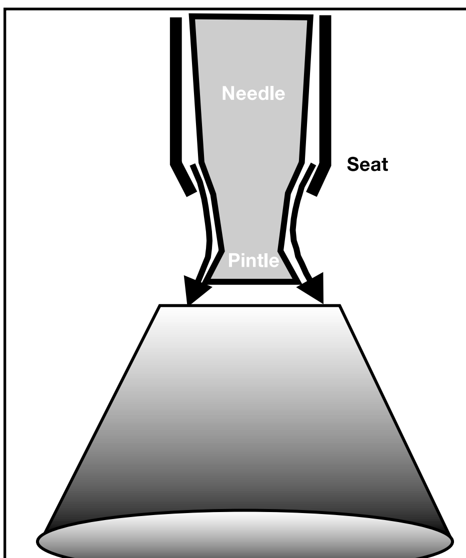
Fuel is supplied from the fuel rail to the injector body. The fuel is channeled through the injector body to the needle valve and seat at the tip of the injector.

Without electrical current, the needle valve is sprung closed against the seat.

The Fuel Injectors receive voltage from the Engine Control Module Relay. The ECM activates current flow through the injector solenoid creating a magnetic field that pulls the needle "up" off of its seat.

The pressurized fuel flows through the opening and deflects off of the pintle.

The pintle (tip of the needle) is a cone shaped deflector that "fans out" the fuel spray into an angled pattern which helps to atomize the fuel.



13550010.eps

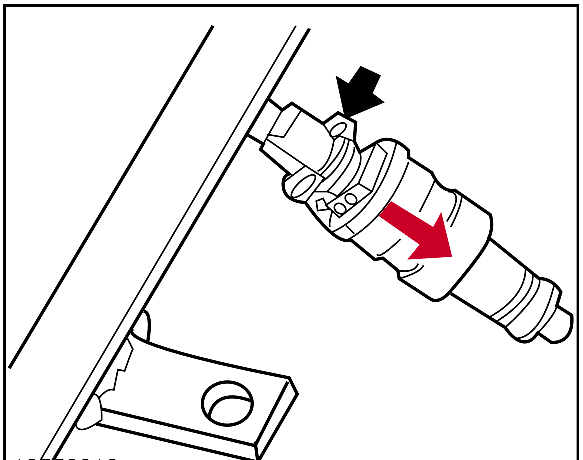
When the ECM deactivates current flow, the needle valve is sprung closed against the seat and fuel flow through the injector is stopped.

The length of time that the ECM activates the Fuel Injectors is very brief, the duration is in milli-seconds (ms). This affects the mount of fuel volume flowing through the Fuel Injectors.

The ECM will vary the length of time (ms) to regulate the air/fuel ratio (mixture).

The Fuel Injectors are mounted in rubber "o-rings" between the fuel rail and the intake manifold to insulate them from heat and vibration.

This insulation also reduces the injector noise from being transmitted through the engine compartment. The Fuel Injectors are held to the fuel rail by securing clips (arrow).


13550016.eps

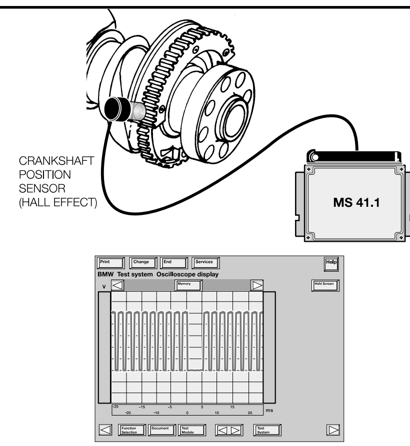
If a Fuel Injector is faulty (mechanical or electrical), it can produce the following complaints:

• "CHECK ENGINE" Light	**• Misfire/Rough Idle (Leaking or Blocked)**
• Excessive Tailpipe Smoke (Leaking)	**• Long Crank Time (Leaking)**
• Engine Hydrolock (Leaking)	
• Oxygen Sensor/Mixture/Injector Related Fault Codes	

Crankshaft Position/RPM Sensor (Hall Effect): This sensor provides the crankshaft position and engine speed (RPM) signal to the ECM for Fuel Pump and Injector operation.

A Hall sensor is mounted on the left side at the rear of the engine block. The impulse wheel is mounted on the crankshaft inside the crankcase, at the rear main bearing support. The impulse wheel contains 58 teeth with a gap of two missing teeth.

The Hall sensor is supplied with voltage from the ECM. A digital square wave signal is produced by the sensor as the teeth of the impulse wheel pass by. The "gap" allows the ECM to establish crankshaft position.



SMOOTH RUNNING ENGINE (NOTE SQUARE WAVE SIGNAL) 13550020.eps

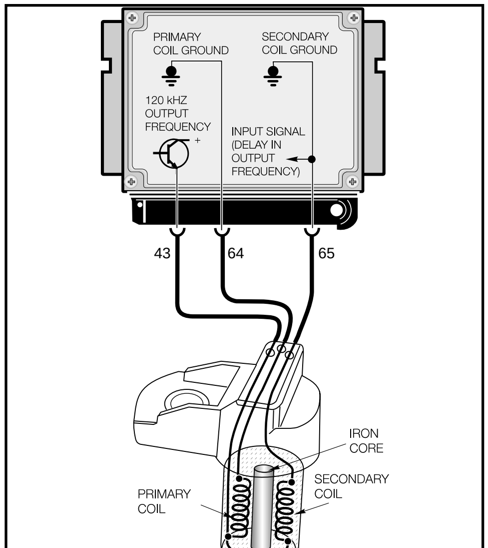
The crankshaft position sensor is monitored as part of OBD II requirements for Misfire Detection. If this input is faulty, the ECM will operate the engine (limited driveability) from the Camshaft Sensor input. A fault with this input will produce the following complaints:

• Hard Starting/Long Crank Time
• Driveability/Misfire/Engine Stalling
• "CHECK ENGINE" Light

Cylinder Identification Signal: An angle pulse generator is used for the camshaft position sensing. The MS41.X ECM uses the signal from the camshaft sensor to set up the fully sequential fuel injection.

This sensor consists of two windings (primary and secondary) that are connected together at one end, and a magnetic core.

The primary winding is supplied with a 120 kHz AC signal. The magnetic coupling causes an induced voltage into the secondary winding (at the same frequency). However the induced voltage has a slight phase shift due to the induction time delay.



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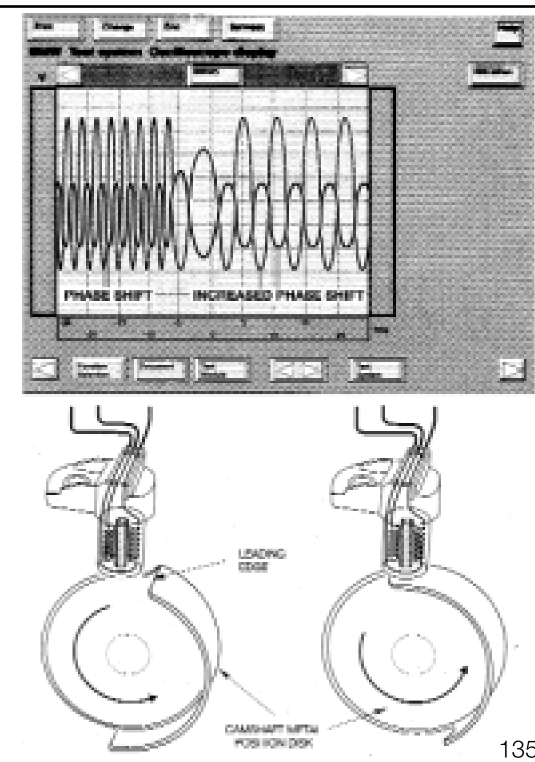
The trigger wheel of the camshaft influences the magnet field of the sensor and causes the phase shift to increase as the disc of the wheel moves closer to the sensor. The ECM monitors this change in phase shift as "TDC" (compression input) from the camshaft.
When the disc passes by the sensor the phase shift moves closer again.

If this input is defective, the system will still operate based on the Crankshaft Position/RPM Sensor. A fault will be set and the ECM will activate the injectors in parallel. The camshaft position sensor is monitored as part of the requirements for OBD II.



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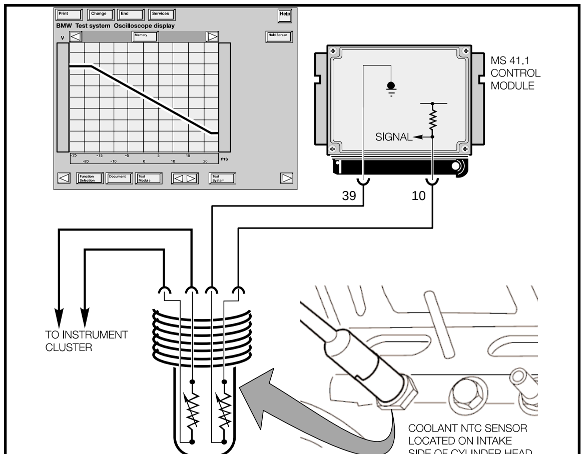
Engine Coolant Temperature: The Engine Coolant Temperature is provided to the ECM from an NTC type sensor located in the coolant jacket of the cylinder head. The sensor contains two NTC elements, the other sensor is used for the instrument cluster temperature gauge.



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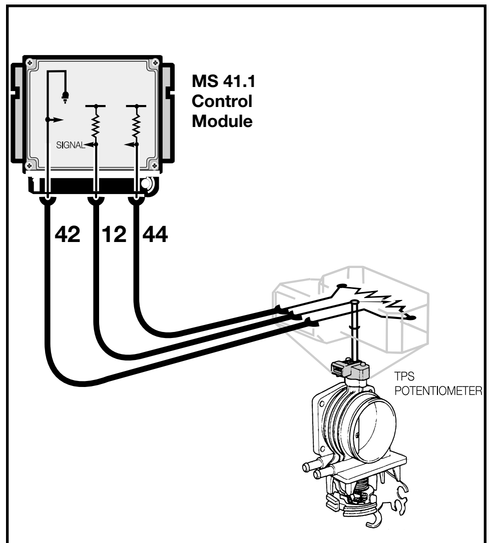
The ECM determines the correct air/fuel mixture required for the engine temperature by monitoring an applied voltage to the sensor (5v). This voltage will vary (0-5v) as coolant temperature changes the resistance value.

If the Coolant Temperature Sensor input is faulty, a fault code will be set the ECM will assume a substitute value (80º C) to maintain engine operation.



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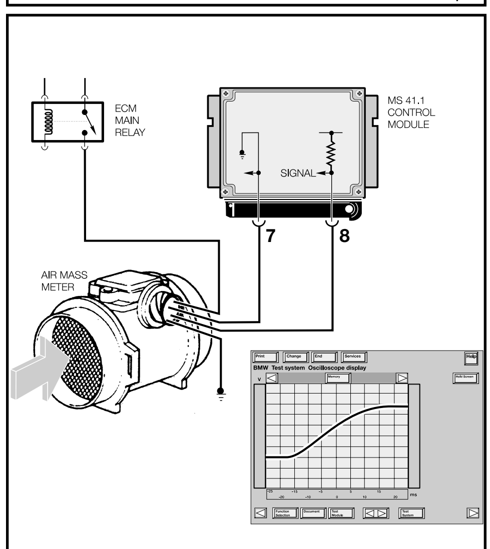
Throttle Position Sensor: The potentiometer is monitored by the ECM for throttle angle position and rate of movement. For details about the sensor, refer to the Air Management section.

As the throttle is opened, the ECM will increase the volume of fuel injected into the engine. As the throttle plate is closed, the ECM activates fuel shut off if the rpm is above idle speed (coasting).

If the Throttle Position input is defective, a fault code will be set. The ECM will maintain fuel injection operation based on the Air Flow Volume Sensor and the Crankshaft Position/RPM Sensor.



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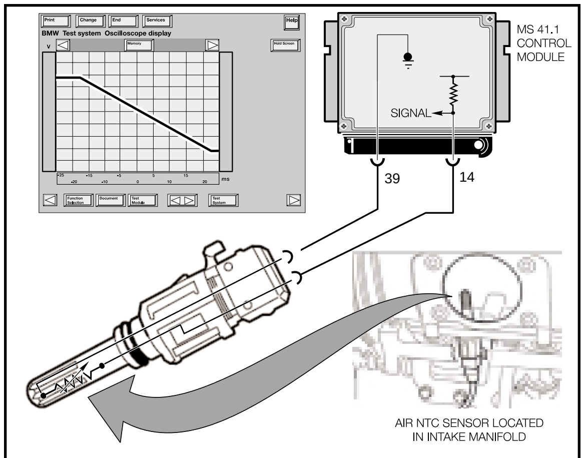
Hot-Film Air Mass Meter (HFM): The air volume input signal is used by the ECM to determine the amount of fuel to be injected for correct air/fuel ratio. For details about the sensor, refer to the Air Management section.

If this input is defective, a fault code will be set and the ECM will operate the engine using the Throttle Position and Engine RPM inputs.

Air Temperature: This signal allows the ECM to make a calculation of air density. For details about the sensor, refer to the Air Management section.



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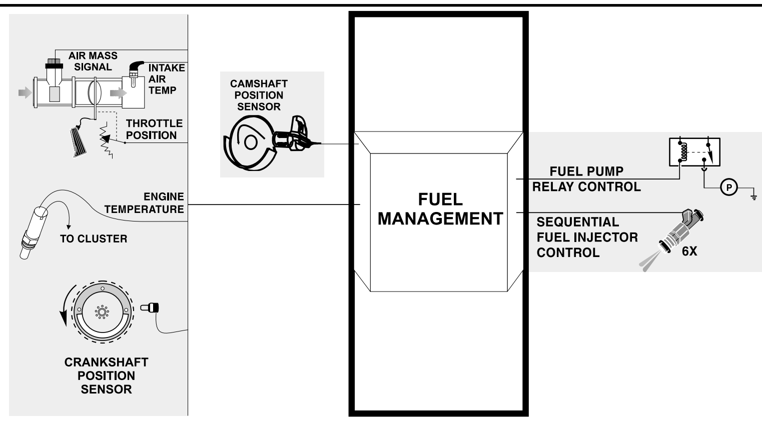
The varying voltage input from the NTC sensor indicates the larger proportion of oxygen found in cold air, as compared to less oxygen found in warmer air. The ECM will adjust the amount of injected fuel because the quality of combustion depends on oxygen sensing ratio.

If this input is defective, a fault code will be set and the ECM will operate the engine using the Engine Coolant Sensor input.

Principle of Operation

Fuel Management delivers fuel from the tank to the intake ports of the engine. To accomplish this, **fuel supply** must be available to the fuel injectors. Then the fuel must be **injected** in the precise amount and at the correct time. The ECM does not directly monitor fuel supply, although it does control fuel supply. **The Fuel Pump** supplies fuel when it receives operating voltage from the Engine Control Module Relay supplying the Fuel Pump Relay. The ECM controls and monitors **fuel injection**.



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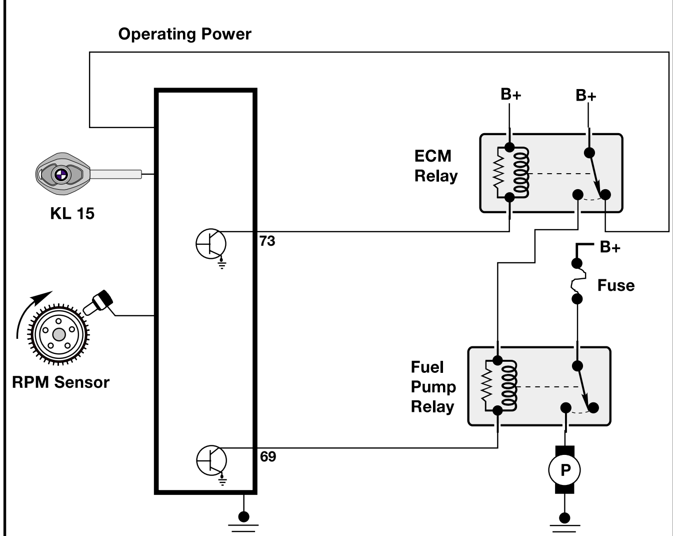
The Fuel Pump will be activated when the ignition (KL15) is switched "on" and the ECM supplies a ground circuit to activate the Fuel Pump Relay. The Fuel Pump Relay supplies operating power to the in-tank mounted fuel pump. This is a momentary activation to "pressurize" (prime) the fuel system.

The ECM then requires an engine RPM signal from the Crankshaft Position/RPM Sensor to maintain continuous Fuel Pump Relay activation.

If the engine RPM signal is not present, the ECM will deactivate the Fuel Pump Relay.



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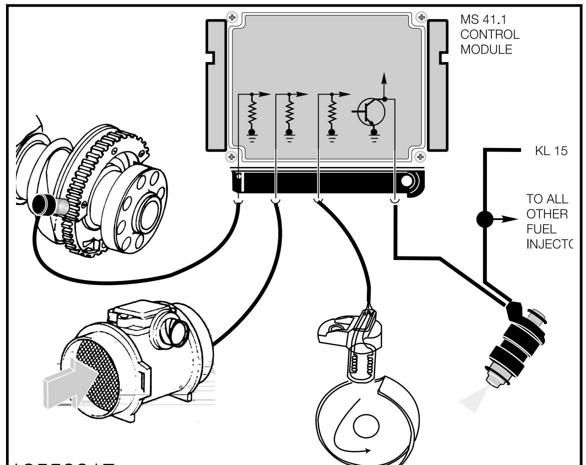
The Fuel Injectors will be opened by the ECM to inject pressurized fuel into the intake ports. The Fuel Injectors receive voltage from the Engine Control Module Relay. The ECM controls the opening by activating the ground circuits for the Solenoid Windings. The ECM will vary the duration (in milli-seconds) of "opening" time to regulate the air/fuel ratio.

The ECM has six Final Stage output transistors that switch ground to the six injector solenoids. The Injector "triggering" is first established from the Crankshaft Position/RPM Sensor.



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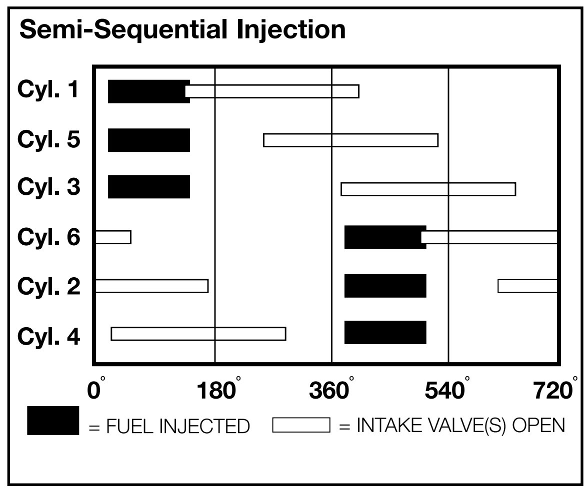
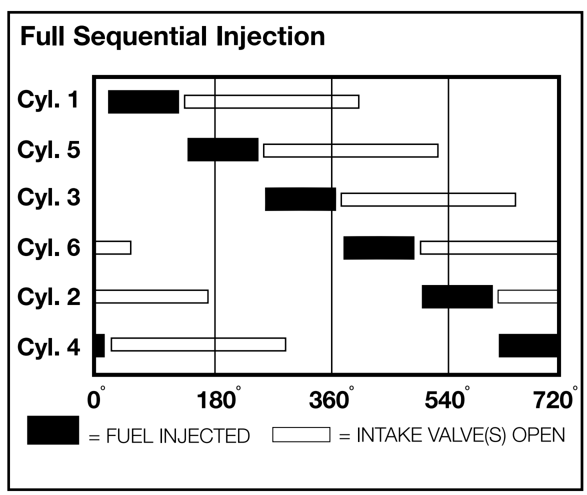
The ECM is programmed to activate the Final Stage output transistors once for every two revolutions of the crankshaft in two groups (Semi-Sequential Injection).

The injectors are opened in two groups for every complete "working cycle" of the engine. This delivers the fuel charge for cylinders 1,5,3 during one revolution of the crankshaft and cylinders 6,2,4 during the second revolution of the crankshaft. This process enhances fuel atomization during start up.



During start up, the ECM recognizes the Camshaft Position (Cylinder ID) input. The camshaft position is referenced to the crankshaft position. It then switches the injection to Full Sequential. This process "times" the injection closer to the intake valve opening for increased efficiency.

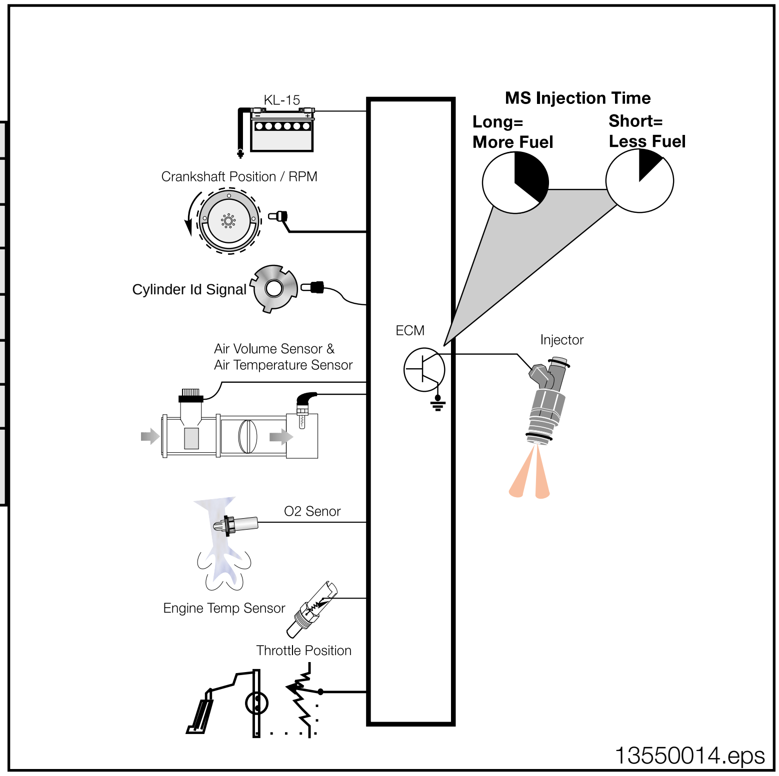
When activated, each injector delivers the full fuel charge at separate times during each engine working cycle.



If this input is faulty, the ECM will activate the injectors in Parallel to maintain engine operation and set a fault code.

The Injector "open" Time to maintain engine operation after it has been started is determined by the ECM (programming). The ECM will calculate the engine "timing" based on a combination of the following inputs:

- **Battery Voltage**
- **Throttle Position**
- **Air Flow Volume/Mass**
- **Air Temperature**
- **Crankshaft Position/RPM**
- **Camshaft Position (Cylinder ID)**
- **Engine Coolant**
- **Oxygen Sensor (Detail in Emissions)**



The injection ms value will be regulated based on battery voltage. When cranking, the voltage is low and the ECM will increase the ms value to compensate for injector "lag time". When the engine is running and the battery voltage is higher, the ECM will decrease the injection ms value due to faster injector reaction time.

Cold starting requires additional fuel to compensate for poor mixture and the loss of fuel as it condenses onto cold intake ports, valves and cylinder walls. The cold start fuel quantity is determined by the ECM based on the Engine Coolant Temperature Sensor input during start up.

During cranking, additional fuel is injected (in Semi-Sequential) for the first few crankshaft revolutions. After the first few crankshaft revolutions, the injected quantity is metered down as the engine comes up to speed. When the engine speed approaches idle rpm, the ECM recognizes the Camshaft Position and switches to Full Sequential injection.

When the engine is cold, optimum fuel metering is not possible due to poor air/fuel mixing and an enriched mixture is required. The Coolant Temperature input allows the ECM to adjust the injection ms value to compensate during warm up and minimize the the injected fuel at engine operating temperature.

When the engine is at idle, minimum injection is required. Additional fuel will be added if the ECM observes low engine rpm and increasing throttle/air volume inputs (acceleration enrichment). As the throttle is opened, the ECM monitors acceleration and rate of movement. The ECM will increase the volume of fuel injected into the engine by increasing the injection ms value. The "full throttle" position indicates maximum acceleration and the ECM will add more fuel (full load enrichment).

As the throttle is closed, the ECM decreases the injection ms value (fuel shut off) if the rpm is above idle speed (coasting). This feature decreases fuel consumption and lowers emissions. When the engine rpm approaches idle speed, the injection ms value is increased (cut-in) to prevent the engine from stalling. The cut-in rpm is dependent upon the engine temperature and the rate of deceleration.

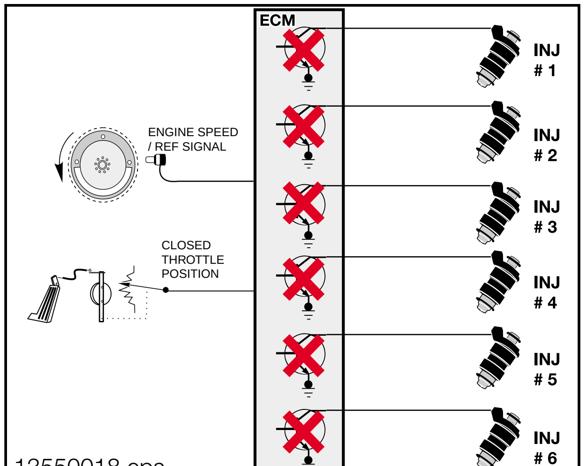
The Hot-Film Air Mass (HFM) signal provides the measured amount of intake air volume/mass. This input is used by the ECM to determine the amount of fuel to be injected to "balance" the air/fuel ratio.

The Air Temperature Signal allows the ECM to make an additional calculation of air density. The varying voltage input from the NTC sensor indicates the larger proportion of oxygen found in cold air, as compared to less oxygen found in warmer air. The ECM will adjust the amount of injected fuel because the quality of combustion depends on oxygen sensing ratio (details in Emissions).

The Crankshaft Position/RPM signals the ECM to start injection as well as providing information about the engine operation. This input is used in combination with other inputs to determine engine load which increases/decreases the injection ms value. Without this input, the ECM will not activate the injectors.

The Camshaft Postion (Cylinder ID) affects the injection timing (Semi-Sequential/Full Sequential). To accomplish this, the ECM contains six Final Stage output transistors that activate the injectors individually. The engine operates sufficiently on Semi-Sequential Injection (two groups of three), but more efficiently on Full Sequential Injection (six individual). If one of the fuel injector circuits faulted, the engine can still operate on limited power from the other remaining fuel injector circuits.

Injection "Reduction" Time is required to control fuel economy, emissions, engine and vehicle speed limitation. The ECM will "trim" back or deactivate the fuel injection as necessary while maintaining optimum engine operation.



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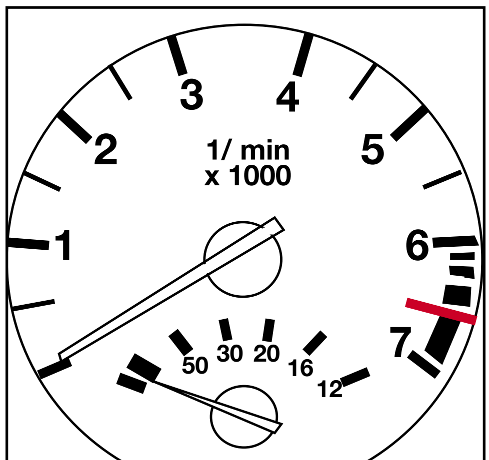
As the throttle is closed during deceleration, the ECM decreases the injection ms value (fuel shut off) if the rpm is above idle speed (coasting). This feature decreases fuel consumption and lowers emissions.

When the engine rpm approaches idle speed, the injection ms value is increased (cut-in) to prevent the engine from stalling. The cut-in rpm is dependent upon the engine temperature and the rate of deceleration. This function can be observed as displayed on the Fuel Economy (MPG) gauge.



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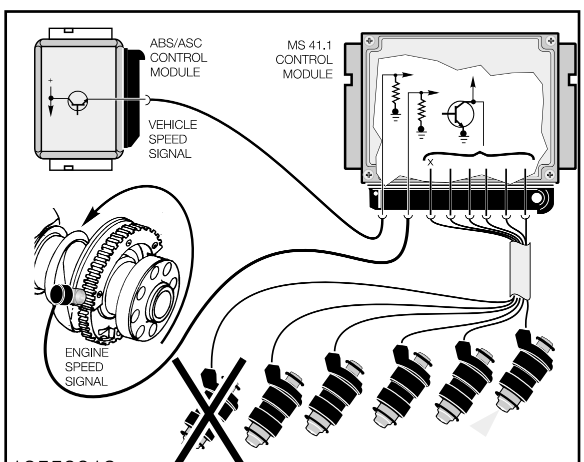
The ECM will selectively deactivate injectors to control maximum engine rpm (regardless of vehicle speed). When the engine speed reaches 6500 rpm (7600 rpm M3), the injectors will be individually deactvated as required to protect the engine from over-rev. As the engine speed drops below 6500 (7600 M3) rpm, injector activation will be resumed. **This feature does not protect the engine from a forced over-rev such as improperly downshifting a manual transmission equipped vehicle (driver error).**

Maximum vehicle speed is also limited by the ECM selectively deactivating the injectors (regardless of engine rpm).

This limitation is based on the vehicle dimensions, specifications and installed tires (speed rating).



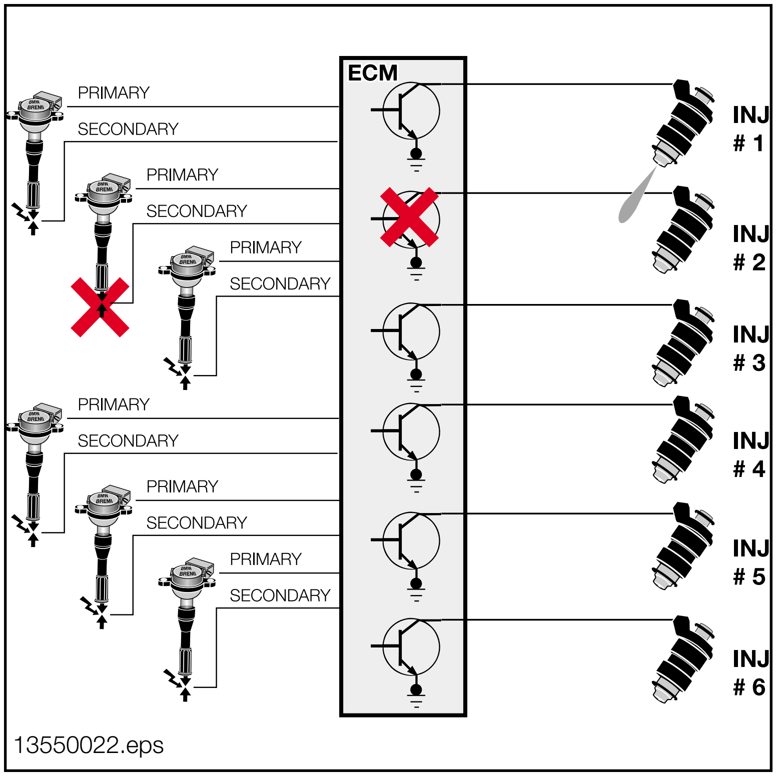
13550019.eps

The ECM will also protect the Catalytic Converter by deactivating the injectors.

If the ECM detects a "misfire" (ignition, injection or combustion) it can selectively deactivate the Final Stage output transistor for that cylinder(s).

The injector(s) will not open, preventing unburned fuel from entering the exhaust system.

On the MS41.X system, there are six individual injector circuits resulting in deactivation of one or multiples. This will limit engine power, but protect the Catalytic Converter.

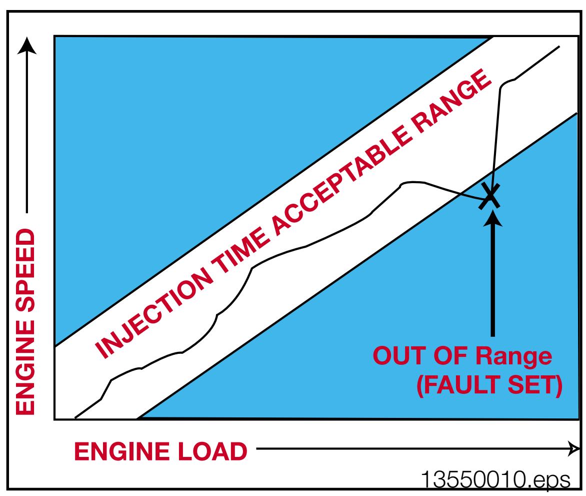


Fuel Injection Control Monitoring is performed by the ECM for OBD II requirements. Faults with the fuel injectors and/or control circuits will be stored in memory. This monitoring includes:

- Closed Loop Operation
- Oxygen Sensor Feedback

These additional corrections are factored into the calculated injection time. If the correction factor exceeds set limits a fault will be stored in memory.

When the criteria for OBD II monitoring is achieved, the "CHECK ENGINE" Light will be illuminated.



Workshop Hints

Before any service work is performed on any fuel system related component, always adhere to the following:

• Observe relevent safety legislation pertaining to your area.
• Ensure adequate ventilation.
• Use exhaust extraction system where applicable (alleviate fumes).
• DO NOT OPERATE THE FUEL PUMP unless it is properly installed in the fuel tank and is submersed in the fuel (fuel lubricates the pump).
• DO NOT SMOKE while performing fuel system repairs.
• Always wear adequate protection clothing including eye protection.
• Use caution when working around a HOT engine compartment.
• During fuel system repairs that involve "sealing rings", always replace them with new COPPER sealing rings only.
• BMW does not recommend any UNAUTHORIZED MODIFICATIONS to the fuel system. The Fuel systems are designed to comply with strict federal safety and emissions regulations. In the concern of product liability, it is unauthorized to sell or perform modifications to customers vehicles, particularly in safety related areas.
• Always consult the Repair Instructions on the specific model you are working on before attempting a repair.

Fuel

Fuel quality should always be considered when diagnosing a driveability complaint. The type of fuel, proper AKI rating, impurities and moisture are not factored by the ECM.

Please refer to the Owner's Manual and following Service Information Bulletins regarding fuel:

• Gasoline Fuel Quality S.I. #13 01 88 (1564)	**• Gasoline Additive S.I. #13 04 88 (1591)**

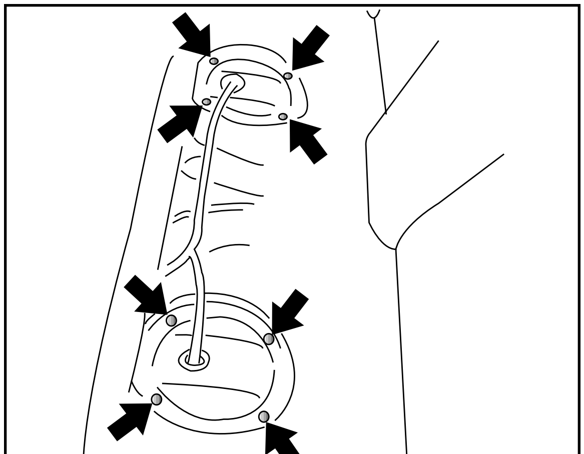
Fuel Supply

The fuel supply hardware should be visually inspected for damage that can affect pick-up, transfer, pressure and return. Please refer to the Repair Instructions and the following Service Information Bulletins details on fuel supply hardware:

• Fuel System Modifications S.I. #16 01 81
• Reposition Fuel Line - Z3 with M52 Engine S.I. #16 03 97

Fuel Pump and Sending Unit Access

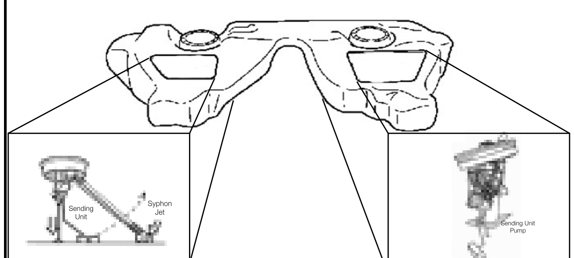
All BMW vehicles have access plates to service the fuel pump and sending unit(s) without removing the fuel tank.



13550027.eps

The E36/E39 access plates are located under the rear seat. The “saddle” type fuel tank (under rear seat) has two access plates.

The passenger side allows access to the fuel pump/sending unit. The driver side allows access to the sending unit.



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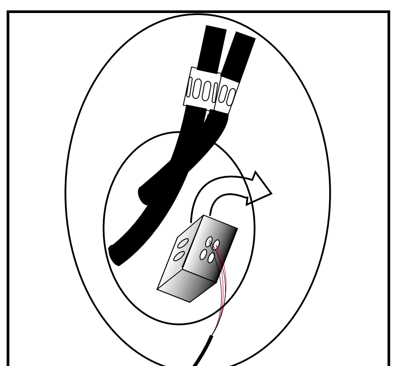
The Z3 has a single access plate located behind the passenger seat.



13550023.eps

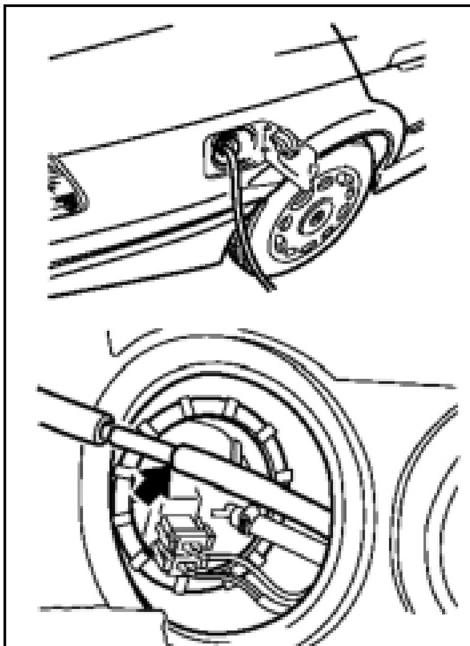
Draining the Fuel Tank

In order to remove the fuel tank it must be drained first to avoid fuel spills and handling excessive weight. In some cases depending on the fuel tank dimensions (vehicle specific), it is also necessary to drain the fuel tank to replace the sending units and/or fuel pump.

CAUTION: In some vehicles, the sending units/fuel pump is mounted lower than the top of the fuel tank. A fuel spill will be encountered if the fuel is not drained.

NOTE: Consult the BMW Service Workshop Equipment for the proper evacuation equipment.

The saddle type tank requires an additional step to drain the fuel from the driver side. The evacuation equipment should be attached to the tank compensating hose (arrow) to drain out the remaining fuel.



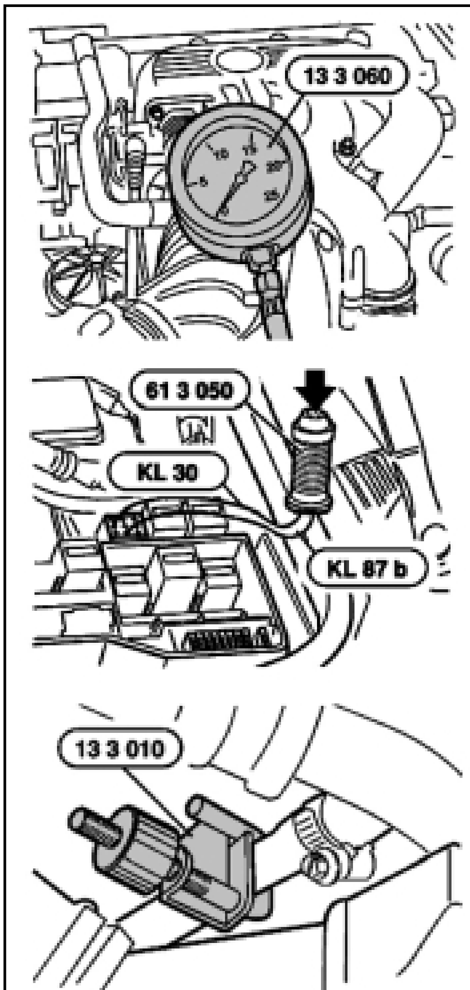
13550015.eps

Fuel Pump/Pressure Regulator - Testing

The fuel pump should be tested for delivery pressure and volume. **Caution** when disconnecting fuel hoses because there is the possibility of residual fuel pressure! Install the fuel pressure gage between the fuel filter and and pressure regulator.

Remove the fuel pump relay (located in the Electronics Box E36/Z3, and right side of the trunk E39 - see relay testing in the power supply section) and connect the Relay Bypass Switch to pin 87b and 30 of the relay socket. This will activate the fuel pump without running the engine.

If the 3.5 bar fuel pressure is not achieved or bleed off is more than 0.5 bar, refer to **13 31 of the Repair instructions** for further diagnosis. The Fuel Hose Clamp Tool can be used to isolate bleed off from the pump (non-return check valve) or the pressure regulator (restriction valve). Also verify power supply to the fuel pump.



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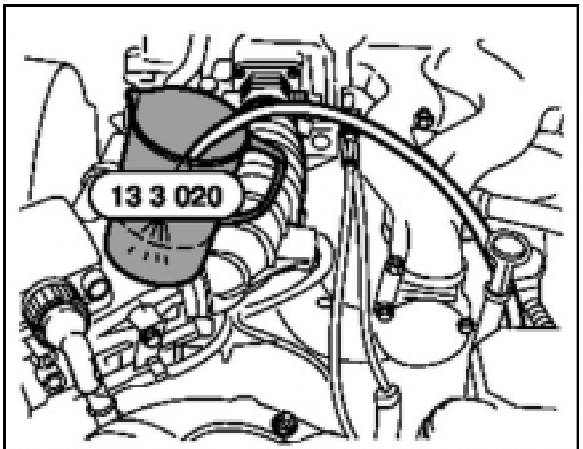
Fuel volume must be tested to verify:

• **Fuel Pump Output**
• **Restriction are not present in the pump pickup lines/hoses and fuel filter**

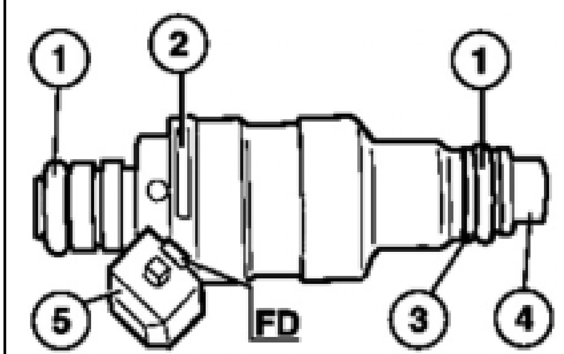


13550029.jpg

Fuel Injectors

When inspecting the fuel injectors, consider the following:

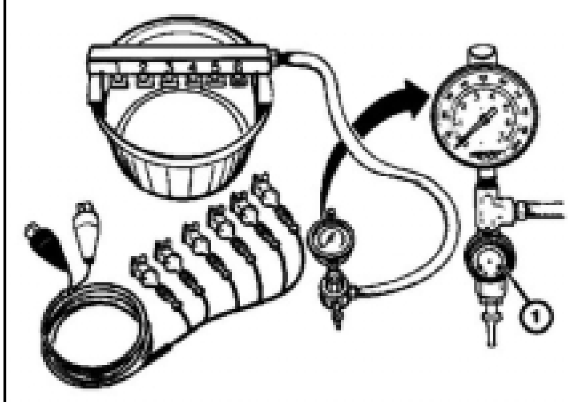
• **O-rings should be replaced, lubricated with vaseline or SAE 90 gear oil for installation**
• **Verify the code number**
• **Plastic spacer washer is not damaged**
• **Color code of nozzle housing**
• **Color code injector housing**



13550030.bmp

Fuel injectors can leak which bleeds off fuel pressure and increases emissions. The injectors can be tested using the Fuel Injector Leakage Tester.

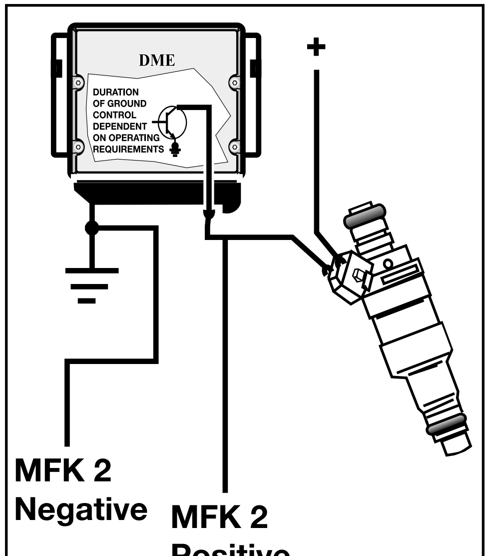
The fuel injectors can be cleaned, refer to Service Information Bulletin S.I. #04 07 86.



13550031.jpg

The Fuel Injectors should also be tested using the DIS/MoDIC for:

• **Resistance**
• **Power Supply**
• **Status Display - Fuel Injection Signal (approximate 3.5 - 5 ms)**
• **ECM Final Stage transistor activation. This test function is found under the Oscilloscope Preset list - "Ti Injection Signal". Install the 88 pin adapter, Diagnostic cable, MFK 2 negative lead to ECM ground and MFK 2 positive lead to the ground activation cicuit for the injector. This test is performed with the engine running.**



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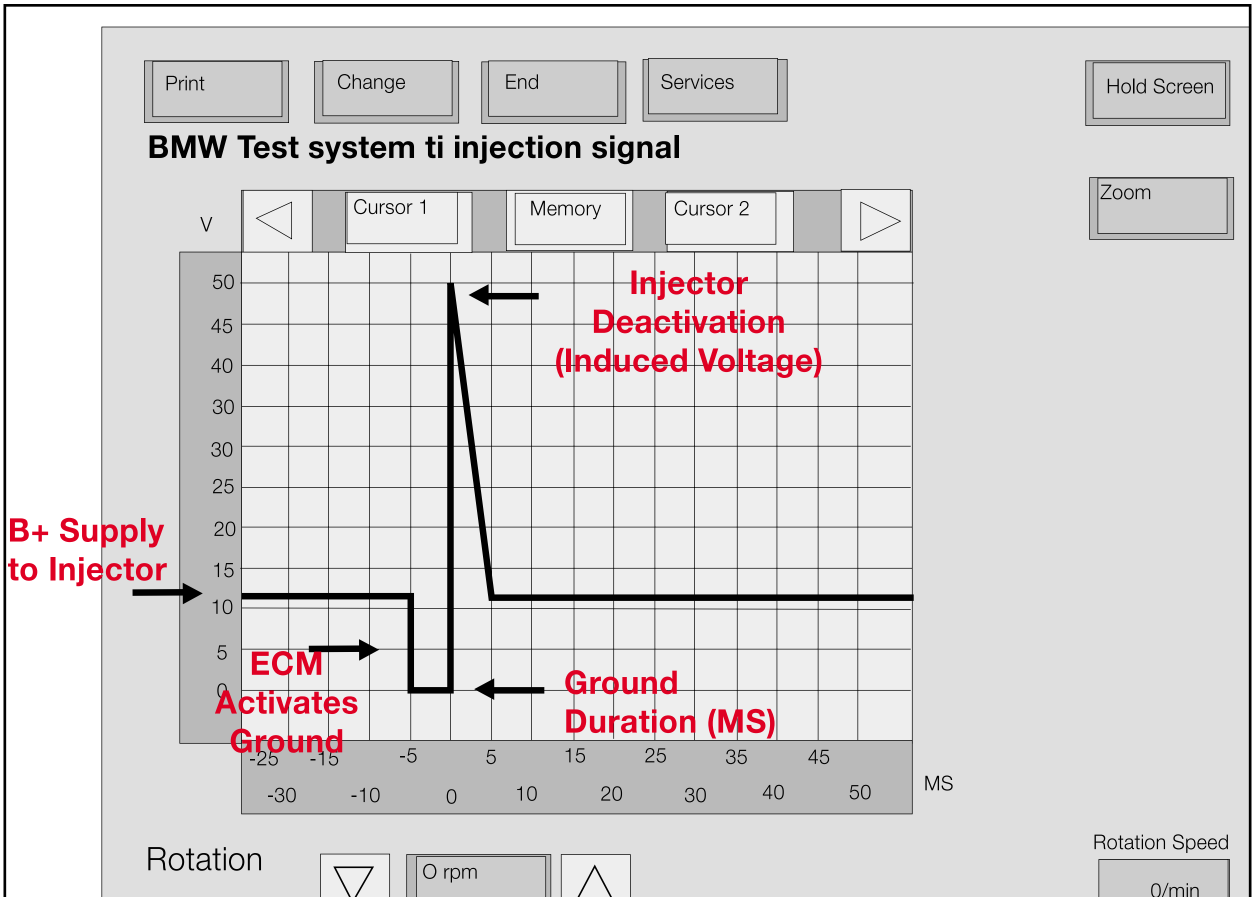


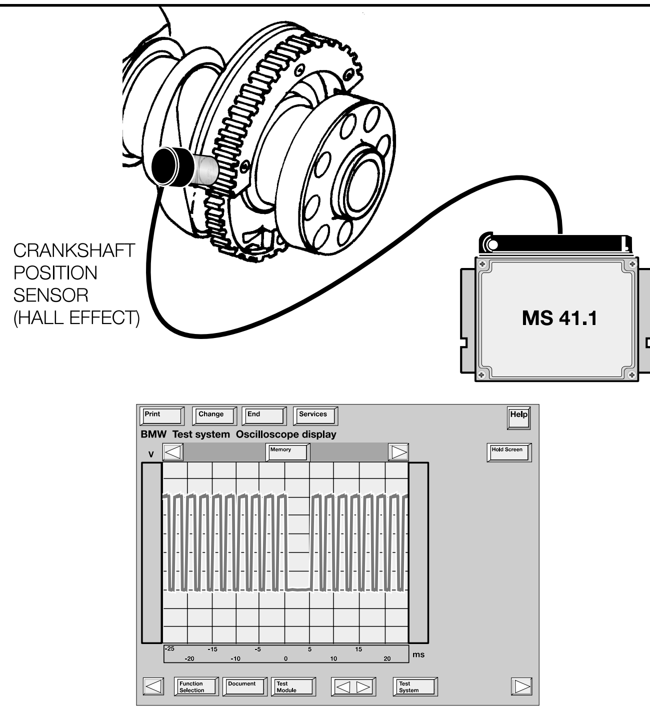
13550018.eps

Crankshaft Position/RPM Sensor

This sensor should be tested using the DIS/MoDIC for:

• Power Supply
• DC Voltage
• Status Display
• Oscilloscope Display found under Preset Measurements - “Engine Speed Sensor Signal”

NOTE: Refer to Service Information SI # 12 10 99 **Voluntary Emissions Recall Campaign No. 99E-A01** for additional Crankshaft Sensor information.

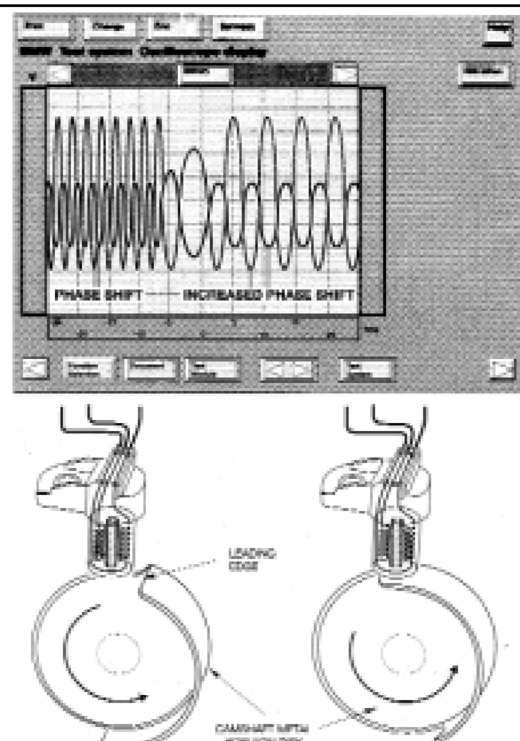


SMOOTH RUNNING ENGINE
(NOTE SQUARE WAVE SIGNAL) 13550020.eps

Camshaft Position Sensor (Cylinder ID)

This sensor should be tested using the DIS/MoDic for:

• Resistance
• Power Supply
• AC Voltage
• Status Display
• Oscilloscope Display found under Preset list - “Camshaft Sensor Signal”



13550014.eps

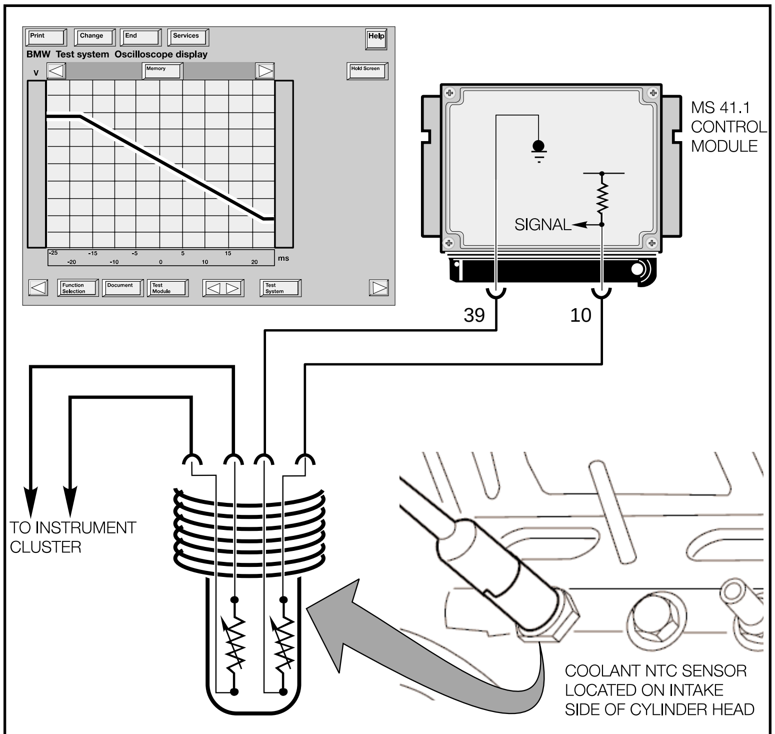
Engine Coolant Temperature

NTC sensors decrease in resistance as the temperature rises and vice versa. The ECM monitors the sensor voltage which varies as temperature changes the resistance value. For example, as temperature rises:

• Resistance through the sensor decreases
• Voltage drop of the sensor decreases
• Input signal voltage also decreases (5-Ov)

The Sensor should be tested using:

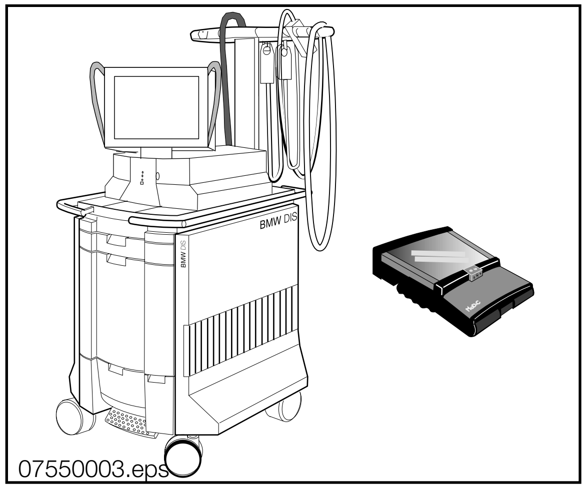
• DIS/Modic Status page degrees C (dependent on engine temperature).
• DIS/Modic Multimeter ECM input 2.250 K ohms at 20º C Temp. Gauge input 6.7 K ohms at 20º C



13550015.eps

Tools and Equipment

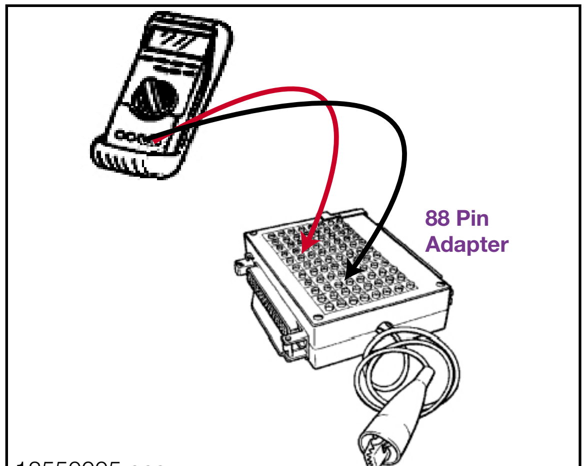
The DIS/Modic as well as a reputable hand held multimeter can be used when testing inputs/components.



07550003.eps

It is best to make the checks at the ECM connection, this method includes testing the wiring harness.

The correct Universal Adapter for the MS41.X application should be used (#88 88 6 614 410). This will ensure the pin connectors and the harness will not be damaged.

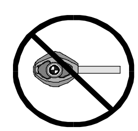


12550005.eps

The interior of this Universal Adapter is shielded, therefore it is vital that the ground cable is connected to the vehicle chassis whenever the adapter is used.

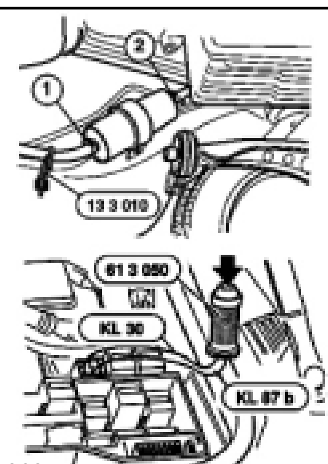
The adapter uses a Printed Circuit board inside keeping the capacitive and inductive load to a minimum.

When installing the Universal Adapter to the ECM (located below the windshield on the passenger side of the engine compartment), make sure the ignition is switched off.



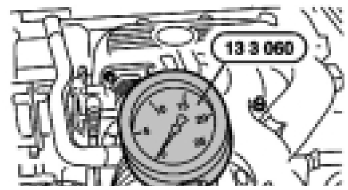
The Fuel Hose Clamp Tool (#13 3 010) can be used for isolating pressure faults. In addition, fuel loss can be reduced when changing the fuel filter while losening clamps (1 and 2).

The Relay Bypass Switch (#61 3 050) must be used especially **when fuel vapors are present!** The switch eliminates the risk of electrical arcing.



13550020.eps

When testing fuel pressure, the hand held fuel pressure gage (#13 3 060) can be used.

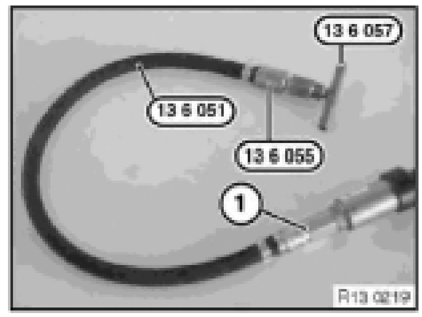


Caution: Residual fuel pressure may be present!

The DIS is equipped with a pressure measuring function, found in Measurement testing. The following adapters (Special Tool numbers) will be necessary:

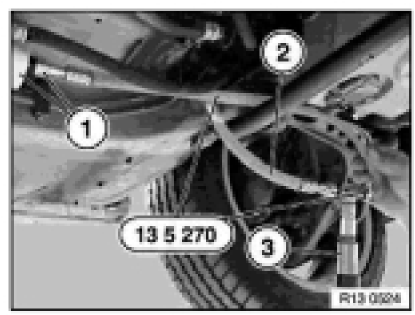
• #13 6 051	**• #13 6 055**	**• #13 6 057**

These adapters install "in line" in the fuel pressure hose.

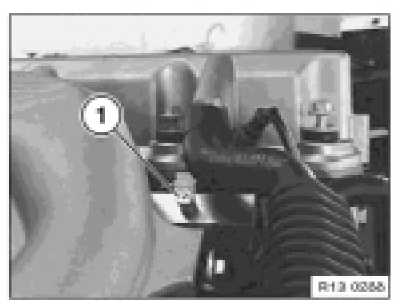


13550021.eps

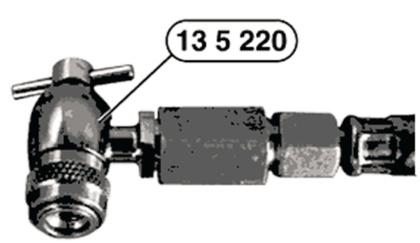
For vehicles equipped with "quick-release" couplings, install special tool (#13 5 270) between the fuel filter (1) and pressure supply hose (2). This tool will couple to the DIS Pressure Adapter (3).



Later production fuel rails are equipped with a threaded adapter fitting (1).

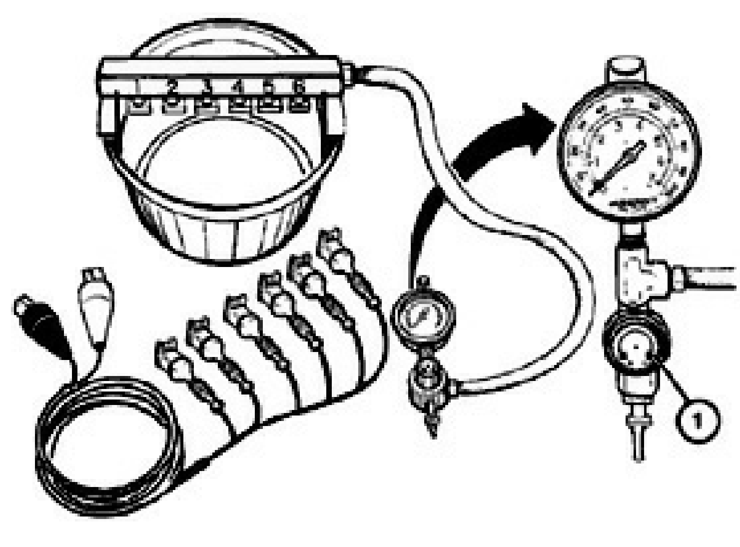


This threaded adapter fitting allows Adapter #13 5 220 to be threaded on to the fuel rail and coupled to the DIS Pressure Adapter.



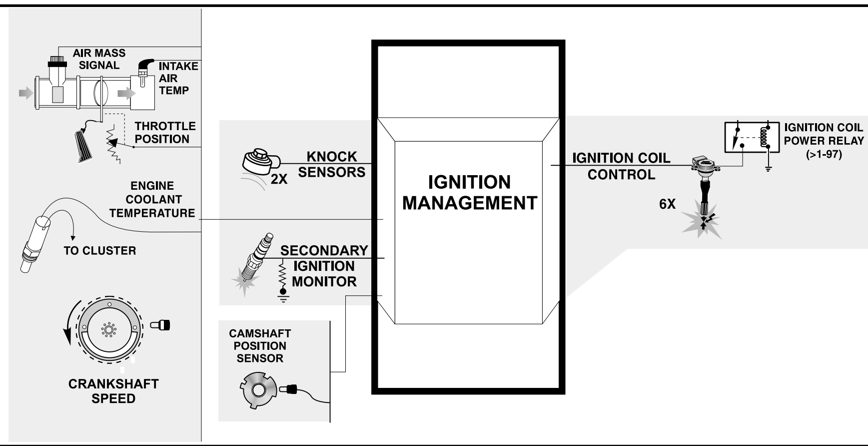
13550022.eps

When testing the fuel injectors for leakage, use Special Tool #88 88 5 000 362. Leak testing the fuel injectors is one of the diagnostic steps listed in “Long Cranking Times” S.I. #13 08 90 (3096). This tool pressurizes the injectors with air and the injector tips are submersed in water. If air bubles are present, this indicates the leaking injector(s).



13550032.jpg

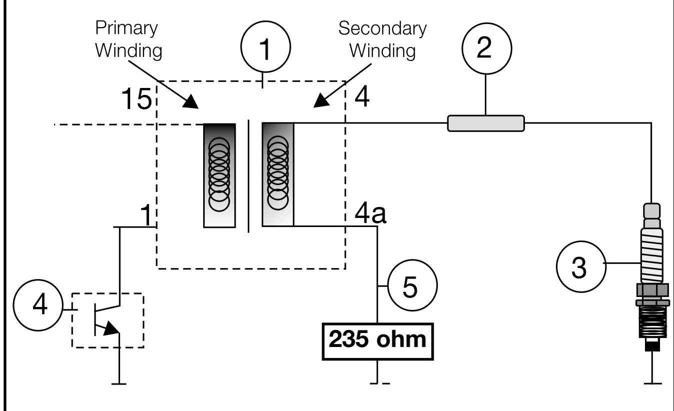
Ignition Management



13550020.eps

Ignition Coils: The high voltage supply required to ignite the mixture in the combustion chambers is determined by the stored energy in the ignition coils. The stored energy contributes to the ignition duration, ignition current and rate of high voltage increase. The Coil circuit including primary and secondary components consists of:

1. Coil Assembly • **Primary Winding** • **Secondary Winding**
2. Resistor (Boot Connector)
3. Spark Plug
4. ECM Final Stage Transistor
5. Secondary Coil Ground with 235 ohm resistor



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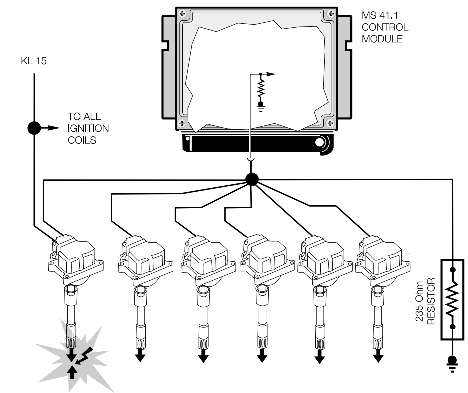
The Coil Assembly contains two copper windings insulated from each other. One winding is the primary winding, formed by a few turns of thick wire. The secondary winding is formed by a great many turns of thin wire.

The primary winding receives battery voltage from the ignition switch (KL 15), or Ignition Coil Power Relay (>9/97 activated by the ignition switch KL15). The ECM provides a ground path for the primary coil (Terminal 1) by activating a Final Stage transistor. The length of time that current flows through the primary winding is the “dwell” which allows the coil to “saturate” or build up a magnetic field. After this storage process, the ECM will interupt the primary circuit at the point of ignition by deactivating the Final Stage transistor. The magnetic field built up within the primary winding collapses and induces the ignition voltage in the secondary winding.

The voltage generated in the secondary winding is capable of 50,000 volts (50 KV). The high voltage is discharged (Terminal 4) through the secondary ignition spark plug connector (boot) to the spark plug.



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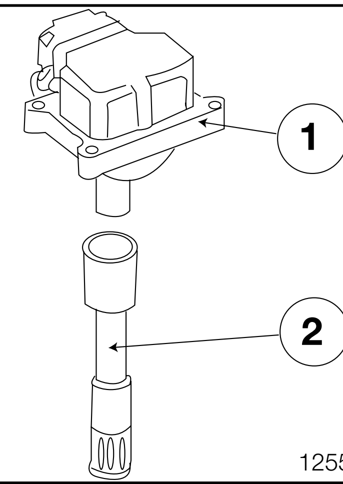
The primary and secondary windings are uncoupled, therefore, the secondary winding requies a ground supply (Terminal 4a).

The secondary grounds through a “shunt resistor” (approximately 235 ohms). The secondary ground is also supplied to the ECM which allows monitoring of secondary ignition. The resistor is located in the wiring tray on top of the cylinder head cover.

As the secondary magnetic field collapses, a voltage spike is induced in the windings. The ECM monitors the voltage drop across the resistor as an indication of coil firing. After the ECM activates the primary ignition, this feedback signal **(Terminal 4a Signal)** is confirmation that secondary ignition took place. The ECM measures the duration of time it takes the voltage drop for each ignition coil to dissipate below two volts. The time scale constantly changes based on engine rpm.

• If the 2 volt signal is not maintained long enough, the ECM detects a week spark.
• If the feedback signal is not present (0 volts) ignition did not take place.

If the signal is missing, an ignition coil fault will be set for that cylinder. If multiple signals are missing, a feedback circuit fault will be set. If the ground circuit is defective, a ground fault will be set.



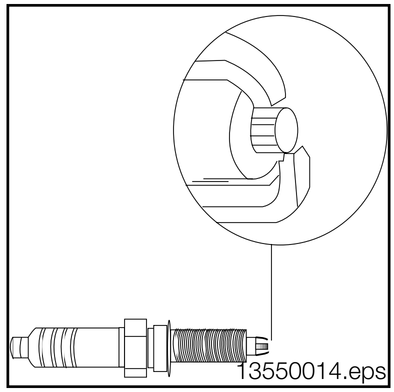
12550010.jpg

There is an individual ignition circuit and coil for each cylinder on the MS41.X system.

The six individual ignition coils (1) are coupled to spark plug connectors (2) which contain a resistor. The assemblies are mounted on top of the cylinder head cover.

There are two manufacturers of ignition coils: Bremi and Bosch.

Spark Plugs: The spark plugs introduce the ignition energy into the combustion chamber. The high voltage “arcs” across the air gap in the spark plug from the positive electrode to the negative electrode. This creates a spark which ignites the combustable air/fuel mixture.



13550014.eps

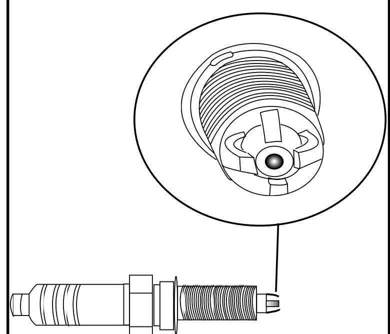
The spark plugs are located in the center of the combustion area (on the top of the cylinder head) which is the most suitable point for igniting the compressed air/fuel mixture.

The correct spark plugs for this system are:

- **Bosch F8LDCR (dual electrode, non-adjustable gap)**

Note: The High Performance Platinum Spark Plugs are also approved for use.

- **NGK BKR6EQUP (quad electrode, non-adjustable gap)**



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Faults with the Ignition Output Components are monitored by the ECM. If there are faults with the ignition coil(s) output and/or spark plugs, the following complaints could be encountered:

- **“CHECK ENGINE” Light With Mixture Related Fault Codes**
- **Poor Engine Performance**
- **Engine Misfire**
- **No Start / Hard Starting**
- **Excessive Exhaust Emissions / Black Smoke**

The ignition is monitored by the ECM via the secondary ignition feedback circuit and Crankshaft Position/RPM Sensor. If a Misfire fault is present, the “CHECK ENGINE” Light will illuminate when the OBD II criteria is achieved and the ECM will deactivate the corresponding fuel injector for that cylinder. Engine operation will still be possible.

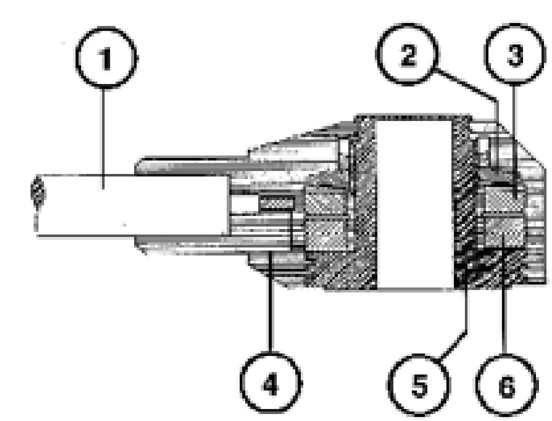
The Ignition Output Components must be individually tested (see Workshop Hints).

Knock Sensors: are required to prevent detonation (pinging) from damaging the engine. The Knock Sensor is a piezoelectric conductor-sound microphone. The ECM will retard the ignition timing (cylinder selective) based on the input of these sensors. Detonation can occur due to:

• High Compression Ratio	**• Maximum Timing Advance Curve**
• Poor Quality Fuel (Octane Rating)	**• High Intake Air and Engine Temperature**
• High Level of Cylinder Filling	**• Carbon Build-Up (Combustion Chamber)**

The Knock Sensor consists of:

1. Shielded Wire
2. Cup Spring
3. Seismic Mass
4. Housing
5. Inner Sleeve
6. Piezo-Ceramic Element



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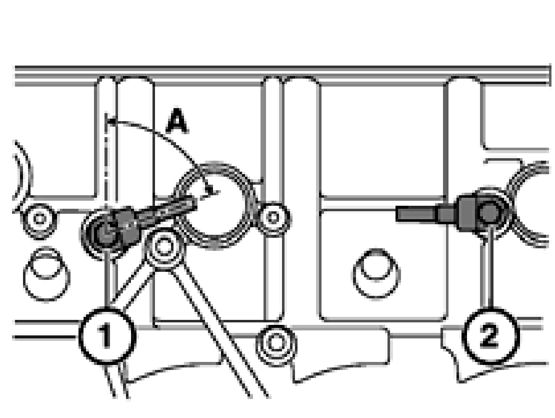
A piezo-ceramic ring is clamped between a seismic mass and the sensor body. When the seismic mass senses vibration (flexing), it exerts a force on the peizo-ceramic element. Opposed electrical charges build up on the upper and lower ceramic surfaces which generates a voltage signal. The acoustic vibrations are converted into electrical signals. These low voltage signals are transmitted to the ECM for processing.

There are two Knock Sensors bolted to the engine block on the intake manifold side, (1) between cylinders 1 - 3 and (2) between cylinders 4 - 6. If the signal value exceeds the threshold, the ECM identifies the “knock” and retards the ignition timing for that cylinder.



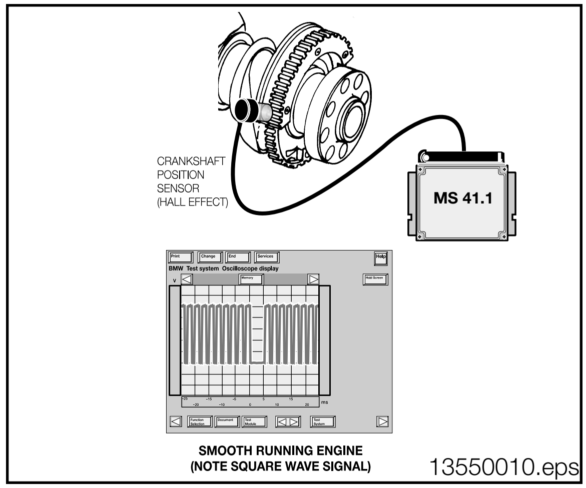
13550001.bmp

If a fault is detected with the sensor(s), the ECM deactivates Knock Control. The “CHECK ENGINE” Light will be illuminated when the OBD II criteria is achieved, the ignition timing will be set to a conservative basic setting and a fault will be stored.

Crankshaft Position/RPM Sensor: This sensor provides the crankshaft position and engine speed (RPM) signal to the ECM for ignition activation and correct timing. This input is also monitored for Misfire Detection. For details about the sensor, refer to the Fuel Management section.

A fault with this input will produce the following complaints:

• **No Start**
• **Intermitant Misfire/Driveabilty**
• **Engine Stalling**

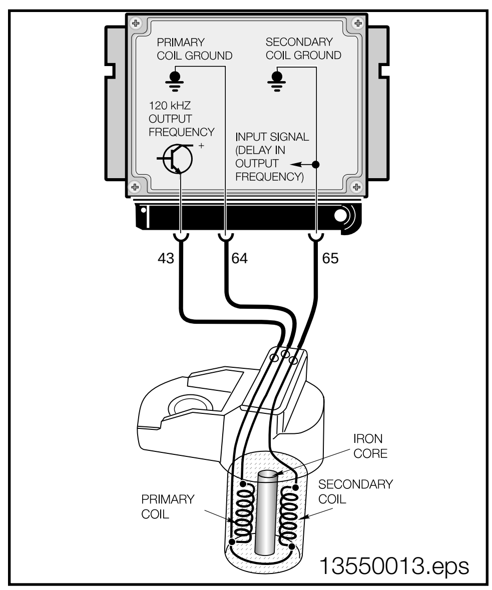


13550010.eps

Camshaft Position Sensor (Cylinder Identification): The cylinder ID sensor input allows the ECM to determine camshaft position in relation to crankshaft position. It is used by the ECM to establish the “working cycle” of the engine for precise ignition timing. For details about the sensor, refer to the Fuel Management section.

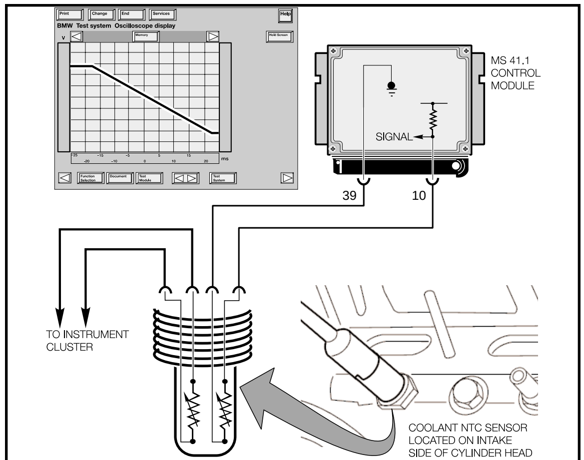
If the ECM detects a fault with the Cylinder ID Sensor, the “CHECK ENGINE” Light will be illuminated when the OBD II criteria is achieved and the system will still operate precise **single ignition** based on the Crank-shaft Position/RPM Sensor.

If the signal is impaired during a restart, the ECM will activate **“double ignition”**. The ignition coils will be activated on both the compression and exhaust strokes to maintain engine operation.



13550013.eps

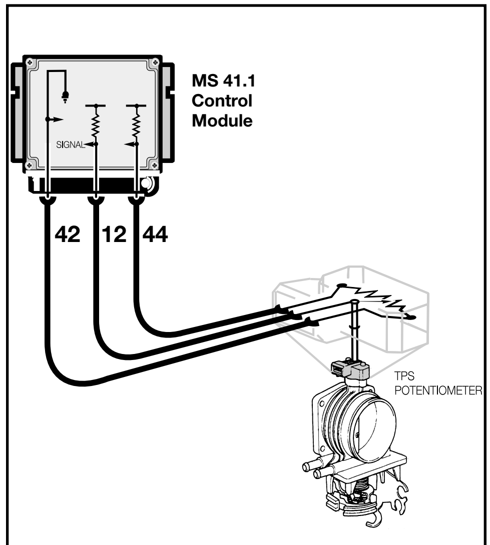
Engine Coolant Temperature: The ECM determines the correct ignition timing required for the engine temperature. For details about the sensor, refer to the Fuel Management section. This sensor is located in the coolant jacket of the cylinder head.



13550015.eps

If the Coolant Temperature Sensor input is faulty, the “CHECK ENGINE” Light will be illuminated when the OBD II criteria is achieved and the ECM will assume a substitute value (80º C) to maintain engine operation. The ignition timing will be set to a conservative basic setting.

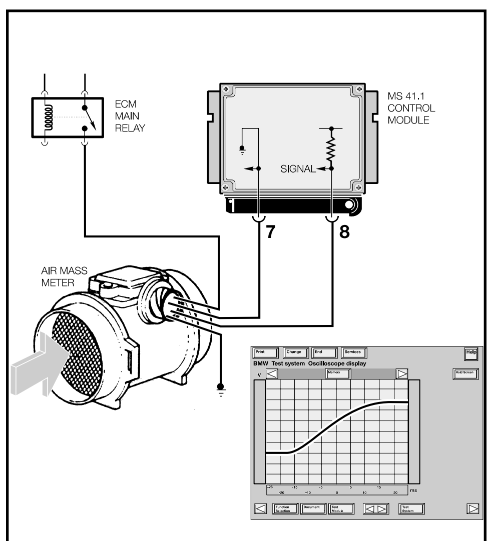
Throttle Position Sensor: This sensor provides the ECM with throttle angle position and rate of movement. As the throttle is opened the ECM will advance the ignition timing. The “full throttle” position indicates maximum acceleration to the ECM, the ignition will be advanced for maximum torque. For details about the sensor, refer to the Air Management section.



13550002.eps

If the Throttle Position input is defective, a fault code will be set and the “Check Engine” Light will illuminate when the OBD II criteria is achieved. The ECM will maintain engine operation based on the HFM and the Engine Speed Sensor, and the ignition timing will be set to a conservative basic setting.

Hot-Film Air Mass Meter: This input is used by the ECM to determine the amount of ignition timing advance based on the amount of intake air volume. For details about the sensor, refer to the Air Management section.



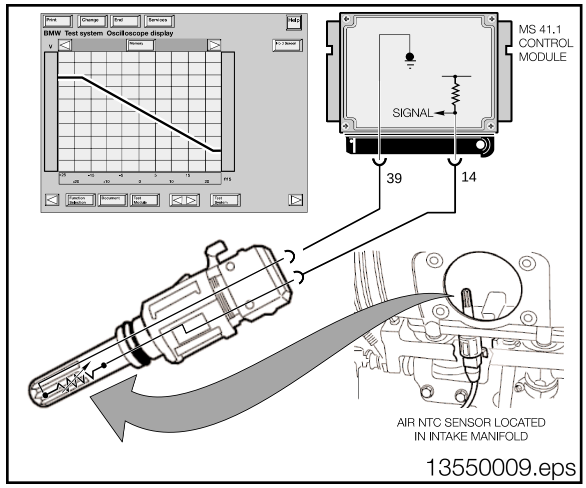
13550004.eps

If this input is defective, a fault code will be set and the “CHECK ENGINE” Light will illuminate when the OBD II criteria is achieved. The ECM will maintain engine operation based on the Throttle Position Sensor and Engine Speed Sensor, and the ignition timing will be set to a conservative basic setting.

Air Temperature: This signal allows the ECM to make a calculation of air density. The sensor is located in the intake manifold behind the throttle housing. For details about the sensor, refer to the Air Management section.

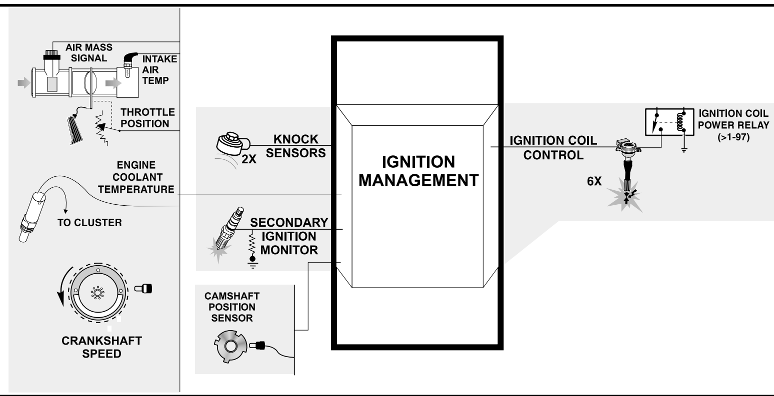
The ECM will adjust the ignition timing based on air temperature. If the intake air is hot the ECM retards the igniton timing to reduce the risk of detonation. If the intake air is cooler, the ignition timing will be advanced.

If this input is defective, a fault code will be set and the "Check Engine" Light will illuminate when the OBD II criteria is achieved. The ignition timing will be set to a conservative basic setting.



Principle of Operation

Ignition Management provides ignition to the combustion chambers with the required voltage at the correct time. Based on the combination of inputs, the ECM calculates and controls the **ignition timing** and **secondary output voltage** by regulating the activation and dwell of the **primary ignition circuits.** The ECM controls and monitors the primary ignition circuits and the secondary ignition output including **Misfire Detection**.



13550020.eps

The ECM has a very "broad" range of ignition timing. This is possible by using a Direct Ignition System, or sometimes refered to as "Static Ignition System" (RZV). Reliability is also increased by having separate individual ignition circuits.

The Ignition Control is determined by the ECM (load dependant). The ECM will calculate the engine "load" based on a combination of the following inputs:

• Battery Voltage	**• Throttle Position**	**• Air Flow Volume**
• Air Temperature	**• Engine Coolant**	**• Crankshaft Position/RPM**
• Camshaft Position (Cylinder ID)	**• Knock Sensors**	

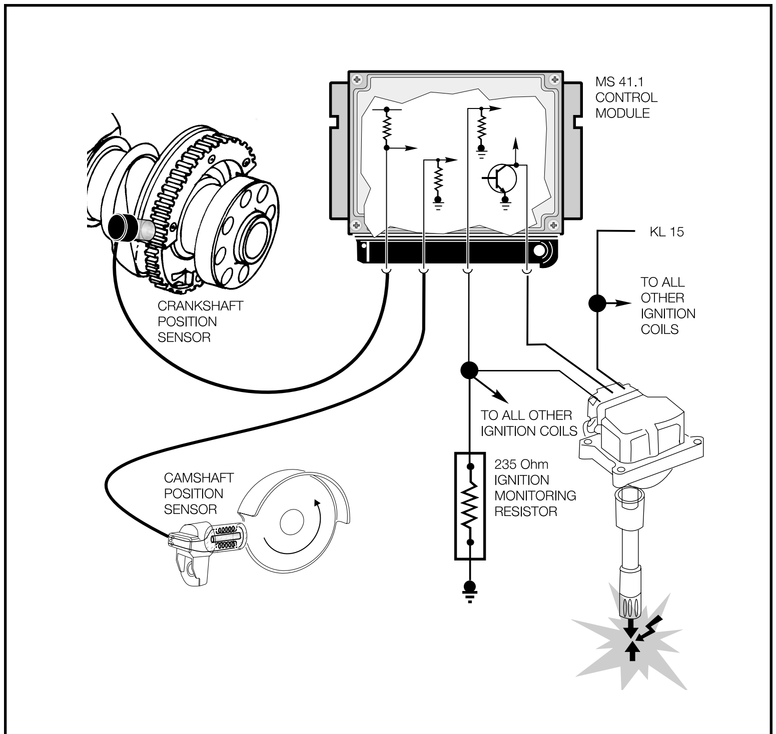
The dwell time will be regulated based on battery voltage. When cranking, the voltage is low and the ECM will increase the dwell to compensate for saturation "lag time". When the engine is running and the battery voltage is higher, the ECM will decrease the dwell due to faster saturation time.

The Crankshaft Position/RPM signals the ECM to start ignition in firing order (1-5-3-6-2-4) as well as providing information about the engine operation. This input is used in combination with other inputs to determine engine load which advances/retards the ignition timing. Without this input, the ECM will not activate the ignition.

Cold start is determined by the ECM based on the engine coolant temperature and rpm during start up. A cold engine will crank over slower than a warm engine, the ignition timing will range between top dead center to slightly retarded providing optimum starting.

When starting a warm engine, the rpm is higher which results in slightly advanced timing.

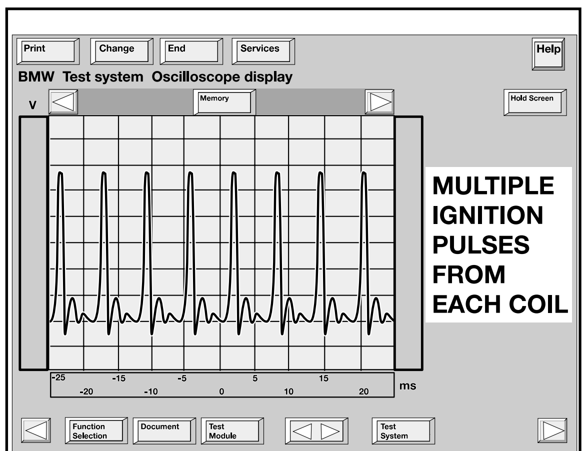
If the engine coolant and intake air temperature is hot, the ignition timing will not be advanced reducing starter motor "load".



12550010.eps

Multiple Ignition Pulses ensure good spark quality during engine start up. The ECM will activate the ignition coils 9 times per 720º of crankshaft revolution.

The ignition timing will be progressively advanced assisting the engine in coming up to speed. As the engine speed approaches idle rpm, the timing remains slightly advanced to boost torque. When the engine is at idle speed, minimum timing advance is required. This will allow faster engine and catalyst warm up.



12550011.eps

The multiple pulsing switches to single pulse after the engine has been running for a short period of time or:

• Engine Temperature >55º
• Engine Speed >800 RPM

The timing will be advanced when the ECM observes low engine rpm and increasing throttle/air volume inputs (acceleration torque). As the throttle is opened, the ECM advances the timing based on engine acceleration and at what rate. The ECM will fully advance timing for the "full throttle" position indicating maximum acceleration (torque).

The HFM signal represents the amount of intake air volume. This input is used by the ECM to determine the amount of timing advance to properly combust the air/fuel mixture.

The Air Temperature Signal assists the ECM in reducing the risk of detonation (ping). If the intake air is hot the ECM retards the igniton timing. If the intake air is cooler, the ignition timing will be advanced.

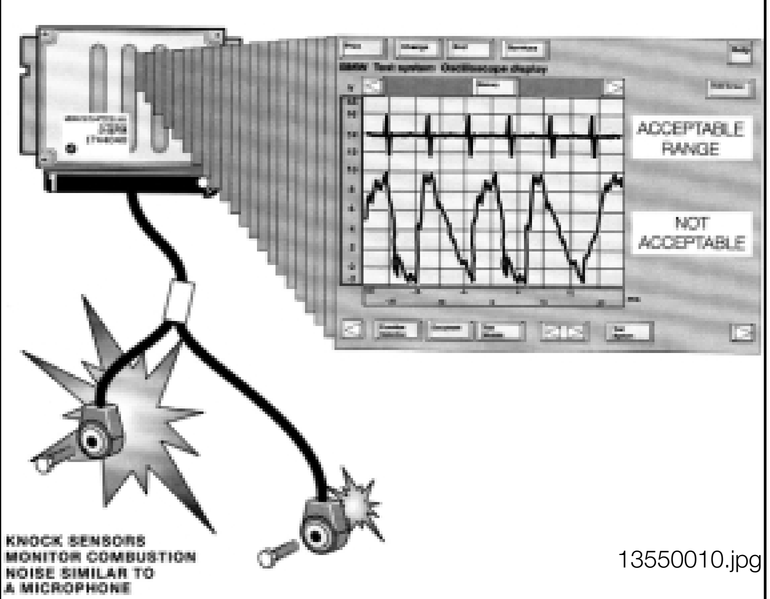
As the throttle is closed, the ECM decreases the ignition timing if the rpm is above idle speed (coasting). This feature lowers the engine torque for deceleration. When the engine rpm approaches idle speed, the timing is slightly advanced to prevent the engine from stalling. The amount of advance is dependent upon the engine temperature and the rate of deceleration.

Knock Control allows the ECM to further advance the ignition timing under load for increased torque. This system uses two Knock Sensors located between cylinders 1,2,3 and between cylinders 4,5,6. Knock Control is only in affect when the engine temperature is greater than 35 ºC and there is a load on the engine. This will disregard false signals while idling or from a cold engine.

Based on the firing order, the ECM monitors the Knock Sensors after each ignition for a normal (low) signal.

If the signal value exceeds the threshold, the ECM identifies the "knock" and retards the ignition timing (3º) for that cylinder the next time it is fired. This process is repeated in 3º increments until the knock ceases.

The ignition timing will be advanced again in increments to just below the knock limit and maintain the timing at that point.



13550010.jpg

If a fault is detected with the Knock Sensor(s) or circuits, the ECM deactivates Knock Control. The ignition timing will be set to a conservative basic setting (to reduce the risk of detonation) and a fault will be stored. The "CHECK ENGINE" Light will be illuminated when the OBD II criteria is achieved.

Workshop Hints

Before any service work is performed on any ignition system related component, always adhere to the following:

• Observe relevent safety legislation pertaining to your area
• Always wear adequate protection clothing including eye protection.
• Use caution when working around a HOT engine compartment.
• Always consult the REPAIR INSTRUCTIONS on the specific model you are working on before attempting a repair.
• Always SWITCH OFF THE IGNITION (KL15) before working on the ignition system.
• Use only BMW approved test leads.
• NEVER TOUCH COMPONENTS CONDUCTING CURRENT with the engine running.
• Do not connect suppression devices or a "test light" to terminal 1 of the ignition coils.
• Terminal 1 from the ignition coil to the ECM (High Voltage approximately 350 V)

HIGH VOLTAGE - DANGER!

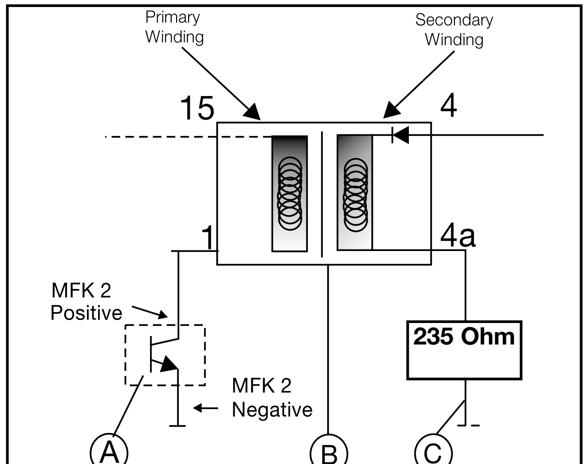
Caution! Hazardous voltages occur at:

• Ignition Leads
• Spark Plug Connector
• Spark Plug
• Ignition Coil (High Voltage at terminal 4 is approximately 30 KV)
• Terminal 1 from the ignition coil to the ECM (High Voltage approximately 350V)

Ignition System Diagnosis

A fault survey should first be performed using the DIS/MoDIC to determine if there is a fault in the primary ignition or secondary ignition. If there is a fault in the primary ignition, testing should include:

• **Power Supply at the Coil (KL15)**
• **Resistance of the harness and ignition coil primary winding (terminal 15 to 1 approximate 0.8 ohms) - using the 88 Pin Adapter with the ECM disconnected**

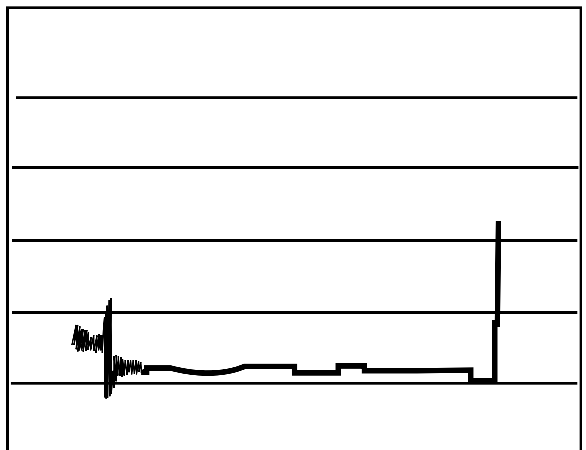


13550034.eps

A. ECM Primary Circuit Final Stage Transistor
B. ECM Ignition Coil (one of six)
C. Secondary Coil Ground

ECM Final Stage transistor activation. This test function is found under the Oscilloscope Preset list - “Ignition Signal Primary” (normal Terminal 1 Signal shown on the right).

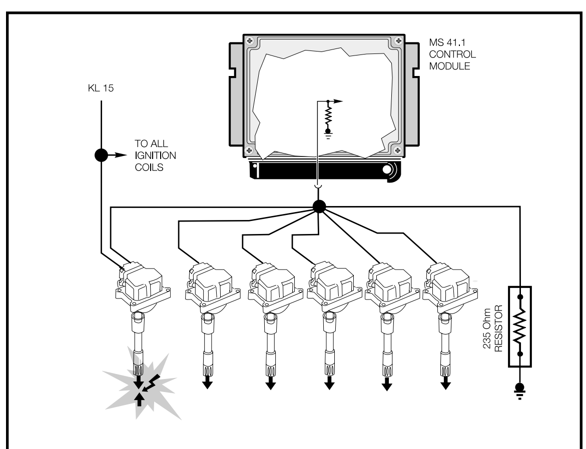
Install the 88 Pin Adapter, Diagnostic cable, MFK 2 negative lead to ECM ground and MFK 2 positive lead to the ground activation circuit for Terminal 1 of the ignition coil. This test is performed with the engine running.


13550017.eps

The Terminal 4a Signal should be tested using the DIS “Preset Measurements”. Refer to the HELP button for additional (on screen) connections.

There is one signal present for each secondary ignition. This signal represents successful coil induction.

This Signal does not verify the adapter (boot) and spark plug is functioning correctly! Therefore additional secondary ignition testing should be performed.



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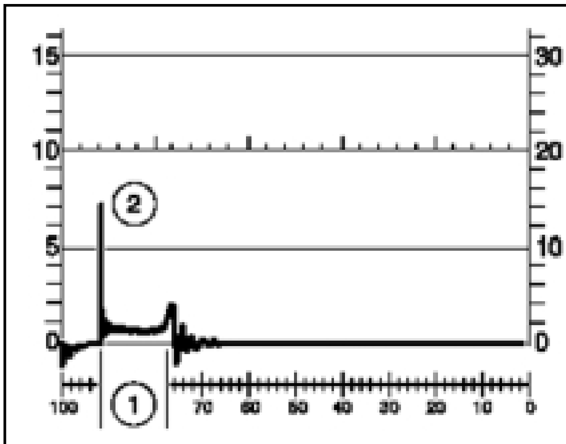
If there is a fault in the secondary ignition, testing should include:

• Primary Ignition	**• Evaluation of Secondary Oscilloscope Patterns**

The Following are Examples of Secondary Oscilloscope Patterns (consult Repair Instructions for ignition pattern variations per coil manufacturer)**:**

This is a normal pattern for one ignition circuit with the engine at idle speed.

1. Normal Combustion Period
2. Normal Ignition Voltage Peak

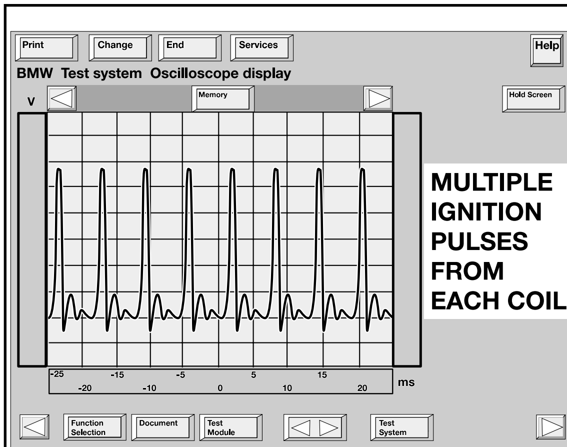


07550001.bmp

Multiple Ignition Pulses ensure good spark quality during engine start up. The ECM will activate the ignition coils 9 times per 720º of crankshaft revolution.

This is a normal pattern for one ignition circuit when:

• Engine Temperature <55º C
• Engine speed <800 RPM



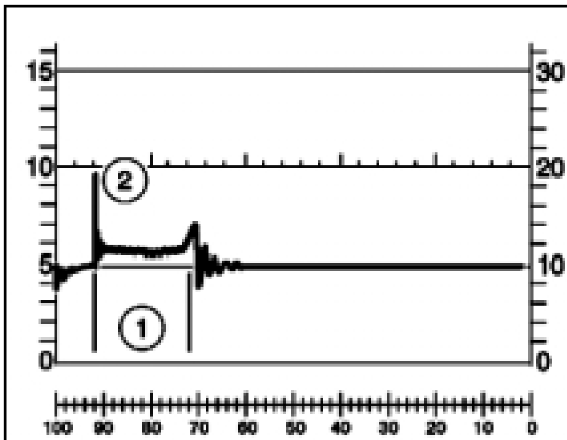
12550011.eps

Long Spark Period (1) with Low Ignition Voltage Peak (2). If Spark Period is Fluctuating:

• Indicates Low Compression
• Contamination on Spark Plug or Defective Spark Plug

Short Spark Period (1) with High Ignition Voltage Peak (2).

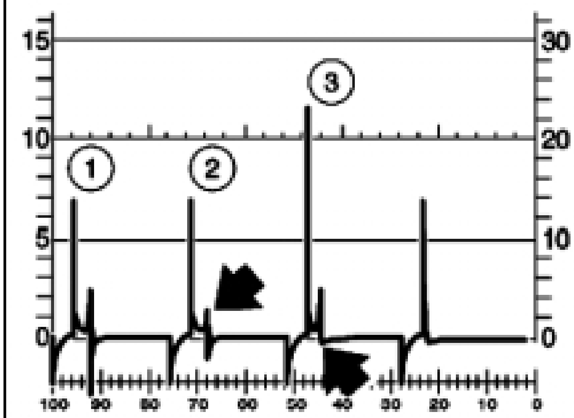
• Defective Ignition Connector or Resistive adapter Boot



07550002.bmp

Evaluation of Ignition Voltage Peaks at Idle Speed (Multiple Cylinders Displayed).

1. Normal Attenuation (Voltage Reduction) Process
2. Shorten Attenuation Process-Defective Ignition Coil
3. Abscence of Attenuation - Defective Igniton Coil



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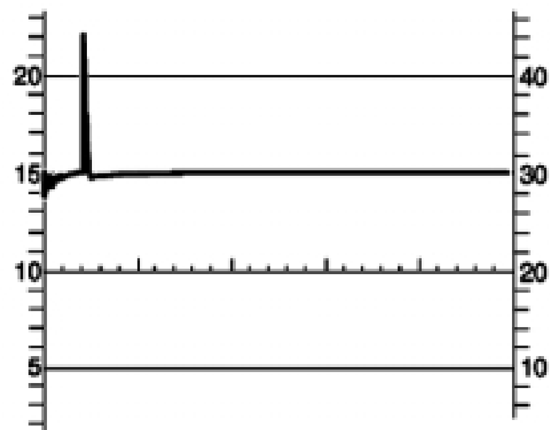
No Sparking Volatge Line (Single Cylinder Displayed)

• Defective Igniton Coil



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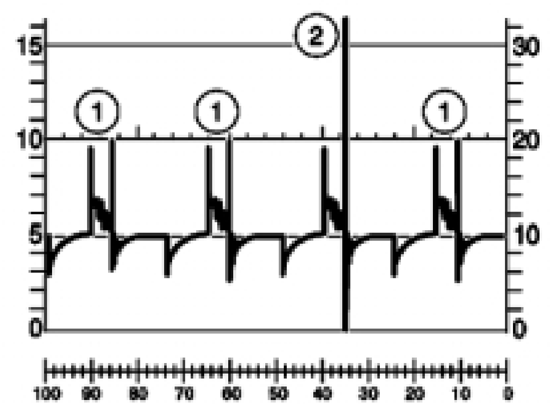
Evaluation of Ignition Voltage Peaks under Sudden Loads (Multiple Cylinders Displayed).

1. Decaying Process is not much Higher than Igniton Voltage Peak - System is Ok.

Decaying Process is considerably Higher than Ignition Voltage Peak (2):

• Lean Mixture
• Defective Fuel Injector
• Low Compression



07550006.bmp

The Repair Instructions should be consulted for additional Oscilloscope Patterns under various engine speeds.

In Summary,

If the Secondary Ignition **Voltage is Too High (Excessive Resistance for Ignition):**

• Spark Plug Gap is to Large (Worn or Burned)
• Incorrect Heat Range Spark Plug
• Compression is too High (Carbon, etc.)
• Lean Mixture (Vacuum Leak, etc.)
• Interruption in the Secondary Ignition Connector or Resistive Adapter Boot

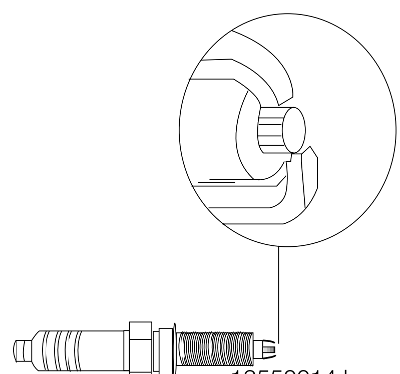
If the Secondary Ignition **Voltage is Too Low (Low Resistance for Ignition):**

• Spark Plug Gap is Too Small (Mishandled on Installation)
• Incorrect Heat Range Spark Plug
• Compression is Too Low
• Voltage Leak in the Secondary Ignition Connector or Resistive Boot to Ground

Spark Plugs

The Spark Plugs should be inspected for the proper type, gap and replaced at the specified intervals.

Refer to the Service Information Bulletin S.I. #12 01 99 for the proper type and a visual of the spark plug (showing effects of combustion, fouling, etc.)



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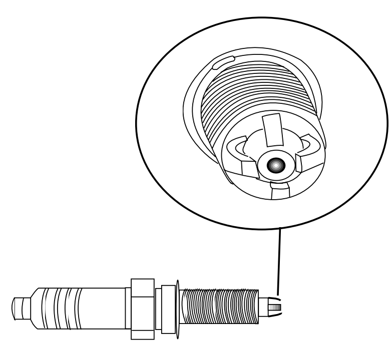

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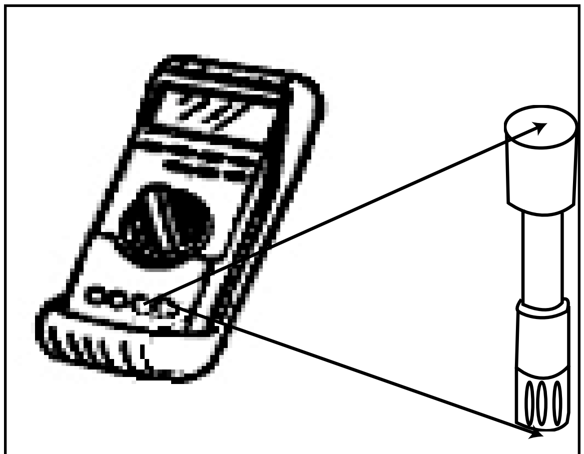
Ignition Adapter (Boot)

The secondary ignition Resistive Adapter Boot should be visually inspected and checked for resistance.

For example, the Resistive Adapter Boot has a different ohmic value depending on the manufacturer:

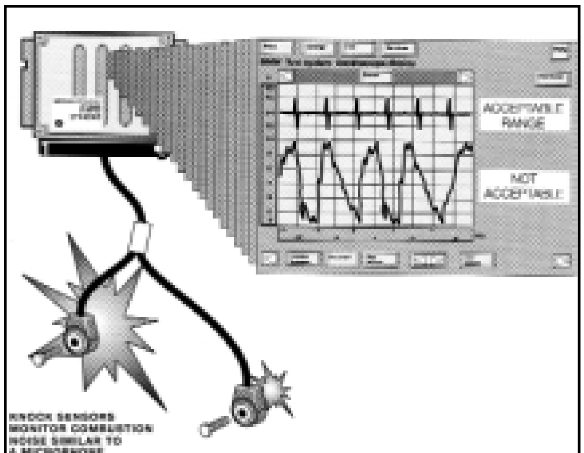
• Bosch - 1k ohm +/- 20%
• Bremi - 1.8k ohm +/- 20%


13550035-1.eps

Knock Sensors

The Knock Sensors should be tested using the DIS/MoDIC for:

• Fault Codes
• Status Display - Knock Control (active / not active)
• Oscilloscope Display (Low DC Voltage - mV setting)



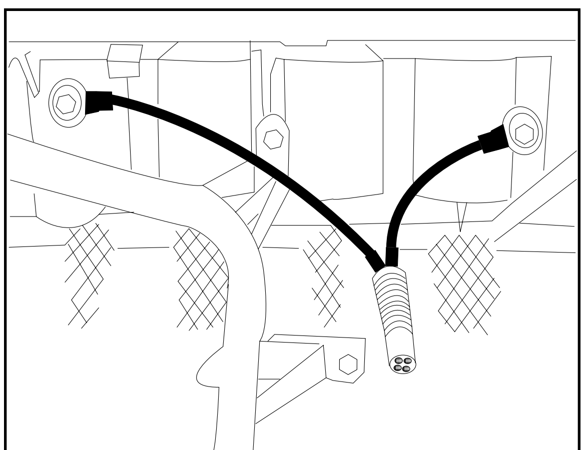
13550010.jpg

When installing Knock Sensors:

DO NOT MIX THE LOCATIONS or Engine Damage will result! The Knock Sensors use a combined connection to the engine harness. The Knock Sensor with the shorter cable is for cylinders 4 - 6.

Do Not Over Tighten attaching bolt! - Piezo ceramic will be cracked. Torque to 20 nm.

Do Not Under Tighten attaching bolt, a lose sensor can vibrate producing a similar signal to a knock.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Tools and Equipment

The DIS/Modic as well as a reputable hand held multimeter can be used when testing inputs/ components.

It is best to make the checks at the ECM connection, this method includes testing the wiring harness.

The correct Universal Adapter for the MS41.X application should be used (#88 88 6 614 410). This will ensure the pin connectors and the harness will not be damaged.

The interior of this Universal Adapter is shielded, therefore it is vital that the ground cable is connected to the vehicle chassis whenever the adapter is used.

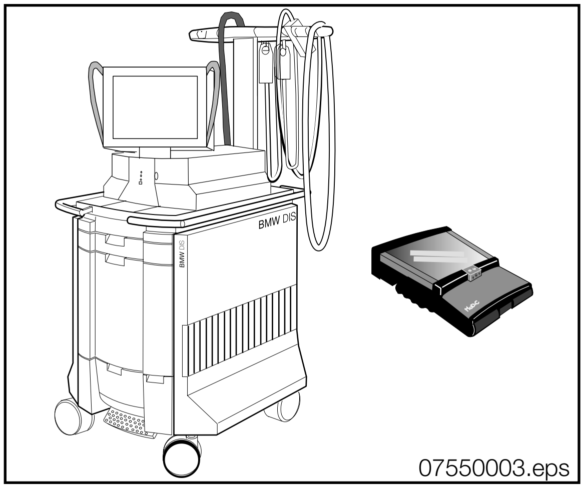
The adapter uses a Printed Circuit board inside keeping the capacitive and inductive load to a minimum.

When installing the Universal Adapter to the ECM (located below the windshield on the passenger side of the engine compartment), make sure the ignition is switched off.

When Testing the Secondary Ignition System, use Special Tool #88 88 6 127 040 (Secondary Ignition Adapter Set shown to the right) which connects to the DIS. The instruction book is included with the kit. Refer to the HELP button for additional (on screen) connections.

Caution!

Observe Safety Precautions, High Voltage is Present with the Engine Running



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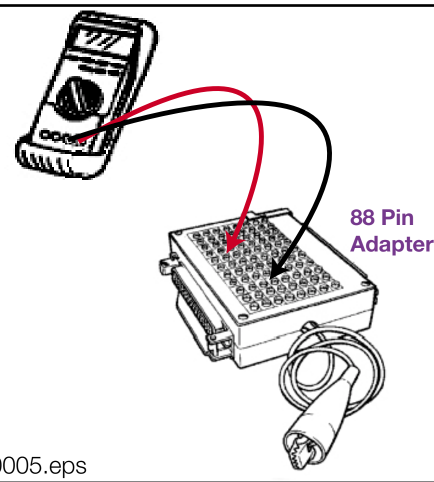

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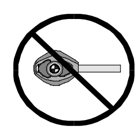
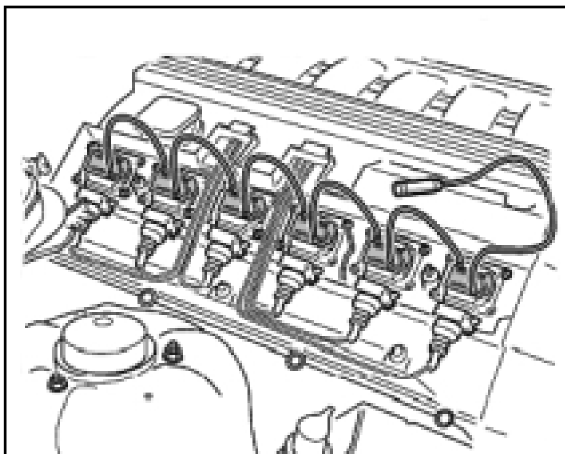
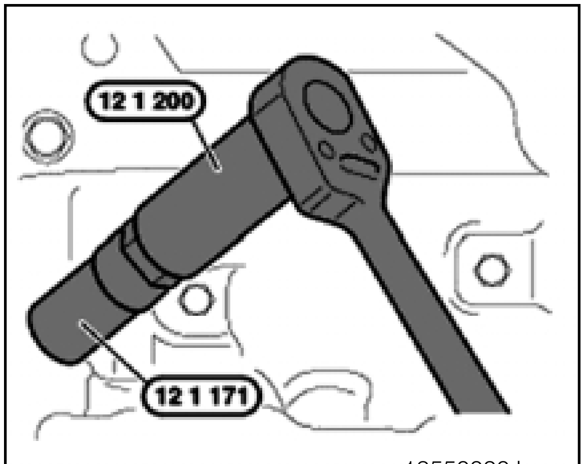




13550012.bmp

The Spark Plugs should be properly installed and torqued using the following Special Tools:

• **12 1 200 Torque Adapter (prevents over tightening)**
• **12 1 171 Spark Plug Socket**



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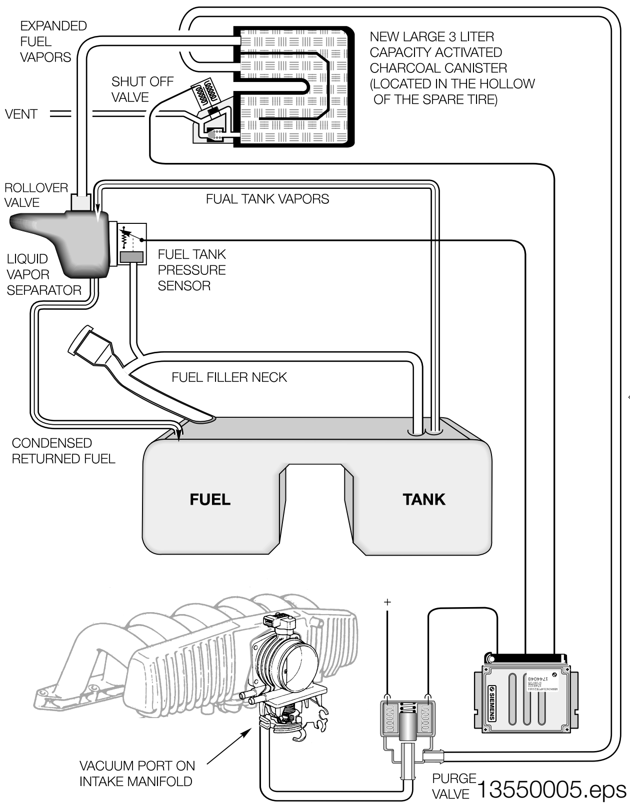
NOTE: NEVER USE AIR TOOLS FOR REMOVAL OR INSTALLATION!

Emissions Management-Transitional Low Emission Vehicle (TLEV) Compliant

E36



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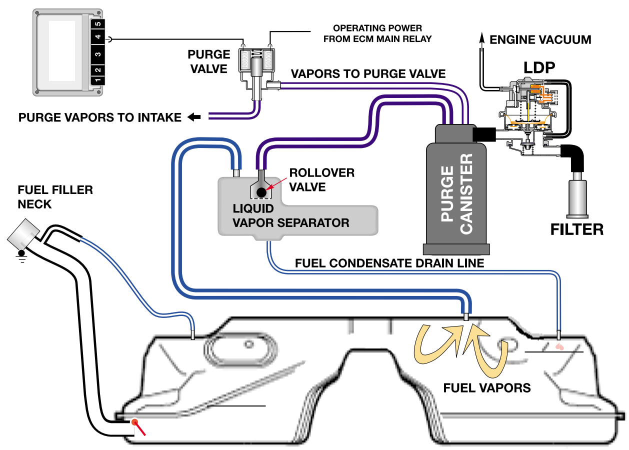
E39



13550005-1.eps

Evaporative Emissions: The control of the evaporative fuel vapors (Hydrocarbons) from the fuel tank is important for the overall reduction in vehicle emissions. The evaporative system has been combined with the ventilation of the fuel tank, which allows the tank to breath (equalization). The overall operation provides:

- **An inlet vent, to an otherwise "sealed" fuel tank, for the entry of air to replace the fuel consumed during engine operation.**
- **An outlet vent with a storage canister to "trap and hold" fuel vapors that are produced by the expansion/evaporation of fuel in the tank, when the vehicle is stationary.**

The canister is then "purged" using the engine vacuum to draw the fuel vapors into the combustion chamber. This "cleans" the canister allowing for additional storage. Like any other form of combustible fuel, the introduction of these vapors on a running engine must be controlled.

The ECM controls the Evaporative Emission Valve which regulates purging of evaporative vapors. The evaporative system must be monitored for correct purge operation and Leak Detection.

On-Board Refueling Vapor Recovery (ORVR 98 MY E39): The ORVR system recovers and stores hydrocarbon fuel vapor that was previously released during refueling. Non ORVR vehicles vent fuel vapors from the tank venting line back to the filler neck and in many states reclaimed by a vacuum receiver on the filling station's fuel pump nozzle.

When refueling an ORVR equipped vehicle, the pressure of the fuel entering the tank forces the hydrocarbon vapors through the larger tank vent line to the liquid/ vapor separator, through the rollover valve and into the charcoal canister. The HC is stored in the charcoal canister, and the system can then "breath" through the LDP and the air filter.

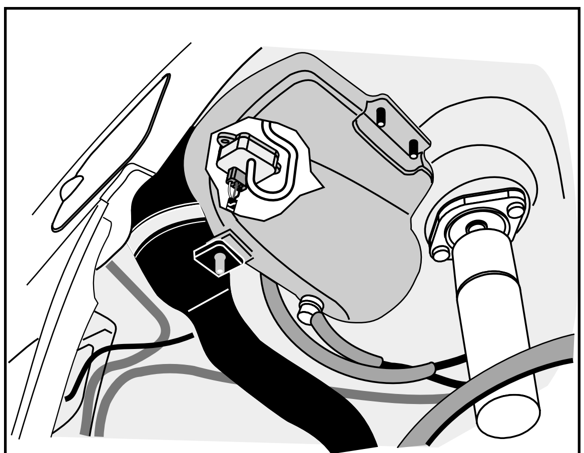
The vent line to the filler neck is smaller, but still necessary for checking the filler cap/neck during Evaporative Leak Testing.

Liquid/Vapor Separator: Fuel vapors are routed from the fuel tank filler neck through a hose to the Liquid/Vapor Separator (E36 shown, consult Repair Instructions for E39/Z3). The vapors cool when exiting the fuel tank, the condensates separate and drain back to the fuel tank through a return hose. The remaining vapors exit the Liquid/ Vapor Separator to the Active Carbon Canister.

Fuel Tank Pressure Sensor (E36/Z3 Vehicles): The pressure transducer mounted on the liquid/ vapor separator (fuel tank on Z3) provides the fuel tank pressure input to the ECM. This is used by the ECM to check the fuel storage and evaporative (purge) system for leaks.

The pressure sensor receives a power supply from the ECM and produces a varying voltage input (0-5v) to the ECM, representing the amount of pressure in the fuel tank/evaporative system.

If this input is defective, a fault code will be set and the "CHECK ENGINE" Light will illuminate when the OBD II criteria is achieved.



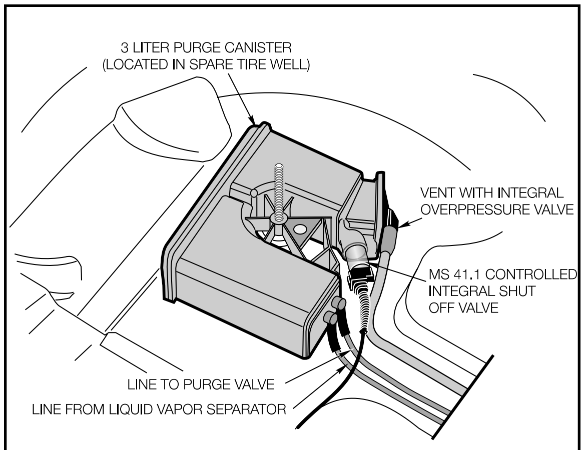
13550060.eps

Active Carbon Cannister: As the hydrocarbon vapors enter the 3 liter canister, they will be absorbed by the active carbon. The remaining air will be vented to the atmosphere through the end of the canister allowing the fuel tank to “breath”. When the engine is running, the canister is then "purged" using intake manifold vacuum to draw air through the canister which extracts the hydrocarbon vapors into the combustion chamber. The canister is located in the spare tire well (E36 shown, consult Repair Instructions for E39/Z3).

Air Inlet Shut Off Valve (E36 VEHICLES): A shut-off valve is installed on the intake or vent side of the charcoal canister as a component of the vacuum type Evaporative Fuel System Leak system.

Operation of the valve is controlled by the ECM. When the shut-off valve and purge valve are closed, the entire fuel tank/evaporative system is sealed from the atmosphere.

The shut-off valve is required to test the system for leaks. If this valve is defective, a fault code will be set and the “CHECK ENGINE” Light will illuminate when the OBD II criteria is achieved.



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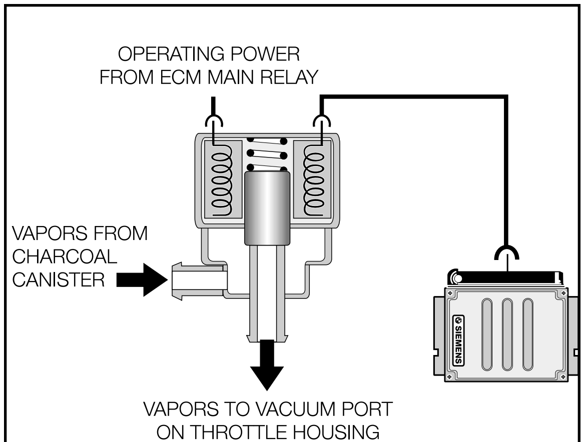
Evaporative Emission Valve: This ECM controlled solenoid valve regulates the purge flow from the Active Carbon Canister into the intake manifold (located next to the HFM). The ECM Relay provides operating voltage and the ECM controls the valve by regulating the ground circuit. The valve is powered open and closed by an internal spring.

If the Evaporative Emission Valve circuit is defective, a fault code will be set and the “CHECK ENGINE” Light will illuminate when the OBD II criteria is achieved.

If the valve is “mechanically” defective, a driveability complaint could be encountered and a mixture related fault code will be set.



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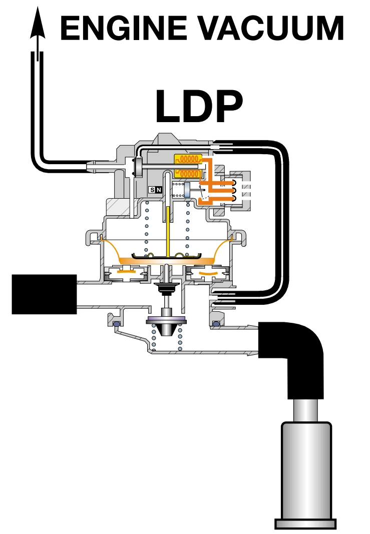
LDP (Leak Diagnosis Pump - E39): The LDP provides a means of testing the fuel/evaporative system for leaks. The pump is activated by ECM control. It pressurizes the fuel tank and evaporative system.

The upper chamber contains an integrated reed switch that produces a switched high/low voltage signal that is monitored by the ECM. The switch is opened by the magnetic interruption of the metal rod connected to the diaphragm when in the top dead center position.

The repetitive up/down stroke is confirmation to the ECM that the valve is functioning and the basis for determining if a leak is present in the system.



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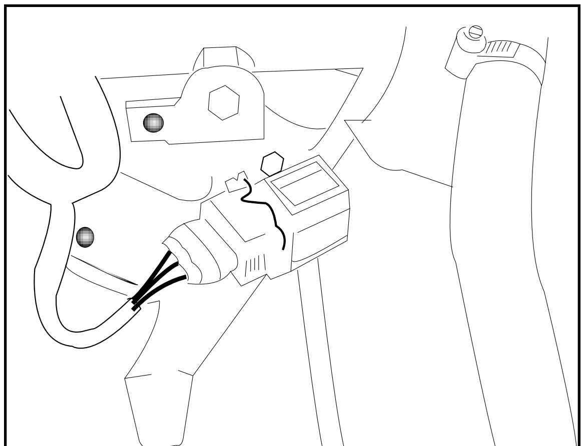
The ECM monitors the length of time it takes for the reed switch to open, which is opposed by pressure under the diaphragm in the lower chamber. If this component/circuits are defective, a fault code will be set and the "CHECK ENGINE" Light will illuminate when the OBD II criteria is achieved.

Barometric Pressure Sensor (98 MY E39): The 1998 528i with MS 41.1 requires an additional input signal for activation of the LDP function test.

The sensor is located on passenger side strut tower forward of ASC 5 Hydraulic Unit.



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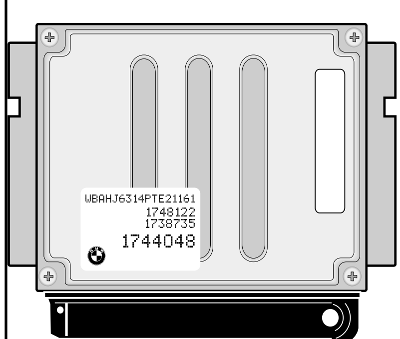
The LDP test function can occur during a long trip. If the test occurs while the vehicle is driven down a very steep grade just prior to the LDP test, the barometric pressure sensor provides a rapid change (varied DC voltage signal) informing the ECM to postpone the test function.

If this component/circuits are defective, a fault code will be set and the "CHECK ENGINE" Light will illuminate when the OBD II criteria is achieved.



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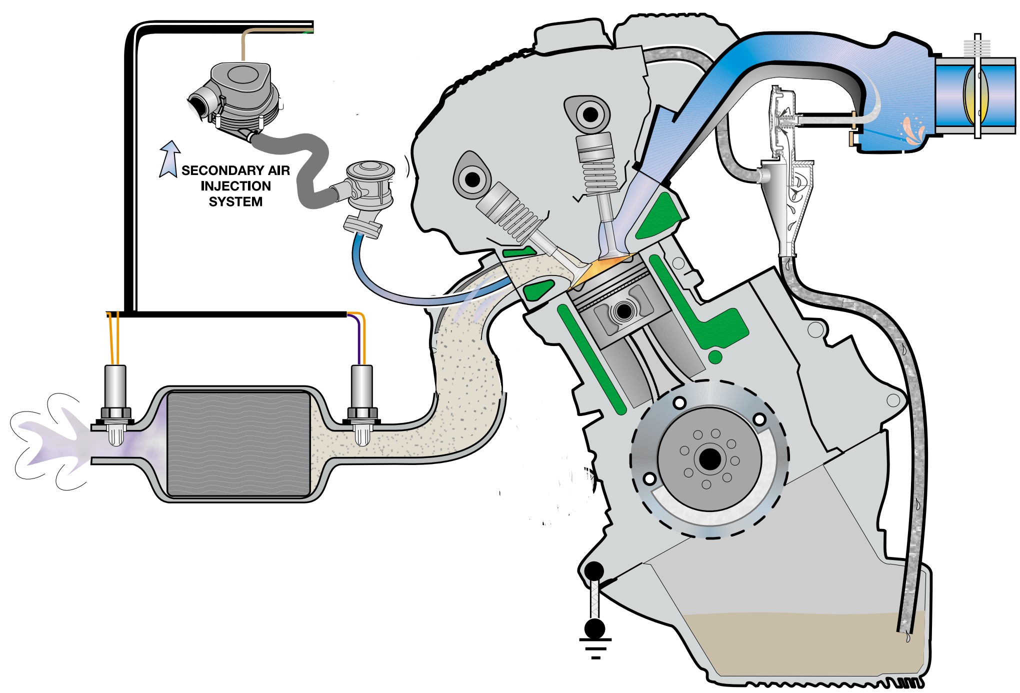


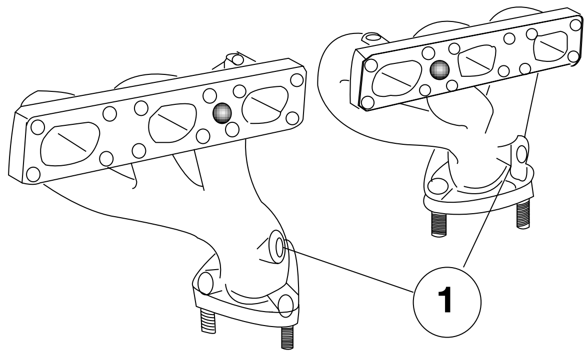
Exhaust Emissions: The combustion process of a gasoline powered engine produces Carbon Monoxide (CO), Hydrocarbons (HC) and Oxides of Nitrogen (NOx).

• Carbon Monoxide is a product of incomplete combustion under conditions of air deficiency. CO emissions are strongly dependent on the air/fuel ratio.
• Hydrocarbon are also a product of incomplete combustion which results in unburned fuel. HC emissions are dependent on air/fuel ratio and the ignition of the mixture.
• Oxides of Nitrogen are a product of peak combustion temperature (and temperature duration). NOx emissions are dependent on internal cylinder temperature affected by the air/fuel ratio and ignition of the mixture.

Control of exhaust emissions is accomplished by the engine and engine management design as well as after-treatment.

• The ECM manages exhaust emissions by controlling the air/fuel ratio and ignition.
• The ECM controlled Secondary Air Injection further dilutes exhaust emissions leaving the engine and reduces the catalyst warm up time.
• The Catalytic Converter further reduces exhaust emissions leaving the engine.

Siemens Oxygen Sensor: The pre-catalyst oxygen sensors (single sensor for 323i and Z3) measure the residual oxygen content of the exhaust gas. The sensors vary in resistance proportional to the oxygen content that allows the ECM to monitor the air/fuel ratio. If necessary, the ECM will "correct" the air/fuel ratio by regulating the injection time. The sensors are mounted in the exhaust manifolds on the E36/E39 (1), up-stream of the catalytic converter. The 323i and Z3 sensor mounts in the down pipe.



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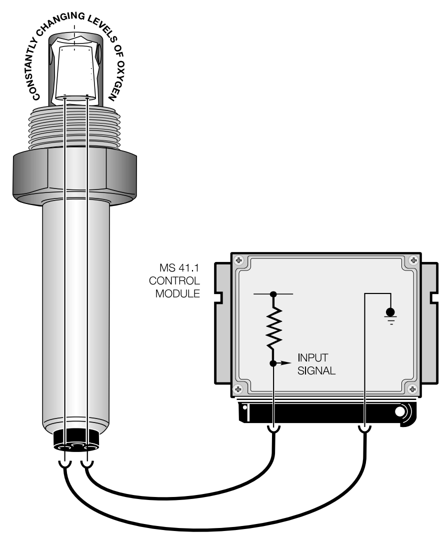
The probe of the sensor which is exposed to the exhaust gas is made from titanium dioxide (semi-conductive material). When heated and maintained to an operating temperature of 600º to 700º C, the titanium dioxide becomes conductive and will allow current to flow, based on the amount of oxygen content.

The ECM supplies the oxygen sensors with 5 volts. The ECM then monitors the voltage drop through the tip of the sensors as a measure oxygen deviation.



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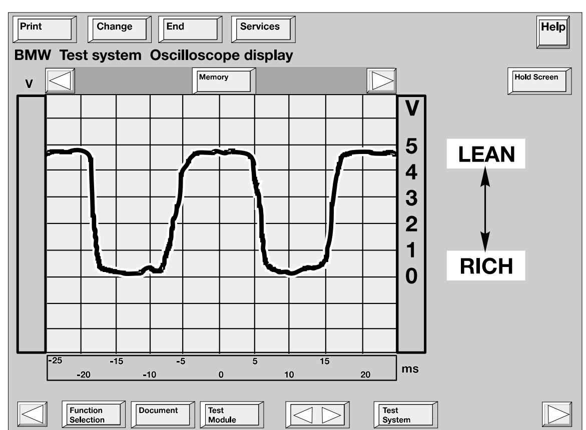
The resistance value of the sensor changes rapidly when the mixture deviates. If the oxygen content of the exhaust is high (lean mixture), the oxygen molecules will block the flow of electrons through the titanium dioxide. This creates high resistance and a small voltage drop across the sensor tip (4.6v monitored by the ECM). If the oxygen content in the exhaust is low (rich mixture), the resistance in the semi-conductive tip decreases and allows electron flow, creating a large voltage drop (0.1v monitored by the ECM).



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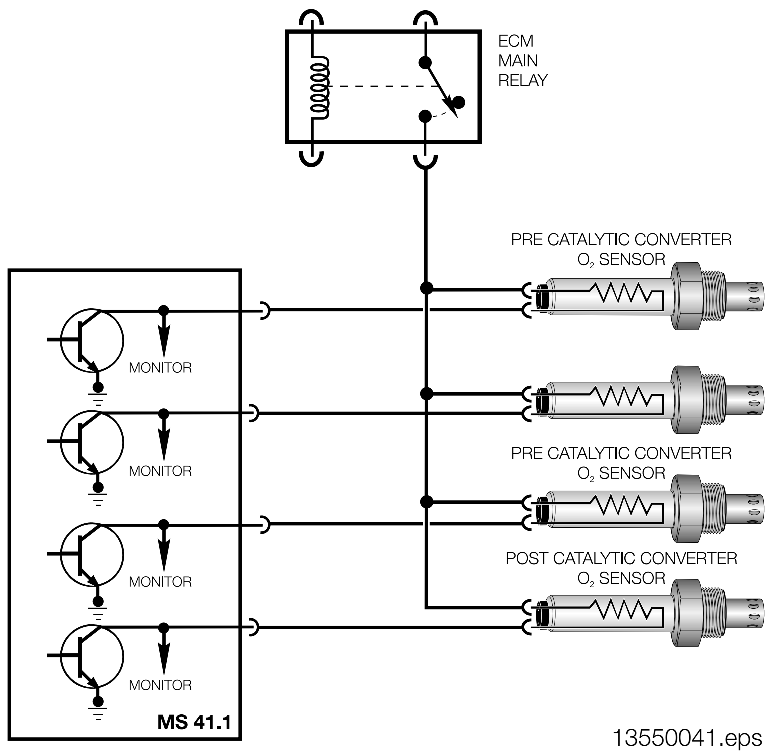
The voltage signal monitored by the ECM will vary between approximately 4.6 to 0.1 volts as the mixture changes from lean to rich. The ECM monitors the length of time the sensor is operating in the lean, rich (including time of rise and fall) and rest conditions. The evaluation period of the sensor is over a predefined number of oscillation cycles.

Direct Oxygen Sensor Heating: The oxygen sensor conductivity is efficient when it is hot (600º - 700º C). For this reason, the sensors contain heating elements. These "heated" sensors reduce warm up time and retain the heat during low engine speed when the exhaust temperature is cooler. OBD II requires monitoring of the oxygen sensor heating function and heating elements for operation.

The four oxygen sensor heating circuits (E36/E39 shown) receive operating voltage from the ECM Relay when KL15 is switched "ON". Each of the sensor heaters are controlled through separate final stage transistors.

The sensor heaters are controlled with a pulsed square wave voltage during a cold start. This allows the sensors to be brought up to operating temperature without the possibility of thermal shock. The duty cycle is then varied to maintain the heating of the sensors.



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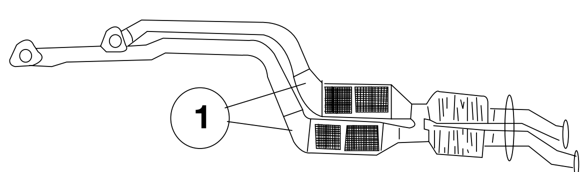
When the engine is decelerating (closed throttle), the ECM increases the duty cycle of the-heating elements to compensate for the decreased exhaust temperature.

Metal Monolith Catalytic Converter: The dual (single on the 323i and Z3) three-way catalysts on the E36/E39 (1) after-treats exhaust emissions leaving the engine. A properly operating catalyst consumes/stores most of the oxygen that is present in the exhaust gas which is a result of burning the remaining pollutants.

The oxygen sensor monitors the air/fuel mixture which allows the ECM to maintain the correct mixture for catalyst efficiency.

The gases that flow into the catalyst are converted from CO, HC and NOx to CO2, H2O and N2.



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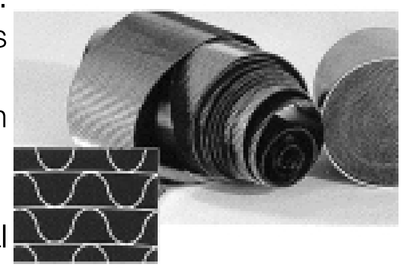
The exhaust flow heats the catalyst and with the remaining oxygen, the exhaust pollutants are further reduced by burning. The temperature operating range for the highest efficiency is 400º - 800º C which is also influenced by the air/fuel mixture. This type of catalyst will store small amounts of excess oxygen which will aid in diluting the exhaust.



13550044.bmp

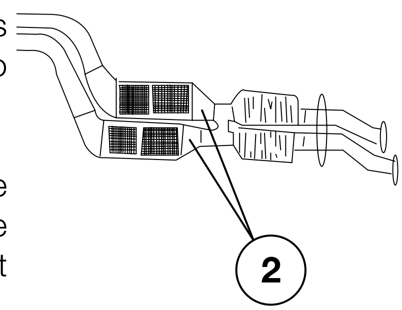
The metal monolith matrix consists of thin (0.04 mm) metal strips (flat and corrugated) that are wound together to form circular bodies. The complete wrapped assembly is inserted into a round sheet metal jacket (1.5 mm thick). The jacket and matrix are coated with chrome-nickel and chrome steel.

This type of catalyst is compact and offers low back pressure with a large internal surface area. The metal monolith has a very rapid "light off" time and an even heat distribution.

13550045.bmp

Catalytic Converter Monitoring: In order to determine if the catalysts are working correctly, post catalyst oxygen sensors (2 E36/E39 and single on the 323i and Z3)) are installed to monitor exhaust gas content exiting the catalysts.

The signal of the post cat. O_2 sensor is evaluated over the course of several pre cat. O_2 sensor oscillations. During the evaluation period, the signal of the post cat. sensor must remain within a relatively constant voltage range (3.5 - 4.6v).



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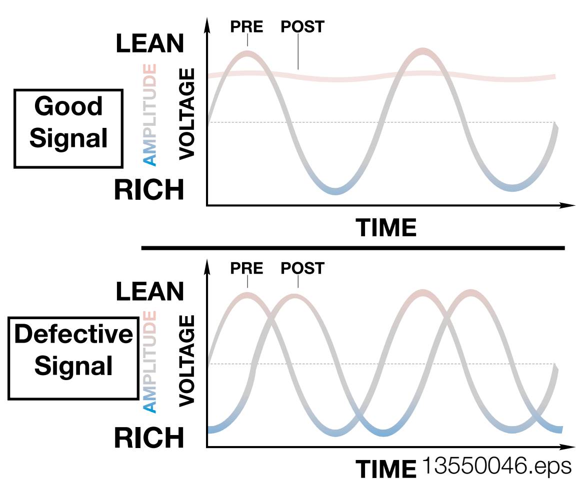
The post cat. O_2 voltage remains high with a very slight fluctuation. This indicates a consistant amount of oxygen when compared to the pre cat. sensor.

If this signal decreased in voltage and/or increased in fluctuation, a fault code will be set for Catalyst Efficiency and the "CHECK ENGINE" Light will illuminate when the OBD II criteria is achieved.



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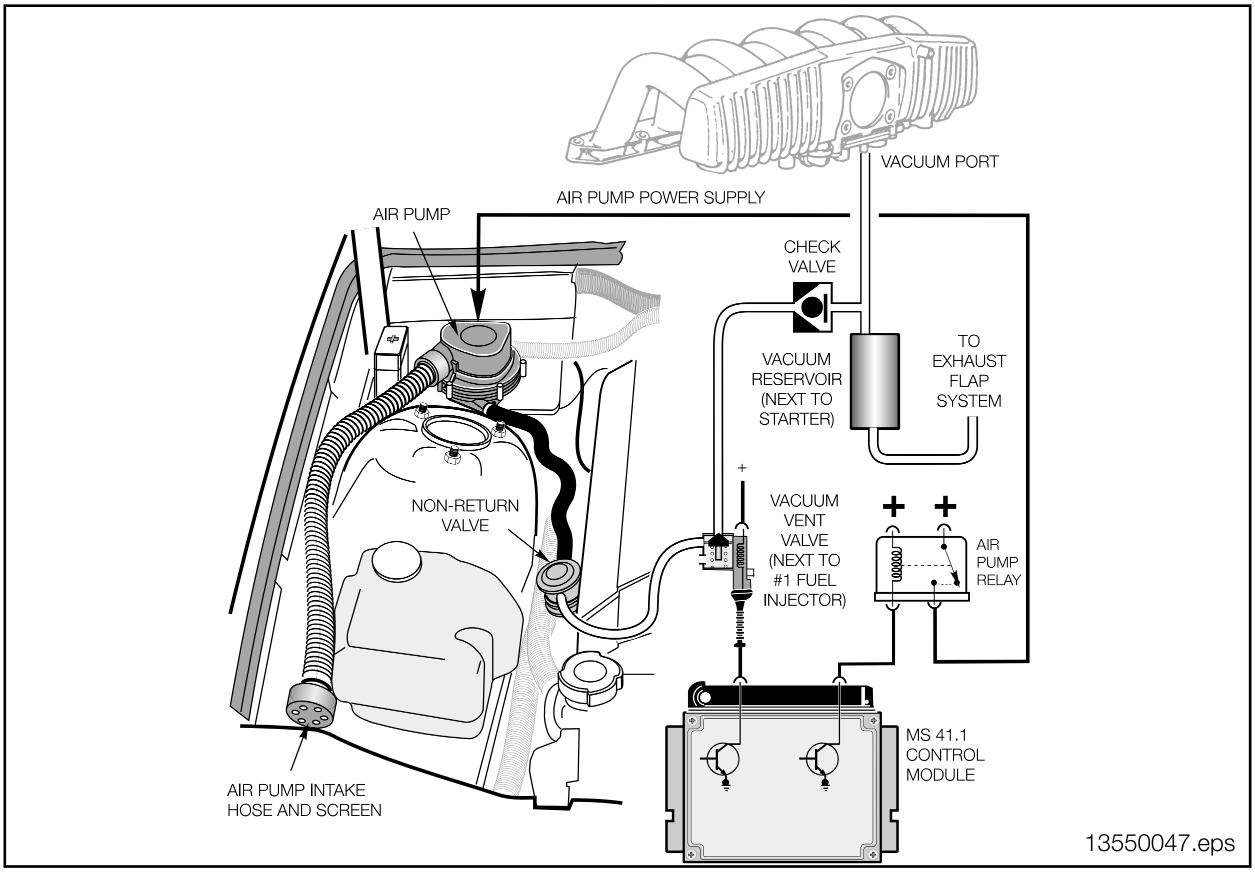
Secondary Air Injection: Injecting ambient air into the exhaust stream after a cold engine start reduces the warm up time of the catalyst and reduces HC and CO emissions. The ECM controls and monitors the Secondary Air Injection. The components of the system (E36 shown) include:

• Secondary Air Injection Pump - Electric pump that draws in ambient air and supplies it to the Non-Return Valve. The pump motor is activated by Secondary Air Injection Pump Relay.
• Secondary Air Injection Pump Relay - Supplies operating voltage to the Secondary Air Injection Pump when activated by the ECM.
• Vacuum Vent Valve (Solenoid) - Switches vacuum to open the Non-Return Valve when activated by the ECM.
• Non-Return Valve - Opened by the Vacuum Vent Valve allowing air to be pumped into the exhaust stream. Sprung closed to prevent exhaust (pressure) from reaching the Secondary Air Injection Components.
• Secondary Air Injection Pipes - Distributes injected air to the exhaust manifold for bank 1 (cylinders 1,2,3) and bank 2 (cylinders 4,5,6).



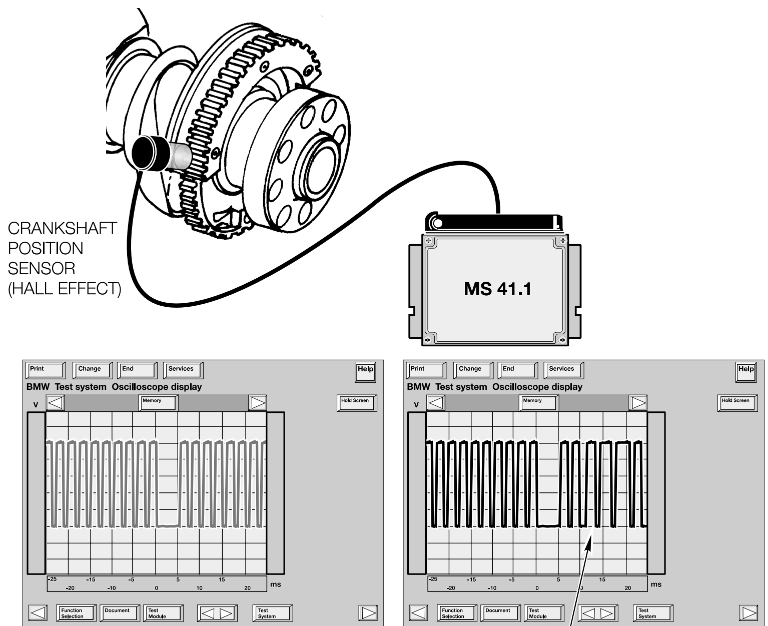
Misfire Detection: As part of the OBD II regulations the ECM must determine misfire and also identify the specific cylinder(s), the severity of the misfire and whether it is emissions relevant or catalyst damaging based on monitoring crankshaft acceleration.

In order to accomplish these tasks the ECM monitors the crankshaft for acceleration by the impulse wheel segments of cylinder specific firing order. The misfire/engine roughness calculation is derived from the differences in the period duration of individual increment gear segments.

Each segment period consist of an angular range of 90° crank angle that starts 54° before Top Dead Center.

If the expected period duration is greater than the permissible value, a misfire fault for the particular cylinder is stored in the fault memory of the ECM.

Depending on the level of misfire rate measured, the ECM will illuminate the "CHECK ENGINE" Light, deactivate the specific fuel injector to the particular cylinder and switch oxygen sensor control to open-loop.



SMOOTH RUNNING ENGINE (NOTE SQUARE WAVE SIGNAL)

ENGINE MISFIRE DETECTED

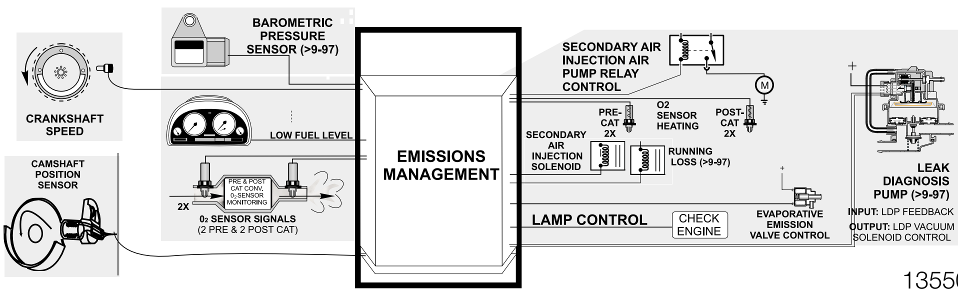
13550003.eps

In order to eliminate misfire faults that can occur as a result of varying flywheel tolerances (manufacturing process) an internal adaptation of the flywheel is made. The adaptation is made during periods of decel fuel cut-off in order to avoid any rotational irregularities which the engine can cause during combustion. This adaptation is used to correct segment duration periods prior to evaluation for a misfire event.

If the sensor wheel adaptation has not been completed the misfire thresholds are limited to engine speed dependent values only and misfire detection is less sensitive. The crankshaft sensor adaptation is stored internally and is not displayed via DIS or MoDIC. If the adaptation limit is exceeded, a fault will be set.

Principle of Operation

Emissions Management controls evaporative and exhaust emissions. The ECM monitors the fuel storage system for **evaporative leakage** and controls the **purging** of evaporative vapors. The ECM monitors and controls the exhaust emissions by regulating the **combustable mixture** and after treating by injecting **fresh air** into the exhaust system. The catalytic converter further breaks down remaining combustable exhaust gases and is monitored by the ECM for **catalyst efficiency**.



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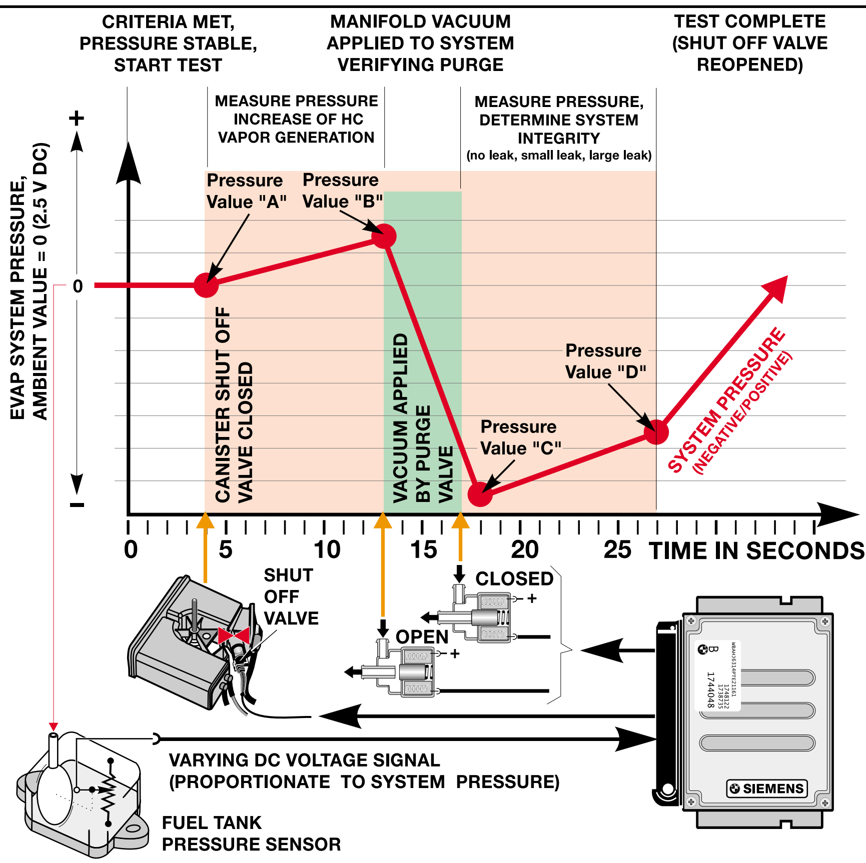
The Evaporative Leakage Detection (E36 and Z3) is conducted by the ECM and can detect a leak as small as 1.0mm (0.040”) when the following conditions are met:

• No faults present. There are several fault codes relating to the evaporative system. In addition, the ECM also monitors the components for evaporative system operation. Any detected faults will be stored in the memory and the “CHECK ENGINE” Light will illuminate when the OBD II critera is achieved and the test will not conclude.
• Engine coolant temperature must be > 80º C.
• Current altitude <2500m (8,202 Feet).
• Accumulated Canister Purge time > 360 seconds (6 minutes) since start of drive cycle.
• Canister purge cycle times between 10 and 150 seconds in length (dependent on HC saturation).
• Vehicle speed = 0 (vehicle at standstill).
• Engine Speed = idle

Once all of the testing criteria have been met, the ECM will start the test on the evaporative system. The test is carried out in the following sequence:

• The ECM reads and stores the current fuel tank pressure input value.
• The Evaporative Emission Valve and shut-off valve are closed for approx. 8 seconds.

- The ECM reads the pressure build up in the fuel tank. If the pressure build up is below a stored threshold value, the Evaporative Emission Valve is switched on for approximately 3 seconds.
- The ECM reads the tank pressure after purging. If the pressure has dropped, the purge function is OK.
- The Evaporative Emission Valve is switched OFF again for approximately 8 seconds.
- The ECM reads the tank pressure again to verify pressure build up.
- If the pressure build up is not within a stored value range, the ECM detects this as a leak within the evaporative system.
- Depending on the degree of pressure build up, the ECM detects this as a leak within the evaporative system.
- Following the test cycle, the shut-off valve is switched OFF and normal purge operation is resumed.



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The Evaporative Leakage Detection (98 MY E39) uses a Leak Diagnosis Pump (LDP) to pressurize the fuel tank and the evaporative emission system (approx. 25mb.). The LDP equipped system is capable of detecting a leak as small as 0.5 mm. (0.020”). The LDP is located in the left rear (driver’s side) fender well and is only replaceable as a complete component. The vacuum supply line (required for pump operation) is in the wiring harness from the engine compartment and runs down the driver’s side of the vehicle.

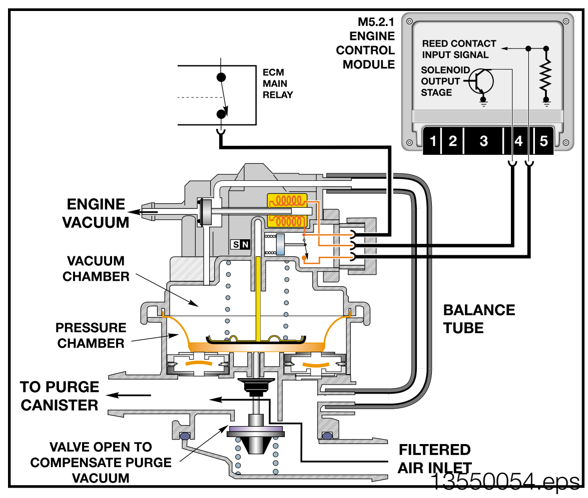
The LDP is a unitized component that contains the following:

• Vacuum Chamber.
• Pneumatic Pressure Chamber.
• DME Activated Vacuum Solenoid.
• Reed Switch - Providing A Switched Voltage Feedback Signal To The ECM.

In the inactive state, the LDP diaphragm is at the bottom end (of down stroke). The diaphragm pushes a rod downward against spring pressure to open the canister vent valve.

This open valve serves as the filtered air inlet path for normal evaporative “breathing”.

During Leak Testing of the evaporative system, the vent valve is sprung closed to block atmospheric venting. The Evaporative Emission Valve is also sprung closed to seal the system.



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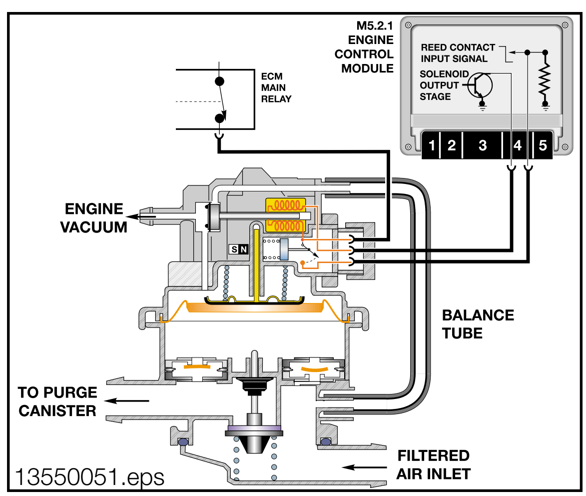
During every engine cold start the LDP solenoid is energized by the ECM. Engine manifold vacuum enters the upper chamber of the LDP to lift up the spring loaded diaphragm.

As the diaphragm is lifted it draws in ambient air through the filter and into the lower chamber of the LDP through the one way valve.



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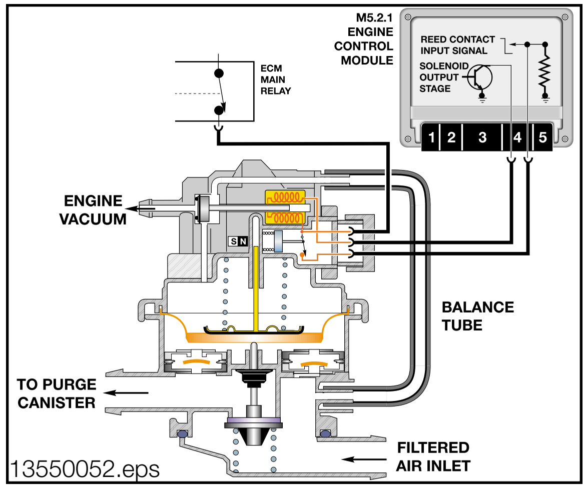
The solenoid is then de-energized, spring pressure closes the vacuum port blocking the engine vacuum and simultaneously opens the vent port to the balance tube which releases the captive vacuum in the upper chamber.

This allows the compressed spring to push the diaphragm down, starting the “limited down stroke”. The air that was drawn into the lower chamber of the LDP during the upstroke is forced out of the lower chamber and into the fueltank/evaporative system.



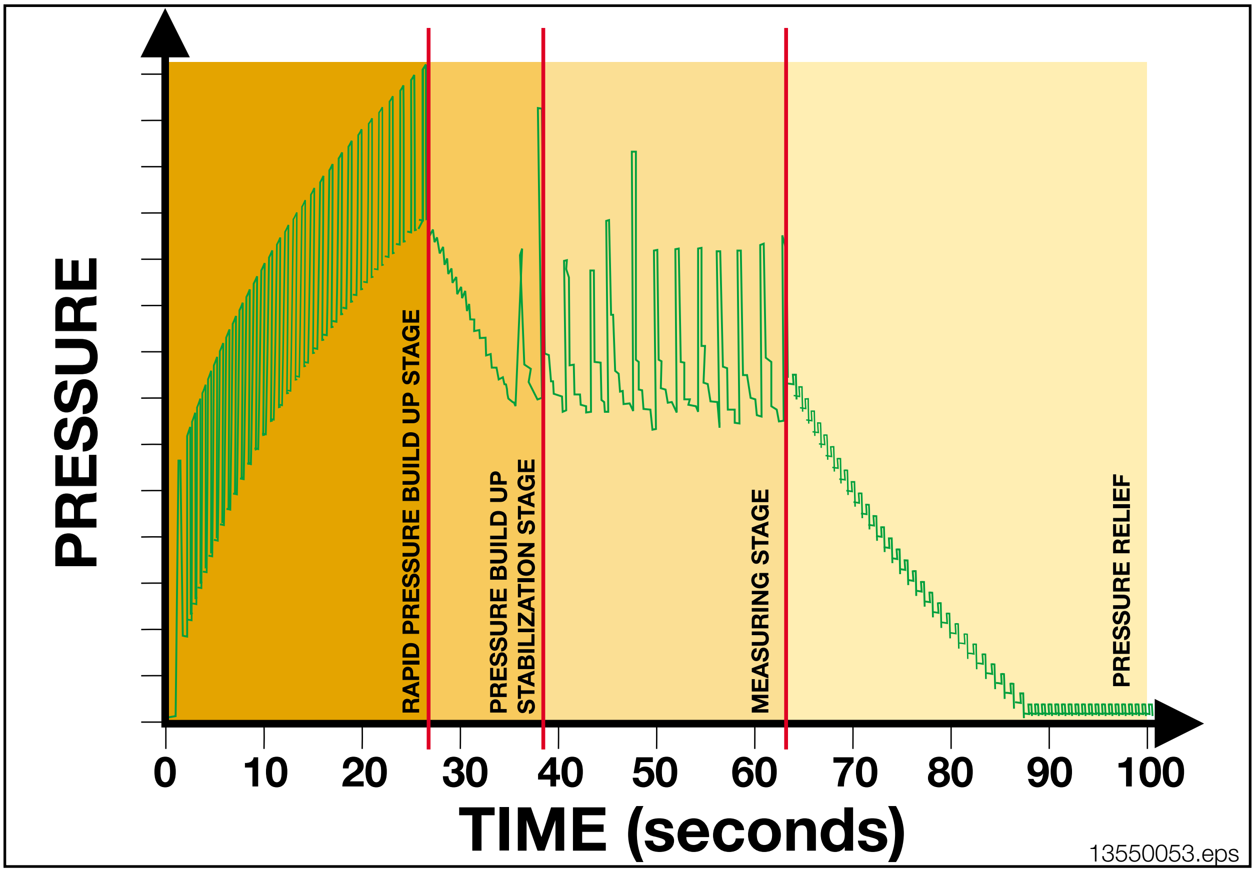
• This electrically controlled repetitive up/down stroke is cycled repeatedly building up a total pressure of approximately +25mb in the evaporative system. After sufficient pressure has built up (LDP and its cycling is calibrated to the vehicle), the leak diagnosis begins and lasts about 100 seconds.

• The upper chamber contains an integrated reed switch that produces a switched high/low voltage signal that is monitored by the ECM. The switch is opened by the magnetic interrup tion of the metal rod connected to the diaphram is in the top dead center position.

• The repetitive up/down stroke is confirmation to the ECM that the valve is functioning. The ECM also monitors the length of time it takes for the reed switch to open, which is opposed by pressure under the diaghragm in the lower chamber. The LDP is still cycled, but at a frequen cy that depends upon the rate of pressure loss in the lower chamber.

• If the pumping frequency is below parameters, there is no leak present. If the pumping fre quency is above parameters, this indicates sufficient pressure can not build up in the lower chamber and evaporative system, indicating a leak.

The chart represents the diagnostic leak testing time frame in seconds. When the ignition is switched on, the ECM performs a "static check" of circuit integrity to the LDP pump including the reed switch.



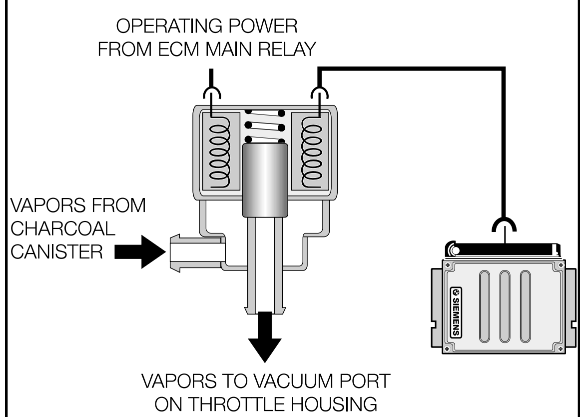
- **On cold engine start up, the pump is activated for the first 27 seconds at approximately 166-200 Hz. This rapid pumping phase is required to pressurized the evaporative components.**

- **Once pressurized, the build up phase then continues from 27-38 seconds. The ECM monitors the system through the reed switch to verify that pressure has stabilized.**

- **The measuring phase for leak diagnosis lasts from 38-63 seconds. The pump is activated but due to the pressure build up under the diaphragm, the pump moves slower, if the pump moves quickly, this indicates a lack of pressure of a leak. The registers as a fault in the ECM's.**

- **From 63-100 seconds the pump is deactivated, allowing full down stroke of the diaphragm and rod. At the extreme bottom of rod travel, the canister vent valve is pushed open relieving pressure and allowing normal purge operation when needed.**

Evaporative Emission Purging is regultated by the ECM controlling the Evaporative Emission Valve. The Evaporative Emission Valve is a solenoid that regulates purge flow from the Active Carbon Cannister into the intake manifold. The ECM Relay provides operating voltage and the ECM controls the valve by regulating the ground circuit. The valve is powered open and closed by an internal spring.



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The “purging” process takes place when:

• Oxygen Sensor Control Is Active.
• Engine Coolant Temperature is > 67° C.
• Engine Load is present.

The Evaporative Emission Valve is opened in stages to moderate the purging.

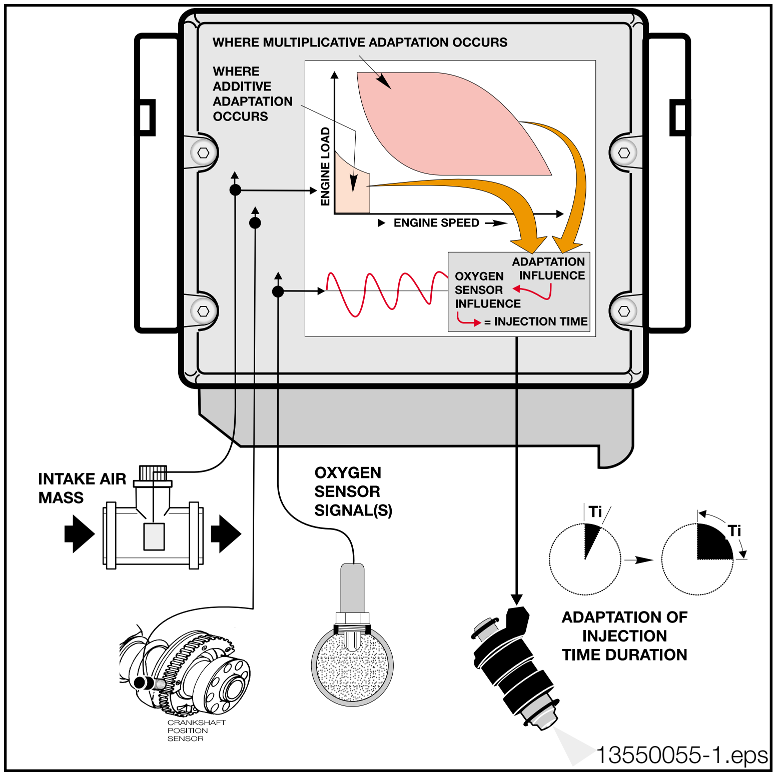
• Stage 1 opens the valve for 10 ms (mill-seconds) and then closes for 150 ms.
• The stages continue with increasing opening times (up to 16 stages) until the valve is completely open.
• The valve now starts to close in 16 stages in reverse order.
• This staged process takes 6 minuites to complete. The function is inactive for 1 minute then starts the the process all over again.
• During the purging process the valve is completely opened during full throttle operation and is completely closed during deceleration fuel cutoff.

Evaporative Purge System Flow Check is performed by the ECM when the oxygen sensor control and purging is active on the E39. When the Evaporative Emission Valve is open the ECM detects a rich/lean shift as monitored by the oxygen sensors indicating the valve is functioning properly.

If the ECM does not detect a rich/lean shift a second step is performed when the vehicle is stationary and the engine is at idle speed. The ECM opens and close the valve (abruptly) several times and monitors the engine rpm for changes. If there are no changes, a fault code will be set. The E36 and Z3 is checked during the Evaporative Leakage Test.

Fuel System Monitoring is performed by the ECM which verifies the calculated injection time (ti) in relation to engine speed, load and the oxygen sensor signal as a result of the residual oxygen in the exhaust stream.

The ECM uses the oxygen sensor signal as a correction factor for adjusting and optimizing the mixture pilot control under all engine operating conditions.



Adaptation Values are stored by the ECM iIn order to maintain an "ideal" air/fuel ratio. The ECM is capable of adapting to various environmental conditions encountered while the vehicle is in operation (changes in altitude, humidity, ambient temperature, fuel quality, etc.).

The adaptation can only make slight corrections and can not compensate for large changes which may be encountered as a result of incorrect airflow or incorrect fuel supply to the engine.

Within the areas of adjustable adaption, the ECM modifies the injection rate under two areas of engine operation:

- **During idle and low load mid range engine speeds (Additive Adaptation).**
- **During operation under a normal to higher load when at highter engine speeds (Multiplicative Adaptation).**

These values indicate how the ECM is compensating for a less than ideal initial air/fuel ratio.

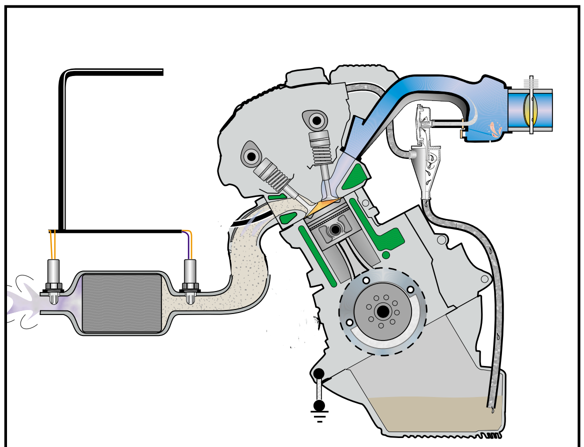
NOTE: If the adaptation value is greater than "0.0” Additive (% Multiplicative), the ECM is trying to richen the mixture. If the adaptation value is less then "0.0” Additive (% Multiplicative), the ECM is trying to lean-out the mixture.

Catalyst Monitoring is performed by the ECM under oxygen sensor closed loop operation. The changing air/fuel ratio in the exhaust gas results in lambda oscillations at the pre-catalyst sensors. These oscillations are dampened by the oxygen storage activity of the catalysts and are reflected at the post catalyst sensors as a fairly stable signal (indicating oxygen has been consumed). Conditions for Catalyst Monitoring:

Requirements	Status/Condition
• Closed Loop Operation	Yes
• Engine Coolant Temperature	Operating Temperature
• Vehicle Road Speed	3-50 MPH (5 to 80 Km/h)
• Catalyst Temperature (Calculated)	350ºC to 650º C
• Throttle Angle Deviation	Steady Throttle
• Engine Speed Deviation	Steady / Stable Engine Speed
• Average Lamboda Value Deviation	Steady / Stable Load

* Catalyst temperature is an internally calculated value that is a function of load/air mass and time.

As part of the monitoring process, the pre and post O2 sensor signals are evaluated by the ECM to determine the length of time each sensor is operating in the rich and lean range.



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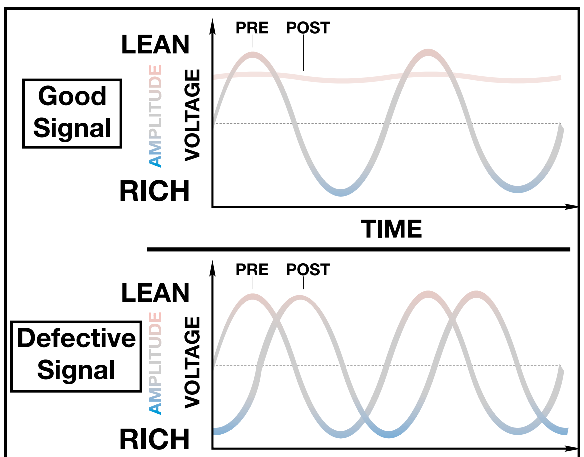
If the catalyst is defective, the post O2 sensor signal will reflect the pre- O2 sensor signal (minus a phase shift/time delay), since the catalyst is no longer able to store oxygen.

The catalyst monitoring process is stopped once the predetermined number of cycles are completed, until the engine is shut-off and started again. After completing the next "customer driving cycle" whereby the specific conditions are met and a fault is again set, the "CHECK ENGINE" Light will be illuminated.



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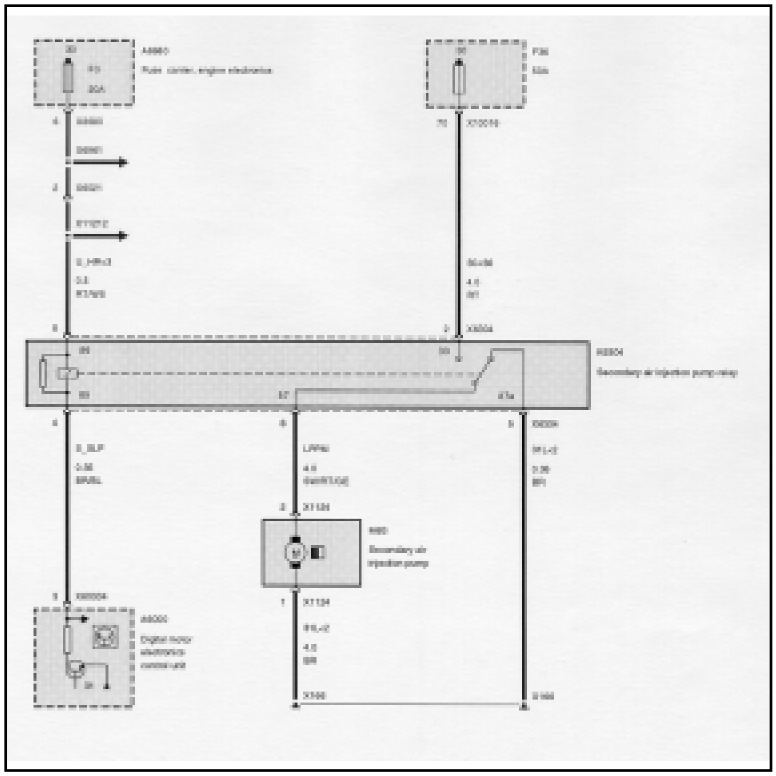
Note: The catalyst efficiency is monitored once per trip while the vehicle is in closed loop operation.

Secondary Air Injection is required to reduce HC and CO emissions while the engine is warming up. Immediately following a cold engine start (-10 to 40°C) fresh air/oxygen is injected directly into the exhaust stream.

The temperature signal is provided to the ECM by the Air Temperature Sensor in the HFM*.



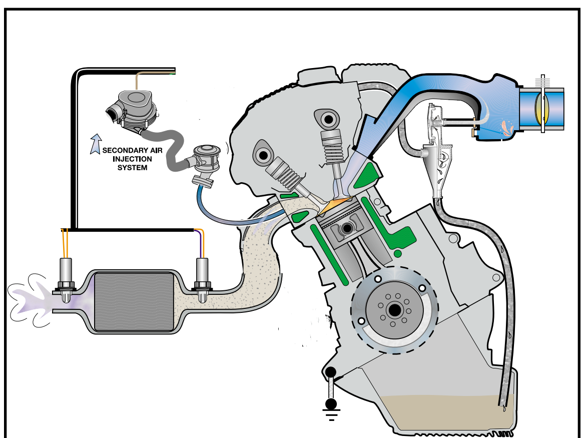
The ECM provides a ground circuit to activate the Secondary Air Injection Pump Relay. The relay supplies voltage to the Secondary Air Injection Pump.

The single speed pump runs for approximately 90 seconds after engine start up.

* Below -10º C the pump is activated briefly to “blow out” any accumulated moisture.

Secondary Air Injection Monitoring is performed by the ECM via the use of the pre-catalyst oxygen sensors. Once the air pump is active and air is injected into the exhaust system the oxygen sensor signals will indicate a lean condition (up to 16 seconds).

If the oxygen sensor signals do not change within a predefined time, a fault will be set and identify the faulty bank (E36 328i and E39).



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If the additional oxygen is not detected for two consecutive cold starts, the ECM determines a general fault with the function of the secondary air injection system. After completing the next cold start and a fault is again detected the "CHECK ENGINE" Light will be illuminated when the OBD II criteria is achieved.

Misfire Detection is part of the OBD II regulations. The ECM must determine misfire and also identify the specific cylinder(s). The ECM must also determine the severity of the misfire and whether it is emissions relevant or catalyst damaging based on monitoring crankshaft acceleration.

Emission Increase:

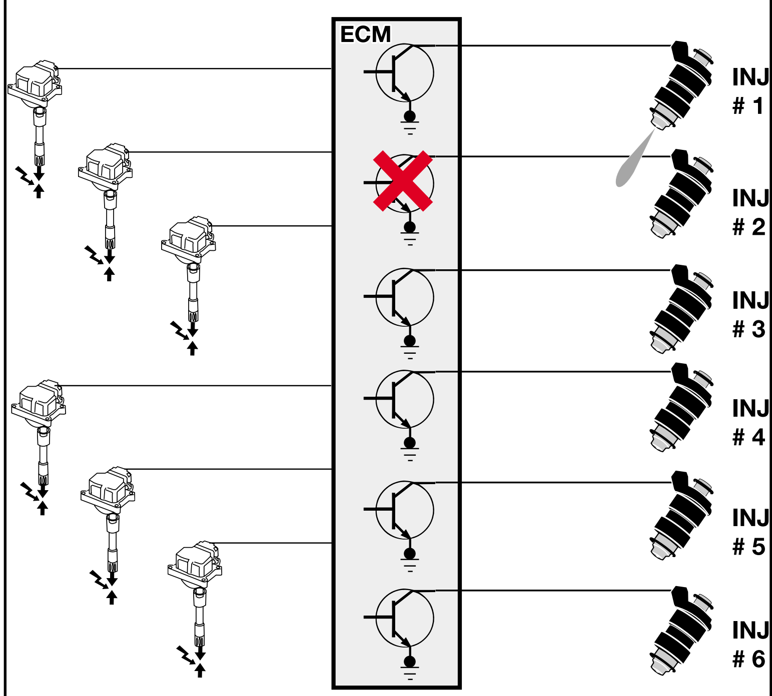
• Within an interval of 1000 crankshaft revolutions, the ECM adds the detected misfire events for each cylinder. If the sum of all cylinder misfire incidents exceeds the predetermined value, a fault code will be stored and the "CHECK ENGINE" Light will be illumnated.
• If more than one cylinder is misfiring, all of the misfiring cylinders will be specified and the individual fault codes for each misfiring cylinder, or multiple cylinders will be stored. The "CHECK ENGINE" Light will be illuminated.

Catalyst Damage:

• Within an interval of 200 crankshaft revolutions the detected number of misfiring events is calculated for each cylinder. The ECM monitors this based on load/rpm. If the sum of cylinder misfire incidents exceeds a predetermined value, a "Catalyst Damaging" fault code is stored and the "CHECK ENGINE" Light will be illuminated.

If the cylinder misfire count exceeds the predetermined threshold the ECM will take the following measures:

• The oxygen sensor control will be switched to open loop.
• The cylinder selected fault code is stored.
• If more than one cylinder is misfiring, the fault code for all individual cylinders and for multiple cylinders will be stored.
• The fuel injector to the respective cylinder(s) is deactivated.



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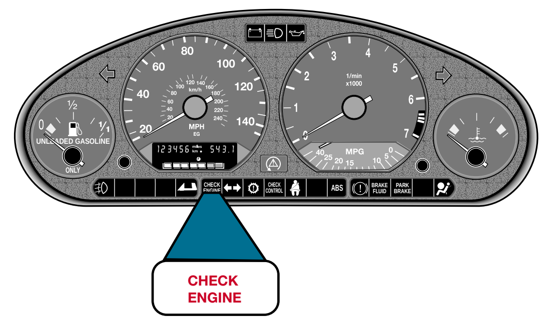
The “CHECK ENGINE” Light, also referred to as the Malfunction Indicator Light (MIL), is illuminated under the following conditions:

- **Upon the completion of the *next consecutive driving cycle* where the previously faulted system is monitored again and the emissions relevant fault is again present.**
- **Immediately if a “Catalyst Damaging” fault occurs (See Misfire Detection).**



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The illumination of the light is performed in accordance with the Federal Test Procedure (FTP) which requires the lamp to be illuminated when:

- **A malfunction of a component that can affect the emission performance of the vehicle occurs and causes emissions to exceed 1.5 times the standards required by the (FTP).**
- **Manufacturer-defined specifications are exceeded.**
- **An Implausible input signal is generated.**
- **Catalyst deterioration causes HC-emissions to exceed a limit equivalent to 1.5 times the standard (FTP).**
- **Misfire faults occur.**
- **A leak is detected in the evaporative system or “purging” is defective.**
- **ECM fails to enter closed-loop oxygen sensor control operation within a specified time interval.**
- **Engine control or automatic transmission control enters a “limp home” operating mode.**
- **Ignition is on (KL15) position before cranking = Bulb Check Function.**

Within the BMW system, the illumination of the check engine light is performed in accordance with the regulations set forth in CARB mail-out 1968.1 and as demonstrated via the Federal Test Procedure (FTP). The following page provides several examples of when and how the "CHECK ENGINE" Light is illuminated based on the "customer drive cycle".

	DRIVE CYCLE # 1			DRIVE CYCLE # 2			DRIVE CYCLE # 3			DRIVE CYCLE # 4			DRIVE CYCLE # 5			* DRIVE CYCLE # 43		
TEXT NO.	FUNCTION CHECKED	FAULT CODE SET	MIL STATUS CHECK ENGINE	FUNCTION CHECKED	FAULT CODE SET	MIL STATUS CHECK ENGINE	FUNCTION CHECKED	FAULT CODE SET	MIL STATUS CHECK ENGINE	FUNCTION CHECKED	FAULT CODE SET	MIL STATUS CHECK ENGINE	FUNCTION CHECKED	FAULT CODE SET	MIL STATUS CHECK ENGINE	FUNCTION CHECKED	FAULT CODE ERASED	MIL STATUS CHECK ENGINE
1.	YES	YES	OFF															
2.	YES	YES	OFF	YES	YES	ON												
3.	YES	YES	OFF	NO	NO	OFF	YES	YES	ON									
4.	YES	YES	OFF	YES	NO	OFF	YES	NO	OFF	YES	YES	OFF	YES	YES	ON			
5.	YES	YES	OFF	YES	YES	ON	YES	NO	ON	YES	NO	ON	YES	NO	OFF			
6.	YES	YES	OFF	YES	YES	ON	YES	NO	ON	YES	NO	ON	YES	NO	OFF	YES	FAULT CODE ERASED	OFF

3550058.eps

1. A Fault Code is stored within the ECM upon the first occurrence of a fault in the system being checked.
2. The “CHECK ENGINE” light will not be illuminated until the completion of the second consecutive “customer driving cycle” where the previously faulted system is again monitored and a fault is still present or a catalyst damaging fault has occcured.
3. If the second drive cycle was not complete and the specific function was not checked as shown in the example, the ECM counts the third drive cycle as the “next consecutive” drive cycle. The “CHECK ENGINE” light to be illuminated.
4. If there is an intermittent fault present and does not cause a fault to be set through multiple drive cycles, two complete consecutive drive cycles with the fault present are required for the “CHECK ENGINE” Light to be illuminated.
5. Once the “CHECK ENGINE” Light is illuminated it will remain illuminated unless the specific function has been checked without fault through three complete consecutive drive cycles.
6. The fault code will also be cleared from the memeory automatically if the specific function is checked through 40 consecutive drive cycles without the fault being detected or with the use of either the DIS, MODIC, or Scan Tool.

NOTE: In order to clear a catalyst damaging fault (see Misfire Detection) from memory, the condition under which the fault occurred must be evaluated for 80 consecutive cycles without the fault reoccurring.

With the use of a universal scan tool, connected to the "OBD" DLC an SAE standardized DTC can be obtained, along with the condition associated with the illumination of the "CHECK ENGINE" Light. Using the DIS or MODIC, a fault code and the conditions associated with its setting can be obtained prior to the illumination of the "CHECK ENGINE" Light.

OBD II Drive Cycle's & Trips

• A "Drive Cycle" consists of engine startup and engine shutoff.
• "Trip" is determined as vehicle operation (follow an engine-off period) of duration and driving style so that all components and systems are monitored at least once by the diagnostic system except catalyst efficiency or evaporative system monitoring.
• Within this text the term "customer driving cycle" will be used and is defined as engine start-up, operation of vehicle (dependent upon customer drive style) and engine shut-off.

Federal Test Procedure (FTP)

The Federal Test Procedure (FTP) is a **specific driving cycle** that is utilized by the EPA to test light duty vehicle emissions. As part of the procedure for a vehicle manufacturer to obtain emission certification for a particular model/engine family the manufacturer must demonstrate that the vehicle(s) can pass the FTP defined driving cycle **two consecutive times** while monitoring various components/systems.

Some of the components/systems must be monitored ***either once per driving cycle or continuously.*** Systems and their components required to be monitored **once within one driving cycle:**

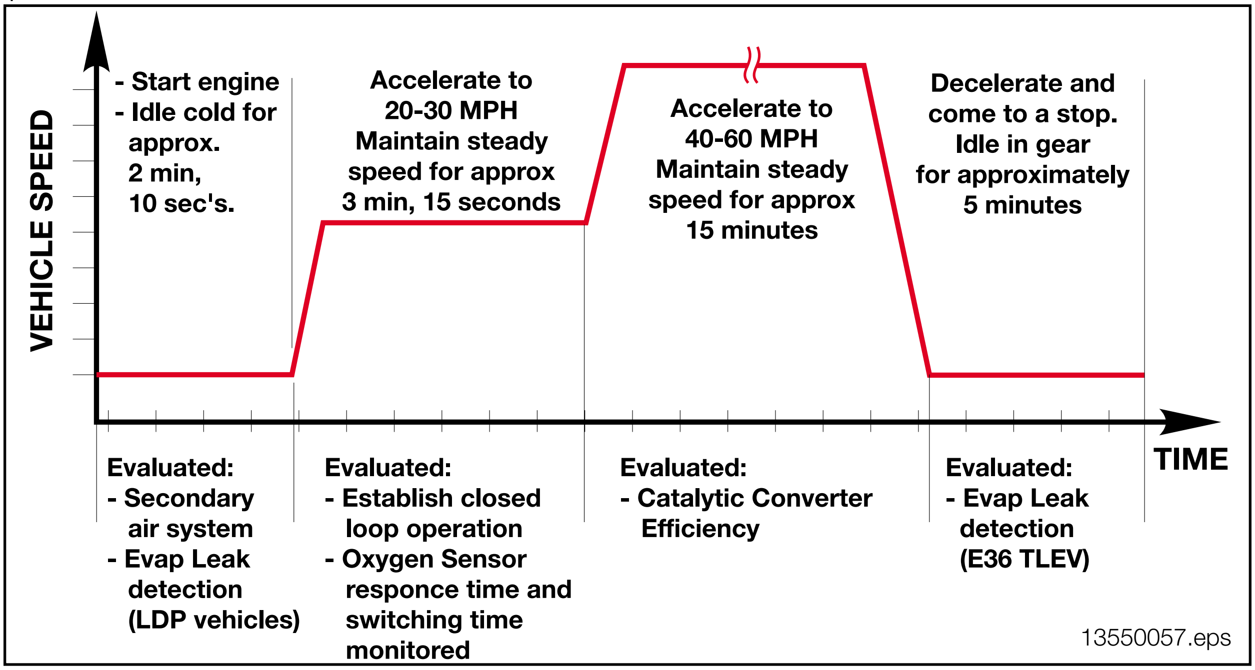
• Oxygen Sensors
• Secondary Air Injection System
• Catalyst Efficiency
• Evaporative Vapor Recovery System

Due to the complexity involved in meeting the test criteria within the FTP defined driving cycle, all tests may not be completed within one "customer driving cycle". The test can be successfully completed within the FTP defined criteria, however customer driving styles may differ and therefore may not always monitor all involved components/systems in one "trip".

Components/systems required to be monitored continuously:

• Cylinder Misfire Detection
• Fuel System
• Oxygen Sensors
• All Emissions Related Components / Systems - DME, EGS, or EML (comprehensive component monitoring).

The graph shown below is an example of the driving cycle that is used by BMW to complete the FTP.



The diagnostic routine shown above will be discontinued whenever:

• Engine Speed Exceeds 3000 RPM
• Large Fluctuation In Throttle Angle
• Road Speed Exceeds 60 MPH

NOTE: The driving criteria shown can be completed within the FTP required ~11 miles in a controlled environment such as a dyno test or test track.

A "customer driving cycle" may vary according to traffic patterns, route selection and distance traveled, which may not allow the "diagnostic trip" to be fully completed each time the vehicle is operated.

Readiness Code

The readiness code provides status (Yes/No) of the system having completed all the required monitoring functions or not. The readiness code is displayed with an aftermarket scan tool. The code is a binary (1/0) indicating:

• 0=Test Completed or Not Applicable
• 1= Test Not Complete

A "readiness code" must be stored after any clearing of fault memory or disconnection of the ECM. A readiness code of "0" will be stored (see below) after a complete diagnostic check of all components/systems, that can turn on the “CHECK ENGINE” Light is performed.

The readiness code was established to prevent anyone with an emissions related fault and a “CHECK ENGINE” Light on from disconnecting the battery or clearing the fault memory to manipulate the results of the emissions test procedure (IM 240).

Interpretation of the Readiness Code by the ECM(s) (SAE J1979)

The complete readiness code is equal to "one" byte (eight bits). Every bit represents one complete test and is displayed by the scan tool, as required by CARB/EPA.

1 = EGR Monitoring (=0, N/A with BMW)
0 = Oxygen Sensor Heater Monitoring
1 = Oxygen Sensor Monitoring
1 = Air Condition (=0, N/A with BMW)
0 = Secondary Air Delivery Monitoring
1 = Evaporative System Monitoring
1 = Catalyst Heating (=0, N/A with BMW at this time).
0 = Catalyst Efficiency Monitoring

Drive the car in such a manner that all tests listed above can be completed (refer to the FTP cycle). When the complete "readiness code" equals "0" then all tests have been completed and the system has established its "readiness". Accessibility of the readiness code is also possible using the DIS/MoDIC.

OBD II Diagnostic Trouble Codes (DTC)

The Society of Automotive Engineers (SAE) established the Diagnostic Trouble Codes used for OBD II systems (SAE J2012). The DTC's are designed to be identified by their alpha/numeric structure. The SAE has designated the emission related DTC's to start with the letter "P" for Powertrain related systems, hence their *nickname* "P-code".

For example: **P 0 4 4 0**

P-Powertrain, B-Body, C-Chassis

DTC Source; 0-SAE, 1-BMW

System; 0-Total System
1-Air/Fuel Induction
2-Fuel Injection
3-Ignition System or Misfire
4-Auxiliary Emission Control
5-Vehicle Speed & Idle Control
6-Control Module Inputs/Outputs
7-Transmission

Sequentially numbered fault identifying individual components or circuits (00-99)

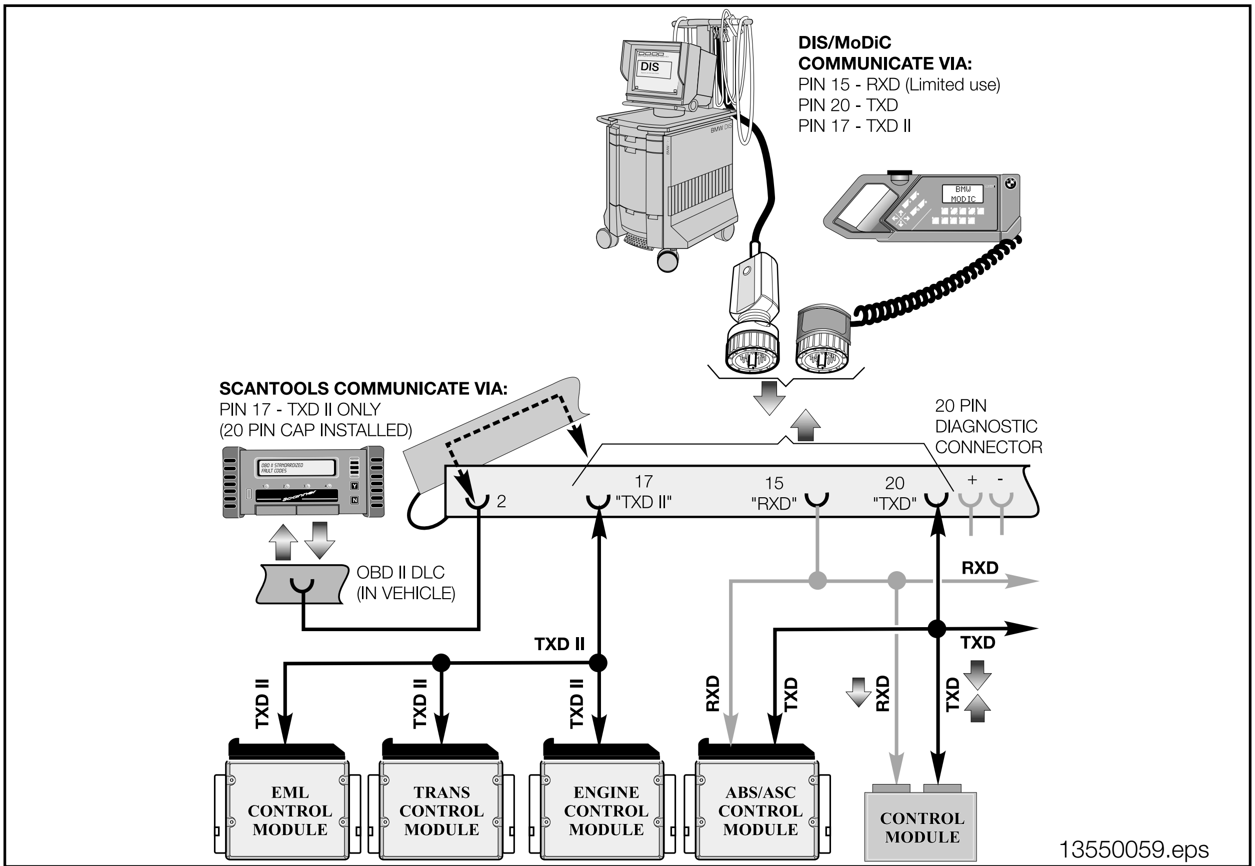
• DTC's are stored whenever the "CHECK ENGINE" Light is illuminated.
• A requirement of CARB/EPA is providing universal diagnostic access to DTC's via a standardized Diagnostic Link Connector (DLC) using a standardized tester (scan tool).
• DTC's only provide one set of enviromental operating conditions when a fault is stored This single "Freeze Frame" or snapshot refers to a block of the vehicles enviromental conditions for specific time when the fault first occurred. The information which is stored is defined by SAE and is limited in scope. This information may not even be specific to the type of fault.

Scan Tool Connection

The MS41.x has a separate OBD II Diagnostic Link Connector (DLC). The OBD II connector is located in the drivers footwell to the left of the steering column (right side of center console on the Z3). The DLC provides access for an aftermarket scan tool to all emission related control systems:

• ECM - Engine Management Monitored Emissions Functions/Components
• TCM (AGS/EGS) - Transmission Control
• EML - Electronic Throttle Control

This diagnostic communication link uses the existing TXD II circuit in the vehicle through a separate circuit on the DLC when the 20 pin cap is installed.



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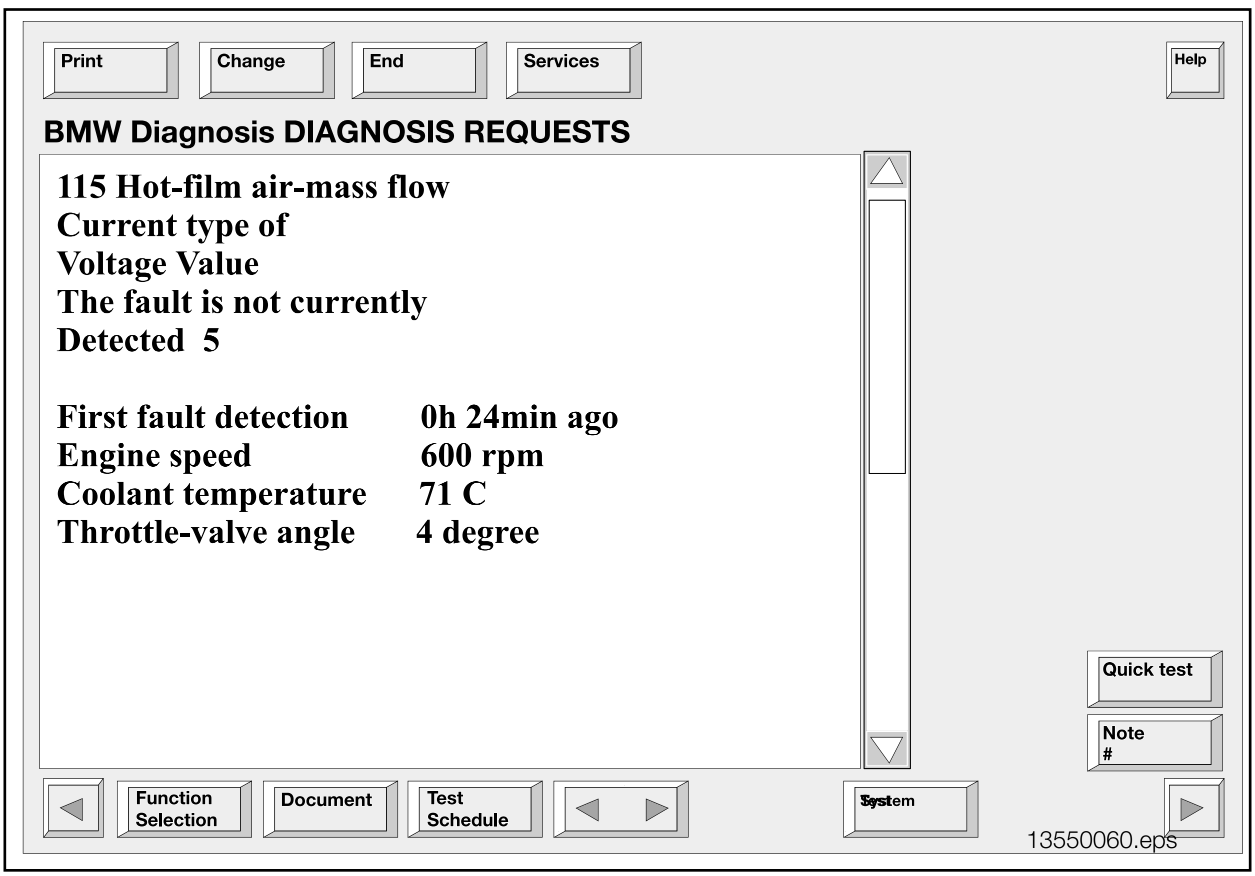
BMW Fault Code (DIS/MoDiC)

- BMW codes are stored as soon as they occur even before the “CHECK ENGINE” Light comes on.
- BMW Codes are defined by BMW and Siemens Engineers to provide greater detail to fault specific information.
- Siemens system - one set of four fault specific environment conditions are stored with the first fault occurrence. This information can change and is specific to each fault code to aid in diagnosing. A maximum of ten different faults containing four environmental conditions can be stored.
- BMW Codes also store and displays a “time stamp” when the fault last occurred.
- BMW Fault Codes determine the diagnostic output for BMW DIS/Modic



Workshop Hints

Before any service work is performed on any fuel system related component, always adhere to the following:

- **Observe relevent safety legislation pertaining to your area.**
- **Ensure adequate ventilation.**
- **Use exhaust extraction system where applicable (allivate fumes).**
- **DO NOT SMOKE while performing fuel system repairs.**
- **Always wear adequate protection clothing including eye protection.**
- **Use caution when working around a HOT engine compartment.**
- **BMW does not recommend any UNAUTHORIZED MODIFICA TIONS to the fuel system. The fuel systems are designed to comply with strict Federal Safety and Emissions Regulations. In the concern of product liability, it is unauthorized to sell or perform modifications to customer vehicles, particularly in safety related areas.**
- **Always consult the REPAIR INSTRUCTIONS on the specific model you are working on before attempting a repair.**

The "CHECK ENGINE" Light can be diagnosed with an aftermarket Scan Tool that allows Technicians without BMW Special Tools or Equipment to Diagnose an emission system failure.

CHECK ENGINE

Further fault explanations can be found in the Service Information Bulletin SI # 16 05 97 **Evaporative Emission Control On-Board Diagnostic System.**

Secondary Air Injection

Refer to Service Information Bulletin SI # 12 04 96 for details about the **VOLUNTARY EXHAUST EMISSION RECALL CAMPAIGN No. 96E-A01** regarding Secondary Air Pump wiring.

Misfire Detection

Refer to Service Information Bulletin SI # 12 02 97 for details about M52 Misfire Fault Codes.

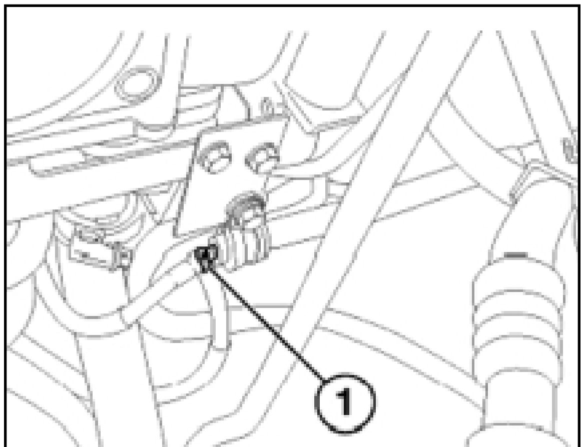
Checking Fuel Tank and Ventilation System for Leak-Tightness (E36/Z3/E39)

Refer to the Repair Information Section **16 00 100** for procedures on testing the fuel tank/ventilation system. Refer to Service Information Bulletins SI # **04 26 00** and # **04 01 98** for the special tools and adapters to perform the Evaporative Leakage Diagnosis Test.

E39

Refer to Service Information Bulletin SI # 16 02 99 for **LDP Pump Operation** related fault codes.

IF the vacuum "T" (1) refered to in the SI is restricted, it must be replaced with a modified T-fitting **P/N 11 72 1 439 973.**



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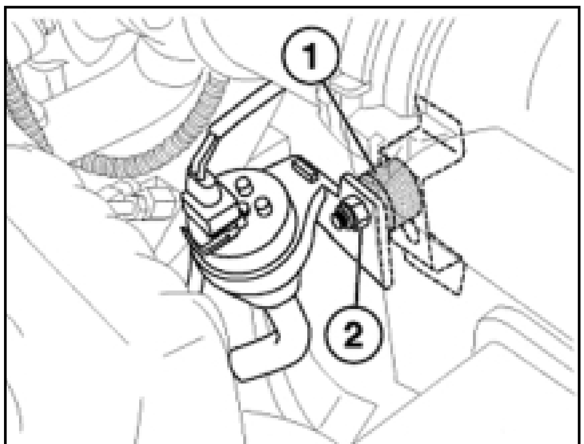
E36

Refer to Service Information Bulletin SI # 13 01 96 for details about **Fuel Tank Vent Valve Noise.**

This noise is eliminated by placing an insulating mount (1) between the valve bracket and the mounting bracket and secured by a hex nut (2).



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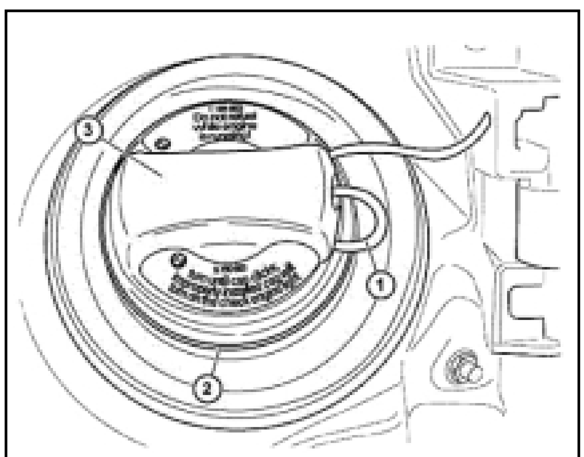
Refer to Service Information Bulletin:

- **SI # 16 04 97 New Evaporative (charcoal) Canister Purge Line**

"CHECK ENGINE" Light Illuminated, TANK LEAK Fault Stored in the ECM (DME).

Refer to Service Information Bulletin SI # 16 01 00 for details on the **Fuel Filler Cap.**

1. Pinched Retainer Strap
2. Insufficiently Sealed Cap
3. Cap Not Fully "Seated" When Installed



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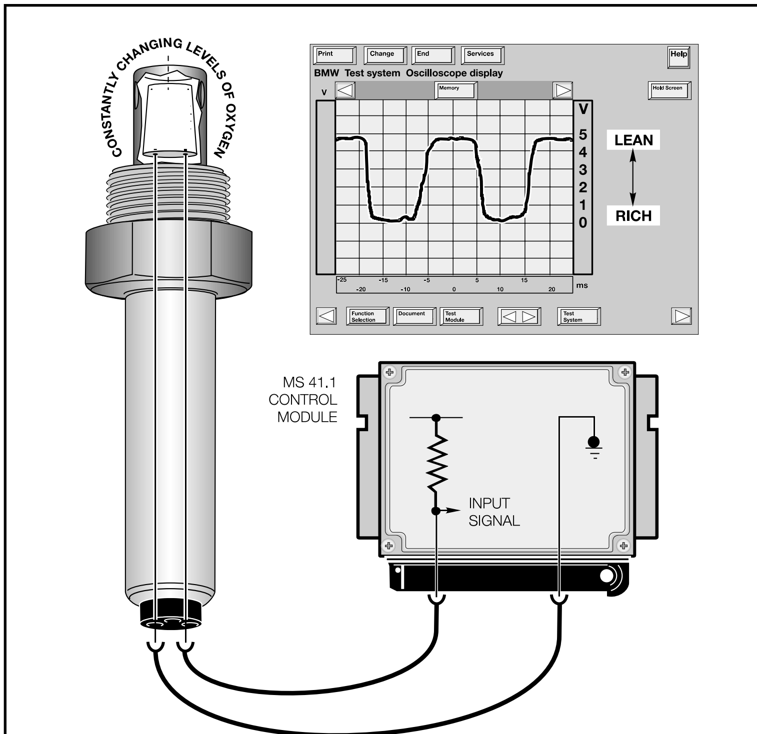
Refer to the following Service Information Bulletins pertaining to oxygen sensor/mixture fault codes:

• **SI # 12 10 97 VOLUNTARY EXHAUST EMISSIONS Service Action No 98E-A01**
• **SI # 12 12 97 FC 227/228 Mixture Deviation**

Testing the Oxygen Sensor should be performed using the DIS Oscilloscope from the "Preset Measurement" List. The scope pattern should appear as below for a normal operating pre-catalyst sensor.

If the signal remains low (rich condition) the following should be checked:

• Fuel Injectors
• Fuel Pressure
• Ignition System
• Input Sensors that influence air/fuel mixture
• Engine Mechanical



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If the signal remains high (lean condition) the following should be checked:

• Air/Vacuum Leaks
• Fuel Pressure
• Input Sensor that influence air/fuel mixture
• Engine Mechanical

NOTE: A MIXTURE RELATED FAULT CODE SHOULD BE INVESTIGATED FIRST AND DOES NOT ALWAYS INDICATE A DEFECTIVE OXYGEN SENSOR!

Tools and Equipment

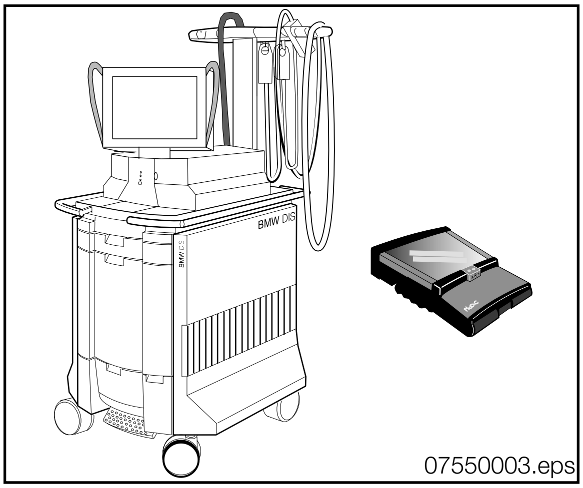
The DIS/Modic as well as a reputable hand held multimeter can be used when testing inputs/components.

It is best to make the checks at the ECM connection, this method includes testing the wiring harness.

The correct Universal Adapter for the MS41.x application should be used (#88 88 6 614 410). This will ensure the pin connectors and the harness will not be damaged.

The interior of this Universal Adapter is shielded, therefore it is vital that the ground cable is connected to the vehicle chassis whenever the adapter is used.

The adapter uses a Printed Circuit board inside keeping the capacitive and inductive load to a minimum.



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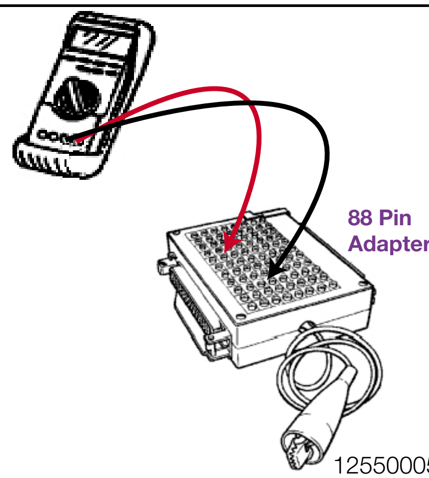

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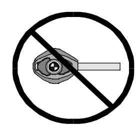
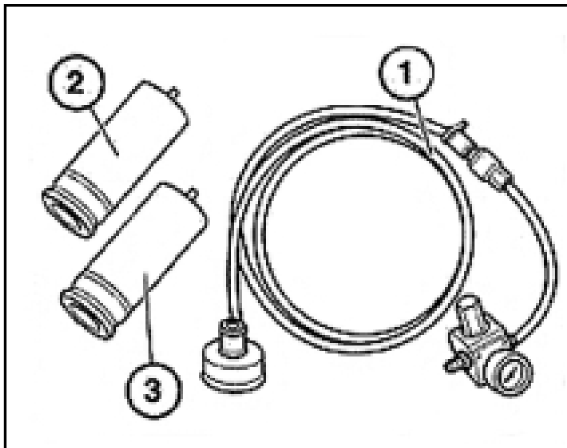
When installing the Universal Adapter to the ECM (located below the windshield on the passenger side of the engine compartment), make sure the ignition is switched off.



Refer to Repair Information 13 00 060 for detailed information on checking exhaust contents.

When checking the fuel tank and ventilation system for leak-tightness use Special Tool Set #90 88 6 161 170 which includes all of the pieces shown to the right.



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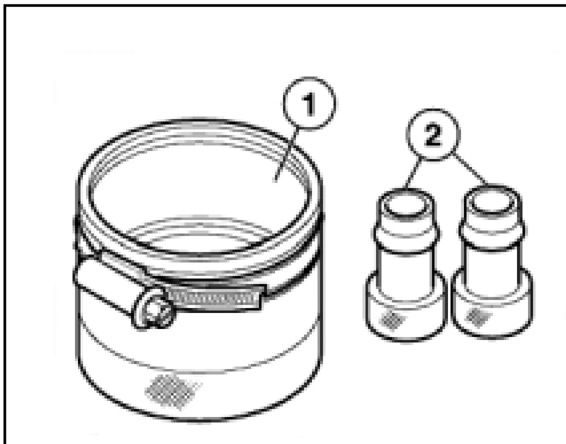
1. Pressure Control Valve
2. & 3. Quick Coupling Adapters

This set is used in conjunction with shop supplied compressed air and the DISplus Multimeter function for reading the pressure bleed off.

E39

This Special Tool Set #90 88 6 161 160 will also be required to "cap off" the LDP air filter and Evaporative Emission Valve hose when performing the Leakage Diagnosis Test.



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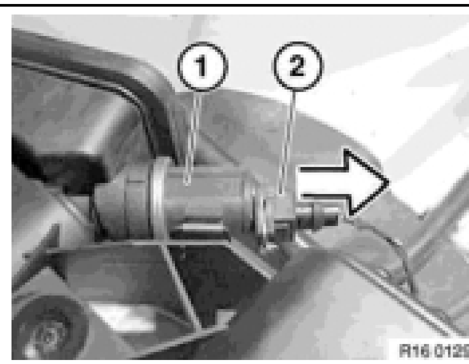
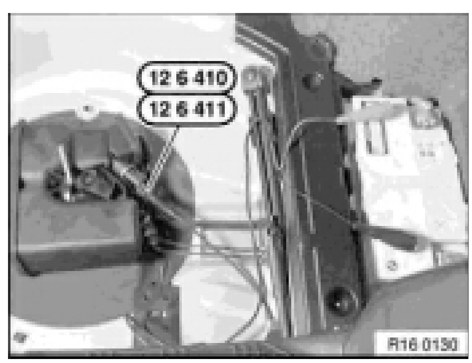
E36

The Fresh Air Inlet Valve (1) must be closed when checking the fuel tank and ventilation system for leak-tightness.



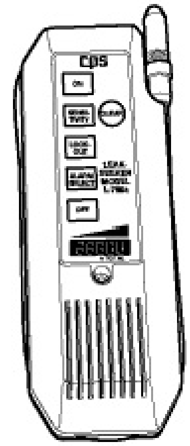
Disconnect plug connector (2) and install Special Tool # 88 88 6 126 410/411.



Connect the other end of the tool to the vehicle battery to power the valve closed during testing.

If the test indicates excessive bleed off an ultrasonic leak detector should be used (refer to Repair Instructions) to check for leaks at:

• Fuel Filler Cap and Filler Neck
• Fuel Tank Ventilation Lines
• Evaporative Emission Valve
• Fuel Tank and Fuel Sending Unit
• Liquid / Vapor Separator



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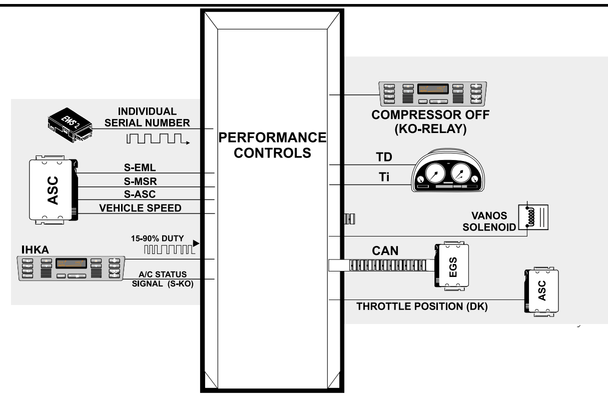
Performance Controls



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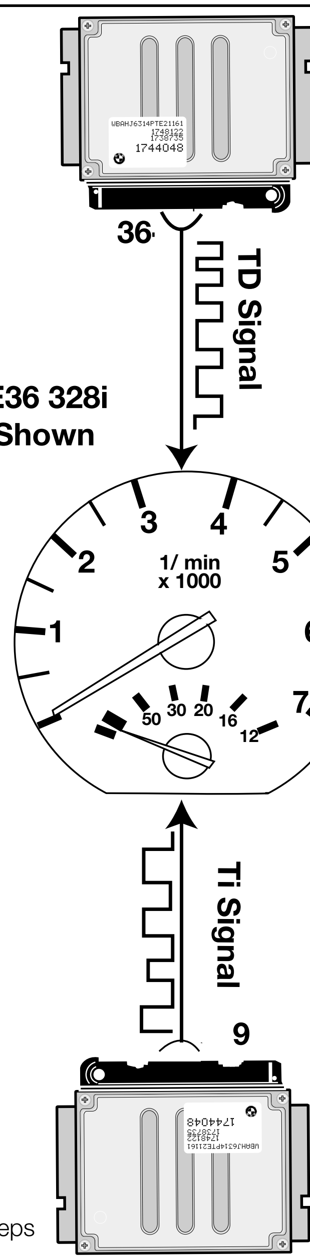
Engine Speed Signal (TD): is produced by the ECM as an output function. The TD signal is a processed square wave signal that indicates engine rpm. The signal is made available to other control modules including the Instrument Cluster, IHKA, EWS II and the 20 pin Diagnostic Socket.

The TD output is a square wave modulated signal. The frequency of the signal is directly proportional to RPM. The receiving control module detects RPM by the number of pulses.

Load Signal (Ti): is produced by the ECM as an output function that represents the actual amount of fuel injected. It is made available to other control modules as an input for operation. These control modules include:

• OBC = Fuel Consumption for MPG and Range
• Instrument Cluster = MPG Gauge (Except M3)

The Ti output is a processed square wave signal. The frequency of the signal is proportional to engine RPM. The pulse width and duty cycle will vary to reflect the injection quantity.



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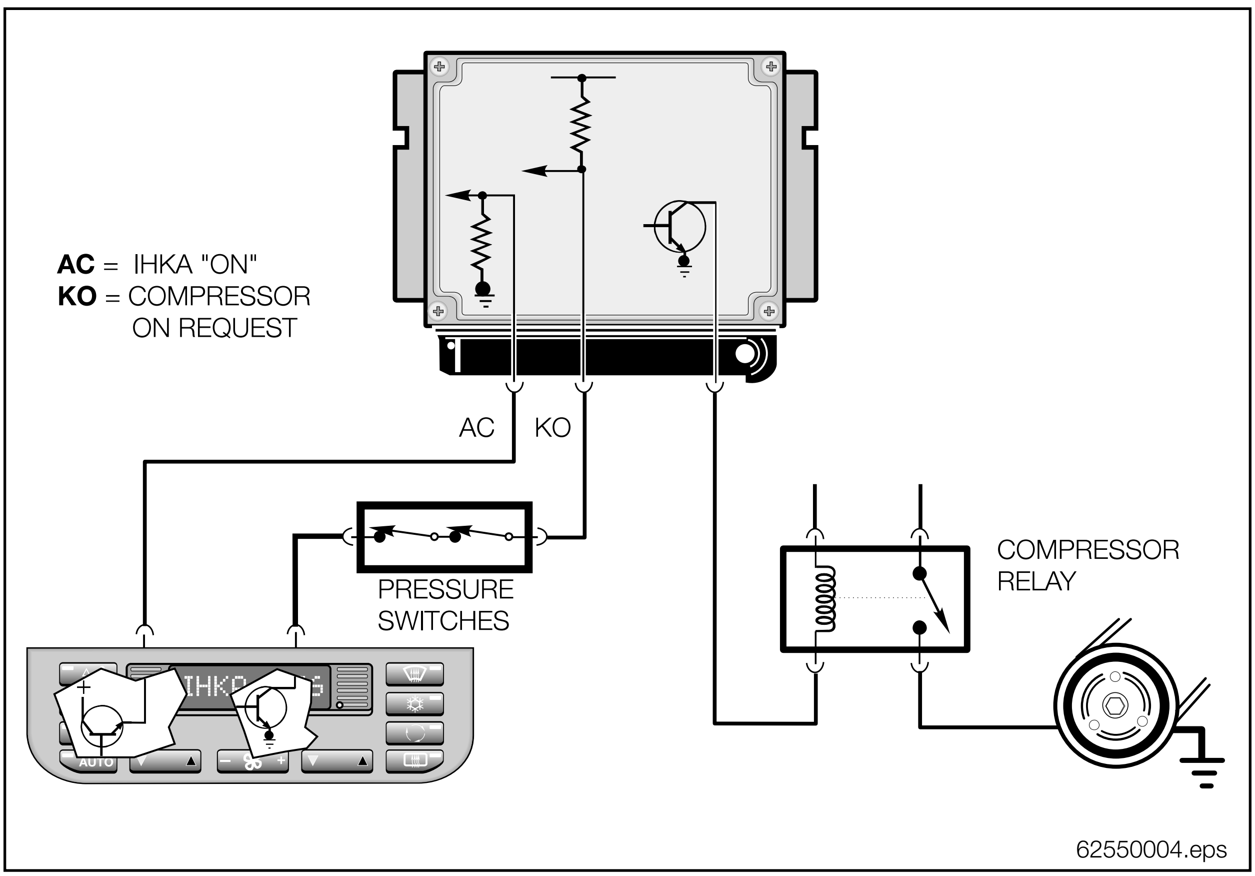
A/C Compressor Control: is an output of the ECM. The ECM controls the A/C Compressor Relay based on signals from the IHKA Control Module.

When the driver selects the “snow flake” button, the IHKA Control Module signals the ECM (AC) which “arms” it for compressor activation.

The ECM prepares for the additional load of the compressor by modifying the ignition timing and stabilizing idle speed.

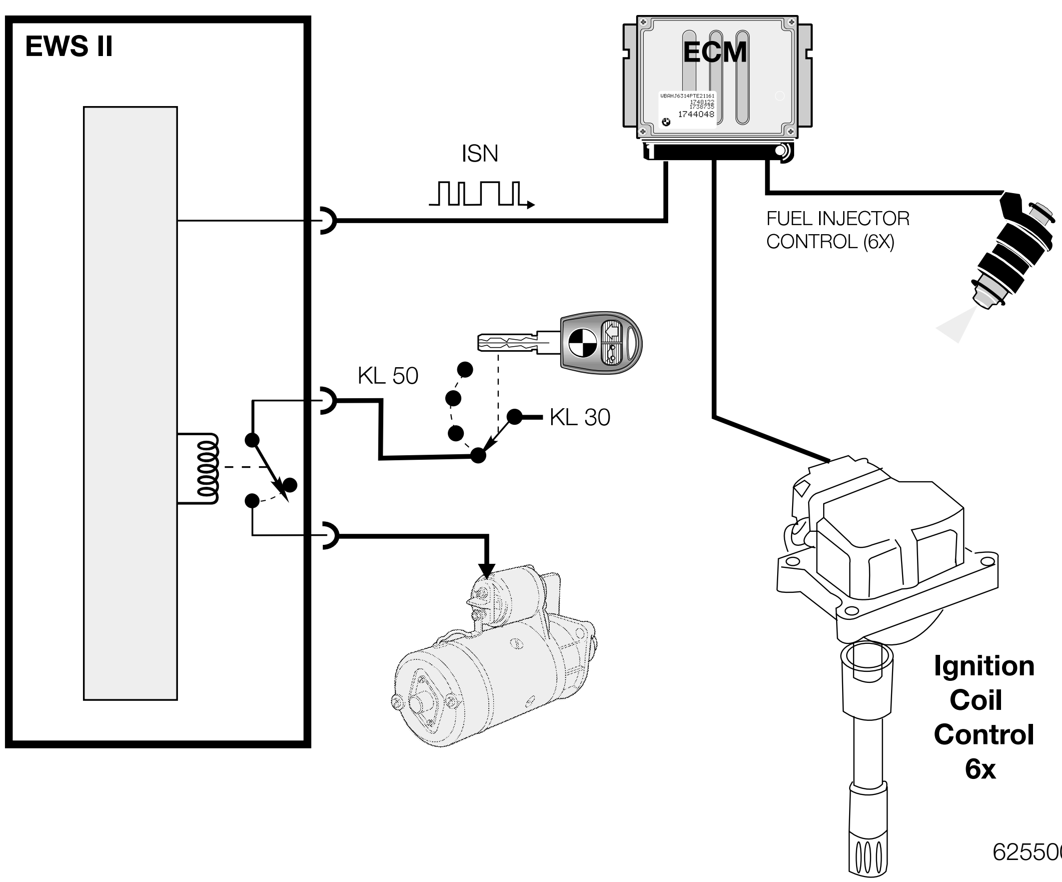
When A/C compressor activation is required the IHKA signals the ECM through the high/low refrigerant pressure switches (KO). The ECM will provide a ground circuit for the A/C Compressor Relay.

The A/C Compressor Relay is deactivated during wide open throttle acceleration at low speeds to allow the engine to quickly achieve maximum power.



Driveaway Protection System Interface EWS II: and ECM Control Modules are synchronized through an ***individual serial number*** (ISN). The ISN is a unique code number that is permanently assigned to the ECM and also stored in the EWS II Control Module. The ISN must match every time the ignition is switched “ON”, before the ECM drive away protection feature will be cancelled.

• Engine Control Module designed to operate with the EWS II system will not interchange with ECMs from previous models.
• The ISN replaces the BC Code input to the ECM.
• The ISN is unique to each ECM and cannot be changed or overwritten. The ISN is transferred/ stored in the EWS II Control Module using the DIS/MoDIC (including diagnosis).
• Everytime the ignition is switched “ON”, the ISN number is sent from the EWS Control Module to the ECM, as a digital coded signal. The numbers must match before the ECM will release the driveaway protection.
• The ISN is continously sent to the ECM as long as the ignition is switched on (KL 15).
• The ECM will disregard the loss of the ISN after the engine is running.



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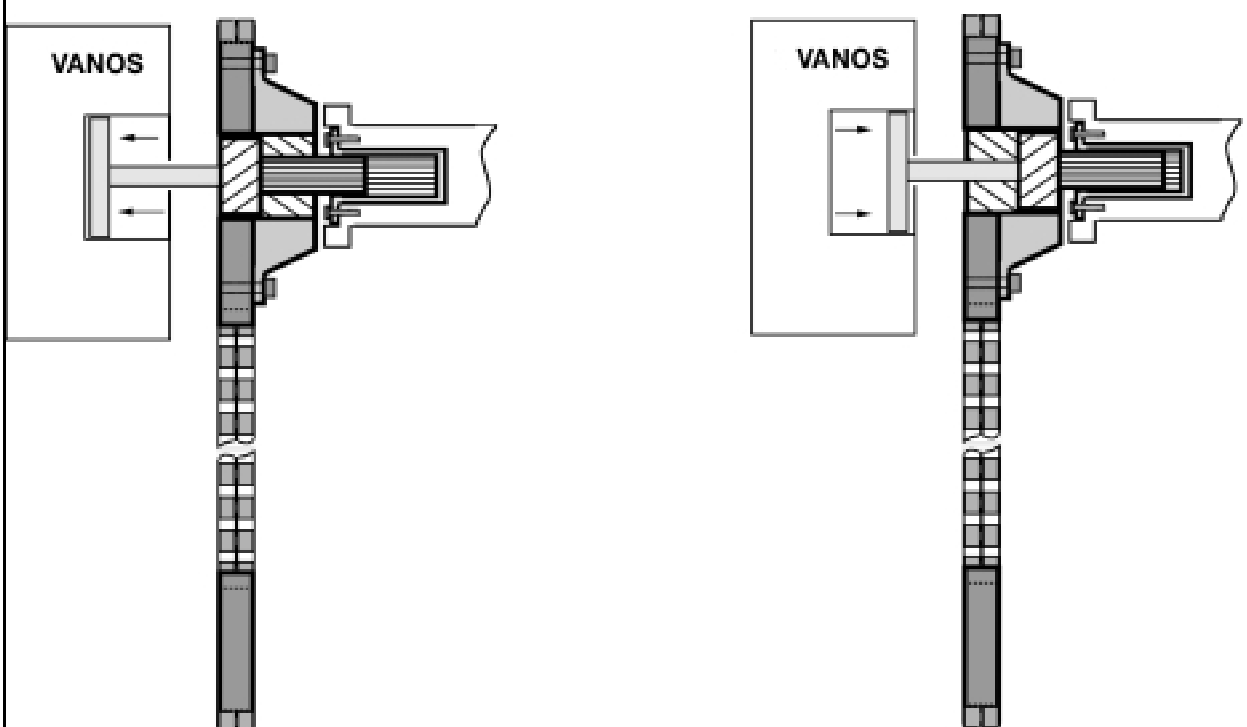
VANOS Control: Performance, torque, idle characteristics and exhaust emissions reduction are improved by Variable Camshaft Timing (VANOS). The VANOS unit is mounted directly on the front of the cylinder head and adjusts the **Intake** camshaft timing from retarded to advanced. The ECM controls the operation of the VANOS solenoid which regulates the oil pressure required to move the control piston. Engine RPM, load and temperature are used to determine VANOS activation.

VANOS mechanical operation is dependent on engine oil pressure applied to position the control piston. When oil pressure is applied to the control piston (regulated by the solenoid), the piston moves causing the splined adjustment shaft to move. The straight splines slide within the camshaft sleeve. The helical splines rotate the camshaft drive sprocket changing the position in relation to the camshaft position which advances/retards the intake camshaft timing.

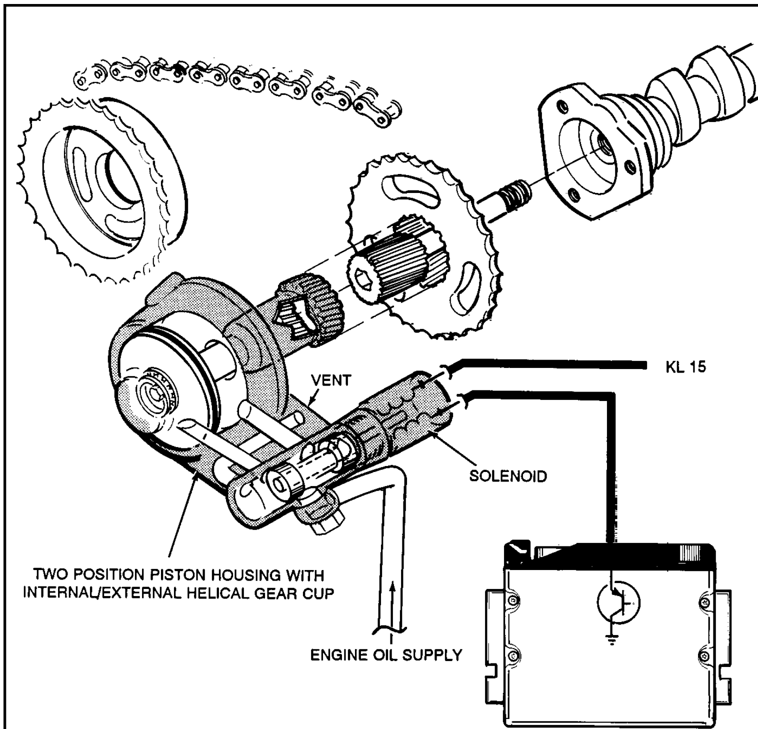


13550066.bmp

The operation of the VANOS solenoid is monitored in accordance with the OBD II requirements for emission control. The ECM monitors the final stage output control and the signal from the Camshaft Position Sensor for VANOS operation.

Retarded Timing: In the normal or off position, the spool valve in the piston housing is held by spring pressure directing the engine oil to the back side of the piston.

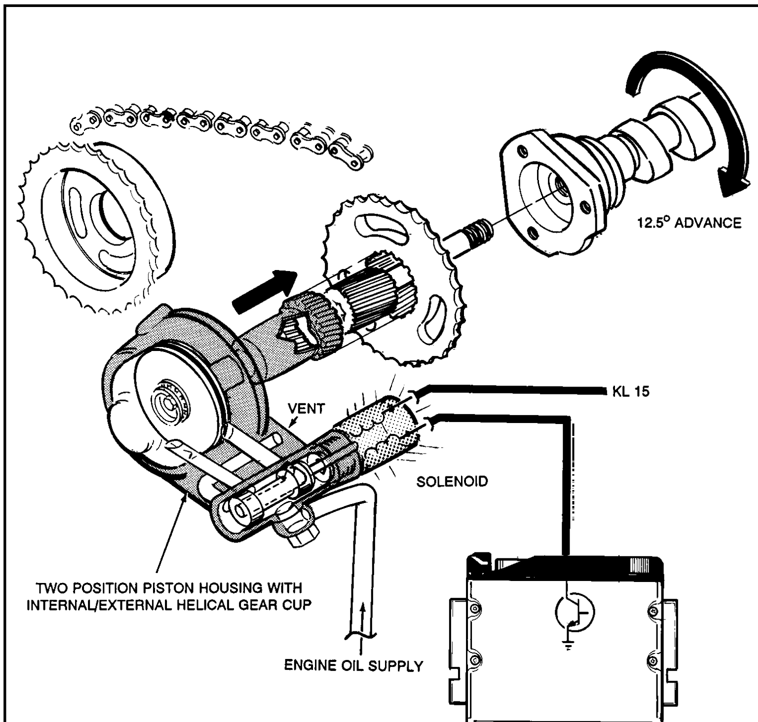
This pulls the attached helical gear cup forward and maintains the late (retarded) valve timing position.



13550064.tiff

Advanced Timing: When the ECM provides a ground circuit to the solenoid, the spool valve pushes against the spring pressure diverting the pressurized engine oil to the front side of the piston. This pushes the helical gear cup further into the matched helical camshaft secondary gear drive.

The angled teeth of the helical gears cause the pushing movement of the helical cup to be converted into a rotational movement. This rotational movement is added to the turning of the camshaft and causes the intake camshaft to “advance” 12.5^{+}.



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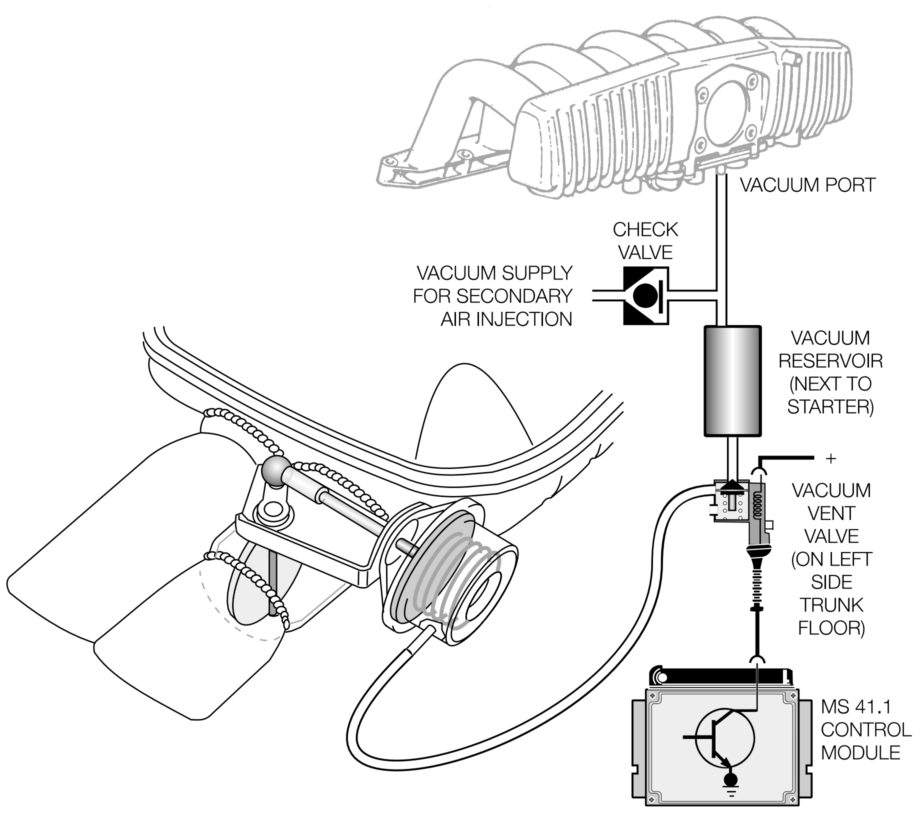
Exhaust Flap Damper Control (E36): To meet European noise level compliance, the rear silencer incorporates a flap that is designed to reduce exhaust noise at idle, low RPM and while coasting. Components of the system include:

• **Exhaust Flap with Vacuum Actuator**	• **Vacuum Reservoir**
• **Switch Solenoid**	• **Check Valve**

The ECM will power the switching solenoid and apply vacuum to the exhaust flap actuator to close the flap allowing additional damping of the exhaust for the following conditions:

• **Engine Idle - up to 2500 RPM**
• **Engine Deceleration**

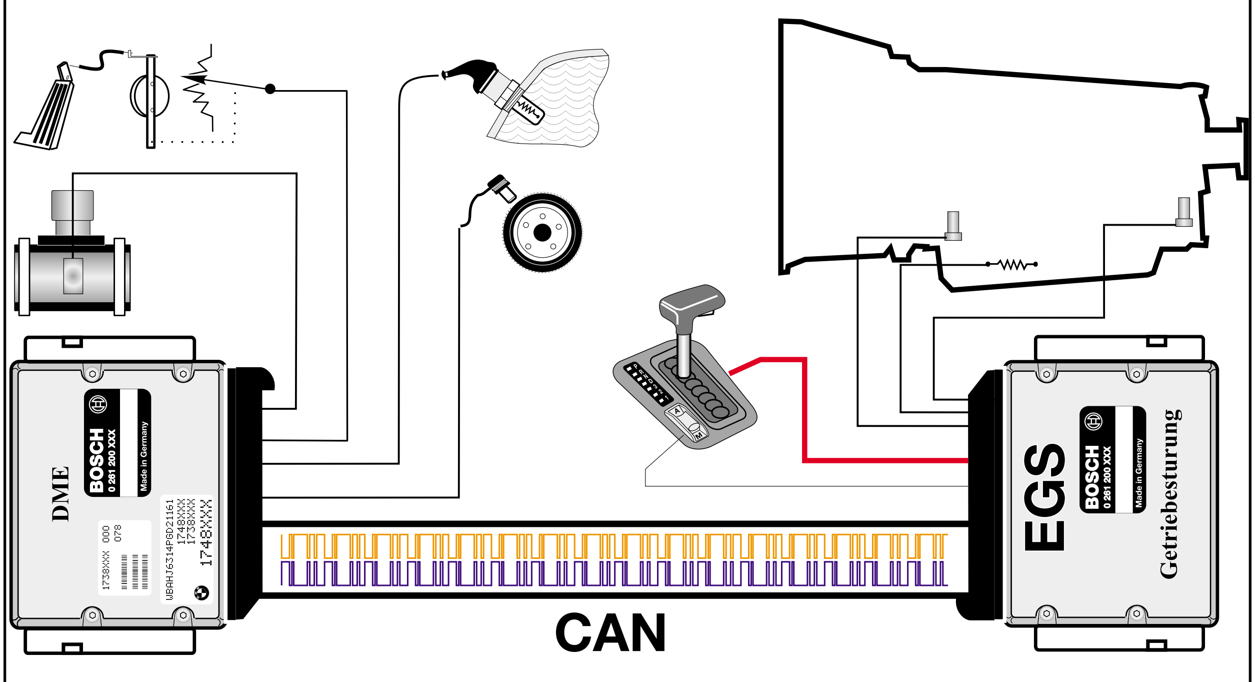
The ECM will deactivate the solenoid when accelerating above 2500 RPM. The vacuum is vented from the flap actuator and the flap opens. This decreases the exhaust backpressure for improved torque.



12550020.eps

Controller Area Network (CAN): The CAN is used between the engine and automatic transmission control modules (if equipped). The CAN is a high speed bus that transfers one million bits of information per second. The CAN supplies the ECM and the EGS with all related operating data required by their operation:

• Throttle Position	**• Engine Load (ti)**
• Engine Temperature	**• Engine RPM**
• Gear Selection Position	**• Timing Retard (Shift Intervention)**
• Torque Converter Lock Up	



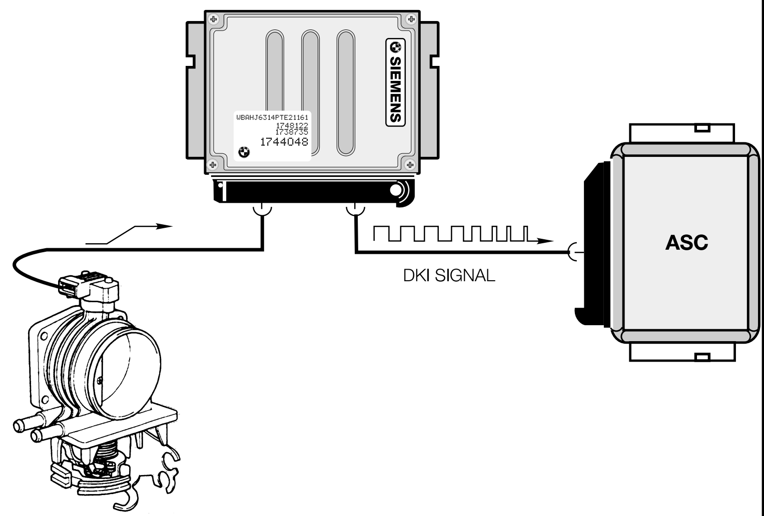
12550021.eps

NOTE: The DIS/MoDIC will display CAN faults with on screen diagnosis under DME (ECM) or EGS Fault survey.

Throttle Position Output (DKI): DKI is the throttle position output signal to the ASC Control Module (if equipped).

The DKI signal is directly proportional to the throttle position sensor input signal.

This output signal is used by the ASC control module during ASC regulation. DKI is a pulse width modulated signal created by the ECM.



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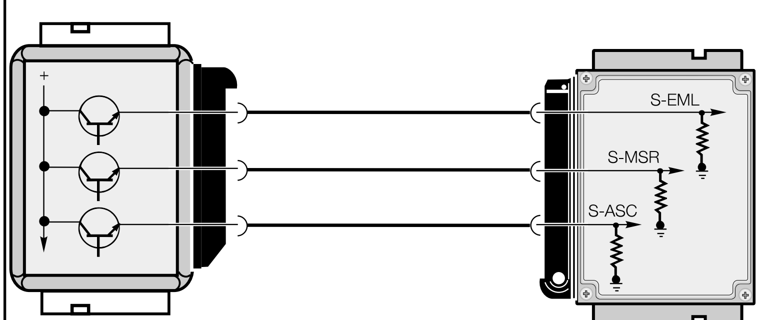
ASC Interfaces: The ECM is linked to the ASC Control Module (if equipped) through three signal lines for ASC regulation. The three signals are switched high/low input requests for power reduction/ drag torque reduction.

- S-EML - Signal to the ECM of throttle regulation (reduce engine torque during acceleration).
- S-ASC (ZA) - Signal request to the ECM for fade out of ignition/ injection and idle rpm increase (further reduction in engine torque during acceleration).
- S-MSR (ZWV) - Signal request to the ECM for ignition timing retard and idle rpm increase (reduce engine torque during deceleration).



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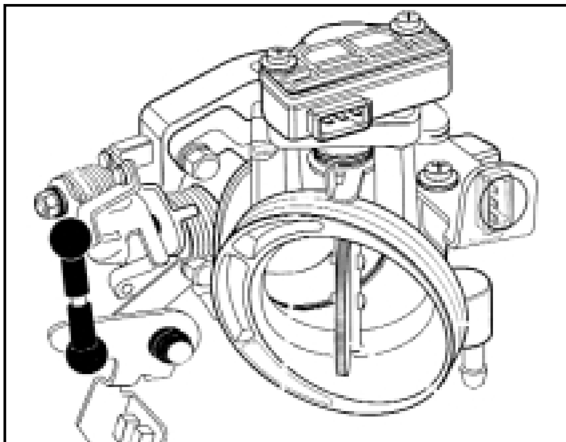
Auxilliary Throttle: A second throttle housing is mounted "upstream" of the main throttle housing. This auxilliary throttle is used in conjunction with ASC (if equipped).

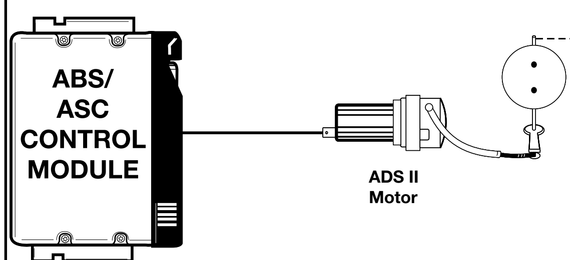
The throttle is normally open and is closed by the ASC Control Module which restricts intake air flow reducing engine torque to restore traction/maintain stability.



13550071.jpg

The Auxilliary Throttle is linked by a cable to the ADS II motor which regulates the throttle plate position. Activation of the ADS II motor is an output function of the ASC Control Module.

The Auxilliary Throttle is closed briefly when the ignition is switched on "KL15" allowing the ASC to conduct a brief test of the ADS II motor and Auxilliary Throttle Position Potentiometer..



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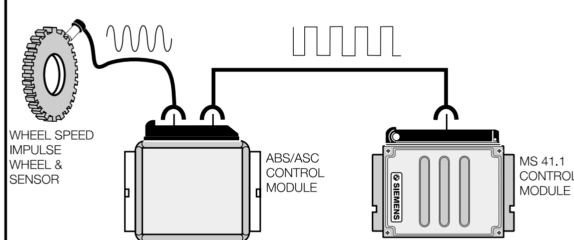
Vehicle Speed Signal: The vehicle speed input signal is provided by the ABS/ASC Control Module. The vehicle speed input is a digital square wave and the frequency is proportional to the speed of the vehicle. The speed signal is used for idle speed regulation and for vehicle top speed regulation.

For OBD II compliance, the ECM also monitors the signal (as compared to engine rpm and load) for abrupt fluctuations in the signal frequency to "detect rough road surfaces" for the purpose of Misfire Detection plausibility.



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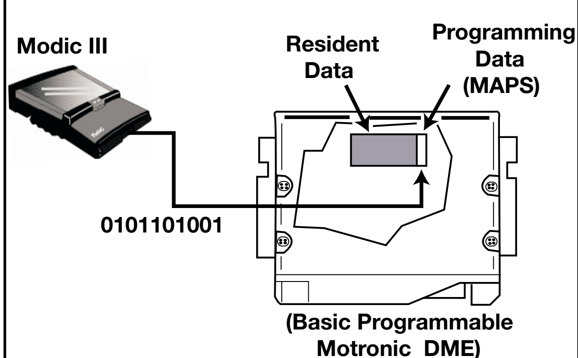
ECM Programming - FLASH Control Modules

The MS41.x ECM is a programmable “FLASH” Control Module. The ECM contains a soldered in **FLASH EPROM** which can be programmed/updated up to 13 times. The EPROM has basic information always present in it refered to as “resident data”. This resident data gives the EPROM its identification and contains instructions for the programming of the operational maps. When you program, you are inputting operational maps to the ECM such as injection timing and ignition timing, etc.

Always refer to the latest programming IDC Bulletin for a complete list of FLASH programmable control modules and the latest program highlights. **An unprogrammed control module will not allow the engine to start**. DME (ECM) FLASH programming is performed with the DIS/MoDIC using the latest software.

Using the “automatic” determination process (preferred method), the MoDIC compares the part numbers stored in the FLASH EPROM of the currently installed ECM with a list of possible replacement part numbers stored in the MoDIC’s memory. The comparison is done to:

- **Display the part number for the replacement programmable control module for that vehicle.**
- **Determine if the MoDIC can “recommend” a replacement part number(s) from the list part numbers stored in its memory.**
- **Identify a proper replacement program or control module.**



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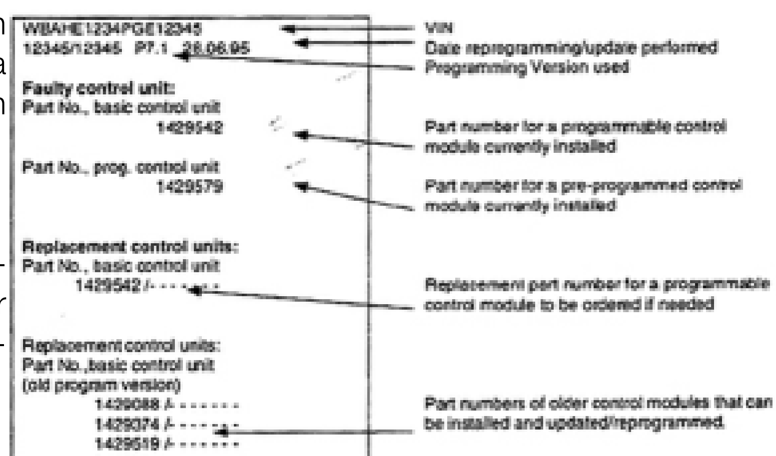
The determination identification screen is an example of the data displayed once the determination is made.



13550075.jpg

NOTE: Refer to Service Information Bulletin SI # 12 05 96 for detailed information on Programming FLASH Control Modules.

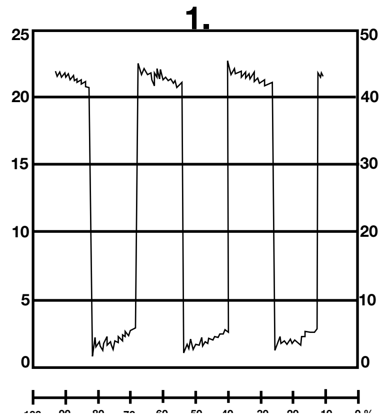
Workshop Hints

The following signals are "manufactured" by the ECM for other control modules and are not the "raw" inputs to the ECM.

These signals should be tested if another Control Module, gauge or function is inoperative due to a lack of the signal(s).

With the 88 Pin adapter and the DIS Oscilloscope (Preset Measurements) the following signals can be observed with the ECM installed and engine running:

1. TD = Engine RPM	
2. Ti = Fuel Injection	



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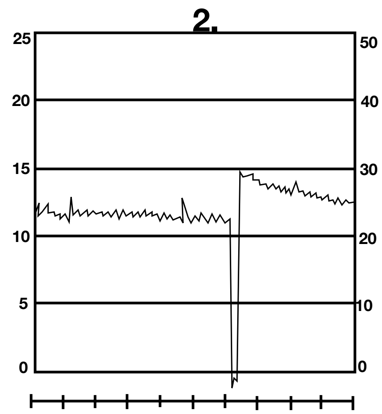

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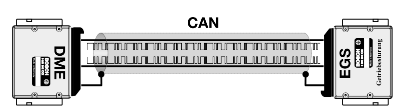
The waveform on the scope should be even, continuous, without interference and of sufficient heigth (indicates signal strength). Examples of "good" patterns are shown to the right.

The test should be performed at the ECM and at the output Controle Module/component.

CAN Signal



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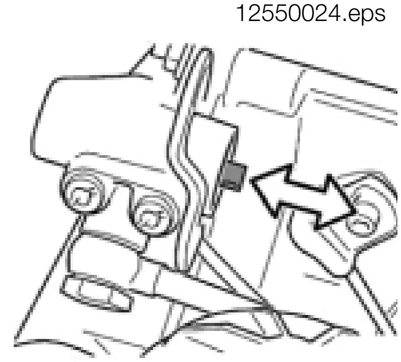
The DIS/MoDIC will display CAN faults with on screen diagnosis under DME (ECM) or EGS Fault survey.

The CAN lines should be checked using an ohm meter or Oscilloscope function of the DIS.

VANOS



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VANOS adjustment and electrical/hydraulic operation should be checked as outlined in the Repair Instructions # 11 36 010.

The VANOS Valve should be checked for mechanically jamming. Refer to Service Information Bulletin SI # 11 09 98 for details.

ECM Programming

Refer to the following Service Information Bulletins regarding ECM programming:

• SI # 12 16 99 Reprogramming of Engine Control Module May Not Be Possible.
• SI # 12 09 96 EPROM Replacement / Application Chart.
• SI # 12 02 98 Programming of Engine Control Modules.
• SI # 12 01 97 Intermittent Crank/No Start.
• SI# 12 09 97 z3 DME Reprogramming.
• SI # 12 13 96 M52 Engine Control Module Fault Code 12.
• SI # 12 06 98 No Start Caused by Faulty Oil Level Switch.

Tools and Equipment

The DIS/Modic as well as a reputable hand held multimeter can be used when testing inputs/ components.

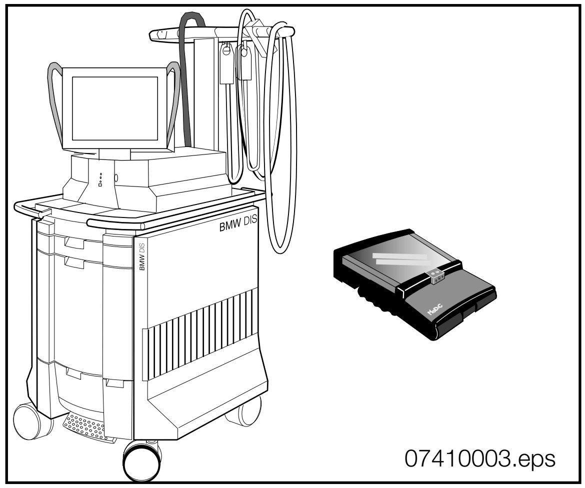
It is best to make the checks at the ECM connection, this method includes testing the wiring harness.

The correct Universal Adapter for the MS41.x application should be used (#88 88 6 614 410). This will ensure the pin connectors and the harness will not be damaged.

The interior of this Universal Adapter is shielded, therefore it is vital that the ground cable is connected to the vehicle chassis whenever the adapter is used.

The adapter uses a Printed Circuit board inside keeping the capacitive and inductive load to a minimum.

When installing the Universal Adapter to the ECM (located below the windshield on the passenger side of the engine compartment), make sure the ignition is switched off.



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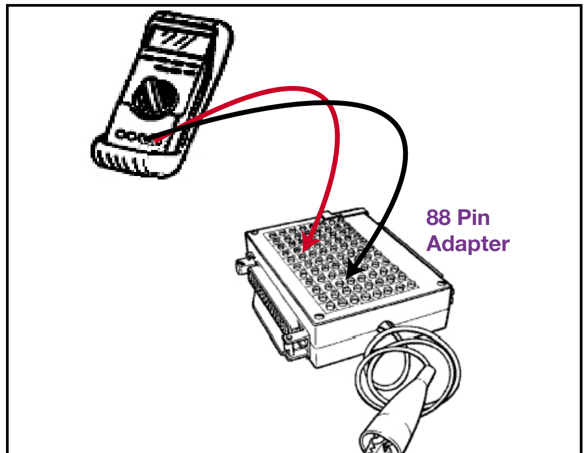

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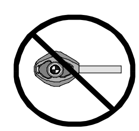
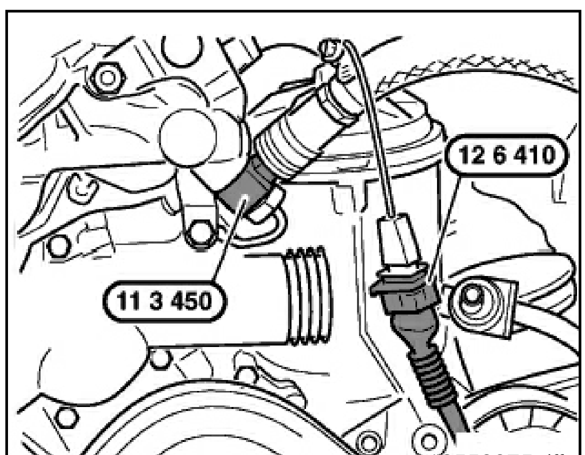


VANOS

The electrical/hydraulic function can be checked “statically” by using the adapter tools and shop supplied **regulated** compressed air.

Special Tool # 90 88 6 113 450 adapts regulated compressed air to substitute for engine oil pressure required to move the VANOS piston.

Special Tool # 90 88 6 126 410 allows battery voltage and ground to activate the solenoid.



16550075.tiff

Review Questions

1. How many speeds will the Secondary Air Injection Pump run at? ____________________
____

2. Describe the Running Losses Fuel Supply System: __________________________________
____
____
____

3. Describe the LDP Pump Operation: ____
____
____
____

4. Describe the Knock Sensor Function:____
____
____
____

5. Name two types of Emissions the ECM controls:_______________ _______________

6. Describe what is required to illuminate the “CHECK ENGINE” Light: ________________
____
____
____

7. How is the secondary ignition monitored for misfire? ______________________________
____
____
____
____

8. What is the Repair Instruction (number) for the procedure to perform a Leakage Diagnosis Test? ____

9. How is the A/C compressor controlled?
____
____
____
____

10. MS41.x refers to what vehicles?___________ ___________ ___________ ___________