Welcome to ST055 Engine Electronics!

ST055 Engine Electronics is 5 days in length.
This handout is representative of selected 4, 6, 8, and 12 cylinder Engine Management Systems from 1996 to present. The handout serves two purposes; Instructor lead training and "stand alone" system reference material for the BMW Technician.

Obviously, all of the material in the handout can not be covered in 5 days, therefore a system will be selected to cover the basic required information. The information from other systems will cover the differences or variants that make them unique. Where possible, use the latest diagnostic equipment and DISplus/MoDIC software programs.

Objectives

The Instructor will familiarize the BMW Technicians with an understanding of the current Engine Electronics Systems and diagnostic skills. Also the Technicians will perform hands on practicals in the shop to ensure participation in diagnosis and component testing.

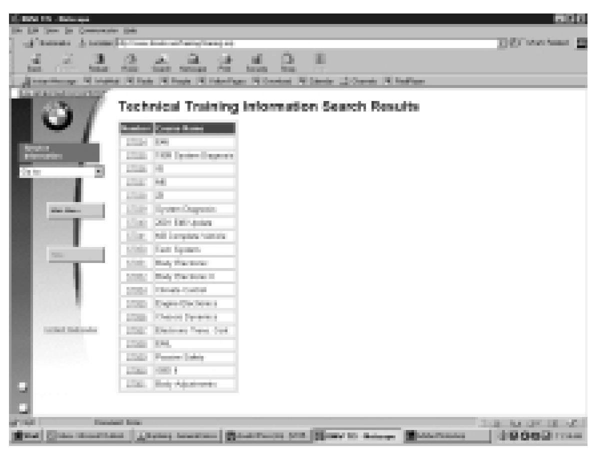
Objectives are provided on page 2 of each system to guide you to the key learning points of each module. Review questions are provided at the conclusion of each module to verify that you achieve the learning objectives during the course. A final test will be given at the end of the course.

It is very important to study the content which will assist you with important "on the job" information and successful completion of this course.

As a Mention . . .

Please visit our website at Http://www.bmwtis.net for the latest information about:

- Service Information
  Bulletins
- Technical Training Information
  Courses
- Repair Information
  Manuals
- Electrical Troubleshooting Manual Information
  Wiring Schematics
- Technician Feedback Systems
  Quality Control Information Reports



The chart shown below is a quick reference of BMW Engine Management Systems by application to BMW models, engines and model years. This will help you to get familiar with the systems by identifying the correct version that you are diagnosing.

Engine Management Control Versions

VERSIONS	MODEL	ENGINE	MODEL YEAR
Bosch = M Siemens = MS			
M1.2	E32 / M5	M70 / S38	M70 = 1988 - 1999 S38 = 1991 - 1993
M1.7	E31 / E32	M70	1991 - 1994
M1.7	E30	M42	1990 - 1993
M1.7	E36	M42	1992
M1.7	E36	M42 / DISA	1992 - 1995
M1.7.1	E31	S70	1994 - 1995
* M1.7.2	E36	M42 / DISA	1995
M3.1	E34	M50	1991 - 1992
M3.1	E36	M50	1992
M3.3	E32	M60	1993 - 1994
M3.3	E31 / E34	M60	1994 - 1995
M3.3.1	E34 / E36	M50 TU	1993 - 1995
M5.2	E36 / Z3	M44	1996 - 1998
M5.2	E31 / E38 / E39	M62 / M73	1995 - 1997
* MS41.1	E36 / E39 / Z3	M52	1996 - 1998
* MS41.2	E36 M3	S52	1996 - 1998
* M5.2.1	E38 / E39	M62 / M73	> 1998
* MS42	E46 / E39 / Z3	M52TU	1998 - 2000
* MS43	E46 / E39 / E53 / Z3	M54	> 2001
* ME 7.2	E39 / E38 / E53	M62TU	> 1999
* MS S52	E39 (M5) E52 (Z8)	S62	>1999
* MS S54	E46 (M3)	S54	> 2001
* = Systems covered in this course			

Table of Contents

Subject **Page**

M1.7.2

Model: E36-M42 Engine

Production Date: 1995

Manufacturer: Bosch

Pin Connector: 88 Pins

Objectives of the Module

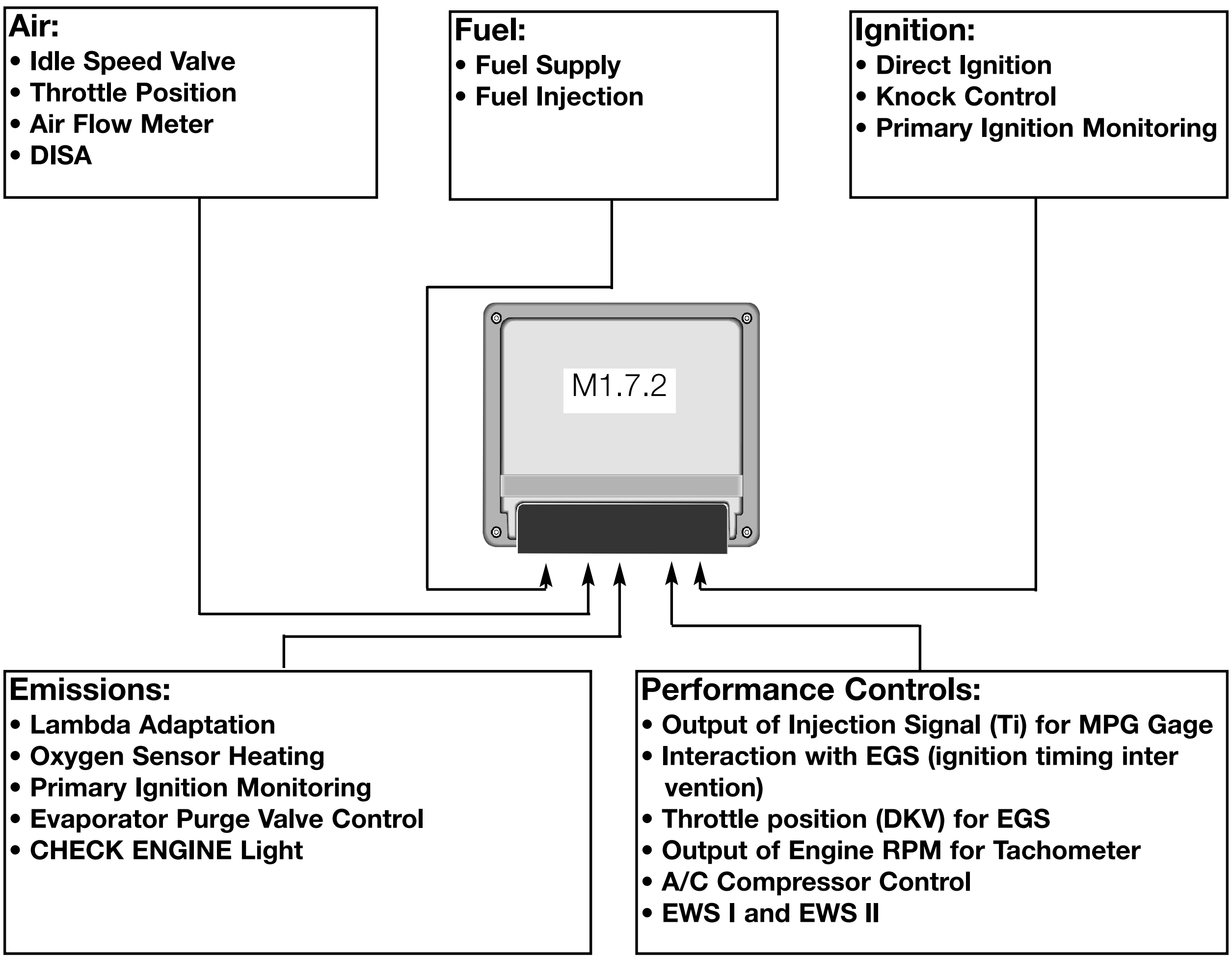
After completing this module, you will be able to:

- Describe the Power Supply for the Fuel Injectors
- Name the Components of the Fuel Supply System
- List the Inputs Required for Ignition Operation
- Decribe the Knock Sensor Function
- Name Two Types of Emissions the ECM Controls
- List Two Reasons for the “CHECK ENGINE” Light to Illuminate
- Describe Semi-Sequential Fuel Injection
- Understand How EWS Affects ECM Output Functions to Deter Vehicle Theft

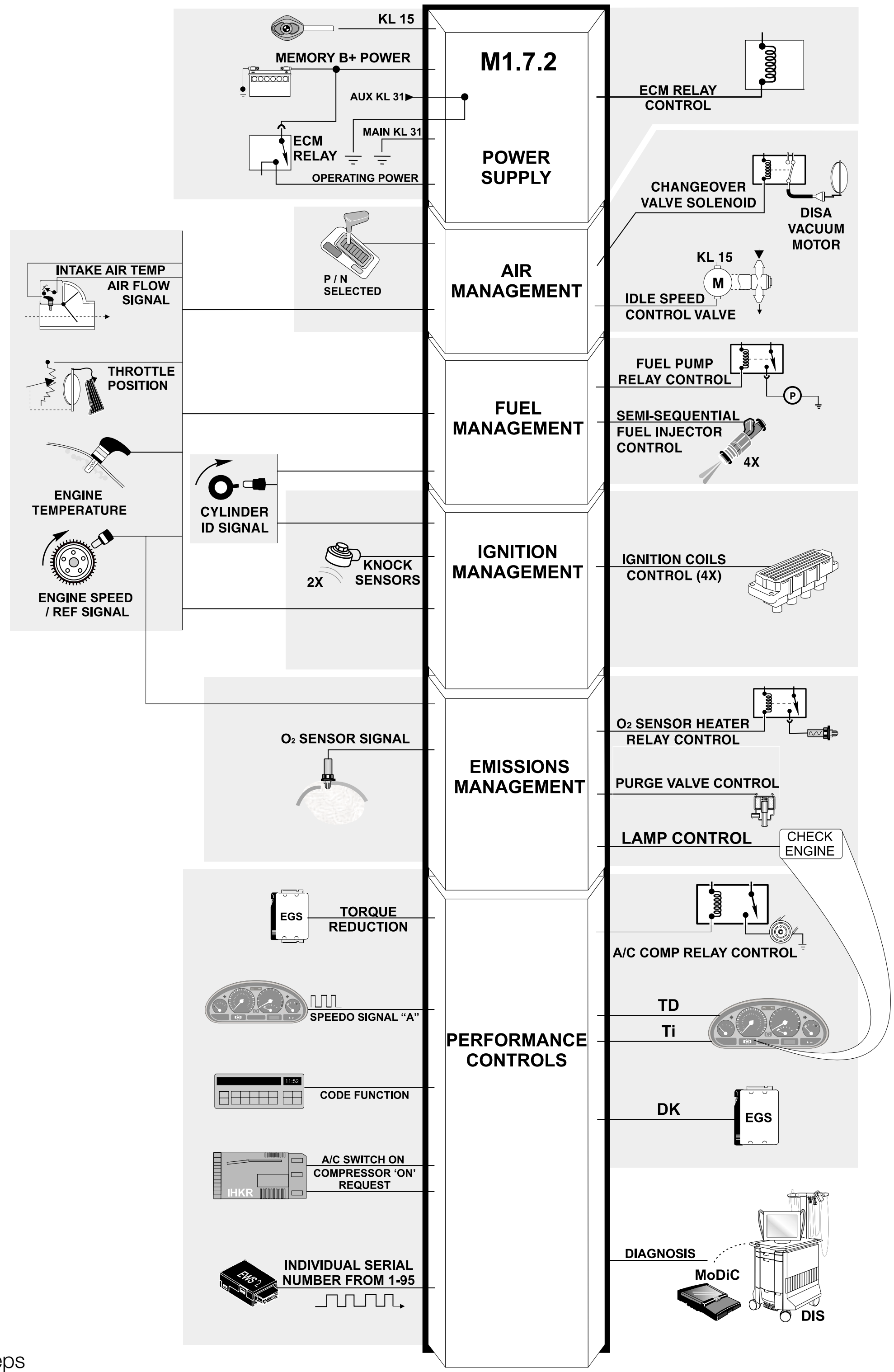
M1.7.2

Purpose of the System

The M1.7.2 system manages the following functions:



System Components: INPUTS - PROCESSING - OUTPUTS



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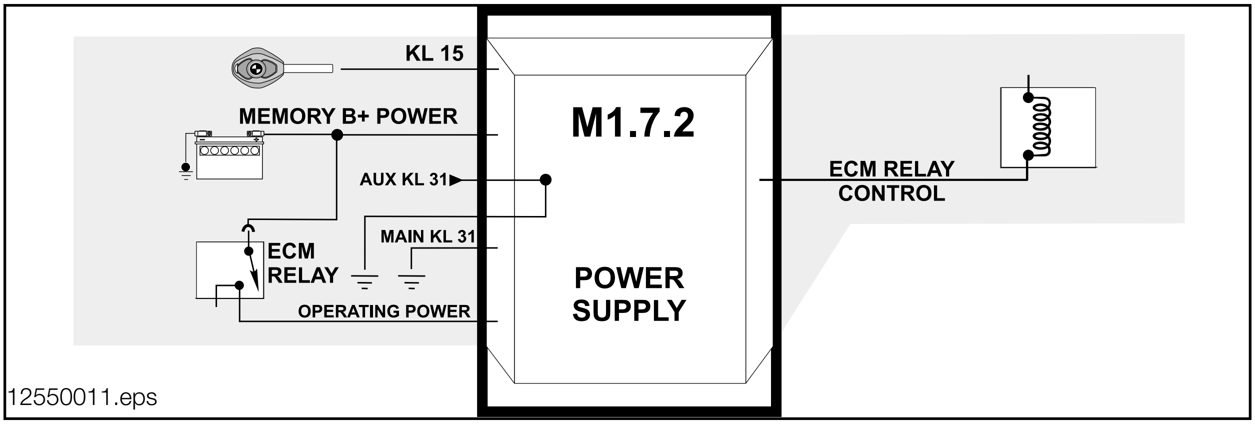
Power Supply



KL30 - Battery Voltage: It supplies the operating voltage to the ECM. Battery voltage also sustains system memory for fault codes and adaptation values.

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	• Intake Air Resonance Changeover Valve
• Purge Valve	• EGS "wakeup" Call (Terminal 87a)

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

Pin#	Ground
06	Fuel Injection
28	Electronics and Sensor Shielding
34	Remaining Output Stages (Except Ignition & Injection)
43	Sensors
55	Ignition
71	Oxygen Sensor Signal

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:

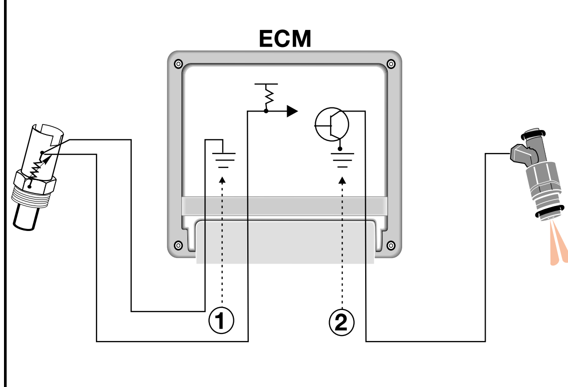
• **Modify Pulse Width Duration of Fuel Injection**
• **Modify Dwell Time of Ignition**

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 to hold the Evaporative Purge Valve closed (to prevent engine run on).

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 ground (2) to activate components**



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Workshop Hints

Power Supply - Testing

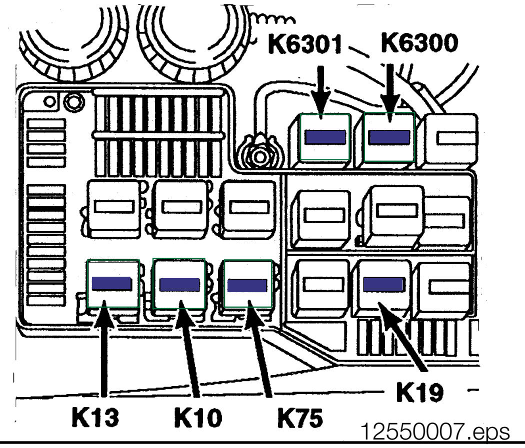
Inadequate power and ground supply can result in:

• 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)

K6300 Engine Control Module Relay



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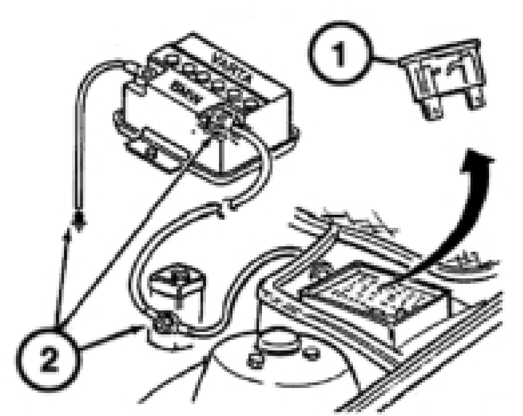

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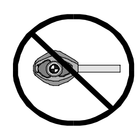
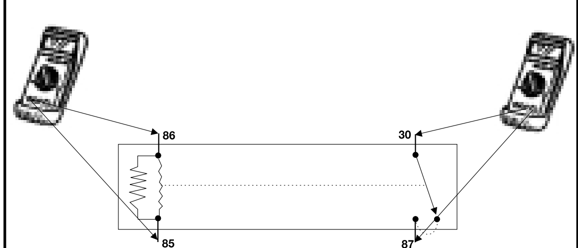
The ignition (KL15) must be switched off when removing or installing the ECM connector to prevent voltage spikes (arcing) that can damage the Control Module!



The Engine Control Module **Relay** (located in the fuse box) should be tested for:

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



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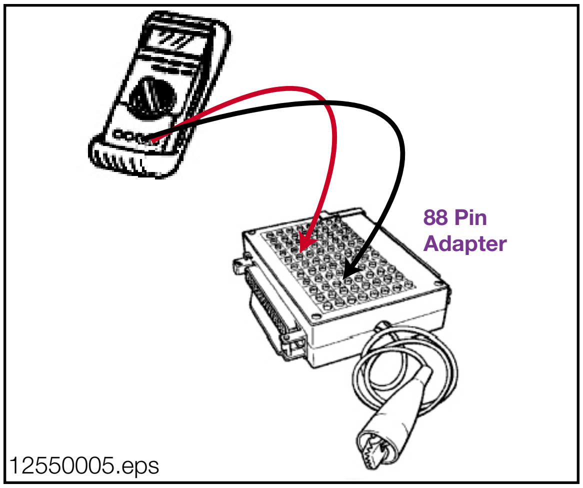
Tools and Equipment

Power Supply

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



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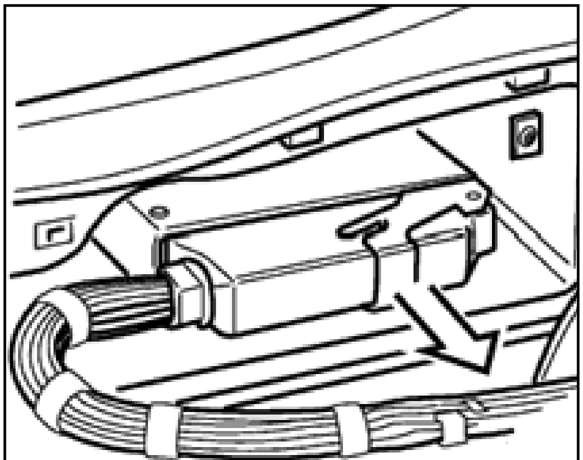
It is best to make the checks at the ECM connection, this method includes testing the wiring harness.

The correct Universal Adapter for the M1.7.2 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.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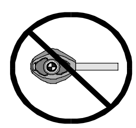
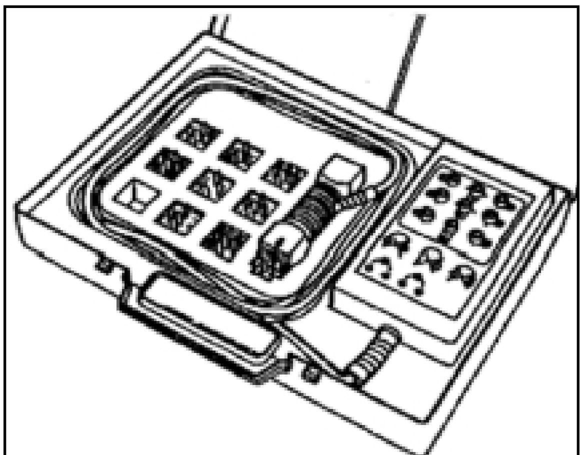
The adapter uses a Printed Circuit board inside keeping the capacitive and inductive load to a minimum.

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 Engine Control Module **Relay** should be tested using the relay test kit (P/N 88 88 6 613 010) shown on the right.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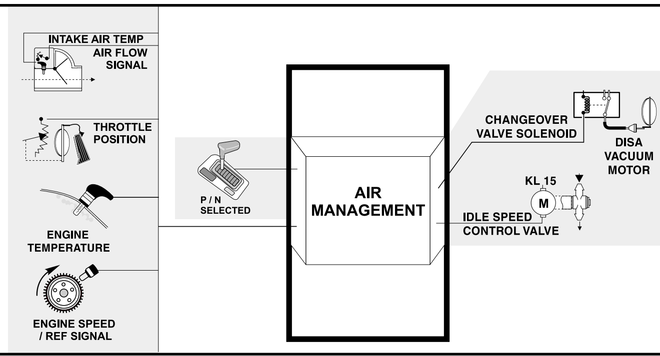
This kit allows testing of relays from a remote position.

Always consult the ETM for proper relay connections.

Air Management



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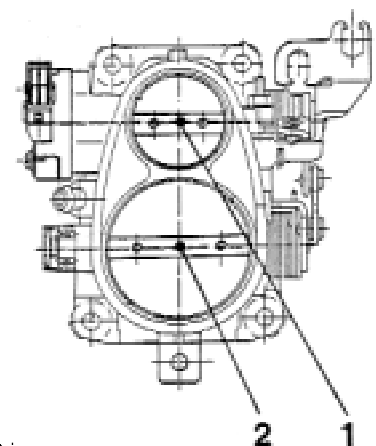
Throttle Valve: The mechanical throttle valve regulates the intake air flow and it is linked by a cable to the accelerator pedal.



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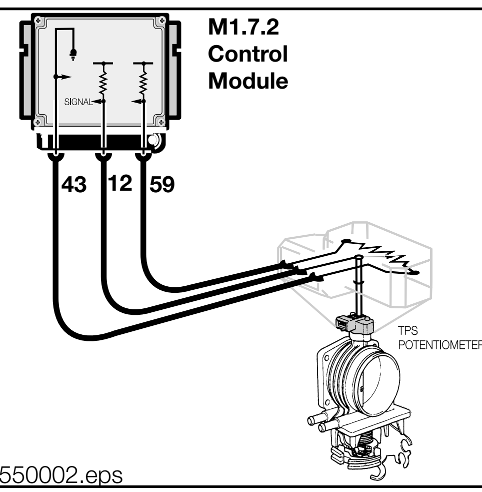
The throttle valve is a two stage (progressive linkage) plate arrangement with integral closing springs. This allows a smaller primary opening (1) for low to mid-range rpm and a larger secondary opening (2) that opens for the higher rpm range.

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

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.



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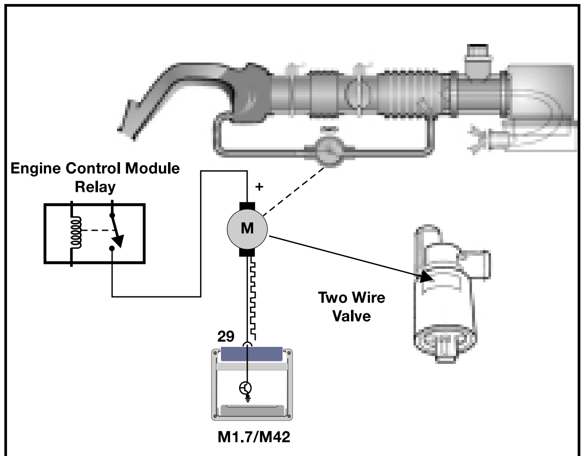
The Potentiometer is non-adjustable because the ECM "learns" the throttle angle voltage at idle speed. If the throttle position sensor is replaced, the ECM must be disconnected from the power supply for at least one minute (to clear memory).

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



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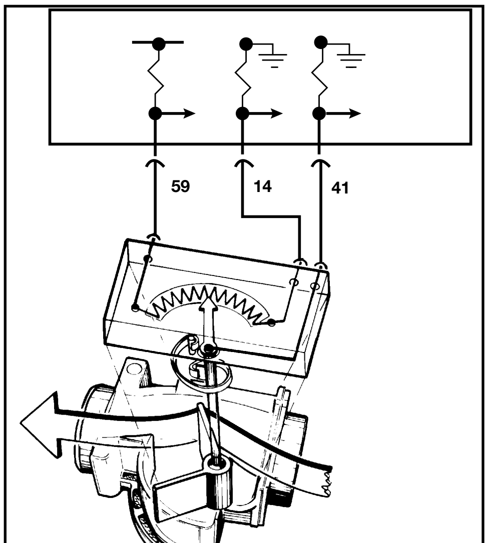
The idle speed control valve is spring loaded closed. It will “failsafe” to a fixed opening (21%) to allow the engine to idle in the event of a power failure.

The valve is supplied with battery voltage from the Engine Control Module Relay. The valve opening is controlled by the ECM modulating the ground signal which opens the valve against spring tension.

Air Flow Volume Sensor: This sensor measures the total volume of air drawn into the engine.



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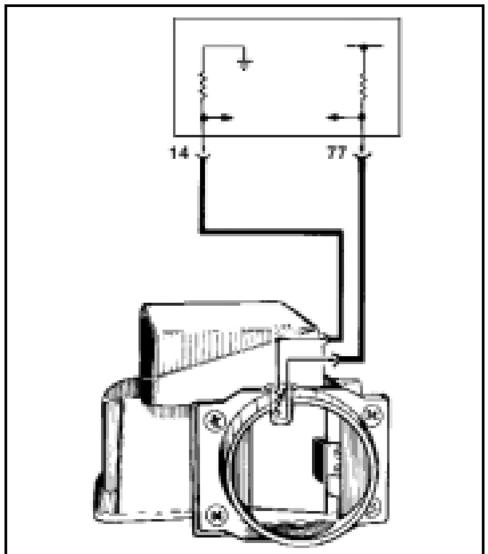
The ECM provides the power supply for the Air Flow Volume Sensor. A potentiometer is connected to the sensing flap and as air flow causes the sensing flap to move, a varying voltage signal (0-5v) is sent to the ECM that “represents” the inducted air volume.

Attached to the sensing flap is a “compensation flap” that moves within a closed chamber. This creates a dampening effect on flap movement for pulsations in the intake system caused by cylinder filling and intake valve operation.

NOTE: The Air Flow Volume Sensor is non-adjustable.

Air Temperature Signal: The Air Flow Volume Sensor contains an integral air temperature sensor. This signal is needed by the ECM to correct the air volume input for changes in the intake air temperature (air density).

The sensor is located in front of the measuring flap. 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 an applied voltage to the sensor (5v) that will vary as air temperature changes the resistance value (0-5v).



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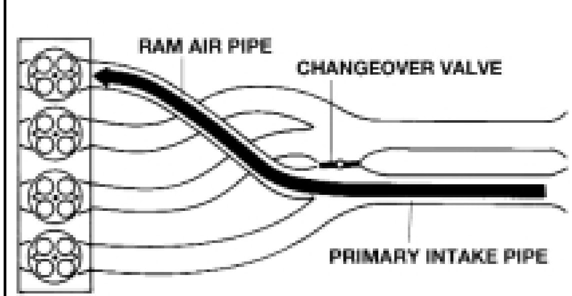
Differential Air Intake System (DISA): DISA allows the dynamics of varied intake manifold tuning. This feature provides necessary intake air "velocity" producing good mid-range torque. Additionally, DISA can divert intake air flow providing "volume" for higher rpm requirements.

The ECM closes the changeover valve to take advantage of a long single intake runner at mid-range RPM. This produces air **velocity** that increases engine torque at mid-range.



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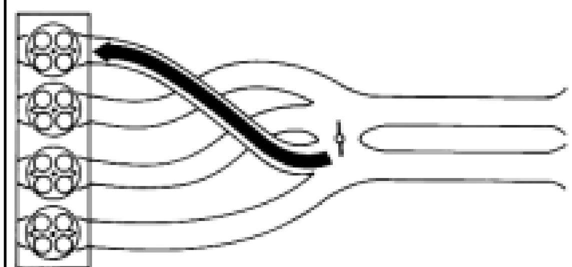
At high rpm, the ECM opens the changeover valve allowing the engine breathing dynamics to change to the dual short air pipes (**volume**). This change enables additional power output at the higher RPM range.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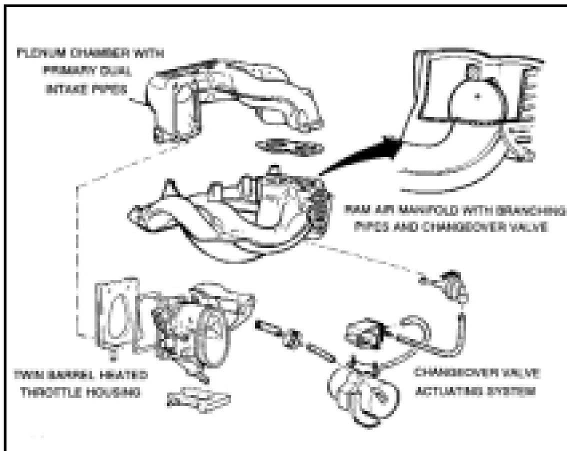
To accomplish this function, the M42 intake manifold incorporates a non-replaceable brass change over valve.

The DISA system vacuum components are:

• Motor (actuator)	**• Reservoir**
• Solenoid	**• Check Valve**

The solenoid receives voltage from the Engine Control Module Relay and the ECM controls the ground supply to activate the solenoid.



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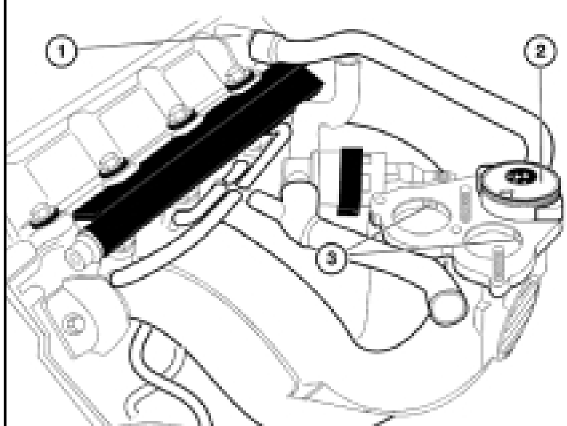
Pressure Control Valve: The pressure control valve varies the vacuum applied to the crankcase ventilation depending on engine load. The valve is balanced between spring pressure and the amount of manifold vacuum.

The oil vapors exit the separator labyrinth in the cylinder head cover (1). The oil vapors are drawn into the intake manifold (3) regulated by the pressure control valve (2).



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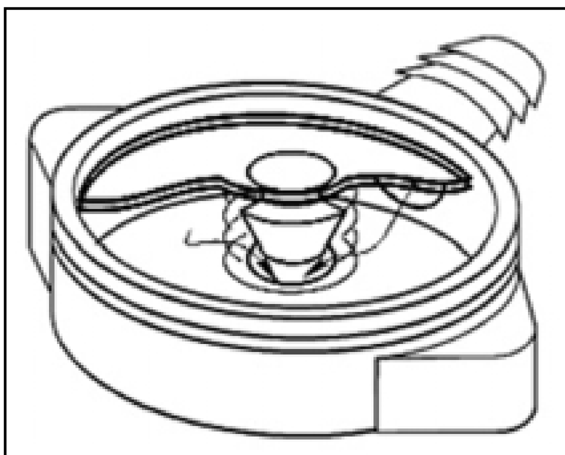
At idle when the intake manifold vacuum is high, the vacuum decrease the valve opening and only allows a small amount of crankcase vapors to be drawn into the intake manifold.

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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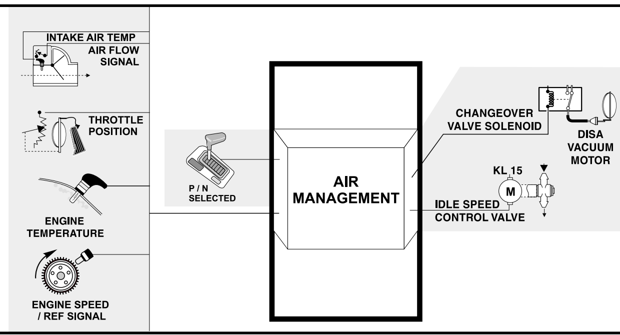
Principle of Operation

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 M1.7.2 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, this will have an effect on the A/C compressor (covered in Performance Controls).

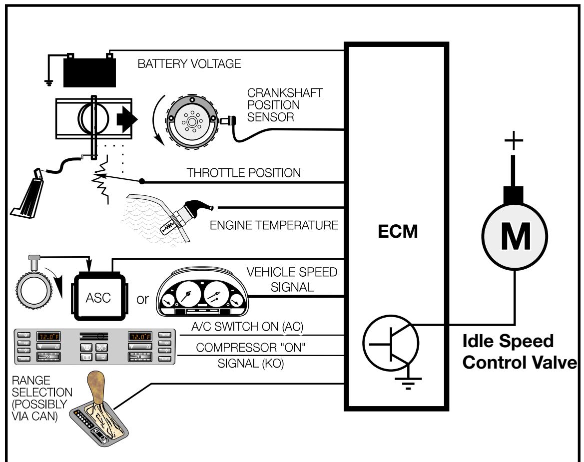
As the throttle plate is closed (integral springs), a decrease in voltage signals the ECM to activate fuel shut off if the rpm is above idle speed (coasting). The Idle Speed Control Valve will then be opened to maintain idle speed.

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. To clear this “learned” value, disconnect the ECM for at least one minute. If the Throttle Position input is defective, a fault code will be set and the “CHECK ENGINE” Light will illuminate. The ECM will maintain engine operation based on the Air Flow Volume Sensor and the Engine RPM Sensor.

The Idle Speed Control Valve is controlled by the ECM modulating the ground signal to the valve, opening it against spring pressure. By varying the duty cycle applied to the winding, 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. The valve will spring to the fixed opening, allowing the engine to idle.

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 (fractional 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) acknowlegment.
• Range selector provides a Park/Neutral input to the ECM identifying when the vehicle is in a drive gear. This signal allows idle stabilization for the increased load on the engine.



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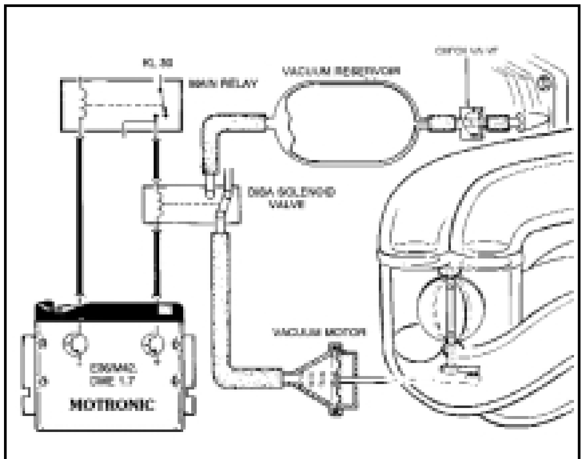
The Air Flow Volume Sensor sends a varying voltage (0-5v) to the ECM representing the measured amount of intake air volume. This input is used by the ECM to determine the amount of fuel to be injected. If this input is defective, a fault code will be set and the "CHECK ENGINE" Light will illuminate. The ECM will maintain engine operation based on the Throttle Position Sensor and Engine RPM Sensor.

The Air Temperature Signal allows the ECM to make a 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.

The ignition timing is also affected by air temperature. If the intake air is hot the ECM retards the base igniton 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.

DISA is controlled by the ECM activating the Change Over Solenoid below 4,840 RPM.

- **When activated the solenoid applies vacuum to the change over valve and the valve closes, providing the long pipe effect.**
- **Above the RPM, the solenoid is switched off and the Change Over Valve springs opens, providing the short pipe effect.**
- **On decel, the solenoid will not be activated until 4,760 RPM. This over lap prevents repeated opening and closing of the valve while driving at a constant engine speed of 4800 rpm.**



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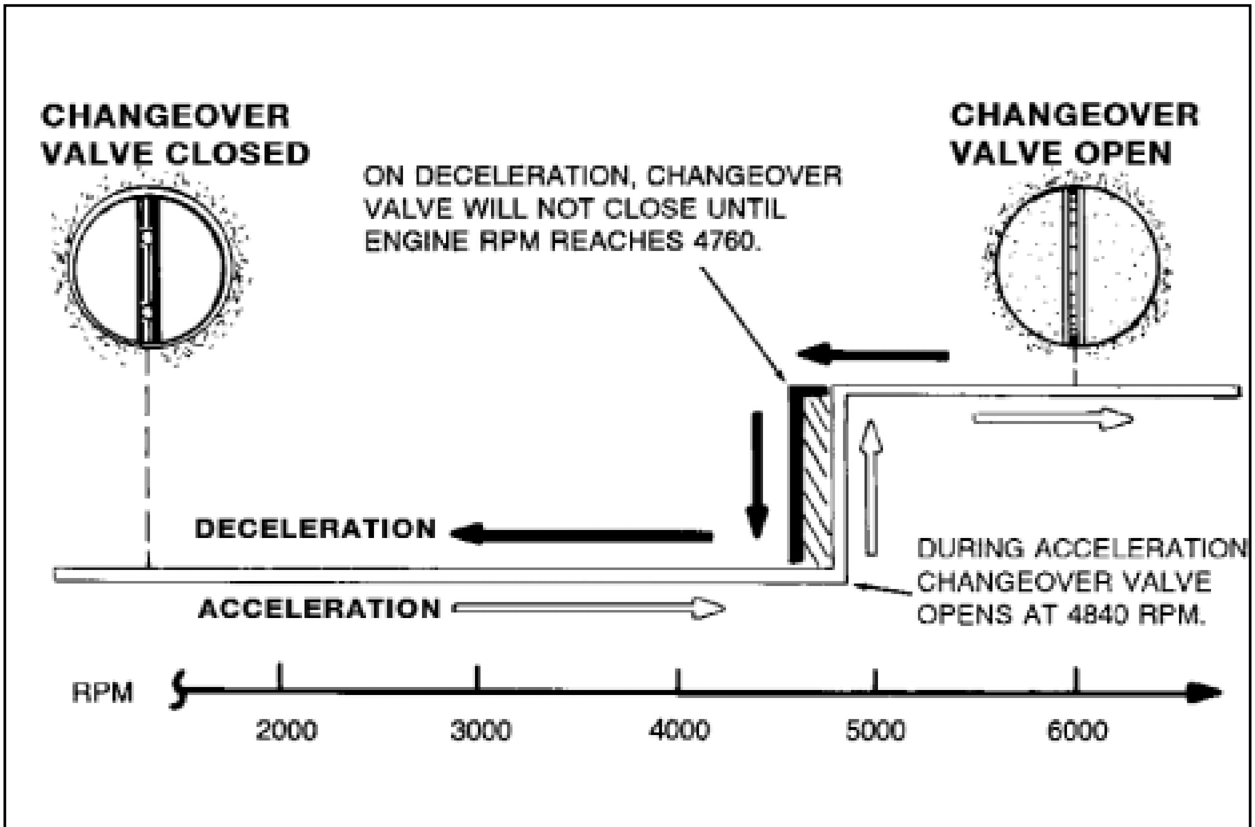

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If there is a defect in this system, the Changeover Valve will be opened to ensure intake air availability for maximum power (short pipe affect). The Vacuum Motor and valve shaft are both spring loaded to open the Changeover Valve if vacuum is not applied.

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 Housing Recall Campaign (Crankcase Ventilation Routing) S.I. #13 06 91 (3440)

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).

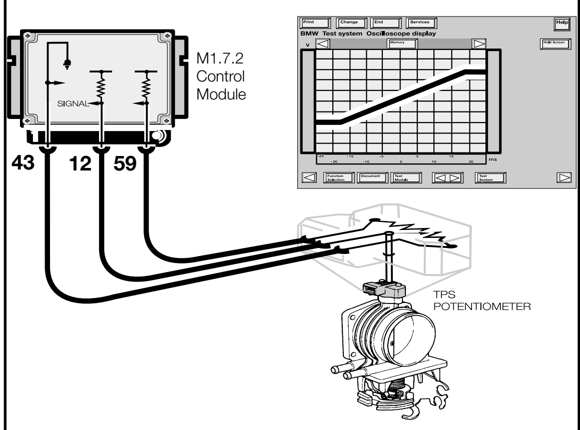
Please refer to the following Service Information Bulletins for details on the Throttle Valve Housing and Throttle Position Sensor:

• Increase Pedal Effort S.I. #13 03 94 (4042)
• Throttle Body Recall Campaign (Throttle Body Heater) S.I. #13 02 94 (3980)
• Throttle Potentiometer - Fault code 12 S.I. #13 09 90 (3141)

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 measurement with the ECM and Universal Adapter connected to the circuit.
• Resistance check of the entire circuit, using the Universal Adapter with the ECM disconnected (approx. 1-4 K ohms).



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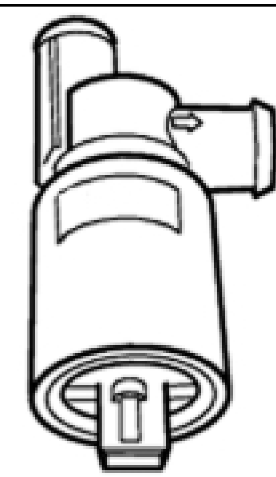
Idle Speed Control Valve - Testing

• The Idle Speed Control Valve and idle air circuit (passage ways) should be checked for physical obstructions.
• The resistance of the valve winding should be checked (8 +/-2 ohms).
• The ECM output and Idle Speed Control Valve operation can be tested by "Component Activation" on the DIS/MoDIC.
• The Pulse Width Modulated ground output from the ECM can be tested using the DIS/ MoDIC Oscilloscope.
• Consult Technical Data for specified idle speed.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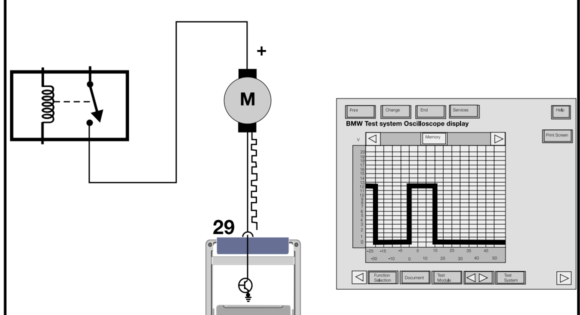


13550002.eps

Air Flow Volume Sensor

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

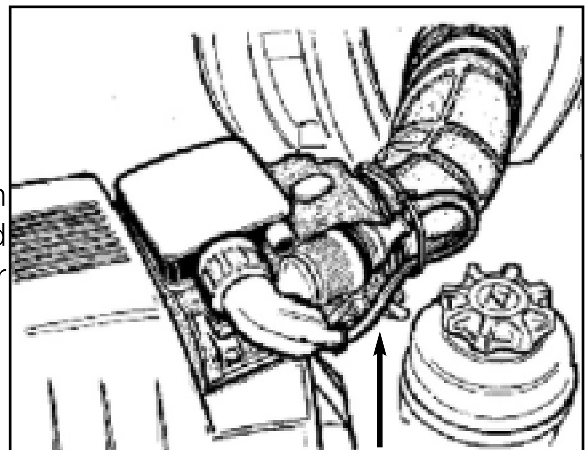
A faulty Air Flow Volume Sensor can produce the following complaints:

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

Please refer to the following Service Information Bulletin for details on the **Air Flow Volume Sensor:**

• Fault Code "41" S.I. #12 09 95

Some early versions have been modified with an additional harness. This is a BMW approved modification, refer to S.I. #13 03 91 (3290) for details.



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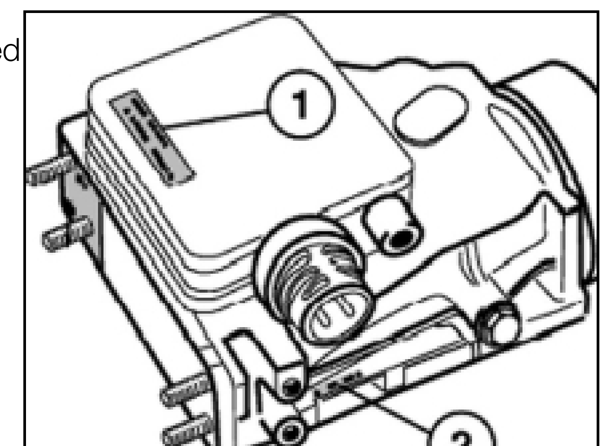
The Air Flow Volume Sensor should be checked for:

• Code Number (1)
• Production Date (2)

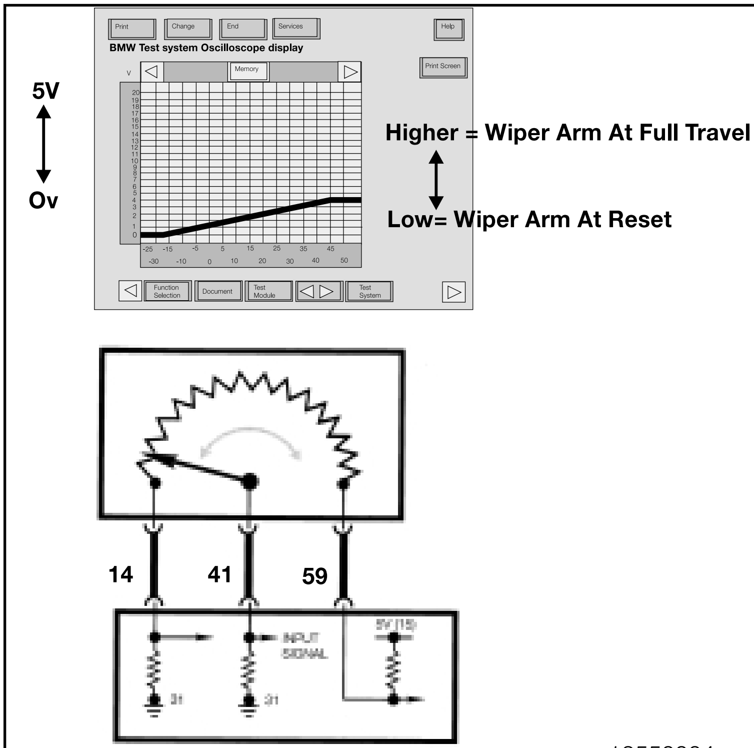


13550010.jpg

Air Flow Volume Sensor - Testing

The Air Flow Volume Sensor (potentiometer) can be tested with the following methods:

- **DIS Status Page (Up/Uv Ratio 0.1 - 0.3 at idle speed).**
- **DIS Oscilloscope - Select from the Preset Measurements which requires taking the measurements with the ECM disconnected and the Universal Adapter connected to the circuit.**
- **Resistance check of the entire circuit, using the Universal Adapter with the ECM disconnected.**



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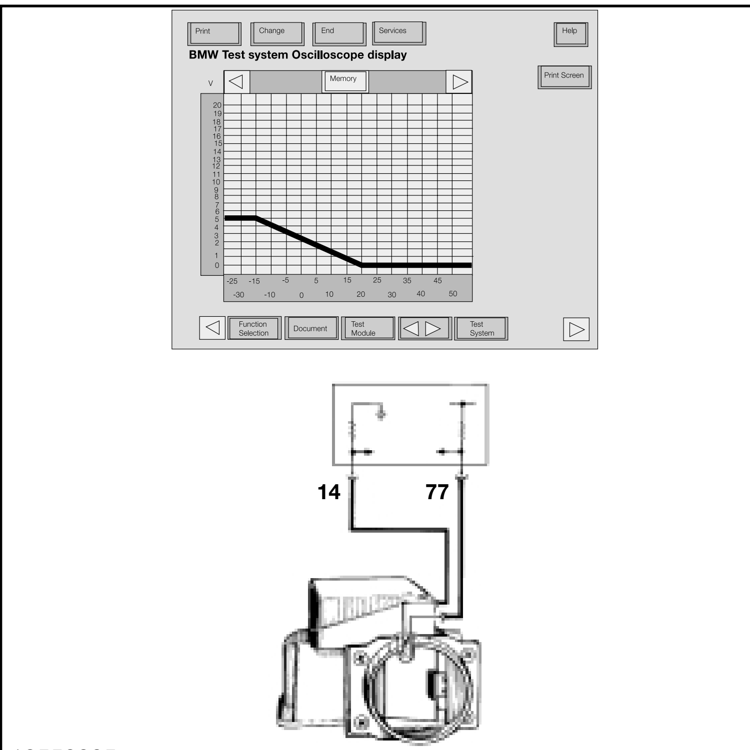
Air Temperature Signal - Testing

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).**

This Sensor should be tested using:

- **DIS/Modic Status page.**
- **DIS/Modic Multimeter At 20º C 2.2 - 2.7 k ohms**



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DISA - Testing

The DISA System can be tested by raising the RPM to 4,840 (briefly) and visually checking the Vacuum Motor Actuator Arm for movement.

If the Actuator Arm does not move, repeat test and check for vacuum at:

• Vaccum Motor
• Solenoid Valve
• Reservoir

Repeat the test to verify the ECM is providing a ground signal to the Solenoid Valve.
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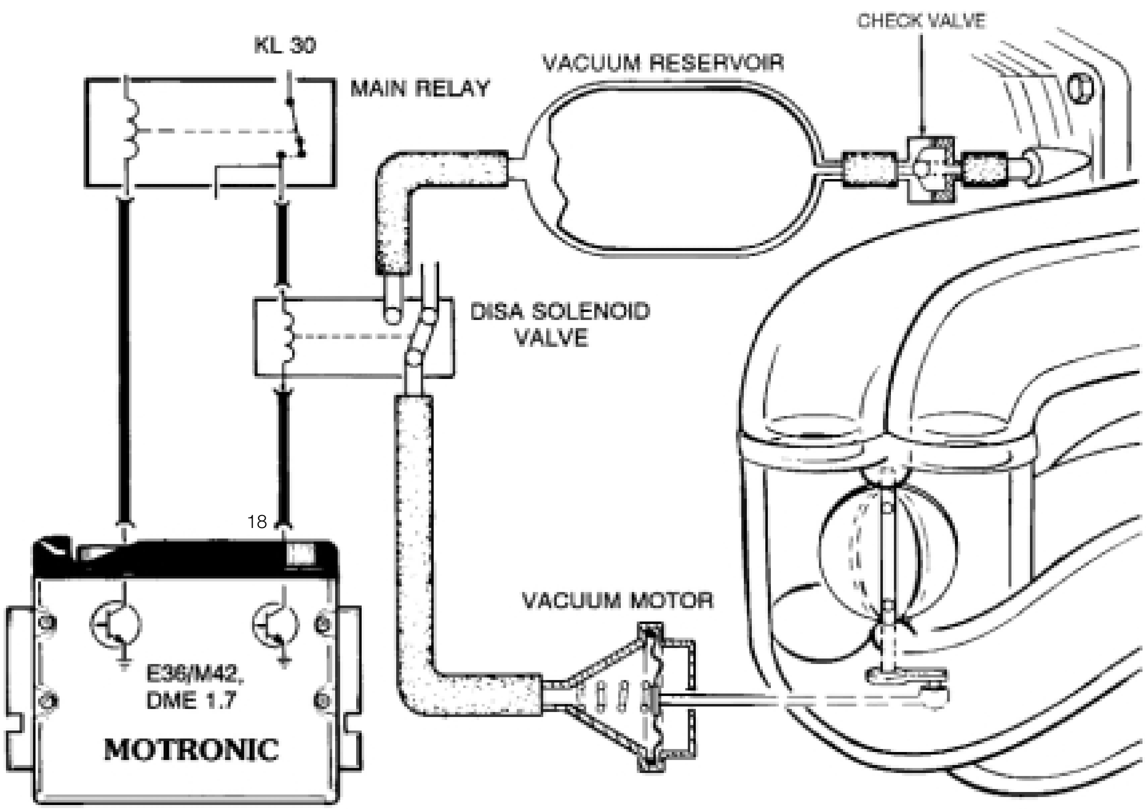


13550011.jpg

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.

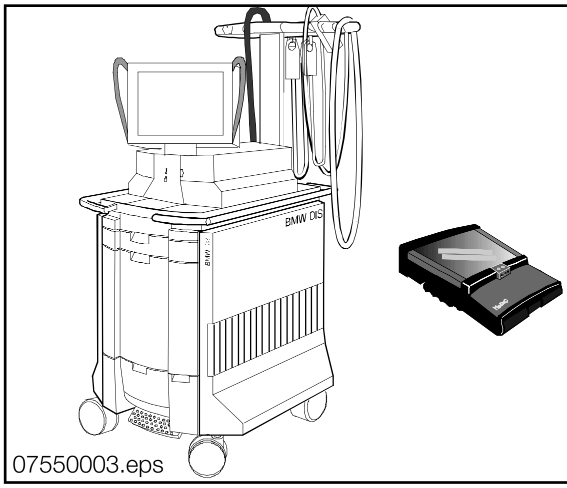
The correct Universal Adapter for the M1.7.2 application should be used (#88 88 6 614 410). This will ensure the pin connectors and the harness will not be damaged.

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.

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



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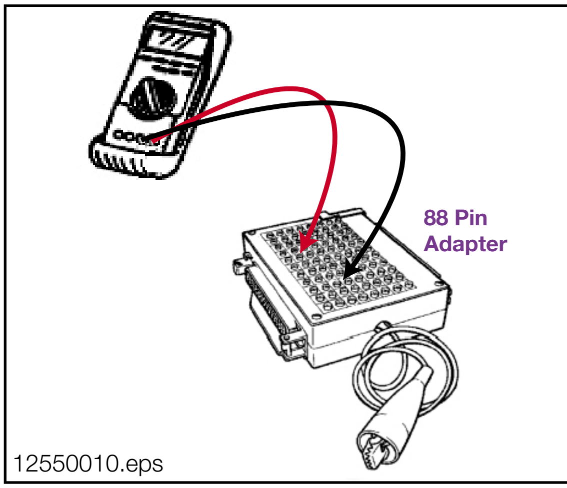

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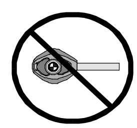

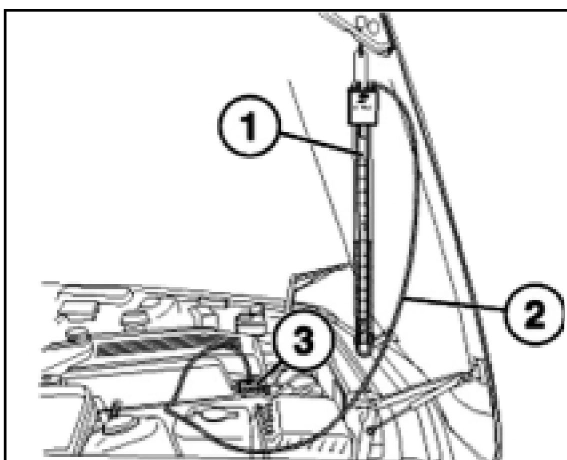

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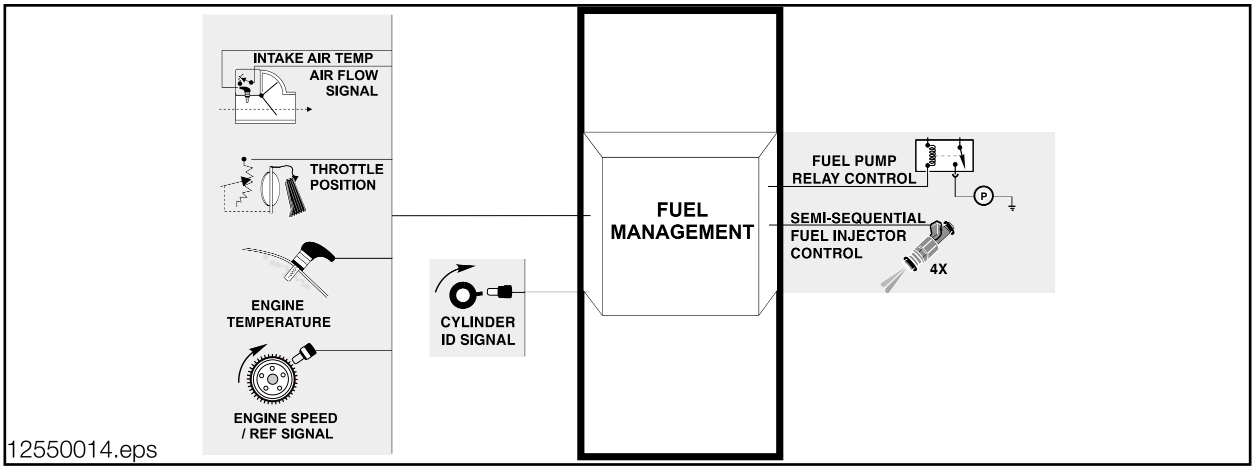
Fuel Management



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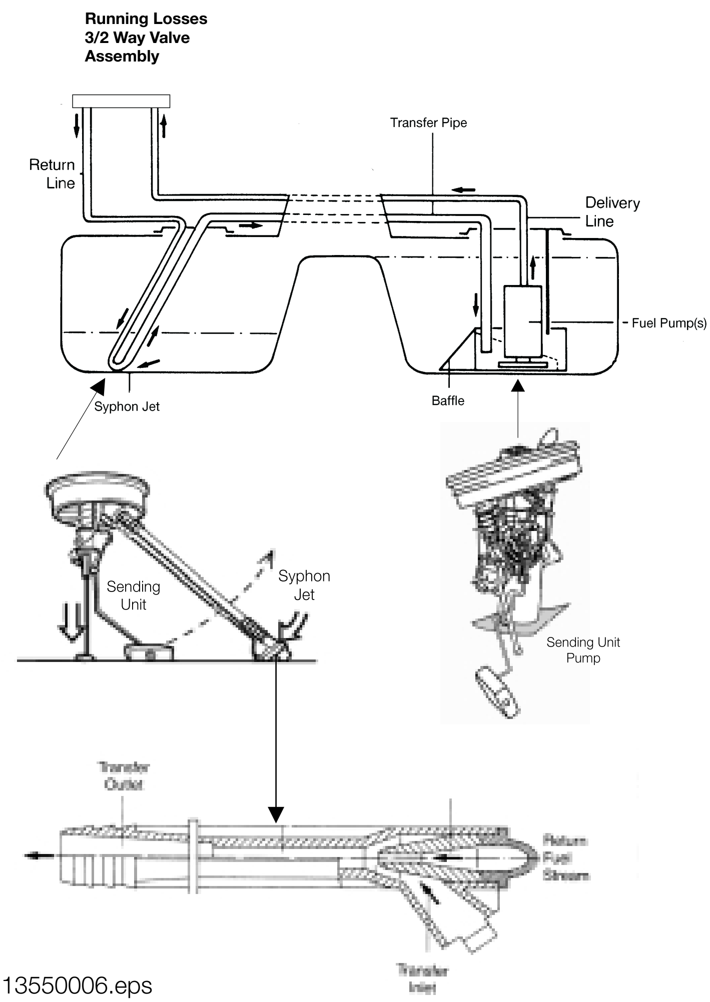
Fuel Tank: The fuel tank is made of high density polyethylene (reduced weight) which is manufactured to meet safety requirements.

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

When the fuel pump is powered, the armature will rotate the impeller disk 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.

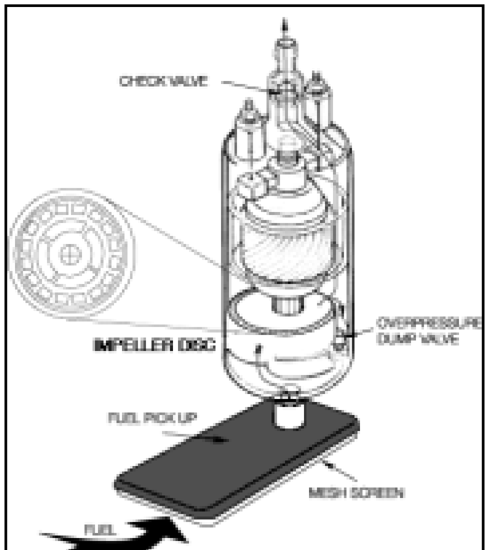
The pump contains an internal overpressure relief valve that will open (reducing roller cell pressure) if there is a restriction in the fuel supply hardware.

Fuel Supply Hardware: The fuel is transfered from the fuel pump to the fuel filter then on to the fuel rail. This is accomplished by a combination of steel lines (2) and high pressure hoses (1).

The fuel pump delivers more volume than the injection system requires. The unused fuel is routed through a return line to the tank. The fuel is constantly circulated in this manner.

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. The large filter size also serves as a volume reservoir for pressurized fuel (dampening fuel pump pulsations).

The fuel rail distributes an even supply of fuel to all of the injectors, and also serves as a volume reservoir.



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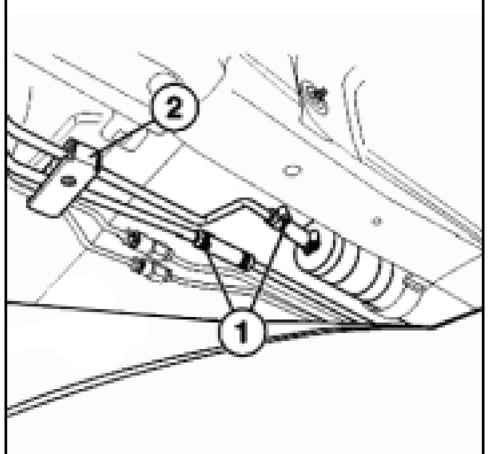

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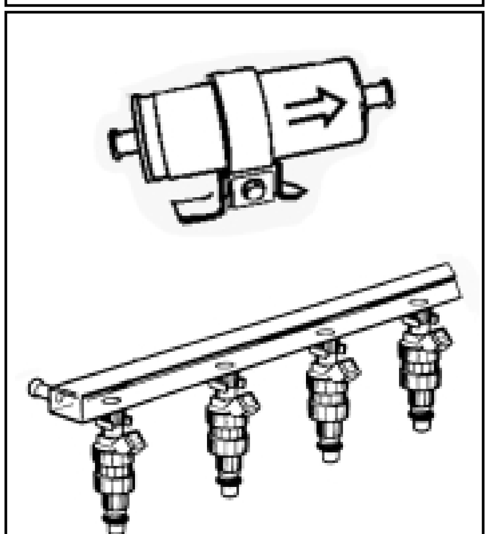
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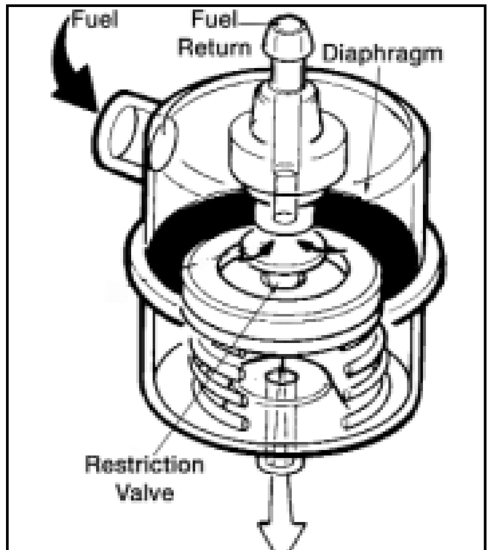
Fuel Pressure Regulator: The Fuel Pressure Regulator maintains a constant “pressure differential" for the fuel injectors.

The fuel pressure is set to 3.0 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).

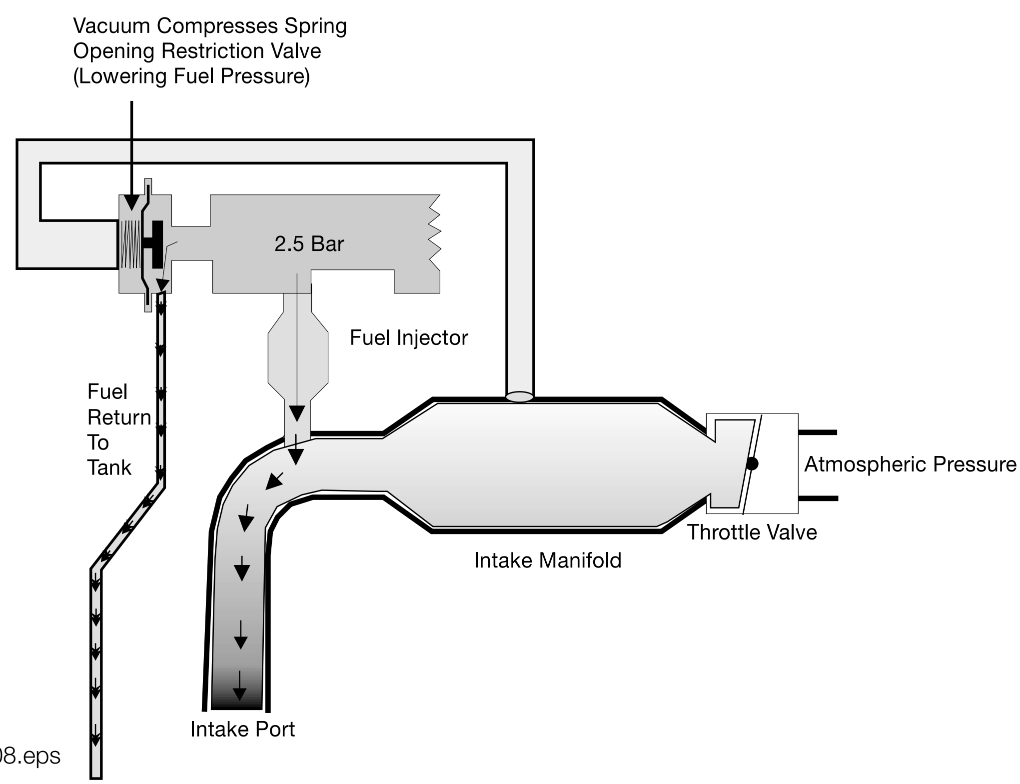
When the restriction valve opens, unused fuel returns back to the fuel tank.



13550025.jpg

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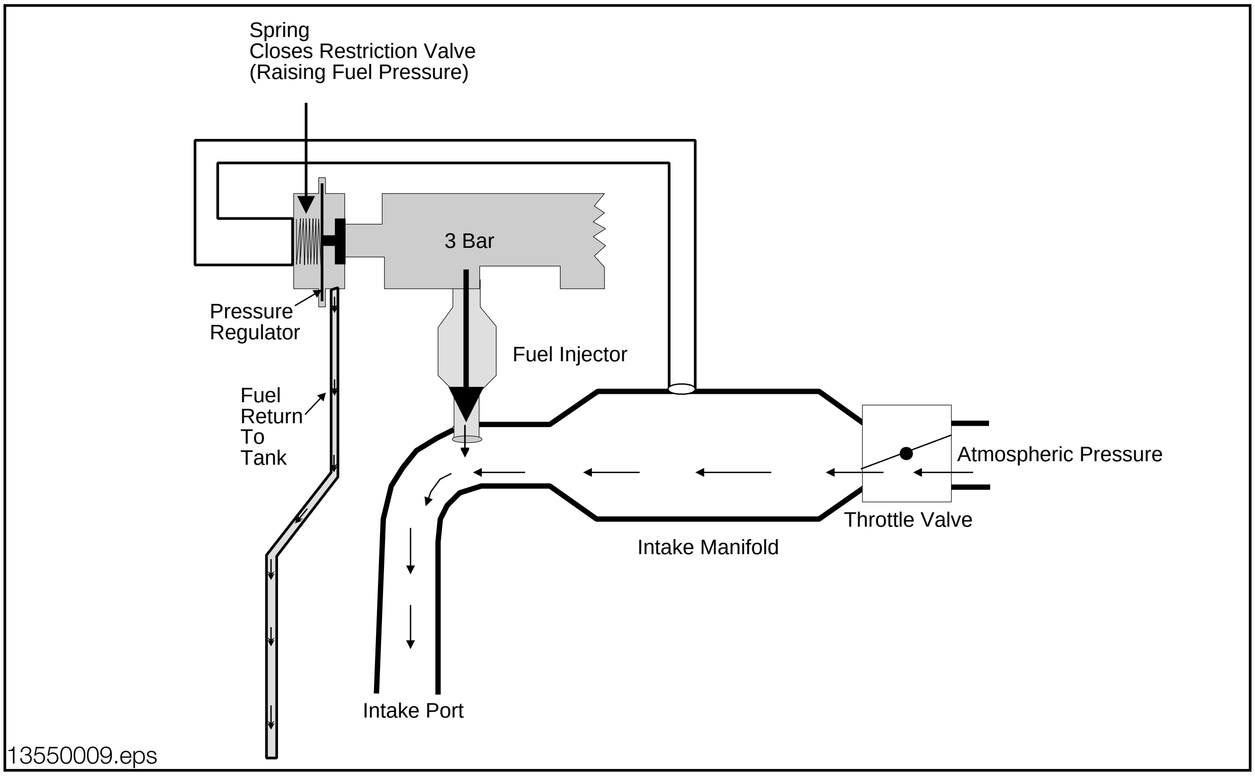
• Wide open throttle depletes intake manifold vacuum at the tip of the fuel injectors and in the fuel pressure regulator vacuum chamber. The spring closes the restriction valve to raise fuel pressure available to the fuel injectors. This maintains pressure differential (fuel flow through) for the fuel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



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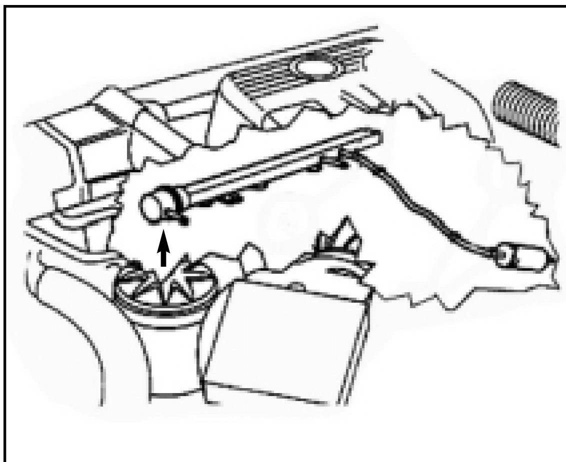
By maintaining constant Fuel Pressure Differential through vacuum sensing (engine load), the ECM can then regulate volume and mixture by the length of time the injectors are open (duration).

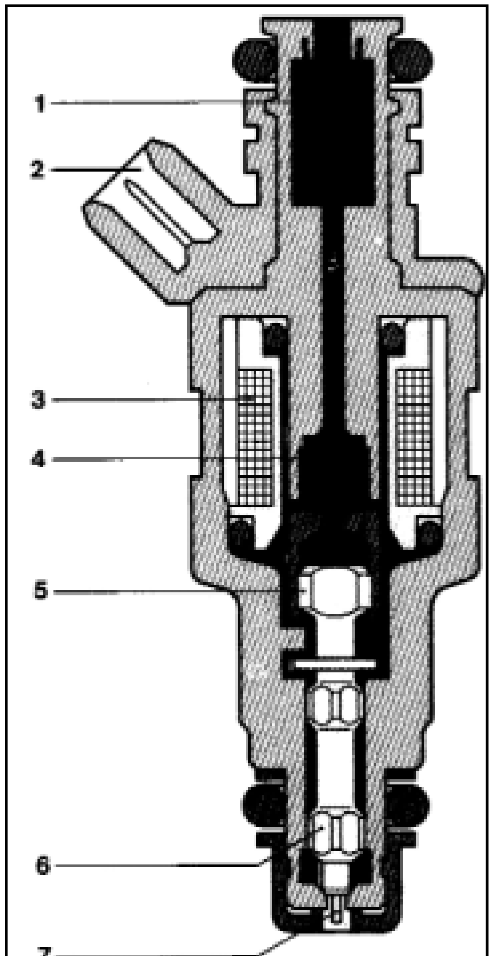
The Fuel Pressure Regulator is mounted on the fuel rail (arrow).



13550014.jpg

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

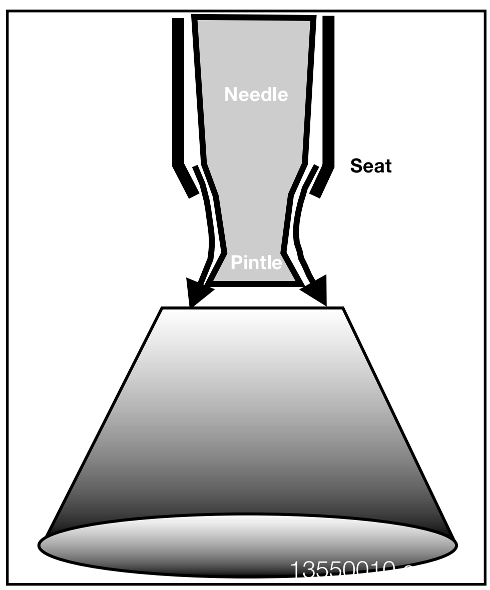
Fuel is supplied from the fuel rail to the injector body. The fuel is channeled through the injector body to the needle valve and seat at the tip of the injector.

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.



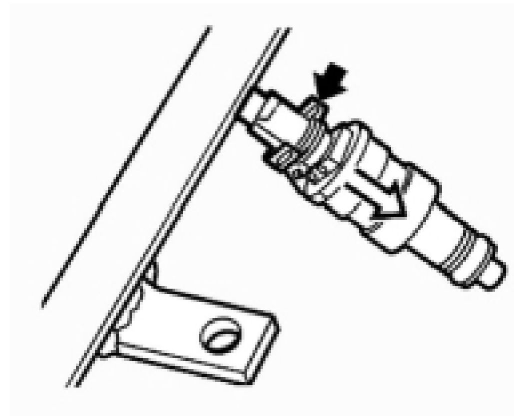
When the ECM deactivates current flow, the needle valve is sprung closed against the seat and fuel flow through the injector is stopped.

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).

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



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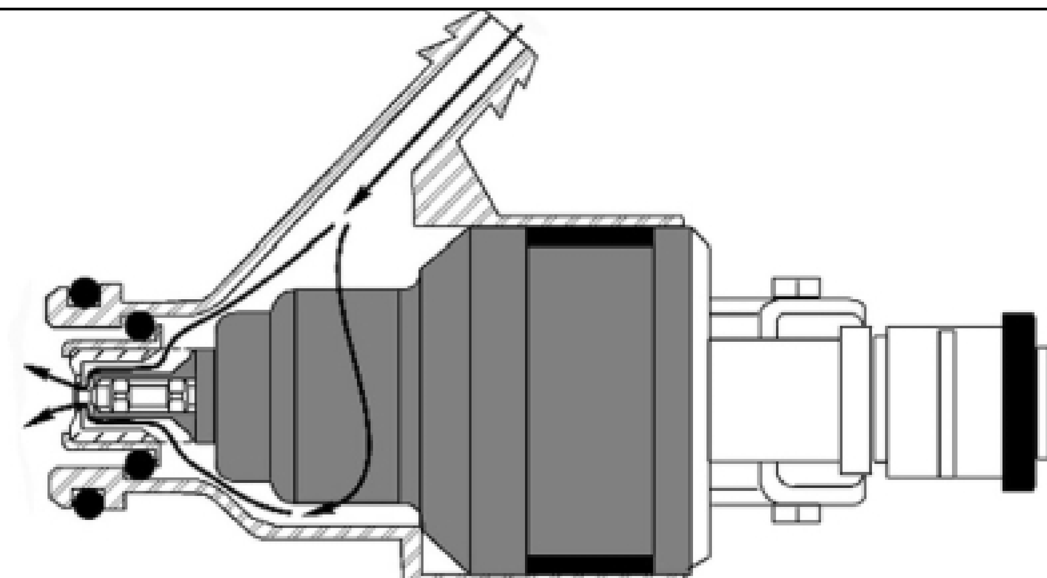
• "CHECK ENGINE" Light	**• Misfire/Rough Idle (Leaking or Blocked)**
• Excessive Tailpipe Smoke (leaking)	**• Long Crank Time (leaking)**
• Engine Hydrolock (leaking)	
• Oxygen Sensor/Mixture/Injector Related Fault Codes	

Air Shroud Injector: To comply with emission regulations, Air Shrouded Injectors have been fitted on the M42 engine since 1994 MY. There is an air gap between the inner and outer body of the fuel injector which allows additional metered air to be drawn in. This air disperses and mixes with the injected fuel which improves fuel atomization as it enters the combustion chamber thus lowering CO/HC emissions.



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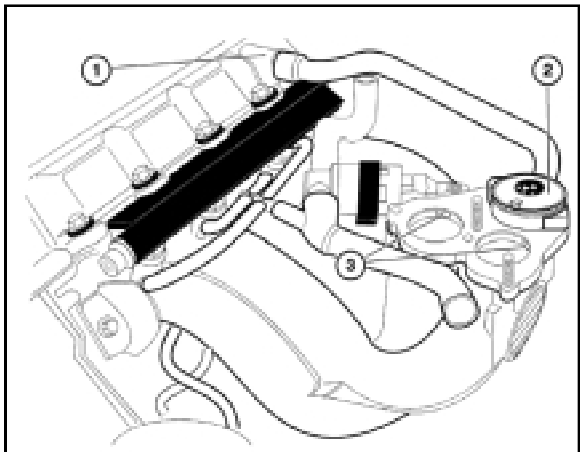
The Air Shrouded Injectors incorporate a hose fitting on the outer injector body which connects each injector via a rubber hose, to the molded Idle Speed Control Valve hose, under the intake manifold.

The metered air is taken from a fitting located in the intake bellows boot in front of the throttle valve (ported vacuum). The system is self regulating with greater air flow at idle and low load engine ranges (intake manifold vacuum drawing air in).



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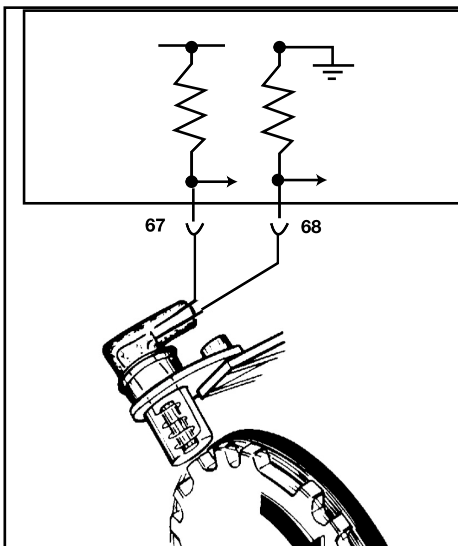
The Air Shrouded supply components are:

1.	**Idle Speed Control Valve**
2.	**Connection to Intake Bellows Boot**
3.	**Connection to Intake Manifold**
4.	**Hoses for Air Shrouded Injectors**

Crankshaft Position/RPM Sensor: This sensor provides the crankshaft position and engine speed (RPM) signal to the ECM for Fuel Pump and Injector operation. This is an inductive pulse type sensor. The ECM provides the power supply to this component.



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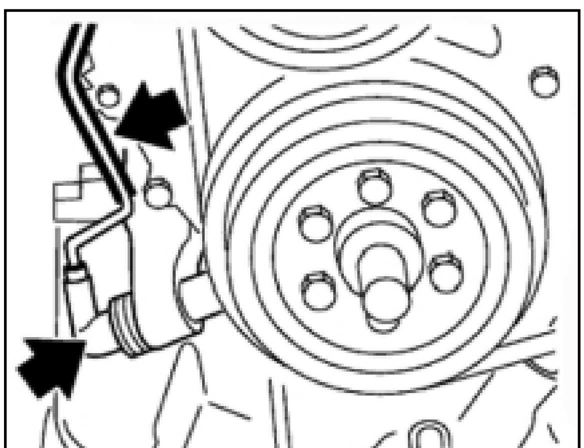
The sensor scans an incremental impulse/gear wheel that has a total of 58 teeth and a gap of two missing teeth. The rotation of the impulse wheel generates an A/C voltage signal in the sensor where-by each tooth of the wheel produces one pulse. The ECM counts the pulses and determines engine rpm.

The gap of two missing teeth provides a reference point that the ECM recognizes as crankshaft position.

The impulse wheel is mounted behind the crankshaft pulley. The Sensor is mounted on the front timing cover (housing).

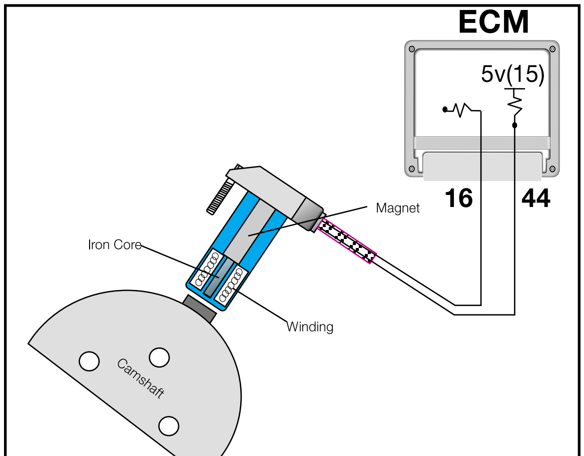

13550021.jpg

A fault with this input will produce the following complaints:

• No Start
• Intermitant Misfire / Driveability
• Engine Stalling

Camshaft Position Sensor (Cylinder Identification): The cylinder ID sensor (inductive pulse) input allows the ECM to determine camshaft position in relation to crankshaft position. It is used by the ECM to establish the firing order for the direct ignition system and the semi-sequential fuel injection timing.

The sensor scans a tooth mounted on the intake camshaft drive gear (mounted in the front of the cylinder head). The ECM provides the power supply for this component and monitors the A/C voltage generated when the tooth passes the sensor tip. This input provides one pulse per revolution of the camshaft.



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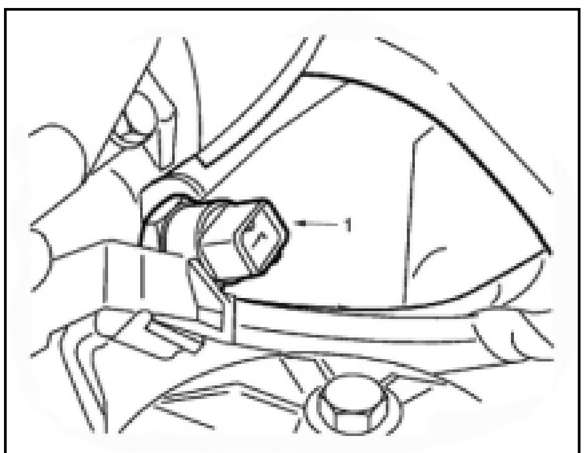
This input is only checked by the ECM during "start up". The camshaft position is referenced to the crankshaft position, and is not monitored until the next engine start up.

If the ECM detects a fault with the Cylinder ID Sensor, the "CHECK ENGINE" Light will be illuminated and the system will still operate based on the Crankshaft Position/RPM Sensor. Upon a restart, a slight change in driveability could occur because the ECM will activate Parallel Fuel Injection, all of the injectors will be activated at the same time.

Engine Coolant Temperature: The Engine Coolant Temperature is provided to the ECM from a Negative Temperature Coefficient (NTC) type sensor. The ECM determines the correct fuel mixture and base ignition timing required for the engine temperature.

The sensor decreases in resistance as the temperature rises and vice versa.



13550022.jpg

The ECM monitors an applied voltage to the sensor (5v). This voltage will vary (0-5v) as coolant temperature changes the resistance value.

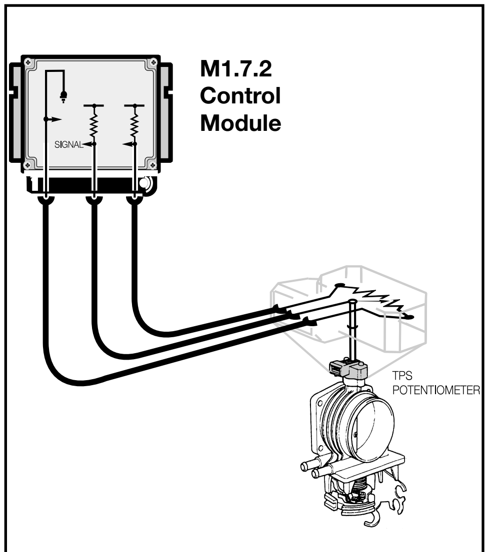
This sensor is located in the coolant jacket of the cylinder head (1).

If the Coolant Temperature Sensor input is faulty, the "CHECK ENGINE" Light will be illuminated and the ECM will assume a substitute value (80º C) to maintain engine operation.

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 and the “CHECK ENGINE” Light will illuminate. The ECM will maintain fuel injection operation based on the Air Flow Volume Sensor and the Crankshaft Position/RPM Sensor.



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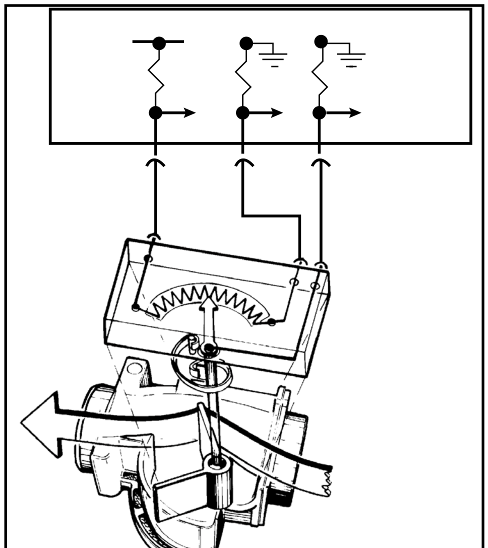
Air Flow Volume Sensor: This potentiometer sends a signal to the ECM representing the measured amount of intake air volume. This input is used by the ECM to determine the amount of fuel to be injected for correct air/fuel ratio. For details about the sensor, refer to the Air Management section.

If this input is defective, a fault code will be set and the “CHECK ENGINE” Light will illuminate. The ECM will maintain fuel injection operation based on the Throttle Position Sensor and Crankshaft Position/RPM Sensor.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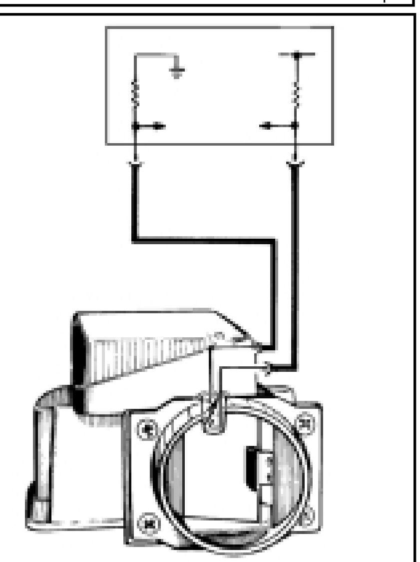
Air Temperature: This signal allows the ECM to make a calculation of air density. The sensor is located in front of the measuring flap. For details about the sensor, refer to the Air Management section.

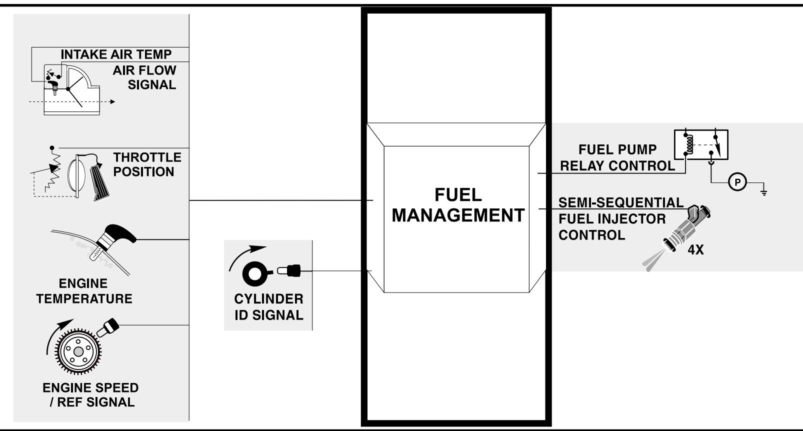
The varying voltage input from the NTC sensor indicates the larger proportion of oxygen found in cold air, as compared to less oxygen found in warmer air. The ECM will adjust the amount of injected fuel because the quality of combustion depends on oxygen sensing ratio.

If this input is defective, a fault code will be set and the “CHECK ENGINE” Light will illuminate.


13550001.jpg

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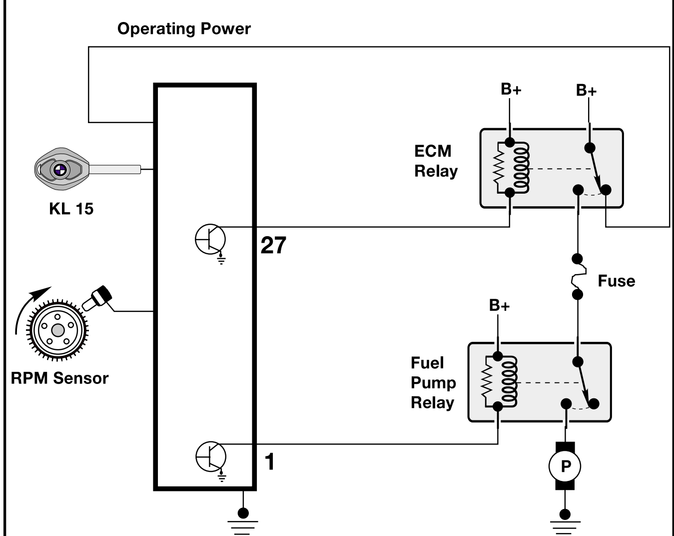
The Fuel Pump will be activated when the igniton (KL15) is switched "on" and the ECM supplies a ground circuit to activate the Fuel Pump Relay. The Fuel Pump Relay supplies operating power to the in-tank mounted fuel pump. This is a momentary activation to "pressurize" (prime) the fuel system.

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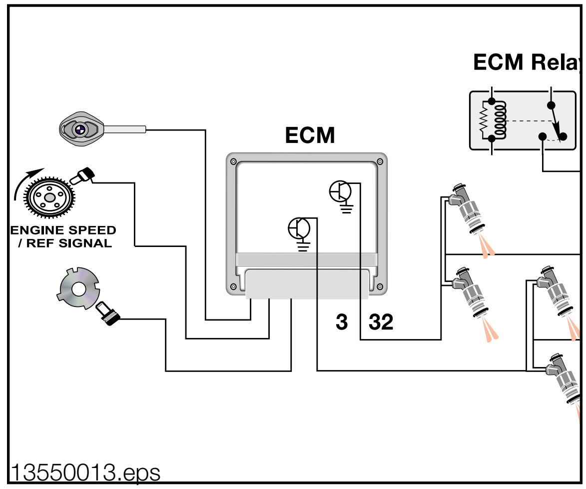
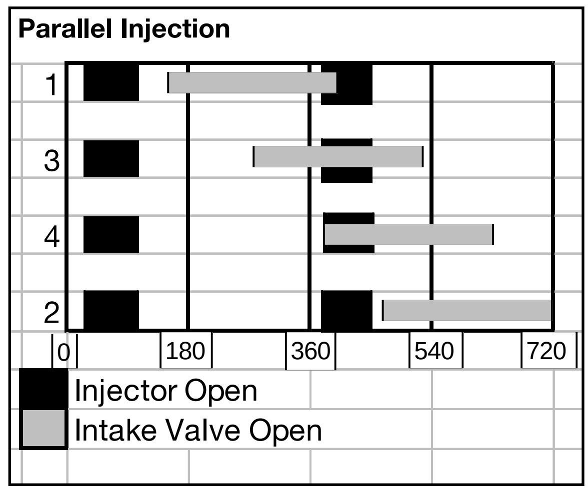
The Fuel Injectors will be opened by the ECM to inject pressurized fuel into the intake ports. The Fuel Injectors receive voltage from the Engine Control Module Relay. The ECM controls the opening by activating the ground circuit for the Solenoid Windings. The ECM will vary the duration (in milli-seconds)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

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

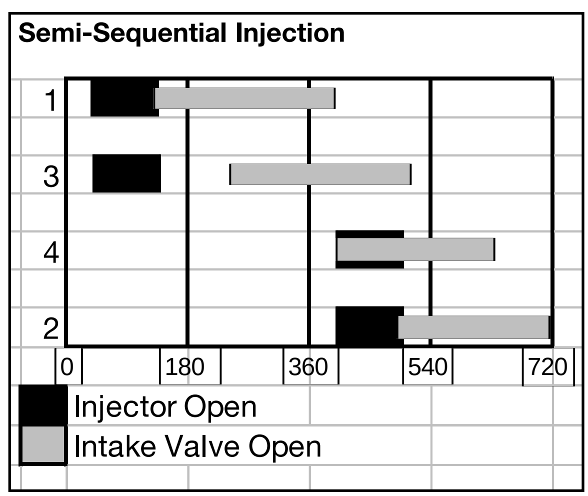
The ECM is programmed to activate the Final Stage output transistors once for every revolution of the crankshaft (Parallel Injection). The ECM calculates the total milli-second time to open the injectors and cuts that value in half.



The injectors are all opened at the same time (in parallel) for every complete crankshaft revolution. This delivers half of the fuel charge at each injection so that the engine receives the full fuel charge during a complete working cycle. This process enhances fuel atomization during start up.



During start up, the ECM recognizes the Camshaft Position (Cylinder ID) input. It then switches the injection to Semi-Sequential. This process "times" the injection closer to the intake valve opening for increased efficiency.

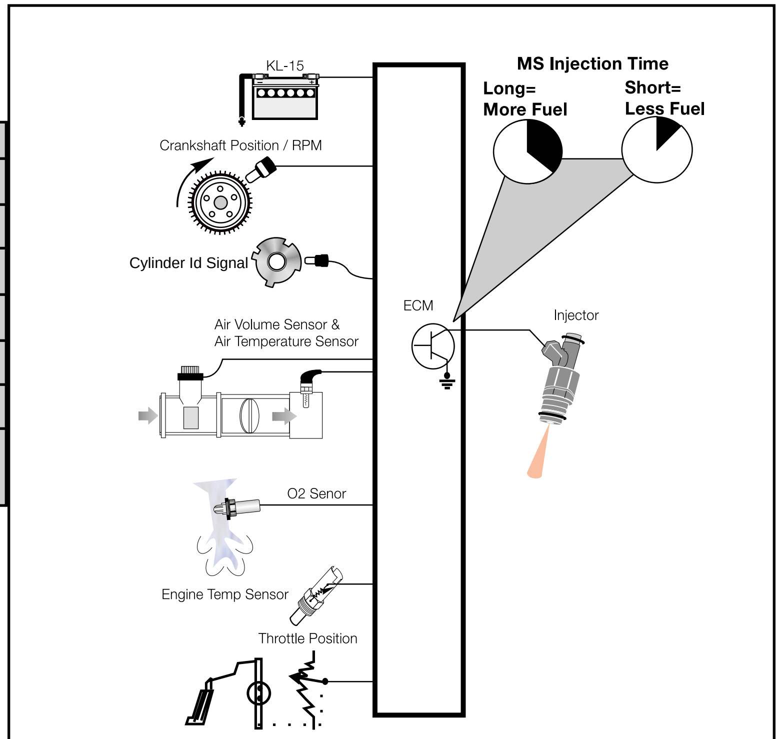


When activated, each group (grouped in pairs) delivers the full fuel charge at separate times for each engine working cycle.

The Camshaft Position input is only checked by the ECM during start up. The camshaft position is referenced to the crankshaft position, and is not monitored until the next engine start up. Therefore, if this input is lost when the engine is already running, there will be no effect. There will only be an effect if this input is missing when the engine is started. For this condition, the ECM will continue operating the injectors in Parallel.

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 "load" based on a combination of the following inputs:

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



13550014.eps

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 Parallel) 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 Semi-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.

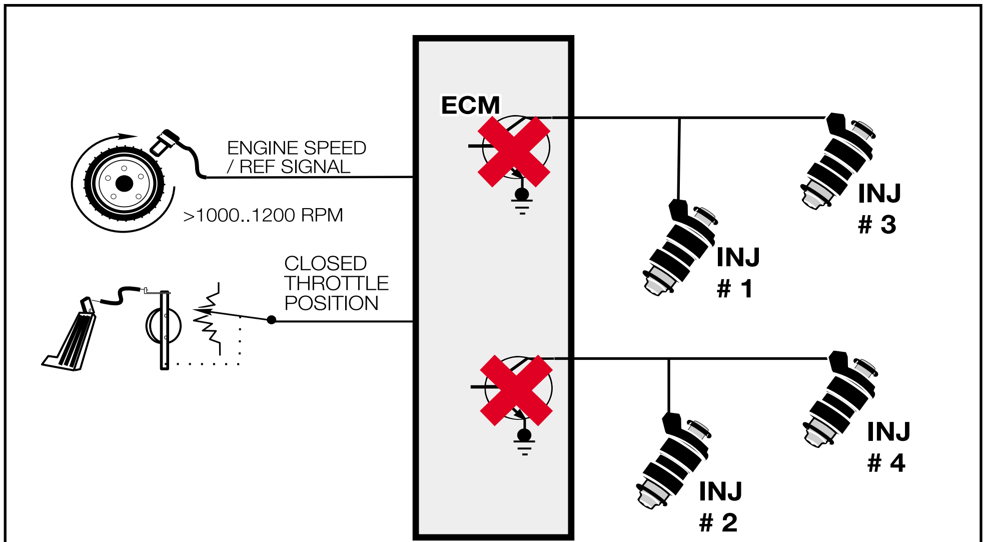
The Air Flow Volume signal provides the measured amount of intake air volume. This input is used by the ECM to determine the amount of fuel to be injected to “balance” the air/fuel ratio.

The Air Temperature Signal allows the ECM to make a 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 ms value (half= Parallel Injection or full= Semi-Sequential Injection) and the timing when it is injected to the engine. To accomplish this, the ECM contains two Final Stage output transistors that activate the injectors in two groups. The engine operates sufficiently on Parallel Injection, but more efficiently on Semi-Sequential Injection. If one of the circuits faulted, the engine can still operate on limited power from the remaining circuit.

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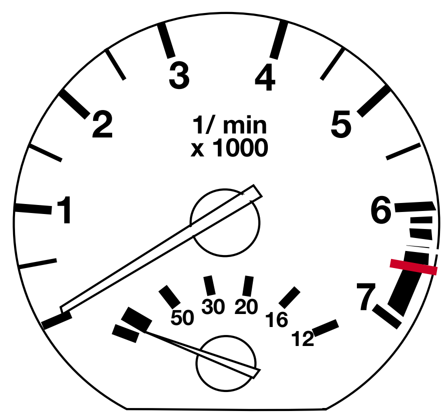
As the throttle is closed during deceleration, the ECM decreases the injection ms value (fuel shut off) if the rpm is above idle speed (coasting). This feature decreases fuel consumption and lowers emissions.

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) gage.



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The ECM will deactivate the injectors to control maximum engine rpm (regardless of vehicle speed). When the engine speed reaches 6500 rpm, the injectors will be deactvated to protect the engine from over-rev. As the engine speed drops below 6500 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).**

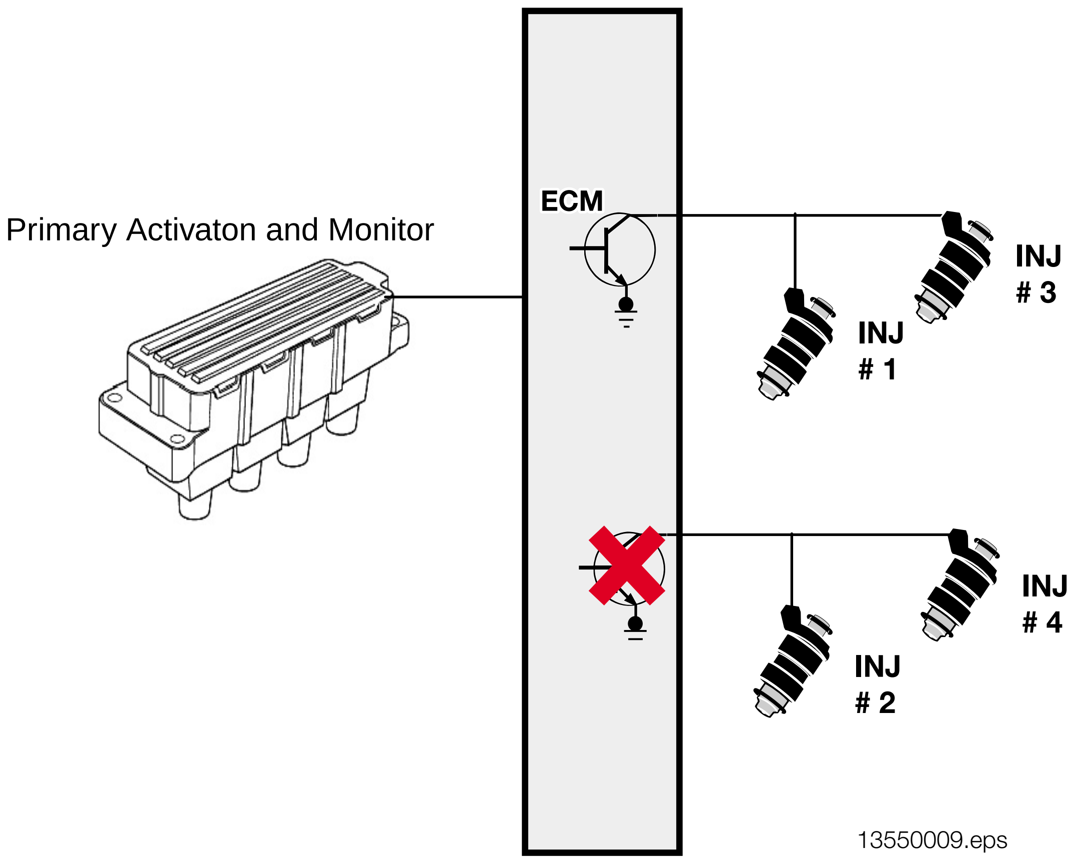
Maximum vehicle speed is limited by the ECM reducing the injection ms value (regardless of engine rpm). This limitation is based on the vehicle dimensions, specifications and installed tires (speed rating).

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

If the ECM detects a fault in the primary ignition system, it can selectively deactivate the Final Stage output transistor for that cylinder.

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

On the M1.7.2 system, there are two injectors per circuit resulting in deactivation of both. This will limit engine power, but protect the Catalytic Converter.



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 protective 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 system 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.

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:

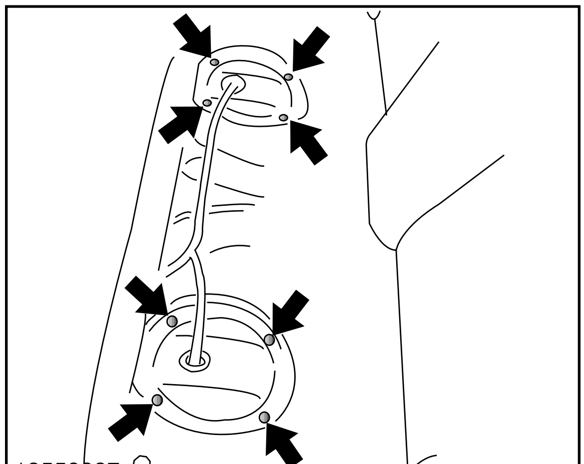
• Engine Compartment Return Fuel Hose S.I. #13 03 92 (3589)
• Feed Fuel Hose Recall Campaign S.I. #13 04 92 (3657)
• Refueling S.I. #16 01 92 (3553)
• Fuel System Modifications S.I. #16 01 81

Fuel Pump and Sending Unit Access

All BMW vehicles have access plates to service the fuel pump and sending units without removing the fuel tank.

The access plates are located under the rear seat.

The "saddle" type fuel tank (under rear seat) has two access plates.



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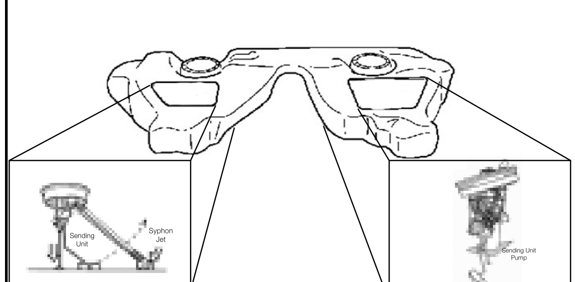
The passenger side allows access to the fuel pump/sending unit.

The driver side allows access to the sending unit.



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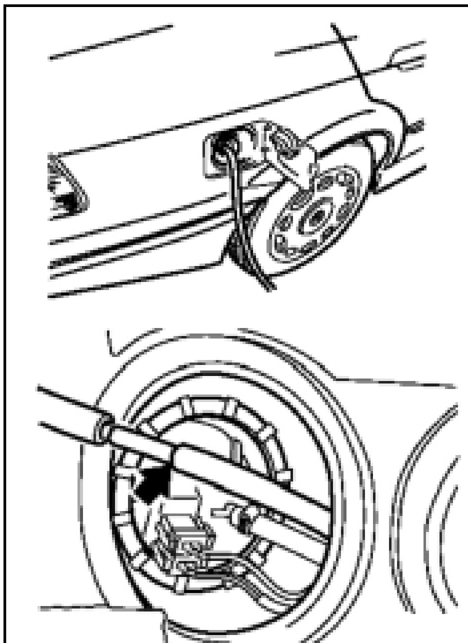
Draining the Fuel Tank

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.



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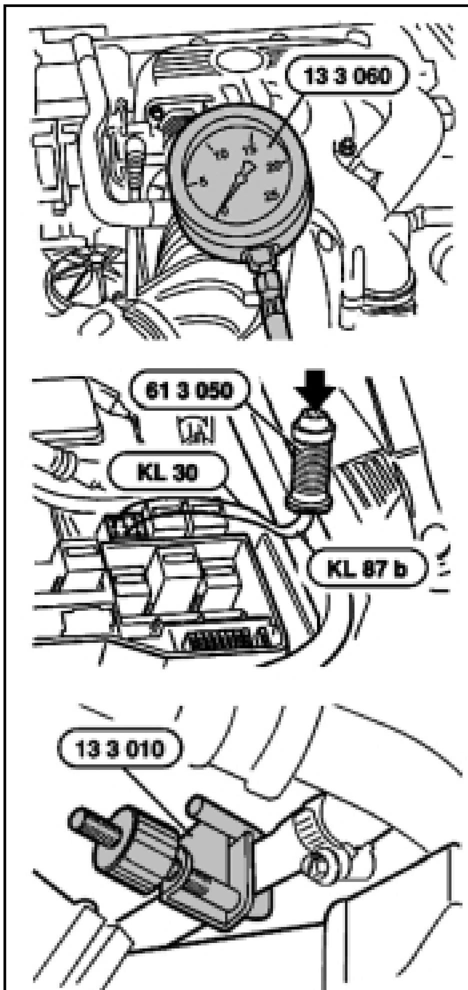
Fuel Pump/Pressure Regulator - Testing

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 (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 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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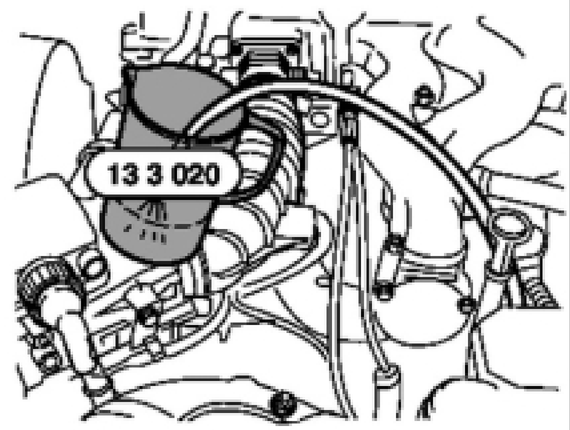
Fuel volume must be tested to verify:

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



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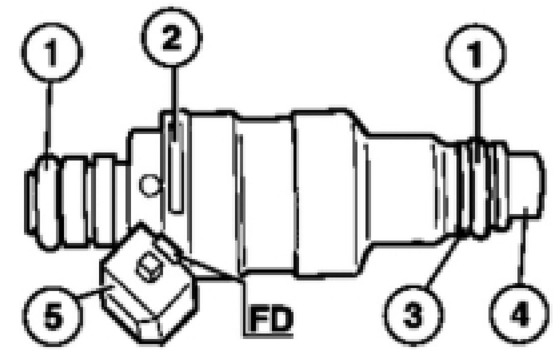
Fuel Injectors

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 hosing**
• **Color code injector housing**



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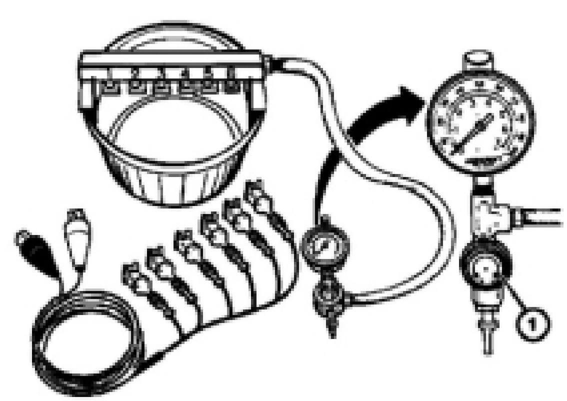
Fuel injectors can leak which bleeds off fuel pressure and increases emissions. The injectors can be tested using the Fuel Injector Leakage Tester.

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



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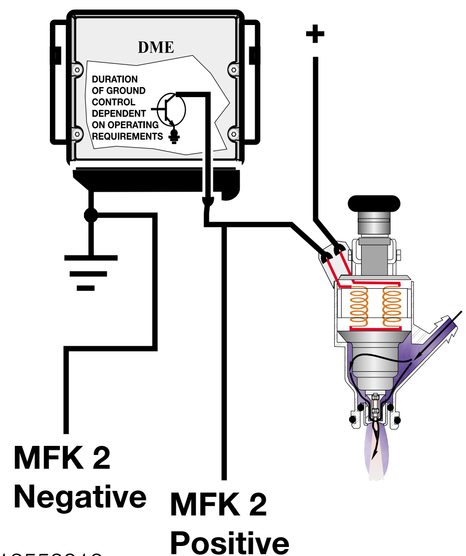
The Fuel Injectors should also be tested using the DIS/MoDIC for:

• **Resistance (15 - 17 ohms)**
• **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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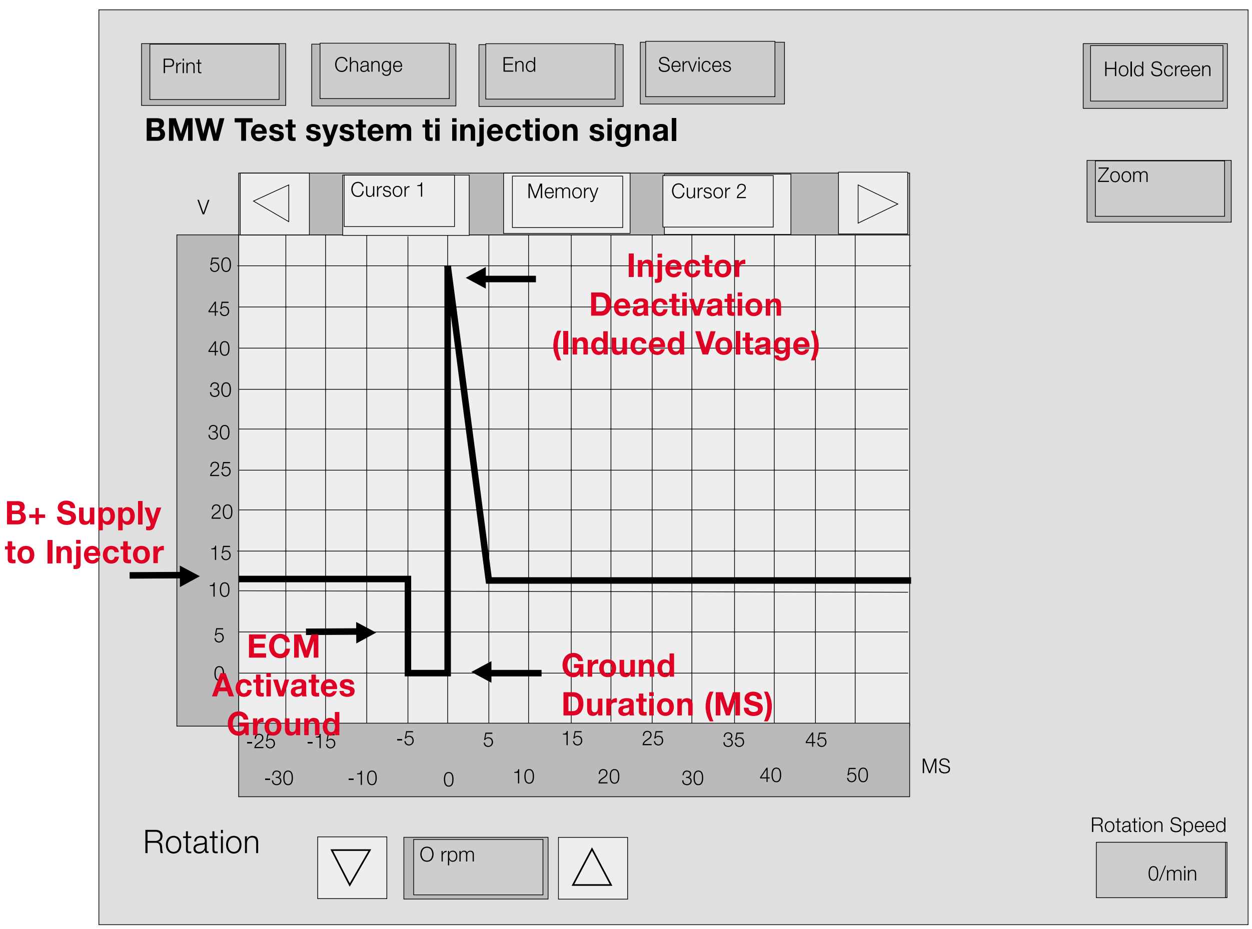

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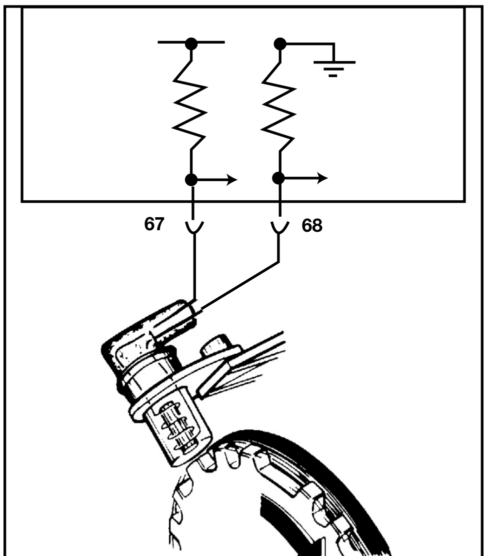
Crankshaft Position/RPM Sensor

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

• Resistance (540 ohms +/- 10%)	• Power Supply	• AC Voltage	• Status Display
• Oscilloscope Display found under Preset list - "Rotation Speed Sensor Signal"			



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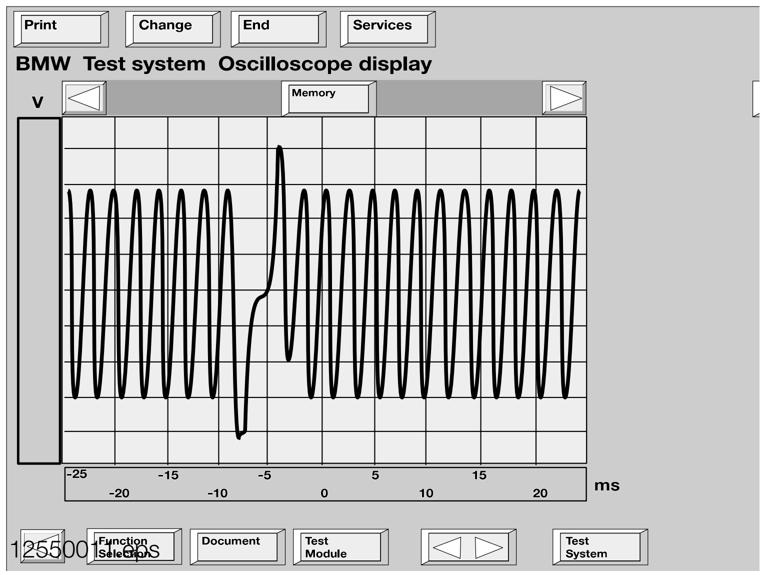

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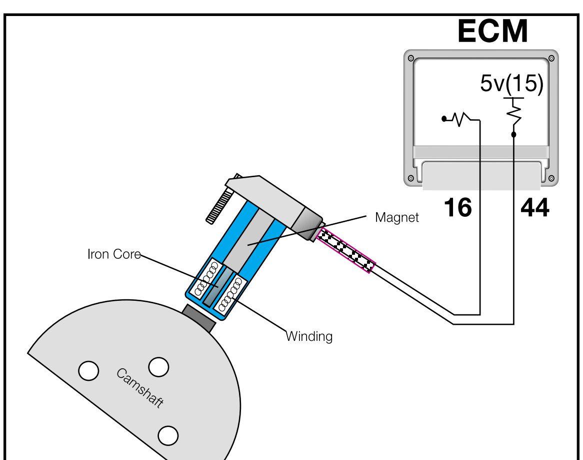
Camshaft Position Sensor (Cylinder ID)

This sensor should be tested using the DIS / MoDic for

• Resistance (0.1 - 1 ohm)	• Power Supply	• AC Voltage	• Status Display - "ON"
• Oscilloscope Display found under Preset list - "Rotation Speed Sensor Signal"			



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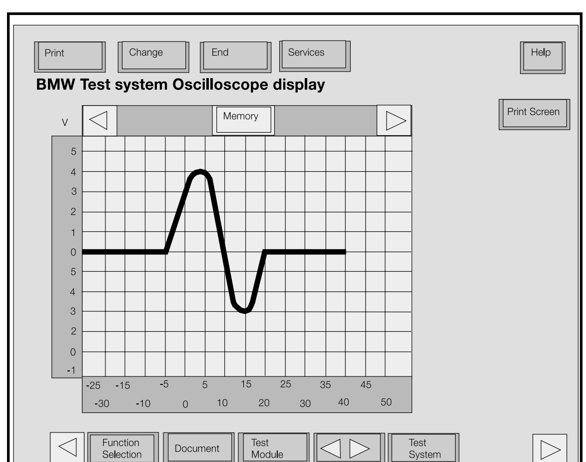

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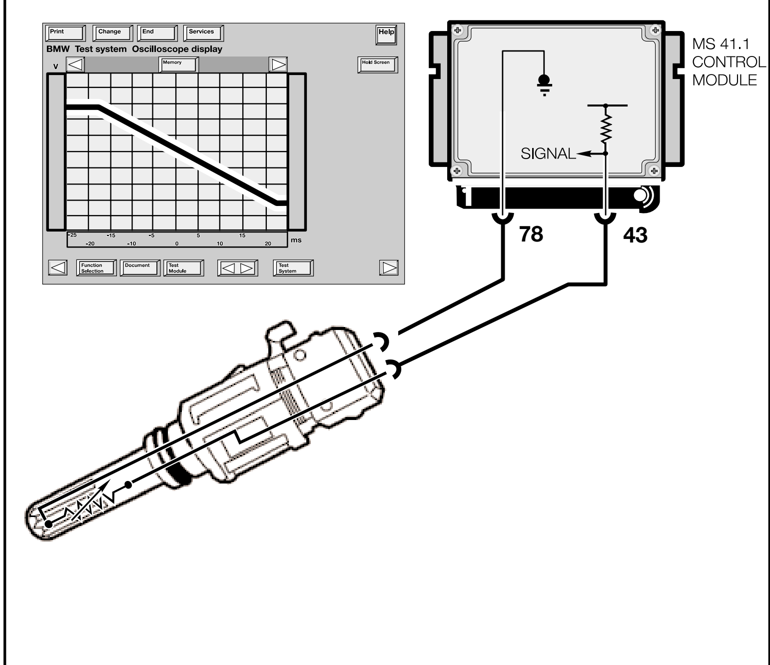
Engine Coolant Temperature

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)



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The Sensor should be tested using:

• DIS/Modic Status page degrees C (dependent on engine temperature).
• DIS/Modic Multimeter 20º C 2.2 - 2.7 K ohms 80º C 0.3 - 0.36 K ohms

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 M1.7.2 application should be used (#88 88 6 614 410). This will ensure the pin connectors and the harness will not be damaged.

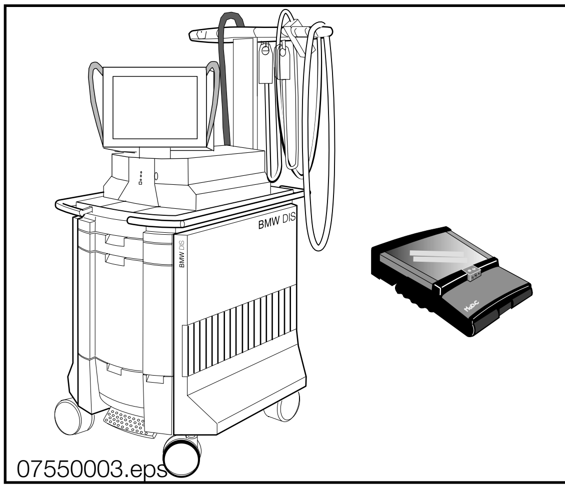
The interior of this Universal Adapter is shielded, therefore it is vital that the ground cable is connected to the vehicle chassis whenever the adapter is used.

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.

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.



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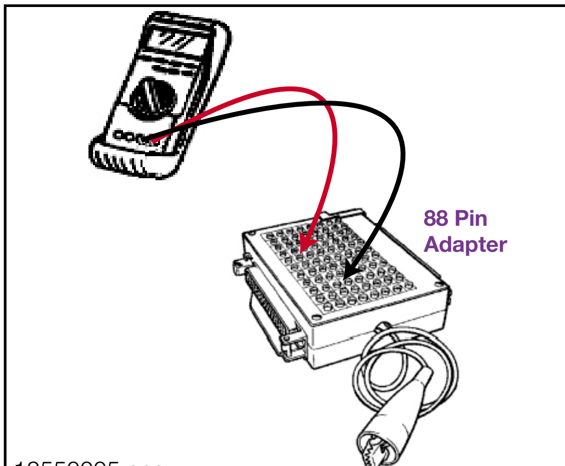

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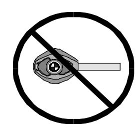

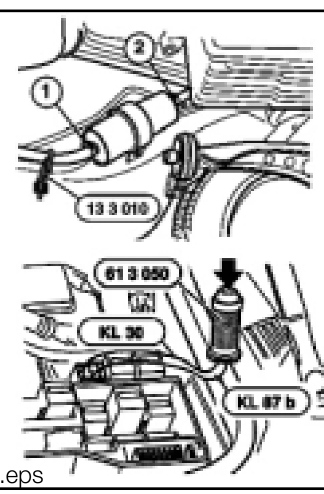

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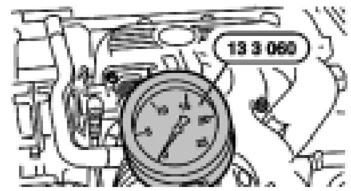
When testing fuel pressure, the hand held fuel pressure gage (#13 3 060) can be used.

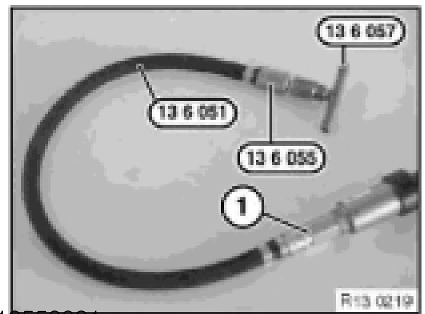
Caution: Residual fuel pressure may be present!



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.



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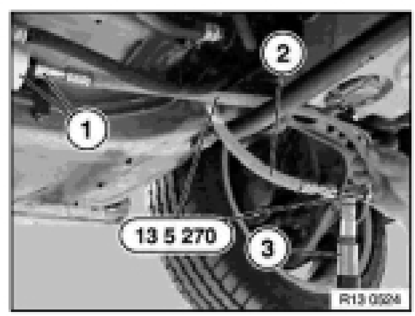
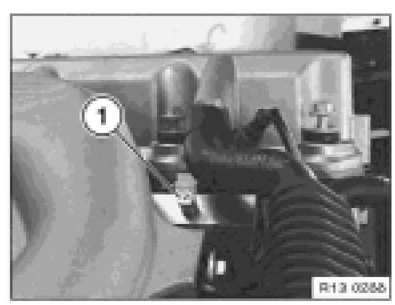
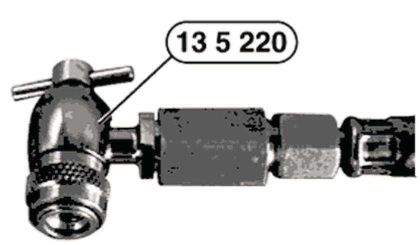
For vehicles equipped with “quick-release” couplings, install special tool (#13 5 270) between the fuel filter (1) and pressure supply hose (2). This tool will couple to the DIS Pressure Adapter (3).



Later 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.



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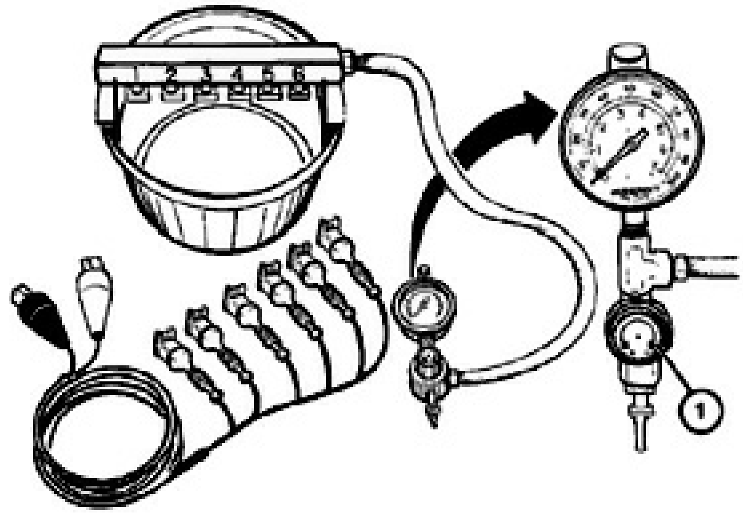
When testing the fuel injectors for leakage, use Special Tool #88 88 5 000 362. Leak testing the fuel injectors is one of the diagnostic steps listed in “Long Cranking Times” S.I. #13 08 90 (3096). This tool pressurizes the injectors with air and the injector tips are submersed in water. If air bubles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



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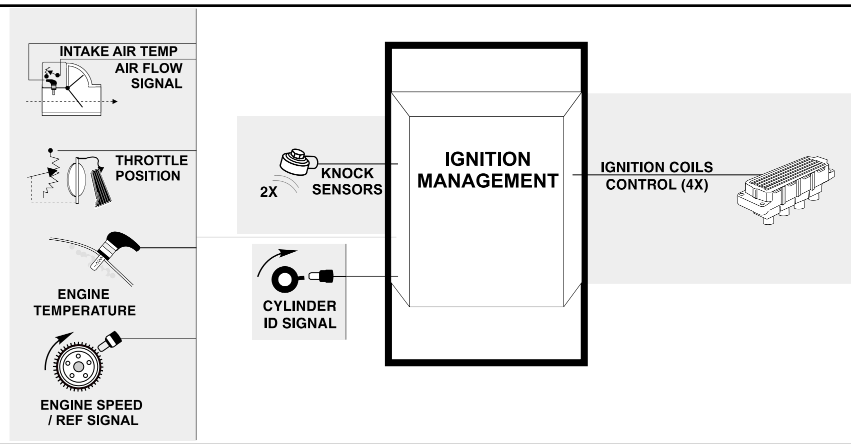
Ignition Management



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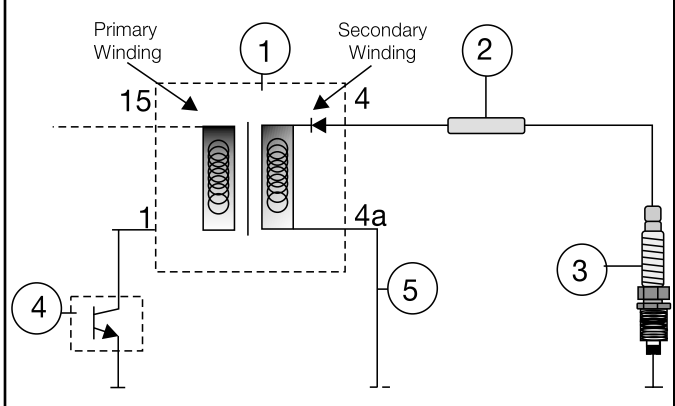
Ignition Coils: The high voltage supply required to ignite the mixture in the combustion chambers is determined by the stored energy in the ignition coils. The stored energy contributes to the ignition duration, ignition current and rate of high voltage increase. The Coil circuit including primary and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

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



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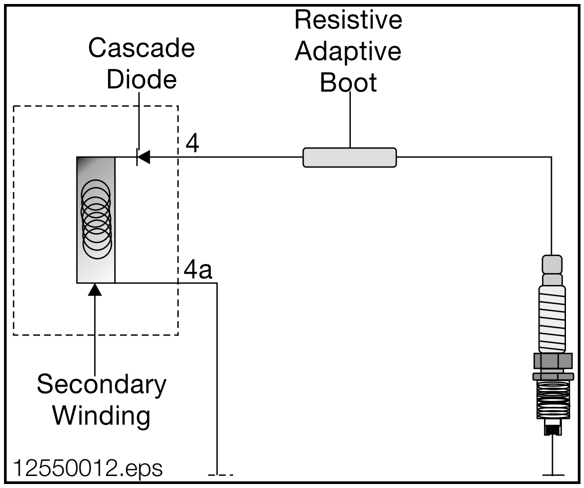
The Coil Assembly contains two copper windings insulated from each other. One winding is the primary winding, formed by a few turns of thick wire. The secondary winding is formed by a great many turns of thin wire.

The primary winding receives battery voltage from the ignition switch (Terminal 15). 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 30,000 volts (30 KV). The high voltage is discharged (Terminal 4) through the secondary ignition cable and resistor (boot connector) to the spark plug.



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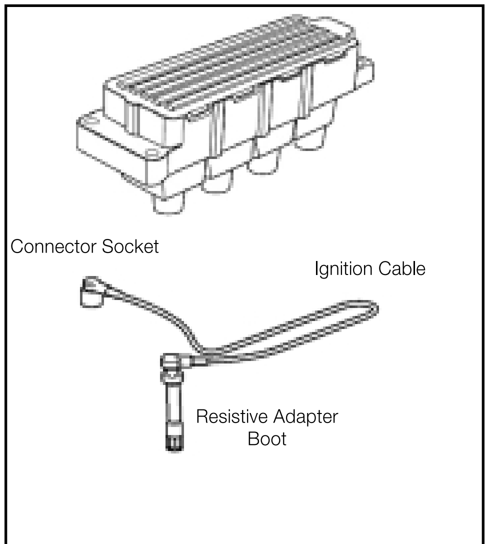
The primary and secondary windings are uncoupled, therefore, the secondary winding requies a ground supply (Terminal 4a).

The secondary winding connects to a cascade diode which suppresses any unwanted induced voltages as the primary circuit is switched on and off. This permits a clean, high voltage discharge from the secondary winding.

There is an individual ignition circuit and coil for each cylinder on the M1.7.2 system

The four ignition coils are combined into a single component (coil pack) located on the right front strut tower.



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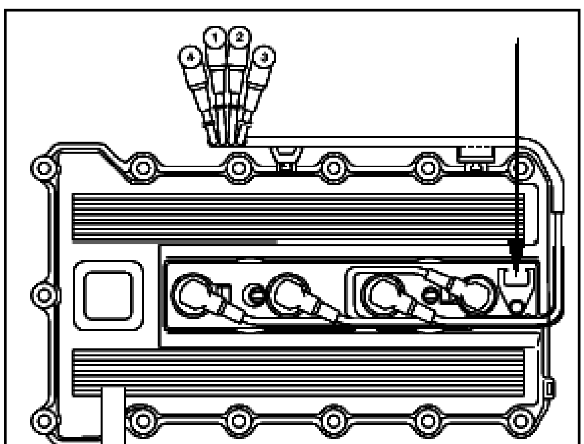
The ignition primary circuits are fault monitored by the ECM. If a fault is present, the “CHECK ENGINE” Light will illuminate and the ECM will deactivate the corresponding fuel injector for that cylinder and engine operation will still be possible.

Ignition Leads: The secondary ignition cables (high tension leads) direct the high voltage from the ignition coils to the spark plugs. The ignition lead assembly consists of:

• Connector Socket
• Ignition Cable
• Resistive Adaptive Boot

The ignition cables are routed into a covered cable tray located on the top of the cylinder head, which contains the boot connector removal tool (arrow).



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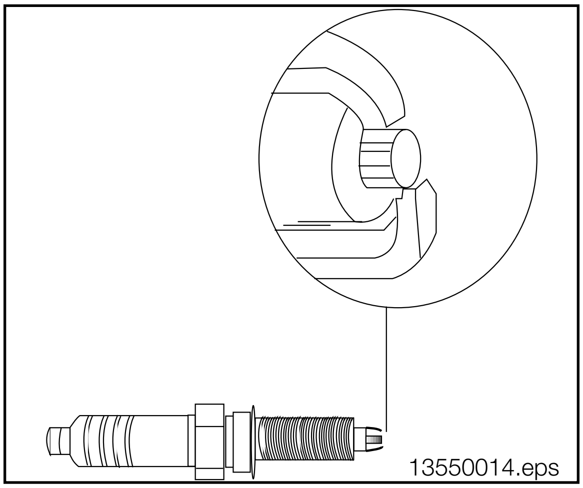
Spark Plugs: The spark plugs introduce the ignition energy into the combustion chamber. The high voltage "arcs" across the air gap in the spark plug from the positive electrode to the negative electrode. This creates a spark which ignites the combustable air/fuel mixture.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The 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 (as seen above right) for this system are:

• Bosch F7LDCR (dual electrode, non-adjustable gap)
• NGK BKR7EK (dual electrode, non-adjustable gap)

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

Faults with the Ignition Output Components are not monitored by the ECM, with the exception of the primary ignition circuit. If there are faults with the igniton coil(s) output, ignition leads 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

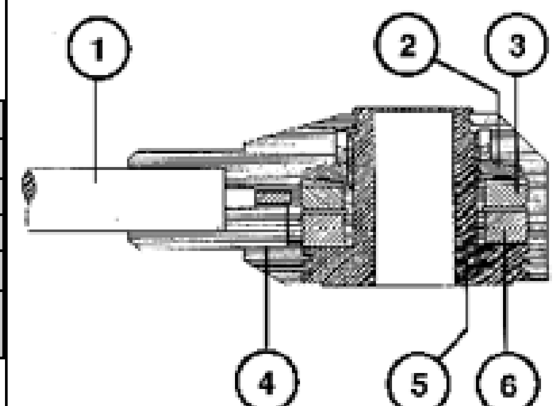
The Ignition Output Components must be individually tested (see Workshop Hints)

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

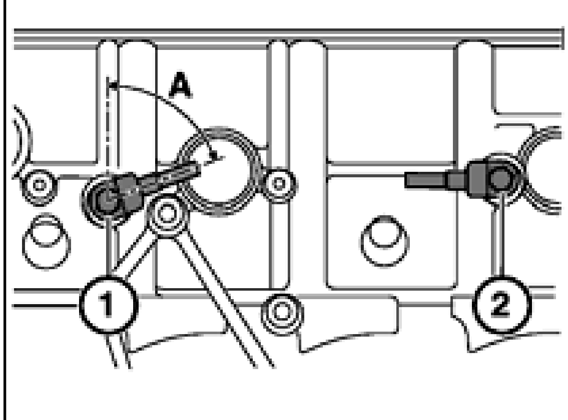


13550005.bmp

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.

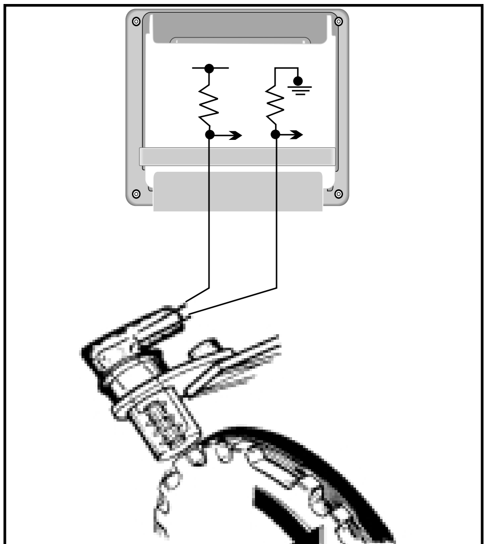
There are two Knock Sensors bolted to the engine block (1) between cylinders 1 & 2 and (2) between cylinders 3 & 4. If the signal value exceeds the threshold, the ECM identifies the "knock" and retards the ignition timing for that cylinder.

If a fault is detected with the sensors, the ECM deactivates Knock Control. The "CHECK ENGINE" Light will be illuminated, the ignition timing will be set to a conservative basic setting and a fault will be stored.



13550001.bmp

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

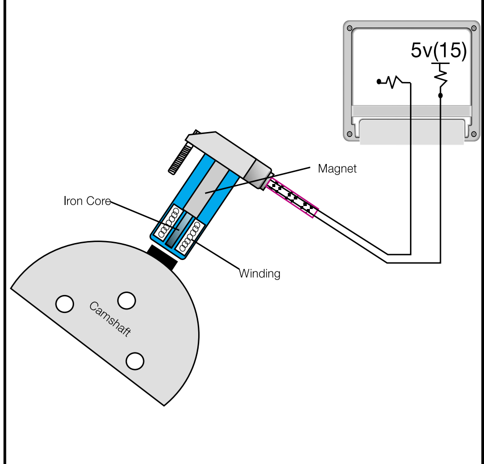


13550027.eps

A fault with this input will produce the following complaints:

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

Camshaft Position Sensor (Cylinder Identification): The cylinder ID sensor (inductive pulse) 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.

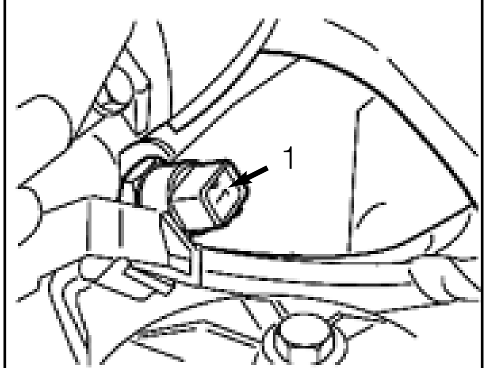


13550028.eps

If the ECM detects a fault with the Cylinder ID Sensor, the "CHECK ENGINE" Light will be illuminated and the system will still operate based on the Crankshaft Position/RPM Sensor.

Upon a restart, a slight change in driveability could occur because the ECM will activate **"double ignition"**. The ignition coils will be activated on both the compression and exhaust strokes to maintain engine operation.

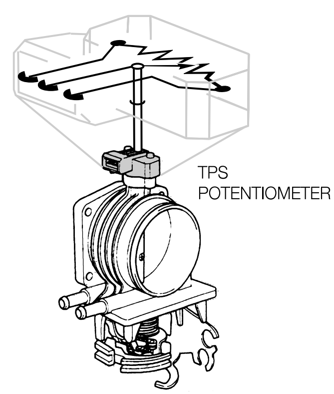
Engine Coolant Temperature: The ECM determines the correct ignition timing required for the engine temperature. For details about the sensor, refer to the Fuel Management section. This sensor is located in the coolant jacket of the cylinder head (1).



13550002.bmp

If the Coolant Temperature Sensor input is faulty, the “CHECK ENGINE” Light will be illuminated 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. For details about the sensor, refer to the Air Management section.

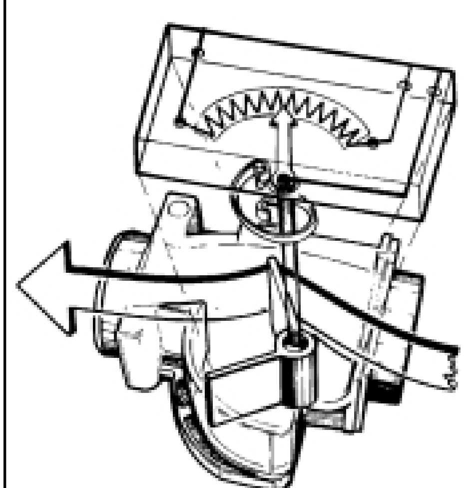


13550013.eps

As the throttle plate is opened, this requests acceleration and at what rate. 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.

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

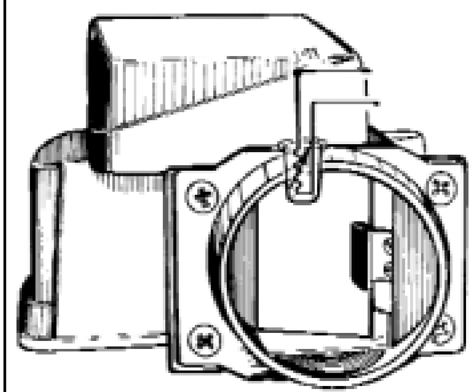
Air Flow Volume Sensor: This signal to the ECM represents the measured amount of intake air volume. This input is used by the ECM to determine the amount of ignition timing advance. For details about the sensor, refer to the Air Management section.



13550004.bmp

If this input is defective, a fault code will be set and the “Check Engine” Light will illuminate. 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 front of the measuring flap. For details about the sensor, refer to the Air Management section.



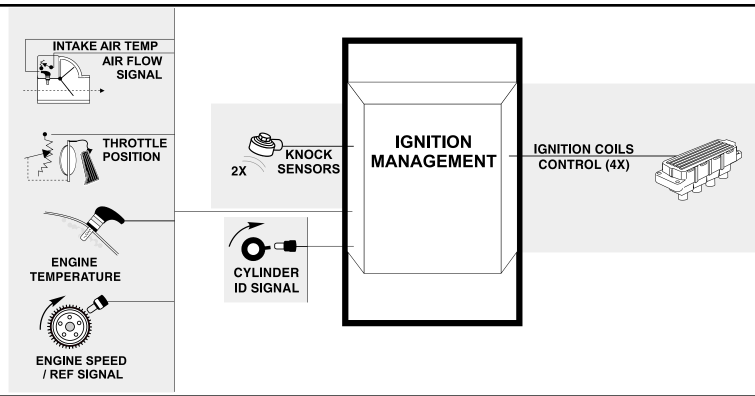
13550033.jpg

The ECM will adjust the ignition timing based on air temperature. If the intake air is hot the ECM retards the ignition 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. 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 circuit.** The ECM does not directly monitor secondary ignition output, although it does control and monitor the primary ignition circuit.



12550015.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”. 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**	

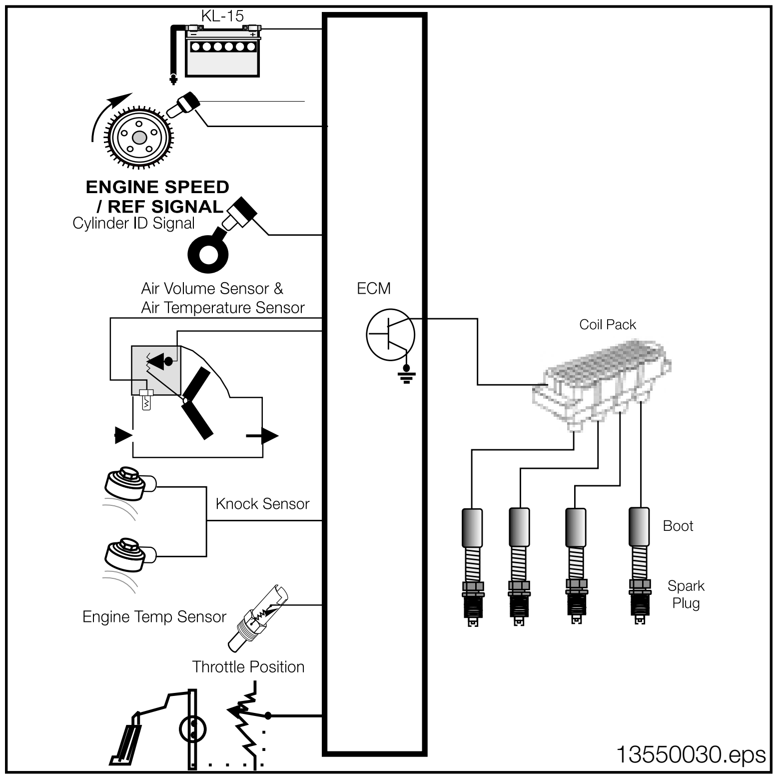
The dwell time will be regulated based on battery voltage. When cranking, the voltage is low and the ECM will increase the dwell to compensate for saturation “lag time”. When the engine is running and the battery voltage is higher, the ECM will decrease the dwell due to faster saturation time.

The Crankshaft Position/RPM signals the ECM to start ignition in firing order (1-3-4-2) 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".

During cranking, the ECM recognizes the Camshaft Position (compression stroke) and activates a single ignition per cylinder.



If this signal is not recognized, the ECM will activate **"Double Ignition"**. The ignition coils will be activated on both the compression and exhaust strokes to maintain engine operation. The ignition timing will be progressively ad-vanced asisting 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.

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 Air Flow Volume signal provides the measured 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

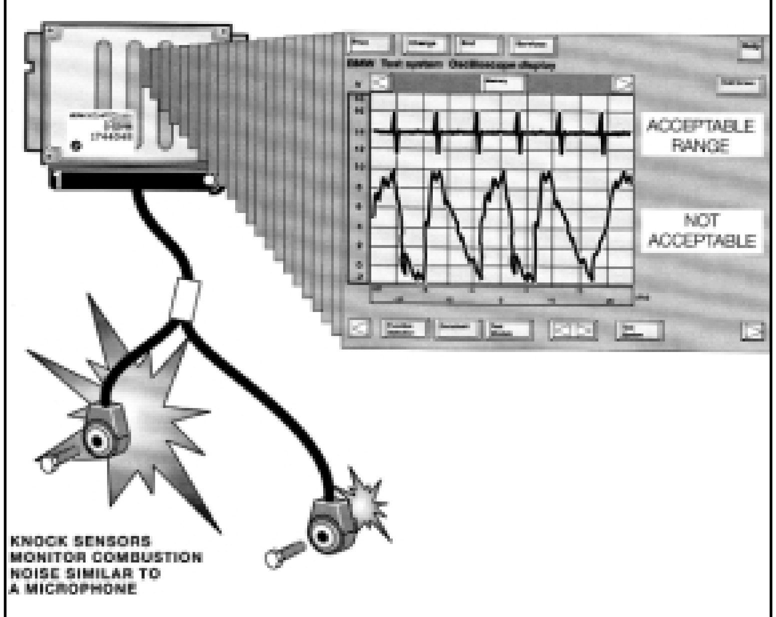
The use of Knock Control allows the ECM to further advance the ignition timing under load for increased torque. This system uses two Knock Sensors located between cylinders 1 & 2 and between cylinders 3 & 4.

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 right up to 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 "CHECK ENGINE" Light will be illuminated, the ignition timing will be set to a conservative basic setting (to reduce the risk of detonation) and a fault will be stored.

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)

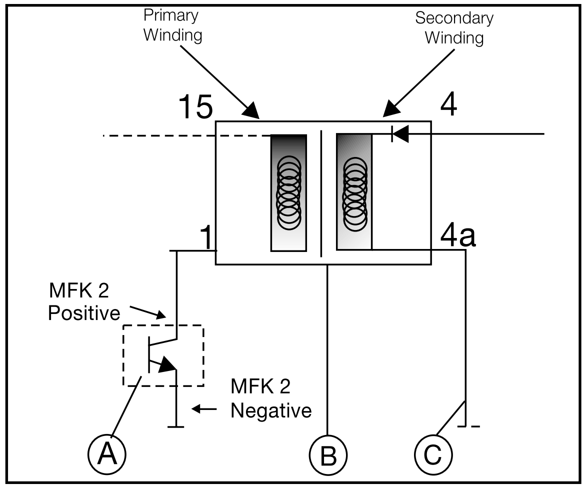
Ignition System Diagnosis

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

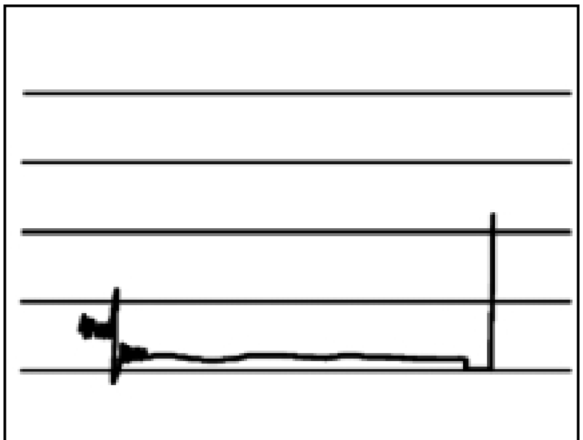
• ECM Primary Circuit Final Stage Transistor
• ECM Ignition Coil (one of four)
• Secondary Coil Ground



13550034.eps

• 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.bmp

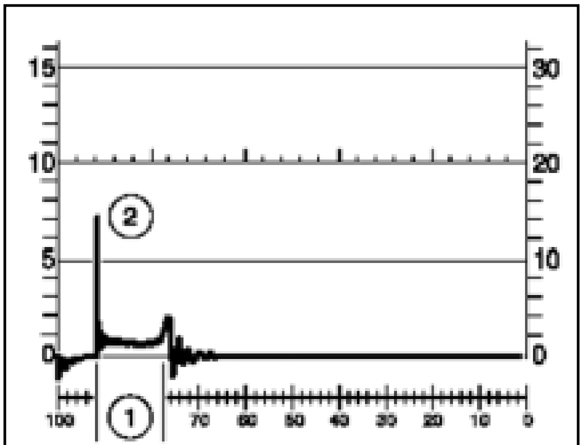
If there is a fault in the secondary ignition, testing should include:

• Primary Ignition	• Evaluation of Secondary Oscilloscope Patterns

The Following are Examples of Secondary Oscilloscope Patterns:

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

1. Normal Combustion Period
2. Normal Ignition Voltage Peak



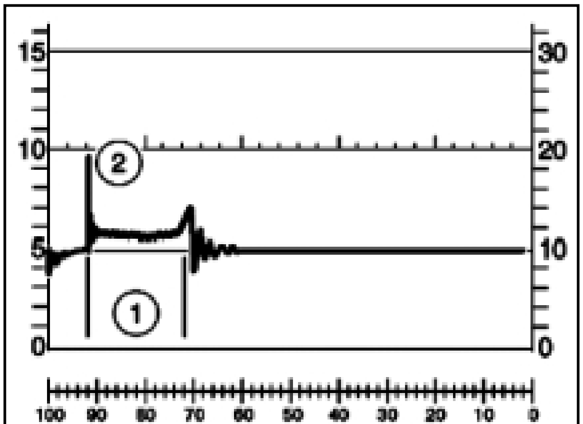
07550001.bmp

Long Spark Period (1) with Low Ignition Voltage Peak (2)

• Indicates Low Compression

If Spark Period is Fluctuating:

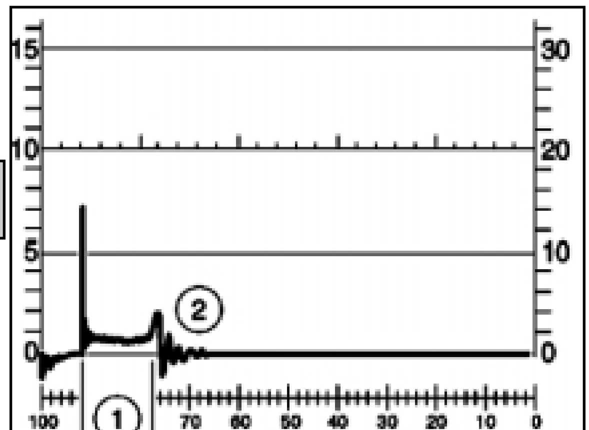
• Contamination on Spark Plug or Defective Spark Plug



07550002.bmp

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

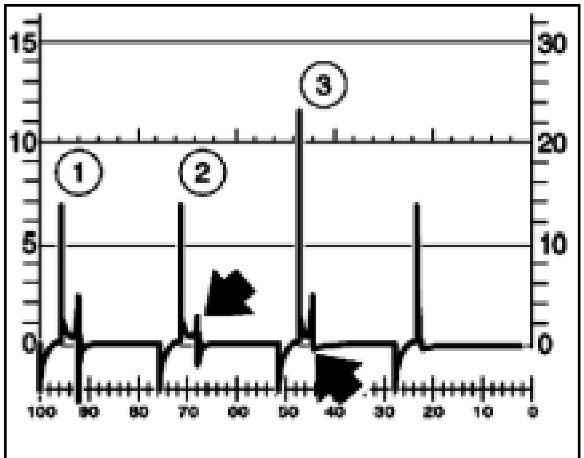
• Defective Ignition Cable, Connector, or Resistive Adapter Boot



07550003.bmp

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

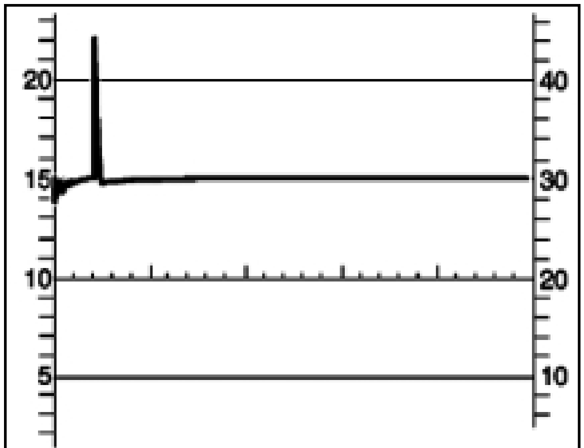
• Normal Attenuation (Voltage Reduction) Process
• Shorten Attenuation Process-Defective Ignition Coil
• Abscence of Attenuation - Defective Ignition Coil



07550004.bmp

No Sparking Voltage Line (Single Cylinder Displayed)

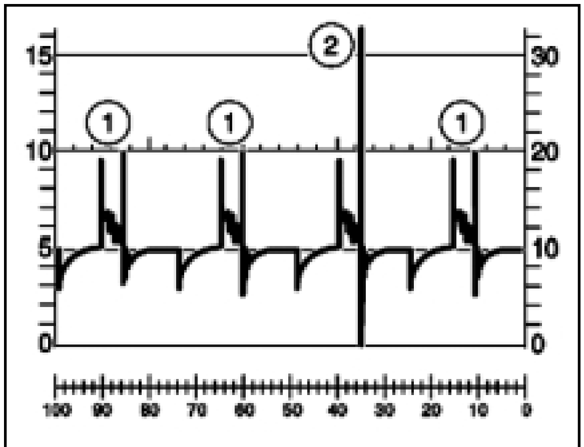
• Defective Ignition Coil



07550005.bmp

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

• Decaying Process is not much Higher than Ignition Voltage Peak - System is Ok.
• Decaying Process is considerably Higher than Ignition Voltage Peak:
• 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 Cable, Connector, or Resistive Adapter Boot

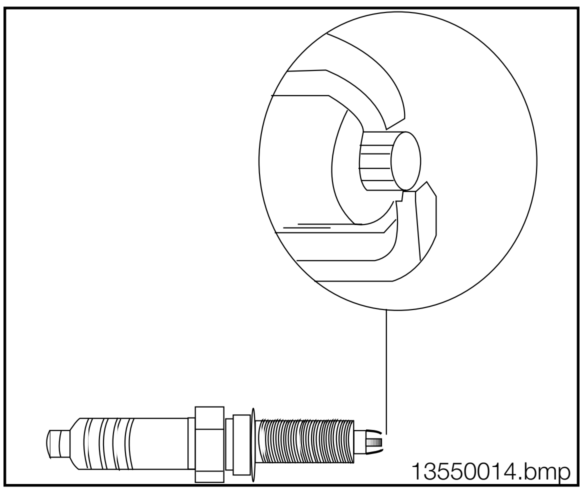
If the Secondary Ignition **Voltage is Too Low (Low Resistance for Ignition):**

• Spark Plug Gap is Too Small (Mishandled on Installation)
• Incorrect Heat Range Spark Plug
• Compression is Too Low
• Voltage Leak in the Secondary Ignition Cable, 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.)

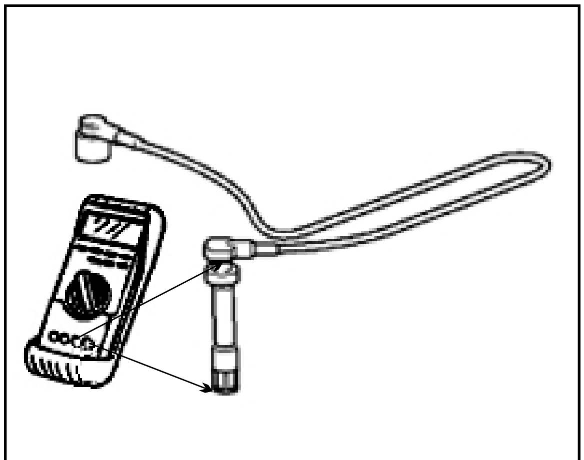

13550014.bmp

Ignition Leads

The secondary ignition cable (high tension lead) assembly includes the Connector Socket, Ignition Cable and Resistive Adapter Boot. These components 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%

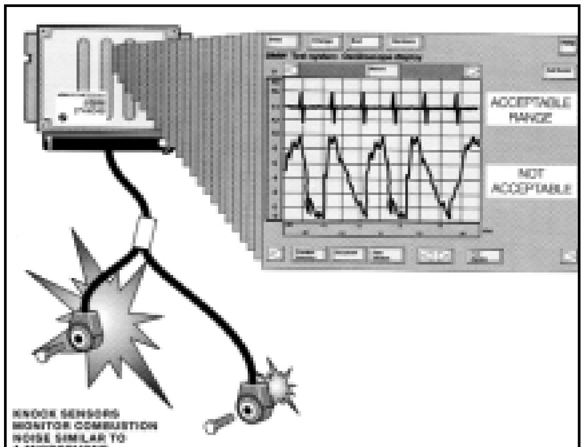


13550035.eps

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)



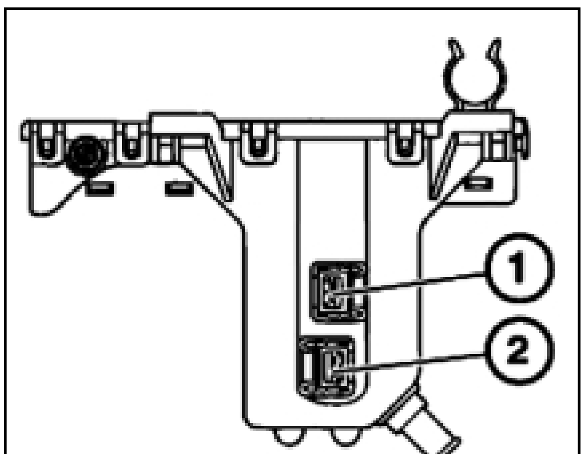
13550010.jpg

When installing Knock Sensors:

DO NOT MIX THE CONNECTORS: Engine Damage will result! - the connector is critical to sensor location (1) cylinder 1 & 2 and (2) cylinder 3 & 4.

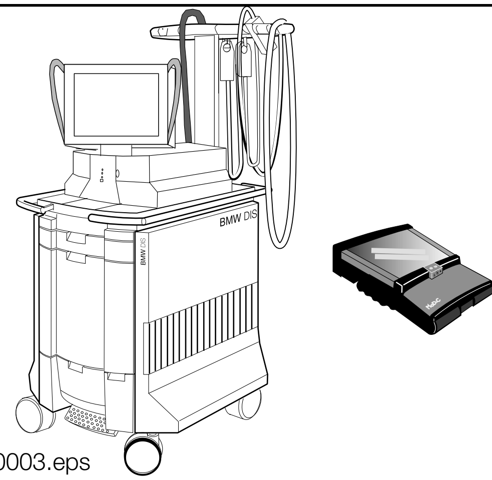
Do Not Over Tighten attaching bolt! - Piezo ceramic will be cracked. Torque to 20 nm.

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



13550015.bmp

Tools and Equipment

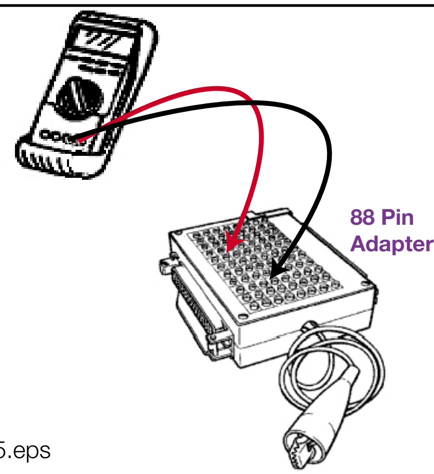


07550003.eps

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 M1.7.2 application should be used (#88 88 6 614 410). This will ensure the pin connectors and the harness will not be damaged.

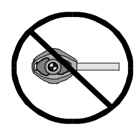


12550005.eps

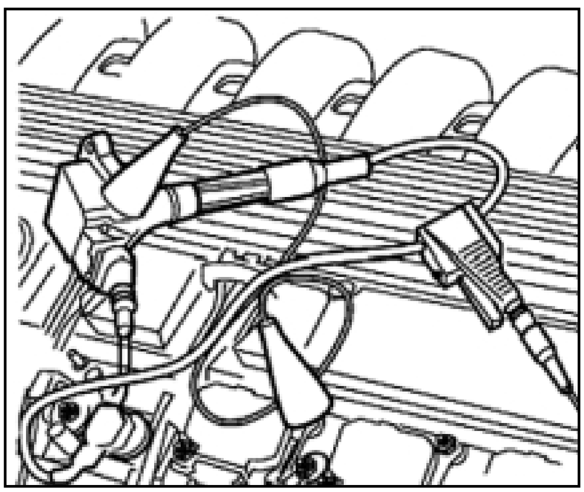
The interior of this Universal Adapter is shielded, therefore it is vital that the ground cable is connected to the vehicle chassis whenever the adapter is used.

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.



When Testing the Secondary Ignition System, use the High Tenision clip of the DIS. Refer to the HELP button for additional (on screen) connections.

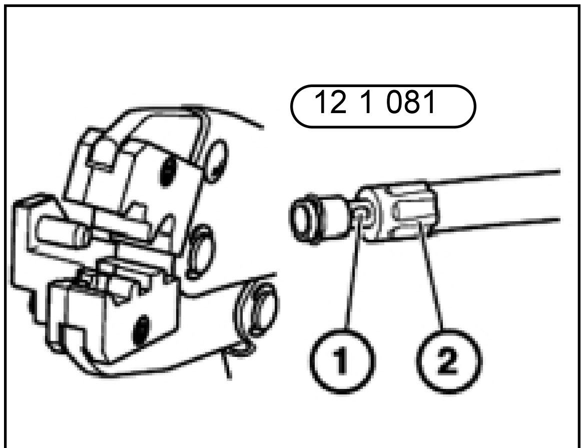

13550016.bmp

Caution!

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

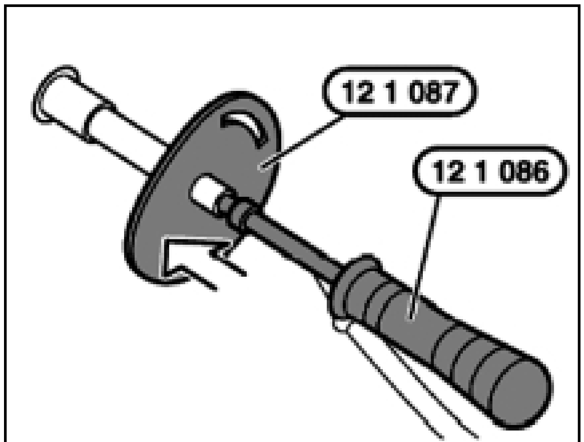
The secondary ignition cables, connectors and sockets can be replaced separately.

New connectors can be "crimped" on using Special Tool #12 1 081. This tool provides a two stage crimp, crimping the core conductor (1) and the insulator (2).



13550018.bmp

The connector with ignition cable should be installed into the Resistive Adapter Boot with Special Tools #12 1 087 and #12 1 086 to ensure the connector properly "seats". `

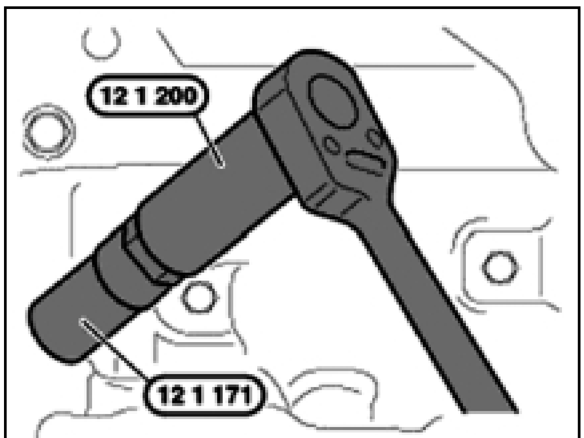


13550019.bmp

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**

NOTE: NEVER USE AIR TOOLS FOR REMOVAL OR INSTALLATION!



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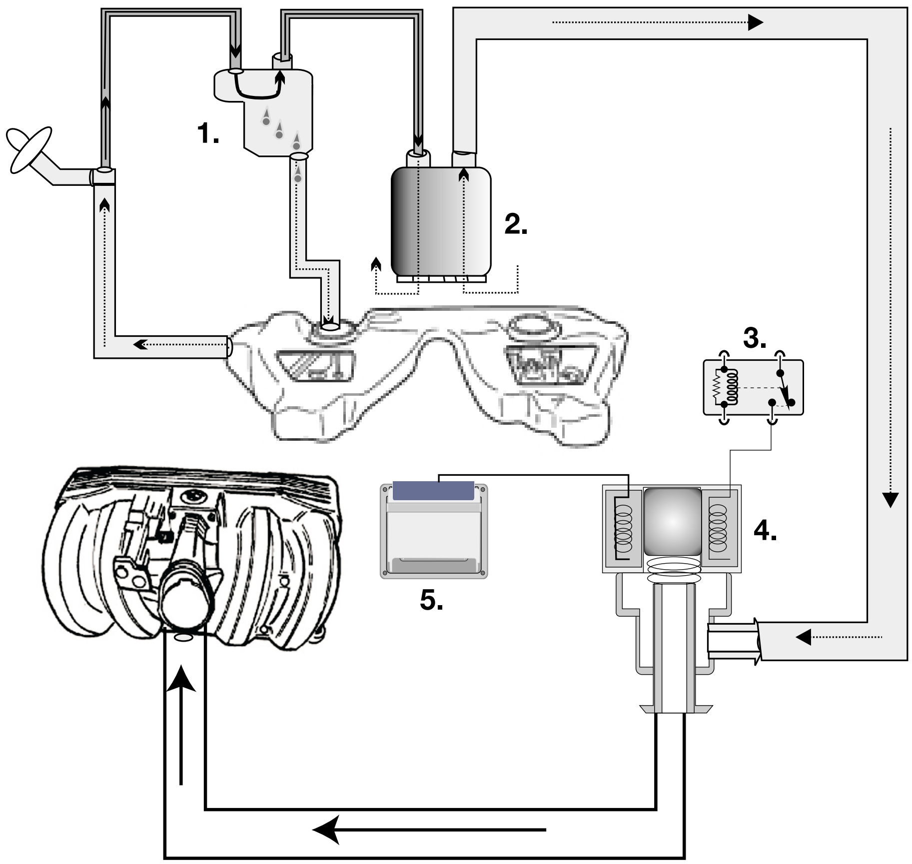
Emissions Management - HC II Compliant (as of 96 MY)



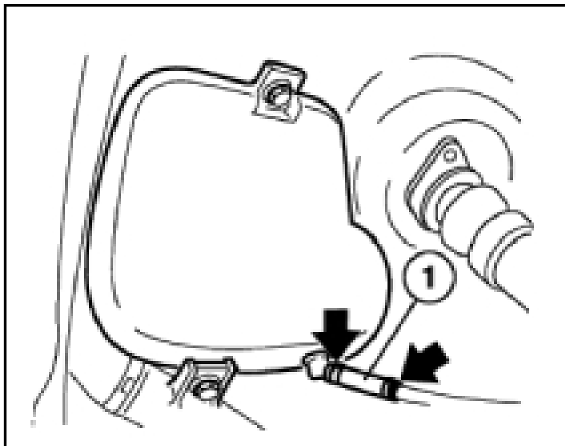
1. Liquid/Vapor Seperator	**3. ECM Relay**	**5.ECM**
2. Active Carbon Canister	**4. Evaporative Emission Valve**	

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.

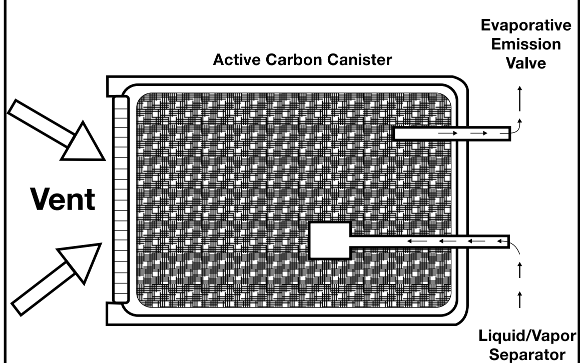
The canister is then "purged" using the engine vacuum to draw the fuel vapors into the combustion chamber. This "cleans" the canister allowing for additional storage. Like any other form of combustible fuel, the introduction of these vapors on a running engine must be controlled. The ECM controls the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

Liquid/Vapor Separator: Fuel vapors are routed from the fuel tank filler neck through a hose to the Liquid/Vapor Separator (located in the right rear wheel well behind the trim). The vapors cool when exiting the fuel tank, the condensates separate and drain back to the fuel tank through a return hose (1). The remaining vapors exit the Liquid/ Vapor Separator to the Active Carbon Canister.



135500147.eps

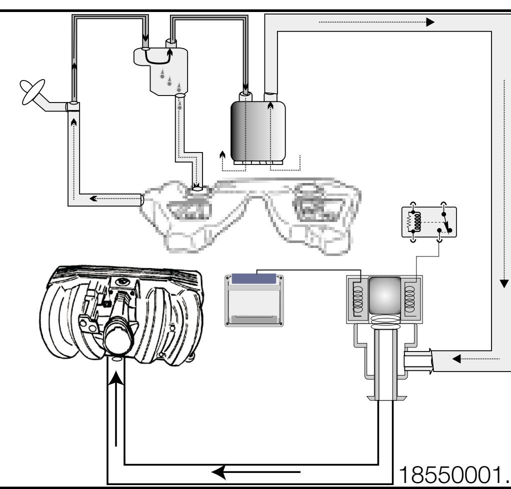
Active Carbon Cannister: As the hydrocarbon vapors enter the canister, they will be absorbed by the active carbon. The remaining air will be vented to the atmosphere through the end of the canister allowing the fuel tank to "breath".



135500147.eps

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 Active Carbon Canister is located in the engine compartment on the left strut tower (spare tire well on late 95 MY).

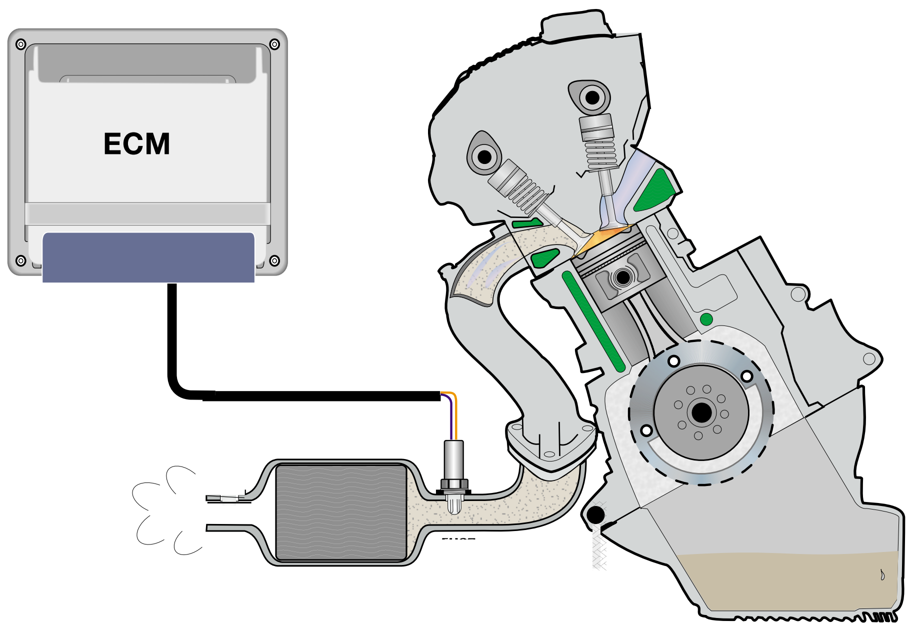
Evaporative Emission Valve: This ECM controlled solenoid valve regulates the purge flow from the Active Carbon Canister into the intake manifold (located next to the Air Volume Mass Meter).



18550001.eps

The ECM Relay provides operating voltage, and the ECM controls the valve by regulating the ground circuit. The valve is powered closed and opened 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. If the valve is "mechanically" defective, a driveability complaint could be encountered and a mixture related fault code will be set.



12550016.eps

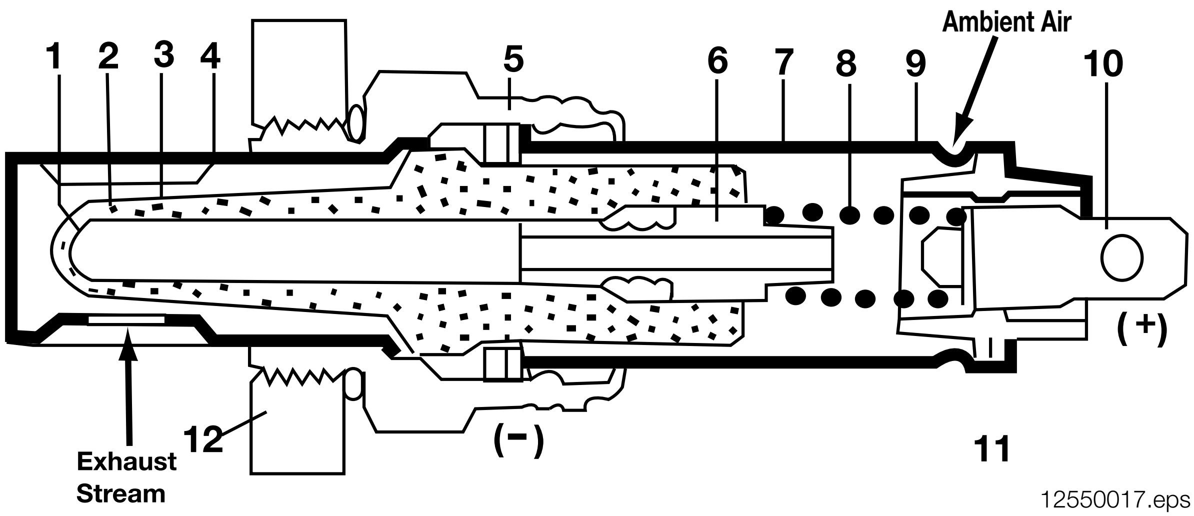
Exhaust Emissions: The combustion process of a gasoline powered engine produces Carbon Monoxide (CO), Hydrocarbons (HC) and Oxides of Nitrogen (NOx).

• 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 Catalytic Converter further reduces exhaust emissions leaving the engine.

Bosch Oxygen Sensor: The oxygen sensor measures the residual oxygen content of the exhaust gas. The sensor produces a low voltage (0-1000 mV) 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 ms injection time. The sensor is mounted in the hot exhaust stream directly in front of the catalytic converter.



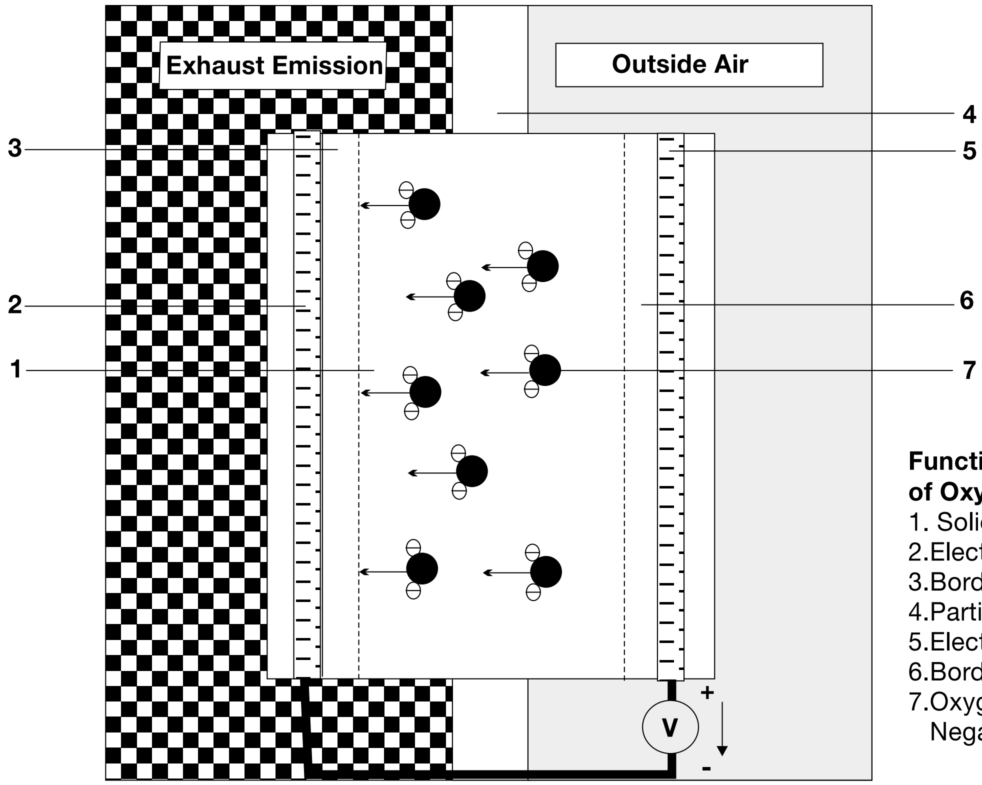
12550017.eps

1. Electrode (+)	7. External Body (Ventilated)
2. Electrode (-)	8. Contact Spring
3. Porous Ceramic Coating (Encasing Electrolyte)	9. Vent Opening
4. Protective Metal Cage (Ventilated)	10. Output Lead
5. Casing	11. Insulator
6. Contact Sleeve	12. Exhaust

The "tip" of the sensor contains a microporous platinum coating (electrodes) which conduct current. The platinum electrodes are separated by solid electrolyte which conducts oxygen ions.

The platinum conductors are covered with a highly porous ceramic coating and the entire tip is encased in a ventilated metal "cage". This assembly is submersed in the exhaust stream. The sensor body (external) has a small vent opening in the housing that allows ambient air to enter the inside of the tip.

The ambient air contains a constant level of oxygen content (21%) and the exhaust stream has a much lower oxygen content. The oxygen ions (which contain small electrical charges) are "purged" through the solid electrolyte by the hot exhaust gas flow. The electrical charges (low voltage) are conducted by the platinum electrodes to the sensor signal wire that is monitored by the ECM.



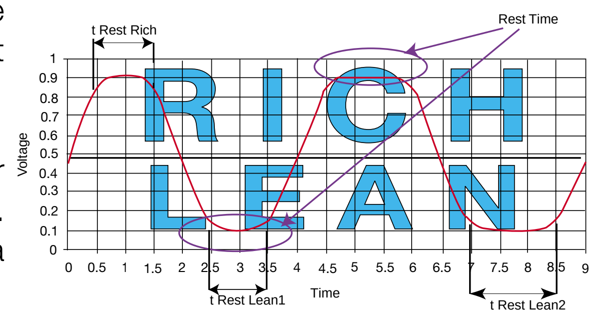
Functional Layout of Oxygen Sensor

1. Solid Electrolyte
2. Electrode Exhaust Side
3. Border Zone Exhaust Side.
4. Partition Wall (Exhaust Pipe)
5. Electrode, Air Side
6. Border Zone, Air Side
7. Oxygen Ion With Double Negative.

18550002.eps

If the exhaust has a lower oxygen content (rich mixture), there will be a large ion "migration" through the sensor generating a higher voltage (950 mV). If the exhaust has a higher oxygen content (lean mixture), there will be a small ion "migration" through the sensor generating a lower voltage (080 mV).

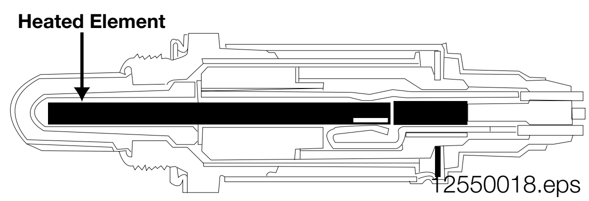
This voltage signal is constantly changing due to combustion variations and normal exhaust pulsations.



13550011.eps

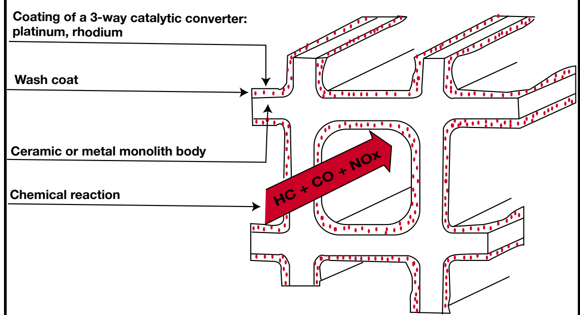
The ECM monitors the length of time the sensor is operating in the lean, rich and rest conditions. The evaluation period of the sensor is over a predefined number of oscillation cycles.

This conductivity is efficient when the oxygen sensor is hot (250º - 300º C). For this reason, the sensor contains a heating element. This "heated" sensor reduces warm up time, and retains the heat during low engine speed when the exhaust temperature is cooler.



12550018.eps

Catalytic Converter: The three-way catalyst after-treats exhaust emissions leaving the engine. A properly operating catalyst consumes 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 respectively.



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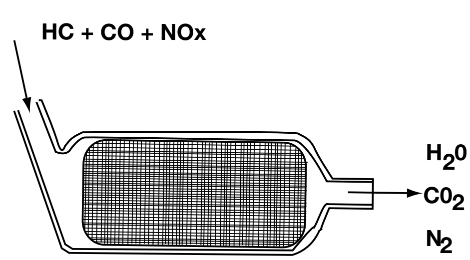
The catalytic converter (monolith) is made of thousands of small ceramic blocks that the exhaust must flow through. The entire ceramic structure is supported in the shell by a flexible mat and wire mesh layer.

The ceramic is coated with the precious metals Platinum which speeds up oxidation of HC and CO and Rhodium which speeds up the reduction of NOx.

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.



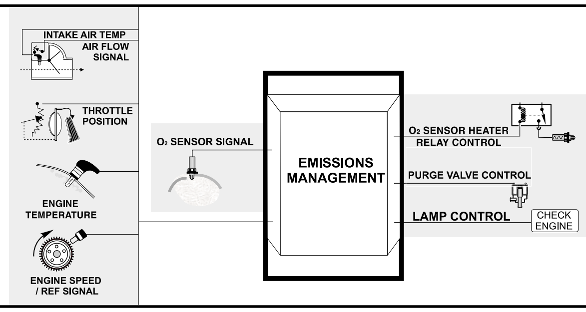
135500150.eps

The M1.7.2 system uses the redesign catalytic converter which distributes the exhaust gas uniformly as it enters the converter through a lateral discharge inlet.

This design allows the exhaust gas to strike the entire surface of the monolith to ensure that emissions from the exhaust system are reduced to a consistenly low level.

Principle of Operation

Emissions Management controls evaporative and exhaust emissions. The ECM controls the **purging** of evaporative fuel. The ECM monitors and controls the exhaust emissions by regulating the **combustable mixture**. The catalytic converter after-treats by further breaking down remaining combustable exhaust gasses.



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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 closed and opened by an internal spring. The "purging" process takes place when:

• **Oxygen Sensor Control is active**
• **Engine Coolant Temperature is >60ºC**
• **Engine Load is present**

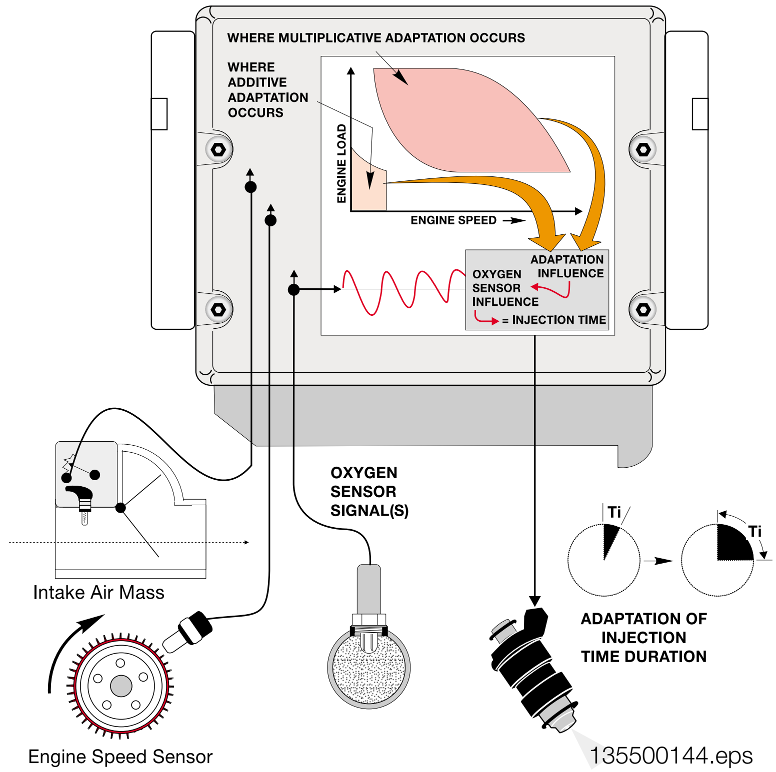
The Evaporative Emission Valve is opened in stages to moderate the purging.

• **Stage 1 opens the valve for 10 ms (milli-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 minutes to complete. The function is inactive for 1 minute then starts 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 (1996 MY - HC II Emission Compliance) is performed by the ECM when the oxygen sensor control and purging is active. When the Evaporative Emission Valve is open the ECM detects a lean/rich shift as monitored by the oxygen sensors indicating the valve is functioning properly. If the ECM does not detect a lean/rich 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.

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).

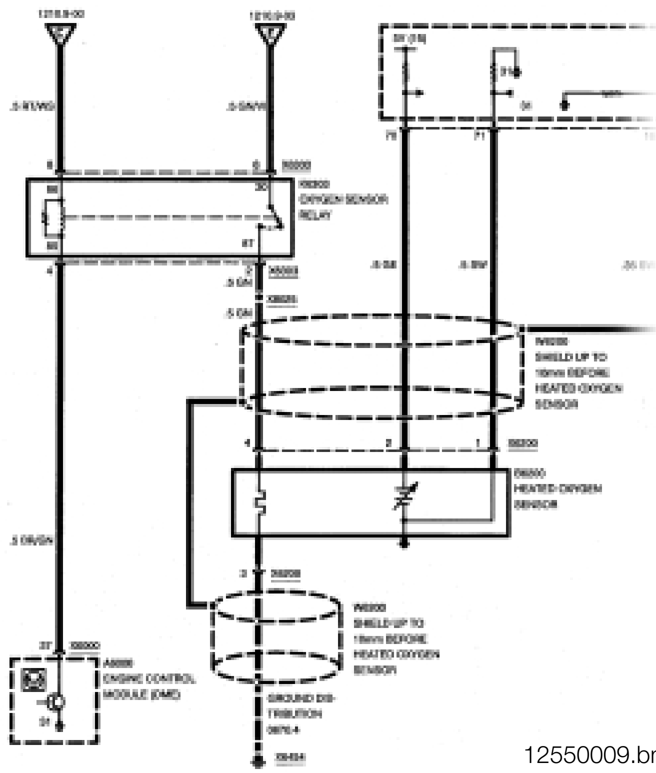
These values indicate how the ECM is compensating for a less than ideal initial air/fuel ratio.

NOTE: If the adaptation value is greater than "0.0 ms" the ECM is trying to richen the mixture. If the adaptation value is less then "0.0 ms" the ECM is trying to lean-out the mixture.

Oxygen Sensor Heating is controlled by the ECM to reduce warm up time and retain heat during low engine rpm when the exhaust temperature is cooler.

Voltage is supplied from the Oxygen Sensor Heater Relay and the ground circuit for the relay is provided by the ECM when engine rpm is present.

During full throttle operation electrical heating is not required and is deactivated by the ECM.



12550009.bmp

Oxygen Sensor Heater Relay Monitoring is checked separately for electrical integrity and operation. The Heater Relay function is monitored continuously while the vehicle is in closed loop operation, during activation by the ECM.

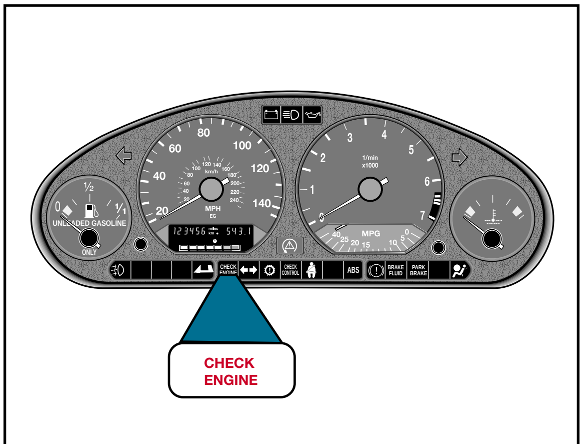
An improperly/non operating Heater Relay will not allow the sensor signal to reach its predefined maximum and minimum thresholds which can:

• Result in delayed closed loop operation causing an impact on emission levels.
• Result in increased emission levels while in closed loop operation.

As part of the monitoring function for Heater Relay current and voltage, the circuit is also checked for an open, short to ground and short to B+ depending on the values of the current or voltage being monitored. If the power of the Heater Relay is not within a specified range, a fault will be set and the “CHECK ENGINE" light will be illuminated.

The "CHECK ENGINE" Light required for OBD is located in the instrument cluster and is activated by the ECM under the following conditions:

- **Ignition "on" (KL15) and engine not running- bulb check function.**
- **A component malfunction that affects the vechicle emissions.**
- **An Implausible input signal is generated**
- **Manufacturer-defined specifications are exceeded.**
- **ECM fails to enter oxygen sensor closed-loop control within a specified time interval.**



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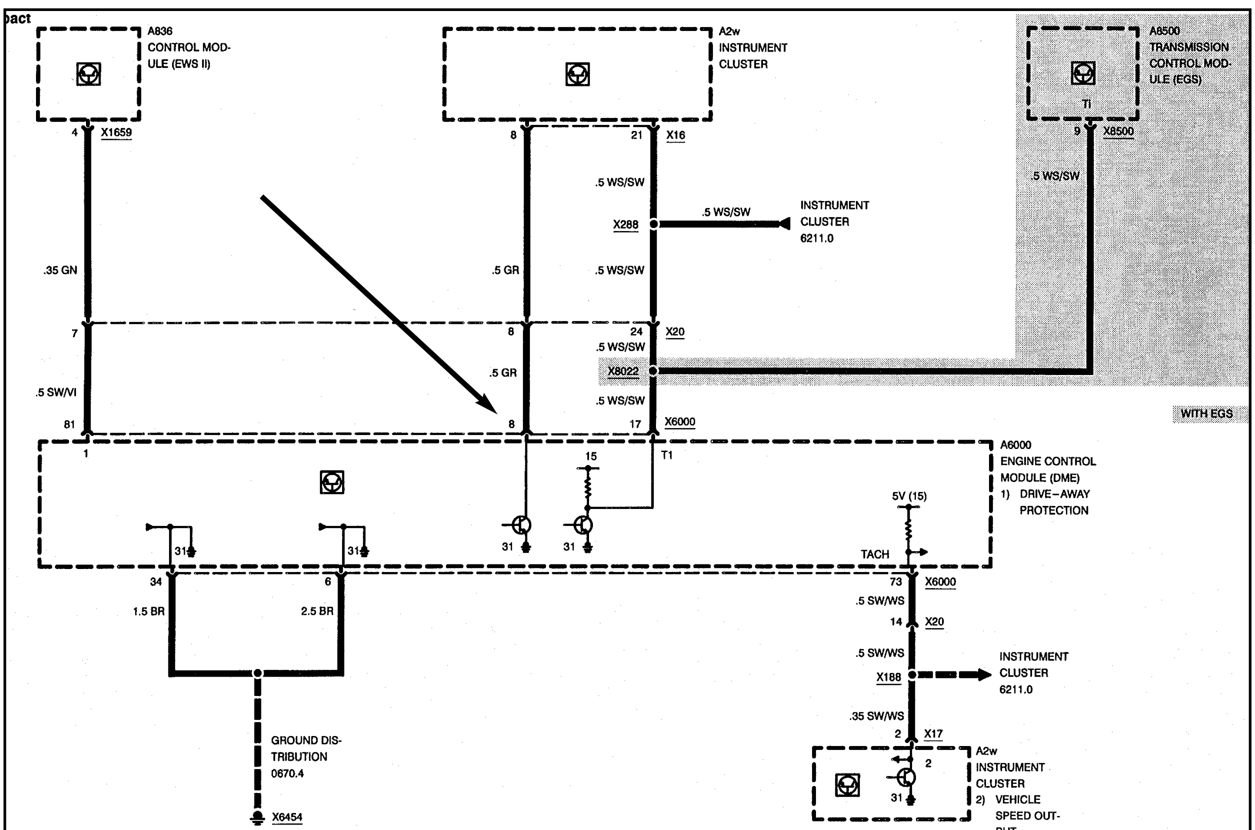
The ECM illuminates the "CHECK ENGINE" Light by activating a final stage transistor to supply a ground circuit (arrow). The light has voltage supplied whenever KL15 is switched "on".



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Workshop Hints

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

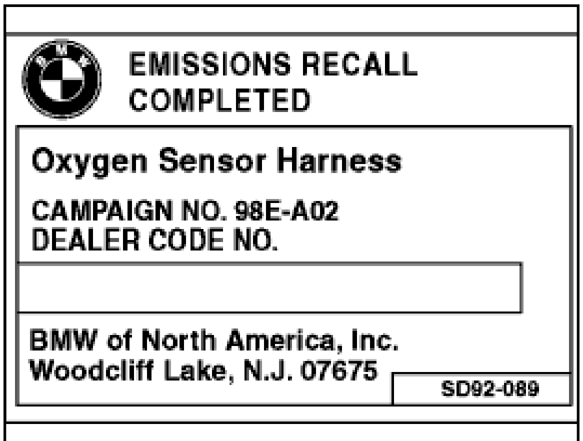
- **Observe relevent safety legislation pertaining to your area.**
- **Ensure adequate ventilation.**
- **Use exhaust extraction system where applicable (alleviate fumes).**
- **DO NOT SMOKE while performing fuel system repairs.**
- **Always wear adequate protection clothing including eye protection.**
- **Use caution when working around a HOT engine compartment.**
- **BMW does not recommend any UNAUTHORIZED MODIFICATIONS to the fuel system. The fuel systems are designed to comply with strict Federal Safety and Emissions Regulations. In the concern of product liabilty, 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 also has flash code readouts that allows Technicians without BMW Special Tools or Equipment to Diagnose an emission system failure.

For more information and ordering procedure for the On-Board Emission System Diagnostic Guide refer to Service Information Bulletin SI #13 08 88 (1718).

CHECK ENGINE

Oxygen Sensor Wiring Harness Voluntary Recall Campaign No. 98E-A02 pertains to oxygen sensor harness breakage due to the retainer clips (1 and 2). For more information and details, refer to Service Information Bulletin SI # 11 03 98.



EMISSIONS RECALL
COMPLETED

Oxygen Sensor Harness

CAMPAIGN NO. 98E-A02
DEALER CODE NO.

BMW of North America, Inc.
Woodcliff Lake, N.J. 07675

SD92-089

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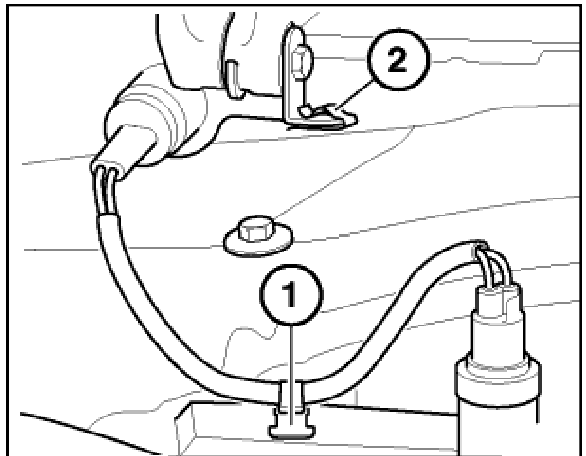


04550003.bmp

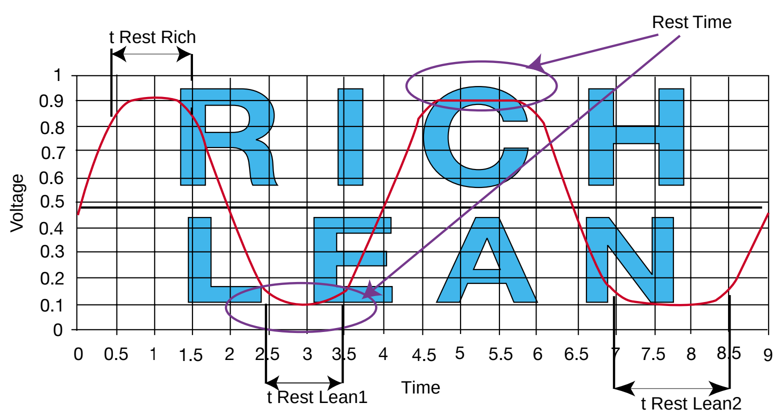
Testing the Oxygen Sensor should be performed using the DIS Oscilloscope from the "Preset" List. The scope pattern should appear as below for a normal operating sensor.

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

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

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

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



13550011.eps

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

Tools and Equipment

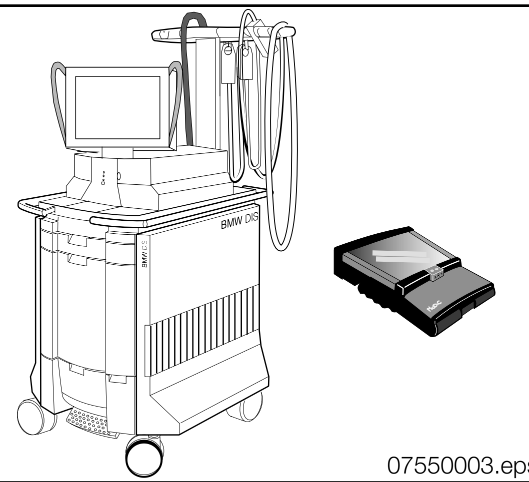
The DIS/Modic as well as a reputable hand held multimeter can be used when testing inputs/ components.

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

The correct Universal Adapter for the M1.7.2 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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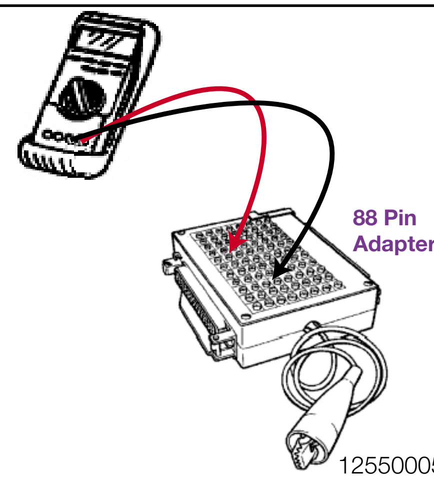

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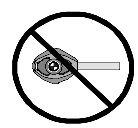
When installing the Universal Adapter to the ECM (located below the windshield on the passenger side of the engine compartment), make sure the ignition is switched off.

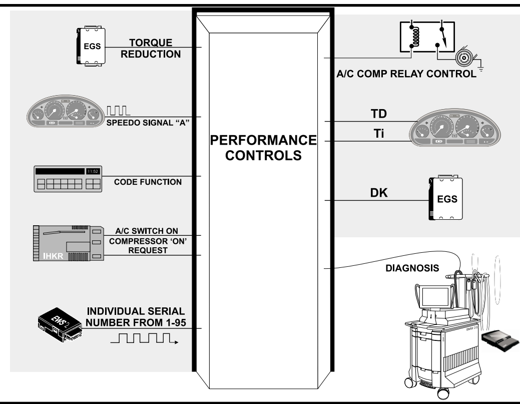


Troubleshooting the closed-loop oxygen sensor control should be performed using Special Tool # 90 88 6 117 450 (operational instruction book included).

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

04550001.bmp

Performance Controls



12550017.eps

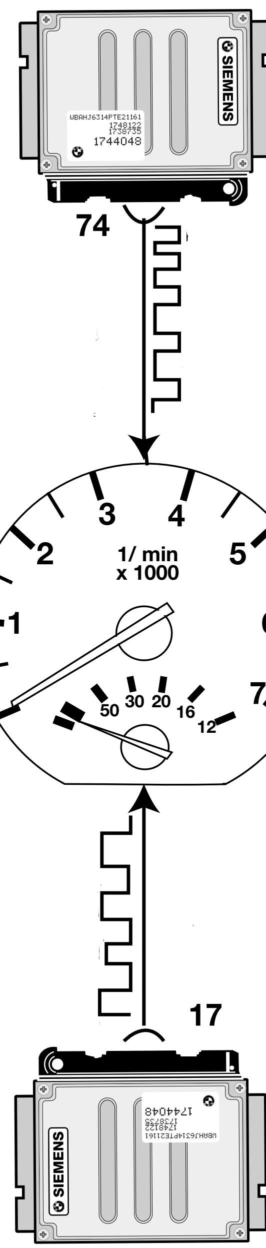
Engine Speed Signal (TD): is produced by the ECM as an output function. The TD signal is a processed square wave signal that indicates engine rpm. The signal is made available to other control modules including the Instrument Cluster, EWS and the 20 pin Diagnostic Socket.

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
• EGS = Load signal for shift points (If Equipped)

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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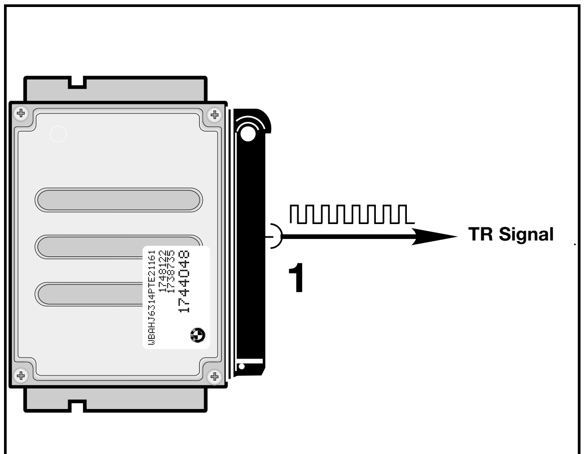
Engine Speed (TR) for EGS: is an additional variation of the engine speed signal. The “TR” signal is produced ECM as an additional output function. Like TD, “TR” is a processed signal that indicates engine rpm for the EGS (if equipped) to determine shift points.

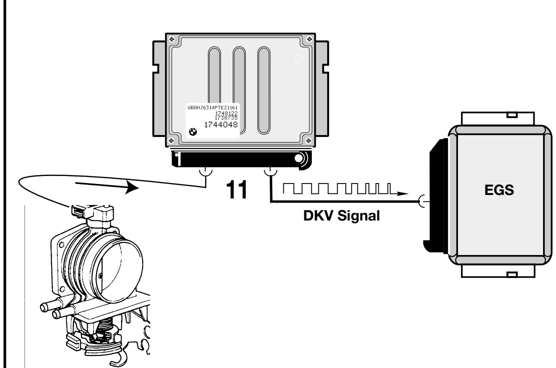
The TR signal is a pulse wave signal. The frequency of the signal directly proportional to RPM. The signal is overlapped on the fuel pump relay control signal from the ECM.



62550001.eps

Throttle Position (DKV) for EGS: is the output signal to the EGS Control Module (if equipped). The DKV signal is a pulse width modulated signal directly proportional to the linear throttle position sensor input signal.

This output signal is used by the EGS Control Module for determining shift points.



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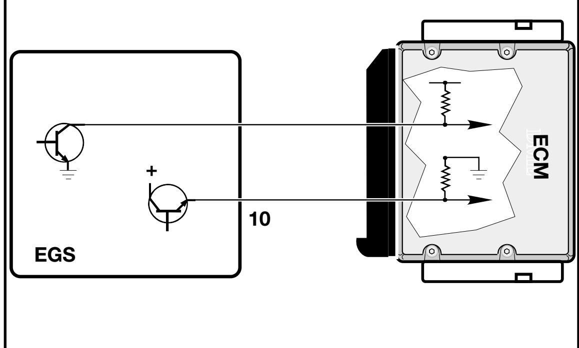
EGS Ignition Timing Intervention Signal: The ECM receives an input signal from the EGS Control Module (if equipped) that will retard the ignition timing. This is a momentary ground signal from the EGS during a gear change to reduce engine torque for smoother shifts.

The EGS releases the ground so the ECM will resume ignition timing advance at the completion of the “shift”.



62550003.eps

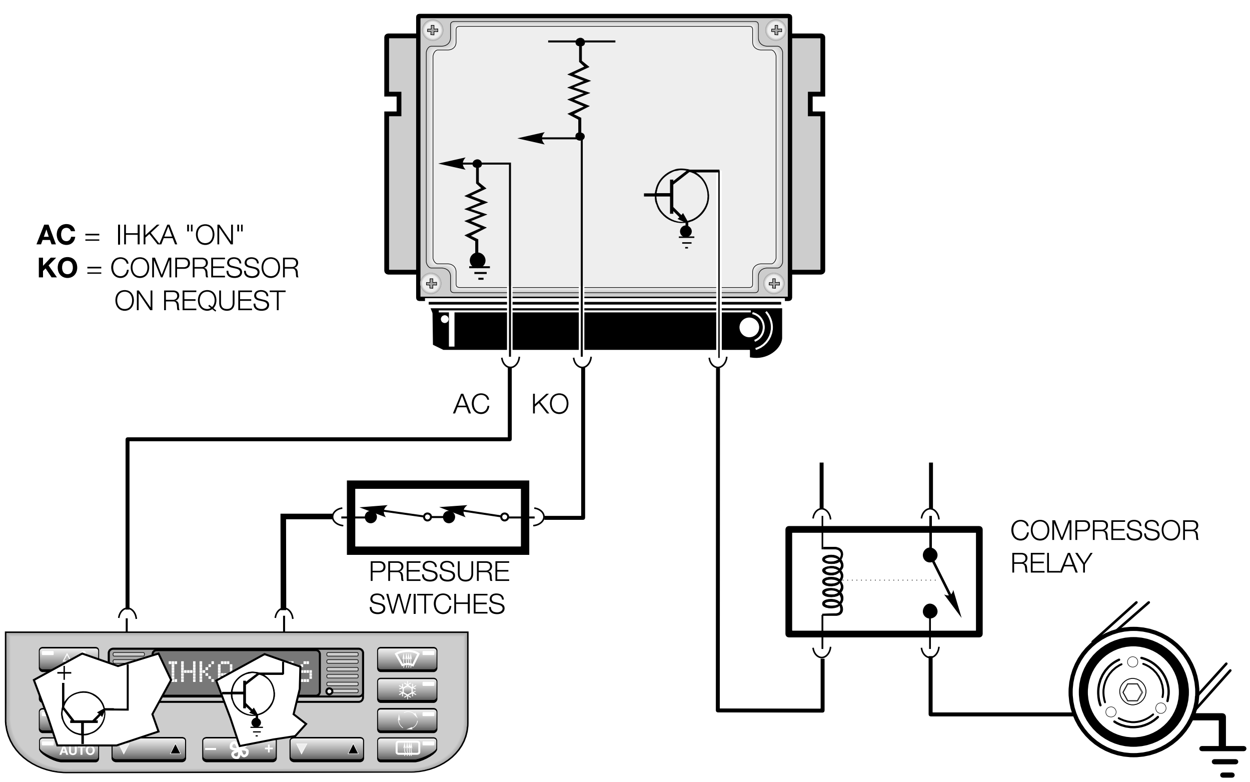
A/C Compressor Control: is an output of the ECM. The ECM controls the A/C Compressor Relay based on signals from the IHKA/IHKR Control Modules.

When the driver selects the “snow flake” button, the IHKA/IHKR 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/IHKS 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.



62550004.eps

Driveaway Protection System Interface EWS I (1-94 thru 12-94 production): was added to all vehicles in January 1994. It is controlled by the Central Locking System of ZKE and by the On-Board Computer code function (if equipped).

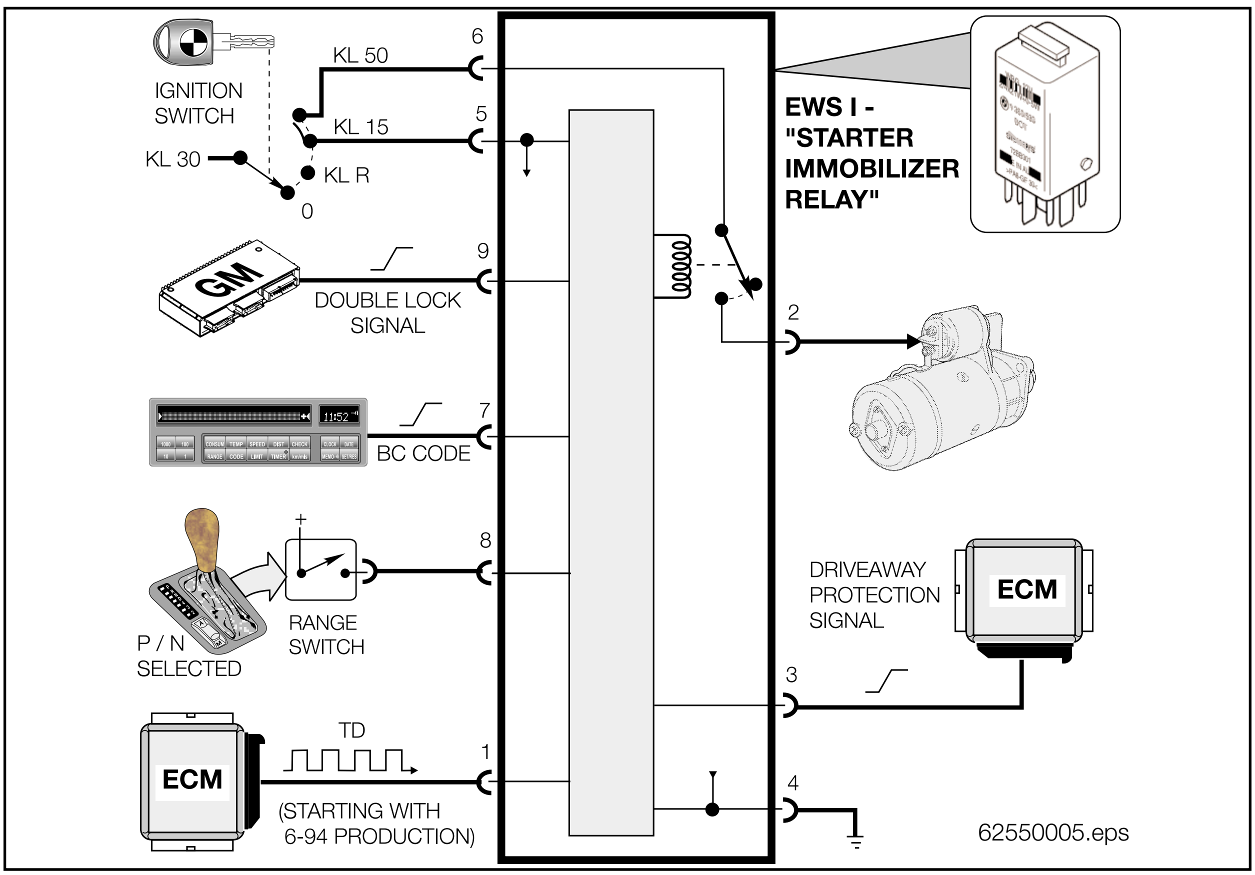
The Starter Immobilization Relay is activated when:

• **The vehicle is locked from the outside (Central Locking - GM output to Relay).**
• **The On-Board Code function is set.**

An activated relay performs two functions to deter vehicle theft:

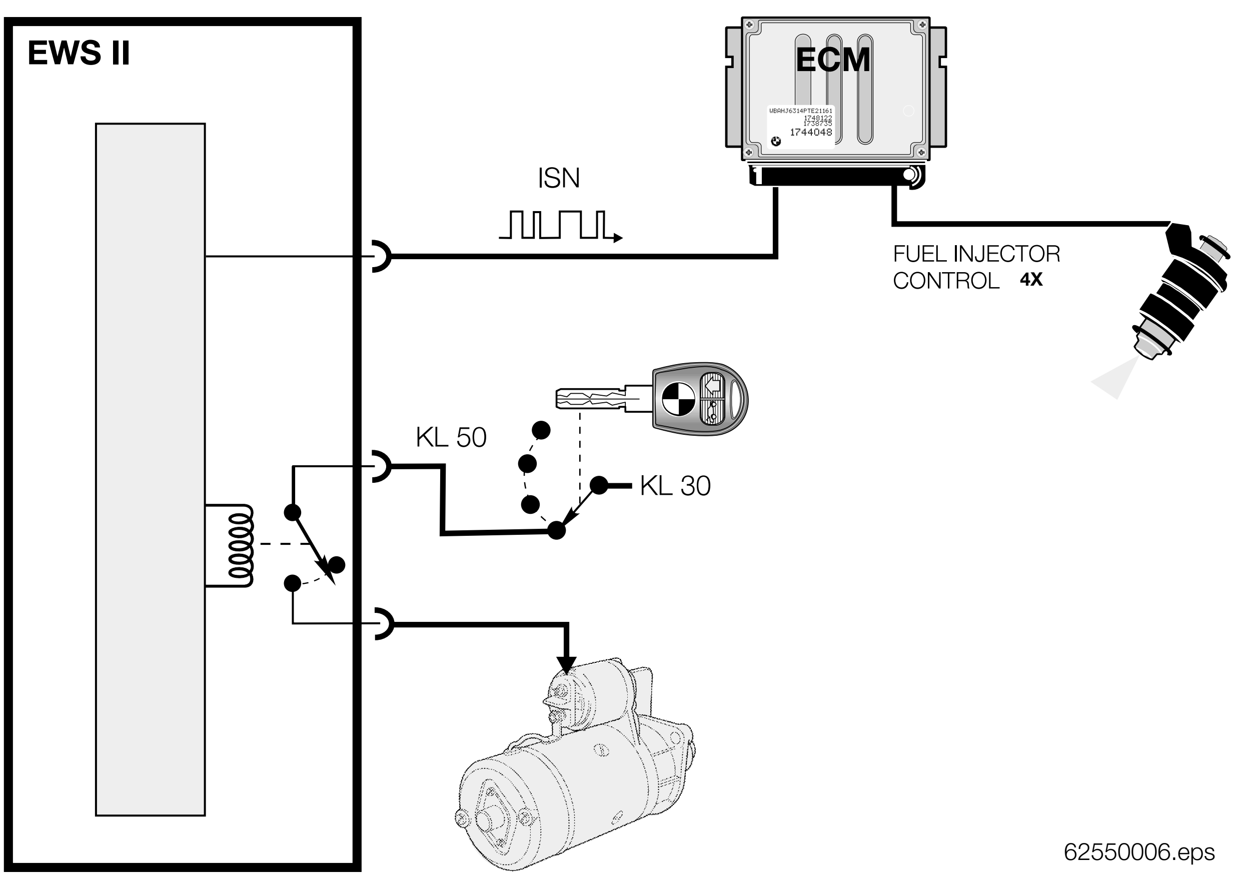
• **Ignition and Injection functions of DME are disabled (switched high output signal.)**
• **The KL 50 start signal circuit is opened to prevent starter operation.**

* Conventional troubleshooting using the ETM.



Driveaway Protection System Interface EWS II (from 1-95 production): 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 Modules 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).
• Everything 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 continuously sent to the ECM as long as the ignition is switched on (KL15).
• The ECM will disregard the loss of the ISN after the engine is running.



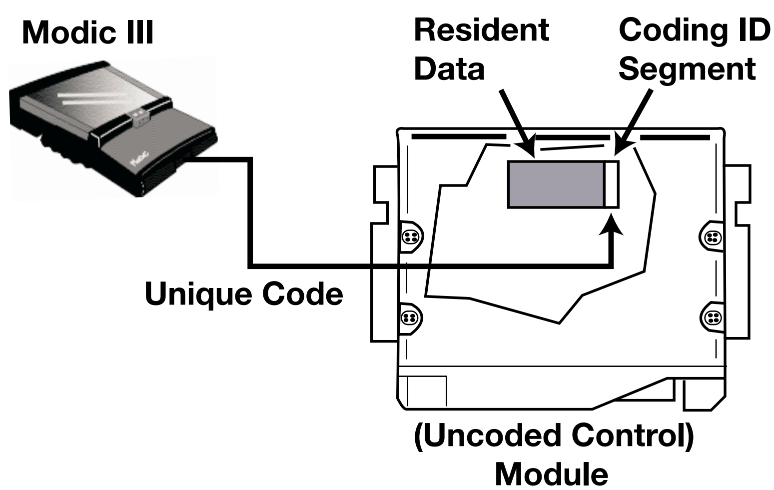
62550006.eps

Variant Coding

The ECM used in the M1.7.2 system is a codeable module that requires Variant Coding if it is replaced. The control module is programmed with “resident data” stored in the EPROM and Variant Coding simply means that one of the “data sets” will be activated for the engine/vehicle.

DME (ECM) Variant Coding is performed with the DIS/MoDIC using the latest software:

• DME Varient Coding uses a 4 Digit code to determine which of the internal maps (data sets) to utilize.
• The 4 digit code describes which maps to use.
• The proper variant code can be found on the cover of the old ECM or Modic variant coding software.
• The actual program software can be found for DME variant coding can be found only in DME Programing software.
• A codeable DME can only be coded 8 times.



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Please refer to the following Service Information Bulletins for updated information on the ECM regarding coding:

• SI #09 Group for the latest on Programing/Coding Explanation
• SI #12 14 97 M42 Fault Code 200/333
• SI #12 15 97 M42 Acceleration Jot in 2nd and 3rd Gear
• SI #12 09 95 M42 ECM (DME) 1.7.2 Fault Code 41

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).

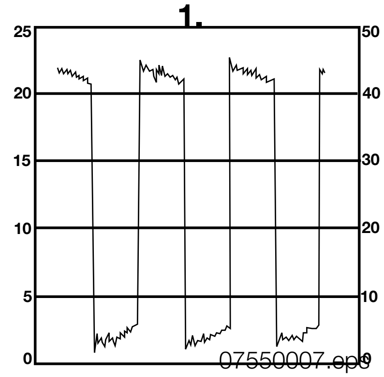
With the 88 Pin adapter and the DIS Oscil- loscope (Preset Measurements) the following signals can be observed with the ECM installed and engine running:

1. TD = Engine RPM
2. Ti = Fuel Injection
3. TR = Engine RPM (for EGS if equipped)
4. DKV = Throttle Postion (for EGS if equipped)

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.

1.



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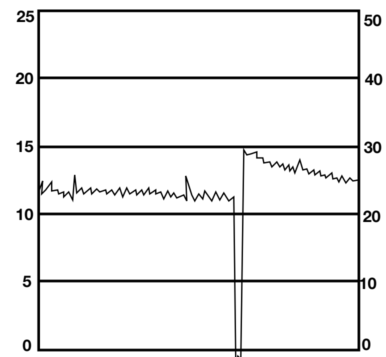
2.



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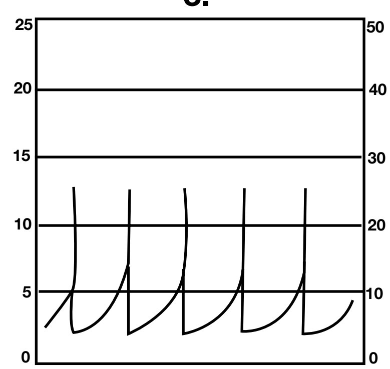
3.



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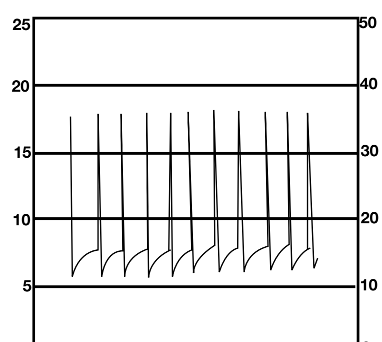
4.



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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.

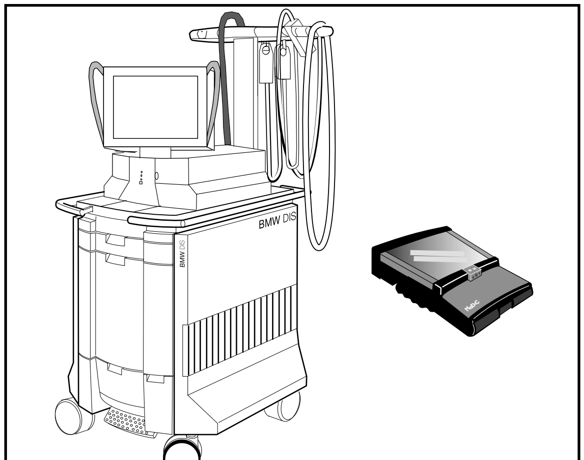
It is best to make the checks at the ECM connection, this method includes testing the wiring harness.

The correct Universal Adapter for the M1.7.2 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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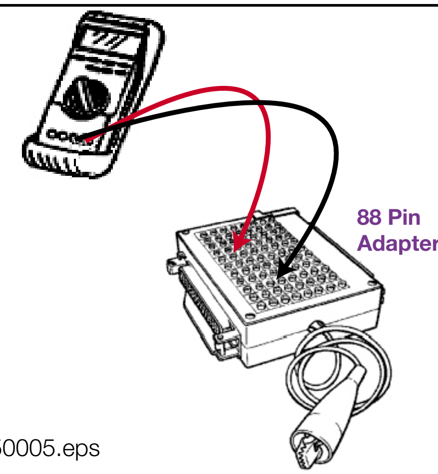

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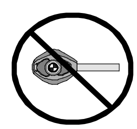


Review Questions

1. Describe the Power Supply for the Fuel Injectors:

2. Name the Components of the Fuel Supply System:

3. List the inputs required for igniton operation:

4. Describe the Knock Sensor Function:

5. Name two types of Emissions the ECM controls:

6. List two reasons for the “CHECK ENGINE” Light to illuminate:

7. List four different tests that can be performed on the fuel injectors:

8. Describe Semi-Sequential Injection:

9. EWS (I or II) affects what ECM output functions to deter vehicle theft?

Table of Contents

Subject **Page**

MS42/MS43

Models: E46/E39/Z3 - MS42 with M52TU Engine
E46/E39/Z3/E53 - MS43 with M54 Engine

Production Date: MS42 1998 - 2000
MS43 2001 MY to Present

Manufacturer: Siemens

Pin Connector: 134 Pins - 5 Modular Connectors

Objectives of the Module

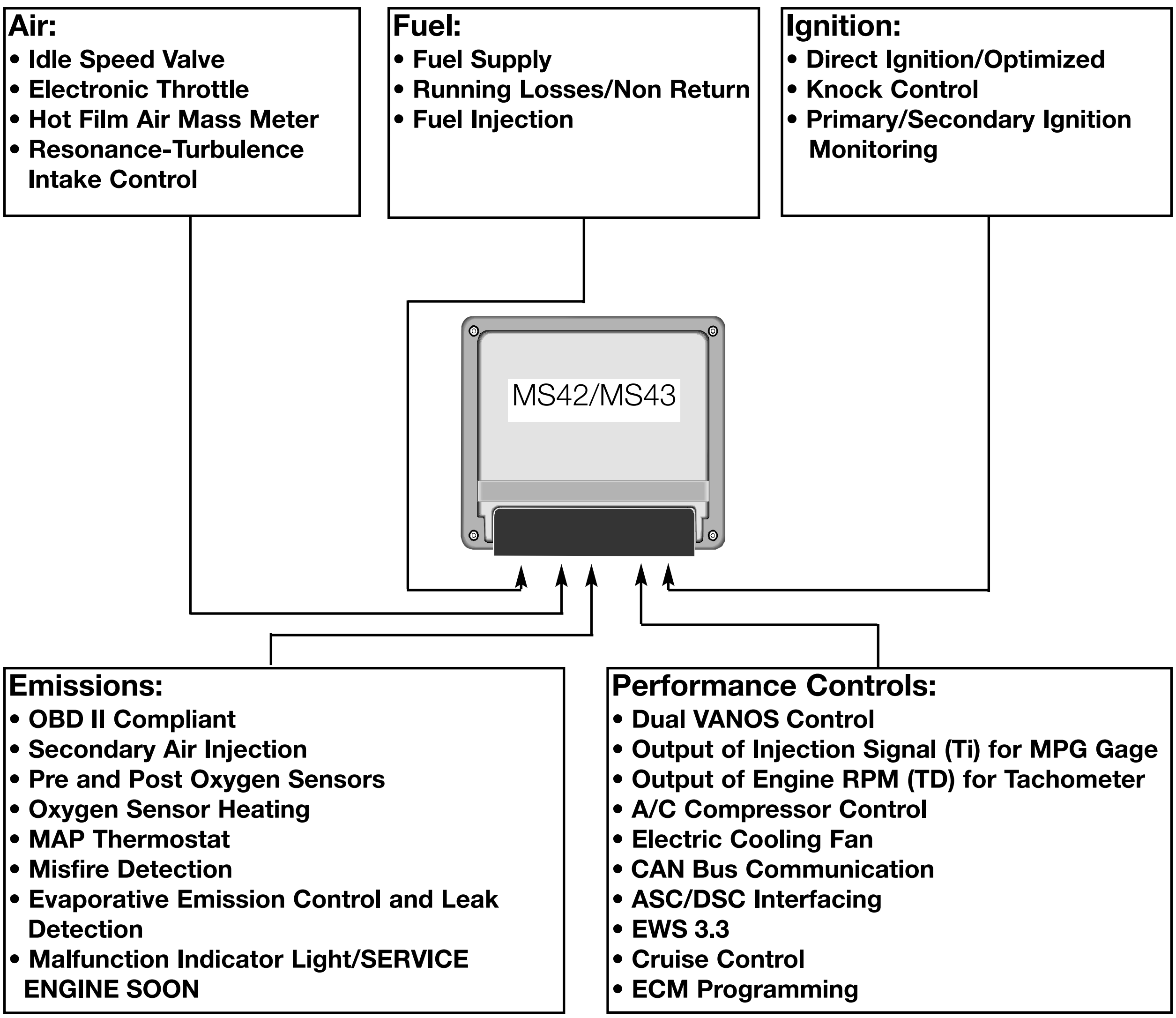
After completing this module, you will be able to:

- Describe the Power Supply for the Fuel Injectors and Ignition Coils
- Understand the MDK/EDK and Idle Air Actuator Operation
- Name the Differences Between the MS42/MS43 Fuel Supply System
- List the Inputs Required for Fuel Injector Operation
- Describe Emission Optimized Function
- Name the Two Types of Emissions the ECM Controls
- Explain Why Two Sensors are Used to Monitor Accelerator Pedal Movement
- Understand LDP and DM TL Evaporative Leak Testing
- Describe How the Ignition System is Monitored

MS42/MS43

Purpose of the System

The MS42/MS43 systems manage the following functions:



System Components

MS42/MS43 Engine Control Module: The Engine Control Module (ECM) features a single printed circuit board with two 32-bit microprocessors.

The task of the first processor is to control:

• **Engine Load**
• **Electronic Throttle**
• **Idle Actuator**
• **Ignition**
• **Knock Control**

The task of the second processor is to control:

• **Air / Fuel Mixture**
• **Emission Control**
• **Misfire Detection**
• **Evaporative Leak Detection**

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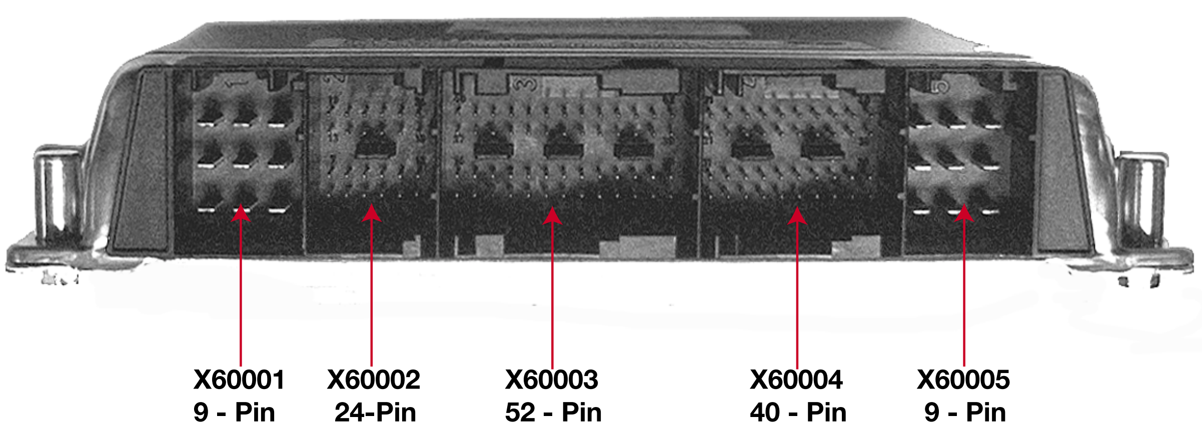
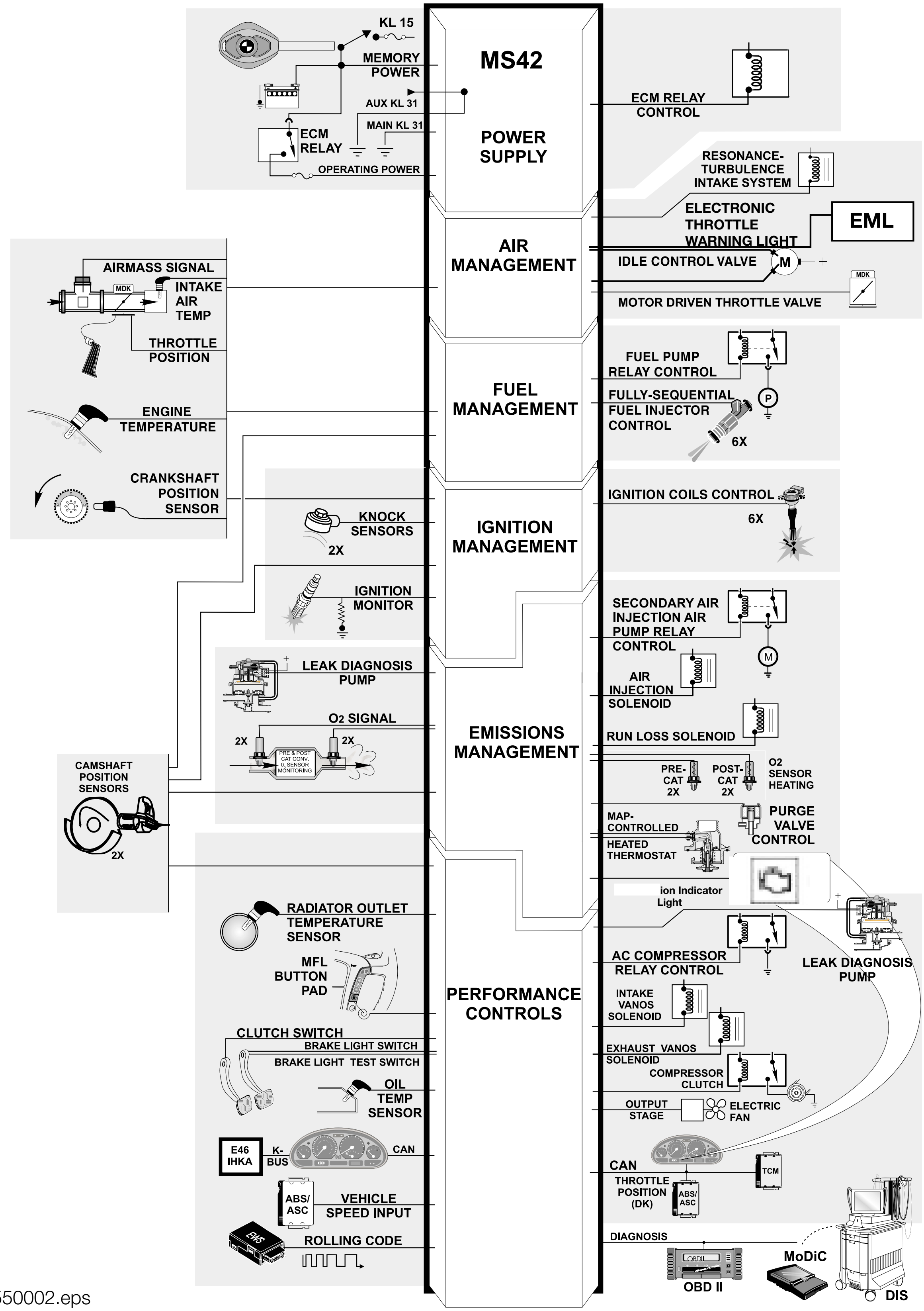


The 134 pin ECM is manufactured by Siemens to BMW specifications. The ECM is the SKE (standard shell construction) housing and uses 5 modular connectors. For testing, use the Universal Adapter Set (break-out box) Special Tool # 90 88 6 121 300.

System Components: Inputs - Processing - Outputs



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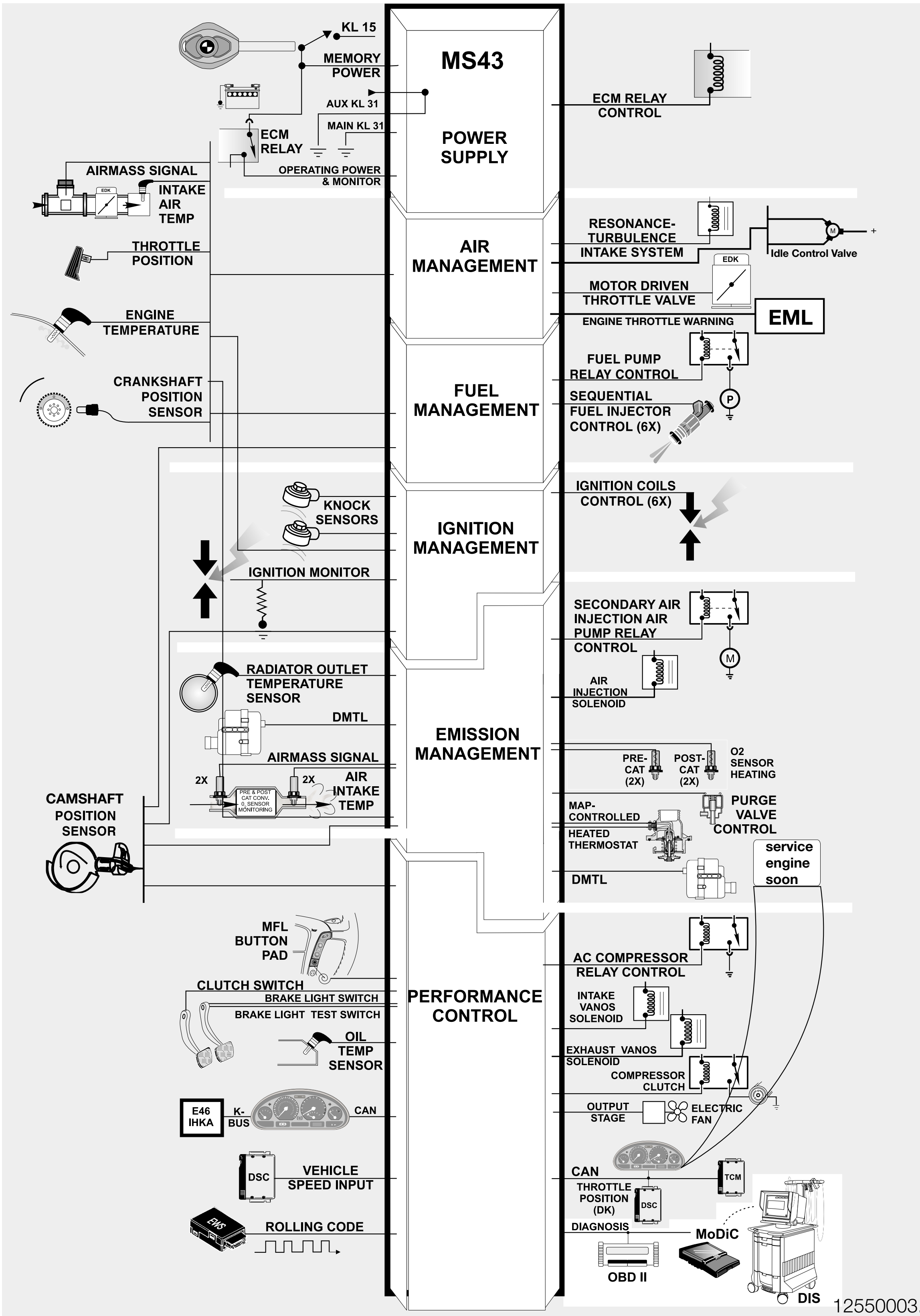
System Components: Inputs - Processing - Outputs



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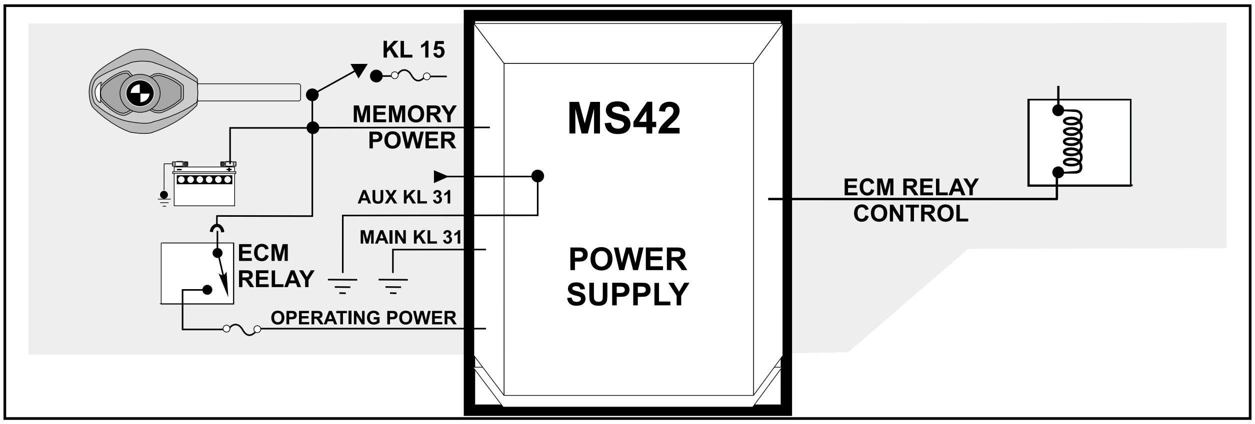
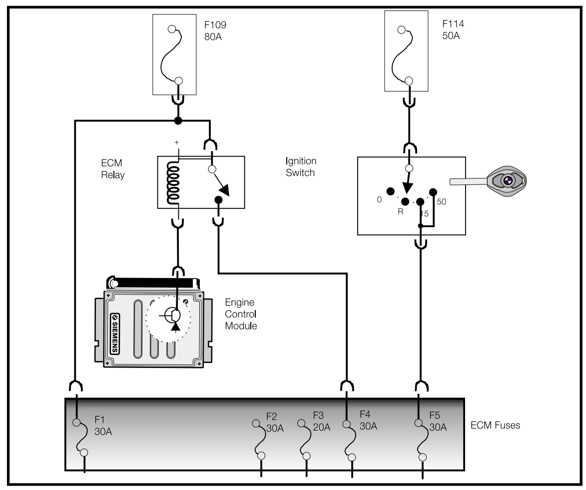
Power Supply



KL30 - Battery Voltage: B+ is the main supply of operating voltage to the ECM.

Power Supplies: The power supplies (KL15 and ECM Relay) are fused to the MS42/MS43 ECM. The fuses are housed in the Engine Fuse Block located in the Electronics Box.

KL15 - Ignition Switch: When the ignition is switched “on” the ECM is informed that the engine is about to be started. KL15 (fused) supplies voltage to the Engine Control Module Relay and the Fuel Injector Relay. Switching KL15 “off” removes the ECM operating voltage.



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Engine Control Module Relay: The ECM Relay provides the operating voltage for:

1.	**ECM**	**6.**	**Ignition Coils**
2.	**Fuel Injection**	**7.**	**Evaporative Leak Detection Pump**
3.	**Idle Air Actuator**	**8.**	**Camshaft Sensors**
4.	**Evaporative Emission Valve**	**9.**	**Hot Film Air Mass**
5.	**Fuel Pump Relay**	**10.**	**Oxygen Sensor Heaters**

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

Connector X60001	**Connector X60005**
Pin 4 - Ground for ECM	**Pin 5 - Ground for ECM**
Pin 5 - Ground for ECM	**Pin 6 - Ground for ECM (MS42)**
Pin 6 - Ground for ECM	

Principle of Operation

Battery Voltage is monitored by the ECM for fluctuations. It will adjust the output functions to compensate for a lower (6v) and higher (14v) voltage value. For example, the ECM will:

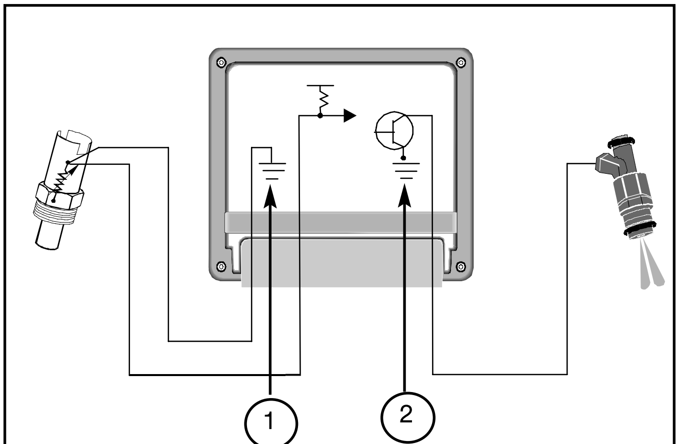
• Modify pulse width duration of fuel injection.
• Modify dwell time of igniton

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. MS43 - Five seconds after the ignition is switched on and the voltage at the KL15 input is >9 volts, the ECM compares the voltage to the ECM Relay supplied voltage. If the voltage difference between the two terminals is greater than 3 volts, a fault code will be set.

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 to maintain ignition coil activation (MS43 Emission Optimized).

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 ground (2) to activate components.



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Workshop Hints

Power Supply - Testing

Inadequate power and ground supply can result in:

1.	**No Start**
2.	**Hard Starting (Long Crank Times)**
3.	**Inaccurate Diagnostic Status or ECM (Not Found)**
4.	**Intermittant/Constant "ENGINE EMISSION/EML" Light**
5.	**Intermittant/Constant Driveability Problems**

Power supply including fuses should be tested for:

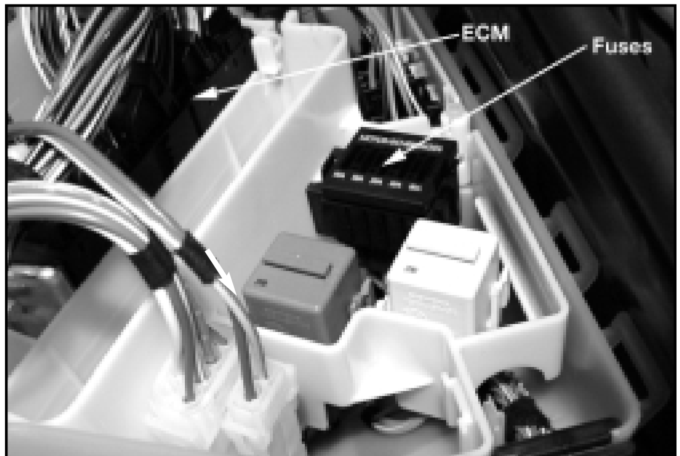
1.	**Visual (1) Blown Fuse**
2.	**Available Voltage (2)**
3.	**Voltage Drop (Dynamic Resistance) (2)**
4.	**Resistance of Cables and Wires (2)**

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 (located in the Electronics Box) should be tested for:

1.	**Battery Voltage and Switched Ground (1)**
2.	**Resistance (1)**
3.	**Battery Voltage and Voltage Drop (2)**

E46 Electronics Box - ECM and Fuses



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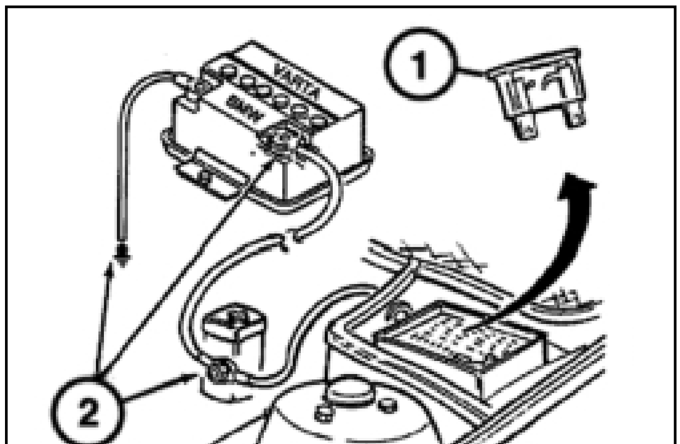

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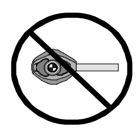

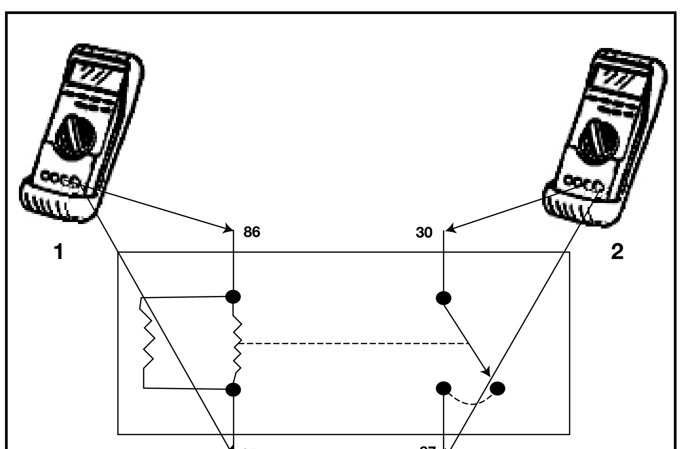

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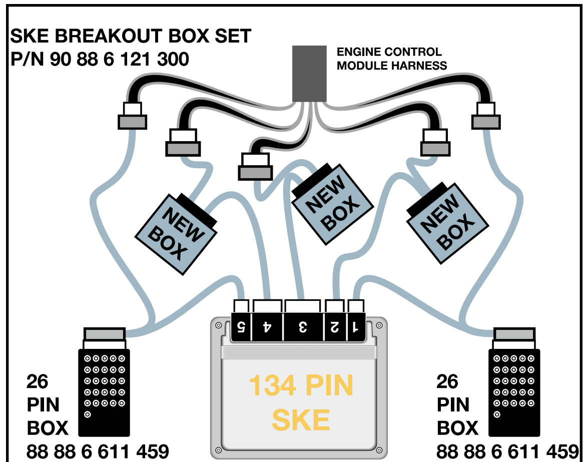
Tools and Equipment

Power Supply

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



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

The correct Universal Adapter for the MS42/MS43 application should be used (#90 88 6 121 300). This will ensure the pin connectors and the harness will not be damaged.


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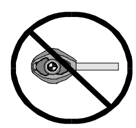
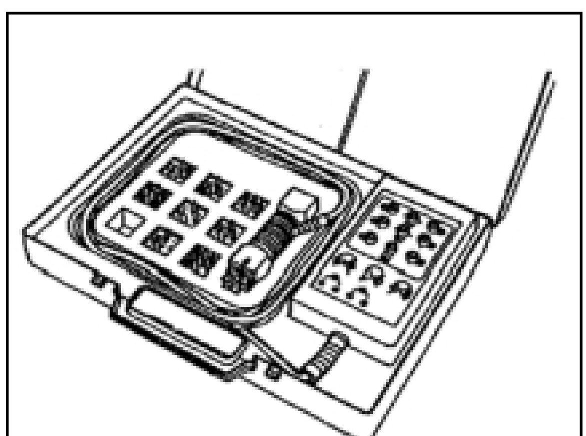
When installing the Universal Adapter to the ECM (located in the Electronics Box in the engine compartment), make sure the ignition is switched off.



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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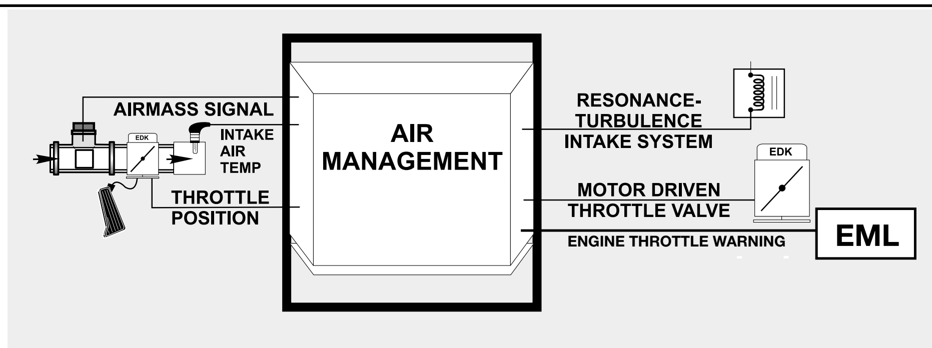
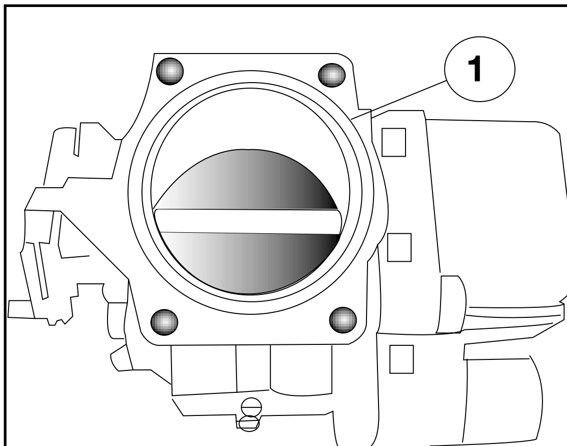
Air Management



Throttle Valve: The throttle valve plate is electronically operated to regulate intake air flow by the ECM. The purpose is for precision throttle operation, OBD II compliant for fault monitoring, ASC/DSC and cruise control. This integrated electronic throttle reduces extra control modules, wiring, and sensors. **Adjusting electronic throttles is not permitted, the throttle assembly must be replaced as a unit. The adaptation values must be cleared and adaptation procedure must be performed using the DISplus/MoDIC.**

The throttle assembly for the **MS42** system is referred to as the **MDK** (Motor Driven Throttle Valve)**.** The MDK is distinguished by:

- **The accelerator position potentionmeters (PWG = driver's wish) are integrated in the MDK housing.**
- **A throttle cable is used to actuate the accelerator pedal position potentiometers and also serves as a backup to open the throttle plate (full control) if the MDK system is in failsafe.**



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The throttle assembly for the **MS43** system is referred to as the **EDK.** The EDK is distigiuished by:

- **EDK does not contain a PWG, It is remotely mounted (integrated in the accelerator pedal assembly).**
- **The accelerator pedal is not mechanically "linked" to the EDK**

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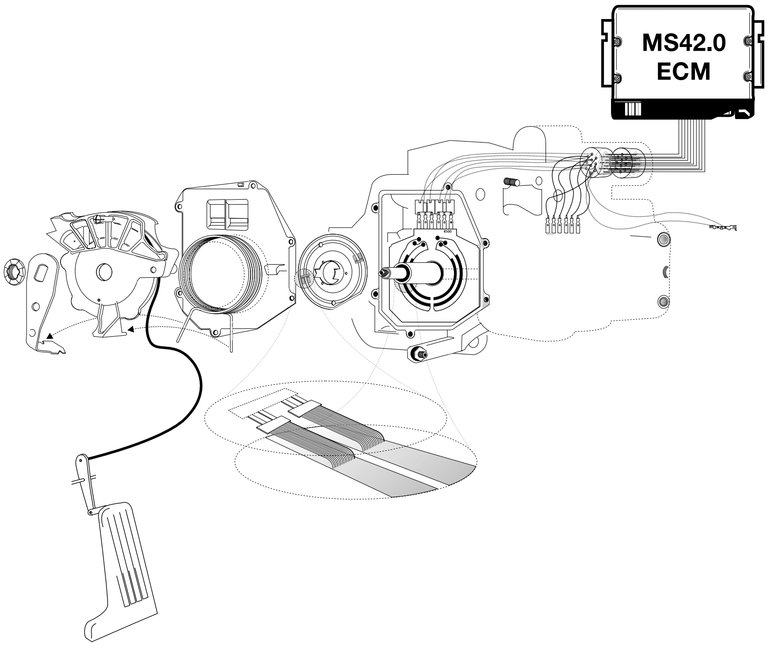
Throttle Position Sensor



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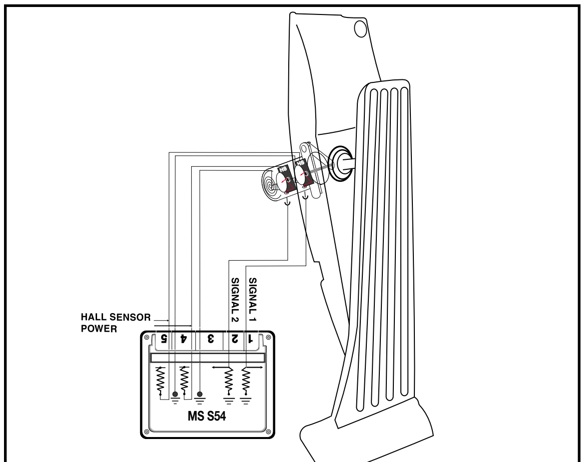
MDK: The throttle cable (foot pedal controlled) is connected to a pulley on the side of the MDK. The pulley is linked by springs to one end of the throttle shaft (springs also return the accelerator pedal to the rest position).

With the pulley linked by springs to the throttle shaft, this allows ASC intervention to override the driver's set throttle position.

As the pulley and shaft are rotated, the dual potentiometers (integral in the MDK housing = driver's wish) monitor the requested load for the ECM. Dual potentiometers are used for request plausibility.

EDK: The accelerator pedal module provides two variable voltage signals to the ECM that represents accelerator pedal position and rate of movement. Dual Hall Sensors are integral in the accelerator pedal module. The ECM compares the two values for plausibility. The module contains internal springs to return the accelerator pedal to the rest position.



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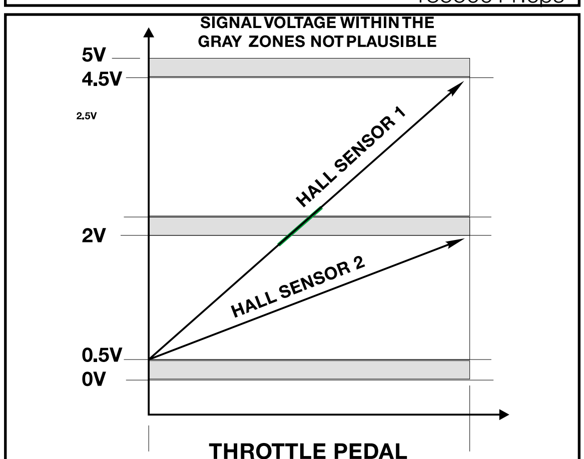
The ECM provides voltage (5v) and ground for the Hall sensors. As the accelerator pedal is moved from rest to full throttle, the sensors produce a variable voltage signal.

Hall sensor 1(request) = 0.5 to 4.5 volts
Hall sensor 2 (plausibility) = 0.5 to 2.0 volts

If the signals are not plausible, the ECM will use the lower of the two signals as the requested input. The throttle response will be slower and the maximum throttle response will be reduced.



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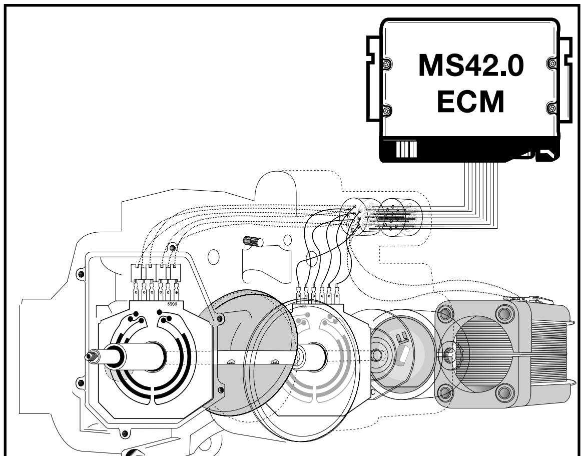
Throttle Motor and Feedback Position



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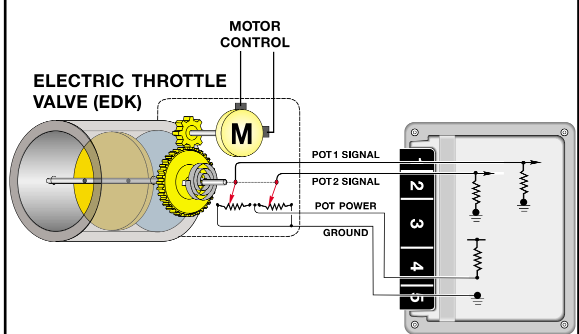
MDK: The MS42 ECM powers the MDK motor using pulse width modulation for opening and closing at a basic frequency of 600 Hz which positions the throttle plate. The throttle plate is also closed by an integrated return spring.

Dual potentiometers feedback the actual throttle plate position, allowing the ECM to verify correct throttle position. Dual potentiometers are used for feedback plausibility.



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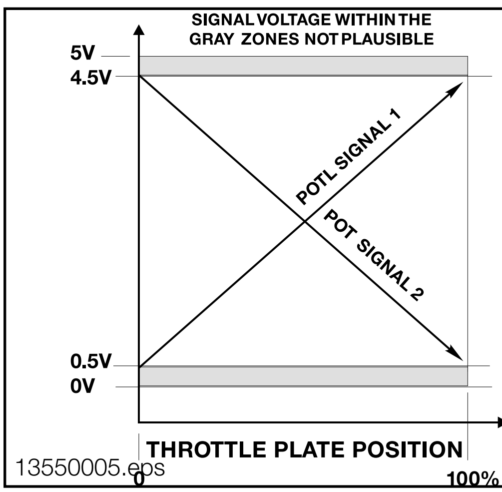
EDK: The MS43 ECM powers the EDK motor using pulse width modulation for opening and closing the throttle plate. The throttle plate is also closed by an integrated return spring.

Two integrated potentiometers provide voltage feedback signals to the ECM as the throttle plate is opened and closed.

• Feedback signal 1 provides a signal from 0.5v (closed) to 4.5 V (full throttle).
• Feedback signal 2 provides a signal from 4.5v (closed) to 0.5 V (Full Throttle).



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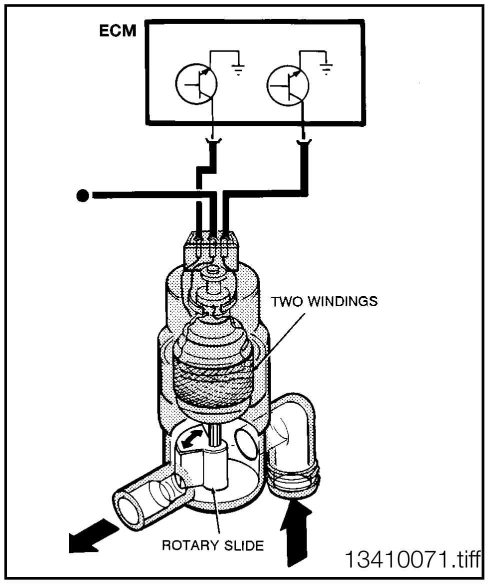
Potentiometer 1 is the primary feedback signal of throttle plate position and signal 2 is the plausibility cross check through the complete throttle plate movement.

Idle Air Actuator: This valve regulates air by-passing the throttle valve to control the engine idle/low speed.

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 "Malfunction Indicator Light" will be illuminated when the OBD II criteria is achieved.



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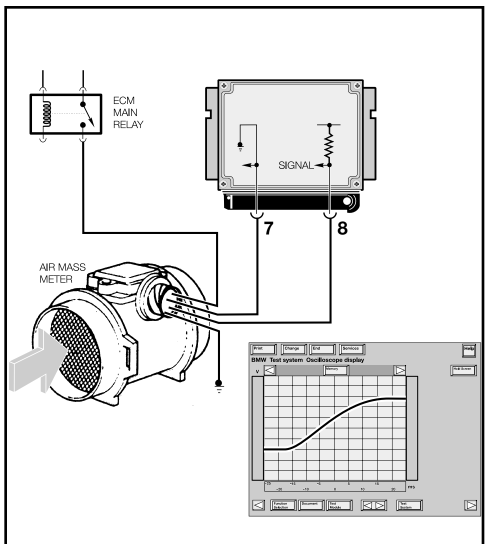
Hot-Film Air Mass Meter (HFM): The air volume input signal is produced electronically by the HFM which uses a heated metal film (180º C above intake air temperature) in the air flow stream.

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 injected fuel.

If this input is defective, a fault code will be set and the "Malfunction Indicator 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.



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NOTE: The Siemens 2 Type B designation simply indicates that the sensor is smaller in design. The mass air meter has different diameters based on engine application. The HFM is non-adjustable.


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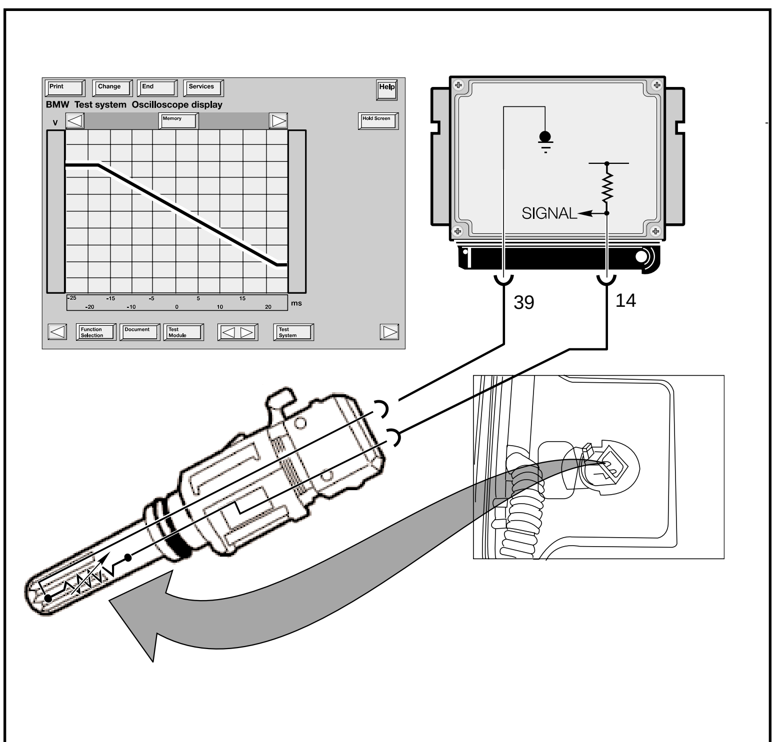
Air Temperature Signal: This signal is needed by the ECM to correct the air volume input for changes in the intake air temperature affecting the amount of fuel injected, ignition timing and Secondary Air Injection activation. The sensor is located in the center of the intake manifold (1).

The ECM provides the operating voltage (5v) to this sensor. The sensor decreases in resistance as the intake air temperature rises and vice versa (NTC). The ECM monitors the voltage signal that varies (0-5v) as the resistance changes.

If this input is defective, a fault code will be set and the “Malfunction Indicator Light” will be illuminated when the OBD II criteria is achieved. The ECM will operate the engine using the Engine Coolant Sensor input as a back up.



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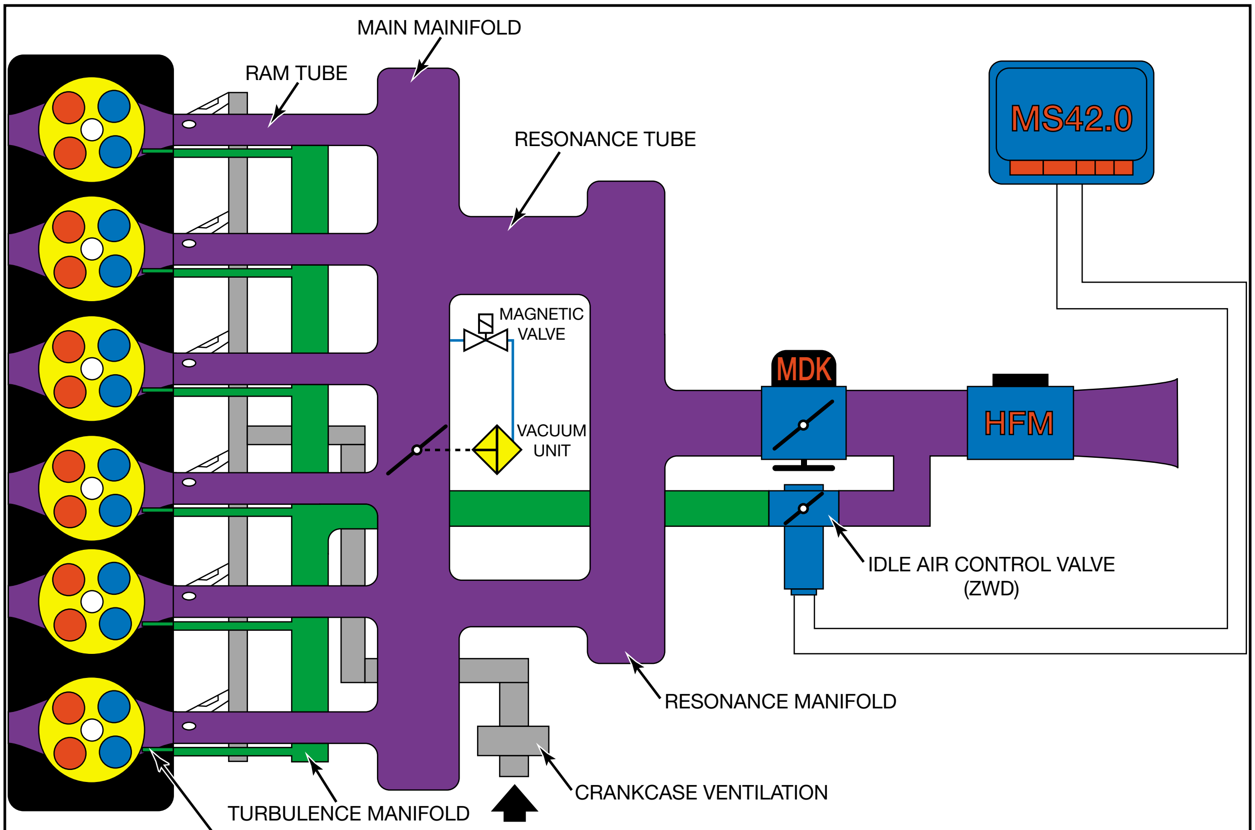
Resonance/Turbulence Intake System: On the M52TU andM54, the intake manifold is split into two groups of three (runners) which increases low end torque. The intake manifold also has separate (internal) turbulence bores which channels air from the idle speed actuator directly to one intake valve of each cylinder (matching bore of 5.5mm in the cylinder head).

Routing the intake air to only one intake valve causes the intake to swirl in the cylinder. Together with the high flow rate of the intake air due to the small intake cross sections, this results in a reduction in fluctuations and more stable combustion.



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Resonance System: The resonance system provides increased engine torque at low RPM, as well as additional power at high RPM. Both of these features are obtained by using an ECM controlled resonance flap (in the intake manifold).

During the low to mid range rpm, the resonance flap is closed. This produces a long/single intake tube which increases engine torque.

During mid range to high rpm, the resonance flap is open. This allows the intake air to draw through both resonance tubes, providing the air volume necessary for additional power at the upper RPM range.

The Resonance Flap (shown on the right) is closed when vacuum is applied and sprung open. This is a unitized assembly that is bolted into the intake manifold.


13550012.jpg

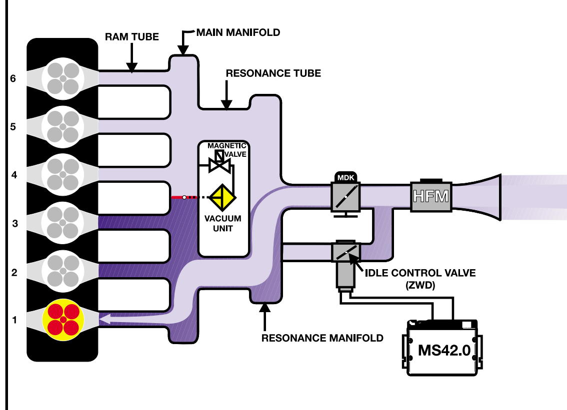
The ECM controls a solenoid valve for resonance flap activation. At speeds below 3750 RPM, the solenoid valve is energized and vacuum supplied from an accumulator closes the resonance flap. This channels the intake air through one resonance tube, but increases the intake velocity.

When the engine speed is greater than 3750 RPM (which varies slightly - temperature influenced), the solenoid is de-energized. The resonance flap is sprung open, allowing flow through both resonance tubes, increasing volume.

When the flap is closed, this creates another "dynamic" effect.

- **# 1 Cylinder Intake Valve open Low to Mid Range RPM (<3750 RPM)**

As the intake air is flowing into cylinder #1, the intake valves will close.



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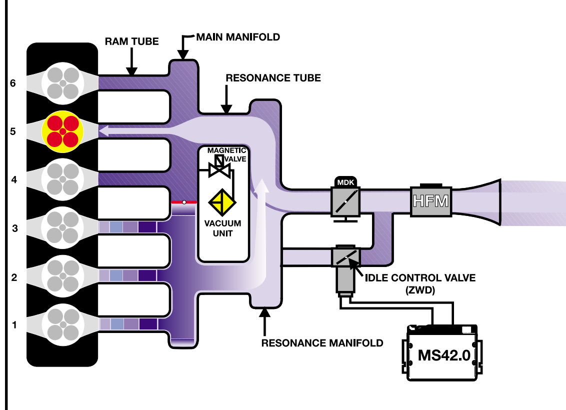
This creates a "block" for the in rushing air. The air flow will stop and expand back (resonance wave back pulse) with the in rushing air to cylinder #5.

- **#1 Cylinder Intake Valve closes #5 Intake Valve Open => Intake Air Bounce Effect Low to Mid Range RPM (<3750 RPM).**

The resonance "wave", along with the intake velocity, enhances cylinder filling.



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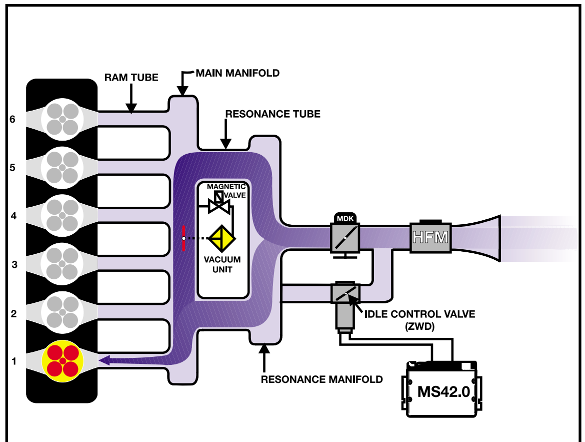
When the engine speed is greater than 3750 RPM the solenoid is de-energized. The resonance flap is sprung open, allowing flow through both resonance tubes, increasing volume.

- **#1 Cylinder Intake Valve Open - Intake air drawn from both resonance tubes. Mid to High Range RPM (>3750 RPM)**



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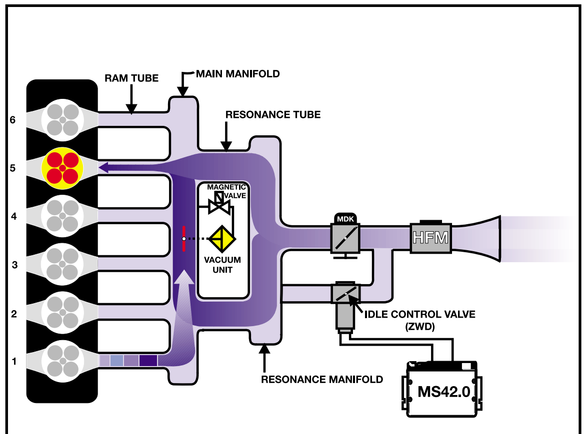
- **#5 Cylinder Intake Valve Open - Intake air drawn from both resonance tubes. Mid to High Range RPM (>3750 RPM).**

The resonance "wave", along with the intake volume, enhances cylinder filling.



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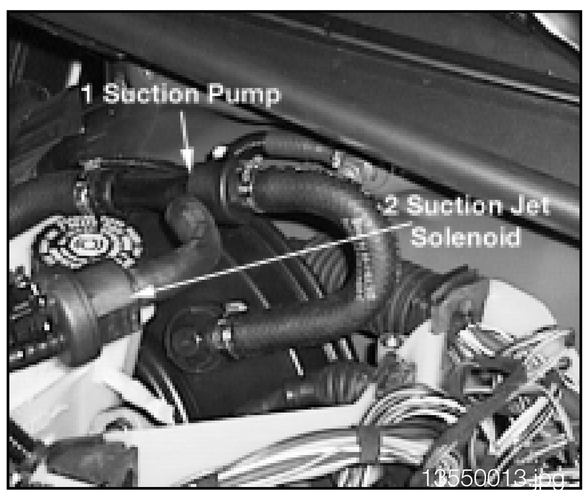
Suction Jet Pump: The ECM regulates the Suction Jet Pump (1) to provide sufficient vacuum for the brake booster under all operating conditions. The ECM controls the Suction Jet Pump Solenoid (2) to allow vacuum flow through.

Additional vacuum compensation is applied to the brake booster when the circuit is "deactivated" (solenoid sprung open).

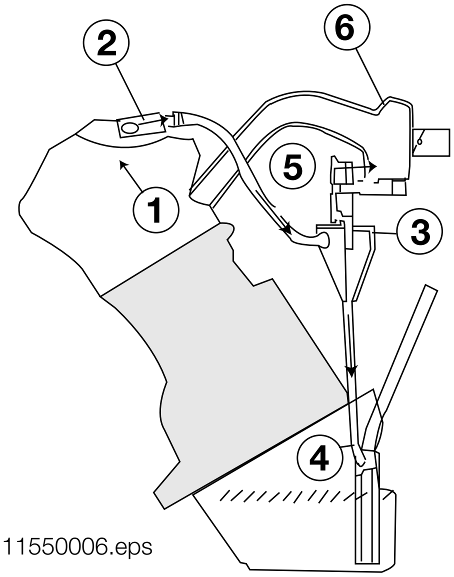
Vacuum enhancement is limited to the brake booster when the control circuit is "activated" (solenoid powered closed).



13550013.jpg

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 oil vapors exit the pressure control valve into the intake manifold. The collected oil will drain back into the oil pan (4).



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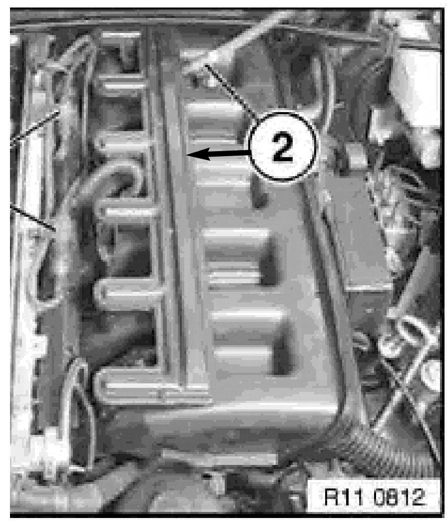
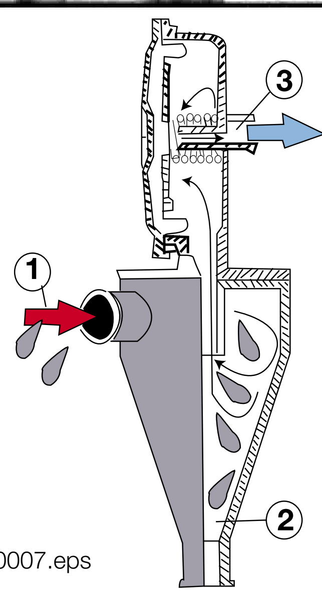
The vapors exit the pressure control valve and are drawn into the intake manifold through an external distribution tube (2). The tube has a splice at the front to equally distribute vapors to the back.

As the vapors exit the pressure control valve, they are drawn into the intake manifold through this external tube for even distribution.



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.

1. Engine Oil Vapors
2. Collective Drain Back Oil
3. Oil Vapors to the Intake Manifold (Distribution Tube)



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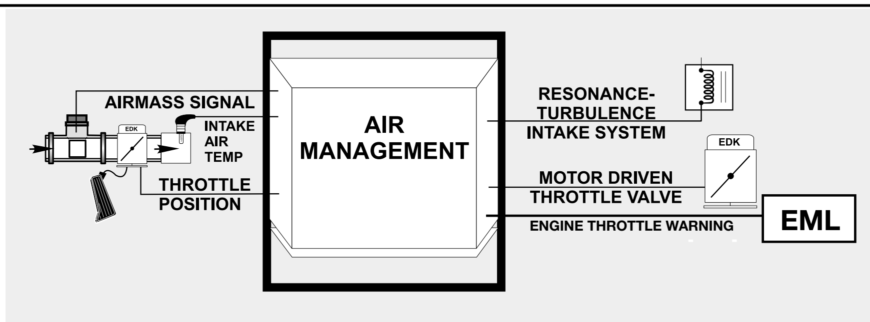
Principle of Operation

Air flow into the engine is regulated by the Throttle Valve and/or the Idle Air Actuator. Both of these air "passages" are necessary for smooth engine operation from idle to full load. On the MS42/MS43 system, the Throttle Valve and the Idle Air Actuator are **electrically controlled**. All of the ECM monitoring, processing and output functions are a result of regulated air flow.



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The Accelerator Pedal Position (PWG) is monitored by the ECM for pedal angle position and rate of movement. As the accelerator is moved, a rising voltage signal from the potentiometers/Hall sensors requests acceleration and at what rate. The ECM will increase the volume of fuel injected into the engine, advance the ignition timing and open the Throttle Valve and/or Idle Air Actuator.

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 air conditioning compressor (covered in Performance Controls).

As the accelerator pedal is released (integral springs), a decrease in voltage signals the ECM to activate fuel shut off if the RPM is above idle speed (coasting). The Throttle Valve will be closed and Idle Air Actuator Valve will open to maintain idle speed.

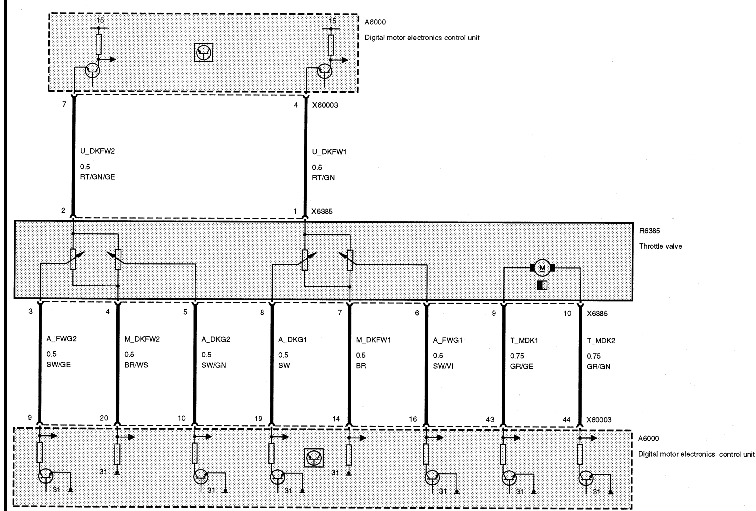
The ECM monitors the engine idle speed in addition to the accelerator pedal position and throttle position voltage. If the voltage values have changed (mechanical wear of throttle plate or linkage), the ECM will adjust the Idle Air Actuator to maintain the correct idle speed.

The potentiometers/Hall sensors are non-adjustable because the ECM "learns" the throttle angle voltage at idle speed. If the throttle housing/accelerator pedal module is replaced, the **ADAPTATIONS MUST BE CLEARED and ADAPTATION PROCEDURE MUST BE PERFORMED** using the DISplus/MoDIC. **If this is not performed, the vehicle will not start, or run in "fail-safe" mode.**

If this input is defective, a fault code will be stored and the "Malfunction Indicator and/or EML" Light will be illuminated. Limited engine operation will be possible.

The MS42 PWG (Driver's Wish) pedal position sensor is integrated in the MDK assembly. The PWG section of the MDK consists of two separate potentiometers with independent voltage supply and monitor circuits (provided by the ECM).

The pedal position sensor is monitored by checking each individual sensor circuit and comparing the two values. Monitoring is active as soon as the sensors receive voltage (KL15).



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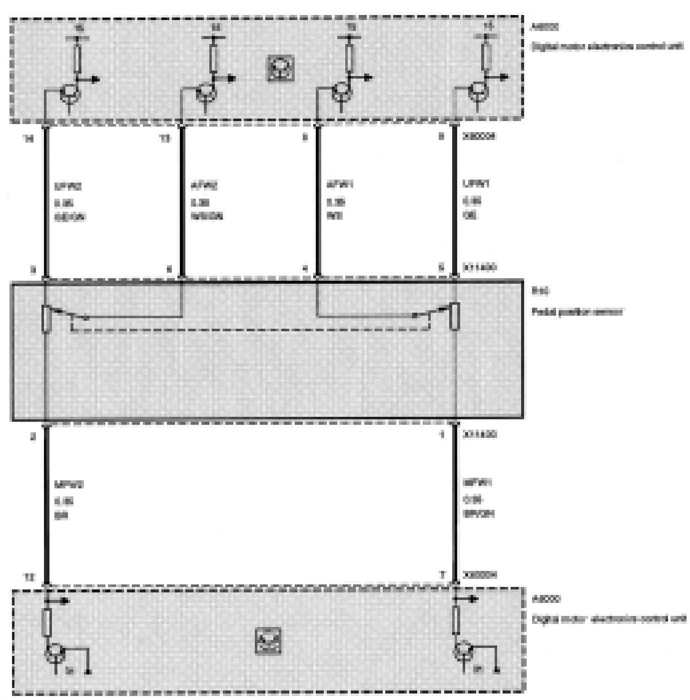
The MS43 PWG pedal position sensor consists of two separate Hall sensors with different voltage characteristics and independent power supply (located in the accelerator pedal module).

The pedal position sensor is monitored by checking each individual sensor circuit and comparing the two pedal values. Monitoring is active as soon as the sensors receive voltage (KL15). The ECM decides what operating mode the pedal position sensor is to assume.

- **Mode 0 = Pedal position sensor fully operable**
- **Mode 1 = Failure of one pedal position sensor (maximum engine speed is limited)**
- **Mode 2 = Failure of both pedal position sensors (engine speed limited to 1500 rpm)**



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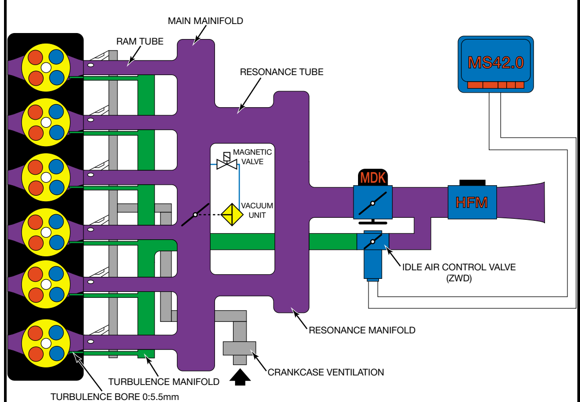
The Idle Air Actuator is controlled by the ECM modulating the ground signals (PWM at 100 Hz) to the valve. By varying the duty cycle applied to the windings, the valve can be progressively opened, or held steady to maintain the idle speed.

The ECM controls the Idle Air Actuator to supply the necessary air to maintain idle speed. When acceleration is requested and the engine load is low (<15%), the actuator will also supply the required air.

The basic functions of the idle speed control are:

• Control the initial air quantity (air temp <0º C, MDK/EDK is simultaneously opened).
• Variable preset idle based on load and inputs.
• Monitor RPM Feedback for each preset position.
• Lower RPM range intake air flow (even while driving)
• Vaccum Limitation
• Smooth out the transition from acceleration to deceleration.



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Under certain engine operating parameters, the MDK/EDK throttle control and the Idle Air Actuator are operated simultaneously. This includes all idling conditions and the transition from off idle. As the request for load increases, the idle valve will remain open and the MDK/EDK will supply any additional air volume required to meet the demand.

Emergency Operation of Idle Air Actuator:

If a fault is detected with the Idle Air Actuator, the ECM will initiate failsafe measures depending on the effect of the fault (increased air flow or decreased air flow). If there is a fault in the Idle Air Actuator/circuit, the MDK/EDK will compensate to maintain idle speed. The “Malfunction Indicator and/or EML” Light will be illuminated to inform the driver of a fault.

If the fault causes increased air flow (actuator failed open), VANOS and Knock Control are deactivated which noticeably reduces engine performance.

The MS42 MDK Feedback Signal Monitoring/Emergency Operation when a fault is detected in the system is as follows:

• Emergency operation 1 - Faults which do not impair actuator control, but which adversely affect the functioning of the MDK.
• Emergency operation 2 - Applies when faults are encountered which might affect the performance of the MDK.
• Emergency operation of idle Air Actuator.

EMERGENCY OPERATION 1

Emergency operation 1 limits the dynamic operation if one or more of the potentiometers fail. The engine can slowly reach maximum speed with limited power.

EMERGENCY OPERATION 2

If another fault is encountered in addition to emergency operation 1 or if the plausibility is affected, emergency operation 2 is activated by the ECM. An example of plausibility fault would be that the pulley position does not match the MDK position and the associated airflow (from the HFM). Emergency operation 2 can also be initiated by simultaneously pressing both the accelerator pedal and the brake pedal, or if a fault is encountered in the brake light switch diagnosis (see Performance Controls).

When in emergency 2 operation mode, there is an engine speed limitation (slightly above idle speed) in addition to the measures for emergency operation 1. In emergency operation 2, the engine speed is always limited to 1300 RPM if the brake is not applied, and approximately 1000 RPM if the brake is applied. The vehicle speed is limited to approximately 20-25 mph.

The emergency operation functions are inactive when:

• Emergency operation 1 - Faults which affect the fuctioning of the MDK.
• Emergency operation 2 - Applies when faults are encountered which might affect driveability.
• Emergency operation of Idle Air Actuator.

Further Monitoring Concepts

The MDK safety concept can detect a jammed or binding throttle valve as well as a broken link spring. This fault is detected by the ECM monitoring the feedback potentiometers from the MDK in relation to the pulse width modulation to activate the MDK motor.

Emergency operation functions if the throttle valve is jammed:

• Activation of the "EML" Light to alert the driver of a fault.
• MDK is deactivated, the throttle valve is compensated for by closing the idle speed actuator and retarding the ignition (engine power reduction).
• To maintain vehicle control, the MDK opening is compensated for by closing the idle speed actuator and retarding the ignition (engine power actuator).
• Engine power is further limited by fuel injector cutout.

In the event of a fault, the DISplus or MoDIC must be used to interrogate the fault memory, and clear the fault once the proper repair has been performed.

The MS43 EDK Feedback Signal Monitoring/Failsafe Operation when a fault is detected in the system is as follows:

- **The EDK provides two seperate signals from two integrated potentiometers (Pot 1 and Pot 2) representing the exact position of the throttle plate.**

- **EDK Pot 1 provides the primary throttle plate position feedback. As a redundant monitoring feature, Pot 2 is continuously cross checked with Pot 1 for signal plausibility.**

- **If plausibility errors are detected between Pot 1 and Pot 2, MS 43.0 will calculate the inducted engine air mass (from HFM signal) and only utilize the potentionmeter signal that closely matches the detected intake air mass.**

    - **The MS 43.0 uses the air mass signalling as a "virtual potentiometer" (pot 3) for a comparative source to provide failsafe operation.**

    - **If MS 43.0 cannot calculate a plausible conclusion from the monitored pots (1 or 2 and virtual 3) the EDK motor is switched off and fuel injection cut out is activated (failsafe operation is not possible).**

- **The EDK is continuously monitored during all phases of engine operation. It is also briefly activated/adapted when KL 15 is initially switched on as a "pre-flight check" to verify it's mechanical integrity (no binding, appropriate return spring tension, etc). This is accomplished by monitoring both the motor control amperate and the reaction speed of the EDK feedback potentiometers. If faults are detected the EDK motor is switched off and fuel injection cut off is activated (failsafe operation is not possible). The engine does however continue to run extremely rough at idle speed.**

- **When in emergency operation, the engine speed is always limited to 1300 RPM by fuel injector cutout, and activation of the "EML" Light to alert the driver of a fault.**

- **When a replacement EDK is installed, the MS 43.0 adapts to the new component (required amperage draw for motor control, feedback pot tolerance difference, etc). This occurs immediately after the next cycle of KL15 for approximately 30 seconds. During this period of adaptation, the maximum opening of the throttle plate is 25%.**

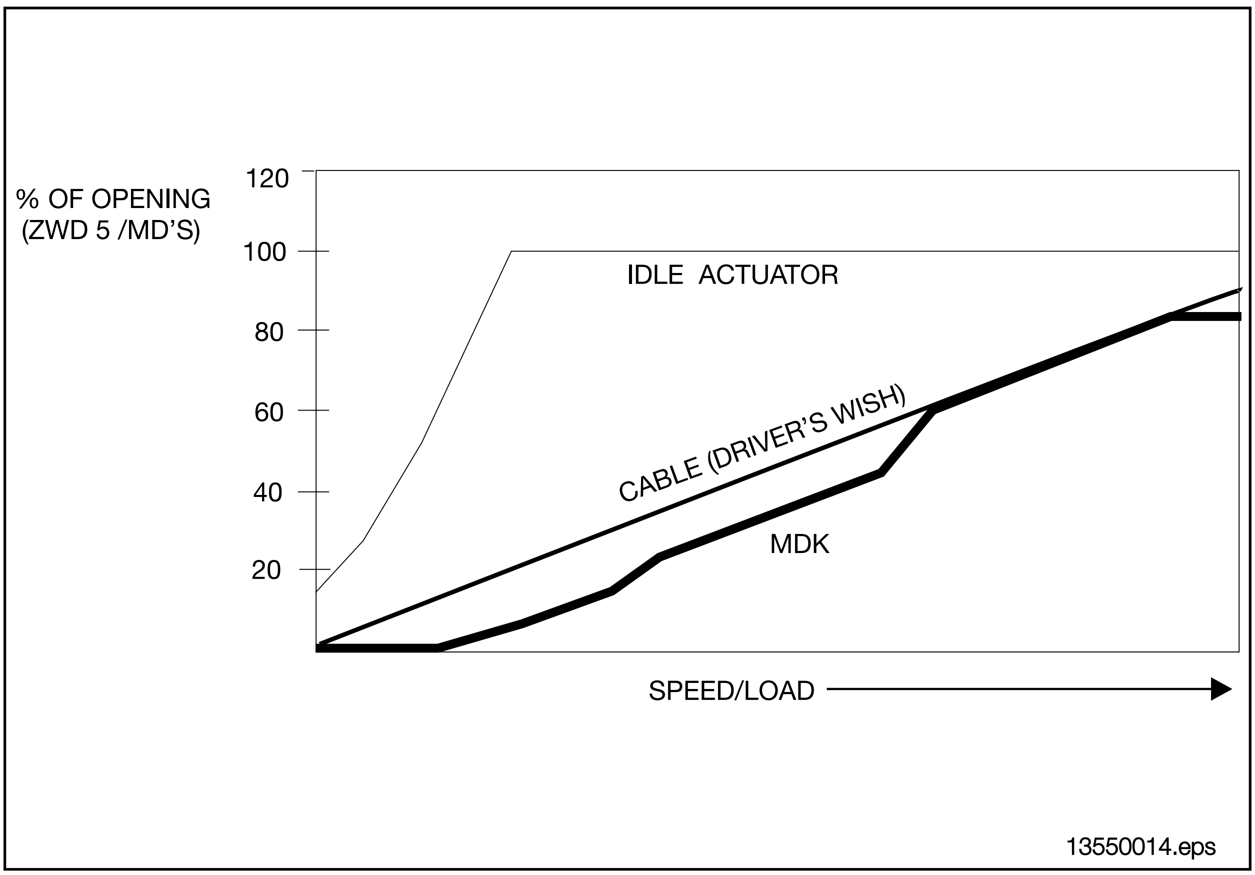
The Total Intake Air Flow Control is performed by the ECM simultaneously operating the MDK/EDK throttle control and the Idle Air Actuator.

The ECM detects the driver's request from the potentiometers/Hall Sensors monitoring the accelerator pedal position. This value is added to the Idle Air control value and the total is what the ECM uses for MDK/EDK activation. The ECM then controls the Idle Air Actuator to satisfy the idle air "fill". In addition, the MDK/EDK will also be activated = pre-control idle air charge. Both of these functions are utilized to maintain idle RPM.

The MDK/EDK is electrically held at the idle speed position, and all of the intake air is drawn through the Idle Air Actuator. Without a load on the engine (<15%), the MDK/EDK will not open until the extreme upper RPM range. If the engine is under load (>15%), the Idle Air Actuator is open and the MDK/EDK will also open.

MDK: In the upper PWG range (approximately >60%), the MDK is switched off. The throttle valve is opened wider exclusively by the pulley via the spring linkage.

At the full throttle position, "kickdown" is obtained by depressing the accelerator pedal fully. This will overwind the pulley, but the spring linkage will not move the throttle plate past 90 degrees of rotation.



The Hot-Film Air Mass Meter (HFM) varies voltage monitored by 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.

The heated surface of the hot-film in the intake air stream is regulated by the ECM to a constant temperature of 300º C above inyake air temperature. The incoming air cools the film and the ECM monitors the changing resistance which affects current flow through the circuit. The hot-film does not require a “clean burn”, it is self cleaning due to the high operating temperature for normal operation.

If this input is defective, a fault code will be set and the “Malfunction Indicator Light” will illuminate when the OBD II criteria is achieved. The ECM will maintain engine operation based on the Throttle Position Sensors and Crankshaft Position/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 igniton timing to reduce the risk of detonation. If the intake air is cooler, the base ignition timing will be advanced. The ECM uses this input as a determining factor for Secondary Air Injection activation (covered in the Emissions section).

If this input is defective, a fault code will be set and the “Malfunction Indicator Light” will illuminate when the OBD II criteria is achieved. The ECM will maintain engine operation based on the HFM and Engine Coolant Temperature sensor.

The Suction Jet Pump is regulated by the ECM to provide sufficient vacuum for the brake booster under all operating conditions. The ECM controls the Suction Jet Pump Solenoid to allow vacuum flow through. The additional vacuum compensation is activated by the ECM when the idle air actuator is regulated for:

• A/C Compressor “on”
• Vehicle in gear and the clutch is released (driving under load)
• Engine in warm-up phase <70º C

Additional vacuum compensation is applied to the brake booster when the circuit is “deactivated” (Solenoid sprung open). Vacuum enhancement is limited to the brake booster when the control circuit is “activated” (Solenoid powered closed).

Workshop Hints

Air Management

Unmetered air leaks can be misleading when diagnosing faults causing “Malfunction Indicator 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 detected codes
• Whistling noises
• Performance/driveability complaints

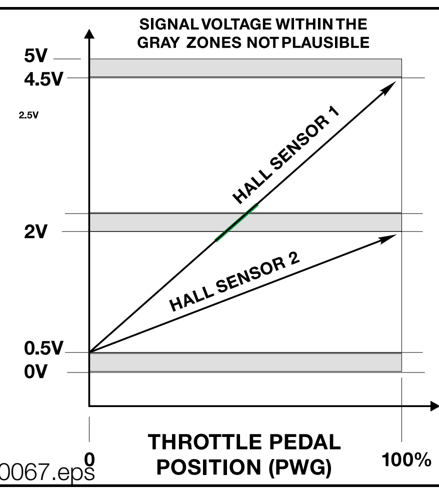
Please refer to the following Service Information Bulletins for details on the **Crankcase Ventilation System:**

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

Throttle Position Sensors - Testing

The Throttle Position Sensors can be tested with the following methods:

• DISplus Status Page (appox. 0.5v. to 4.5v)
• DISplus Oscilloscope - Select from the Preset Measurement which requires taking the measurement with the ECM and Universal Adapter connected to the circuit (as shown on the right).
• MS42: Resistance check of the dual potentiometer circuits, using the Universal Adapter with the ECM disconnected.
• MS43 (shown): Voltage check of the dual Hall sensor circuits, using the Universal Adapter with the ECM disconnected.



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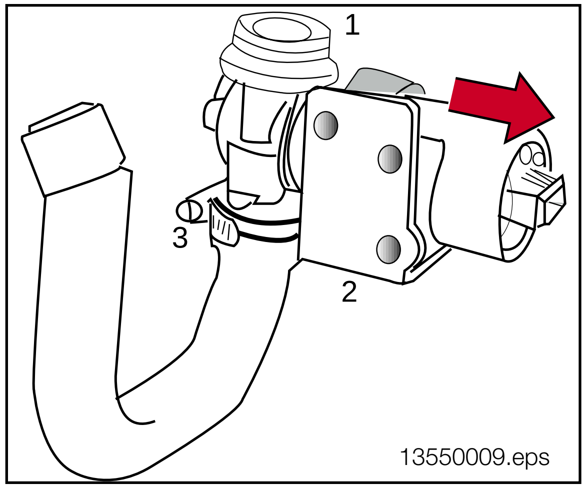
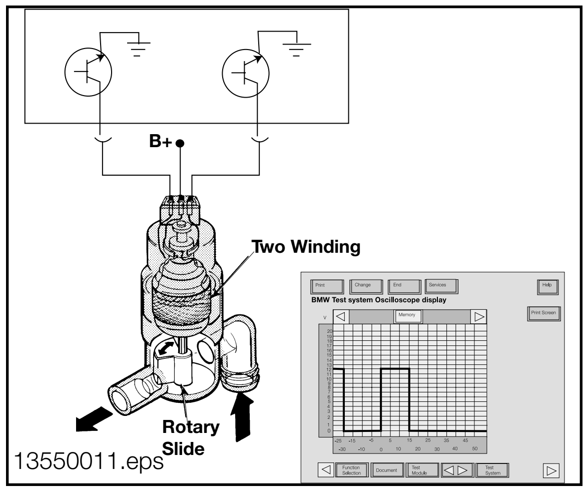
Idle Air Actuator Valve - Testing



• **The Idle Air Actuator Valve and air circuit (pas sage 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 DISplus/MoDIC.**
• **The Pulse Width Modulated ground outputs from the ECM can be tested using the DISplus/ MoDIC Oscilloscope.**
• **Consult Technical Data for specified idle speed.**



NOTE: If the valve is blocked or contaminated, an HFM fault code can also be present.

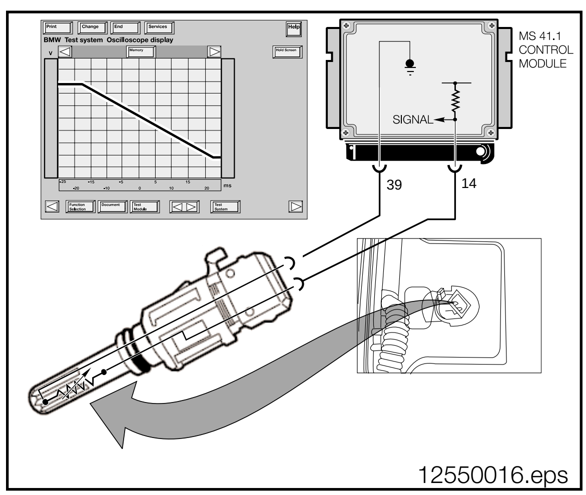
For complaints on M54 3.0 Hesitates, Stumbles at Idle refer to Service Information Bulletins:

• **S.I. #12 51 00 and #12 10 00 on ECM Calibration**

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)**



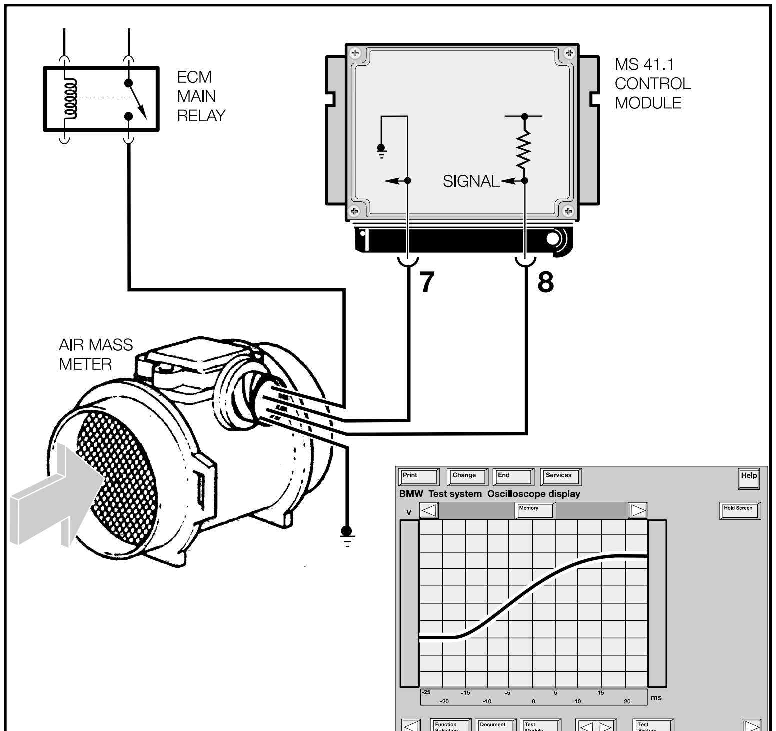
This sensor should be tested using:

• **DISplus/Modic Status page**
• **DISplus/Modic Multimeter 2.2 - 2.7 k ohms at 20° C**

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
• "Malfunction Indicator Light" Illuminated
• Engine Starts And Runs Only With Accelerator Pedal Depressed



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

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

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.

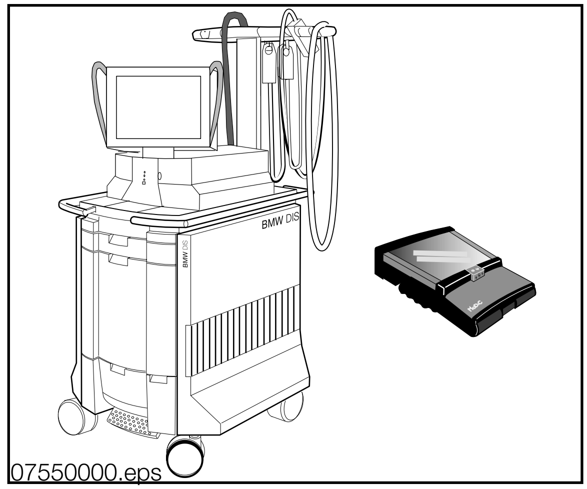
MS42 MDK

• If a vehicle has a customer complaint of the "Malfunction Indicator and/or EML" Light on and fault codes relating to the **MDK/plausibility**, refer to the Service Information Bulletin "**Motor Driven Throttle Valve (MDK)" SI # 12 07 99** for further detailed troubleshooting.

• If a vehicle has a customer complaint of **"Engine Speed Appears To Hang During Shifts"**, refer to the Service Information Bulletin SI # 12 17 99. This SI further details troubleshooting regarding the **Clutch Switch/Circuit and upgrade to a three wire switch including ECM reprogramming.**

Tools and Equipment

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



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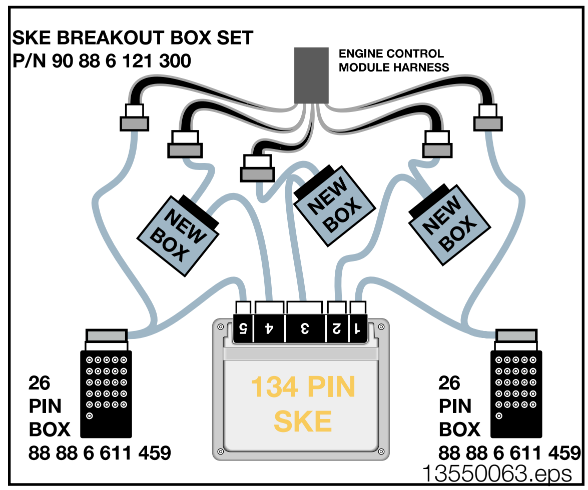
It is best to make the checks at the ECM connection, this method includes testing the wiring harness.

The correct Universal Adapter for the MS42/ MS43 application should be used (#90 88 6 121 300). This will ensure the pin connectors and the harness will not be damaged.



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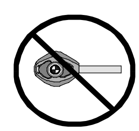
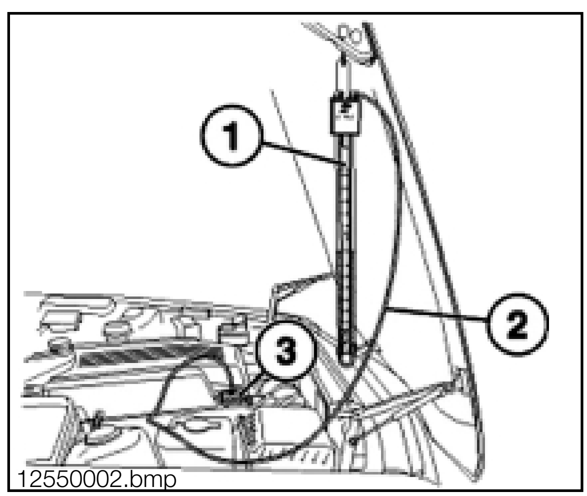
When installing the Universal Adapter to the ECM (located in the Electronics Box in the engine compartment), make sure the ignition is switched off.



NOTE for MS43: Allow at least 3 minutes to elapse after the key was set to the "OFF" position before disconnecting the ECM/ TCM. This will allow sufficient time to complete the DM TL test. Voltage may be present (up to 3 minutes) causing damage to the ECM/TCM if they are disconnected during this time period (arcing).

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



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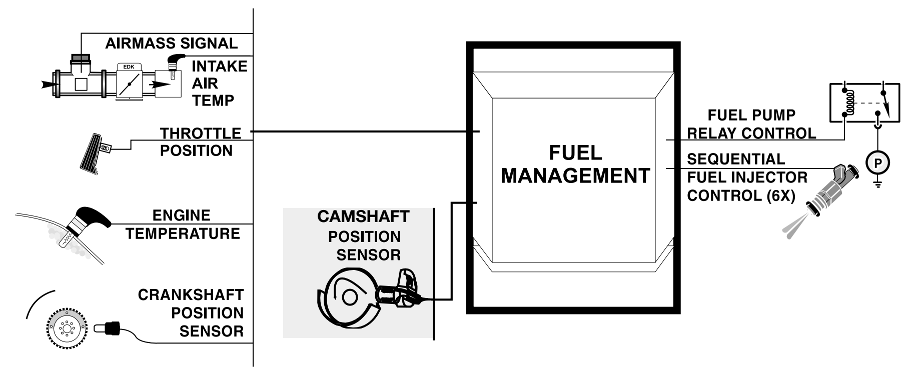
Fuel Management



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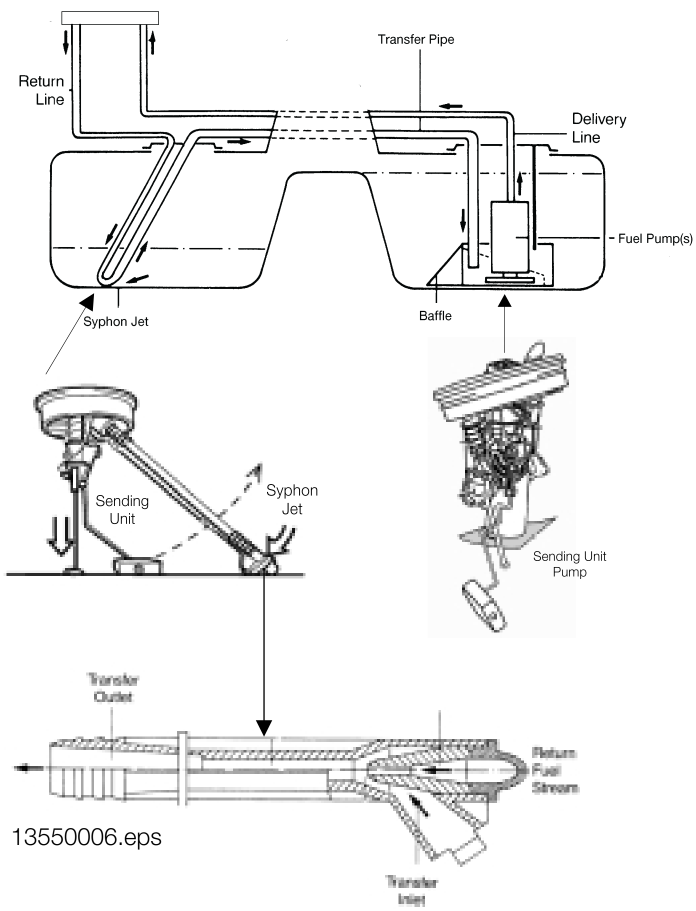

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Fuel Tank: The fuel tank is made of high density polyethylene (reduced weight) which is manufactured to meet safety requirements.

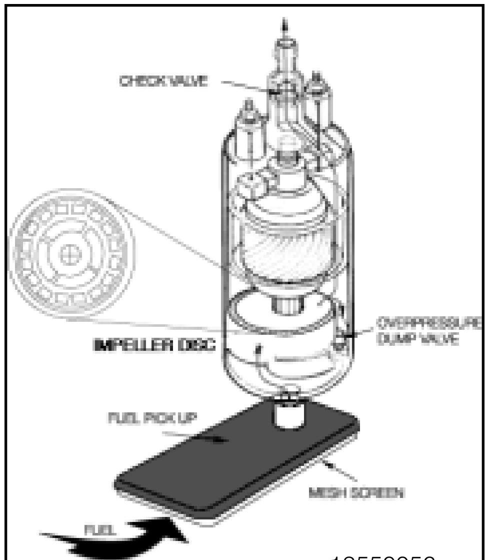
A mid-chassis mounted “saddle” type tank is used (E46, E39, E53) which provides a tunnel for the driveshaft but creates two separate low spots in the tank.

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.

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.



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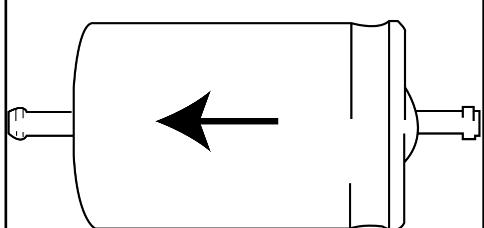
When the fuel pump is powered, the armature will rotate the impeller disc creating low pressure at the inlet. The fuel will be drawn into the inlet and passed through the fuel pump housing (around the armature). The fuel lubricates and cools the internals of the pump motor.

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.



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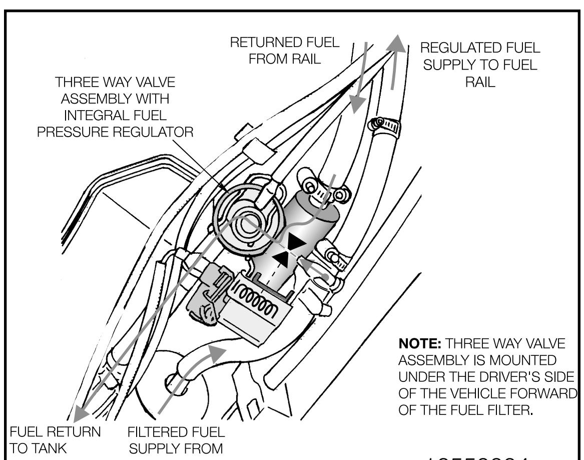
The pump contains an internal overpressure relief valve that will open (reducing roller cell pressure) if there is a restriction in the fuel supply hardware.

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).

MS42 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.



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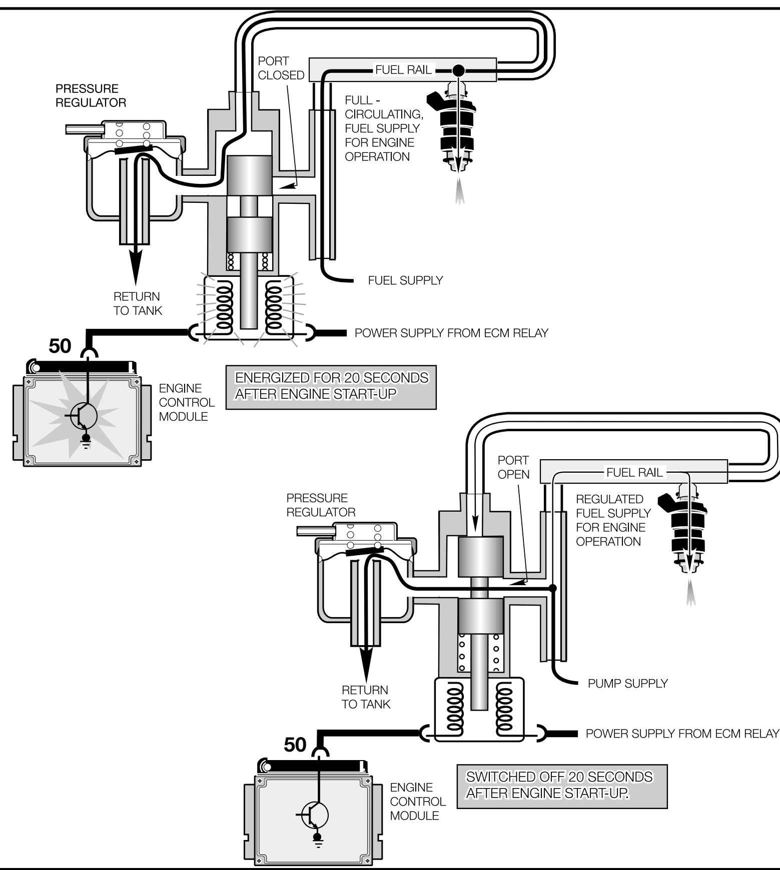
Using the by-pass type regulator reduces the returned fuel temperature to the tank.

MS42 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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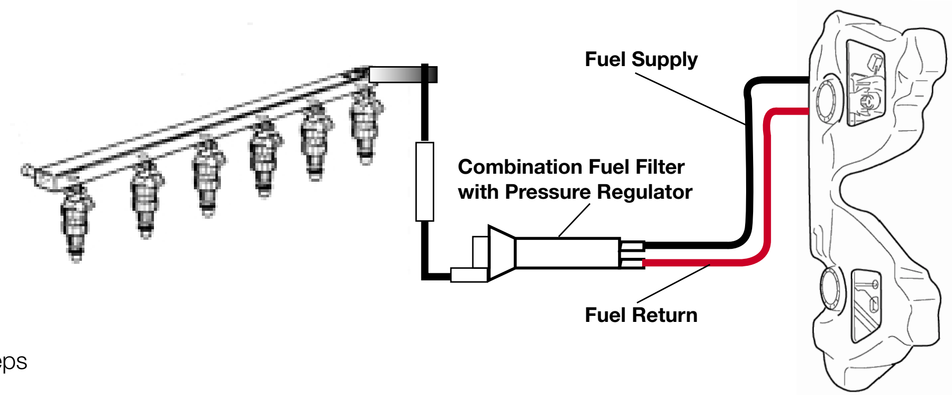
MS43 Fuel Supply: The fuel is supplied through a Non Return Fuel Rail System. This system meets Running Loss compliance without the use of the 3/2 Way Valve.

The fuel supply pressure is controlled by the 3.5 Bar fuel pressure regulator integrated in the fuel filter assembly. The regulator is influenced by internal fuel pressure and not intake manifold vacuum. The fuel exits the fuel pressure regulator supplying the fuel rail and the injectors. The fuel filter assembly is located under the left front floor area (next to the frame rail).

The fuel return line is located on the filter/regulator assembly which directs the unused fuel back to the fuel tank. The fuel tank hydrocarbons are reduced by returning the fuel from this point (lower temperatures) instead of from the fuel rail.



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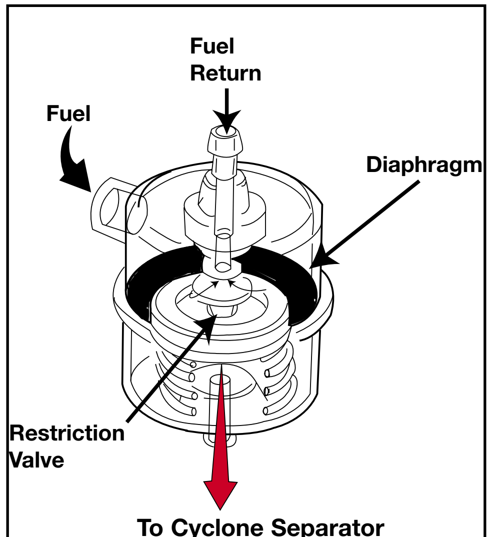
The fuel rail distributes an even supply of fuel to all of the injectors, and also serves as a volume reservoir. The fuel rail is secured by bolts to the intake manifold.

Fuel Pressure Regulator: The Fuel Pressure Regulator maintains a constant pressure for the fuel injectors. The fuel pressure is set to 3.5 bar (+/- 0.2) by internal spring tension on the restriction valve. The attached fuel pressure regulator is not influenced by vacuum.

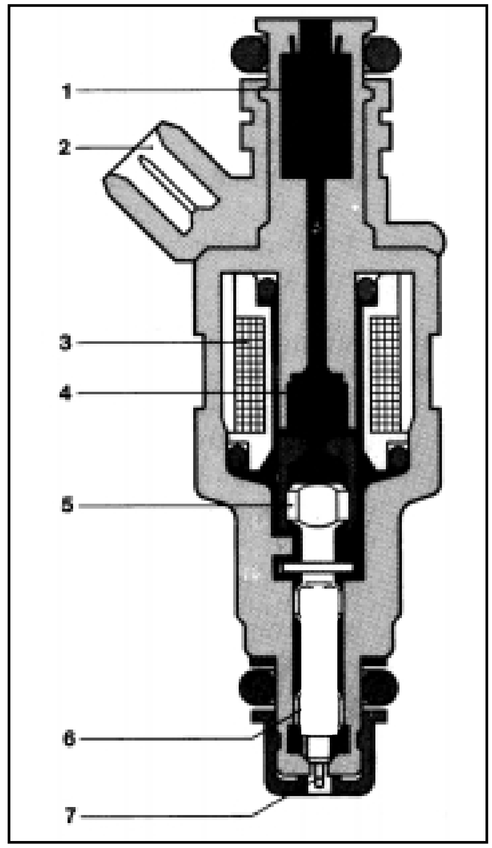
The ECM determines the fuel quantity compensation for manifold vacuum changes. This is based on throttle position, HFM and load for precise compensation.

A small hose is routed to the crankcase cyclone separator (in case of regulator diaphragm leakage). When the restriction valve opens, unused fuel returns from the regulator/filter assembly back to the fuel tank.



13550025.eps

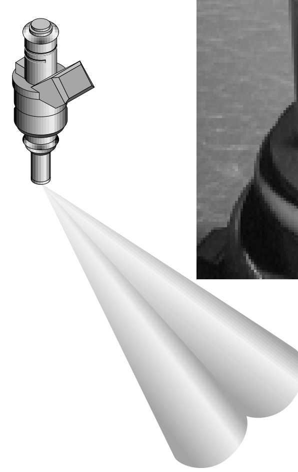
Siemens Fuel Injectors: The Fuel Injectors are electronically controlled solenoid valves that provide precise metered and atomized fuel into the engine intake ports. The Fuel Injector Valve consists of:



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

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 ECM 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 tip of the injector that is fitted with a directional angle "plate" with dual outlets. This "fans out" the spray into an angled patterns which helps to atomize the fuel. When the ECM deactivates current flow, the needle valve is sprung closed against the seat and fuel flow through the injector is stopped. The lower portion of the injector body is jacketed in metal.



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).

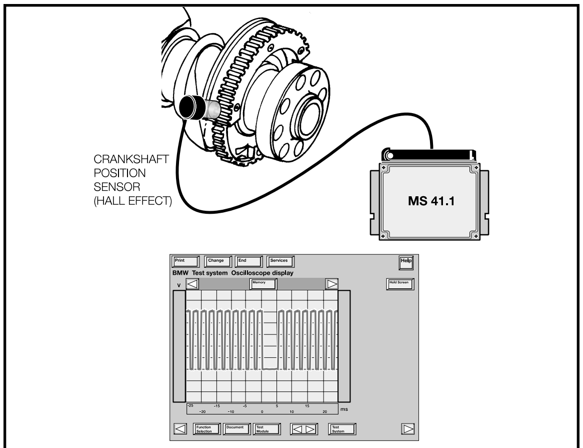
A Fuel Injector is faulty (mechanical or electrical), it can produce the following complaints:

• "Malfunction Indicator 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

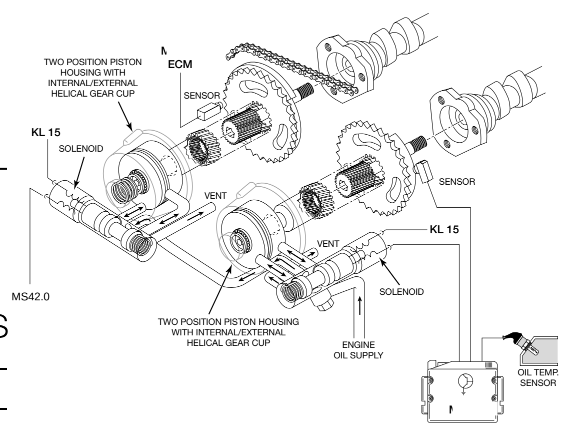
The crankshaft position sensor is monitored as part of OBD II requirements for Misfire Detection. If this input is faulty, the ECM will operate the engine (limited driveability) from the Camshaft Sensor input. A fault with this input will produce the following complaints:

• Hard Starting/Long Crank Time	**• Driveability/Misfire/Engine Stalling**
• "Malfunction Indicator Light"	

Camshaft Sensors - Intake and Exhaust Camshafts

The "static" Hall sensors are used so that the camshaft positions are recognized once ignition is on (KL15) before the engine is started. The function of the intake cam sensor is:

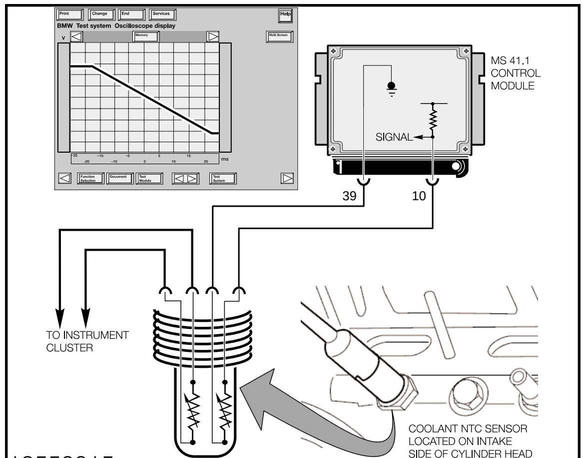
- Cylinder "work cycle" for injection timing
- Synchronization
- Engine speed sensor (if crankshaft speed sensor fails)
- VANOS position control of the intake cam



The exhaust cam sensor is used for VANOS position control of the exhaust cam. If these sensors fail there are no substitute values, the system will operate in the failsafe mode with no VANOS adjustment. The engine will still operate, but torque reduction will be noticeable.

NOTE: Use caution on repairs as not to bend the impulse wheels.

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 (left rear). 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.

Throttle Position: 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).

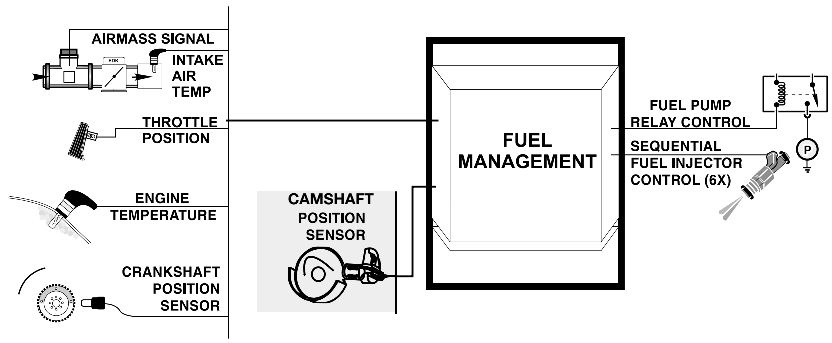
Hot-Film Air Mass Meter (HFM): The air volume input signal is used by the ECM to determine the amount of fuel to be injected for correct air/fuel ratio. For details about the sensor, refer to the Air Management section.

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.

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.

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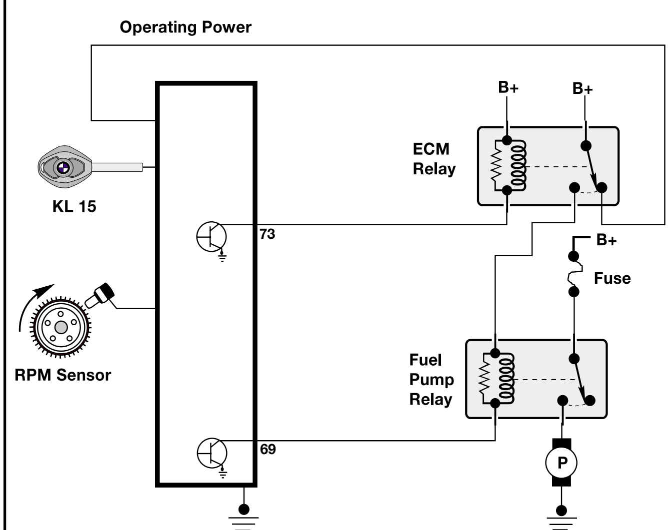
The Fuel Pump will be activated when the ignition (KL15) is switched "on" and the ECM supplies a ground circuit to activate the Fuel Pump Relay. The Fuel Pump Relay supplies operating power to the in-tank mounted fuel pump. This is a momentary activation to "pressurize" (prime) the fuel system.

The ECM then requires an engine speed 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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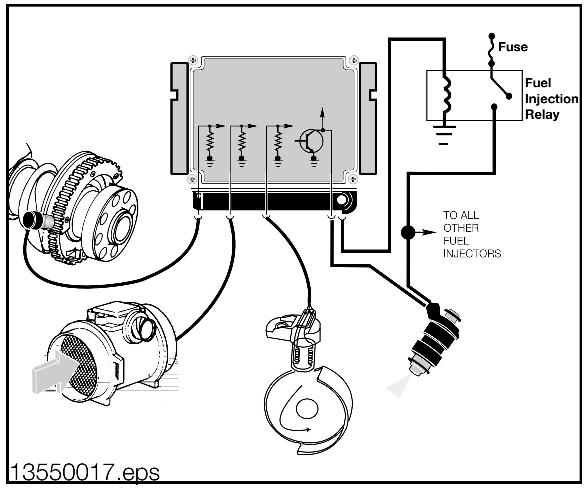
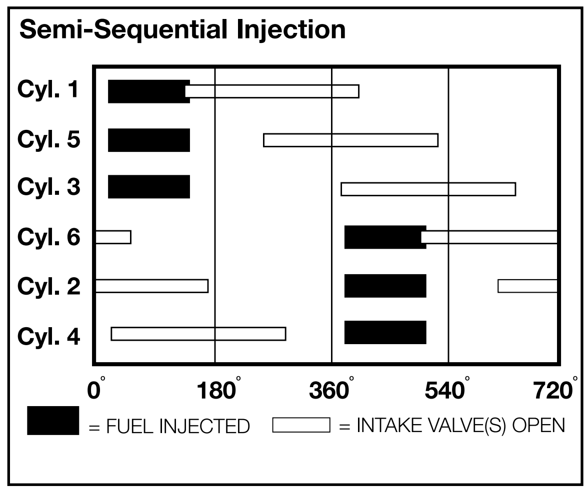
The Fuel Injectors will be opened by the ECM to inject pressurized fuel into the intake ports. The Fuel Injectors receive voltage from the Engine Control Module Relay. The ECM controls the opening by activating the ground circuits for the Solenoid Windings. The ECM will vary the duration (in milli-seconds) 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.



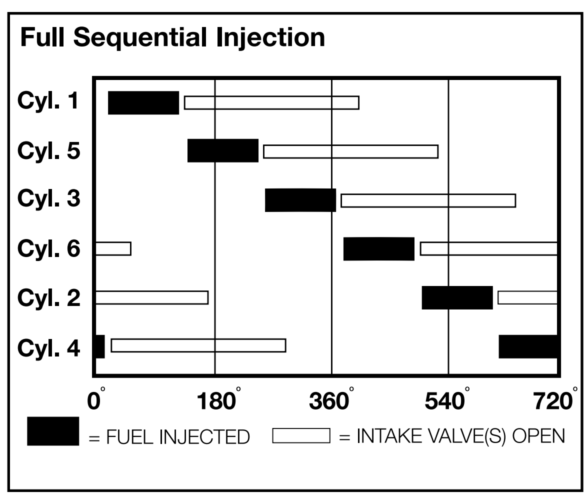
The ECM is programmed to activate the Final Stage output transistors once for every two revolutions of the crankshaft in two groups (Semi-Sequential Injection).

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.

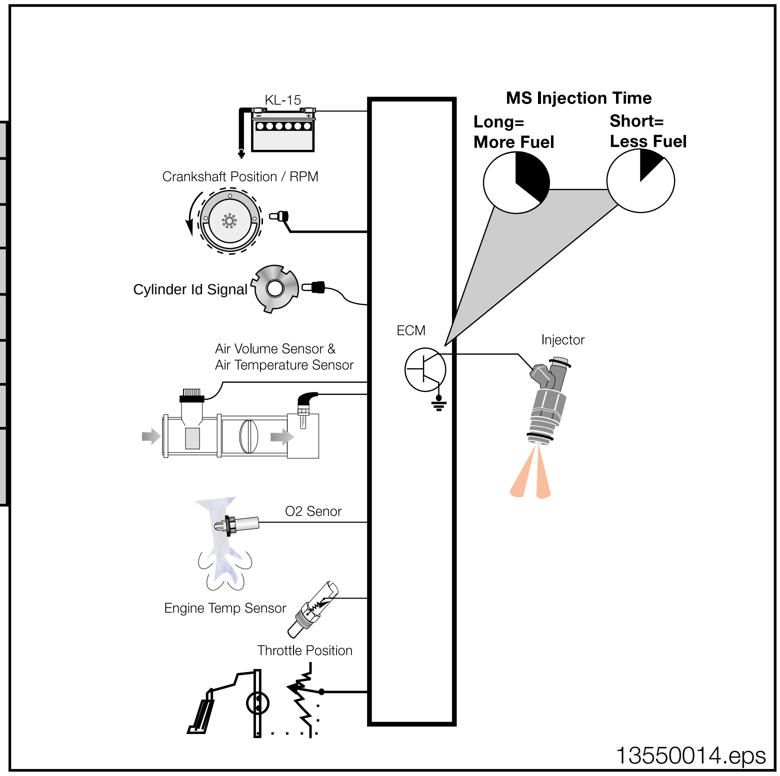
When activated, each injector delivers the full fuel charge at separate times during each engine working cycle.



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 injection "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.

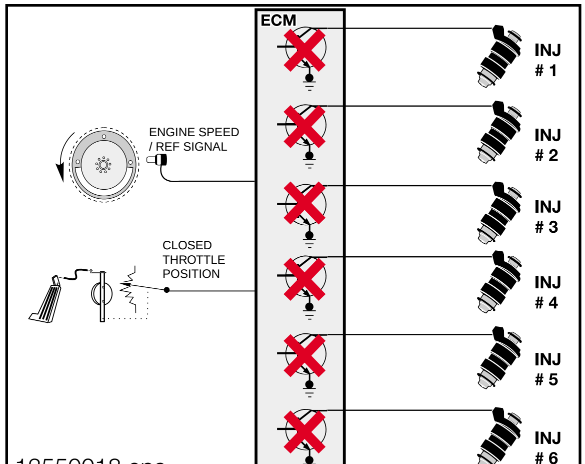
The Hot-Film Air Mass (HFM) signal provides the measured amount of intake air volume/mass. This input is used by the ECM to determine the amount of fuel to be injected to “balance” the air/fuel ratio.

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.

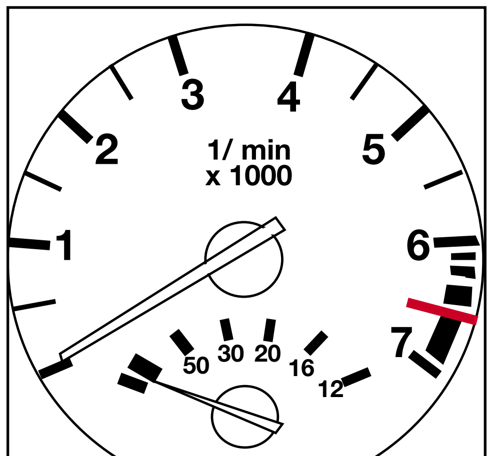
Injection "Reduction" Time is required to control fuel economy, emissions, engine and vehicle speed limitation. The ECM will "trim" back or deactivate the fuel injection as necessary while maintaining optimum engine operation.



13550018.eps

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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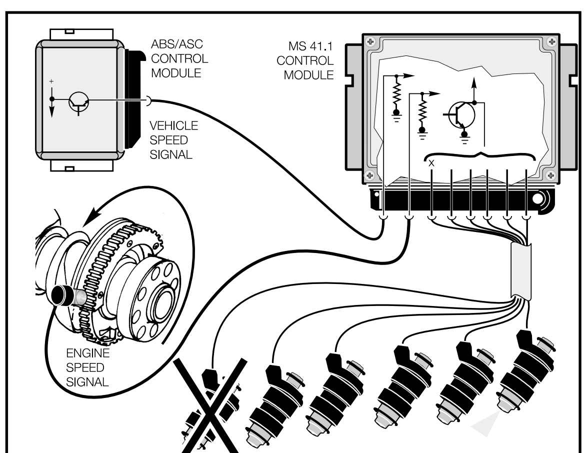
The ECM will selectively deactivate injectors to control maximum engine rpm (regardless of vehicle speed). When the engine speed reaches 6500 rpm, the injectors will be individually deactvated as required to protect the engine from over-rev. As the engine speed drops below 6500 rpm, injector activation 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).



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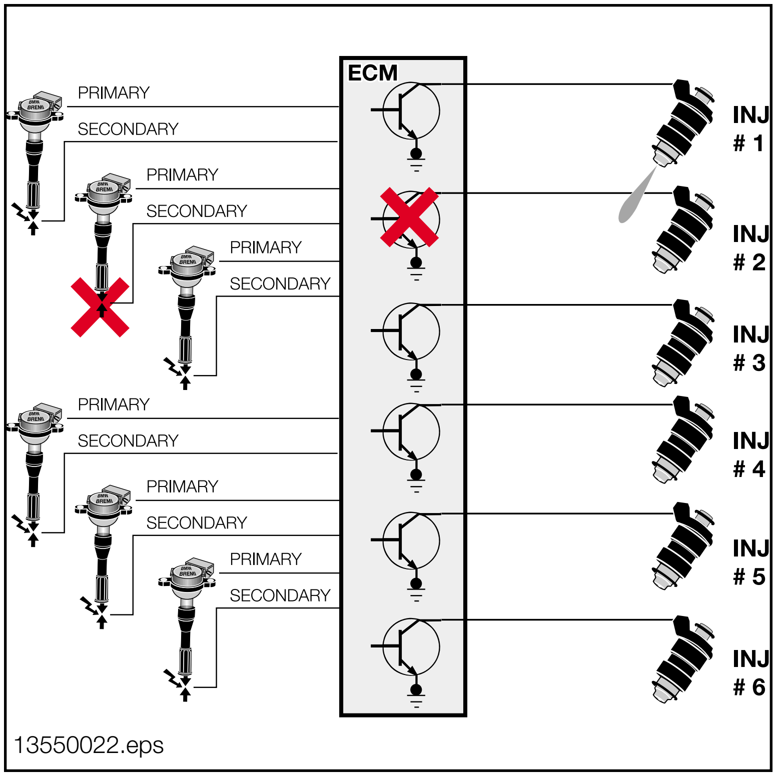
The ECM will also protect the Catalytic Converter by deactivating the injectors.



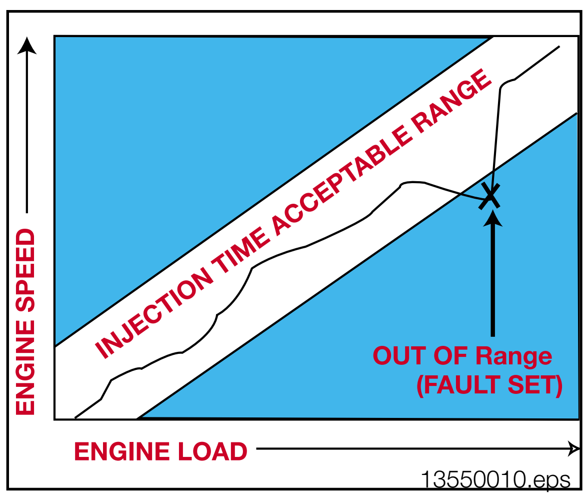
If the ECM detects a "misfire" (ignition, injection or combustion) it can selectively deactivate the Final Stage output transistor for that cylinder(s).

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

On the MS42/MS43 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 "Malfunction Indicator 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

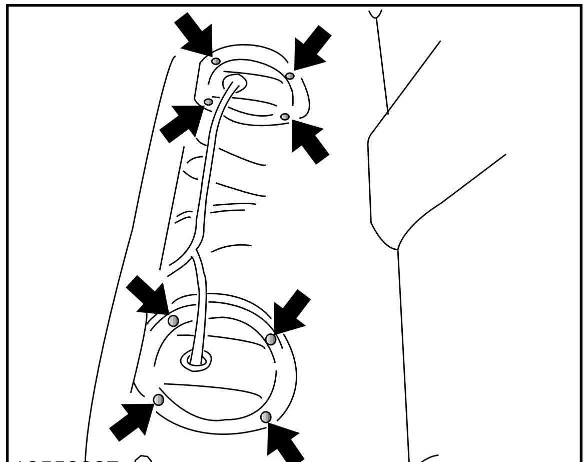
The fuel supply hardware should be visually inspected for damage that can affect pick-up, transfer, pressure and return. Please refer to the Repair Instructions and the following Service Information Bulletins details on fuel supply hardware:

• Fuel System Modifications S.I. #16 01 81

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.

The E46/E39 access plates are located under the rear seat. The “saddle” type fuel tank (under rear seat) has two access plates.



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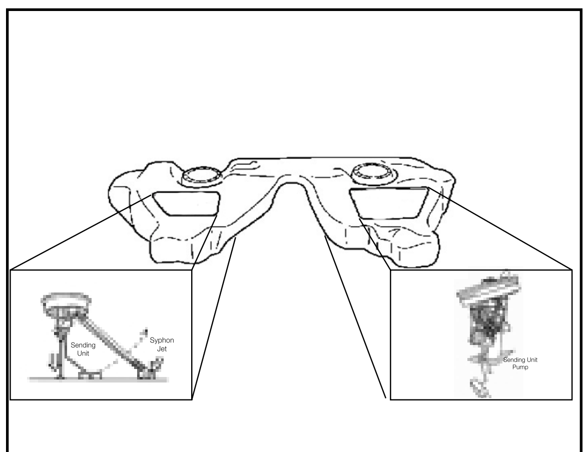
The passenger side allows access to the fuel pump/sending unit. The driver side allows access to the sending unit.



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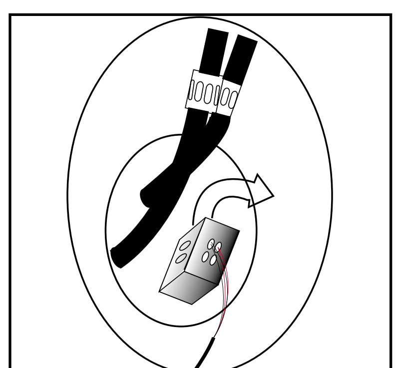
The Z3 has a single access plate located behind the passenger seat.



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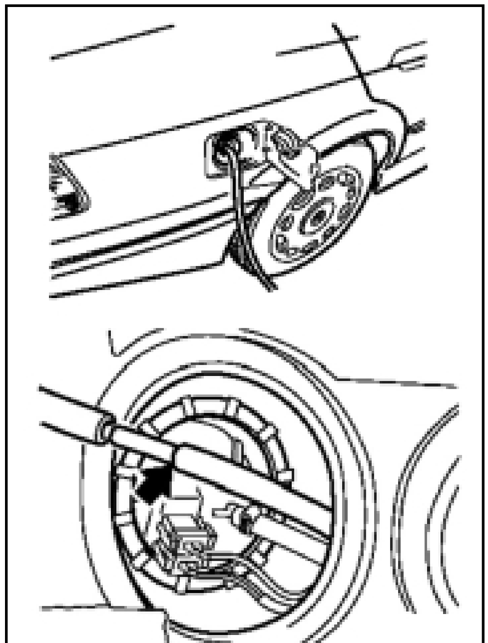
Draining the Fuel Tank

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.



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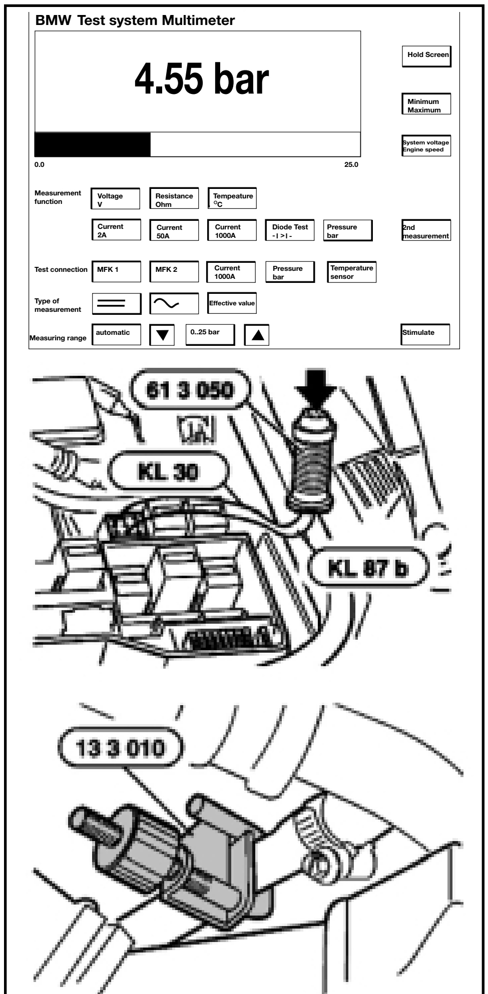
Fuel Pump/Pressure Regulator - Testing

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 adapter and DISplus pressure sensing lead to the fuel pressure fitting *DISplus starts with atmospheric pressure as the base.

Remove the fuel pump relay (Z3 located in the Electronics Box, E46 located behind the glove box and E39 right side of the trunk - 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 (*+ atmosphere DISplus base starting point) 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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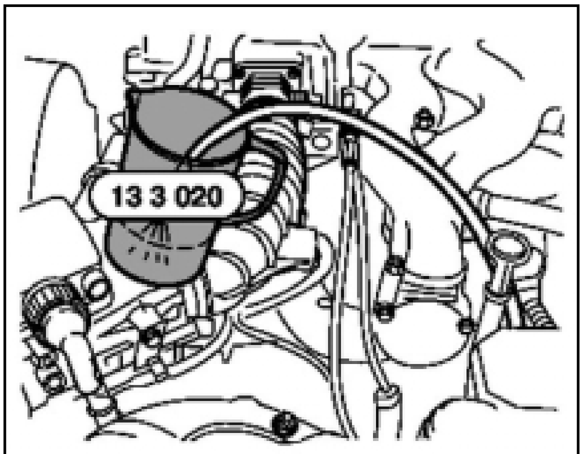
Fuel volume must be tested to verify:

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

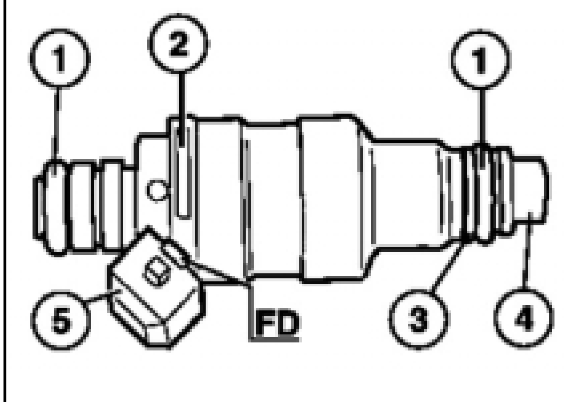


13550029.jpg

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 (different engine applications)**
• **Plastic spacer washer is not damaged**
• **Color code of housing (different engine applications)**



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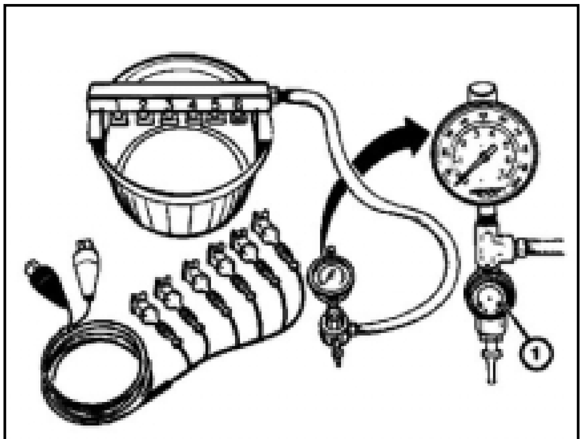
Fuel injectors can leak which bleeds off fuel pressure and increases emissions. The injectors can be tested using the Fuel Injector Leakage Tester.

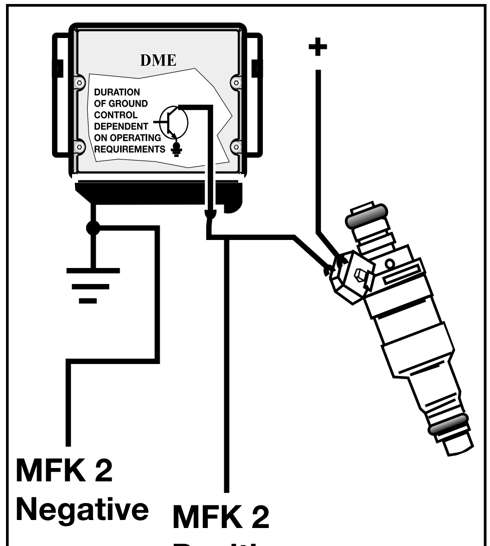
The fuel injectors can be cleaned, refer to Service Information Bulletin S.I. #04 07 86.



13550031.jpg

The Fuel Injectors should also be tested using the DISplus/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 Universal 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 cranking or running.**



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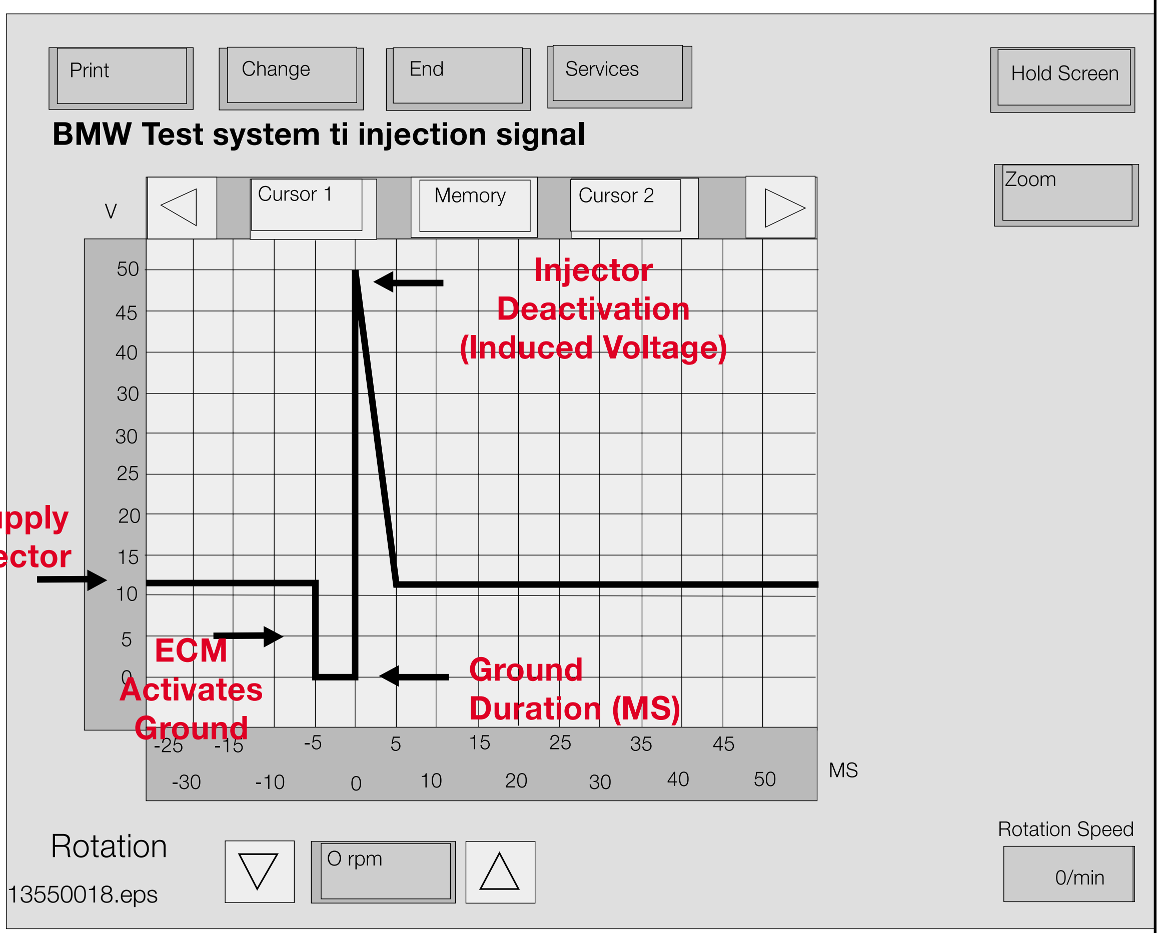

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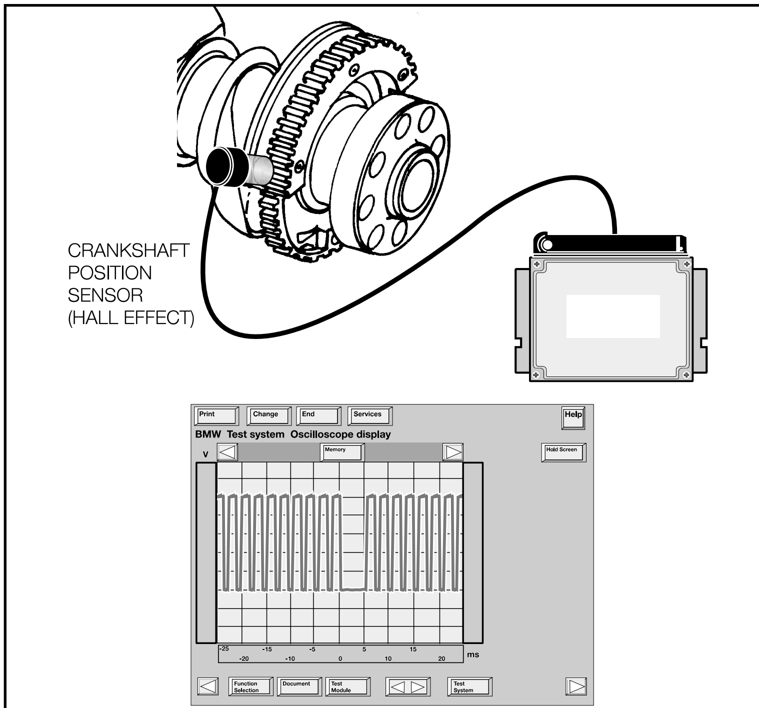
Crankshaft Position/RPM Sensor

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

- **Power Supply**
- **DC Voltage**
- **Status Display**
- **Oscilloscope Display found under Preset Measurements - "Engine Speed Sensor Signal"**



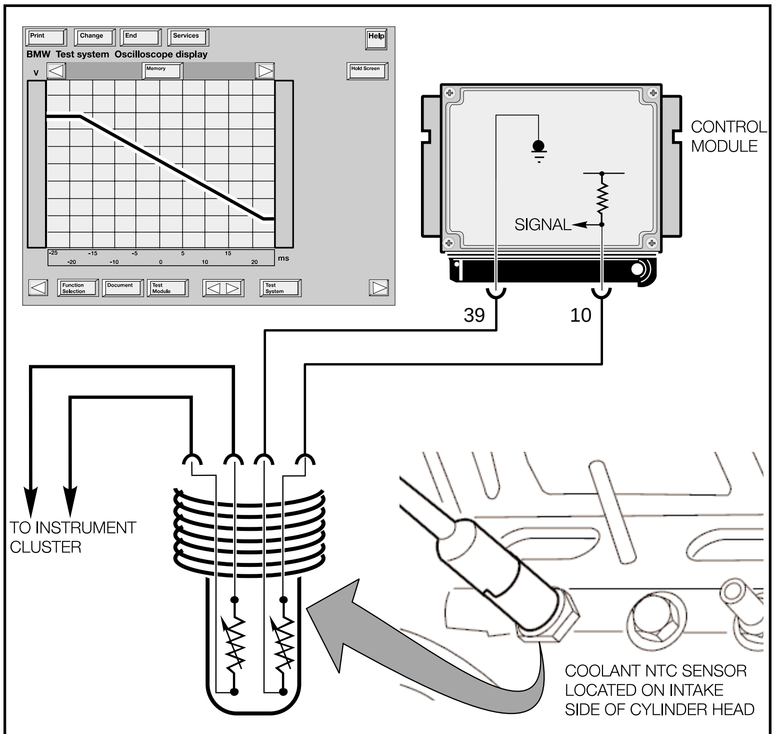
SMOOTH RUNNING ENGINE
(NOTE SQUARE WAVE SIGNAL)

13550020.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)



13550015.eps

The Sensor should be tested using:

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

Tools and Equipment

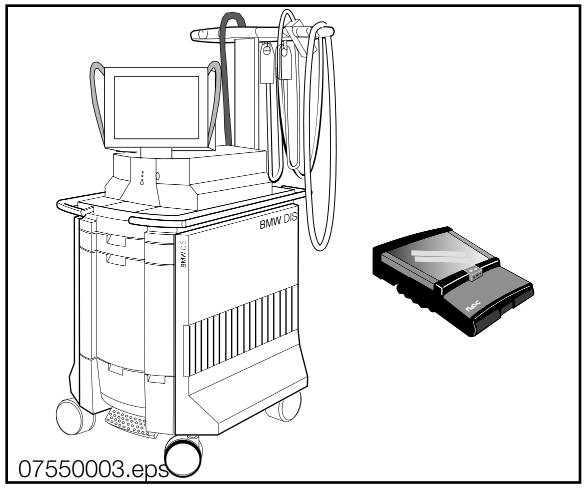
The DISplus/Modic as well as a reputable hand held multimeter can be used when testing inputs/components.

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

The correct Universal Adapter for the MS42/MS43 application should be used (#90 88 6 121 300). This will ensure the pin connectors and the harness will not be damaged.

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.

NOTE for MS43: Allow at least 3 minutes to elapse after the key was set to the "OFF" position before disconnecting the ECM/TCM. This will allow sufficient time to complete the DM TL test. Voltage may be present (up to 3 minutes) causing damage to the ECM/TCM if they are disconnected during this time period (arcing).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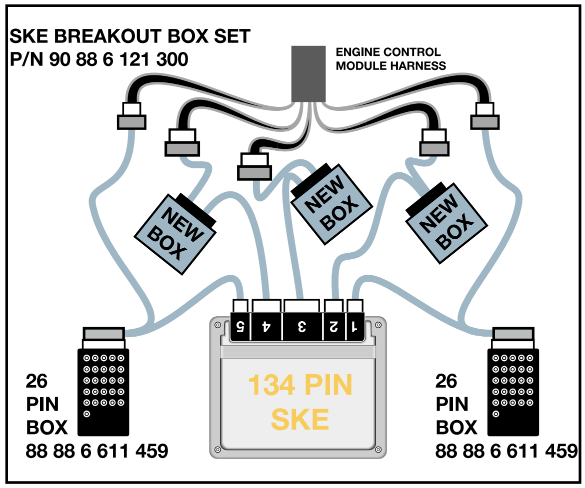
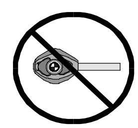
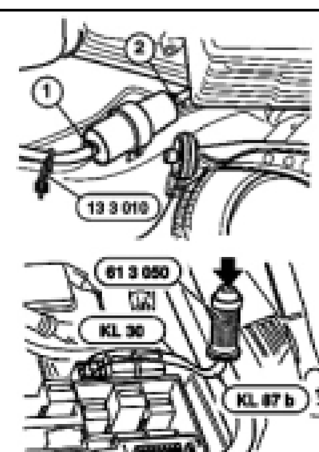




The Fuel Hose Clamp Tool (#13 3 010) can be used for isolating pressure faults. In addition, fuel loss can be reduced when changing the fuel filter while losening clamps (1 and 2).

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

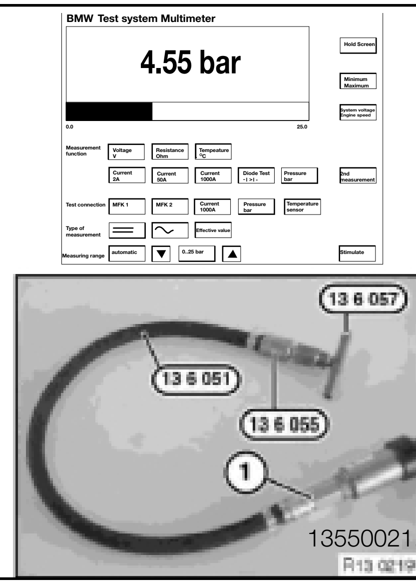
When testing fuel pressure, the hand held fuel pressure gage (#13 3 060) can be used.

Caution: Residual fuel pressure may be present!

The DISplus 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.



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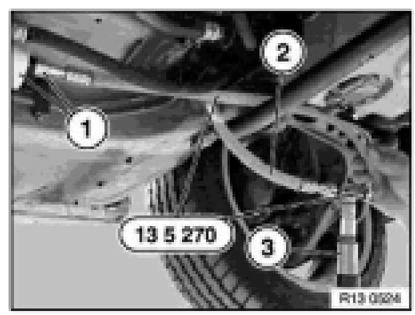
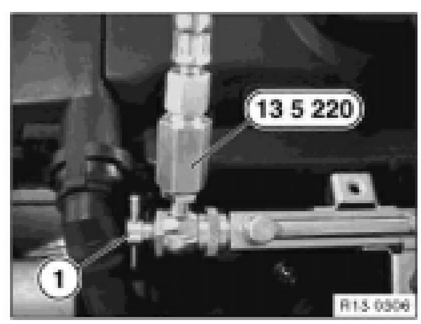
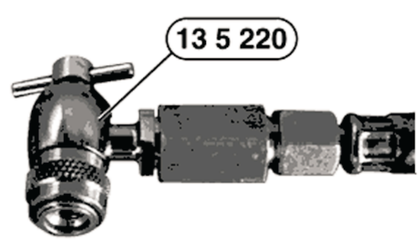
For vehicles equipped with "quick-release" couplings, install special tool (#13 5 270) between the fuel filter (1) and pressure supply hose (2). This tool will couple to the DISplus Pressure Adapter (3).



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

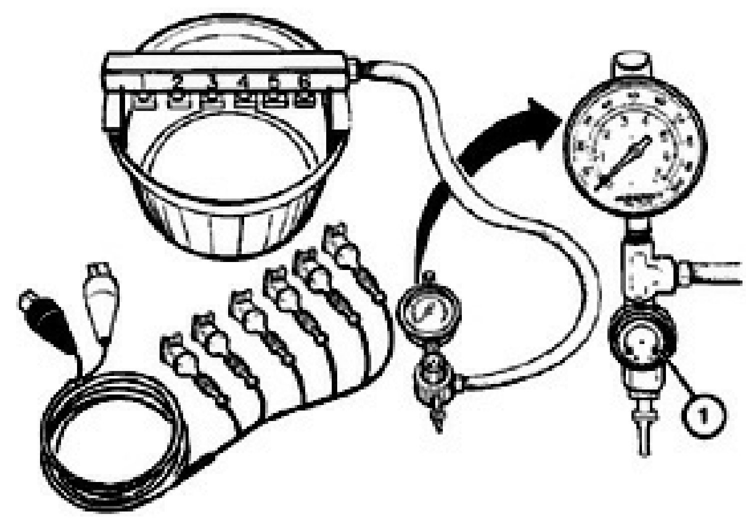


This threaded adapter fitting allows Adapter #13 5 220 to be threaded on to the fuel rail and coupled to the DISplus Pressure Adapter.



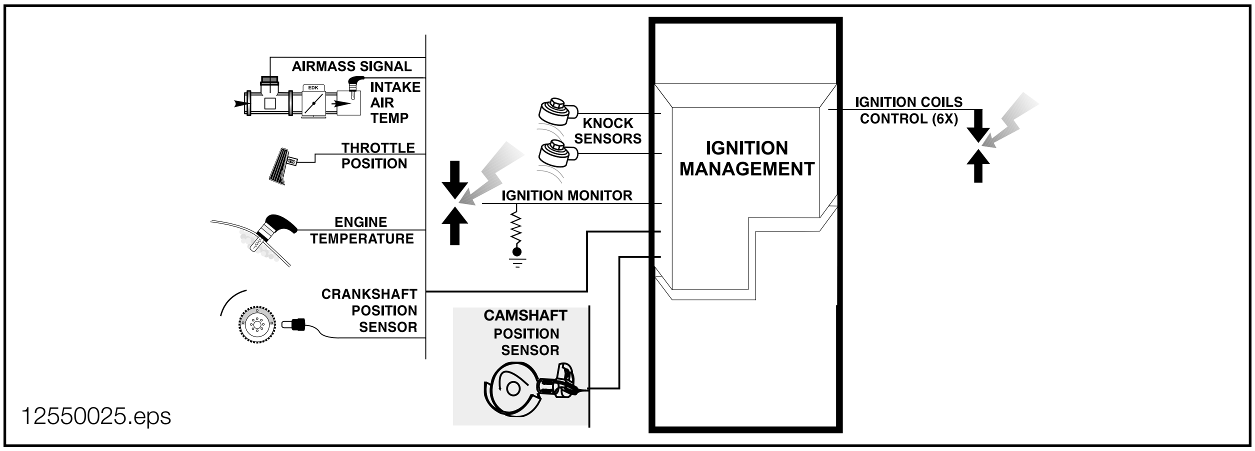
13550022.eps

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



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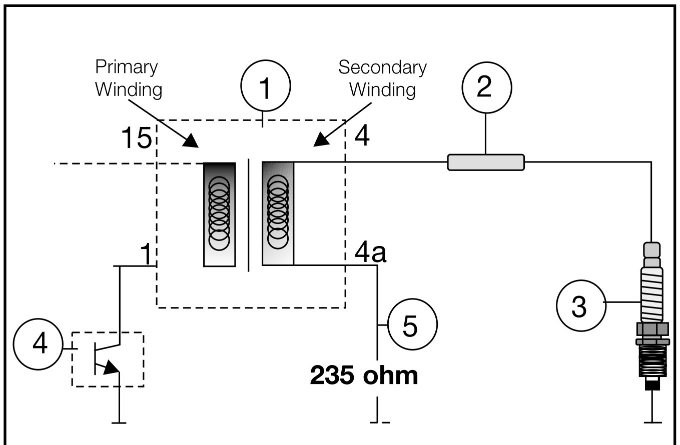
Ignition Coils: The high voltage supply required to ignite the mixture in the combustion chambers is determined by the stored energy in the ignition coils. The stored energy contributes to the ignition duration, ignition current and rate of high voltage increase. The Coil circuit including primary and 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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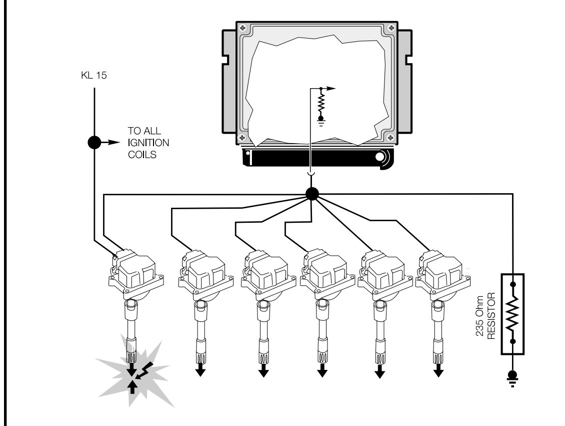
The Coil Assembly contains two copper windings insulated from each other. One winding is the primary winding, formed by a few turns of thick wire. The secondary winding is formed by a great many turns of thin wire.

The primary winding receives battery voltage from the Ignition Coil Power Relay which is 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 40,000 volts (40 KV). The high voltage is discharged (Terminal 4) through the secondary ignition spark plug connector (boot) to the spark plug.



12550009-1.eps

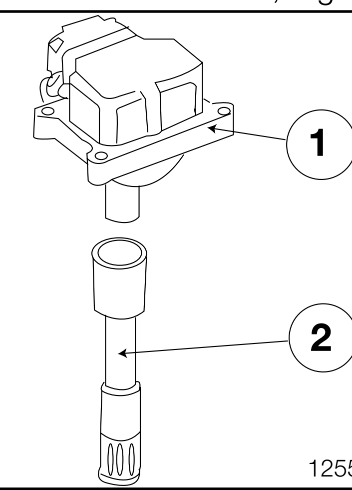
The primary and secondary windings are uncoupled, therefore, the secondary winding requies a ground supply (Terminal 4a).

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.



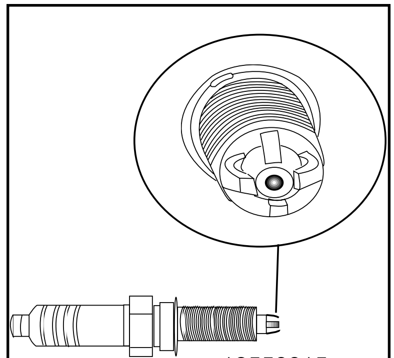
12550010.jpg

There is an individual ignition circuit and coil for each cylinder on the MS42/MS43 systems.

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 manufactures 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.



13550015.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.

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

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

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:

• "Malfunction Indicator 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 "Malfunction Indicator 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.

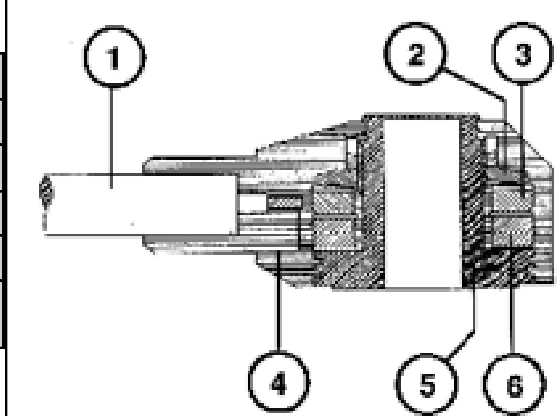
The Ignition Output Components must be individually tested (see Workshop Hints).

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

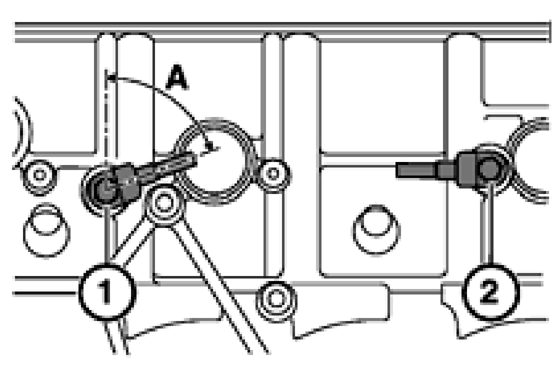


13550005.bmp

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.

If a fault is detected with the sensor(s), the ECM deactivates Knock Control. The "Malfunction Indicator 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.



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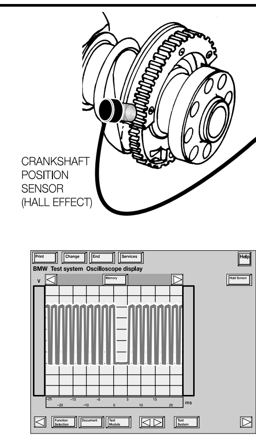
Crankshaft Position/RPM Sensor: This sensor provides the crankshaft position and engine speed (RPM) signal to the ECM for ignition activation and correct timing. This input is also monitored for Misfire Detection. For details about the sensor, refer to the Fuel Management section.

A fault with this input will produce the following complaints:

• No Start
• Intermitant Misfire/Driveabilty
• Engine Stalling



SMOOTH RUNNING ENGINE
(NOTE SQUARE WAVE SIGNAL)

13550010.eps

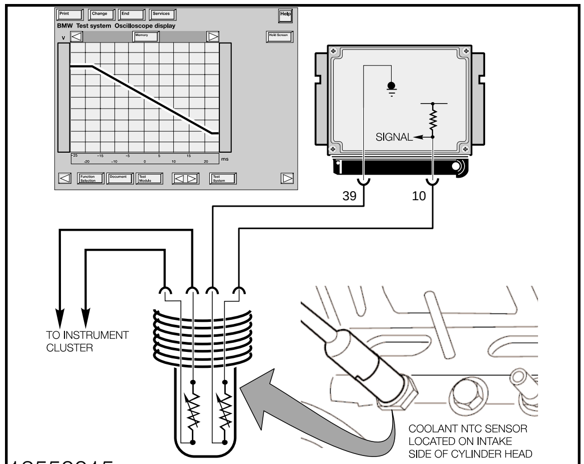
Camshaft Position Sensors (Cylinder Identification): The cylinder ID sensor input allows the ECM to determine camshaft position in relation to crankshaft position. It is used by the ECM to establish the “working cycle” of the engine for precise ignition timing. For details about the sensor, refer to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

If the ECM detects a fault with the Cylinder ID Sensor, the “Malfunction Indicator Light” will be illuminated when the OBD II criteria is achieved and the system will still operate precise **single ignition** based on the Crankshaft 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.

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 (left rear).

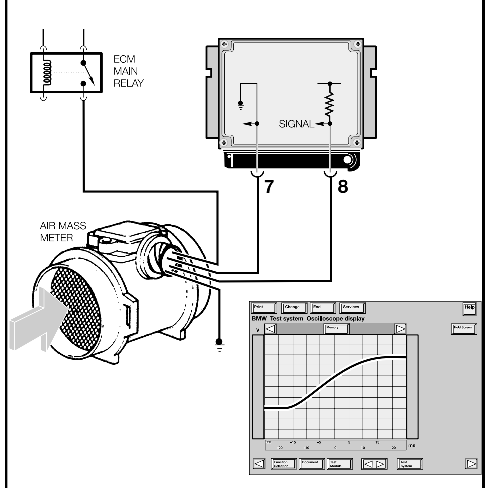
If the Coolant Temperature Sensor input is faulty, the "Malfunction Indicator Light" will be illuminated when the OBD II criteria is achieved and the ECM will assume a substitute value (80º C) to maintain engine operation. The ignition timing will be set to a conservative basic setting.



13550015.eps

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.

If this input is defective, a fault code will be set and the "Malfunction Indicator Light" will illuminate when the OBD II criteria is achieved. The ECM will maintain engine operation based on throttle position and the Engine Speed Sensor, and the ignition timing will be set to a conservative basic setting.



13550004.eps

Throttle Position: This provides the ECM with accelerator pedal position and rate of movement. As the accelerator pedal is depressed 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.

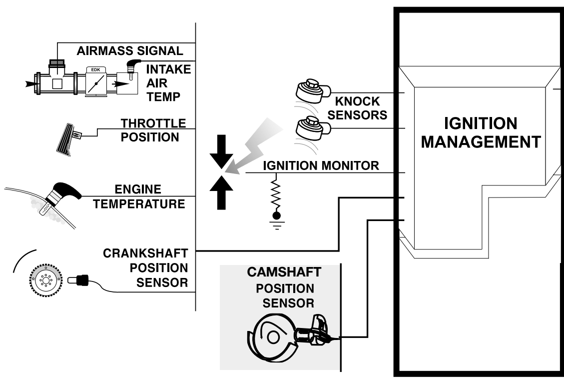
Air Temperature: This signal allows the ECM to make a calculation of air density. For details about the sensor, refer to the Air Management section.

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 “Malfunction Indicator 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 secondary ignition output including **Misfire Detection**.



12550025.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	**• Accelerator Pedal Position**	**• Air Flow Volume**
• Air Temperature	**• Engine Coolant**	**• Crankshaft Position/RPM**
• Camshaft Positions (Cylinder ID)	**• Knock Sensors**	

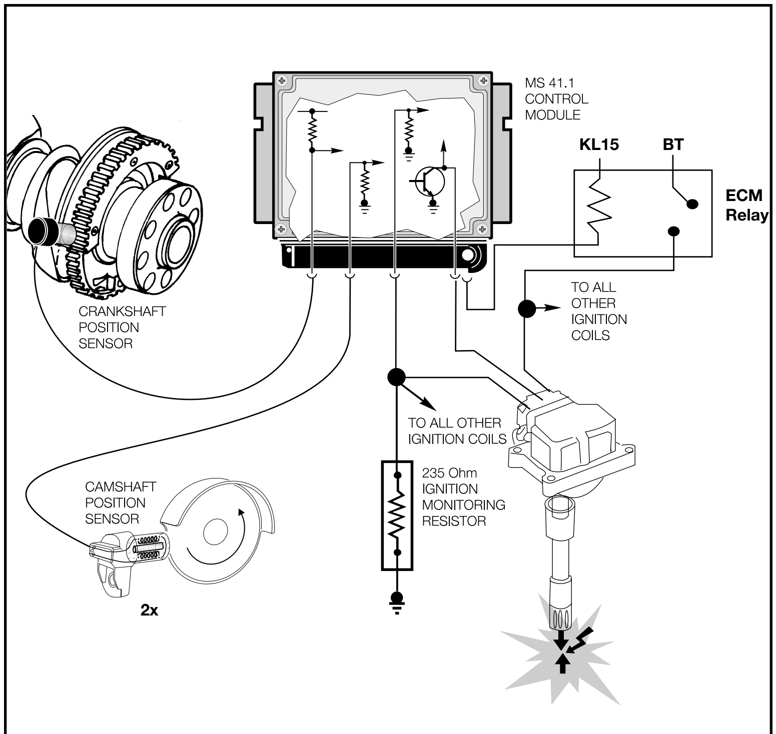
The dwell time will be regulated based on battery voltage. When cranking, the voltage is low and the ECM will increase the dwell to compensate for saturation "lag time". When the engine is running and the battery voltage is higher, the ECM will decrease the dwell due to faster saturation time.

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.

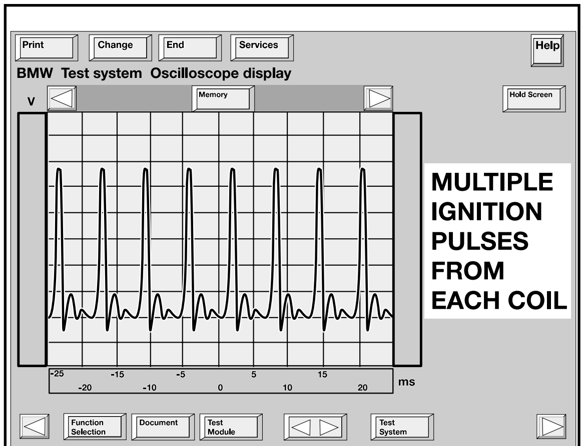
If the engine coolant and intake air temperature is hot, the ignition timing will not be advanced reducing starter motor "load".



12550010.eps

Multiple Ignition Pulses ensure good spark quality during engine start up. The ECM will activate the ignition coils 9 times (voltage dependent) 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 when:

• Engine Speed >1350 RPM (varied with engine temperature)

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).

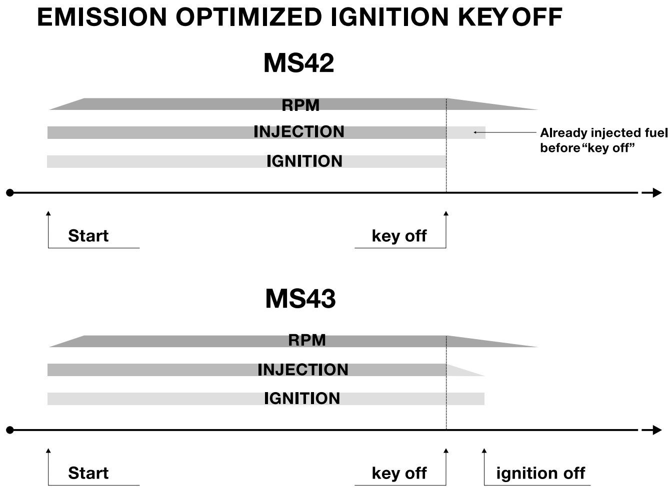
MS43 Emission Optimized - Ignition Key Off

"Emission Optimized Ignition Key Off" is a programmed feature of the MS43 ECM.

After the ECM detects KL15 is switched "off", the ignition stays active (ECM Relay/voltage supply) for two more individual coil firings.

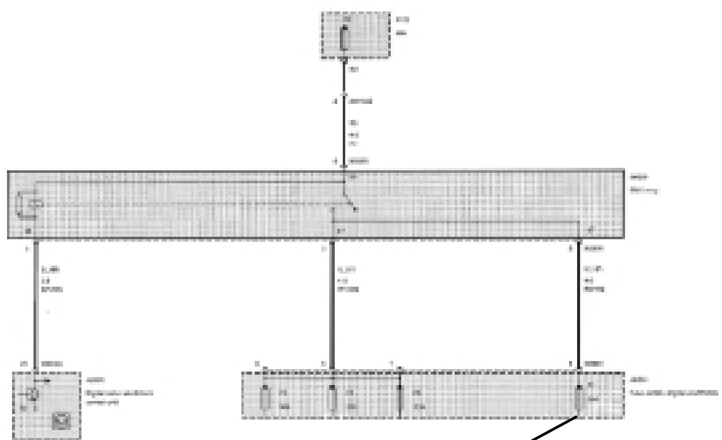
This means that just two cylinders are fired - not two revolutions.

This feature allows residual fuel injected into the cylinders, as the ignition key is switched off, to be combusted as the engine runs down.



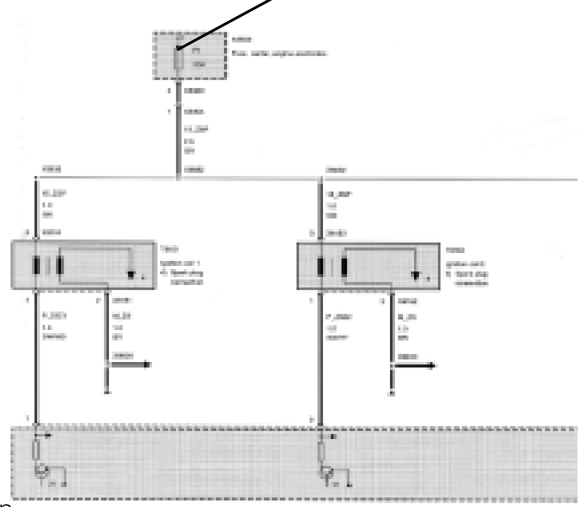
13410009.eps

When **KL15** is switched "off" the ECM operating voltage is removed.



12410004.bmp

The ECM will maintain a ground to the Engine Control Module Relay for a few seconds to maintain ignition coil activation.



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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.

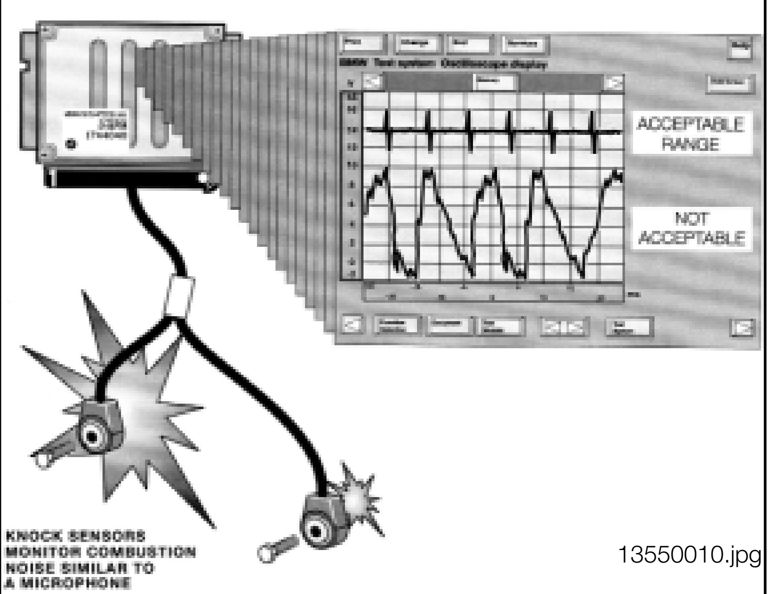
As the throttle is closed, the ECM decreases the ignition timing if the rpm is above idle speed (coasting). This feature lowers the engine torque for deceleration. When the engine rpm approaches idle speed, the timing is slightly advanced to prevent the engine from stalling. The amount of advance is 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 3° 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 "Malfunction Indicator 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!

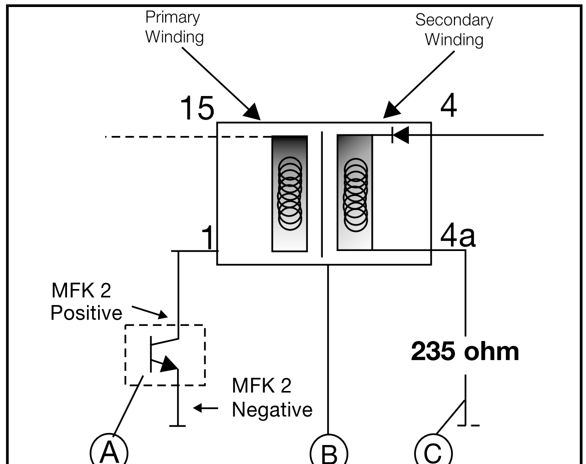
Caution! Hazardous voltages occur at:

• Ignition Leads
• Spark Plug Connector
• Spark Plug
• Ignition Coil (High Voltage at terminal 4 is approximately 40 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 DISplus/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:

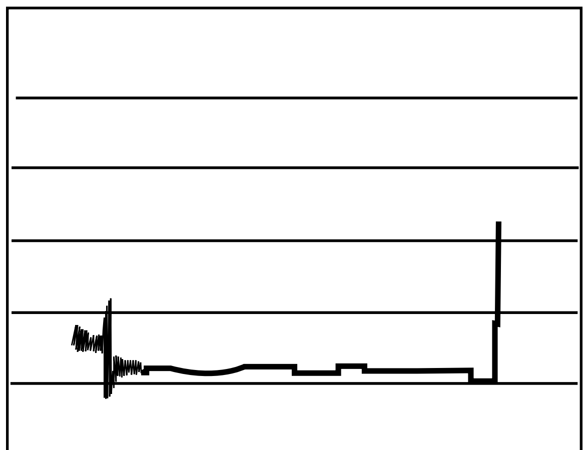
• Power Supply at the Coil (KL15)
• Resistance of the harness and ignition coil primary winding (terminal 15 to 1 approx: 0.8 ohms) - using the Universal Adapter with the ECM disconnected



13550034.eps

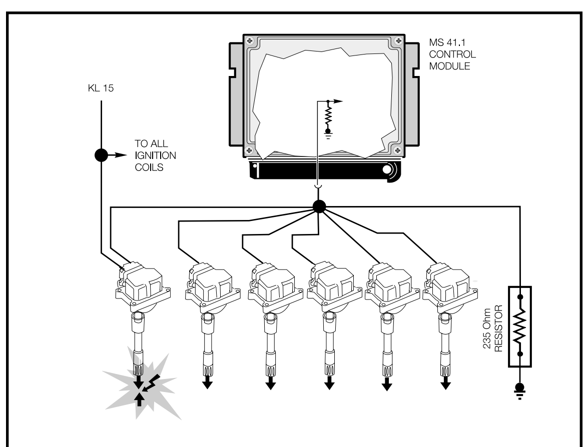
A. ECM Primary Circuit Final Stage Transistor
B. ECM Ignition Coil (one of six)
C. Secondary Coil Ground

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).


13550017.eps

Install the Universal 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 cranking/running.

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



12550009.eps

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.

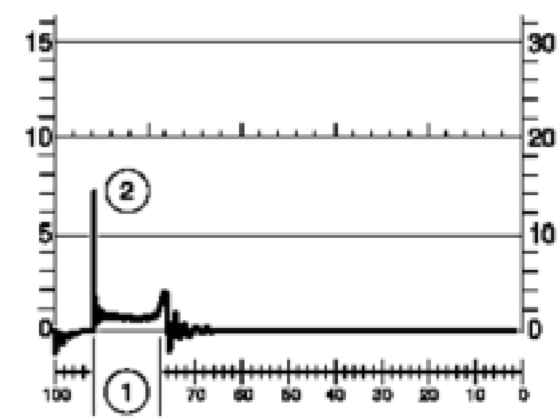
If there is a fault in the secondary ignition, testing should include:

• 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

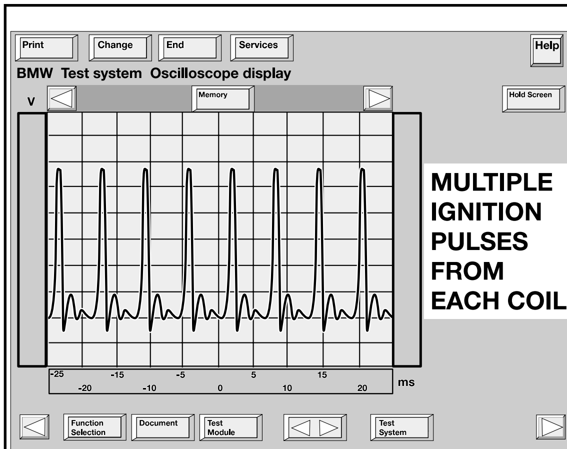


07550001.bmp

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

This is a normal pattern for one ignition circuit when:

• Engine speed <1350 RPM



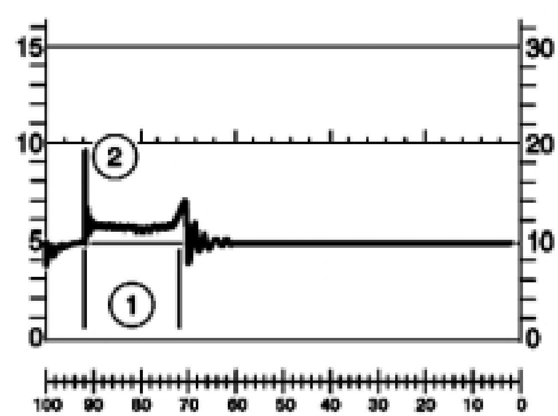
12550011.eps

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).

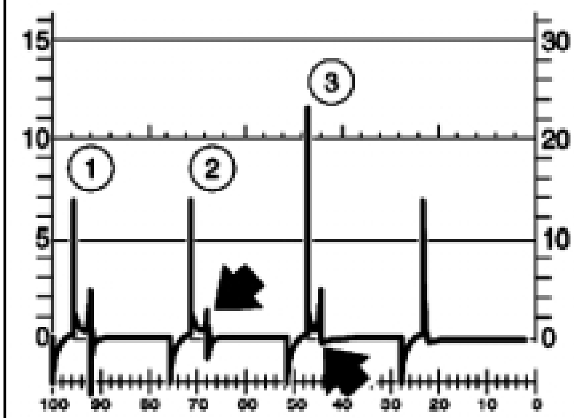
• Defective Ignition Connector or Resistive Adapter Boot



07550002.bmp

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

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



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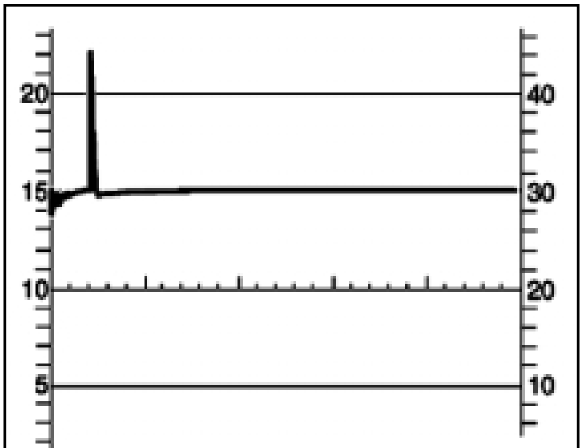
No Sparking Volatge Line (Single Cylinder Displayed)

• Defective Igniton Coil



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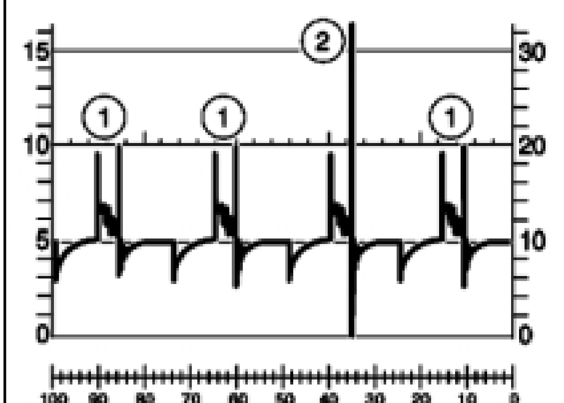
Evaluation of Ignition Voltage Peaks under Sudden Loads (Multiple Cylinders Displayed).

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



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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

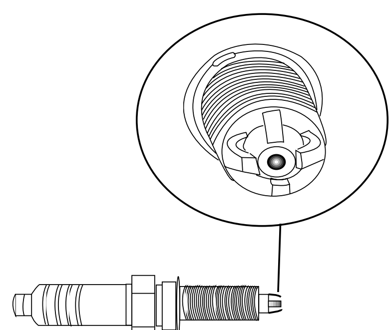
If the Secondary Ignition **Voltage is Too Low (Low Resistance for Ignition):**

• 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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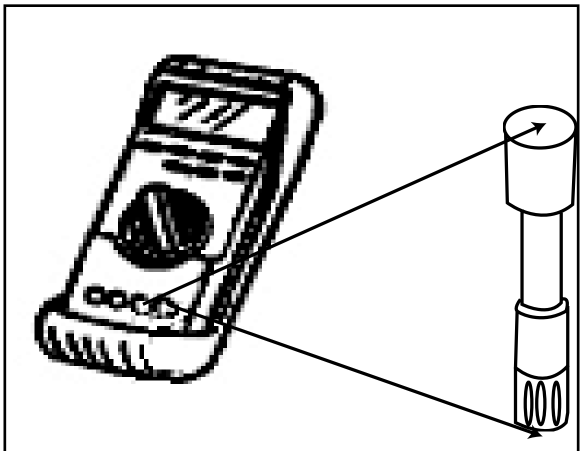
Ignition Adapter (Boot)

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%



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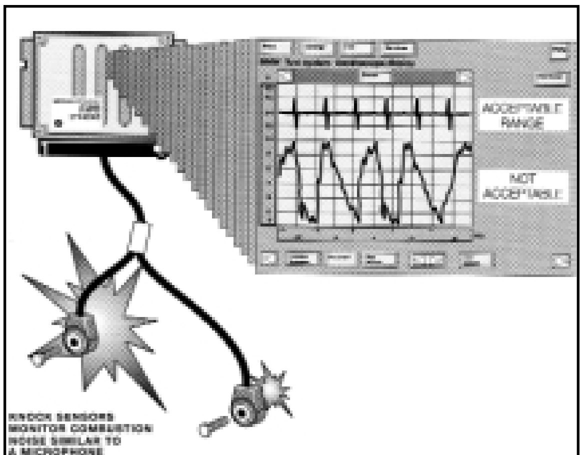
Knock Sensors

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)



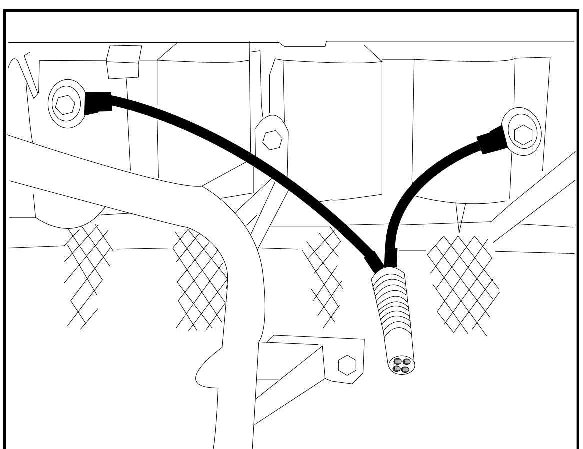
13550010.jpg

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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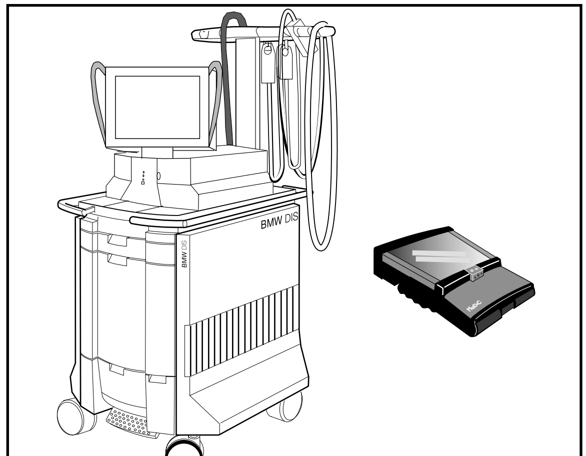
Tools and Equipment



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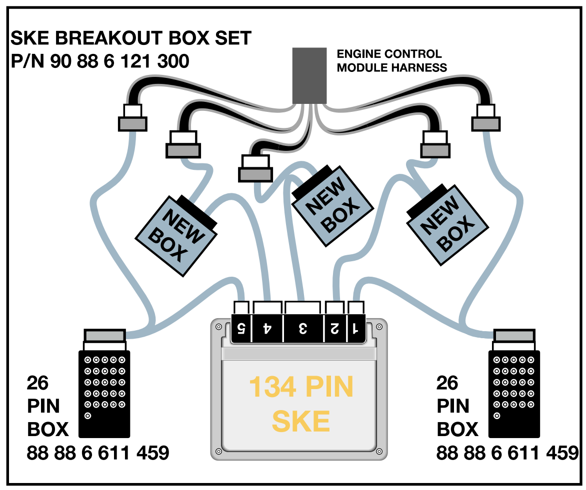
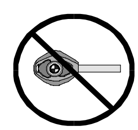
The DISplus/Modic as well as a reputable hand held multimeter can be used when testing inputs/components.

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

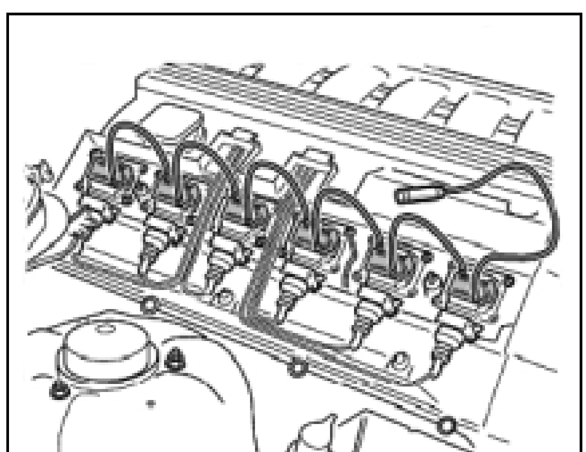


The correct Universal Adapter for the MS42/MS43 application should be used (#90 88 6 121 300). This will ensure the pin connectors and the harness will not be damaged.

When installing the Universal Adapter to the ECM, 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.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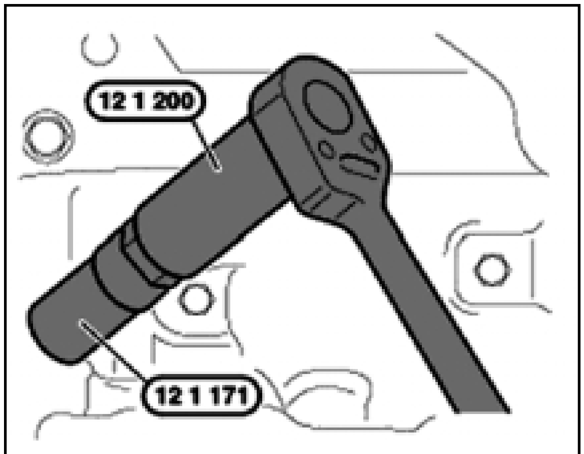
Caution!

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

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**

NOTE: NEVER USE AIR TOOLS FOR REMOVAL OR INSTALLATION!



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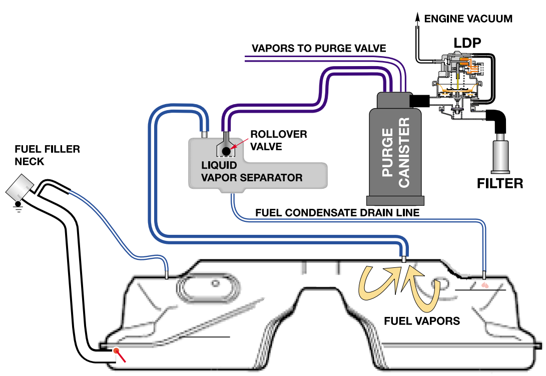
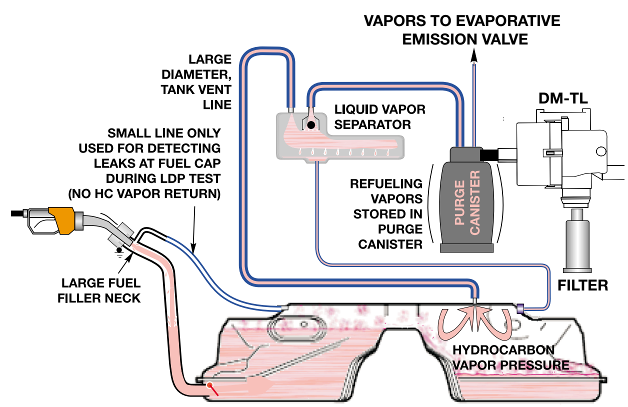
Emissions Management - Low Emission Vehicle (LEV) Compliant
- M54 3.0 Liter Ultra Low Emission Vehicle (ULEV)

LDP Equipped



DM TL Equipped Including ORVR



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 - DM TL Equipped Vehicles): 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 DM TL 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.

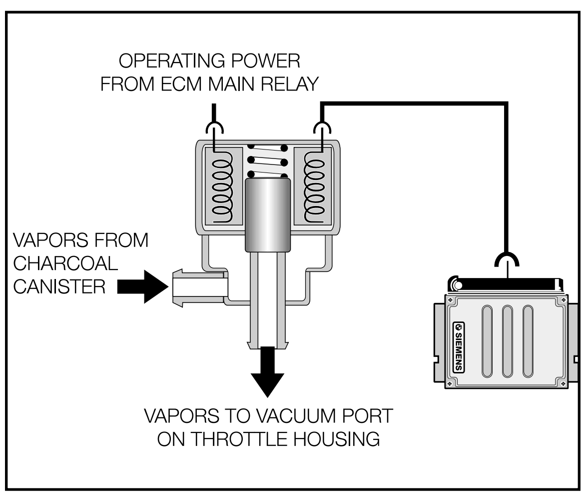
Liquid/Vapor Separator: Fuel vapors are routed from the fuel tank filler neck through a hose to the Liquid/Vapor Separator. The vapors cool when exiting the fuel tank, the condensates separate and drain back to the fuel tank through a return hose. The remaining vapors exit the Liquid/ Vapor Separator to the Active Carbon Canister.

Active Carbon Cannister: As the hydrocarbon vapors enter the 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.

Evaporative Emission Valve: This ECM controlled solenoid valve regulates the purge flow from the Active Carbon Canister 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.

If the Evaporative Emission Valve circuit is defective, a fault code will be set and the "Malfunction Indicator 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.



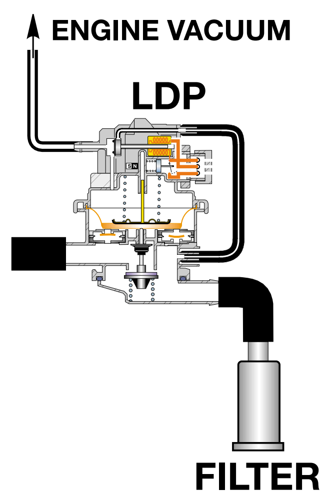
MS42 - Evaporative System Leak Diagnosis with Leakage Diagnosis Pump (LDP): The LDP provides a means of testing the fuel/evaporative system for leaks. The pump is activated by the ECM and pressurizes the fuel tank and evaporative system.

The LDP and charcoal canister (combination) assembly is located under the right rear trunk floor on the E46 (for example). This system is capable of detecting a leak ***as small as 0.5 mm.***

The LDP is a unitized component that contains the following:

- Vacuum chamber
- Pneumatic pump chamber
- DME activated vacuum solenoid
- Reed switch providing a switched voltage feedback signal to the ECM

The LDP assembly is only replaceable as a complete unitized component, however, it is separate from the charcoal canister.



The upper chamber contains an integrated reed switch that produces a switched high/low voltage signal that is monitored by the ECM.

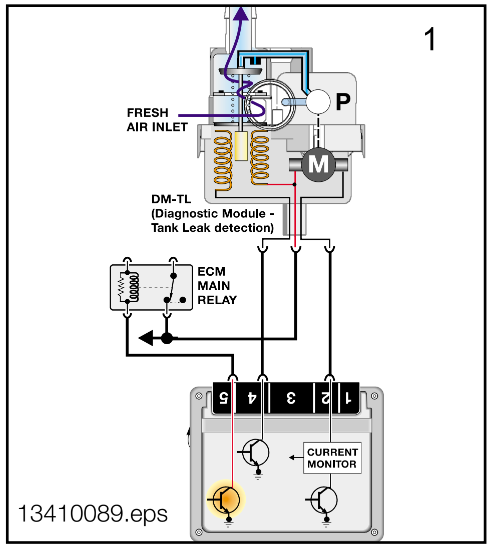
The switch is opened by the magnetic interruption of the metal rod connected to the diaphragm when in the top dead center position.

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.

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 “Malfunction Indicator Light” will illuminate when the OBD II criteria is achieved.

MS43 - Evaporative Leakage Detection (DM TL): This component ensures accurate fuel system leak detection for leaks ***as small as 0.5 mm*** by slightly pressurizing the fuel tank and evaporative components. The DM TL pump contains an integral DC motor which is activated directly by the ECM. The ECM monitors the pump motor operating current as the measurement for detecting leaks.

The pump also contains an ECM controlled change over valve that is energized closed during a Leak Diagnosis test. The change over valve is open during all other periods of operation allowing the fuel system to “breath” through the inlet filter. The DM TL is located under the luggage compartment floor with the Active Carbon Cannister (E46 for example).



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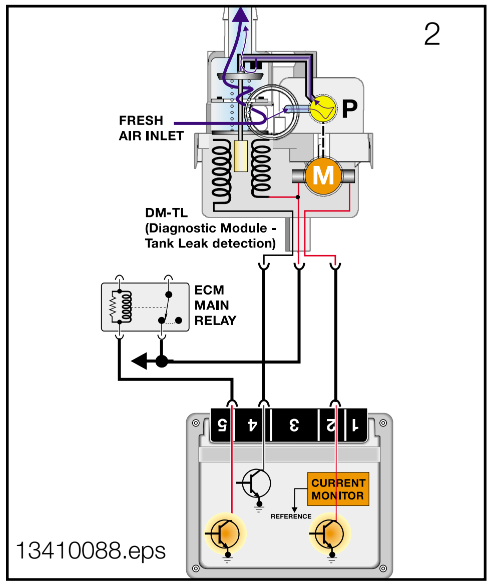
1. In its inactive state, filtered fresh air enters the evaporative system through the sprung open valve of the DM TL.



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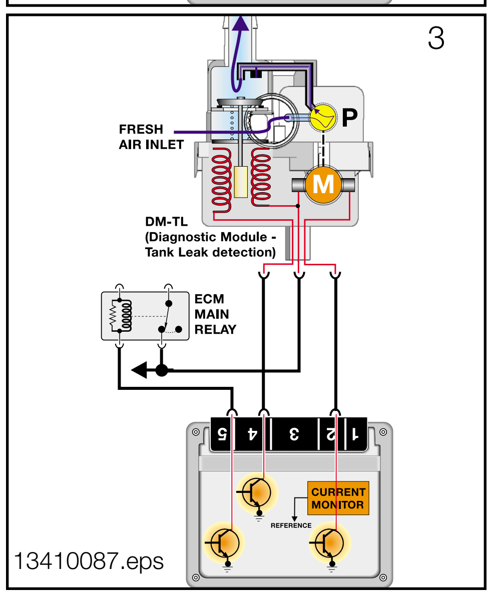
2. When the DME activates the DM TL for leak testing, it first activates only the pump motor. This pumps air through a restricter orifice (0.5 mm) which causes the electric motor to draw a specific amperage value. This value is equivalent to the size of the restricter.



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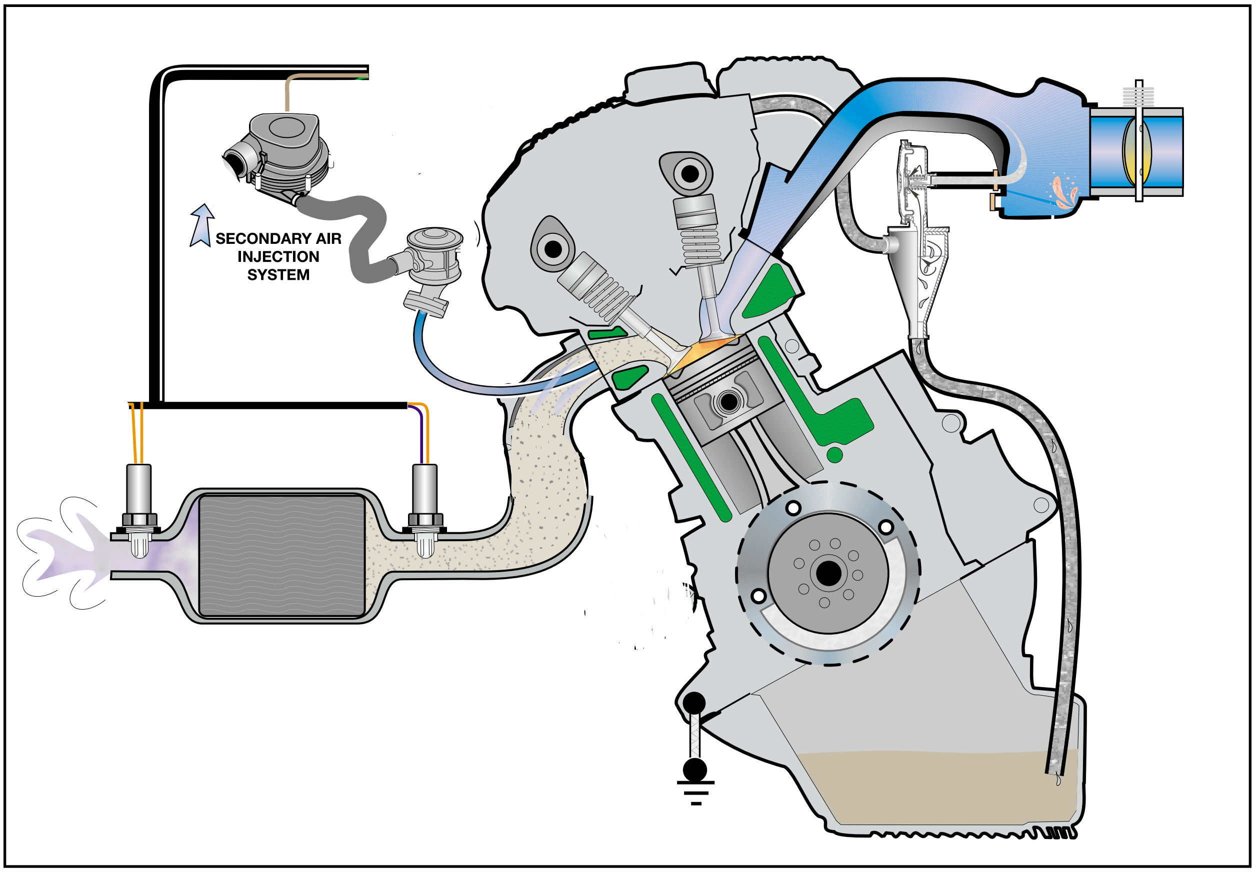
3. The solenoid valve is then energized which seals the evaporative system and directs the pump output to pressurize the evaporative system.

- A large leak is detected in the evaporative system if the amperage value is not achieved.
- A small leak is detected if the same reference amperage is achieved.
- The system is sealed if the amperage value is higher than the reference amperage.



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

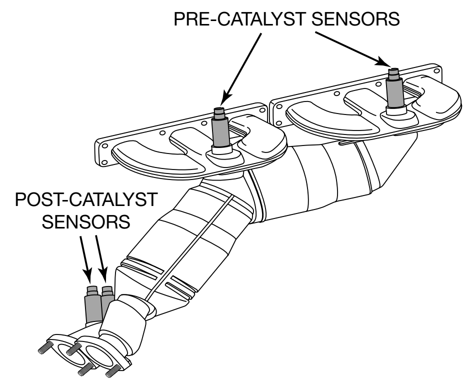
• Carbon Monoxide is a product of incomplete combustion under conditions of air deficiency. CO emissions are strongly dependent on the air/fuel ratio.
• Hydrocarbon are also a product of incomplete combustion which results in unburned fuel. HC emissions are dependent on air/fuel ratio and the ignition 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.

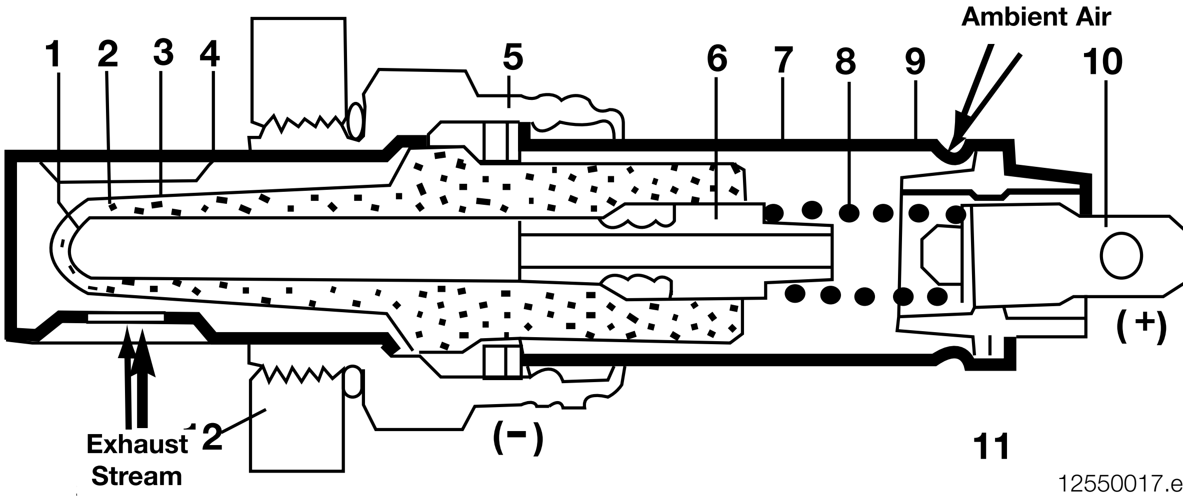
Control of exhaust emissions is accomplished by the engine and engine management design as well as after-treatment.

• 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.

Bosch LSH 25 Oxygen Sensors: The pre-cat oxygen sensors measure the residual oxygen content of the exhaust gas. The sensors produces a low voltage (0-1000 mV) proportional to the oxygen content that allows the ECM to monitor the air/fuel ratio.

The sensors are mounted in the hot exhaust stream directly in front of the catalytic converters.





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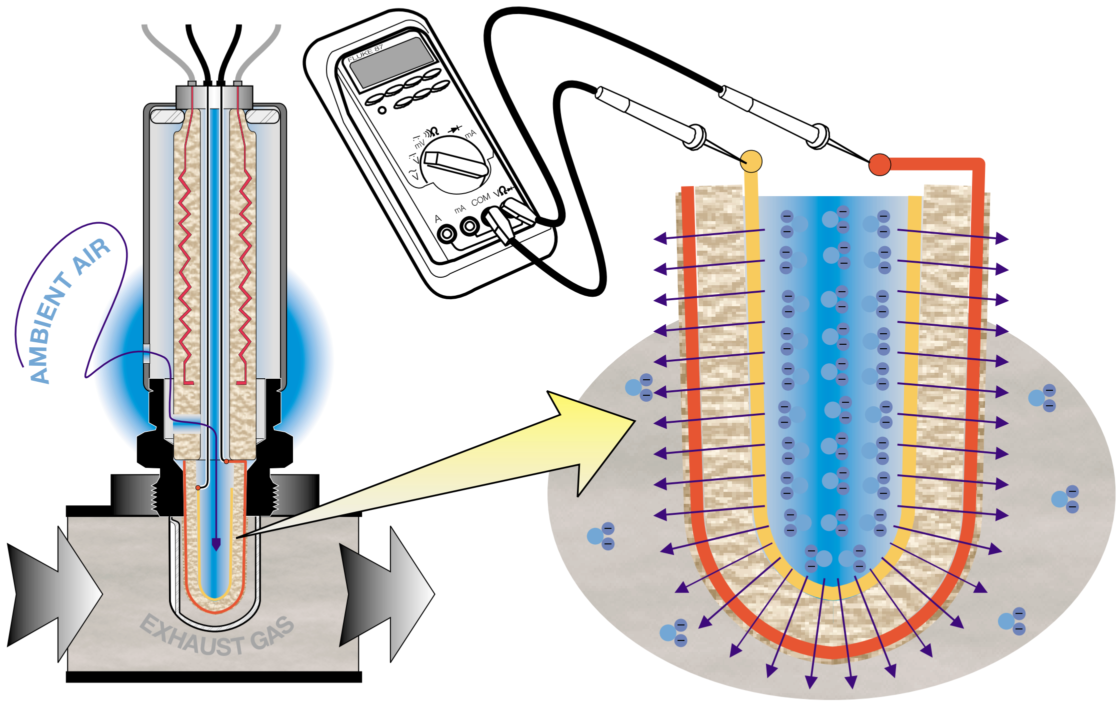
1. Electrode (+)	7. External Body (Ventilated)
2. Electrode (-)	8. Contact Spring
3. Porous Ceramic Coating (encasing electrolyte)	9. Vent Opening
4. Protective Metal Cage (Ventilated)	10. Output Lead
5. Casing	11. Insulator
6. Contact Sleeve	12. Exhaust Pipe Wall

The “tip” of the sensor contains a microporous platinum coating (electrodes) which conduct current. The platinum electrodes are separated by solid electrolyte which conducts oxygen ions. The platinum conductors are covered with a highly porous ceramic coating and the entire tip is encased in a ventilated metal “cage”.

This assembly is submersed in the exhaust stream. The sensor body (external) has a small vent opening in the housing that allows ambient air to enter the inside of the tip.

The ambient air contains a constant level of oxygen content (21%) and the exhaust stream has a much lower oxygen content. The oxygen ions (which contain small electrical charges) are “purged” through the solid electrolyte by the hot exhaust gas flow. The electrical charges (low voltage) are conducted by the platinum electrodes to the sensor signal wire that is monitored by the ECM.

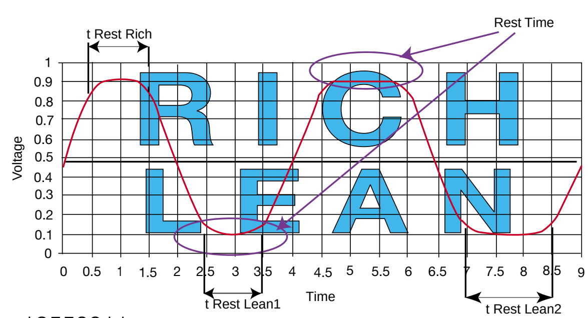


If the exhaust has a lower oxygen content (rich mixture), there will be a large ion "migration" through the sensor generating a higher voltage (950 mV).

If the exhaust has a higher oxygen content (lean mixture), there will be a small ion "migration" through the sensor generating a lower voltage (080 mV).

This voltage signal is constantly changing due to combustion variations and normal exhaust pulsations.

The ECM monitors the length of time the sensors are operating in the lean, rich (including the time of rise and fall) and rest conditions. The evaluation period of the sensors is over a predefined number of oscillation cycles.



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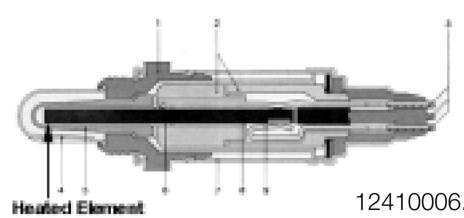
This conductivity is efficient when the oxygen sensor is hot (250º - 300º C). For this reason, the sensor contains a heating element. This "heated" sensor reduces warm up time, and retains the heat during low engine speed when the exhaust temperature is cooler.



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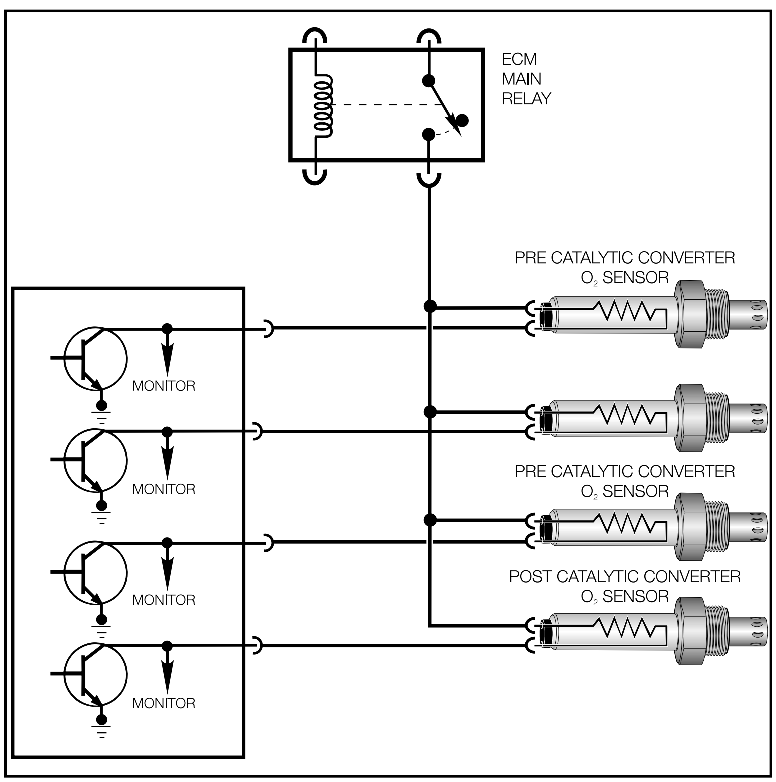
Direct Oxygen Sensor Heating: The oxygen sensor conductivity is efficient when it is hot (600º - 700º C). For this reason, the sensors contain heating elements. These “heated” sensors reduce warm up time, and retain the heat during low engine speed when the exhaust temperature is cooler. OBD II requires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

The four oxygen sensor heating circuits (E46/E39 shown) receive operating voltage from the ECM Relay when KL15 is switched “ON”. Each of the sensors heaters are controlled through separate final stage transistors.

The sensor heaters are controlled with a pulse width modulated 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.

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

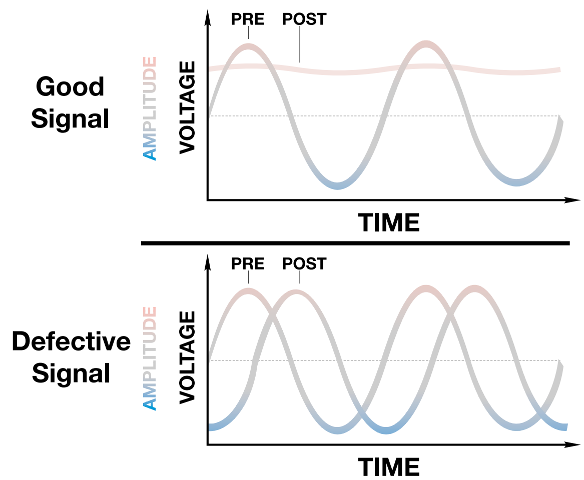


Catalytic Converter Monitoring: The efficiency of catalyst operation is determined by evaluating the oxygen consumption of the catalytic converters using the pre and post oxygen sensor signals. A properly operating catalyst consumes most of the O_2 (oxygen) that is present in the exhaust gas (input to catalyst). The gases that flow into the catalyst are converted from CO, HC and NOx to CO_2, H_2O and N_2 respectively.

In order to determine if the catalysts are working correctly, post catalyst oxygen sensors 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 (700 - 800 mV). The post cat. O_2 voltage remains high with a very slight fluctuation. This indicates a further lack 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 “Malfunction Indicator Light” will illuminate when the OBD II criteria is achieved.



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.

An Electric Air Pump and Air Injection Valve direct fresh air through an internal channel in the cylinder head into the exhaust ports. The Air Injection Valve is opened by air pressure (from the pump) and is closed by an internal spring.

The Air Injection Inlet Valve mounts directly to the cylinder head, with a passageway machined through the head. This eliminates the external Air Injection manifold distribution pipes to the exhaust manifolds.

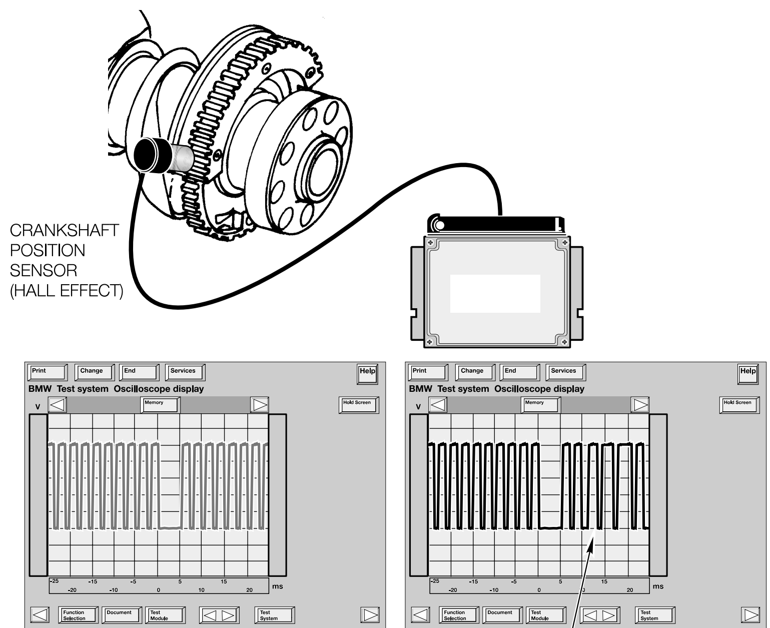
Misfire Detection: As part of the OBD II regulations the ECM must determine misfire and also identify the specific cylinder(s), the severity of the misfire and whether it is emissions relevant or catalyst damaging based on monitoring crankshaft acceleration.

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 "Malfunction Indicator 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

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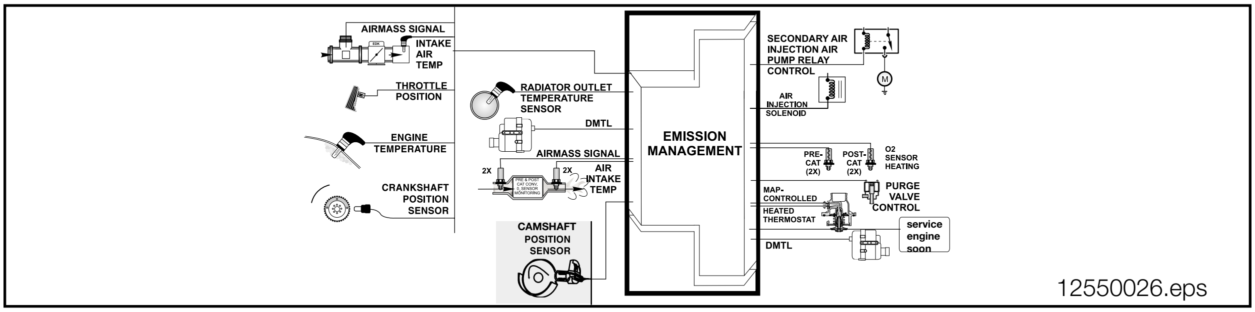
In order to eliminate misfire faults that can occur as a result of varying flywheel tolerances (manufacturing process) an internal adaptation of the flywheel is made. The adaptation is made during periods of decel fuel cut-off in order to avoid any rotational irregularities which the engine can cause 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**.



The MS42 Evaporative Leakage Detection 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. The LDP is replaceable as a complete component. The vacuum supply line (required for pump operation) is in the wiring harness from the engine compartment to the rear of the vehicle.

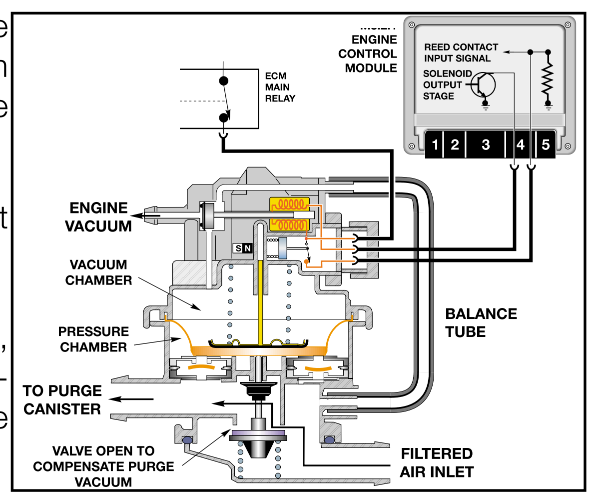
The LDP is a unitized component that contains the following:

• 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.

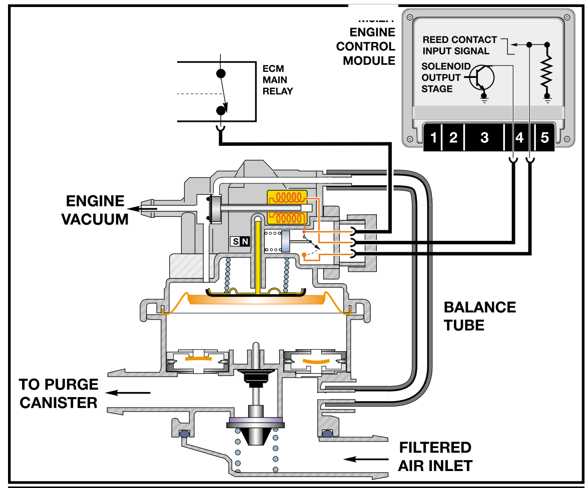


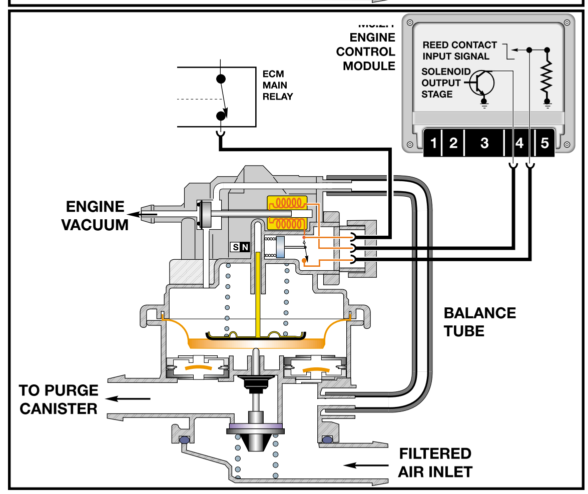
During every engine cold start the LDP solenoid is energized by the ECM. Engine manifold vacuum enters the upper chamber of the LDP to lift up the spring loaded diaphragm.

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.

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.



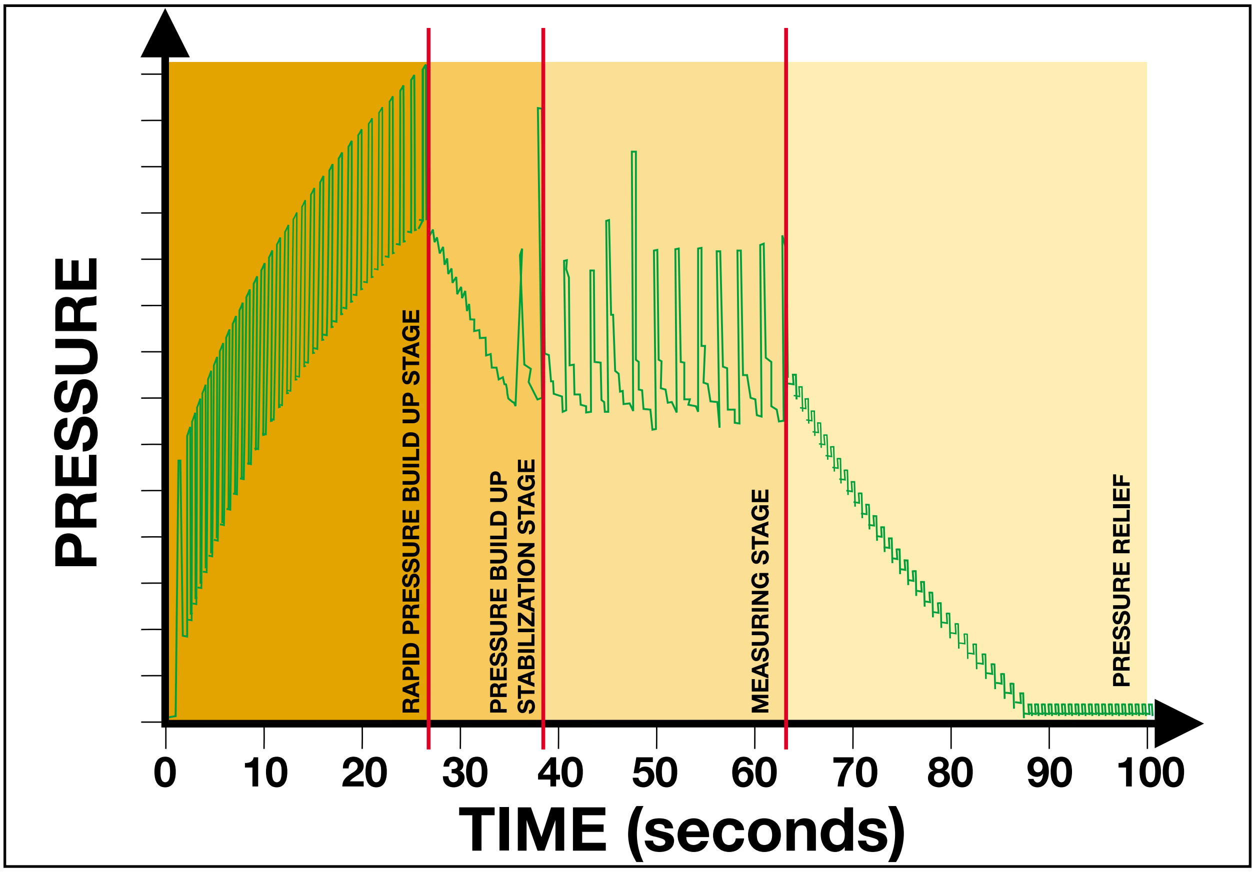


This electrically controlled repetitive up/down stroke is cycled repeatedly building up a total pressure of approximately +25mb in the evaporative system. After sufficient pressure has built up (LDP and its cycling is calibrated to the vehicle), the leak diagnosis begins and lasts about 100 seconds.

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 interruption of the metal rod connected to the diaphragm when in the diaphragm 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 diaphragm in the lower chamber. The LDP is still cycled, but at a frequency 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 frequency 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 rapidly activated for the first 27 seconds. This rapid pumping phase is required to pressurize 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 or a leak. This 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.

The MS43 Evaporative Leakage Detection is performed on the fuel storage system by the DM TL pump which contains an integral DC motor that is activated by the ECM. The ECM monitors the pump motor operating current as the measurement for detecting leaks. The pump also contains an ECM controlled change over valve that is energized closed during a Leak Diagnosis test. The ECM only initiates a leak diagnosis test every second time the criteria are met. The criteria is as follows:

- Engine **OFF** with ignition switched **OFF**.
- ECM still in active state or what is known as "follow up mode" (ECM Relay energized, ECM and components online for extended period after key off).
- Prior to Engine/Ignition switch OFF condition, vehicle must have been driven for a minimum of 20 minutes.
- Prior to minimum 20 minute drive, the vehicle must have been OFF for a minimum of 5 hours.
- Fuel Tank Capacity must be between **15 and 85%** (safe approximation between 1/4 - 3/4 of a tank).
- Ambient Air Temperature between **-7°C & 35°C** (20°F & 95°F)
- Altitude **< 2500m** (8,202 feet).
- Battery Voltage - **11 Volts (minimum)**

When these criteria are satisfied every second time, the ECM will start the Fuel System Leak Diagnosis Test. The test will typically be carried out once a day ie:, once after driving to work in the morning, when driving home in the evening, the criteria are once again met but the test is not initiated. The following morning, the test will run again.

PHASE 1 - Reference Measurement

The ECM activates the pump motor. The pump pulls air from the filtered air inlet and passes it through a precise 1.0 mm reference orifice in the pump assembly.

The ECM simultaneously monitors the pump motor current flow. The motor current raises quickly and levels off (stabilizes) due to the orifice restriction. The ECM stores the stabilized amperage value in memory. The stored amperage value is the electrical equivalent of a 1.0 mm (0.040") leak.

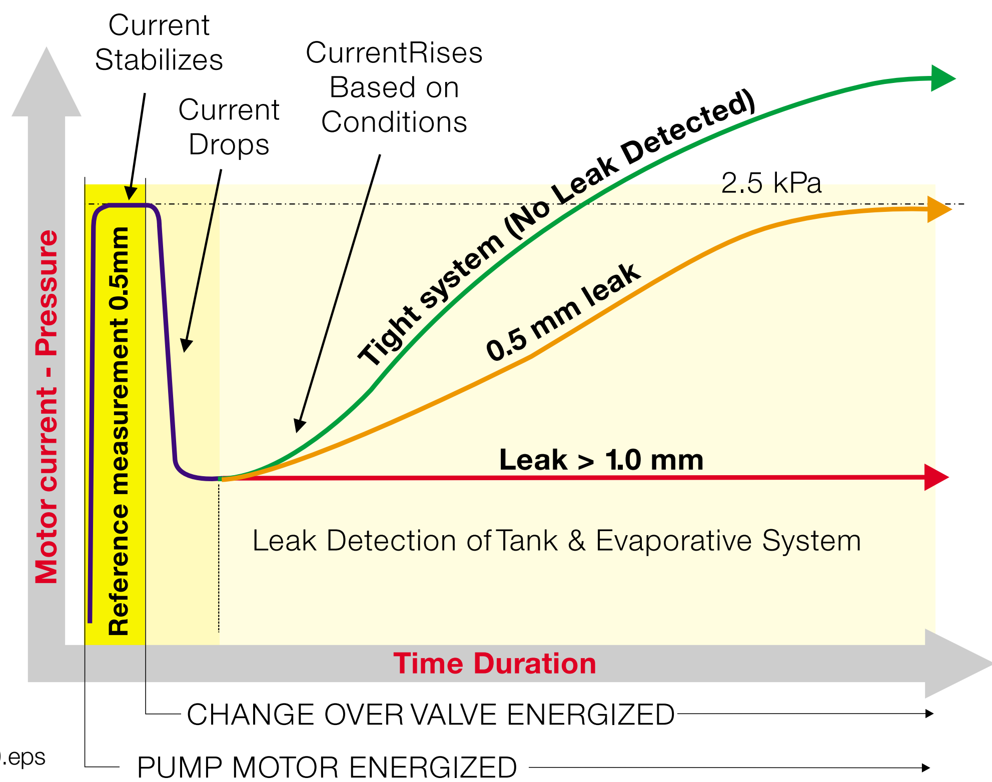
PHASE 2 - Leak Detection

The ECM energizes the Change Over Valve allowing the pressurized air to enter the fuel system through the Charcoal Canister. The ECM monitors the current flow and compares it with the stored reference measurement over a duration of time.

Once the test is concluded, the ECM stops the pump motor and immediately de-energizes the change over valve. This allows the stored pressure to vent thorough the charcoal canister trapping hydrocarbon vapor and venting air to atmosphere through the filter.

Test Results

The time duration varies between 45 & 270 seconds depending on the resulting leak diagnosis test results (developed tank pressure "amperage" / within a specific time period). However the chart below depicts the logic used to determine fuel system leaks.



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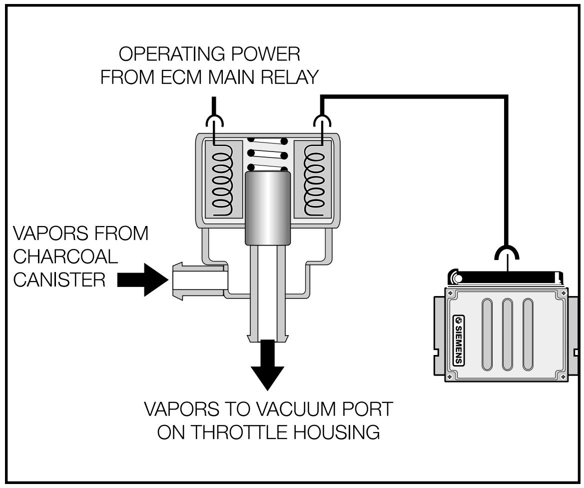
If the ECM detects a leak, a fault will be stored and the "Malfunction Indicator Light" will be illuminated. Depending on the amperage measurement detected by the ECM, the fault code displayed will be "small leak" or "large leak".

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.



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.

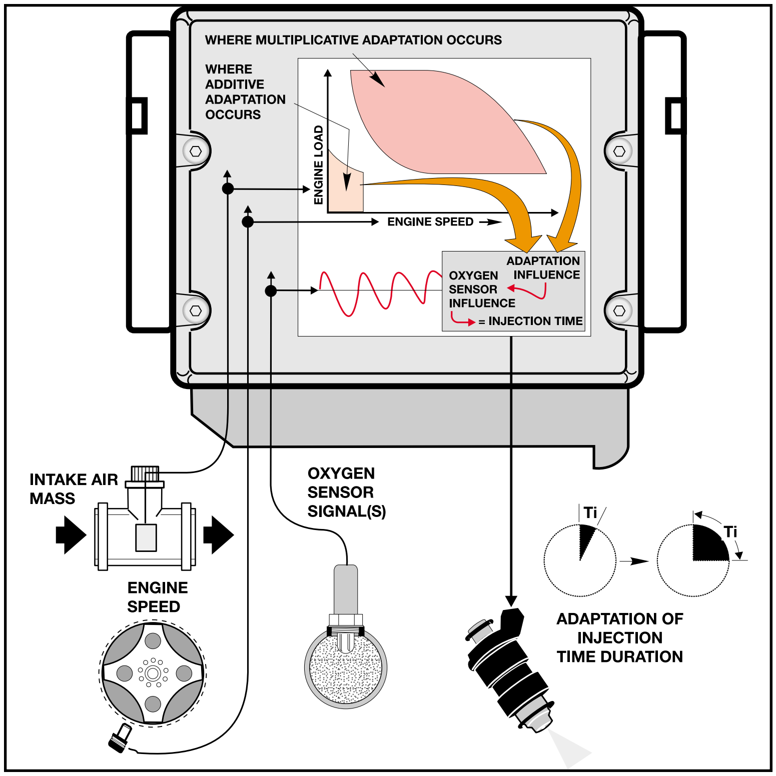
- Stage 1 opens the valve for 10 ms (milli-seconds) and then closes for 150 ms.
- The stages continue with increasing opening times (up to 16 stages) until the valve is completely open.
- The valve now starts to close in 16 stages in reverse order
- This staged process takes 6 minutes to complete. The function is inactive for 1 minute then starts 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. 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.

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).

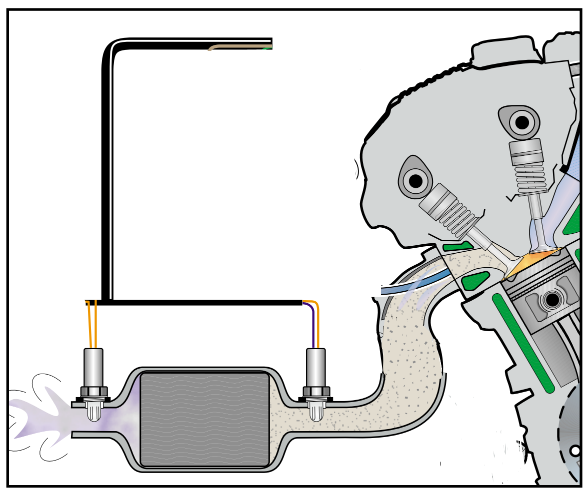
These values indicate how the ECM is compensating for a less than ideal initial air/fuel ratio.

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:

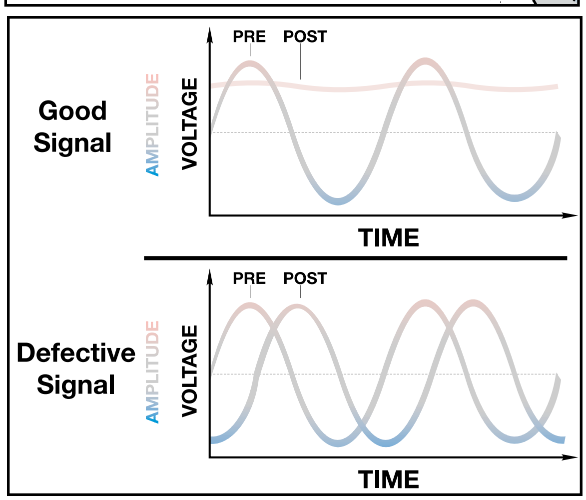
<u>**Requirements**</u>	<u>**Status/Condition**</u>
• Closed loop operation	YES
• Engine coolant temperature	Operating Temp.
• Vehicle road speed	3 - 50 MPH (5 to 80 km/h)
• Catalyst temperature (calculated)*	350°C to 650°C
• Throttle angle deviation	Steady throttle
• Engine speed deviation	Steady/stable engine speed
• Average lambda 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 O_2 sensor signals are evaluated by the ECM to determine the length of time each sensor is operating in the rich and lean range.

If the catalyst is defective the post O_2 sensor signal will reflect the pre O_2 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 "Malfunction Indicator Light" will be illuminated.

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

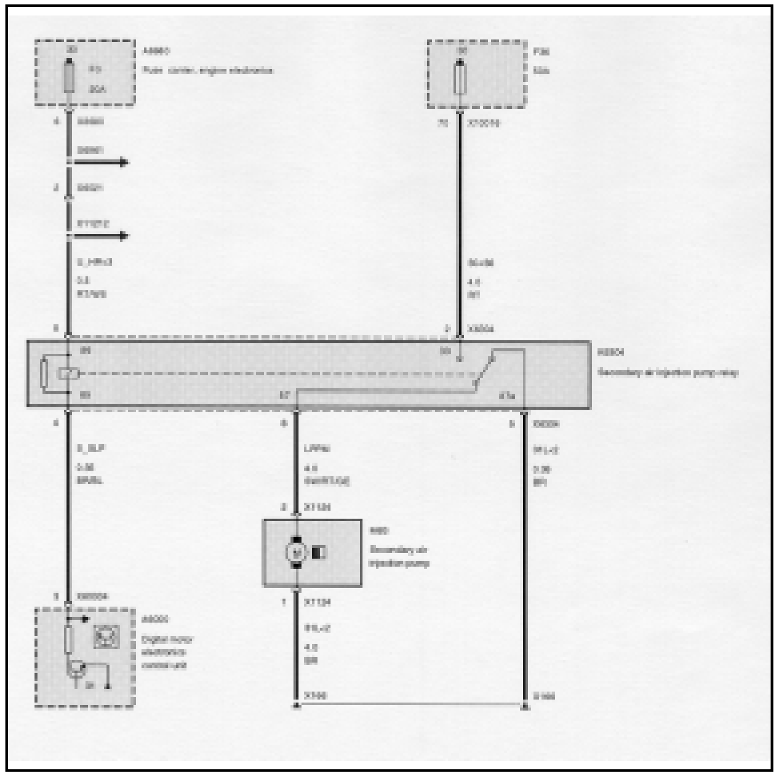
Secondary Air Injection is required to reduce HC and CO emissions while the engine is warming up. Immediately following a cold engine start (-10 to 40°C) fresh air/oxygen is injected directly into the exhaust stream.

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.

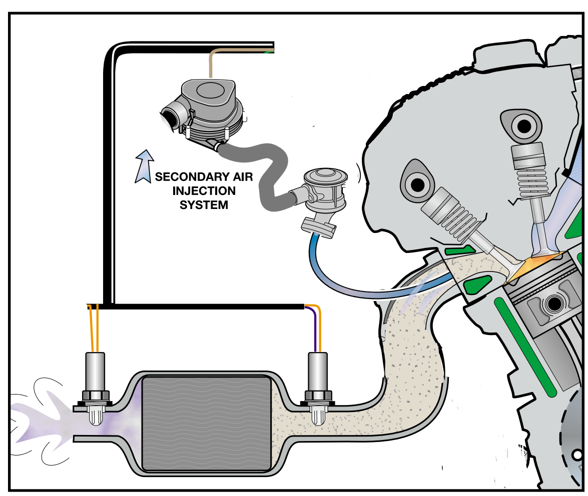
* Below -10º C the pump is activated briefly to “blow out” any accumulated moisture.



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 is air 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.

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 present the "Malfunction Indicator 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 the detected misfire events for each cylinder. If the sum of all cylinder misfire incidents exceeds the predeter mined value, a fault code will be stored and the “Malfunction Indicator Light” will be illuminated.

- If more than one cylinder is misfiring, all misfiring cylinders will be specified and the individual fault codes for each misfiring cylinder, or multiple cylinders will be stored. The “Malfunction Indicator Light” will be illuminated.

Catalyst Damage:

- Within an interval of 200 crankshaft revolutions the detected number of misfiring events is caluated 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 “Malfunction Indicator Light” will be illuminated.

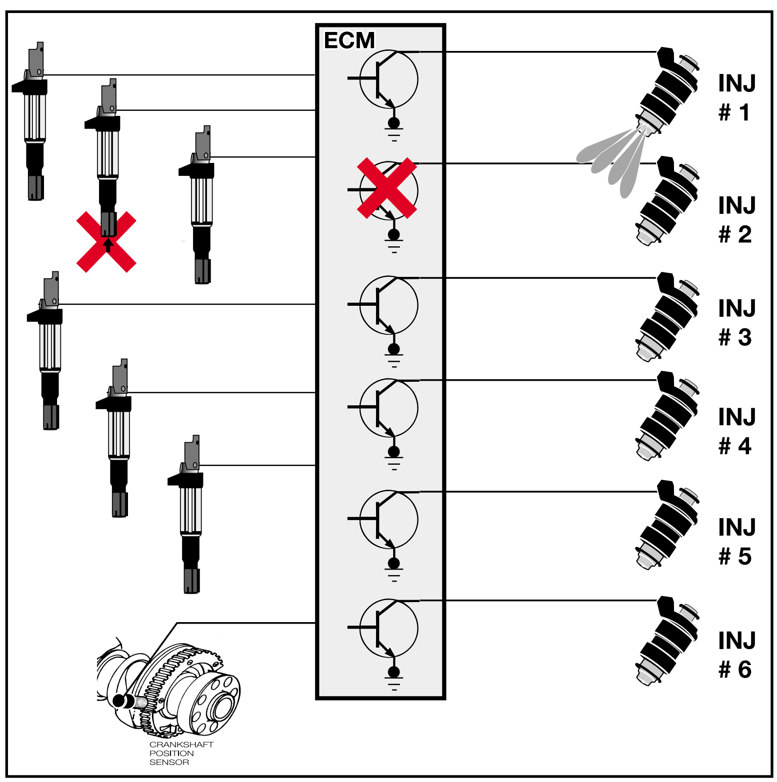
If the cylinder misfire count exceeds the predetermined threshold the ECM will take the following measures:

- The oxygen sensor control will be switched to open loop.

- The cylinder selective fault code is stored.

- If more than one cylinder is mis firing the fault code for all indi vidual cylinders and for multiple cylinders will be stored.

- The fuel injector to the respec tive cylinder(s) is deactivated.



Electrically Heated Thermostat

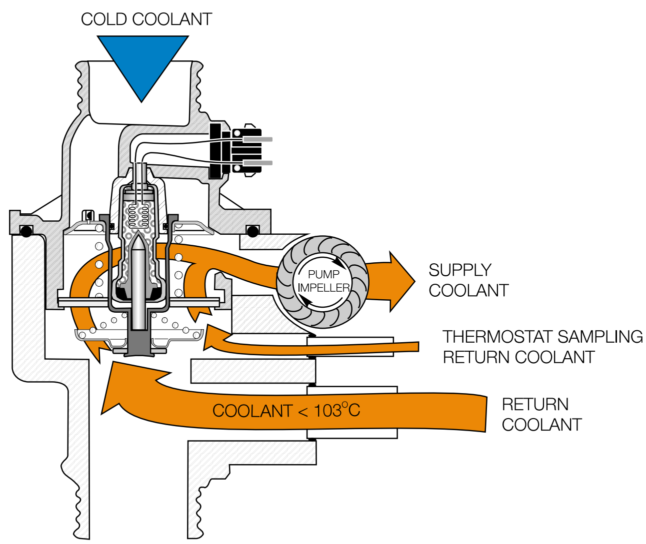
Model specific variants of the electrically heated thermostat are now equipped on all LEV/ULEV compliant engines. This thermostat allows the engine to run hotter than conventional thermostats improving fuel economy.

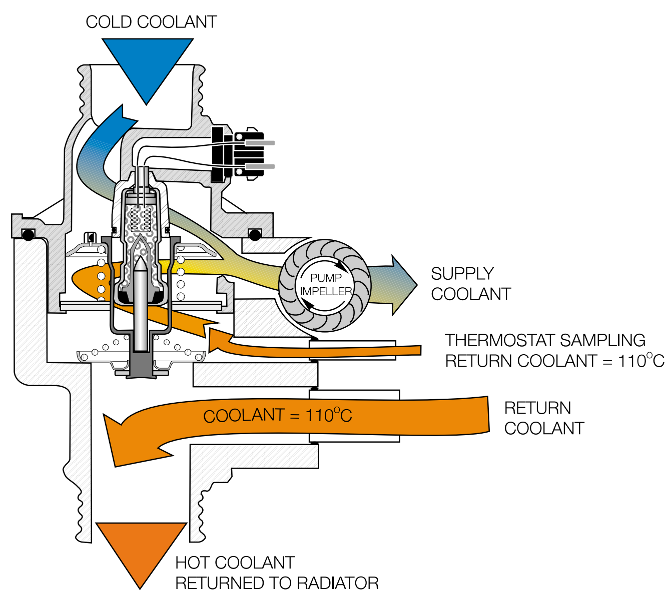
The ECM also electrically activates the thermostat to lower the engine coolant temperatures based on monitored conditions. It is both a conventionally functioning and ECM controlled thermostat (two stage operation). ECM control adds heat to the wax core causing the thermostat to open earlier than it's mechanical temperature rating providing increased coolant flow.

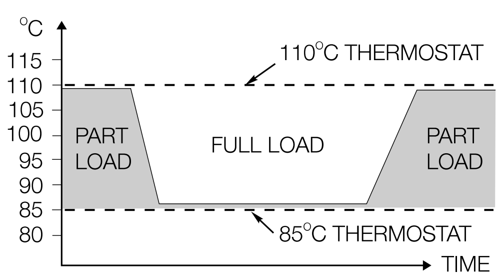
Conventional Function: The thermostat begins to open at 103°C. This is at the inlet side of the water pump and represents the temperature of the coolant entering the engine. Before the 103°C temperature is realized, the coolant is circulated through the engine block by the water pump.

After the temperature reaches 103°C it is maintained as the inlet temperature by the thermostat. The coolant temperature at the water pump engine outlet is approximately 110°C. The additional 7°C is achieved after the coolant has circulated through the block.

The operating temperature of the engine will remain within this range as long as the engine is running at part load conditions and the engine coolant temperature does not exceed 113°C.







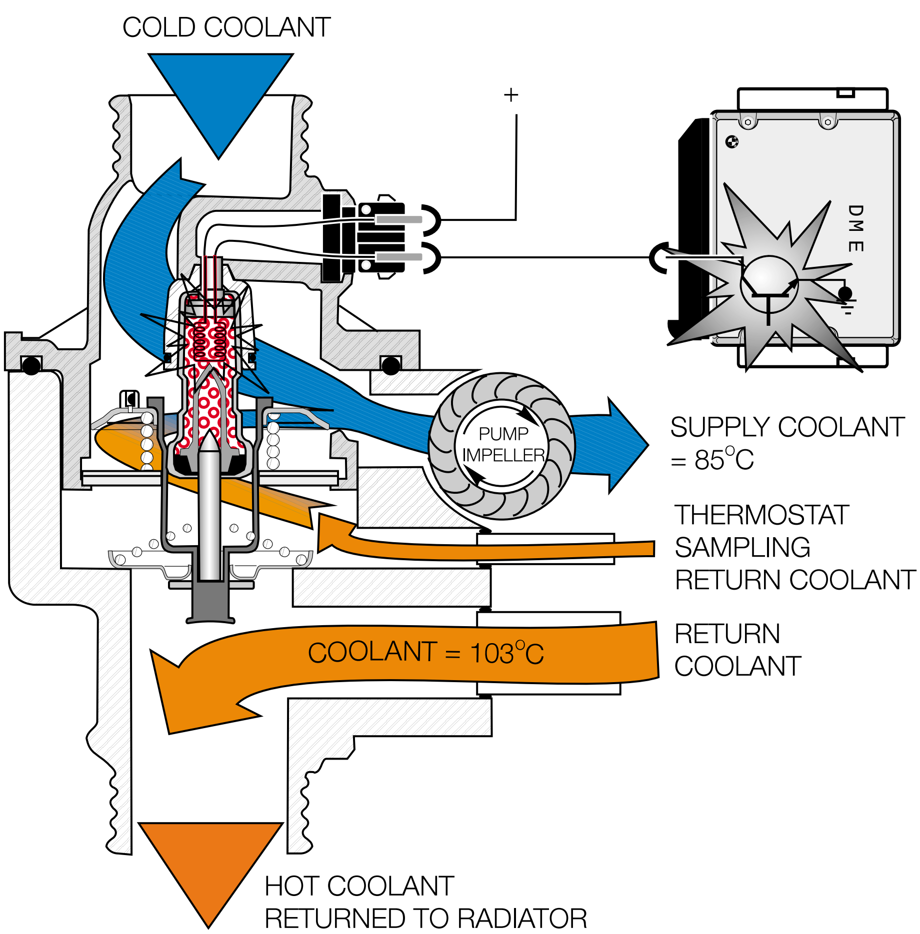
ECM Control

Electric thermostat activation is based on the following parameters:

- Engine temperature > 113°C
- Radiator Coolant Outlet Temperature
- Load signal “ti” > 5.8 ms
- Intake air temp > 52°C
- Vehicle speed > 110 MPH

When one or more of these monitored conditions is determined, the ECM activates (switched ground) the thermostat circuit. The activated heating element causes the wax core in the thermostat to heat up and open the thermostat increasing coolant circulation through the radiator which brings the engine temperature down.

The temperature of the coolant at the inlet side of the water pump will drop to approximately 85°C and the temperature at the outlet side will drop to approximately 103°C when activated.

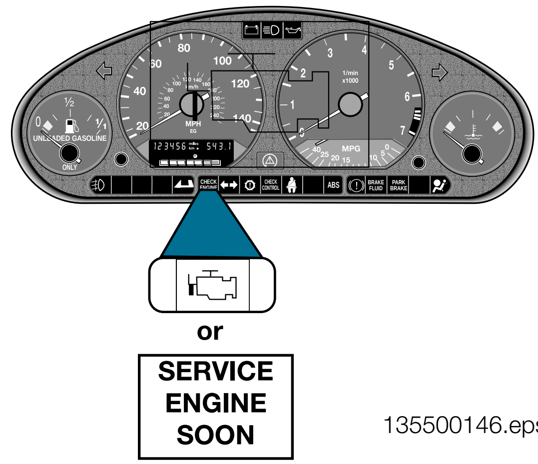


The “Malfunction Indicator Light” (MIL) will be illuminated under the following conditions:

- 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).

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



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- 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 Malfunction Indicator 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 Malfunction Indicator Light is illuminated based on the "customer drive cycle".

TEXT NO.	DRIVE CYCLE # 1			DRIVE CYCLE # 2			DRIVE CYCLE # 3			DRIVE CYCLE # 4			DRIVE CYCLE # 5			* DRIVE CYCLE # 43		
	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

1. A fault code is stored within the ECM upon the first occurrence of a fault in the system being checked.

2. The "Malfunction Indicator 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 occurred.

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 "Malfunction Indicator Light” is illuminated if the function is checked and the fault is still present.

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 "Malfunction Indicator Light” to be illuminated.

5. Once the "Malfunction Indicator 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 memory 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 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 "Malfunction Indicator 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 "Malfunction Indicator Light”.

OBD II Drive Cycle's & Trips

- A **"Drive cycle"** consists of engine startup and engine shutoff.

- **"Trip"** is defined as vehicle operation (following 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.

  This definition is subject to the limitations that the manufacturer-defined trip monitoring conditions are all monitored at least once during the first engine start portion of the Federal Test Procedure (FTP).

- 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:**

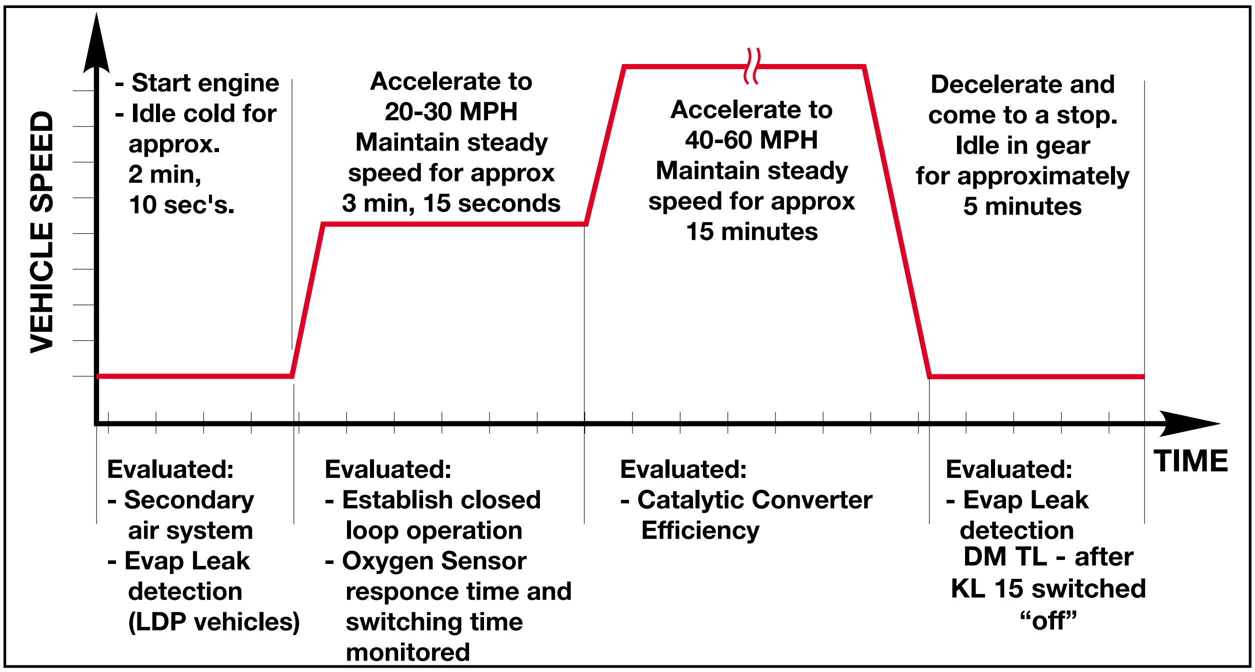
- Oxygen Sensors
- Secondary Air Injection System
- Catalyst Efficiency
- Evaporative Vapor Recovery System

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 - ECM, 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 fluctuations 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 Completed

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 "Malfunction Indicator Light" is performed.

The readiness code was established to prevent anyone with an emissions related fault and a "Malfunction Indicator 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 "Malfunction Indicator 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 environmental operating conditions when a fault is stored. This single "Freeze Frame" or snapshot refers to a block of the vehicles environmental conditions for a 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

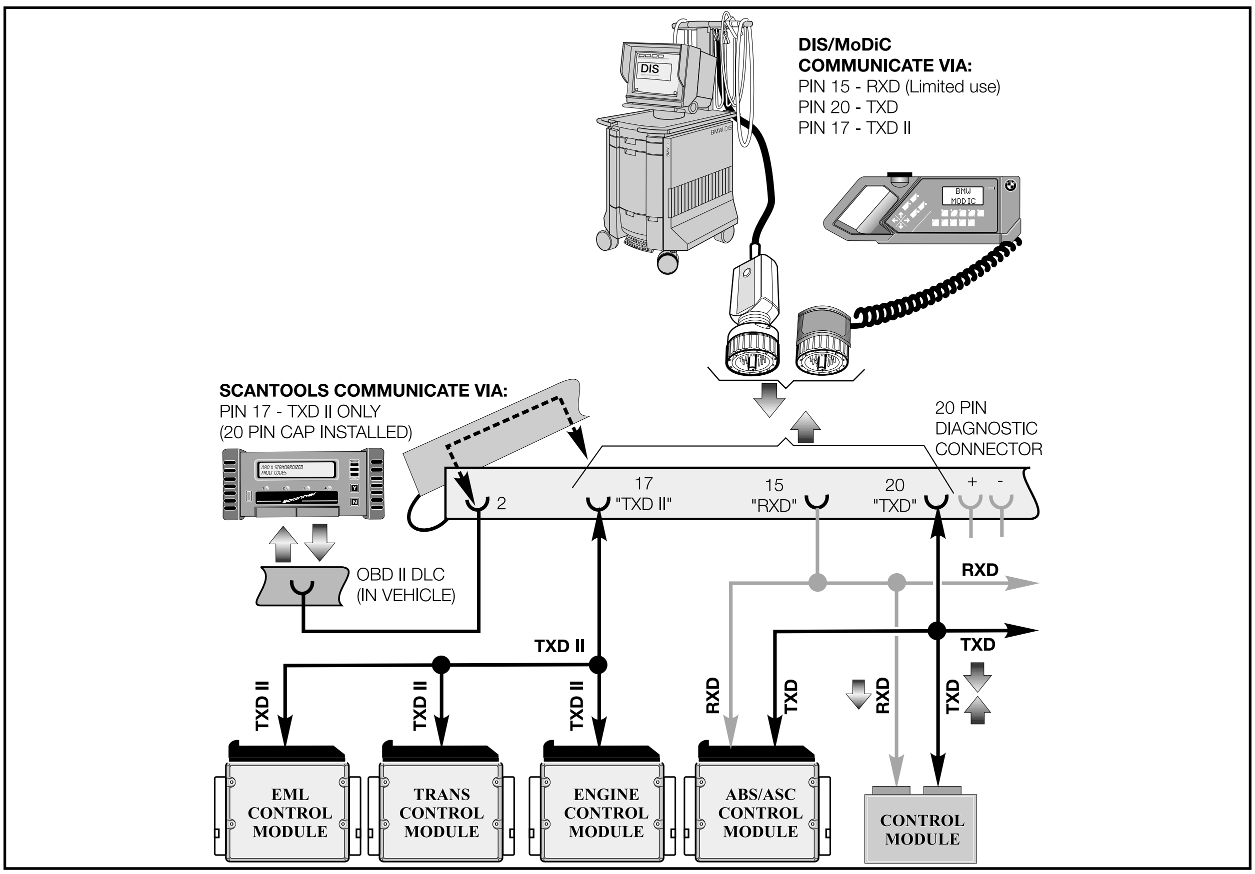
The MS42/MS43 has a separate OBD II Diagnostic Link Connector (DLC). The OBD II connector is located in the drivers footwell to the left of the steering column (right side of center console on the Z3). The DLC provides access for an aftermarket scan tool to all emission related control systems:

• 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.



BMW Fault Code (DIS/MoDiC)

- BMW Codes are stored as soon they occur even before the "Malfunction Indicator Light" comes on.

- BMW Codes are defined by BMW and Siemens Engineers to provide greater detail to fault specific information.

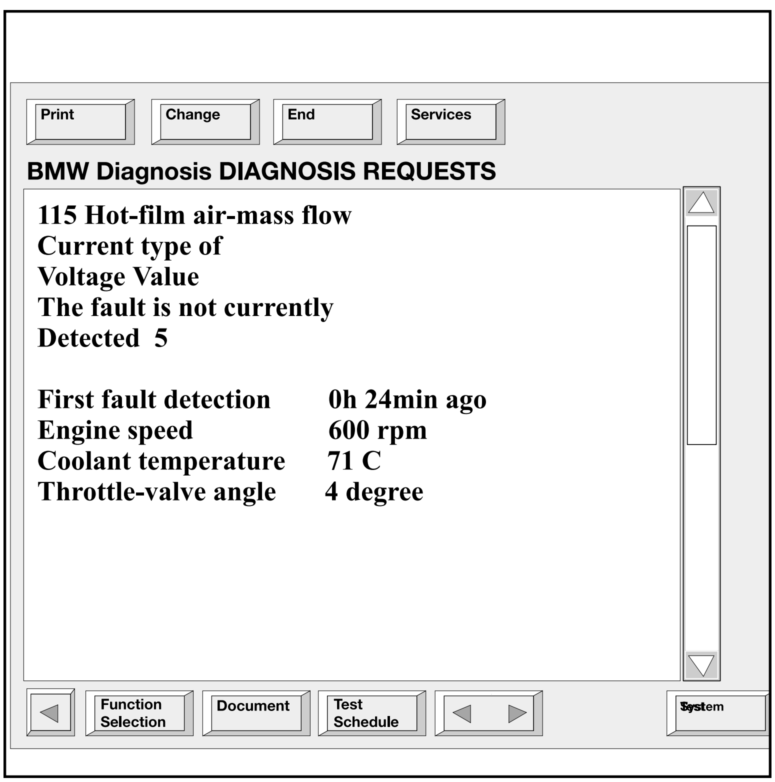
- Siemens systems - one set of four fault specific environmental conditions are stored with the first fault occurrence. This information can change and is specific to each fault code to aid in diagnosing. A maximum of ten different faults containing four environmental conditions can be stored.

- BMW Codes also store and displays a "time stamp" when the fault last occurred.

- A fault qualifier gives more specific detailed information about the type of fault (upper limit, lower limit, disconnection, plausibility, etc.).

- BMW Fault Codes will alert the Technician of the current fault status. He/she will be advised if the fault is actually still present, not currently present or intermittent. The fault specific information is stored and accessible through DISplus/MoDIC.

- BMW Fault Codes determine the diagnostic output for BMW DISplus/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 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 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 "Malfunction Indicator Light” can be diagnosed with an aftermarket Scan Tool that allows Technicians without BMW Special Tools or Equipment to Diagnose an emission system failure.

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

Refer to Service Information Bulletin S.I. #11 03 00 on Coolant Thermostat and Associated Fault Codes.

Misfire Detection

Refer to Service Information Bulletin **S.I. #12 02 97** for details about Misfire Fault Codes.

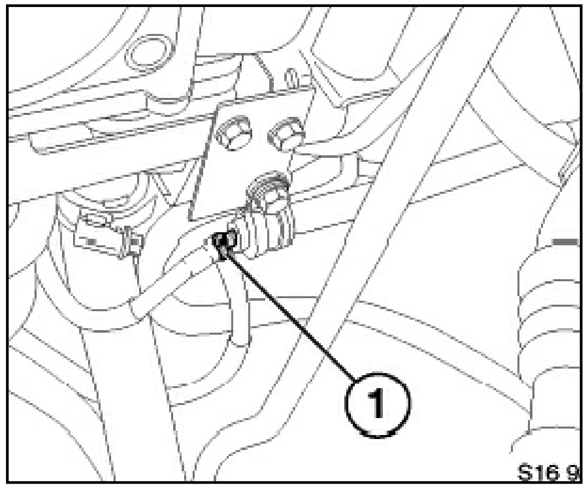
Checking Fuel Tank and Ventilation System for Leak-Tightness

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.

MS42

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

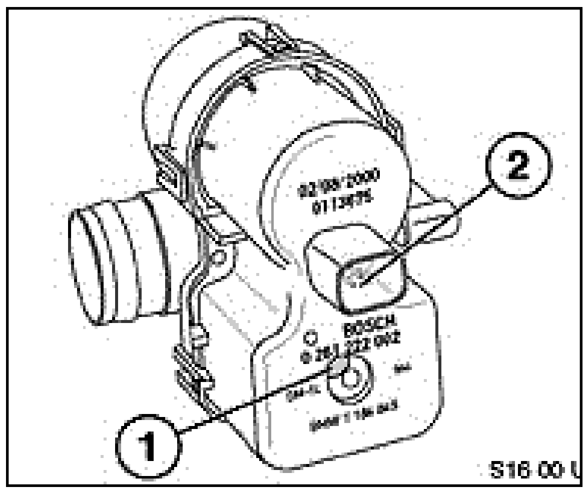
IF the vacuum “T” (1) refered to in the SI is restricted, it must be replaced with a modified T-fitting **P/N 11 72 1 439 973.**



MS43

Refer to Service Information Bulletin S.I. #12 13 00 for **E46 DMTL FC 142 Stored in the ECM (DME).**

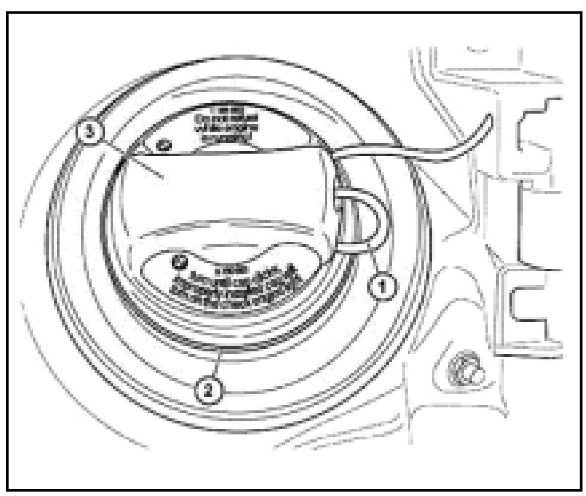
Refer to p/n **#16 13 1 184 849 for a “green dot”(1)** below electrical connector(2).



Malfunction Indicator 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



Testing the Oxygen Sensor should be performed using the DISplus Oscilloscope from the “Preset Measurement” List. The scope pattern should appear as below for a normal operating sensor.

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

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

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

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

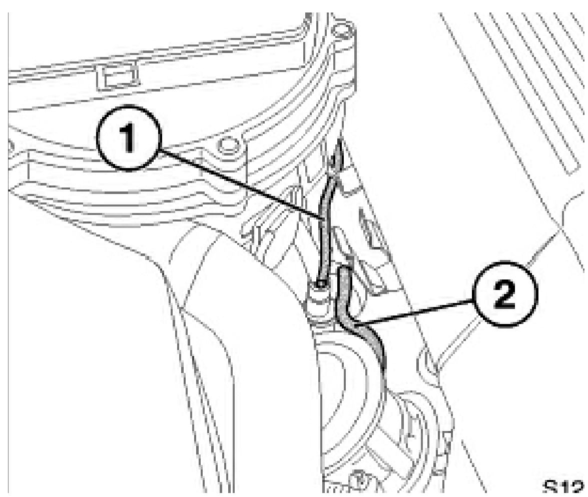
NOTE: A MIXTURE RELATED FAULT CODE SHOULD BE INVESTIGATED FIRST AND DOES NOT ALWAYS INDICATE A DEFECTIVE OXYGEN SENSOR!

For “Fault Access/O2 Readiness Codes” refer to Service Information Bulletin S.I. #12 15 99 on Voluntary Emissions Recall 00E-A01.

Refer to Service Information Bulletin S.I. #12 04 98 on **Vacuum Hose to Secondary Air Non-Return Valve and Associated Fault Codes.**

1. Check for damage to the plastic tube.

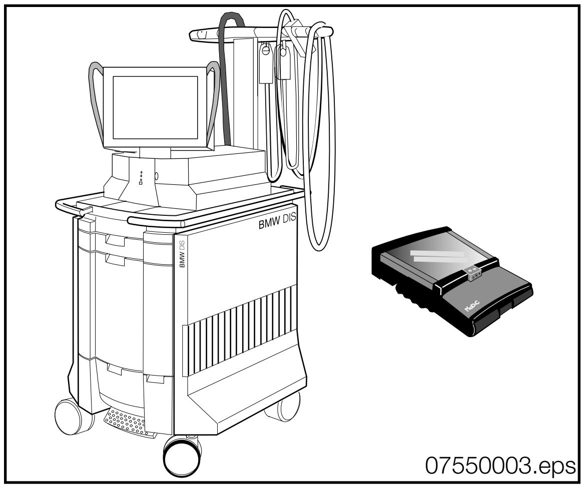
2. Check for damage to the rubber hose.



Tools and Equipment

The DISplus/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.



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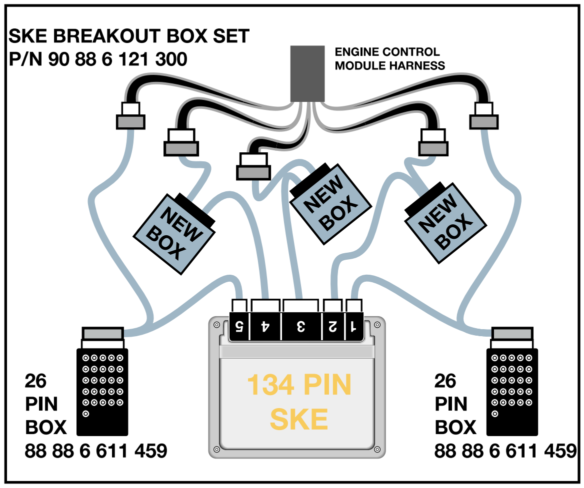
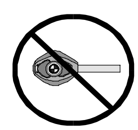
The correct Universal Adapter for the MS42/MS43 application should be used (#90 88 6 121 300). This will ensure the pin connectors and the harness will not be damaged.



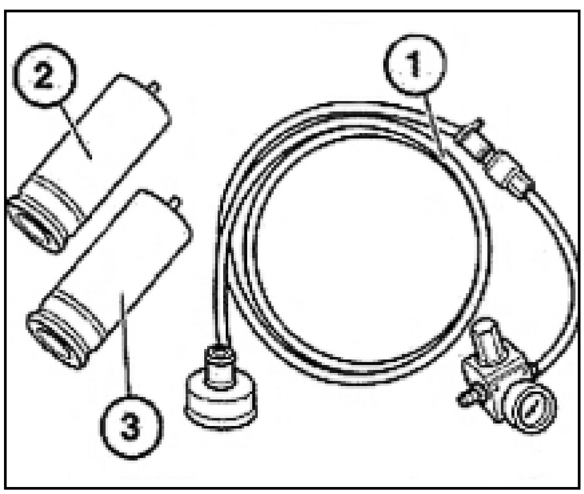
When installing the Universal Adapter to the ECM (located below the windshield on the passenger side of the engine compartment), make sure the ignition is switched off.

NOTE for MS43: Allow at least 3 minutes to elapse after the key was set to the "OFF" position before disconnecting the ECM/TCM. This will allow sufficient time to complete the DM TL test. Voltage may be present (up to 3 minutes) causing damage to the ECM/TCM if they are disconnected during this time period (arcing).



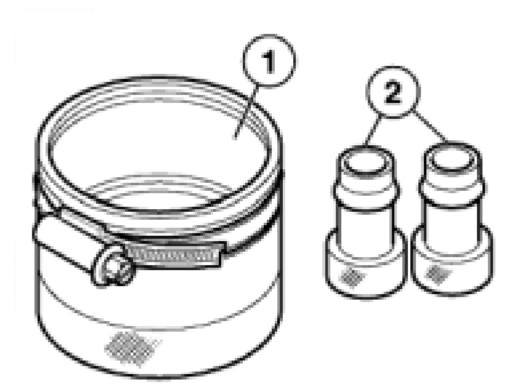
When checking the fuel tank and ventilation system for leak-tightness use Special Tool Set #90 88 6 161 170 which includes all of the pieces shown to the right.

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

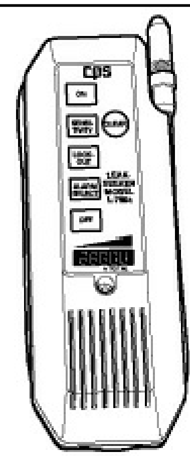


This set is used in conjunction with shop supplied compressed air and the DISplus/Multimeter function for reading the pressure bleed off.

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



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



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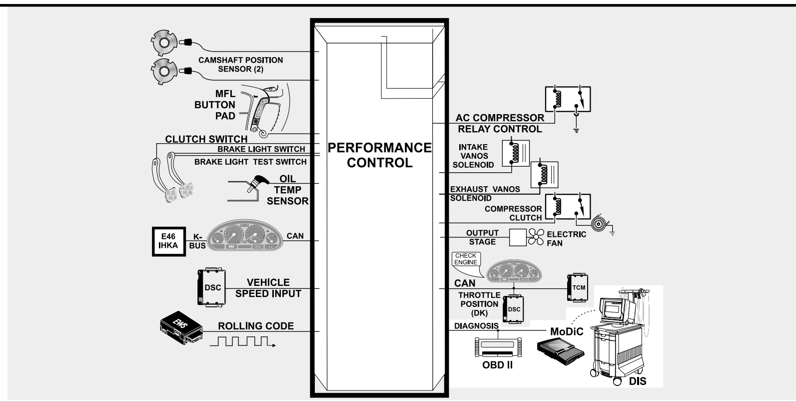
- Fuel Filler Cap and Filler Neck
- Fual Tank Ventilation Lines
- Evaporative Emission Valve
- Fuel Tank and Fuel Sending Unit
- Liquid/Vapor Separator

Performance Controls

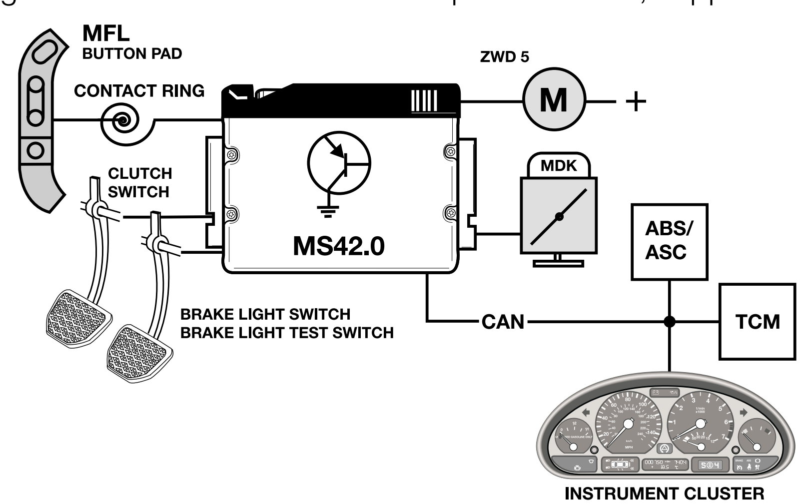


Cruise Control

Cruise control functions are activated directly by the multifunction steering wheel to the ECM. The individual buttons are digitally encoded in the MFL switch and is input to the ECM over a serial data wire. Cruise Control is integrated into the ECM because of the MDK/EDK operation.

- The ECM controls vehicle speed by activation of the Electronic Throttle Valve (MDK/EDK).
- The clutch switch disengages cruise control to prevent over-rev during gear changes.
- The brake light switch and the brake light test switch are input to the ECM to disengage cruise control as well as fault recognition during engine operation of the MDK/EDK.

Road speed is input to the ECM for cruise control as well as DSC regulation. The vehicle speed signal for normal engine operation is supplied from the DSC module (right rear wheel speed sensor). The road speed signal for cruise control is supplied from the DSC module. This is an average taken from both front wheel speed sensors, supplied via the CAN bus.



A/C Compressor Control

The ECM controls the A/C Compressor Relay based on signals from the IHKA/IHKR Control Module. The IHKR system in an E46 is shown here as an example.

The IHKR control module sends the following signals to the ECM over the K-bus-Kombi-CAN -bus connection:

- IHKR on stand-by (signal AC)
- Request for A/C activation (signal KO)
- Calculated compressor load
- Request for auxiliary fan

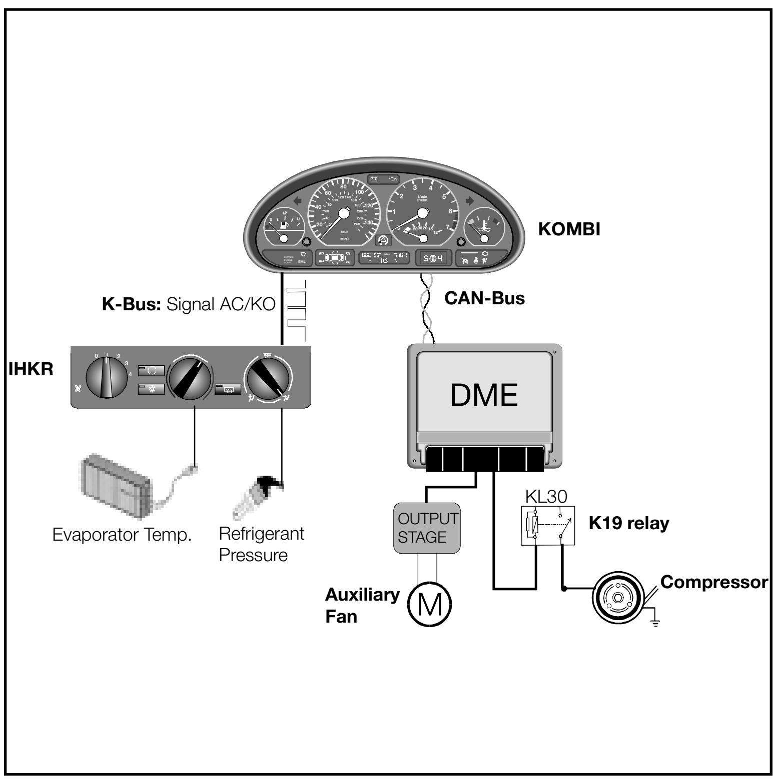
The IHKR determines the load torque for compressor activation and required auxiliary fan speed from the refrigerant pressure sensor mounted on the high side line next to the receiver/dryer.

The refrigerant pressure sensor provides a voltage input signal (0-5 volts) to the IHKR. The voltage value increases as pressure in the high side refrigerant circuit increases. The IHKR processes this signal to determine the calculated load that will be placed on the engine when the compressor is switched on. Pressure values that are too high or too low will cause the compressor to be switched off.

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

Once all of the criteria for compressor operation have been met, the ECM will activate a gound circuit to the compressor relay to energize the compressor magnetic clutch.

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

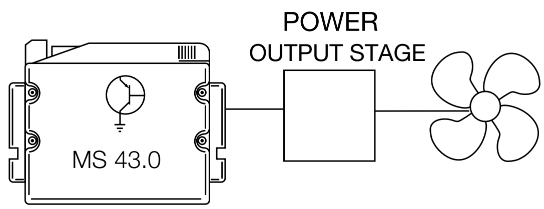


Electric Fan

The electric cooling fan is controlled by the ECM. The ECM uses a remote power output final stage (mounted on the fan housing). The power output stage receives power from a 50 amp fuse (E46 - located in glove box above the fuse bracket). The electric fan is controlled by a pulse width modulated signal from the ECM.

The fan is activated based on the ECM calculation (sensing ratio) of:

- Coolant outlet temperature
- Calculated (by the ECM) catalyst temperature
- Vehicle speed
- Battery voltage
- Air Conditioning pressure (calculated by IHKA and sent via the K-Bus to the ECM)



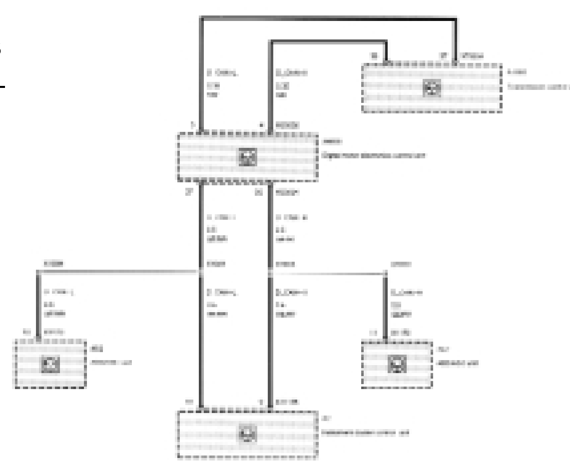
After the initial test has been performed, the fan is brought up to the specified operating speed. At 10% (sensing ratio) the fan runs at 1/3 speed. At a sensing ratio of between 90-95% the fan is running at maximum speed. Below 10% or above 95% the fan is stationary.

The sensing ratio is suppressed by a hysteresis function, this prevents speed fluctuation. When the A/C is switched on, the electric fan is not immediately activated.

Torque Interfaces

If torque reduction or increase is required for ASC/DSC/MSR/AGS, the ECM will regulate engine power in the following manner:

- If less torque is required, the ignition timing is reduced (fast intervention), the idle speed actuator and MDK/EDK reduce intake air.
- If increased torque is required (MSR), the idle speed actuator and MDK increase intake air.

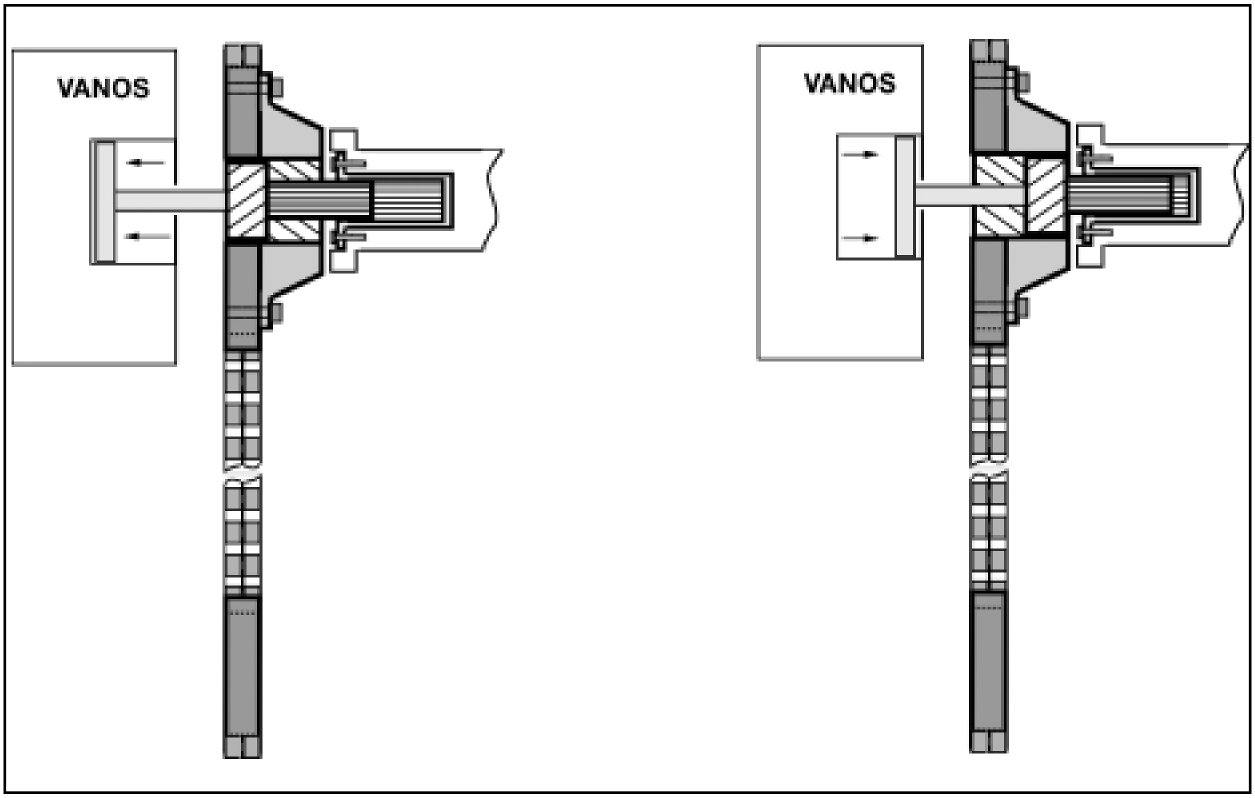


The data required for engine torque manipulation is relayed via the CAN bus.

Dual 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 and Exhaust** 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.

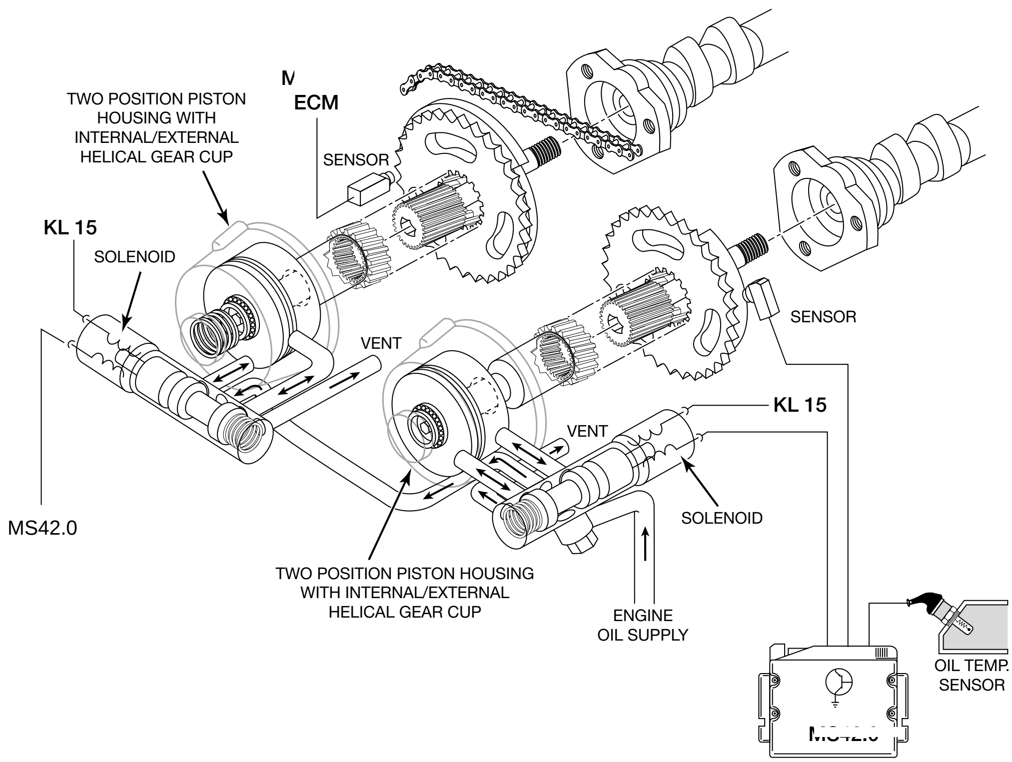
VANOS mechanical operation is dependent on engine oil pressure applied to position the control pistons. When oil pressure is applied to the control pistons (regulated by the solenoids), the pistons move causing the splined adjustment shafts to move. The straight splines slide within the camshaft sleeves. The helical splines rotate the camshaft drive sprockets changing the position in relation to the camshaft position which advances/retards the intake/exhaust camshaft timing.



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 Sensors for VANOS operation.

Dual VANOS consists of the following parts:

- Intake and exhaust camshafts with helical gear insert
- Sprockets with adjustable gears
- VANOS actuators for each camshaft
- 2 three-way solenoid switching valves
- 2 impulse wheels for detecting camshaft position
- 2 camshaft position sensors (Hall effect)



When the engine is started, the camshafts are in the "failsafe" position (deactivated). The intake camshaft is in the RETARDED position - held by oil pressure from the sprung open solenoid. The exhaust camshaft is in the ADVANCED position - held by a preload spring in the actuator and oil pressure from the sprung open solenoid.

After 50 RPM (2-5 seconds) from engine start, the ECM is monitoring the exact camshaft position. The ECM positions the camshafts based on engine RPM and the throttle position signal. From that point the camshaft timing will be varied based on intake air and coolant temperatures.

The dual VANOS system is "fully variable". When the ECM detects the camshafts are in the optimum positions, the solenoids are modulated (approximately 100-220 Hz) maintaining oil pressure on both sides of the actuators to hold the camshaft timing.

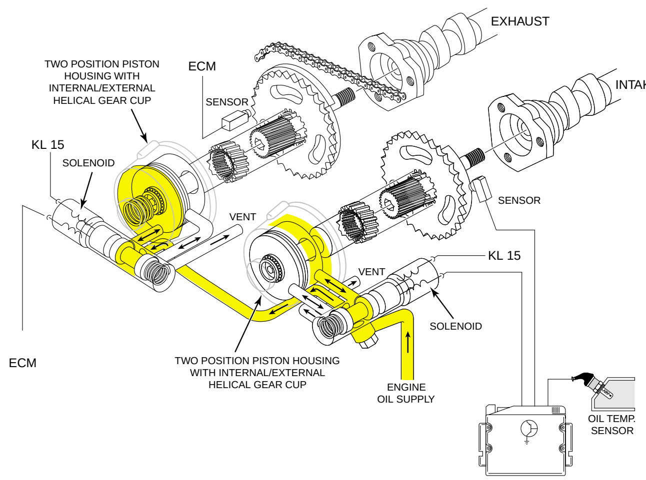
CAUTION: The VANOS MUST be removed and installed exactly as described in the Repair Instructions!

NOTE: If the VANOS camshaft system goes to the failsafe mode (deactivated) there will be a noticeable loss of power.

DEACTIVATED

EXHAUST: Advanced - piston moved in

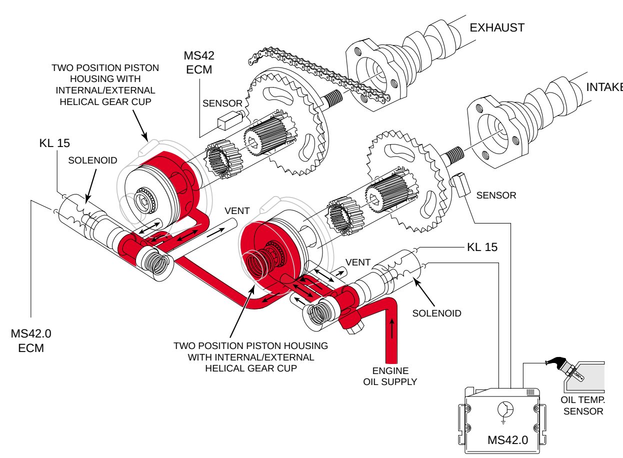
INTAKE: Retard - piston moved out



ACTIVATED

EXHAUST: Advanced - piston moved out

INTAKE: Retard - piston moved in

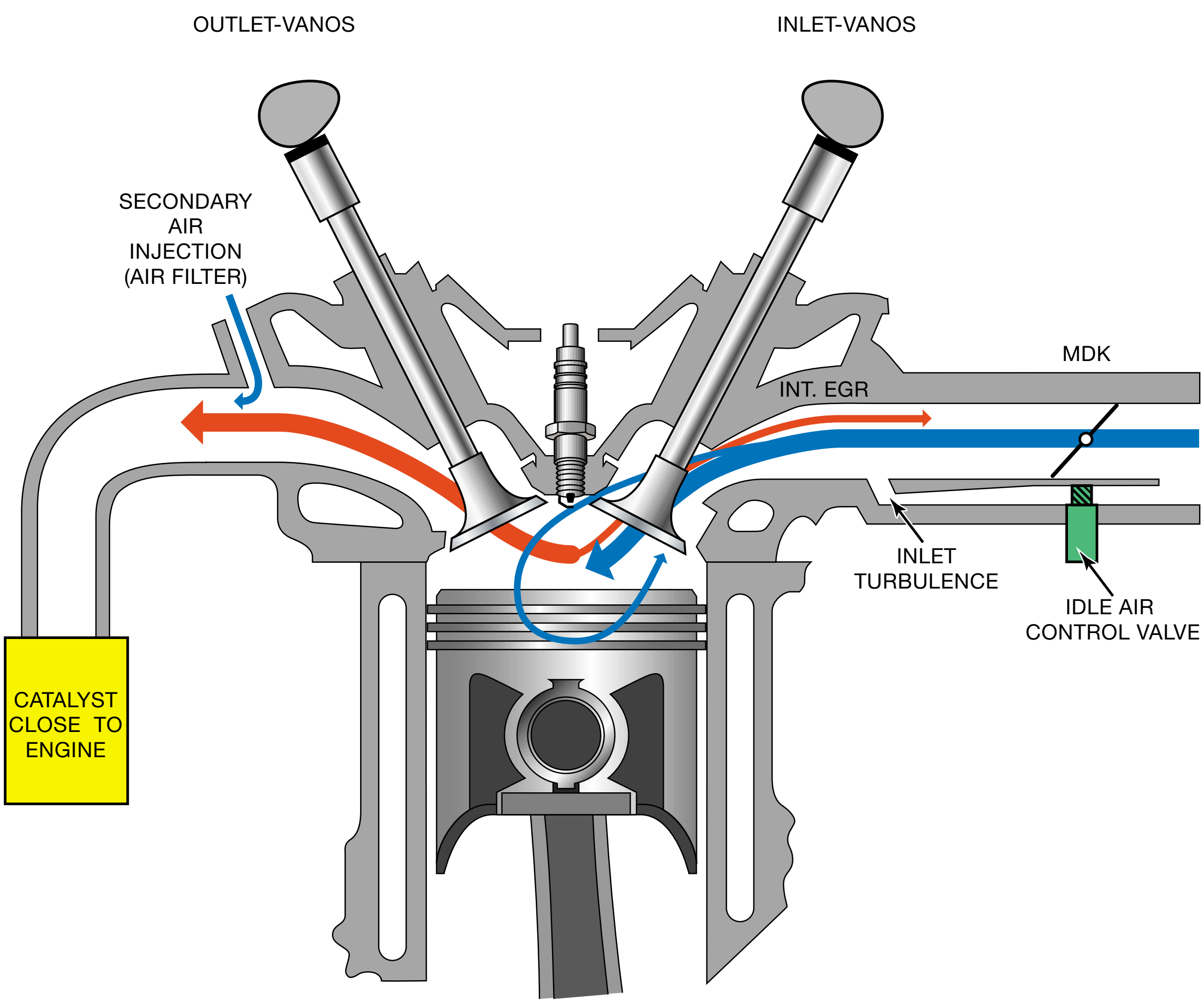


The dual VANOS in conjunction with the variable intake manifold provides an additional emission control feature.

Because of the improved combustion, the camshaft timing is adjusted for more overlap. The increased overlap supports internal exhaust gas recirculation (EGR) which reduces tailpipe emissions and lowers fuel consumption.

During the part load engine range, the intake camshaft overlap opens the intake valve. This allows limited exhaust gas reflow the intake manifold.

The “internal” EGR reduces the cylinder temperature thus lowering NOx. This feature provides EGR without the external hardware as seen on previous systems.



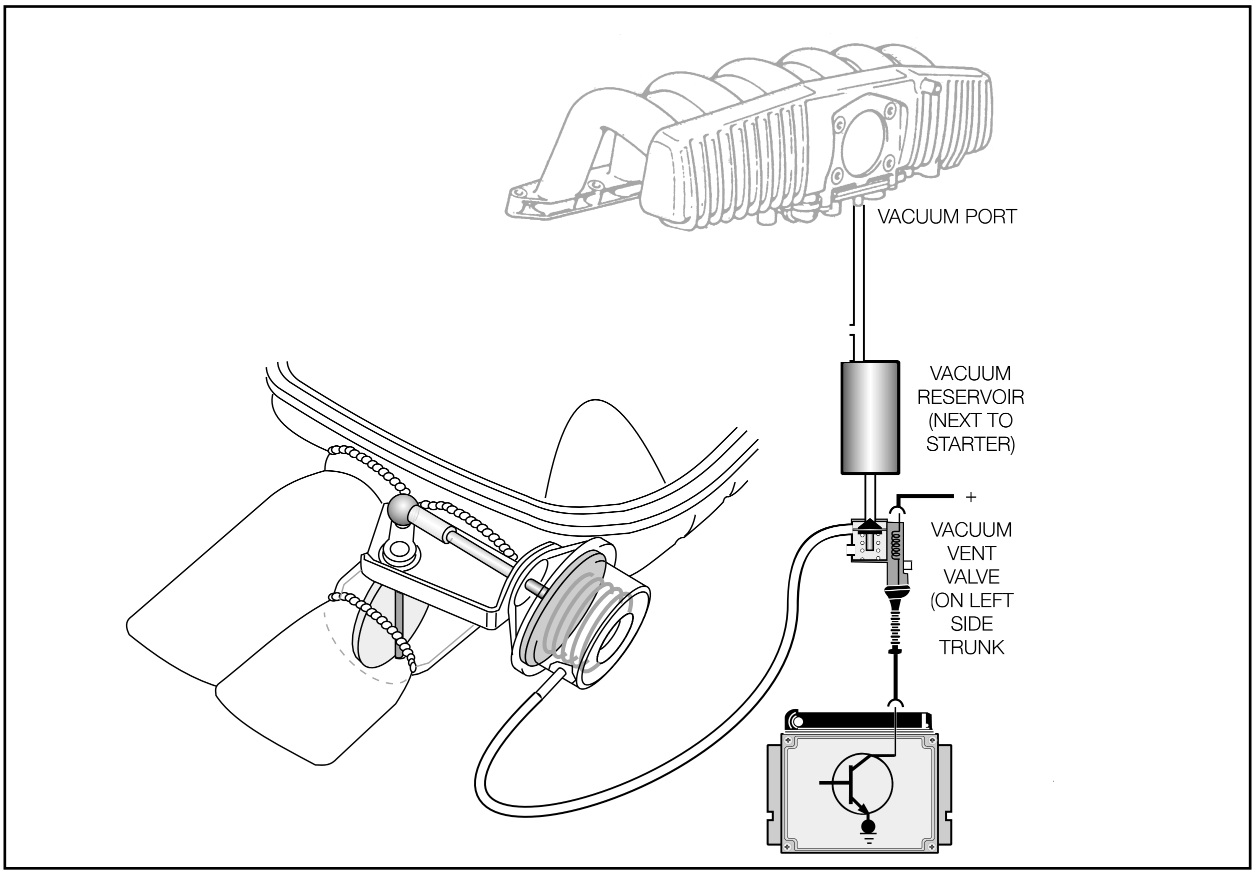
Exhaust Flap Damper Control (M54 - if equipped)

To meet European noise level compliance, the rear silencer incorporates a flap that is designed to reduce exhaust noise at idle, low rpm acceleration and while coasting. Components of the system include:

- Exhaust Flap with Vacuum Actuator
- Switching Solenoid
- Vacuum Reservoir

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.

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



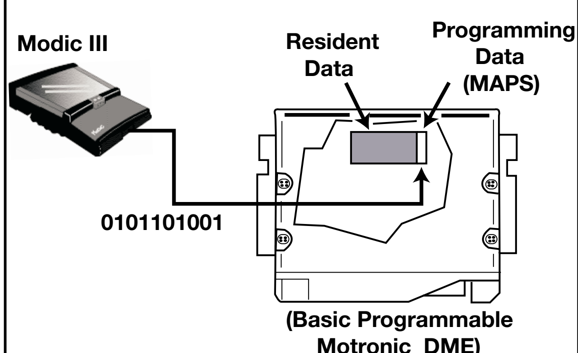
ECM Programming - FLASH Control Modules

The MS42/MS43 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 DISplus/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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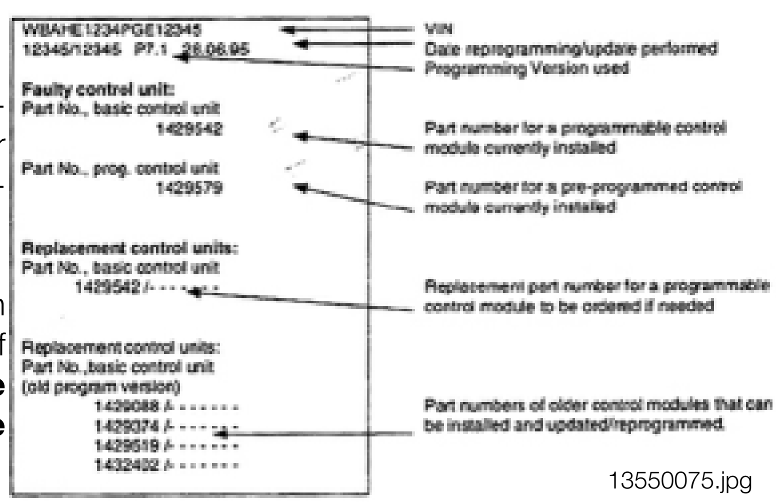
The determination identification screen is an example of the data displayed once the determination is made.

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

Refer to Service Information Bulletin #12 16 99 if **Reprogramming of Engine Control Module May Not Be Possible.**



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Tools and Equipment

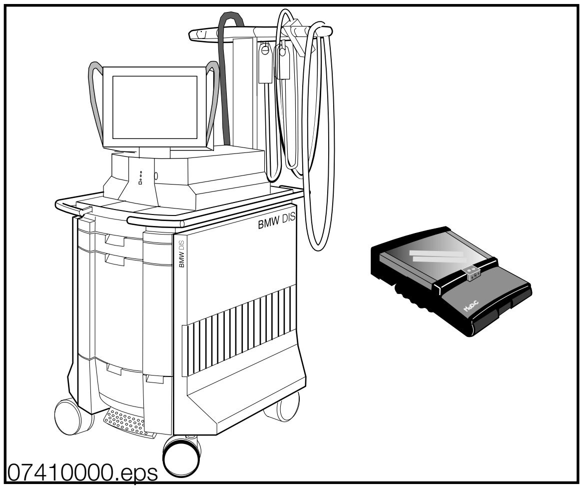
The DISplus/Modic as well as a reputable hand held multimeter can be used when testing inputs/components.

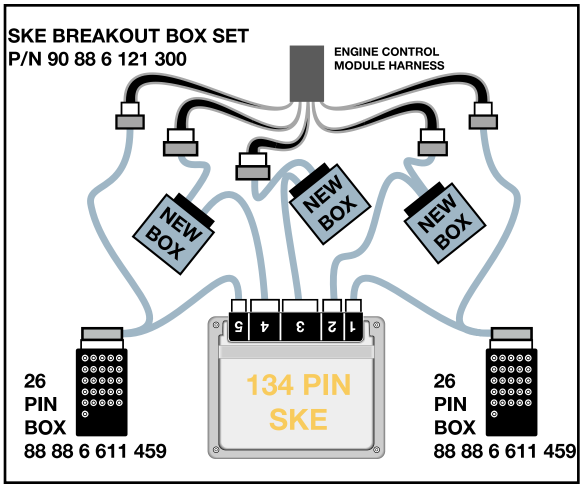
It is best to make the checks at the ECM connection, this method includes testing the wiring harness.

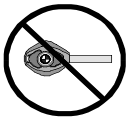
The correct Universal Adapter for the MS42/MS43 application should be used (#90 88 6 121 300). This will ensure the pin connectors and the harness will not be damaged.

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.

NOTE for MS43: Allow at least 3 minutes to elapse after the key was set to the "OFF" position before disconnecting the ECM/TCM. This will allow sufficient time to complete the DM TL test. Voltage may be present (up to 3 minutes) causing damage to the ECM/TCM if they are disconnected during this time period (arcing).





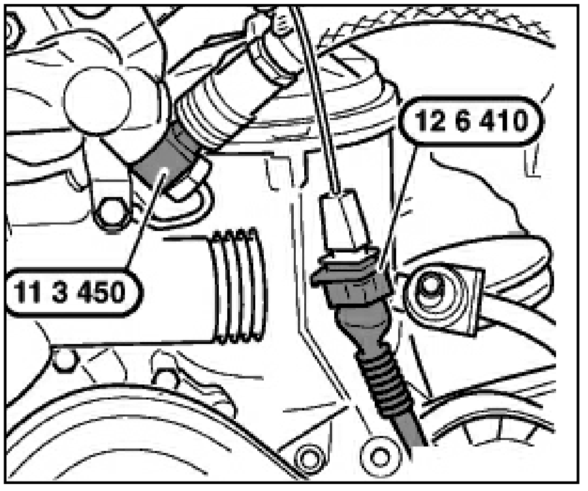


VANOS

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.



Review Questions

1. Describe the Power Supply for the MS43 Fuel Injectors and Ignition Coils:

2. Name the Components of the MS42 Fuel Supply System:

3. List the inputs required fpr Fuel Injector operation:

4. Describe the Emission Optimized Function:

5. Name two types of Emissions the ECM controls:

6. What two sensors are used to monitor MS43 accelerator movement?

7. Why are there two inputs from the Accelerator Module?

8. Where is the LDP located on an E46?

9. Why does the M42/M43 have multiple ignition pulses?

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

11. How is the ignition system monitored?

Table of Contents

M5.2.1

Models: E38 with M73/M73TU Engine
E38/E39 with M62 Engine

Production Date: E38 with M62 Engine 5/97 Through 98 MY
E39 with M62 Engine 9/97 Through 98 MY
E38 with M73 Engine 5/97 Through 98 MY
E38 with M73TU Engine 99 MY to Present

Manufacturer: Bosch

Pin Connector: 134 Pins - 5 Modular Connectors (2 ECMs on M73)

Objectives of the Module

After completing this module, you will be able to:

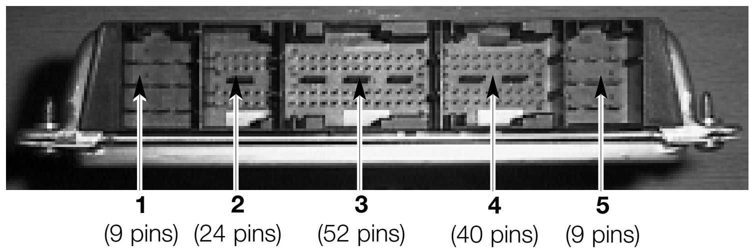
- Explain How the Power is Supplied to the Ignition Coils
- Describe the Air Shrouded Injector Control on the M73
- Understand Why the Idle Speed is Influenced by Battery Charge Logic
- Explain the Electrically Heated Thermostat Operation
- Understand the Elecrtic Catalytic Converter Function
- Describe What “ISN” Means
- Name the Location of Evaporative Components
- List the Differences of the 99MY M73TU

M5.2.1 (1998 MY M73 & M62 equipped vehicles)

Purpose of the System

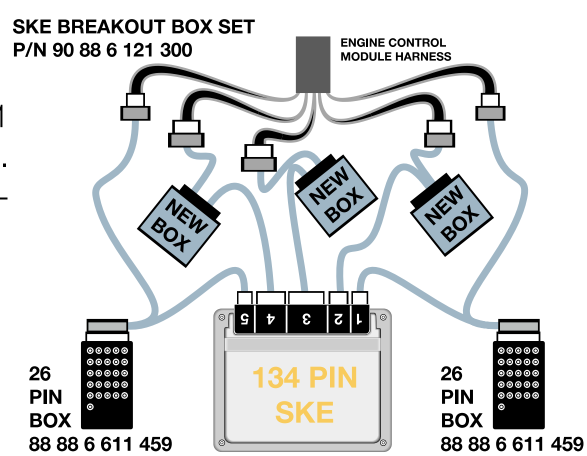
The M5.2.1 engine control system is manufactured by Bosch to BMW specifications. In addition to quality improvement modifications, emphasis was placed on enhancing functions for OBD II and Tier 1 compliance.

M5.2.1 control modules utilize the ***SKE*** (standard shell construction housing). The SKE utilizes a modular connector configuration. There are a total of 5 connectors providing a combined total of **134 pins.**



The modular harness connectors are color coded by cylinder bank on the M73. When removing control modules from the E-Box, note the color of the plugs and mark each module to prevent incorrect replacement. This step is important to prevent EWS III (3.3) ISN incompatibility.

The correct Universal Adapter for the M5.2.1 application should be used (#90 88 6 121 300). This will ensure the pin connectors and the harness will not be damaged.

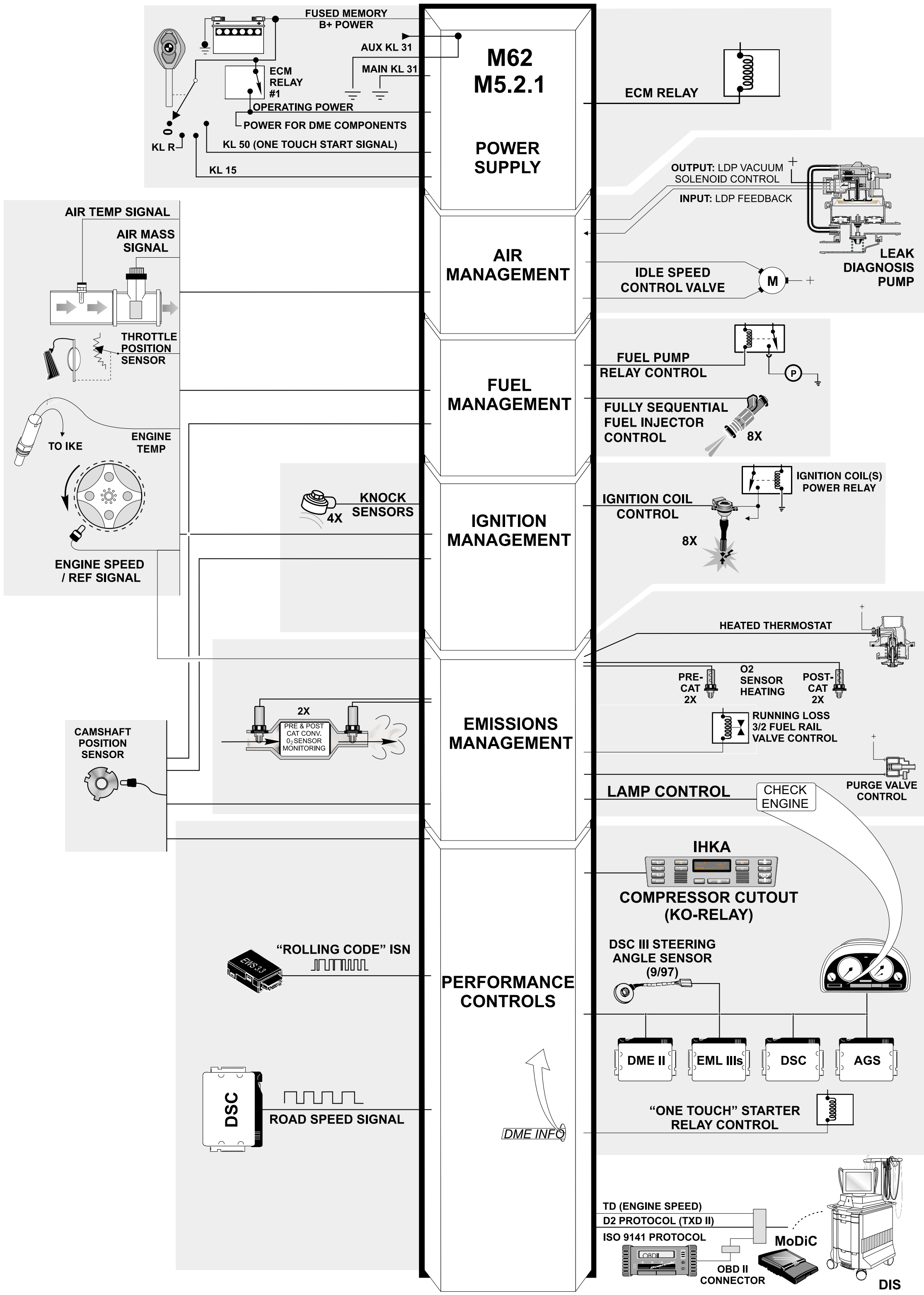


FEATURES OF M5.2.1

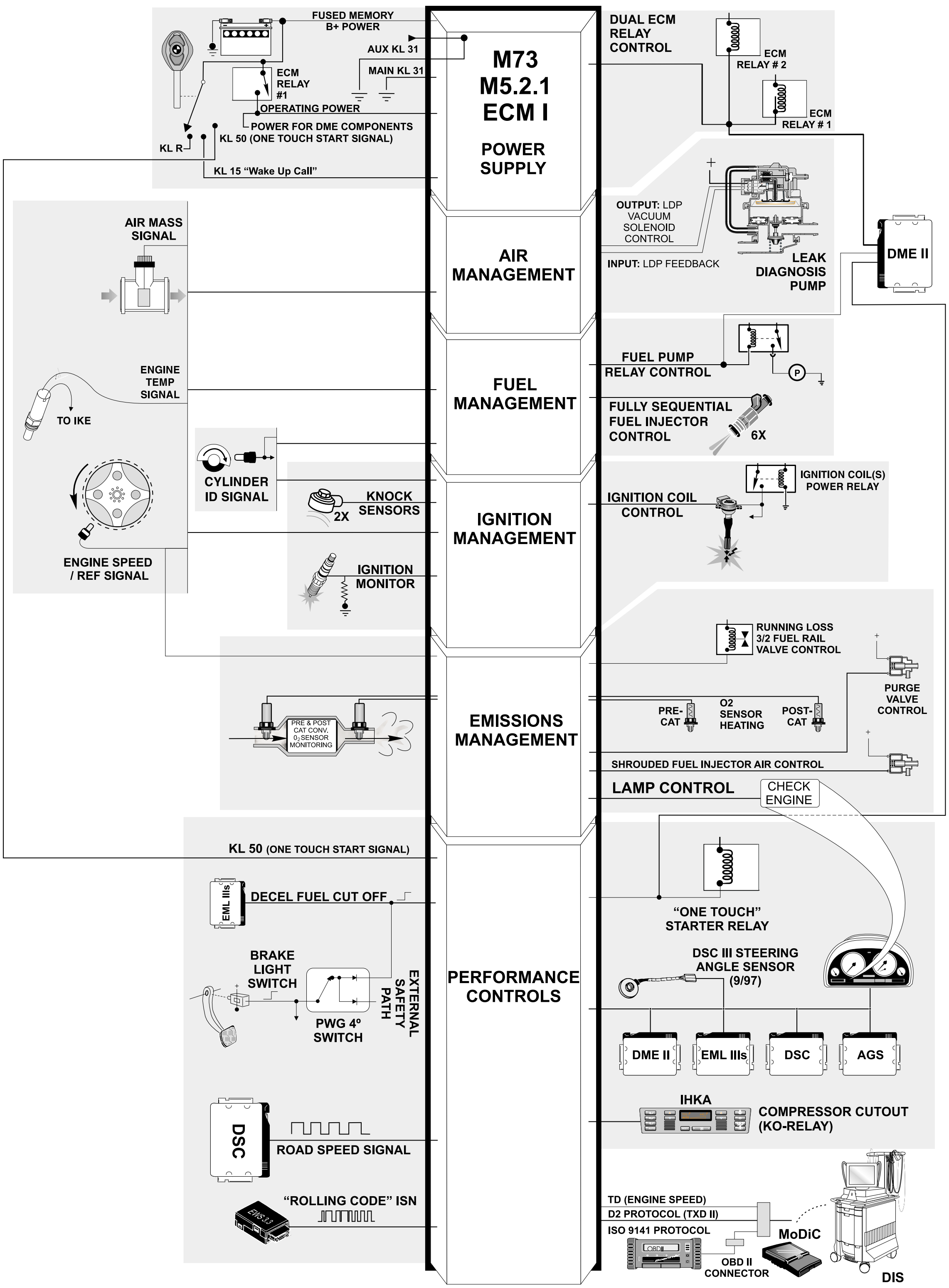
The M5.2.1 system has the following functions or capabilities:

- Separate power supply relay for ignition coils.
- Leak Diagnosis Pump control and feedback monitoring for evaporative system leak testing. Integration of this system also brought forth modifications to the total fuel evaporative system providing ORVR (On-board Refueling Vapor Recovery) compliancy.
- Shrouded Fuel Injector Air control ***(M73 Engine Only).***
- Battery charge logic (idle speed varied with the battery state of charge).
- CAN communications with the instrument cluster.
- “Rolling Code” ISN interface with EWS III (3.3).
- Knock Sensors are more sensitive in determining ignition knock.
- Pulse width modulated IHKA Status Signal (S-KO).
- Running Loss 3/2 Fuel Rail Valve

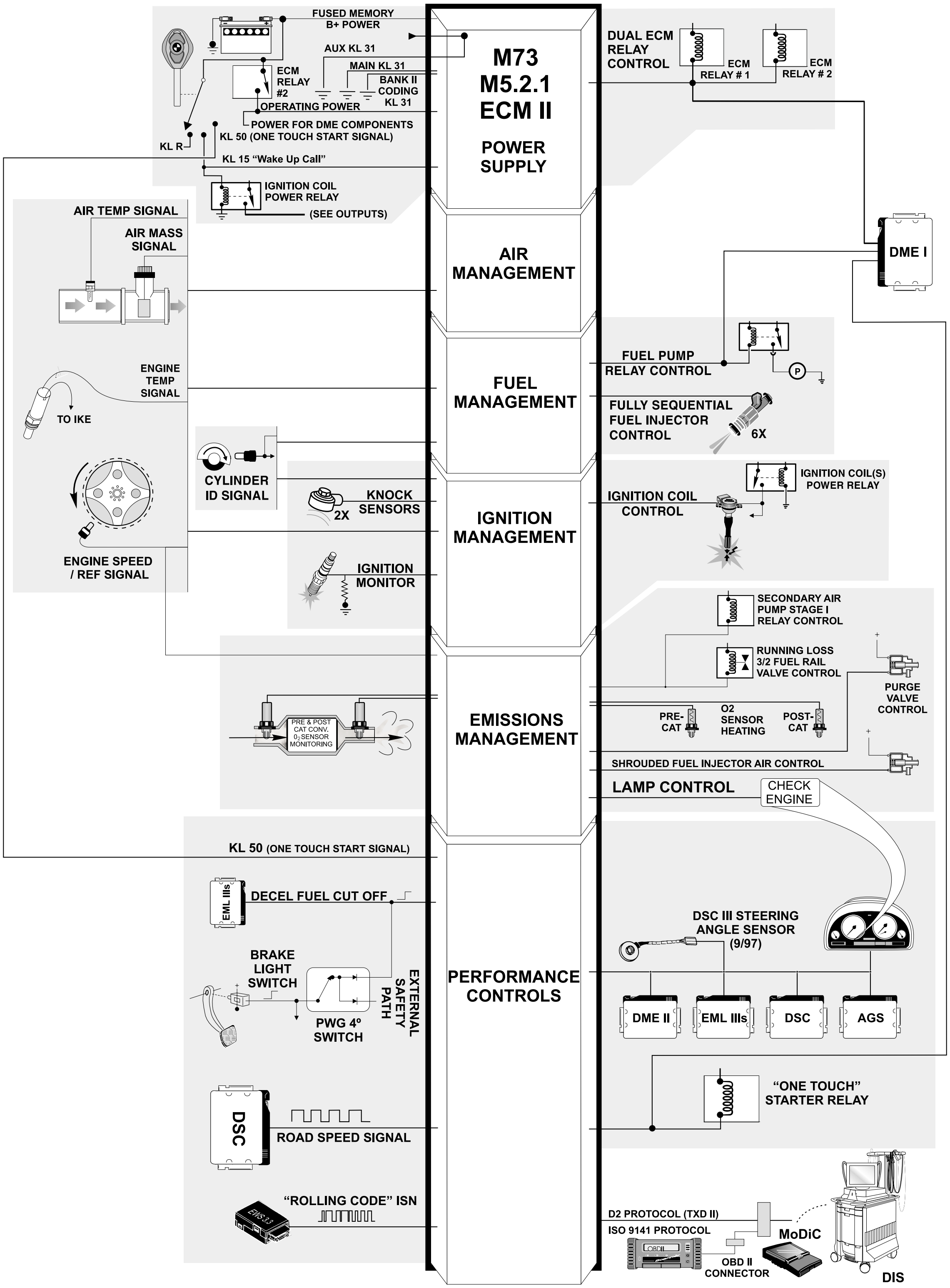
System Components: Inputs - Processing - Outputs



System Components: Inputs - Processing - Outputs



System Components: Inputs - Processing - Outputs

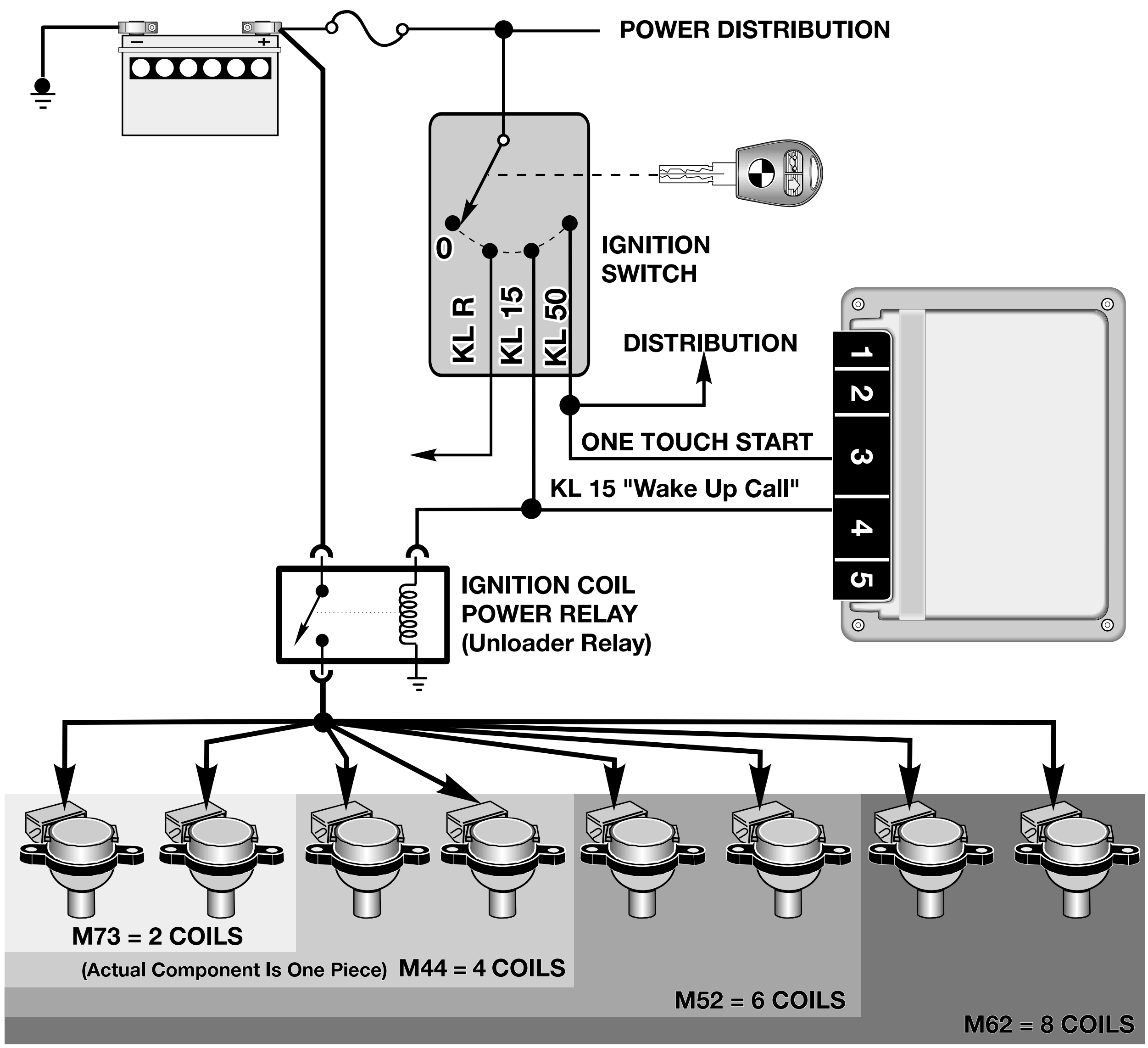


IGNITION COIL POWER SUPPLY (Unloader) RELAY

The power supply for the ignition coils is provided by a relay. This relay is identified as an ***"unloader relay"*** in the ETM and component listing displays.

The unloader relay was integrated into all vehicles starting with the 1997 model year. The purpose of this relay is to isolate the voltage supply as well as relieving the ignition switch of the additional current draw needed by the ignition coils.

When KL15 is switched on, the relay control circuit is provided power to close the relay providing operating voltage to ignition coils.



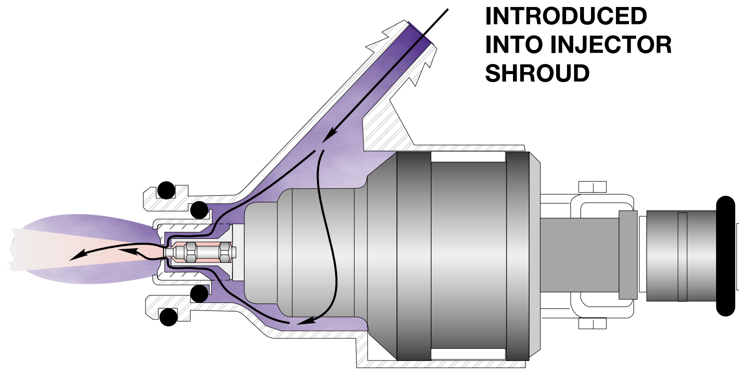
SHROUDED FUEL INJECTOR AIR CONTROL (M73 Equipped Vehicles only)

In compliance with emission regulations, air shrouded injectors are used on the M73 with M5.2.1. This system allows additional metered air to be drawn into the combustion chamber thus lowering CO/HC emissions.

With the air routing through the injector, it also creates additional turbulence to help atomize the fuel mixture.

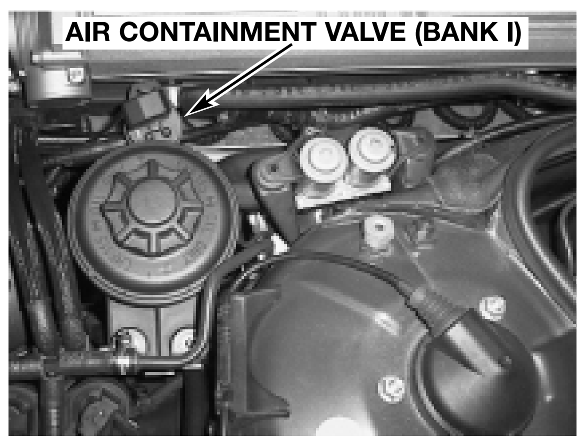
The system is ECM controlled and uses the following components:

- 2 Air Containment solenoids for air inlet to the fuel injectors.
- Vacuum "balancing" bleeds to the intake manifolds.



OPERATION

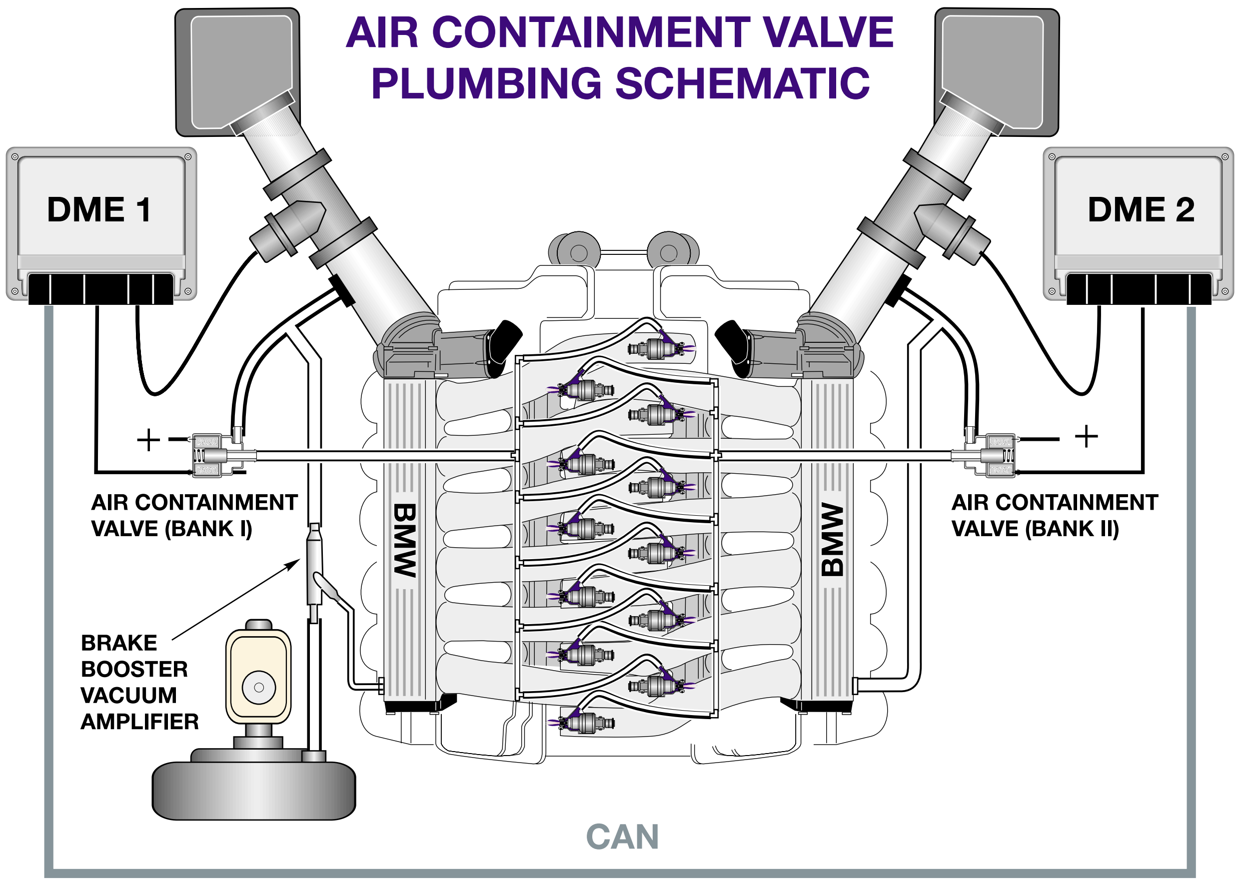
Operation of the system begins on cold engine start up. The ECMs provide a ground path to open the valves allowing additional metered air to be drawn into the fuel injectors to the manifold.



If the vehicle is stationary and idling, this process continues until the engine coolant temperature reaches 75°C. If the vehicle is started and driven, the additional air is injected through the warm up phase of the engine. The ECM then releases the ground path so the valves spring closed.

NOTE: Air injection will be interrupted during idle at engine operating temperature, if the idle speed becomes too high!

Similar to the M62, a brake booster is linked into the system by the vacuum amplifier. On the M73 this requires an equal "balance" of vacuum bleed on the opposite bank allowing equal DK motor synchronization. This system has fault recognition and is diagnosible using the DIS.


AIR CONTAINMENT VALVE
PLUMBING SCHEMATIC
DME 1
DME 2
AIR CONTAINMENT
VALVE (BANK I)
AIR CONTAINMENT
VALVE (BANK II)
BRAKE
BOOSTER
VACUUM
AMPLIFIER
BMW
BMW
CAN

BATTERY CHARGE LOGIC

The 5.2.1 ECM (ECM 1 on the M73) monitors the "system voltage" from voltage supply inputs.

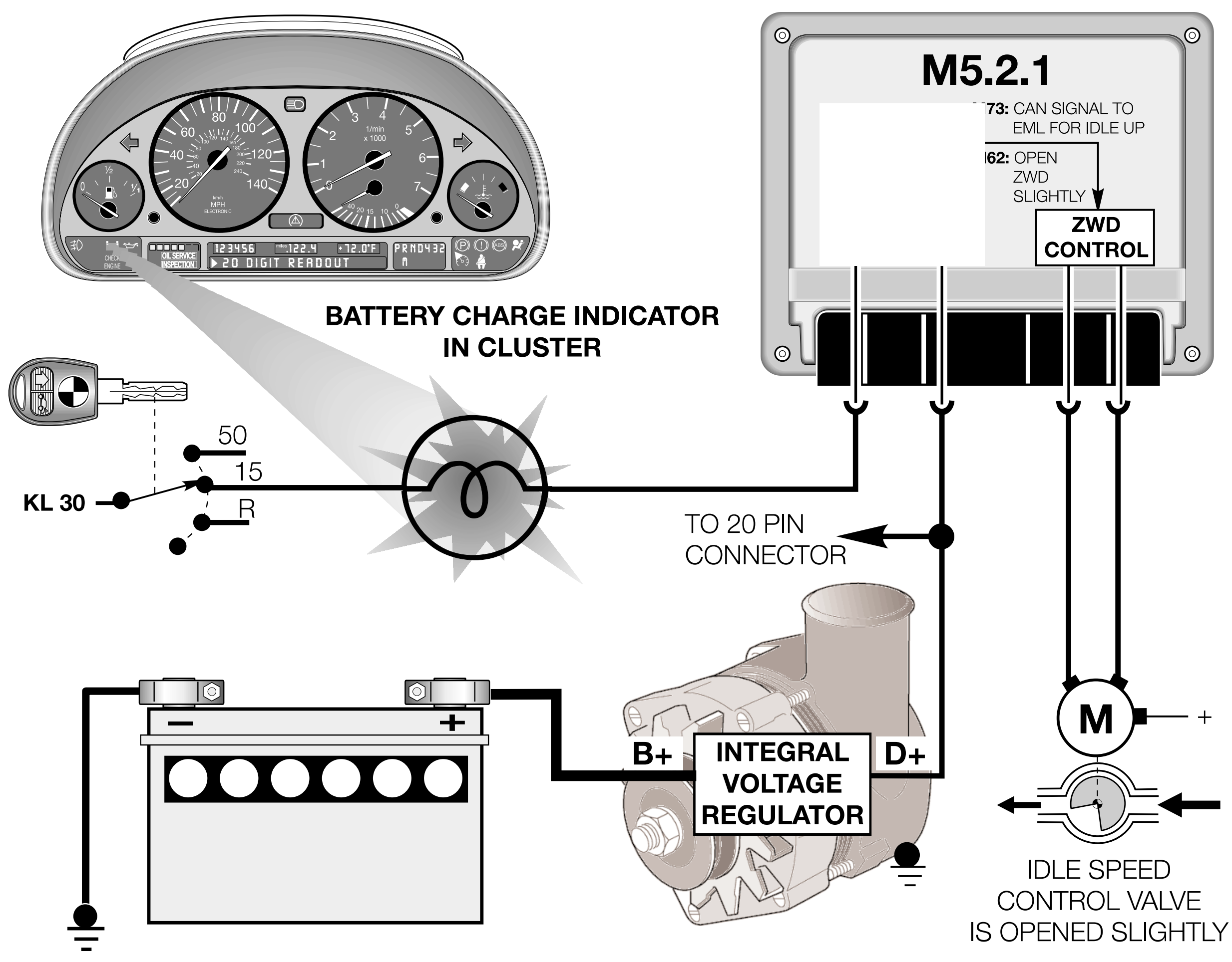
The following situations will occur upon engine start up:

- If the charging system output is sufficient, the engine rpm will be normal.

- If the charging system output is lower than normal, the engine idle will increase to provide a higher charge capability of the alternator.

  M62: The ECM opens the idle control valve slightly.
  M73: ECM I will request via "CAN bus" that the EML control module increase the engine rpm.

  Engine idle speed will be raised to 900 RPM until the generator output is sufficient.



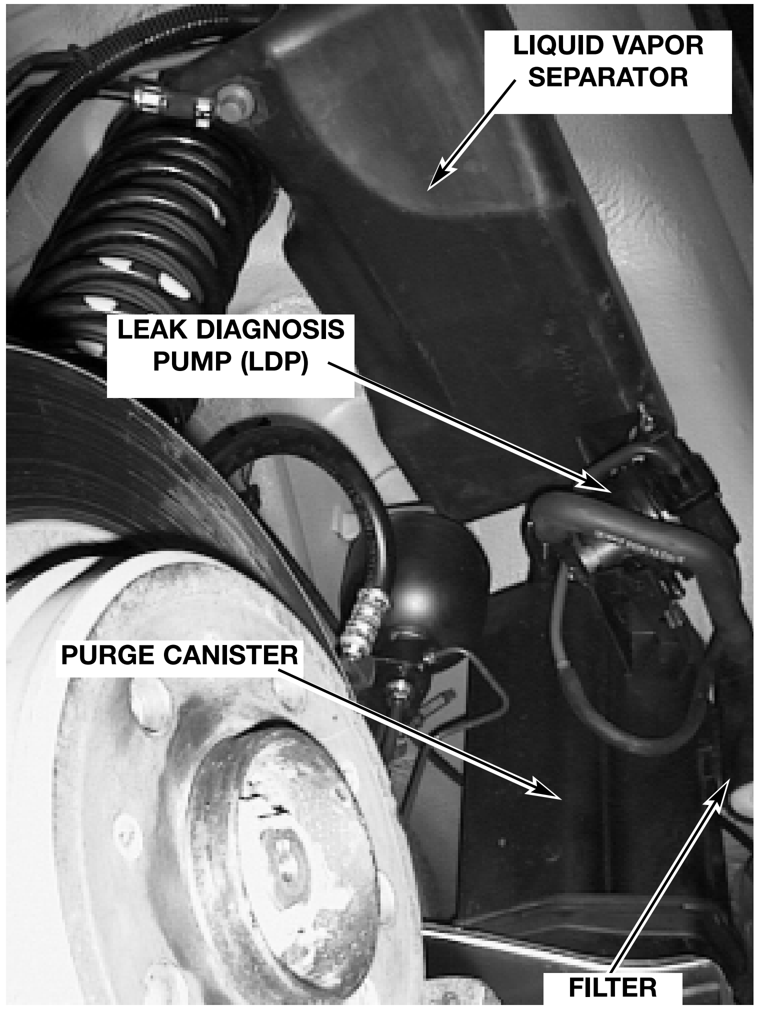
EVAPORATIVE FUEL SYSTEM PRESSURE LEAK DIAGNOSIS

To meet Tier 1 (emission stage) compliancy, a Leak Diagnosis Pump (LDP) is installed for fuel system evaporative leak testing.

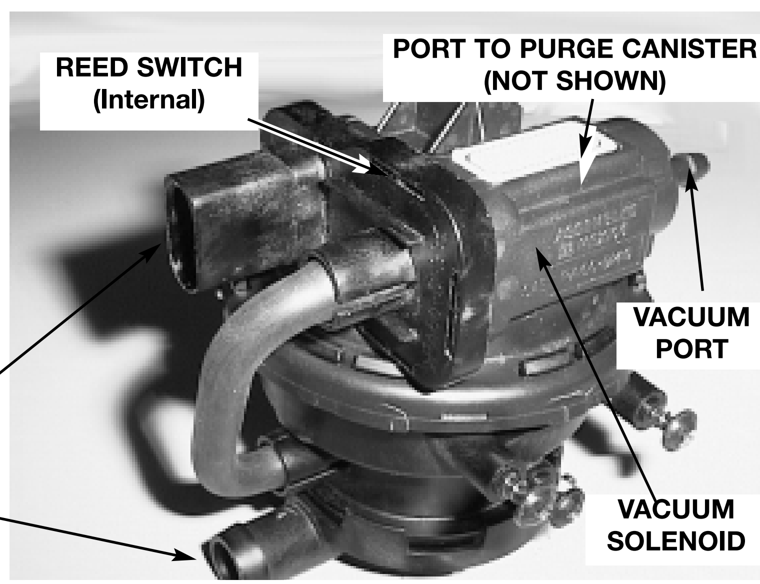
This system with the LDP is capable of detecting a leak ***as small as 0.5 mm.***

The LDP is located in the left rear (driver's side) fender well. The LDP is a unitized component that contains the following:

- Vacuum chamber
- Pneumatic pump chamber
- DME activated vacuum solenoid
- Reed switch providing a switched voltage feedback signal to the DME.



The vacuum supply line is in the wiring harness from the engine compartment and runs down the driver's side of the vehicle.



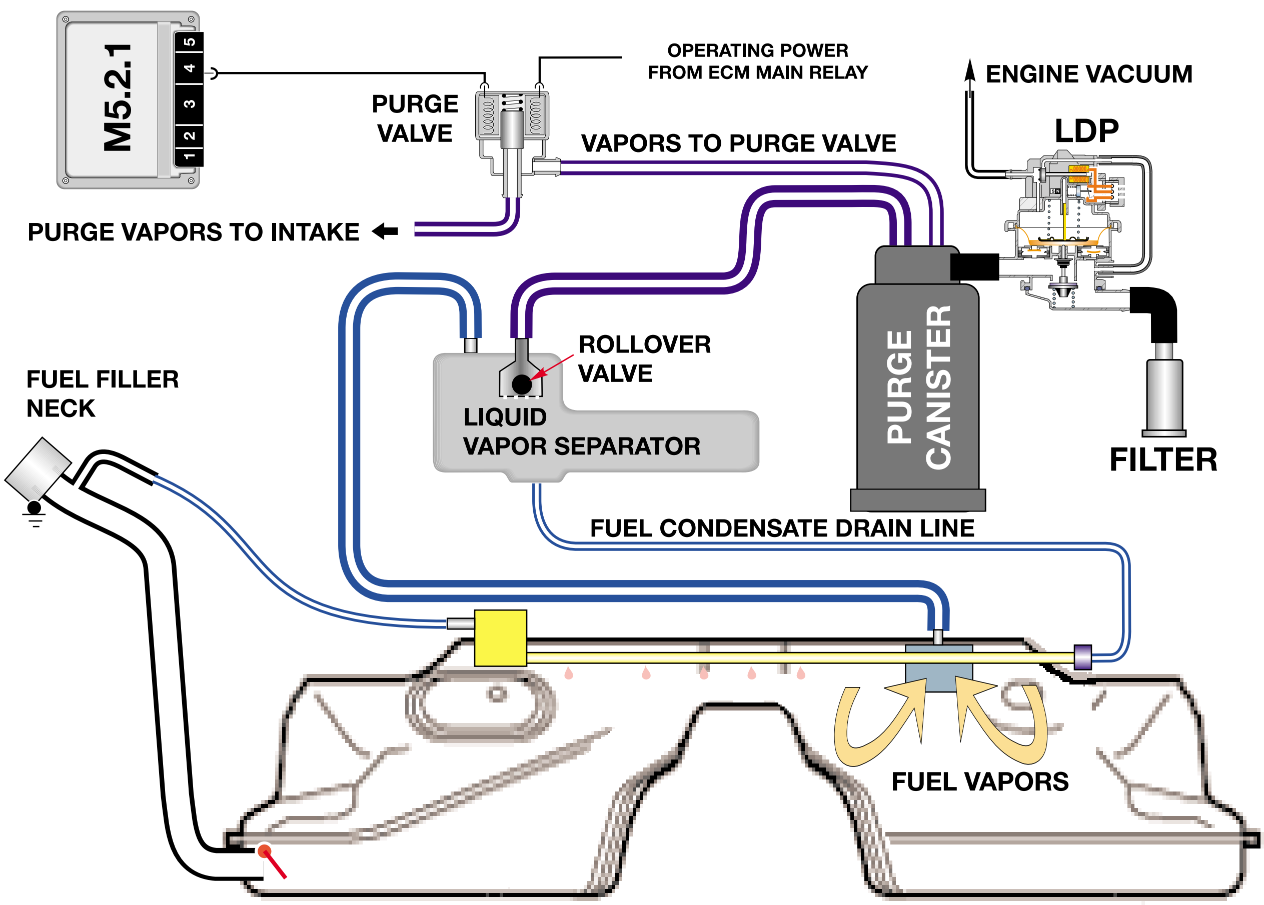
LDP-PURGE SYSTEM INTEGRATION

- The function of the LDP is to pressurize the fuel tank and the evaporative emission system (approx. 25mb.) for the purpose of detecting leaks.

- The canister vent valve is integrated into the LDP which is electrically controlled by the ECM. The canister vent valve is sprung open to provide fresh air entry into the fuel system during purge operation.

- Purge operation characteristics are:

  Off Idle through Full Throttle: Purge Valve(s) opened by pulse width modulated control of the ECM(s). Duty cycle varied by engine operating conditions.
  Warm Idle: Purge valve(s) open slightly
  Cold Idle/Decel: Engine temp < 67°C, Purge valve(s) closed.

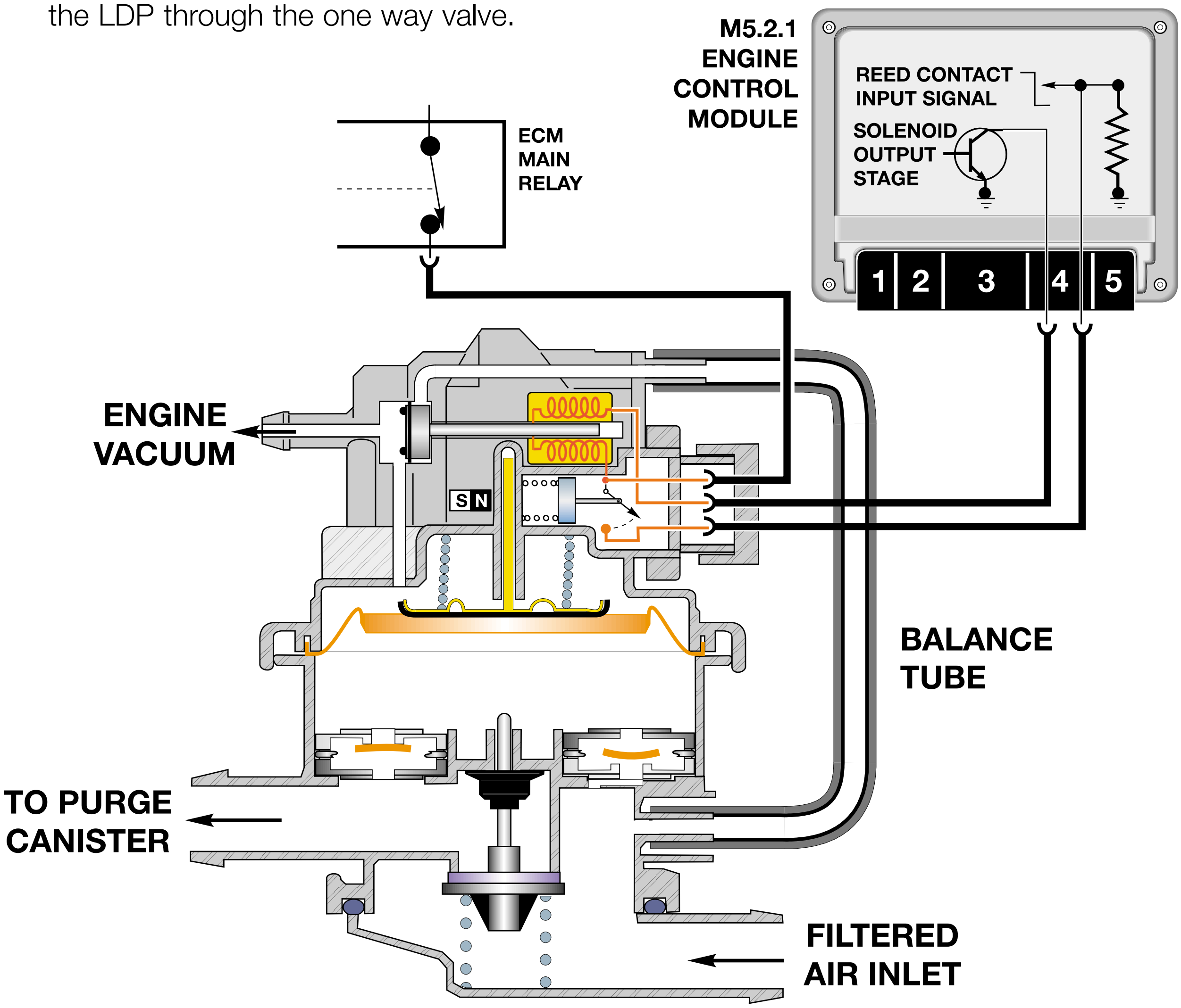


- During diagnostic testing of the evaporative emission system, the vent valve is closed and will block atmospheric venting. The purge valves are also sprung closed to seal the system.

LDP OPERATION

During every engine cold start, the following occurs:

- 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 pulling ambient air through the filter and into the lower chamber of the LDP through the one way valve.

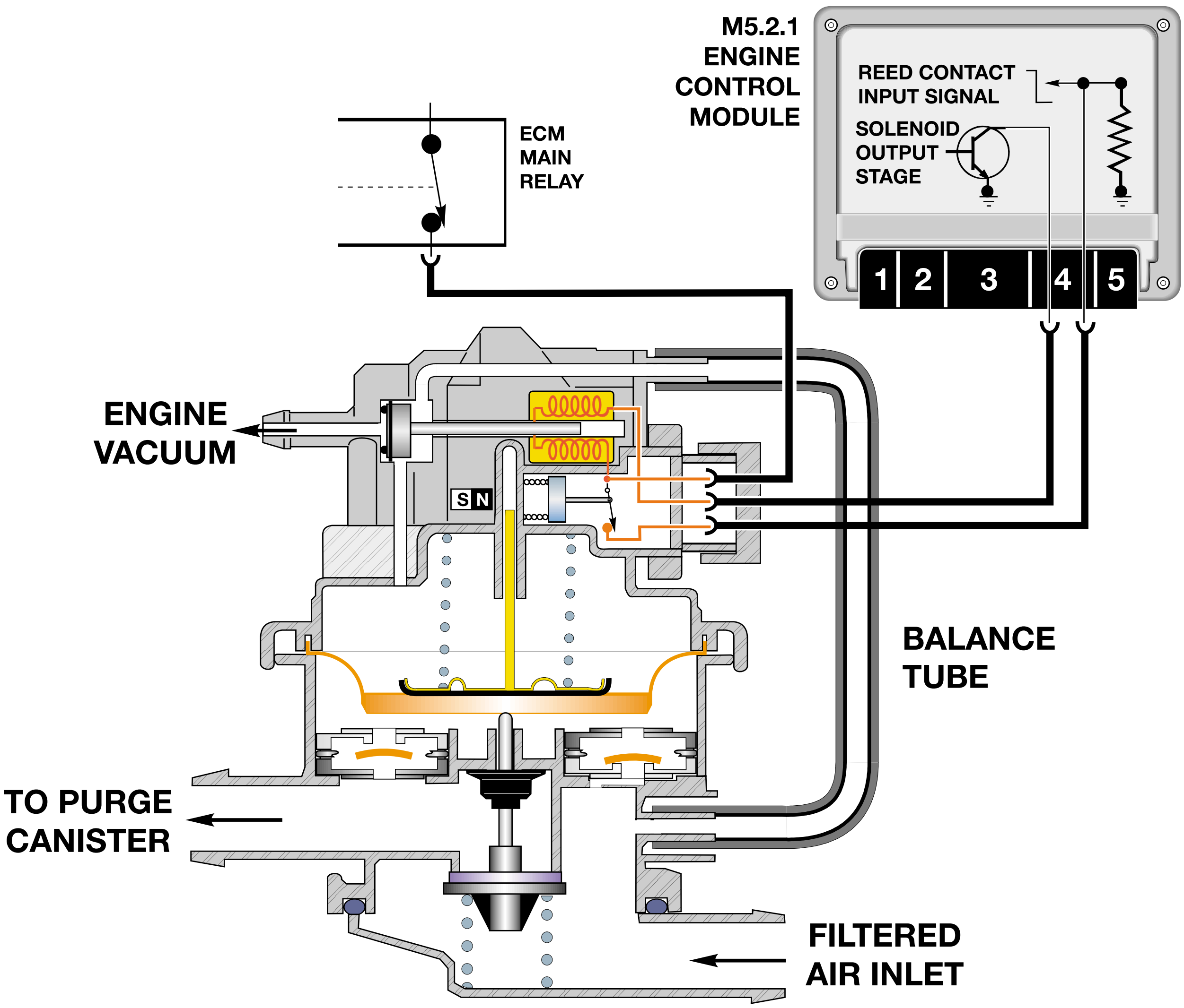


- The solenoid is then de-energized, spring pressure closes the vacuum port blocking the engine vacuum and simultaneously opens the vent port to the balance tube which releases the captive vacuum in the upper chamber.
- This allows the compressed spring to push the diaphragm down, starting the “limited 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 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.



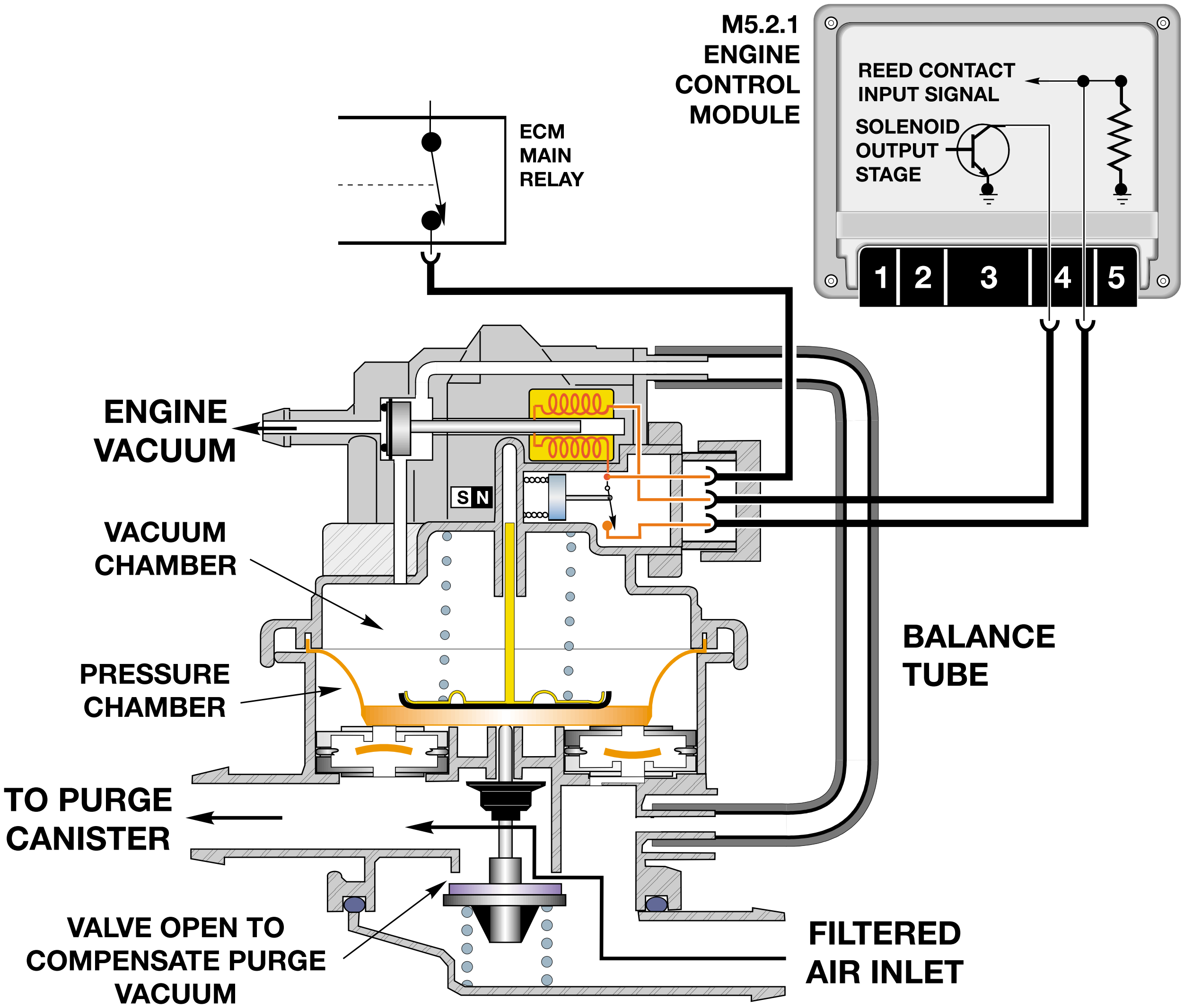
- The upper chamber contains an integrated reed switch that produces a switched high-low voltage signal that is monitored by the ECM. The switch is opened by the magnetic interruption of the metal rod connected to the diaphragm when in the diaphragm is in the top dead center position.

- 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 diaphragm in the lower chamber. The LDP is still cycled, but at a frequency that depends upon the rate of pressure loss in the lower chamber.

- If the pumping frequency is below parameters, there is no leak present.

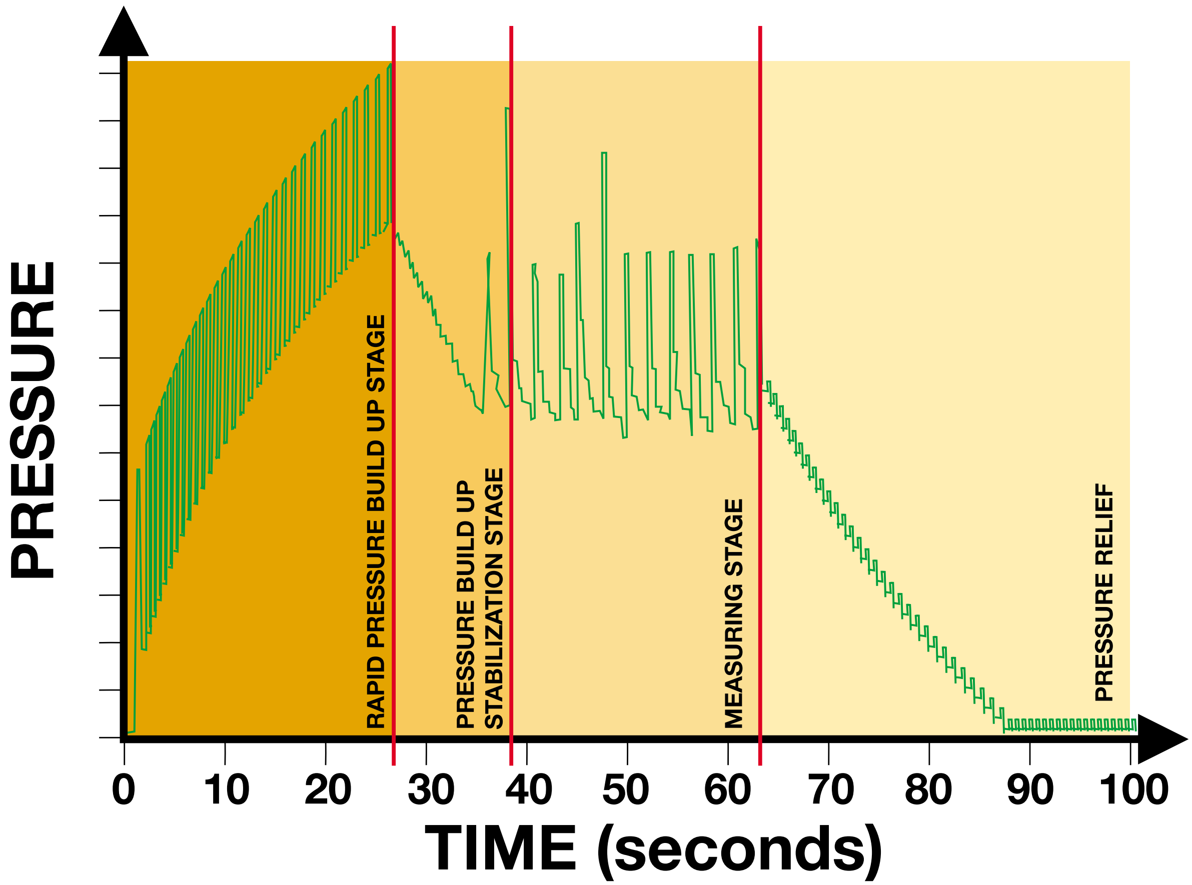
- If the pumping frequency is above parameters, this indicates sufficient pressure can not build up in the lower chamber and evaporative system, indicating a leak.



A fault code can be recorded by each ECM indicating an evaporative system leak. Upon test completion, the ECM releases the ground path to the LDP and the internal spring pushes the diaphragm for the “full down stroke”.

At bottom dead center, the diaphragm rod opens the canister vent valve. This allows for fresh air intake from the filter for normal purge system operation. The LDP is diagnosible with the DIS including a service function activation test.

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 pressurize 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 or a leak. This 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.

ORVR FUNCTION (On-board Refueling Vapor Recovery)

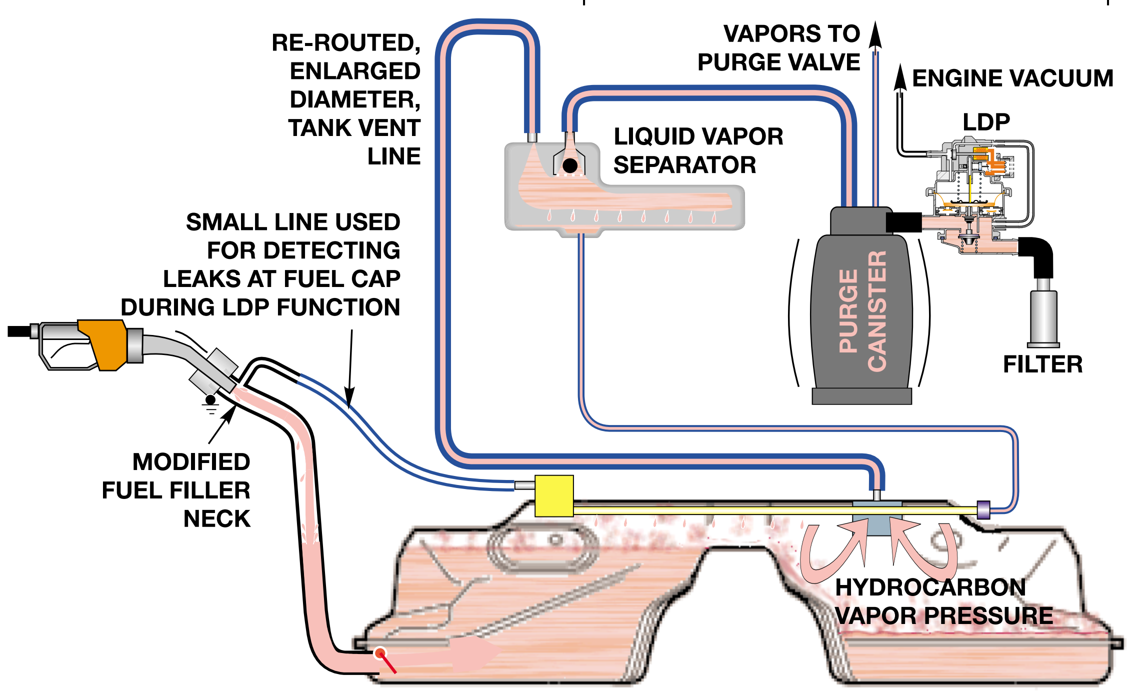
Any vehicle fitted with the LDP is also ORVR compliant. The ORVR system addresses recovering fuel vapor which is released during refueling. Previously, fuel vapors were vented from the tank venting line back to the filler neck and in many states reclaimed by a vacuum receiver on the filling station's fuel pump nozzle.

ORVR provides a means to "capture" these hydrocarbon vapors resulting from the rush of fuel into the tank during fuel filling. The following changes were installed to achieve this:

- Re-routing the previous tank vent hose from the filler neck to the liquid/vapor separator. This hose was also enlarged to accommodate the increased "vapor flow" being introduced into the liquid vapor separator.
- Enlarging the rollover valve and the hose from the liquid/vapor separator to the charcoal canister.
- Modified filler neck which allows a higher flow rate.
- Modifications to the fuel tank to form a liquid seal during refueling - forcing vapors to the liquid/vapor separator.

When refueling, the pressure of the fuel entering the tank will force the hydrocarbon vapors through the tank vent line to the liquid/vapor separator, through the rollover valve and into the charcoal canister. The hydrocarbons are stored in the charcoal canister, and the system can then "breathe" through the LDP pump and the air filter.

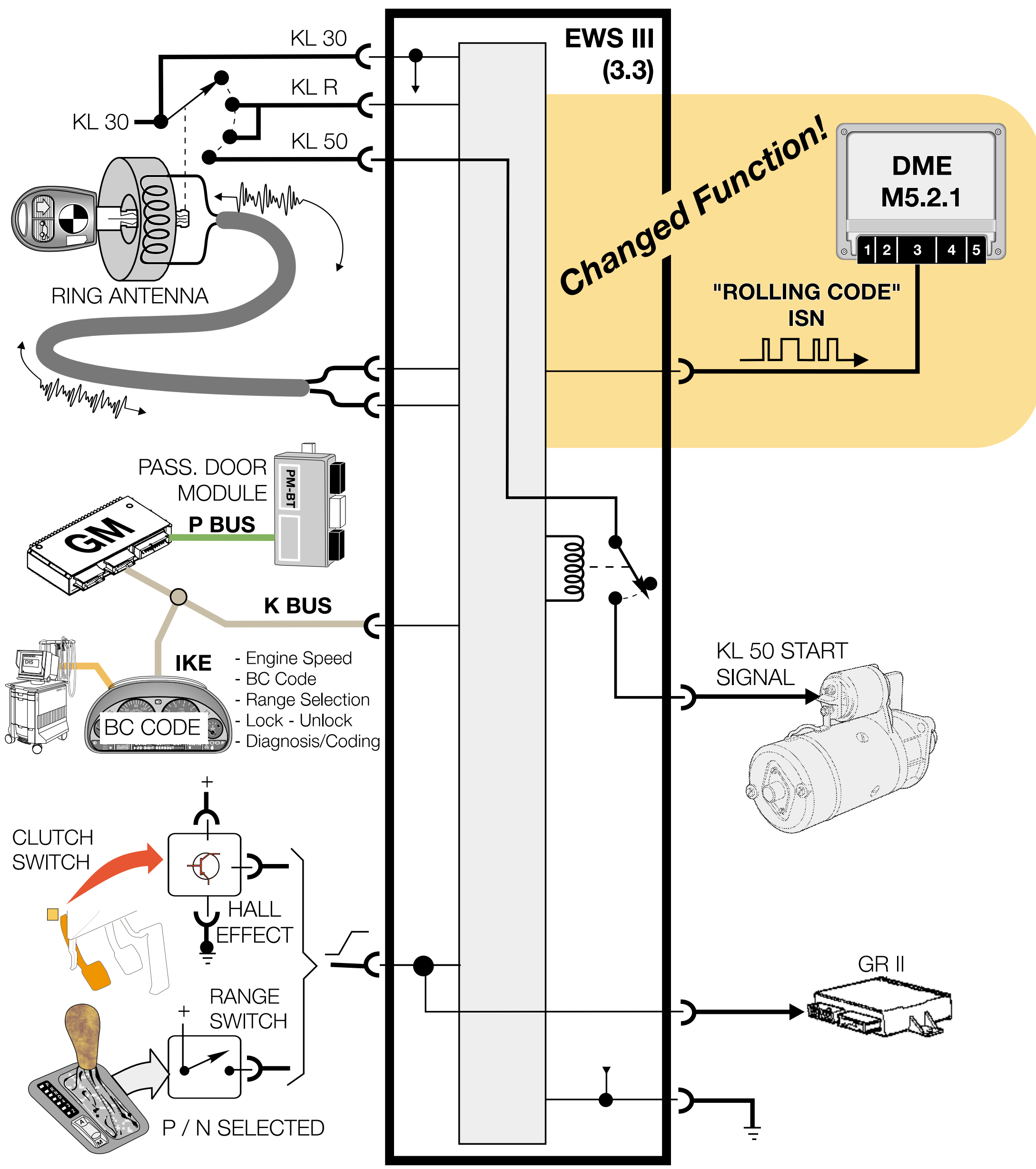
The small hose at the fuel filler neck is still required to check for leaks at the filler cap.



EWS III (3.3)

The EWS III is modified for compatibility with the M5.2.1 engine control system and is designated as **EWS 3.3.**

EWS 3.3 is installed in the 1998 MY E38 (from 5/97 production) and 1998 MY E39 (from 9/97 production). The system inputs remain unchanged compared with the 3.2 system, however, the ISN signal is now a **"Rolling Code ISN".**



ROLLING CODE OPERATION

The “rolling code” is a one way signal from the EWS 3.3 to the ECM. The “Rolling Code” provides a higher level of sophistication than the ISN of previous EWS systems. Similar to the data exchange between the EWS control module and the transponder chip in each key, the “rolling code” is different every time the engine is started.

The rolling code system requires that each vehicle receive a unique “Rolling Code Table”. The rolling code table is assigned and installed by the factory into both the EWS 3.3 and M5.2.1 control modules. The code tables are “burned” into the control modules and can not be overwritten by ZCS encoding software, ECM programming software or the EWS/ECM Alignment Procedure of the Service Function section in the DIS for each system.

ENGINE STARTING PROCEDURE

- All EWS 3.3 input requirements are met:
  - System power and grounds provided
  - Positive data exchange between the key and EWS control module (key accepted).
  - BC code function is not active.
  - Range selector in P or N (E38s and 540iA), or Clutch pedal depressed (540i Sport).

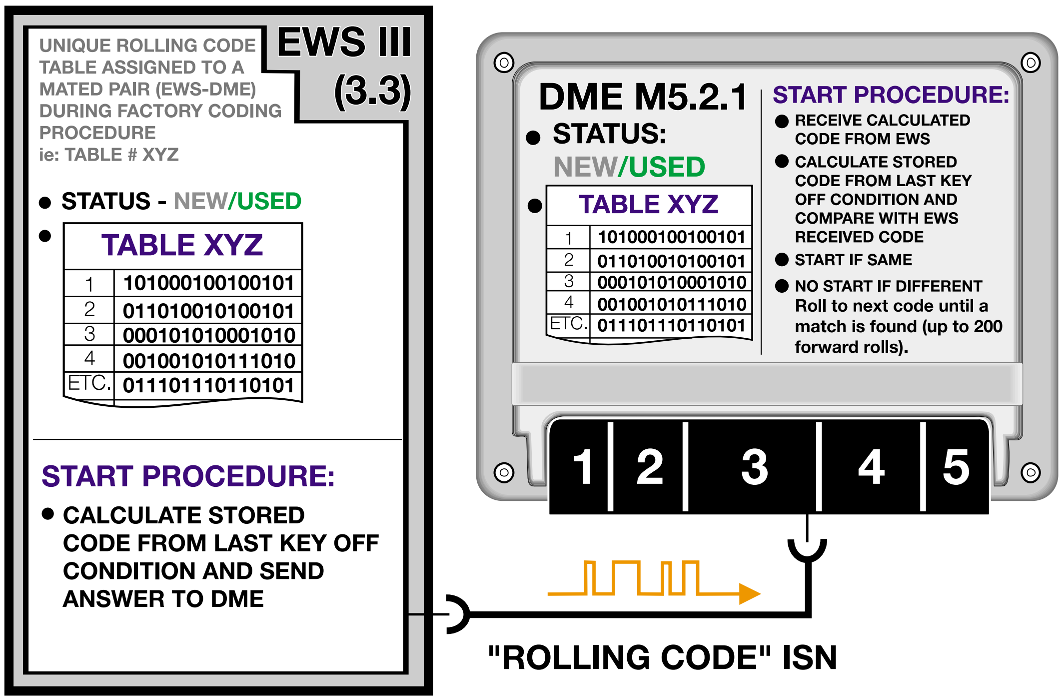
- EWS 3.3 control module closes the internal relay contacts providing the KL50 Start signal to the starter solenoid. Simultaneously, it calculates a stored code from the rolling code table and sends the calculated results to the ECM.

- On receipt of EWS’s calculated results, ECM calculates it’s own stored code and compares it’s results with the received results from EWS.

  - Results Identical: **Engine Starts!**
  - Results ***not*** identical: ECM “rolls forward” to the next code in the rolling code table and calculates it. It continues to “roll forward” until it finds a match. If no match is found: **Engine cranks but does not start!**

  The “forward roll” occurs up to a maximum of 200 times. This is necessary for the following reason. **Example scenario:** ECM is temporarily disconnected for service reasons. The ignition key is inadvertently switched on. When switched back off, the EWS is advanced one “rolling code” ahead of the ECM because the ECM was not connected. Once reconnected and the ignition key is turned to start, the ECM advances until a match is found. The rolling codes in each module are once again synchronized.

- When the ignition is switched off and no engine RPM signal is present in either the ECM and EWS, each module will automatically “roll forward” to the next pre-determined code (based on the code table.) This code is used for the next start sequence.



SERVICE INFORMATION

- Rolling code tables are rigidly assigned. For this reason, ECM control modules can not be swapped from another vehicle and re-aligned for troubleshooting purposes.

- Replacement EWS 3.3 control modules are ordered VIN specifically. They are received with the same rolling code table as the original module. Once ZCS encoded, the DIS software “resets” the current rolling code in the DME back to rolling code #1, providing synchronization in both modules.

- Replacement ECM control modules are “off the shelf parts” and are “blank”. After ECM programming, the DIS software informs the EWS control module that a new ECM has been installed. With this information the EWS will send the entire rolling code table to the ECM on the next key on condition. It also resets itself to rolling code #1. The DIS software then informs the ECM that the first code it receives from the EWS is actually the rolling code table. When it’s received ECM automatically “burns” it into it’s memory.

- The alignment procedure is still available in the **SERVICE FUNCTIONS** menus of EWS or ECM. This procedure only “resets” the rolling codes back to #1 in each module. **It does not change the coding tables.** The ignition key must be switched off for 10 seconds after the adjustment is completed.

- **Final note:** ***Once a DME control module is programmed it can not be used in any other vehicle!!***

IKE MODIFICATION - CAN BUS ADDITIONS

The external IKE control module was been incorporated into the Instrument Cluster for the 1998 model year. If IKE replacement is necessary, a complete "Cluster" must be ordered and ZCS encoded at time of replacement.

The CAN bus has also been linked to the Instrument Cluster in the 98 model year. The cluster is an important link in the system, and vital information is now updated faster to the control modules.

The CAN bus connection to the instrument cluster is found at pins 8, 9 and 10 of the blue 26 pin ELO connector on the back.

The signals transmitted from M5.2.1 ECM over the CAN bus to the instrument cluster include:

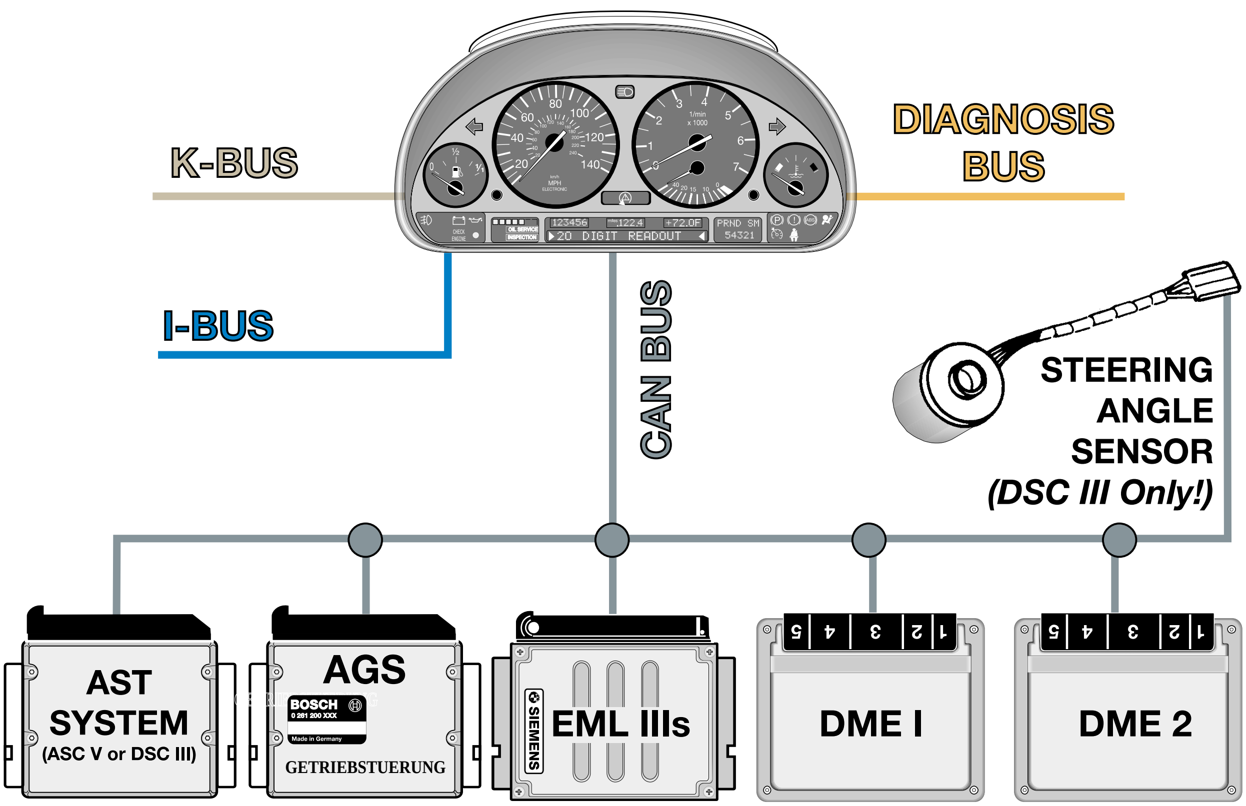
- Engine temperature
- Engine rpm
- Ti signal (MPG Gauge)
- "CHECK ENGINE" Light activation

A malfunction with the interface to the instrument cluster could cause the ASC and transmission fail-safe indicators to appear. In addition, the instruments affected by the signals listed above will be inoperative.

The CAN bus users as of the 98 E38 and E39 vehicles are:

- ECM (750iL: ECM 1&2)
- AGS
- ABS/ASC-DSC
- EML IIIs (750iL)
- Instrument Cluster
- Steering Angle Sensor (DSC III vehicles only, 9/97 production)

Note: The CAN Bus network of the 528i does not include the instrument cluster until 3/98 production.



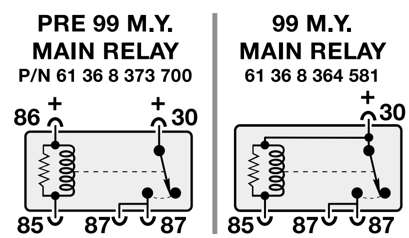
M5.2.1 FOR 1999 MY M73 TU

M5.2.1 continues to be used for the M73 TU 750iL. To meet LEV compliance there are additional functions included in the 1999 model year variant.

M5.2.1 Engine Management System Changes:

- Minimum idle speed reduction (530 rpm).
- Long-life spark plugs.
- Input signal from Radiator Outlet Temperature sensor.
- E-CAT control program function responsibility of ECM.
- CAN bus configuration = twisted pair wiring.
- Electrically heated coolant system map thermostat.
- Two speed Secondary Air Injection system control as with previous engine. Expanded pin assignments to improve comprehensive component monitoring.
- Variable IHKA auxiliary condenser fan speed control.
- ECM Relay Wiring Configuration.
- Air Shrouded Fuel Injectors with dual cone spray pattern.

M73 TU ECM Relays

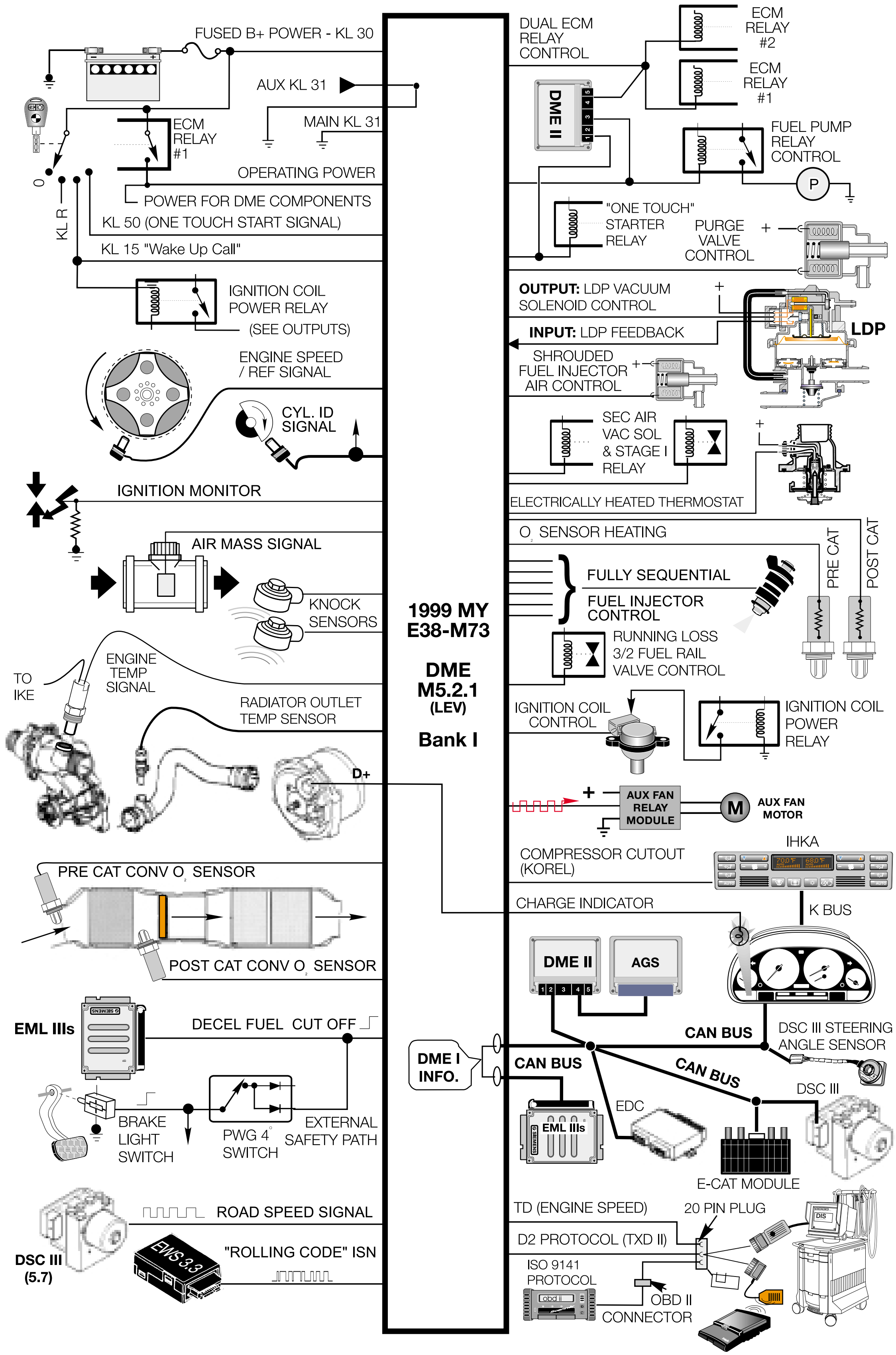


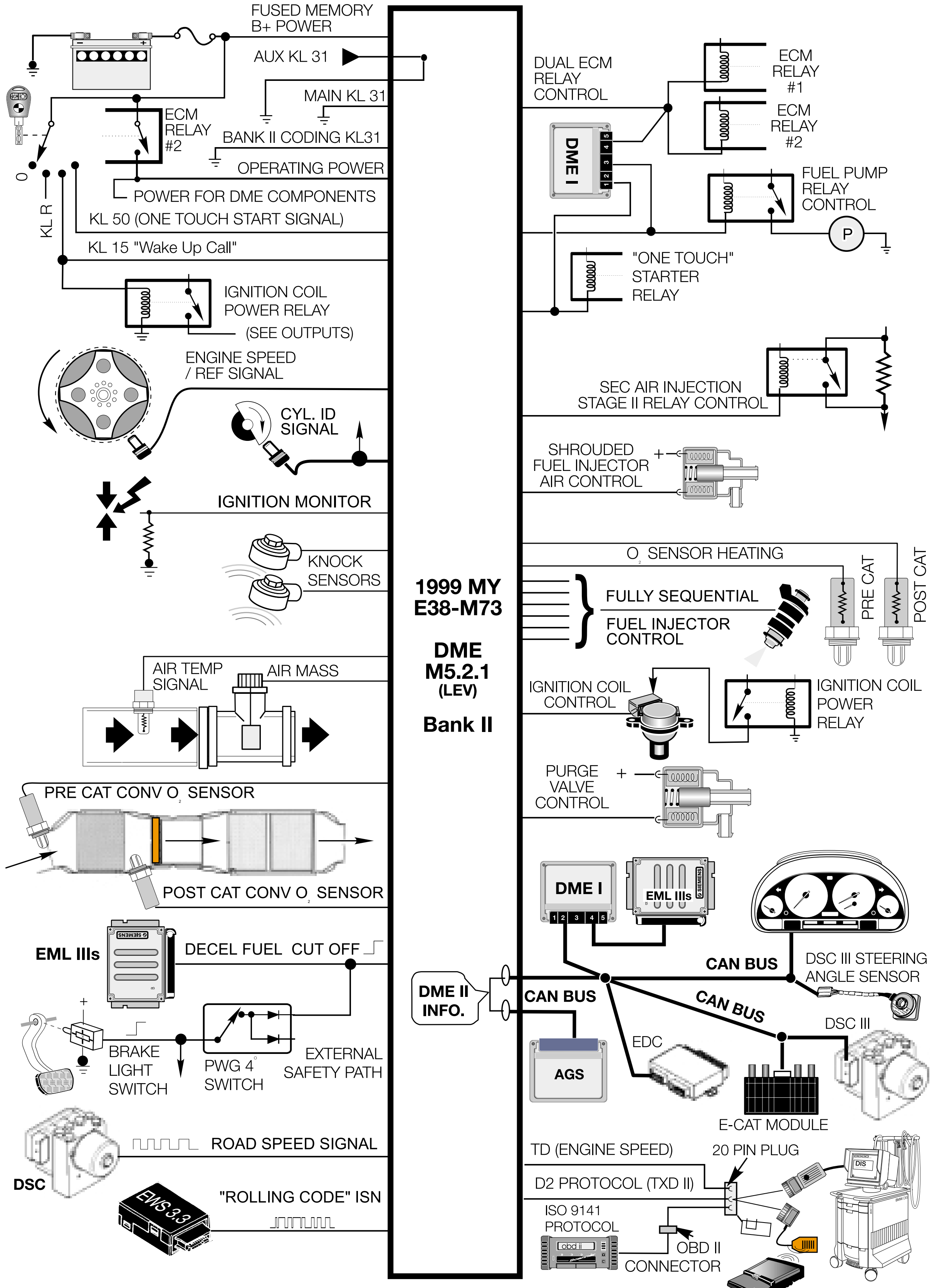
The ECM Relays are now manufactured with an internal control circuit power supply splice off of terminal 30. Terminal 86 has been omitted.

M73 TU Air Shrouded Fuel Injectors

The air shrouded fuel injectors of the M73 TU incorporate a new dual port injection spray plate in the injector tip that produces a dual cone spray pattern. The dual cone spray pattern improves atomization by separating the spray jets into two streams.

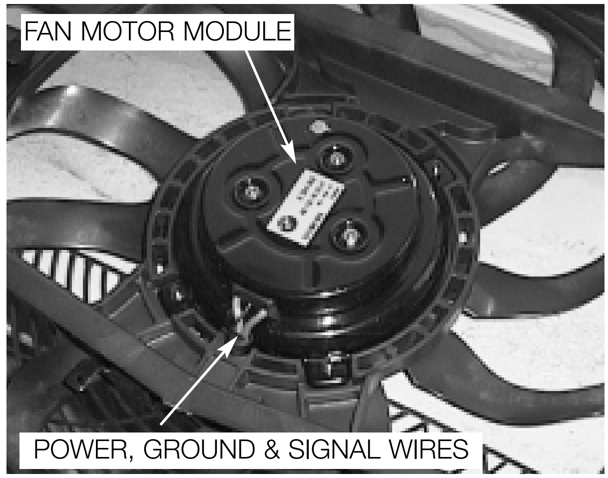
The injectors have an ohmic value of 15 ohms.


FUSED B+ POWER - KL 30
AUX KL 31
MAIN KL 31
ECM RELAY #1
OPERATING POWER
POWER FOR DME COMPONENTS
KL 50 (ONE TOUCH START SIGNAL)
KL 15 "Wake Up Call"
KL R
0
IGNITION COIL POWER RELAY
(SEE OUTPUTS)
ENGINE SPEED / REF SIGNAL
CYL. ID SIGNAL
IGNITION MONITOR
AIR MASS SIGNAL
KNOCK SENSORS
TO IKE
ENGINE TEMP SIGNAL
RADIATOR OUTLET TEMP SENSOR
D+
PRE CAT CONV O2 SENSOR
POST CAT CONV O2 SENSOR
EML IIIs
DECEL FUEL CUT OFF
BRAKE LIGHT SWITCH
PWG 4° SWITCH
EXTERNAL SAFETY PATH
ROAD SPEED SIGNAL
DSC III (5.7)
EWS 3.3
"ROLLING CODE" ISN
1999 MY
E38-M73
DME
M5.2.1
(LEV)
Bank I
DUAL ECM RELAY CONTROL
DME II
ECM RELAY #2
ECM RELAY #1
FUEL PUMP RELAY CONTROL
P
"ONE TOUCH" STARTER RELAY
PURGE VALVE CONTROL
OUTPUT: LDP VACUUM SOLENOID CONTROL
INPUT: LDP FEEDBACK
LDP
SHROUDED FUEL INJECTOR AIR CONTROL
SEC AIR VAC SOL & STAGE I RELAY
ELECTRICALLY HEATED THERMOSTAT
O2 SENSOR HEATING
PRE CAT
POST CAT
FULLY SEQUENTIAL
FUEL INJECTOR CONTROL
RUNNING LOSS 3/2 FUEL RAIL VALVE CONTROL
IGNITION COIL CONTROL
IGNITION COIL POWER RELAY
AUX FAN RELAY MODULE
M
AUX FAN MOTOR
IHKA
COMPRESSOR CUTOUT (KOREL)
K BUS
CHARGE INDICATOR
DME II
AGS
CAN BUS
DSC III STEERING ANGLE SENSOR
DME I INFO.
CAN BUS
CAN BUS
EDC
DSC III
EML IIIs
E-CAT MODULE
TD (ENGINE SPEED)
20 PIN PLUG
D2 PROTOCOL (TXD II)
ISO 9141 PROTOCOL
OBD II CONNECTOR
DIS


FUSED MEMORY
B+ POWER
AUX KL 31
MAIN KL 31
ECM
RELAY
#2
BANK II CODING KL31
OPERATING POWER
POWER FOR DME COMPONENTS
KL 50 (ONE TOUCH START SIGNAL)
KL 15 "Wake Up Call"
KL R
0
IGNITION COIL
POWER RELAY
(SEE OUTPUTS)
ENGINE SPEED
/ REF SIGNAL
CYL. ID
SIGNAL
IGNITION MONITOR
KNOCK
SENSORS
AIR TEMP
SIGNAL
AIR MASS
PRE CAT CONV O2 SENSOR
POST CAT CONV O2 SENSOR
EML IIIs
DECEL FUEL CUT OFF
BRAKE
LIGHT
SWITCH
PWG 4
SWITCH
EXTERNAL
SAFETY PATH
ROAD SPEED SIGNAL
DSC
"ROLLING CODE" ISN
EWS 3.3
1999 MY
E38-M73
DME
M5.2.1
(LEV)
Bank II
DME II
INFO.
DUAL ECM
RELAY
CONTROL
DME I
ECM
RELAY
#1
ECM
RELAY
#2
FUEL PUMP
RELAY
CONTROL
P
"ONE TOUCH"
STARTER
RELAY
SEC AIR INJECTION
STAGE II RELAY CONTROL
SHROUDED
FUEL INJECTOR
AIR CONTROL
O2 SENSOR HEATING
PRE CAT
POST CAT
FULLY SEQUENTIAL
FUEL INJECTOR
CONTROL
IGNITION COIL
CONTROL
IGNITION COIL
POWER
RELAY
PURGE
VALVE
CONTROL
DME I
EML IIIs
CAN BUS
DSC III STEERING
ANGLE SENSOR
CAN BUS
CAN BUS
EDC
DSC III
AGS
E-CAT MODULE
TD (ENGINE SPEED)
20 PIN PLUG
D2 PROTOCOL (TXD II)
ISO 9141
PROTOCOL
OBD II
CONNECTOR
DIS

AUXILIARY FAN CONTROL

The Auxiliary Fan motor incorporates an output final stage that activates the fan motor at variable speeds.

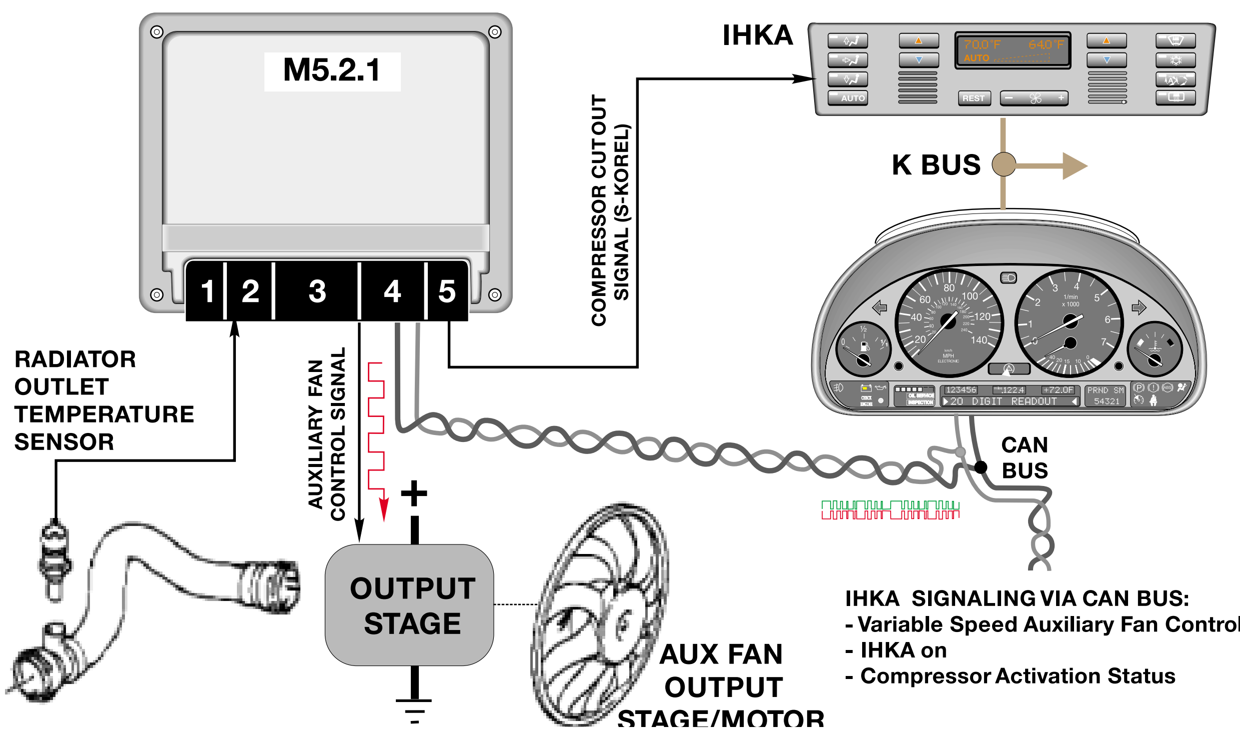


The auxiliary fan is controlled by M5.2.1 ECM. The motor output stage receives power and ground and activates the motor based on a PWM signal (10 - 100 Hz) received from the ECM.

The fan is activated based on the following factors:

- Radiator outlet temperature sensor input exceeds a preset temperature.
- IHKA signalling via the K and CAN bus based on calculated refrigerant pressures.
- Vehicle speed
- Battery voltage level

When the over-temperature light in the instrument cluster is on (120°C) the fan is run in the overrun function. This signal is provided to the ECM via the CAN bus. When this occurs the fan is run at a frequency of 10 Hz.



SECONDARY AIR INJECTION SYSTEM

The purpose of the secondary air injection system is to provide fresh air to the catalytic converters during the warm-up phase of operation immediately after cold start. This accelerates oxidation of hydrocarbons and brings the catalytic converters to the point of light-off earlier.

The M73 TU secondary air injection system continues to be a two speed system utilizing two relays and a slow speed resistor. The introduction of the M5.2.1 ECMs allocated a dedicated control circuit for the vacuum vent valve improving comprehensive component monitoring. This continues with the M73 TU M5.2.1 system.

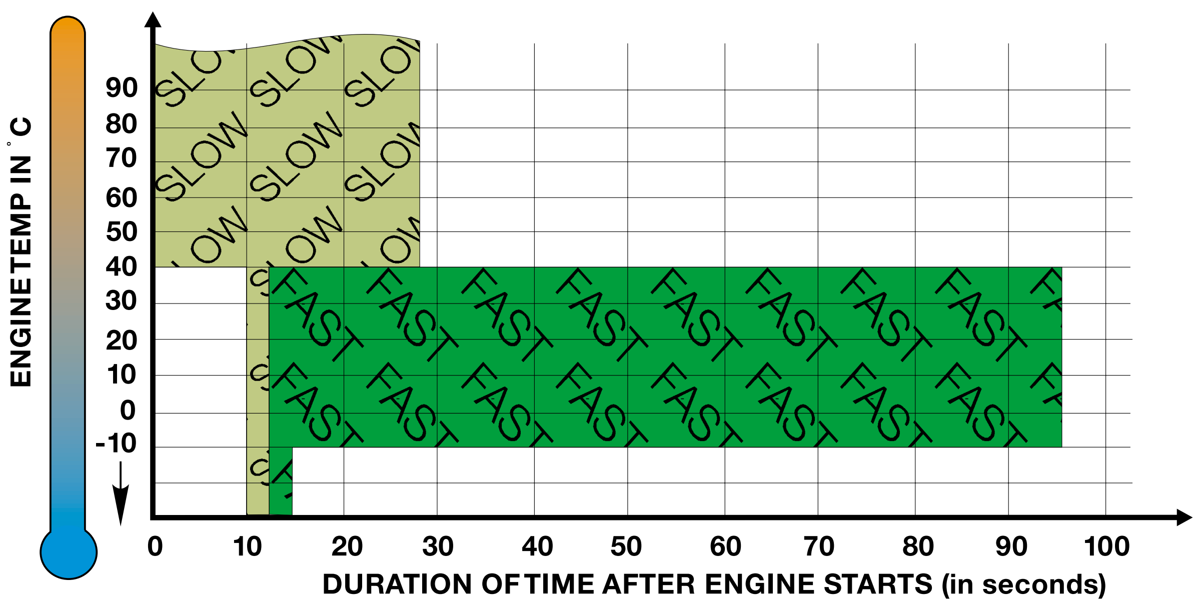
However, the primary controller of the Secondary Air Injection System has switched for the 1999 model year (M73 TU - M5.2.1)

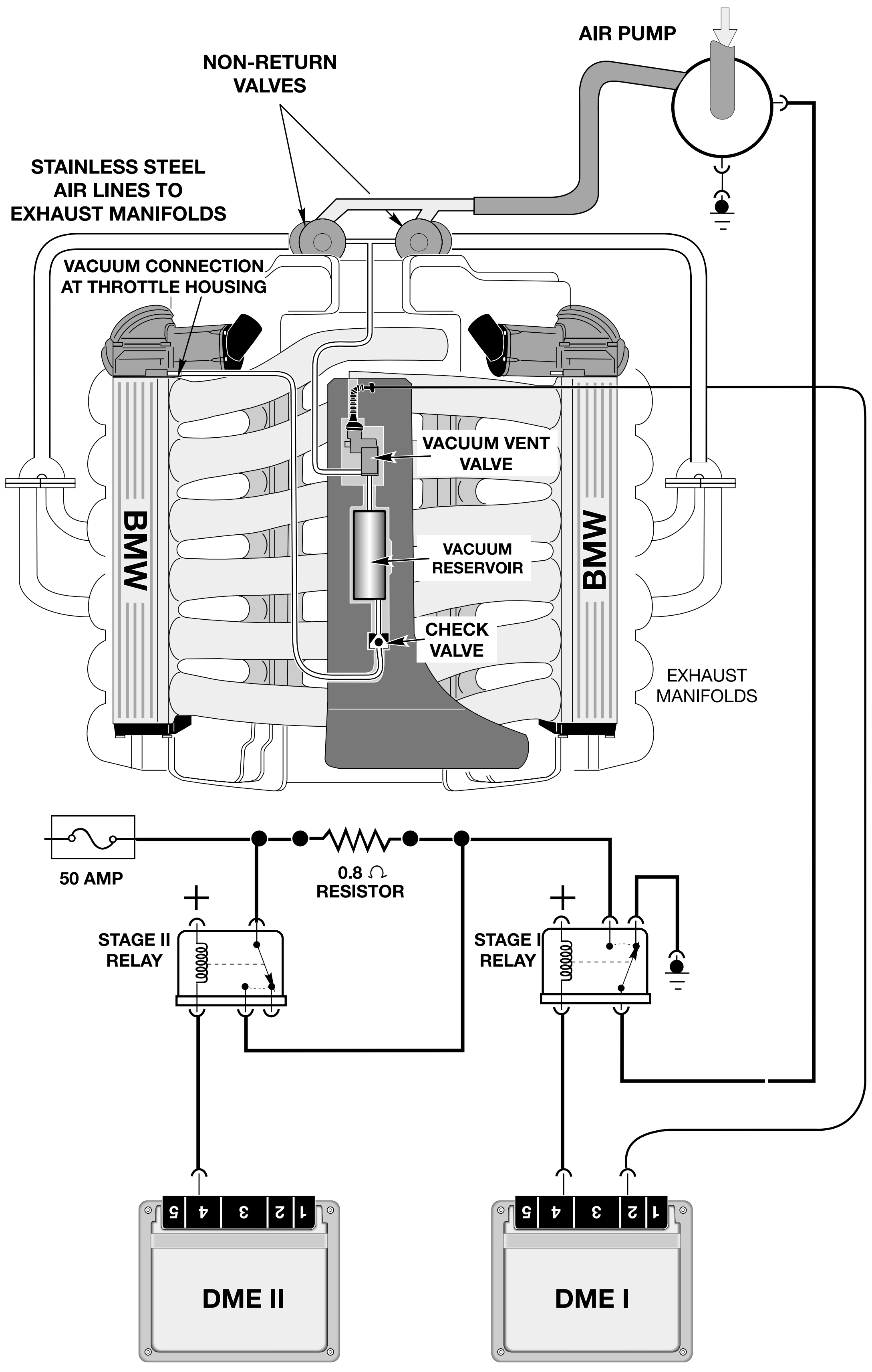
- ECM I activates the vacuum vent valve and Stage I relay simultaneously but separately providing the open air ports through the non return valves and slow air pump speed.

- ECM II activates the resistor bypass circuit through activation of the stage II relay providing the fast air pump speed if necessary.

All parameters of operation are programmed in the M 5.2.1 control modules and varied by monitored conditions:

- Engine Temp
- Engine Speed
- Engine Load




AIR PUMP
NON-RETURN
VALVES
STAINLESS STEEL
AIR LINES TO
EXHAUST MANIFOLDS
VACUUM CONNECTION
AT THROTTLE HOUSING
VACUUM VENT
VALVE
BMW
BMW
VACUUM
RESERVOIR
CHECK
VALVE
EXHAUST
MANIFOLDS
50 AMP
0.8 Ω
RESISTOR
STAGE II
RELAY
STAGE I
RELAY
DME II
DME I

ELECTRICALLY HEATED THERMOSTAT

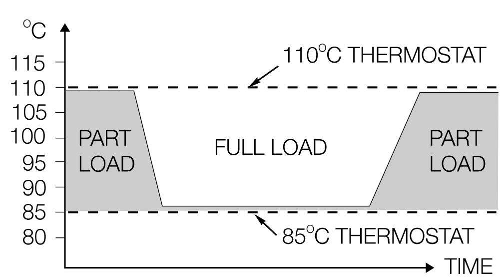
Model specific variants of the electrically heated thermostat are now equipped on all LEV compliant engines. The M73 TU thermostat housing has a quick connect coupling.

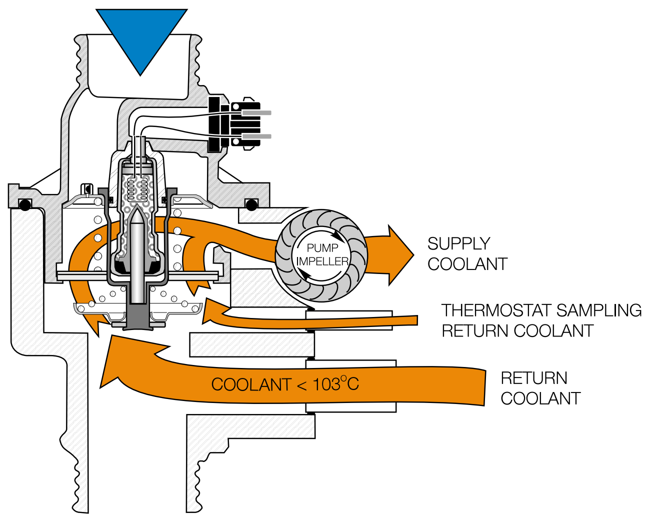
This thermostat allows the engine to run hotter than conventional thermostats improving fuel economy. The ECM also electrically activates the thermostat to lower the engine coolant temperatures based on monitored conditions. It is both a conventionally functioning and ECM controlled thermostat (two stage operation). ECM control adds heat to the wax core causing the thermostat to open earlier than it's mechanical temperature rating providing increased coolant flow.

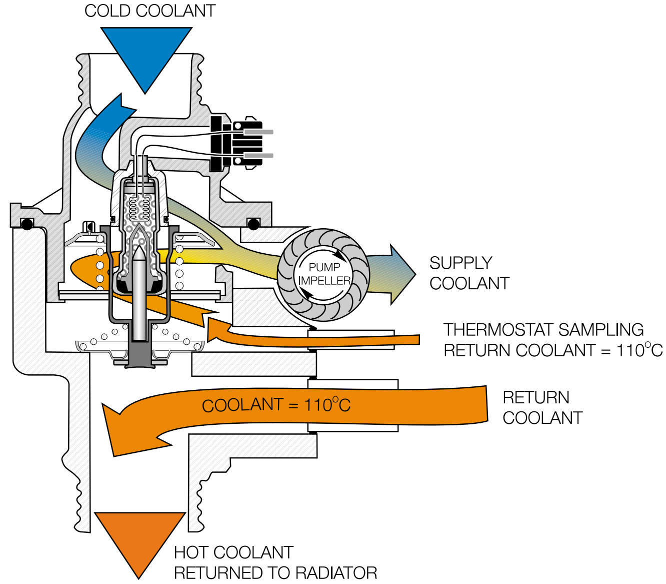
CONVENTIONAL FUNCTION: The thermostat begins to open at 103°C. This is at the inlet side of the water pump and represents the temperature of the coolant entering the engine. Before the 103°C temperature is realized, the coolant is circulated through the engine block by the water pump.

After the temperature reaches 103°C it is maintained as the inlet temperature by the thermostat. The coolant temperature at the water pump engine outlet is approximately 110°C. The additional 7°C is achieved after the coolant has circulated through the block.

The operating temperature of the engine will remain within this range as long as the engine is running at part load conditions and the engine coolant temperature does not exceed 113°C.







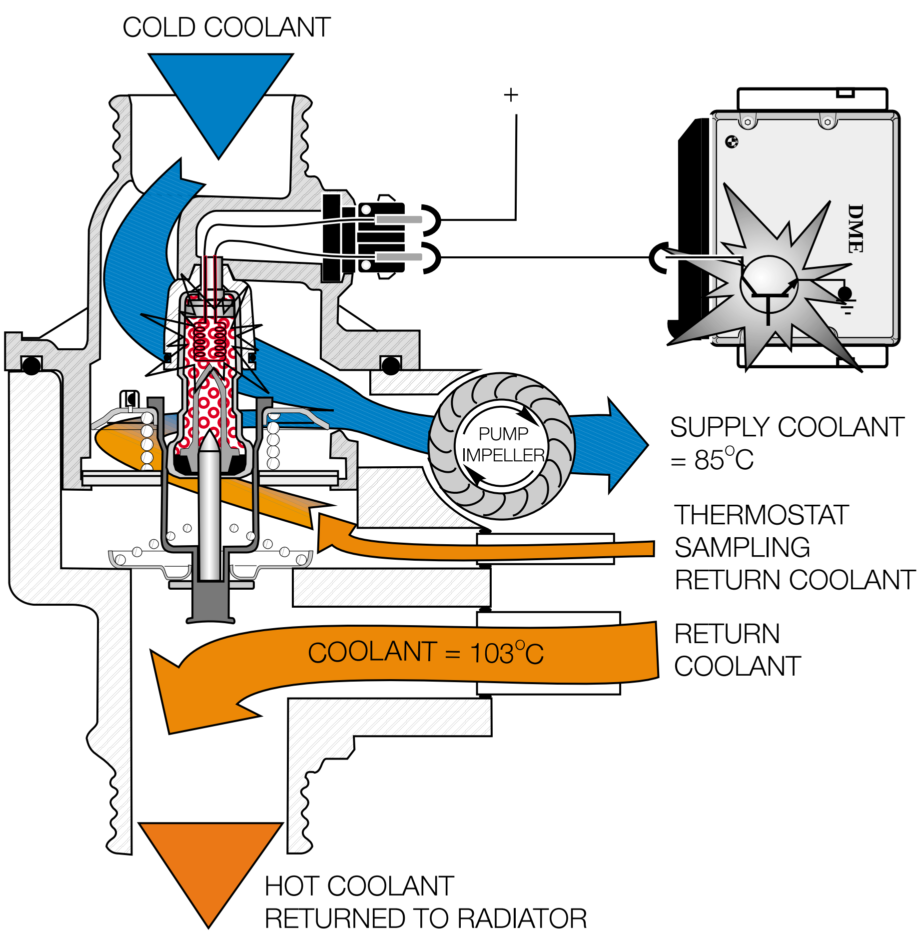
ECM CONTROL

Electric thermostat activation is based on the following parameters:

- Engine temperature > 113°C
- Radiator Coolant Outlet Temperature
- Load signal “ti” > 5.8 ms
- Intake air temp > 52°C
- Vehicle speed > 110 MPH

When one or more of these monitored conditions is determined, the ECM activates (switched ground) the thermostat circuit. The activated heating element causes the wax core in the thermostat to heat up and open the thermostat increasing coolant circulation through the radiator which brings the engine temperature down.

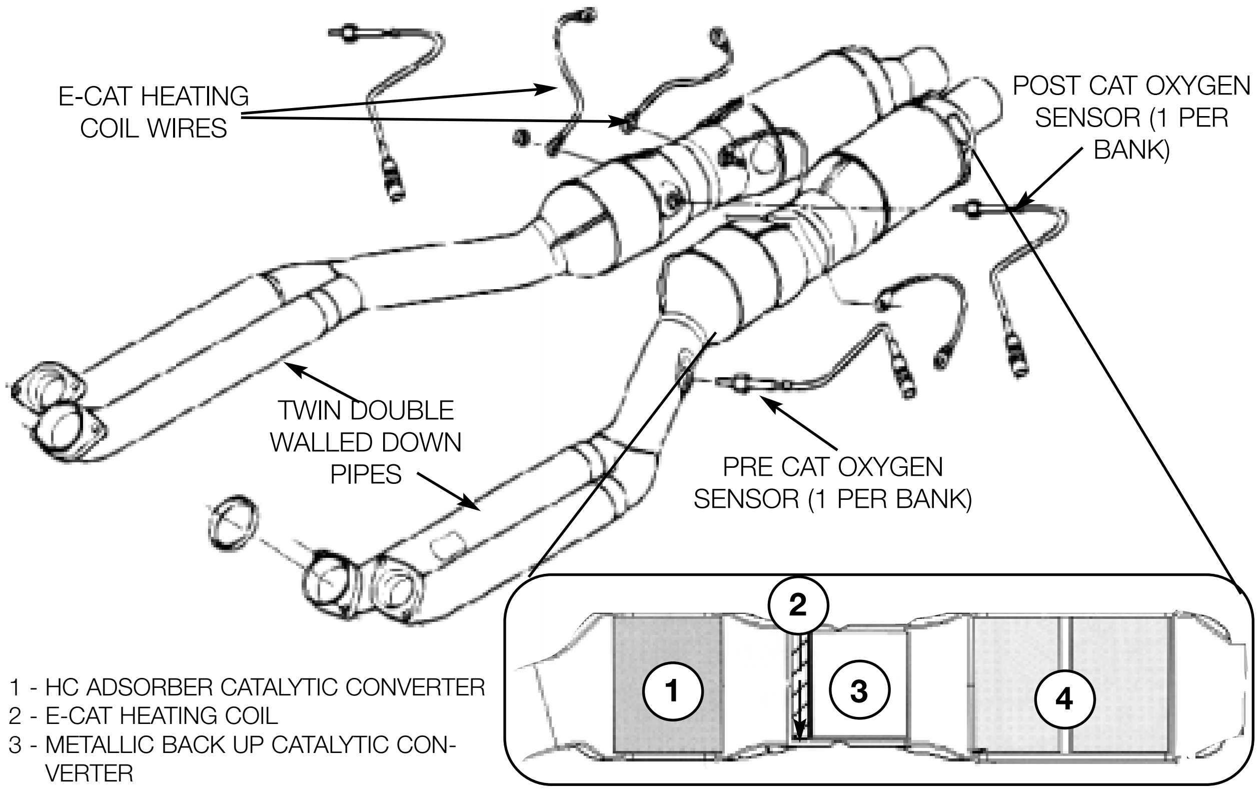
The temperature of the coolant at the inlet side of the water pump will drop to approximately 85°C and the temperature at the outlet side will drop to approximately 103°C when activated.



M73 TU EXHAUST SYSTEM

The 750iL exhaust system consists of the following:

- Each cylinder bank has two double-walled down pipes which converge into a single pipe for entry into the ***integrated electric catalytic converter assembly.***



1 - HC ADSORBER CATALYTIC CONVERTER
2 - E-CAT HEATING COIL
3 - METALLIC BACK UP CATALYTIC CONVERTER
4 - MAIN CATALYTIC CONVERTERS

INTEGRATED ELECTRIC CATALYTIC CONVERTER ASSEMBLY

- Integrated catalytic converter assembly including:
  - Hydrocarbon (HC) adsorber in thin-wall ceramics (105.7 mm dia.)
  - Electric catalytic converter heater and metallic backup converter (80 mm dia.)
  - Main catalytic converters in thin-wall ceramics (105.7 mm dia.)
- Twelve liter volume Central muffler.
- Two rear mufflers with a volume of 18 liters each.

The location of the post oxygen sensor is just behind the HC adsorber and complies with the ARB catalytic converter monitoring function following the same criteria with the familiar post oxygen sensor signal. However, the metallic backup and two main converters are not monitored.

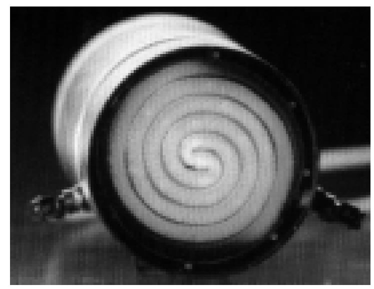
The ARB allows this configuration since the adsorber catalytic converter is the critical element in the assembly. The logic being, if the adsorber is detected as being defective the entire assembly requires replacement.

ELECTRIC CATALYTIC CONVERTER (E-CAT) ASSEMBLIES

The name “Adsorber” identifies the first converter of each assembly as a unique critical component. The Adsorber has the unique ability to attract and retain residual hydrocarbon molecules as it cools. As it warms up it releases the residual HC allowing it to be converted as it passes through the heating coil, back-up metallic converter and twin main converters. This feature is what makes this catalytic converter so unique providing cleaner cold starts and LEV compliance.

The proportion of HC in the exhaust is very high just after a cold start. This is due to the rich fuel/air mixture and incomplete combustion. When initially driving away and during an increase in acceleration which follows, the HC proportion sharply increases again.

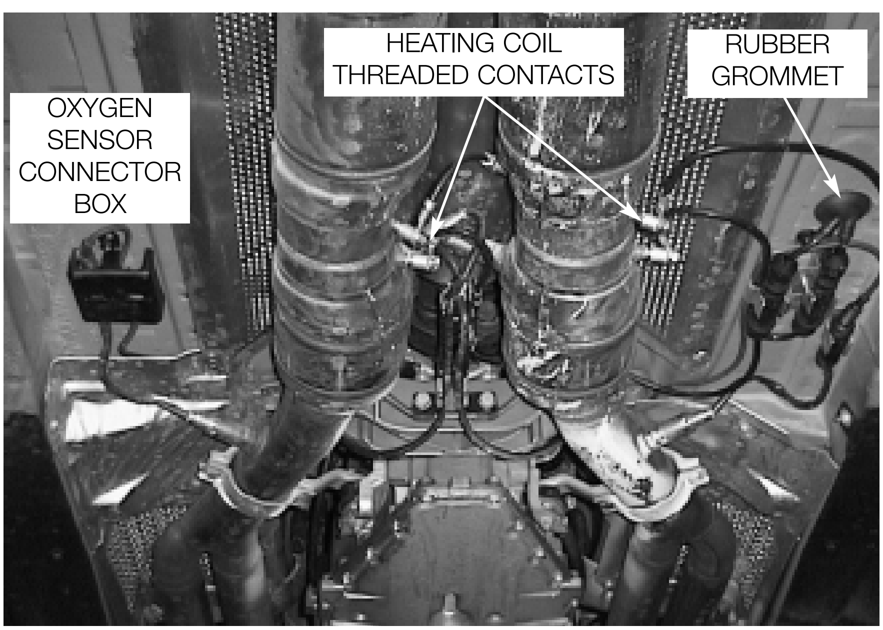
The electric catalytic converter's heating coil, which is installed directly behind the adsorber, is energized for a maximum of 30 seconds immediately after the engine has started (engine speed > 400 rpm). This ensures that the metallic back-up converter and the main catalytic converters downstream attain light-off much earlier.

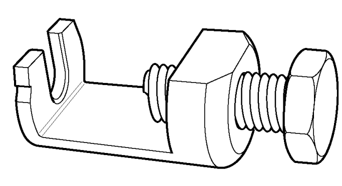


The heating coils are provided operating current from an E-CAT control module located under the passenger seat. The coils are connected to the E-Cat control module by high amperage cables. The cables pass through a rubber grommet on the passenger side floor to the E-CAT module location.

Special Tool Note: The cables must only be removed from the catalytic converters with tool *90 88 6 180 050.* This tool is designed to prevent damage to the ceramic insulation on the threaded contacts.

Refer to SI 04 02 99.

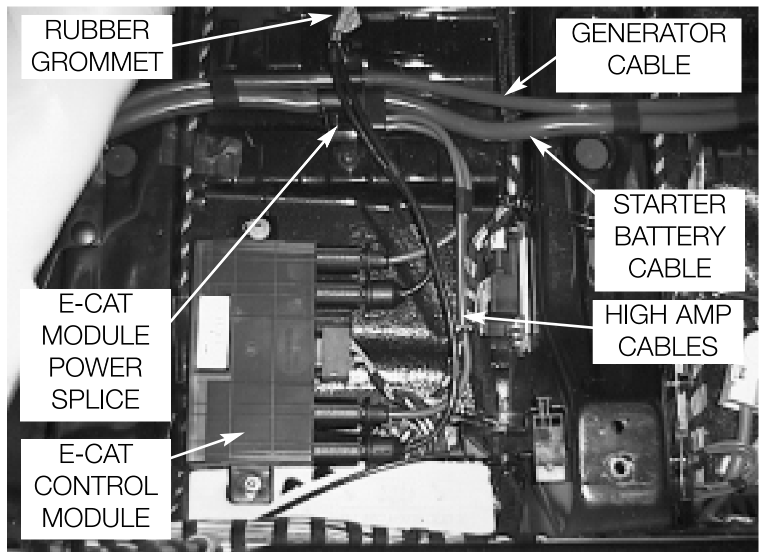




E-CAT CONTROL FUNCTION

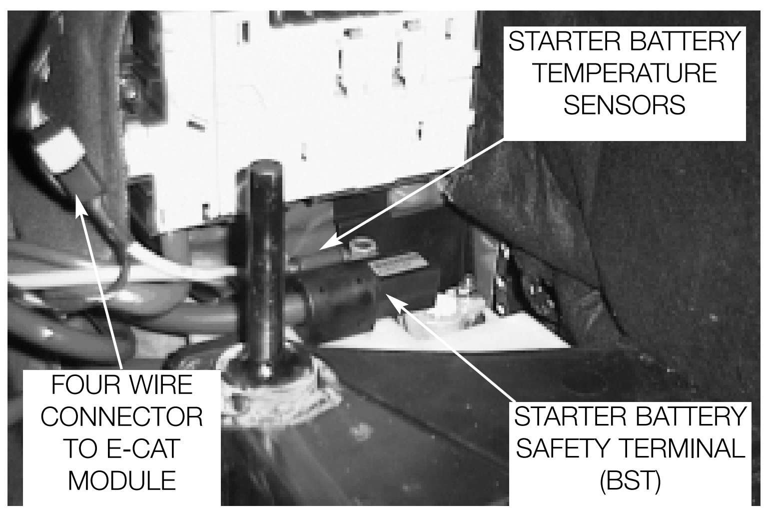
The primary function of the E-CAT control module is to simultaneously control the heating of both E-CAT heating coils through high amperage (120A each) power output switches. ECM I signals the E-CAT module via the CAN bus requesting activation and deactivation of the heating coils. Heating time is for a maximum of 30 seconds but can be shorter in duration depending on monitored conditions.

When on, the metallic back-up converters which are located just behind the heating coils, heat up rapidly. As a result, catalytic converter light-off starts almost immediately reducing cold start emissions in the warm-up phase.



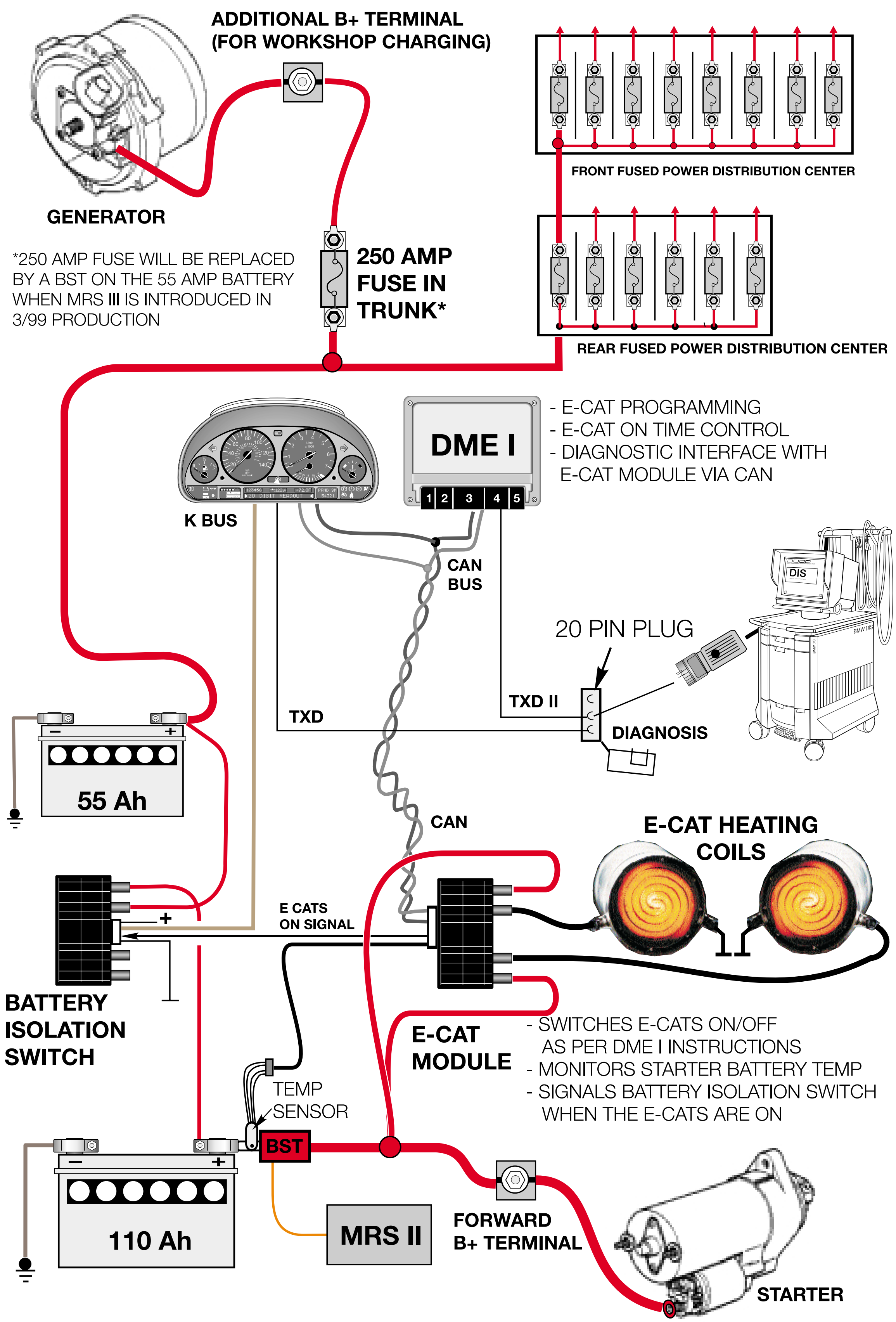
The E-CAT module receives two redundant starter battery temperature signals for monitoring the battery temperature.

The sensors are located in a sealed housing connected directly to the positive terminal of the battery.



If the starter battery temperature falls below 0°C, the E-CAT heating coils are not switched on.

Once the E-CATs are activated, the control module simultaneously provides the output control signal to the dual battery isolation switch (signal KATON) requesting the switch which opens the circuit between the starter battery and vehicle circuit battery. This ensures the E-Cat's operating power is supplied only from the starter battery (detailed description of two battery system further on).


ADDITIONAL B+ TERMINAL
(FOR WORKSHOP CHARGING)
GENERATOR
FRONT FUSED POWER DISTRIBUTION CENTER
*250 AMP FUSE WILL BE REPLACED BY A BST ON THE 55 AMP BATTERY WHEN MRS III IS INTRODUCED IN 3/99 PRODUCTION
250 AMP FUSE IN TRUNK*
REAR FUSED POWER DISTRIBUTION CENTER
DME I
1 2 3 4 5
- E-CAT PROGRAMMING
- E-CAT ON TIME CONTROL
- DIAGNOSTIC INTERFACE WITH E-CAT MODULE VIA CAN
K BUS
CAN BUS
DIS
20 PIN PLUG
TXD II
TXD
DIAGNOSIS
55 Ah
CAN
E-CAT HEATING COILS
E CATS ON SIGNAL
BATTERY ISOLATION SWITCH
E-CAT MODULE
- SWITCHES E-CATS ON/OFF AS PER DME I INSTRUCTIONS
- MONITORS STARTER BATTERY TEMP
- SIGNALS BATTERY ISOLATION SWITCH WHEN THE E-CATS ARE ON
TEMP SENSOR
BST
110 Ah
MRS II
FORWARD B+ TERMINAL
STARTER

CRITERIA FOR E-CAT HEATING COIL ACTIVATION

All conditions for switching the E-Cats on are monitored and activated by ECM I. ***Maximum*** heating time is 30 seconds. The degree of “on” time (calculated amount of necessary E-Cat heating) is dependent on the intake air and coolant temperatures as well as the duration of time the engine has been off since the last trip.

Engine start recognition is determined by the ECM on the basis of various input signals (mass air flow, engine speed etc.). All of the following criteria must be met for the coils to be switched on:

- Engine coolant temperature > 0°C and < 90°C
- Starter battery temperature > 0°C and < 60°C
- Distance travelled since last engine start > 1 mile.
- Catalytic converter temperature < 300°C (programmed temperature map)
- > 30 min since engine was previously switched off
- Vehicle road speed < 3 mph
- Engine starting time < 5 seconds
- Time after start recognition > 0.1 seconds
- Throttle pedal not at WOT

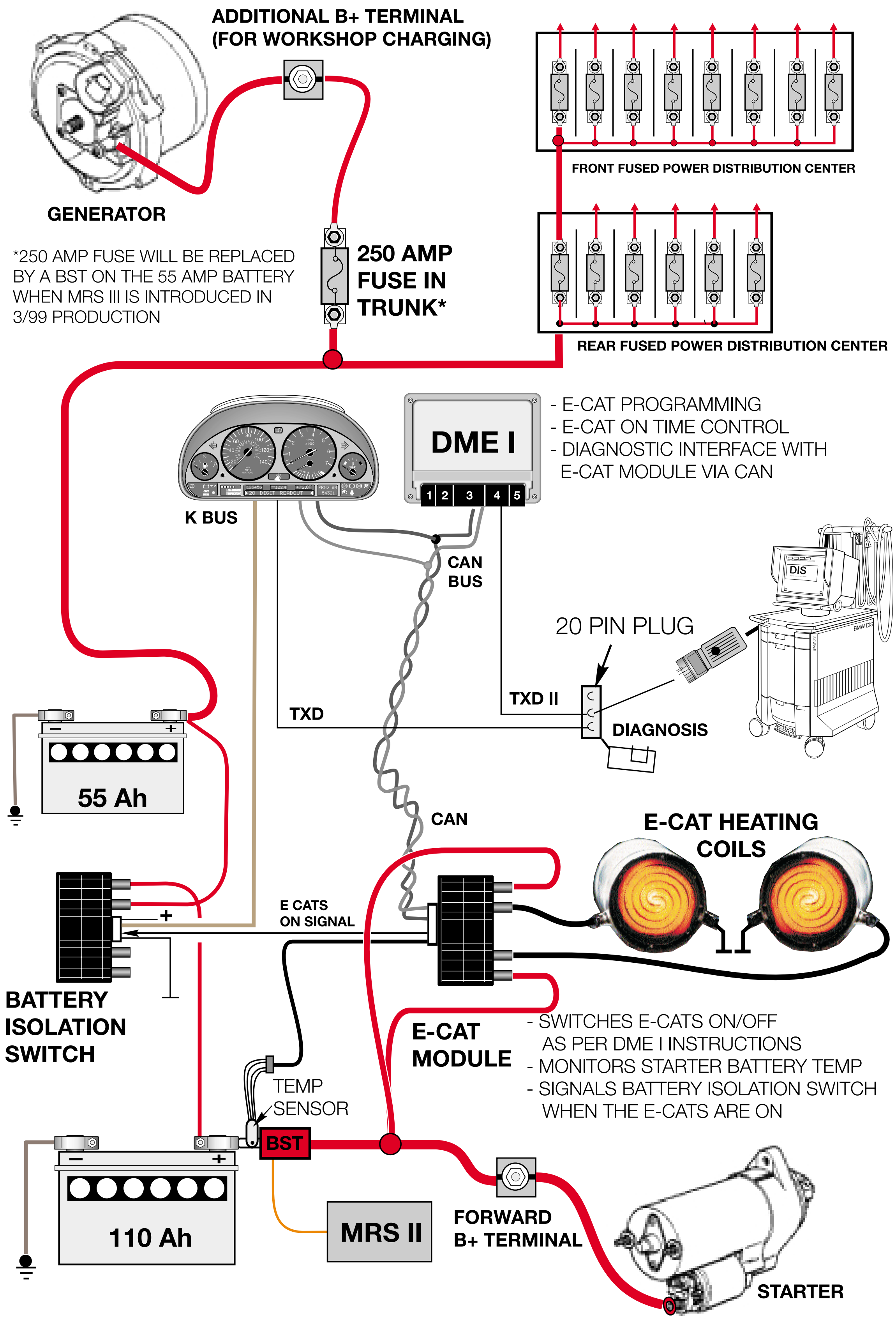
The E-CAT's are immediately switched off when one or more of the following faults occur during an activation period:

- CAN bus fault -- Instrument Cluster
- CAN bus fault -- ECM and E-CAT module
- Fuel injector fault
- Misfire detection faults which might damage catalytic converter
- Fault in output stage of secondary air injection components
- Fault in engine temperature signal
- Fault in engine speed sensor

DIAGNOSIS

The E-CAT module communicates fault information to ECM I via the CAN bus. The ECM relays the diagnostic communication to the DIS/MoDiC. A maximum of 14 E-CAT fault codes can be retrieved through ECM I.

E-CAT specific faults with an illuminated "CHECK ENGINE" Light indicates there have been two unsuccessful attempts to heat the catalytic converters.


ADDITIONAL B+ TERMINAL
(FOR WORKSHOP CHARGING)
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1 2 3 4 5
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TXD
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DIAGNOSIS
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CAN
E-CAT HEATING COILS
E CATS ON SIGNAL
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E-CAT MODULE
- SWITCHES E-CATS ON/OFF AS PER DME I INSTRUCTIONS
- MONITORS STARTER BATTERY TEMP
- SIGNALS BATTERY ISOLATION SWITCH WHEN THE E-CATS ARE ON
TEMP SENSOR
BST
110 Ah
MRS II
FORWARD B+ TERMINAL
STARTER

Review Questions

1. How is the power supply for the ignition coils is provided?________________________

2. Describe the Air Shrouded Injector Control on the M73:________________________

3. If the engine idle speed is higher than normal on an M73, what does this indicate?

4. What will cause a complaint of "engine cranks but does not start": ________________

5. How many speeds will the Secondairy Air Injection Pump run at and what controls this? ______ ________________________

6. Explain what happens when the ECM activates the thermostat circuit: ______________

7. Why is it necessary to use Special Tool # 90 88 6 180 050 when working on an electrically heated catalyst? ________________________

8. What will cause an E-CAT to be switched off?

9. Where is the E-CAT Module Power Splice located? ________________________

Table of Contents

Subject **Page**

EML IIIs

Model: E38 - M73 Engine
E31 - M73 Engine

Production Date: E38 1995 - Present
E31 1996 - End of Production

Manufacturer: Siemens

Pin Connector: 88 Pins

Objectives of the Module

After completing this module, you will be able to:

- Name the Components that are Contained in the DK motors
- Explain the Stepper Motor Functions that are Monitored
- List the Inputs Required for EML Operation
- Decribe How the Throttle Valves are Synchronized
- List What Control Modules Require a Throttle Input Signal
- Understand What Type of Signal is Generated by the PWG

EML IIIs

Purpose of the System

The EML IIIs is an electronic throttle control system for the M73 V-12 engine. The EML IIIs was designed and developed by Siemens to BMW specifications.

The EML IIIs system uses two throttle valves and one pedal position sensor (PWG). The EML IIIs control module regulates the position of the throttle valves based on the input from the pedal position sensor.

In addition to throttle control, the main functions of the EML IIIs include:

- Idle stabilization by regulating the throttle openings at idle.
- Throttle valve positioning for optimum starting.
- Synchronization of the cylinder banks.
- Air volume control for ASC/DSC operation.
- Cruise control regulation (the EML IIIs control module contains the GR II logic introduced on the E38 740).
- Maximum road speed limiting

The operation of the EML IIIs is enhanced with additional backup (redundancy) features. This helps ensure reliable operation while maintaining a high level of operational safety.

The fault memory of the EML IIIs control module is stored in an **EEPROM** so that disconnection of the battery will not erase any stored faults.

The EML IIIs system is incorporated into the driving management system and is connected to the CAN line for signal interfacing with the ECM, ASC+T and AGS control modules.

The EML III system includes:

- The EML IIIs control module contains two separate processors for redundant checking of inputs and output controls.

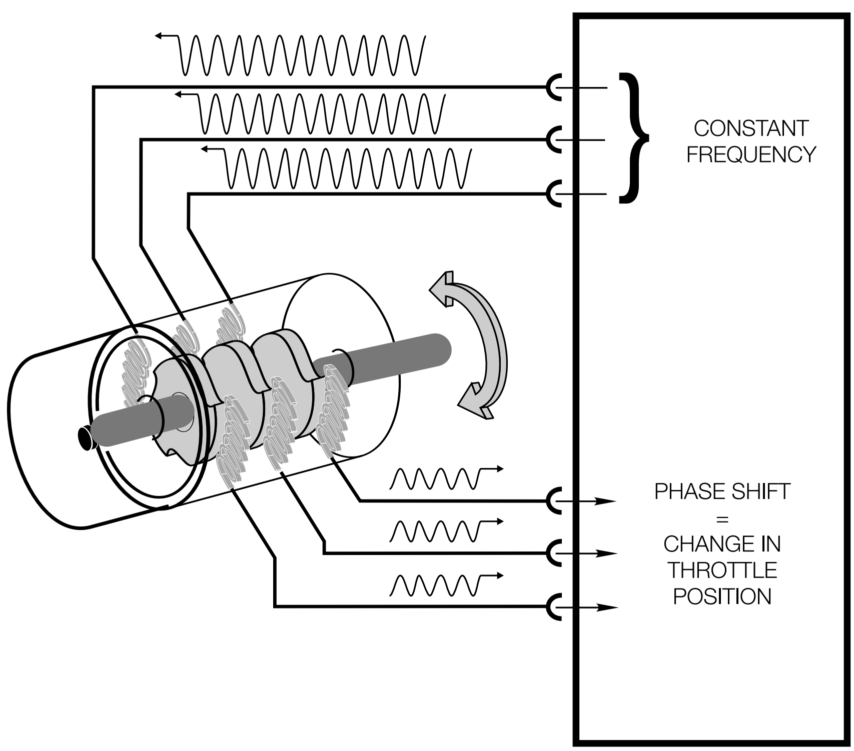
- Each throttle valve is controlled by two separate stepper motors driving one rotor

- The external safety path.

- E38 EML fault indication is handled by the Check Control Module, through the instrument cluster matrix display.

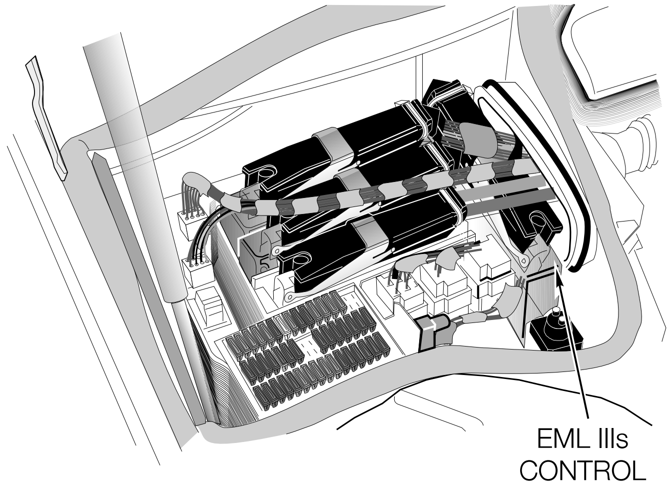
- The hall sensor brake pedal switch is used for the brake pedal input.

- Logic monitoring of pedal/throttle valve operation

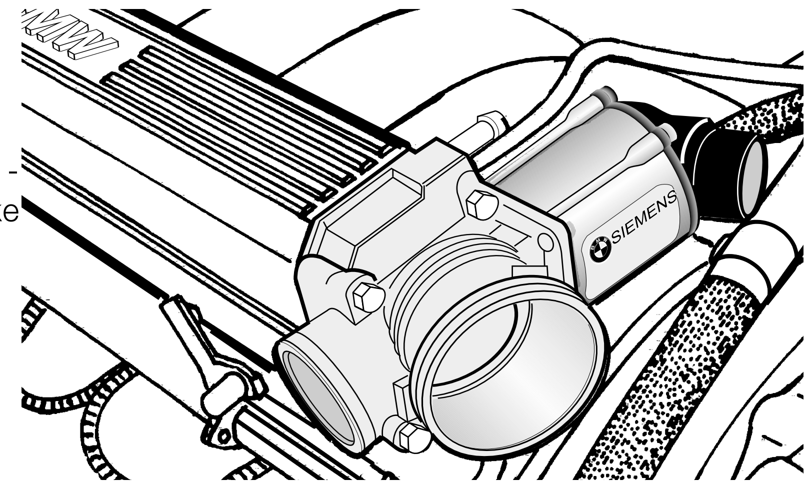


COMPONENTS

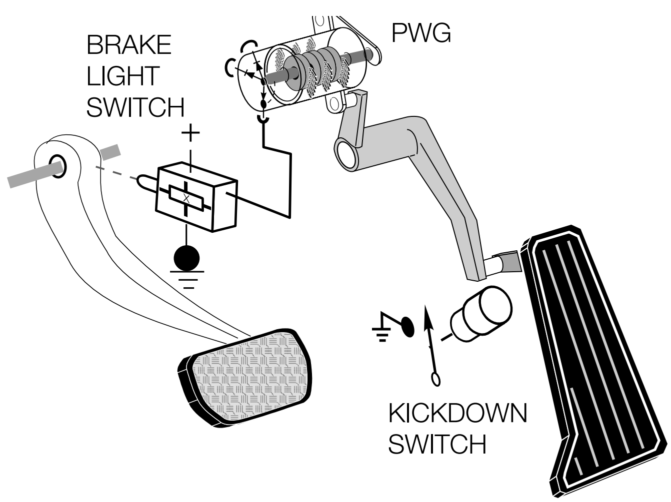
The main components of the EML IIIs system include:



• The EML IIIs control module - located in the E-box.



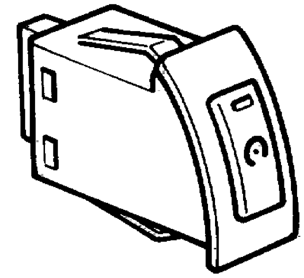
• Two throttle (DK) assemblies - mounted on each intake manifold.



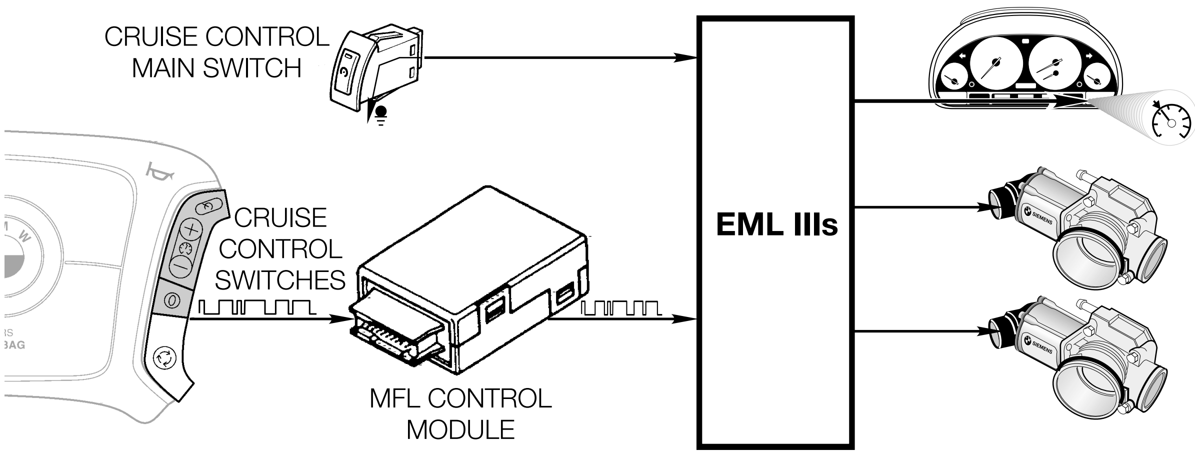
• One pedal position sensor (PWG) - connected to the accelerator pedal (with a separate kick-down switch).

• Electronic brake light switch.

• Cruise control main switch - mounted on the instrument panel. Provides a switched ground input to the EML control module (Early E38 only, incorporated in the steering wheel control switch on later models).

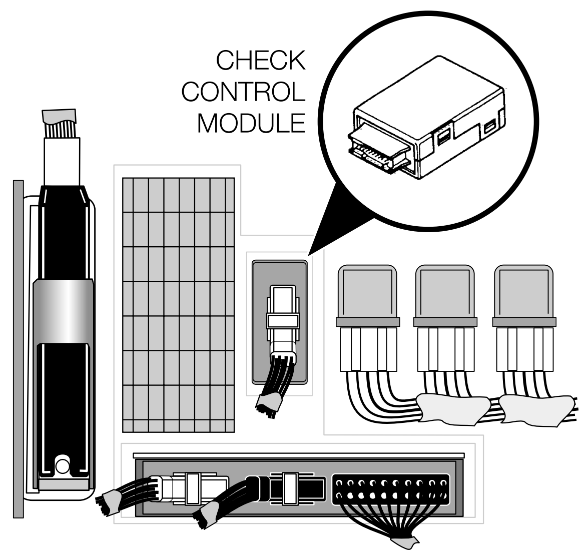


• Multi-Function Steering Wheel - cruise control switch pad and the MFL control module.



(E38 only)

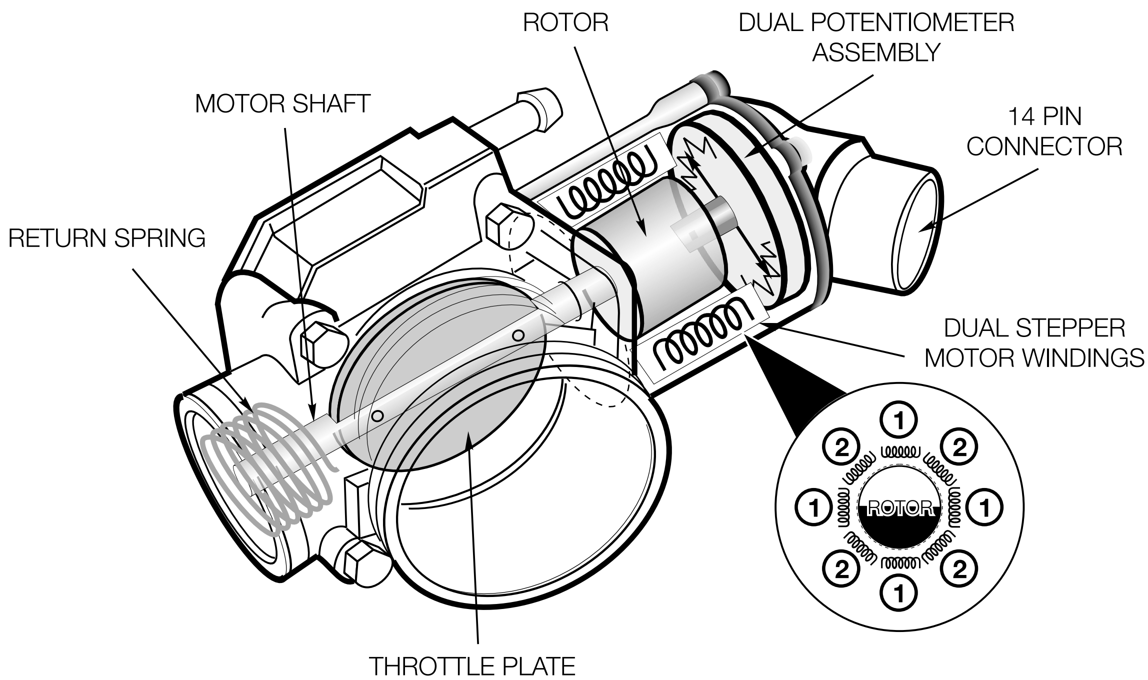
• Check control module - for activation of the fault warning display.



THROTTLE VALVE (DK) MOTORS

The throttle valve assembly consists of the DK housing with the throttle valve plate, return spring, drive motor and feedback potentiometers. The EML IIIs throttle valve plate is driven directly by the motor shaft which allows for a precise control of the throttle plate positioning.

A dual stepper motor configuration is used to drive the throttle plate. Both stepper motors are controlled through separate final stages in the EML control module and operate on the one armature. The final stages for one stepper motor windings are controlled by one micro processor while the second motor windings are controlled by the second processor. The control of the stepper motors takes place simultaneously by each processor.



The dual feedback potentiometers signal the movement and position of the throttle plate to each processor. The two potentiometers have separate power and ground circuits to ensure the reliability of their operation.

This dual redundancy system allows the EML IIIs to continue operation, without driver inconvenience, if one stepper motor or control circuit malfunctions. If the self diagnosis of the EML IIIs detects a fault with one of the stepper motor controls, it will switch off the affected circuit and continue operation from one motor control circuit. The fault will be logged and the EML fault warning will be displayed in the cluster matrix.

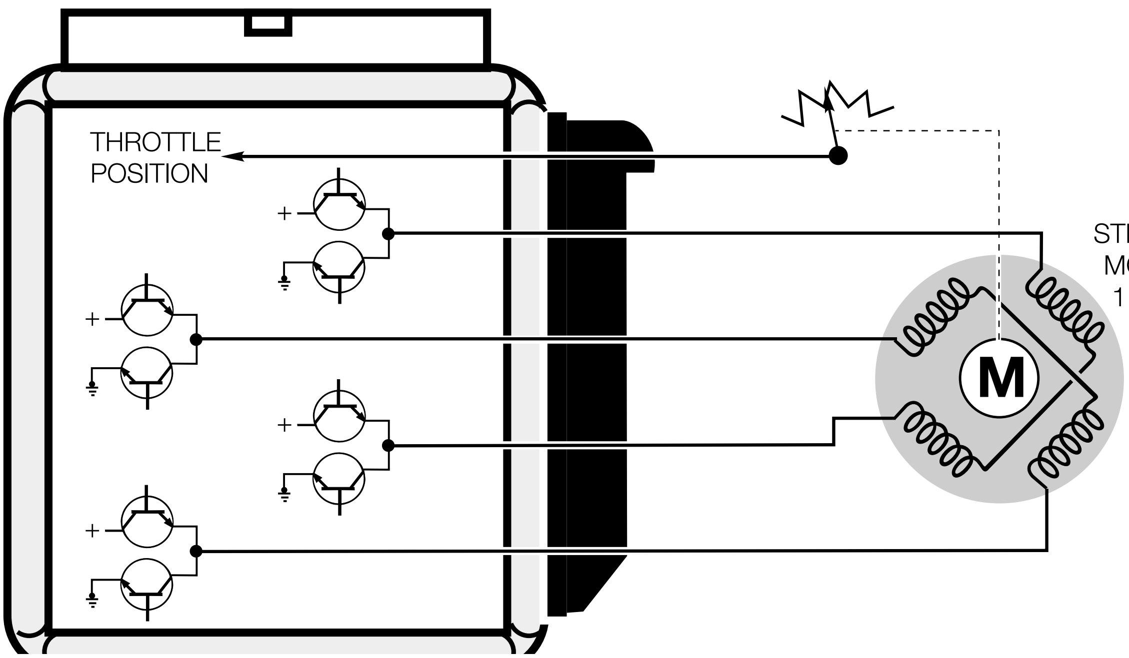
If a fault occurs that cannot allow continued operation of the throttle valve, the control for that bank of cylinders will be switched off.

Stepper Motor Control

A digital square wave signal is used to drive the stepper motor of the DK assembly. The duty cycle of the frequency and trigger of the signal are changed to produce the magnetic field required to move the stepper motor rotor.

Each set of stepper motor windings are controlled by four final stages. Each final stage has the ability to switch between power and ground to reverse the direction of current flow through the windings (trigger). This switching allows the magnetic field of the coils to be reversed allowing the rotor to be driven in either direction to position the throttle plate at the precise setting called for by the PWG input request.

The final stage control varies the duty cycle to control the speed of movement and position of the throttle plate.



Self Diagnosis: The scope of EML self diagnosis for stepper motor operation includes:

- Checking
  - Both throttle valves are checked dynamically prior to engine starting (part of pre-start check with KL 15 on).
  - All eight final stage controls per stepper motor when KL 15 is switched on.
- Monitoring
  - The supply voltages for all potentiometers.
  - Throttle valve set position with the feedback potentiometers position.
  - Comparing the two potentiometer signals.
  - Comparing the set points calculated by each individual processor.
  - The throttle valve operation for OBD II checking requirements.

CONDITIONS OF STEPPER MOTOR CONTROL

Starting: The EML IIIs control module will position the throttle valves to the optimum opening for engine start when it receives the KL 50 input over the CAN line.

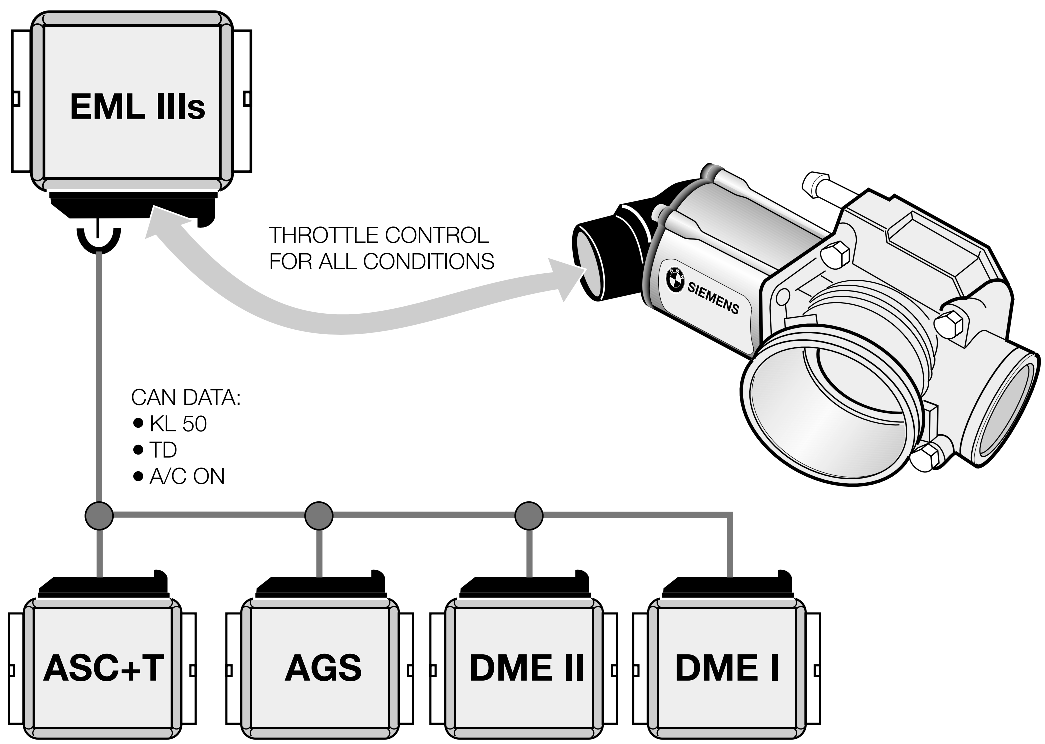
Idle: The EML IIIs programming will maintain a stable idle by adjusting the opening of the throttle valves when the vehicle is at a standstill. The EML receives the engine RPM signal from the ECM over the CAN line.

The idle will be stabilized for A/C compressor activation to compensate for the load of the compressor.

The EML receives TD and AC on signals over the can line.

Decel Fuel Cutoff: Decel fuel cutoff is activated based on the input from the pedal position sensor and the engine RPM signals. A high signal is supplied from the EML control module to the ECM control modules for the purpose of activating decel fuel cut off.

These input signals to the ECM control modules are separate hard wire lines that are also used for the “safety fuel cut off” feature of the EML control.



THROTTLE POSITION SENSOR (PWG)

The throttle position sensor uses an inductive coil “oscillator” principle for accelerator position recognition input. The PWG consists of:

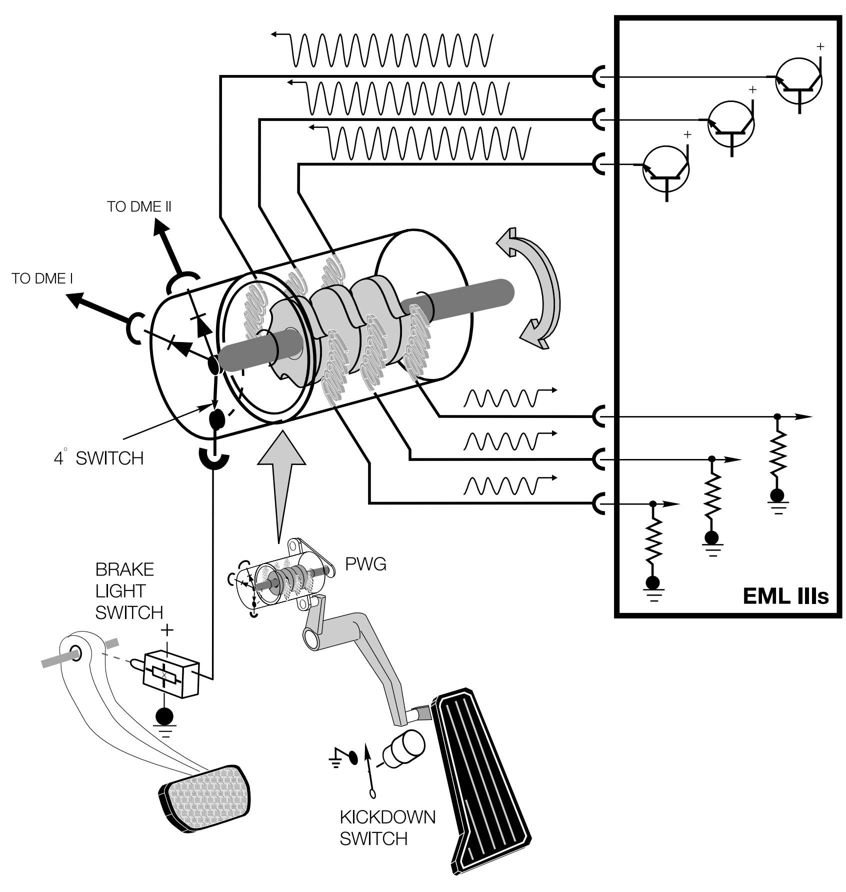
• Three separate inductive coils.

• One soft iron core eccentric, attached to the accelerator pedal through the PWG shaft.

• One 4° switch, for the external safety path function.

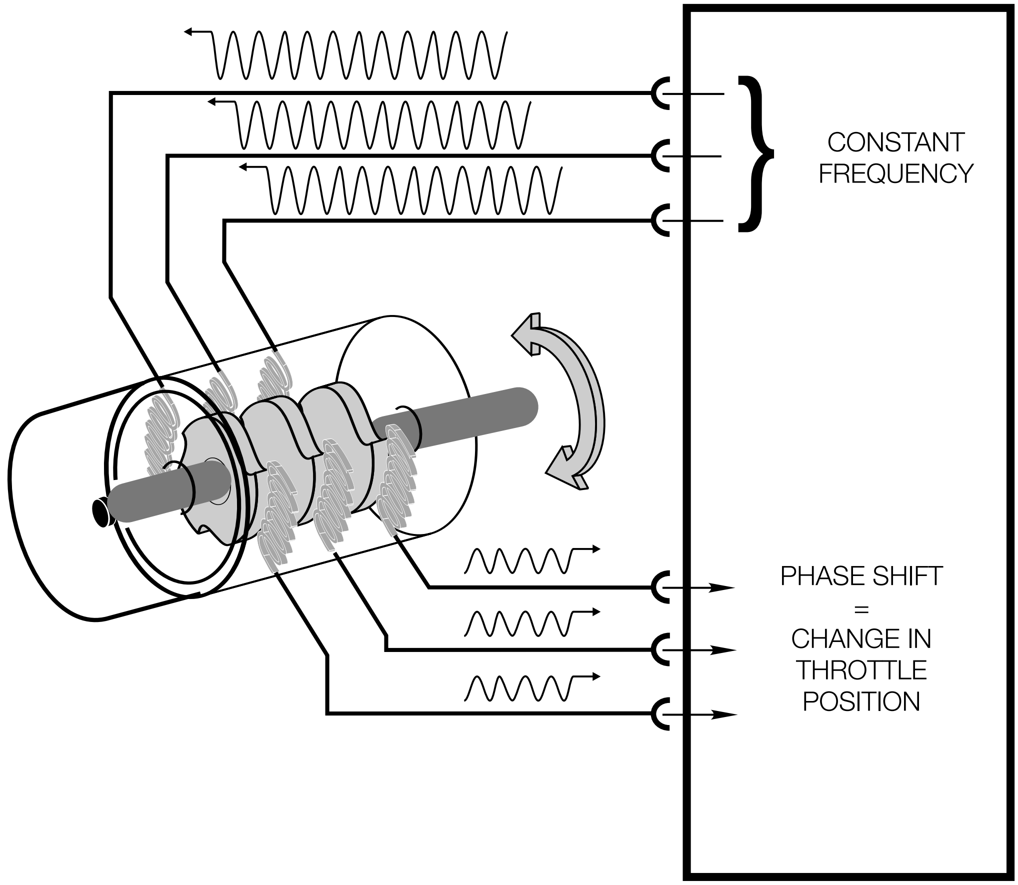
Each coil is supplied with an AC voltage signal, at a specific frequency, from the EML IIIs control module. As the pedal is moved, the eccentric shape of the iron core moves closer to the PWG coils.

This causes the inductance of the coils to increase due to the concentration of the magnetic field. The increasing inductance in the coil causes the amplitude of the AC frequency to be reduced.



The amplitude is decreased as the pedal is pressed down.

The EML control module monitors and processes the changing amplitude as the input request for throttle opening/closing.



The changing amplitude value is a measure of accelerator pedal movement. The EML control module is programmed to recognize pedal movement from 0° (idle) to 99° (WOT) based on the changing voltage signal.

The three inductive coils are used for redundancy purposes. All three signals from the PWG are input and evaluated by both processors of the EML IIIs control module.

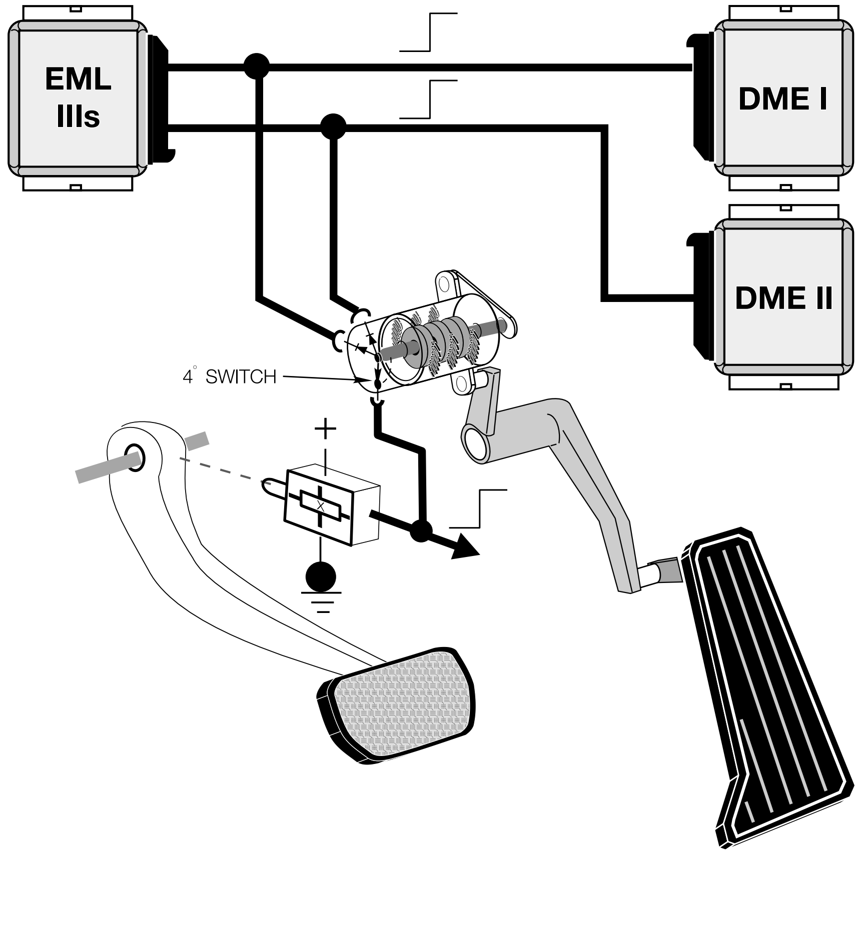
If one signal were to fail, the operation of the EML system, from the driver's perspective, would not be affected. The EML IIIs control module would continue to function from the remaining two signals. The fault will be recognized and stored in the fault memory and a failure warning message would be posted in the display matrix. If a second signal were to fail, the system would go into the failsafe operation and the EML IIIs control module would stop responding to the throttle input. The engine will start but not run above idle. This second fault would also be stored in the fault memory.

EXTERNAL SAFETY PATH

The external safety path circuit is maintained to ensure that the decel fuel cutoff is activated if a fault occurs with the output control of the throttle motors causing the engine not to return to idle.

The external safety path exists from the electronic brake light switch, through the 4° switch, to the decel fuel cutoff inputs of the ECM control modules.

With the accelerator pedal released (4° switch closed) and the brake pedal pressed, a high signal is supplied (bypassing the EML control module) to the DME control modules to activate decel fuel cutoff.



A special tool is not required to test the safety path circuit for proper operation. A procedure is listed in the diagnostic pages for this purpose.

It requires stepping on the accelerator < 4° but far enough to display an off idle condition. With this displayed on the DIS/MoDIC screen, stepping on the brake pedal will display the decel fuel cut off request to the ECM.

BASIC ADAPTION OF THE PWG

The PWG adaption allows the EML control module to learn the idle and wide open throttle limit positions. This adaption procedure must be carried out in the following instances:

- The EML control module is replaced
- The pedal position sensor is replaced
- The PWG is disconnected with the ignition “ON”
- A new variant code is installed in the EML control module
- The DIS/MoDIC diagnostic procedures request an adaption be carried out as part of the troubleshooting

NOTE: The engine will start but the throttle control system will not respond to inputs from the PWG until this basic adaption has been completed. The procedure for the basic adaption is listed in the “SPECIAL FUNCTIONS” section of the DIS/MoDIC - EML test pages.

The adaption procedure is carried out with KL 15 switched “ON” and the engine “OFF”. Driving the vehicle is not required for pedal adaption.

EML III S CONTROL MODULE

The EML IIIs control module is located in the E-Box. All control and safety monitoring functions of the EML are backed up by redundant processing. Each pair of the output control final stages of the DK motors is controlled by a separate processor. The EML control module communicates with the ECM, ASC+T and EGS control modules over the CAN line for the following inputs/outputs:

ECM Control Modules

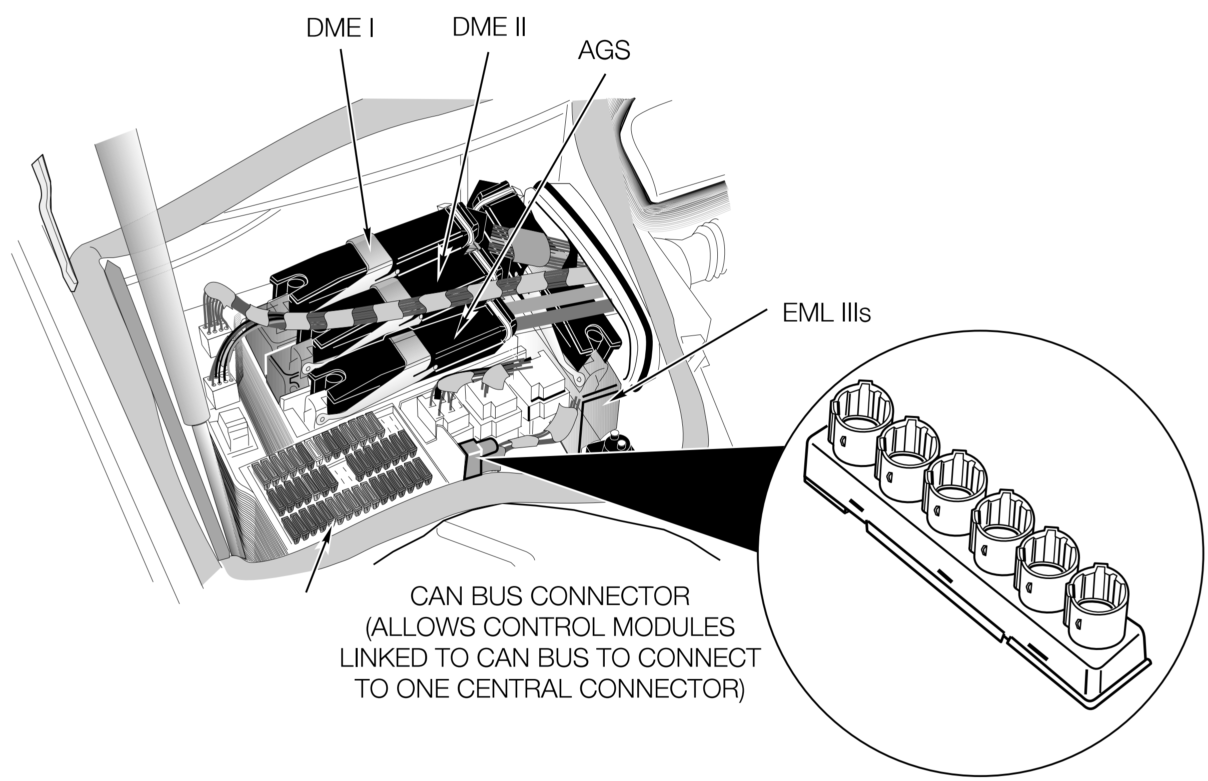
- Engine coolant temperature
- Throttle position
- A/C status (ON/OFF)
- Load signal (ti) for each DME
- Engine speed (TD)

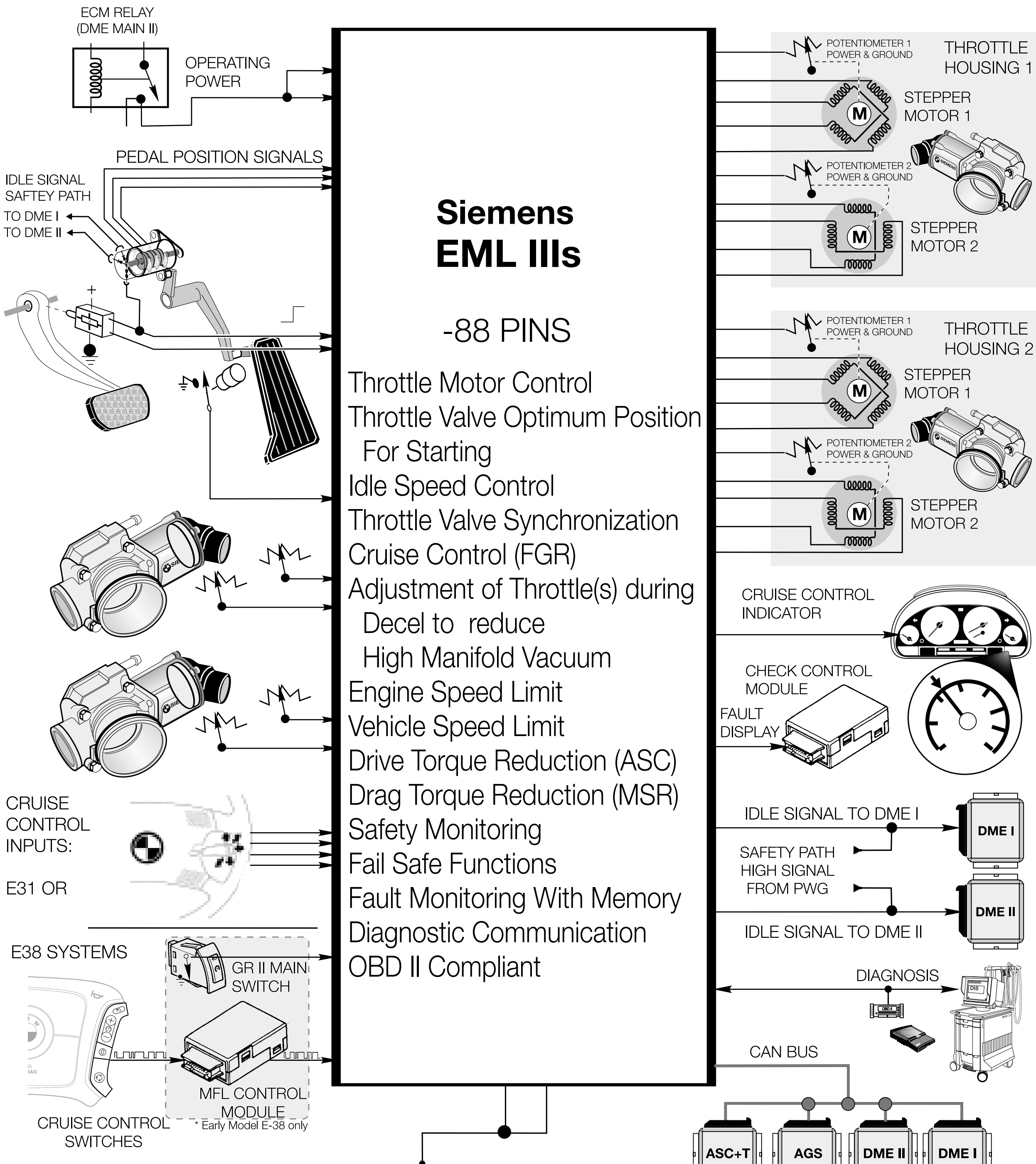
AGS Control Module

- Kickdown
- Transmission range/program
- Shift Characteristics

ASC+T Control Module

- Throttle valve angle
- Throttle valve increase
- Throttle valve decrease
- Vehicle speed

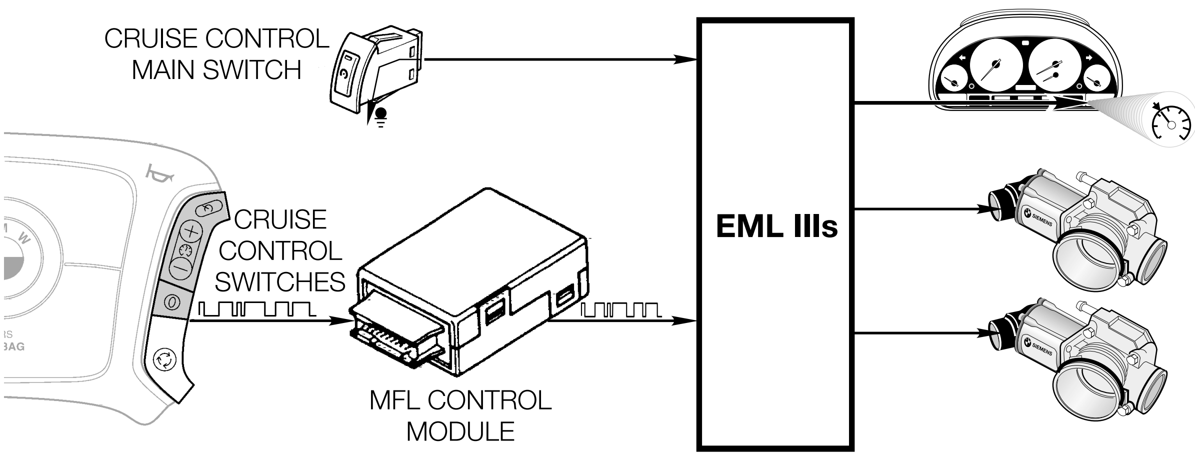



ECM RELAY
(DME MAIN II)
OPERATING
POWER
PEDAL POSITION SIGNALS
IDLE SIGNAL
SAFTEY PATH
TO DME I
TO DME II
Siemens
EML IIIs
-88 PINS
Throttle Motor Control
Throttle Valve Optimum Position
For Starting
Idle Speed Control
Throttle Valve Synchronization
Cruise Control (FGR)
Adjustment of Throttle(s) during
Decel to reduce
High Manifold Vacuum
Engine Speed Limit
Vehicle Speed Limit
Drive Torque Reduction (ASC)
Drag Torque Reduction (MSR)
Safety Monitoring
Fail Safe Functions
Fault Monitoring With Memory
Diagnostic Communication
OBD II Compliant
POTENTIOMETER 1
POWER & GROUND
THROTTLE
HOUSING 1
STEPPER
MOTOR 1
POTENTIOMETER 2
POWER & GROUND
STEPPER
MOTOR 2
POTENTIOMETER 1
POWER & GROUND
THROTTLE
HOUSING 2
STEPPER
MOTOR 1
POTENTIOMETER 2
POWER & GROUND
STEPPER
MOTOR 2
CRUISE CONTROL
INDICATOR
CHECK CONTROL
MODULE
FAULT
DISPLAY
CRUISE
CONTROL
INPUTS:
E31 OR
IDLE SIGNAL TO DME I
SAFETY PATH
HIGH SIGNAL
FROM PWG
DME I
DME II
IDLE SIGNAL TO DME II
E38 SYSTEMS
GR II MAIN
SWITCH
DIAGNOSIS
CAN BUS
MFL CONTROL
MODULE
* Early Model E-38 only
CRUISE CONTROL
SWITCHES
ASC+T
AGS
DME II
DME I

CRUISE CONTROL OPERATION

All functions of the cruise control system are incorporated in the EML IIIs control module. The cruise control main switch is wired directly to the EML IIIs control module. The multi-function steering wheel inputs are direct to the EML through a separate serial data bus.

The EML control module regulates the operation of the cruise control by regulating the position of the throttle valves as it did in the past. The new cruise control logic adopted with the GR II E38 740I are incorporated in the EML control logic.



The EML controls the cruise control indicator lamp in the instrument cluster. When the main switch is pressed, the indicator lamp is illuminated.

The switching "OFF" priorities for cruise operation are carried over from the GR II system. The commands for cruise control operation are carried out according to the highest priority as follows:

5 - brake light switch -	directly from EML control module
4 - transmission in neutral -	from AGS control module over CAN
3 - "OFF" request -	from MFL steering wheel
2 - Set/Accelerate -	from MFL steering wheel
1 - Resume -	from MFL steering wheel

The new logic incorporated into the cruise control include:

- Smoother acceleration under the Resume feature.

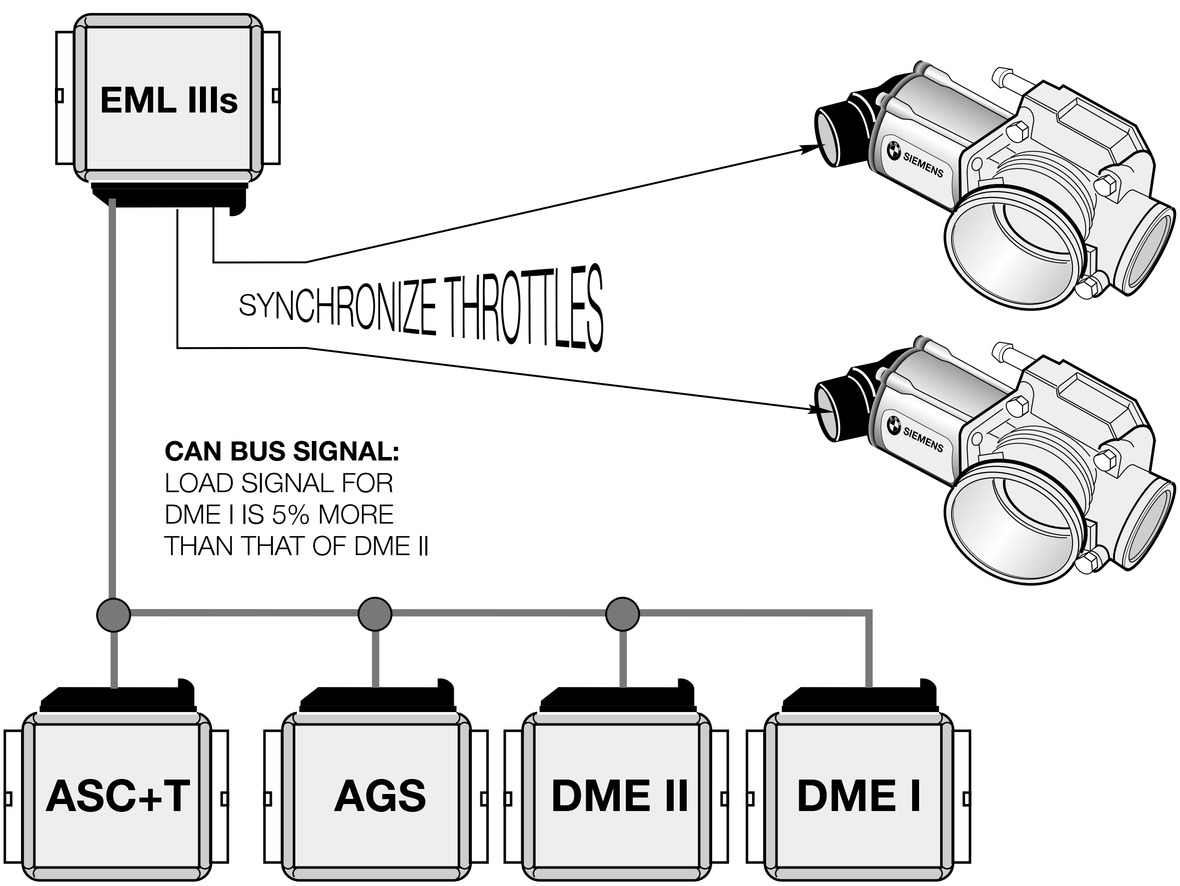
- Downshift on decel (down hill) to provide engine braking effect.

CYLINDER BANK SYNCHRONIZATION

The throttle valves are synchronized automatically on the EML IIIs system. This ensures that both cylinder banks receive the same air charge and creates a smooth running engine. The synchronization takes place at an idle during the purge system shut off time. The synchronization process last approx. 100 seconds.

The total conditions for synchronization to take place are:

- Idling
- Engine speed between 560 - 720 RPM
- Throttle valve stops recognized (DK idle position)
- Load difference side-to-side no more than .04 to 10 %
- No faults in DME/EML control modules
- Purge system shut down



The EML control module processes the load signals from the two DME control modules. If a difference exists, the EML will adjust the DK motors to achieve equal air throughput on both banks. If the load difference is greater than 10%, the synchronization will not take place and a fault is stored in the memory.

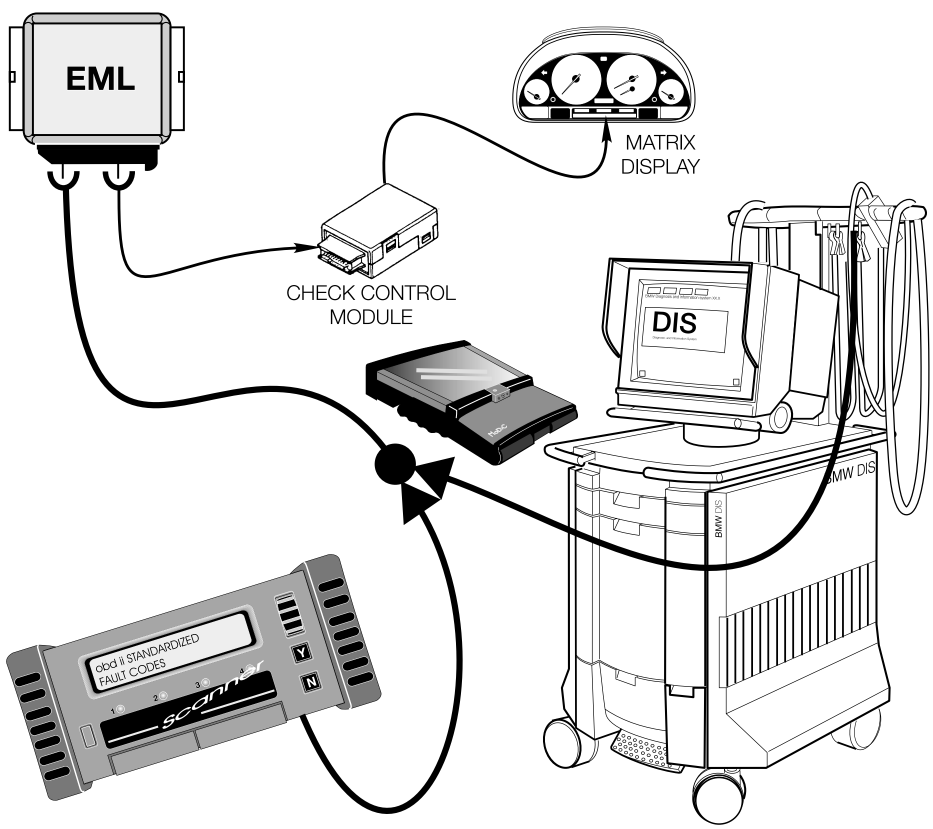
FAULT RECOGNITION/DIAGNOSIS

The OBD II regulations require that any fault with the EML IIIs system that can affect emissions must turn on the “Check Engine Lamp” and be accessible through the OBD II read out connector. These faults will also be stored in the fault memory of the EML IIIs control module for access through the DIS test programs.

The failure warning of the EML IIIs system is through the check control system (CCM) of the E38. A fault message from the EML control module is sent to the CCM and the message will be posted in the matrix display of the instrument cluster.

The diagnosis program of the DIS includes the “Fault Symptom” troubleshooting paths as well as the Test Modules, Service Functions and Expert Modes introduced with the E38 740i.

Diagnosis and troubleshooting should always begin with the fault symptom troubleshooting mode. Follow the test modules and diagnostic path provided by the DIS Tester.



BASIC TROUBLESHOOTING

- Always personally verify the customer complaint.
- Perform a Quick Test to determine if the vehicle systems have logged fault codes.
- Call up the faulted system or appropriate test schedule to verify the correct control module is installed in the car.
- Follow the DIS/MoDIC on screen instructions and perform all tests as specified.
- Use the DIS and fault symptom diagnostic procedures as trained.
- Follow the appropriate test module procedures for systems that malfunction but fail to set faults in memory.
- System problems which elude diagnostic procedures must be brought to the attention of BMW of North America, Inc.
- **BMW Technical Assistance Hotline 1-800-472-7222**

Review Questions

1. Why are faults not erased when the battery is not disconnected?

2. What components are contained in the DK motors?

3. What Stepper Motor Functions are Monitored?

4. What happens to the AC frequency when the accelerator pedal is depressed?

5. If the engine does not respond after the PWG is replaced, what should you do?

6. How are the throttle valves synchronized?

7. What control modules require a throttle input signal?

8. How many final stage transistors are required to control one stepper motor?

Table of Contents

ME 7.2

Model: E39/E38/E53 with M62TU Engine

Production Date: 99 MY - Present

Manufacturer: Bosch

Pin Connector: 134 Pins - 5 Modular Connectors

Objectives of the Module

After completing this module, you will be able to:

• Explain what the "ME" Designation Identifies

• Understand the EDK Operation

• Explain How the ECM Monitors LDP Pump Operation

• Describe the Non-Return Fuel Rail System

• Understand the Purpose of the Radiator Outlet Temperature Sensor

• List What Two Systems Affect the Fuel Pump Operation

• Understand PWG "Failsafe" Operation

• Describe How the Active Hall Sensors Monitor the Camshafts

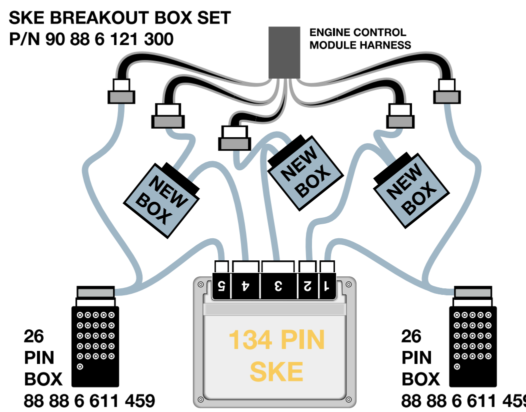
• Demonstrate a VANOS Adjustment

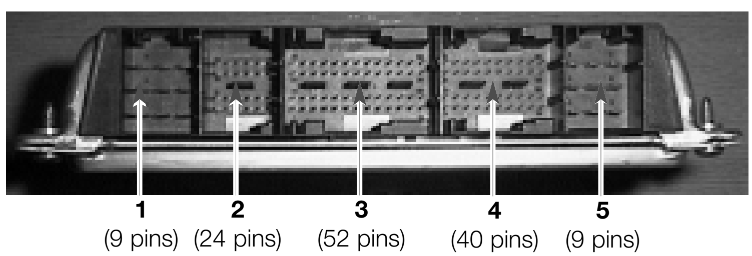
ME 7.2 ENGINE MANAGEMENT SYSTEM

Purpose of the System

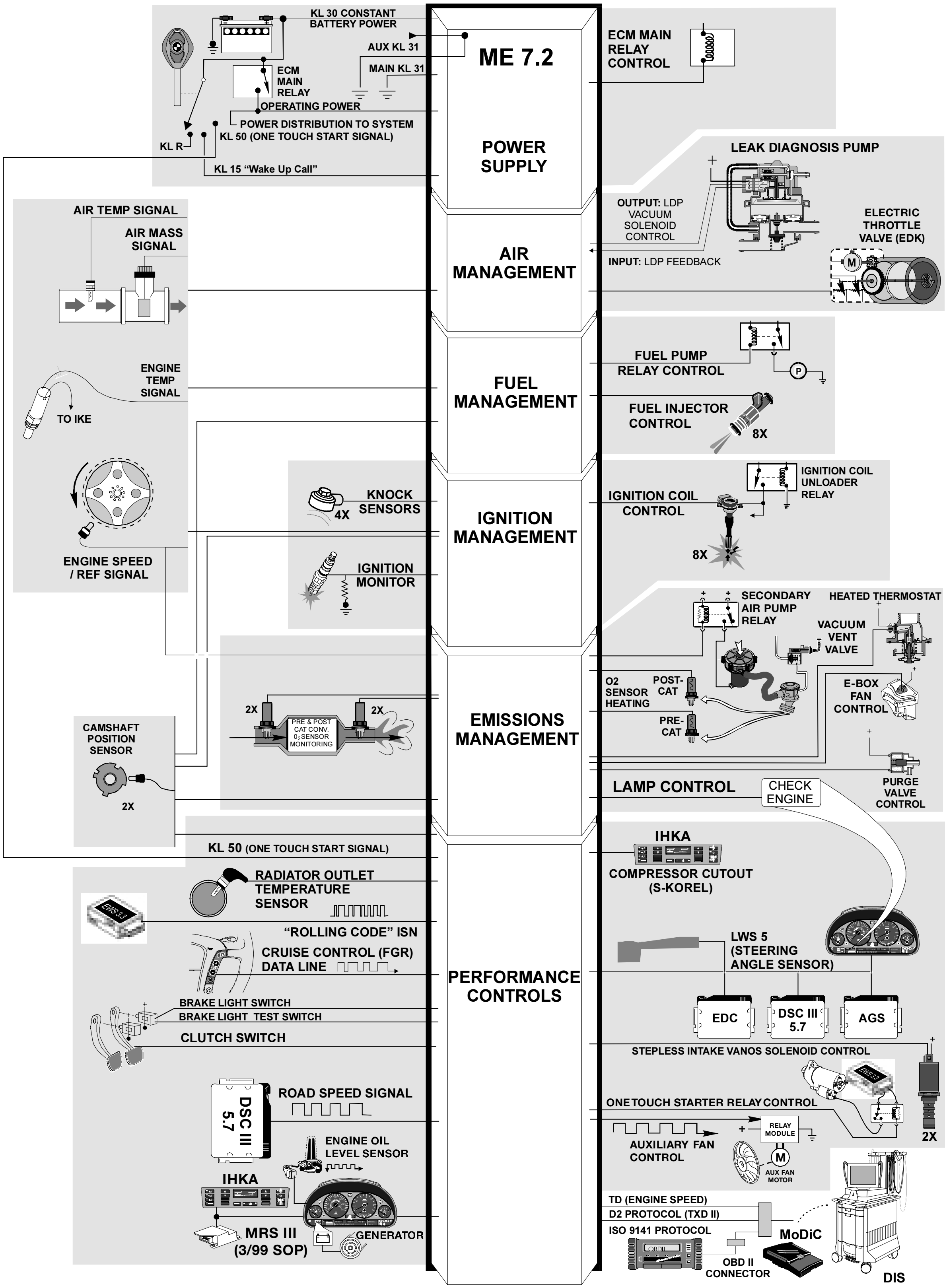
ME 7.2 replaces M5.2.1 for all 8 cylinder engine applications. The “ME” designation identifies the system as “M = Motronic, E = EML.

- Manufactured by Bosch to BMW specifications
- 134 pin SKE (standard shell construction) control module located in E box
- Diagnostic communication protocol (KWP2000)
- Uses break-out box set (P/N 90 88 6 121 300)
- Integral EML throttle control system
  - monitors an interior installed PWG
  - actuates an electric throttle valve (EDK)
- Integral Cruise control functionality
  - monitors cruise control requests
  - monitors brake pedal and clutch switches
  - carries out throttle control directly via EDK
- Carries out DSC III torque reduction requests.
- VANOS control
- Integrated altitude sensor
- Integrated temp sensor for monitoring E box temperatures
- Control of E-box fan
- One touch engine start control
- Oxygen Sensor heating
- Engine overrev & Max speed limitation
- Active Hall sensor for camshaft position monitoring
- Single speed secondary air injection system
- Electrically heated coolant system thermostat (same function as previous M62 engine)
- Longlife spark plugs
- IHKA Auxiliary Fan control





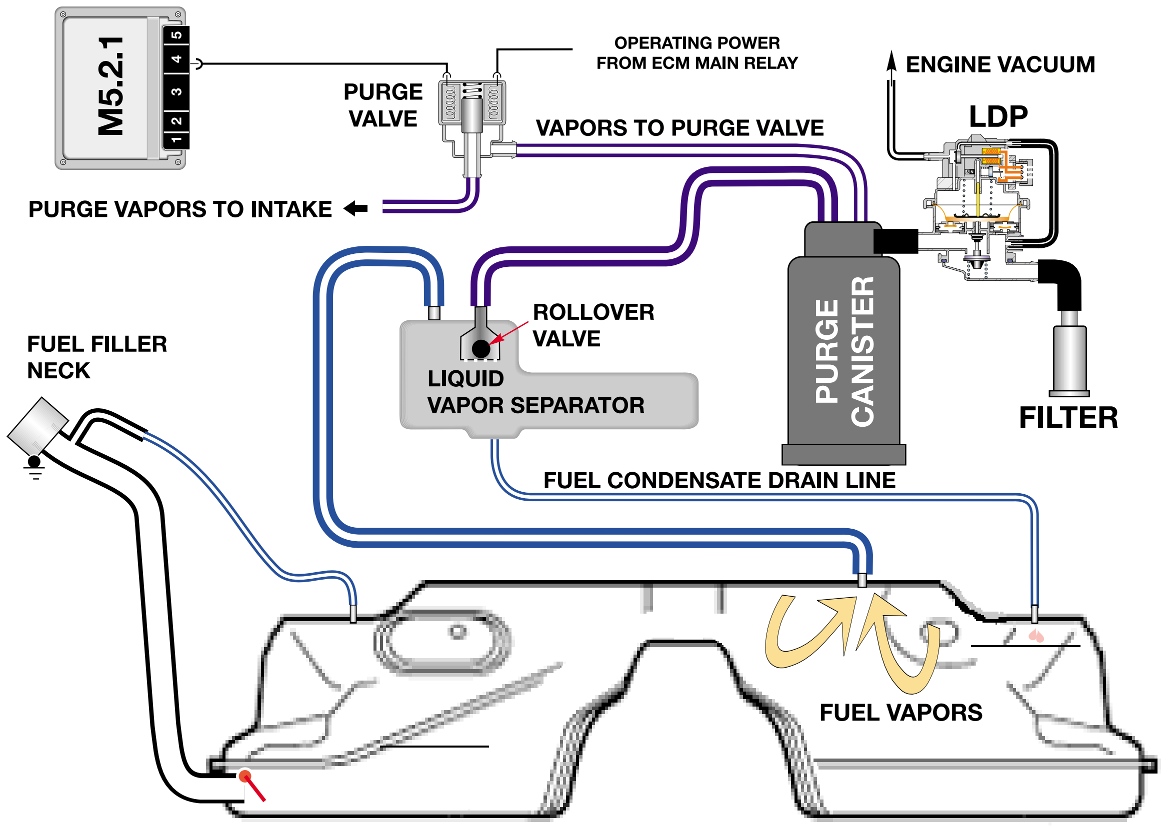
System Components: INPUTS - PROCESSING - OUTPUTS



LEAK DIAGNOSIS PUMP (LDP SYSTEM)

Starting with the 98 model year the LDP method of evaporative system leak detection was introduced on E38 and E39 vehicles.

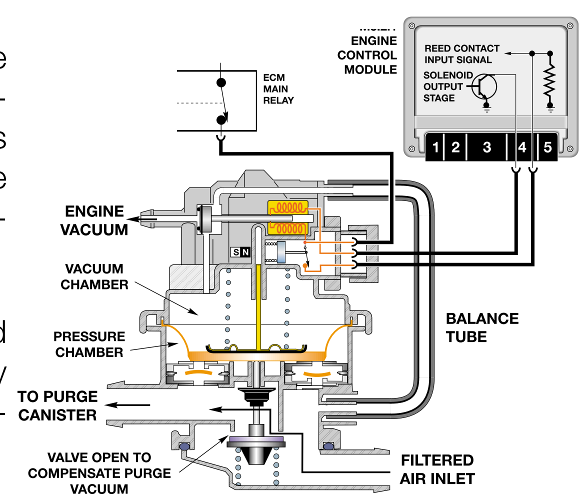
Components:



Functional Overview:

- The function of the LDP is to pressurize the fuel tank and the evaporative emission system to detect leaks. The pump also serves as the fresh air inlet path during normal purge operation when leak diagnosis is not occurring.

- The pump contains a spring loaded diaphragm which is moved up and down by solenoid controlled engine vacuum to generate the air pressure



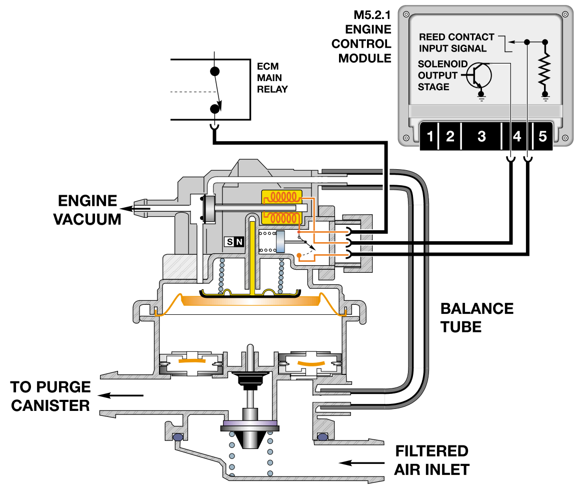
- During a leak test, the normally open vent valve is sprung closed to retain the built up pressure.

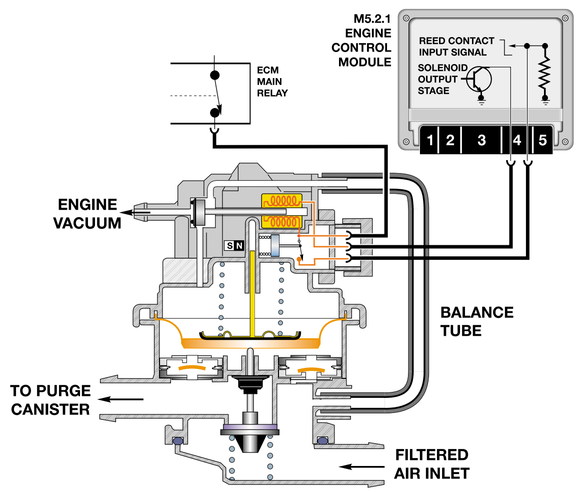
- The purge valve(s) are also sprung closed to seal the system.

- The reciprocation of the diaphragm pulls in filtered ambient air and pumps it into the fuel system via the purge canister as the vacuum supply is repetitively opened and closed electrically by the ECM.

- The ECM monitors the diaphragm movement through a reed contact feedback signal and compares it to its activation output frequency of the vacuum solenoid in the LDP.

- As the pump continues to operate the diaphragm begins to slow down against the built up pressure in the system. The time delay between the vacuum solenoid activation and the reed contact feedback is the basis for leak detection.





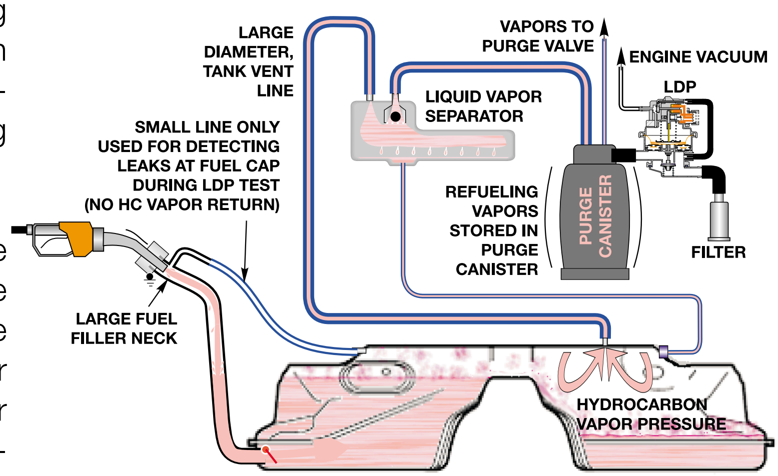
- If the reed contact feedback signal slows down considerably this indicates the pressure is being held by the system and no leaks are present.

- If the reed contact feedback signal is slowed down but not to the satisfaction of a sealed system the ECM will determine a small leak is present.

- If there is no delay in the feedback signal the ECM determines a large leak is present (ie: missing fuel filler cap).

ON-BOARD REFUELING VAPOR RECOVERY (ORVR)

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 (Stage II) on the filling station's fuel pump nozzle.



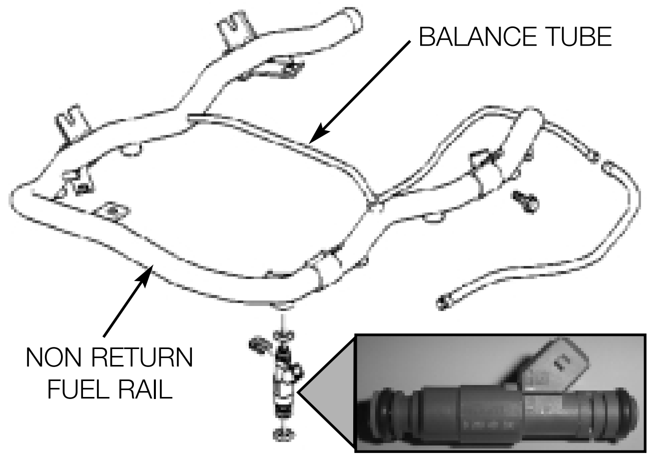
When refueling, the pressure of the fuel entering the tank forces the hydrocarbon vapors through the tank vent line to the liquid/ vapor separator, through the rollover valve and into the charcoal canister.

The HC is stored in the charcoal canister, and the system can then "breathe" through the LDP and the air filter.

ON BOARD DIAGNOSTICS II

OBD II requires that all vehicle manufacturers comply with extensive fault monitoring capabilities for all emission related drivetrain control systems. These systems; ECM, AGS and EML must monitor their components electrically and monitor for plausible mechanical engine function. Additionally, OBD II provides a separate Diagnostic Link Connector (DLC) located in the vehicle interior to access OBD II fault codes with an aftermarket scan tool. BMW center technicians utilize BMW diagnostic equipment and software (DIS/MoDiC) to interface with all vehicle control systems.

FUEL INJECTORS

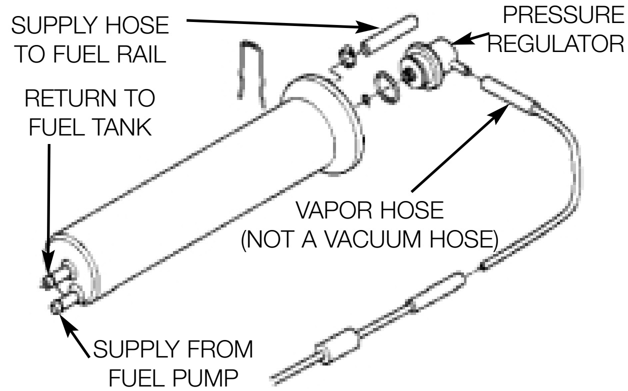


The M62 TU utilizes new fuel injectors manufactured by Bosch. The injector pintle consists of a two ball seat.

The ball seat design provides a tight seal when the injector is closed preventing HC formation in the intake.

The injectors have an ohmic value of 15.5 ohms.

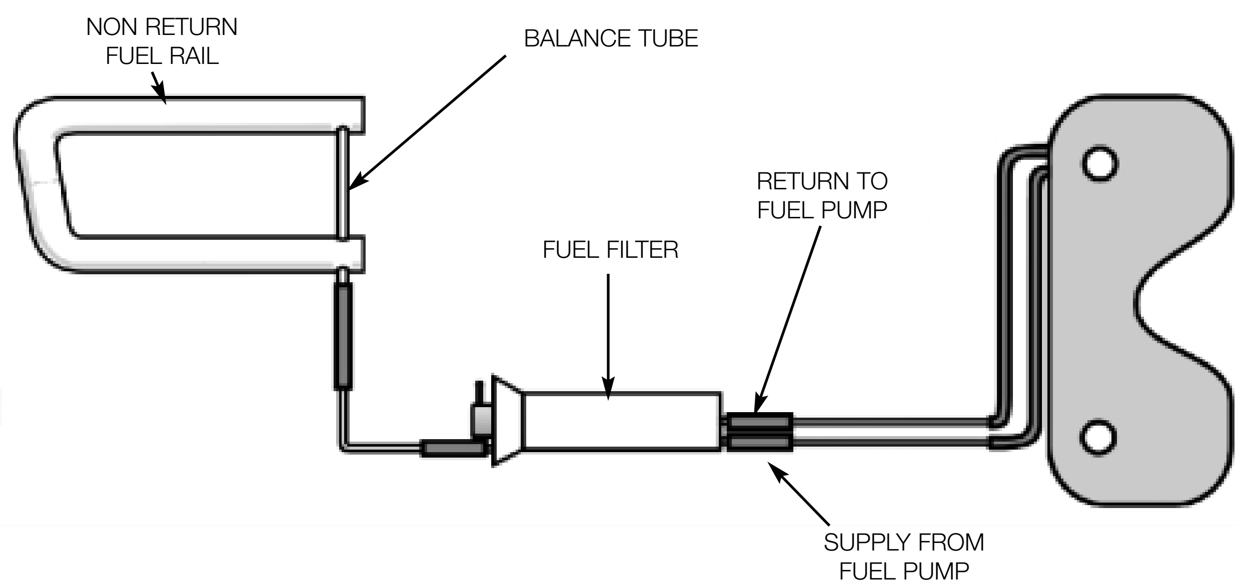
NON RETURN FUEL RAIL SYSTEM



The M62 TU introduces a new method of meeting Running Loss Compliance without the use of the familiar 3/2 way running loss valve.

The regulated fuel supply is controlled by the fuel pressure regulator integrated in the fuel filter. A fuel return line is located on the fuel filter.

The system provides even fuel distribution to all fuel injectors due to a balance tube connecting the feed with the end of the fuel rail. The new fuel rail does not have a fuel return line.

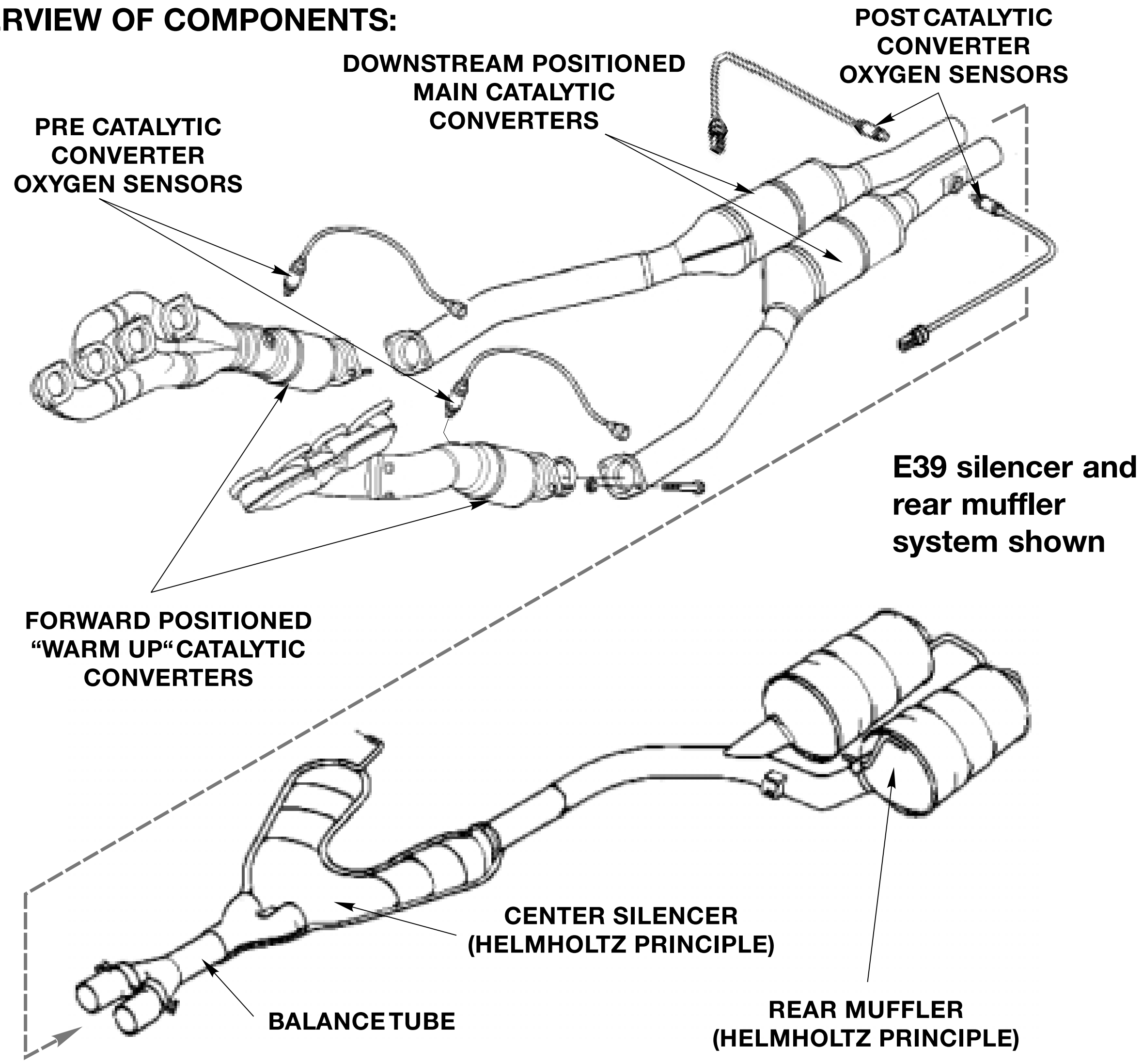


M62 TU EXHAUST SYSTEM

The M62 TU is equipped with two additional catalytic converters known as “warm-up converters”. This configuration positions the forward mounted warm-up catalytic converters closer to the hot exhaust gasses immediately exiting the combustion chambers. The closer location heats the catalytic converters to the point of light-off faster than previous systems. Earlier light-off reduces cold start emissions by allowing the gas conversion (HC to H2O, CO to CO2 and NOx by reduction to N2 and O2) to occur more rapidly just after cold start.

The system also contains two main catalytic converters. The main exhaust gas conversion process occurs further downstream in the main catalytic converters.

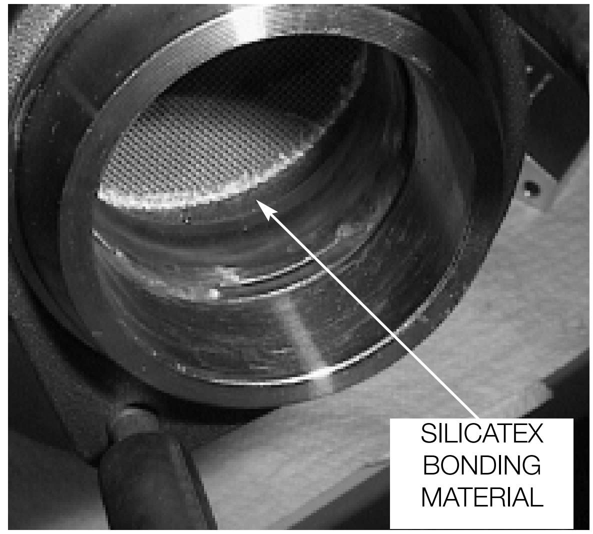
OVERVIEW OF COMPONENTS:

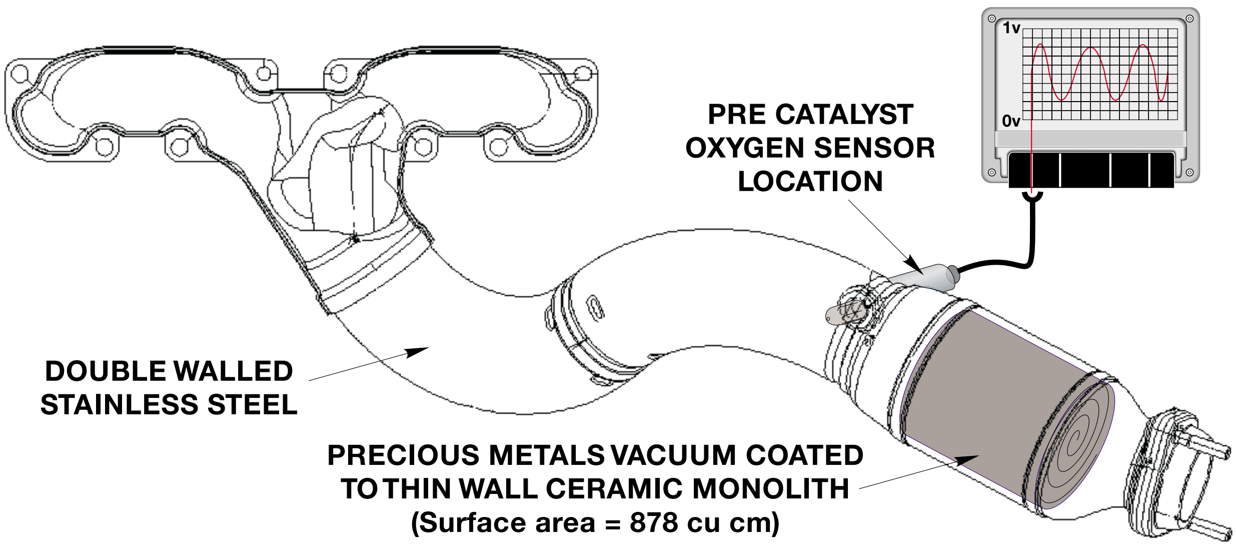


The forward mounted warm-up catalytic converters are made of thin-wall ceramics. They are mounted in a pliable material called silicatex which isolates them from vibrations ensuring a long service life.

For their relatively small size, the catalyst volume of 878 cm^3 provides a large conversion surface area. Use of the thin-wall ceramic design also minimizes exhaust back pressure.

Both pre-catalytic converter oxygen sensors are positioned forward of each warm-up catalyst.





The Bosch LSH 25 oxygen sensors are carried over from the M62 engine and provide the familiar "swinging" voltage signal (0.2 - max lean to 0.8 - max rich) representing oxygen content in the exhaust gas.

The main catalytic converters are also made of thin-wall ceramics. The post catalytic converter oxygen sensors are positioned just behind the main catalytic converters to monitor the catalytic converter function.

The pipes of the exhaust system up to the rear main catalytic converters are made from dual wall stainless steel. This design insulates exhaust noise as well as insulating the thermal energy in the hot exhaust gasses to light-off the converters as quickly as possible.

INPUT SIGNALS/COMPONENTS

CAMSHAFT POSITION SENSORS

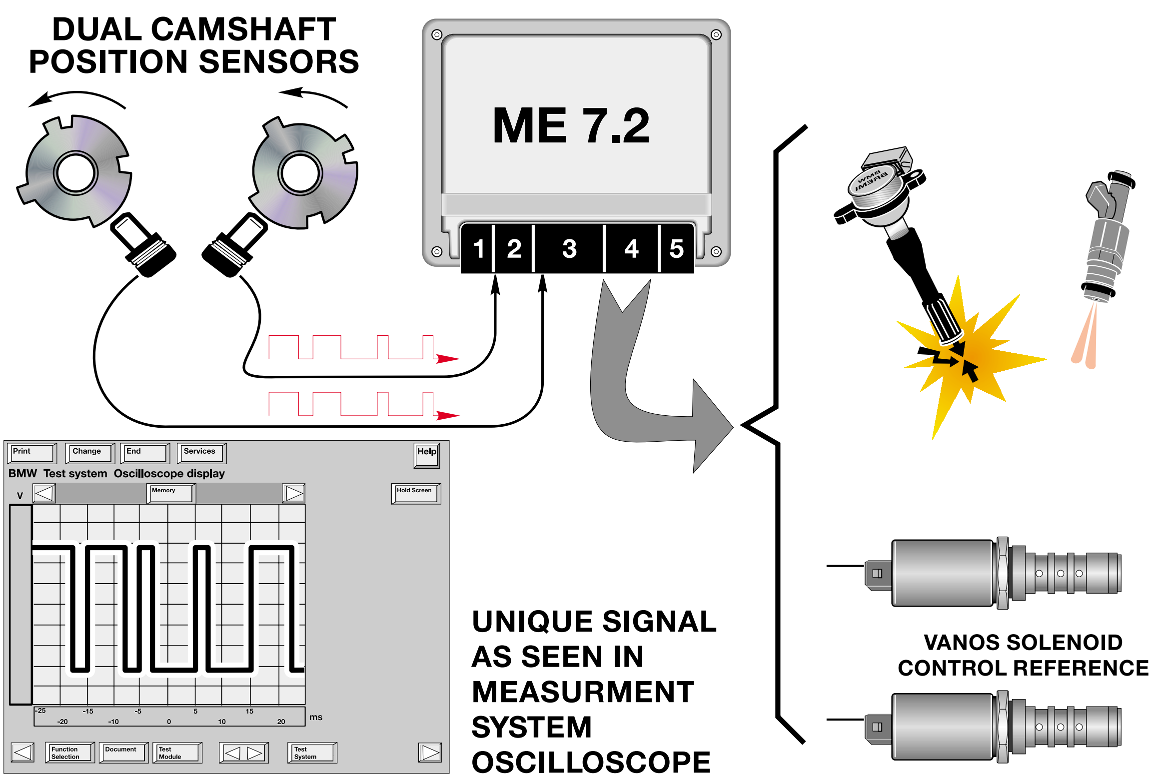
Located on the upper timing case covers, the camshaft position sensors monitor the position of the camshafts to establish start of ignition firing order, set up sequential fuel injection triggering and for accurate camshaft advance-retard (VANOS) timing feedback.

Each intake camshaft's advance-retard angles are adjusted simultaneously yet independently. For this reason ME 7.2 requires a camshaft position sensor on each cylinder bank for accurate feedback to monitor the VANOS controlled camshaft positioning.

The sensors are provided with operating power from the ECM relay. The sensors produce a unique asymmetrical square-wave signal representative of the impulse wheel shape. The sensors are new in the fact that they are "active" hall effect sensors. Active hall sensors provide:

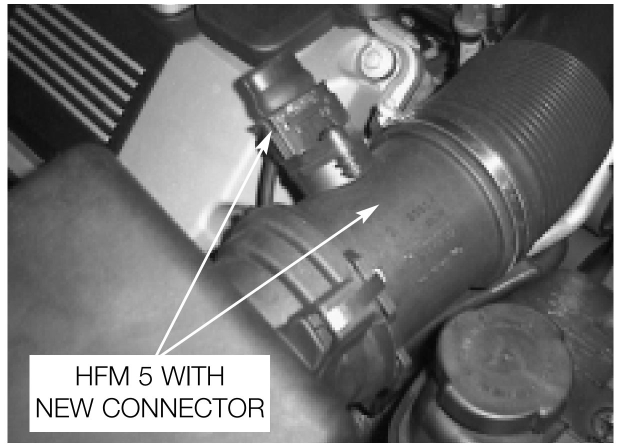
- low signal when a tooth of the camshaft impulse wheel is located in front of the sensor
- high signal when an air gap is present.

The active hall sensors supply a signal representative of camshaft position even before the engine is running. The ME 7.2 determines an approximate location of the camshafts positions prior to engine start up optimizing cold start injection (reduced emissions.)

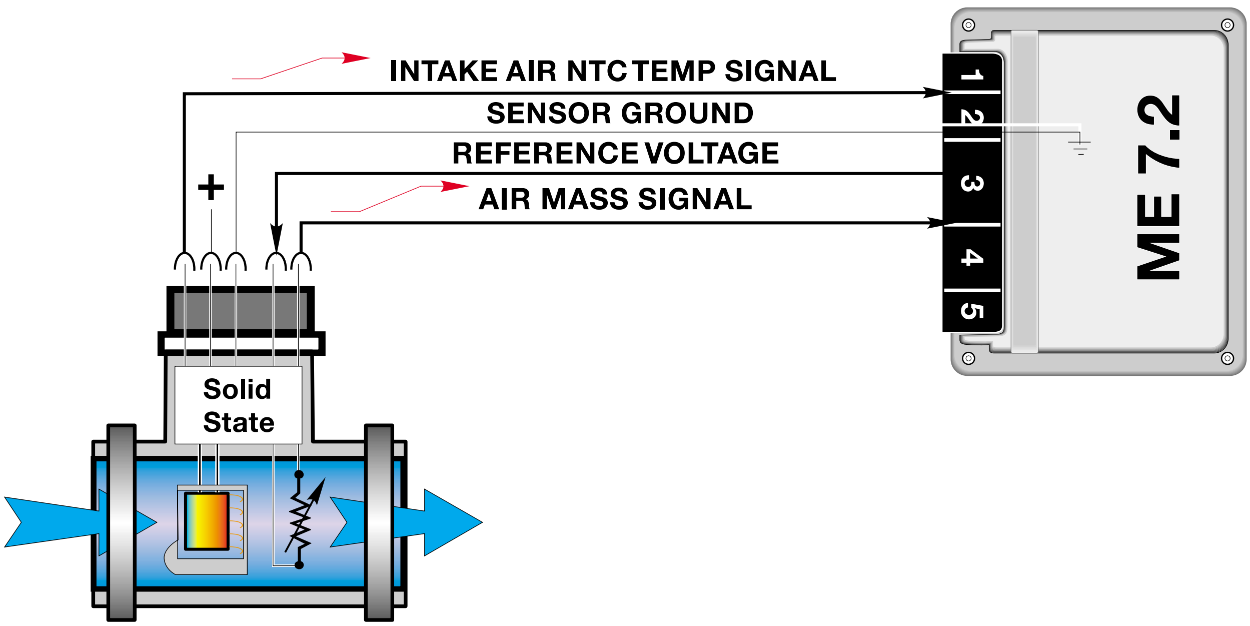


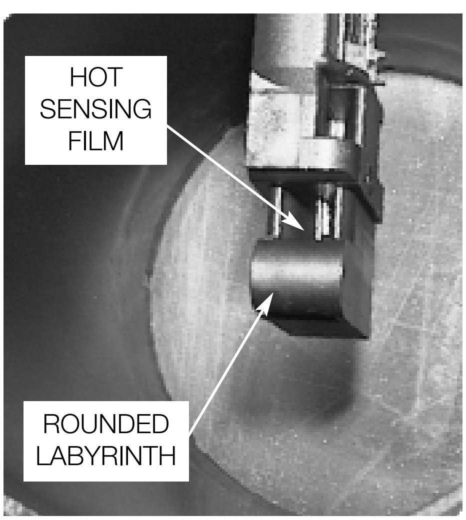
HOT FILM AIR MASS SENSOR (HFM 5)

The M62 TU is equipped with a new Hot Film Air Mass Sensor identified as HFM 5. It is a combined air mass/intake air temperature sensor. The separate intake air temperature sensor is no longer used on the M62 TU.



The HFM 5 is provided with operating power from the ECM relay. Based on calculated intake air mass, the HFM 5 generates a varying voltage between 0.5 and 4.5 volts as an input signal to the ME 7.2





An additional improvement of the HFM 5 is that the hot film element is not openly suspended in the center bore of the sensor as with previous HFMs. It is shrouded by a round fronted plastic labyrinth which isolates it from intake air charge pulsations.

This feature allows the HFM to monitor and calculate the intake air volume with more accuracy. This feature adds further correction for calculating fuel injection “on” time (ti) which reduces emissions further.

INTEGRATED AMBIENT BAROMETRIC PRESSURE SENSOR

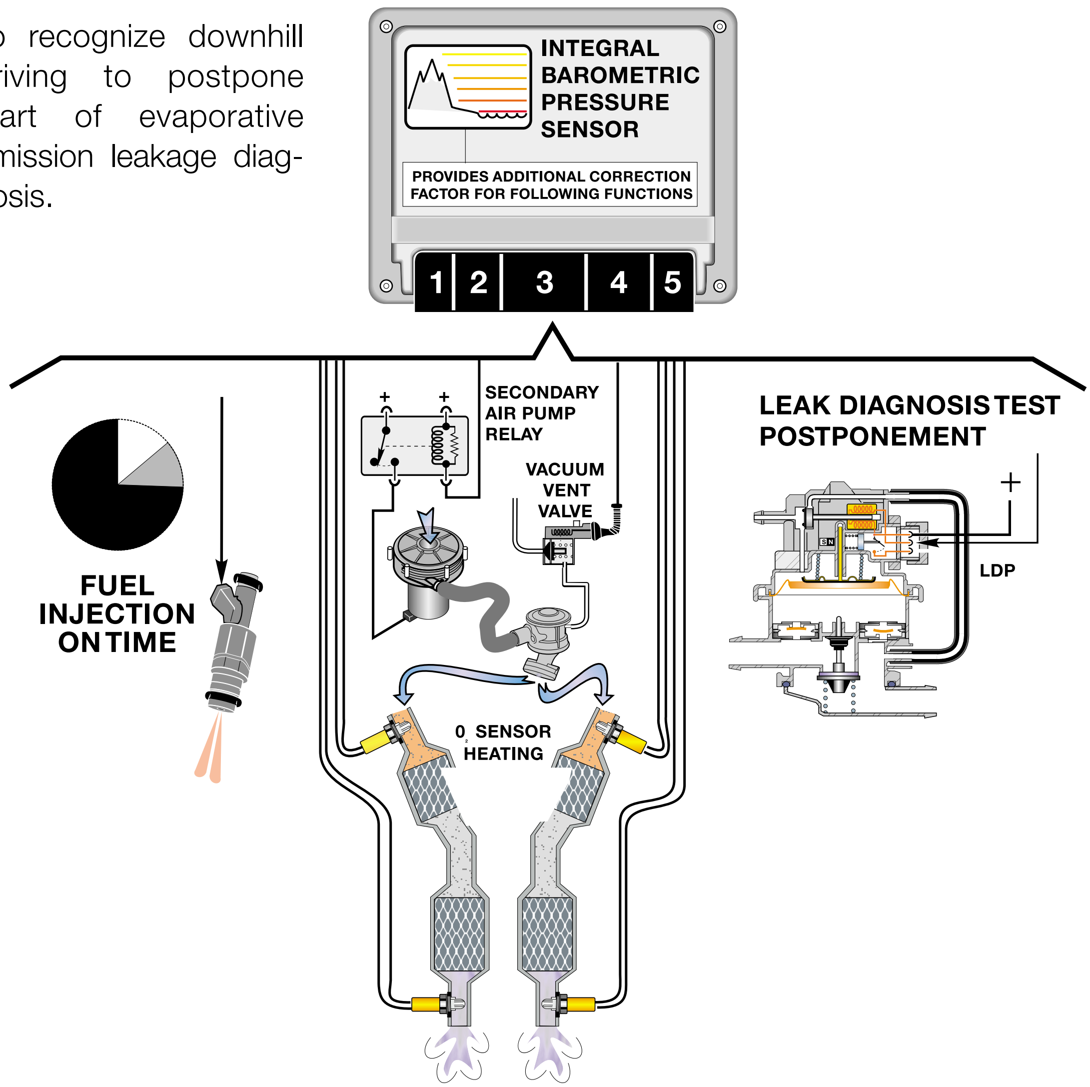
The ME 7.2 Control Module contains an integral ambient barometric pressure sensor. The sensor is part of the SKE and is not serviceable. The internal sensor is supplied with 5 volts. In return it provides a linear voltage of approx. 2.4 to 4.5 volts representative of barometric pressure (altitude).

The ME 7.2 monitors barometric pressure for the following reasons:

- The barometric pressure signal along with calculated air mass provides an additional correction factor to further refine injection "on" time.

- Provides a base value to calculate the air mass being injected into the exhaust system by the secondary air injection system. This correction factor alters the secondary air injection "on" time, optimizing the necessary air flow into the exhaust system.

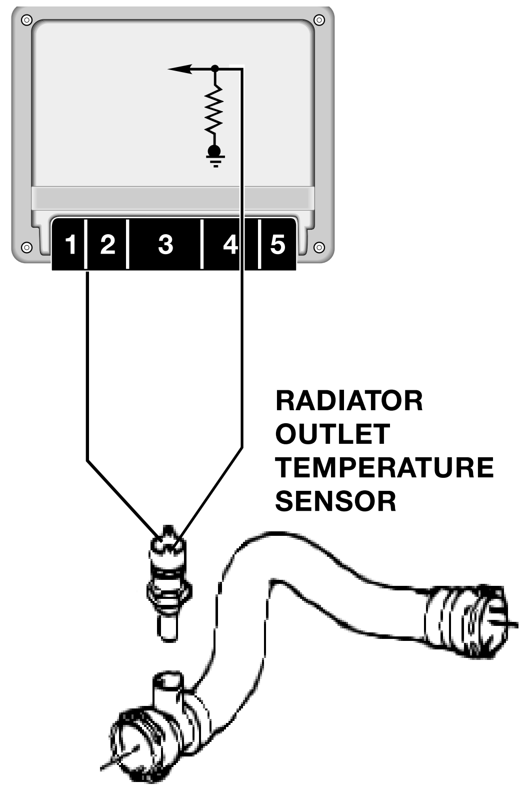
- To recognize downhill driving to postpone start of evaporative emission leakage diagnosis.



RADIATOR OUTLET TEMP SENSOR

The ME 7.2 uses an additional water temperature sensor located on the radiator outlet.

ME 7.2 requires this signal to monitor the water temperature leaving the radiator for precise activation of the IHKA auxiliary fan.

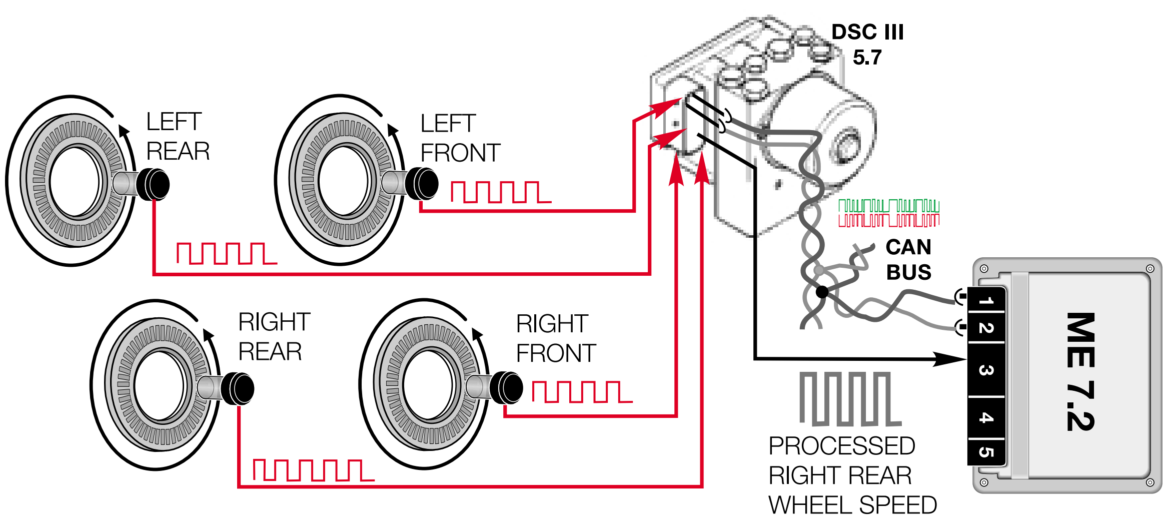


DSC III - ROAD SPEED SIGNAL

ME 7.2 receives the road speed signal directly from the DSC III control module for maximum vehicle speed management. The DSC control module provides a processed output of the right rear wheel speed sensor as a digital square wave signal. The frequency of the signal is proportional to the speed of the vehicle (48 pulses per one revolution of the wheel).

The cruise control function (FGR) of the ME 7.2 also monitors vehicle speed from the redundant vehicle speed CAN bus signal. The CAN bus speed signal is provided by the DSC III control module and based on the combined average of both front wheel speed signals.

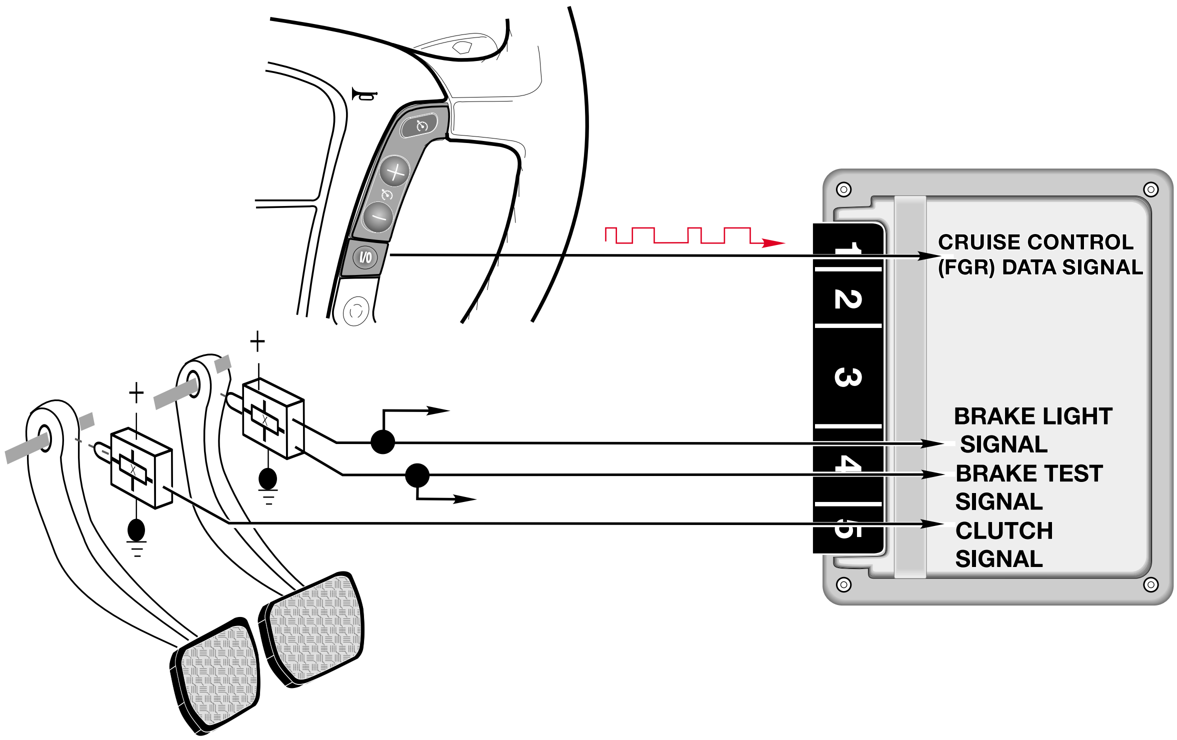
Additionally, ME 7.2 monitors all four wheel speed signals via CAN bus signalling to detect abrupt fluctuations in vehicle speed signals for the purpose of detecting rough road surfaces. This is continuously monitored as part of the OBD II emission requirements providing a correction factor for misfire detection plausibility. Earlier systems only monitored the right rear speed signal input from DSC.



MFL CRUISE CONTROL DATA SIGNAL

The ME 7.2 control module provides the FGR cruise control function. Throttle activation is provided by ME 7.2 automatic control of the EDK and monitoring of the throttle plate position feedback potentiometer signals.

All of the familiar driver requested cruise control function requests are provided to the ME 7.2 control module via the MFL control module on a single FGR data signal wire.



BRAKE LIGHT SWITCH

The Electronic Brake Switch (Hall effect) provides brake pedal position status to the ME 7.2. The control module monitors both the brake light and a separate brake light test switch circuits for plausibility.

When the brake pedal is pressed the brake light segment of the switch provides a ground signal. Simultaneously, the brake light test switch (located in the same housing) provides a high signal.

CLUTCH SWITCH

The clutch switch is equipped on manual transmission vehicles for deactivating the FGR. It is housed in the footwell by the clutch pedal. The hall effect clutch switch interrupts the single wire circuit to the ME 7.2 control module when the clutch pedal is pressed.

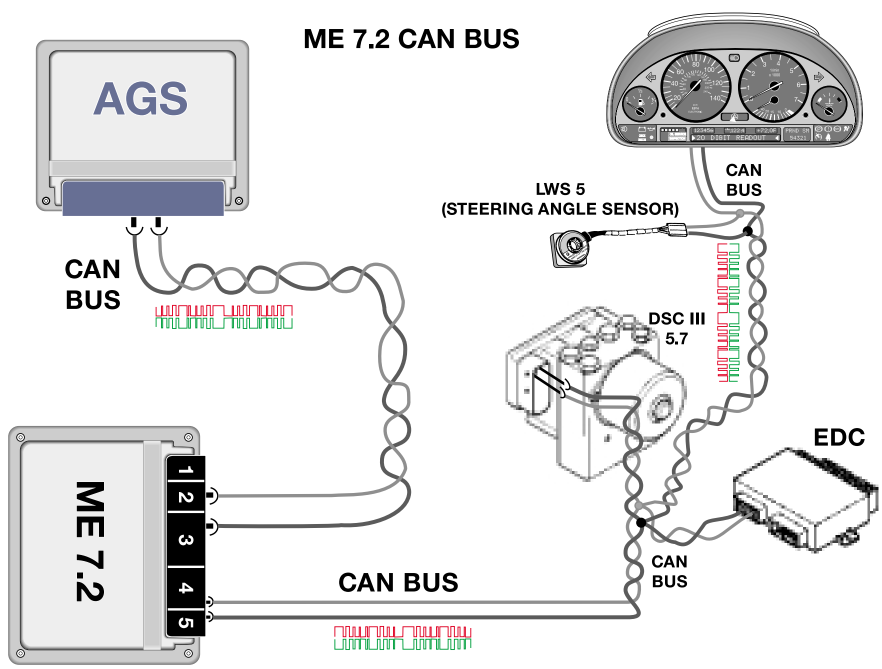
ME 7.2 CAN BUS TOPOLOGY

The CAN bus consists entirely of a twisted pair wire set. This configuration eliminates the need for a ground shield.

The Engine Control Module has two CAN bus communication ports, one dedicated to AGS and the other for the balance of the vehicle's CAN bus control modules.

This configuration improves the reliability of CAN bus signalling. If an open occurs in one area, the other control systems can still communicate on either side of the open.

However, signals not reaching their intended recipients will cause CAN bus faults to be stored in the affected systems.

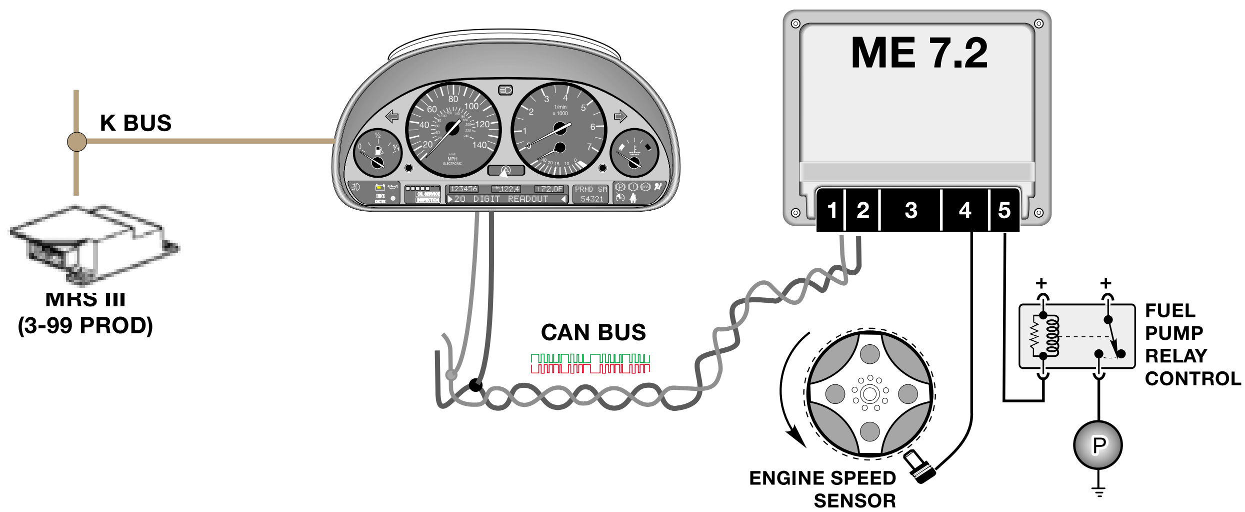


OUTPUT CONTROL FUNCTIONS/COMPONENTS

FUEL PUMP RELAY CONTROL

ME 7.2 controls the fuel pump relay as with previous systems with regard to engine speed input for continual activation of the relay.

When MRS III was incorporated into production (3-99) the ME 7.2 deactivates the fuel pump relay when an airbag is activated as an additional safety function.

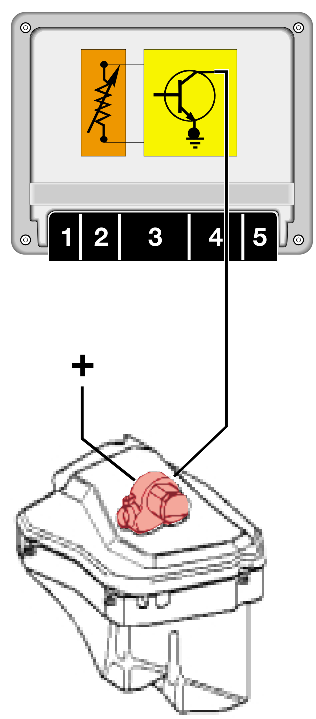


E BOX FAN CONTROL

The E Box fan is controlled by ME 7.2. The control module contains an integral NTC temperature sensor for the purpose of monitoring the E box temperature and activating the fan.

When the temperature in the E-Box exceeds predetermined values, ME 7.2 provides a switched ground for the E Box fan to cool the E box located control modules.

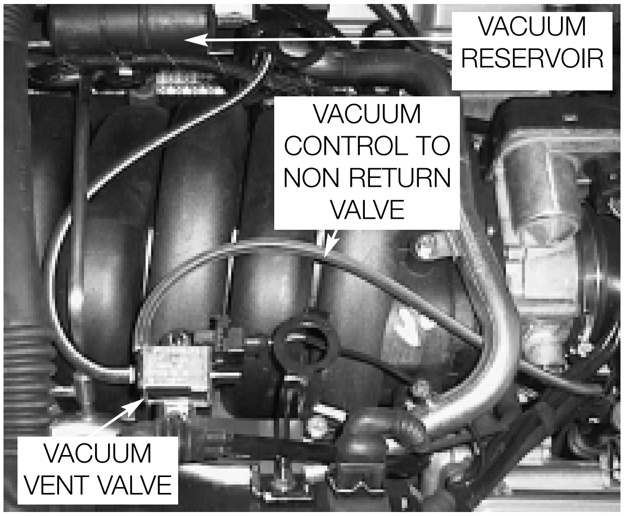
With every engine start-up, ME 7.2 briefly activates the fan ensuring continued fan motor operation for the service life of the vehicle. This feature is intended to prevent fan motor "lock up" from lack of use due to pitting or corrosion over time.

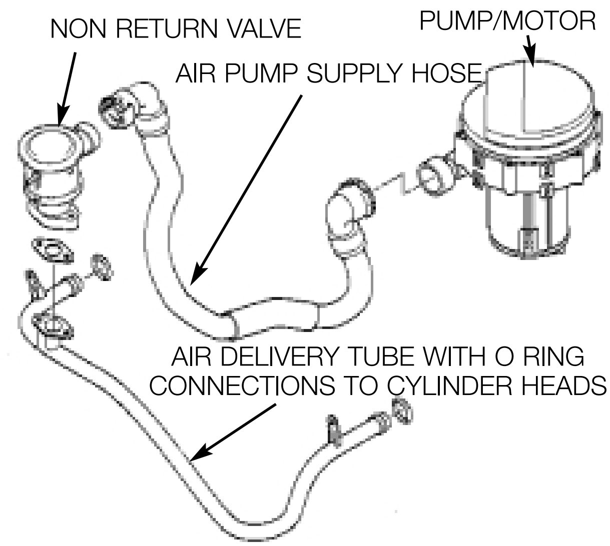


E-BOX FAN
CONTROL

SECONDARY AIR INJECTION

The secondary air injection system is new to the 4.4 liter V8 engine. The system consists of the same components as previous systems with V8 specific locations.



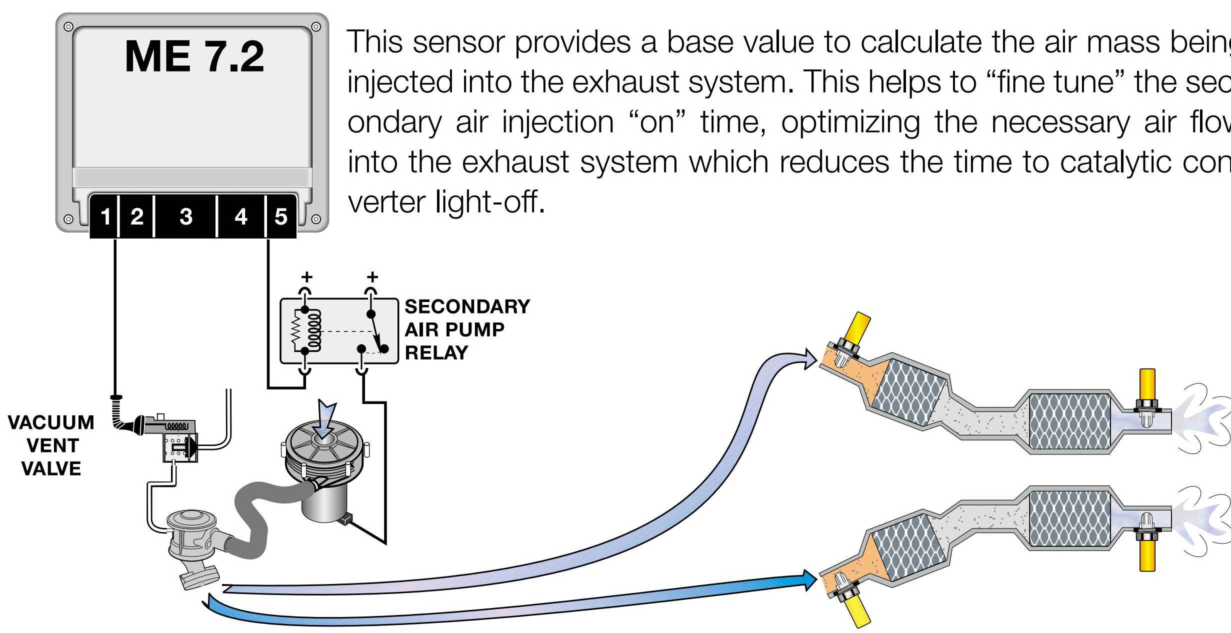


The ME7.2 control unit controls the vacuum vent valve and the secondary air injection pump relay separately but simultaneously.

The secondary air pump operates at a start temperature of between 10°C and 40°C. It continues to operate for a max. of 2 minutes at idle speed.

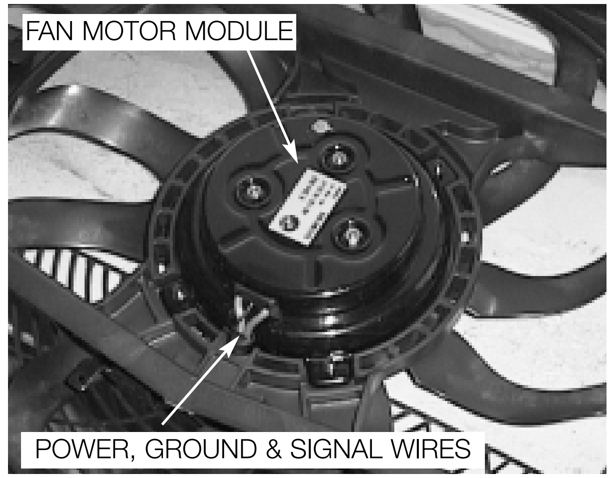
ME 7.2 contributes an additional correction factor for secondary air "on" time with the additional input from the integral ambient barometric pressure sensor.

This sensor provides a base value to calculate the air mass being injected into the exhaust system. This helps to "fine tune" the secondary air injection "on" time, optimizing the necessary air flow into the exhaust system which reduces the time to catalytic converter light-off.



AUXILIARY FAN CONTROL

The Auxiliary Fan motor incorporates an output final stage that activates the fan motor at variable speeds.

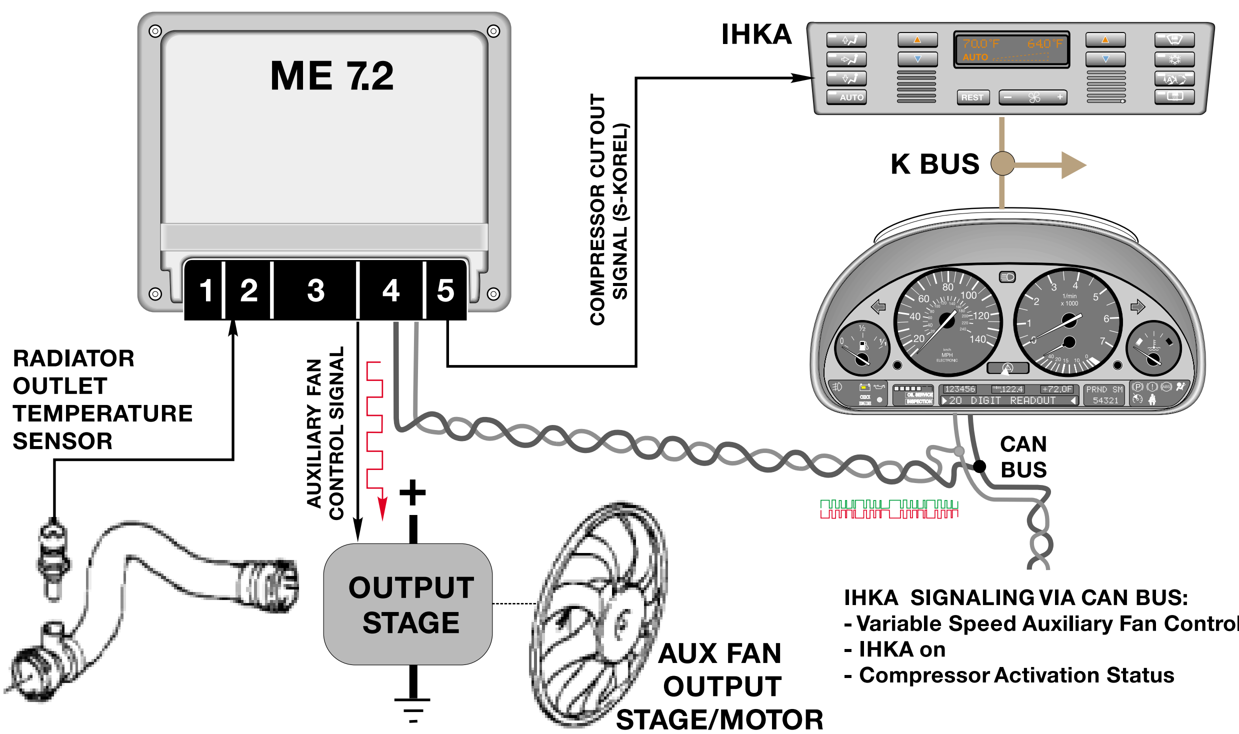


The auxiliary fan is controlled by ME 7.2. The motor output stage receives power and ground and activates the motor based on a PWM signal (10 - 100 Hz) received from the ME 7.2.

The fan is activated based on the following factors:

- Radiator outlet temperature sensor input exceeds a preset temperature.
- IHKA signalling via the K and CAN bus based on calculated refrigerant pressures.
- Vehicle speed
- Battery voltage level

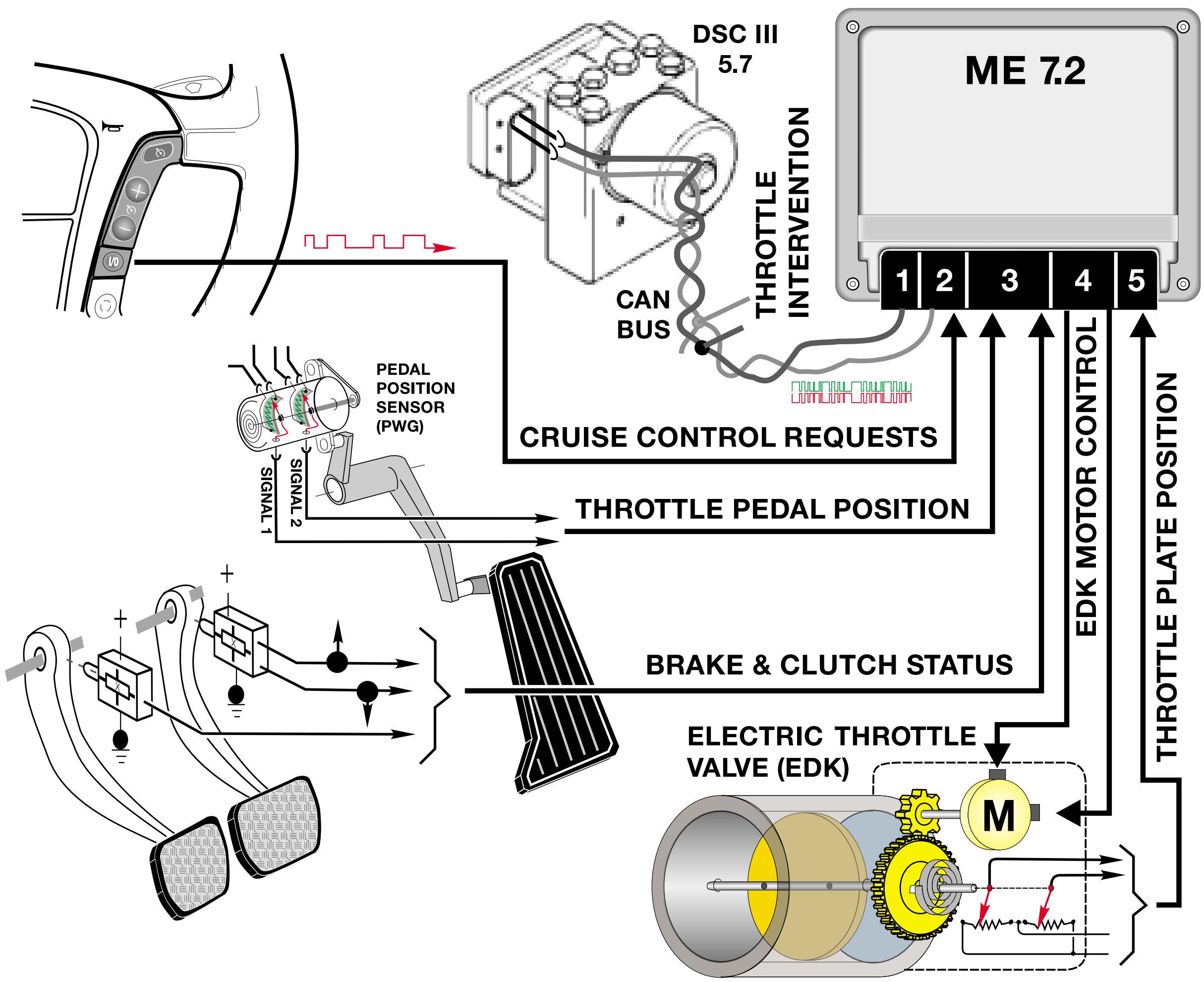
When the over temperature light in the instrument cluster is on (120°C) the fan is run in the overrun function. This signal is provided to the DME via the CAN bus. When this occurs the fan is run at a frequency of 10 Hz.



INTEGRAL ELECTRIC THROTTLE SYSTEM (EML)

FUNCTIONAL OVERVIEW

When the accelerator pedal is moved, the PWG provides a change in the monitored signals. The ME 7.2 compares the input signal to a programmed map and appropriately activates the EDK motor via proportional pulse width modulated control signals. The control module self-checks it's activation of the EDK motor via the EDK feedback potentiometers.

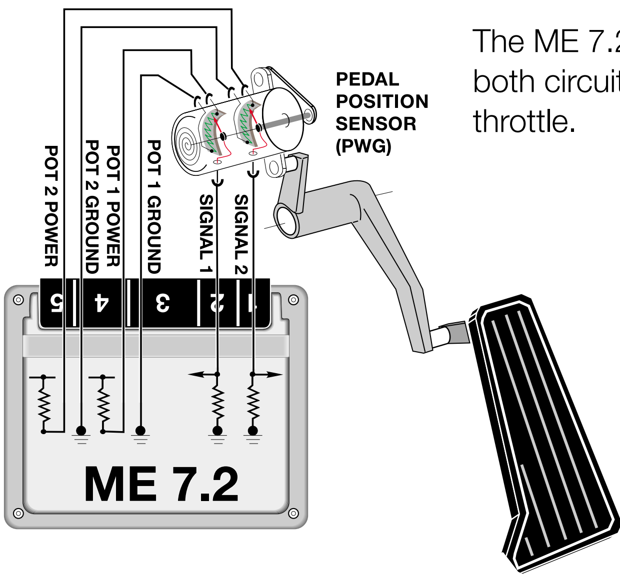


Requirements placed on the Electric Throttle System:

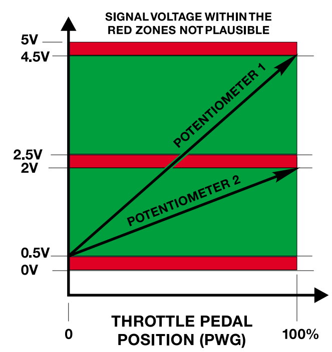
- Regulate the calculated intake air load based on PWG input signals and programmed mapping.
- Control idle air when LL detected with regard to roadspeed as per previous systems.
- Monitor the driver's input request for cruise control operation.
- Automatically position the EDK for accurate cruise control (FGR) operation.
- Perform all DSC III throttle control interventions.
- Monitor and carryout max engine and roadspeed cutout.

ACCELERATOR PEDAL SENSOR (PWG)

The driver's application of the accelerator pedal is monitored by a PWG sensor in the driver's footwell. The PWG provides two separate variable voltage signals to the ME 7.2 control module for determining the request for operating the Electric Throttle Valve (EDK) as well as providing a kickdown request with automatic transmission vehicles.



The ME 7.2 monitors the changing signal ranges of both circuits as the pedal is pressed from idle to full throttle.



- Standard transmission vehicles (E39 540i) have slightly lower voltage signals at max throttle position due to the throttle pedal stop (ie Pot 1 = 3.8volts). However, ME 7.2 programming recognizes the lower values of a standard transmission vehicle as the max throttle position.
- In vehicles equipped with an automatic transmission (A5S 440Z), the ME 7.2 recognizes the max pedal value (4.5V) as a kickdown request and signals the AGS via CAN bus.

PWG SIGNAL MONITORING & PWG FAILSAFE OPERATION:

- If the monitored PWG potentiometer signals are not plausible, ME 7.2 will only use the lower of the two signals as the driver’s pedal request input providing failsafe operation. Throttle response will be slower and maximum throttle position will be reduced.
- When in PWG failsafe operation, ME 7.2 sets the EDK throttle plate and injection time to idle (LL) whenever the brake pedal is depressed.
- When the system is in PWG failsafe operation, the instrument cluster matrix display will post “Engine Emergency Program” and PWG specific fault(s) will be stored in memory.

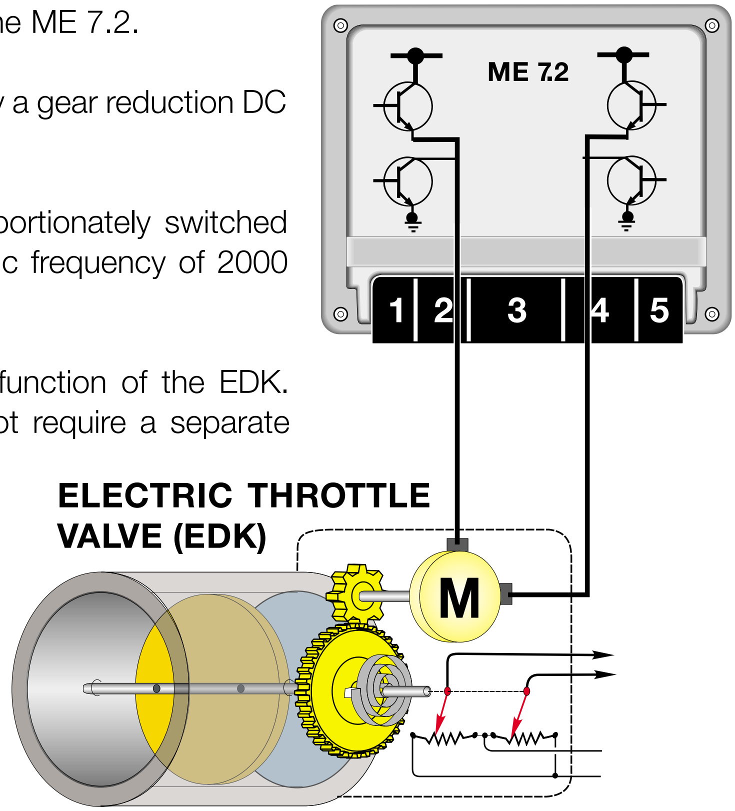
ELECTRIC THROTTLE VALVE (EDK) CONTROL

- The throttle valve assembly of the M62 TU is an electric throttle valve (EDK) controlled by an integral EML function of the ME 7.2.

- The throttle plate is positioned by a gear reduction DC motor drive.

- The motor is controlled by proportionately switched high/low PWM signals at a basic frequency of 2000 Hz.

- Engine idle speed control is a function of the EDK. Therefore, the M62 TU does not require a separate idle control valve.



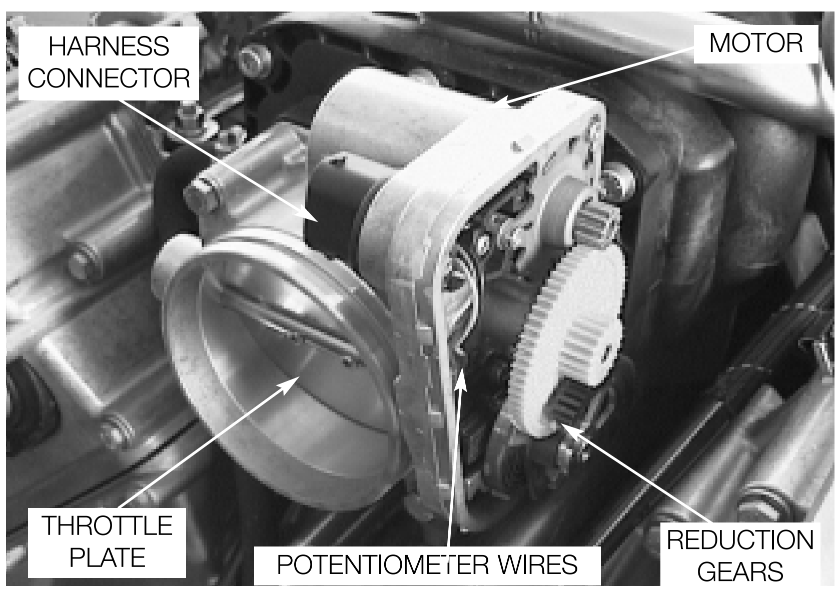
EDK ADAPTATION PROCEDURE:

When a replacement EDK is installed the adaptation values of the previous EDK must be cleared from the ME 7.2 control module.

1. From the Service Function Menu of the DIS/MoDiC, clear adaptation values.

2. Switch the ignition OFF for 10 seconds.

3. Switch the ignition ON (KL15). At approximately 30 seconds the EDK is briefly activated allowing the ME 7.2 to “electrically learn” the new component.

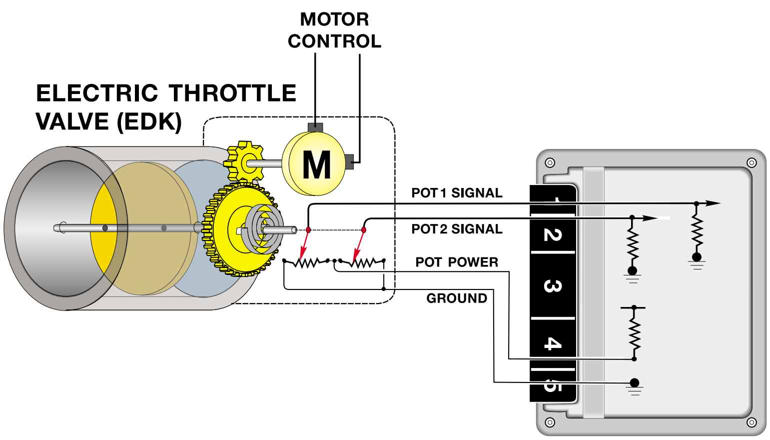


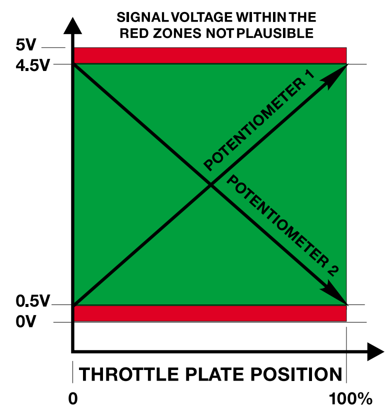
This procedure is also necessary after replacing an ME 7.2 control module. However, the adaptation values do not require clearing since they have not yet been established.

EDK THROTTLE POSITION FEEDBACK SIGNALS

The EDK throttle plate position is monitored by two integrated potentiometers. The potentiometers provide DC voltage feedback signals as input to the ME 7.2 for throttle and idle control functions.

Potentiometer signal 1 is the primary signal, Potentiometer signal 2 is used as a plausibility cross-check through the total range of throttle plate movement.





EDK FEEDBACK SIGNAL MONITORING & FAILSAFE OPERATION:

- If plausibility errors are detected between Pot 1 and Pot 2, ME 7.2 will calculate the inducted engine air mass (from HFM signal) and only utilize the potentiometer signal that closely matches the detected intake air mass.

    - The ME 7.2 uses the air mass signalling as a “virtual potentiometer” (pot 3) for a comparative source to provide failsafe operation.

    - If ME 7.2 cannot calculate a plausible conclusion from the monitored pots (1 or 2 and virtual 3) the EDK motor is switched off and fuel injection cut out is activated (no failsafe operation possible).

- The EDK is continuously monitored during all phases of engine operation. It is also briefly activated when KL15 is initially switched on as a “pre-flight check” to verify it’s mechanical integrity (no binding, appropriate return spring tension) by monitoring the motor control amperage and the reaction speed of the EDK feedback potentiometers.

  If faults are detected the EDK motor is switched off and fuel injection cut off is activated (no failsafe operation possible). The engine does however continue to run extremely rough at idle speed.

M62 TU VANOS

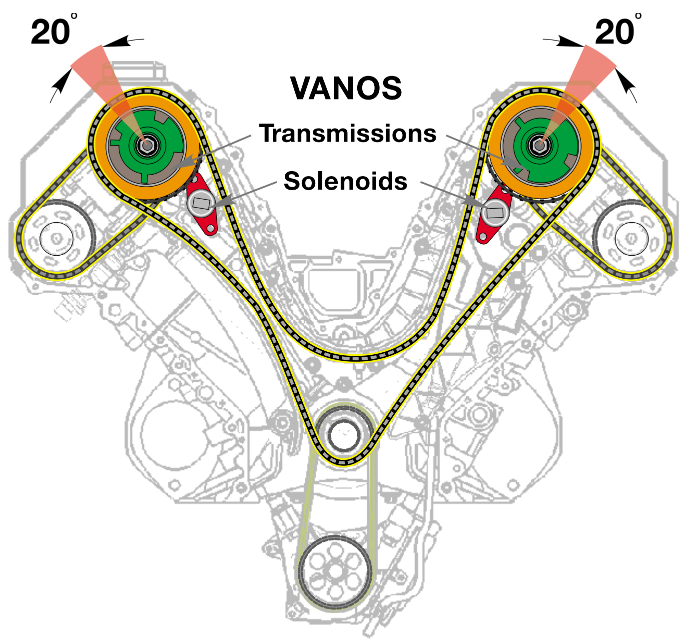
OVERVIEW

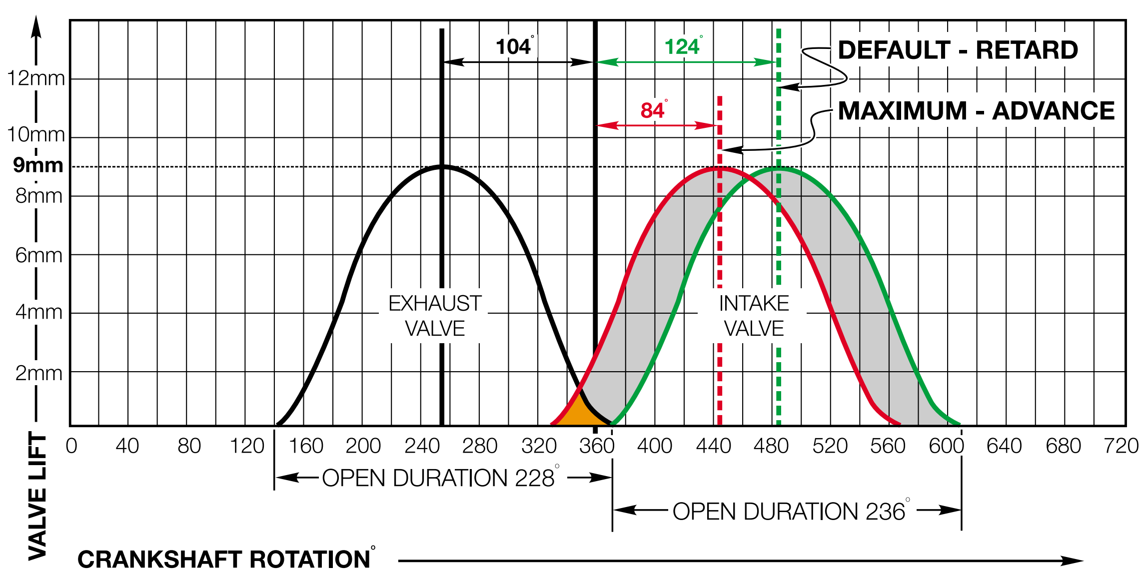
The M62 TU VANOS system provides stepless VANOS functionality on each intake camshaft. The system is continuously variable within its range of adjustment providing optimized camshaft positioning for all engine operating conditions.

While the engine is running, both intake camshafts are continuously adjusted to their optimum positions. This enhances engine performance and reduces tailpipe emissions.

Both camshafts are adjusted simultaneously within 20° (maximum) of the camshafts rotational axis.

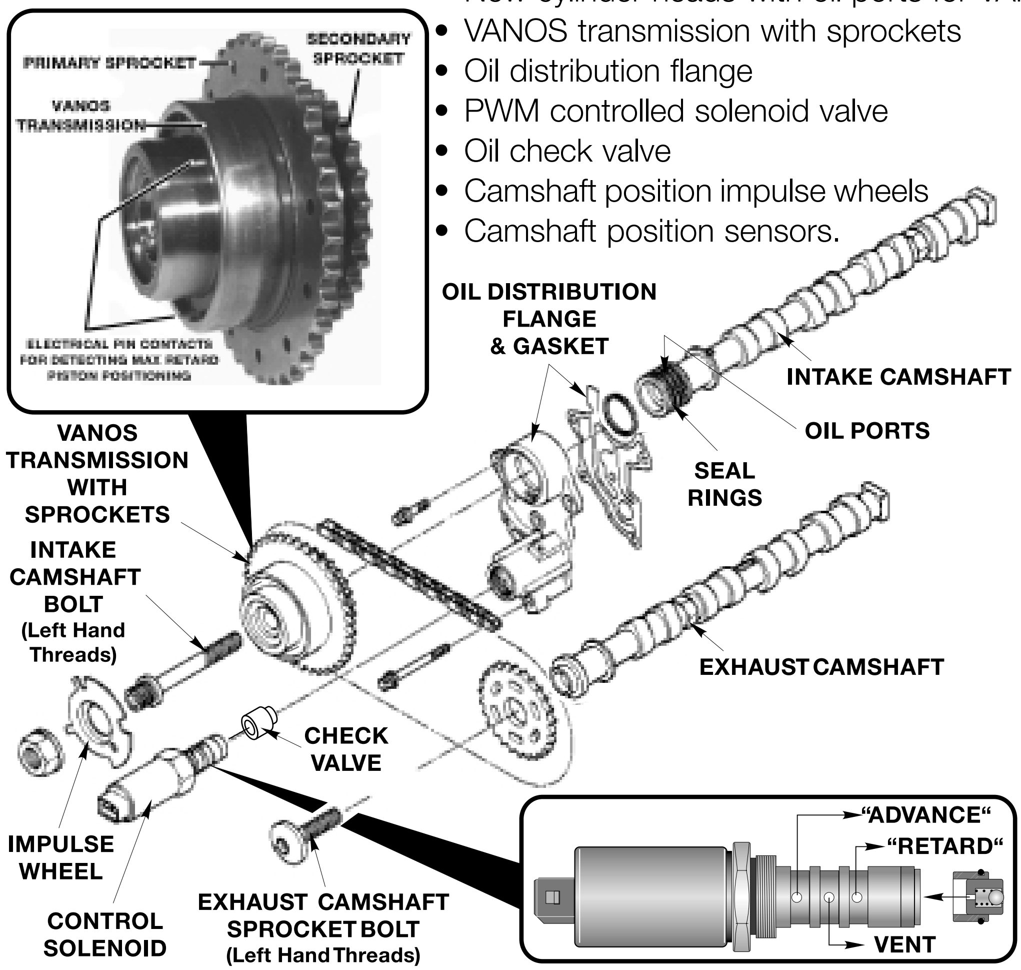
This equates to a maximum span of 40° crankshaft rotation. The camshaft spread angles for both banks are as follows.





M62 TU VANOS components include the following for each cylinder bank:

- New cylinder heads with oil ports for VANOS
- VANOS transmission with sprockets
- Oil distribution flange
- PWM controlled solenoid valve
- Oil check valve
- Camshaft position impulse wheels
- Camshaft position sensors.



VANOS CONTROL SOLENOID & CHECK VALVE: The VANOS solenoid is a two wire, pulse width modulated, oil flow control valve. The valve has four ports;

1. Input Supply Port - Engine Oil Supply
2. Input/Output Retard Port - Rear of piston/helical gear (retarded camshaft position)
3. Input/Output Advance Port - Front of piston/helical gear (advanced camshaft position)
4. Output Vent - Released oil

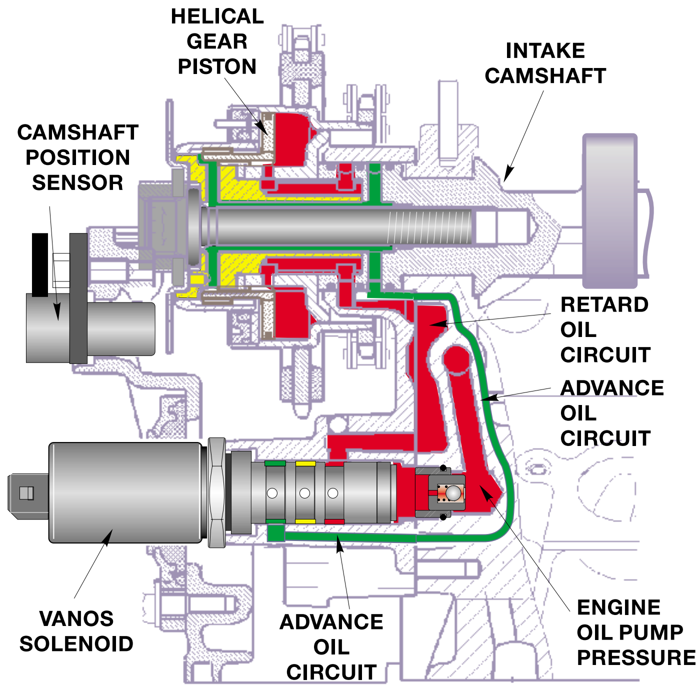
A check valve is positioned forward of the solenoid in the cylinder head oil gallery. The check valve retains oil in the VANOS transmission and oil circuits after the engine is turned off. This prevents the possibility of piston movement (noise) within the VANOS transmission system on the next engine start.

VANOS TRANSMISSION: The primary and secondary timing chain sprockets are integrated with the VANOS transmission. The transmission is a self-contained unit.

The controlled adjustment of the camshaft occurs inside the "transmission". Similar in principle to the six cylinder engine VANOS systems, controlled oil flow moves the piston.

The helical gear cut of the piston acts on the helical gears on the inside surface of the transmission and rotates the camshaft to the specific advanced or retarded angle position.

Three electrical pin contacts are located on the front surface to verify the default maximum retard position using an ohmmeter. This is required during assembly and adjustment.

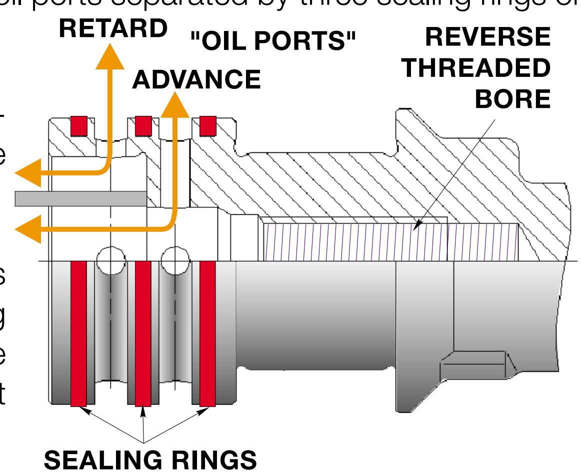


OIL DISTRIBUTION FLANGES: The oil distribution flanges are bolted to the front surface of each cylinder head. They provide a mounting location for the VANOS solenoids as well as the advance-retard oil ports from the solenoids to the intake camshafts.

CAMSHAFTS: Each intake camshaft has two oil ports separated by three sealing rings on their forward ends.

The ports direct the flow of oil from the oil distribution flange to the inner workings of the VANOS transmission.

Each camshaft has ***REVERSE*** threaded bores in their centers for the attachment of the timing chain sprockets on the exhaust cams and the VANOS transmissions for each intake camshaft as shown.

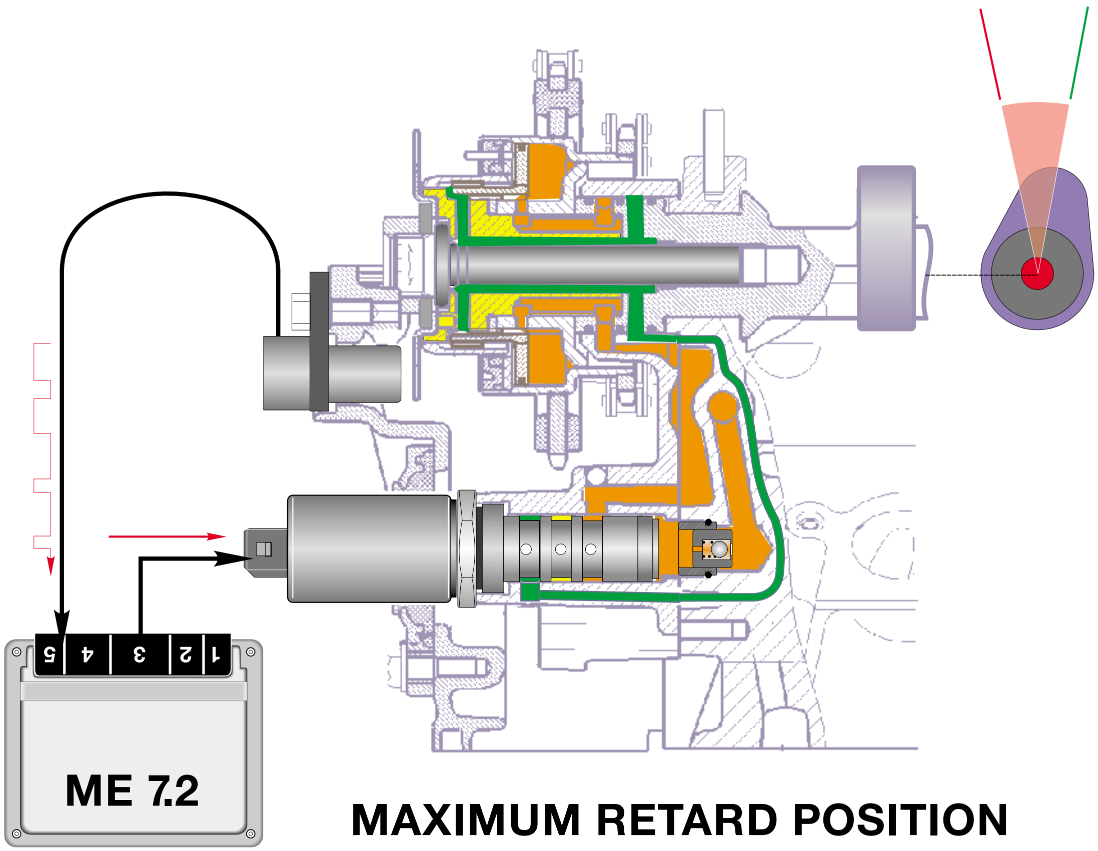


CAMSHAFT POSITION IMPULSE WHEELS: The camshaft position impulse wheels provide camshaft position status to the engine control module via the camshaft position sensors. The asymmetrical placement of the sensor wheel pulse plates provides the engine control module with cylinder specific position ID in conjunction with crankshaft position.

M62 TU VANOS CONTROL

As the engine camshafts are rotated by the primary and secondary timing chains, the ME7.2 control module activates the VANOS solenoids via a PWM (pulse width modulated) ground signal based on a program map. The program is influenced by engine speed, load, and engine temperature.

- **Shown below:** In the inactive or default position, the valves direct 100% engine oil flow to achieve max "retard" VANOS positioning.

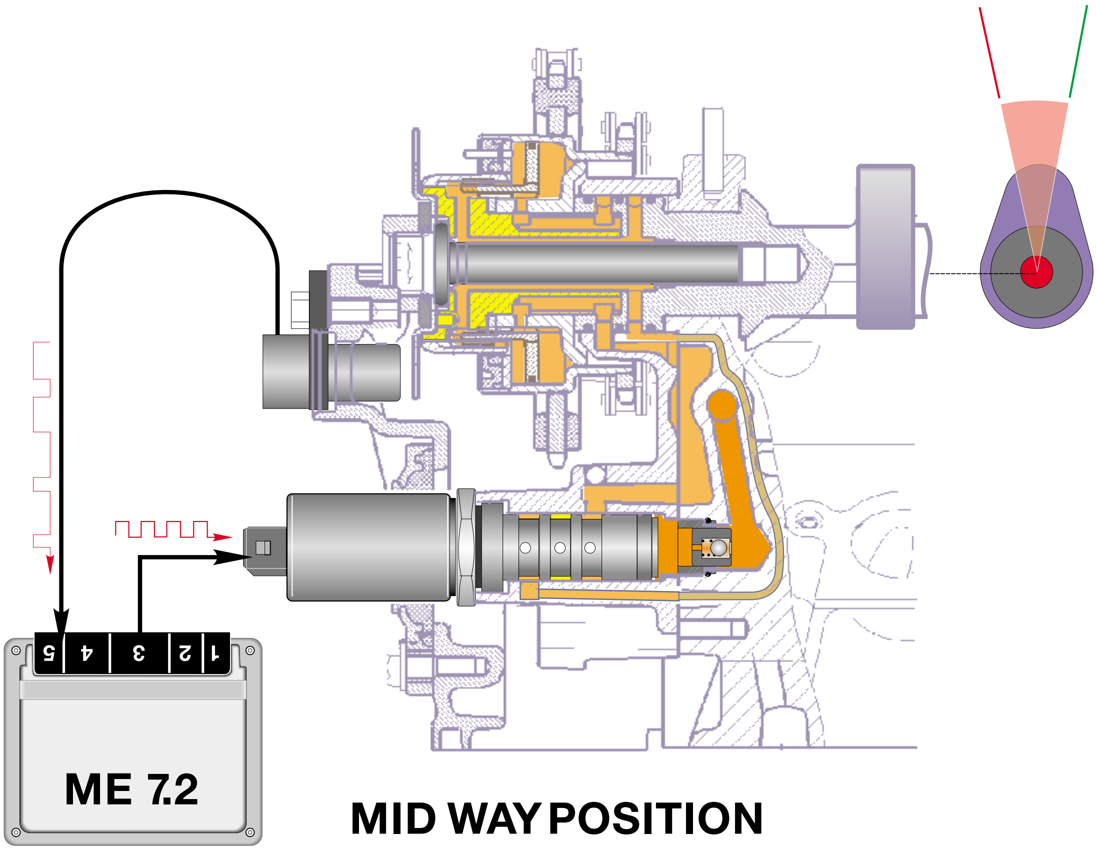


MAXIMUM RETARD POSITION

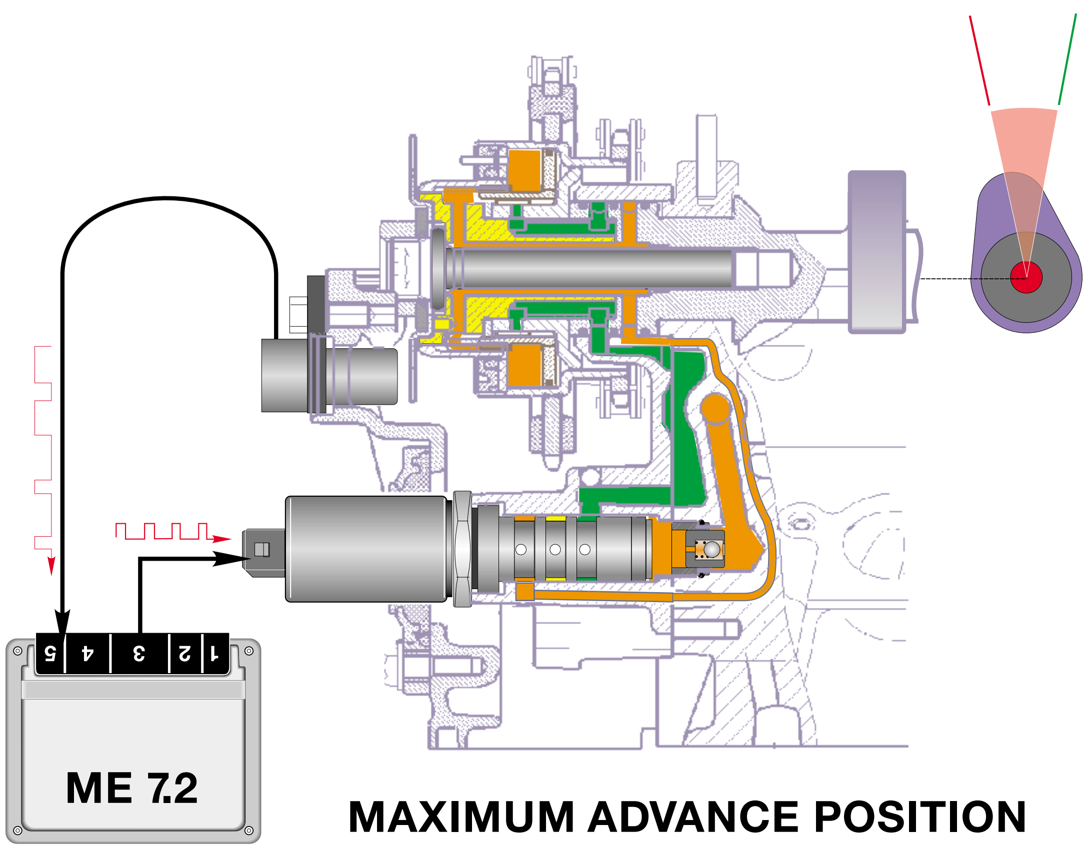
- **Top of next page**: As the Pulse Width Modulation (PWM) increases on the control signal, the frequency of on time increases and opens the advanced oil port more often. Oil flow pushes the piston toward the advance position. Simultaneously the oil flow on the retard side (rear) of the piston is proportionally decreased and directed to the vent port in the solenoid valve and drains into the cylinder head.

- **Bottom of next page:** At maximum PWM control, 100% oil flow is directed to the front surface of the piston pushing it rearward to maximum advance.

Varying the pulse width (on time) of the solenoids control signals proportionately regulates the oil flow on each side of the pistons to achieve the desired VANOS advance angle.



MID WAY POSITION



MAXIMUM ADVANCE POSITION

M62 TU CAMSHAFT POSITION SENSORS

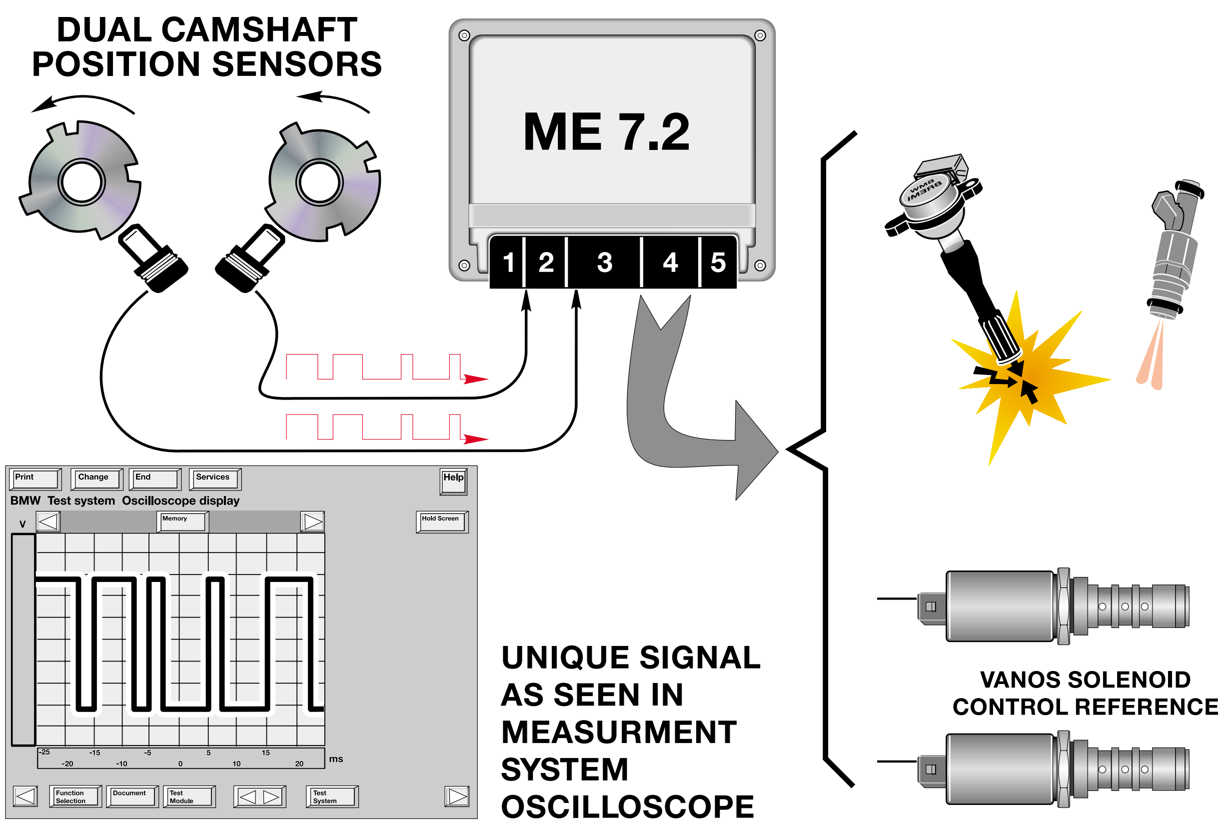
Located on the upper timing case covers, the camshaft position sensors monitor the position of the camshafts to establish start of ignition firing order, set up sequential fuel injection triggering and for accurate camshaft advance-retard (VANOS) timing feedback.

Each intake camshaft's advance-retard angles are adjusted simultaneously yet independently. For this reason ME 7.2 requires a camshaft position sensor on each cylinder bank for accurate feedback to monitor the VANOS controlled camshaft positioning.

The sensors are provided with operating power from the ECM relay. The sensors produce a unique asymmetrical square-wave signal representative of the impulse wheel shape. The sensors are new in the fact that they are "active" Hall effect sensors. Active Hall sensors provide:

- low signal when a tooth of the camshaft impulse wheel is located in front of the sensor
- high signal when an air gap is present.

The active hall sensors supply a signal representative of camshaft position even before the engine is running. The ME 7.2 determines an approximate location of the camshafts positions prior to engine start up optimizing cold start injection (reduced emissions.)



VANOS SERVICE NOTES

VALVE TIMING PROCEDURES

Refer to TIS for complete Valve Timing Procedures. M62 TU valve timing adjustment requires setting the VANOS transmissions to the max. retard positions with an ohmmeter and attaching the camshaft gears to each camshaft with single reverse threaded bolts.

- After locking the crankshaft at TDC, the camshaft alignment tools (P/N 90 88 6 112 440) are placed on the square blocks on the rear of the camshafts locking them in place.

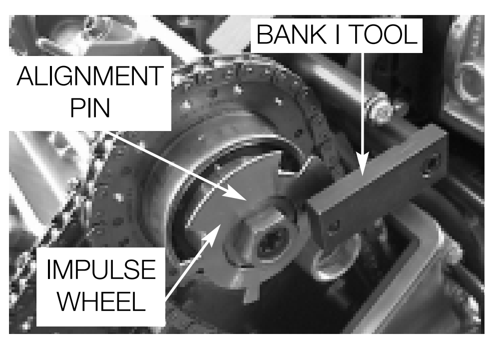
- The exhaust camshaft sprockets and VANOS transmission units with timing chains are placed onto their respective camshafts.

- The exhaust camshaft sprockets and VANOS transmissions are secured to the camshafts with their respective single, reverse threaded bolt. Finger tighten only at this point. Install the chain tensioner into the timing chain case and tension the chain.

- Connect an ohmmeter across two of the three pin contacts on the front edge of one of the VANOS transmissions. Twist the inner hub of transmission to the left (counter clockwise). Make sure the ohmmeter indicates closed circuit. This verifies that the transmission in the default max retard position.

- Using an open end wrench on the camshaft to hold it in place, torque the VANOS transmission center bolt to specification.

CAMSHAFT IMPULSE WHEEL POSITION TOOLS



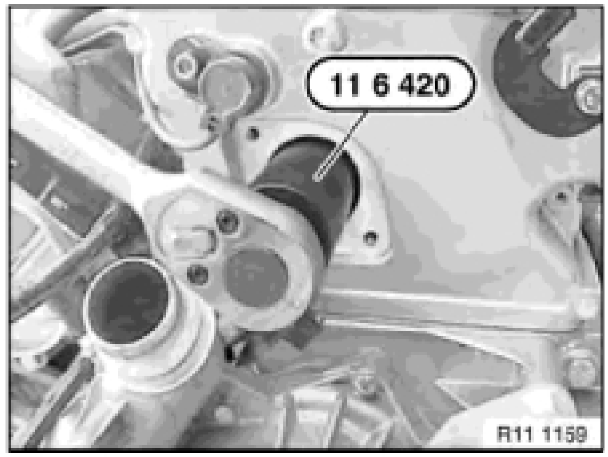
The camshaft impulse wheels require a special tool set to position them correctly prior to torquing the retaining nuts.

The impulse wheels are identical for each cylinder bank. The alignment hole in each wheel must align with the tool's alignment pin. Therefore the tools are different and must be used specifically for their bank.

The tool rests on the upper edge of the cylinder head and is held in place by the timing case bolts.

Refer to the TIS repair manual section for complete information.

VANOS SOLENOID REPLACEMENT



Refer to TIS repair manual section for complete solenoid replacement procedures.

The solenoids are threaded into the oil distribution flanges through a small opening in the upper timing case covers.

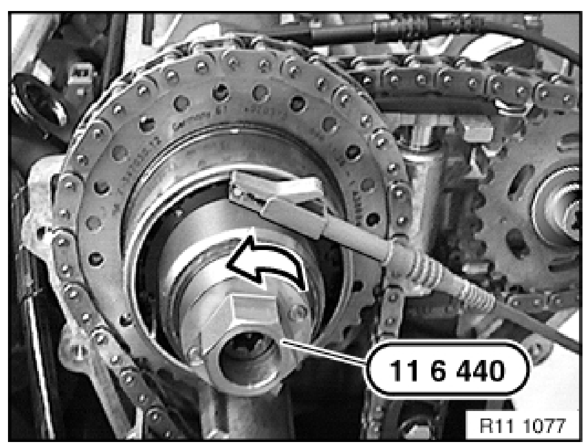
Special Tool 11 6 420 is required.

VANOS TRANSMISSION RETARD POSITION SET UP TOOLS

Special Tool 11 6 440 is used to rotate the transmission to the full retard position when checking the piston position with an ohmmeter.

This tool engages the inner hub of the transmission provides an easy method of twisting it to the left for the ohmmeter test.

Refer to SI Bulletin 04 12 98 for additional special tool information.



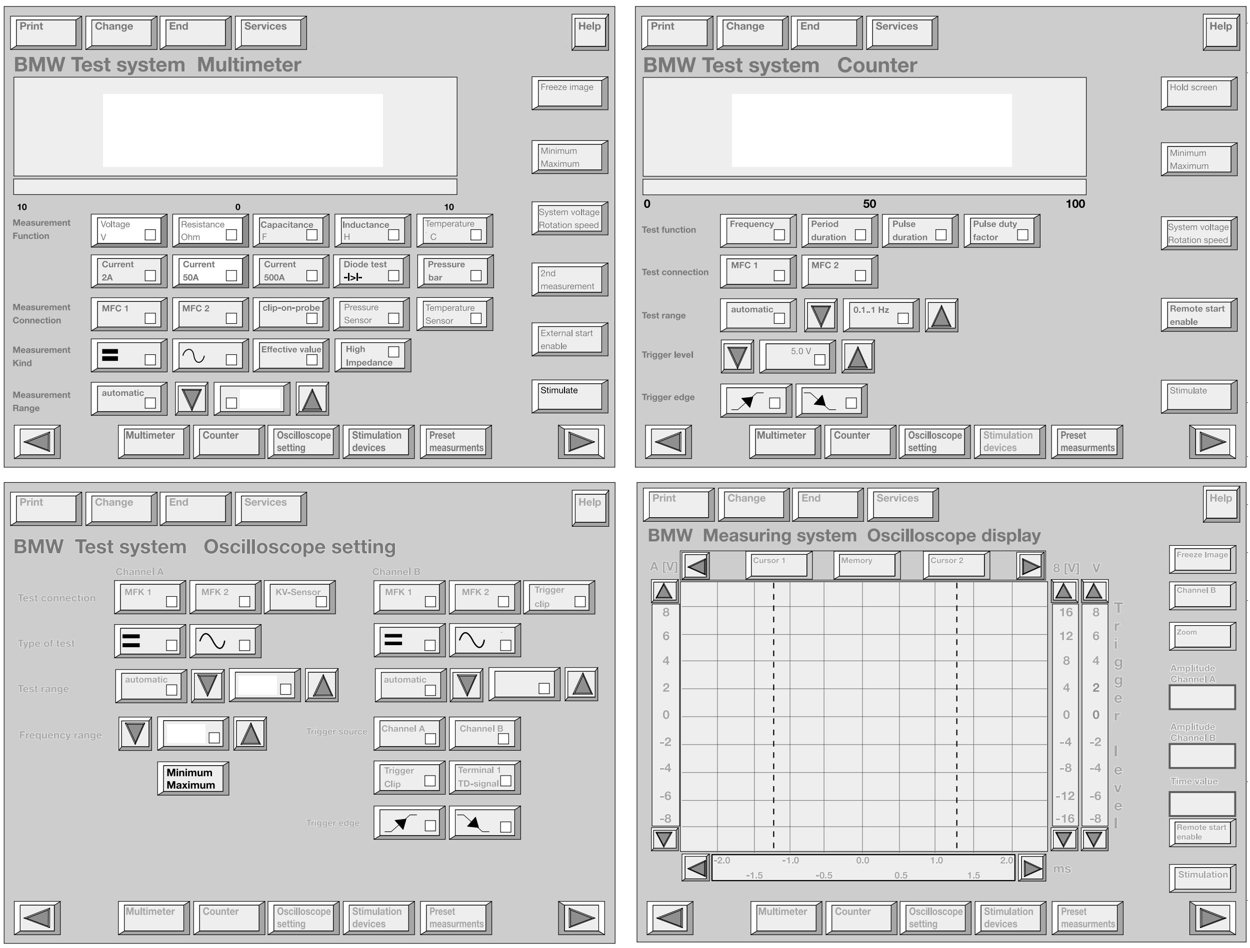
DIAGNOSIS

The VANOS is fully compatible with the diagnostic software providing specific fault codes and test modules. Additionally, diagnostic requests section provides status of the PWM of the VANOS solenoids and camshaft position feedback via the camshaft position sensors. The Service Functions section of the DIS/MoDiC also provides a VANOS system test.

NAME OF SIGNAL OR FUNCTION: PWG Signals - ME 7.2

MEASUREMENT SYSTEM WORKSHEET: While connecting and setting up the DIS/ MoDiC measument system for signal/circuit validation, note the settings in the approriate locations for future reference. Document your findings by entering the displayed values in the Multimeter or Counter Display. If the signal requires the use of the oscilloscope, note your set up selections and sketch the waveform.

Vehicle: **M.Y.:** **DIS CD Version:**



MEASUREMENT SYSTEM WORKSHEET: While connecting and setting up the DIS/MoDiC measurement system for signal/circuit validation, note the settings in the appropriate locations for future reference. Document your findings by entering the displayed values in the Multimeter or Counter Display. If the signal requires the use of the oscilloscope, note your set up selections and sketch the waveform.

NAME OF SIGNAL OR FUNCTION: ____________________

Vehicle: ________ **M.Y.:** ______ **DIS CD Version:** ________

What type of signal is this? ☐ Switched Power ☐ Switched Ground ☐ Pulse Width Modulated (PWM)

☐ Linear Voltage ☐ Linear Resistance ☐ Digital ☐ Other: ____________________

How will the control system react if this signal becomes impaired or lost ?

____

____

____

Is there a substitute value for this signal? ☐ Yes ☐ No

Does the DIS software provide a Status Display for this signal? ☐ Yes ☐ No

Is "component activation" possible with this signal/function? ☐ Yes ☐ No

Does signal status display or the component activation functions help you with diagnosis? ☐ Yes ☐ No **Why?** ____________________

____

____

____

____

What is (are) the most suitable measurement(s) for this signal/component?

☐ Voltage ☐ Resistance ☐ Capacitance ☐ Inductance ☐ Temperature ☐ Current ☐ Pressure ☐ Scope

Signal Range?: ____________ **Nominal Value(s)?:** ____________

Notes:

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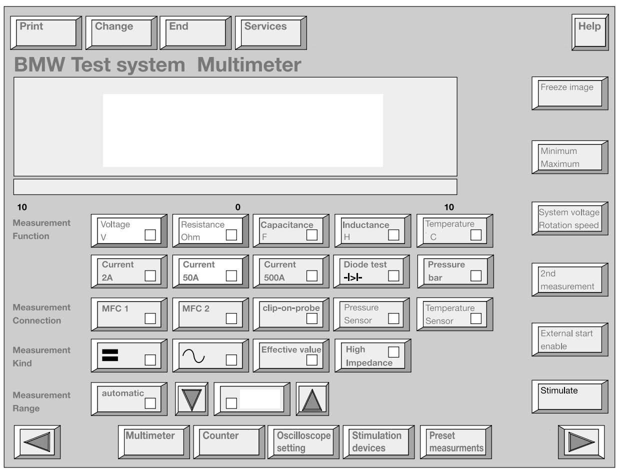
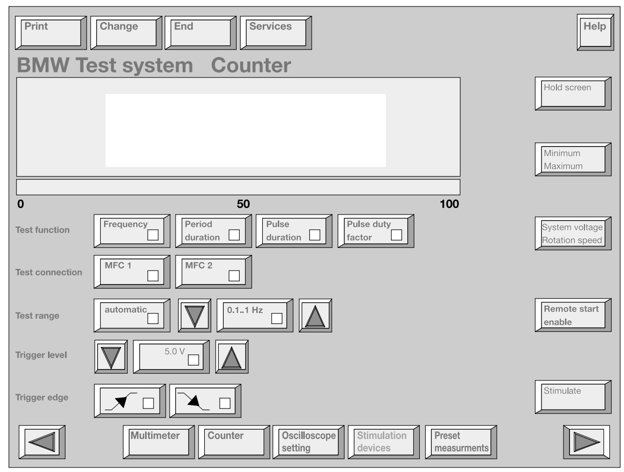
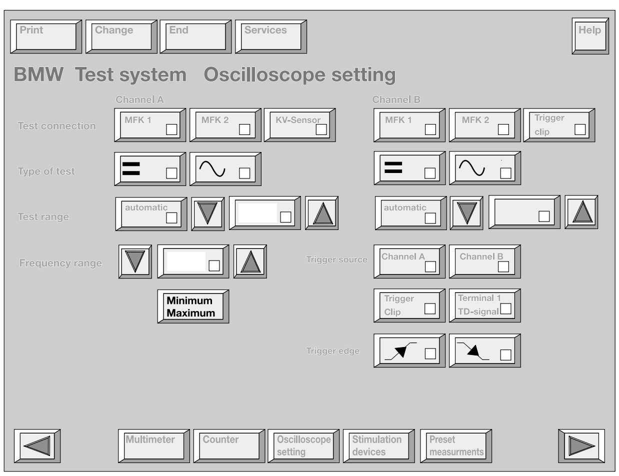
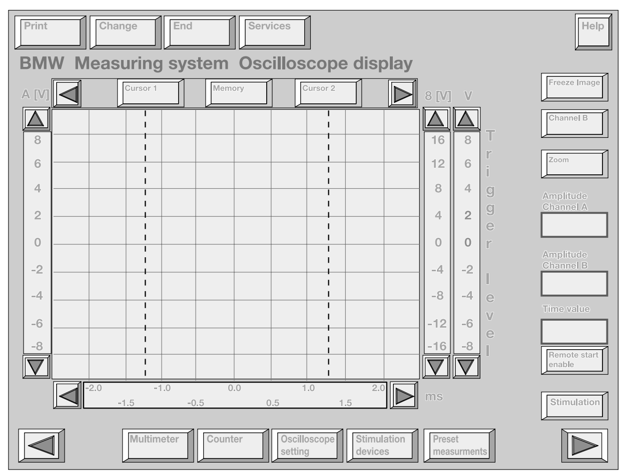
NAME OF SIGNAL OR FUNCTION: *EDK Control -- ME 7.2*

MEASUREMENT SYSTEM WORKSHEET: While connecting and setting up the DIS/MoDiC measument system for signal/circuit validation, note the settings in the appropriate locations for future reference. Document your findings by entering the displayed values in the Multimeter or Counter Display. If the signal requires the use of the oscilloscope, note your set up selections and sketch the waveform.









MEASUREMENT SYSTEM WORKSHEET: While connecting and setting up the DIS/MoDiC measurement system for signal/circuit validation, note the settings in the appropriate locations for future reference. Document your findings by entering the displayed values in the Multimeter or Counter Display. If the signal requires the use of the oscilloscope, note your set up selections and sketch the waveform.

NAME OF SIGNAL OR FUNCTION:

Vehicle: __________ **M.Y.:** ______ **DIS CD Version:** ______________

What type of signal is this? ☐ Switched Power ☐ Switched Ground ☐ Pulse Width Modulated (PWM)

☐ Linear Voltage ☐ Linear Resistance ☐ Digital ☐ Other: ________________________________

How will the control system react if this signal becomes impaired or lost ?

____

____

____

Is there a substitute value for this signal? ☐ Yes ☐ No

Does the DIS software provide a Status Display for this signal? ☐ Yes ☐ No

Is "component activation" possible with this signal/function? ☐ Yes ☐ No

Does signal status display or the component activation functions help you with diagnosis? ☐ Yes ☐ No **Why?** ____

____

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What is (are) the most suitable measurement(s) for this signal/component?

☐ Voltage ☐ Resistance ☐ Capacitance ☐ Inductance ☐ Temperature ☐ Current ☐ Pressure ☐ Scope

Signal Range?: ______________________ **Nominal Value(s)?:** __________________________

Notes:

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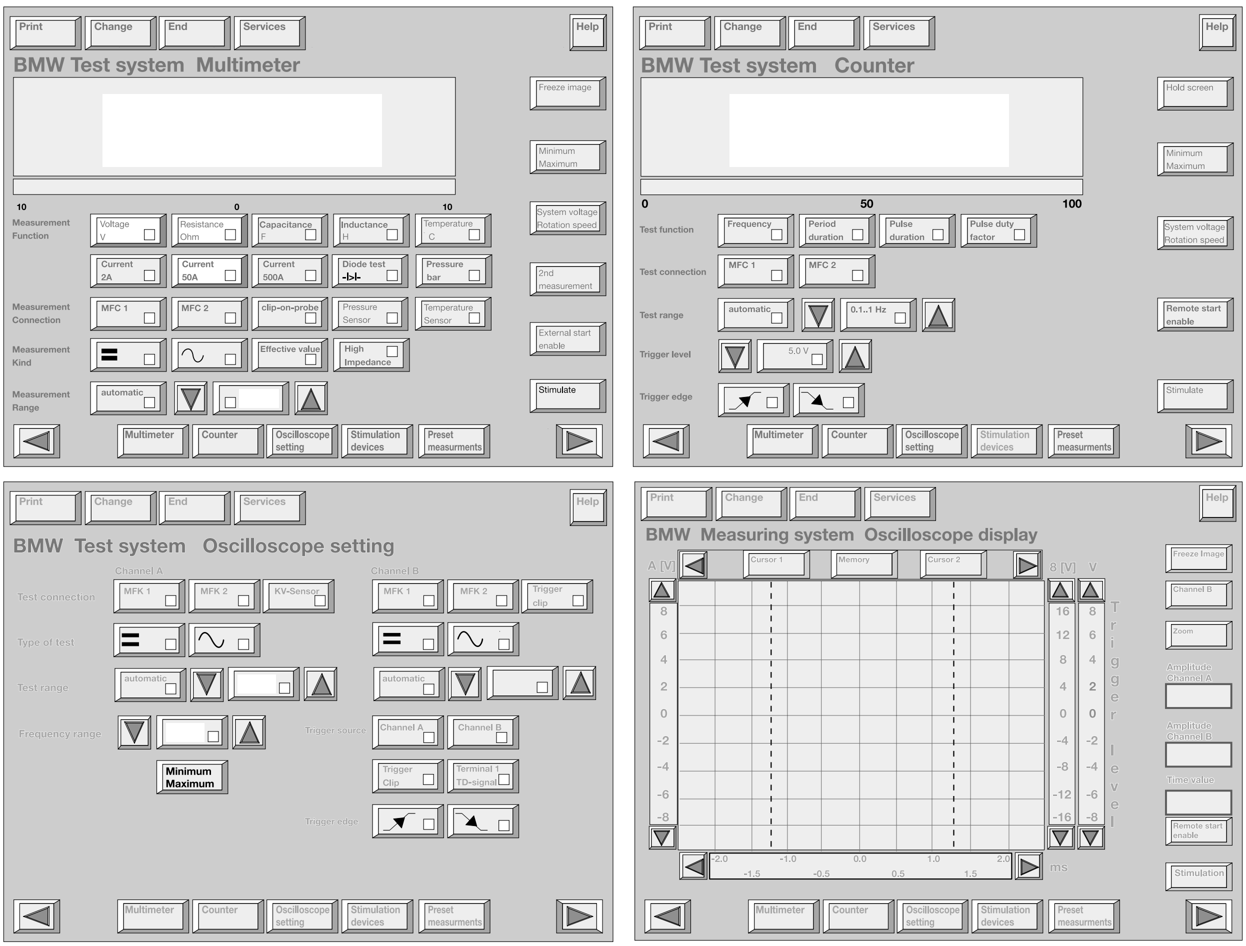
____

NAME OF SIGNAL OR FUNCTION: *EDK Feedback Potentiometers*

MEASUREMENT SYSTEM WORKSHEET: While connecting and setting up the DIS/MoDiC measument system for signal/circuit validation, note the settings in the appro-riate locations for future reference. Document your findings by entering the displayed val-ues in the Multimeter or Counter Display. If the signal requires the use of the oscilloscope, note your set up selections and sketch the waveform.



MEASUREMENT SYSTEM WORKSHEET: While connecting and setting up the DIS/MoDiC measurement system for signal/circuit validation, note the settings in the appropriate locations for future reference. Document your findings by entering the displayed values in the Multimeter or Counter Display. If the signal requires the use of the oscilloscope, note your set up selections and sketch the waveform.

NAME OF SIGNAL OR FUNCTION: ____________________

Vehicle: __________ **M.Y.:** ______ **DIS CD Version:** __________

What type of signal is this? ☐ Switched Power ☐ Switched Ground ☐ Pulse Width Modulated (PWM)

☐ Linear Voltage ☐ Linear Resistance ☐ Digital ☐ Other: ____________________

How will the control system react if this signal becomes impaired or lost ?

____

____

____

Is there a substitute value for this signal? ☐ Yes ☐ No

Does the DIS software provide a Status Display for this signal? ☐ Yes ☐ No

Is "component activation" possible with this signal/function? ☐ Yes ☐ No

Does signal status display or the component activation functions help you with diagnosis? ☐ Yes ☐ No **Why?** ____________________

____

____

____

____

What is (are) the most suitable measurement(s) for this signal/component?

☐ Voltage ☐ Resistance ☐ Capacitance ☐ Inductance ☐ Temperature ☐ Current ☐ Pressure ☐ Scope

Signal Range?: ____________________ **Nominal Value(s)?:** ____________________

Notes:

____

____

____

NAME OF SIGNAL OR FUNCTION: *VANOS Solenoid Control*

Vehicle: **M.Y.:** **DIS CD Version:** ____________

What type of signal is this ? ☐

How will the control system react if this signal becomes impaired or lost ?

Was a fault code(s) present with this defective signal/component? ☐ Yes ☐ No

If yes what is (are) the specific code(s)? ____________

Does the DIS software provide a Status Display for this signal? ☐ Yes ☐ No

Is “component activation” possible with this signal/function? ☐ Yes ☐ No

Is there a Test Function selection to test this system? ☐ Yes ☐ No

If yes what does it do? ____________

Does this help you with diagnosis? ☐ Yes ☐ No **Why?** ____________

What is (are) the most suitable measurement(s) for this signal/component?
☐ Voltage ☐ Resistance ☐ Capacitance ☐ Inductance ☐ Temperature ☐ Current ☐ Pressure ☐ Scope

Signal Range?: ________ **Nominal Value?:** ____________

MEASUREMENT SYSTEM WORKSHEET: While connecting and setting up the DIS/MoDiC measurement system for signal/circuit validation, note the settings in the appropriate locations for future reference. Document your findings by entering the displayed values in the Multimeter or Counter Display. If the signal requires the use of the oscilloscope, note your set up selections and sketch the waveform.

NAME OF SIGNAL OR FUNCTION: ______________________

Vehicle: __________ **M.Y.:** ______ **DIS CD Version:** ____________

What type of signal is this? ☐ Switched Power ☐ Switched Ground ☐ Pulse Width Modulated (PWM)

☐ Linear Voltage ☐ Linear Resistance ☐ Digital ☐ Other: ______________________

How will the control system react if this signal becomes impaired or lost ?

____

____

____

Is there a substitute value for this signal? ☐ Yes ☐ No

Does the DIS software provide a Status Display for this signal? ☐ Yes ☐ No

Is "component activation" possible with this signal/function? ☐ Yes ☐ No

Does signal status display or the component activation functions help you with diagnosis? ☐ Yes ☐ No **Why?** ______________________

____

____

____

____

What is (are) the most suitable measurement(s) for this signal/component?

☐ Voltage ☐ Resistance ☐ Capacitance ☐ Inductance ☐ Temperature ☐ Current ☐ Pressure ☐ Scope

Signal Range?: ______________ **Nominal Value(s)?:** ______________

Notes:

____

____

____

NAME OF SIGNAL OR FUNCTION: *Camshaft Position Sensor Signals*

Vehicle: **M.Y.:** **DIS CD Version:** ______________

What type of signal is this ? ☐

How will the control system react if this signal becomes impaired or lost ?

Was a fault code(s) present with this defective signal/component? ☐ Yes ☐ No

If yes what is (are) the specific code(s)? ______________________________

Does the DIS software provide a Status Display for this signal? ☐ Yes ☐ No

Is "component activation" possible with this signal/function? ☐ Yes ☐ No

Is there a Test Function selection to test this system? ☐ Yes ☐ No

If yes what does it do? ______________________________

Does this help you with diagnosis? ☐ Yes ☐ No **Why?** ______________________________

What is (are) the most suitable measurement(s) for this signal/component?

☐ Voltage ☐ Resistance ☐ Capacitance ☐ Inductance ☐ Temperature ☐ Current ☐ Pressure ☐ Scope

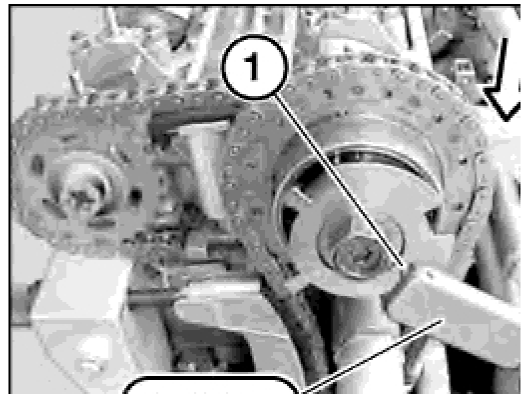
Signal Range?: __________ **Nominal Value?:** ______________________________

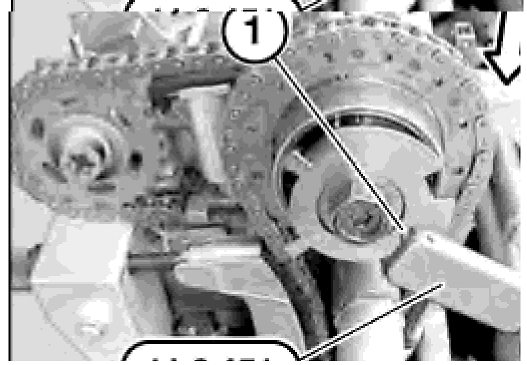
Repair Manual Worksheet : *Adjusting Camshaft Timing (M62 TU)*

Vehicle: ______ **M.Y.:** ______ **TIS CD Version:** ____________

What Main Group/Sub Group is this procedure found in ? ____________________

Identify and list all the special tools (with P/N) required for this procedure:





What is the purpose of the special tool shown in the illustration?

Why is it necessary to use an ohmeter to adjust the valve timing?

In your own words, list the steps required to carry out this procedure (breif)

What components require a torque wrench when tightening?

Review Questions

1. What does the “ME” designation identify?____________________

2. Is ORVR monitored by the ECM? ____________________

3. What is the ECM monitoring from the LDP Pump during Operation? ____________________

4. Describe the Non-Return Fuel Rail System: ____________________

5. What is the purpose of the Radiator Outlet Temperature Sensor? ____________________

6. What two systems affect the Fuel Pump operation? ____________________

7. When in PWG failsafe operation, what is the effect when the brake pedal is depressed?____________________

8. The EDK throttle plate position monitoring has two voltage signals, what is the voltage range of each as the throttle plate is opened? ____________________

9. Active Hall sensors (monitoring the camshafts) provide two types of signals, low and high. What conditions are present that produce a:

   - Low Signal ____________________

   - High Signal ____________________

10. What is the Special Tool Set number for VANOS adjustment?____________________

11. The EDK Adaptation Proceedure requires three steps that include:____________________

Table of Contents

Subject **Page**

EMISSIONS OVERVIEW

Models: All Equipped with OBD II

Production Date: 1995 to Present

Manufacturer: Bosch and Siemens Engine Control Modules

Pin Connector: 88 and 134 Pins

Objectives of the Module

After completing this module, you will be able to:

- Describe What is Required to Illuminate the “Malfunction Indicator” Light.
- Describe The Difference Between TLEV, LEV and ULEV.
- Identify Vehicle Emission Compliance by Production Date.
- List the Systems/Components that are Permanently Monitored.
- Access the Readiness Codes using the DISplus/MoDIC.
- Find the DLC Connector Locations in Various BMW Vehicles.

Emissions Overview

Purpose of the System

What is OBD?

Today many of the engine's control systems such as throttle opening, fuel injection, ignition, emissions and performance are controlled by an electronic control module and the related sensors and actuators. The first on-board diagnostic (OBD) systems were developed by the manufacturer as a way to detect problems with the electronic systems.

Beginning with 1994 model year, requirements for OBD systems have been established by the EPA and CARB. The purpose of the OBD system is to assure proper emission control system operation for the vehicle's lifetime by monitoring emission-related components and systems for deterioration and malfunction. This includes also a check of the tank ventilation system for vapor leaks.

The OBD system consists of the engine and transmission control modules, their sensors and actuators along with the diagnostic software. The control modules can detect system problems even before the driver notices a driveability problem because many problems that affect emissions can be electrical or even chemical in nature.

What happens if a problem is detected?

When the OBD system determines that a problem exists, a corresponding "Diagnostic Trouble Code" is stored in the control module's memory.

The control module also illuminates a yellow dashboard Malfunction Indicator Light indicating "Check Engine" or "Service Engine Soon" or displays an engine symbol.

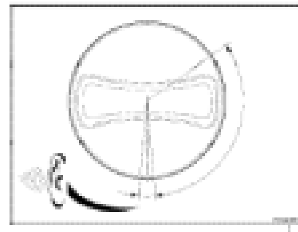
This light informs the driver of the need for service, NOT of the need to stop the vehicle. A blinking or flashing dashboard light indicates a rather severe level of engine misfire.

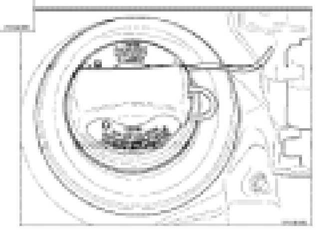
After fixing the problem the Fault code is deleted to turn off the light. If the conditions that caused a problem are no longer present the vehicle's OBD system can turn off the dashboard light automatically. If the OBD system evaluates the component or system three consecutive times and no longer detects the initial problem, the dashboard light will turn off automatically.

What is the most common problem detected by OBD?

Fuel Filler Cap

If the fuel filler cap is not properly closed after refueling, the OBD system will detect the vapor leak that exists from the cap not being completely tightened.





If you tighten the cap subsequently, the dashboard light should be extinguished within a few days or after deleting the Fault code. This is not an indication of a faulty OBD system. The OBD system has properly diagnosed the problem and accordingly alerted the driver by illuminating the dashboard light.

Please check the fuel filler cap first when the dashboard light comes on to avoid unnecessary diagnostic time. To check the fuel filler cap turn the cap to the right until you hear a click or the cap reaches the full stop. Make sure that the retaining strap is not caught between the filler pipe and the fuel filler cap. If the light should stay on further in depth evaporative leak diagnosis is required.

Misfire Detection

As part of the CARB/OBD II regulations the Engine Control Module must determine if misfire is occurring and also identify the specific cylinder(s). The ECM will determine severity of the misfire event, and whether it is emissions relevant or catalyst damaging. In order to accomplish these tasks the ECM monitors the crankshaft for acceleration losses during firing segments of cylinder specific firing order. If the signal is implausible an erroneous reference mark can be obtained by the ECM which will result in a misfire fault being set.

Possible causes of cylinder misfire faults (actual field findings):

- Vehicle ran low or out of fuel
- Poor fuel quality (ex. water in fuel, customer uses an additive, etc.)
- Low/high fuel pressure
- Ignition coil
- Fouled spark plug(s)
- Restricted / contaminated fuel injector(s)
- Crankshaft position sensor
- Poor combustion due to low compression or high leakage
- Blocked/restricted Catalyst

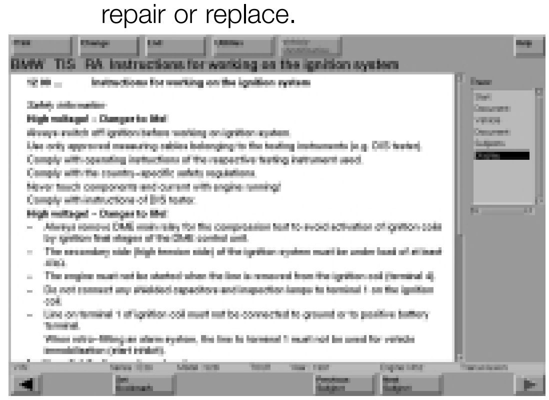
Engine Misfire Diagnosis

Engine Misfire is the result of inefficient combustion in one or more cylinders. The causes of Engine Misfire are extensive but can be grouped into the following sub-systems. Consider the charts below as an additional diagnostic aid once the DISplus/MoDIC is connected, the correct fault symptom has been chosen and the fault memory has been interrogated. Follow the Test Module as displayed by the DISplus/MoDIC.

IGNITION SYSTEM

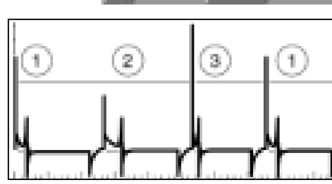
COMPONENT	POSSIBLE CONDITION	TEST	CORRECTION
Spark Plug:	• Incorrect spark plug installed • Electrode gap closed or too small • Electrode(s) missing • Oil or fuel fouled spark plug • Ceramic insulation cracked	Secondary Ignition DISplus Preset Measurement	• Verify correct spark plug • Replace if necessary • Swap with another cylinder
Secondary circuit: (wiring, M73-cap, rotor)	• Wet or moist due to water infiltration. • High resistance due to corrosion.		• Check water ingress, repair, replace • Check resistance value, replace
Ignition Coil(s):	• Secondary/Primary Circuits open or shorted. • Housing cracked, damaged.	Secondary and Primary	• Inspect and replace if necessary • Swap with another cylinder
Ignition Coil & Engine Harness Connectors	• Power supply, Primary control and ground (shunt signal) circuits impaired.	Primary Ignition & Term 4A feed-back Preset Measurements	• Look for open, loose connector, corrosion, crossed or backed out pins (also consider ignition unloader or ECM relay on MY97 and newer cars). • Determine defective condition, repair or replace.

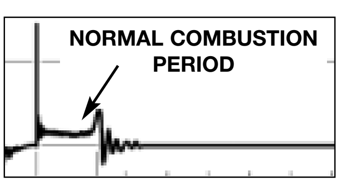
- A secondary ignition oscilloscope display provides vital information about the ignition system's condition.
- Follow the precautions in group 12 of the Repair Instructions.
- Use the following scope patterns as a guideline for ignition system diagnosis. Use the preset measurement function of DISplus.

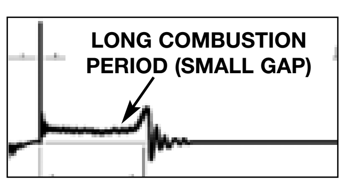


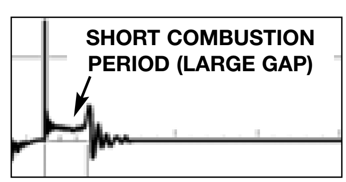
Evaluation of secondary signal amplitude at idle speed.

1. Normal Ignition Voltage Peak: ***Spark Plug is OK***
2. Low Ignition Voltage Peak: ***Gap too small (defective)***
3. High Ignition voltage peak: ***Gap too large (defective)***









ENGINE MECHANICAL SYSTEMS

COMPONENT	POSSIBLE CONDITION	TEST	CORRECTION
Pistons, Rings, Valves, Camshaft:	• Hole in piston crown, ring(s) broken, valve(s) not seating, valve(s) bent, valve spring(s) broken, camshaft lobe cracked, etc.	• Idle Quality - Rough Running Preset. • Cylinder compression & leakdown tests.	• Correct condition as required.
Hydraulic Valve Actuator (HVA):	• HVA oil bore restricted or blocked. • Engine oil pressure builds up too slow. • **Intermittant Misfire Fault** - Not Currently Present. • HVA binding/sticking in bore.	• Idle Quality - Rough Running Preset. • Listen to HVA • Check Oil Pressure • Cylinder leakdown	• Always consider mechanical components when diagnosing misfire. • Inspect for scoring.
Vacuum Leaks:	• Unmetered vacuum leaks causing a **"lean"** operating condition. Possible **"Excessive Mixture Deviation"** fault codes.	• Idle Quality - Rough Running Preset. Test for vacuum leaks per Repair Instr. and SIB on **"Crankcase Ventilation".** • Interpret Add. & Multipl. adaptation values	• Correct condition as required.

FUEL QUALITY, DELIVERY, INJECTION & EVAPORATIVE SYSTEMS

COMPONENT	POSSIBLE CONDITION	TEST	CORRECTION
Fuel (quality):	• Contaminated fuel. (water, other non combustible).		• Clean fuel system, replace fuel.
Fuel Delivery:	• Fuel pump delivery pressure low, restriction in fuel line to fuel rail or running loss valve. • Fuel filter restricted (clogged). • Low fuel in tank.	• Check fuel pressure & volume. • Check fuel pump power and ground	• Determine restriction/flow reduction, replace component as necessary. • Interpret Additive and Multiplicative adaptation values.
Running Loss Valve:	• Valve stuck in "small circuit" position.	• Check valve	• Display "diagnosis requests" in DISplus and test valve for proper function, replace valve as necessary.
Fuel Injectors:	• Leaking fuel injector pintle seats cause rich engine starts with hot ambient temperatures. • Blocked (dirty) injector(s).	• Ti Preset & status page. • Sec Ign scope pattern.	• Check injectors for leakiage. • Swap suspect injector with another cylinder. • Inspect injector, replace if necessary.
Fuel Pressure Regulator:	• Regulator defective, causes fluctuation in the injected quantity of fuel causing mixture adaptation faults.	• Fuel pressure	• Check nominal fuel pressure value with engine operating under varied speeds.
Evaporative System:	• Defective evaporative system vent causing fuel tank collapse and fuel . starvation.	• DISplus status, Evap test with pressure tool, purge valve func. test.	• Check the fuel tank condition and vent line. • Check Fresh Air Valve on TLEV E36 vehicles or LDP/DM TL and filter on ORVR vehicles for proper system "breathing".

IMPLAUSIBLE ECM CONTROL FUNCTION OR SENSOR INPUT SIGNALS

COMPONENT	POSSIBLE CONDITION	TEST	CORRECTION
Crankshaft Position Sensor or Increment Wheel:	• Implausible signal for misfire detection. • Increment wheel loose or damaged (internal on M44, M52 and M54, external on M62 & M73). • Air gap between sensor and wheel. • Noticeable at higher rpm.	• DISplus preset measurement.	• Determine defective sensor or increment wheel and replace.
Catalyst Damaged:	• Excessive exhaust back pressure (bank specific fault present, more noticeable under heavy load and high rpm).	• DISplus preset measurement of oxygen sensor. • Back pressure test per SIB with Special Tool.	• Determine catalyst condition, replace or repair as necessary.
Oxygen Sensor:	• Excessive mixture deviation, **possible vacuum leaks.**	• Monitor oxygen sensor signal via DIS preset.	• Swap sensor from other bank (if applicable) and see if fault transfers to other bank.
Engine Control Module	• Internal control module fault. • Misfire Reprogramming.	• Check fault memory. • Refer to SIB	• Highly unlikely but must be considered. • Check Model/Prod range - reprogram

When diagnosing a Misfire fault code, Remember:

"Misfire" is caused by a defect in the internal combustion engine or a defect in the control of the engine operation.

"Misfire" is the result of <u>improper combustion</u> (variation between cylinders) as measured at the crankshaft due to:

- Engine mechanical defects; breakage, wear, leakage or improper tolerances.

- Excessive mixture deviation; air (vacuum leaks), fuel and all the components that deliver air/fuel into the combustion chambers.

- Faulty ignition; primary, secondary including spark plugs.

- Faulty exhaust flow; affecting back pressure.

- Tolerance parameters; ECM programming.

A Misfire fault code(s) is the "symptom" of a faulty input for proper combustion. When diagnosing a misfire, review the charts to assist you in finding the faulty input.

OBD History

As a result of low fuel costs, together with a high standard of living and a dense population, the state of California was affected particularly heavily by air pollution. This spurred the state to pass the most comprehensive and stringent emissions and consumption laws in the world. The automobile manufacturers were reminded of their obligations and this drove them on to comply with the new regulations at enormous expense.

- In continuing efforts to improve air quality, the Environmental Protection Agency (EPA) amended the Clean Air Act in 1990. The Clean Air Act was originally mandated in 1970. The Clean Air Act has a direct impact on automobile manufactures whereby they are responsible to comply with the regulations set forth by the EPA. The 1990 amendment of the Clean Air Act set forth all of the changes currently being introduced on vehicles sold in the United States today.

- In 1967, the State of California formed the California Air Resources Board (CARB) to develop and carryout air quality improvement programs for California's unique air pollution conditions. Through the years, CARB programs have evolved into what we now know as ON Board Diagnostics and the National Low Emission Vehicle Program.

- The EPA has adopted many of the CARB programs as National programs and laws. One of these earlier programs was OBD I and the introduction of the "CHECK ENGINE" Light.

- BMW first introduced OBD I and the check engine light in the 1987 model year. This enhanced diagnosis through the display of "flash codes" using the check engine light as well as the BMW 2013 and MoDiC. OBD I was only the first step in an ongoing effort to monitor and reduce tailpipe emissions.

- By the 1989 model year all automotive manufactures had to assure that all individual components influencing the composition of exhaust emissions would be electrically monitored and that the driver be informed whenever such a component failed.

- Since the 1996 model year all vehicles must comply with OBD II requirements. OBD II requires the monitoring of virtually every component that can affect the emission performance of a vehicle plus store the associated fault code and condition in memory.

  If a problem is detected and then re-detected during a later drive cycle more than one time, the OBD II system must also illuminate the "CHECK ENGINE" Light in the instrument cluster to alert the driver that a malfunction has occurred. **However, the flash code function of the Check Engine Light in OBD I vehicles is not a function in OBD II vehicles.**

- This requirement is carried out by the Engine Control Module (ECM/DME) as well as the Automatic Transmission Control Module (EGS/AGS) and the Electronic Throttle Control Module (EML) to monitor and store faults associated with all components/systems that can influence exhaust and evaporative emissions.

OBD I

The essential elements here are that electrical components which affect exhaust emissions are monitored by the motor-electronics system and an optical warning signal (CHECK ENGINE Light) is issued in the event of an OBD I-relevant malfunction. The corresponding fault can be read out via a flashing code without the aid of a testing device.

OBD II

Since January 1996, OBD II has been compulsory on all vehicles in the US market. The main difference from OBD I is that not only are the purely electrical components monitored but also all the systems and processes that affect exhaust emissions and fuel system evaporative emissions.

The operational reliability of the exhaust-treatment system must be guaranteed for 5 years and/or 100,000 miles; this is maintained by emission certification. In this case, the data relevant to exhaust/evaporative emissions are read out via a standardized interface with a universal "diagnosis device". If a violation is identified, the vehicle manufacturer in question is legally bound to eliminate the fault throughout the entire vehicle series.

Objectives of OBD II:

- Permanent monitoring of components relevant to exhaust emissions in all vehicles.

- Immediate detection and indication of significant emission increases over the entire service life of each vehicle.

- Permanently low exhaust emissions in the field.

Overview of the National Low Emission Vehicle Program

Emission Reduction Stages:

While OBD II has the function of monitoring for emission related faults and alerting the operator of the vehicle, the National Low Emission Vehicle Program requires a certain number of vehicles produced (specific to manufacturing totals) ***currently*** comply with the following emission stages;

TLEV: Transitional Low Emission Vehicle

LEV: Low Emission Vehicle

ULEV: Ultra Low Emission Vehicle.

Prior to the National Low Emission Vehicle Program, the most stringent exhaust reduction compliancy is what is known internally within BMW as **HC II**. The benefit of exhaust emission reductions that the National Low Emission Vehicle Program provides compared with the HC II standard is as follows:

TLEV- 50% cleaner.

LEV- 70% cleaner.

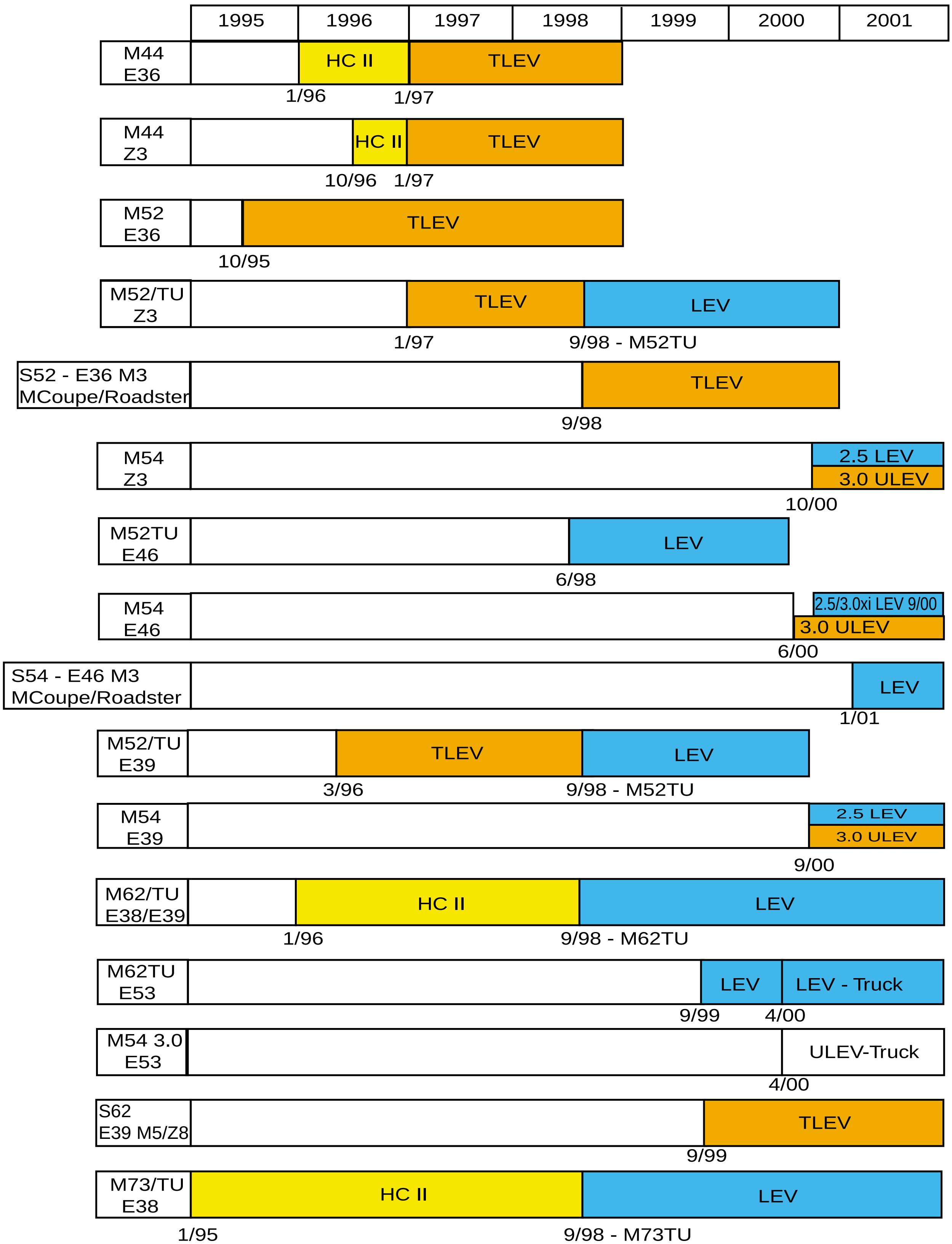
ULEV- 84% cleaner.

Grams per Mile @ 50^{O} F - Cold Engine Startup			
Compliance Level	NMHC Non Methane Hydrocarbon	CO Carbon Monoxide	NOx Oxide(s) of Nitrogen
TLEV	0.250	3.4	0.4
LEV	0.131	3.4	0.2
ULEV	0.040	1.7	0.2

Grams/Mile at 50,000 miles			
Compliance Level	NMHC Non Methane Hydrocarbon	CO Carbon Monoxide	NOx Oxide(s) of Nitrogen
TLEV	0.125	3.4	0.4
LEV	0.075	3.4	0.2
ULEV	0.040	1.7	0.2

Grams/Mile at 100,000 miles			
Compliance Level	NMHC Non Methane Hydrocarbon	CO Carbon Monoxide	NOx Oxide(s) of Nitrogen
TLEV	0.156	4.2	0.6
LEV	0.090	4.2	0.3
ULEV	0.055	2.1	0.3

OBD II Emission Compliance



System Monitoring

Within the framework of OBD II, certain components/systems must be monitored once per driving cycle while other control systems (e.g. misfire detection) must be monitored permanently. ***A "driving cycle" consists of engine startup, vehicle operation (exceeding of starting speed), coasting and engine stopping.***

Permanent Monitoring

Permanently monitored systems are monitored according to temperature immediately after startup. In the event of malfunctions (e.g. oxygen sensor), the Malfunction Indicator Light will illuminate immediately.

The following are monitored permanently:

- Misfire Detection
- Fuel System (duration of injection)
- All emission related electrical circuits, components and systems of the ECM, TCM and EML (if equipped).

Cyclic monitoring

Systems monitored once per driving cycle will only result in a fault being registered after the corresponding operating conditions have been completed. Therefore, there is no possibility for checking when the engine is started up briefly and then shut down.

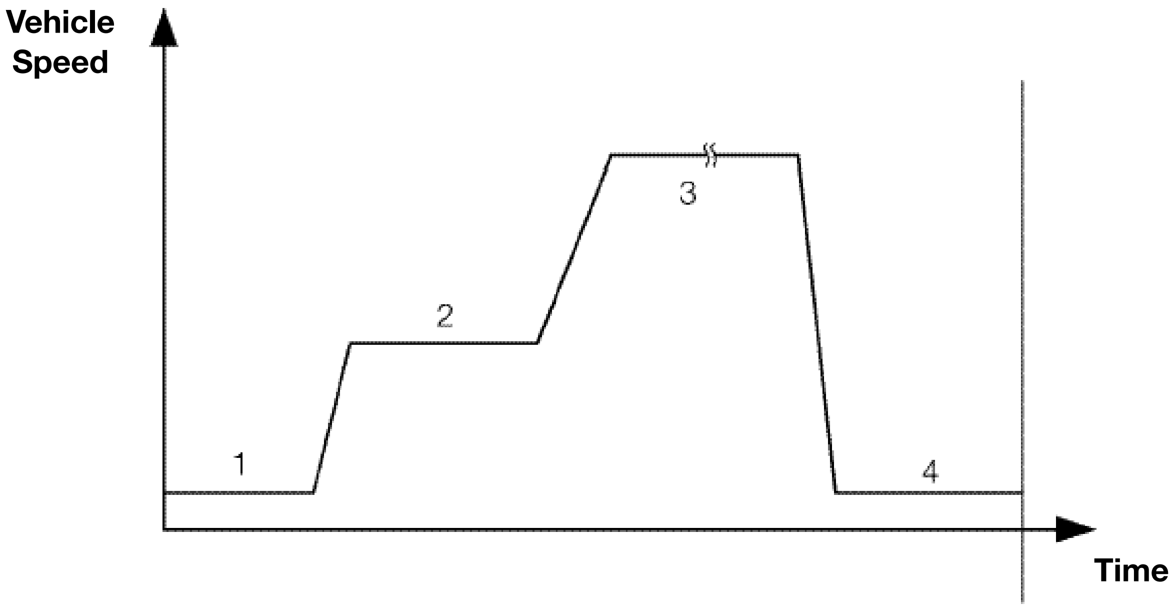
The following are monitored once per driving cycle:

- Oxygen Sensor Function
- Secondary Air Injection System
- Catalytic Converter Function (efficiency)
- Evaporative Vapor Recovery System

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

Drive Cycle

The following diagram shows how a drive cycle is set (test drive) in order for all the systems to be monitored once. The test conditions can be created in any desired order after start-up.



Example of a Drive Cycle for Completing all OBD II Relevant Checks

1. Engine cold start, idling, approximately 3 minutes. Evaluated:

• Secondary Air System **• Evaporative Leak Detection (LDP Equipped Vehicles)**

2. Constant driving at 20 to 30 MPH, approximately 4 minutes. Evaluated:

• Oxygen Sensors - Achieved "Closed Loop" Operation **• Oxygen Sensors - Response Time and Switching Time (Control Frequency)**

3. Constant driving at 40 to 60 MPH, approximately 15 minutes (sufficient vehicle coast ing phases included). Evaluated:

• Catalytic Converter Efficiency **• Oxygen Sensors - Response Time and Switching Time (Control Frequency)**

4. Engine idling, approximately 5 minutes. Evaluated:

• Tank-Leak Diagnosis (DM TL Equipped Vehicles after KL 15 is switched OFF)

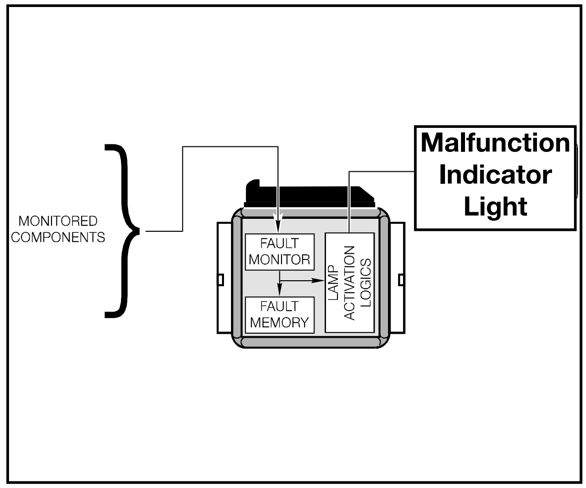
NOTE: The diagnostic sequence illustrated above will be interrupted if:

• The engine speed exceeds 3000 RPM.	**• Large fluctuations in the accelerator pedal position.**
• The driving speed exceeds 60 MPH.	

The “Malfunction Indicator Light” (MIL) will be 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 (Misfire Detection).



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 Malfunction Indicator 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 Malfunction Indicator Light is illuminated based on the "customer drive cycle".

TEXT NO.	DRIVE CYCLE # 1			DRIVE CYCLE # 2			DRIVE CYCLE # 3			DRIVE CYCLE # 4			DRIVE CYCLE # 5			* DRIVE CYCLE # 43		
	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

1. A fault code is stored within the ECM upon the first occurrence of a fault in the system being checked.

2. The "Malfunction Indicator 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 occurred.

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 "Malfunction Indicator Light” is illuminated if the function is checked and the fault is still present.

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 "Malfunction Indicator Light” to be illuminated.

5. Once the "Malfunction Indicator 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 memory 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 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 "Malfunction Indicator Light”. Using the DISplus or MODIC, a fault code and the conditions associated with its setting can be obtained prior to the illumination of the "Malfunction Indicator Light”.

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 or the DISplus/MoDIC**. The code is a binary (1/0) indicating;

- 0 = Test Not Completed or Not Applicable - six cylinder vehicles (not ready - V8 and V12)
- 1 = Test Completed - six cylinder vehicles (ready - V8 and V12)

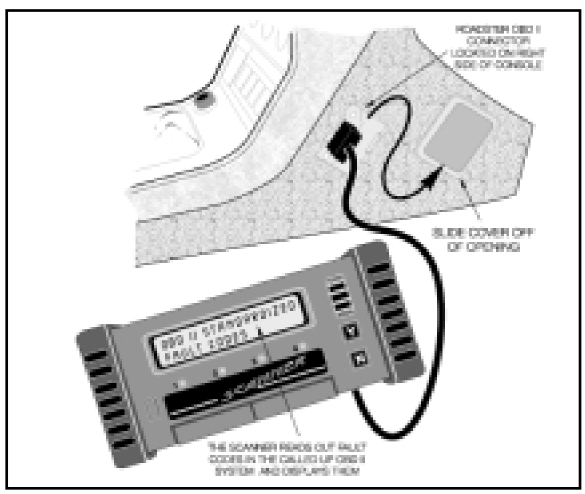
A "readiness code" must be stored after any clearing of fault memory or disconnection of the ECM. A readiness code of "0" will be stored (see below) after a complete diagnostic check of all components/systems, that can turn on the "Malfunction Indicator Light" is performed.

The readiness code was established to prevent anyone with an emissions related fault and a "Malfunction Indicator 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. For example:

0 = EGR Monitoring (=0, N/A with BMW)



1 = Oxygen Sensor Heater Monitoring

1 = Oxygen Sensor Monitoring

0 = Air Condition (=0, N/A with BMW)

1 = Secondary Air Delivery Monitoring

1 = Evaporative System Monitoring

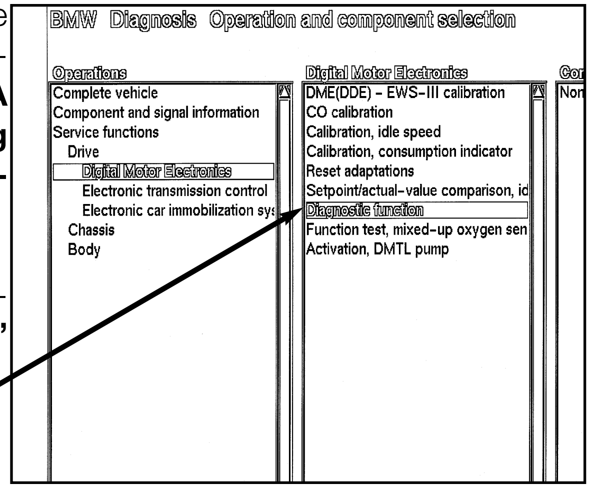
0 = Catalyst Heating

1 = Catalyst Efficiency Monitoring

Drive the car in such a manner that all tests listed above can be completed (refer to the drive cycle). When the complete "readiness code" equals "1" (ready) then all tests have been completed and the system has established its "readiness".

Readiness Code using the DISplus/MoDIC

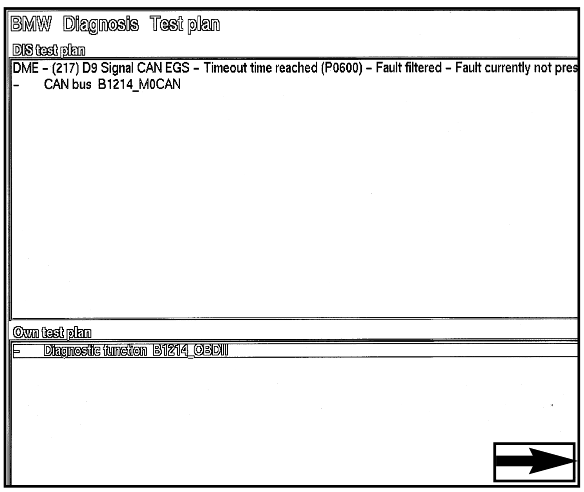
The readiness code can be checked with the DISplus/MoDIC. This is particularly helpful in verifying that "drive cycle" criteria was achieved. **A repair can be confirmed before returning the vehicle to the customer by a successfully completed drive cycle.**

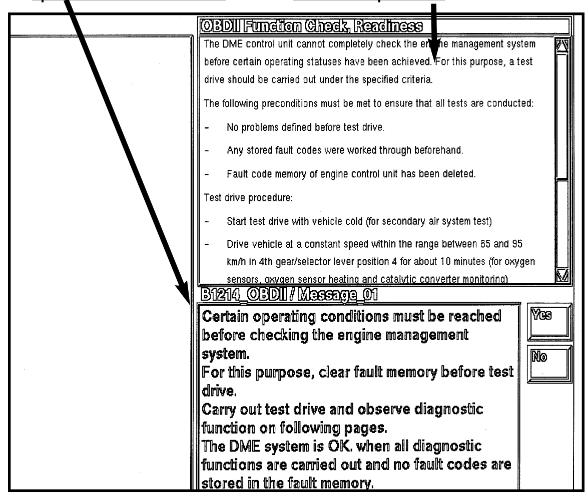


Using an MS43 system for example, the readiness code is found under **"Service Functions"**

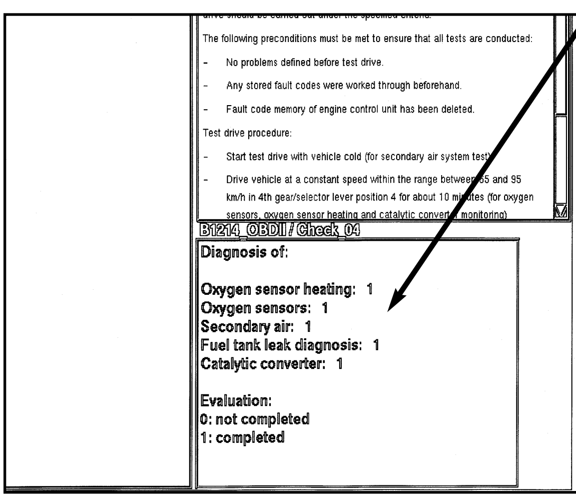
- **Drive**
- **Digital Motor Electronics**
- **Diagnostic Function**

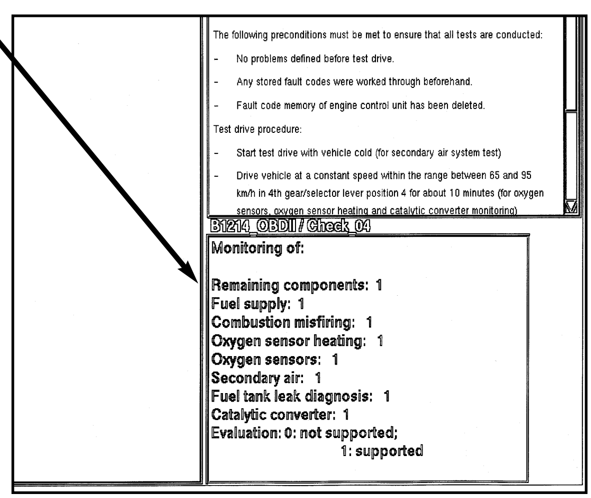
Select **"Own Test Plan"** OBD II Readiness preconditions and description is shown:





Examples of functions/components checked are shown below:





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 "Malfunction Indicator 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 environmental operating conditions when a fault is stored. This single "Freeze Frame" or snapshot refers to a block of the vehicles environmental conditions for a 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.

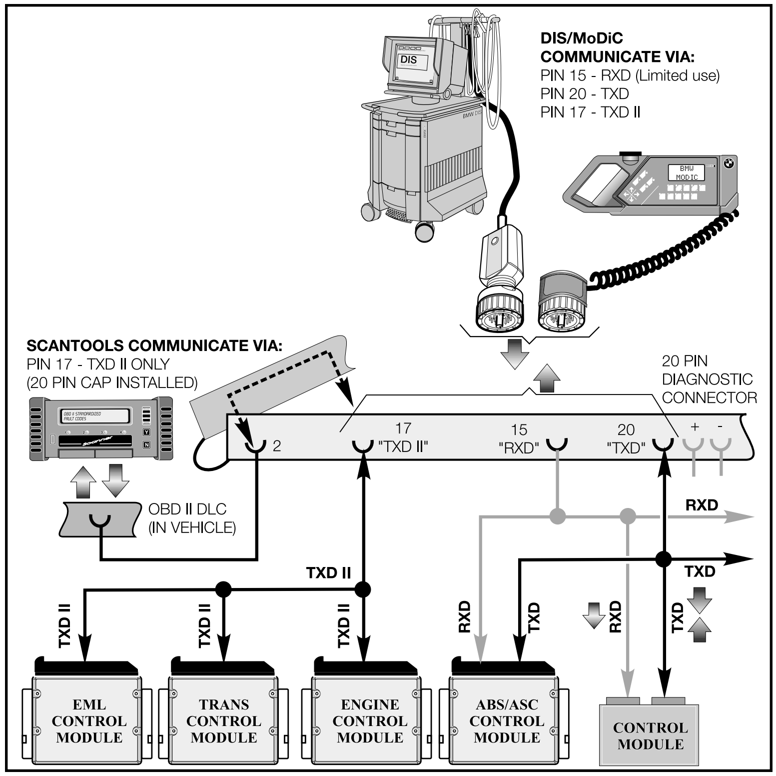
Scan Tool Connection

Starting with the 1995 750iL, soon after on all 1996 model year and later BMW vehicles, a separate OBD II Diagnostic Link Connector (DLC) was added.

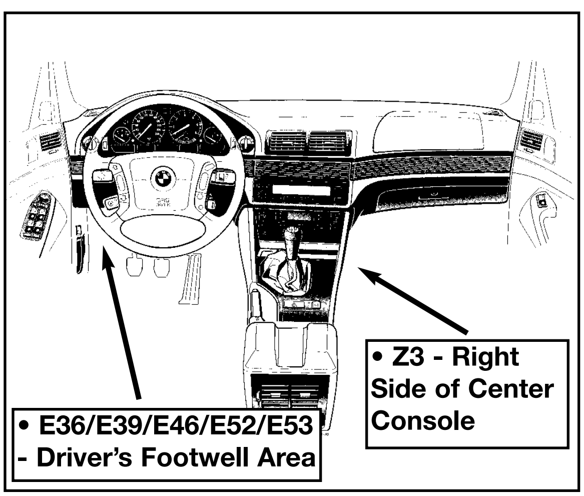
The DLC provides access for an aftermarket scan tool to all emission related control systems:

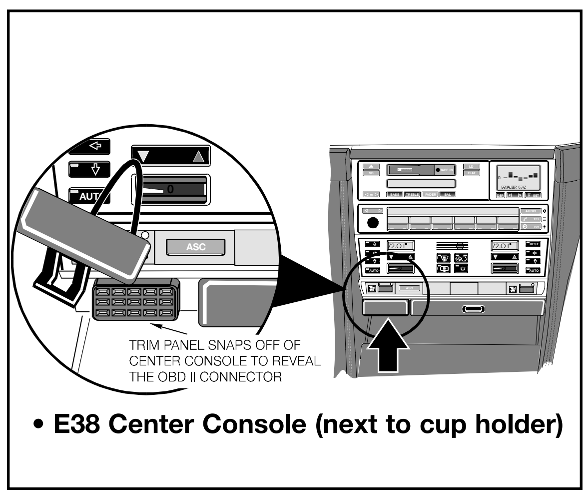
- ECM - Engine Management Monitored Emissions Functions/ Components
- TCM (AGS/EGS) -Transmission Control
- EML - Electronic Throttle Control

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.



The DLC Connector bridging cap is marked **"OBD II"** and is found:





NOTE: E38 and older models have a cosmetic cover and a secured DLC cover.

20 Pin Diagnostic Socket Deletion

Model and Production Date: E46 from 6/00
E39, E52, E53 from 9/00

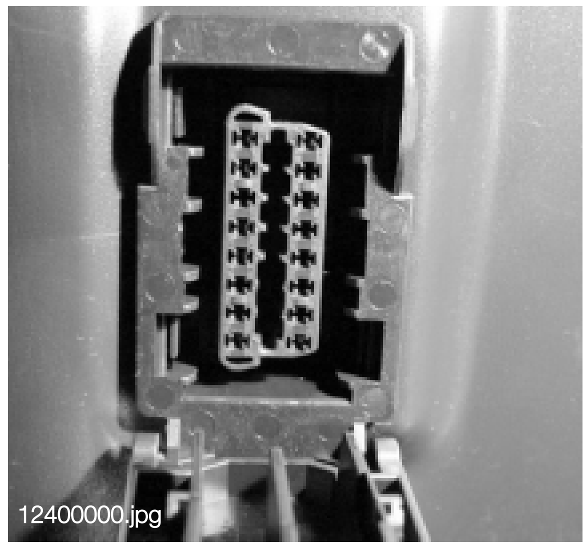
For model year 2001 the E39, E46 and E53 will eliminate the 20 pin diagnostic connector from the engine compartment. The 16 pin OBD II connector located inside the vehicle will be the only diagnosis port.

The E38 and Z3 will continue to use the 20 pin connector until the end of production.

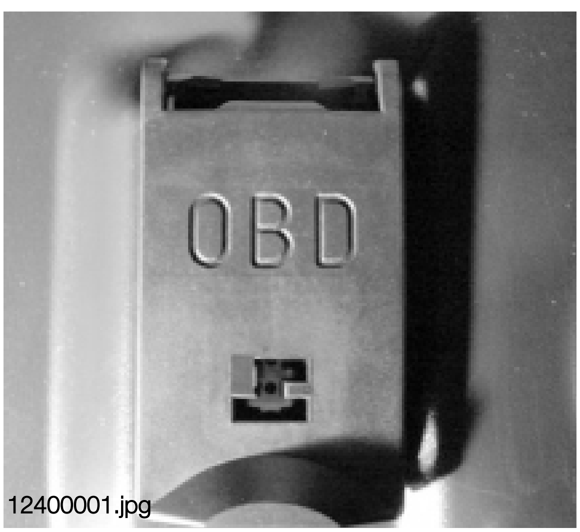
The 16 pin OBD II connector has been in all BMWs since 1996 to comply with OBD regulations requiring a standardized diagnostic port.

Previously before 2001, only emissions relevant data could be extracted from the OBD II connector because it did not provide access to TXD (D-bus).

The TXD line is connected to pin 8 of the OBD II connector on vehicles without the 20 pin diagnostic connector.


12400000.jpg

The cap to the OBD II connector contains a bridge that links KL 30 to TXD and TXD II. This is to protect the diagnostic circuit integrity and prevent erroneous faults from being logged.

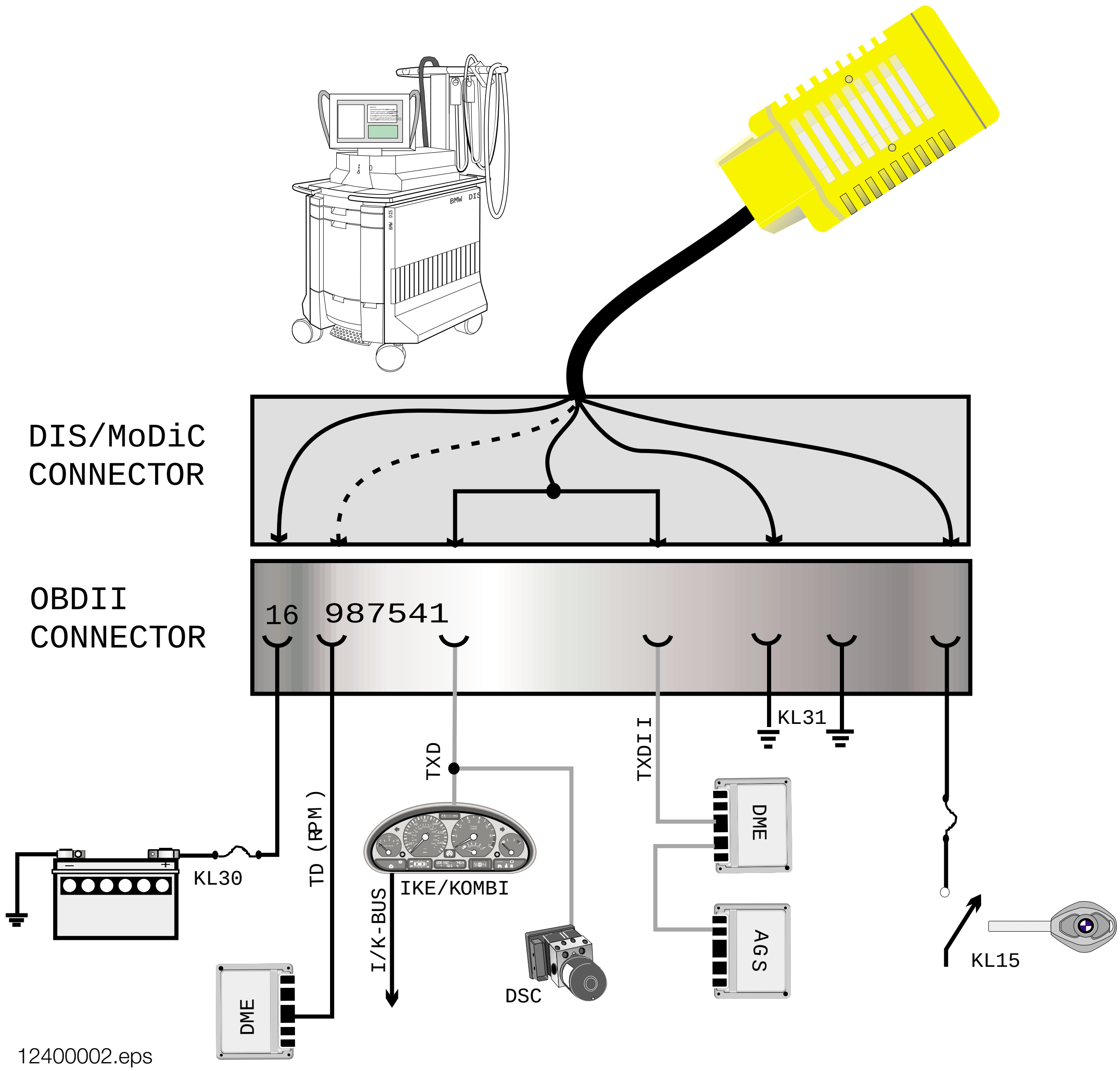


12400001.jpg

The OBD II connector is located in the driver's footwell to the left of the steering column for E39, E46 and E53 vehicles.

Special tool 61 4 300 is used to connect to the 20 pin diagnostic lead of the DIS until the introduction of the DISplus.

Diagnostics via the OBD II Connector



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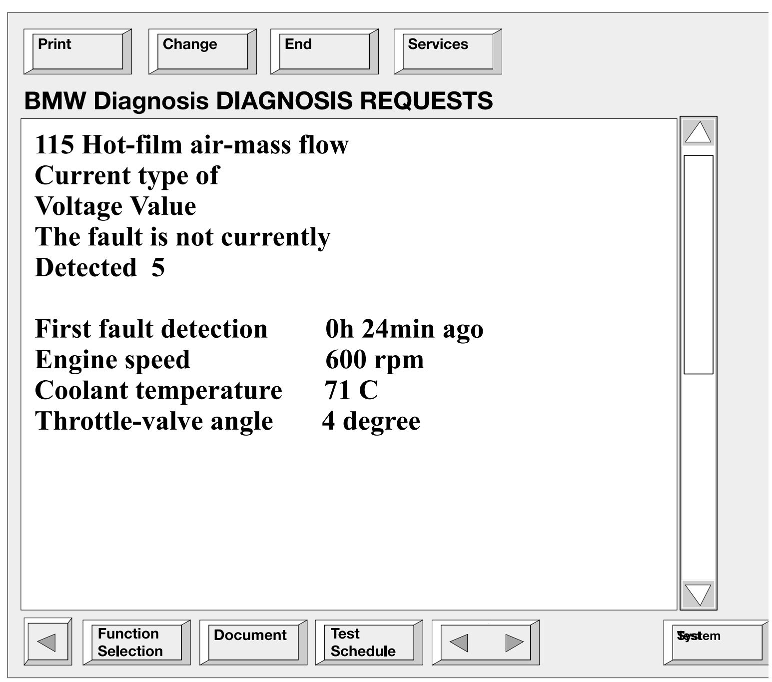
BMW Fault Code (DISplus/MoDiC)

- BMW Codes are stored as soon they occur even before the "Malfunction Indicator Light" comes on.
- BMW Codes are defined by BMW, Bosch and Siemens Engineers to provide greater detail to fault specific information.
- **Siemens systems** - one set from four fault specific environmental conditions is 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.
- **Bosch systems** - a maximum of four sets from three fault specific environmental conditions is stored within each fault code. This information can change and is specific to each fault code to aid in diagnosing. A maximum of ten different faults containing three environmental conditions can be stored.
- BMW Codes also store and displays a "time stamp" when the fault last occurred.
- A fault qualifier gives more specific detailed information about the type of fault (upper limit, lower limit, disconnection, plausibility, etc.).
- BMW Fault Codes will alert the Technician of the current fault status. He/she will be advised if the fault is actually still present, not currently present or intermittent.

  The fault specific information is stored and accessible through DISplus/MoDIC.

- BMW Fault Codes determine the diagnostic output for BMW DISplus/MoDIC.



OBD II Fault Memory and Fault Codes

Within the framework of OBD II, a diagnosis of all emission-related components/functions must take place during driving. Faults will be stored and displayed if necessary. For this purpose, the ECM includes OBD II memory. The standardized P codes for malfunctions are stored in this memory. The memory can be read out with the DISplus/MoDIC or a Scantool.

Emission Control Function Monitoring & Comprehensive Component Monitoring

OBD II regulations are based on section 1968.1 of Title 13, California Code of Regulations (CCR), The law set forth in section 1968.1 requires an increased scope of monitoring emission related control functions including:

- Catalyst Monitoring
- Heated Catalyst Monitoring (currently used on BMW 750iL vehicles)
- Misfire Monitoring
- Evaporative System Monitoring
- Secondary Air System Monitoring
- Air Conditioning System Refrigerant Monitoring (Not applicable for BMW vehicles)
- Fuel System Monitoring
- Oxygen Sensor Monitoring
- Exhaust Gas Recirculation (EGR) System Monitoring (Not applicable for BMW vehicles)
- Positive Crankcase Ventilation (PCV) System Monitoring (Not required at this time).
- Thermostat Monitoring (if equipped)

Monitoring these emission requirements is a function of the ECM which uses "data sets" while monitoring the conditions of the environment and the operation of the engine using existing input sensors and output actuators.

The data sets are programmed reference values the ECM refers to when a specific monitoring procedure is occurring. If the ECM cannot determine the environmental and/or engine operating conditions due to an impaired or missing signal, it will set a fault and illuminate the "Malfunction Indicator Light".

This input or control signal monitoring falls under another category called ***"Comprehensive Component Monitoring".*** The ECM must recognize the loss or impairment of the signal or component. The ECM determines a faulted signal or sensor via three conditions:

1. Signal or component shorted to ground.
2. Signal or component shorted to B+.
3. Signal or component *lost* (open circuit).

Specific fault codes are used to alert the diagnostician of these conditions.

Review Questions

1. What is required to illuminate the “Malfunction Indicator” Light? ____________________
____
____
____
____

2. What are the definitions and differences between TLEV, LEV and ULEV?

   - TLEV = ____
   - LEV = ____
   - ULEV = ____

3. What is the OBD II Emission Compliance of a:

   - E46 M3 _______ • 2001 3.0 Liter E46 _______ • 1997 six cylinder E39 _______

4. What systems/components that are:

Permanently Monitored	Monitored Once per Drive Cycle
• ____________________________	• ____________________________
• ____________________________	• ____________________________
• ____________________________	• ____________________________
	• ____________________________

5. Under what Operations “heading” (using the DISplus/MoDIC) will you access the Readiness Code status for an MS43 equipped E46? ______________________________

6. List the DLC connector locations in the following BMW vehicles:

   - E38 ___________________________ • Z3 ___________________________
   - Z8 ___________________________ • E46 ___________________________

7. What are the three conditions an ECM uses to determine a faulted signal/sensor?

   - ______________________________________
   - ______________________________________
   - ______________________________________

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X	X	1	1	EVAP: LDP Valve - Final Stage	Final stage check	Output digital on/off (active low)	LDP	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. Occurs
X			1	1	Ignition Coil Cyl. 2	Ignition feedback	Input analog 100 mV Timing	Ignition Shunt Resistor	The DME initiates the secondary ignition for each cylinder then looks for the feedback through the shunt resistor in the harness to determine if the ignition actually occurred.
		X	2	2	Running losses valve - Final stage	Final stage check	Output digital pulse width (active low)	Running losses -valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. Occurs
X			2	2	Ignition Coil Cyl. 4	Ignition feedback	Input analog 100 mV Timing	Ignition Shunt Resistor	The DME initiates the secondary ignition for each cylinder then looks for the feedback through the shunt resistor in the harness to determine if the ignition actually occurred.
		X	3	3	EVAP: Reed Switch not closed, doesn't open or doesn't close	EVAP monitoring	Input digital 0-12V on/off	LDP reed contact switch	Within a predetermined time the LDP reed switch signal has to change from high to low or from low to high or LDP reed switch is "low" for longer then the predetermined time.
X			3	3	Ignition Coil Cyl. 6	Ignition feedback	Input analog 100 mV Timing	Ignition Shunt Resistor	The DME initiates the secondary ignition for each cylinder then looks for the feedback through the shunt resistor in the harness to determine if the ignition actually occurred.
	X		2	2	EVAP: DMTL Valve - Final Stage	Final stage check	Output digital on/off (active low)	DMTL	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. Occurs
	X		3	3	Swapped O2 Sensors Pre Cat.	O2-Sensor check	DME internal Value logical	O2-Sensor	Fault will set if the fuel control from one bank reaches the rich threshold while the other bank reaches the lean threshold.
	X		4	4	O2-Sensor-Heater, Post Cat.(Bank2), final stage and insufficient heating.	Final stage check	Output digital pulse width (active low)	O2 Sensor Heater	The final stage is monitored for proper voltage drop: output on u <= 3.6 V; output off u >= 2.34 V; heater power is checked by the inner resistance of the sensor which represents the sensor
		X	4	4	O2-Sensor-Heater, Post Cat.(Bank2), Insufficient Heating.	Final stage check	Output digital pulse width (active low)	O2 Sensor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		5	5	O2-Sensor-Heater, Pre Cat.(Bank2), final stage and insufficient heating.	Final stage check	Output digital pulse width (active low)	O2 Sensor Heater	The final stage is monitored for proper voltage drop: output on u <= 3.6 V; output off u >= 2.34 V; heater power is checked by the inner resistance of the sensor which represents the sensor
X			5	5	Injector Circuit Cylinder 2	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	5	5	O2 Sensor Heater, Pre Cat.(Bank2), insufficient.	Final stage check	Output digital pulse width (active low)	O2 Sensor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			6	6	Injector Circuit Cylinder 1	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
		X	6	6	CAN-Timeout Instrument Cluster	Timing check	Input digital 0-12V Binary information	Instrument Cluster	The CAN message was not received within the expected time
		X	7	7	Engine coolant temperature, radiator outlet	Signal range check	Input analog 0-12V Voltage	temperature sensor on radiator outlet	Failed the Signal Range check against predefined diagnostic limits
		X	8	8	Misfire with low fuel detected	Misfire monitoring	DME internal values logical	Calculated	Misfire fault was recorded while the low fuel / reserve light in the instrument cluster was illuminated.
X			8	8	Mass or Volume Air Flow Circuit, Range/Perf.	Signal range check	Input analog 0-5V Voltage	HFM	Failed the Signal Range check against predefined diagnostic limits
	X	X	10	0A	O2 Sensor Pre Cat. (Bank1)	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	The oxygen sensor signal range is checked to determine if electrical faults exist on the sensor line.
X			10	0A	Engine Coolant Temp, Circuit Range/Perf.	Signal range check	Input analog 0-5V Voltage	Coolant Temp sensor	Signal Range is checked against the predefined diagnostic limits within specific engine operations.
X			11	0B	Coolant Temperature Cooler outlet	Signal range check	Input analog 0-5V Voltage	Coolant Temp sensor	Signal Range is checked against the predefined diagnostic limits within specific engine operations.
	X	X	12	0C	O2 Sensor Post Cat.(Bank1)	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	The oxygen sensor signal range is checked to determine if electrical faults exist on the sensor line.
	X		13	0D	O2-Sensor-Heater, Pre Cat.(Bank1), final stage and insufficient heating.	Final stage check	Output digital pulse width (active low)	O2 Sensor Heater	The final stage is monitored for proper voltage drop: output on u <= 3.6 V; output off u >= 2.34 V; heater power is checked by the inner resistance of the sensor which represents the sensor
		X	13	0D	O2 Sensor Heater Circuit Pre Cat (Bank1)	Final stage check	Output digital pulse width (active low)	O2 Sensor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		14	0E	O2-Sensor-Heater, Post Cat.(Bank1), final stage and insufficient heating.	Final stage check	Output digital pulse width (active low)	O2 Sensor Heater	The final stage is monitored for proper voltage drop: output on u <= 3.6 V; output off u >= 2.34 V; heater power is checked by the inner resistance of the sensor which represents the sensor
		X	14	0E	O2-Sensor-Heater, Post Cat. (Bank1), insufficient.	Final stage check	Output digital pulse width (active low)	O2 Sensor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			14	0E	Intake Air Temperature Range/Performance	Signal range check	Input analog 0-5V Voltage	IntakeTempsensor	Signal Range is checked against predefined diagnostic limits within specific engine operations.
	X	X	15	0F	O2 Sensor Pre Cat. (Bank1) Slow Response time	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	Checks the amount of time the oxygen sensor stays in its rich or lean state. If it remains too long in either rich or lean condition, the fault will set.

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X		17	11	O2 Sensor Post Cat. (Bank1) Activity	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	If engine is in fuel cut off for a predeterminded time the sensor voltage must be below 200 mV. If trim control is active the sensor voltage must change.
		X	17	11	O2 Sensor Post Cat. (Bank1), Slow Response time	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	Checks the amount of time the oxygen sensor stays in its rich or lean state. If it remains too long in either the rich or the lean condition, the fault will set.
	X	X	18	12	O2 Sensor Pre Cat. (Bank2)	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	The oxygen sensor signal range is checked to determine if electrical faults exist on the sensor line.
X			18	12	Camshaft Position Sensor exhaust cam, Malfunction	Rationality check	Input analog 0-5V phase shift	CAM sensor	Internal check of the phase shift from the cam sensor which should change during every crankshaft revolution. The phase shift occurs due to the 2:1 mechanical relationship between cam
X			19	13	VANOS-Magnetical valve; exhaust side	Final stage check	Output digital pulse width (active low)	VANOS-Solenoid exhaust	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	19	13	CAN Signal, Timeout EKAT	Timing check	Input digital 0-5V Binary information	EKAT-ECU	The CAN message from the EKat ECU was not received within the expected time
	X	X	20	14	O2 Sensor Post Cat. (Bank2)	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	The oxygen sensor signal range is checked to determine if electrical faults exist on the sensor line.
X			21	15	VANOS-Magnetical valve;Intake side	Final stage check	Output digital pulse width (active low)	VANOS-Solenoid intake	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
	X	X	21	15	O2 Sensor Pre Cat. (Bank2) Slow Response time	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	Checks the amount of time the oxygen sensor stays in its rich or lean state. If it remains too long in either the rich or the lean condition, the fault will set.
X			22	16	Injector Circuit Cylinder 3, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
X			23	17	Injector Circuit Cylinder 6, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
	X		23	17	O2 Sensor Post Cat. (Bank2) Activity	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	If engine is in fuel cut off for a predeterminded time the sensor voltage must be below 200 mV. If trim control is active the sensor voltage must change.
X			24	18	Injector Circuit Cylinder 4, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
	X		24	19	Fuel Trim at part load above threshold (Bank2) Multiplicative	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
		X	24	18	AC Compressor Function	Rationality check	Input digital 0-12V on/off	IHKA	Fault will set if AC-Switch is off and Compressor Switch is on.
X			25	19	O2 Sensor Heater Circuit Pre Cat (Bank1)	Final stage check	Output digital pulse width (active low)	O2 Sensor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
	X		25	19	Fuel Trim at part load above threshold (Bank2) Multiplicative	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
		X	26	1A	Fuel Trim at part load (Bank1), Multiplicative	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
	X		26	1A	Fuel Trim at part load below threshold (Bank1) Multiplicative	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
X			27	1B	Idle Control Valve Closing Coil, Malfunction	Final stage check	Output digital pulse width 120Hz (active low)	Idle control valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	27	1B	Fuel Adaptation Additive at idle air leak (Bank 1)	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
	X		27	1B	Fuel Trim at part load below threshold (Bank2) Multiplicative	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
	X	X	28	1C	Fuel Trim (Bank1) Additive	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
		X	29	1D	Air containment valve for air control of shrouded fuel Injector (Bank 1)	Final stage check	Output digital on/off (active low)	air containment valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			29	1D	Ignition Coil Cyl. 1	Ignition feedback	Input analog 100 mV Timing	Ignition Shunt Resistor	The DME initiates the secondary ignition for each cylinder then looks for the feedback through the shunt resistor in the harness to determine if the ignition actually occurred.
	X		29	1D	Fuel Trim (Bank2) Additive	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
X			30	1E	Ignition Coil Cyl. 3	Ignition feedback	Input analog 100 mV Timing	Ignition Shunt Resistor	The DME initiates the secondary ignition for each cylinder then looks for the feedback through the shunt resistor in the harness to determine if the ignition actually occurred.
		X	30	1E	EKAT-Status 7 - power switch control	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set by the EKat ECU, if an internal generated voltage in the EKat ECU drops below threshold

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			31	1F	Ignition Coil Cyl. 5	Ignition feedback	Input analog100 mVTiming	Ignition Shunt Resistor	The DME initiates the secondary ignition for each cylinder then looks for the feedback through the shunt resistor in the harness to determine if the ignition actually occurred.
	X	X	32	20	Idle Control	Rationality check	DME internal values logical	Idle control	Plausibility check between the actual engine speed and the predetermined engine speed. Fault will set if not within the desired RPM range (+200/-100 rpm)
	X		33	21	VANOS System Malfunction Bank 1	Rationality check	DME internal values logical	VANOS unit camshaft sensor wheel	The VANOS system is monitored for mechanical faults (slow response) by the time it takes to reach the target position;The position of the sensor wheel is checked by comparison of cam
X			33	21	Injector Circuit Cylinder 5, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	33	21	EKAT-Status 8 - EKAT-ECU	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set by the EKat ECU, if an checksum error is detected
	X		34	22	VANOS System Malfunction Bank 2	Rationality check	DME internal values logical	VANOS unit camshaft sensor wheel	The VANOS system is monitored for mechanical faults (slow response) by the time it takes to reach the target position;The position of the sensor wheel is checked by comparison of cam
		X	34	22	Fuel Trim (Bank2), Multiplicative	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
X			35	23	Secondary Air Injection System , el. Pump	Final stage check	Output digital on/off (active low)	Air pump	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	35	23	Fuel Adaptation Additive at idle air leak (Bank 2)	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
		X	36	24	Fuel Trim at idle (Bank2), Additive	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
X			39	27	plausibility between breaklight switch and breaklight test	Rationality check	Input digital 0-12V	Breaklight switch	Whenever the breaklight switch is active, the breaklight test switch must be also active. If not then this fault is stored
	X	X	39	27	EWS Content of Message	Manipulation Check	Input binary stream 0-12V Bit information	EWS	The content of the binary message received from EWS was invalid
X			40	28	plausibility between Breaklight switch and Pedal sensor	Rationality check	Input digital / analog 0-12V / 0-5V	Braklight swithch and Pedal sensor poti	If the pedal sensor is showing an angle greater than the "limp home angle" and additionally the breaklight switch is active than this fault is stored.
	X	X	40	28	Catalyst Efficiency Bank 1 Below Threshold	Catalyst monitoring	Input analog 0-1V Voltage	O2 Sensor pre/post catalyst	Compares the value of the pre cat O2 sensor to value of the post cat O2 sensor to measure the oxygen storage capability / efficiency of the catalytic converter. The post O2 sensor must be

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
		X	42	2A	EKAT-Status 1 - Disabeling of heater for Catalyst 1	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set, if the EKat ECU detects an electrical error of heater 1 (disconnection, low voltage befor / during heating, short circuit)
X			42	2A	Signal multi functional steering wheel, redundant code transmission	Rationality check	Input binary stream 0-12V	Multi functional steering wheelCruise control switch	Every signal from the cruese control switch is transfered redundantly coded. A Fault is set, whenever the two redundant information paths are showing a different status.
X			43	2B	Signal multi functional steering wheel, control switch	Rationality check	Input binary stream 0-12V	Multi functional steering wheel	When the status from cruise control showing set/accelerate and deceleration at the same time, then a fault is set.
		X	43	2B	EKAT-Status 2 - heater power for Catalyst 1	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set by the EKat ECU, if heater power of heater 1 drops below threshold
		X	44	2C	EKAT-Status 3 - power switch Catalyst 1	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set, if the EKat ECU detects overtemperature of power switch for Catalyst 1or range check error of the temperature sensor
X			45	2D	Signal multi functional steering wheel, toggle-bit	Time out check	Input binary stream 0-12V	Multi functional steering wheel	every 0.5 sec. a message that includes a toggle bit (toggles between 0->1 and 1->0) is transmitted. The change of this bit is monitored and it indicates proper functionality.
	X	X	45	2D	Catalyst Efficiency Bank 2 Below Threshold	Catalyst monitoring	Input analog 0-1V Voltage	O2 Sensor pre/post catalyst	Compares the value of the pre cat O2 sensor to value of the post cat O2 sensor to measure the oxygen storage capability / efficiency of the catalytic converter. The post O2 sensor must be
		X	46	2E	EKAT-Status 4 - Disabeling of heater for Catalyst 2	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set, if the EKat ECU detects an electrical error of heater 2 (disconnection, low voltage befor / during heating, short circuit)
		X	47	2F	EKAT-Status 5 - heater power of Catalyst 2	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set by the EKat ECU, if heater power of heater 1 drops below threshold
		X	48	30	EKAT-Status 6 - power switch catalyst 2	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set, if the EKat ECU detects overtemperature of power switch for Catalyst 2 or range check error of the temperature sensor
X			50	32	Running Loss Valve (3/2), final stage	Final stage check	Output digital on/off (active low)	RL valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
	X	X	50	32	Cylinder 1 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 1 is longer the fault
		X	51	33	Cylinder 2 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 2 is longer the fault
	X		51	33	Cylinder 8 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 2 is longer the fault

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			52	34	Rear Exhaust Valve flap	Final stage check	Output digitalsteady (active low)	Valve for exhaust flap	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	52	34	Cylinder 3 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 3 is longer the fault
	X		52	34	Cylinder 6 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 3 is longer the fault
X			53	35	Idle Control Valve Opening Coil, Malfunction	Final stage check	Output digital pulse width 120Hz (active low)	Idle control valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	53	35	Cylinder 4 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 4 is longer the fault
	X		53	35	Cylinder 3 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 4 is longer the fault
		X	54	36	Cylinder 5 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 5 is longer the fault
	X		54	36	Cylinder 2 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 5 is longer the fault
X			55	37	O2 Sensor Heater Circuit Pre Cat (Bank2)	Final stage check	Output digital pulse width (active low)	O2 Sensor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	55	37	Cylinder 6 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 6 is longer the fault
	X		55	37	Cylinder 5 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 6 is longer the fault
	X	X	56	38	Cylinder 7 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 7 is longer the fault
X			56	38	Ignition Feedback, interruption at shunt resistor	Ignition feedback	Input analog 32V Voltage	Ignition Shunt Resistor	Check for correct signal voltage. If Voltage is 32V (Zener limitation voltage) than secondary ignition voltage is detected then there might be a problem with the shunt resistor in the
X			57	39	Knock Sensor 1 Circuit, (Bank 1)	Circuit continuitySignal range check	Input analog 13-19kHz Amplitude	Knock sensor	Plausibility Check between the knock sensor amplitude during knocking with the internal knock detection mapped DME values.

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
		X	57	39	Cylinder 8 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 8 is longer the fault
	X		57	39	Cylinder 4 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 8 is longer the fault
X			59	3B	Knock Sensor 2 Circuit, (Bank 2)	Circuit continuitySignal range check	Input analog 13-19kHz Amplitude	Knock sensor	Plausibility Check between the knock sensor amplitude during knocking with the internal knock detection mapped DME values.
X			61	3D	O2 Sensor Heater Circuit Post Cat (Bank2)	Final stage check	Output digital pulse width (active low)	O2 Sensor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
X			62	3E	Secondary Air Inj. System Switching Valve	Final stage check	Output digital on/off (active low)	Air valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
	X	X	62	3E	Random/Multiple Cylinder Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for a cylinder is longer the fault will set.
		X	63	3F	Cylinder 1 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 1 is longer the fault
		X	64	40	Cylinder 2 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 2 is longer the fault
X			65	41	Camshaft Position Sensor intake cam, Malfunction	Rationality check	Input analog 0-5V phase shift	CAM sensor	Internal check of the phase shift from the cam sensor which should change during every crankshaft revolution. The phase shift occurs due to the 2:1 mechanical relationship between cam
		X	65	41	Cylinder 3 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 3 is longer the fault
		X	66	42	Cylinder 4 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder41 is longer the fault
		X	67	43	Cylinder 5 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 5 is longer the fault
X			68	44	EVAP System, Purge Control Valve Circuit	Final stage check	Output digital pulse width (active low)	purge valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
		X	68	44	Cylinder 6 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 6 is longer the fault
X			69	45	Relay Fuel Pump	Final stage check	Output digital on/off (active low)	Relay fuel pump	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	69	45	Cylinder 7 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 7 is longer the fault
		X	70	46	Cylinder 8 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 8 is longer the fault
		X	71	47	Cylinder 9 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 9 is longer the fault
		X	72	48	Cylinder 10 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 10 is longer the
		X	73	49	Cylinder 11 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 11 is longer the
X			74	4A	Relay AC Compressor	Final stage check	Output digital on/off (active low)	Relay AC Compr.	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	74	4A	Cylinder 12 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 12 is longer the
		X	75	4B	Random/Multiple Cylinder, Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for a cylinder is longer the fault
		X	77	4D	air containment valve for air control of shrouded fuel Injector (Bank 2)	Final stage check	Output digital on/off (active low)	air containment valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	78	4E	Crankshaft Position Sensor (too many teeth)	Rationality check	Input digital 0-12V Frequency/pattern	Crank sensor	Crank sensor signal reports that too many teeth were detected within one crankshaft revolution. The fault will set if more teeth was detected than the default value.
X			79	4F	O2 Sensor Heater Circuit (Bank1,Sensor2)	Final stage check	Output digital pulse width (active low)	O2 Sensor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
	X		80	50	Secondary Air Control Bank 1	Secondary Air Delivery	Input analog 0-1V Voltage	O2 Sensor	Checks to see if the O2 sensor reacts to the increase in unmetered air flow generated by the secondary air pump operation. The O2 sensor must sense the lean condition or a

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
		X	80	50	Secondary Air Control	Secondary Air Delivery	Input analog 0-1V Voltage	O2 Sensor	Checks to see if the O2 sensor reacts to the increase in unmetered air flow generated by the secondary air pump operation. The O2 sensor must sense the lean condition or a
		X	81	51	EKAT-Status 9 - sensor check temperature sensor (1) in battery terminal	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Signal Range is checked against predefined diagnostic limits
	X		81	51	Secondary Air Control Bank 2	Secondary Air Delivery	Input analog 0-1V Voltage	O2 Sensor	Checks to see if the O2 sensor reacts to the increase in unmetered air flow generated by the secondary air pump operation. The O2 sensor must sense the lean condition or a
		X	82	52	EKAT-Status 10 - sensor check temperature sensor (2) in battery terminal	Electrical heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Signal Range is checked against predefined diagnostic limits
		X	83	53	EKAT-Status 11 - plausibility check of temperature sensor in battery terminal	Electrical heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Plausibility check between the two temperature sensors in the battery terminal
X			83	53	Crankshaft Position Sensor, Malfunction	Rationality check	Input digital 0-12V Frequency/pattern	Crank sensor	Checks for correct signal pattern and correct number of expected flywheel teeth.
	X	X	84	54	Relay for Secondary Air Pump Final stage	Final stage check	Output digital on/off (active low)	Relay for Secondary Air pump	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X	X	85	55	Secondary Air Inj. System Switching Valve Final stage	Final stage check	Output digital on/off (active low)	Secondary Air valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	91	5B	EVAP System, Purge Control Valve Circuit (Bank 2)	Final stage check	Output digital on/off (active low)	purge valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		93	5D	EVAP System Purge Control Valve	EVAP monitoring	DME internal values logical	purge valve	This functional check looks for the engine reaction during canister purging. It checks whether the fuel control or RPM values react to the purging of the canister.
	X	X	98	62	EVAP System Purge Control Valve Final stage	Final stage check	Output digital on/off (active low)	purge valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	100	64	Transmission/ coolant heat exchanger	Final stage check	Output digital on/off (active low)	Trans/coolant heat exchanger	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			100	64	Internal Control Module, Memory check sum or internal communication	DME HW Test Memory	DME internal values logical	DME internally	Internal hardware test of RAM, ROM, and Flash Prom.
		X	101	65	Internal Control Module, RAM	DME HW Test Memory	DME internal values logical	DME internally	Internal hardware test of RAM, ROM, and Flash Prom.

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X		101	65	Internal Control Module, CPU	Rationality check	DME internal values logical	DME internally	Checks if the torque limitation works properly. If it does not the throttle is switched off.
		X	102	66	Internal Control Module, Keep Alive Memory	DME HW Test Memory	DME internal values logical	DME internally	Internal hardware test of RAM, ROM, and Flash Prom.
	X		102	66	Signal multi functional steering wheel, redundant code transmission	Rationality check	Input binary stream 0-12V	Multi functional steering wheel	Fault is set, when no signal is detected or when the transmission from the steering wheel is disturbed (timing check, single bit check)
X			103	67	VANOS faulty reference value intake	Rationality check	DME internal values logical	Crank-/Cam-sensor intake	The maximum VANOS adjustment angle, checked at every engine start must be within a specified limit.
		X	103	67	Internal Control Module, Memory check sum	DME HW Test Memory	DME internal values logical	DME internally	Internal hardware test of RAM, ROM, and Flash Prom.
	X		103	67	Internal Control Module, CPU	Rationality check	DME internal values logical	DME internally	Internal functional checks of the system
	X		104	68	Clutch switch faulty	Rationality check	Input digital 0-12V	Clutch Switch	The system detects the gear change by calculation of the ratio between engine and vehicle speed. If several gear changes are detected and there was no signal from the clutch switch a fault is
X			104	68	VANOS faulty reference value exhaust	Rationality check	DME internal values logical	Crank-/Cam-sensor exhaust	The maximum VANOS adjustment angle, checked at every engine start must be within a specified limit.
		X	104	68	Internal Control Module, RAM	DME HW Test Memory	DME internal values logical	DME internally	Internal hardware test of RAM, ROM, and Flash Prom.
X			105	69	VANOS mechanically stuck (Bank1) intake	Rationality check	DME internal values logical	Crank-/ cam sensor	Motitoring of a desired VANOS adjustment within a predefined diagnostic time limit.
	X		105	69	Internal Control Module, RAM	DME HW Test Memory	DME internal values logical	DME internally	Internal hardware test of RAM.
		X	105	69	Internal Control Module, EEPROM	DME HW Test Memory	DME internal values logical	DME internally	Internal hardware test of RAM, ROM, and Flash Prom.
	X		106	6A	plausibility between breaklight switch and breaklight test	Rationality check	Input digital 0-12V	Breaklight switch	Whenever the breaklight switch is active, the breaklight test switch must be also active. If not then this fault is stored
X			106	6A	VANOS mechanically stuck (Bank2) exhaust	Rationality check	DME internal values logical	Crank-/ cam sensor	Motitoring of a desired VANOS adjustment within a predefined diagnostic time limit.

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X		107	6B	Internal Control Module, ROM	DME HW Test Memory	DME internal values logical	DME internally	Internal hardware test of ROM and Flash Prom.
		X	107	6B	Battery Voltage	Signal range check	Input analog Batt.Voltage Voltage	Battery Voltage	Check that proper battery voltage is present between 9 and 16 Volts. This check is not performed during cranking due to voltage drop.
	X		108	6C	Internal Control Module	Reset logic	DME internal values logical	DME internally	Internal functional checks of the system
		X	108	6C	Battery Voltage Disconnected	Rationality check	Input analog Batt. Voltage Voltage continuity	Battery Voltage	ECU internal test determines if the unit has been disconnected from battery power. This fault could be set by disconnection of the battery or control unit or wiring problem effecting B+ supply
X			109	6D	Motor throttle valve mechanically;pulse width not plausiple	Rationality check	Output digital 0-12V pulse width	Motor Throttle Valve	The throttle position control algorithm checks for problems with the mechanical coupling spring within the mtor throttle body. If the calculated pulse width signal is not plausible with the actual
	X		109	6D	Battery Voltage	Signal range check	Input analog Batt. Voltage Voltage	DME internally	Checks the Analog to Digital Converter. If the system can detect voltages lower than 2.5 Volts then a fault is set.
	X		110	6E	Torque limitation, level 1	Rationality check	DME internal values logical	DME internally	Internal check of the actual torque demand against a limit. If the limit is exceeded then a fault is set. The torque will be limited.
X			110	6E	Pedal Sensor Potentiometer 1	Signal range check	Input analog 0-5V Voltage	Pedal Sensor Potentiometer1	Failed the Signal Range check against predefined diagnostic limits
X			111	6F	Pedal Sensor Potentiometer 2	Signal range check	Input analog 0-5V Voltage	Pedal Sensor Potentiometer2	Failed the Signal Range check against predefined diagnostic limits
		X	111	6F	Crankshaft Position Sensor, Malfunction	Rationality check	Input digital 0-12V Frequency/pattern	Crank sensor	Checks for correct signal pattern and correct number of expected flywheel teeth.
	X		111	6F	Crankshaft Position Sensor Malfunction	Rationality check	Input digital 0-12V Frequency/pattern	Crank sensor	A fault is set if a signal from the cam sensor is detected and there is no signal from the crank sensor (engine speed).
		X	112	70	Camshaft Position Sensor Circuit, Malfunction	Rationality check	Input digital 0-12V Frequency/pattern	Cam sensor	Internal check of the phase shift from the cam sensor which should change during every crankshaft revolution. The phase shift occurs due to the 2:1 mechanical relationship between cam
X			112	70	Motor Throttle Valve Potentiometer 1	Signal range check	Input analog 0-5V Voltage	Motor ThrottleFeedback potentiometer 1	Failed the Signal Range check against predefined diagnostic limits
	X		112	70	Crankshaft Position Sensor Malfunction	Rationality check	Input digital 0-12V Frequency/pattern	Crank sensor	Checks for correct signal pattern and correct number of expected flywheel teeth.

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X		113	71	Camshaft Position Sensor Bank 1 Malfunction	Rationality check	Input digital 0-12V Frequency/pattern	CAM sensor	Internal check of the signal from the cam sensor. The signal state must change at every reference mark (2 missing teeth) of the crank.
X			113	71	Motor Throttle Valve Potentiometer 2	Signal range check	Input analog 0-5V Voltage	Motor ThrottleFeedback potentiometer 2	Failed the Signal Range check against predefined diagnostic limits
X			114	72	Motor Throttle Valvefinal stage	Final Stage Check	DME internally Test	Motor Throttle Valve	The final stage inside the DME, a special H-bridge, will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the
	X		114	72	Camshaft Position Sensor Bank 2 Malfunction	Rationality check	Input digital 0-12V Frequency/pattern	CAM sensor	Internal check of the signal from the cam sensor. The signal state must change at every reference mark (2 missing teeth) of the crank.
	X	X	115	73	Mass or Volume Air Flow Circuit Malfunction	Signal range check	Input analog 0-6V Voltage	HFM	Failed the Signal Range check against predefined diagnostic limits
X			115	73	Output voltage 5V for Potentiometer operation 1	Signal range check	DME internal 5V Voltage	DME internal Voltage controller1	Check for proper 5 volts supply to the potentiometers is possible within a predefined voltage limit.
X			116	74	Output voltage 5V for Potentiometer operation 2	Signal range check	DME internal 5V Voltage	DME internal Voltage controller2	Check for proper 5 volts supply to the potentiometers is possible within a predefined voltage limit.
	X		117	75	Throttle Position Sensor	Rationality check	Input analog 0-5V Voltage	Throttle position sensor	This error occurs always together with fault code 118 or 119; the only additonal information consists of more environmental conditions
		X	117	75	Throttle Position Sensor	Rationality check	DME internal values logical	Throttle position sensor	Signal Range is checked against the predetermined diagnostic limits. A fault will set if the Air Flow meter value (volume) does not logically match throttle position sensor value (throttle
X			117	75	Pedal Sensor PotentiometerPlausibility	Rationality check	Input analog 0-5V Voltage	Pedal Sensor Potentiometer	If there is a difference greater than specified between the two redundant signals from the potentiometer, a fault will be set.
	X		118	76	Throttle Position Sensor 1	Rationality check	Input analog 0-5V Voltage	Throttle position sensor 1	Signal Range is checked against the predetermined diagnostic limits.Rationality check with Sensor 2. The sum of the values of Sensor 1 and Sensor 2 must be 5 V.
X			118	76	Motor Throttle Feedback Potentiometer Plausibility	Rationality check	Input analog 0-5V Voltage	Motor Throttle feedback Potentiometer	If there is a difference greater than specified between the two redundant signals from the potentiometer, a fault will be set.
X			119	77	MDK, Throttle mechanical sticking	Rationality check	DME internally Test	Motor Throttle Valve	The throttle doesent reach the desired opening angle within a specified time
	X		119	77	Throttle Position Sensor 2	Rationality check	Input analog 0-5V Voltage	Throttle position sensor 2	Signal Range is checked against the predetermined diagnostic limits.Rationality check with Sensor 1. The sum of the values of Sensor 1 and Sensor 2 must be 5 V.

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			120	78	Pedalsensor/Motor Throttle Valve Potentiomenternot plausible	Rationality check	DME internal values logical	Motor Throttle, Pedal Sensor	The signal from the motor throttle valve potentiometer must be equal the signal from the pedal sensor potentiometer plus any adaptive values, A fault is set if the difference exceeds a
		X	120	78	Vehicle Speed Sensor	Rationality check	Input digital 0-12V Frequency	ASC	Signal Range is checked against predefined diagnostic limits. No vehicle speed is observed after a specific time when compared to engine speed and load which is equivalent to a
	X		120	78	Vehicle Speed Sensor	Rationality check	Input digital 0-12V Frequency	ASC	No vehicle speed is observed for a specific time when the engine is in fuel cut off.
	X		121	79	Vehicle Speed Sensors	Rationality check	Input digital binary information from CAN	ASC	Plausibility check of wheel speed information from ASC
		X	121	79	Load Calculation Cross Check, Range/Perf.	Signal range check Rationality check	DME internal values logical	HFM, Throttle position sensor	Plausibility check between the Throttle Position Sensor Signal and the HFM.
X			122	7A	Oil Temperature sensor malfunction	Signal range check	Input analog 0-5V Voltage	Coolant Temp sensor	Signal Range is checked against the predefined diagnostic limits and the calculated temperature.
X			123	7B	Electric Thermostat Control, final stage	Final stage check	Output digital on/off (active low)	Electric Thermostat	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
	X	X	123	7B	Engine Coolant Temp Circuit Range/Perf.	Signal range check	Input analog 0-5V Voltage	Coolant Temp sensor	Signal Range is checked against the predefined diagnostic limits and the calculated temperature.
X			124	7C	DISA, Range/Performance	Final stage check	Output digital on/off (active low)	Disa Valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
	X	X	124	7C	Intake Air Temperature Range/Performance	Signal range check	Input analog 0-5V Voltage	Intake Temp. sensor	Signal Range is checked against predefined diagnostic limits
X			125	7D	Coolant Fan, Final stage	Final stage check	Output digital pulse width (active low)	Coolant Fan	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
	X		125	7D	Coolant Temperature Cooler outlet	Signal range check	Input analog 0-5V Voltage	Coolant Temp sensor	Signal Range is checked against the predefined diagnostic limits.
X			126	7E	LDP-Magnetic Valve	Final Stage Check	Output digital on/off (active low)	Leak Detection Pump	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
X			127	7F	Fuel Pump	Final stage check	Output digital on/off (active low)	fuel pump (relay)	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			128	80	EWS Signal not present or faulty	DME HW Test SIO	Input binary stream 0-12V Bit information	EWS	During the time out check no signal was present within the specific time or faulty information from serial interface (parity, overrun, etc.)
		X	130	82	Swapped O2 Sensors Pre Cat.	O2-Sensor check	DME internal values logical	O2 Sensor	Fault will set if the O2 sensor from one bank shows a rich condition while the other bank shows a lean condition.
	X		130	82	Throttle valve position Throttle sticking	Rationality check	DME internal values logical	Motor Throttle Valve	Fault is set when the actual position of the throttle valve and the target positon don't match.
X			130	82	CAN Time Out (ASC1)	DME HW Test CAN	Input digital 0-12V Binary information	ASC	CAN message between DME/EGS was not received within the expected time
	X		131	83	Throttle valve position	Rationality check	DME internal values logical	Motor Throttle Valve	Fault is set if the position control reaches predefined threshold because of a slow moving throttle valve
X			131	83	CAN Time Out (instr2)	DME HW Test CAN	Input digital 0-12V Binary information	instr2	CAN message between DME/EGS was not received within the expected time
	X		132	84	Motor Throttle Valve Final stage	Rationality check	DME internal values logical	Motor Throttle Valve	Fault is set if the position control reaches predefined threshold and the final stage for the throttle motor indicates malfunction.
X			132	84	CAN Time Out (instr3)	DME HW Test CAN	Input digital 0-12V Binary information	instr3	CAN message between DME/EGS was not received within the expected time
	X		133	85	Motor Throttle Valve open/closing test failed	Rationality check	DME internal values logical	Motor Throttle Valve	pre drive check. Opening and closing of throttle must be fulfilled within a pre defined time (only small opening).
		X	133	85	DME Bank identification input	Rationality check	Input digital 0-12V on/off	Bank identification- pin wiring harness check	DME identifies itself as a DME_Right or DME_Left depending how the input signal is wired. If it determines that the "learned" value has changed then a fault is detected.
X			133	85	CAN Time Out (ASC3)	DME HW Test CAN	Input digital 0-12V Binary information	ASC3	CAN message between DME/EGS was not received within the expected time
	X		134	86	Motor Throttle Valve closed position adaptation	Rationality check	DME internal values logical	Motor Throttle Valve	The closed position is within a pre defined limit. If this limit has been exceeded, this fault will be set.Also if there is a need for adaptation (after changing the throttle) and the adaptation is
	X		135	87	Motor Throttle Valve Amplifier adjustment	Rationality check	DME internal values logical	DME internally	The signal from throttle position sensor 1 is amplified to get better resolution in idle position. If there is a mismatch between the base sensor information and the amplified sensor this fault is
		X	135	87	Transmission: Torque Reduction	Rationality check	Input digital binary information from CAN	EGS	CAN message had an invalid or undefined value

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X		136	88	Motor Throttle Valve check of the limp home position	Rationality check	DME internal values logical	Motor Throttle valve	The limp home position must be within a specified range. If the range is exceeded, a fault is set.Also if the adaptation of the limp home position (part of the throttle adaptation) is interrupted the
		X	138	8A	AC Compressor Torque Reduction	Timing check	Input digital binary information from CAN	IHKA via K-Bus from the Instr. Cluster	Checks CAN message for proper content of pulse width modulation signal (>MY97)
		X	139	8B	Electric Thermostat Control, final stage	Final stage check	Output digital on/off (active low)	Electric Thermostat	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			140	8C	LDP Reed-switch not closed	EVAP monitoring	Input digital 12V on/off	Leak Detection Pump	With shut off valve open and no pressure on the system, the read contact should be closed showing a "high signal". If this is not the case in the beginning of every diagnostics check, the
	X		140	8C	Electric Thermostat Control, final stage.	Final stage check	Output digital on/off (active low)	Electric Thermostat	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	140	8C	Torque imbalance	Rationality check	Input analog 0-5V Voltage	HFM1 and HFM2	Comparison between the 2 air mass signals. If the difference is too large then a fault is detected. Most likely cause is and air leak.
X			141	8D	EVAP: Reed Switch not closed, doesn't open or doesn't close	EVAP monitoring	Input digital 0-12V on/off	LDP reed contactswitch	Within a predetermined time the LDP reed switch signal has to change from high to low or from low to high or LDP reed switch is "low" for longer then the predetermined time.
	X		141	8D	Coolant Fan Final stage	Final stage check	Output digital pulse width (active low)	Coolant Fan	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	141	8D	ASC Signal, Plausibility check	Rationality check	Input digital binary information from CAN	ASC	Internal check of binary signals from ASC/MSR/EML. The control unit knows what are the possible combinations of signals. If the combined signals don't match the internal table the fault will
X			142	8E	EVAP: Reed Switch not closed, doesn't open or doesn't close	EVAP monitoring	Input digital 0-12V on/off	LDP reed contactswitch	Within a predetermined time the LDP reed switch signal has to change from high to low or from low to high or LDP reed switch is "low" for longer then the predetermined time.
X			143	8F	EVAP: Clamped Tube Check	EVAP monitoring	Input digital 0-12V Frequency	LDP reed contact	The frequency of the LDP pumps reed switch is lower then the predetermined limit. The volume of leak is determined to be too small as in a pinched or restricted hose.
		X	143	8F	MSR Signal	Timing check	Input digital binary information from CAN	ASC	Internal check of binary signals from ASC/MSR/EML. The control unit knows what are the possible combinations of signals. If the combined signals don't match the internal table the fault will
		X	144	90	ASC Signal, Plausibility Torque Reduction	Timing check	Input digital binary information from CAN	ASC	Internal check of binary signals from ASC/MSR/EML. The control unit knows what are the possible combinations of signals. If the combined signals don't match the internal table the fault will
X			144	90	EVAP System, Leak Detected (large leak)	EVAP monitoring	Input analog 0-5V Voltage	Tank pressure sensor	During purging with the open TEV valve the tank pressure sensor must react to the decrease in pressure. It must reach a minimum pressure differential after a predetermined time or a

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			145	91	EVAP System, Leak Detected (small leak)	EVAP monitoring	Input analog 0-5V Voltage	Tank pressure sensor	With the purge and shut off valves closed the gas tank is introduced to intake manifold vacuum. The tank pressure sensor looks for a predetermined pressure (vacuum) difference within a
		X	147	93	Electric Thermostat Control, Range/Performance.	Final stage check	Output digital on/off (active low)	Electric Thermostat	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X	X	148	94	EWS Signal not present or faulty	DME HW Test SIO	Input binary stream 0-12V Bit information	EWS	During the time out check no signal was present within the specific time or faulty information from serial interface (parity, overrun, etc.)
X			149	95	Motor Throttle Feedback Potentiometer and Air Mass Sensor Signal not plausible	Rationality check	Input analog 0-5V Voltage	Motor Throttle feedback Poti; Air Mass Sensor	The signal from the motor throttle valve potentiometer must be suitable to the signal from the air mass sensor. A fault is set if the difference exceeds a specified limit.
X			150	96	O2 Sensor Pre Cat. (Bank1),short to battery voltage	O2-Sensor check	Input analog 0-5V (high is lean)	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical shorts exist on the input line. The voltage signal has to be within a predetermined range (0,1V - 1V) or a fault will set.
	X	X	150	96	Injector Circuit Cylinder 1 Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			151	97	O2 Sensor Pre Cat. (Bank1),short to ground	O2-Sensor check	Input analog 0-5V	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical shorts exist on the input line. The voltage signal has to be within a predetermined range (0,1V - 1V) or a fault will set.
		X	151	97	Injector Circuit Cylinder 2, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		151	97	Injector Circuit Cylinder 5 Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			152	98	O2 Sensor Pre Cat. (Bank1),disconnection	O2-Sensor check	Input analog 0-5V	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical disconnection exist on the input line. The voltage signal has not to be clamped to the specific internally value
		X	152	98	Injector Circuit Cylinder 3, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		152	98	Injector Circuit Cylinder 4 Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			153	99	O2 Sensor Pre Cat. (Bank2),short to battery voltage	O2-Sensor check	Input analog 0-5V	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical shorts exist on the input line. The voltage signal has to be within a predetermined range (0,1V - 1V) or a fault will set.
		X	153	99	Injector Circuit Cylinder 4, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X		153	99	Injector Circuit Cylinder 8 Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			154	9A	O2 Sensor Pre Cat. (Bank2),short to ground	O2-Sensor check	Input analog 0-5V	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical shorts exist on the input line. The voltage signal has to be within a predetermined range (0,1V - 1V) or a fault will set.
		X	154	9A	Injector Circuit Cylinder 5, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		154	9A	Injector Circuit Cylinder 6 Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			155	9B	O2 Sensor Pre Cat. (Bank2),disconnection	O2-Sensor check	Input analog 0-5V	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical disconnection exist on the input line. The voltage signal has not to be clamped to the specific internally value
		X	155	9B	Injector Circuit Cylinder 6, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		155	9B	Injector Circuit Cylinder 3 Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			156	9C	O2 Sensor Post Cat.(Bank1),short to battery voltage	O2-Sensor check	Input analog 0-5V	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical shorts exist on the input line. The voltage signal has to be within a predetermined range (0,1V - 1V) or a fault will set.
		X	156	9C	Injector Circuit Cylinder 7, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		156	9C	Injector Circuit Cylinder 7 Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			157	9D	O2 Sensor Post Cat.(Bank1),short to ground	O2-Sensor check	Input analog 0-5V	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical shorts exist on the input line. The voltage signal has to be within a predetermined range (0,1V - 1V) or a fault will set.
		X	157	9D	Injector Circuit Cylinder 8, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		157	9D	Injector Circuit Cylinder 2 Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	158	9E	Injector Circuit Cylinder 9, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			159	9F	O2 Sensor Post Cat.(Bank2),short to battery voltage	O2-Sensor check	Input analog 0-5V	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical shorts exist on the input line. The voltage signal has to be within a predetermined range (0,1V - 1V) or a fault will set.
		X	159	9F	Injector Circuit Cylinder 10, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			160	A0	O2 Sensor Post Cat.(Bank2),short to ground	O2-Sensor check	Input analog 0-5V	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical shorts exist on the input line. The voltage signal has to be within a predetermined range (0,1V - 1V) or a fault will set.
		X	160	A0	Injector Circuit Cylinder 11, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	161	A1	Injector Circuit Cylinder 12, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	163	A3	Electric Fuel Pump Relay, Final stage (Bank 2)	Final stage check	Output digital on/off (active low)	Fuel pump relay	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		163	A3	plausibility check between air mass meter and throttle position	Rationality check	DME internal values logical	HFM, Throttle position sensor	Plausibility check between the Throttle Position Sensor Signal and the HFM.
		X	164	A4	EVAP: Barometric Tank Pressure Sensor	Signal range check	Input analog 0-5V Voltage	Tank pressure sensor	The Signal Range is checked to detect shorts on the input line
	X		164	A4	Barometric Pressure Sensor	Signal range check	Input analog 0-5V Voltage	barometric pressure sensor inside the ECU	The Signal Range is checked to detect faults on the input line
		X	165	A5	Check Engine Light, Final stage Malfunction	Final stage check	Output digital on/off (active low)	Instrument Cluster	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		165	A5	VANOS electrical fault Bank 1	Final stage check	Output digital on/off (active low)	VANOS valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		166	A6	VANOS electrical fault Bank 2	Final stage check	Output digital on/off (active low)	VANOS valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X	X	167	A7	Electric Fuel Pump Relay Final stage	Final stage check	Output digital on/off (active low)	Fuel pump relay	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	168	A8	Idle Control Valve Opening Coil, Malfunction	Final stage check	Output digital pulse width (active low)	Idle control valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			169	A9	MDK Final Stage shut off	DME HW-Test	DME internally Test	DME internally	This fault indicates a main problem on ether the pedal sensor, the throttle potentiometer or the Throttle. A separately stored fault code indicates the problem.
		X	169	A9	Idle Control Valve Closing Coil, Malfunction	Final stage check	Output digital pulse width (active low)	idle control valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			170	AA	Communication between Microcontroller and Safety Controller is disturbed	DME HW-Test	DME internally Test	DME internally	The microcontroller and the safety controller are calculation the same output values for the motor throttle valve. If the calculated result is different then this fault is stored.
	X	X	170	AA	AC Compressor Control	Final stage check	Output digital on/off (active low)	AC Comp.	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. Occurs
X			171	AB	System has been shut down due to the Safety controller	DME HW-Test	DME internally Test	DME internally	The safety controller has shut down the Motor Throttle Valve function due to not plausible MDK input values.
X			172	AC	Pedalsensor potentiometer contactshort between the two poti paths	Rationality check	DME internal check	Pedal sensor potentiometer	The 5volts for the potentiometers are switched on within a specific time pattern. A check for shorts between the two independent potentiometers is possible by checking the signal
X			173	AD	Motor Throttle Valve potentiometer contactshort between the two poti paths	Rationality check	DME internal check	Motor Throttle valve potentiometer	The 5volts for the potentiometers are switched on within a specific time pattern. A check for shorts between the two independent potentiometers is possible by checking the signal
X			174	AE	Motor Throttle Valve PotentiometerAdaptation of the idle end position	Signal range check	Input 0-5V analog	Motor Throttle valve potentiometer	The signal for idle position must be within a specified range. If the range is exceeded, a fault is set.
X			175	AF	Pedal Sensor Potentiometer 1Adaptation of the idle end position	Signal range check	Input 0-5V analog	Pedal sensor potentiometer	The signal for idle position must be within a specified range. If the range is exceeded, a fault is set
		X	175	AF	DISA, Range/Performance	Final stage check	Output digital on/off (active low)	Disa Valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			176	B0	Pedal Sensor Potentiometer 2Adaptation of the idle end position	Signal range check	Input 0-5V analog	Pedal sensor potentiometer	The signal for idle position must be within a specified range. If the range is exceeded, a fault is set
		X	179	B3	AC Compressor Control (Bank 2)	Final stage check	Output digital on/off (active low)	AC-Control	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X	X	183	B7	EVAP: Leak detected	EVAP monitoring	Input digital 0-12V Frequency	LDP reed contact	The frequency of the LDP pumps reed switch is above the predetermined leak range. The larger the leak the higher the frequency will be.
	X	X	184	B8	EVAP: pinched hose check	EVAP monitoring	Input digital 0-12V Frequency	LDP reed contact	The frequency of the LDP pumps reed switch is lower then the predetermined limit. The volume of leak is determined to be too small as in a pinched or restricted hose.

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X		185	B9	EVAP: Reed Switch	EVAP monitoring	Input digital 0-12V on/off	LDP reed contactswitch	Within a predetermined time the LDP reed switch signal has to change from high to low or from low to high or LDP reed switch is "low" for longer then the predetermined time.
X			188	BC	O2-Sensor-Heater, Pre Cat. (Bank1), insufficient.	Final stage check	Output digital pulse width (active low)	O2 Sensor	The DME internally calculated heater power is checked against predefined diagnostic limits.
X			189	BD	O2-Sensor-Heater, Pre Cat. (Bank2), insufficient.	Final stage check	Output digital pulse width (active low)	O2 Sensor	The DME internally calculated heater power is checked against predefined diagnostic limits.
X			190	BE	O2-Sensor-Heater, Post Cat. (Bank1), insufficient.	Final stage check	Output digital pulse width (active low)	O2 Sensor	The DME internally calculated heater power is checked against predefined diagnostic limits.
X			191	BF	O2-Sensor-Heater, Post Cat. (Bank2), insufficient.	Final stage check	Output digital pulse width (active low)	O2 Sensor	The DME internally calculated heater power is checked against predefined diagnostic limits.
X			202	CA	Fuel Trim (Bank1), O2 Control Limit	Fuel system monitoring	DME internal values logical	Calculated	The Controller for Lambda is too long beyond a min. or a max. limit
X			203	CB	Fuel Trim (Bank2), O2 Control Limit	Fuel system monitoring	DME internal values logical	Calculated	The Controller for Lambda is too long beyond a min. or a max. limit
		X	203	CB	Ignition Feedback (bank failed)	Ignition feedback	Input analog 100 mV Timing	Ignition Shunt Resistor	Check for correct signal timing after each ignition has been initiated by this feedback signal
	X		186	BA	EVAP: DMTL Pump Motor - Final Stage	Final stage check	Output digital on/off (active low)	DMTL pump motor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		187	BB	EVAP: 0.5 mm leak detected	EVAP monitoring	DME internal values logical	DMTL pump motor current	The current of the pump motor is monitored. If the current does not reach predefined thresholds after a given time, this is a indication of a leak;
	X		188	BC	EVAP: 1 mm leak detected	EVAP monitoring	DME internal values logical	DMTL pump motor current	The current of the pump motor is monitored. If the current does not reach predefined thresholds after a given time, this is a indication of a leak;
	X		189	BD	EVAP: DMTL module	EVAP monitoring	DME internal values logical	DMTL module	The pump motor current is monitored, escepially during the reference leak measurement. If the current is not in a predefined range a fault is set.
	X	X	204	CC	EWS, rolling code storage	DME HW-Test	DME internal values logical	EWS	The EWS3.3 rolling code is not stored properly in the DME internal memory
X			204	CC	Idle Control System, Idle Speed not plausible	Rationality check	DME internal values logical	calculated	Functional Check between the actual engine speed (RPM) and the predetermined RPM exceeds the maximum deviation of +200/-100 RPM.

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			208	D0	EWS, engine speed check not ok	Rationality check	DME internally Test	EWS	The Engine speed signal is also transfered by the EWS back to the DME. A fault is set if the transfered signal is not reflecting the real engine speed due to an input problem in the EWS
		X	208	D0	Secondary Air Induction System (Bank 2)	Secondary Air Delivery	Input analog 0-1V Voltage	O2 Sensor	Checks to see if the O2 sensor reacts to the increase in unmetered air flow generated by the secondary air pump operation. The O2 sensor must sense the lean condition or a
X			209	D1	EWS, Content of Message	Manipulation check	Input binary stream 0-12V Bit information	EWS	The content of the binary message received from EWS was invalid
	X	X	210	D2	Knock Sensor 1 Circuit Bank 1	Circuit continuity Signal range check	Input analog 13-19kHz Amplitude	Knock sensor	Plausibility Check between the knock sensor amplitude during knocking with the internal knock detection mapped DME values.
X			210	D2	Ignition Feedback, faulty (>2 Cylinders)	Ignition feedback	Input analog 100 mV Timing	Ignition Shunt Resistor	Check for correct signal timing after each ignition has been initiated by this feedback signal. If more than two ignition is not recognized than there might be a problem in the feedback line
	X	X	211	D3	Knock Sensor 2 Circuit Bank 2	Circuit continuity Signal range check	Input analog 13-19kHz Amplitude	Knock sensor	Plausibility Check between the knock sensor amplitude during knocking with the internal knock detection mapped DME values.
X			211	D3	Idle Control Valve stuck mechanically	Rationality check	DME internal values logical	calculated	Functional Check against a calculated value by monitoring the flow though the air mass meter to determine is the idle valve is mechanically stuck open. Tested during closed throttle
	X	X	212	D4	Knock Sensor 3 Circuit	Circuit continuity Signal range check	Input analog 13-19kHz Amplitude	Knock sensor	Plausibility Check between the knock sensor amplitude during knocking with the internal knock detection mapped DME values.
	X	X	213	D5	Knock Sensor 4 Circuit	Circuit continuity Signal range check	Input analog 13-19kHz Amplitude	Knock sensor	Plausibility Check between the knock sensor amplitude during knocking with the internal knock detection mapped DME values.
	X		214	D6	Knock control, Base test	Rationality check	DME internal values logical	DME internally	The ECU checks internal values with disconnected sensor. The values must be in a predetermined range.
X			214	D6	Vehicle Speed Sensor	Rationality check	Input digital 0-12V Frequency	ASC	Signal Range is checked against predefined diagnostic limits. No vehicle speed is observed after a specific time when compared to engine speed and load which is equivalent to a moving vehicle.
		X	214	D6	CAN-Index Verification	CAN message check	Input digital 0-12V Binary information	Any ECU on CAN	Logical check of every ECU on the CAN bus has a CAN message interpretation (refer to CAN-Index on the DIS-Tester page) that applies to the vehicle
X			215	D7	O2 Sensor Post Cat.(Bank1),disconnection	O2-Sensor check	Input analog 0-1 V	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical disconnection exist on the input line. The voltage signal has not to be clamped to the specific internally value
		X	215	D7	CAN-Signal, Timeout Left / Right DME	Timing check	Input digital 0-12V Binary information	both DMEs	The Left DME will check for the Right DME and vice versa. If the CAN message was not received by either within the Expected time a fault will set.

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X		215	D7	Knock control, Signal offset	Rationality check	DME internal values logical	Knock sensor	The ECU checks internal values with disconnected sensor. The values must be in a predetermined range.
X			216	D8	O2 Sensor Post Cat.(Bank2),disconnection	O2-Sensor check	Input analog 0-1 V	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical disconnection exist on the input line. The voltage signal has not to be clamped to the specific internally value
	X		216	D8	Knock control, Test pulse	Rationality check	DME internal values logical	DME internally	The ECU internally generated pulse was not detected. It is used to verify electrical integrity (shorts or disconnection) of the knock control circuitry both internally and externally.
		X	216	D8	CAN Signal, Timeout ASC	Timing check	Input digital 0-12V Binary information	ASC	The CAN message was not received within the Expected time
		X	217	D9	CAN-Signal, Timeout EML	Timing check	Input digital 0-12V Binary information	EML ECU	The CAN message was not received within the Expected time
X			217	D9	CAN Time Out (EGS1)	DME HW Test CAN	Input digital 0-12V Binary information	EGS	CAN message between DME/EGS was not received within the expected time
X			219	DB	CAN-Chip, Bus Off	DME HW Test CAN	Input digital 0-12V Binary information	Any ECU on CAN	Hardware test determines if Can Bus is off line. Data transmission is disturbed.
		X	220	DC	Knock control, Test pulse	Circuit Continuity Signal range check	DME internal values logical	DME internally	The ECU internally generated pulse was not detected. It is used to verify electrical integrity (shorts or disconnection) of the knock control circuitry both internally and externally.
X			220	DC	O2 Sensor Post Cat. (Bank1) Slow Response time	O2-Sensor check	Input analog 0-5V (high is lean)	O2 Sensor	Checks the amount of time the oxygen sensor stays in its rich or lean state. If it remains there too long in either the fault will set.
	X		220	DC	CAN Time Out (EGS)	DME HW Test CAN	Input digital 0-12V Binary information	EGS	CAN message between DME/EGS was not received within the expected time
	X		219	DB	CAN Time Out (TCU)	DME HW Test CAN	Input digital 0-12V Binary information	TCU transfer box controller	CAN message between DME/TCU was not received within the expected time
X			221	+	O2 Sensor Post Cat. (Bank2) Slow Response time	O2-Sensor check	Input analog 0-5V (high is lean)	O2 Sensor	Checks the amount of time the oxygen sensor stays in its rich or lean state. If it remains there too long in either the fault will set.
	X		221	DD	CAN Time Out (DSC)	DME HW Test CAN	Input digital 0-12V Binary information	DSC	CAN message between DME/DSC was not received within the expected time

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
		X	222	DE	Knock control, Test pulse (Bank2)	Circuit Continuity Signal range check	DME internal values logical	DME Internally	The ECU internally generated pulse was not detected. It is used to verify electrical integrity (shorts or disconnection) of the knock control circuitry both internally and externally.
X			222	DE	Insufficient Coolant Temp. to permit Closed Loop Operation.	Rationality check	Input analog 0-5V Voltage	Coolant Temp sensor	Comparison of actual coolant temperature against the calculated DME value which varies with the load signal.
	X		222	DE	CAN Time Out (instr)	DME HW Test CAN	Input digital 0-12V Binary information	instr	CAN message between DME/Instrument cluster was not received within the expected time
X			223	DF	O2-Sensor Post Cat (Bank 1), Switching time too slow	O2-Sensor check	Input analog 0-5V (high is lean)	O2 Sensor	Checks the amount of time the oxygen sensor takes to switch from rich to lean and vice versa. If it takes too long to switch the fault will set.
	X		223	DF	CAN Time Out (ACC)	DME HW Test CAN	Input digital 0-12V Binary information	ACC	CAN message between DME/ACC (Adaptive cruise control) was not received within the expected time
	X		224	E0	MSR Signal, Plausibility Torque Rising	Rationality check	Input digital binary information from CAN	DSC	Internal check of DSC signals sent for torque rising. A certain combination of signals is necessary to allow a torque interference. If DSC does not send this combination, a fault is set.
X			224	E0	O2-Sensor Post Cat (Bank 2), Switching time too slow	O2-Sensor check	Input analog 0-5V (high is lean)	O2 Sensor	Checks the amount of time the oxygen sensor takes to switch from rich to lean and vice versa. If it takes too long to switch the fault will set.
X			225	E1	Post Cat. Sensor Bank 1;Trim control	O2-Sensor check	Input analog 0-1V	O2-Sensor	Rationality Check for O2 Control adaptation with post catalyst sensor bank 1
		X	225	E1	EKAT-Status 12 - temperature sensor - plausibility power switch	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Plausibility check between the two temperature sensors in the power switch
	X		225	E1	ACC Signal Plausibility Torque Rising	Timing check	DME internal values logical	ACC	Internal check of ACC signals sent for torque rising. A certain combination of signals is necessary to allow a torque interference. If ACC does not send this combination, a fault is set.
X			226	E2	Post Cat. Sensor Bank 2;Trim control	O2-Sensor check	Input analog 0-1V	O2-Sensor	Rationality Check for O2 Control adaptation with post catalyst sensor bank 2
		X	226	E2	EKAT-Status 13 - power switch voltage plausibility	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Plausibility check between the two input voltages for heater 1 and 2
		X	227	E3	EKAT-Status 14 - check of battery disconnection switch	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set, if a short to ground, a short to battery voltage or a disconnection between the output transistor and the battery disconnection switch occures
X			227	E3	Fuel Trim (Bank1), O2 Control Adaptation Limit	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
		X	228	E4	Automatic Start, Output (Bank 2)	Final stage check	Output digital on/off (active low)	Starter Relay	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs (0.02A<i<2A).
X			228	E4	Fuel Trim (Bank2), O2 Control Adaptation Limit	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
X			229	E5	O2 Sensor Pre Cat. (Bank1) Slow Response time	O2-Sensor check	Input analog 0-5V (high is lean)	O2 Sensor	Checks the amount of time the oxygen sensor stays in its rich or lean state. If it remains there too long in either the fault will set.
	X		229	E5	Pedal Sensor Supply Voltage	Signal range check	Output analog 0-5V	Pedal Sensor	The control module monitors the supply voltage of the pedal sensors: The nominal value must be 5V.
	X		230	E6	Pedal Sensor	Rationality check	Input analog 0-5V	Pedal Sensor	This fault is always set together with fault #231 and/or fault #232. It delivers additional environmental conditions.
X			230	E6	O2 Sensor Pre Cat. (Bank2) Slow Response time	O2-Sensor check	Input analog 0-5V (high is lean)	O2 Sensor	Checks the amount of time the oxygen sensor stays in its rich or lean state. If it remains there too long in either the fault will set.
	X		231	E7	Pedal Sensor Potentiometer 1	Signal range check	Input analog 0-5V	Pedal Sensor Potentiometer1	Failed the Signal Range check against predefined diagnostic limits.Also when the pedal sensor signal from Sensor 1 has not the double value of Sensor 2 a fault code is set.
X			231	E7	O2-Sensor Pre Cat (Bank 1), Switching time too slow	O2-Sensor check	Input analog 0-5V (high is lean)	O2 Sensor	Checks the amount of time the oxygen sensor takes to switch from rich to lean and vice versa. If it takes too long to switch the fault will set.
	X		232	E8	Pedal Sensor Potentiometer 2	Signal range check	Input analog 0-5V	Pedal Sensor Potentiometer2	Failed the Signal Range check against predefined diagnostic limits.Also when the pedal sensor signal from Sensor 2 has not half the value of Sensor 1 a fault code is set.
X			232	E8	O2-Sensor Pre Cat (Bank 2), Switching time too slow	O2-Sensor check	Input analog 0-5V (high is lean)	O2 Sensor	Checks the amount of time the oxygen sensor takes to switch from rich to lean and vice versa. If it takes too long to switch the fault will set.
	X	X	233	E9	Automatic Start Final stage	Final stage check	Output digital on/off (active low)	Starter Relay	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs (0.02A<i<2A).
X			233	E9	Catalyst Efficiency Bank 1, Below Threshold	Catalyst monitoring	Input analog 0-5V Voltage	O2 Sensor pre/post catalyst	Compares the value of the of pre cat O2 sensor to value of the post cat O2 sensor to measure the oxygen storage capability / efficiency of the catalytic converter. The post O2 sensor must be relatively lean.
	X	X	234	EA	Automatic Start Input	Rationality check	Input digital 0-12V on/off	KL50	Fault will set if after a predetermined time K148engine revolution is greater than a limit and Kl50 still active

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			234	EA	Catalyst Efficiency Bank 2, Below Threshold	Catalyst monitoring	Input analog 0-5V Voltage	O2 Sensor pre/post catalyst	Compares the value of the of pre cat O2 sensor to value of the post cat O2 sensor to measure the oxygen storage capability / efficiency of the catalytic converter. The post O2 sensor must be relatively lean.
X			235	EB	Pre Cat. Sensor Bank 1:Trim Control	O2-Sensor check	Input analog 0-1V (high is rich)	O2-Sensor	Rationality Check for O2 Control adaptation with pre catalyst sensor bank 1
X			236	EC	Pre Cat. Sensor Bank 2:Trim Control	O2-Sensor check	Input analog 0-1V (high is rich)	O2-Sensor	Rationality Check for O2 Control adaptation with pre catalyst sensor bank 2
		X	236	EC	CAN Time Out (EGS)	DME HW Test CAN	Input digital 0-12V Binary information	EGS	CAN message between DME/EGS was not received within the expected time
X			238	EE	Cylinder 1 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 1 is longer the fault will set.
X			239	EF	Cylinder 2 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 2 is longer the fault will set.
X			240	F0	Cylinder 3 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder3 is longer the fault will set.
X			241	F1	Cylinder 4 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 4 is longer the fault will set.
X			242	F2	Cylinder 5 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 5 is longer the fault will set.
X			243	F3	Cylinder 6 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 6 is longer the fault will set.
X			244	F4	Segment Timing faulty- Flywheel adaptation	Rationality check	Input digital 0-12V Timing	Crank sensor	The flywheel segmentsare monitored during deceleration to establish a baseline for misfire calculation. If the segments are too long/short (bad flywheel) and exceed the limit a fault will set or one tooth too much/less.
X			245	F5	Secondary Air Injection (Bank1),Flow too Low	Secondary Air Delivery	Input analog 0-5V Voltage	O2-Sensor signal	Checks to see if the O2 sensor reacts to the increase in unmetered airflow generated by the secondary air pump operation. The O2 sensor must sense the lean condition or a fault will set.

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			246	F6	Secondary Air Injection (Bank2),Flow too Low	Secondary Air Delivery	Input analog 0-5V Voltage	O2-Sensor signal	Checks to see if the O2 sensor reacts to the increase in unmetered airflow generated by the secondary air pump operation. The O2 sensor must sense the lean condition or a fault will set.
X			247	F7	Secondary Air Valve stuck open	Secondary Air Delivery	Input analog 0-5V Voltage	O2-Sensor signal	Checks to see if the O2 sensor reacts to the increase in unmetered airflow generated by the secondary air pump operation. The O2 sensor must sense the lean condition or a fault will set.
X			248	F8	Post Catalyst Sensor ;signal after decel phase not plausible; bank 1 (sensor 3)	O2-Sensor check	Input analog 0-5 V	O2-Sensor	Signal is checked for a lean signal in decel and a transition between lean to rich after decel
X			249	F9	Post Catalyst Sensor ;signal after decel phase not plausible; bank 2 (sensor 4)	O2-Sensor check	Input analog 0-5 V	O2-Sensor	Signal is checked for a lean signal in decel and a transition between lean to rich after decel
X			250	FA	Functional check Purge Valve	EVAP monitoring	Input analog 0-5V	O2-Sensor Signal	This functional check looks for the reaction of the O2 sensor signal during canister purging. The O2 sensor, Air Flow meter and RPM values must react to the purging of the canister
		X	253	FD	Coolant Fan, Final stage	Final stage check	Output digital pulse width (active low)	Coolant Fan	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs (0.02A<i<2A).

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation

M52	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X		237	ED	Automatic Start	Rationality check	DME internal values logivcal	Starter Relay	Fault will set if there is a engine speed detected prior to the engaging of the starter relay by the DME.

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X	X	1	1	EVAP: LDP Valve - Final Stage	Final stage check	Output digital on/off (active low)	LDP	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. Occurs
X			1	1	Ignition Coil Cyl. 2	Ignition feedback	Input analog 100 mV Timing	Ignition Shunt Resistor	The DME initiates the secondary ignition for each cylinder then looks for the feedback through the shunt resistor in the harness to determine if the ignition actually occurred.
		X	2	2	Running losses valve - Final stage	Final stage check	Output digital pulse width (active low)	Running losses -valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. Occurs
X			2	2	Ignition Coil Cyl. 4	Ignition feedback	Input analog 100 mV Timing	Ignition Shunt Resistor	The DME initiates the secondary ignition for each cylinder then looks for the feedback through the shunt resistor in the harness to determine if the ignition actually occurred.
		X	3	3	EVAP: Reed Switch not closed, doesn't open or doesn't close	EVAP monitoring	Input digital 0-12V on/off	LDP reed contact switch	Within a predetermined time the LDP reed switch signal has to change from high to low or from low to high or LDP reed switch is "low" for longer then the predetermined time.
X			3	3	Ignition Coil Cyl. 6	Ignition feedback	Input analog 100 mV Timing	Ignition Shunt Resistor	The DME initiates the secondary ignition for each cylinder then looks for the feedback through the shunt resistor in the harness to determine if the ignition actually occurred.
	X		2	2	EVAP: DMTL Valve - Final Stage	Final stage check	Output digital on/off (active low)	DMTL	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. Occurs
	X		3	3	Swapped O2 Sensors Pre Cat.	O2-Sensor check	DME internal Value logical	O2-Sensor	Fault will set if the fuel control from one bank reaches the rich threshold while the other bank reaches the lean threshold.
	X		4	4	O2-Sensor-Heater, Post Cat.(Bank2), final stage and insufficient heating.	Final stage check	Output digital pulse width (active low)	O2 Sensor Heater	The final stage is monitored for proper voltage drop: output on u <= 3.6 V; output off u >= 2.34 V; heater power is checked by the inner resistance of the sensor which represents the sensor
		X	4	4	O2-Sensor-Heater, Post Cat.(Bank2), Insufficient Heating.	Final stage check	Output digital pulse width (active low)	O2 Sensor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		5	5	O2-Sensor-Heater, Pre Cat.(Bank2), final stage and insufficient heating.	Final stage check	Output digital pulse width (active low)	O2 Sensor Heater	The final stage is monitored for proper voltage drop: output on u <= 3.6 V; output off u >= 2.34 V; heater power is checked by the inner resistance of the sensor which represents the sensor
X			5	5	Injector Circuit Cylinder 2	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	5	5	O2 Sensor Heater, Pre Cat.(Bank2), insufficient.	Final stage check	Output digital pulse width (active low)	O2 Sensor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			6	6	Injector Circuit Cylinder 1	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
		X	6	6	CAN-Timeout Instrument Cluster	Timing check	Input digital 0-12V Binary information	Instrument Cluster	The CAN message was not received within the expected time
		X	7	7	Engine coolant temperature, radiator outlet	Signal range check	Input analog 0-12V Voltage	temperature sensor on radiator outlet	Failed the Signal Range check against predefined diagnostic limits
		X	8	8	Misfire with low fuel detected	Misfire monitoring	DME internal values logical	Calculated	Misfire fault was recorded while the low fuel / reserve light in the instrument cluster was illuminated.
X			8	8	Mass or Volume Air Flow Circuit, Range/Perf.	Signal range check	Input analog 0-5V Voltage	HFM	Failed the Signal Range check against predefined diagnostic limits
	X	X	10	0A	O2 Sensor Pre Cat. (Bank1)	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	The oxygen sensor signal range is checked to determine if electrical faults exist on the sensor line.
X			10	0A	Engine Coolant Temp, Circuit Range/Perf.	Signal range check	Input analog 0-5V Voltage	Coolant Temp sensor	Signal Range is checked against the predefined diagnostic limits within specific engine operations.
X			11	0B	Coolant Temperature Cooler outlet	Signal range check	Input analog 0-5V Voltage	Coolant Temp sensor	Signal Range is checked against the predefined diagnostic limits within specific engine operations.
	X	X	12	0C	O2 Sensor Post Cat.(Bank1)	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	The oxygen sensor signal range is checked to determine if electrical faults exist on the sensor line.
X			12	0C	Coolant Temperature maximal temperature plausibility	Temperature range check	DME internal values logical	Calculated	The temperature at engine start must be lower then at engine stop after delaytime
	X		13	0D	O2-Sensor-Heater, Pre Cat.(Bank1), final stage and insufficient heating.	Final stage check	Output digital pulse width (active low)	O2 Sensor Heater	The final stage is monitored for proper voltage drop: output on u <= 3.6 V; output off u >= 2.34 V; heater power is checked by the inner resistance of the sensor which represents the sensor
		X	13	0D	O2 Sensor Heater Circuit Pre Cat (Bank1)	Final stage check	Output digital pulse width (active low)	O2 Sensor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		14	0E	O2-Sensor-Heater, Post Cat.(Bank1), final stage and insufficient heating.	Final stage check	Output digital pulse width (active low)	O2 Sensor Heater	The final stage is monitored for proper voltage drop: output on u <= 3.6 V; output off u >= 2.34 V; heater power is checked by the inner resistance of the sensor which represents the sensor
		X	14	0E	O2-Sensor-Heater, Post Cat. (Bank1), insufficient.	Final stage check	Output digital pulse width (active low)	O2 Sensor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			14	0E	Intake Air Temperature Range/Performance	Signal range check	Input analog 0-5V Voltage	IntakeTempsensor	Signal Range is checked against predefined diagnostic limits within specific engine operations.

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X	X	15	0F	O2 Sensor Pre Cat. (Bank1) Slow Response time	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	Checks the amount of time the oxygen sensor stays in its rich or lean state. If it remains too long in either rich or lean condition, the fault will set.
	X		17	11	O2 Sensor Post Cat. (Bank1) Activity	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	If engine is in fuel cut off for a predeterminded time the sensor voltage must be below 200 mV. If trim control is active the sensor voltage must change.
		X	17	11	O2 Sensor Post Cat. (Bank1), Slow Response time	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	Checks the amount of time the oxygen sensor stays in its rich or lean state. If it remains too long in either the rich or the lean condition, the fault will set.
	X	X	18	12	O2 Sensor Pre Cat. (Bank2)	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	The oxygen sensor signal range is checked to determine if electrical faults exist on the sensor line.
X			18	12	Camshaft Position Sensor exhaust cam, Malfunction	Rationality check	Input analog 0-5V phase shift	CAM sensor	Internal check of the phase shift from the cam sensor which should change during every crankshaft revolution. The phase shift occurs due to the 2:1 mechanical relationship between cam
X			19	13	VANOS-Magnetical valve; exhaust side	Final stage check	Output digital pulse width (active low)	VANOS-Solenoid exhaust	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	19	13	CAN Signal, Timeout EKAT	Timing check	Input digital 0-5V Binary information	EKAT-ECU	The CAN message from the EKat ECU was not received within the expected time
	X	X	20	14	O2 Sensor Post Cat. (Bank2)	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	The oxygen sensor signal range is checked to determine if electrical faults exist on the sensor line.
X			21	15	VANOS-Magnetical valve;Intake side	Final stage check	Output digital pulse width (active low)	VANOS-Solenoid intake	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
	X	X	21	15	O2 Sensor Pre Cat. (Bank2) Slow Response time	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	Checks the amount of time the oxygen sensor stays in its rich or lean state. If it remains too long in either the rich or the lean condition, the fault will set.
X			22	16	Injector Circuit Cylinder 3, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
X			23	17	Injector Circuit Cylinder 6, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
	X		23	17	O2 Sensor Post Cat. (Bank2) Activity	O2-Sensor check	Input analog 0-1V (high is rich)	O2 Sensor	If engine is in fuel cut off for a predeterminded time the sensor voltage must be below 200 mV. If trim control is active the sensor voltage must change.
X			24	18	Injector Circuit Cylinder 4, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X		24	19	Fuel Trim at part load above threshold (Bank2) Multiplicative	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
		X	24	18	AC Compressor Function	Rationality check	Input digital 0-12V on/off	IHKA	Fault will set if AC-Switch is off and Compressor Switch is on.
X			25	19	O2 Sensor Heater Circuit Pre Cat (Bank1)	Final stage check	Output digital pulse width (active low)	O2 Sensor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
	X		25	19	Fuel Trim at part load above threshold (Bank2) Multiplicative	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
		X	26	1A	Fuel Trim at part load (Bank1), Multiplicative	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
	X		26	1A	Fuel Trim at part load below threshold (Bank1) Multiplicative	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
X			27	1B	Idle Control Valve Closing Coil, Malfunction	Final stage check	Output digital pulse width 120Hz (active low)	Idle control valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	27	1B	Fuel Adaptation Additive at idle air leak (Bank 1)	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
	X		27	1B	Fuel Trim at part load below threshold (Bank2) Multiplicative	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
	X	X	28	1C	Fuel Trim (Bank1) Additive	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
		X	29	1D	Air containment valve for air control of shrouded fuel Injector (Bank 1)	Final stage check	Output digital on/off (active low)	air containment valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			29	1D	Ignition Coil Cyl. 1	Ignition feedback	Input analog 100 mV Timing	Ignition Shunt Resistor	The DME initiates the secondary ignition for each cylinder then looks for the feedback through the shunt resistor in the harness to determine if the ignition actually occurred.
	X		29	1D	Fuel Trim (Bank2) Additive	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
X			30	1E	Ignition Coil Cyl. 3	Ignition feedback	Input analog 100 mV Timing	Ignition Shunt Resistor	The DME initiates the secondary ignition for each cylinder then looks for the feedback through the shunt resistor in the harness to determine if the ignition actually occurred.

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
		X	30	1E	EKAT-Status 7 - power switch control	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set by the EKat ECU, if an internal generated voltage in the EKat ECU drops below threshold
X			31	1F	Ignition Coil Cyl. 5	Ignition feedback	Input analog100 mVTiming	Ignition Shunt Resistor	The DME initiates the secondary ignition for each cylinder then looks for the feedback through the shunt resistor in the harness to determine if the ignition actually occurred.
	X	X	32	20	Idle Control	Rationality check	DME internal values logical	Idle control	Plausibility check between the actual engine speed and the predetermined engine speed. Fault will set if not within the desired RPM range (+200/-100 rpm)
	X		33	21	VANOS System Malfunction Bank 1	Rationality check	DME internal values logical	VANOS unit camshaft sensor wheel	The VANOS system is monitored for mechanical faults (slow response) by the time it takes to reach the target position;The position of the sensor wheel is checked by comparison of cam
X			33	21	Injector Circuit Cylinder 5, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	33	21	EKAT-Status 8 - EKAT-ECU	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set by the EKat ECU, if an checksum error is detected
	X		34	22	VANOS System Malfunction Bank 2	Rationality check	DME internal values logical	VANOS unit camshaft sensor wheel	The VANOS system is monitored for mechanical faults (slow response) by the time it takes to reach the target position;The position of the sensor wheel is checked by comparison of cam
		X	34	22	Fuel Trim (Bank2), Multiplicative	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
X			35	23	Secondary Air Injection System , el. Pump	Final stage check	Output digital on/off (active low)	Air pump	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	35	23	Fuel Adaptation Additive at idle air leak (Bank 2)	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
		X	36	24	Fuel Trim at idle (Bank2), Additive	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
X			36	24	Malfunction main relay	Analog monitoring of main relay power circuit	Input analog 0-12V	main relay - ignition	Singal range check between DME ignition analog input and main relay power circut analog input
X			38	26	Clutch switch faulty	Plausibility check	Input digital 0-12V	Clutch switch	Plausibility check of clutch switch an DME internal values like load and engie speed
X			39	27	plausibility between breaklight and breaklight test switch	Rationality check	Input digital 0-12V	Breaklight switch	Whenever the breaklight switch is active, the breaklight test switch must be also active. If not then this fault is stored

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X	X	39	27	EWS Content of Message	Manipulation Check	Input binary stream 0-12V Bit information	EWS	The content of the binary message received from EWS was invalid
	X	X	40	28	Catalyst Efficiency Bank 1 Below Threshold	Catalyst monitoring	Input analog 0-1V Voltage	O2 Sensor pre/post catalyst	Compares the value of the pre cat O2 sensor to value of the post cat O2 sensor to measure the oxygen storage capability / efficiency of the catalytic converter. The post O2 sensor must be
		X	42	2A	EKAT-Status 1 - Disabeling of heater for Catalyst 1	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set, if the EKat ECU detects an electrical error of heater 1 (disconnection, low voltage befor / during heating, short circuit)
X			42	2A	Signal multi functional steering wheel, redundant code transmission	Rationality check	Input binary stream 0-12V	Multi functional steering wheelCruise control switch	Every signal from the cruese control switch is transfered redundantly coded. A Fault is set, whenever the two redundant information paths are showing a different status.
X			43	2B	Signal multi functional steering wheel, control switch	Rationality check	Input binary stream 0-12V	Multi functional steering wheel	When the status from cruise control showing set/accelerate and deceleration at the same time, then a fault is set.
		X	43	2B	EKAT-Status 2 - heater power for Catalyst 1	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set by the EKat ECU, if heater power of heater 1 drops below threshold
		X	44	2C	EKAT-Status 3 - power switch Catalyst 1	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set, if the EKat ECU detects overtemperature of power switch for Catalyst 1or range check error of the temperature sensor
X			45	2D	Signal multi functional steering wheel, toggle-bit	Time out check	Input binary stream 0-12V	Multi functional steering wheel	every 0.5 sec. a message that includes a toggle bit (toggles between 0->1 and 1->0) is transmitted. The change of this bit is monitored and it indicates proper functionality.
	X	X	45	2D	Catalyst Efficiency Bank 2 Below Threshold	Catalyst monitoring	Input analog 0-1V Voltage	O2 Sensor pre/post catalyst	Compares the value of the pre cat O2 sensor to value of the post cat O2 sensor to measure the oxygen storage capability / efficiency of the catalytic converter. The post O2 sensor must be
		X	46	2E	EKAT-Status 4 - Disabeling of heater for Catalyst 2	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set, if the EKat ECU detects an electrical error of heater 2 (disconnection, low voltage befor / during heating, short circuit)
		X	47	2F	EKAT-Status 5 - heater power of Catalyst 2	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set by the EKat ECU, if heater power of heater 1 drops below threshold
X			47	2F	Torque monitoring level 1	Rationality check	DME internal values logical	Calculated	
		X	48	30	EKAT-Status 6 - power switch catalyst 2	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set, if the EKat ECU detects overtemperature of power switch for Catalyst 2 or range check error of the temperature sensor
X			48	30	Internal Control Module, Memory check sum or internal communication	DME HW Test Memory	DME internal values logical	Calculated	

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			49	31	ECU internal test	DME HW Test	DME internal values logical	Calculated	
X			50	32	ECU internal test	DME HW Test	DME internal values logical	Calculated	
	X	X	50	32	Cylinder 1 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 1 is longer the fault ...
		X	51	33	Cylinder 2 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 2 is longer the fault ...
	X		51	33	Cylinder 8 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 2 is longer the fault ...
X			51	33	ECU internal test	DME HW Test	DME internal values logical	Calculated	
X			52	34	Rear Exhaust Valve flap	Final stage check	Output digitalsteady (active low)	Valve for exhaust flap	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	52	34	Cylinder 3 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 3 is longer the fault ...
	X		52	34	Cylinder 6 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 3 is longer the fault ...
X			53	35	Idle Control Valve Opening Coil, Malfunction	Final stage check	Output digital pulse width 120Hz (active low)	Idle control valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	53	35	Cylinder 4 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 4 is longer the fault ...
	X		53	35	Cylinder 3 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 4 is longer the fault ...
		X	54	36	Cylinder 5 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 5 is longer the fault ...
	X		54	36	Cylinder 2 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 5 is longer the fault ...

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			55	37	O2 Sensor Heater Circuit Pre Cat (Bank2)	Final stage check	Output digital pulse width (active low)	O2 Sensor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	55	37	Cylinder 6 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 6 is longer the fault
	X		55	37	Cylinder 5 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 6 is longer the fault
	X	X	56	38	Cylinder 7 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 7 is longer the fault
X			56	38	Ignition Feedback, interruption at shunt resistor	Ignition feedback	Input analog 32V Voltage	Ignition Shunt Resistor	Check for correct signal voltage. If Voltage is 32V (Zener limitation voltage) than secondary ignition voltage is detected then there might be a problem with the shunt resistor in the
X			57	39	Knock Sensor 1 Circuit, (Bank 1)	Circuit continuitySignal range check	Input analog 13-19kHz Amplitude	Knock sensor	Plausibility Check between the knock sensor amplitude during knocking with the internal knock detection mapped DME values.
		X	57	39	Cylinder 8 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 8 is longer the fault
	X		57	39	Cylinder 4 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 8 is longer the fault
X			59	3B	Knock Sensor 2 Circuit, (Bank 2)	Circuit continuitySignal range check	Input analog 13-19kHz Amplitude	Knock sensor	Plausibility Check between the knock sensor amplitude during knocking with the internal knock detection mapped DME values.
X			61	3D	O2 Sensor Heater Circuit Post Cat (Bank2)	Final stage check	Output digital pulse width (active low)	O2 Sensor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
X			62	3E	Secondary Air Inj. System Switching Valve	Final stage check	Output digital on/off (active low)	Air valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
	X	X	62	3E	Random/Multiple Cylinder Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for a cylinder is longer the fault will set.
		X	63	3F	Cylinder 1 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 1 is longer the fault

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
		X	64	40	Cylinder 2 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 2 is longer the fault
X			65	41	Camshaft Position Sensor intake cam, Malfunction	Rationality check	Input analog 0-5V phase shift	CAM sensor	Internal check of the phase shift from the cam sensor which should change during every crankshaft revolution. The phase shift occurs due to the 2:1 mechanical relationship between cam
		X	65	41	Cylinder 3 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 3 is longer the fault
		X	66	42	Cylinder 4 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder41 is longer the fault
		X	67	43	Cylinder 5 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 5 is longer the fault
X			68	44	EVAP System, Purge Control Valve Circuit	Final stage check	Output digital pulse width (active low)	purge valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	68	44	Cylinder 6 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 6 is longer the fault
X			69	45	Relay Fuel Pump	Final stage check	Output digital on/off (active low)	Relay fuel pump	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
		X	69	45	Cylinder 7 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 7 is longer the fault
		X	70	46	Cylinder 8 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 8 is longer the fault
		X	71	47	Cylinder 9 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 9 is longer the fault
		X	72	48	Cylinder 10 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 10 is longer the
		X	73	49	Cylinder 11 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 11 is longer the
X			74	4A	Relay AC Compressor	Final stage check	Output digital on/off (active low)	Relay AC Compr.	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
		X	74	4A	Cylinder 12 Misfire detected, catalyst damaging	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 12 is longer the
		X	75	4B	Random/Multiple Cylinder, Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for a cylinder is longer the fault
		X	77	4D	air containment valve for air control of shrouded fuel Injector (Bank 2)	Final stage check	Output digital on/off (active low)	air containment valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	78	4E	Crankshaft Position Sensor (too many teeth)	Rationality check	Input digital 0-12V Frequency/pattern	Crank sensor	Crank sensor signal reports that too many teeth were detected within one crankshaft revolution. The fault will set if more teeth was detected than the default value.
X			79	4F	O2 Sensor Heater Circuit (Bank1,Sensor2)	Final stage check	Output digital pulse width (active low)	O2 Sensor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
	X		80	50	Secondary Air Control Bank 1	Secondary Air Delivery	Input analog 0-1V Voltage	O2 Sensor	Checks to see if the O2 sensor reacts to the increase in unmetered air flow generated by the secondary air pump operation. The O2 sensor must sense the lean condition or a
		X	80	50	Secondary Air Control	Secondary Air Delivery	Input analog 0-1V Voltage	O2 Sensor	Checks to see if the O2 sensor reacts to the increase in unmetered air flow generated by the secondary air pump operation. The O2 sensor must sense the lean condition or a
		X	81	51	EKAT-Status 9 - sensor check temperature sensor (1) in battery terminal	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Signal Range is checked against predefined diagnostic limits
	X		81	51	Secondary Air Control Bank 2	Secondary Air Delivery	Input analog 0-1V Voltage	O2 Sensor	Checks to see if the O2 sensor reacts to the increase in unmetered air flow generated by the secondary air pump operation. The O2 sensor must sense the lean condition or a
		X	82	52	EKAT-Status 10 - sensor check temperature sensor (2) in battery terminal	Electrical heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Signal Range is checked against predefined diagnostic limits
		X	83	53	EKAT-Status 11 - plausibility check of temperature sensor in battery terminal	Electrical heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Plausibility check between the two temperature sensors in the battery terminal
X			83	53	Crankshaft Position Sensor, Malfunction	Rationality check	Input digital 0-12V Frequency/pattern	Crank sensor	Checks for correct signal pattern and correct number of expected flywheel teeth.
	X	X	84	54	Relay for Secondary Air Pump Final stage	Final stage check	Output digital on/off (active low)	Relay for Secondary Air pump	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X	X	85	55	Secondary Air Inj. System Switching Valve Final stage	Final stage check	Output digital on/off (active low)	Secondary Air valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
		X	91	5B	EVAP System, Purge Control Valve Circuit (Bank 2)	Final stage check	Output digital on/off (active low)	purge valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		93	5D	EVAP System Purge Control Valve	EVAP monitoring	DME internal values logical	purge valve	This functional check looks for the engine reaction during canister purging. It checks whether the fuel control or RPM values react to the purging of the canister.
	X	X	98	62	EVAP System Purge Control Valve Final stage	Final stage check	Output digital on/off (active low)	purge valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	100	64	Transmission/ coolant heat exchanger	Final stage check	Output digital on/off (active low)	Trans/coolant heat exchanger	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			100	64	Internal Control Module, Memory check sum or internal communication	DME HW Test Memory	DME internal values logical	DME internally	Internal hardware test of RAM, ROM, and Flash Prom.
		X	101	65	Internal Control Module, RAM	DME HW Test Memory	DME internal values logical	DME internally	Internal hardware test of RAM, ROM, and Flash Prom.
	X		101	65	Internal Control Module, CPU	Rationality check	DME internal values logical	DME internally	Checks if the torque limitation works properly. If it does not the throttle is switched off.
		X	102	66	Internal Control Module, Keep Alive Memory	DME HW Test Memory	DME internal values logical	DME internally	Internal hardware test of RAM, ROM, and Flash Prom.
	X		102	66	Signal multi functional steering wheel, redundant code transmission	Rationality check	Input binary stream 0-12V	Multi functional steering wheel	Fault is set, when no signal is detected or when the transmission from the steering wheel is disturbed (timing check, single bit check)
X			103	67	VANOS faulty reference value intake	Rationality check	DME internal values logical	Crank-/Cam-sensor intake	The maximum VANOS adjustment angle, checked at every engine start must be within a specified limit.
		X	103	67	Internal Control Module, Memory check sum	DME HW Test Memory	DME internal values logical	DME internally	Internal hardware test of RAM, ROM, and Flash Prom.
	X		103	67	Internal Control Module, CPU	Rationality check	DME internal values logical	DME internally	Internal functional checks of the system
	X		104	68	Clutch switch faulty	Rationality check	Input digital 0-12V	Clutch Switch	The system detects the gear change by calculation of the ratio between engine and vehicle speed. If several gear changes are detected and there was no signal from the clutch switch a fault is
X			104	68	VANOS faulty reference value exhaust	Rationality check	DME internal values logical	Crank-/Cam-sensor exhaust	The maximum VANOS adjustment angle, checked at every engine start must be within a specified limit.

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
		X	104	68	Internal Control Module, RAM	DME HW Test Memory	DME internal values logical	DME internally	Internal hardware test of RAM, ROM, and Flash Prom.
X			105	69	VANOS mechanically stuck (Bank1) intake	Rationality check	DME internal values logical	Crank-/ cam sensor	Motitoring of a desired VANOS adjustment within a predefined diagnostic time limit.
	X		105	69	Internal Control Module, RAM	DME HW Test Memory	DME internal values logical	DME internally	Internal hardware test of RAM.
		X	105	69	Internal Control Module, EEPROM	DME HW Test Memory	DME internal values logical	DME internally	Internal hardware test of RAM, ROM, and Flash Prom.
	X		106	6A	plausibility between breaklight switch and breaklight test	Rationality check	Input digital 0-12V	Breaklight switch	Whenever the breaklight switch is active, the breaklight test switch must be also active. If not then this fault is stored
X			106	6A	VANOS mechanically stuck (Bank2) exhaust	Rationality check	DME internal values logical	Crank-/ cam sensor	Motitoring of a desired VANOS adjustment within a predefined diagnostic time limit.
	X		107	6B	Internal Control Module, ROM	DME HW Test Memory	DME internal values logical	DME internally	Internal hardware test of ROM and Flash Prom.
		X	107	6B	Battery Voltage	Signal range check	Input analog Batt.Voltage Voltage	Battery Voltage	Check that proper battery voltage is present between 9 and 16 Volts. This check is not performed during cranking due to voltage drop.
	X		108	6C	Internal Control Module	Reset logic	DME internal values logical	DME internally	Internal functional checks of the system
		X	108	6C	Battery Voltage Disconnected	Rationality check	Input analog Batt. Voltage Voltage continuity	Battery Voltage	ECU internal test determines if the unit has been disconnected from battery power. This fault could be set by disconnection of the battery or control unit or wiring problem effecting B+ supply
X			109	6D	Motor throttle valve mechanically; pulse width not plausiple	Rationality check	Output digital 0-12V pulse width	Motor Throttle Valve	The throttle position control algorithm checks for problems with the mechanical coupling spring within the mtor throttle body. If the calculated pulse width signal is not plausible with the actual
	X		109	6D	Battery Voltage	Signal range check	Input analog Batt. Voltage Voltage	DME internally	Checks the Analog to Digital Converter. If the system can detect voltages lower than 2.5 Volts then a fault is set.
	X		110	6E	Torque limitation, level 1	Rationality check	DME internal values logical	DME internally	Internal check of the actual torque demand against a limit. If the limit is exceeded then a fault is set. The torque will be limited.
X			110	6E	Pedal Sensor 1	Signal range check	Input analog 0-5V Voltage	Pedal Sensor 1	Failed the Signal Range check against predefined diagnostic limits

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			111	6F	Pedal Sensor 2	Signal range check	Input analog 0-2.5V Voltage	Pedal Sensor 2	Failed the Signal Range check against predefined diagnostic limits
		X	111	6F	Crankshaft Position Sensor, Malfunction	Rationality check	Input digital 0-12V Frequency/pattern	Crank sensor	Checks for correct signal pattern and correct number of expected flywheel teeth.
	X		111	6F	Crankshaft Position Sensor Malfunction	Rationality check	Input digital 0-12V Frequency/pattern	Crank sensor	A fault is set if a signal from the cam sensor is detected and there is no signal from the crank sensor (engine speed).
		X	112	70	Camshaft Position Sensor Circuit, Malfunction	Rationality check	Input digital 0-12V Frequency/pattern	Cam sensor	Internal check of the phase shift from the cam sensor which should change during every crankshaft revolution. The phase shift occurs due to the 2:1 mechanical relationship between cam
X			112	70	Throttle Position Sensor 1	Signal range check	Input analog 0-5V Voltage	Throttle position sensor 1	Failed the Signal Range check against predefined diagnostic limits
	X		112	70	Crankshaft Position Sensor Malfunction	Rationality check	Input digital 0-12V Frequency/pattern	Crank sensor	Checks for correct signal pattern and correct number of expected flywheel teeth.
	X		113	71	Camshaft Position Sensor Bank 1 Malfunction	Rationality check	Input digital 0-12V Frequency/pattern	CAM sensor	Internal check of the signal from the cam sensor. The signal state must change at every reference mark (2 missing teeth) of the crank.
X			113	71	Throttle Position Sensor 2	Signal range check	Input analog 0-5V Voltage	Throttle position sensor 2	Failed the Signal Range check against predefined diagnostic limits
X			114	72	A second pedal sensor range check failure is determinded	Logical test	DME internal values logical	DME internally	Is on pedal sensor mailfunktion detected and later happens a second
	X		114	72	Camshaft Position Sensor Bank 2 Malfunction	Rationality check	Input digital 0-12V Frequency/pattern	CAM sensor	Internal check of the signal from the cam sensor. The signal state must change at every reference mark (2 missing teeth) of the crank.
	X	X	115	73	Mass or Volume Air Flow Circuit Malfunction	Signal range check	Input analog 0-6V Voltage	HFM	Failed the Signal Range check against predefined diagnostic limits
X			115	73	Range check for throttle position adaptation	Range check	Input analog 0-5V	Throttle position sensors	Range Check for the closed position of the throttle sensors
	X		117	75	Throttle Position Sensor	Rationality check	Input analog 0-5V Voltage	Throttle position sensor	This error occurs always together with fault code 118 or 119; the only additonal information consists of more environmental conditions
		X	117	75	Throttle Position Sensor	Rationality check	DME internal values logical	Throttle position sensor	Signal Range is checked against the predetermined diagnostic limits. A fault will set if the Air Flow meter value (volume) does not logically match throttle position sensor value (throttle

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			117	75	Pedal Sensor Plausibility	Rationality check	Input analog 0-5V Voltage	Pedal Sensor	If there is a difference greater than specified between the two redundant signals from the potentiometer, a fault will be set.
	X		118	76	Throttle Position Sensor 1	Rationality check	Input analog 0-5V Voltage	Throttle position sensor 1	Signal Range is checked against the predetermined diagnostic limits.Rationality check with Sensor 2. The sum of the values of Sensor 1 and Sensor 2 must be 5 V.
X			118	76	Throttle Position Sensor 1; Plausibility check sensor 1 to air flow mass meter	Rationality check	DME internally Test	Throttle position sensor 1	Signal Range is checked against the predetermined diagnostic limits.Rationality check with airflow mass meter
X			119	77	Throttle Position Sensor 2; Plausibility check sensor 1 to air flow mass meter	Rationality check	DME internally Test	Throttle position sensor 2	Signal Range is checked against the predetermined diagnostic limits.Rationality check with airflow mass meter
	X		119	77	Throttle Position Sensor 2	Rationality check	Input analog 0-5V Voltage	Throttle position sensor 2	Signal Range is checked against the predetermined diagnostic limits.Rationality check with Sensor 1. The sum of the values of Sensor 1 and Sensor 2 must be 5 V.
X			120	78	plausibility check between break switch and pedal sensor	Rationality check	Input digital / analog	Break switch, pedal sensor	Plausibility check between a constant padal value and break switch. First the padal value must be constant and for the next step break switch must be aktiv
		X	120	78	Vehicle Speed Sensor	Rationality check	Input digital 0-12V Frequency	ASC	Signal Range is checked against predefined diagnostic limits. No vehicle speed is observed after a specific time when compared to engine speed and load which is equivalent to a
	X		120	78	Vehicle Speed Sensor	Rationality check	Input digital 0-12V Frequency	ASC	No vehicle speed is observed for a specific time when the engine is in fuel cut off.
	X		121	79	Vehicle Speed Sensors	Rationality check	Input digital binary information from CAN	ASC	Plausibility check of wheel speed information from ASC
		X	121	79	Load Calculation Cross Check, Range/Perf.	Signal range check Rationality check	DME internal values logical	HFM, Throttle position sensor	Plausibility check between the Throttle Position Sensor Signal and the HFM.
X			122	7A	Oil Temperature sensor malfunction	Signal range check	Input analog 0-5V Voltage	Coolant Temp sensor	Signal Range is checked against the predefined diagnostic limits and the calculated temperature.
X			123	7B	Electric Thermostat Control, final stage	Final stage check	Output digital on/off (active low)	Electric Thermostat	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
	X	X	123	7B	Engine Coolant Temp Circuit Range/Perf.	Signal range check	Input analog 0-5V Voltage	Coolant Temp sensor	Signal Range is checked against the predefined diagnostic limits and the calculated temperature.
X			124	7C	DISA, Range/Performance	Final stage check	Output digital on/off (active low)	Disa Valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X	X	124	7C	Intake Air Temperature Range/Performance	Signal range check	Input analog 0-5V Voltage	Intake Temp. sensor	Signal Range is checked against predefined diagnostic limits
X			125	7D	Coolant Fan, Final stage	Final stage check	Output digital pulse width (active low)	Coolant Fan	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
	X		125	7D	Coolant Temperature Cooler outlet	Signal range check	Input analog 0-5V Voltage	Coolant Temp sensor	Signal Range is checked against the predefined diagnostic limits.
X			126	7E	DMTL valve	Final Stage Check	Output digital on/off (active low)	DMTL	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected component
X			128	80	EWS Signal not present or faulty	DME HW Test SIO	Input binary stream 0-12V Bit information	EWS	During the time out check no signal was present within the specific time or faulty information from serial interface (parity, overrun, etc.)
		X	130	82	Swapped O2 Sensors Pre Cat.	O2-Sensor check	DME internal values logical	O2 Sensor	Fault will set if the O2 sensor from one bank shows a rich condition while the other bank shows a lean condition.
	X		130	82	Throttle valve position Throttle sticking	Rationality check	DME internal values logical	Motor Throttle Valve	Fault is set when the actual position of the throttle valve and the target positon don’t match.
X			130	82	CAN Time Out (ASC1)	DME HW Test CAN	Input digital 0-12V Binary information	ASC	CAN message between DME/EGS was not received within the expected time
	X		131	83	Throttle valve position	Rationality check	DME internal values logical	Motor Throttle Valve	Fault is set if the position control reaches predefined threshold because of a slow moving throttle valve
X			131	83	CAN Time Out (instr2)	DME HW Test CAN	Input digital 0-12V Binary information	instr2	CAN message between DME/EGS was not received within the expected time
	X		132	84	Motor Throttle Valve Final stage	Rationality check	DME internal values logical	Motor Throttle Valve	Fault is set if the position control reaches predefined threshold and the final stage for the throttle motor indicates malfunction.
X			132	84	CAN Time Out (instr3)	DME HW Test CAN	Input digital 0-12V Binary information	instr3	CAN message between DME/EGS was not received within the expected time
	X		133	85	Motor Throttle Valve open/closing test failed	Rationality check	DME internal values logical	Motor Throttle Valve	pre drive check. Opening and closing of throttle must be fulfilled within a pre defined time (only small opening).
		X	133	85	DME Bank identification input	Rationality check	Input digital 0-12V on/off	Bank identification- pin wiring harness check	DME identifies itself as a DME_Right or DME_Left depending how the input signal is wired. If it determines that the "learned" value has changed then a fault is detected.

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			133	85	CAN Time Out (ASC3)	DME HW Test CAN	Input digital 0-12V Binary information	ASC3	CAN message between DME/EGS was not received within the expected time
	X		134	86	Motor Throttle Valve closed position adaptation	Rationality check	DME internal values logical	Motor Throttle Valve	The closed position is within a pre defined limit. If this limit has been exceeded, this fault will be set.Also if there is a need for adaptation (after changing the throttle) and the adaptation is
	X		135	87	Motor Throttle Valve Amplifier adjustment	Rationality check	DME internal values logical	DME internally	The signal from throttle position sensor 1 is amplified to get better resolution in idle position. If there is a mismatch between the base sensor information and the amplified sensor this fault is
		X	135	87	Transmission: Torque Reduction	Rationality check	Input digital binary information from CAN	EGS	CAN message had an invalid or undefined value
X			135	87	Limp Home position adaptation necessary	Rationality check	DME internal values logical	Trottle position sensors	The limp home position must be within a specified range. If the range is exceeded, a fault is set. Also if the adaptation of the limp home position (part of the throttle adaptation) is interrupted the
	X		136	88	Motor Throttle Valve check of the limp home position	Rationality check	DME internal values logical	Motor Throttle valve	The limp home position must be within a specified range. If the range is exceeded, a fault is set. Also if the adaptation of the limp home position (part of the throttle adaptation) is interrupted the
X			136	88	Motor Throttle Valve open/closing test failed	Rationality check	DME internal values logical	Motor Throttle valve	From the limp home postion the throttle valve will be open, afterwards it muß fallback in the limp home position. Is the fall back position not in specifierd range the fault is set.
		X	138	8A	AC Compressor Torque Reduction	Timing check	Input digital binary information from CAN	IHKA via K-Bus from the Instr. Cluster	Checks CAN message for proper content of pulse width modulation signal (>MY97)
		X	139	8B	Electric Thermostat Control, final stage	Final stage check	Output digital on/off (active low)	Electric Thermostat	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			140	8C	DMTL pump final stage	EVAP monitoring	Output digital on/off (active low)	DMTL	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		140	8C	Electric Thermostat Control, final stage.	Final stage check	Output digital on/off (active low)	Electric Thermostat	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	140	8C	Torque imbalance	Rationality check	Input analog 0-5V Voltage	HFM1 and HFM2	Comparison between the 2 air mass signals. If the difference is too large then a fault is detected. Most likely cause is and air leak.
	X		141	8D	Coolant Fan Final stage	Final stage check	Output digital pulse width (active low)	Coolant Fan	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	141	8D	ASC Signal, Plausibility check	Rationality check	Input digital binary information from CAN	ASC	Internal check of binary signals from ASC/MSR/EML. The control unit knows what are the possible combinations of signals. If the combined signals don't match the internal table the fault will

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			142	8E	DMTL modul fault	EVAP monitoring	DME internal values logical	Calculated	
X			143	8F	EVAP: Clamped Tube Check	EVAP monitoring	Input digital 0-12V Frequency	DMTLt	
		X	143	8F	MSR Signal	Timing check	Input digital binary information from CAN	ASC	Internal check of binary signals from ASC/MSR/EML. The control unit knows what are the possible combinations of signals. If the combined signals don't match the internal table the fault will
		X	144	90	ASC Signal, Plausibility Torque Reduction	Timing check	Input digital binary information from CAN	ASC	Internal check of binary signals from ASC/MSR/EML. The control unit knows what are the possible combinations of signals. If the combined signals don't match the internal table the fault will
X			146	92	Range check voltage supply pedal sensor 1 and throttle position sensors	range check	DME internal analog input	DME internally	The supply voltage for the senosrs must be within a spicified range.
		X	147	93	Electric Thermostat Control, Range/Performance.	Final stage check	Output digital on/off (active low)	Electric Thermostat	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			147	93	Range check voltage supply for pedal sensor 2	range check	DME internal analog input	DME internally	The supply voltage for the senosrs must be within a spicified range.
	X	X	148	94	EWS Signal not present or faulty	DME HW Test SIO	Input binary stream 0-12V Bit information	EWS	During the time out check no signal was present within the specific time or faulty information from serial interface (parity, overrun, etc.)
X			149	95	Throttle Position and Air Mass Sensor Signal not plausible	Rationality check	Input analog 0-5V Voltage	Air Mass Sensor	The signal from the motor throttle valve potentiometer must be suitable to the signal from the air mass sensor. A fault is set if the difference exceeds a specified limit.
X			150	96	Signal range check O2 Sensor Pre Cat. (Bank1)	O2-Sensor check	Input analog 0-5V (high is lean)	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical shorts exist on the input line. The voltage signal has to be within a predetermined range (0,1V - 1V) or a fault will set.
	X	X	150	96	Injector Circuit Cylinder 1 Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			151	97	Signal range check O2 Sensor Pre Cat. (Bank2)	O2-Sensor check	Input analog 0-5V	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical shorts exist on the input line. The voltage signal has to be within a predetermined range (0,1V - 1V) or a fault will set.
		X	151	97	Injector Circuit Cylinder 2, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		151	97	Injector Circuit Cylinder 5 Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			152	98	Signal range check O2 Sensor Post Cat. (Bank1)	O2-Sensor check	Input analog 0-5V	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical disconnection exist on the input line. The voltage signal has not to be clamped to the specific internally value
		X	152	98	Injector Circuit Cylinder 3, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		152	98	Injector Circuit Cylinder 4 Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			153	99	Signal range check O2 Sensor Post Cat. (Bank2)	O2-Sensor check	Input analog 0-5V	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical shorts exist on the input line. The voltage signal has to be within a predetermined range (0,1V - 1V) or a fault will set.
		X	153	99	Injector Circuit Cylinder 4, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		153	99	Injector Circuit Cylinder 8 Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	154	9A	Injector Circuit Cylinder 5, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		154	9A	Injector Circuit Cylinder 6 Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	155	9B	Injector Circuit Cylinder 6, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		155	9B	Injector Circuit Cylinder 3 Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	156	9C	Injector Circuit Cylinder 7, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		156	9C	Injector Circuit Cylinder 7 Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	157	9D	Injector Circuit Cylinder 8, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		157	9D	Injector Circuit Cylinder 2 Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
		X	158	9E	Injector Circuit Cylinder 9, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	159	9F	Injector Circuit Cylinder 10, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			160	A0	Throttle valve position controller	controller monitoring	DME internal values logical	throttle valve DME internal	
		X	160	A0	Injector Circuit Cylinder 11, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			161	A1	Throttle valve position controller	controller monitoring	DME internal values logical	throttle valve DME internal	
		X	161	A1	Injector Circuit Cylinder 12, Malfunction	Final stage check	Output digital pulse width (active low)	Injector	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			162	A2	Throttle valve position controller	controller monitoring	DME internal values logical	throttle valve DME internal	
		X	163	A3	Electric Fuel Pump Relay, Final stage (Bank 2)	Final stage check	Output digital on/off (active low)	Fuel pump relay	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		163	A3	plausibility check between air mass meter and throttle position	Rationality check	DME internal values logical	HFM, Throttle position sensor	Plausibility check between the Throttle Position Sensor Signal and the HFM.
		X	164	A4	EVAP: Barometric Tank Pressure Sensor	Signal range check	Input analog 0-5V Voltage	Tank pressure sensor	The Signal Range is checked to detect shorts on the input line
	X		164	A4	Barometric Pressure Sensor	Signal range check	Input analog 0-5V Voltage	barometric pressure sensor inside the ECU	The Signal Range is checked to detect faults on the input line
		X	165	A5	Check Engine Light, Final stage Malfunction	Final stage check	Output digital on/off (active low)	Instrument Cluster	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		165	A5	VANOS electrical fault Bank 1	Final stage check	Output digital on/off (active low)	VANOS valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		166	A6	VANOS electrical fault Bank 2	Final stage check	Output digital on/off (active low)	VANOS valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X	X	167	A7	Electric Fuel Pump Relay Final stage	Final stage check	Output digital on/off (active low)	Fuel pump relay	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	168	A8	Idle Control Valve Opening Coil, Malfunction	Final stage check	Output digital pulse width (active low)	Idle control valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
X			168	A8	Throttle valve position Throttle sticking	Functional check	DME internally Test	Calculated	
		X	169	A9	Idle Control Valve Closing Coil, Malfunction	Final stage check	Output digital pulse width (active low)	idle control valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X	X	170	AA	AC Compressor Control	Final stage check	Output digital on/off (active low)	AC Comp.	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. Occurs
		X	175	AF	DISA, Range/Performance	Final stage check	Output digital on/off (active low)	Disa Valve	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
		X	179	B3	AC Compressor Control (Bank 2)	Final stage check	Output digital on/off (active low)	AC-Control	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X	X	183	B7	EVAP: Leak detected	EVAP monitoring	Input digital 0-12V Frequency	LDP reed contact	The frequency of the LDP pumps reed switch is above the predetermined leak range. The larger the leak the higher the frequency will be.
	X	X	184	B8	EVAP: pinched hose check	EVAP monitoring	Input digital 0-12V Frequency	LDP reed contact	The frequency of the LDP pumps reed switch is lower then the predetermined limit. The volume of leak is determined to be too small as in a pinched or restricted hose.
	X		185	B9	EVAP: Reed Switch	EVAP monitoring	Input digital 0-12V on/off	LDP reed contactswitch	Within a predetermined time the LDP reed switch signal has to change from high to low or from low to high or LDP reed switch is "low" for longer then the predetermined time.
X			188	BC	O2-Sensor-Heater, Pre Cat. (Bank1), insufficient.	Final stage check	Output digital pulse width (active low)	O2 Sensor	The DME internally calculated heater power is checked against predefined diagnostic limits.
X			189	BD	O2-Sensor-Heater, Pre Cat. (Bank2), insufficient.	Final stage check	Output digital pulse width (active low)	O2 Sensor	The DME internally calculated heater power is checked against predefined diagnostic limits.
X			190	BE	O2-Sensor-Heater, Post Cat. (Bank1), insufficient.	Final stage check	Output digital pulse width (active low)	O2 Sensor	The DME internally calculated heater power is checked against predefined diagnostic limits.
X			191	BF	O2-Sensor-Heater, Post Cat. (Bank2), insufficient.	Final stage check	Output digital pulse width (active low)	O2 Sensor	The DME internally calculated heater power is checked against predefined diagnostic limits.

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			197	C5	Signal Range check	Singal range check	DME intern analog input	Umgebungsdrucksenso r	Analogsignal des Umgebungsdrucksensor liegt außerhalb des spezifizierten Wertes
X			202	CA	Fuel Trim (Bank1), O2 Control Limit	Fuel system monitoring	DME internal values logical	Calculated	The Controller for Lambda is too long beyond a min. or a max. limit
X			203	CB	Fuel Trim (Bank2), O2 Control Limit	Fuel system monitoring	DME internal values logical	Calculated	The Controller for Lambda is too long beyond a min. or a max. limit
		X	203	CB	Ignition Feedback (bank failed)	Ignition feedback	Input analog 100 mV Timing	Ignition Shunt Resistor	Check for correct signal timing after each ignition has been initiated by this feedback signal
	X		186	BA	EVAP: DMTL Pump Motor - Final Stage	Final stage check	Output digital on/off (active low)	DMTL pump motor	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs
	X		187	BB	EVAP: 0.5 mm leak detected	EVAP monitoring	DME internal values logical	DMTL pump motor current	The current of the pump motor is monitored. If the current does not reach predefined thresholds after a given time, this is a indication of a leak;
	X		188	BC	EVAP: 1 mm leak detected	EVAP monitoring	DME internal values logical	DMTL pump motor current	The current of the pump motor is monitored. If the current does not reach predefined thresholds after a given time, this is a indication of a leak;
	X		189	BD	EVAP: DMTL module	EVAP monitoring	DME internal values logical	DMTL module	The pump motor current is monitored, escepially during the reference leak measurement. If the current is not in a predefined range a fault is set.
	X	X	204	CC	EWS, rolling code storage	DME HW-Test	DME internal values logical	EWS	The EWS3.3 rolling code is not stored properly in the DME internal memory
X			204	CC	Idle Control System, Idle Speed not plausible	Rationality check	DME internal values logical	calculated	Functional Check between the actual engine speed (RPM) and the predetermined RPM exceeds the maximum deviation of +200/-100 RPM.
		X	208	D0	Secondary Air Induction System (Bank 2)	Secondary Air Delivery	Input analog 0-1V Voltage	O2 Sensor	Checks to see if the O2 sensor reacts to the increase in unmetered air flow generated by the secondary air pump operation. The O2 sensor must sense the lean condition or a
X			209	D1	EWS, Content of Message	Manipulation check	Input binary stream 0-12V Bit information	EWS	The content of the binary message received from EWS was invalid
	X	X	210	D2	Knock Sensor 1 Circuit Bank 1	Circuit continuity Signal range check	Input analog 13-19kHz Amplitude	Knock sensor	Plausibility Check between the knock sensor amplitude during knocking with the internal knock detection mapped DME values.
X			210	D2	Ignition Feedback, faulty (>2 Cylinders)	Ignition feedback	Input analog 100 mV Timing	Ignition Shunt Resistor	Check for correct signal timing after each ignition has been initiated by this feedback signal. If more than two ignition is not recognized than there might be a problem in the feedback line

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X	X	211	D3	Knock Sensor 2 Circuit Bank 2	Circuit continuity Signal range check	Input analog 13-19kHz Amplitude	Knock sensor	Plausibility Check between the knock sensor amplitude during knocking with the internal knock detection mapped DME values.
X			211	D3	Idle Control Valve stuck mechanically	Rationality check	DME internal values logical	calculated	Functional Check against a calculated value by monitoring the flow though the air mass meter to determine is the idle valve is mechanically stuck open. Tested during closed throttle
	X	X	212	D4	Knock Sensor 3 Circuit	Circuit continuity Signal range check	Input analog 13-19kHz Amplitude	Knock sensor	Plausibility Check between the knock sensor amplitude during knocking with the internal knock detection mapped DME values.
	X	X	213	D5	Knock Sensor 4 Circuit	Circuit continuity Signal range check	Input analog 13-19kHz Amplitude	Knock sensor	Plausibility Check between the knock sensor amplitude during knocking with the internal knock detection mapped DME values.
	X		214	D6	Knock control, Base test	Rationality check	DME internal values logical	DME internally	The ECU checks internal values with disconnected sensor. The values must be in a predetermined range.
X			214	D6	Vehicle Speed Sensor	Rationality check	Input digital 0-12V Frequency	ASC	Signal Range is checked against predefined diagnostic limits. No vehicle speed is observed after a specific time when compared to engine speed and load which is equivalent to a moving vehicle.
		X	214	D6	CAN-Index Verification	CAN message check	Input digital 0-12V Binary information	Any ECU on CAN	Logical check of every ECU on the CAN bus has a CAN message interpretation (refer to CAN-Index on the DIS-Tester page) that applies to the vehicle
X			215	D7	O2 Sensor Post Cat.(Bank1),disconnection	O2-Sensor check	Input analog 0-1 V	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical disconnection exist on the input line. The voltage signal has not to be clamped to the specific internally value
		X	215	D7	CAN-Signal, Timeout Left / Right DME	Timing check	Input digital 0-12V Binary information	both DMEs	The Left DME will check for the Right DME and vice versa. If the CAN message was not received by either within the Expected time a fault will set.
	X		215	D7	Knock control, Signal offset	Rationality check	DME internal values logical	Knock sensor	The ECU checks internal values with disconnected sensor. The values must be in a predetermined range.
X			216	D8	O2 Sensor Post Cat.(Bank2),disconnection	O2-Sensor check	Input analog 0-1 V	O2-Sensor	The oxygen sensor signal range is checked to determine if electrical disconnection exist on the input line. The voltage signal has not to be clamped to the specific internally value
	X		216	D8	Knock control, Test pulse	Rationality check	DME internal values logical	DME internally	The ECU internally generated pulse was not detected. It is used to verify electrical integrity (shorts or disconnection) of the knock control circuitry both internally and externally.
		X	216	D8	CAN Signal, Timeout ASC	Timing check	Input digital 0-12V Binary information	ASC	The CAN message was not received within the Expected time

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
		X	217	D9	CAN-Signal, Timeout EML	Timing check	Input digital 0-12V Binary information	EML ECU	The CAN message was not received within the Expected time
X			217	D9	CAN Time Out (EGS1)	DME HW Test CAN	Input digital 0-12V Binary information	EGS	CAN message between DME/EGS was not received within the expected time
X			219	DB	CAN-Chip, Bus Off	DME HW Test CAN	Input digital 0-12V Binary information	Any ECU on CAN	Hardware test determines if Can Bus is off line. Data transmission is disturbed.
		X	220	DC	Knock control, Test pulse	Circuit Continuity Signal range check	DME internal values logical	DME internally	The ECU internally generated pulse was not detected. It is used to verify electrical integrity (shorts or disconnection) of the knock control circuitry both internally and externally.
X			220	DC	O2 Sensor Post Cat. (Bank1) Slow Response time	O2-Sensor check	Input analog 0-5V (high is lean)	O2 Sensor	Checks the amount of time the oxygen sensor stays in its rich or lean state. If it remains there too long in either the fault will set.
	X		220	DC	CAN Time Out (EGS)	DME HW Test CAN	Input digital 0-12V Binary information	EGS	CAN message between DME/EGS was not received within the expected time
	X		219	DB	CAN Time Out (TCU)	DME HW Test CAN	Input digital 0-12V Binary information	TCU transfer box controller	CAN message between DME/TCU was not received within the expected time
X			221	DD	O2 Sensor Post Cat. (Bank2) Slow Response time	O2-Sensor check	Input analog 0-5V (high is lean)	O2 Sensor	Checks the amount of time the oxygen sensor stays in its rich or lean state. If it remains there too long in either the fault will set.
	X		221	DD	CAN Time Out (DSC)	DME HW Test CAN	Input digital 0-12V Binary information	DSC	CAN message between DME/DSC was not received within the expected time
		X	222	DE	Knock control, Test pulse (Bank2)	Circuit Continuity Signal range check	DME internal values logical	DME Internally	The ECU internally generated pulse was not detected. It is used to verify electrical integrity (shorts or disconnection) of the knock control circuitry both internally and externally.
X			222	DE	Insufficient Coolant Temp. to permit Closed Loop Operation.	Rationality check	Input analog 0-5V Voltage	Coolant Temp sensor	Comparison of actual coolant temperature against the calculated DME value which varies with the load signal.
	X		222	DE	CAN Time Out (instr)	DME HW Test CAN	Input digital 0-12V Binary information	instr	CAN message between DME/Instrument cluster was not received within the expected time
X			223	DF	O2-Sensor Post Cat (Bank 1), Switching time too slow	O2-Sensor check	Input analog 0-5V (high is lean)	O2 Sensor	Checks the amount of time the oxygen sensor takes to switch from rich to lean and vice versa. If it takes too long to switch the fault will set.
	X		223	DF	CAN Time Out (ACC)	DME HW Test CAN	Input digital 0-12V Binary information	ACC	CAN message between DME/ACC (Adaptive cruise control) was not received within the expected time

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
	X		224	E0	MSR Signal, Plausibility Torque Rising	Rationality check	Input digital binary information from CAN	DSC	Internal check of DSC signals sent for torque rising. A certain combination of signals is necessary to allow a torque interference. If DSC does not send this combination, a fault is set.
X			224	E0	O2-Sensor Post Cat (Bank 2), Switching time too slow	O2-Sensor check	Input analog 0-5V (high is lean)	O2 Sensor	Checks the amount of time the oxygen sensor takes to switch from rich to lean and vice versa. If it takes too long to switch the fault will set.
X			225	E1	Post Cat. Sensor Bank 1;Trim control	O2-Sensor check	Input analog 0-1V	O2-Sensor	Rationality Check for O2 Control adaptation with post catalyst sensor bank 1
		X	225	E1	EKAT-Status 12 - temperature sensor - plausibility power switch	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Plausibility check between the two temperature sensors in the power switch
	X		225	E1	ACC Signal Plausibility Torque Rising	Timing check	DME internal values logical	ACC	Internal check of ACC signals sent for torque rising. A certain combination of signals is necessary to allow a torque interference. If ACC does not send this combination, a fault is set.
X			226	E2	Post Cat. Sensor Bank 2;Trim control	O2-Sensor check	Input analog 0-1V	O2-Sensor	Rationality Check for O2 Control adaptation with post catalyst sensor bank 2
		X	226	E2	EKAT-Status 13 - power switch voltage plausibility	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Plausibility check between the two input voltages for heater 1 and 2
		X	227	E3	EKAT-Status 14 - check of battery disconnection switch	Electrically heated catalyst check	Input digital binary information from CAN	EKAT-ECU	Set, if a short to ground, a short to battery voltage or a disconnection between the output transistor and the battery disconnection switch occures
X			227	E3	Fuel Trim (Bank1), O2 Control Adaptation Limit	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
		X	228	E4	Automatic Start, Output (Bank 2)	Final stage check	Output digital on/off (active low)	Starter Relay	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs (0.02A<i<2A).
X			228	E4	Fuel Trim (Bank2), O2 Control Adaptation Limit	Fuel system monitoring	DME internal values logical	Calculated	Range control of adaptation values
X			229	E5	O2 Sensor Pre Cat. (Bank1) Slow Response time	O2-Sensor check	Input analog 0-5V (high is lean)	O2 Sensor	Checks the amount of time the oxygen sensor stays in its rich or lean state. If it remains there too long in either the fault will set.
	X		229	E5	Pedal Sensor Voltage Supply	Signal range check	Output analog 0-5V	Pedal Sensor	The control module monitors the supply voltage of the pedal sensors: The nominal value must be 5V.
	X		230	E6	Pedal Sensor	Rationality check	Input analog 0-5V	Pedal Sensor	This fault is always set together with fault #231 and/or fault #232. It delivers additional environmental conditions.

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			230	E6	O2 Sensor Pre Cat. (Bank2) Slow Response time	O2-Sensor check	Input analog 0-5V (high is lean)	O2 Sensor	Checks the amount of time the oxygen sensor stays in its rich or lean state. If it remains there too long in either the fault will set.
	X		231	E7	Pedal Sensor 1	Signal range check	Input analog 0-5V	Pedal Sensor 1	Failed the Signal Range check against predefined diagnostic limits.Also when the pedal sensor signal from Sensor 1 has not the double value of Sensor 2 a fault code is set.
X			231	E7	O2-Sensor Pre Cat (Bank 1), Switching time too slow	O2-Sensor check	Input analog 0-5V (high is lean)	O2 Sensor	Checks the amount of time the oxygen sensor takes to switch from rich to lean and vice versa. If it takes too long to switch the fault will set.
	X		232	E8	Pedal Sensor 2	Signal range check	Input analog 0-5V	Pedal Sensor 2	Failed the Signal Range check against predefined diagnostic limits.Also when the pedal sensor signal from Sensor 2 has not half the value of Sensor 1 a fault code is set.
X			232	E8	O2-Sensor Pre Cat (Bank 2), Switching time too slow	O2-Sensor check	Input analog 0-5V (high is lean)	O2 Sensor	Checks the amount of time the oxygen sensor takes to switch from rich to lean and vice versa. If it takes too long to switch the fault will set.
	X	X	233	E9	Automatic Start Final stage	Final stage check	Output digital on/off (active low)	Starter Relay	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs (0.02A<i<2A).
X			233	E9	Catalyst Efficiency Bank 1, Below Threshold	Catalyst monitoring	Input analog 0-5V Voltage	O2 Sensor pre/post catalyst	Compares the value of the of pre cat O2 sensor to value of the post cat O2 sensor to measure the oxygen storage capability / efficiency of the catalytic converter. The post O2 sensor must be relatively lean.
	X	X	234	EA	Automatic Start Input	Rationality check	Input digital 0-12V on/off	KL50	Fault will set if after a predetermined time K148engine revolution is greater than a limit and Kl50 still active
X			234	EA	Catalyst Efficiency Bank 2, Below Threshold	Catalyst monitoring	Input analog 0-5V Voltage	O2 Sensor pre/post catalyst	Compares the value of the of pre cat O2 sensor to value of the post cat O2 sensor to measure the oxygen storage capability / efficiency of the catalytic converter. The post O2 sensor must be relatively lean.
X			235	EB	Pre Cat. Sensor Bank 1:Trim Control	O2-Sensor check	Input analog 0-1V (high is rich)	O2-Sensor	Rationality Check for O2 Control adaptation with pre catalyst sensor bank 1
X			236	EC	Pre Cat. Sensor Bank 2:Trim Control	O2-Sensor check	Input analog 0-1V (high is rich)	O2-Sensor	Rationality Check for O2 Control adaptation with pre catalyst sensor bank 2
		X	236	EC	CAN Time Out (EGS)	DME HW Test CAN	Input digital 0-12V Binary information	EGS	CAN message between DME/EGS was not received within the expected time
	X		237	ED	Automatic Start	Rationality check	DME internal values logivcal	Starter Relay	Fault will set if there is a engine speed detected prior to the engaging of the starter relay by the DME.

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			238	EE	Cylinder 1 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 1 is longer the fault will set.
X			239	EF	Cylinder 2 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 2 is longer the fault will set.
X			240	F0	Cylinder 3 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder3 is longer the fault will set.
X			241	F1	Cylinder 4 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 4 is longer the fault will set.
X			242	F2	Cylinder 5 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 5 is longer the fault will set.
X			243	F3	Cylinder 6 Misfire detected	Misfire monitoring	DME internal values logical	Calculated	Crankshaft speed/acceleration is monitored by the crank sensor. The time for each cylinders combustion is compared against the average of the others. If the time for cylinder 6 is longer the fault will set.
X			244	F4	Segment Timing faulty- Flywheel adaptation	Rationality check	Input digital 0-12V Timing	Crank sensor	The flywheel segmentsare monitored during deceleration to establish a baseline for misfire calculation. If the segments are too long/short (bad flywheel) and exceed the limit a fault will set or one tooth too much/less.
X			245	F5	Secondary Air Injection (Bank1),Flow too Low	Secondary Air Delivery	Input analog 0-5V Voltage	O2-Sensor signal	Checks to see if the O2 sensor reacts to the increase in unmetered airflow generated by the secondary air pump operation. The O2 sensor must sense the lean condition or a fault will set.
X			246	F6	Secondary Air Injection (Bank2),Flow too Low	Secondary Air Delivery	Input analog 0-5V Voltage	O2-Sensor signal	Checks to see if the O2 sensor reacts to the increase in unmetered airflow generated by the secondary air pump operation. The O2 sensor must sense the lean condition or a fault will set.
X			247	F7	Secondary Air Valve stuck open	Secondary Air Delivery	Input analog 0-5V Voltage	O2-Sensor signal	Checks to see if the O2 sensor reacts to the increase in unmetered airflow generated by the secondary air pump operation. The O2 sensor must sense the lean condition or a fault will set.
X			248	F8	Post Catalyst Sensor ;signal after decel phase not plausible; bank 1 (sensor 3)	O2-Sensor check	Input analog 0-5 V	O2-Sensor	Signal is checked for a lean signal in decel and a transition between lean to rich after decel

M54	M62	M73	FC dec	FC hex	Fault Type and Function	OBDII Requirement type of test	Signal type Signal range Detection of	Input/Output	Explanation
X			249	F9	Post Catalyst Sensor ;signal after decel phase not plausible; bank 2 (sensor 4)	O2-Sensor check	Input analog 0-5 V	O2-Sensor	Signal is checked for a lean signal in decel and a transition between lean to rich after decel
X			250	FA	Functional check Purge Valve	EVAP monitoring	Input analog 0-5V	O2-Sensor Signal	This functional check looks for the reaction of the O2 sensor signal during canister purging. The O2 sensor, Air Flow meter and RPM values must react to the purging of the canister
		X	253	FD	Coolant Fan, Final stage	Final stage check	Output digital pulse width (active low)	Coolant Fan	The final stage inside the DME will set an internal flag whenever a short to ground, a short to battery voltage or a disconnection between the output transistor and the connected comp. occurs (0.02A<i<2A).