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MS45 - E85 with M54 Engine

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MS45

Models: E85 Z4 - with M54 Engine

Production Date: Start of Production MY 2003

Manufacturer: Siemens

Pin Connector: 134 Pins - 5 Modular Connectors

Objectives of the Module

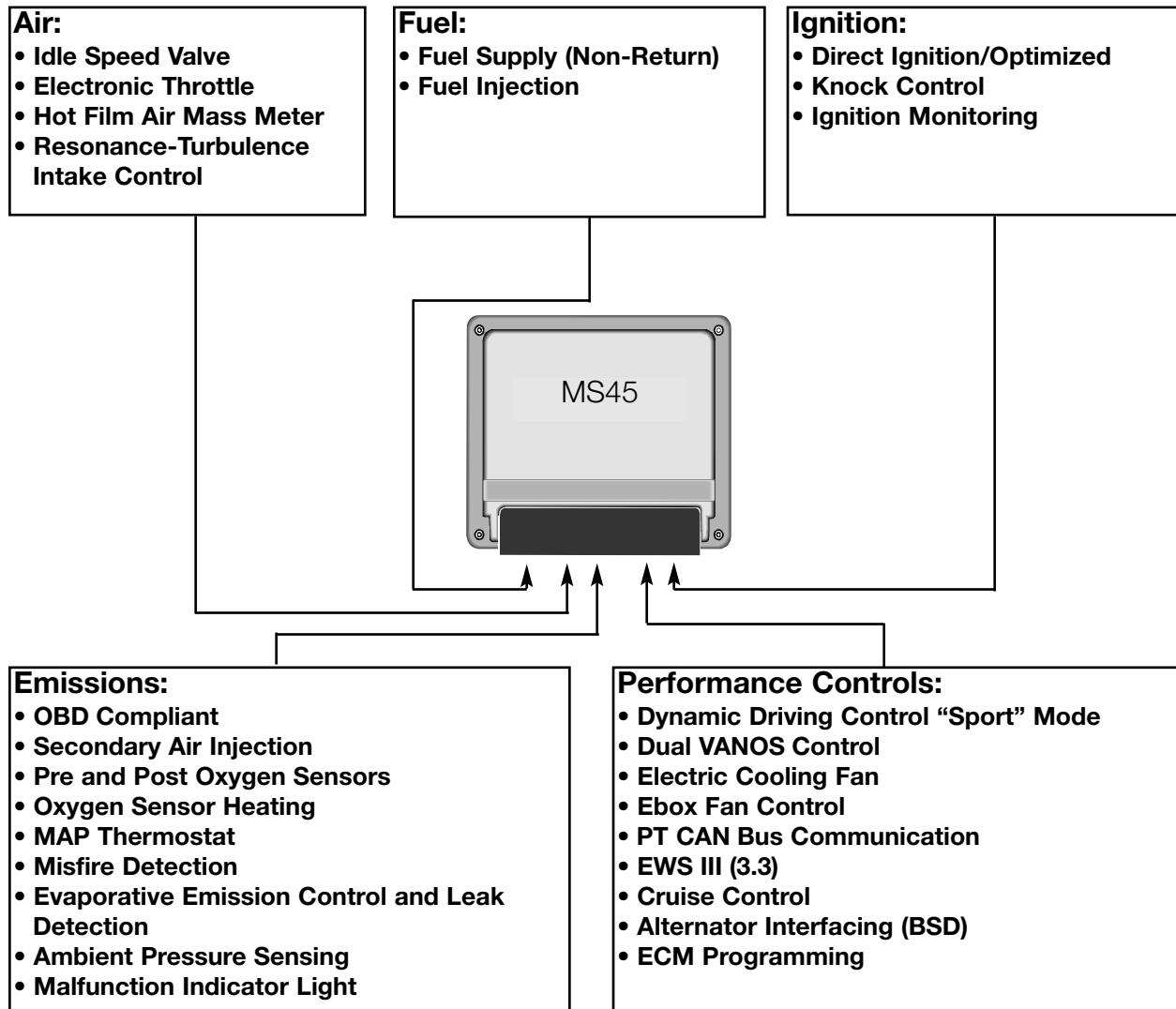
After completing this module, you will be able to:

- Describe the Power Supply for the Fuel Injectors and Ignition Coils.
- Understand the EDK and Idle Air Actuator Operation.
- Name the Differences of the MS45 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 DM TL Evaporative Leak Testing.
- Describe How the Ignition System is Monitored.

MS45

Purpose of the System

The MS45 system is an evolution of the MS43 system and manages the following functions:



System Components

MS45 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:

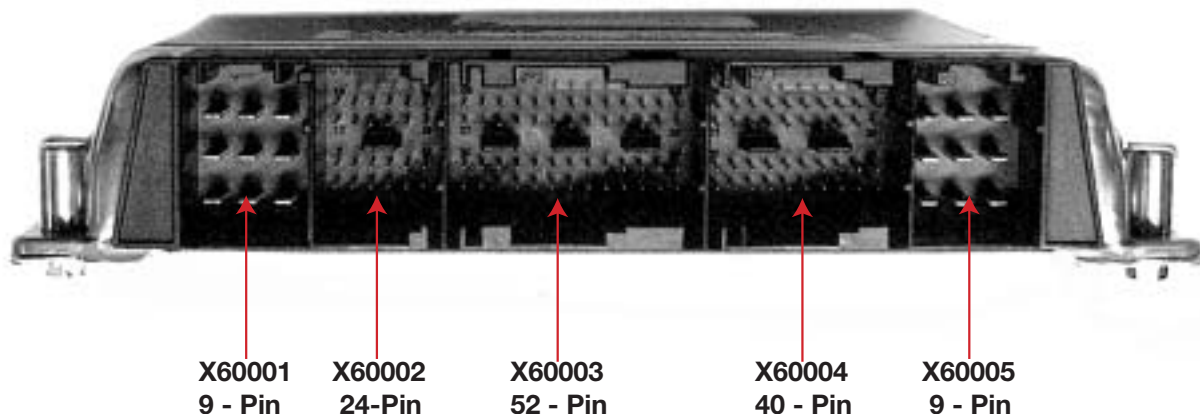
- Engine Load
- Electronic Throttle
- Idle Actuator
- Ignition
- Knock Control

The task of the second processor is to control:

- Air / Fuel Mixture
- Emission Control
- Misfire Detection
- Evaporative Leak Detection

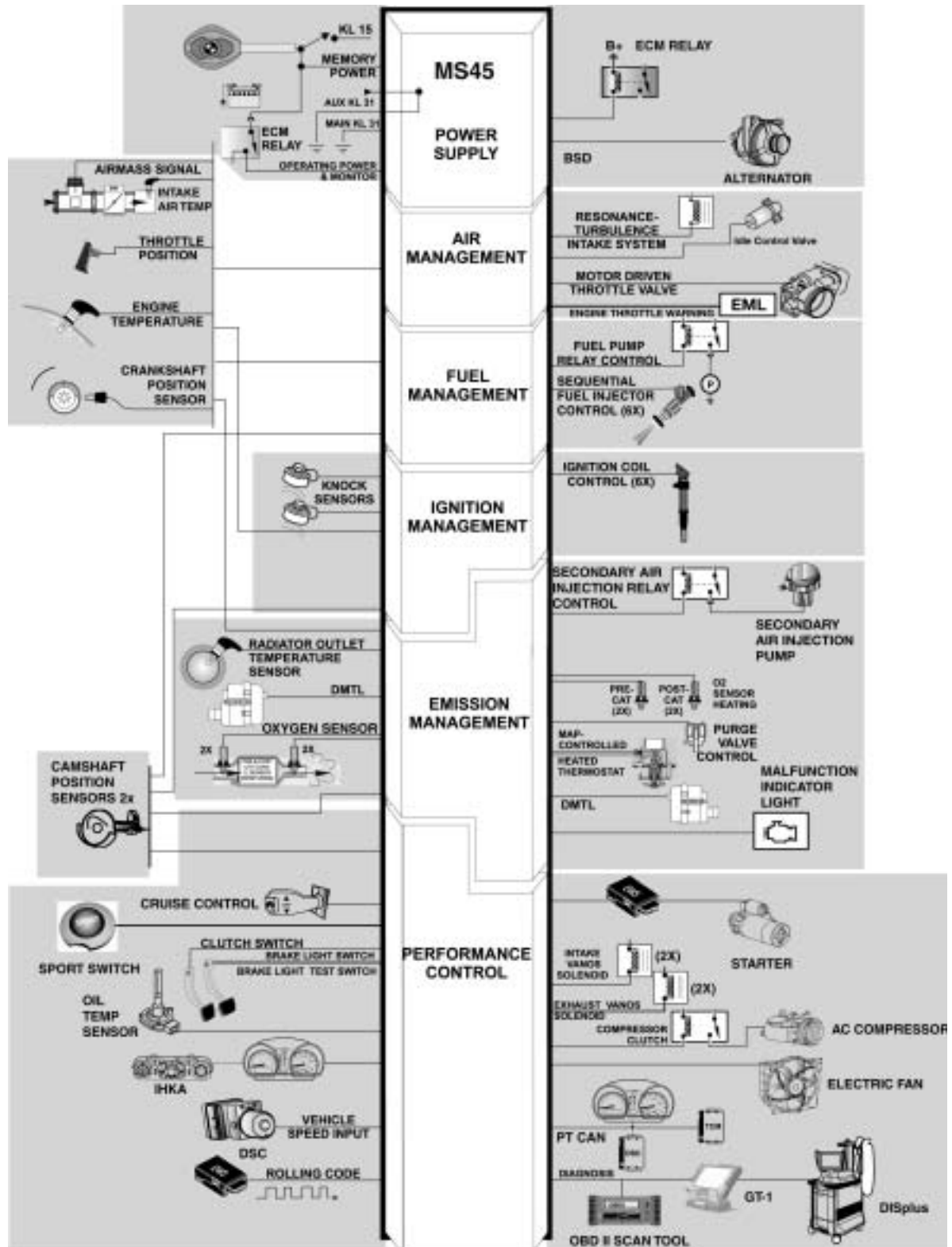


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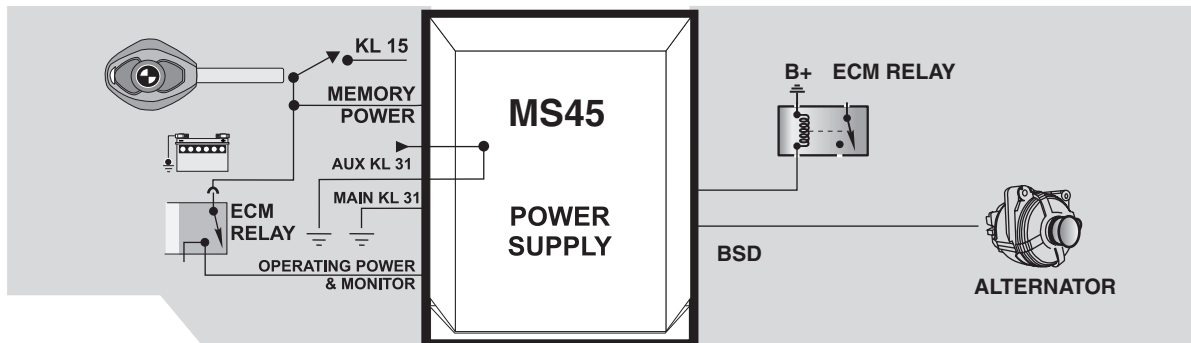
The 134 pin ECM is manufactured by Siemens to BMW specifications. The ECM is the SKE (standard shell construction) housing and uses 5 modular connectors. ***For testing, use the Universal Adapter Set (break-out box) Special Tool # 90 88 6 121 300.***

System Components: Inputs - Processing - Outputs



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Power Supply

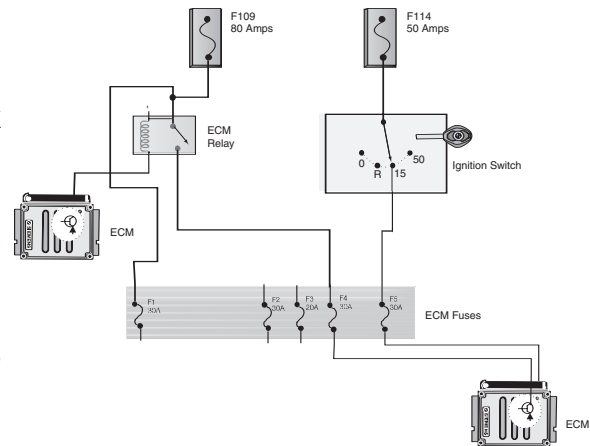


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KL30 - Battery Voltage: B+ is the main supply of operating voltage to the ECM.

Power Supplies: The power supplies (KL15 and ECM Relay) are fused to the MS45 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 Coil
2. Fuel Injection	7. Evaporative Leak Detection Pump
3. Idle Air Actuator	8. Camshaft Sensor
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.

Connector X60001	Connector X60005
Pin 4 – Ground for ECM	Pin 5 – Ground for ECM
Pin 5 – Ground for ECM	
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:

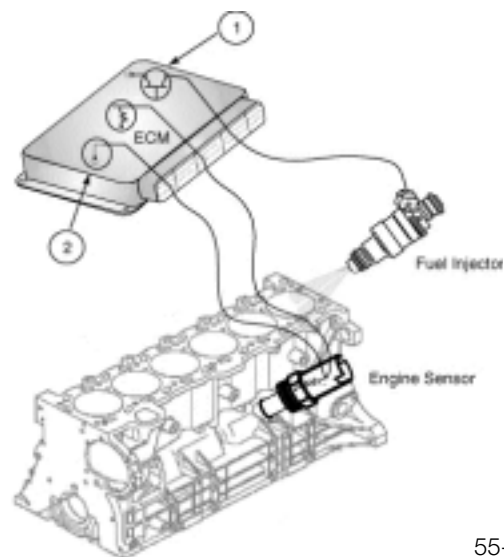
- *Modify pulse width duration of fuel injection*
- *Modify dwell time of ignition*

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. 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 (Emission Optimized) and as long as *three minutes to complete the DM TL test*.

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

- Internal links a constant ground (1) to activate components
- Switches ground (2) to activate components



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Workshop Hints

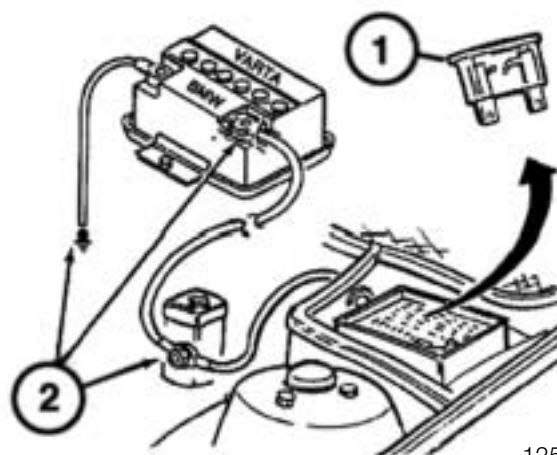
Power Supply - Testing

1. ECM (DME)
2. EGS or SMG (if equipped)
3. ECM main relay
4. Fuel injector relay
5. - SMG (if equipped) hydraulic pump relay
- EGS (if equipped) reverse light relay

Inadequate power and ground supply can result in:

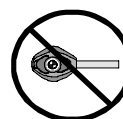
1. No Start
2. Hard Starting (Long Crank Times)
3. Inaccurate Diagnosis Status or ECM (not found)
4. Intermittent/Constant "Engine Emission/EML" Light
5. Intermittent/Constant Driveability Problems

Power supply including *fuses* should be tested.



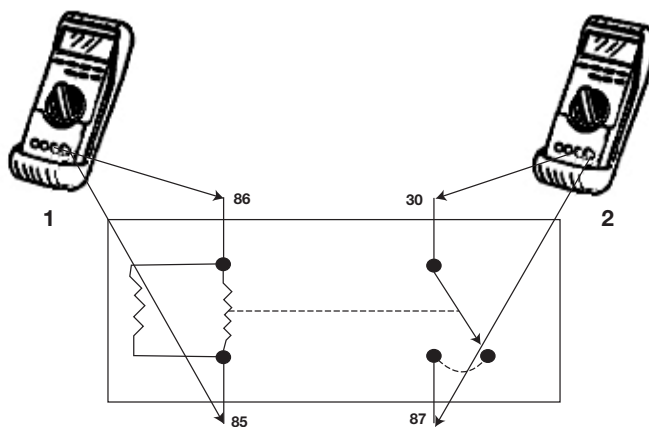
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The ignition (KL15) must be switched off when removing or installing the ECM connector to prevent voltage spikes (arcing) that can damage the Control Module!



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

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



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Tools and Equipment

Power Supply

When testing power supply to an ECM, the DISplus/GT1 multimeter function as well as a reputable hand held multimeter can be used.

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

The correct Universal Adapter for the MS45 application should be used (#90 88 6 121 300). This will ensure the pin connectors and the harness will not be damaged.

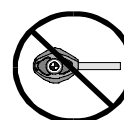
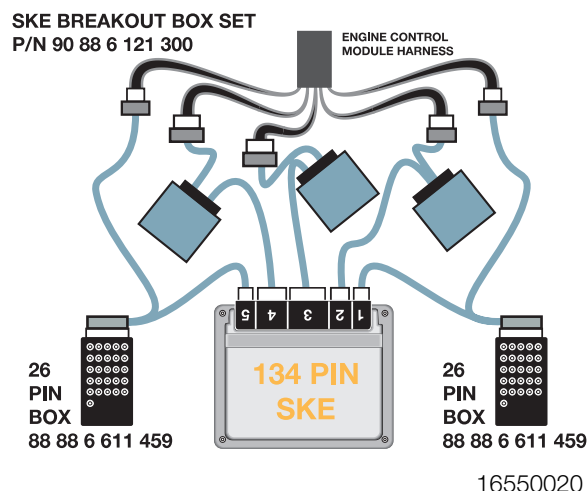
When installing the Universal Adapter to the ECM (located in the Electronics Box in the engine compartment), make sure the ignition is switched off.

NOTE for MS45: Allow at least 3 minutes to elapse after the key was set to the "OFF" position before disconnecting the ECM/ TCM.

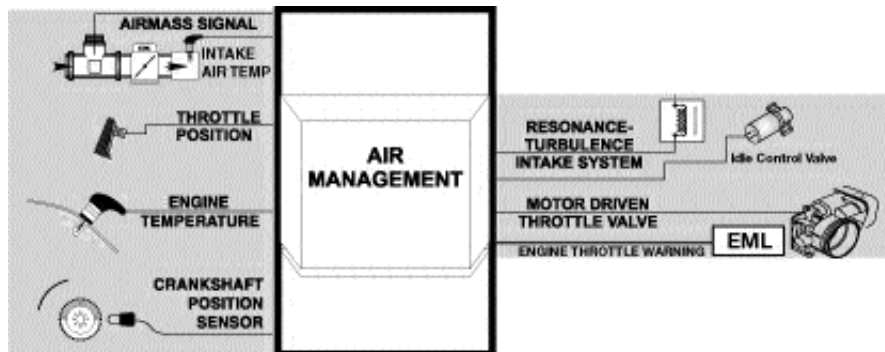
This will allow sufficient time to complete the DM TL test. Voltage may be present (up to 3 minutes) causing damage to the ECM/TCM if they are disconnected during this time period (arcing).

The 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.



Air Management

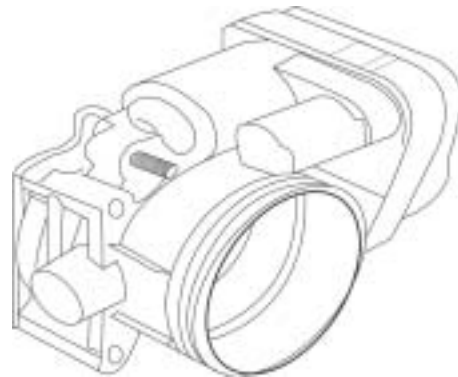


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Throttle Valve: The throttle valve plate is electronically operated to regulate intake air flow by the ECM. The purpose is for precision throttle operation, OBD compliant for fault monitoring, DSC and Cruise Control. This integrated electronic throttle 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/GT1.*

The throttle assembly for the MS45 system is referred to as the EDK. The EDK is distinguished by:

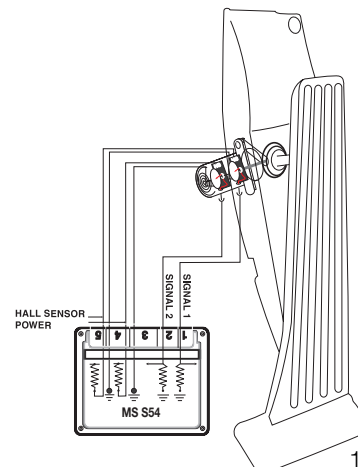
- EDK does not contain a PWG, It is remotely mounted (integrated in the accelerator pedal assembly).
- The accelerator pedal is not mechanically "linked" to the EDK.



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Throttle Position Sensor: 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.

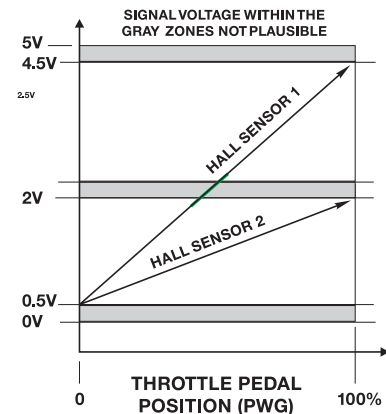


13550011.eps

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.

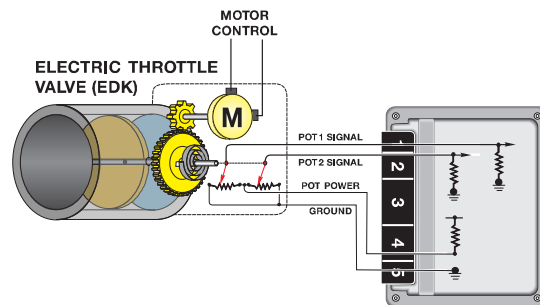
- Hall sensor 1(request) = 0.5 to 4.5 volts
- Hall sensor 2 (plausibility) = 0.5 to 2.0 volts

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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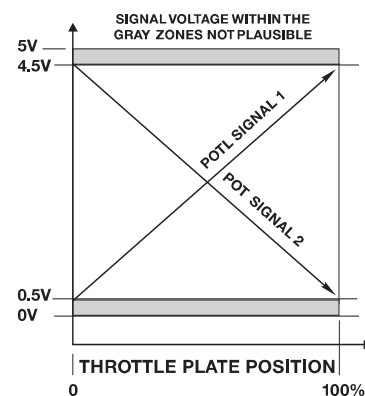
Throttle Motor and Feedback Position: The MS45 ECM powers the EDK motor using pulse width modulation for opening and closing the throttle plate. The throttle plate is also closed by an integrated return spring.



13550002

- 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 0.5V (Full Throttle)

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.



13550005

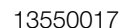
The valve is supplied with battery voltage from the ECM Relay. The Idle Air Actuator is a two-coil rotary actuator. The ECM is equipped with two final stage transistors which will alternate positioning of the actuator.

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.



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.

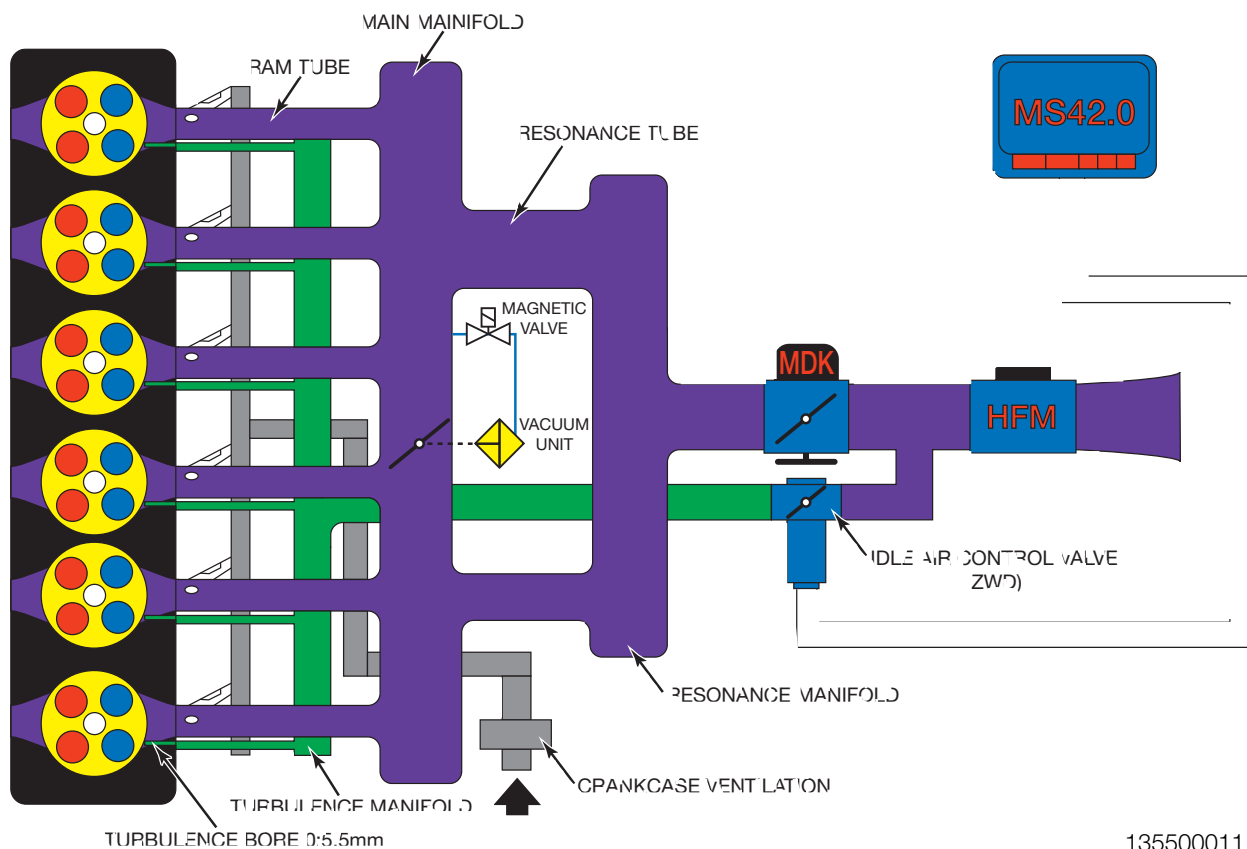
NOTE: *The HFM is non-adjustable.*



The ECM provides the power supply to the sensor which decreases in resistance as the temperature rises and vice versa. The ECM monitors an applied voltage to the sensor that will vary as air temperature changes the resistance value.

Resonance/Turbulence Intake System: On the M54, 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.



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.

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.

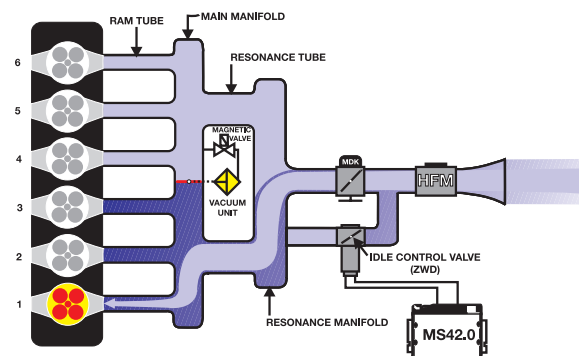


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When the engine speed is greater than 3750 RPM (which varies slightly - temperature influenced), the solenoid is de-energized. The resonance flap is sprung open, allowing flow through both resonance tubes, increasing volume.

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

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

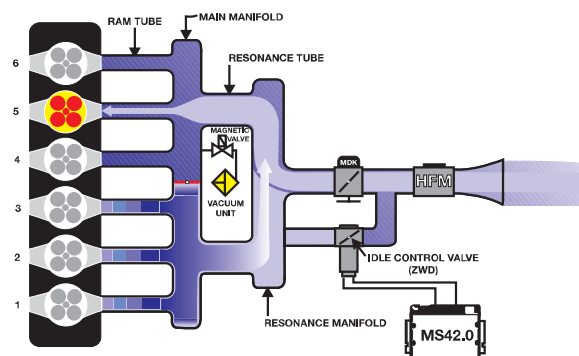


13550010

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

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)).

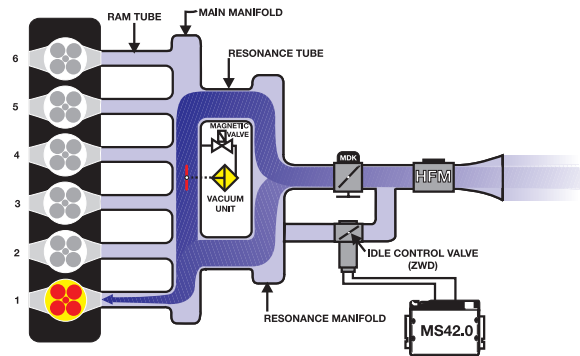


The resonance “wave”, along with the intake velocity, enhances cylinder filling.

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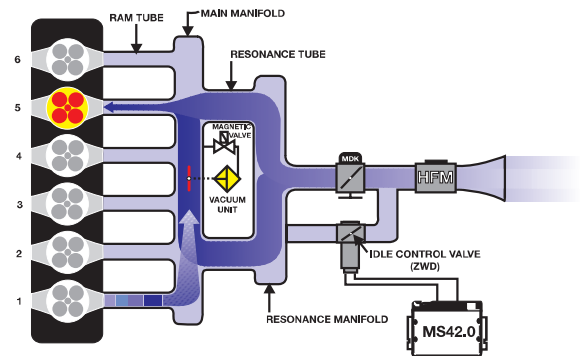
When the engine speed is greater than 3750 RPM the solenoid is de-energized. The resonance flap is sprung open, allowing flow through both resonance tubes, increasing volume.

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



13550008

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

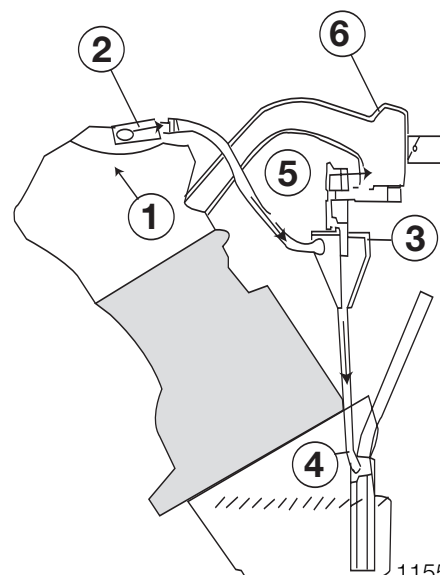


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Pressure Control Valve: The pressure control valve varies the vacuum applied to the crankcase ventilation depending on engine load. The valve is balanced between spring pressure and the amount of manifold vacuum.

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

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



11550006

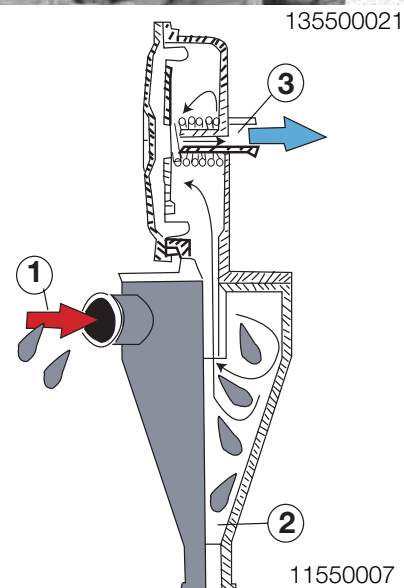
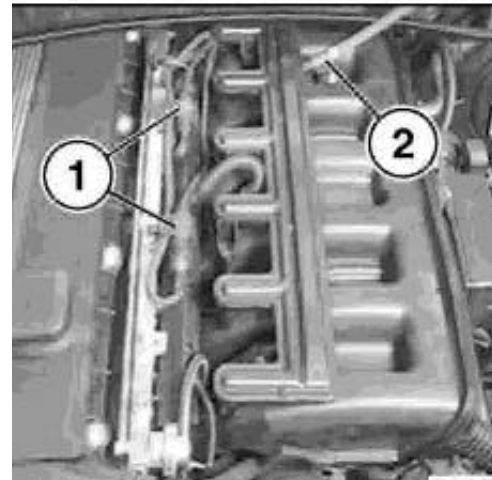
The vapors exit the pressure control valve and are drawn into the intake manifold through an external distribution tube (2). The tube has a splice at the front to equally distribute vapors to the back.

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.

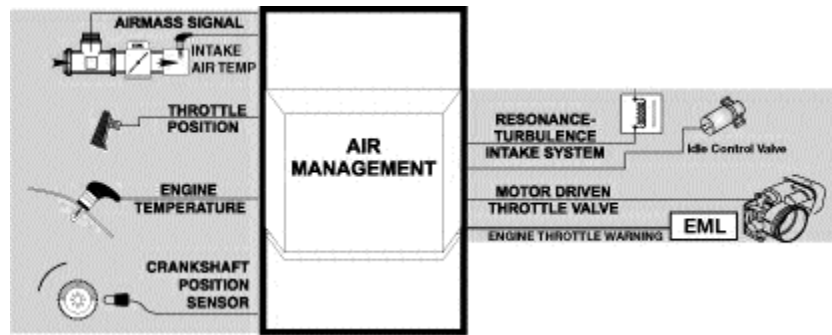
1. Engine Oil Vapors
2. Collective Drain Back Oil
3. Oil Vapors to the Intake Manifold



Notes: _____

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 MS45 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.



45-02-02

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.

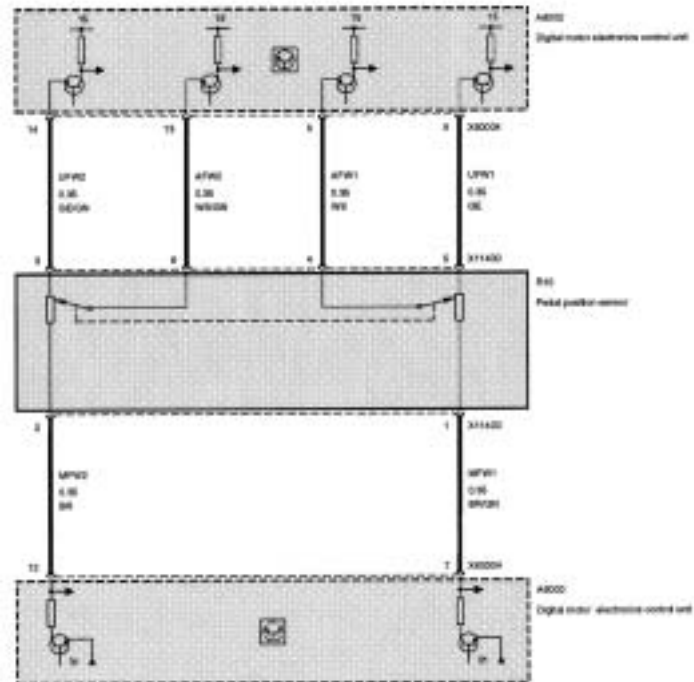
The potentiometers/Hall sensors are non-adjustable because the ECM “learns” the throttle angle voltage at idle speed. If the throttle housing/accelerator pedal module is replaced, the ***adaptations must be cleared and adaptation procedure must be performed using the DISplus/MoDIC. If this is not performed, 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 MS45 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 = 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).



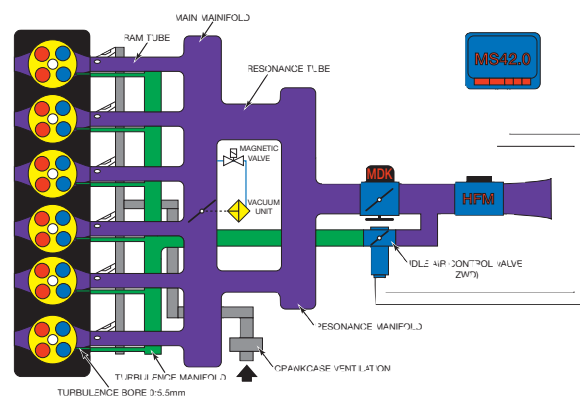
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The Idle Air Actuator is controlled by the ECM modulating the ground signals (PWM at 100 Hz) to the valve. By varying the duty cycle applied to the windings, the valve can be progressively opened, or held steady to maintain the idle speed.

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 <0° C, EDK is simultaneously opened).
- Variable preset idle based on load and inputs.
- Monitor RPM range intake for each preset position.
- Vacuum Limitation
- Smooth out the transition from acceleration to deceleration.



135500011

Under certain engine operating parameters, the 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 EDK will supply any additional air volume required to meet the demand.

Backup 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 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 MS45 EDK Feedback Signal Monitoring/Backup Operation when a fault is detected in the system is as follows:

- The EDK provides two separate 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 safety feature, Pot 2 is continuously cross checked with Pot 1 for signal plausibility.
- If plausibility errors are detected between Pot 1 and Pot 2, MS45 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 MS 43.0 uses the air mass signaling 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 if 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 “preflight check” to verify its mechanical integrity (no binding, appropriate return spring tension, etc). This is accomplished by monitoring both the motor control amperage and the reaction speed of the EDK feedback potentiometers. If faults are detected the EDK motor is switched off and the 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 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 MS45 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 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 EDK activation. The ECM then controls the Idle Air Actuator to satisfy the idle air "fill". In addition, the EDK will also be activated = pre-control idle air charge. Both of these functions are utilized to maintain idle RPM.

The 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 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 EDK will also open.

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 180° C above intake 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 ignition 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.

Workshop Hints

Air Management

Unmetered air leaks can be misleading when diagnosing faults causing “Malfunction Indicator Light”/driveability complaints.

Crankcase Ventilation System

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

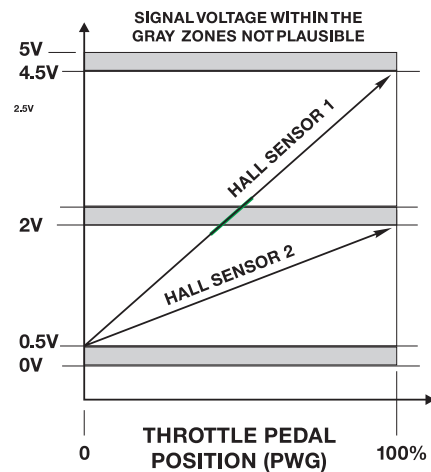
Please refer to the following Service Information Bulletins for details on the *Crankcase Ventilation System*:

- Mixture/misfire detected codes
- Whistling noise
- Performance/driveability complaints

Throttle Position Sensors - Testing

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

- DISplus Status Page (approx. 0.5v. to 4.5v)
- DISplus Oscilloscope - Select from the Present measurement which requires taking the measurement with the ECM and the Universal Adapter connected to the circuit as shown on the right).

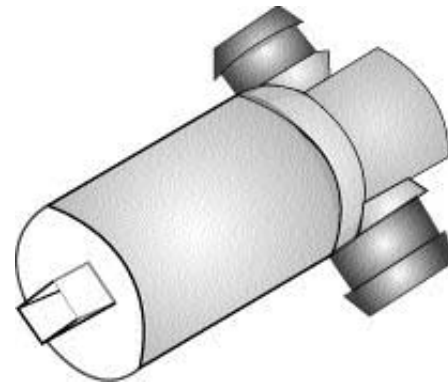


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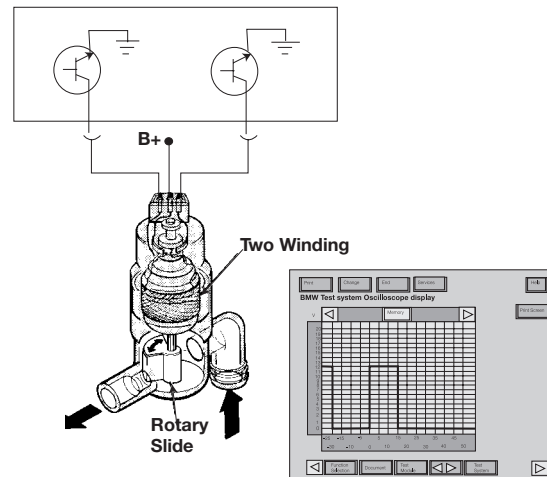
Idle Air Actuator Valve - Testing

- The Idle Air Actuator Valve and air circuit (passage ways) should be checked for physical obstructions. Visually inspect the sealing gasket, mounting bracket and air hose clamps.
- 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/GT1.
- The Pulse Width Modulation ground outputs from the ECM can be tested using the DISplus/GT1 Oscilloscope.
- Consult Technical Data for specified idle speed.

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



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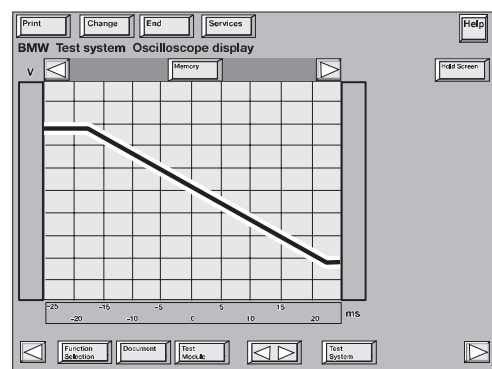
Air Temperature Signal - Testing

The HFM contains an integral air temperature sensor. 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/GT1 Status Page
- DISplus/GT1 Multimeter (ohms)

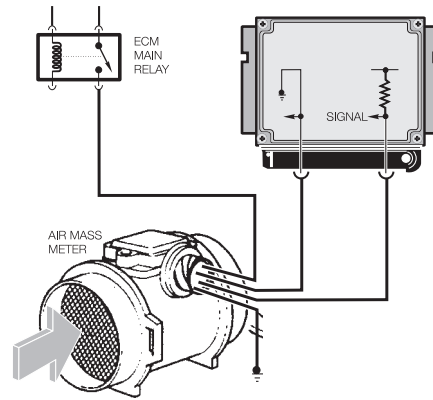


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Hot-Film Air Mass Sensor

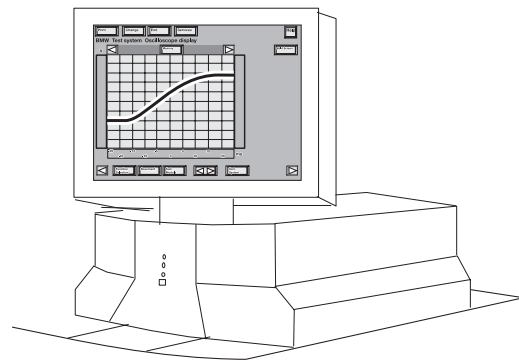
This component is non-adjustable and tampering is not permitted. A faulty Hot-Film Air Mass Sensor can produce the following complaints:

- Difficult To Restart When Engine Is Hot
- Engine Starts Then Stalls
- “Malfunction Indicator Light” Illuminated
- Engine Starts and Runs Only With Accelerator Pedal Depressed



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

- DISplus/GT1 Fault Code and Component Testing.
- DISplus/GT1 Status Page
- DISplus/GT1 Oscilloscope-which requires taking the measurement with the ECM and the Universal Adapter connected to the circuit (engine running).



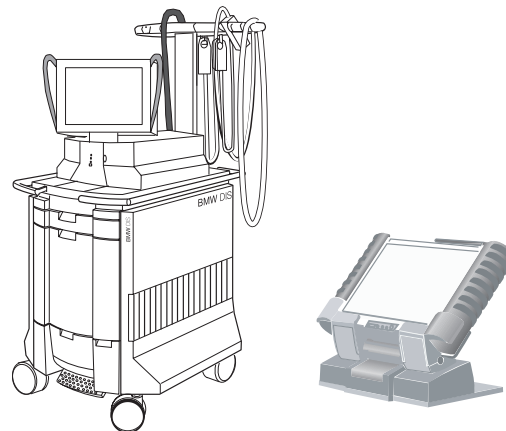
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NOTE: Visually inspect the sensor for damaged, missing or blocked screens. The screens affect air flow calibration. Also inspect the sealing rings where the sensor inserts in the air filter housing and intake boot. Ensure the pin connections are tight.

Tools and Equipment

The DISplus/GT1 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.



DISplus

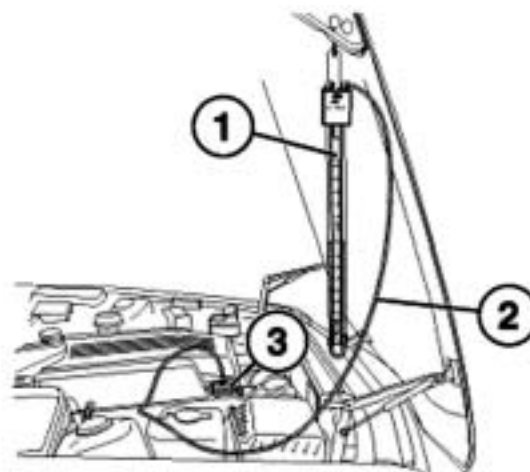
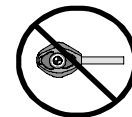
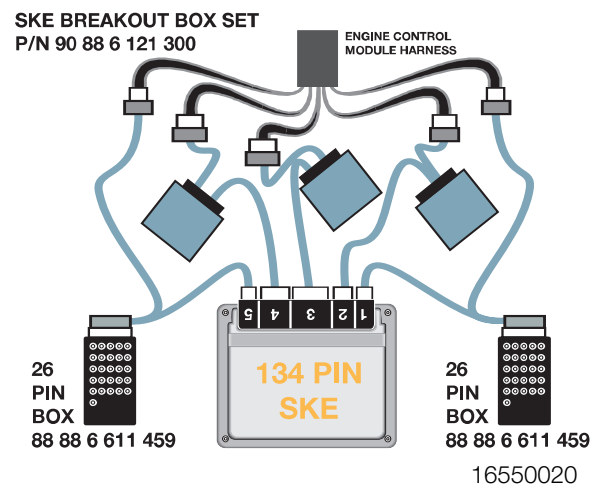
GT-1 16550019

The correct Universal Adapter for the MS45 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 in the Electronics Box in the engine compartment), make sure the ignition is switched off.

NOTE for MS45: 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 Slack Tube Manometer Test Tool (#99 00 0 001 410) should be used to troubleshoot crankcase ventilation valves.