Return To Main Contents

Table of Contents

Subject **Page**

M54 Engine
Introduction 2
Mechanical Changes 4
Performance Charts 6

Siemen's MS 43.0 System

- Introduction 9
- I - P - O 10

MS 43.0 New functions
- Electronic throttle Control 11
- Accelerator Pedal Sensor (PWG) 12
- Electronic Throttle Valve (EDK) 14
- Main Relay Monitor 16
- Engine Optimized Ignition Key OFF 17
- Diagnosis Module Tank Leakage (DM-TL) 18
- DM-TL Function 20
- DM-TL Test Procedure 21

Carry Over Functions
Inputs
- Oxygen Sensor 25
- Camshaft Sensors 27
- Crankshaft Sensor 28
- Misfire Detection 29
- OBD Fault Codes 31
- Mass Air Meter 32

Outputs
- VANOS Control 33
- Electric Fan 37
- Secondary Air Injection 38
- Engine Speed Limit 40
- RZV Ignition 41
- Resonance - Turbulence Manifold 42
- Idle Speed control 46
- Cruise Control 47
- Purge Control 48

Initial Print Date: 02/2000 Revision Date: 3/17/00

M54 ENGINE

Models: E53 X5, E46, E39, E36 - Z3
3.0 and 2.5 Liter
SOP: 3 liter - 4/00, 2.5 liter 9/00

Objectives of the Module:

At the end of this section of the handout, you will be able to:

- Identify the changes to the M54 engines over the M52 TU engine.
- List the design objectives for the M54 engine.

Purpose of the System:

The M54 engine was developed to meet the needs for ULEV compliancy for emission control. The increase in displacement allows the engine to fit the X5 All Roads vehicle while still meeting the demands for power and performance.

INTRODUCTION

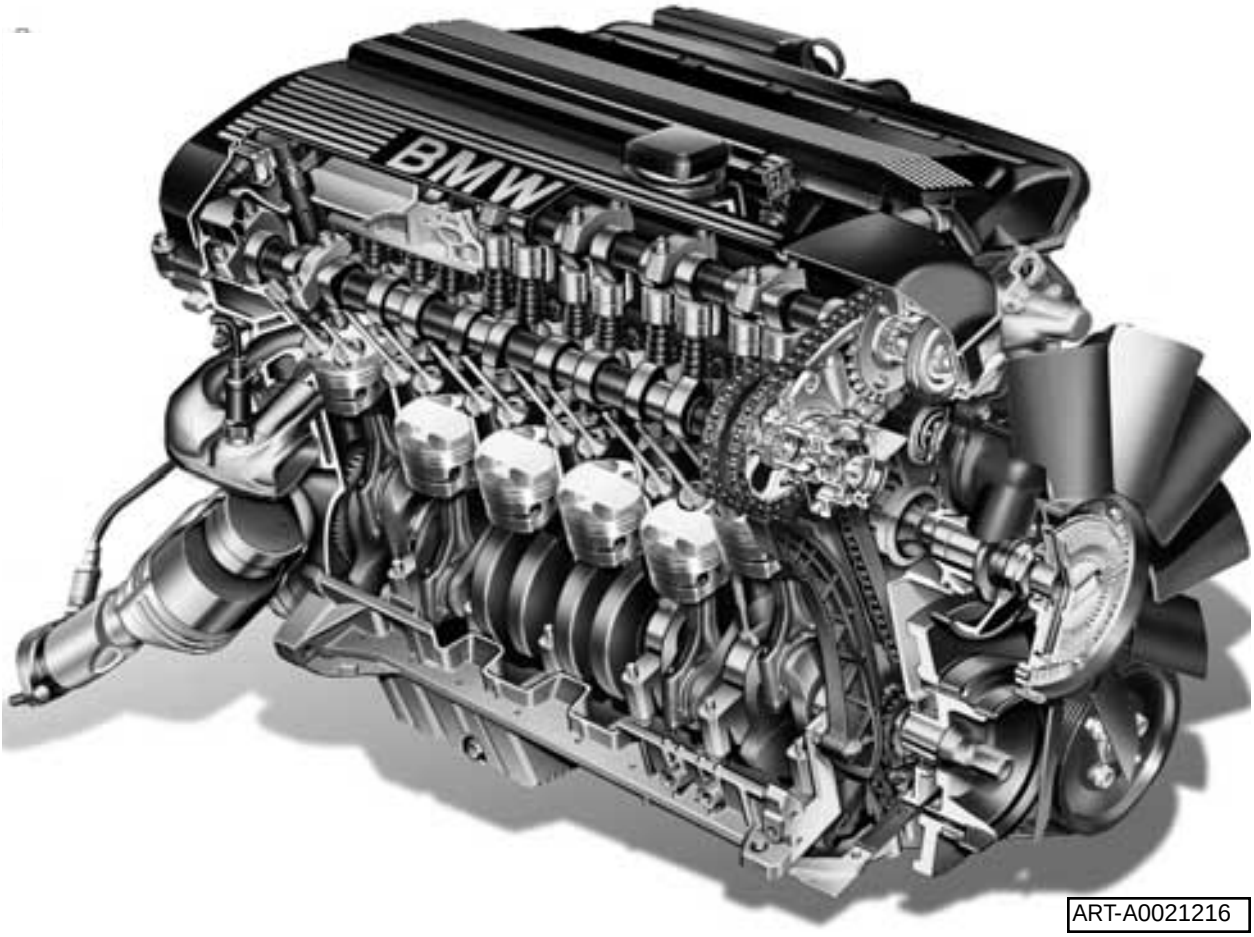
The M54 - 6 cylinder engine is being introduced with the 2001 Model Year E53 - X5. The displacement of the new engine for the X5 is 3 liters and the engine will replace the 2.8 liter engine in the E46/Z3 series in 6/2000 and E39 series vehicles in 9/2000. A 2.5 liter version of the new M54 engine will be introduced starting with 9/2000 production in the E46/E36 Z3 and E39 vehicles.

Although the E53 X5 with the M54 engine will be LEV compliant, the M54 - 3 liter displacement engine meets ULEV compliancy, for emission standards, for the balance of the product. The 2.5 liter version of the M54 engine will remain LEV compliant.

Design objectives for the M54 engine were to provide:

Lower Emissions
Maintain Fuel Economy
Maintain Power and Performance levels

M54 ENGINE



ART-A0021216

	M54B30	M54B25
HORSE POWER	225@5900RPM	184@6000RPM
TORQUE	293Nm@3500RPM	240Nm@3500RPM
BORE	84mm	84mm
STROKE	89.6mm	75mm
COMPRESSION	10.2:1	10.5:1

M54 ENGINE

Mechanical Changes

In addition to the increased displacement of the M54B30 engine, several mechanical changes were incorporated into the engine for reduced emissions and increased fuel economy. These changes include:

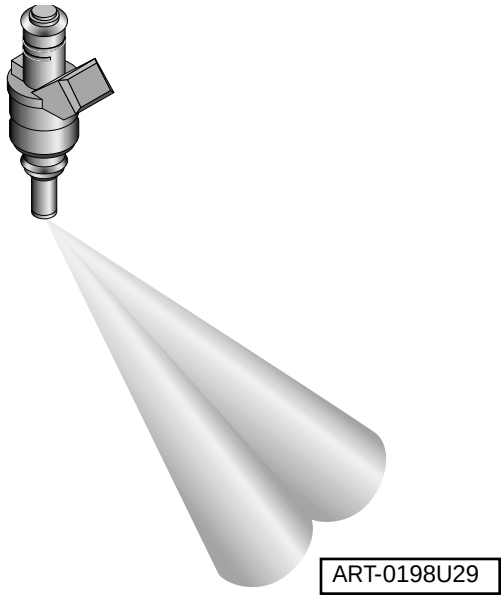
• NEW PISTONS - The piston has a shorter skirt compared to the M52 TU and continues with the graphite coating for friction and emission reducing measures. The piston rings have been modified to reduce friction.

• CRANKSHAFT - The crankshaft for the 3 liter M54 is adopted from the S52B32 - M3 engine. The crankshaft for the 2.5 liter is carried over from M52.

• CAMSHAFT - The camshaft for the 3 liter M54 is modified with more lift (9.7 mm) and new valve springs to accommodate the increased lift. The camshaft of the 2.5 liter M54 is carried over from the M52 engine.

• INTAKE MANIFOLD - The intake manifold is modified with shorter ram tubes (20mm shorter on 3 liter/10mm shorter on 2.5 liter). The diameter of the tubes is increased slightly.

• INJECTION VALVES - The diameter of the injection pintle has increased slightly for the increased displacement of the 3 liter engine. The injector for the 2.5 liter engine carries over from M52.



ART-0198U29



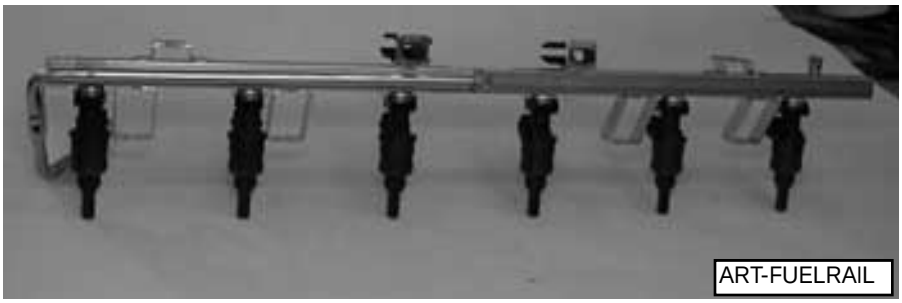
ART-INJECTOR

M54 ENGINE

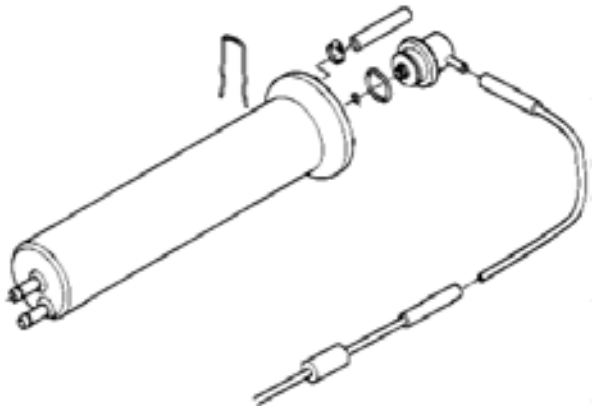
MECHANICAL CHANGES

NON RETURN FUEL RAIL SYSTEM

The M54 engine with MS 43.0 control uses the non return fuel rail system introduced on the M62 TU engine. The system meets running loss compliance without the use of the 3/2-way solenoid valve currently used on the M52 TU engine.



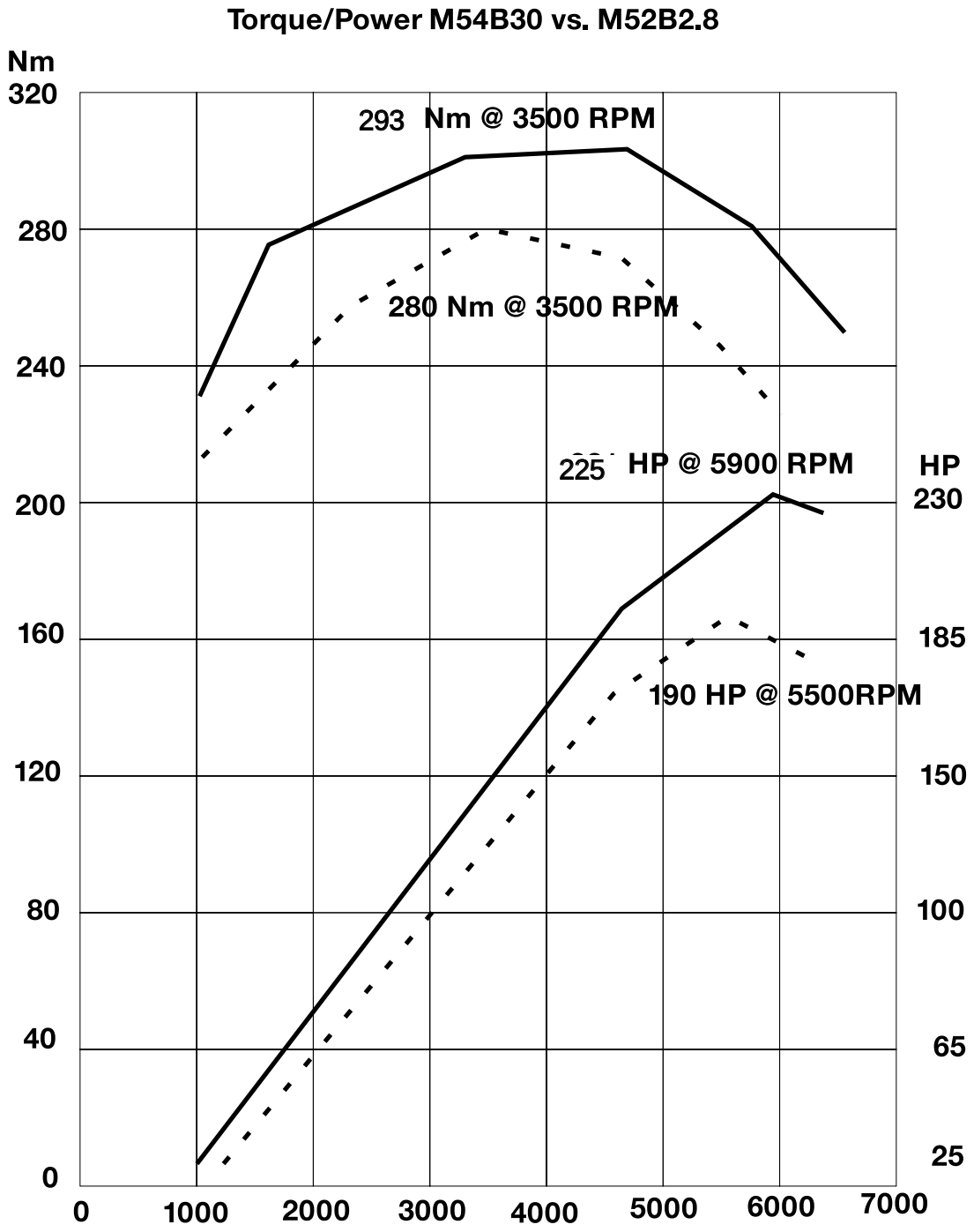
The regulated fuel supply is controlled by the fuel pressure regulator integrated in the fuel filter. The fuel return line is also located on the filter.



The M54 engine uses an Electronic Controlled Throttle Valve (EDK) for intake air control. The idle control valve and turbulence function of the intake manifold carries over from the M52 TU engine.



M54B30 ENGINE

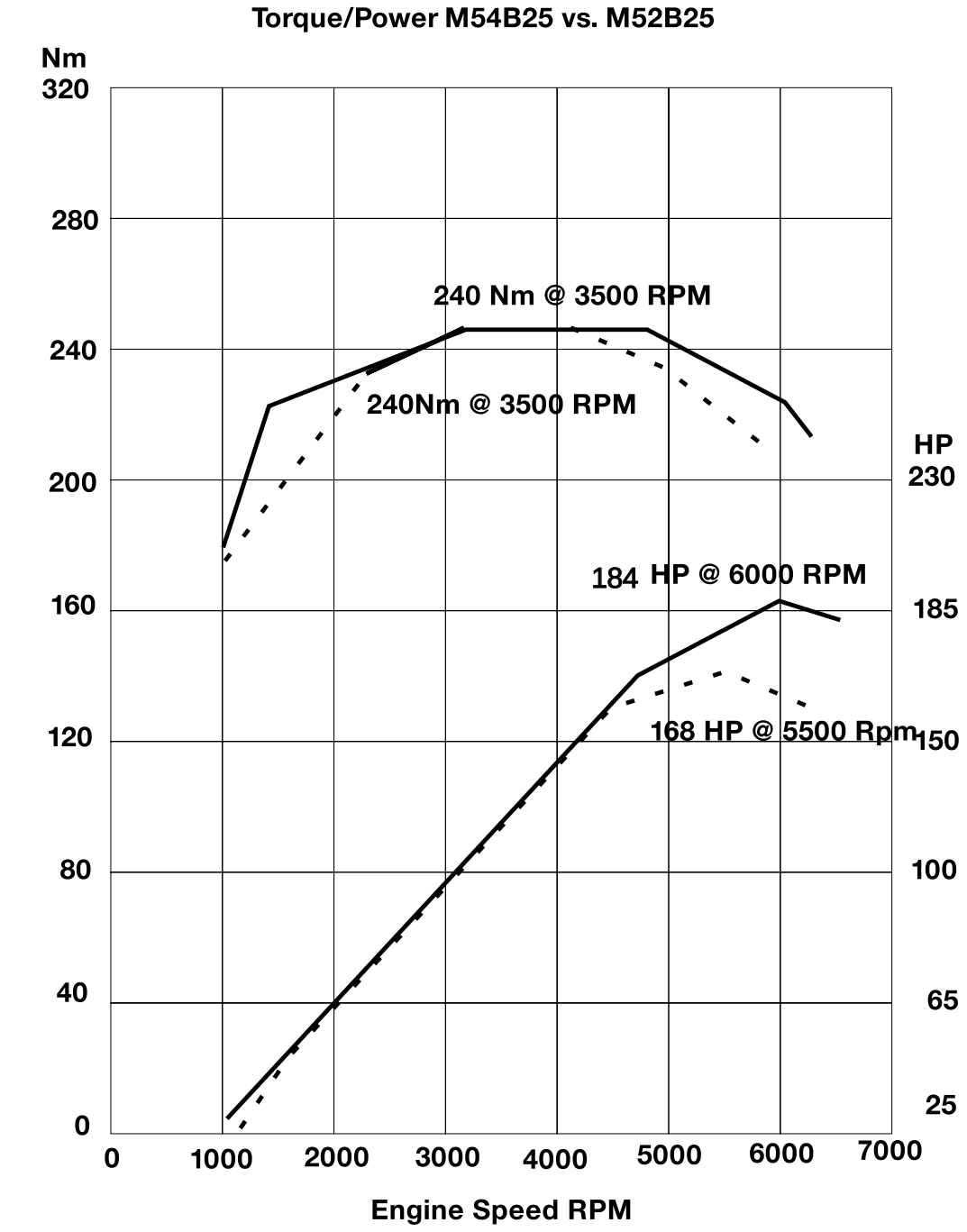


3.0 Liter

2.8 Liter

ART-HPCHARTB30.

M54B25 ENGINE



ARTHPCHARTB25.

REVIEW QUESTIONS

1. What is the major reason for the development of the M54 engine?

_____

2. What are the major mechanical changes that were integrated into the3 liter M54 engine?

_____

_____

_____

_____

_____

SIEMENS ENGINE MANAGEMENT SYSTEM

Models: E53 X5, E46, E39, E36 - Z3
3.0 and 2.5 Liter
SOP: 3 liter - 4/00, 2.5 liter 9/00

Objectives of the Module:

At the end of this section of the handout you will be able to:

- Identify the changes that have occurred to the MS 43 system compared to the MS 42
- Describe the operation of the new inputs
- Describe the operation of the new outputs
- Discuss which new components/subsystems relate directly to ULEV compliancy

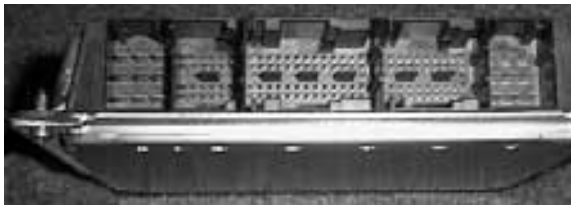
This new generation Siemens system is designated as MS 43.0.

Siemens MS 43.0 is a newly developed engine management system to meet the needs of Ultra Low Emission Vehicle (ULEV) compliancy and continuing with present systems is also OBD II compliant. This system also includes control of the Motor-driven Throttle Valve (EDK).

The ECM uses a pc-board dual-processor control unit in the SKE housing configuration. The MS 43.0 ECM is flash programmable as seen with previous systems.

ECM hardware includes:
Modular plug connectors featuring 5 connectors in the SKE housing with 134 pins.

- Connector 1 = Supply voltages and grounds
- Connector 2 = Peripheral signals (oxygen sensors, CAN, etc.)
- Connector 3 = Engine signals
- Connector 4 = Vehicle signals
- Connector 5 = Ignition signals

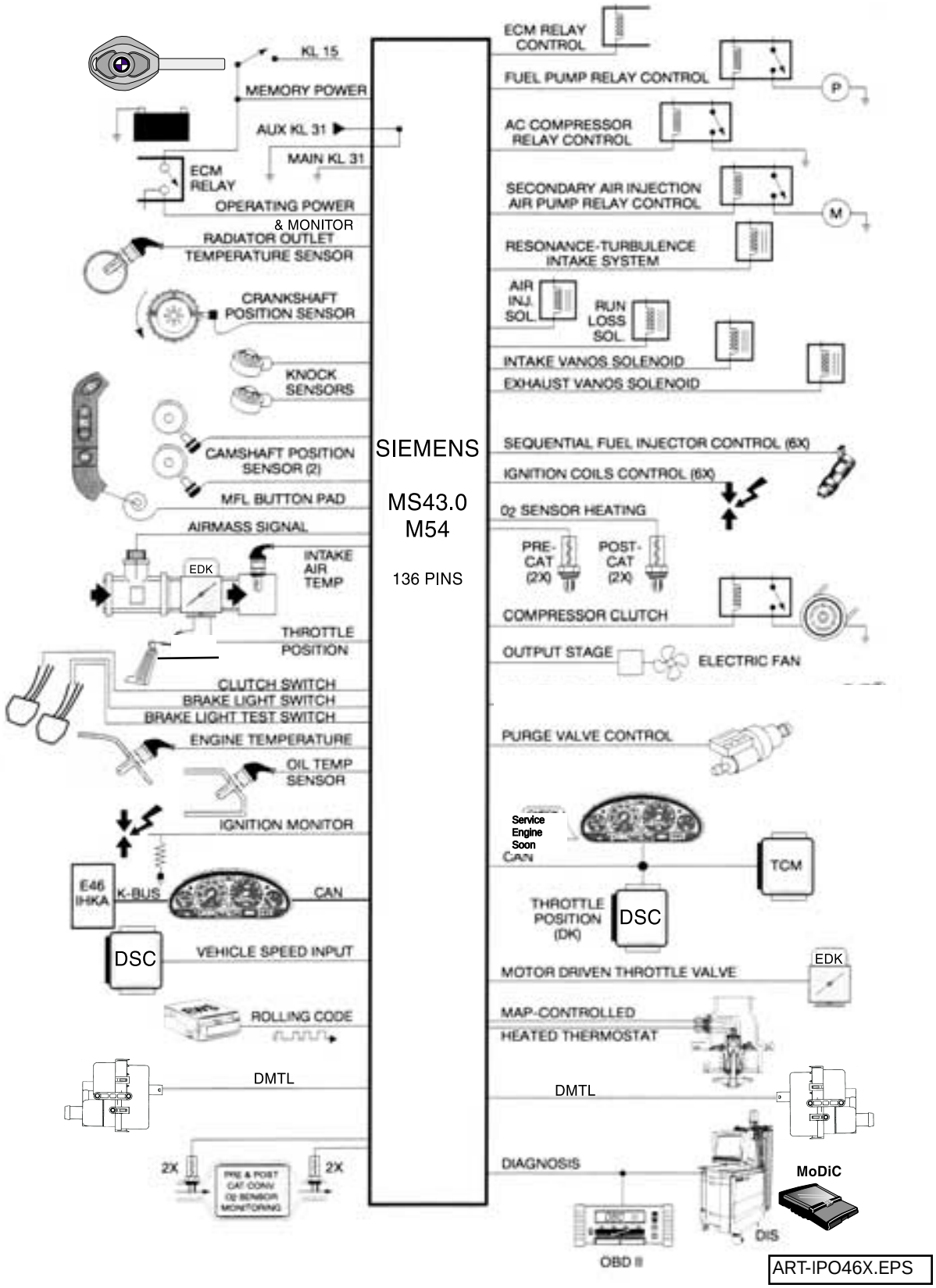


Special features:

- Flash EPROM which is adaptable to several M52 LEV engines and has the capability to be programmed up to 13 times

- Once a control unit is installed and coded to a vehicle it cannot be swapped with another vehicle for diagnosing or replacement (because of EWS 3.3).

SYSTEM OVERVIEW I-P-O



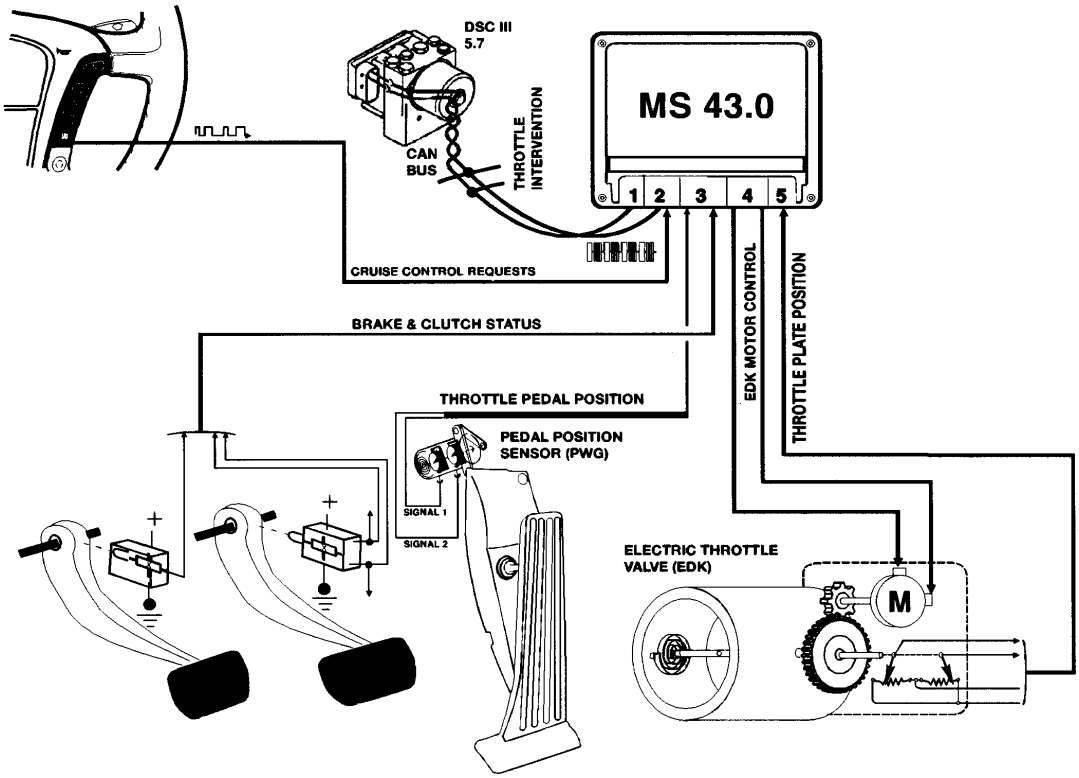
ART-IPO46X.EPS

MS 43 NEW FUNCTIONS

ELECTRONIC THROTTLE SYSTEM - EML

The M54 engine with MS 43 engine control uses an electronic throttle control system adopted from the ME 7.2 system on the M62 engine. The system incorporates an electric throttle valve (EDK) and pedal position sensor (PWG) for engine power control.

The MS 43 control module monitors the PWG input and activates the EDK motor based on the programmed maps for throttle control. The MS 43 module self checks the activation of the EDK via feedback potentiometers motor on the EDK motor.



ART-SCANDIAGRAM

Additional functions of the EML system include:

- Cruise control function
- DSC throttle interventions
- Maximum engine and road speed control

MS 43 NEW FUNCTIONS

ACCELERATOR PEDAL SENSOR

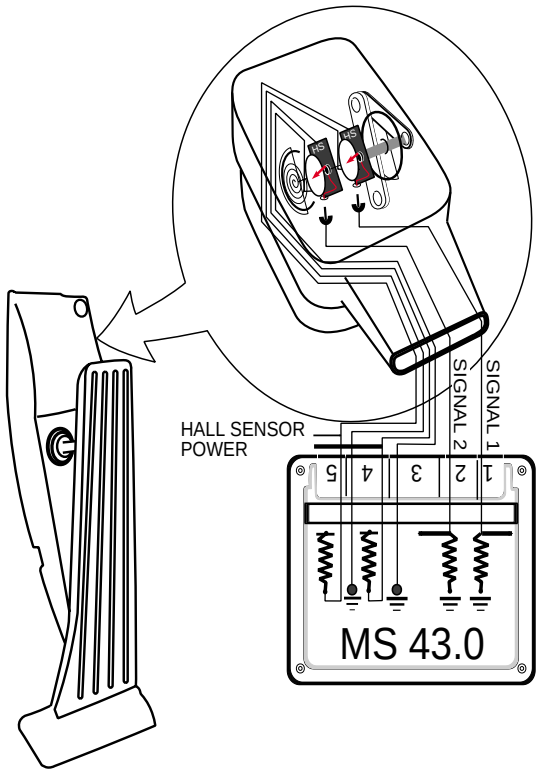
The accelerator pedal sensor is similar to the PWG used on the ME 7.2 system. It is integrated into the accelerator pedal housing. Two hall sensors are used to provide the driver's input request for power.

The hall sensors receive power (5 volts) and ground from the MS 43 control module and produce linear voltage signals as the pedal is pressed from LL to VL.

PWG SENSOR 1 = 0.5 to 4.5 V

PWG SENSOR 2 = 0.5 to 2.0 V

The MS 43 control module uses the signal from sensor 1 as the driver's request and the signal from sensor 2 as plausibility checking.



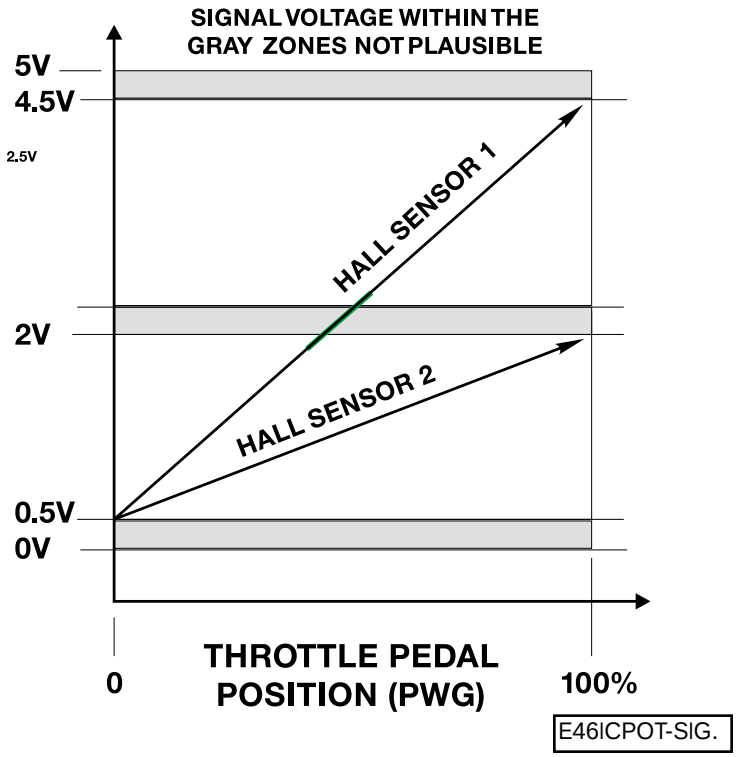
61460015

MS 43 NEW FUNCTIONS

ACCELERATOR PEDAL SENSOR

PWG SIGNAL MONITORING & PWG FAILSAFE OPERATION:

- As a redundant safety feature the PWG provides two separate signals from two integral angle hall sensors (HS #1 and HS #2) representing the driver's request for throttle activation.
- If the monitored PWG signals are not plausible, MS 43.0 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, MS 43.0 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.



MS 43 NEW FUNCTIONS

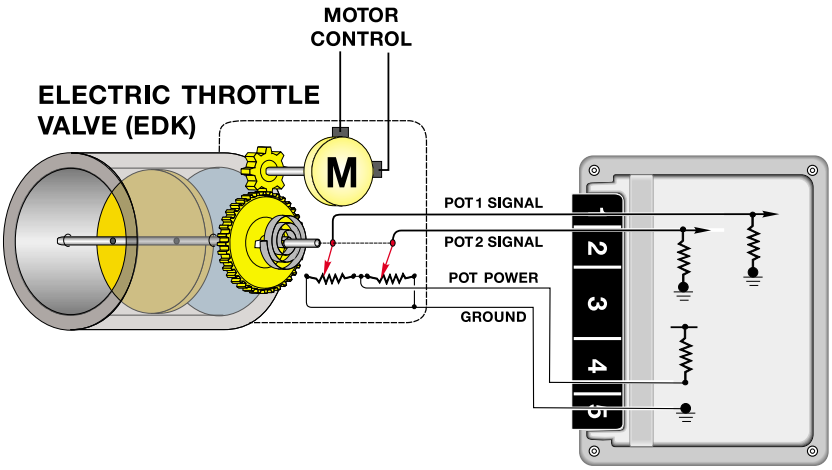
EDK THROTTLE POSITION FEEDBACK SIGNALS

The EDK throttle plate is monitored by two integrated potentiometers. The potentiometers provide linear voltage feedback signals to the control module as the throttle plate is opened and closed.

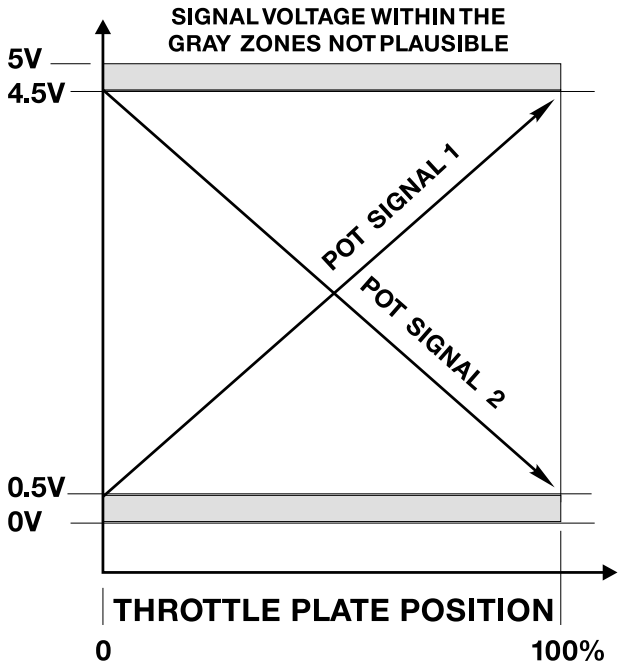
Feedback signal 1 provides a signal from 0.5 V (LL) to 4.5 V (VL).

Feedback signal 2 provides a signal from 4.5 V (LL) to 0.5 V (VL)

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



ART-EDK.EPS1



ART-E46ICPWG2.

MS 43 NEW FUNCTIONS

EDK THROTTLE POSITION FEEDBACK SIGNALS

EDK FEEDBACK SIGNAL MONITORING & EDK FAILSAFE OPERATION:

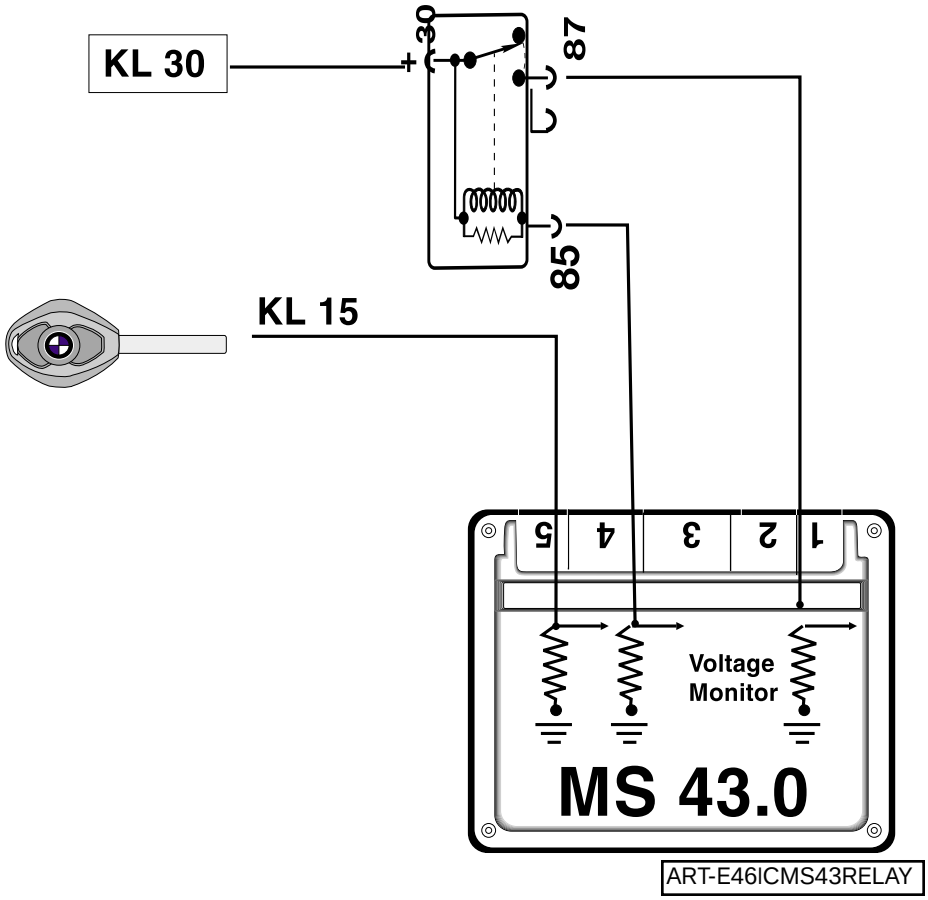
- The EDK provides two separate signals from two integral potentiometers (Pot 1 and Pot 2) representing the exact position of the throttle plate.
- EDK Pot 1 provides the primary throttle plate position feedback. As a redundant safety feature, Pot 2 is continuously cross checked with Pot 1 for signal plausibility.
- If plausibility errors are detected between Pot 1 and Pot 2, MS 43.0 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 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 (no failsafe operation possible).
- The EDK is continuously monitored during all phases of engine operation. It is also briefly activated 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 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.
- When a replacement EDK is installed, the MS 43.0 adapts to the new component (required amperage draw for motor control, feedback pot tolerance differences, etc). This occurs immediately after the next cycle of KL 15 for approximately 30 seconds. During this period of adaptation, the maximum opening of the throttle plate is 25%.

MS 43 NEW FUNCTIONS

MAIN RELAY MONITOR

The MS 43.0 system incorporates a new monitoring feature for terminal 87 (KL 87) of the main relay. The relay is monitored internally for the voltage level at KL 87. Five seconds after the ignition key is switched on, and the voltage at the KL 15 input is greater than 9 volts, the control module checks the voltage at KL 87.

If the voltage difference between the two terminals is greater than 3 volts, a fault will be stored in the ECM.

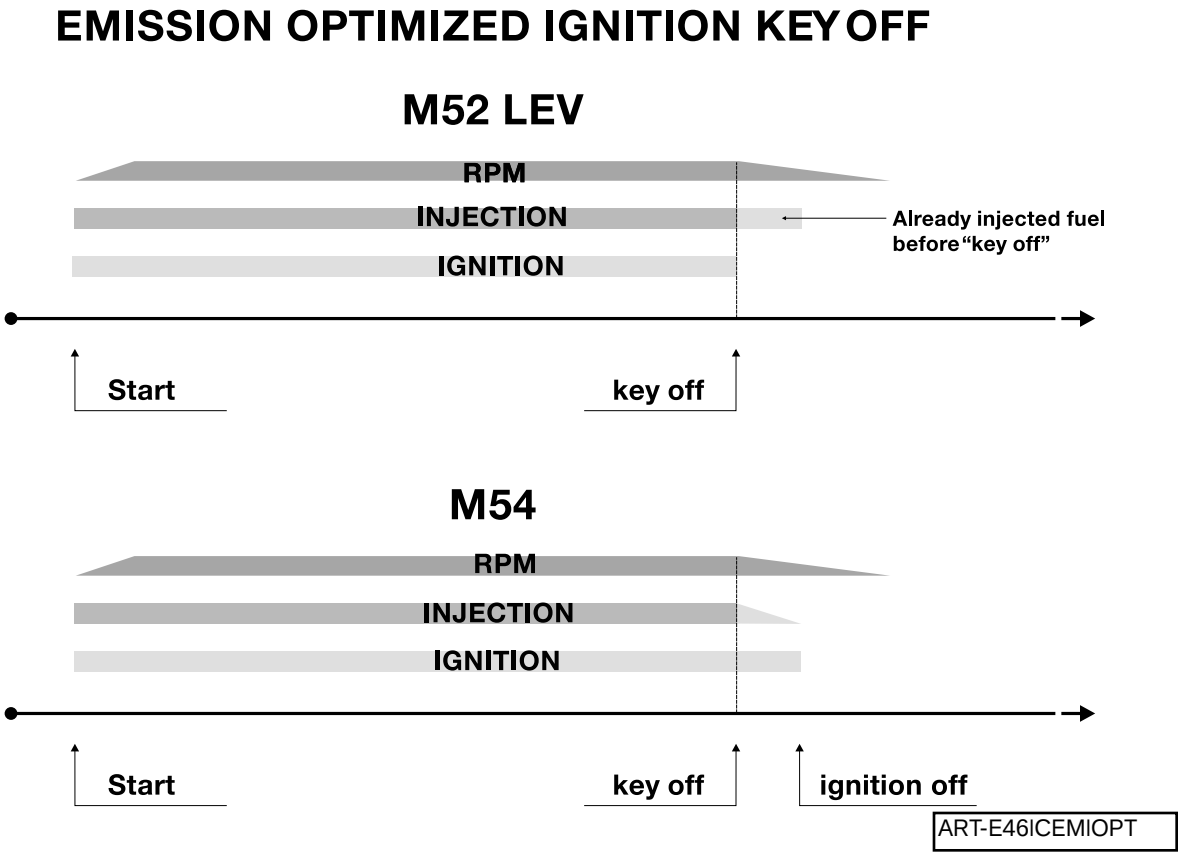


MS 43 NEW FUNCTIONS

EMISSION OPTIMIZED - IGNITION KEY OFF

“Emission Optimized Ignition Key Off” is a programmed feature of the MS 43 control module.
After the ECM detects KL 15 being switched OFF, the ignition stays active for two more individual coil firings. This means that just two cylinders are fired - not two revolutions.

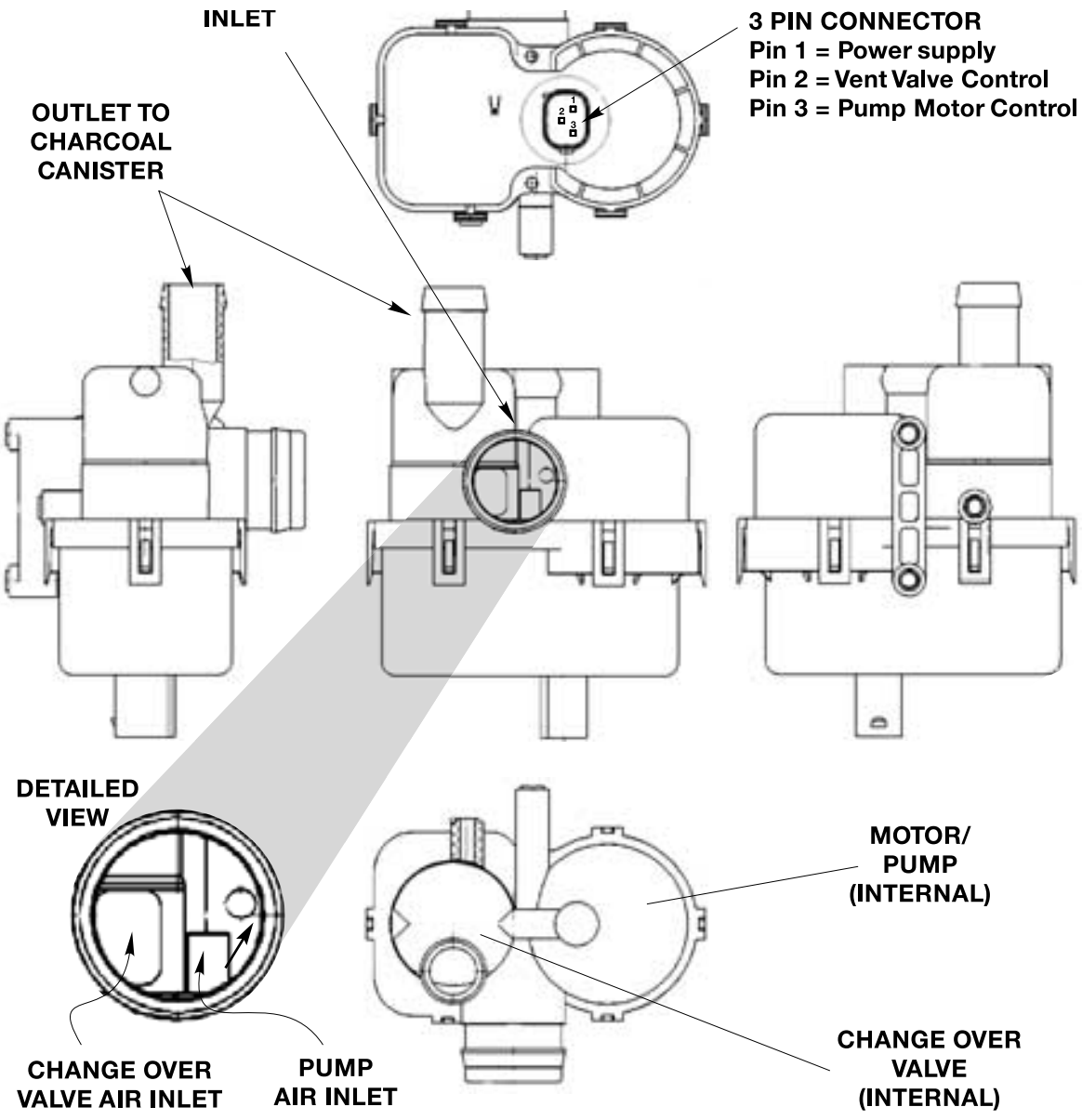
This feature allows residual fuel injected into the cylinders, as the ignition key is switched off, to be burned as the engine runs down.



MS 43 NEW FUNCTIONS

DM-TL (DIAGNOSIS MODULE - TANK LEAKAGE)

The M54 engine with the Siemens MS43.0 engine control system uses the DMTL system for fuel system leakage monitoring. The pump is manufactured by Bosch for use with the Siemen's control system.



DM-TL (DIAGNOSIS MODULE - TANK LEAKAGE)

FUNCTIONAL OVERVIEW:

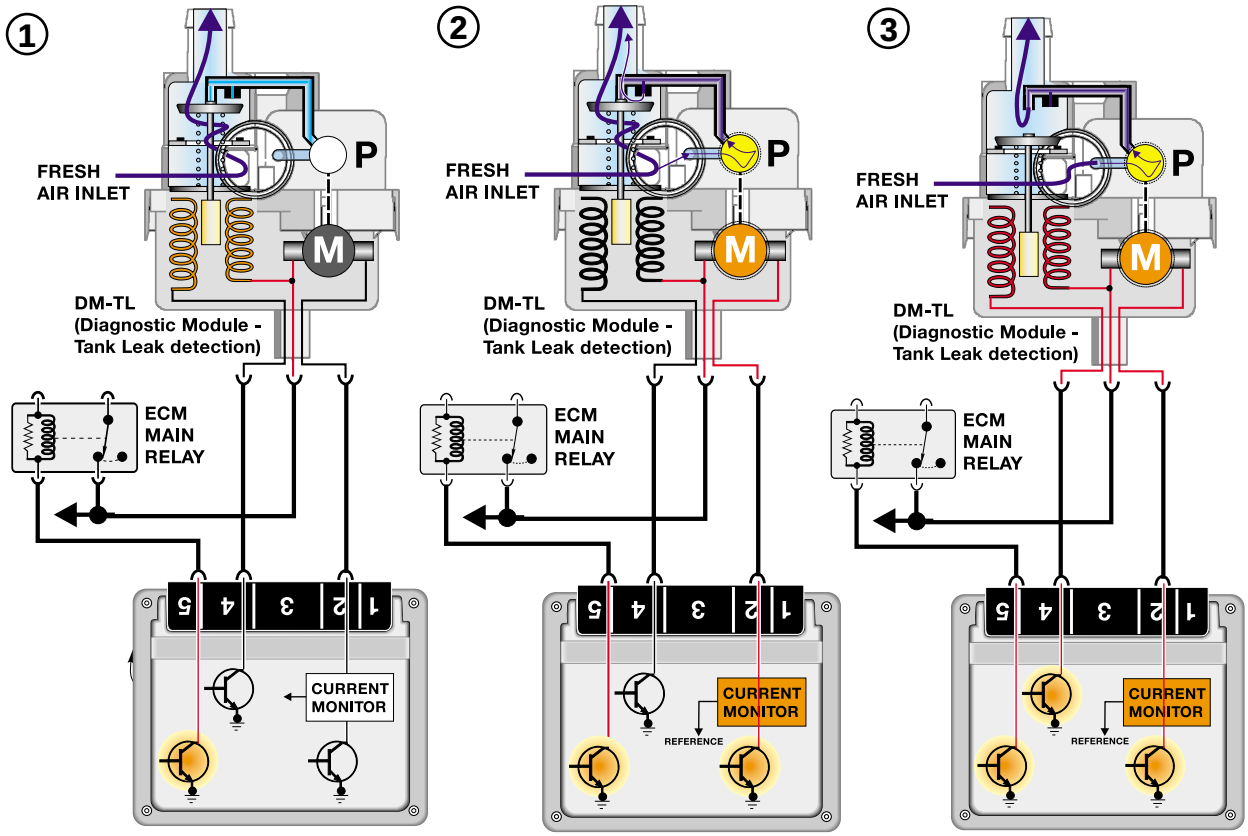
The DM-TL is located in the drivers side rear wheel well in the X5 and next to the charcoal canister on the E46 - M54.

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

2. When the DME activates the DM-TL for leak testing, it first activates only the pump motor. This pumps air through a restrictor orifice (1.0 or 0.5 mm) which causes the electric motor to draw a specific amperage value. This value is equivalent to the size of the restrictor.

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

The evap system is detected as having a large leak if the amperage value is not realized, a small leak if the same reference amperage is realized or no leak if the amperage value is higher than the reference amperage.

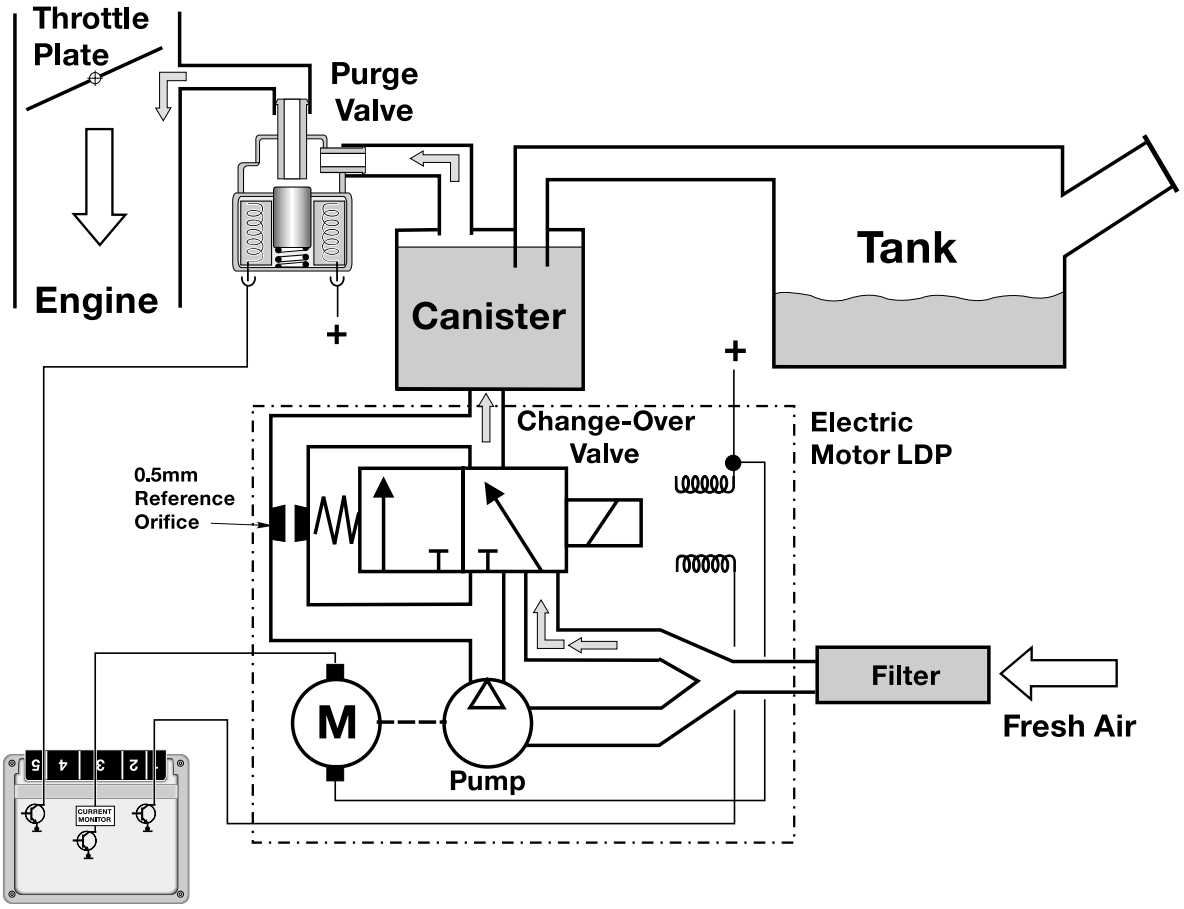


DM-TL (DIAGNOSIS MODULE - TANK LEAKAGE)

FUNCTION

The DC Motor LDP ensures accurate fuel system leak detection for leaks as small as 0.5mm (.020”). The pump contains an integral DC motor which is activated directly by the engine control module. 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 (similar to the full down stroke of the current vacuum operated LDP).



LEAK DIAGNOSIS TEST PRECONDITIONS

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**.
- Engine Control Module still in active state or what is known as “follow up mode” (Main Relay energized, control module and DME 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 between **11.5 and 14.5 Volts**

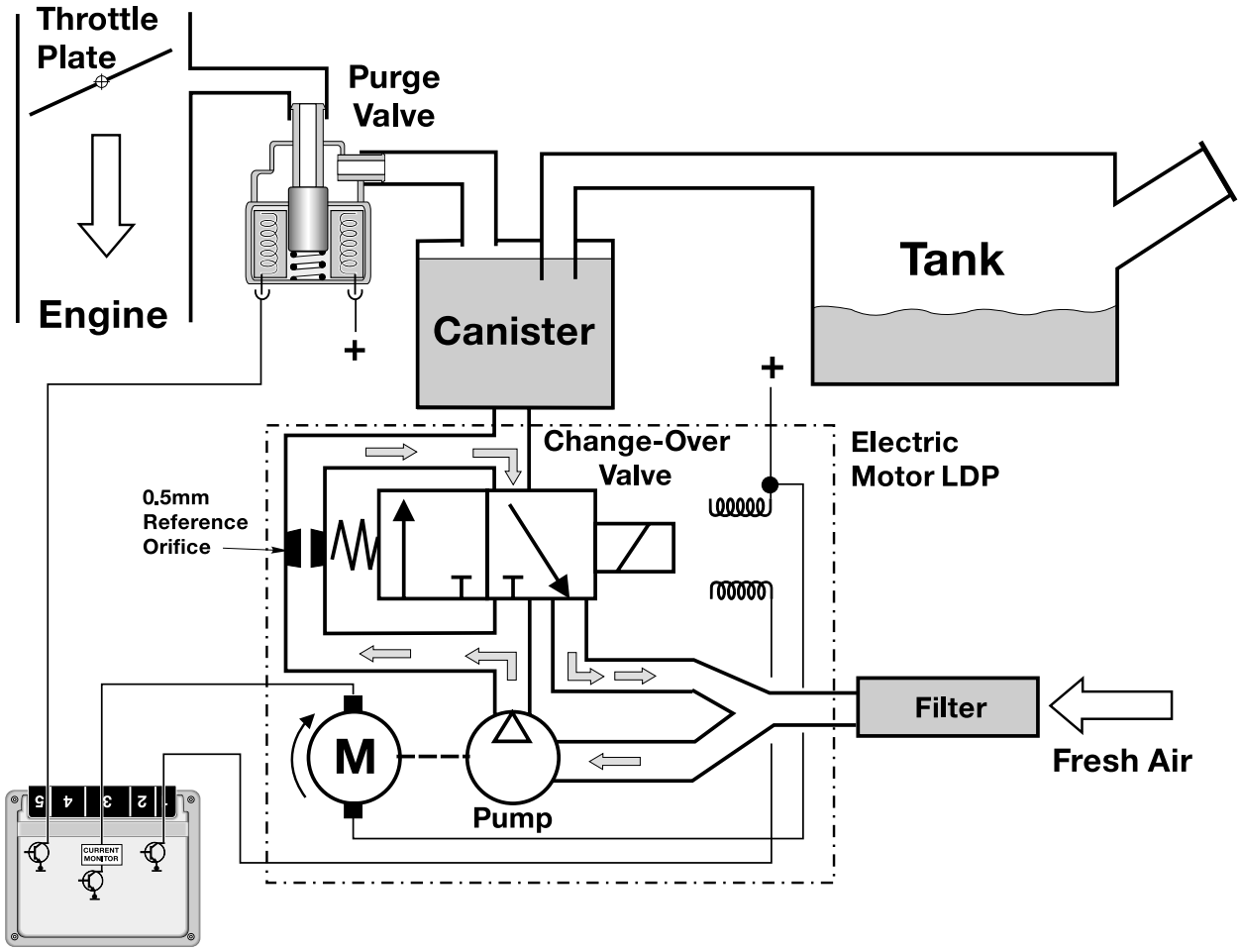
When these criteria are satisfied every second time, the ECM will start the Fuel System Leak Diagnosis Test. The test will typically be carried out once a day i.e. once after driving to work in the morning, when driving home in the evening, the criteria are once again met but the test is not initiated.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

LEAK DIAGNOSIS TEST

PHASE 1 - REFERENCE MEASUREMENT

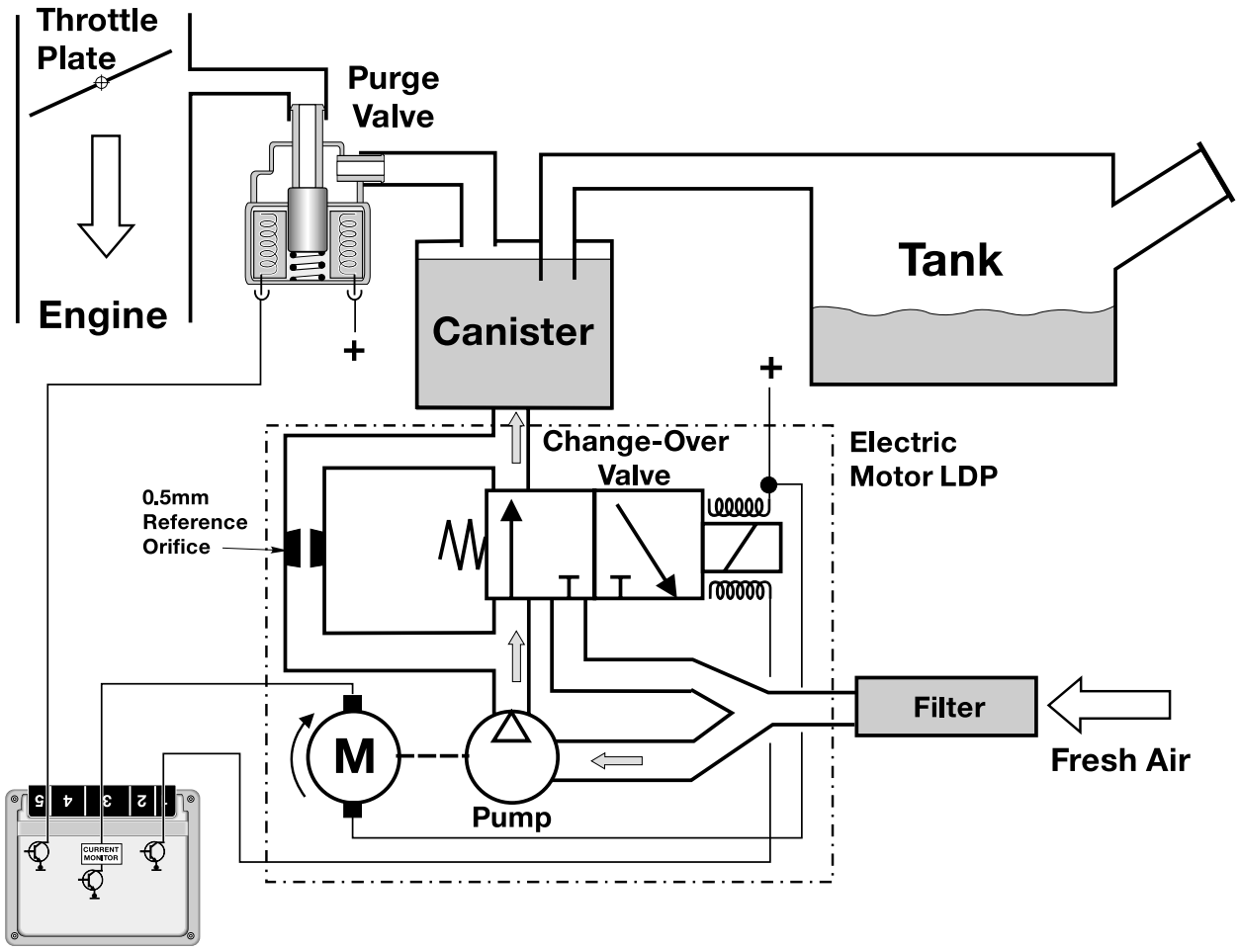
The ECM activates the pump motor. The pump pulls air from the filtered air inlet and passes it through a precise 0.5mm reference orifice in the pump assembly.

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 0.5 mm (0.020") leak.



PHASE 2 - LEAK DETECTION

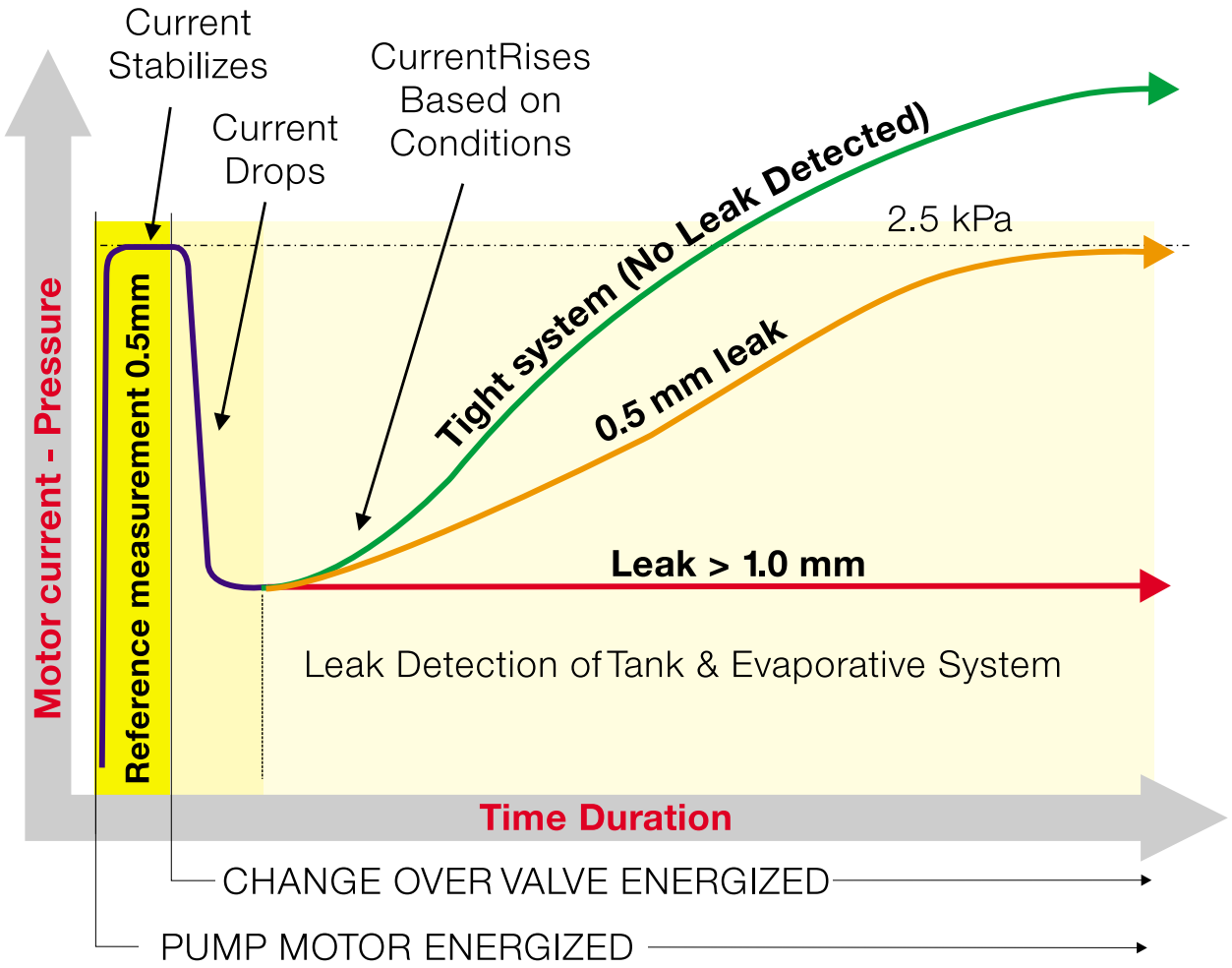
The ECM energizes the Change Over Valve allowing the pressurized air to enter the fuel system through the Charcoal Canister, The ECM monitors the current flow and compares it with the stored reference measurement over a duration of time.



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.



MS 43 CARRY OVER FUNCTIONS

INPUT FUNCTIONS

BOSCH OXYGEN SENSORS

The MS43.0 system uses Bosch LSH 25 oxygen sensors that function basically the same as previously used (in Bosch systems). The voltage range is between 0 - 800 mV.

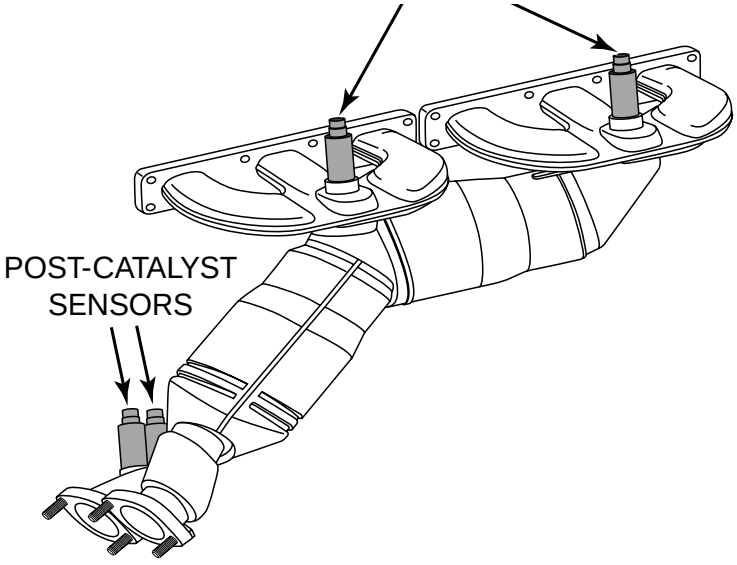


PRE 02 SENSOR



POST 02 SENSOR

The location remains the same with the pre-cat sensors are mounted on top of the exhaust manifolds. The catalysts are now integral with the exhaust manifolds (further detailed in the M52 TU engine section).



OXYGEN SENSOR SIGNAL INFLUENCE ON INJECTOR “OPEN” TIME

The ECM monitors the:

- Amplitude of the signal (highest voltage or range sensor is producing)
- Switching time of the signal (how fast from lean to rich)
- Frequency of complete cycles (how many within a period of time)

These characteristics provide info to the ECM that reflect the overall condition of the sensor.

POST CATALYTIC CONVERTER SENSOR SIGNAL

The post catalyst O2 sensors monitor the efficiency of the catalyst as a requirement of OBD II. This signal also provides feedback of the pre-catalyst sensors efficiency and can cause the ECM to “trim” the ms injection time to correct for slight deviations.

- If the catalyst is operating efficiently, most of the remaining oxygen in the exhaust gas is burned (lack of O2 - “constant lean signal”).

  The sensor signal fluctuates slightly in the higher end of the voltage scale.

- If the post sensor shows ***excessive fluctuations*** (which echo the scope pattern of the pre sensor), this indicates that the catalytic converter is not functioning correctly and cannot consume the O2 (fault set).

- If the post sensor fluctuations move out of the normal voltage “window”, this indicates that the pre sensor is not performing properly due to ***slight*** deterioration. These systems can also “trim” the ms injection time to compensate for this.

The constantly changing oxygen sensor input to the ECM is needed to correct the ms injection time to ensure that the ideal air/fuel ratio is maintained.

CAMSHAFT SENSOR
-INTAKE AND EXHAUST CAMSHAFTS

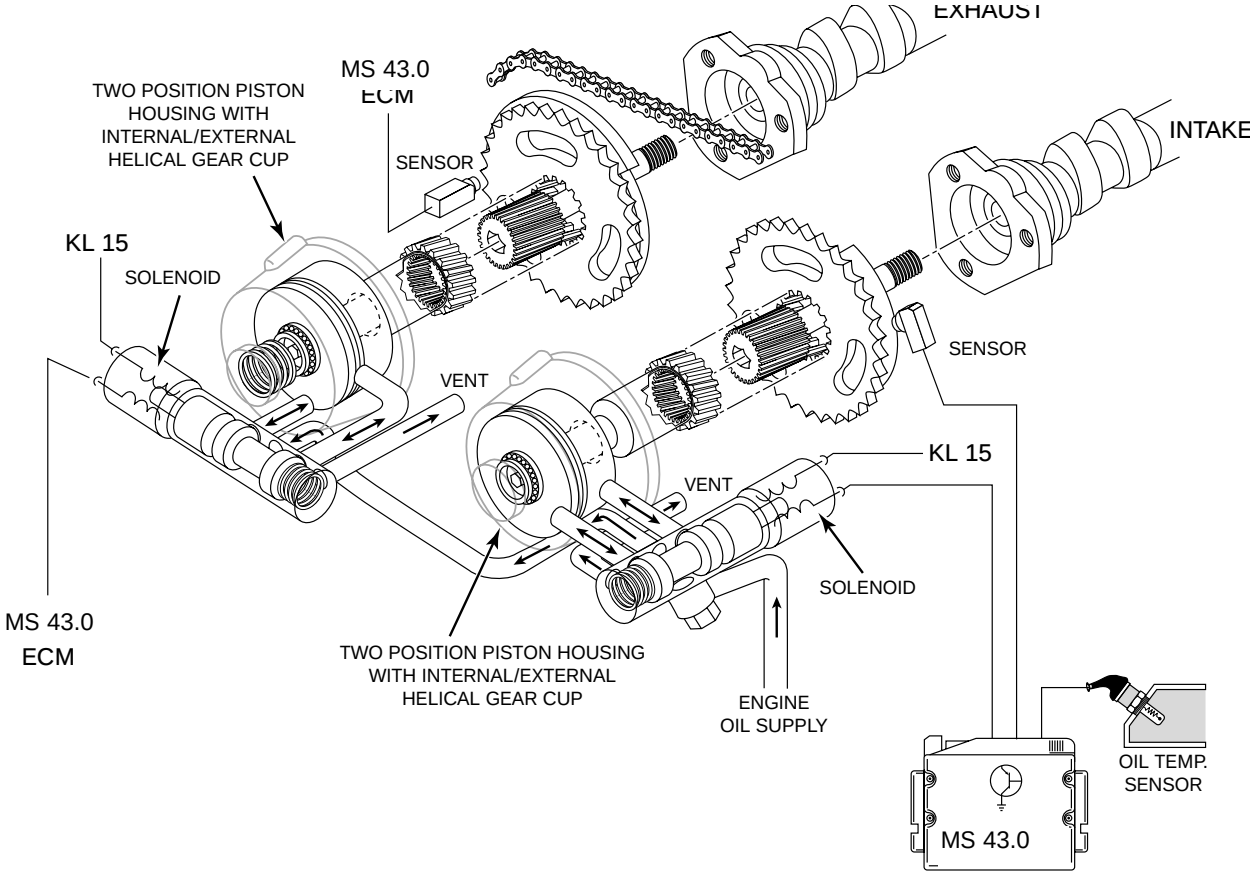
The "static" Hall sensors are used so that the camshaft positions are recognized once ignition is “on” - even before the engine is started.

The function of the intake cam sensor:

- Cylinder bank detection for preliminary injection
- Synchronization
- Engine speed sensor (if crankshaft speed sensor fails)
- Position control of the intake cam (VANOS)

The exhaust cam sensor is used for position control of the exhaust cam (VANOS)

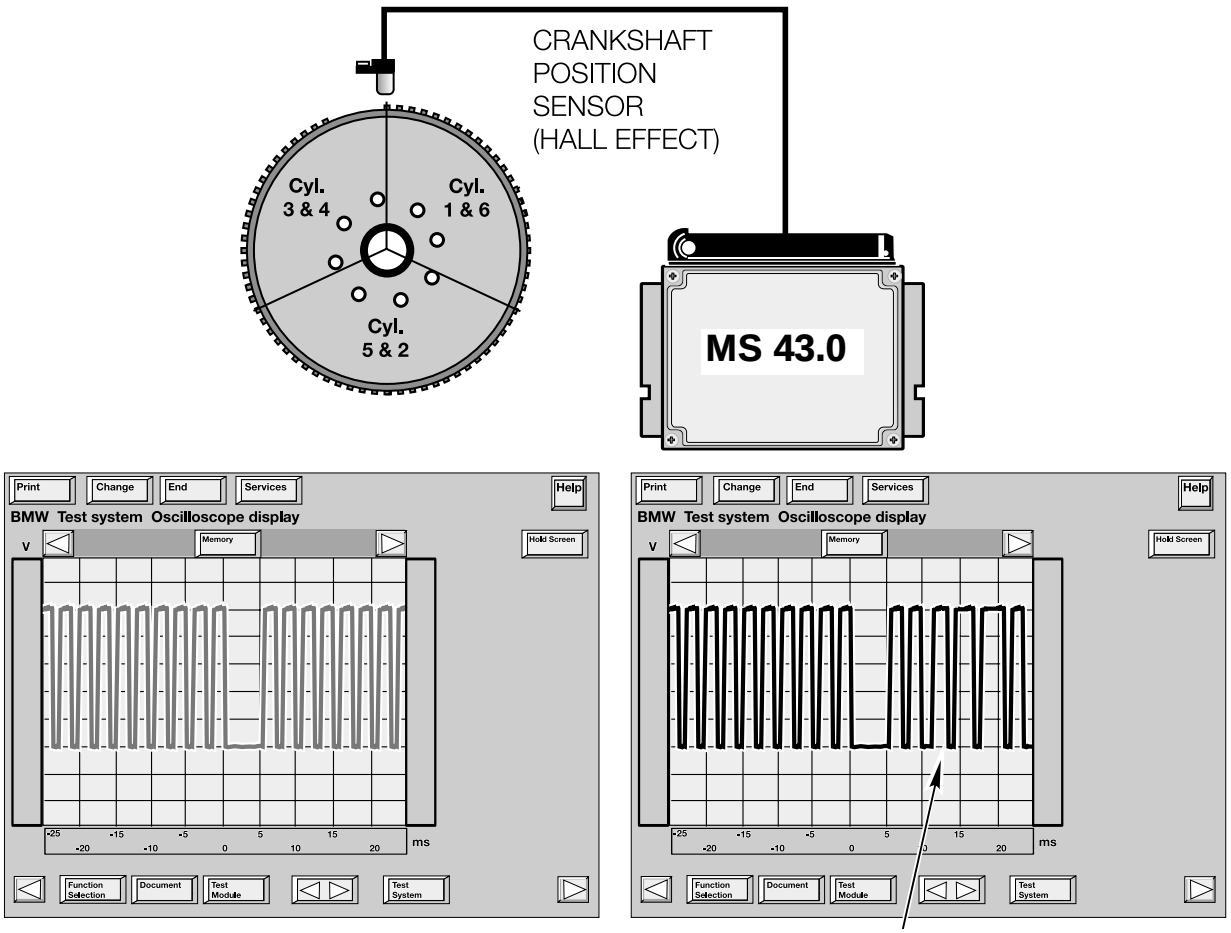
If these sensors fail there are no substitute values, the system will operate in the failsafe mode with no VANOS adjustment. The engine will still operate, but torque reduction will be noticeable.
NOTE: Use caution on repairs as not to bend the impulse wheels



CRANKSHAFT SENSOR

The crankshaft sensor is a dynamic Hall-effect sensor (mounted through the engine block), the signal is sent the moment the crankshaft begins to rotate.

The pulse wheel is mounted directly to the crankshaft as seen on previous models.



SMOOTH RUNNING ENGINE
NOTE SQUARE WAVE

ENGINE MISFIRE DETECTED

MISFIRE DETECTION

As part of the CARB/OBD regulations the engine control module must determine if misfire is occurring and also identify the specific cylinder(s) and the severity of the misfire event, and whether it is emissions relevant or catalyst damaging. In order to accomplish these tasks the control module monitors the crankshaft for acceleration losses during firing segments of each cylinder based on firing order.

Misfire Detection Example: M54 (6 Cyl.) with Siemens System

The misfire/engine roughness calculation is derived from the differences in the period duration (T) of individual increment gear segments. Each segment period consist of an angular range of 120° crank angle that starts 78° before Top Dead Center (TDC).

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 control unit will illuminate the "Service Engine Soon" light, may cut-off fuel to the particular cylinder and may switch lambda operation to open-loop. All misfire faults are weighted to determine if the misfire is emissions relevant or catalyst damaging.

EMISSIONS RELEVANT:

During an interval of **1000 crankshaft revolutions** the misfire events of all cylinders are added and if the sum is greater than a predetermined value a fault will be set identifying the particular cylinder(s). The “Service Engine Soon” light will be illuminated during and after the second cycle if the fault is again present.

CATALYST DAMAGING:

During an interval of **200 crankshaft revolutions** the misfire events of all cylinders are added and if the sum is greater than a predetermined value a fault will be set identifying the particular cylinders(s). The “Service Engine Soon” lamp:

- On vehicles with a Siemens Control Module (M54 engines) - the lamp will immediately go to a steady illumination since fuel to the injector(s) is removed. Fuel cut-off to the cylinder will resume after several (>> 7) periods of decel if crankshaft sensor adaptation is successfully completed or the engine is shut-off and restarted.

In each case the number of misfire events permitted is dependent on engine speed, load and temperature map.

The process of misfire detection continues well after the diagnostic drive cycle requirements have been completed. **Misfire detection is an on-going monitoring process** that is only discontinued under certain conditions.

Misfire detection is only disabled under the following conditions:

REQUIREMENTS	STATUS/CONDITION
Engine Speed	< 512 RPM
Engine Load	Varying/Unstable
Throttle Angle	Varying/Unstable
Timing	Timing retard request active (i.e. knock control - ASC, AGS)
Engine Start-up	Up to 5 seconds after start-up
A/C	Up to 0.5 seconds after A/C activation
Decel fuel cut-off	Active
Rough road recognition	Active
ASC Control	Active

OBD II - Misfire Faults

FAILED COMPONENT	POSSIBLE FAULT	MISFIRE EFFECT/LOCATION
Spark plug	electrode gap too small	affected cylinders
	electrodes missing	affected cylinders
	electrodes oil/fuel soaked	affected cylinders
	electrodes oil/feul soaked fouled	
	spark plug ceramic broken	affected cylinders
	oil level too high	most likely more than one cylinder affected
	oil foaming	
	oil level too high, oil/fuel fouled	
	heat range too cold	
	crank case ventilation defective	most likely more than one cylinder affected
Spark plug connector	wet, water or moisture	most likely more than one cylinder affected
	broken	affected cylinders
Ignition Coil	internal defect, arcing	affected cylinders
Connectors ignition	corrosion	one or more cylinders
	pin backed out	one or more cylinders
	plug loose	one or more cylinders
	loose wire from connector	one or more cylinders
Injection Valve	metal filing	on the affected cylinders
	leaking	on the affected cylinders
	carbon fouled	one or more cylinders
	dirty/contaminated	one or more cylinders
Injector connectors	corrosion	one or more cylinders
	pin backed out	one or more cylinders
	plug loose	one or more cylinders
	loose wire from connector	one or more cylinders
Intake manifold leaks	intake plenum, unmetere air leak (i.e. injector seals)	
Intake/Exhaust valve	carbon built up (intake)	most likely more than one cylinder affected
	burnt or damaged	on the affected cylinders
	overrev:intake or exhaust valves leaking (bent)	most likely more than one cylinder affected

FAILED COMPONENT	POSSIBLE FAULT	MISFIRE EFFECT/LOCATION
Camshaft	broken	most likely more than one cylinder affected
Piston	hole in piston crown/piston seized in bore	on the affected cylinders
Hydraulic lash adjusters (HVA)	defective: i.e. oil bore restricted/blocked	on the affected cylinders
	engine oil pressure built up too slow	
Fuel pressure	fuel pump, pressure too low	most likely cyl. 1-3 (front cylinders)
	fuel filter restricted/ blocked	most likely cyl. 1-3 (front cylinders)
	fuel pump, pressure build up too slow after start	most likely cyl. 1-3 (front cylinders)
	leaking fuel feed lines	most likely cyl. 1-3 (front cylinders)
	pressure regulator defective (metal filing)	most likely cyl. 1-3 (front cylinders)
	running loss valve defective	most likely cyl. 1-3 (front cylinders)
	fuel tank empty	most likely cyl. 1-3 (front cylinders)
	siphon jet pump and fuel tank empty	most likely cyl. 1-3 (front cylinders)
	water in fuel tank	most likely more than one cylinder affected
Fuel	high content oxygenated	one or more cylinders
	non anti carbon additives	one or more cylinders
Oxygen sensor	excessive mixture deviation	only the affected bank
Purge sytem	excessive rich mixture due to high ambient temperature	one or more banks
	blocked fuel tank vent inlet	all cylinders
Crank sensor/increment wheel	incorrect input signal for misfire detection	all cylinders
	increment wheel loose	all cylinders
	increment wheel damaged	affected segment
	gap between sensor and increment wheel	affected segment
	fly wheel damaged	
Catalyst damaged	exhaust back pressure on the affected bank	only the afftected bank
DME	final stage igntion/injectors	all cylinder

MASS AIR FLOW SENSOR HFM

The Siemens mass air flow sensor is functionally the same as in the past. The designation 2 Type B simply indicates that it is smaller in design. The mass air meter has a diameter of 85 mm.





MS 43 CARRY OVER FUNCTIONS

OUTPUT FUNCTIONS -VANOS CONTROL

With the double VANOS system, the valve timing is changed on both the intake and the exhaust camshafts.

Double VANOS provides the following benefits:

- Torque increase in the low to mid (1500 - 2000 RPM) range without power loss in the upper RPM range.
- Less incomplete combustion when idling due to less camshaft overlap (also improves idle speed characteristics).
- Internal exhaust gas recirculation (EGR) in the part load range (reduces NOx and post-combustion of residual gasses in the exhaust)
- Rapid catalyst warm up and lower “raw” emissions after cold start.
- Reduction in fuel consumption

Double 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)

The “initial” timing is set by gear positioning (refer to the Repair Instructions for details) and the chain tensioner. As with the previous VANOS, the hydraulically controlled actuators move the helical geared cups to regulate camshaft timing. The angled teeth of the helical gears cause the pushing movement of the helical cup to be converted into a rotational movement. This rotational movement is added to the turning of the camshafts and cause the camshafts to “advance” or “retard”. The adjustment rate is dependent oil temperature, oil pressure, and engine RPM.

NOTE: With extremely hot oil temperatures Vanos is deactivated (Power loss). If the oil is too thick (wrong viscosity) a fault could be set.

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.

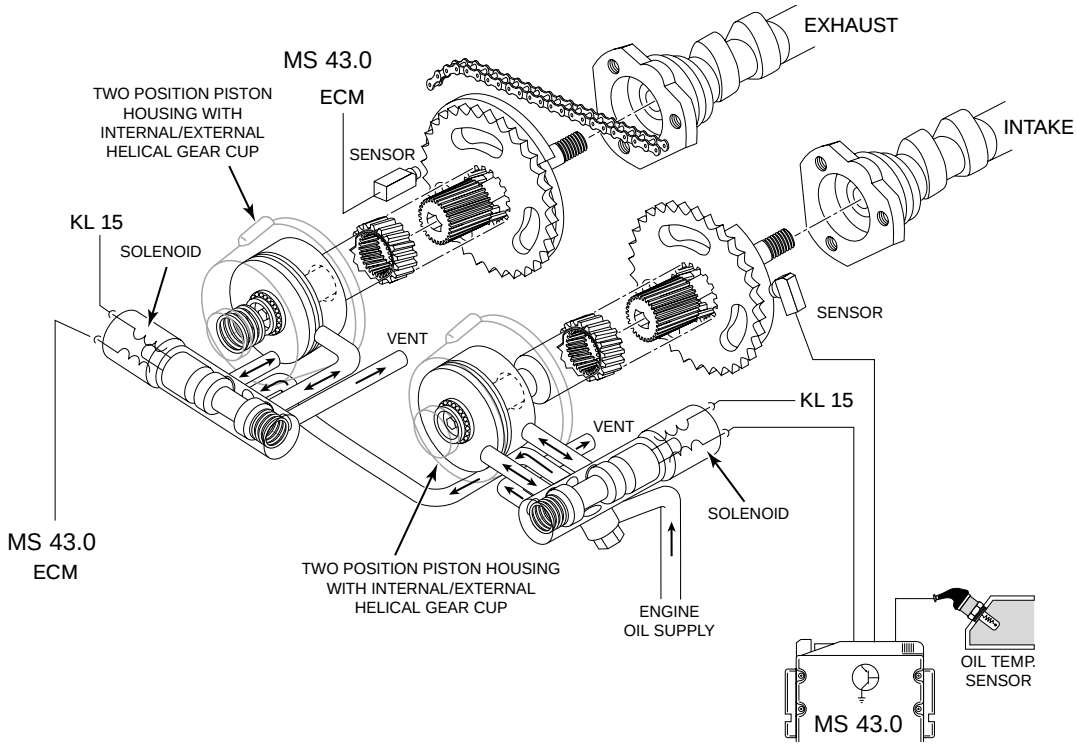
After 50 RPM (2-5 seconds) from engine start, the ECM is monitoring the exact camshaft position.

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.

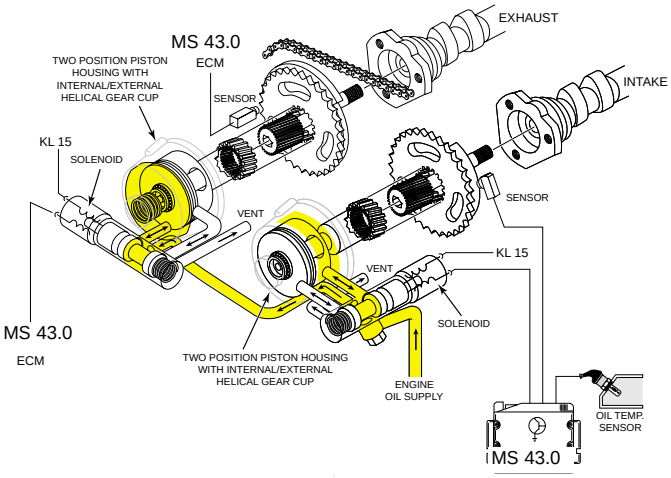
The double VANOS system is “fully variable”. When the ECM detects the camshafts are in the optimum positions, the solenoids are modulated (approximately 100-220 Hz) maintaining oil pressure on both sides of the actuators to hold the camshaft timing.

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. This will be like driving with retarded ignition or starting from a stop in third gear.



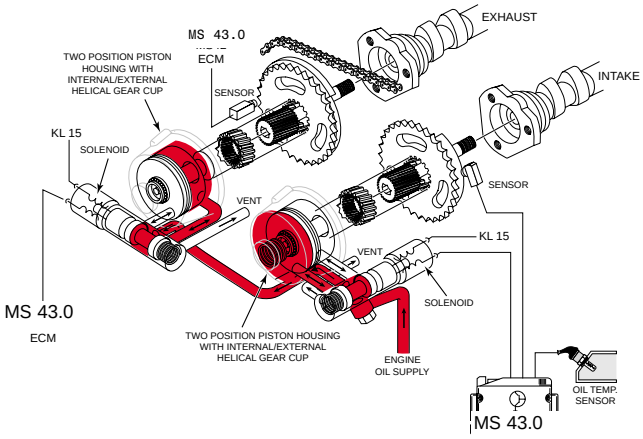
DEACTIVATED



EXHAUST: Advanced piston moved in

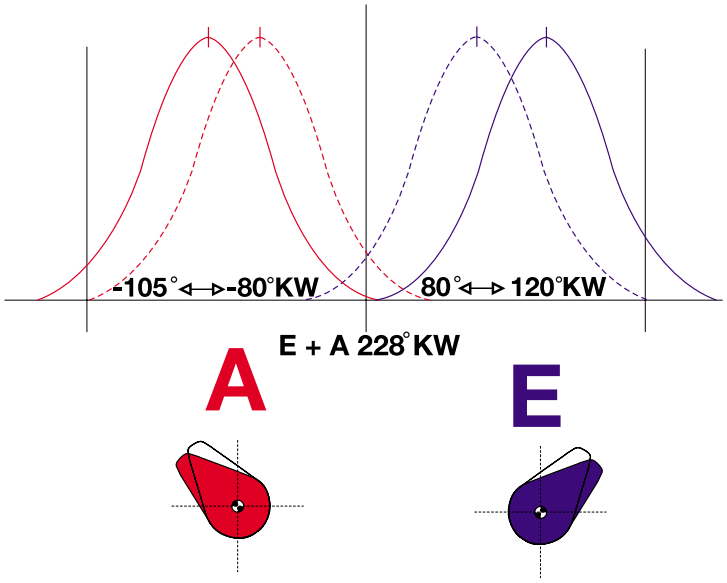
INTAKE: Retard piston moved out

ACTIVATED



EXHAUST: Advanced piston moved out

INTAKE: Retard piston moved in

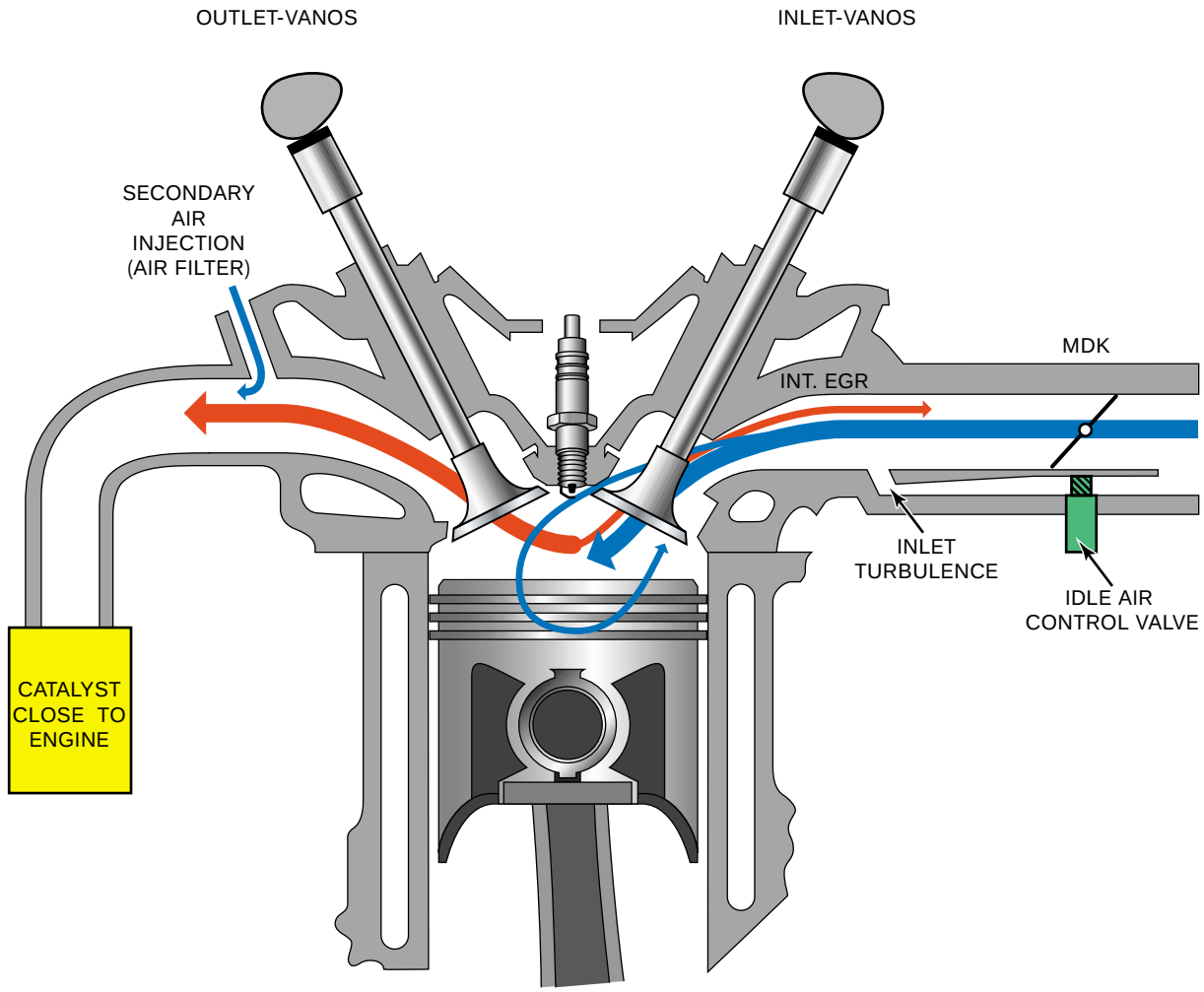


The dual VANOS in conjunction with the variable intake manifold provides an additional emission control feature.

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.



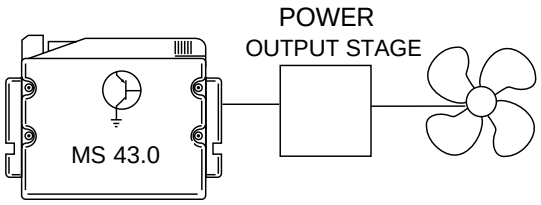
ELECTRIC FAN

The electric cooling fan is now 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 (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)



NOTE: If the ECM indicates a fault check the fan for freedom of movement

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.

After the engine is switched off, the fan may continue to operate at varying speeds (based on the ECM calculated catalyst temperature). This will cool the radiator down from a heat surge (up to 10 minutes).

SECONDARY AIR INJECTION



This ECM controlled function remains unchanged from the previous Siemens MS system, however there is a hardware change.

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.

SECONDARY AIR INJECTION MONITORING

In order to reduce HC and CO emissions while the engine is warming up, BMW implemented the use of a Secondary Air Injection System in. Immediately following a cold engine start (-10 - 40°C) fresh air/oxygen is injected directly into the exhaust manifold. By injecting oxygen into the exhaust manifold:

- The warm up time of the catalyst is reduced
- Oxidation of the hydrocarbons is accelerated

The activation period of the air pump can vary depending on engine type and operating conditions.

Conditions for Secondary Air Pump Activation:

REQUIREMENTS	STATUS/CONDITION MS 43.0	STATUS/CONDITION M73
Oxygen sensor	Open Loop	Open Loop
Oxygen sensor heating	Active	Active
Engine coolant temperature	-10 to 40ºC*	-10 to 40ºC* Stage
Engine bad	Predefined Range	Predefined Range
Engine speed	Predefined Range	Predefined Range
Fault Codes	No Secondary Air Faults “currently present”	No Secondary Air Faults “currently present”

*NOTE: Below -10°C the air injection pump is activated only as a preventive measure to blow out any accumulated water vapor that could freeze in the system.

The Secondary Air Injection System is monitored via the use of the pre-catalyst oxygen sensor(s). Once the air pump is active and is air injected into the system the signal at the oxygen sensor will reflect a lean condition. If the oxygen sensor signal does not change within a predefined time a fault will be set and identify the faulty bank(s). If after completing the next cold start and a fault is again present the "Service Engine Soon" light will be illuminated.

Example: Secondary Air Injection Monitoring (M54-Siemens System)

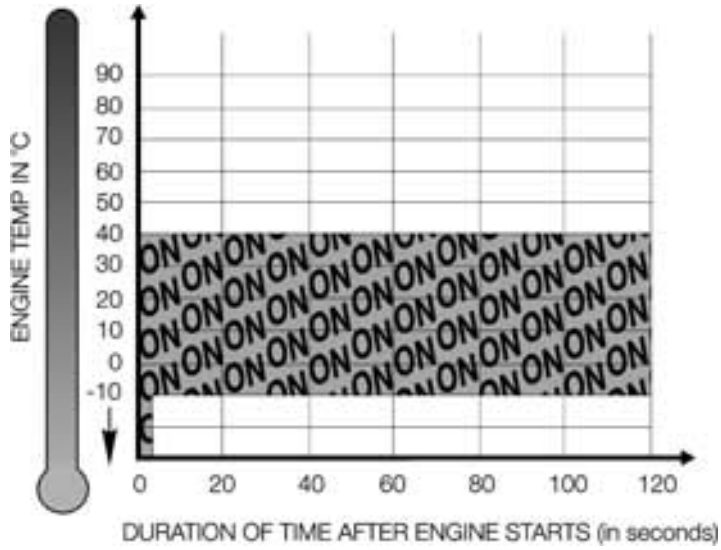
During a cold start condition air is immediately injected into the exhaust manifold and since the oxygen sensors are in open loop at this time the voltage at the pre catalyst sensor will reflect a lean condition) and will remain at this level while the air pump is in operation. Once the pump is deactivated the voltage will change to a rich condition until the system goes into closed loop operation.

M54 System Operation:

The pump draws air through its own air filter and delivers it to both exhaust manifolds through a non-return (shutoff valve). The non-return valve is used to:

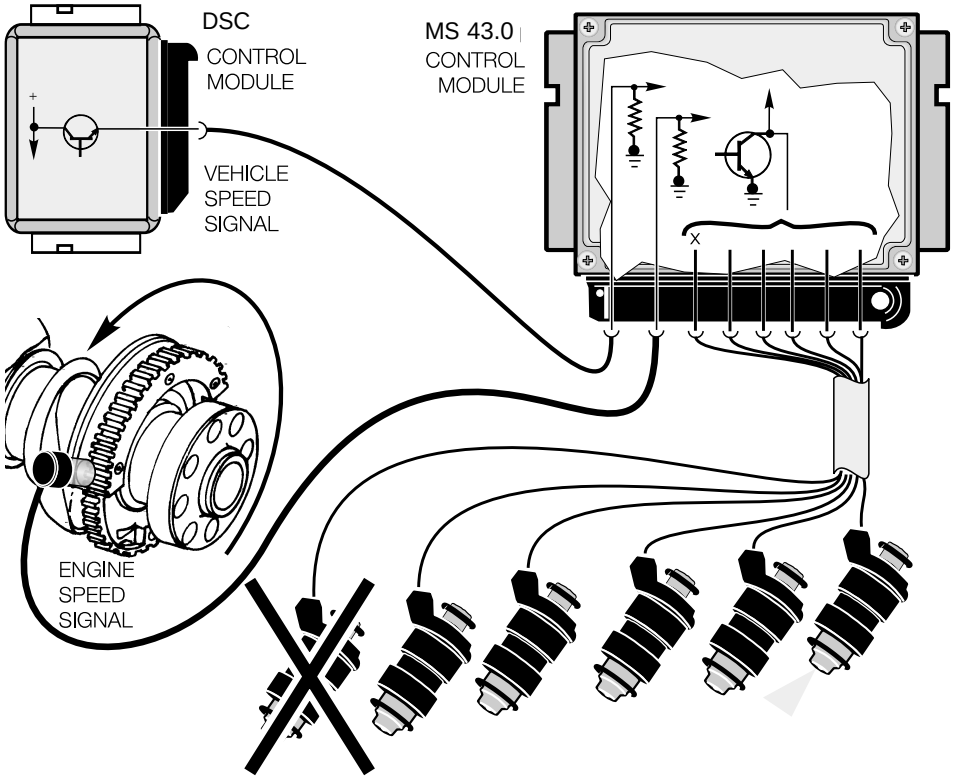
1. Control air injection into the exhaust manifold - A vacuum controlled valve will open the passageway for air to be injected once a vacuum is applied.
2. Prevent possible backfires from traveling up the pipes and damaging the air pump when no vacuum is applied.

The control module activates the vacuum vent valve whenever the air pump is energized. Once the vacuum vent valve is energized a vacuum is applied to the non-return valve which allows air to be injected into the exhaust manifold. A vacuum is retained in the lines, by the use of a check valve, in order to allow the non-return valve to be immediately activated on cold engine start up. When the vacuum/vent valve is not energized, the vacuum to the non-return valve is removed and is vented to atmosphere.



ENGINE/VEHICLE SPEED LIMITATION

For engine/vehicle speed limitation, the ECM will deactivate injection for individual cylinders, allowing a smoother limitation transition. This prevents over-rev when the engine reaches maximum RPM (under acceleration), and limits top vehicle speed (approx. 128 mph).

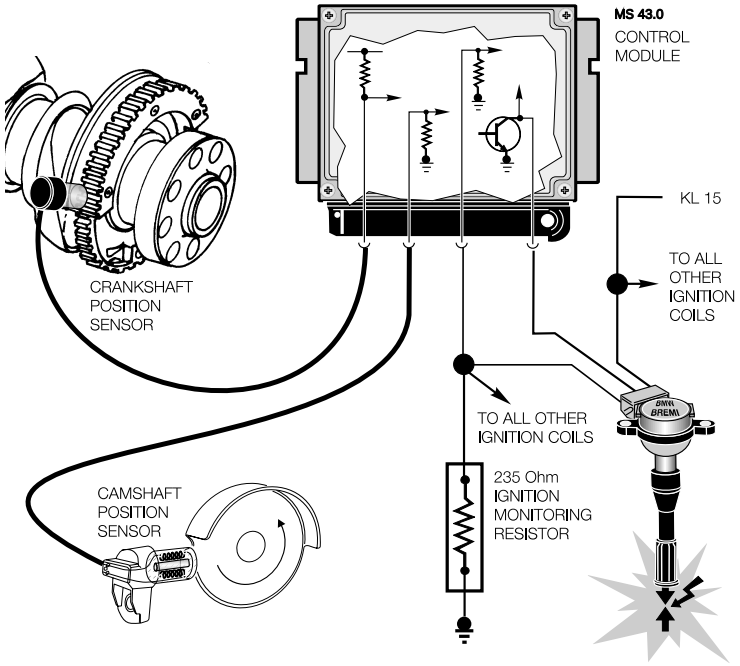


RZV IGNITION SYSTEM

The Siemens MS43.0 system uses a multiple spark ignition function. The purpose of multiple ignition is:

- Provide clean burning during engine start up and while idling (reducing emissions).

- This function helps to keep the spark plugs clean for longer service life (new BMW longlife plugs).



Multiple ignition is active up to an engine speed of approximately 1350 RPM (varied with engine temperature) and up to 20 degrees after TDC.

Multiple ignition is dependent on battery voltage. When the voltage is low, the primary current is also lower and a longer period of time is required to build up the magnetic field in the coil(s).

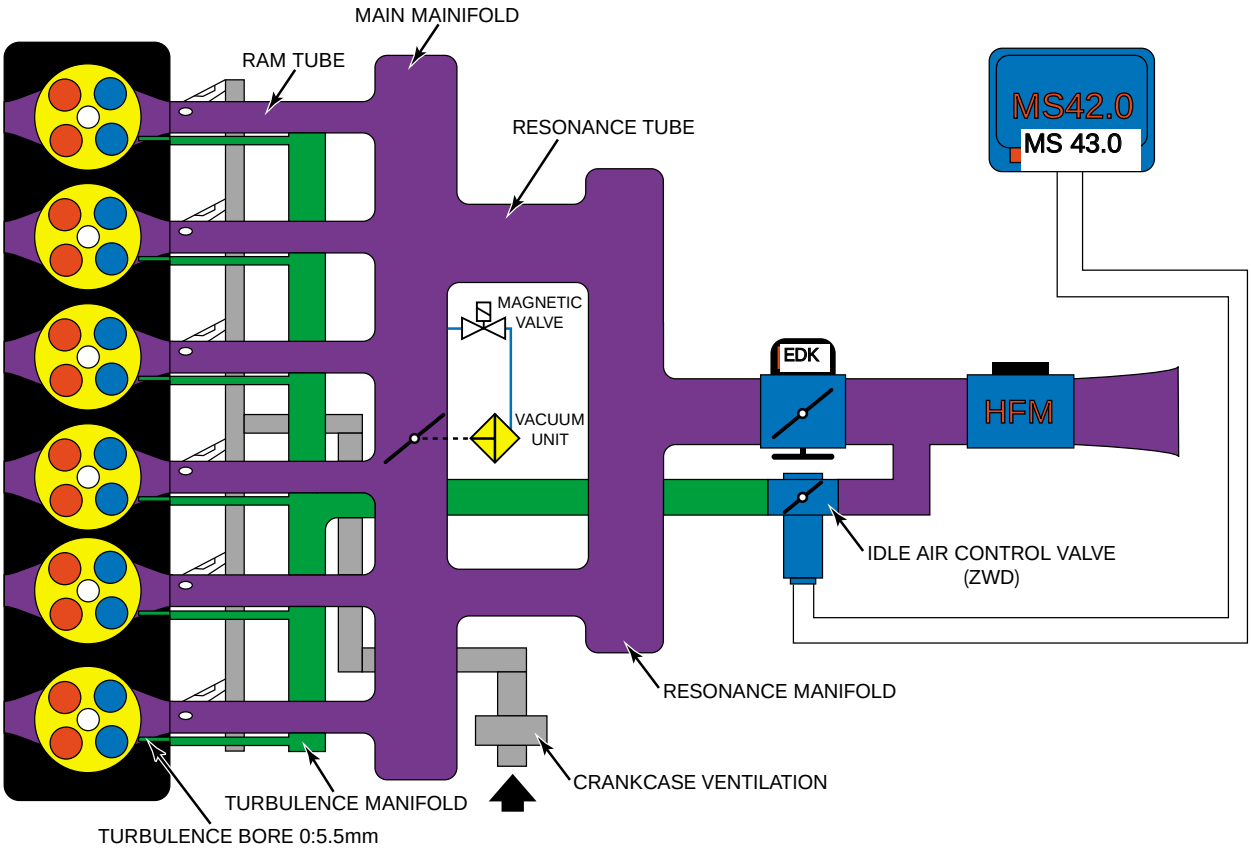
- Low battery voltage = less multiple ignitions
- High battery voltage = more multiple ignitions

The 240 ohm shunt resistor is still used on the MS43.0 system for detecting secondary ignition faults and diagnostic purposes.

RESONANCE/TURBULENCE INTAKE SYSTEM

On the M54, the intake manifold is split into 2 groups of 3 (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 a resonance flap (in the intake manifold) controlled by the ECM.

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

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

When the flap is closed , this creates another “dynamic” effect. For example, as the intake air is flowing into cylinder #1, the intake valves will close. This creates a “roadblock” 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. The resonance “wave”, along with the intake velocity, enhances cylinder filling.

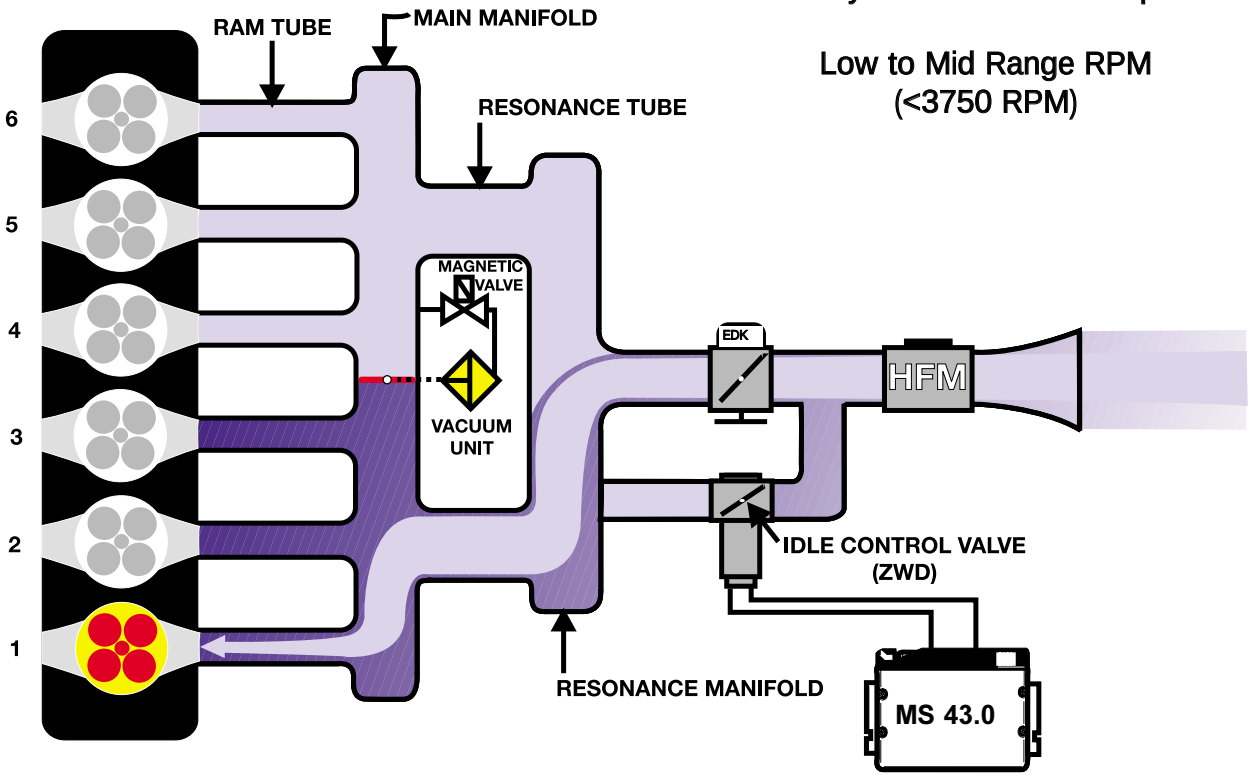
The ECM controls a solenoid valve for resonance flap activation. At speeds below 3750 RPM, the solenoid valve is energized and vacuum supplied from an accumulator closes the resonance flap. This channels the intake air through one resonance tube, but increases the intake velocity.

When the engine speed is greater than 4100 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.



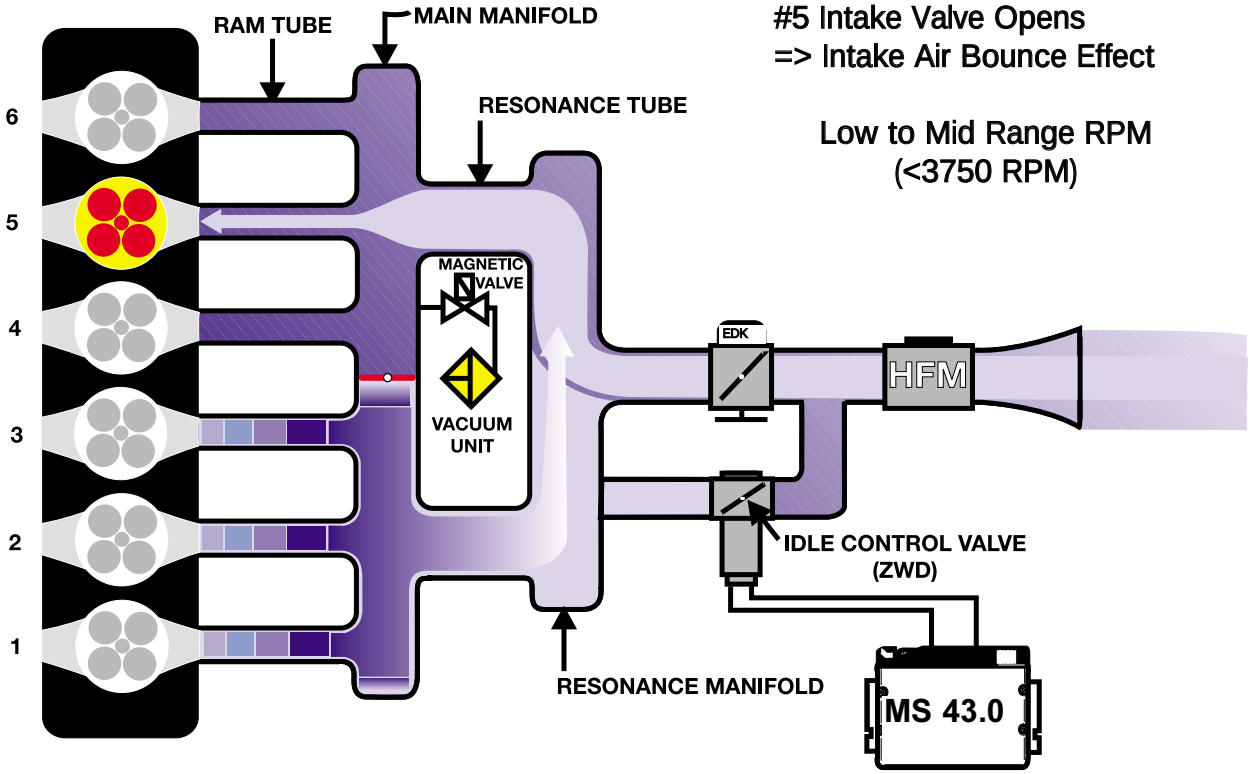
#1 Cylinder Intake Valve open

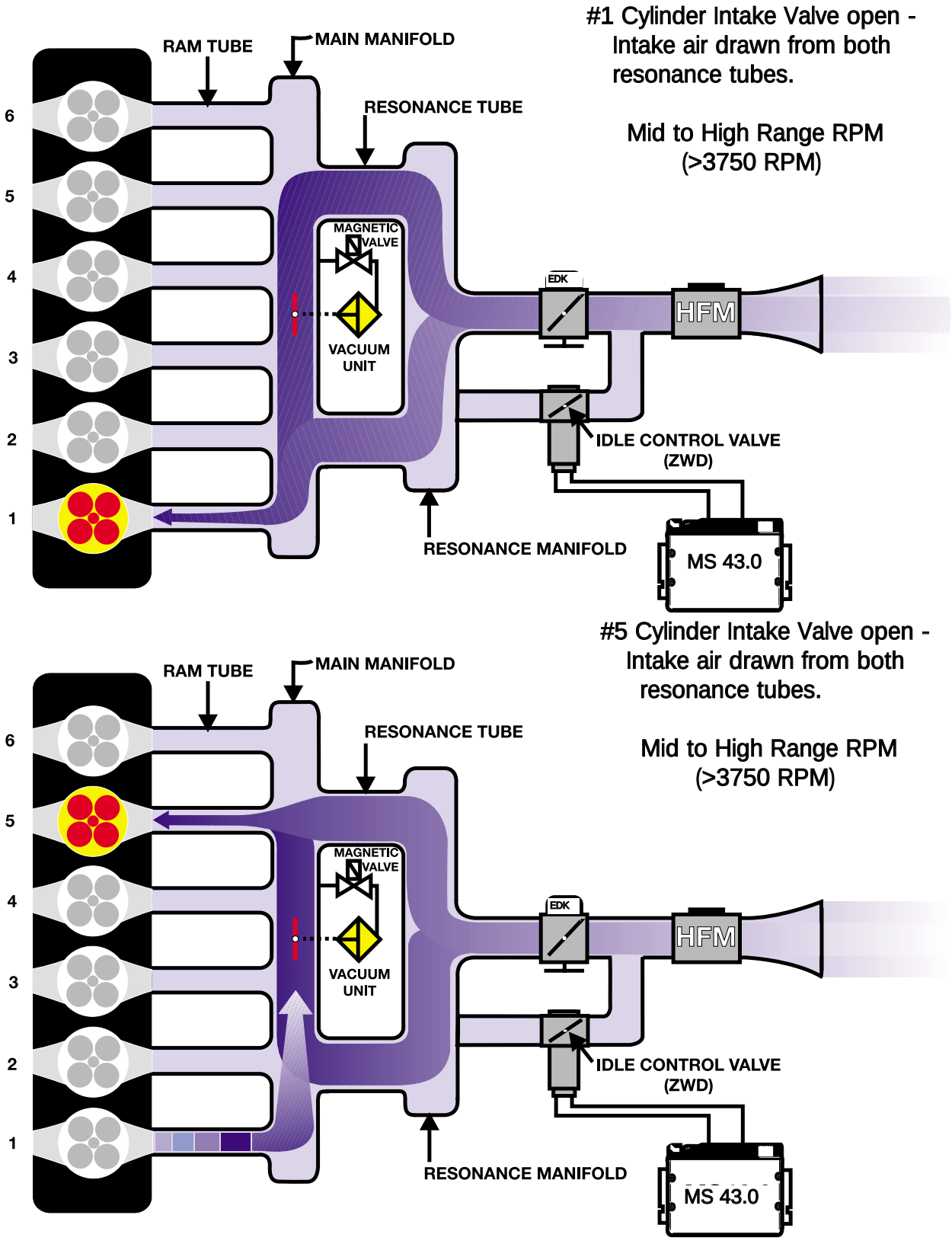
Low to Mid Range RPM
(<3750 RPM)



#1 Cylinder Intake Valve closes
#5 Intake Valve Opens
=> Intake Air Bounce Effect

Low to Mid Range RPM
(<3750 RPM)



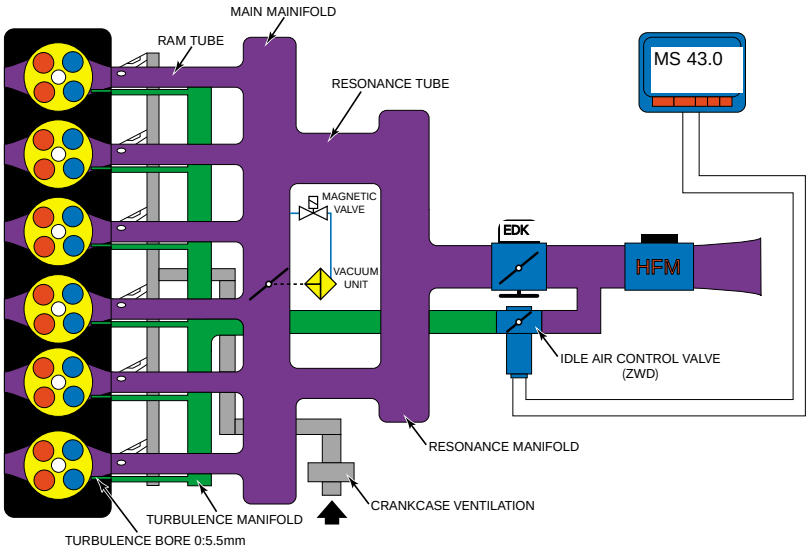

#1 Cylinder Intake Valve open - Intake air drawn from both resonance tubes.
Mid to High Range RPM (>3750 RPM)
RAM TUBE
MAIN MANIFOLD
RESONANCE TUBE
6
5
4
3
2
1
MAGNETIC VALVE
VACUUM UNIT
EDK
HFM
IDLE CONTROL VALVE (ZWD)
RESONANCE MANIFOLD
MS 43.0
#5 Cylinder Intake Valve open - Intake air drawn from both resonance tubes.
Mid to High Range RPM (>3750 RPM)
RAM TUBE
MAIN MANIFOLD
RESONANCE TUBE
6
5
4
3
2
1
MAGNETIC VALVE
VACUUM UNIT
EDK
HFM
IDLE CONTROL VALVE (ZWD)
RESONANCE MANIFOLD
MS 43.0

IDLE SPEED CONTROL

The ECM determines idle speed by controlling an idle speed actuator (dual winding rotary actuator) ZWD 5.

The basic functions of the idle speed control are:

- Control the initial air quantity (at air temperatures <0 C, the 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)
- Vacuum limitation



- Smooth out the transition from acceleration to deceleration

Under certain engine operating parameters, the EDK throttle control and the idle speed actuator (ZWD) are operated simultaneously.This includes All idling conditions and the transition from off idle to load.

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.

Emergency Operation of Idle Speed Actuator:

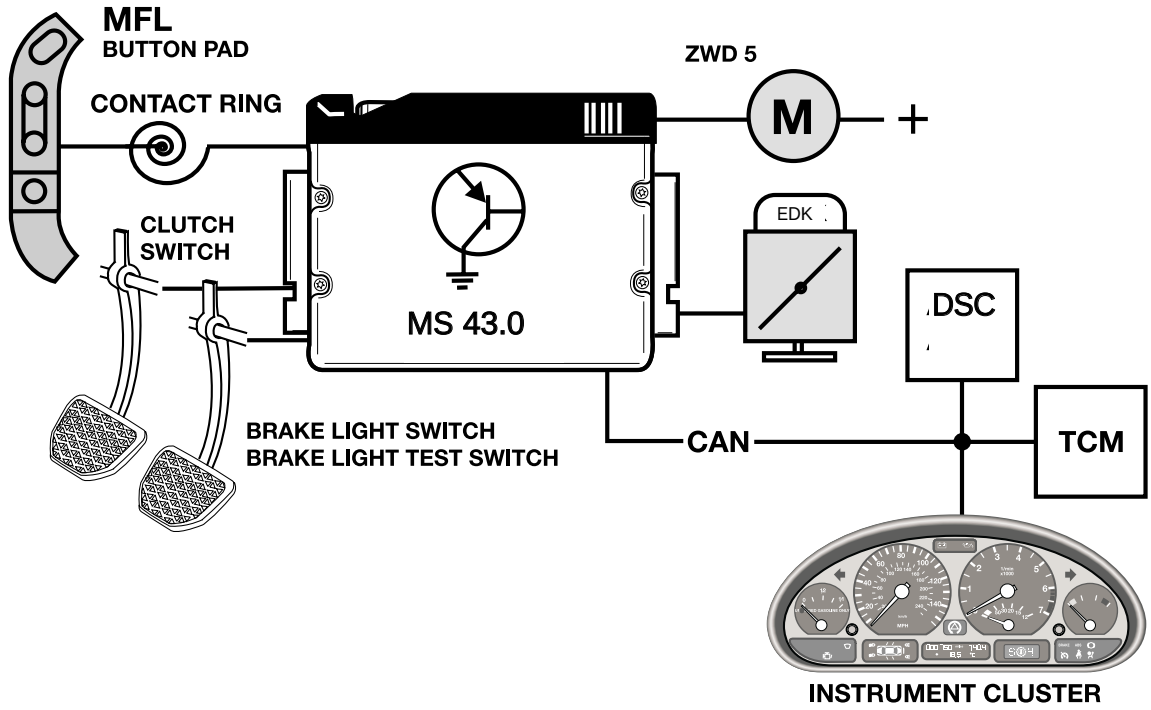
If a fault is detected with the idle speed actuator, the ECM will initiate failsafe measures depending on the effect of the fault (increased air flow or decreased air flow).
If there is a fault in the idle speed actuator/circuit, the EDK will compensate to maintain idle speed. The EML lamp will be illuminated 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.

CRUISE CONTROL

Cruise control is integrated into the ECM because of the EDK operation.

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.



The ECM controls vehicle speed by activation of the Electronic Throttle Valve (EDK)

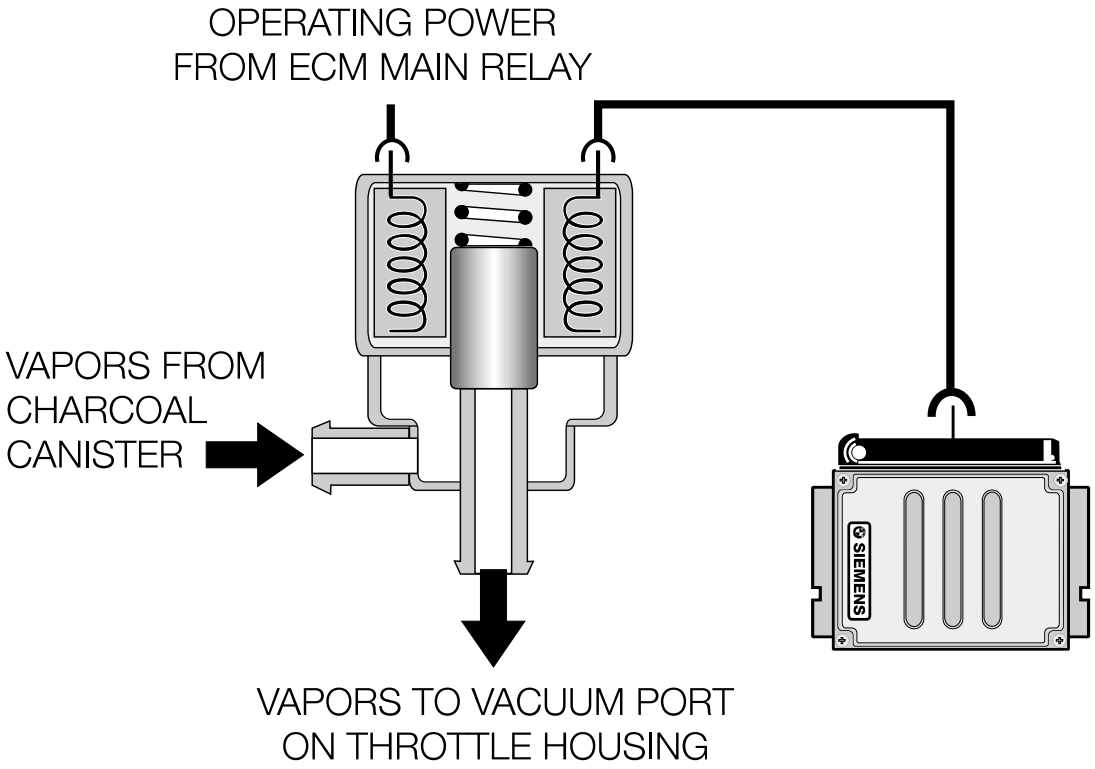
The clutch switch disengages cruise control to prevent over-rev during gear changes.

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 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.

PURGE VALVE

The purge valve (TEV) is activated at 10 Hz by the ECM to cycle open, and is sprung closed. The valve is identical to the purge valve used on the Siemens MS 42 system.



REVIEW QUESTIONS

1. List the major changes to the Siemens MS 43.3 system from MS 42:

_____
_____
_____
_____
_____

2. What type of signal does the Hall Sensor - PWG provide to ECM for throttle request?

_____

3. What PWG signal is used if PWG has a plausibility error?

_____

4. What is the purpose of the KL 87 main relay monitor in the ECM?

_____

5. Why is the ignition left ON after KL 15 is switched OFF?

_____

6. Describe the operation of the DM-TL system on MS 43.0.

_____
_____
_____
_____
_____

7. Describe the operation of the turbulence - resonance manifold.

_____
_____
_____
_____
_____
_____
_____