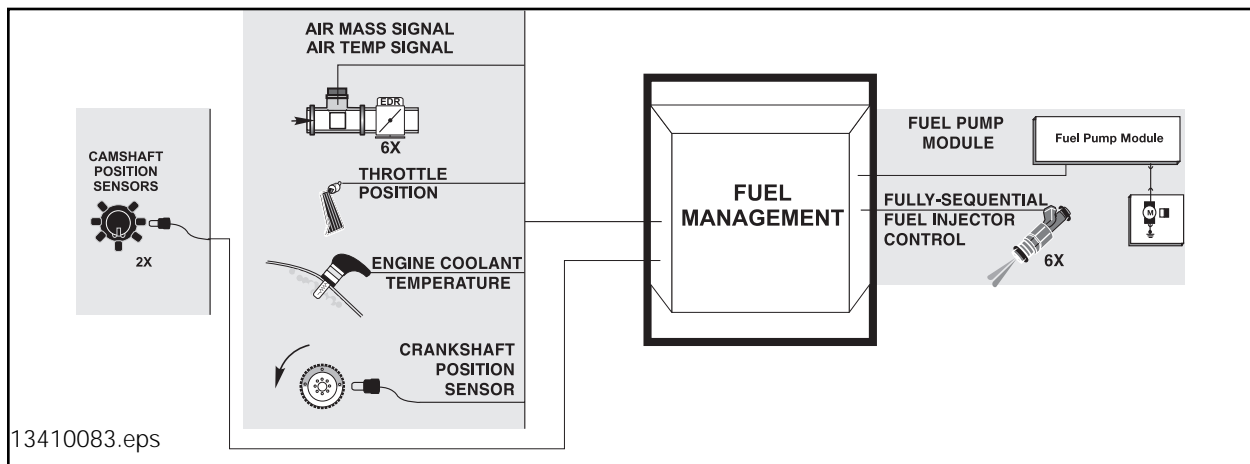

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Fuel Management

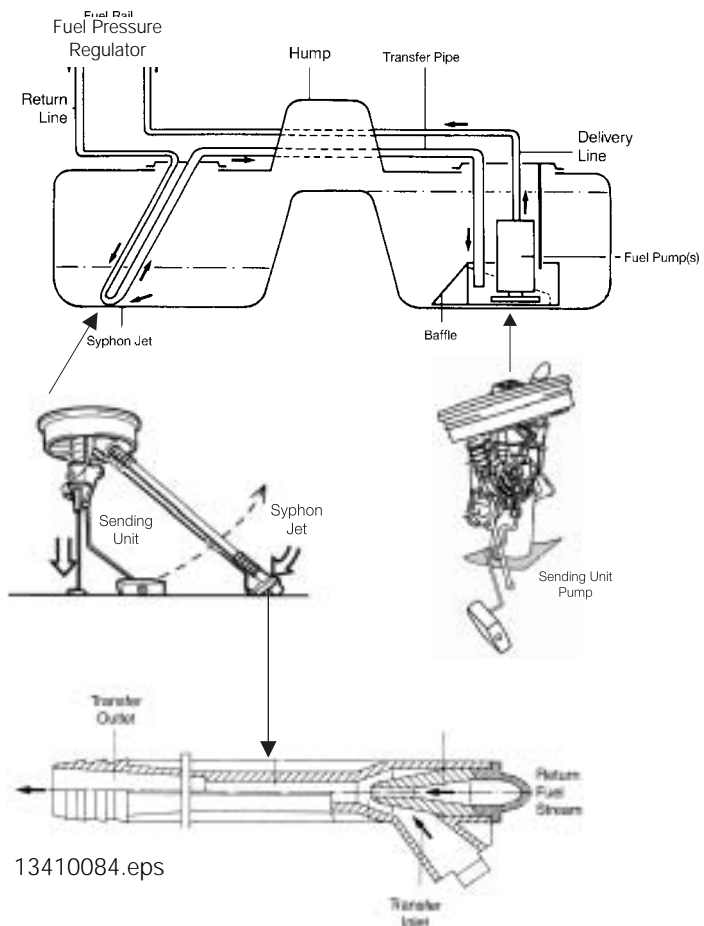


Fuel Tank: The fuel tank is made of high density polyethylene (reduced weight) which is manufactured to meet safety requirements. The baffling has been modified for the E46 M3 fuel pump pickup in the right hand side of the fuel tank to maintain fuel supply during aggressive cornering.

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 of tank to transfer fuel from the left side, linked to the fuel return line.

As fuel moves through the return, the syphon 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 submersible (in the fuel tank) high volume pump. The inlet is protected by a mesh screen.

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

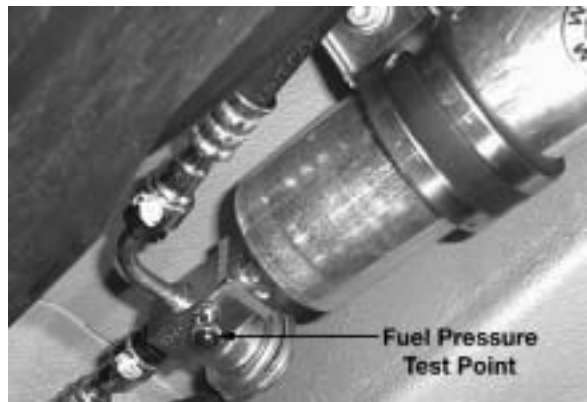
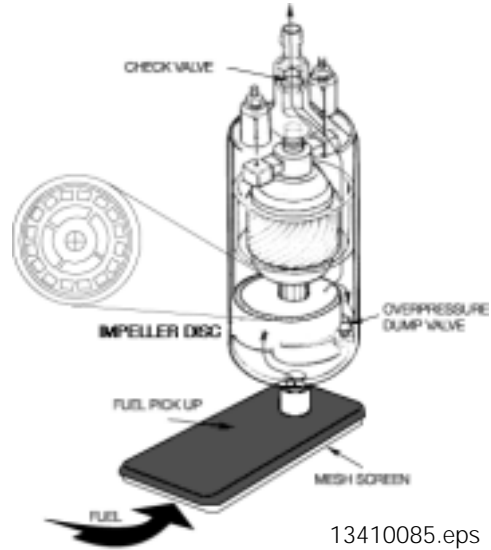
The fuel will exit through a non-return check valve to supply the injection system. The non-return check valve is opened by fuel exiting the pump and will close when the pump is deactivated. This maintains a “prime” of fuel in the filter, lines, hoses and fuel rail.

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

Fuel Supply: The fuel is supplied through a Non Return Fuel Rail System. This system is used on the S54 for LEV compliancy.

The fuel supply pressure is controlled by the 5 Bar fuel pressure regulator integrated in the fuel filter assembly. The regulator is influenced by engine vacuum via a hose connected to the idle air distribution pipe. 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 instead of from the fuel rail.

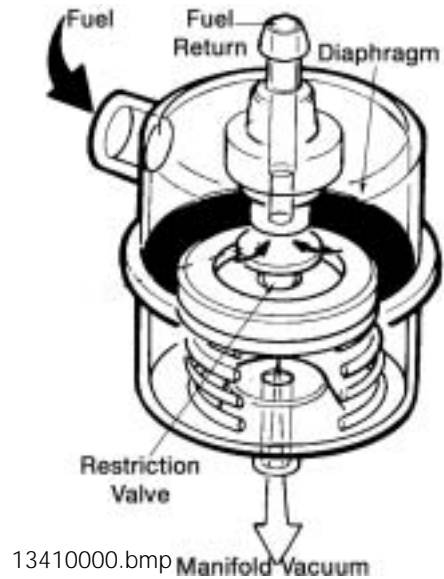


Fuel Pressure Regulator: The Fuel Pressure Regulator maintains a constant "pressure differential" for the fuel injectors.

The fuel pressure is set to 5.0 Bar (+/- 0.2) by internal spring tension on the restriction valve.

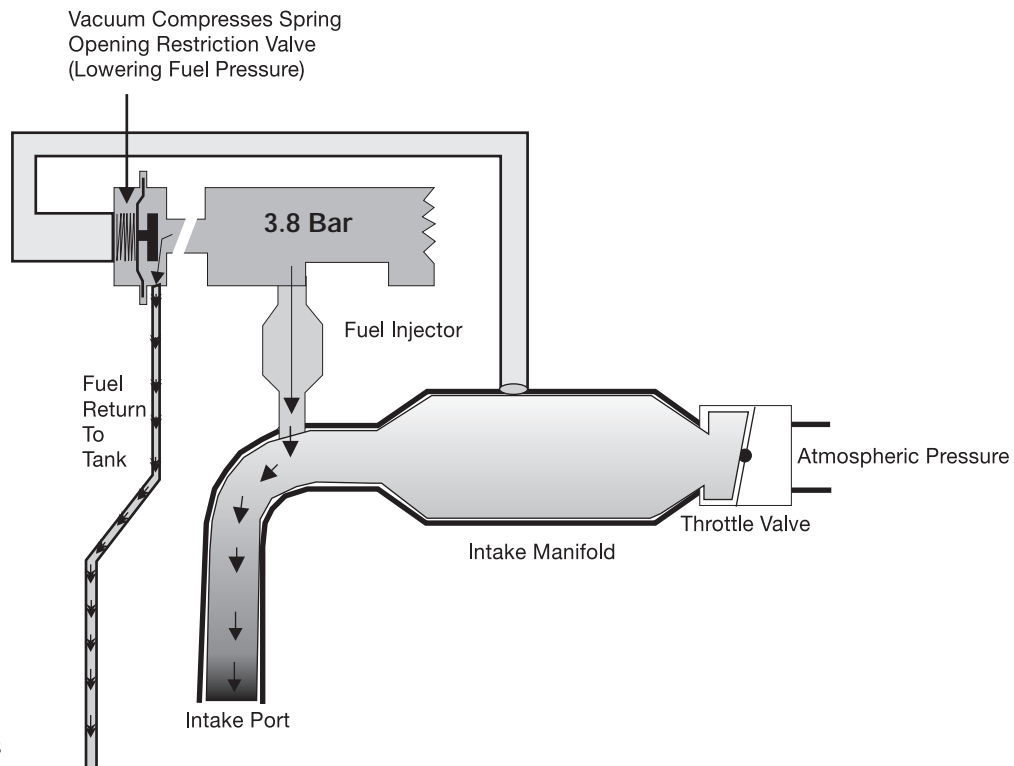
The vacuum chamber is sealed off by a diaphragm which is connected by a hose to the idle air distribution pipe (vacuum). Intake manifold vacuum regulates the fuel pressure by assisting to compress the spring (lowering fuel pressure).

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

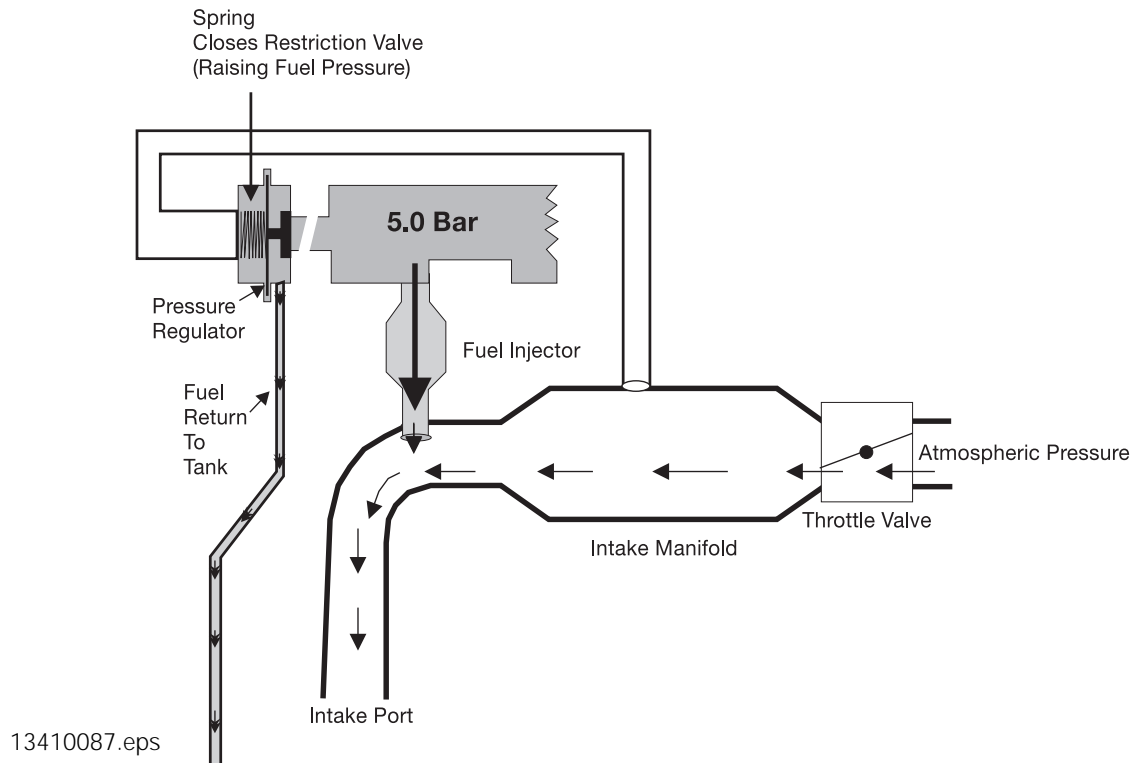


Examples of "pressure differential" are:

- 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.



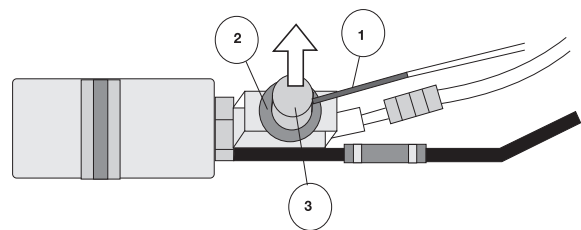
- Wide open throttle depletes intake manifold vacuum at the tip of the fuel injectors and in the fuel pressure regulator vacuum chamber. The spring closes the restriction valve to raise fuel pressure available to the fuel injectors. This maintains pressure differential (fuel flow through) for the fuel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



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 filter assembly.

1.	Vacuum Hose
2.	Retaining Ring
3.	5 Bar Fuel Pressure Regulator



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Bosch Fuel Injectors (4 Hole Plate Type): The Fuel Injectors are electronically controlled solenoid valves that provide precisely metered and atomized fuel into the engine intake ports. The Fuel Injector Valve consists of:

1.	Fuel Strainer
2.	Electronic Connector
3.	Solenoid Winding
4.	Closing Spring
5.	Plate Valve
6.	Outlet Orifice
7.	4 Hole Channeling

Fuel is supplied from the fuel rail to the injector body. The fuel is channeled through the injector body to the plate valve and seat.

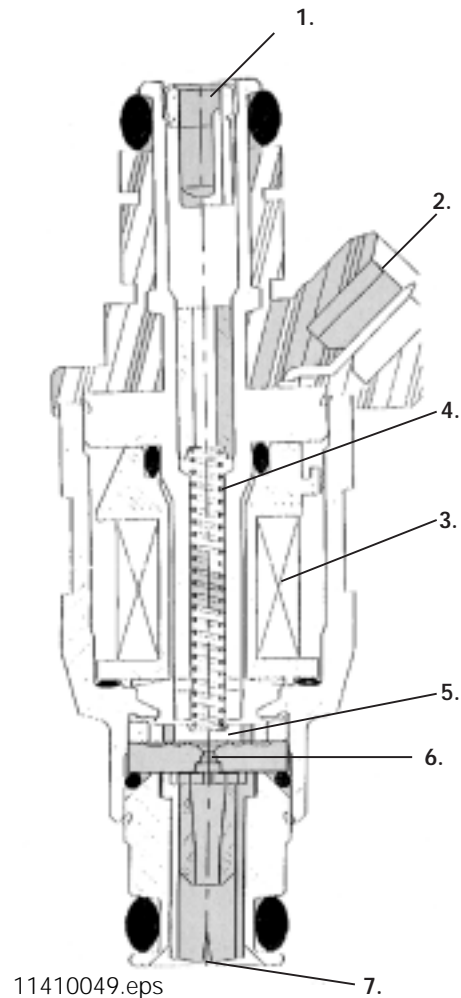
Without electrical current, the plate valve is sprung closed against the seat.

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

The pressurized fuel flows through the outlet orifice into the channeling. The channel "fans out" the fuel spray into four angled spray patterns which helps to atomize the fuel.

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

The length of time that the ECM activates the injectors is very brief, the duration is in milli-seconds (ms). This affects the amount of fuel volume flowing through the Fuel Injectors. The ECM will vary the length of time (ms) to regulate the air/fuel ratio (mixture).

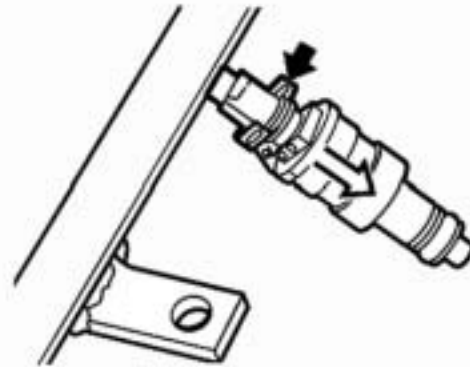


1.	BMW Number
2.	Fuel Injector Code
3.	Mfg Date (week 06 year 2000)
4.	B+ Voltage Connection

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).



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

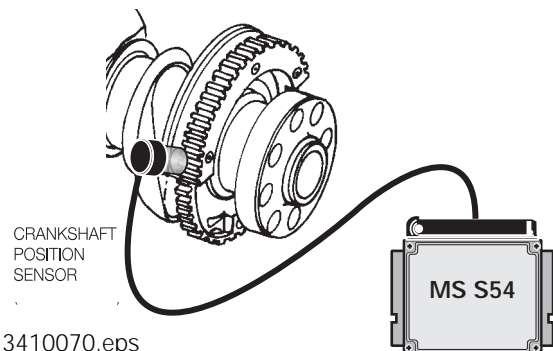
1.	“Engine EMISSION” Light	4.	Excessive Tailpipe Smoke (leaking)
2.	Long Crank Time (Leaking)	5.	Misfire/Rough Idle (leaking/blocked)
3.	Oxygen Sensor/Mixture/Injector Related Fault Codes	6.	Engine Hydrolock (leaking)

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 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 ECM provides the power supply to this component.

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 crankshaft position sensor is monitored as part of OBD II requirements for Misfire Detection.



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Camshaft Position Sensors (Hall Effect): The ECM uses the signal from the camshaft sensors to set up the triggering of the ignition coils, correct timing of fully sequential fuel injection, and VANOS operation. The ECM Relay supplies voltage to the Hall elements and the ECM supplies the ground. The power flow through the Hall elements is the basis for the sensors output to the ECM.

As the camshaft rotates, the leading edge of the impulse wheel approaches the sensor tip creating a magnetic field with the permanent magnet in the sensor.

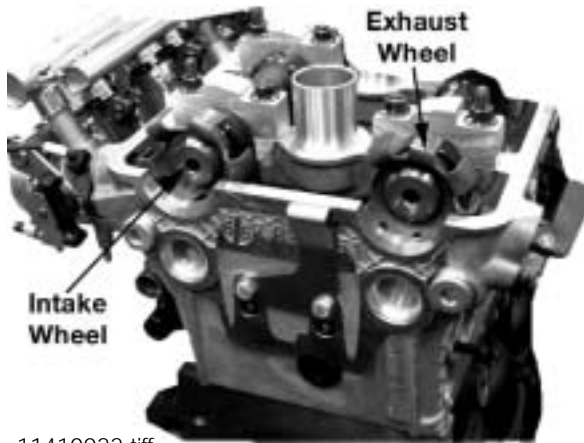
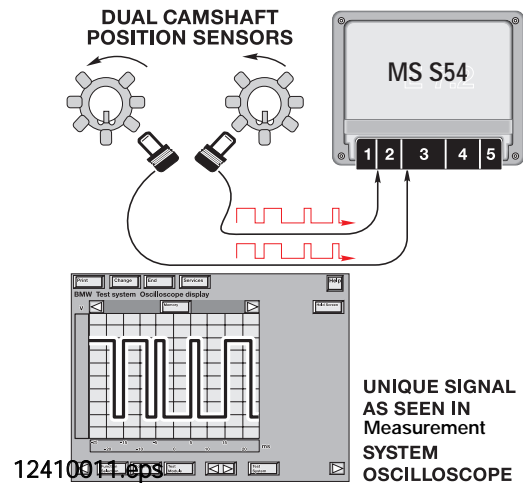
The attraction causes the magnetic field to penetrate through the Hall element. The magnetic field affects the power flow in the element causing the input signal to go high. As the impulse wheel passes by the sensor, the signal goes low.

The repetitive high/low creates a square wave signal that the ECM uses to recognize the camshaft position.

The “active” Hall sensors supply a signal representative of camshaft position even before the engine is running. The ECM determines an approximate location of the camshaft position (high or low signal) prior to engine start up optimizing cold start injection (reduced emissions).

An impulse wheel is mounted on the end of each camshaft for position detection. The intake camshaft impulse wheel has 6 lugs and the exhaust camshaft impulse wheel has 7 lugs. The sensors are mounted on each side at the back of the cylinder head.

If the ECM detects a fault with this type of sensor (shown on the right), the “Malfunction Indicator Light” will be illuminated and the system will maintain engine operation based on the Crankshaft Position/RPM Sensor. Torque reduction will be noticed due to “default” VANOS position.

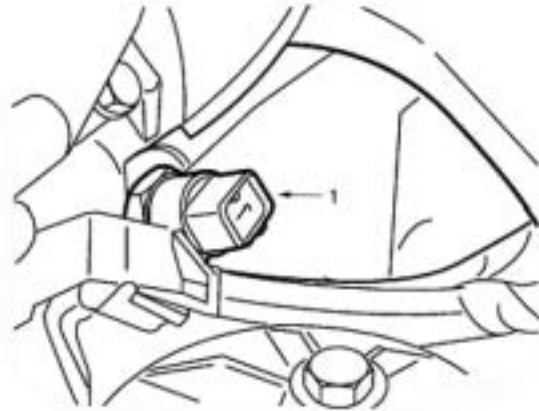


Engine Coolant Temperature: The Engine Coolant Temperature is provided to the ECM from a Negative Temperature Coefficient (NTC) type sensor. The ECM determines the correct fuel mixture and base ignition timing required for the engine temperature.

The dual sensor (ECM/Temp Gage) is located in the coolant return pipe (arrow).

The sensor decreases in resistance as the temperature rises and vice versa. The ECM monitors 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, the "Malfunction Indicator Light" will be illuminated and the ECM will use the oil temperature sensor as an alternate.

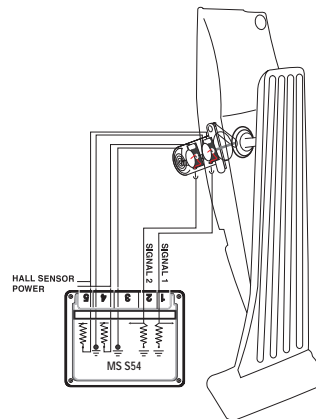


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Accelerator Pedal Position (PWG):

As the accelerator pedal is actuated, the ECM will increase the volume of fuel injected into the engine. As the accelerator pedal is released, the ECM activates fuel shut off if the rpm is above idle speed (coasting).

For details about the sensor, refer to the Air Management section.



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

For details about the sensor, refer to the Air Management section.



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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.

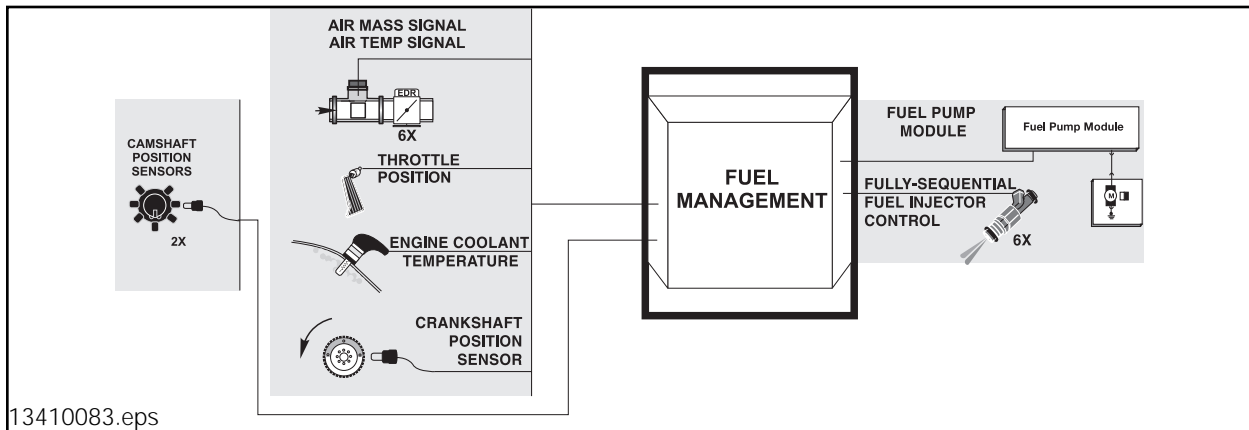
The varying voltage input from the NTC sensor indicates the larger proportion of oxygen found in cold air, as compared to less oxygen found in warmer air. The ECM will adjust the amount of injected fuel because the quality of combustion depends on oxygen sensing ratio.

If a fault is present in this circuit, the ECM will operate on a substitute value.

Notes: _____

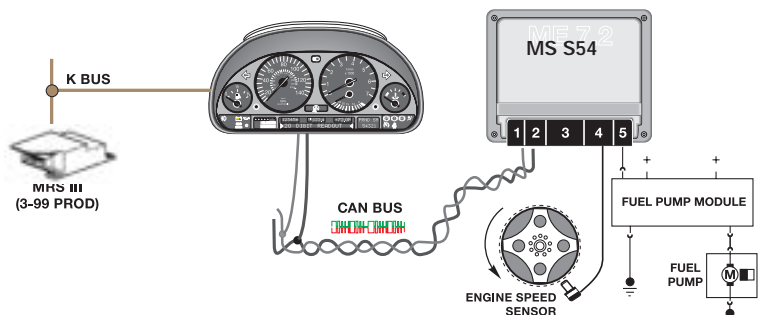
Principle of Operation

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 it. The ECM controls and monitors **fuel injection**.



The **Fuel Pump** supplies fuel when it receives operating voltage from the Fuel Pump Module. The ECM Relay supplies voltage to the Fuel Pump Module (M3 -located in the trunk, above right wheel well).

The ECM controls the activation of the fuel pump module. After the ignition is switched ON, the ECM provides voltage for the fuel pump module and the voltage is maintained (pulse width modulated) with the presence of the engine speed signal.



A high output fuel pump is utilized to match the fuel supply demands of the S54 engine (5 Bar). The ECM will cycle the voltage signal (0 - 120 Hz) to the fuel pump module. The fuel pump module will cycle the voltage to the pump (to reduce the speed). The fuel pump will operate at low speed during idle and part load. The pump will run at full speed during start-up (approx. 20 seconds) and full load.

The power to the fuel pump module will be switched off in the event of an airbag activation. The MRS III control module will signal the ECM over K-bus and CAN bus for this purpose.

The Fuel Injectors will be opened by the ECM to inject pressurized fuel into the intake ports. The ECM Relay supplies voltage to the Fuel Injector Relay, the Fuel Injector Relay supplies operating voltage to the injectors. 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 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.

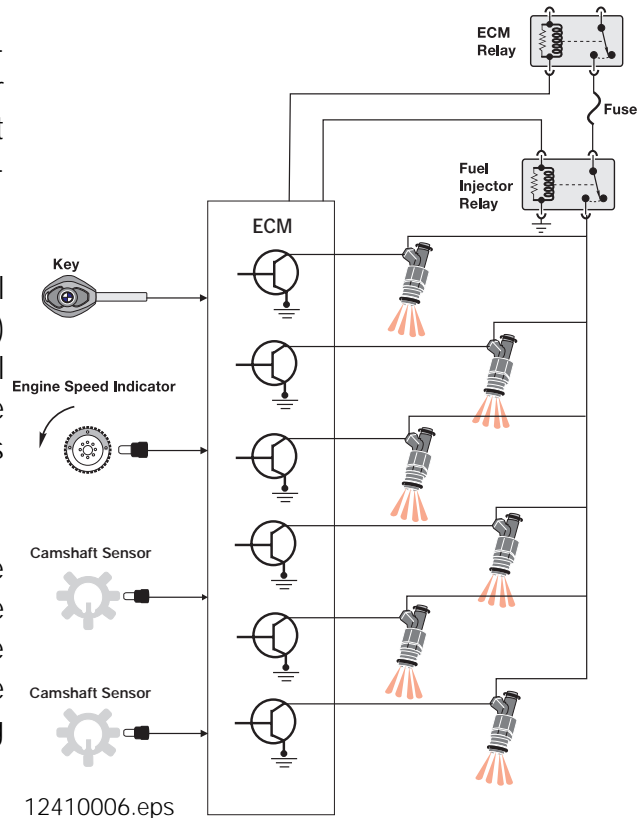
The ECM is programmed to activate the Final Stage output transistors once (per cylinder) for every working cycle of the engine (Full Sequential Injection). The ECM calculates the total milli-second time to open the injectors and triggers them independently.

During start up, the ECM recognizes the Camshaft Position (Cylinder ID) inputs. The camshaft positions are referenced to the crankshaft position. This process “times” the injection closer to the intake valve opening for increased efficiency.

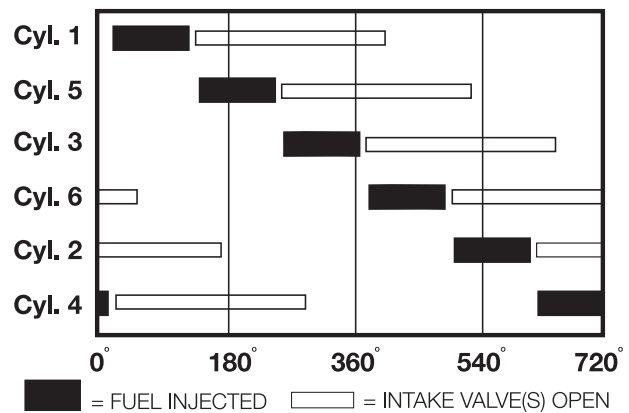
When activated, each injector delivers the full fuel charge at separate times for each cylinder working cycle.

The Camshaft Position input is monitored by the ECM during start up. There will be an effect on injector timing if this input is missing when the engine is started.

When KL15 is switched “off”, the ECM discontinues voltage to the Fuel Injector Relay and deactivates the six Final Stage transistors to discontinue fuel injection.

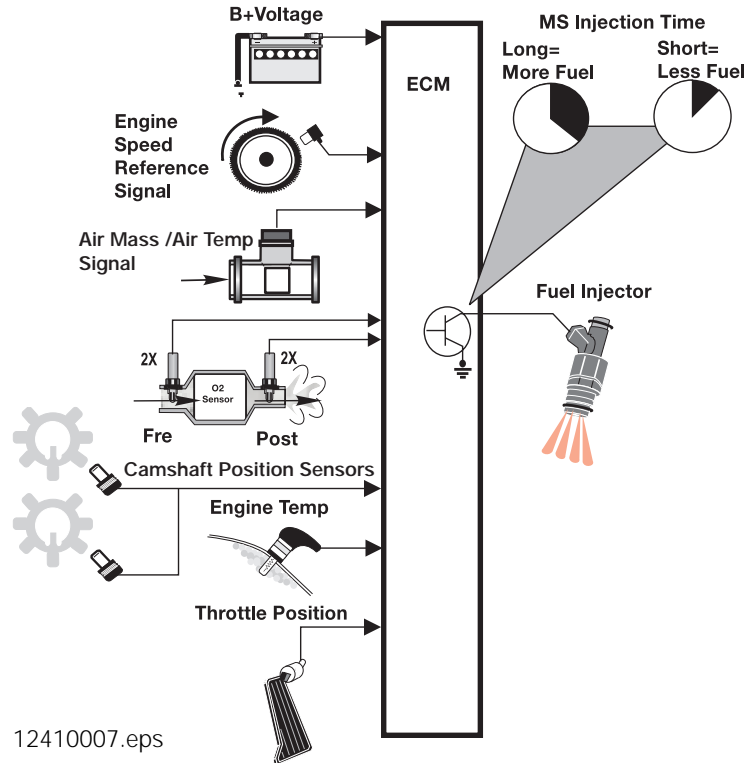


Full Sequential Injection Timing



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

1. Battery Voltage
2. Accelerator Pedal Sensor
3. Air Flow Volume / Mass
4. Air Temperature
5. Crankshaft Position / RPM
6. Camshaft Position (Cylinder ID)
7. Engine Coolant Temperature
8. Oxygen Sensor (details in Emissions Management)



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 for the first few crankshaft revolutions. The ECM recognizes the Camshaft Positions and precisely times the Full Sequential Injection. After the first few crankshaft revolutions, the injected quantity is metered down as the engine comes up to speed.

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 accelerator pedal is actuated, 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 accelerator pedal is released, 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 HFM 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.

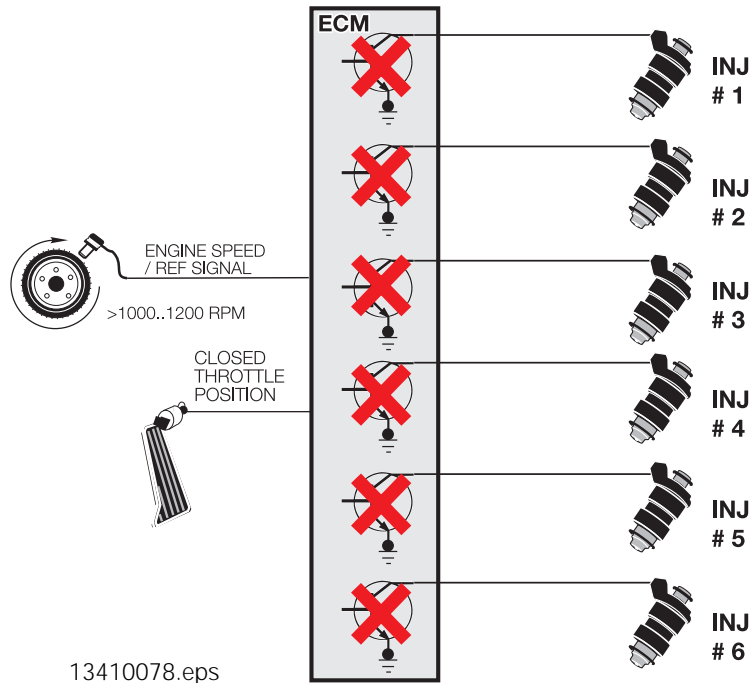
The Air Temperature Signal allows the ECM to make a calculation of air density. The varying voltage input from the NTC sensor indicates the larger proportion of oxygen found in cold air, as compared to less oxygen found in warmer air. The ECM will adjust the amount of injected fuel because the quality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

When KL15 is switched "off", the ECM discontinues voltage to the Fuel Injector Relay and deactivates the six Final Stage transistors to cease fuel injection.

Notes: _____

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.



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.

The ECM will deactivate the injectors to control maximum engine rpm (regardless of vehicle speed). When the engine speed reaches 8000 rpm, the injectors will be deactivated to protect the engine from over-rev. As the engine speed drops below 8000 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).***

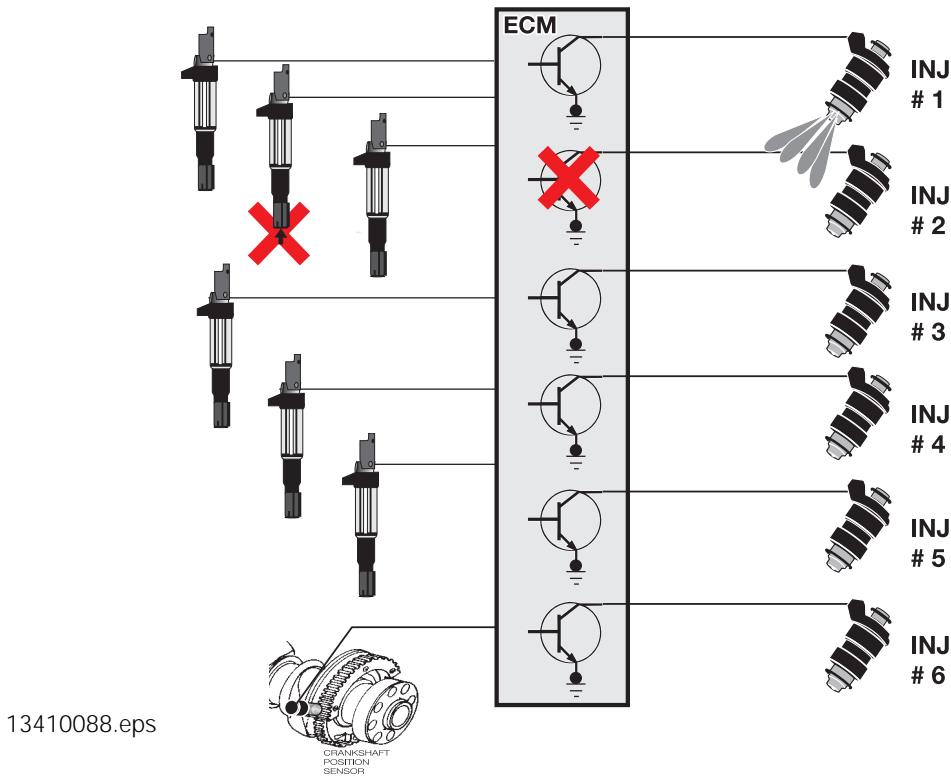


Maximum vehicle speed is limited by the ECM reducing the injection ms value (regardless of engine rpm). This limitation is based on the vehicle dimensions, specifications and installed tires (speed rating).

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

If the ECM detects a "Misfire" (ignition, injection or combustion), it will selectively deactivate the Final Stage output transistor for that cylinder(s). On the MS S54 system, there are six individual injector circuits resulting in deactivation of one or multiples. This will limit engine power, but protect the Catalytic Converters.

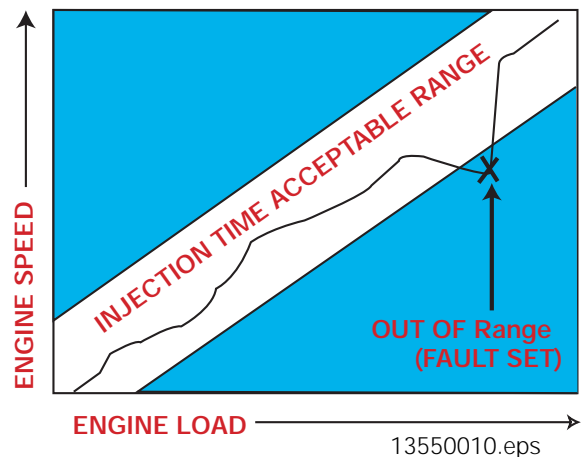


Fuel Injection Control Monitoring is performed by the ECM for OBD II requirements. Faults with the fuel injectors and/or control circuits will be stored in memory. This monitoring includes:

- 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 relevant 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.
- 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.

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.

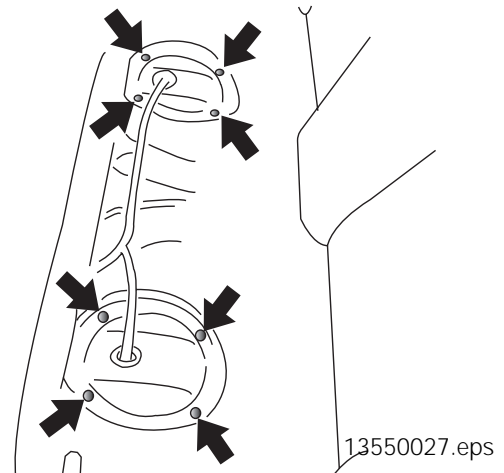
Please refer to the Repair Instructions and Service Information Bulletins details on fuel supply hardware.

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.

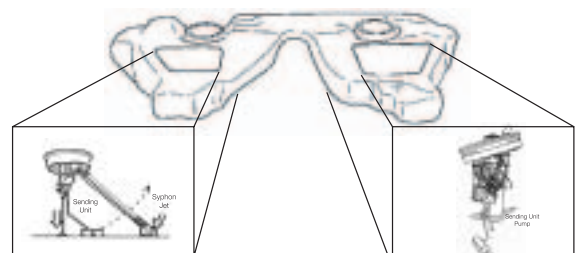
The E46 M3 access plates are located under the rear seat.

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

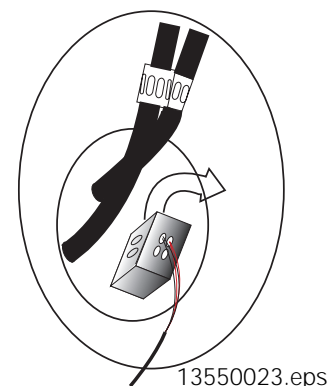


The passenger side allows access to the fuel pump / sending unit.

The driver side accesses the sending unit / syphon jet.



The M roadster and M coupé have a single access plate located behind the passenger seat.



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.

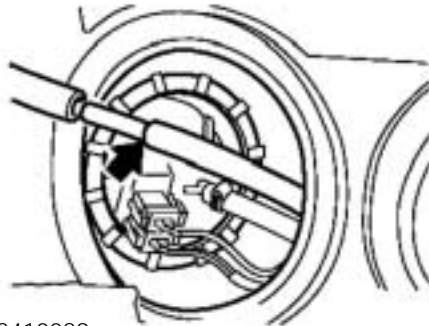
NOTE: Consult the BMW Service Workshop Equipment for the proper evacuation equipment. The saddle type tank requires an additional step to drain the fuel from the driver side. The evacuation equipment should be attached to the tank compensating hose (arrow) to drain out the remaining fuel.

Fuel Pump / Pressure Regulator - Testing

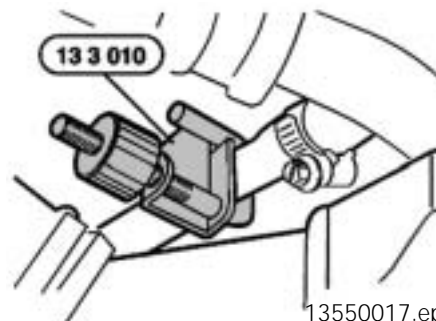
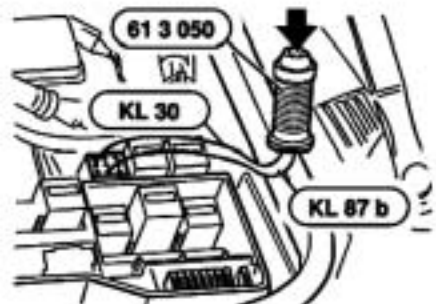
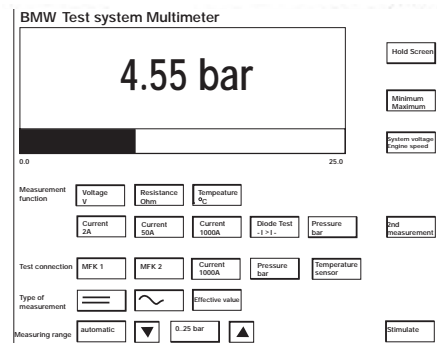
The fuel pump should be tested for delivery pressure and volume. **Caution** when disconnecting fuel hoses because there is the possibility of residual fuel pressure! Install the fuel pressure adapter and DISplus pressure sensing lead to the fuel pressure fitting **DISplus starts with atmospheric pressure as the base.*

Remove the fuel pump relay/module (M roadster/coupé located in the Electronics Box, E46 M3 located in the trunk, above right wheel well - see relay testing in the power supply section). 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 5 bar (*+ atmosphere DISplus base starting point) 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.



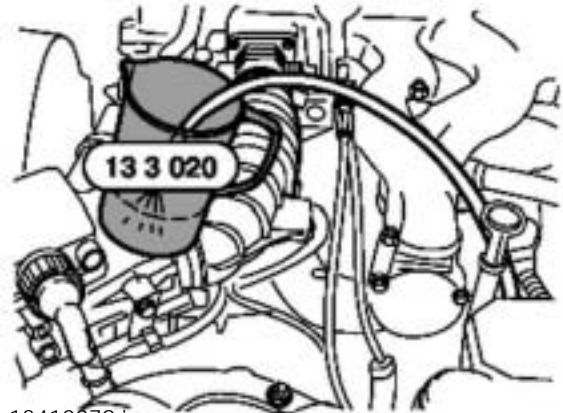
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Fuel volume must be tested to verify:

- | | |
|----|---|
| 1. | Fuel Pump Output |
| 2. | Restriction are not present in the pump, lines/hoses and fuel filter. |



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Fuel Injectors

When inspecting the fuel injectors, consider the following:

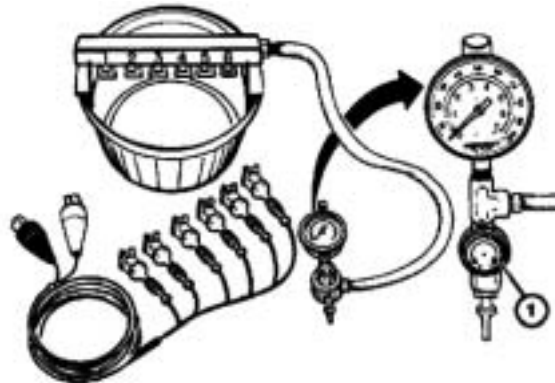
- | | |
|----|--|
| 1. | O-rings should be replaced, lubricate with Vaseline or SAE 90 gear oil for installation. |
| 2. | Verify the code number. |
| 3. | Color code injector housing |



11410046.tiff

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

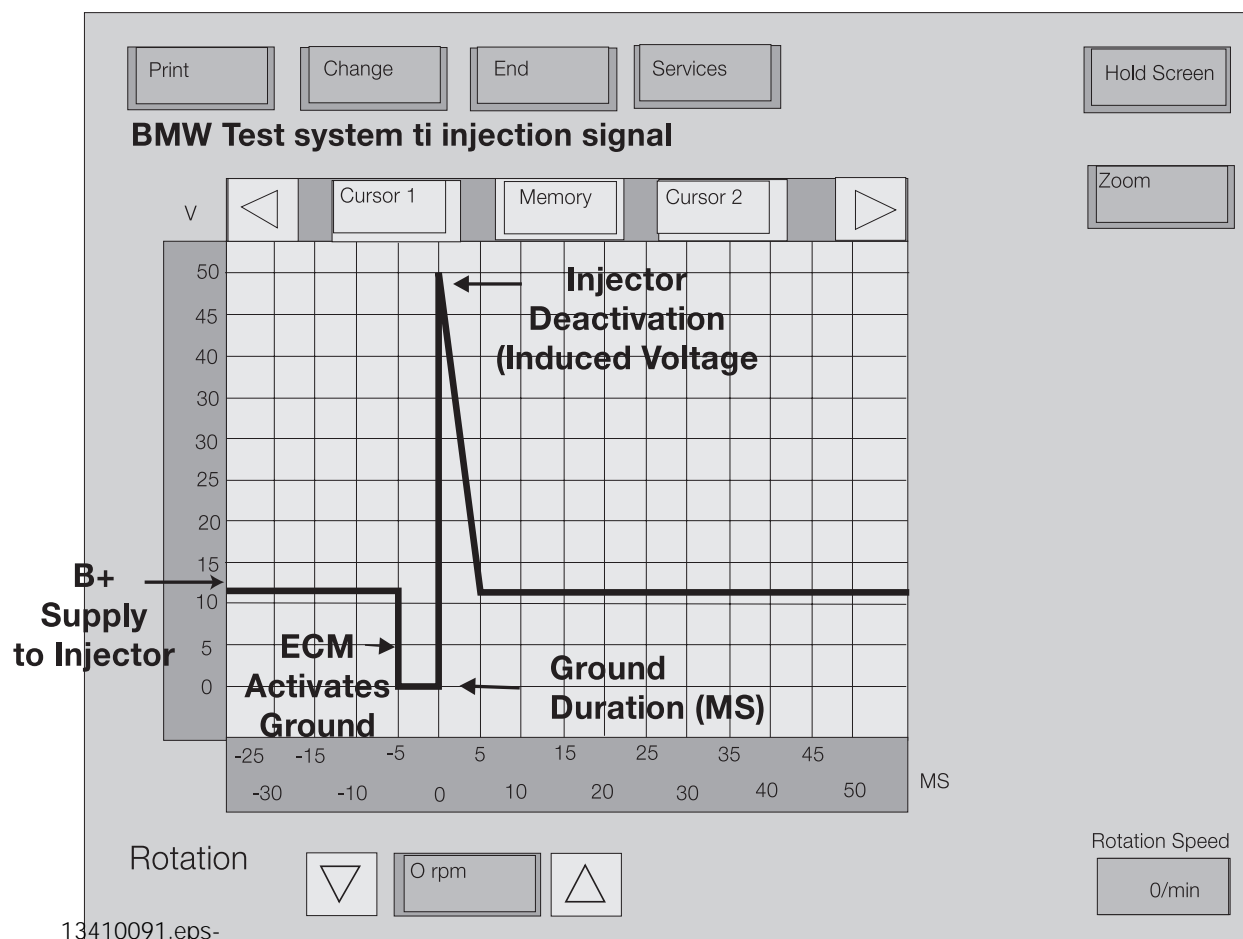
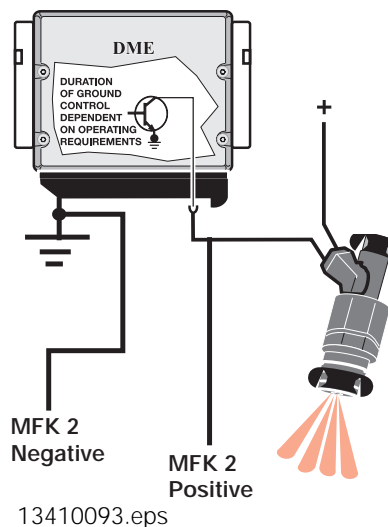
The fuel injectors can be cleaned, refer to Service Information Bulletin S.I. #04 07 86.



13410007.bmp

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

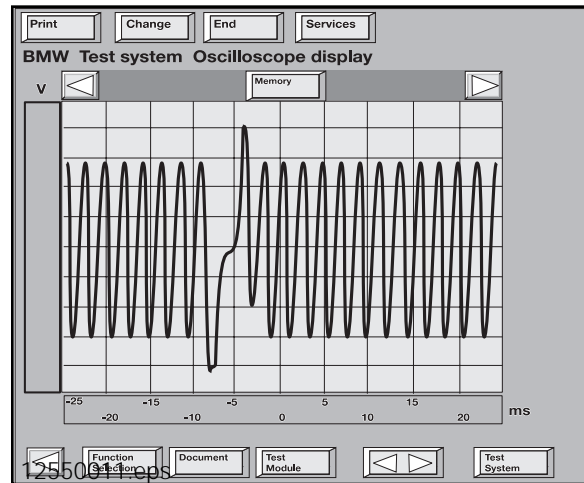
- | | |
|----|---|
| 1. | Resistance |
| 2. | Power Supply |
| 3. | Status Display- Fuel Injection Signal |
| 4. | ECM Final Stage transistor activation. This test function is found under the Oscilloscope Preset list-"Ti Injection Signal" Install the 88 pin adapter, Diagnostic cable MFK 2 positive lead to the ground activation circuit for the injector. This test is performed with the engine running. |



Crankshaft Position/RPM Sensor

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

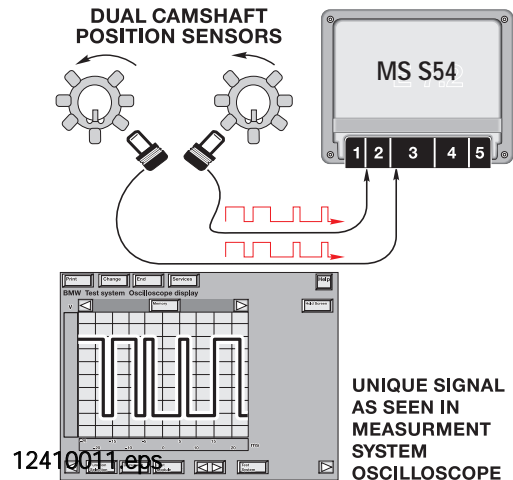
1.	Power Supply
2.	AC Voltage
3.	Status Display
4.	Oscilloscope Display Found Under Preset List "Rotation Speed Sensor Signal"



Camshaft Position Sensor (Cylinder ID)

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

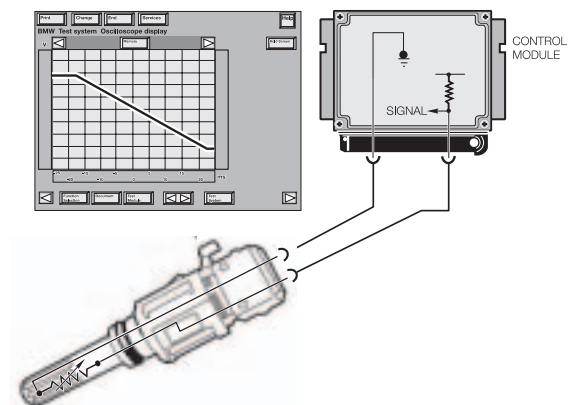
1.	Power Supply
2.	DC Voltage
3.	Status Display
4.	Oscilloscope Display Found Under Preset List "Rotation"



Engine Coolant Temperature

This Sensor should be tested using:

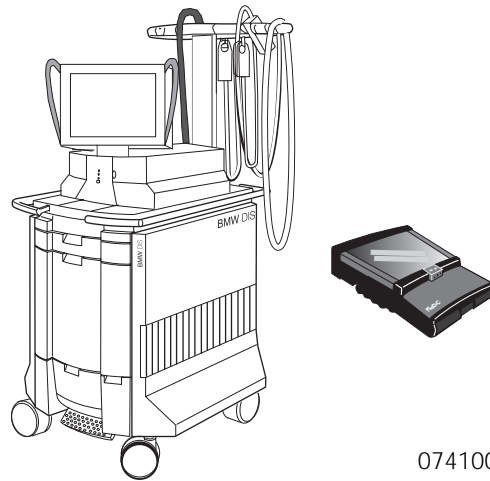
1.	DISplus/Modic Status Page - Degrees C (dependent on engine temperature)
2.	DISplus/Modic Multimeter - Resistance



Tools and Equipment

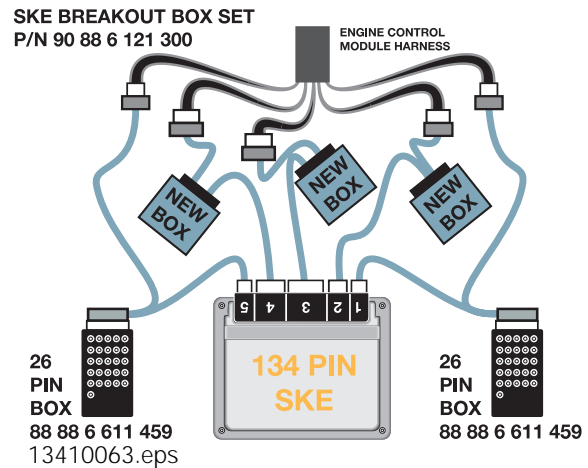
The DISplus/Modic as well as a reputable hand held multimeter can be used when testing inputs/components.

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

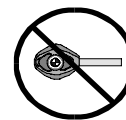


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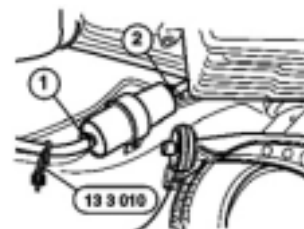
The correct Universal Adapter for the MS S54 application should be used (#90 88 6 121 300). This will ensure the pin connectors and the harness will not be damaged.



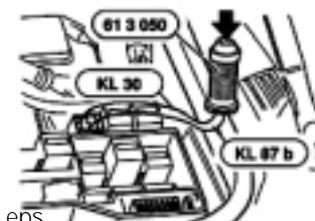
When installing the Universal Adapter to the ECM (located in the Electronics Box in the engine compartment), **make sure the ignition is switched off.**



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 loosening clamps (1 and 2).



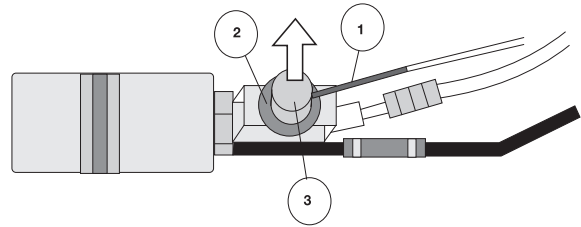
The Relay Bypass Switch (#61 3 050) must be used especially **when fuel vapors are present!** The switch eliminates the risk of electrical arcing.



13410092.eps

When testing fuel pressure, the DISplus is equipped with a pressure measuring function, found in Measurement testing can be used.

A threaded fitting provides a test point at the fuel pressure regulator. This threaded adapter fitting allows Adapter #13 5 220 to be coupled to the DIS Pressure Adapter.

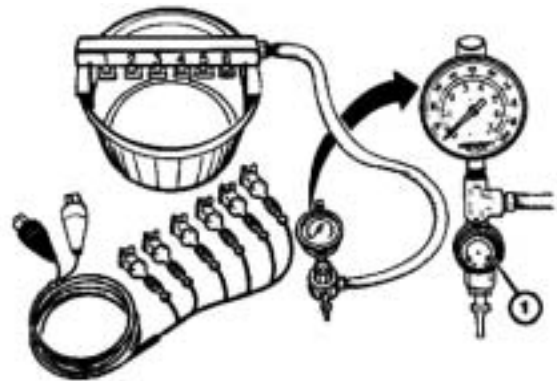


13410071-1.eps

Caution! Residual fuel pressure may be present.

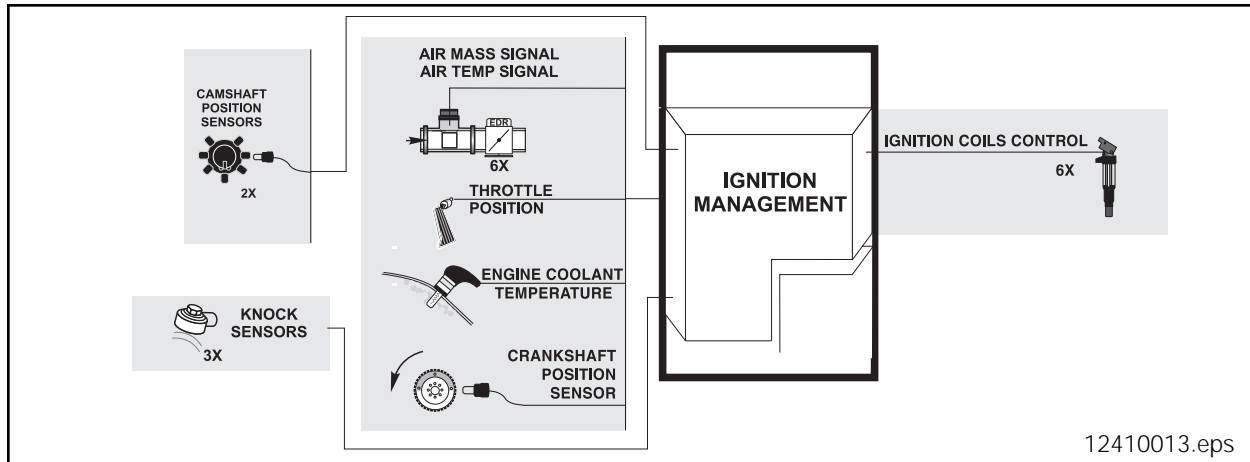
When testing the fuel injectors for leakage, use Special Tool #88 88 5 000 362. Leak testing the fuel injectors is one of the diagnostic steps listed in "Long Cranking Times" S.I. #13 08 90 (3096).

This tool pressurizes the injectors with air and the injector tips are submersed in water. If air bubbles are present, this indicates the leaking injector(s).



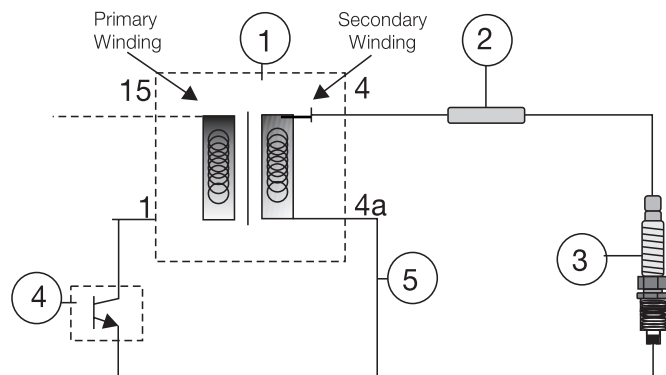
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Ignition Management



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.	Insulator Boot
3.	Spark Plug
4.	ECM Final Stage Transistor
5.	Secondary Coil Ground



12410014.eps

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 ECM Relay (Coil Terminal 15). The ECM provides a ground path for the primary coil (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 interrupt 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.

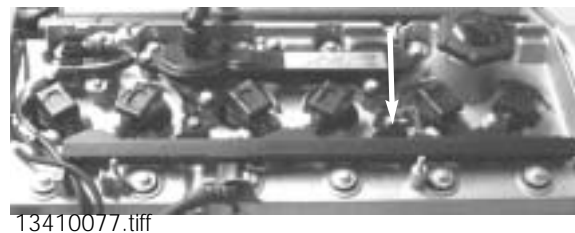
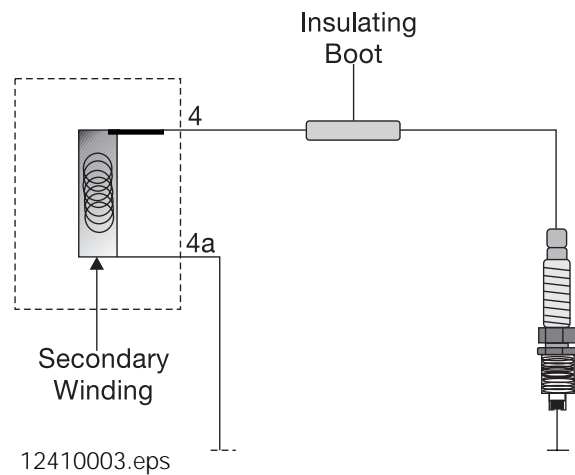
The high voltage generated in the secondary winding is discharged through Coil Terminal 4 to the spark plug (insulated by the boot connector).

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

There is an individual ignition circuit and coil for each cylinder on the MS S54 system. The S54 uses "pencil type" ignition coils manufactured by Bremi. The six individual ignition coils are integrated with the insulated connector (boot).

The coils are removed by lifting the swivel latch connector retainer to release the wiring harness, apply a slight twist and lift the assembly upwards.

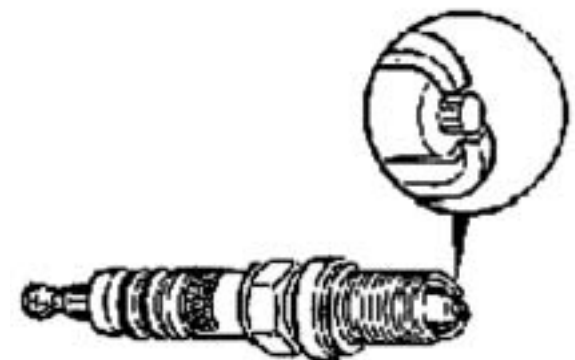
The primary ignition cables are routed on the top of the cylinder head cover. A suppression capacitor is installed on the secondary ignition ground circuit (arrow).



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 electrodes. This creates a spark which ignites the combustible air/fuel mixture.

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

The correct spark plugs for the S54 are NGK DCPR8EKP dual 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:

1.	“Service Engine Soon” Light with Mixture Related and / or Misfire Fault Codes
2.	Poor Engine Performance
3.	Engine Misfire
4.	No Start/Hard Starting
5.	Excessive Exhaust Emission/Black Smoke

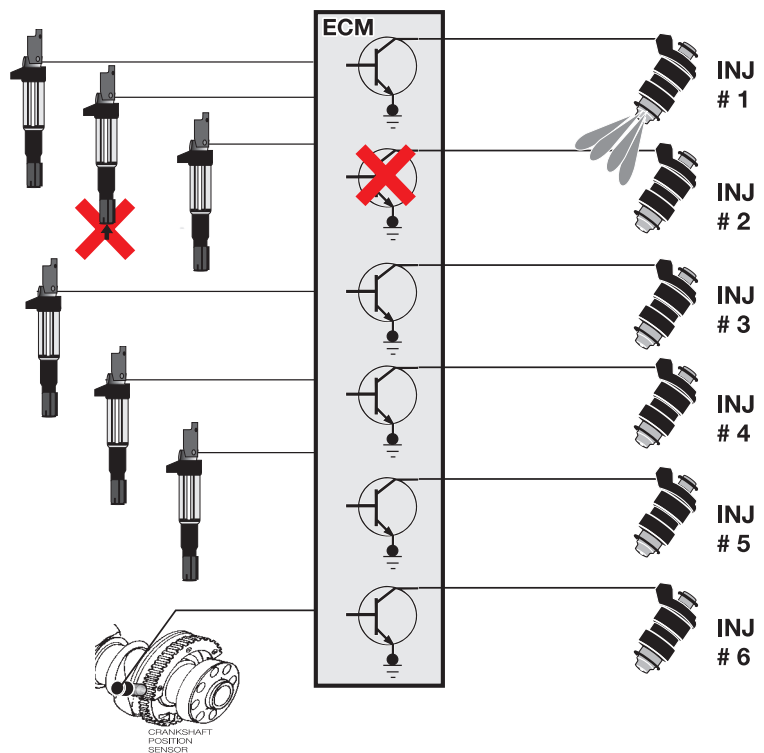
The Ignition Output Components must be individually tested (see Workshop Hints).

The **primary ignition** circuits are monitored by the ECM.

If a fault is present, the “Malfunction Indicator Light” will illuminate and the ECM will deactivate the corresponding fuel injector for that cylinder. Engine operation will still be possible.

The **secondary ignition** is monitored by the ECM via the Crankshaft Position/RPM Sensor.

If a Misfire fault is present, the “Malfunction Indicator Light” will illuminate and the ECM will deactivate the corresponding fuel injector for that cylinder. Engine operation will still be possible.



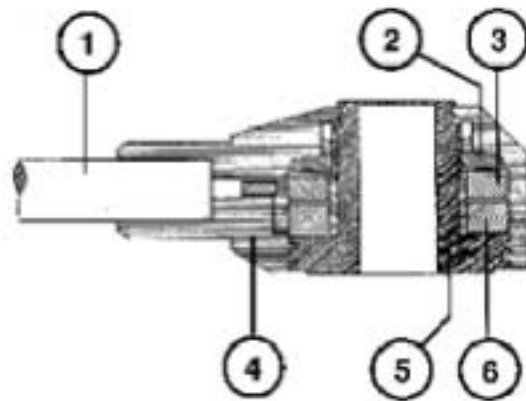
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Knock Sensors: are required to prevent detonation (pinging) from damaging the engine. The Knock Sensor is a piezoelectric conductor-sound microphone. The ECM will retard the ignition timing (cylinder selective) based on the input of these sensors.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

1. High Compression Ratio	4. Maximum Timing Advance Curve
2. Poor Quality Fuel (Octane Rating)	5. High Intake Air and Engine Temperatures
3. High Level of Cylinder Filling	6. Carbon Build-Up (Combustion Chamber)

The Knock Sensor consists of:

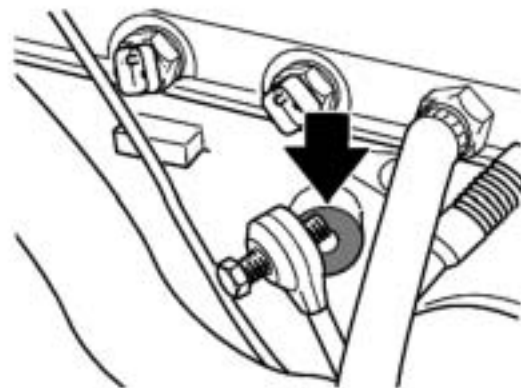
1. Shielded Wire
2. Cup Spring
3. Seismic Mass
4. Housing
5. Inner Sleeve
6. Piezo-Ceramic Element



13400010.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 piezo-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 three Knock Sensors bolted to the engine block between cylinders 1 & 2, 3 & 4 and 5 & 6. If the signal value exceeds the threshold, the ECM identifies the "knock" and retards the ignition timing for that cylinder.



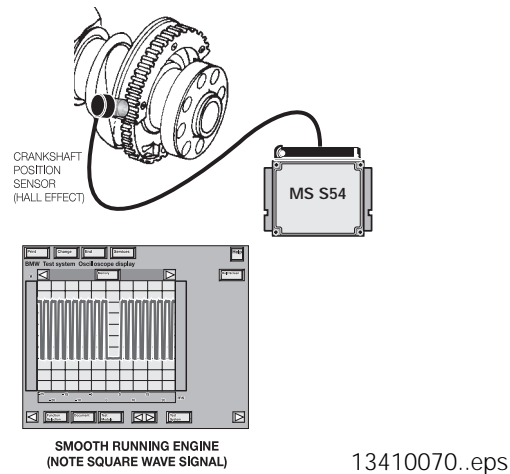
13410078.bmp

If a fault is detected with the sensor(s), the ECM deactivates Knock Control and the "Malfunction Indicator Light" will be illuminated. The ignition timing will be set to a conservative basic setting based on intake air temperature and a fault will be stored.

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

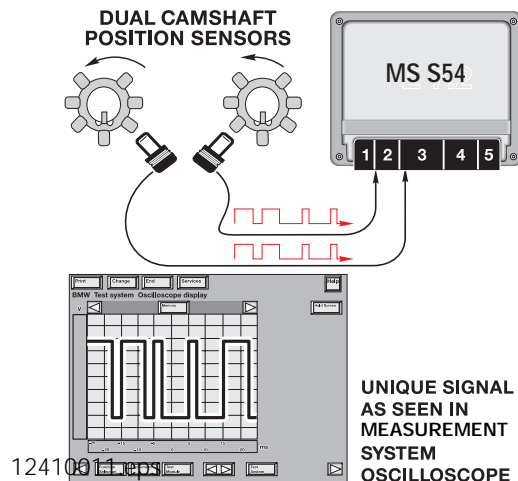
A fault with this input will produce the following complaints:

1.	No Start
2.	Intermittent Misfire/Driveability
3.	Engine Stalling



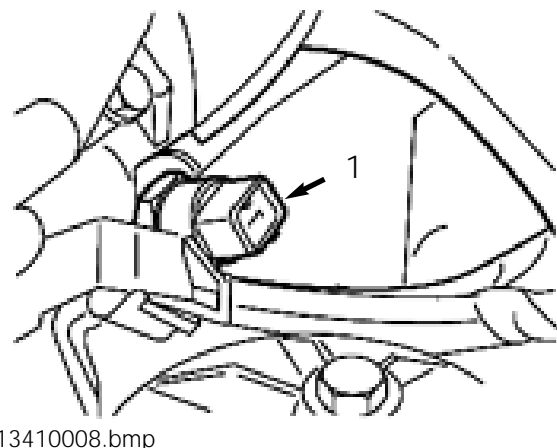
Camshaft Position Sensor (Cylinder Identification): The camshaft sensors (Hall type) inputs allows the ECM to determine camshaft positions in relation to crankshaft position. It is used by the ECM to establish the “working cycle” of the engine for precise ignition timing. For details about the sensor,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

If the ECM detects a fault with the Camshaft Sensors, the “Malfunction Indicator Light” will be illuminated and the ignition will still operate based on the Crankshaft Position/RPM Sensor.



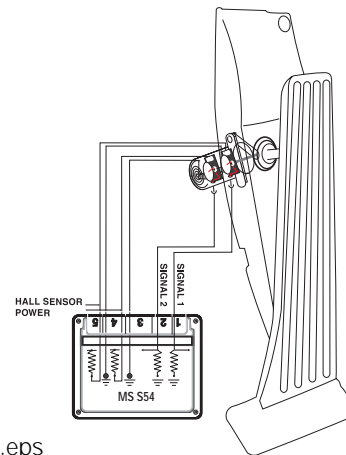
Engine Coolant Temperature: The ECM determines the correct ignition timing required for the engine temperature. For details about the sensor, refer to the Fuel Management section. This sensor is located in the coolant return pipe on the cylinder head (1).

If the Coolant Temperature Sensor input is faulty, the “Malfunction Indicator Light” will be illuminated and the ECM will use the oil temperature sensor as an alternate. The ignition timing will be set to a conservative basic setting.



Accelerator Pedal Position (PWG): As the accelerator pedal is actuated, 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.

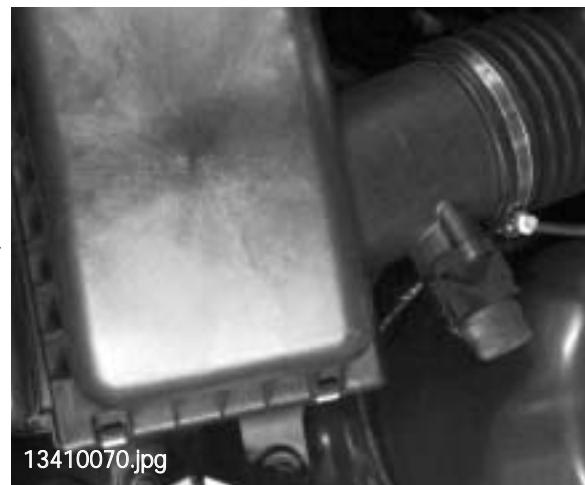
For details about the sensor, refer to the Air Management section.



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Hot-Film Air Mass Meter (HFM): The air volume input signal is used by the ECM to determine the amount of ignition timing advance.

For details about the sensor, refer to the Air Management section.



13410070.jpg

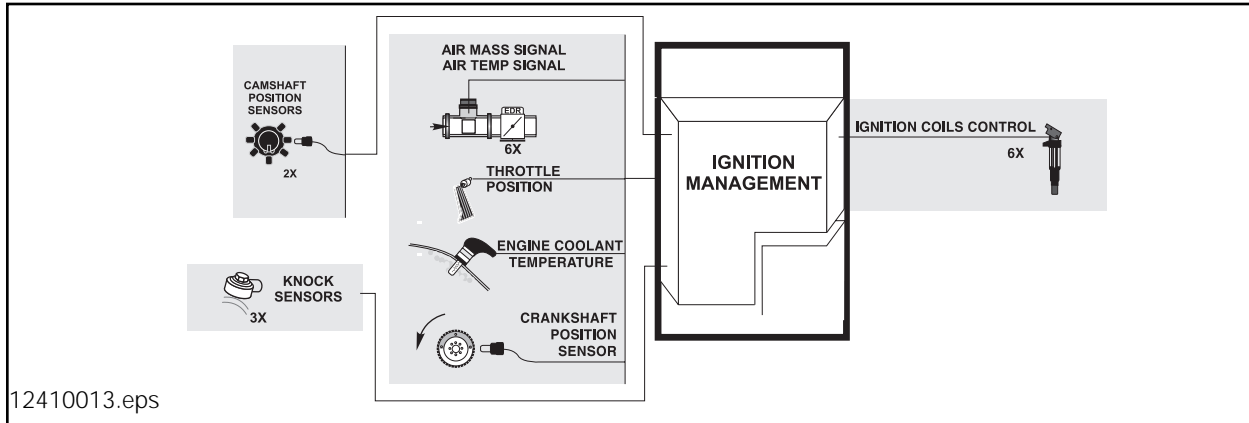
Air Temperature: This signal allows the ECM to make a calculation of air density. The sensor is located in the HFM. For details about the sensor, refer to the Air Management section.

The ECM will adjust the ignition timing based on air temperature. If the intake air is hot the ECM retards the 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 “Malfunction Indicator 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 controls and monitors the primary ignition circuit as well as the secondary ignition output (Misfire Detection).



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

The **Ignition Control** is determined by the ECM (load dependent). The ECM will calculate the engine “load” based on a combination of the following inputs:

1. Battery Voltage	4. Accelerator Pedal Position	7. Knock Sensor
2. Air Temperature	5. Engine Coolant	8. Air Flow Volume
3. Camshaft Position (Cylinder ID)	6. Crankshaft Position/RPM	

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 a 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.

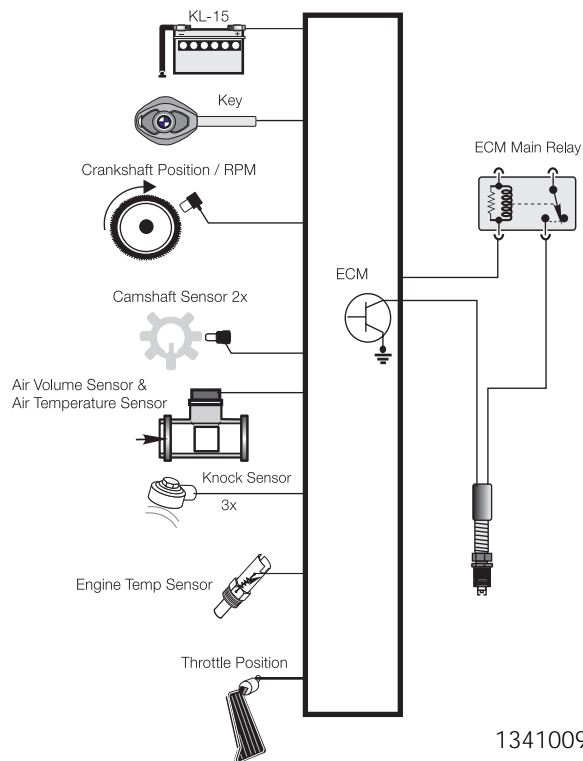
When starting a warm engine, the rpm is higher which results in slightly advanced timing. If the engine coolant and intake air temperature is hot, the ignition timing will not be advanced reducing starter motor "load".

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

The timing will be advanced when the ECM observes low engine rpm and increasing accelerator/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.

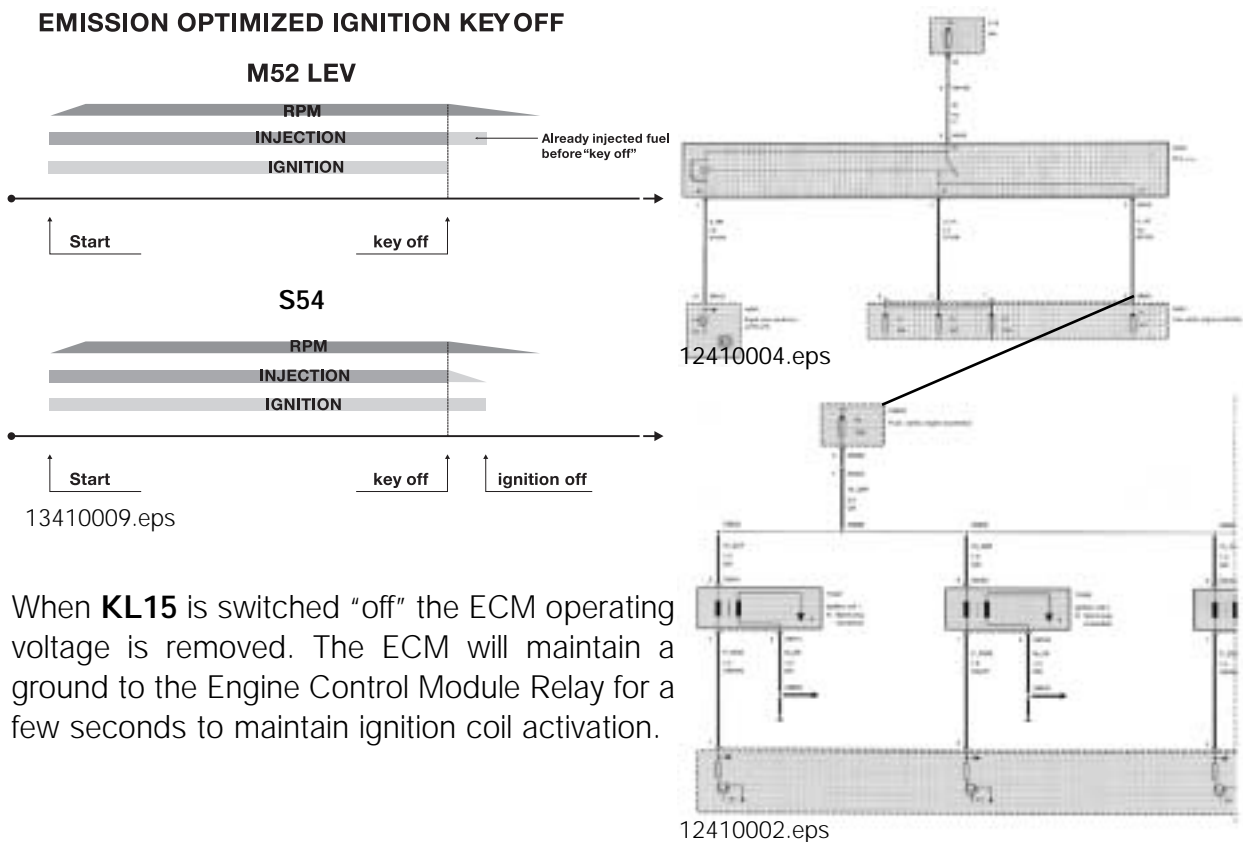
The Air Temperature Signal assists the ECM in reducing the risk of detonation (ping). If the intake air is hot the ECM retards the ignition timing. If the intake air is cooler, the ignition timing will be advanced.

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.

EMISSION OPTIMIZED - IGNITION KEY OFF

“Emission Optimized Ignition Key Off” is a programmed feature of the MS 54 ECM. After the ECM detects KL 15 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.



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.

Knock Control

The use of Knock Control allows the ECM to further advance the ignition timing under load for increased torque. This system uses three Knock Sensors located between cylinders 1 & 2, cylinders 3 & 4 and cylinders 5 & 6.

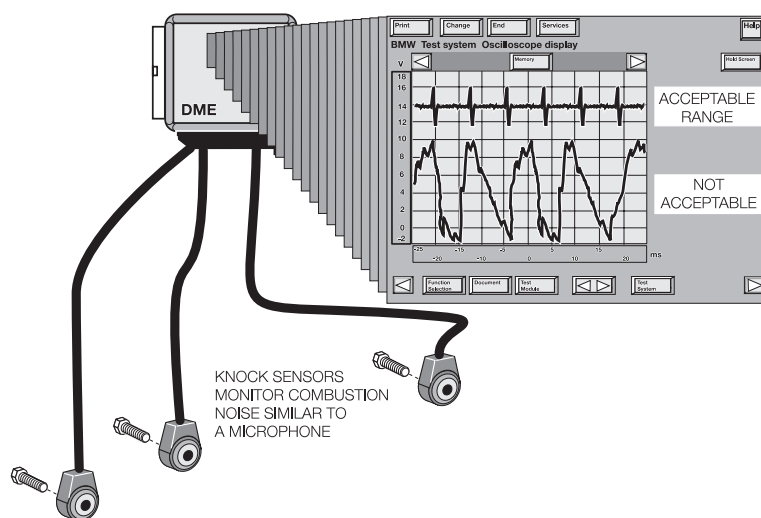
Knock Control is only in affect when the engine temperature is greater than 35 °C and there is a load on the engine. This will disregard false signals while idling or from a cold engine.

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 (3°) 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 right up to the knock limit and maintain the timing at that point.

If a fault is detected with the Knock Sensor(s) or circuits, the ECM deactivates Knock Control. The “Malfunction Indicator 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.



13410082.jpg

Workshop Hints

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

- Observe relevant safety legislation pertaining to your area.
- Always wear adequate protective 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 of the ignition coil must not be connected to Ground or B+.
- Never run the engine with a secondary ignition component disconnected.

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 350 V)

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.

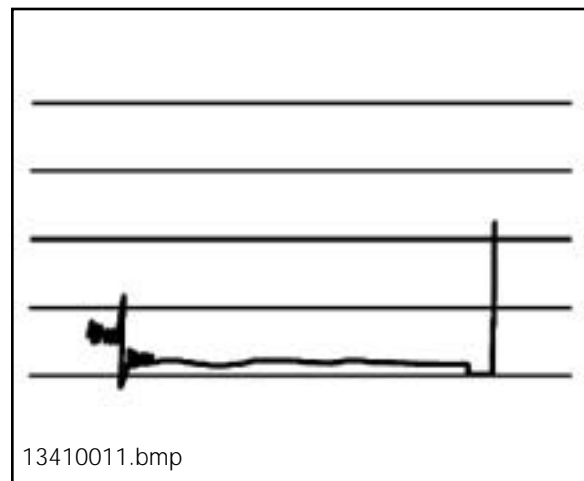
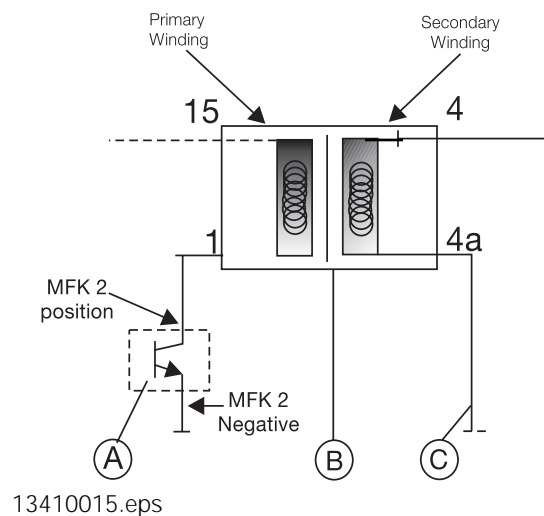
If there is a fault in the primary ignition, testing should include:

- 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 134 Pin Adapter Set with the ECM disconnected.

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

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

Install the 134 Pin Adapter Set, 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.



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

- Primary Ignition
- Evaluation of Secondary Oscilloscope Patterns

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 too 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

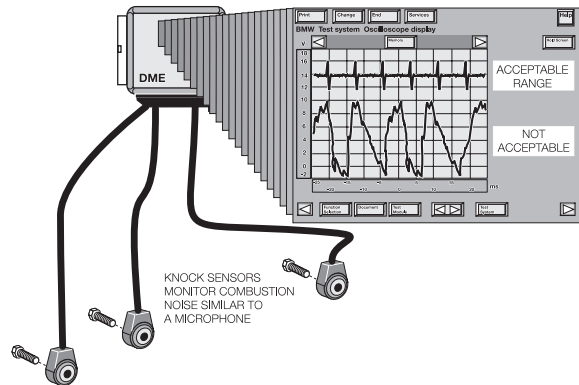
The Spark Plugs should be inspected for the proper type, gap and replaced at the specified intervals.

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.)

Knock Sensors

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

1.	Fault Codes
2.	Status Display -Knock Control (active/not active)
3.	Oscilloscope Display (Low DC Voltage-mV Setting)



When installing Knock Sensors:

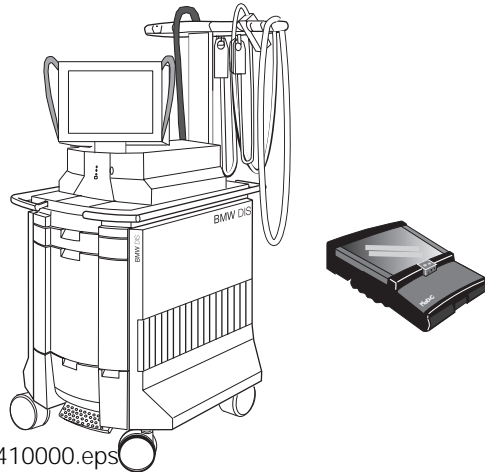
DO NOT MIX THE CONNECTORS: Engine Damage will result! - the connector is critical to sensor location.

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

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

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.

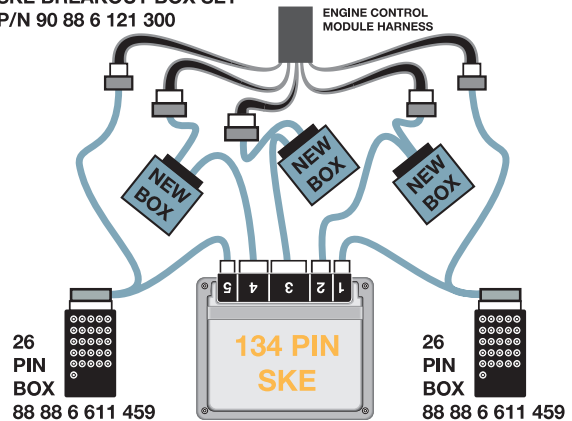


The correct Universal Adapter for the MS S54 application should be used (#90 88 6 121 300). This will ensure the pin connectors and the harness will not be damaged.

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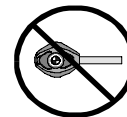
When installing the Universal Adapter to the ECM (located in the Electronics Box in the engine compartment), *make sure the ignition is switched off*.

SKE BREAKOUT BOX SET
P/N 90 88 6 121 300



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

13410063.eps



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!



13410012.bmp