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# ME 9.2

**Model: E65 - 745i / E66 - 745Li**

**Production Date: 11/2001 - E65, 01/2002 - E66**

**Manufacturer: Bosch**

**Pin Connector:  134 Pins - 5 Modular Connectors**

## Objectives of the Module

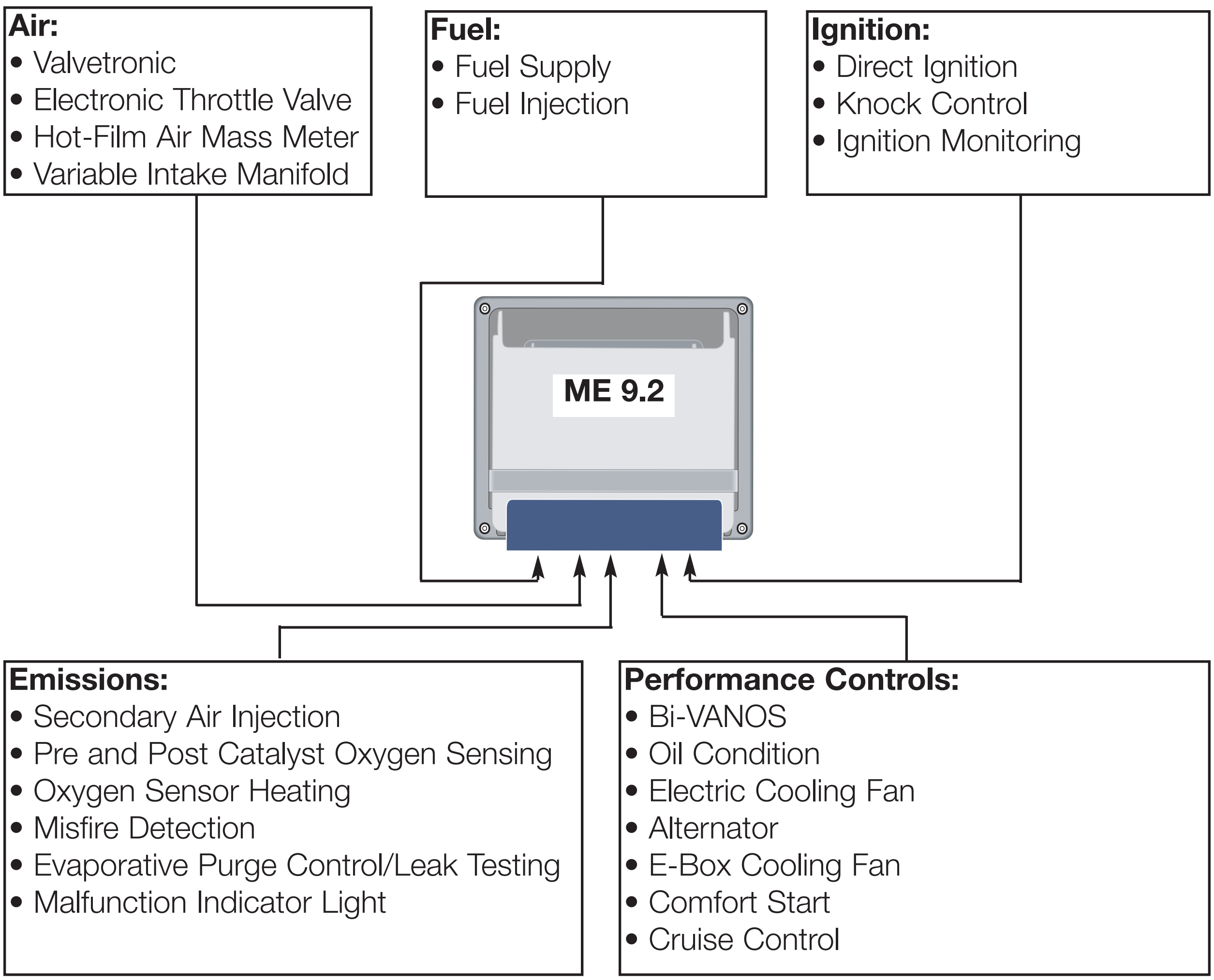
After completing this module, you will be able to:

- Locate and describe the Integrated Voltage Supply Module.
- Understand Valvetronic Positon Sensor operation.
- Name the Component Location of the Fuel Supply System.
- Describe how the Electric Fuel Pump is activated.
- Identify the type of Ignition Coils used in the ignition system.
- List where the Evaporative Emission Components are located.
- Understand Bosch LSU Planar Wideband Oxygen Sensor operation.
- Name the functions of the Oil Condition Sensor.
- Explain the Comfort Start feature.
- Demonstrate how to program and delete Cruise Control preset speeds.

## ME 9.2

### Purpose of the System

The ME 9.2 system manages the following functions:

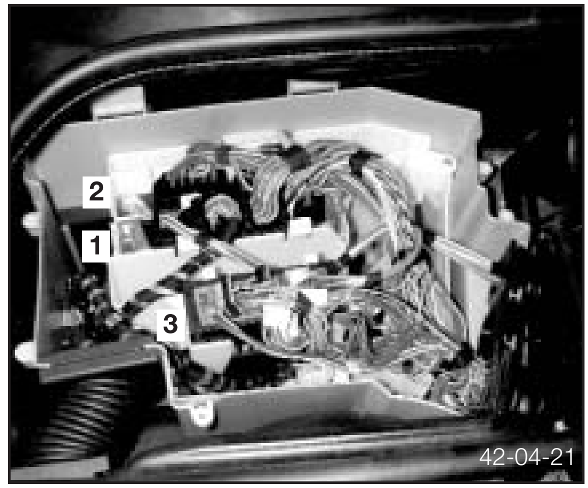



The basic engine management inputs, processes and outputs are not included in this module because they have not changed, refer to the ST055 Engine Electronics hand out for details.

## System Components

**ME 9.2 Engine Control Module - New Features:** This Bosch engine management system is introduced for more stringent emission requirements as well as reducing fuel consumption and increasing driving performance. A flash EEPROM is used as the storage medium for the program data, fault code memory as well as the adaptation values. The ECM works in combination with the Valvetronic Control Module. Both Control Modules control the N62 engine:

- ME 9.2 ECM - overall engine management
- Valvetronic Control Module - intake valve lift

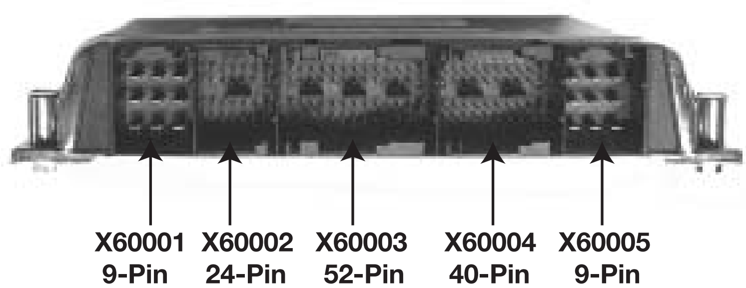


42-04-21

The ECM (1) is located in the electronic box in the engine compartment together with the Valvetronic Control Module (2) and the Integrated Voltage Supply Module (3).

The ECM controls an electric cooling fan in the base of the electronic box to draw in cool air from the passenger compartment.

The 134 pin ME 9.2 ECM is manufactured by Bosch to BMW specifications. The ECM is the SKE (standard shell construction) housing and uses 5 modular connectors.



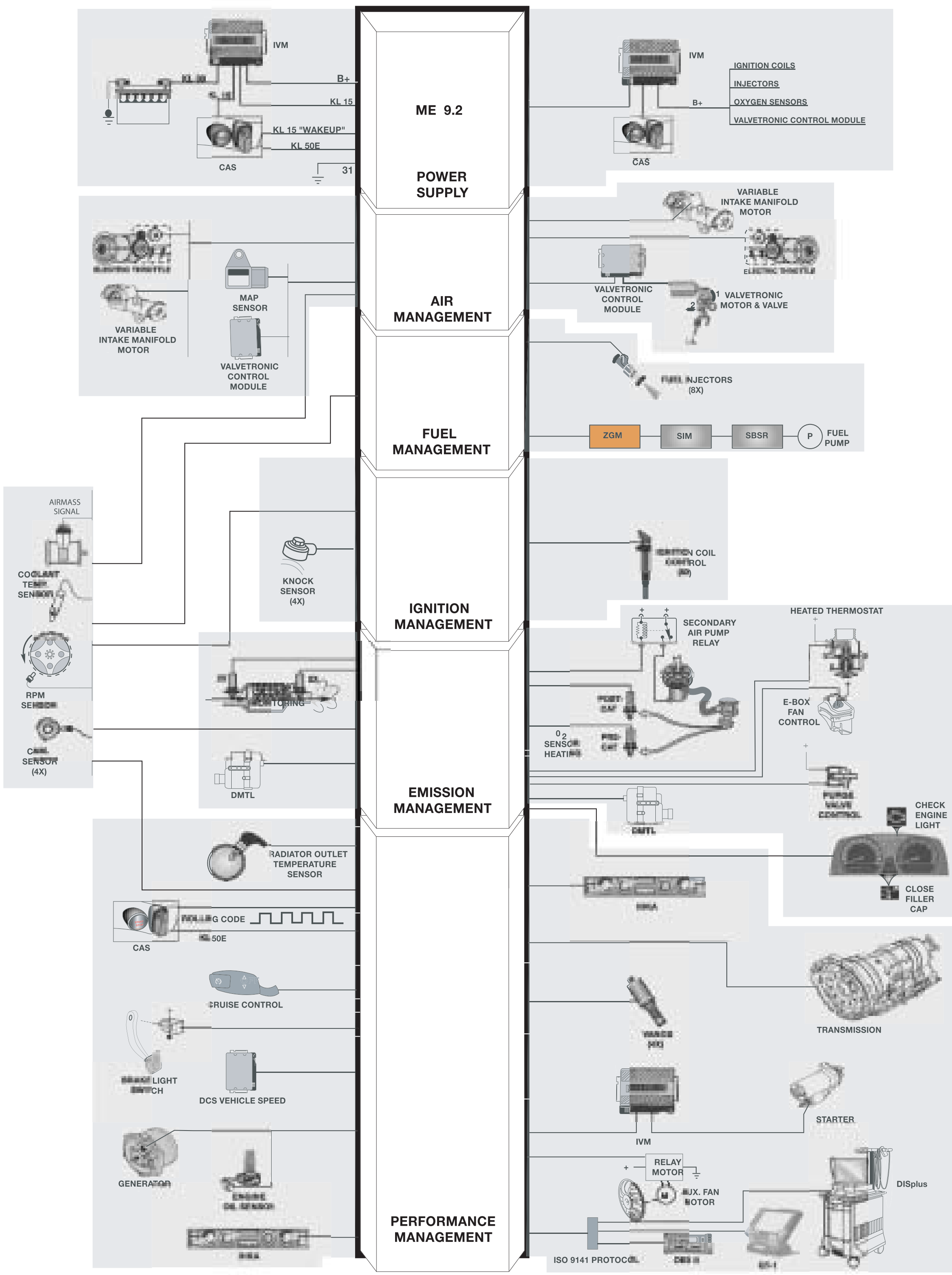
42-04-22

For testing, use the Universal Adapter Set (break-out box) Special Tool: ***# 90 88 6 121 300***

Starting with the ME 9.2 system, a ***Multichannel Adapter Tool*** is used in conjunction with the DISplus to perform the complete N62 Engine Test (found under Service Functions).

The Multichannel Adapter Tool is installed (in series) between the ECM and the engine harness connectors (1, 3 and 5). In addition, the four cables of MFK2 plug into the adapter surface.


W12 1 310



ME 9.2
POWER SUPPLY
AIR MANAGEMENT
FUEL MANAGEMENT
IGNITION MANAGEMENT
EMISSION MANAGEMENT
PERFORMANCE MANAGEMENT
IVM
B+
KL 15
KL 15 "WAKEUP"
KL 50E
31
CAS
IGNITION COILS
INJECTORS
OXYGEN SENSORS
VALVETRONIC CONTROL MODULE
MAP SENSOR
VARIABLE INTAKE MANIFOLD MOTOR
VALVETRONIC CONTROL MODULE
VALVETRONIC MOTOR & VALVE
FUEL INJECTORS (8X)
ZGM
SIM
SBSR
P
FUEL PUMP
AIRMASS SIGNAL
COOLANT TEMP SENSOR
RPM SENSOR
CAM SENSOR (4X)
KNOCK SENSOR (4X)
IGNITION COIL CONTROL
SECONDARY AIR PUMP RELAY
HEATED THERMOSTAT
E-BOX FAN CONTROL
O2 SENSOR HEATING
DMTL
CHECK ENGINE LIGHT
CLOSE FILLER CAP
RADIATOR OUTLET TEMPERATURE SENSOR
ROLLING CODE
CRUISE CONTROL
BRAKE LIGHT SWITCH
DCS VEHICLE SPEED
GENERATOR
TRANSMISSION
STARTER
RELAY MOTOR
AUX. FAN MOTOR
DISplus
ISO 9141 PROTOCOL

## Components

The following list shows the new components of the ME 9.2 Engine Management Control:

| Sensors |
| --- |
| Accelerator Pedal |
| Hot Film Air Mass Meter (HFM) |
| Knock Sensor 1 |
| Knock Sensor 2 |
| Knock Sensor 3 |
| Knock Sensor 4 |
| Crankshaft Sensor |
| Oxygen Sensor Post Catalytic Converter 1 |
| Oxygen Sensor Post Catalytic Converter 2 |
| Oxygen Sensor Pre Catalytic Converter 1 |
| Oxygen Sensor Pre Catalytic Converter 2 |
| Coolant Outlet Temperature Sensor |
| Water Temperature Sensor |
| Exhaust Camshaft Sensor 1 |
| Exhaust Camshaft Sensor 2 |
| Intake Camshaft Sensor 1 |
| Intake Camshaft Sensor 2 |
| Intake Manifold Pressure Sensor |
| Oil Condition Sensor |
| Barometric Pressure Sensor in the ECM (P2) |
| Variable Intake Manifold Position Sensor |

| Actuator |
| --- |
| Variable Intake Manifold |
| Electronic Throttle Valve (EDK) |
| Injector Valves 1-8 |
| Electronic Fan |
| Electronic Box Fan |
| Secondary Air Pump |
| Evaporator Emission Valve |
| VANOS Exhaust Camshaft 1 |
| VANOS Intake Camshaft 1 |
| VANOS Exhaust Camshaft 2 |
| VANOS Intake Camshaft 2 |
| Valvetronic Control Module |
| Ignition Coils 1-8 |
| Map Controlled Thermostat |

42-04-24

## Components

The following list shows the new components of the ME 9.2 Engine Management Control:

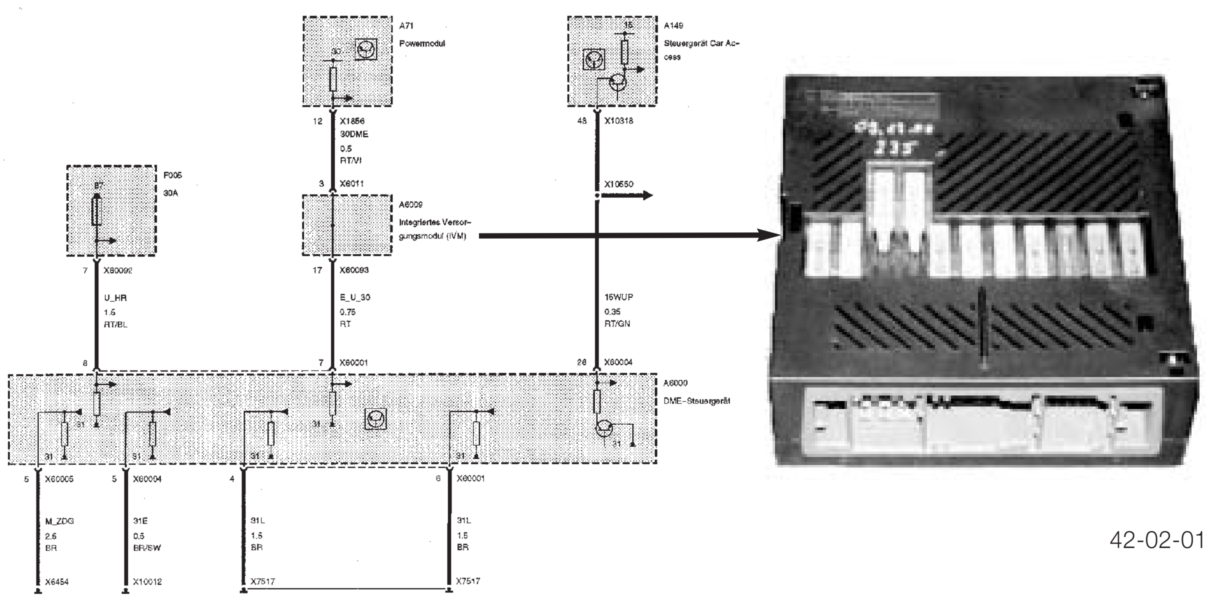
| Switch |
| --- |
| Starter Switch |

| Relay |
| --- |
| ECM Relay |
| Starter Motor Relay |
| Secondary Air Pump Relay |
| Valvetronic Relay |
| Power Supply Relay to Ignition Coils |

| Interface |
| --- |
| Car Can Bus High |
| Car Can Bus Low |
| Engine LoCAN High (Engine Local CAN) |
| Engine LoCAN Low (Engine Local CAN) |

## Power Supply

**KL30 - Battery Voltage:** B+ is the main supply of operating voltage to the ECM which is provided by the Power Module through the Integrated Voltage Supply Module (IVM). The IVM simply provides a splice point to provide B+ to the ECM.




42-02-01

**Power Supplies:** The component power supplies (KL15 and ECM Relays) are fused to the ME 9.2 ECM and output components. The fuses and relays are housed in the Integrated Voltage Supply Module (IVM) located in the Electronic Box. The fuses are separately replaceable, the relays are integral in the IVM.

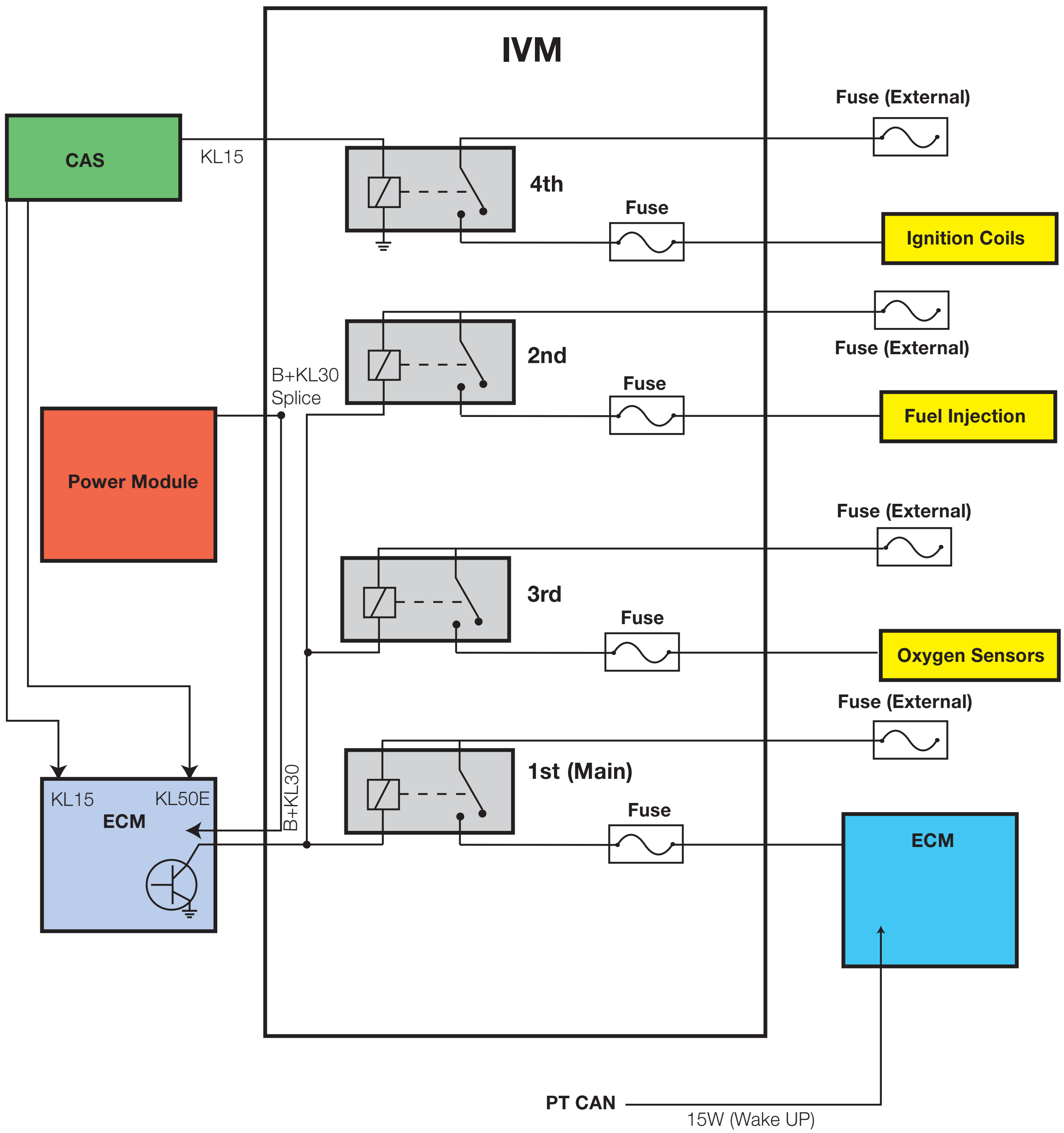
**KL15 - Ignition Switch Signal:** When the ignition is switched “on” the ECM is informed from the CAS Module that the engine is about to be started via a “wakeup” call (15w) over the PT CAN line. The ECM also receives a “hardwire” KL15 input from the CAS Module. The ECM activates a ground circuit to the IVM to energize three relays providing operating power to the ECM and engine management components. KL15 “off” removes the ECM operating voltage and the KL15 signal from the PT CAN bus.

**KL50 E - Start Request Signal:** The momentary start request is transmitted from the CAS Module to inform the ECM to activate the starter relay (in the IVM) and activate engine management components.

**Ground:** Multiple ground paths are necessary to complete current flow through the ECM.

## Integrated Voltage Supply Module (IVM)

The IVM contains integral relays, replaceable fuses and offers a convenient splice point for harness connections. The IVM serves as a central power supply for Engine Management (including Valvetronic), Electronic Transmission and DSC. This diagram is a partial representation of the IVM for Engine Electronics.




42-04-04

## Principle of Operation

When **KL15** is switched "on" the ECM is ready for engine management. The ECM will activate a ground path to energize the three Engine Control Module Relays in the IVM (see diagram on the previous page).

- The 1st ECM Relay supplies operating voltage through a fuse (in the IVM) to the ECM.
- The 2nd ECM Relay supplies operating voltage through a fuse (in the IVM) to the Fuel Injectors.
- The 3rd ECM Relay supplies operating voltage through a fuse (in the IVM) to the Oxygen Sensors.

The Ignition Coil Relay (4th relay) is energized by the CAS Module which supplies operating voltage through a fuse (in the IVM) to the Ignition Coils.

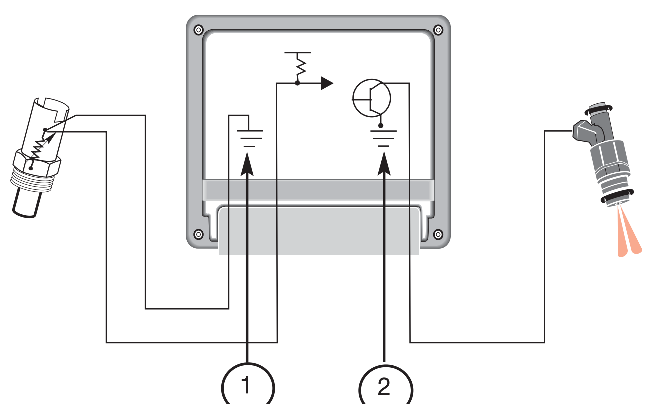
The IVM receives high amperage voltage supply from fuses F101 and F104 (100 Amp). The fuse junction is located on the right inner fender of the engine compartment (under the remote charging post). This supply is for the consumers that are controlled by the IVM internal relays.

When **KL15** is switched "off" the ECM operating voltage is removed. The CAS Module will maintain voltage to the Ignition Coil Relay for a few seconds to maintain ignition coil activation (Emission Optimized - introduced in 2000 MY).

42-08-01

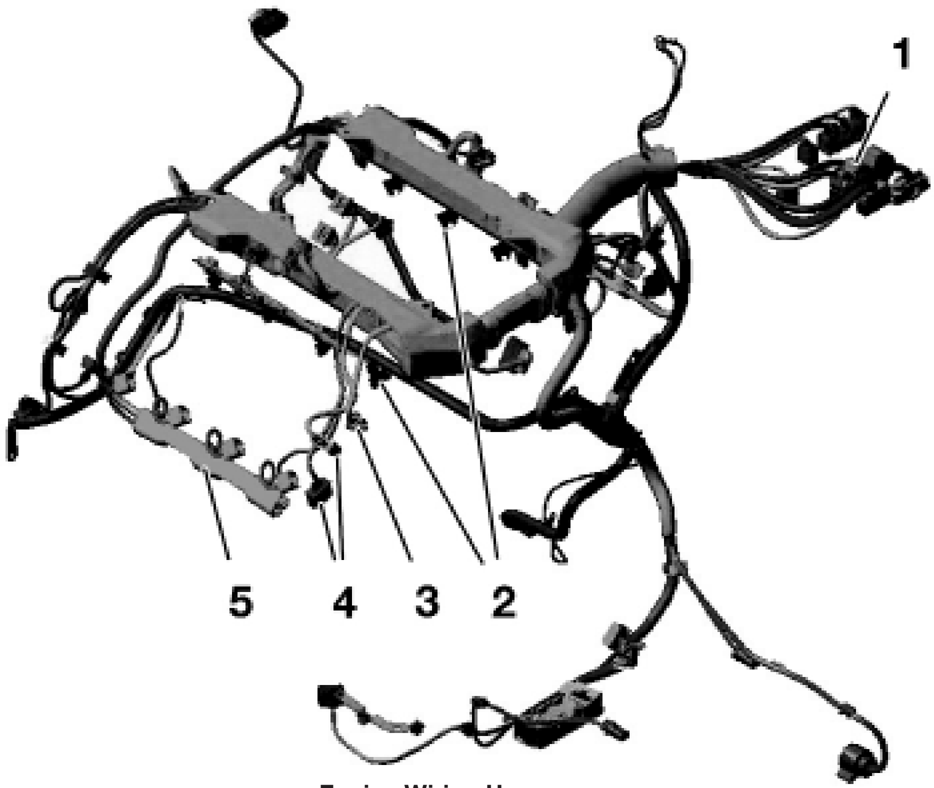
**Ground** is required to complete the current path through the ECM. The ECM also:

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




42-04-03

## Engine Wiring Harness




**Engine Wiring Harness** 42-04-05

1. Plug connectors to electronic box modules: ECM, Valvetronic and IVM
2. Plug connectors to fuel injectors
3. Valvetronic position sensor plug connector
4. Camshaft position sensors plug connectors
5. Plug connector to ignition coils

### Indirect Signals and Wiring

There is no direct connection to the OBD diagnostic connector. The ECM is connected to the ZGM (central gateway module) via the PT-CAN bus. The OBD diagnostic connector is connected to the ZGM.

The fuel pump relay is controlled by the ECM via the ZGM and ISIS (Integrated Safety and Information System) using the airbag control unit in the SBSR (right-hand side satellite B-pillar). This enables the fuel pump to be switched off in the event of an accident.

There is no direct control for the air conditioning compressor. The A/C compressor is now controlled by the IHKA control module. The IHKA signals the ECM via the PT CAN bus and the ZGM.

## Air Management

**Electronic Throttle Valve:** The throttle valve on the N62 is not necessary for engine load control. This is carried out by the intake valve variable lift adjustment (Valvetronic).

- Throttle valve housing with throttle valve
- Throttle valve actuator
- Two Throttle valve potentiometers
- A return spring fitted to the throttle plate shaft that assists in reducing the throttle opening to a minimum present opening.

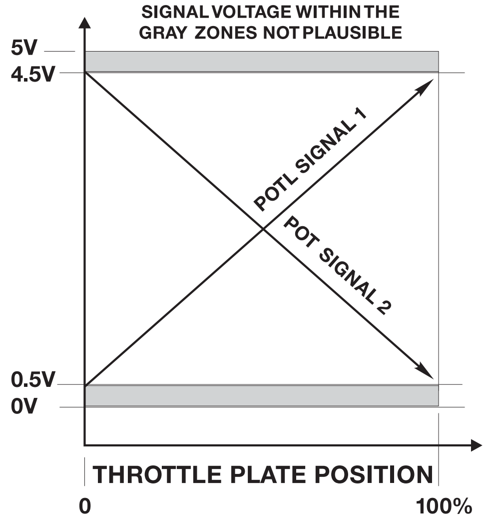

**Electronic Throttle Valve** 42-02-25

The ECM provides the operating voltage and ground to the Electronic Throttle Valve for opening and closing the throttle plate.

**Throttle Valve Position:** The throttle plate position is monitored by two integral potentiometers providing DC voltage feedback signals to the ECM.

Potentiometer signal 1 is the primary signal (closed 0.5V - full open 4.5V).

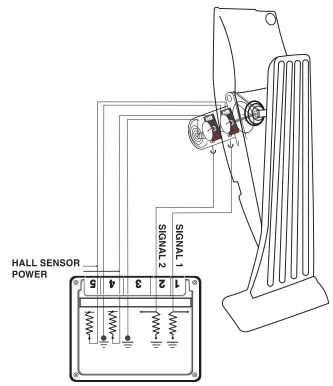
Potentiometer signal 2 is used as a plausibility cross-check (closed 4.5V - full open 0.5V) through the total range of throttle plate movement.




42-04-02

*Notes:*

**Accelerator Pedal Position (PWG):** The accelerator pedal module provides two variable voltage signals to the ECM that represents accelerator pedal position and rate of movement. The ECM will activate the Valvetronic system.

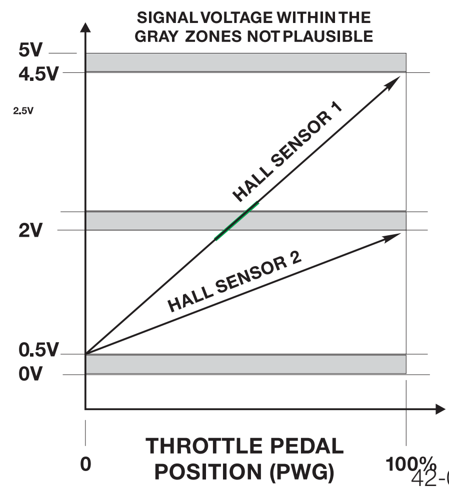



42-04-02

Dual Hall sensors are integral in the accelerator pedal module. The ECM compares the two values for plausibility.

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

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




42-04-03

If the signals are not plausible, the ECM will use the lower of the two signals as the request input. The acceleration response will be slower and the maximum Valvetronic opening will be reduced.

**Hot-Film Air Mass Meter (HFM):** The air volume input signal is produced electronically by the HFM (1) which uses a heated metal film in the air flow stream. The HFM housing is mounted in the air inlet pipe between the air filter and the throttle valve.

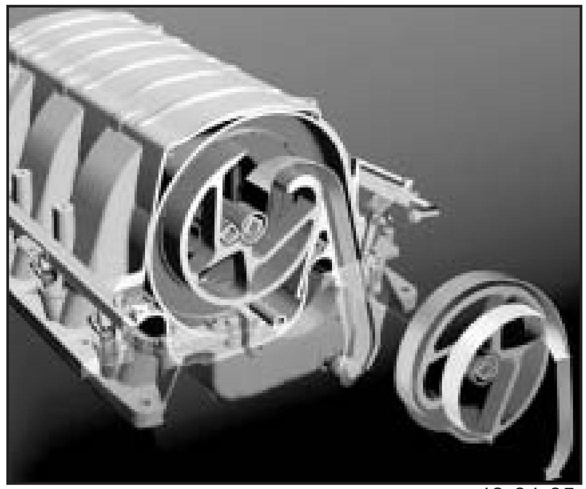

42-04-04

As air flows through the HFM, the film is cooled changing the resistance which affects current flow (voltage drop) through the circuit. The ECM monitors this change regulating the amount of fuel injected.

**Air Temperature Signal:** The HFM contains an integral air temperature sensor. This is a Negative Temperature Coefficient (NTC) type sensor. This signal is needed by the ECM to correct the air volume input for changes in the intake air temperature (air density) affecting the amount of fuel injected, ignition timing and Secondary Air Injection activation.

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

**Variable Intake Manifold:** In the N62 engine, the infinitely variable intake manifold is operated by turning the rotor in the intake manifold.



42-04-05

Adjustments to the intake manifold are carried out by the ECM controlling a drive unit. The drive unit is mounted on the rear of the intake manifold.

The drive unit consists of a 12 V DC electric motor with worm gears and an integral potentiometer for the intake manifold position feedback.

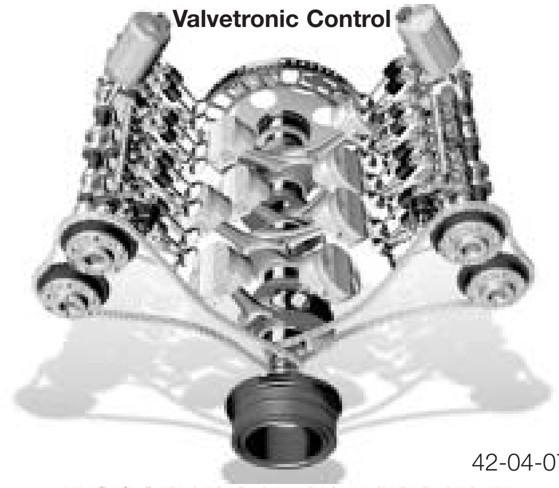
The drive unit is equipped with a 5-pin connector. If the drive unit fails, the system remains in its current position. The driver may notice a loss in power.

42-04-06

*Notes:*

**Valvetronic:** The N62 Valvetronic control system simultaneously varies the valve opening time and the valve opening lift according to engine speed and load. The electrical structure of the fully variable valve lift adjustment consists of the following individual components:

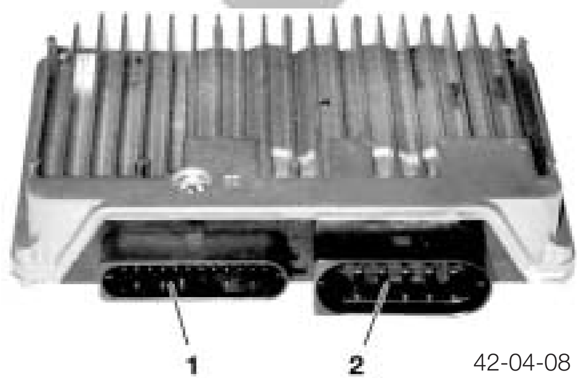
- Valvetronic Control Module
- ECM
- ECM Main Relay (in the IVM)
- Valvetronic Relay (in the IVM)
- Two eccentric shaft adjustment motors
- Two eccentric shaft position sensors
- Two magnetic wheels on the eccentric shafts




42-04-07

The Valvetronic control module adjusts the valve lift based on a request from the ECM. The Valvetronic control module (located in the E Box) adjusts the eccentric shaft motors by two internal power output stages.

Faults in the Valvetronic system are detected by the Valvetronic control module and are transmitted via the LoCAN to the ECM where they are stored for diagnostics.




42-04-08

**Valvetronic Motors:** Two DC motors (2) are fitted to adjust the two eccentric shafts. They are operated at a frequency of 16 kHz in order to make exact adjustments. In order to position the motors exactly, the polarity is briefly reversed once the target position has been reached (as identified by the ECM). This generates braking torque which immediately stops the motors.

The eccentric shaft sensors continuously monitor the position of the Valvetronic assembly. The self-stopping of the motors and the worm gear drives prevents position changes when the system is deactivated. If automatic adjustment is not detected, the fault is recorded and the motors are moved back to the target position.


The adjustment time required to move the motors from the minimum to the maximum valve lift is approximately 300 ms. The motors can peak up to 100 Amps during adjustment.

**Valvetronic Sensors:** Each eccentric shaft is monitored by a magneto-resistive position sensor. The N62 engine has two sensor assemblies, one for each eccentric shaft. These sensors are very durable for the environment (inside the cylinder head) and cope well with vibrations and high temperatures. The sensor assembly consists of:

- Measuring Sensor
- Evaluation Sensor
- Communication Electronics

A magnetic wheel is mounted on the end of the eccentric shaft. The eccentric shaft sensor is mounted through the cylinder head cover at the back.

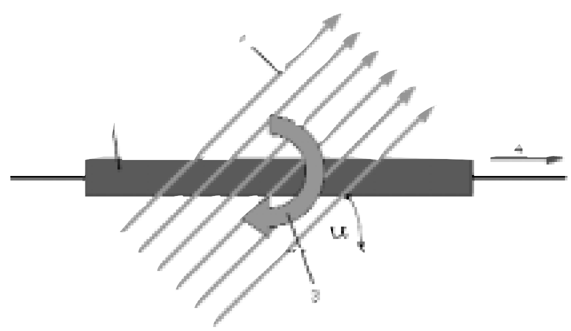
42-04-10

**Eccentric Shaft Position Sensor**

Both sensors monitor the eccentric shaft rotation angle of 180º. The Valvetronic control module supplies the sensors with 5 volts and ground.

1. Magnetoresistance element with resistance R (a)
2. Lines of magnetic field
3. Direction of rotation of magnetic field
4. Current flow 1

The magneto-resistive element consists of a ferromagnetic layer. The resistance R is dependent on the angle (á) under the influence of a strong magnetic field. The magnetic field is generated by permanent magnets.



**Magneto-Resistance Principle**

42-04-11

The resistance of the magneto-resistive element (1) in the sensor is dependent on the direction of the lines of the magnetic field (2) as influenced by the eccentric shaft magnetic wheel. The angle value signal of the measuring sensor is opposite to that of the evaluation sensor (opposing voltage values) during the rotation of the eccentric shaft. The Valvetronic control module constantly compares the values with each other.

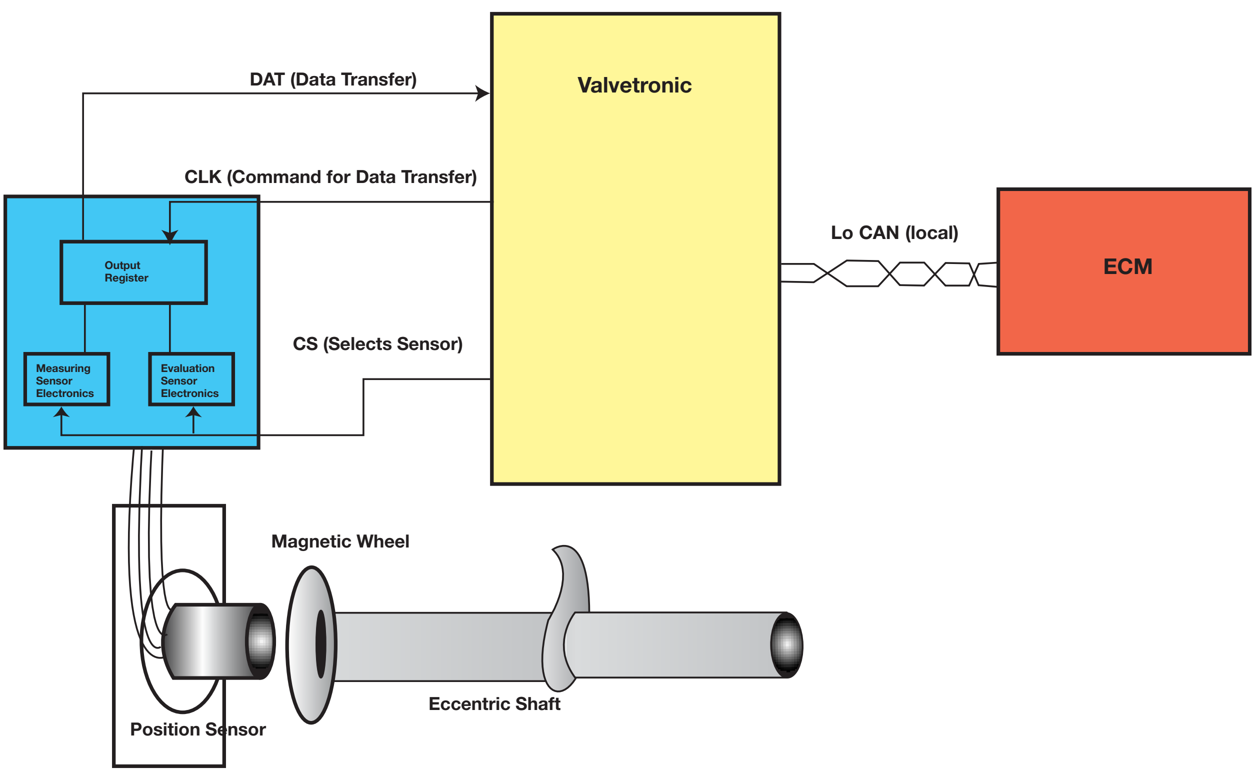
The position data “message” is transmitted via a serial interface from the eccentric shaft sensors to the Valvetronic control module. Each of the two sensors requires three interfaces for data transfer:

- CS (chip select - measuring sensor or evaluation sensor)
- DAT (data transfer - of eccentric shaft position)
- CLK (clock line - signals the sensor requesting an update)

There is only one clock line, but it works inside the sensor assembly on both the measuring and evaluation sensor. The measuring sensor transmits the eccentric shaft positions to the Valvetronic control module at shorter intervals than the evaluation sensor.

Once the exact position of the eccentric shaft has been recorded by the magneto-resistive bridge circuit, this value is stored in an internal register. The Valvetronic control module sends the command to the measuring sensor via the CS line to transmit or upload the data from the internal register to the output register. The Valvetronic control unit then sends the command to the output register via the CLK line to transfer the data.

The data “message” from the measuring sensor is then issued on the DAT line, giving the exact position of the eccentric shaft (at a frequency of 250 kHz). The evaluation sensor works similarly but is only periodically checked for position (plausibility).




42-04-41

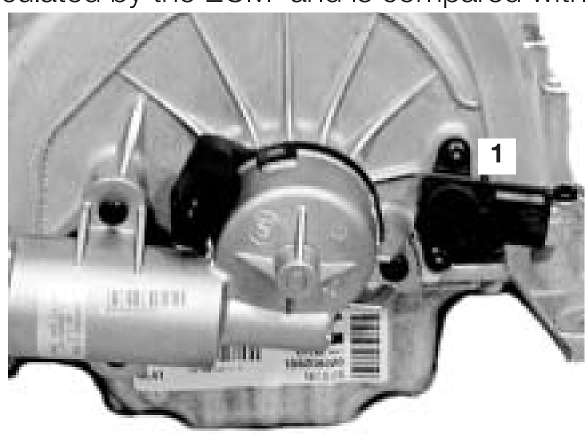
**Ambient Pressure:** The ambient pressure sensor is located in the ECM (integral). This sensor enables continuous measurement of the air pressure. The signal is used in the ECM to calculate the altitude correction for the mixture formation and as a reference value for the intake manifold pressure.

The voltage supply from the ECM is 5 V. The resistance of the sensor is dependent on pressure. The output voltage signal is processed by the ECM.

**Intake Manifold Pressure Sensor:** The pressure sensor is located in the back of intake manifold (1 peizo-electric). The voltage supply from the ECM is 5 V. The varying resistance of the sensor is dependent on manifold pressure. The output voltage signal is processed by the ECM. The intake manifold pressure is calculated by the ECM and is compared with the ambient pressure (internally measured).

An intake manifold vacuum of 50 mbar is required for the fuel tank evaporative purge function.

This vacuum is set by the electronic throttle valve and monitoring with the intake manifold pressure sensor.




42-04-06

*Notes:*

## Principle of Operation

Air flow into the engine is regulated by the Valvetronic system controlling valve lift adjustment. The intake air flow is set by adjusting the valve lift while the throttle valve is fully opened. This further improves cylinder filling and reduces fuel consumption. All of the ECM monitoring, processing and output functions are a result of regulated air flow.

**The Accelerator Pedal Position** is monitored by the ECM for pedal angle position and rate of movement. As the accelerator is moved, a rising voltage signal from the Hall sensors requests acceleration (and at what rate).

The ECM will request the Valvetronic control module to increase the intake valve “lift”. As a result of the increased air flow, the ECM will increase the volume of fuel injected into the engine and advance the ignition timing. The “full throttle” position indicates maximum acceleration to the ECM, and in addition to the functions just mentioned, this will have an effect on the air conditioning compressor (covered in Performance Controls).

As the accelerator pedal is released (integral springs), the decrease in voltage signals the ECM to activate fuel shut off if the rpm is above idle speed (coasting). The Valvetronic control module will decrease the valve lift to maintain idle speed. The ECM monitors the engine idle speed in addition to the accelerator pedal position and Valvetronic position.

The pedal position sensor consists of two separate Hall sensors with different voltage characteristics and independent ground and voltage supply. Sensing of the accelerator pedal position is redundant. The pedal position sensor is monitored by checking each individual sensor channel and comparing the two pedal values. Monitoring is active as soon as the sensors receive their voltage supply (KL15).

**The Electronic Throttle valve** is operated by the ECM (supplying voltage and ground) for opening and closing based on the accelerator pedal position, engine load and intake manifold vacuum.

When the throttle valve is operated, the ECM monitors feedback potentiometers located on the actuator shaft for position/plausibility. These two sensors operate inversely (voltage values) with throttle plate actuation.

The tasks of the throttle valve are:

*Starting the engine*

During the starting procedure at a temperature between 20 ºC and 60 ºC, airflow is controlled by the throttle valve.

If the engine is at operating temperature, it will be switched to non-throttle mode approximately 60 seconds after start up. In cold conditions, however, the engine is started with the throttle valve fully opened, which has a positive effect on the starting characteristics.

*Ensuring a constant vacuum of 50 mbar in the intake manifold*

This vacuum is needed to exhaust the blow-by gases from the crankcase and the fuel vapors from the activated charcoal filter.

*The backup running function*

If the Valvetronic system should fail, the throttle valve implements the engine's backup running function (conventional load control).

**The Hot-Film Air Mass Meter (HFM)** varies voltage monitored by the ECM representing the measured amount of intake air volume. This input is used by the ECM to determine the amount of fuel to be injected.

The heated surface of the hot-film in the intake air stream is regulated by the ECM to a constant temperature of 180º above ambient air temperature. The incoming air cools the film and the ECM monitors the changing resistance which affects current flow through the circuit. The hot-film does not require a “clean burn”, it is self cleaning due to the high operating temperature for normal operation.

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

The ignition timing is also affected by air temperature. If the intake air is hot the ECM retards the base ignition timing to reduce the risk of detonation. If the intake air is cooler, the base ignition timing will be advanced. The ECM uses this input as a determining factor for Secondary Air Injection activation (covered in the Emissions section), VANOS, Valvetronic, Knock adaptation and exhaust flap operation.

**The Valvetronic System** is operational when activation of terminal 15 switches the ECM main relay to supply voltage. The Valvetronic module reduces the voltage supply to the internal electronics and the sensors (5 volts). The system carries out a pre-drive check. The relays (in the IVM) are activated after a delay (approx. 100 ms) which supplies the load circuit for the Valvetronic motors. From this stage on, the ECM and the Valvetronic control module communicate via the LoCAN bus.

The ECM determines the intake valve lift for starting based on engine and ambient temperature (large lift when cold, minimum lift when warm). The ECM also determines the intake valve lift based on the acceleration requested by the driver. The Valvetronic control module converts the ECM command by operating the motors until the actual value from the eccentric shaft position sensor corresponds with the target value. The Valvetronic control module transmits the exact position of the eccentric shaft to the ECM via the LoCAN bus. ***When the Valvetronic module detects a fault, it is also transmitted on the LoCAN bus to the ECM for storage in fault memory.***

| **Fault** | **Emergency Program** | **Effect** |
|---|---|---|
| Sensor Faulty | Activated | Maximum Valve Lift |
| LoCan | Activated | Maximum Valve Lift |
| Valvetronic | Activated | Valve Lift Which is Currently set |
| Operating Motor Fault | Activated | The Second Motor is Driven in Exactly the same position at the faulty motor |

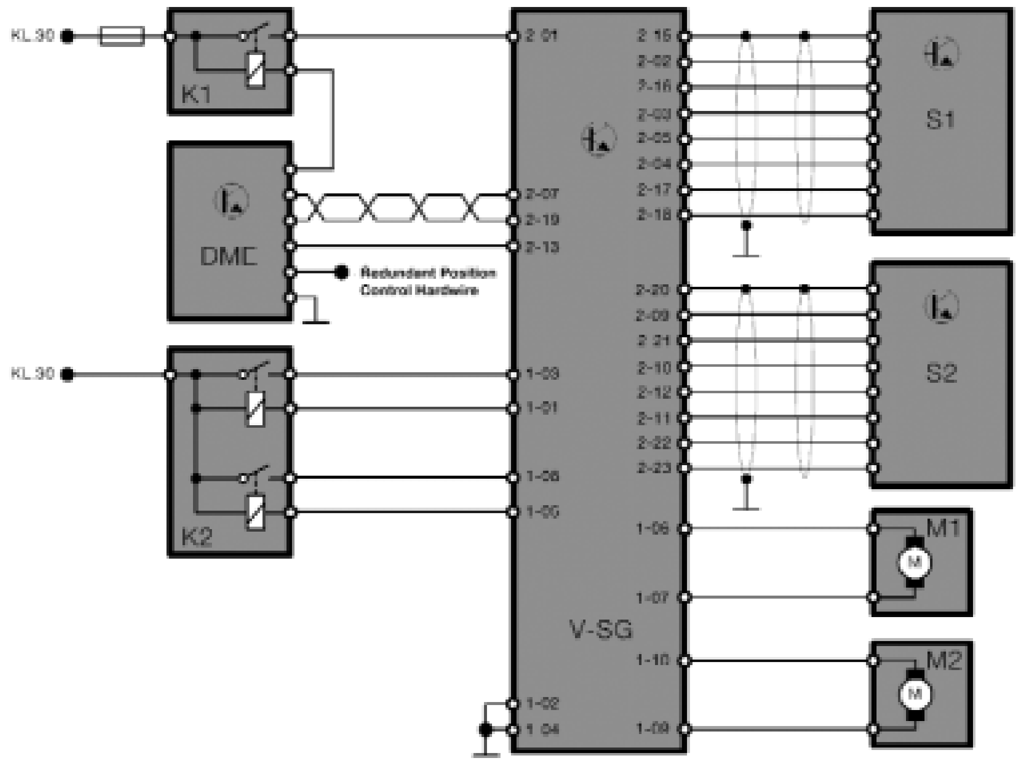
***A Redundant Position Control Hard Wire*** is between the ECM and the Valvetronic control module. Only two messages can be transmitted using this wire:

- Test function
- Maximum valve lift

A signal with a frequency of 100 Hz is placed on this wire to transmit these two messages. The test function is carried out during the pre-drive check. The pulse width rate is 50%.

- The maximum valve lift command is given if the LoCAN bus is faulty. In this case, the pulse width rate is 80%.

- If there is a fault (backup running function) when running with maximum valve lift, the operating motors are supplied with 30% power. This drives the motors softly to the limit stop which prevents additional mechanical faults. ***The load control is now operated conventionally by using the throttle valve.***

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**Valvetronic Block Diagram**

DME (ECM)
K1 Valvetronic Relay (in IVM)
K2 Valvetronic Relays (in IVM)
M1 Valvetronic Motor Bank 1-4
M2 Valvetronic Motor Bank 5-8
V SG Valvetronic Control Unit
S1 Valvetronic Sensor Bank 1-4
S2 Valvetronic Sensor Bank 5-8

*The Bank Alignment* function adjusts the distribution of load between the two cylinder banks. This alignment runs continuously during the engine operation to assure an equal load distribution to both cylinder banks.

The values of the individual cylinders are determined by the load request and the crankshaft reference/rpm signal. The ECM compares these actual values with stored limit values. As soon as the values are recognized, the ECM increases the lift of the intake valves on each bank.

After deletion of the adaptation values, the bank alignment is automatically performed by the ECM (or the DISplus can be used). The eccentric shafts are adjusted in steps (1 degree of rotation increments) until both bank outputs are equal. The following conditions must be present for the bank alignment:

**ECM**

- No load on the engine
- Coolant Temperature > 85 degrees C
- No Faults Present
- All Auxiliary Consumers Switched Off
- Minimum Valve Lift Detected

*If faults relative to bank alignment are present, the following should also be considered during diagnosis:*

**Faults Related to Bank Alignment**

- Damaged Valves
- Defective HVA Elements
- Misfire - Related functions and components (injection, ignition, compression, etc.)

*The Valvetronic control module is assigned (programming) to the appropriate engine and ECM by the DISplus.*

*The Idle Speed Control* is also regulated by the Valvetronic system. Reduced valve lift when the engine is idling ensures that the engine receives the appropriate airflow. When the Valvetronic system is in use, the idle speed control and intake manifold vacuum is also regulated using the electronic throttle valve.

During the starting procedure at a temperature of between 20 ºC and 60 ºC, airflow is controlled by the throttle valve. If the engine is at operating temperature, it will be switched to non-throttle mode approximately 60 seconds after it is started up.

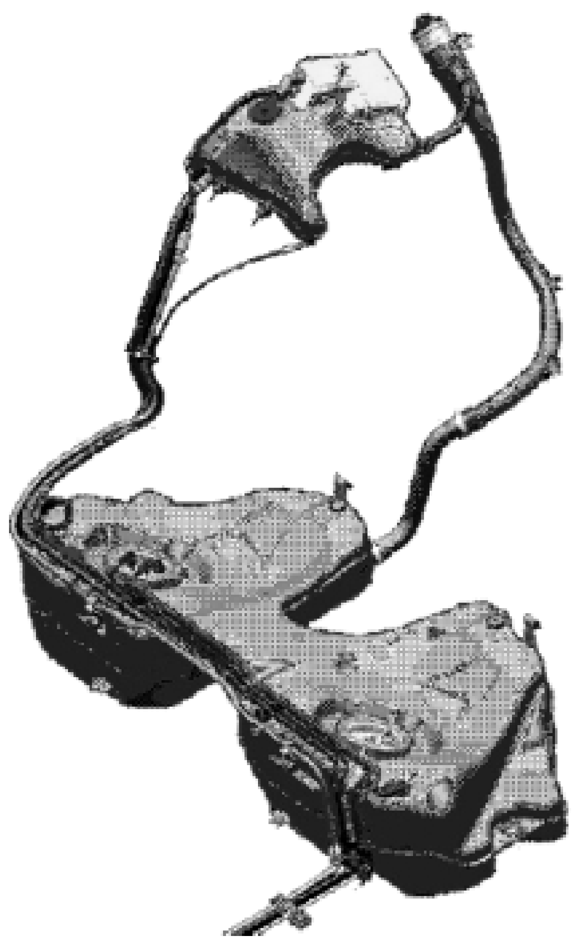
At temperatures below 20 ºC, the engine is started with the throttle valve fully opened using the Valvetronic for idle speed control (this has a positive effect on the starting characteristics).

*Note:* If the idle speed control is faulty, the engine must be checked for vacuum leaks because leaking air has an immediate effect on idling (unmetered air leaks).

## Fuel Management

**Fuel Tank:** The fuel tank is made of high density polyethylene (reduced weight) which is manufactured to meet safety requirements and is mounted over the rear axle. ***The tank capacity is 23.2 US gallons (88 liters) including a reserve capacity of 2.3 US gallons (10 liters)*** for vehicles with the N62 engine. A “saddle” type tank is used which provides a tunnel for the driveshaft but creates two separate low spots in the tank. A Syphon jet is required with this type of tank to transfer fuel from the left side, linked to the fuel return line. As fuel moves through the return, the siphon jet creates a low pressure (suction) to pick up fuel from the left side of the tank and transfer it to the right side at the fuel pick up.

There must be no escape of fuel vapors when the tank is being filled and it must be possible to fill the tank quickly and the fuel must not foam up. The fuel is prevented from foaming up when the tank is being filled because the tank filler pipe is located low down on the fuel tank. An anti-spitback flap is fitted on the fuel tank filler pipe as it enters the tank to prevent fuel from splashing back towards the pump nozzle during refuelling. The filler neck is designed so that the incoming fuel functions like a venturi tube during refuelling and also draws external air into the tank so that no fuel vapors can escape during this stage.



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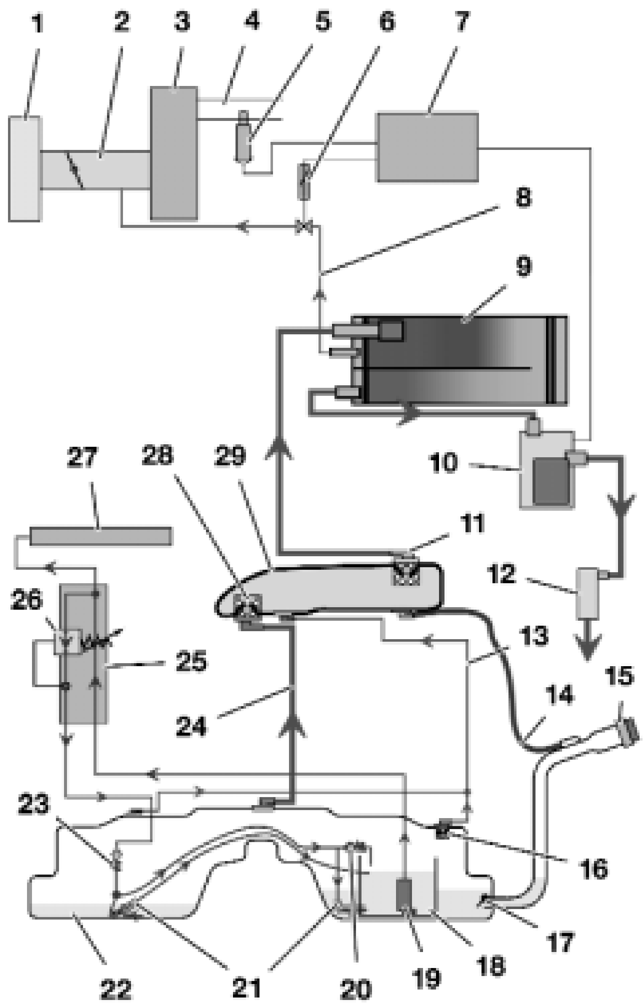



Fuel System

1. Air cleaner
2. Intake manifold
3. Engine
4. Exhaust system
5. Oxygen sensor
6. Evaporative emission valve (TEV)
7. ECM
8. Purge vapors
9. Carbon Canister
10. Fuel tank leak diagnostic module (DM TL)
11. Roll-over valve
12. Dust filter
13. Service Ventilation
14. Pressure test lead
15. Fuel tank cap
16. Service vent valve (float valve)
17. Anti-spitback flap
18. Surge chamber (fuel pump baffling)
19. Electric fuel pump (EKP)
20. Pressure relief valve
21. Suction jet pumps
22. Fuel Tank
23. Outlet protection valve
24. Refueling breather
25. Fuel filter
26. Fuel pressure regulator (3.5 bar)
27. Injection rail
28. Float valve
29. Liquid/vapor expansion tank
30. Filler vent valve

**Tank Ventilation:** Optimum ventilation of the tank system ensures trouble free refuelling and that no vacuum can develop during this operation.

*The Ventilation System Consists of:*

- Two service vent valves (left/right 16)
- Filling ventilation valve (30)
- Hose to the fuel expansion tank (24)
- Two rollover valves in the fuel expansion tank (11+28)
- Service vent hose (13)
- Activated-carbon filter with hoses (9)
- Dust filter (12)

*Tank Ventilation Components:*

- Service vent (16): The service vent valve (16) on the right side of the tank consists of a float which locks the ventilation while fuel is being admitted (ball valve). The service vent valve ensures that no fuel enters the ventilation pipe when the vehicle is on an incline. A simple ventilation connection piece is located in the left tank chamber. Both service vent valves ensure that no air pockets form in the lower portions of the tank.

- Expansion tank (29): The task of the expansion tank is to receive fuel when the fuel tank is full and the vapors have expanded due to heat.

- Rollover valve (11): The rollover valve is also a plastic ball valve. When the vehicle is in its usual position, the rollover valve is open allowing air to flow in and out. In the same way, fuel can flow via the filling vent valve (28) from the fuel tank into the expansion tank and from the expansion tank back into the fuel tank. In the event of an accident in which the vehicle rolls over, the ball locks the expansion tank inlet and outlet openings and prevents fuel from escaping.

- Dust filter (12): The dust filter prevents dust and small insects from entering the activated carbon filter.

*Tank Ventilation Function*

During refuelling, the air escapes via the service ventilation in the expansion tank. Air molecules in the tank have combined with hydrocarbon molecules. These must not escape into the atmosphere. The air containing hydrocarbon molecules is fed through the activated carbon filter. This filters out the hydrocarbon molecules and stores them.

The activated carbon filter is purged when the engine is running. This means that atmospheric air is drawn through the activated carbon filter in the opposite direction and is supplied for combustion via the engine's purge air pipe (8). The evaporative emission valve (6) controls the purging, which is activated by the ECM.

The air which is now free of hydrocarbon molecules escapes via the dust filter into the atmosphere. If the fuel level reaches the ventilation valve (30), the ball floats and closes the ventilation pipe. The tank pressure increases beyond the pump nozzle cut-out pressure and switches it off. During fuel withdrawal, the fuel tank system is ventilated in the reverse direction to prevent the formation of a vacuum.

**Fuel Supply System:** The fuel tank system must fulfill various requirements concerned with supplying the engine with fuel. These include:

- Providing sufficient fuel volume and pressure regardless of the driving style
- Ensuring that the tank can be almost completely drained (full utilization of volume)

The tank is made up of two halves which are only directly connected up to a certain height. A large proportion of the fuel volume cannot reach the fuel pump without assistance (suction jet pumps).

*Fuel Supply System Components:*

- Fuel tank (22)
- Surge chamber (18)
- Fuel pump (19)
- Two suction jet pumps (21)
- Outlet protection valve (23)
- Pressure relief valve (20)
- Internal tank fuel lines
- Fuel filter with fuel pressure regulator (25+26)
- Fuel distributor pipe with injection valves (27)

*Internal Tank Fuel Circuit Operation*

The fuel pump supplies fuel from the surge chamber via the fuel filter (located next to the frame rail under the driver’s floor) to the fuel injection valves. The fuel pump always pumps more fuel than the engine requires in all operating conditions. The fuel pressure regulator built into the fuel filter adjusts the pressure to 3.5 bar and feeds the excess fuel in the return flow back into the tank.

The pressure regulator valve in the return flow sets a return pressure of 1.0 - 1.5 bar. This pressure prevents fuel vapor locks in the return flow and also ensures operation of the two suction jet pumps.

The fuel flows from the pressure regulator valve on to an intersection point where the fuel return flow is split. Some of the fuel flows through the suction jet pump in the left half of the tank via the internal fuel line to the surge chamber. The suction jet pump acts like a venturi tube which draws the fuel from the left half of the tank into the right half.

The other amount of diverted fuel flows via the second internal fuel supply directly to the right half of the tank and to ***the second suction jet pump (21). This pumps the fuel from the right half of the tank into the surge chamber to ensure that the surge chamber is always filled with enough fuel in all driving conditions and takes full advantage of the reserve capacity.***

*Fuel Pressure Regulator*

The pressure regulator is integrated in the fuel filter and the two parts are only available as a single unit. There is a return line from the pressure regulator between the fuel pressure regulator and the fuel tank. The pressure regulator has a small hose connected to ensure that if there are any leaks in the pressure regulator, any leaking fuel does not escape into the environment. This hose connects to the intake air pipe behind the HFM.

*Electric Fuel Pump (EKP)*

The fuel pump is a two part in-tank gear pump. The first part is for the pre-delivery stage. It primes the second  part in-tank gear pump which is designed to eliminate cavitation. The two parts are driven by the same electric motor.

*Electric Fuel Pump (EKP) Regulation*

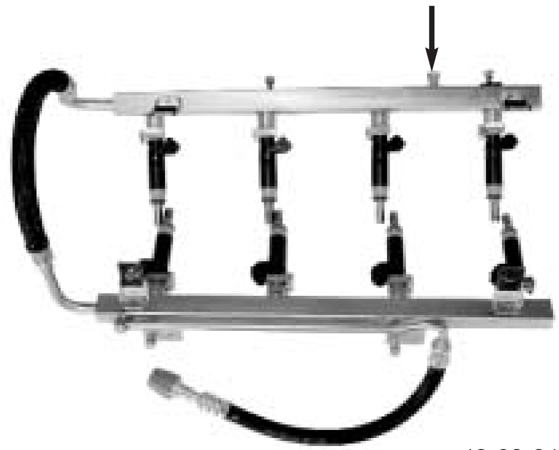
The fuel is delivered in accordance with fuel consumption by engine use controlled regulation. This produces the following benefits:

- The load balance of the alternator/battery is improved (lower pump power demand)
- The lower power input reduces the fuel pump heat radiation in the fuel tank
- Integration of the crash cut-out in the EKP regulation
- Longer EKP service life
- Deletion of the EKP relay

*Injection Valves / Fuel Rail*

The fuel injection valves have been positioned closer to the intake valves. This means that larger injection angles can be covered by the injection spray. Greater fuel spray atomization leads to optimum fuel mixing and thereby reduces fuel consumption and exhaust emissions.

The Non Return Fuel Rail System has been improved for better fuel distribution. A “service valve” is provided to check fuel pressure (arrow).



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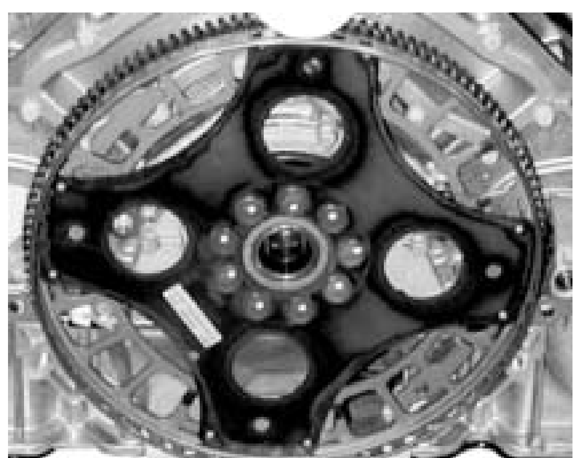
The Siemens fuel injection valves are the dual outlet “directional angle plate” type with a ***coil reisistance of approximately 12 ohms each.***

**Crankshaft Position/RPM Sensor:** This sensor provides the crankshaft position and engine speed (RPM) signal to the ECM for engine management operation. This is a Hall type sensor mounted in the bell housing which scans the impulse wheel (attached to the ring gear). 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 a square wave DC voltage signal in the sensor where by each tooth of the wheel produces one square wave. 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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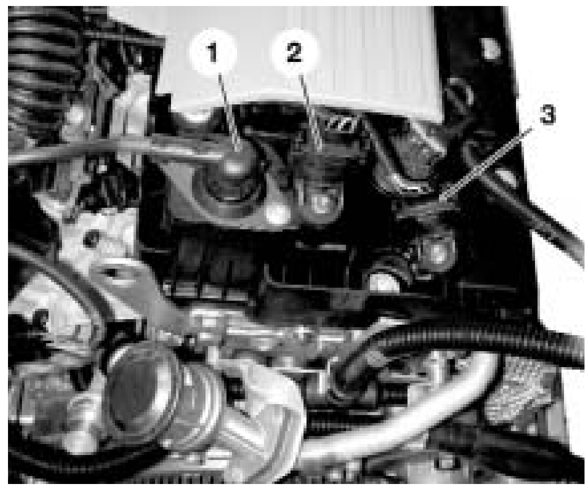
*Notes:*

**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 monitors power flow through the Hall elements as the basis for the signal output.

As the camshafts rotate, 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 ECM determines an approximate location of the camshaft position (high or low signal) during engine start up optimizing cold start injection (reduced emissions).

An impulse wheel is mounted on the end of each camshaft for position detection. The sensors are mounted on each side at the back of the cylinder heads cover (2 and 3).

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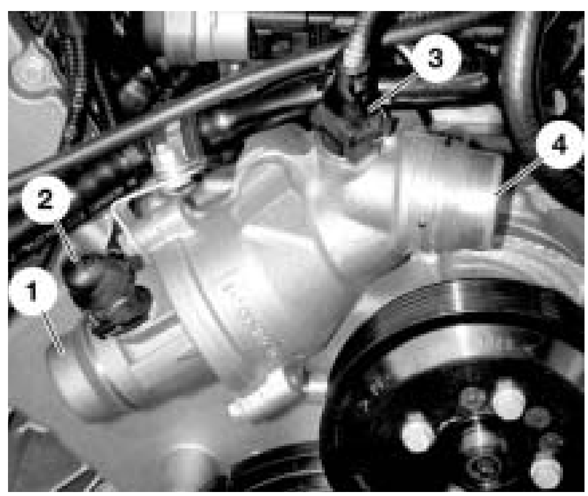
**Engine Coolant Temperature:** The Engine Coolant Temperature is provided to the ECM from a Negative Temperature Coefficient (NTC) type sensor. The ECM determines the correct fuel mixture and base ignition timing required for the engine temperature.

The sensor is located in the thermostat housing (3). The sensor decreases in resistance as the temperature rises and vice verse. The ECM monitors an applied voltage to the sensor (5V). This voltage will vary (0-5V) as coolant temperature changes the resistance value.

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*Notes:*

## Principle of Operation

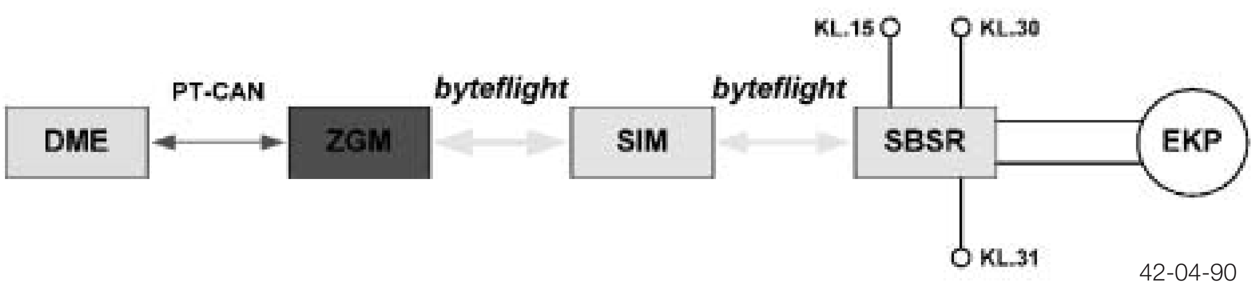
Fuel Management delivers fuel from the tank to the intake ports of the engine. To accomplish this, **fuel supply** must be available to the fuel injectors. Then the fuel must be **injected** in the precise amount and at the correct time. The ECM does not directly monitor fuel supply, although it does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

### The Fuel Pump (EKP)

*EKP regulation and fuel cut-out in the event of a crash, are ISIS (Intelligent Safety Integration System) features.*

The fuel requirement is transmitted by the ECM via the PT CAN bus and the byteflight bus to the right hand side satellite B-pillar (SBSR). The EKP regulation is integrated in the SBSR. The SBSR controls the front right belt force limiter and the fuel pump.

The SBSR controls the EKP via a pulse width modulated (PWM) signal according to the fuel quantity required by the ECM. The present pump speed is recorded in the SBSR from the EKP electrical current consumption to calculate the fuel quantity required. The fuel quantity required is then set (from the coded map in the SBSR) by the PWM signal to control current which regulates the pump speed.




*Fuel Requirement Signal Path*

*Note:* If the fuel quantity requirement from the ECM and/or the EKP rotation speed signal in the SBSR fails, the fuel pump will continue to operate with the greatest delivery rate when terminal 15 is activated. This guarantees the fuel supply even if the control signals fail.

**The Fuel Injectors** will be opened by the ECM to inject pressurized fuel into the intake ports. The ECM Relay (in the IVM) supplies voltage to the fuel 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 eight Final Stage output transistors that switch ground to the eight 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 eight Final Stage transistors to discontinue fuel injection.

**The Injector “open” Time** maintains engine operation after start up is determined by the ECM (programming).

The injection ms value is influenced by 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 fuel injected 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 Valvetronic valve lift / 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 the oxygen content (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 relay discontinues voltage to deactivate  the eight Final Stage transistors to cease fuel injection.

**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 Valvetronic valve lift is decreased 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 6500 rpm, the injectors will be deactivated to protect the engine from Over-Rev. As the engine speed drops below 6500 rpm, injector activation will be resumed.

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

***The ECM will also protect the Catalytic 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 ME 9.2 system, there are eight 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.