Table of Contents

MSV70 Engine Electronics

Initial Print Date: 03/05 Revision Date:

Subject	Page

MSV70 Engine Electronics

Model: All with N52 Engine

Production: All with N52 engine

OBJECTIVES

After completion of this module you will be able to:

- Understand the MSV70 Engine Management System
- Understand the Heat Management System
- Understand the Changes to Valvetronic
- Understand EKP Operation

Introduction

There are several new innovations introduced with the new MSV70 engine management system. The most obvious innovation is the addition of Valvetronic II to the six-cylinder engine line. This is the first use of Valvetronic on the BMW six-cylinder.

The MSV70 engine management system is responsible for the following tasks:

- Ignition control
- Injection control
- VALVETRONIC II control
- Control of “Weight Optimized” double VANOS
- Engine temperature control (characteristic map control of engine thermostat)
- Electric coolant pump control (Heat Management System)
- Knock control
- Lambda control
- Fuel tank ventilation control
- Load request to air conditioning control unit for A/C compressor
- Activation of 3-stage differentiated intake manifold (DISA)
- Electric fuel pump module control (EKP)
- Cruise control
- Alternator control
- Heated crankcase ventilation
- Electronic oil condition monitoring and oil level monitoring
- Energy management (IBS)
- Monitoring of input and output signals
- Calculation of substitute signals and failsafe functions
- Self-diagnosis

The engine management system on the N52 engine complies with OBD regulations and meets the ULEV II requirements for 2006.

Components

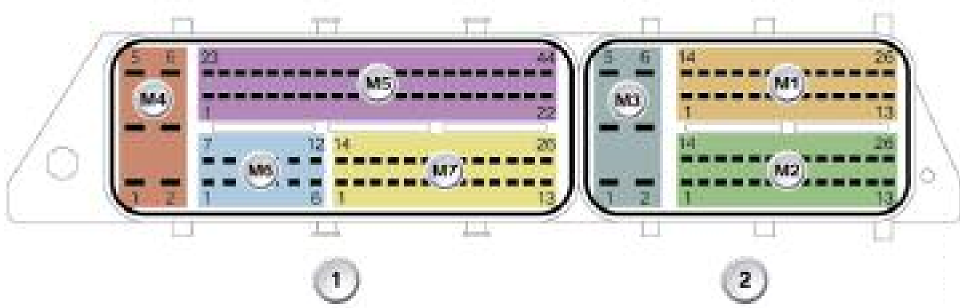
Control Module

The new MSV70 control module is manufactured by Siemens/VDO. The “MSV” designation indicates a Siemens control unit (Motor Control with Valvetronic).

The control module feature an all aluminum housing with a new modular connector configuration. The control unit has two main connections, one with 4 modular connections and the other with 3 for a total of 7 “sub” connectors. This arrangement provides a total of 146 possible pin connections.

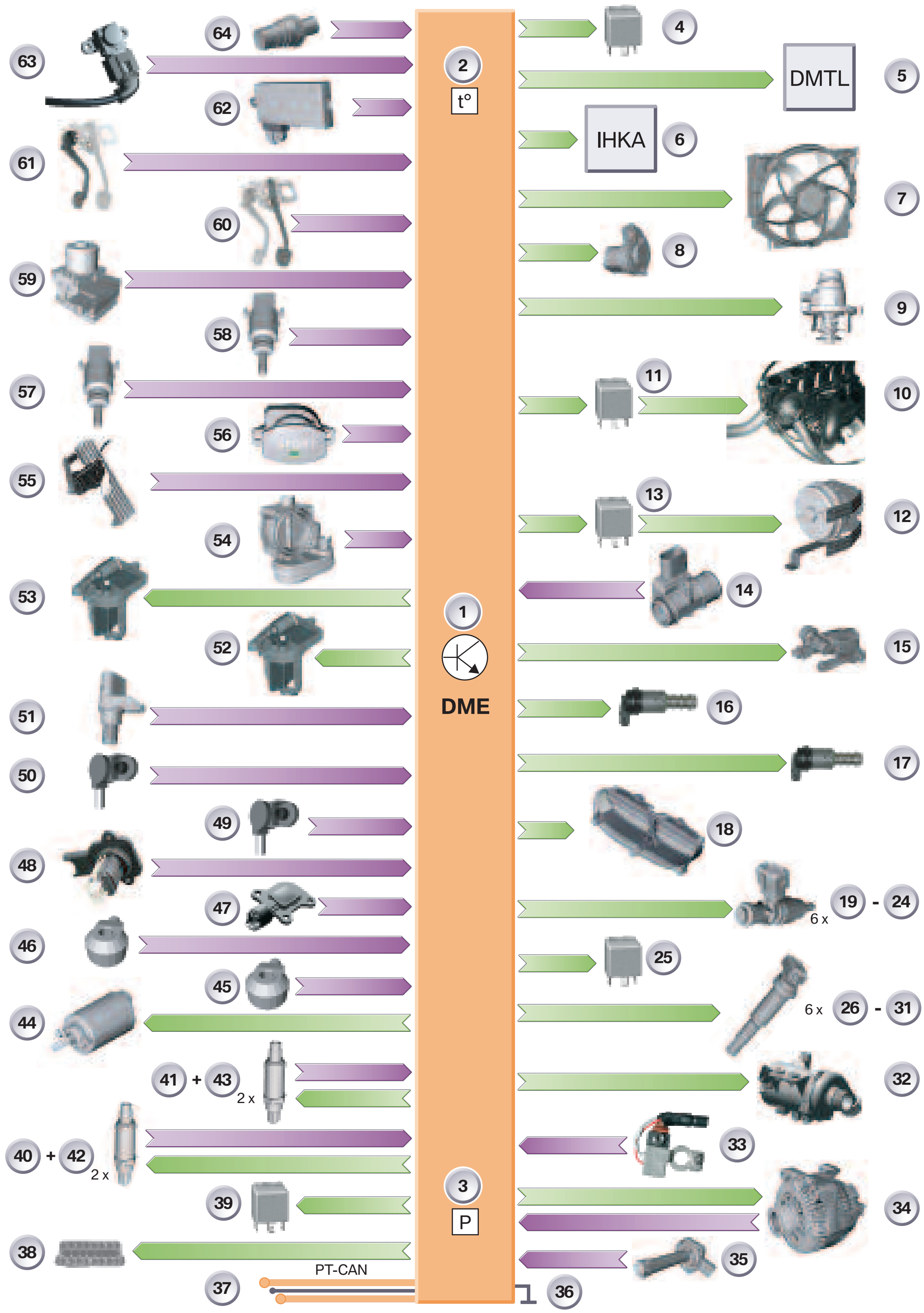
Processor Power

The computing power has been increased to a clock frequency of 60 MHz to accommodate the extended functions.



Index	Explanation	Index	Explanation
1	Connector X60004 to X60007	M4	Connector module 4 (6 pins)
2	Connector X60001 to X60003	M5	Connector module 5 (44 pins)
M1	Connector module 1 (26 pins)	M6	Connector module 6 (12 pins)
M2	Connector module 2 (26 pins)	M7	Connector module 7 (26 Pins)
M3	Connector module 3 (6 pins)		

MSV70 System Overview



Legend for System Overview

Index	Explanation	Index	Explanation
1	DME (ECM)	38	Diagnosis connection
2	Integral ambient temperature sensor	39	Valvetronic relay
3	Integral ambient pressure sensor	40	Oxygen Sensor
4	DME (ECM) main relay	41	Oxygen Sensor
5	DM-TL	42	Oxygen Sensor
6	IHKA	43	Oxygen Sensor
7	Electric engine cooling fan	44	Valvetronic motor
8	E-Box fan	45	Knock sensor (cyl 1-3)
9	Characteristic map thermostat	46	Knock sensor (cyl 4-6)
10	Crankcase ventilation heater	47	Eccentric shaft sensor
11	Crankcase ventilation heater relay	48	Hot-film air mass meter (HFM)
12	Secondary air pump	49	Exhaust camshaft sensor
13	Secondary air pump relay	50	Intake camshaft sensor
14	HFM for Secondary air	51	Crankshaft sensor
15	Fuel tank vent valve (TEV)	52	DISA actuator
16	VANOS solenoid valve (Intake cam)	53	DISA Actuator
17	VANOS solenoid valve (Exhaust cam)	54	Electric Throttle Valve (EDK)
18	Electro-magnet for airflap control (not for US)	55	Accelerator Pedal Module (FPM)
19-24	Fuel injectors	56	SPORT button
25	Fuel injector relay	57	Coolant temperature sensor (engine temp)
26-31	Ignition coils	58	Coolant temperature sensor (radiator outlet)
32	Electric coolant pump	59	DSC module
33	Intelligent Battery Sensor (IBS)	60	Brake Light Switch (BLS)
34	Alternator	61	Clutch switch
35	Oil Condition Sensor (OZS)	62	Car Access System (CAS)
36	Ground connection	63	Differential pressure sensor
37	PT-CAN	64	Oil pressure switch

Power Supply

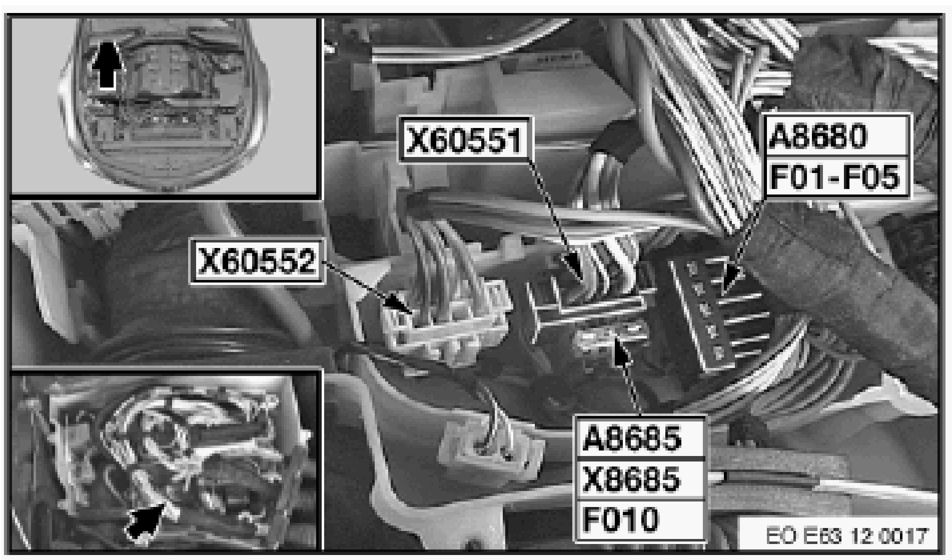
Terminal 30 (KL30) Battery Voltage

The B+ power supply to the ECM comes from a 60A fuse. On the 5 and 6 series vehicles this power is supplied by fuse #8 located in the front power distribution box which is located behind the glove box.

On the E90/E91, the KL30 (B+) power comes from fuse #54 which is located in the junction box which is also located behind the glove box.

Engine Fuses

The engine electronics fuses are located in the e-box. These fuses are supplied by KL87 from the ECM main relay. This is a similar configuration to what has been used in past models.



Terminal 15 (KL15)

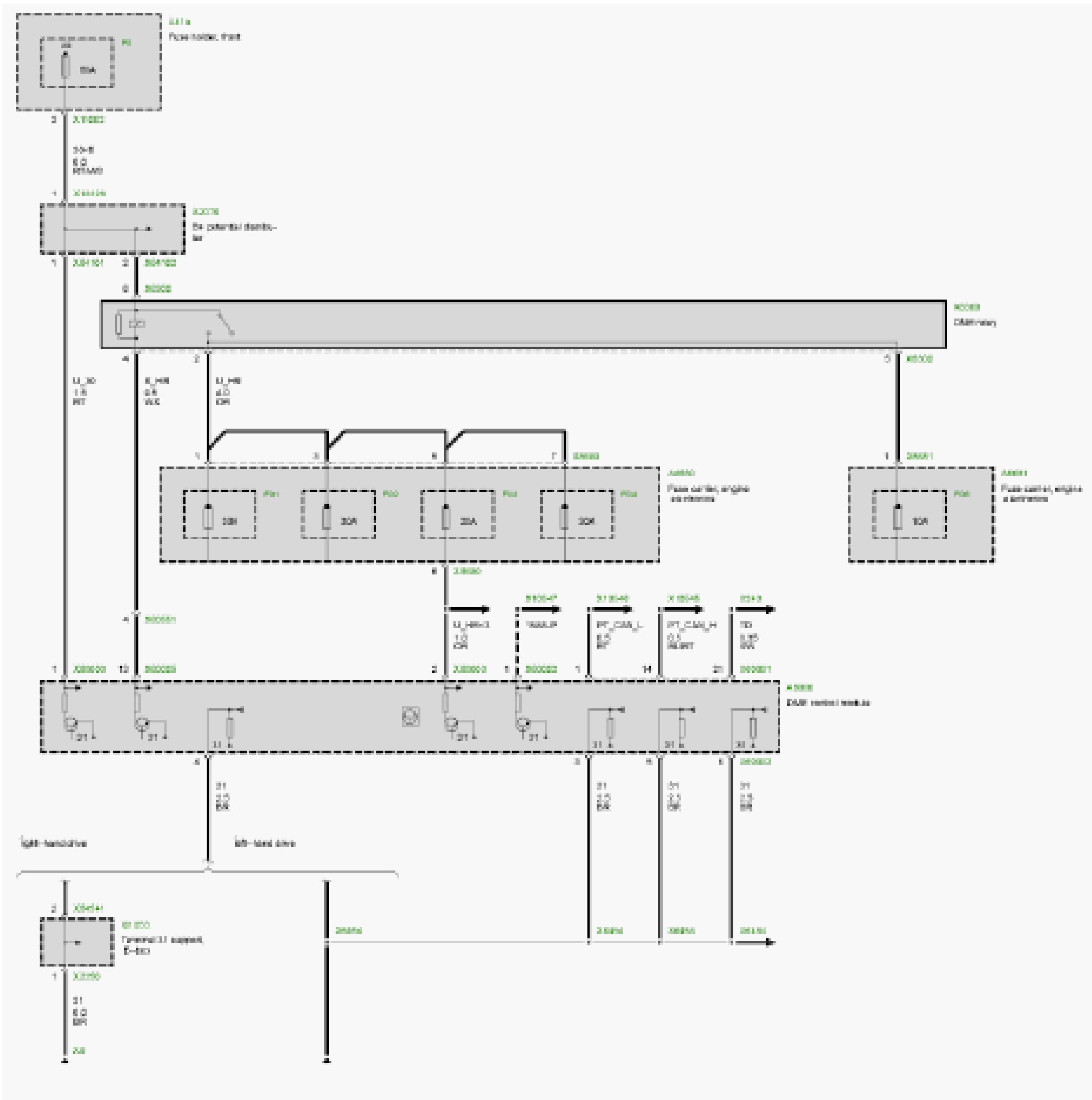
As with previous vehicles equipped with PT-CAN, the ECM receives a KL15w via the bus network and a “hardwire” KL15 wake-up signal directly from the CAS.

When the ignition is switch “ON”, the ECM receives the wake-up signal via CAS, then it will energize the ECM main relay to supply power to the engine electronics fuse carrier to energize other engine related components and systems.

Ground (KL31)

There are multiple ground paths at connector X60003 at pins 3, 4, 5 and 6. These ground connections also supply the ground path for the VVT motor.

Power Supply Schematic



Air Management

Electronic Throttle Valve (EDK)

As with the N62 engine, the throttle is not needed for engine load control. This is carried out by the Valvetronic function of the MSV70 engine management.

The throttle is however slightly closed to allow sufficient manifold vacuum for the crankcase ventilation and canister purge systems.

The ECM provides the operating voltage and ground for the opening and closing of the throttle plate.

Throttle Plate Position

The throttle position is determined by the ECM via two integral potentiometers providing DC voltage feedback signals to the ECM.

Accelerator Pedal Module

The accelerator pedal module provides the input for the driver's request. The accelerator pedal module contains dual Hall sensors which the ECM monitors for plausibility.

The ECM provides an independent voltage and ground supply for each hall sensor. Each Hall sensor is provided with 5 volts and ground. As the accelerator pedal is moved from rest to full throttle, the sensors produce a variable voltage signal.

The Hall sensors are checked for plausibility. The voltage range of Hall sensor 1 is approximately .5 to 4.5 volts. Hall sensor 2 ranges from approximately .5 to 2.5 volts.

Hot Film Air Mass Meter (HFM)

The HFM, which is carried over from MS45.1, is manufactured by Siemens. It is located in the air filter housing and secured with 2 screws. This design allows the HFM to be suspended freely in the intake tract. Due to the elimination of the grill, it is more compact than its predecessor and therefore decreases pressure loss in the intake tract.

The HFM is powered by KL87 and ground via the ECM. It supplies the ECM with an analog signal proportional to air mass.

Air Temperature Sensor

The intake air temperature sensor is integrated into the HFM. The sensor is an NTC thermistor which receives a 5 volt reference and ground from the ECM.

1. Intake air temperature sensor
2. Hot film air mass sensor
3. O-Ring

Differential Pressure Sensor

The differential pressure sensor is located at the rear of the intake manifold.

The sensor is piezo-electric and provides the ECM with information about the pressure in the intake manifold.

The piezo element converts pressure pulses into electrical signals. The ECM supplies the sensor with the power and ground supply.

Intake Air Measurement

In the future, the N52 engine will not use a hot-film air mass meter (HFM) as used on engines in the past. Air mass will be a calculated value which the ECM determines from several inputs. The HFM housing is still used to accommodate the intake air temperature sensor.

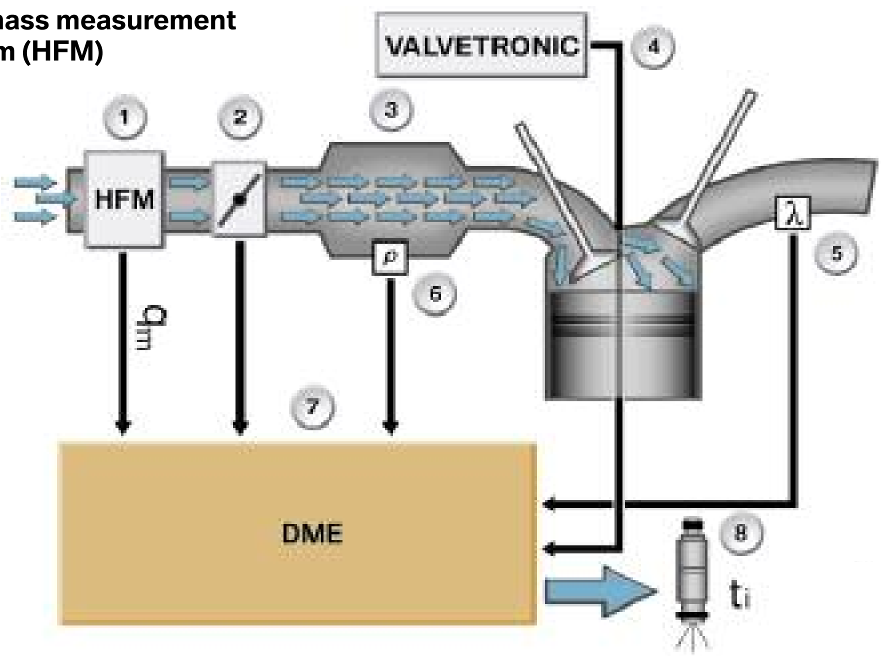
Omission of the hot-film air mass meter (HFM) has been made possible by calculating the air mass with a new, highly accurate charge calculation (charge model) in the DME and the near-engine arrangement of the wideband oxygen sensors (primary O2 sensors).

The near-engine measurement location of the oxygen sensors facilitates a faster lambda control circuit compared to the oxygen sensors arranged further downstream in the exhaust.

This new arrangement offers the following advantages:

- Exact calculation of the intake air mass with an intricate charge model without the measuring tolerances of the HFM (± 6%).
- Reduction in components (HFM, wiring etc.)

Previous air mass measurement using Hot FIlm (HFM)



Index	Explanation	Index	Explanation
1	Measurement of intake air temperature and air mass	5	Residual O2 content in exhaust gas
2	Throttle valve position	6	Intake manifold vacuum
3	Intake manifold	7	Engine speed
4	Intake valve lift (from VVT)	8	Injection Timing

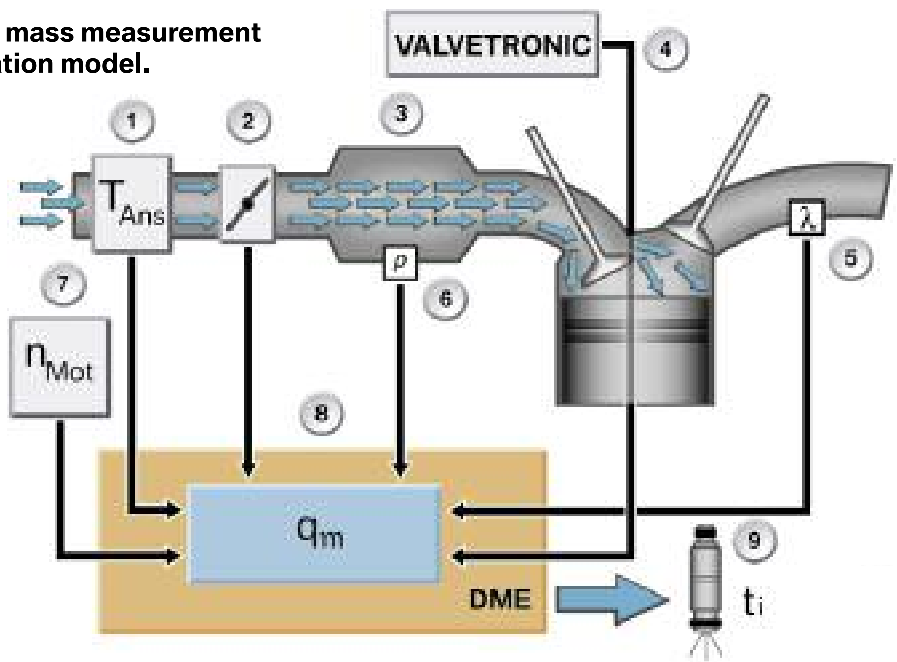
This calculation makes use of the following signals:

- Valve lift of intake valve from VVT (load acquisition)
- VANOS setting (load acquisition)
- Throttle setting (throttling)
- Intake air temperature (air density correction)
- Engine temperature (air density correction)
- Engine speed (cylinder charge)
- Intake manifold pressure (throttling correction)
- Ambient pressure (air density, altitude correction)

The air mass calculated in this way is adjusted with the oxygen sensor signal (mixture ratio) and of the injection time (fuel mass) and corrected if necessary.

A fault code is entered in the DME (air mass plausibility) in the event of the oxygen sensor failing. The calculated air mass is not adjusted in this case.

N52 air mass mass measurement using calculation model.



Index	Explanation	Index	Explanation
1	Intake air temperature	6	Intake manifold vacuum
2	Throttle valve position	7	Engine speed
3	Intake manifold	8	ECM (DME) with characteristic map for air mass calculation
4	Intake valve lift (from VVT)	9	Injection Timing
5	Residual O2 content in exhaust (O2 sensor)		

Intake Manifold

The intake manifold on the N52 uses a three stage differential intake air system (DISA). The air flow through he intake manifold is controlled and re-directed by two DISA actuator motors.

Each actuator motor is operated by an electric motor controlled by the MSV70 engine control module via a PWM signal. The PWM signal is at a frequency of 200 Hz, the ECM varies the duty cycle to control the position of the DISA flap. The actuator consists of a flap and motor drive. There are only two positions possible - closed or opened. When activated, the motor moves the flap to each end position. Both actuators are switched to the closed position at idle.

DISA Actuator 2

DISA Actuator 1

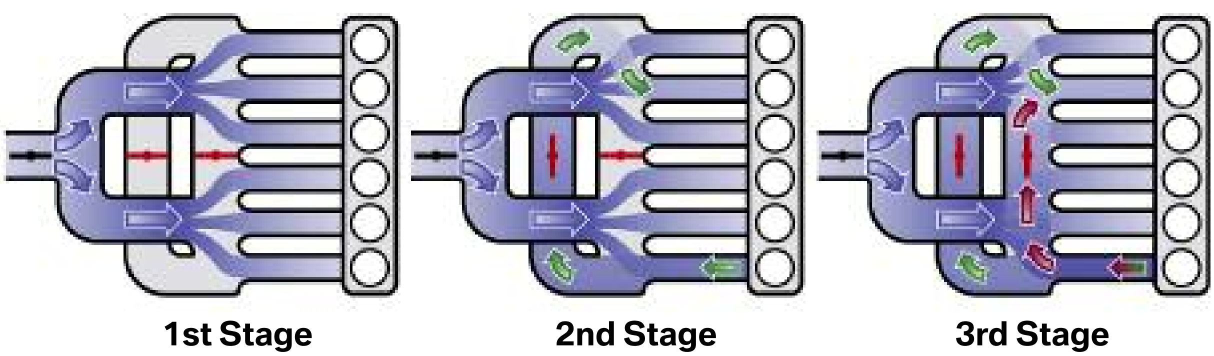
The DISA motors are similar in design and operation, but they are not interchangeable. Each actuator assembly has it’s own individual part number.

DISA Operation

1st stage - idling/lower engine speed range
At idle speed and in the lower engine speed range, actuators 1 and 2 are closed. The intake air flows past the throttle valve into the resonance pipe. In the resonance pipe, the intake air mass splits. The air is fed via the collector pipe and resonating pipes into the individual cylinders. In this way, three cylinders are provided with a comparably high air mass.

2nd stage - medium engine speed range
In the medium engine speed range, DISA actuator motor 2 is opened. In this case, it is assumed that the inlet valves of the first cylinder are just closing. The gas motion creates a pressure peak at the closing inlet valves. This pressure peak is passed on via the resonating and collector pipes to the in next cylinder in the firing order. This improves the fresh gas filling of the next cylinder to be filled.

3rd stage - upper engine speed range
In the upper engine speed range, both DISA actuator motors are opened. In this case, it is assumed that the inlet valves of the first cylinder are just closing. The gas motion creates a pressure peak in front of the closing inlet valves. The intake air mass is now fed via the resonating, overshoot and collector pipes.



Crankcase Ventilation

The crankcase ventilation system on the N52 engine has been redesigned as compared to previous modules. The pressure control valve and cyclonic oil separator are combined into one unit. The assembly is located under the intake manifold.

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

The oil vapors exit the separator labyrinth in the cylinder head cover. The oil vapors are drawn into the cyclone type liquid/vapor separator and regulated by the pressure control valve.

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

The vapors exit the pressure control valve and are drawn into the intake manifold through a centrally located port. The central location of the port in the intake manifold eliminates the need for the distribution tube used on the previous six-cylinder designs such as the M52TU and M54.

As the vapors exit the pressure control valve, they are drawn into the intake manifold.

At idle when the intake manifold vacuum is high, the vacuum reduces the valve opening allowing a small amount of crankcase vapors to be drawn into the intake manifold.

At part to full load conditions when intake manifold vacuum is lower, the spring opens the valve and additional crankcase vapors are drawn into the intake manifold.

Crankcase Ventilation Heating

Also integrated into the design of the crankcase ventilation is an electric heating system designed to prevent moisture buildup. Moisture buildup can eventually lead to ice at low ambient temperatures leading to malfunctions of the crankcase ventilation.

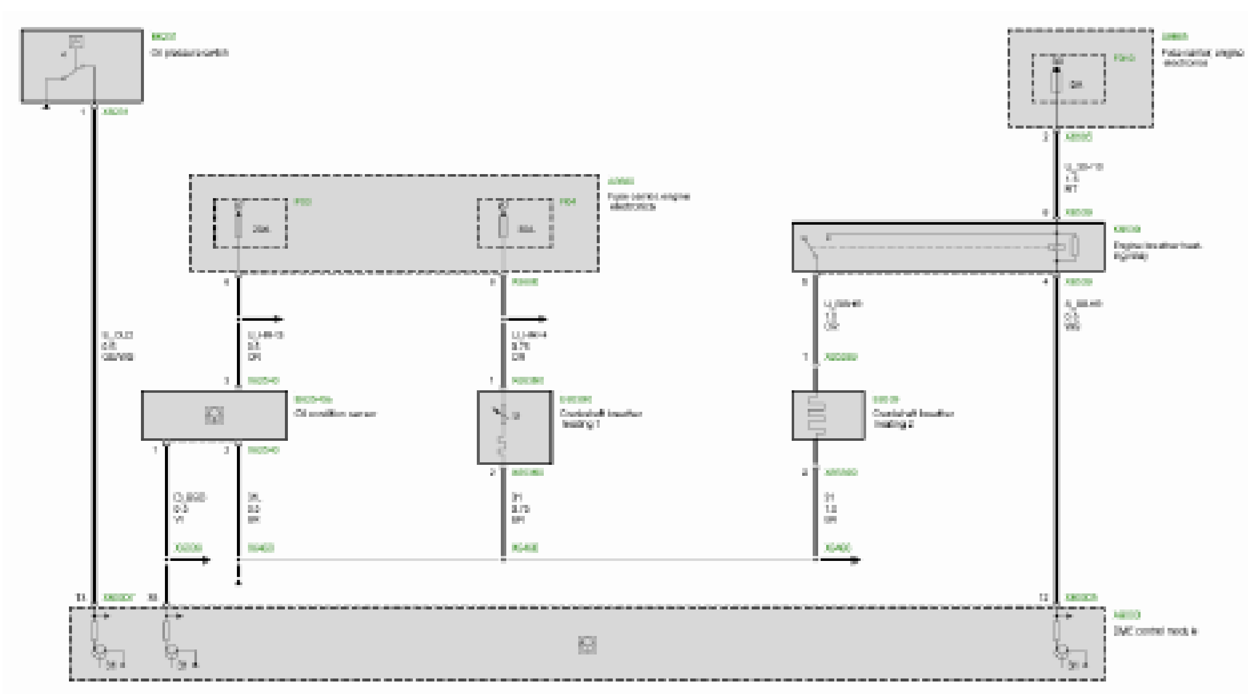
The crankcase vent valve and cyclonic separator are also insulated by a protective foam covering to provide additional shelter from low ambient temperatures.

The PTC heating elements are integrated into the crankcase ventilation valve and hose assemblies. There is a junction point on the intake manifold which provides a connection point for the individual heating elements.

There is also a heating element located on the centrally located port on the intake manifold. This port is also provided with a separate heating circuit controlled by a PTC thermistor.

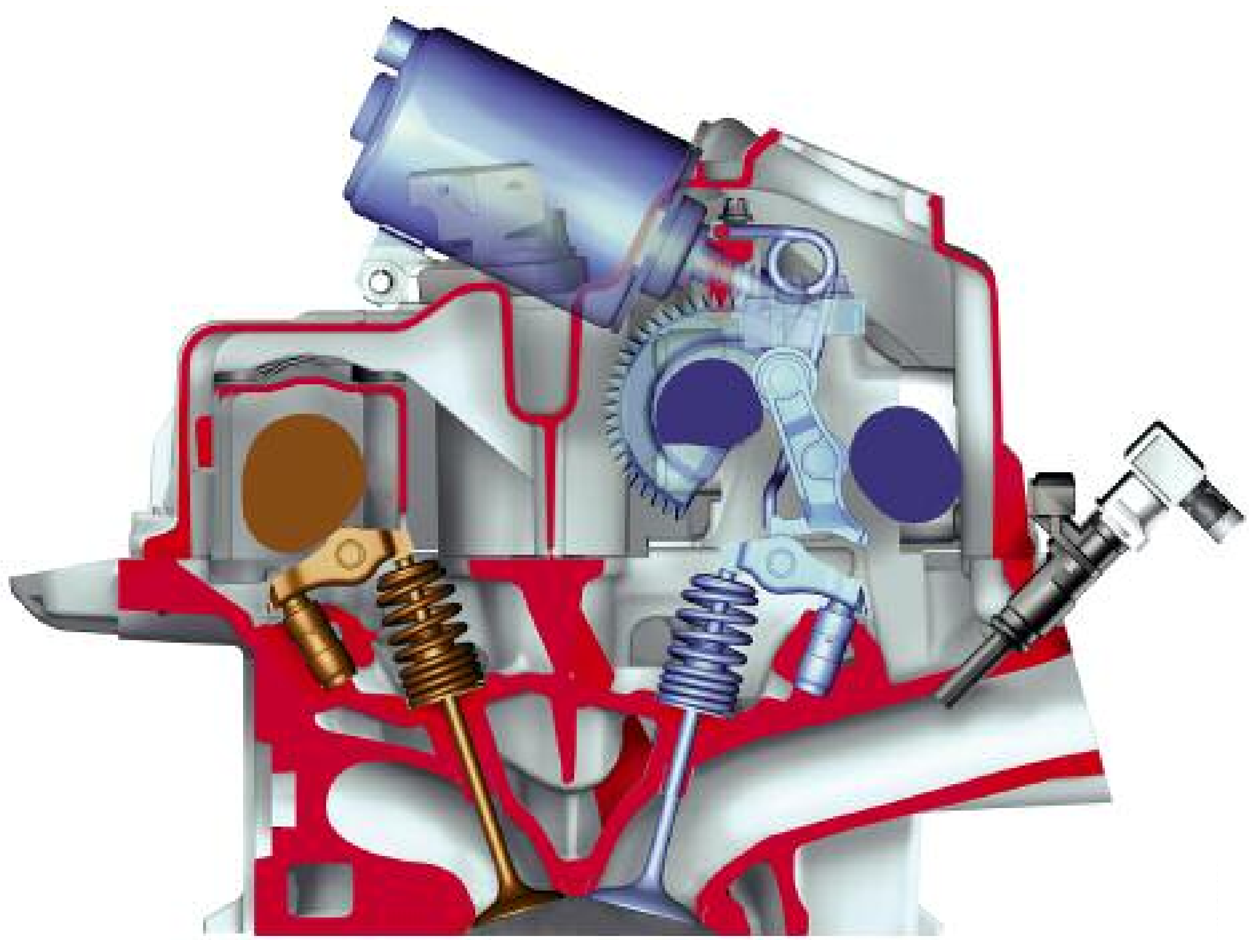
The ECM receives the ambient temperature information from the outside temperature sensor .

Schematic on 5 Series showing crankcase ventilation heating circuit.



Valvetronic II

With the introduction of the N52, the 6-cylinder engine is now also equipped with the load control system based on the valve timing gear. The VALVETRONIC I system that was used on the 8 and 12-cylinder engines already achieved a substantial increase in efficiency.



BMW has further developed this concept with the VALVETRONIC II.

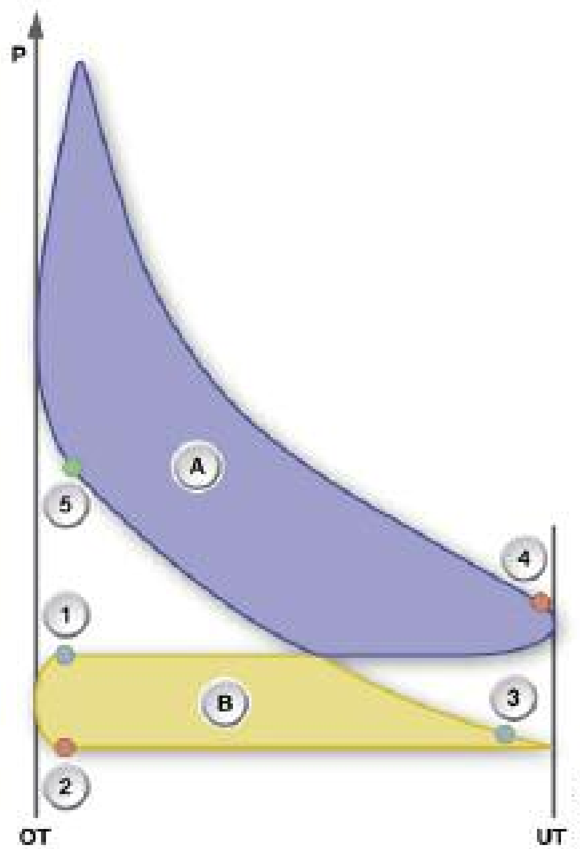
The results of this further development are:

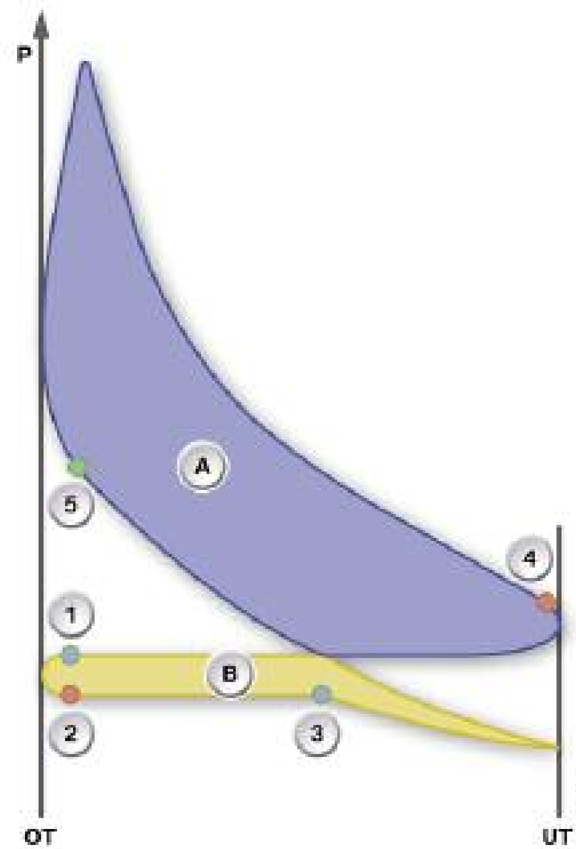
- Increased engine dynamics
- Increased efficiency
- Improved emission values

These results underscore BMW-specific standards. The new N52 engine features the following optimizations which further enhances the Ultimate Driving Machine.

- The top engine speed has been increased to 7,000 rpm
- The specific power output has been increased to 63.4 kW/l
- The specific engine torque is 100 Nm/l over a broad engine speed range
- Distinctly increased valve acceleration values and friction-optimized transmission elements result in an even more responsive engine
- CO emissions reduced
- The world's most stringent exhaust emission regulations are complied with

Load Control





Index	Explanation	Index	Explanation
OT	Top dead center	4	Exhaust valve opens
UT	Bottom dead center	5	Firing point
1	Intake valve opens	A	Gain
2	Exhaust valve closes	B	Loss
3	Intake valve closes	P	Pressure

The illustration on the left shows the conventional method with the slightly higher loss. The reduced loss can be clearly seen in the illustration on the right. The upper area represents the power gained from the combustion process in the petrol engine. The lower area illustrates the loss in this process.

The loss area can be equated to the charge cycle, relating to the amount of energy that must be applied in order to expel the combusted exhaust gasses from the cylinder and then to draw the fresh gasses again into the cylinder.

Apart from the full load setting, the intake of fresh gasses in a throttle valve controlled engine always takes place against the resistance offered by the throttle valve to the inflowing gasses. The throttle valve is virtually always fully opened during intake on the VALVETRONIC-controlled engine. The load is controlled by the closing timing of the valve.

Compared to the conventional engine where the load is controlled by the throttle valve, no vacuum occurs in the intake manifold. This means no energy is expended for the purpose of producing the vacuum. The improved efficiency is achieved by the lower power loss during the intake process.

A minimum vacuum in the intake system is required for the crankcase ventilation and evaporative purge systems. The throttle valve is slightly adjusted for this purpose.

Function

The VALVETRONIC II consists of the fully variable valve lift control combined with the variable camshaft control (double VANOS). The valve lift is controlled only on the intake side while the camshaft (VANOS) is adjusted also on the exhaust side.

The throttle-free load control is implemented by:

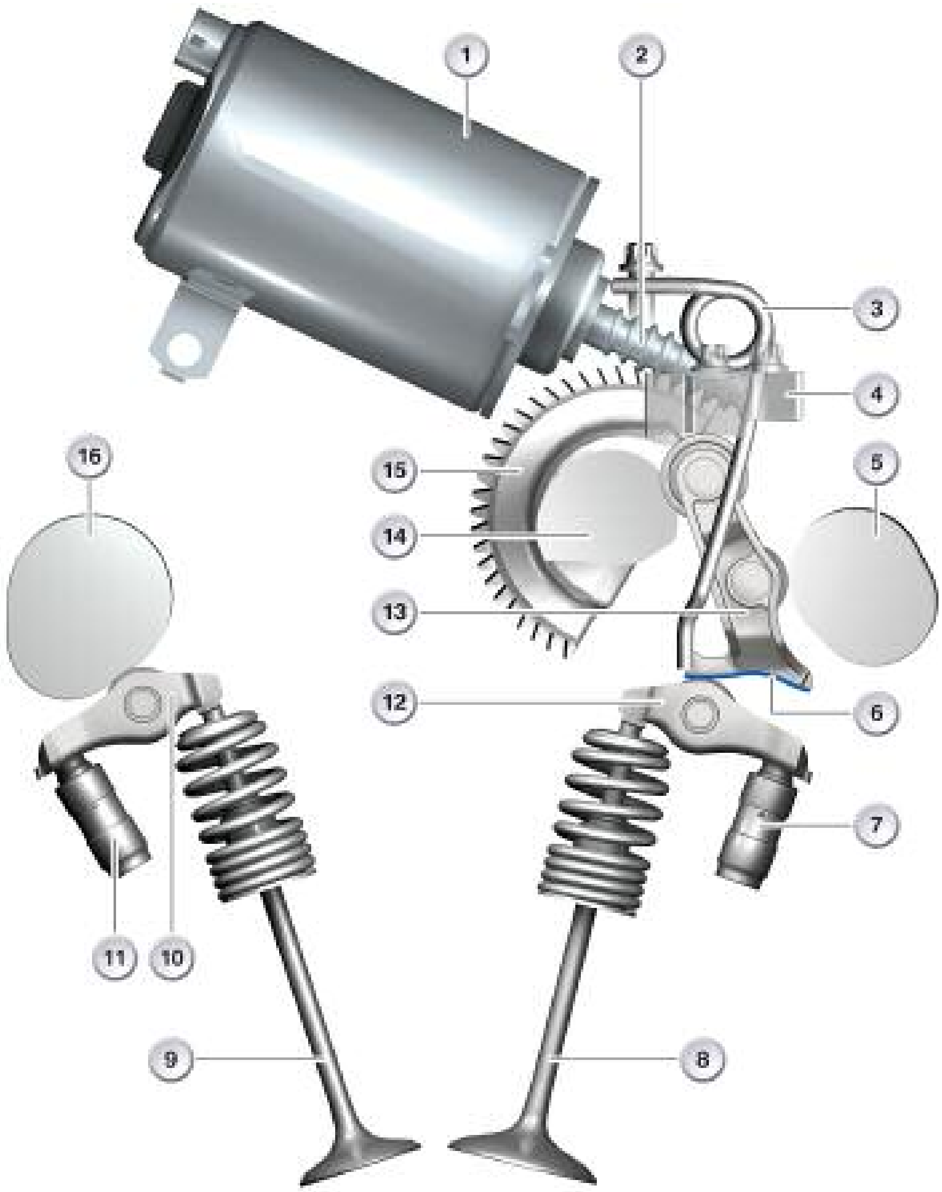
- variable valve lift of the intake valve,
- variable valve opening timing of the intake valve and
- variable camshaft spread of the intake and exhaust camshaft.

System optimization includes modification of the valve gear kinematics, a modified actuator motor and the adapted spread range of the VANOS units.

The main differences are:

- The plain bearing on the intermediate lever to the eccentric shaft has been replaced by a roller bearing, thus reducing the friction in the valve timing gear.
- Guidance of the intermediate lever is more precise. Only one spring is now required to guide and hold the intermediate lever.
- The moved mass of the valve timing gear has been reduced by 13%.
- The lift range of the intake valves has been improved. The maximum lift has been increased to 9.9 mm but more importantly the minimum lift has been further reduced to 0.18 mm.

The overall result is supported by further improvements in the intake manifold and exhaust dynamics.



Index	Explanation	Index	Explanation
1	Actuator	9	Exhaust Valve
2	Worm Shaft	10	Roller Cam Follower
3	Return Spring	11	HVA, exhaust
4	Gate Block	12	Roller Cam Follower, Intake
5	Intake Camshaft	13	Intermediate Lever
6	Ramp	14	Eccentric Shaft
7	HVA, Intake	15	Worm Gear
8	Intake Valve	16	Exhaust Camshaft

The fully variable valve lift control is realized with the aid of an actuator motor (1), an eccentric shaft (14), an intermediate lever (13), the return spring (3), the intake camshaft (5) and the roller cam follower (12). The actuator motor is installed in the cylinder head above the camshafts. It serves the purpose of adjusting the eccentric shaft. The worm shaft of the electric motor meshes with the worm gear mounted on the eccentric shaft. Following adjustment, the eccentric shaft does not have to be locked in position as the worm gear is sufficiently self-locking. The eccentric shaft adjusts the valve lift on the intake side.

The intermediate lever varies the transmission ratio between the camshaft and the roller cam follower. The valve lift (9.9 mm) and opening time are at a maximum in the full load position.

The valve lift (0.18 mm) and opening time are set to minimum in the idling position. The roller cam followers and the associated intermediate levers are divided into four classes. A corresponding code number is punched on the components. They always have the same class per pair. Assignment of the roller cam followers and the intermediate levers at the production plant ensures that the cylinders are uniformly charged even at the minimum valve lift of 0.18 mm.

Valvetronic II at minimum valve lift

Valvetronic II at maximum valve lift

Eccentric Shaft Sensor

The eccentric shaft sensor (3) signals the position of the shaft back to the DME.

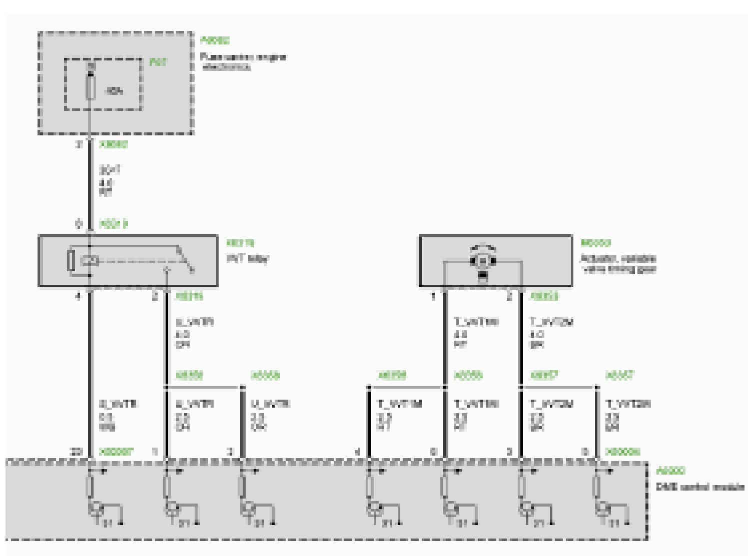
This sensor operates based on the magnetoresistive principle: A ferromagnetic conductor changes its resistance when the applied magnetic field changes its position.

For this purpose, a magnetic wheel (1) that contains a permanent magnet is mounted on the eccentric shaft. As the shaft rotates, the magnetic field lines of the magnet intersect the magnetically conductive material in the sensor. The resulting change in resistance is used as a correcting variable for the signal for the engine control unit.

The magnetic wheel must be secured on the eccentric shaft by means of a non-magnetic screw (2) otherwise the sensor will not function.

VVT Motor and Relay

The VVT motor is controlled directly by the ECM. The motor receives power from a relay located in the E-Box.



Phasing

The new VALVETRONIC II, is a very fast and exact engine control system. So-called phasing is implemented to assist adjustment in the lower valve lift range. The intake valves of a cylinder are opened synchronously up to a lift of 0.2 mm. Valve 1 then begins to lead (advance). Therefore, valve 2 opens with a slight delay behind valve 1 and catches up to valve 1 again at a lift of approximately 6 mm. From here on they open synchronously again.

This opening characteristic has a favorable effect on the inflow of gasses into the cylinder. By keeping the opening cross section of the intake valves small this results in a distinctly higher flow rate at a constant intake volume. In connection with the geometry in the upper area of the combustion chamber, this higher flow rate is used to mix the air/fuel mixture more effectively.

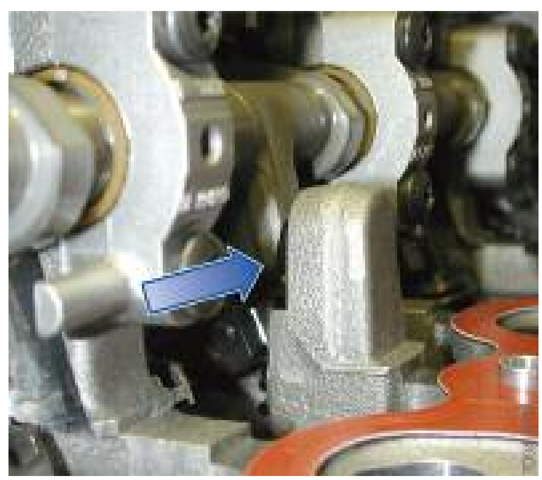
This phasing eliminates the need for the turbulence ports used on the previous generation six-cylinder engines. The phasing feature of the Valvetronic creates the necessary turbulence (swirl) in the combustion chamber.

MIN/MAX Stops

A stop routine can be implemented between the mechanical stops in order to detect the positions of the mechanical stops. For this purpose, the eccentric shaft is adjusted from zero lift to full lift. The stop routine is executed only when the motor electronics determines implausible values during the engine start procedure. This routine can also be initiated by the diagnosis systems.

Eccentric Shaft - MIN Stop

Eccentric Shaft - MAX Stop



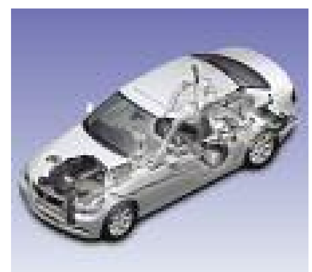
Fuel Supply and Management

Fuel Tank

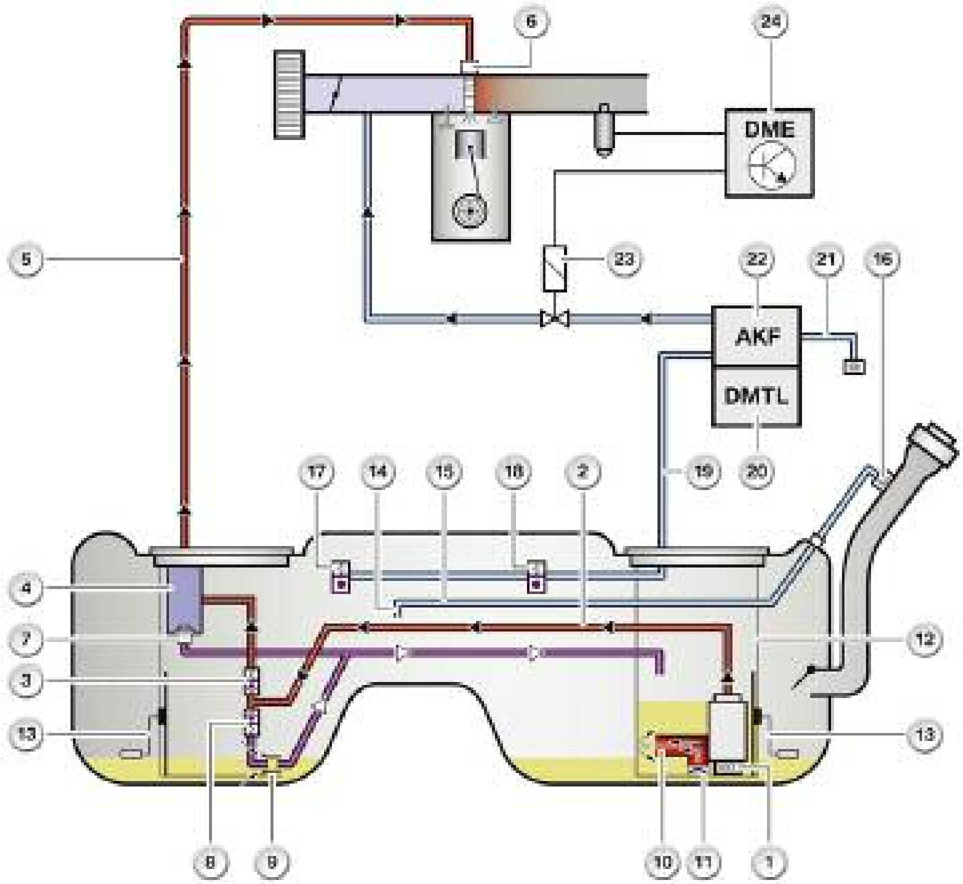
The fuel tank has a capacity of 60 liters including a 6 liter reserve. It is made from 6- layer polyethylene plastic. The fuel tank is located ahead of the rear wheels above the drive shaft and exhaust system. It is held by two tensioning straps and is additionally bolted to a connected bracket.

The fuel level sensor, electric fuel pump and the fuel filter with pressure regulator are accessible through the two service openings.

The fuel filler neck is secured with two hose clips on the right-hand side of the fuel tank. It has an electrically conductive plastic inner layer (10 % conductive particles) for the purpose of diverting electrostatic charge via the fuel filler neck.



Fuel Supply System Overview



Index	Explanation	Index	Explanation
1	Electric Fuel Pump	13	Fuel Level Sensor
2	Feed Line	14	Refuelling Line Connection Piece
3	Check Valve	15	Refuelling Ventilation Line
4	Fuel Filter	16	Refuelling Ventilation
5	Feed Line to Engine	17	Left Operation Ventilation Valve
6	Fuel Injector	18	Right Operation Ventilation Valve
7	Pressure Regulator	19	Operation Ventilation Line
8	Check Valve	20	Diagnosis Module for Tank Leakage (DM-TL)
9	Left Suction Jet Pump	21	Atmosphere Line
10	Right Suction Jet Pump	22	Carbon Canister
11	Initial Filling Valve	23	Fuel Tank Vent Valve
12	Fuel Baffle	24	Digital Motor Electronics

Fuel Delivery Unit

The fuel delivery unit is located inside the fuel tank. It consists of the following:

In the right half of the fuel tank

- Fuel baffle with electric fuel pump (EKP), right fuel level sensor and right suction jet pump.

In the left half of the fuel tank:

- Fuel filter with pressure regulator, left fuel level sensor and left suction jet pump.

The components are firmly connected to the respective service cover. When replacing the electric fuel pump, it can be removed from the fuel tank complete with the service cover, fuel baffle, suction jet pump and fuel level sensor.

Fuel Supply

The fuel is delivered from the fuel tank to the engine in the following sequence:

- From the right half of the fuel tank
- through the initial filler valve (11),
- into the fuel baffle (12),
- from the electric fuel pump (1),
- via a T-piece, on the one side, through the check valve (3) into the fuel filter (4),
- through the feed line (5) in the left-hand service opening to the engine,
- and, on the other side, via the cold start valve (8) to the left-hand suction jet pump (9) back into the fuel baffle,
- parallel from the electric fuel pump to the right-hand suction jet pump (10),
- and from the right half of the fuel tank into the fuel baffle.

The fuel filter (4) and pressure regulator (7) are located at the left-hand service opening. The cold start valve (8) opens at a fuel pressure above 2.5 bar. It ensures the engine receives sufficient fuel before the left suction jet pump cuts into the circuit.

On the N52 engine, the pressure regulator (7) routes the fuel back into the fuel baffle (12). A 5 bar pressure regulator is used for vehicles with the N52 engine.

Carbon Canister AKF

The carbon canister AKF (with DMTL) is located in the rear right wheel arch.

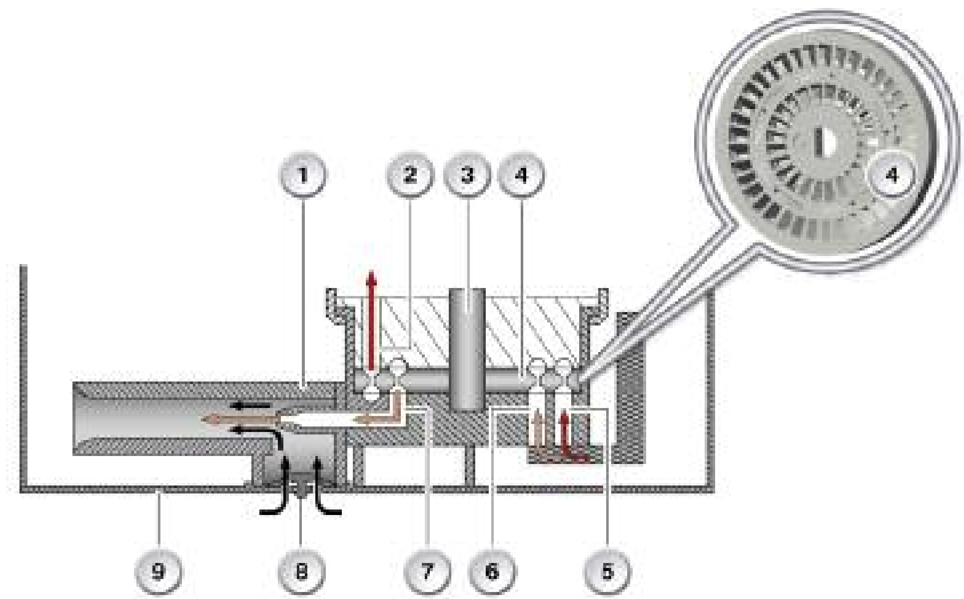
Electric Fuel Pump

The electric fuel pump delivers fuel simultaneously through two separate circuits into a main channel and a secondary channel.

The main channel is used for conveying fuel to the fuel supply system. The secondary channel supplies the right hand suction jet pump with fuel.

Channels are located above the pump wheel, in which a helical flow circulation is produced by the position of the delivery blades.

The fuel is thus conveyed from the intake side to the outlet side. An electric fuel pump with increased output is used in connection with the N52 engine and has a delivery capacity of 95 l/h at 5 bar.



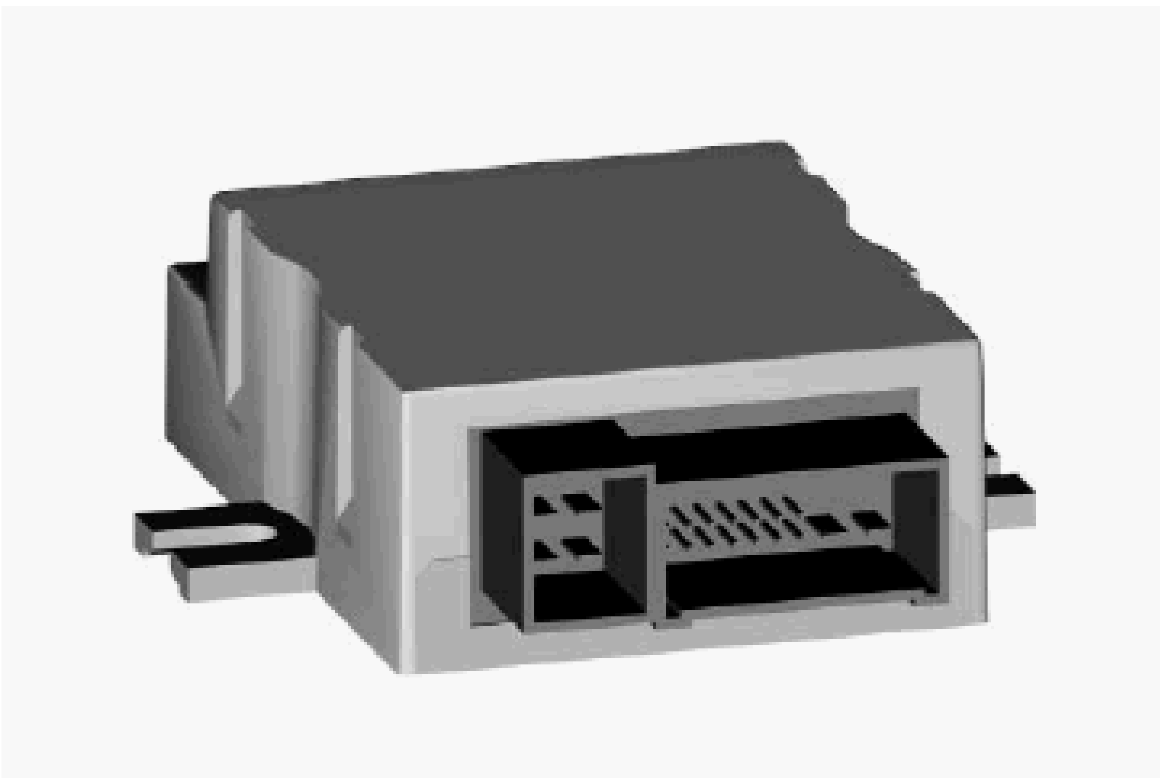
Index	Explanation	Index	Explanation
1	Suction jet pump	6	Intake opening, secondary channel
2	Main channel in supply	7	Secondary channel to suction jet pump
3	Driveshaft from electric motor	8	Initial filling valve
4	Impeller	9	Fuel baffle
5	Intake opening, main channel		

Fuel Pump Control

In conventional systems, the electric fuel pump is operated continuously at maximum speed using the highest on-board supply voltage available. The maximum amount of fuel that may be required is made available regardless of the operating conditions.

In vehicles equipped with the N52 engine, the fuel pump control is now managed by the EKP module. The fuel pump is now a variable speed controlled pump. The EKP module makes it possible to supply only the fuel needed for engine operation.

This eliminates excess fuel delivery. The fuel pump wear is reduced and the running losses are kept to a minimum.



Note: In this case, EKP stands for the "Electronic fuel pump control" system. The EKP abbreviation is often used to refer to the electric fuel pump itself. The electronically controlled fuel pump system described here is controlled by a control unit called the EKP control unit. The abbreviation EKP is used here to refer to the system as a whole.

The ECM (DME) is connected to the EKP module via the PT-CAN network. The electric fuel pump in the EKP system is activated as required. The DME calculates the amount of fuel required at the given point in time. The total volume required is transmitted as a message to the EKP control unit via PT-CAN.

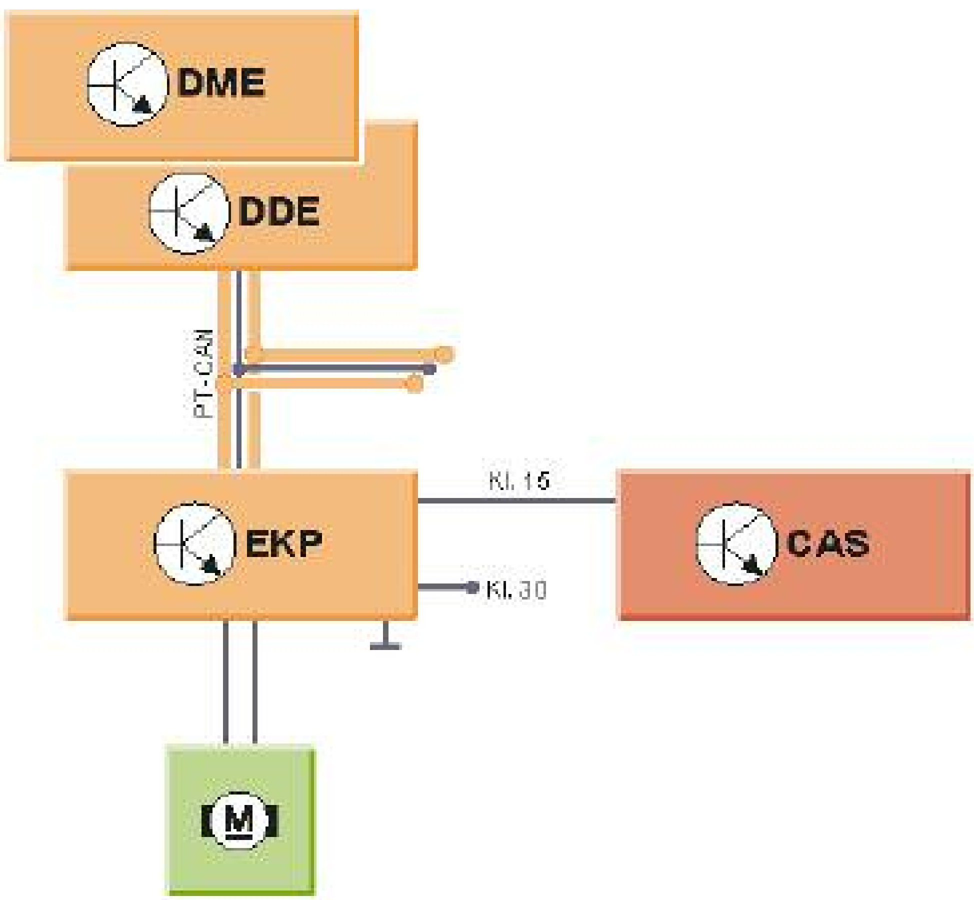
The EKP control unit controls the electric fuel pump on the basis of mappings so that the electric fuel pump delivers the exact amount of fuel required.

The EKP control unit converts this message into an output voltage. This output voltage is then used to control the speed of the electric fuel pump. This achieves a delivery which corresponds with the requirements.

The electric fuel pump is capable of delivering up to 95 liters per hour at a pressure of 5 bar.

The illustration shown below is from an E90. The EKP module on the E90 contains one of the terminating resistors for the PT-CAN.

EKP Circuit (E90)



Principle of Operation

Fuel requirement mappings are stored in the EKP control unit. The fuel requirement mappings are encoded for each specific engine and model. The EKP control unit uses the mappings as the basis on which to calculate the total amount of fuel to be delivered from the following reference variables:

- Amount of fuel required by the engine (request from the ECM)

This results in a pulse-width modulated output voltage from the EKP control unit. The output voltage of the EKP control unit is the supply voltage for the electric fuel pump. The EKP control unit controls the speed of the electric fuel pump via the supply voltage. The EKP control unit controls the speed by comparing the actual speed with the specification.

The current speed of the electric fuel pump is calculated as follows:

The EKP control unit sends the current supply to the fuel pump (pulse-width modulated). This voltage is absorbed as a specific ripple due to the individual armature windings of the rotating electric motor. The ripple corresponds with the number of segments in the commutator which corresponds with the number of armature windings in the electric motor.

The number of waves produced per revolution is equal to the number of existing commutator segments.

This means that the EKP control unit can employ a patented procedure - "Ripple Counter" as the basis for calculating the actual speed of the fuel pump using power consumption ripple.

Component Location

The location of the EKP module is as follows:

- E60, E61 - in the luggage compartment on the right hand side next to the suspension strut dome
- E90 - in the vehicle interior on the right next to the rear-seat backrest

Emergency Operation

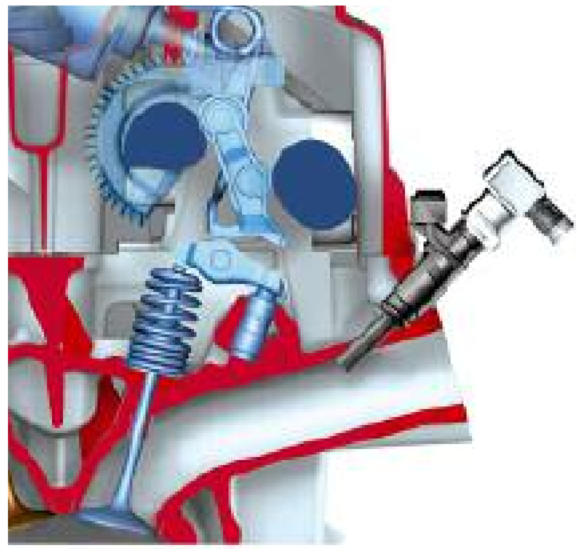
In the event that communication with the DME or DDE fails or is faulty, the EKP control unit will switch to emergency operation. The electric fuel pump is fully activated.

Coding and Programming

The data for the electronically controlled fuel pump system is encoded as follows:

- In the ECM (DME), the engine and model-related characteristic curves for fuel delivery according to requirements.
- In the EKP control unit: specific characteristic curves for the relevant fuel system

Fuel Injectors/Fuel Rail



Due to the wider design of the cylinder head, the fuel injectors are not located in the intake manifold as on previous 6-cylinder engines. The injectors are now mounted into machined bore in the cylinder head. This design allows the injectors to be closely mounted to the intake valves.

The injectors are a compact design manufactured by Deka with a resistance value of approximately 12 ohms each.

Power supply for the fuel injectors is from Terminal 87 of the fuel injector relay.

The fuel rail is a non-return design which includes a service port for diagnosis.

Workshop Exercise - Fuel System

Using an instructor designated vehicle, perform a complete vehicle short test. Access the EKP module using the control module function screen. Complete the following table below using diagnosis requests.

	Actual Fuel Pump Speed	Fuel Pump Voltage	Fuel Pump Current
Terminal 15 ON (Engine OFF)			
Engine at idle			
Engine at part load (3500-4000 rpm)			

Interrupt communication between the EKP module and the ECM by removing KL30 power from the ECM. (pull fuse). Record result below.

	Actual Fuel Pump Speed	Fuel Pump Voltage	Fuel Pump Current
Terminal 15 ON, power removed from ECM			

What is observed regarding fuel pump operation when the ECM and EKP cannot communicate?

Using the ETM, locate the schematic for the EKP module. Locate EKP module in this vehicle.

Does the EKP module in this vehicle contain a terminating resistor for the PT-CAN? If not, which vehicles have the terminating resistor in the EKP module?

If this vehicle has a terminating resistor, measure the resistance and record below:

What is the maximum fuel pressure in this system?

Workshop Exercise - DISA

Using an instructor designated vehicle, connect a breakout box to the ECM. Locate the signal lines for DISA actuators 1 and 2. Monitor the signals using the oscilloscope.

Complete the table below using the results obtained.

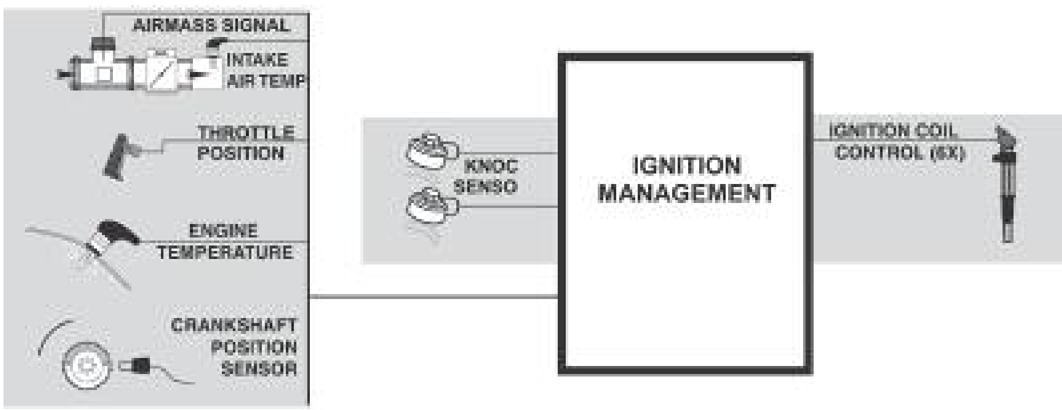
DISA Actuator 1	Frequency	Duty Cycle	Voltage
Engine OFF, Key in KL15			
Engine running at idle			
Engine at 3500 RPM			

DISA Actuator 2	Frequency	Duty Cycle	Voltage
Engine OFF, Key in KL15			
Engine running at idle			
Engine at 3500 RPM			

Ignition Management

Ignition System Inputs

The ignition system on the MSV70 engine management system uses several inputs to control ignition functions. Proper ignition timing control is dependent upon inputs such as RPM, throttle position, crankshaft position, air mass and temperature (coolant and intake air).



Ignition Coils

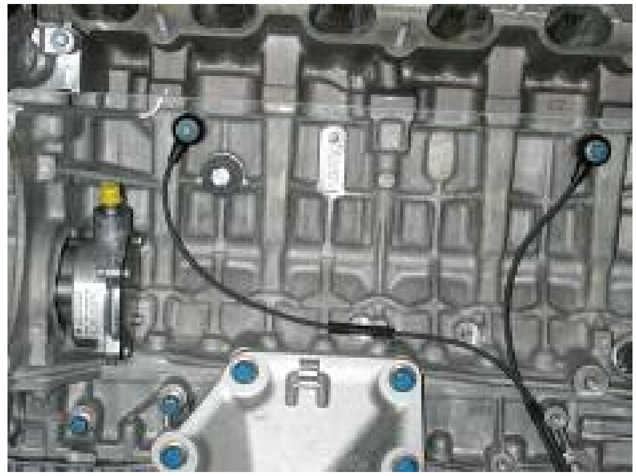
The ignition coils are the familiar “pencil” type manufactured by Bosch. The secondary ignition “boot” and resistor are integrated into the coil housing.

Spark Plugs

The new spark plugs used on the N52 are a new design by NGK. The plugs use an Iridium center electrode. The center electrode is only .6 mm thick. The insulator is also redesigned. The new spark plug technology allows for longer service life and improved cold starting.

Iridium is a precious metal that is 6 times harder and 8 times stronger than platinum, it has a 1,200° F higher melting point than platinum and conducts electricity better.

Knock Sensors



The “dual” knock sensors are located under the intake manifold. The sensors can only be replaced as a pair, they are connected at a single connector. Each knock sensor is responsible for monitoring 3 cylinders (1-3 and 4-6) respectively.

The knock sensors operate on the piezo electric principle. Vibrations from combustion events are converted into electrical signals which are monitored by the ECM. Excessive vibration indicates engine knock which will cause the ECM to retard the ignition timing to retard as necessary.

Excessive knocking will cause the MIL to illuminate.

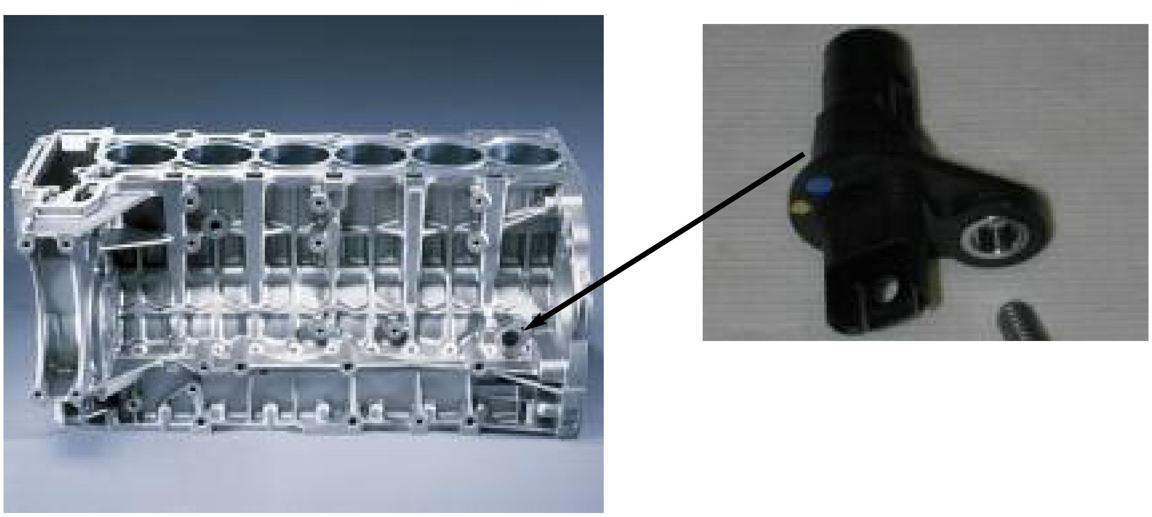
Note: When installing knock sensors, be sure to torque to specification. Under or over-tightening the knock sensors can result is erroneous knock sensor faults or poor engine performance.

Crankshaft Position Sensor

Located on the driver’s side of the engine block neat the starter, the crankshaft position sensor provides the ECM with a 5 volt square wave signal. The ECM calculates engine speed (RPM) and crankshaft position for ignition and injection system operation.

The sensor is supplied with 12 volts from the engine electronics fuses and ground from the ECM.

The crankshaft position sensor is also monitored for variations in crankshaft speed to determine misfires.



Emissions Management

Emission Standard

The Siemens MSV70 engine management system meets the ULEV II standard for 2006.

Bosch LSU Oxygen Sensor

The oxygen sensor used on the N52 is the new Bosch LSU 4.9 sensor. Compared with the LSU 4.2 oxygen sensor previously used, the LSU sensor is twice as fast. Full operational readiness is achieved after 10 seconds (LSU 4.2 20 seconds).

This rapid starting capability is made possible by the use of a smaller ceramic element. The outer dimensions of the sensor remain unchanged.

The previous opening for the supply of ambient air has been eliminated. The new sensor differs from the LSU 4.2 in that a porous layer which is permeable by air is used instead of a reference air channel. The ambient air is directed to the element via the connecting cable.

Post Catalyst Oxygen Sensor

The post catalyst oxygen sensors are the Bosch LSF 4.2 type. They operate similarly to the previous LSH 25 sensors. The voltage range is .10 to 1.0 volts.

The new planar 4.2 sensors offer:

- Fast light-off (ready for control < 10 s)
- Wide operating temperature range
- Stable control characteristic
- Improved exhaust gas values

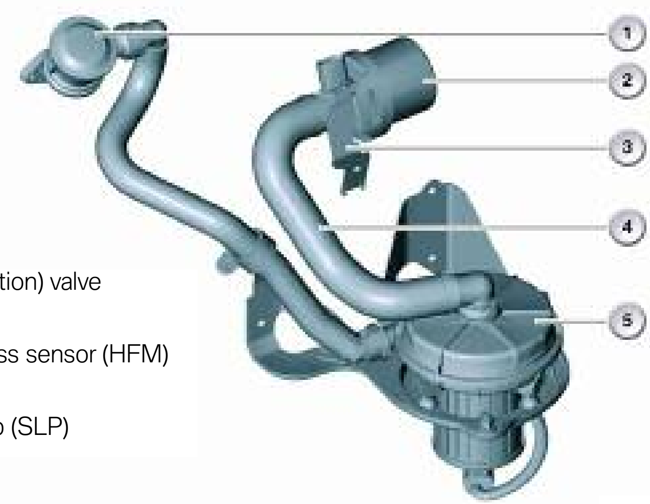
Secondary Air System

Injecting ambient air into the exhaust stream after a cold engine start reduces the warm up time of the catalysts and reduces HC and CO emissions. The ECM controls and monitors the Secondary Air Injection.

An Electric Secondary Air Pump and Air Injection Valve direct fresh air through an internal channel in the cylinder head into the exhaust ports.

The Air Injection Valve is opened by air pressure (from the pump) and is closed by an internal spring.

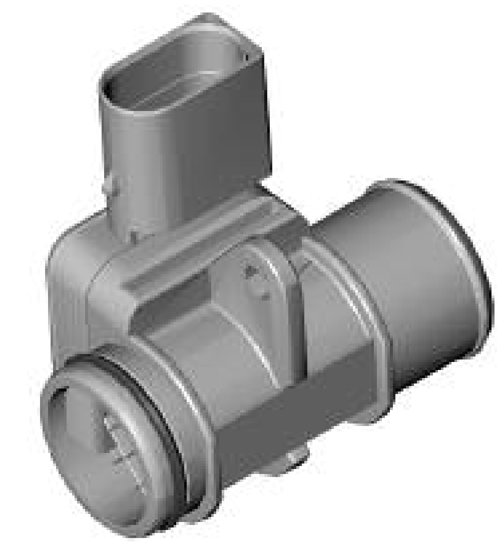
The relay for the secondary air pump is located in the E-box.



1. Secondary air (injection) valve
2. Secondary air filter
3. Mini Hot film air mass sensor (HFM)
4. Intake hose
5. Secondary air pump (SLP)

The secondary air pump is equipped with an additional intake hose (4) to accommodate a secondary air filter with the mini HFM (3). The mini HFM is secured in the secondary air cleaner with two screws.

Mini Hot Film Air Mass Sensor (HFM)



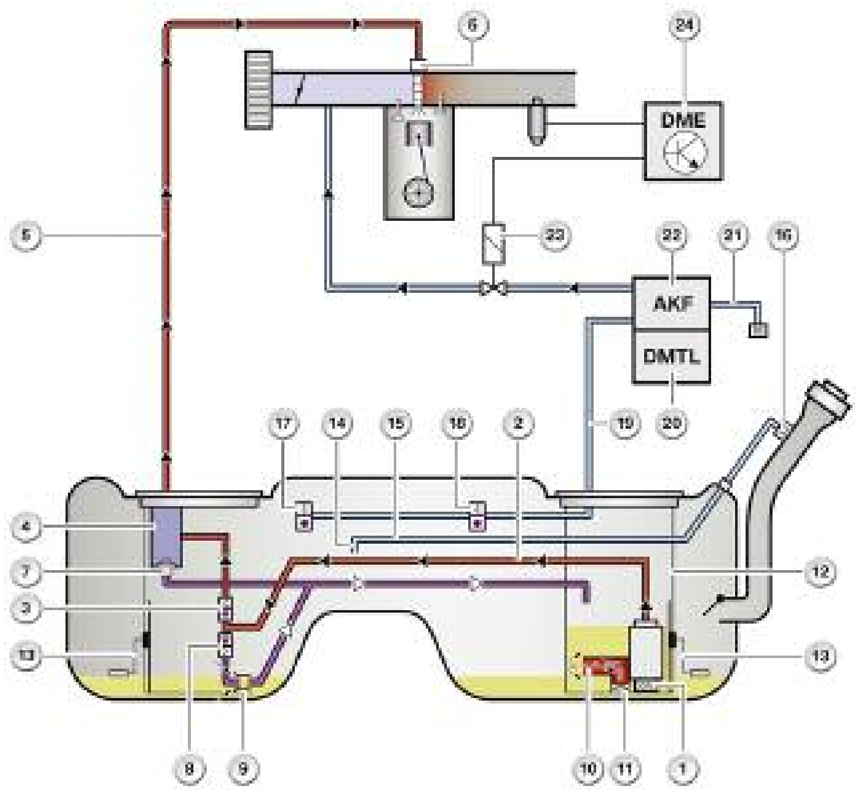
A compact mini hot film air mass sensor (HFM manufactured by Siemens) is used in the secondary air system for the N52 in the E90 (US market).

The mini HFM detects the air mass supplied by the secondary-air pump. This function monitors the secondary air system for OBD compliance.

When the mini HFM detects no air mass or insufficient air mass, a fault is stored in the ECM and the Malfunction Indicator Light (MIL) is activated.

The mini HFM has a compact pipe shaped design with O-ring connections.

On-Board Refueling Vapor Recovery (ORVR)



Index	Explanation	Index	Explanation
1	Electric Fuel Pump	13	Fuel Level Sensor
2	Feed Line	14	Refuelling Line Connection Piece
3	Check Valve	15	Refuelling Ventilation Line
4	Fuel Filter	16	Refuelling Ventilation
5	Feed Line to Engine	17	Left Operation Ventilation Valve
6	Fuel Injector	18	Right Operation Ventilation Valve
7	Pressure Regulator	19	Operation Ventilation Line
8	Check Valve	20	Diagnosis Module for Tank Leakage (DM-TL)
9	Left Suction Jet Pump	21	Atmosphere Line
10	Right Suction Jet Pump	22	Carbon Canister
11	Initial Filling Valve	23	Fuel Tank Vent Valve
12	Fuel Baffle	24	Digital Motor Electronics

The ORVR system recovers and stores hydrocarbon fuel vapors during refuelling. When refueling the E90, a downward open adapter (14) is located on the refuelling ventilation line (15) in the fuel tank. During the refuelling procedure, the air can escape out of the tank via the refuelling ventilation line (15) and the fuel filler neck.

When the fuel level rises up to the opening of the refuelling ventilation line, it is closed off and the fuel level increases in the fuel filler neck up to the fuel station pump. The fuel station pump then switches off automatically.

After the fuel station pump has switched off, an expansion volume (approx. 10 liters) remains above the refuelling ventilation line.

Ventilation During Engine Operation

The fuel vapors produced in the fuel tank pass:

- through the operation ventilation valves (17 + 18)
- through the ventilation line (19),
- into the carbon canister AKF (20),
- through the purge air line and
- through the fuel tank vent valve TEV (22),
- to the engine intake manifold.

The two operation ventilation valves are located above the refuelling ventilation adapter (14). They are connected by a line. The left operation ventilation valve (17) only has a ventilation function while the right operation ventilation valve (18) additionally has a pressure holding function (50 mbar).

The aim of the pressure holding function is to avoid the remaining air of the expansion volume escaping via the carbon canister while refuelling (with refuelling ventilation line closed).

Carbon Canister

As the hydrocarbon vapors enter the canister, they will be absorbed by the active carbon. The remaining air will be vented to the atmosphere through the end of the canister, DM TL and filter, allowing the fuel tank to “breath”.

When the engine is running, the canister is "purged" using intake manifold vacuum to draw air through the canister which extracts the HC vapors into the combustion chamber.

The Carbon Canister with DM TL and air filter are located at the right rear underside of the vehicle, below the luggage compartment floor.

Evaporative Emission Valve

This ECM controlled solenoid valve regulates the purge flow from the Carbon Canister into the intake manifold. The ECM Relay provides operating voltage, and the ECM controls the valve by regulating the ground circuit. The valve is powered open and closed by an internal spring.

If the Evaporative Emission Valve circuit is defective, a fault code will be set and the “Malfunction Indicator Light” will illuminate when the OBD II criteria is achieved.

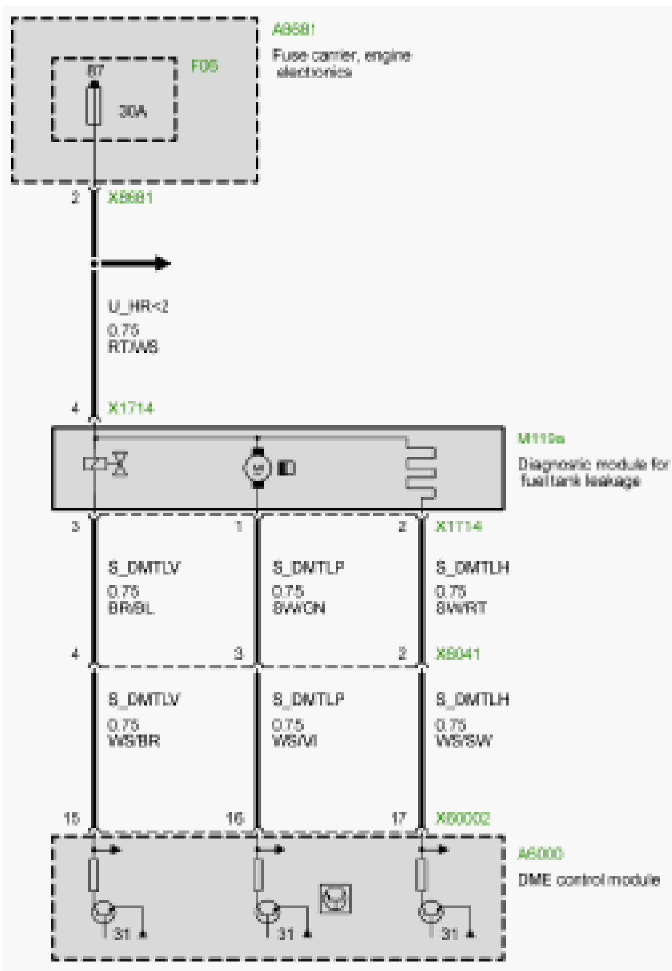
If the valve is “mechanically” defective, a driveability complaint could be encountered and a mixture related fault code will be set.

Evaporative Leakage Detection (DM TL)

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

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

To prevent condensation buildup in the DM-TL pump, a heating element is integrated into the housing of the pump. The heating element is ground controlled by the ECM.

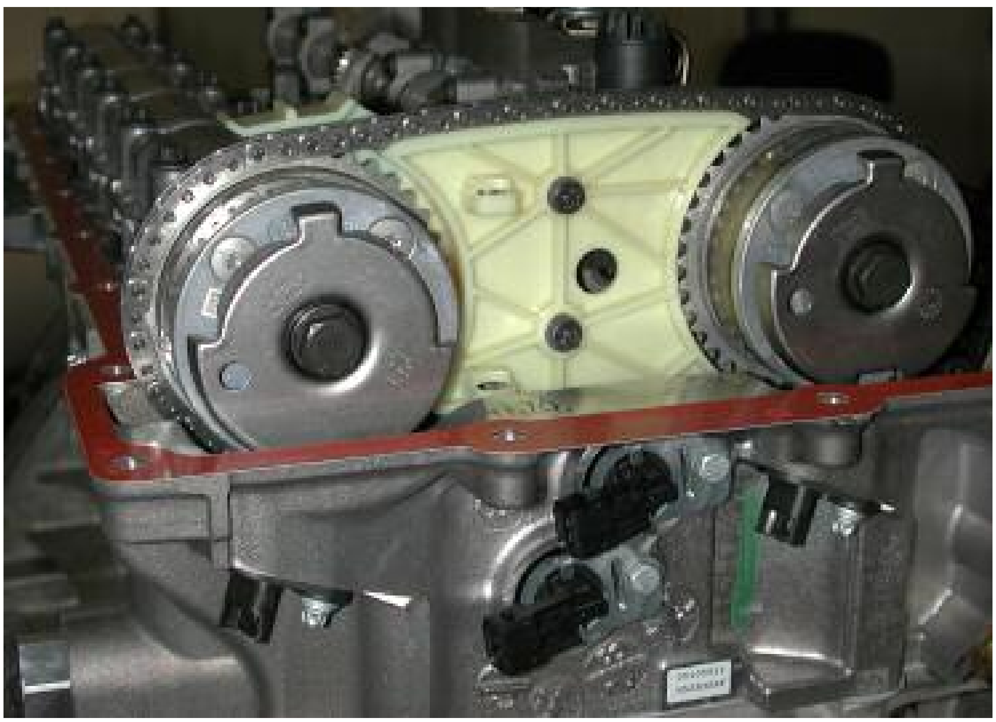


Performance Controls

VANOS

Performance, torque, idle characteristics and exhaust emissions reduction are improved by Variable Camshaft Timing. The VANOS system on the N52 is weight optimized and is similar in design to the VANOS on the N62.

The Vanos units are mounted directly on the front of the camshafts and adjusts the timing of the Intake and Exhaust camshafts throughout the entire spread range from retarded to advanced. The ECM controls the operation of the VANOS solenoids which regulates the oil pressure required to move the VANOS units. Engine Rpm, load and temperature are used to determine VANOS activation.



The VANOS mechanical operation is dependent on engine oil pressure applied to position the VANOS units. When oil pressure is applied to the units (via ports in the camshafts regulated by the solenoids), the camshaft hubs are rotated in the drive sprockets changing the position which advances/retards the intake/exhaust camshafts timing. The VANOS system is “fully variable”. When the ECM detects that the camshafts are in the optimum positions, the solenoids maintain oil pressure on the units to hold the camshaft timing.

The operation of the VANOS solenoids are monitored in accordance with the OBD II requirements for emission control. The ECM monitors the final stage output control and the signals from the Camshaft Position Sensors for VANOS operation.

Solenoid Valves

The VANOS solenoid valves are mounted through the front of the cylinder head. There are two solenoids, one for the intake VANOS and one for the exhaust. The solenoids control the oil flow to the camshaft ports for the intake and exhaust VANOS units.

The 4/3 way proportional solenoid valve is activated by the ECM to direct oil flow. The solenoid valve is sealed to the head by a radial seal and secured by a retaining plate.

Camshaft Sensors

There are two camshaft sensors, one for the intake camshaft and one for the exhaust. They are mounted at the front of the cylinder head and monitor the impulse wheels which are bolted to the front of the VANOS units.

The sensors are supplied power via the engine electronics fuses. Ground is supplied via the ECM. The sensors are hall effect and provide the ECM with a 5 volt square wave signal.

Camshaft Sensor

Camshaft Sensor Trigger Wheel

Cruise Control

In the new E90 the customer can choose between two cruise control systems. The cruise control systems include - Dynamic Cruise Control (DCC) and Active Cruise Control (ACC).

DCC is the “standard” cruise control system, while ACC remain an option. DCC operates similarly to a standard cruise control system. However, the DCC is capable of brake intervention on downhill gradients to maintain set speed. Also, the system will activate the brake lights when braking intervention takes place.

DCC Switch Lever

Unlike conventional cruise control, the E90 DCC system also allows shifting and clutch application on vehicles with a manual transmission.

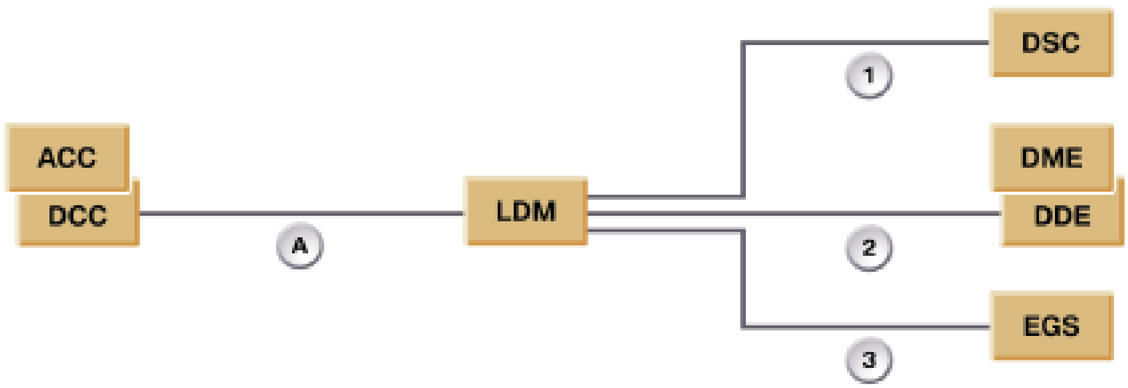
In combination with ACC and DCC, there is an additional control module - the Longitudinal Dynamic Management (LDM).

One of the responsibilities of the LDM is to forward driver input requests from ACC/DCC to the ECM (DME). Also the LDM is used to coordinate drivetrain and brake functions.

In previous BMW vehicles, acceleration control, such as "accelerating" or braking (negative acceleration), was calculated by different systems (DME/DDE, DSC, ACC etc.) in order then to activate the corresponding actuators with the relevant control signals.

This created a problem in that there was a build-up of a whole host of variants (engine, transmission and brake variants). In an E65, for example, there were 36 relevant car/engine/ transmission variants.

In order to take control of the increasing complexity over the course of time and the increase in variants, BMW has taken the decision to implement only one acceleration controller in the E90 vehicle network. This controller records the requests on the input side, calculates the corresponding setpoint variables and forwards them to the system partners such as DME/DDE, EGS, DSC, etc.



Index	Explanation	Index	Explanation
1	Wheel torque for braking	DME	Digital Motor Electronics (ECM)
2	Wheel torque for accelerating	DCC	Dynamic Cruise Control
3	Gearshift request	DSC	Dynamic Stability Control
A	+/- a_ setpoint (cruise request)	EGS	Electronic Transmission Control
ACC	Active Cruise Control	LDM	Longitudinal Dynamics Management

Connected to a longitudinal-force controller, it coordinates and controls the actuators in all the vehicle configurations. The Longitudinal Dynamics Management system (LDM) is housed in an independent new control unit which is located in the E90 behind the light module.

1. LDM Module

Exhaust Flap Control

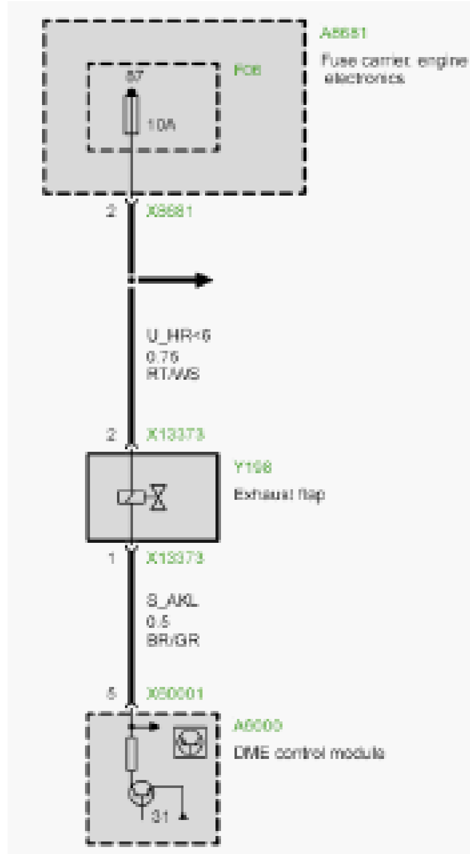
The exhaust flap is designed to reduce noise at idle, low RPM acceleration and while coasting. The exhaust flap is controlled via vacuum actuator. The vacuum actuator is supplied vacuum via the engine driven vacuum pump.

The ECM controls the flap via a vacuum vent valve located in the trunk on the left hand side.

As compared to previous vehicles, the system no longer needs a vacuum reservoir. This is due to the fact that the vacuum is not supplied by the engine and not subject to variations in intake manifold vacuum.

The exhaust flap is sprung open and closed by vacuum. The ECM will de-activate the vacuum vent valve in order to open the flap.

The flap is opened above approximately 2500 RPM. Flap operation is also dependent upon engine load.



Sport Switch (E85)

The MSV70 ECM contains two different throttle progression functions (Sport and Normal). The Dynamic Driving Control function is selected by pressing the “Sport” button located in the center console.

The switch provides a ground signal (input) to the ECM when pressed. The MSV70 system activates the sport characteristics for the Electronic throttle control (EDK). This provides an increase in throttle opening and response time over the non-sport position.

When this function is activated, the function indicator light in the Sport button is illuminated by the Electric Power Steering (EPS) Control Module. When the ignition is cycled, this function resets back to the non-sport function (it must be re-selected by the driver).

The ECM additionally provides the request for the Dynamic Driving Control function over the PT CAN bus to the following control modules:

- Electronic Power Steering
- Instrument Cluster
- EGS/SMG (if equipped)

Alternator

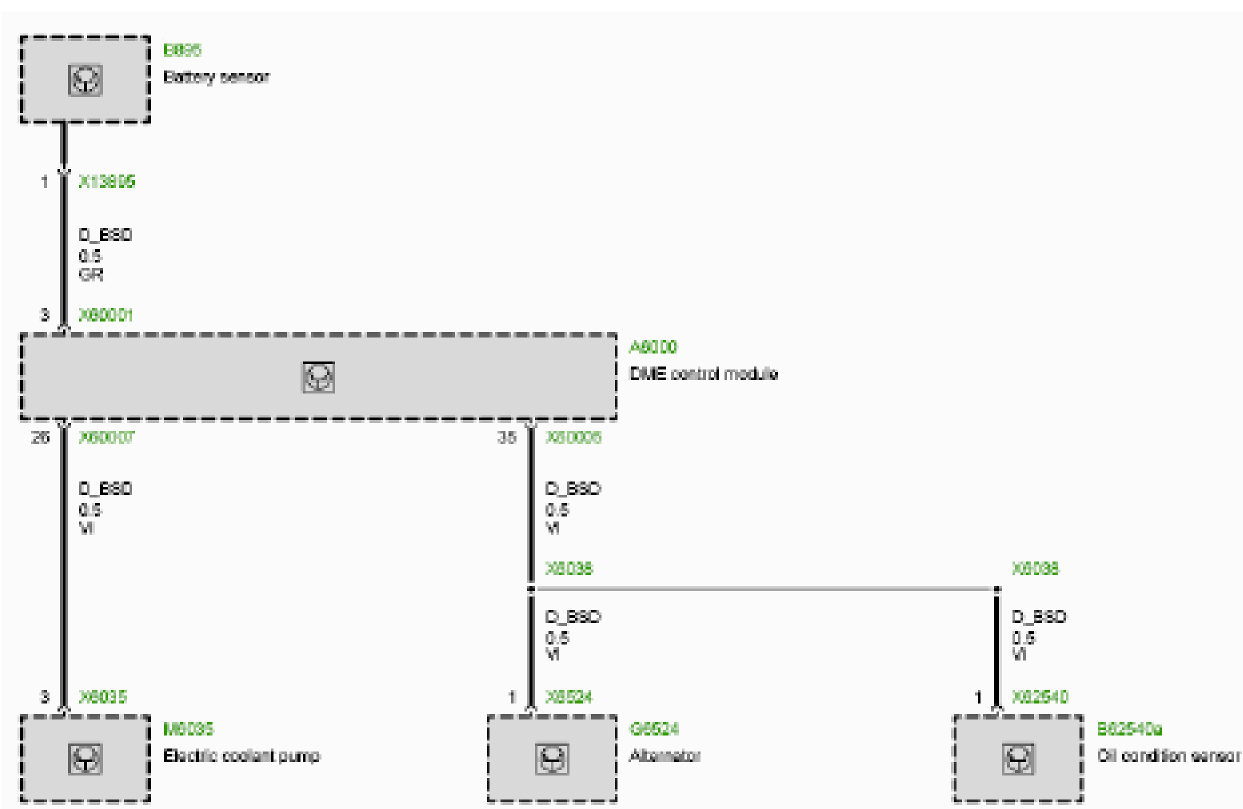
The alternator is a 180 amp unit manufactured by Valeo. The alternator pulley has been modified with a one way clutch.

The alternator communicates with the ECM via the BSD circuit. The bit-serial data interface is a single-wire data bus with a data transfer rate of 1.2 kBd.

The alternator with BSD interface can actively communicate with the engine control module. The alternator is not linked to the charge indicator lamp, only to the engine
control module. The alternator can detect a variety of faults.

Battery charge indicator lamp

The signal for the charge indicator lamp to light up is transferred across CAN to the instrument cluster. The charge indicator lamp lights up if there is mechanical and/or an electrical fault.



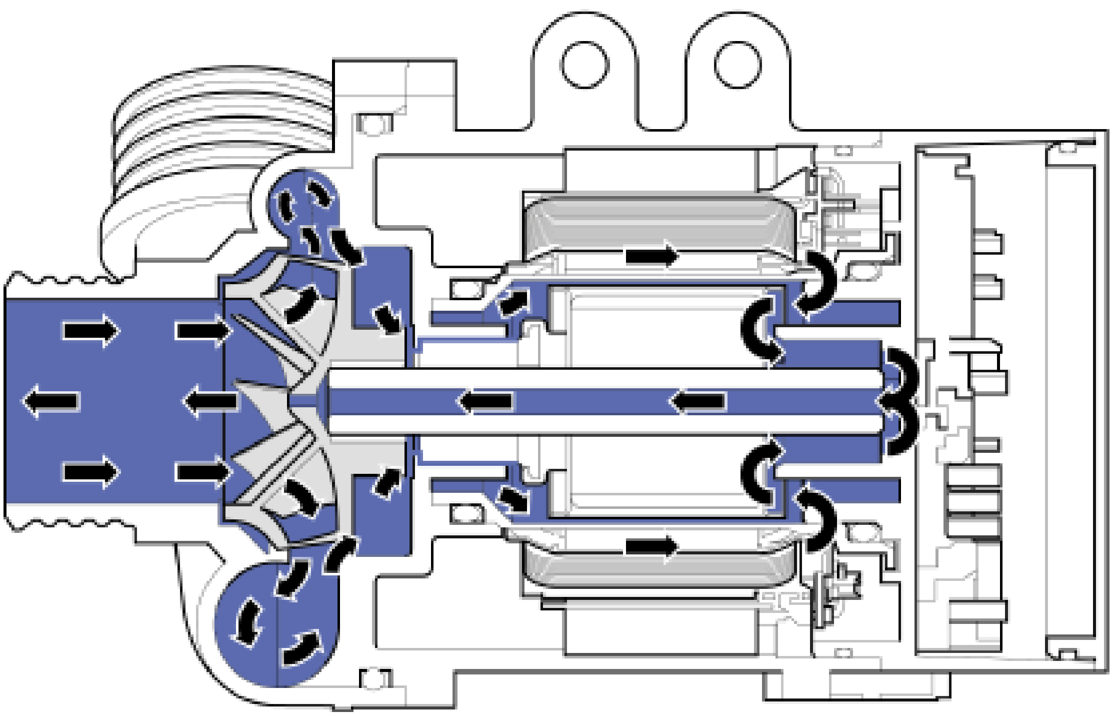
Cooling System

One of the challenges in the cooling system on current engines is having a water pump with an RPM dependent output. As RPM increases, so does the cooling system flow. This is adequate for higher RPM operation, however the large volume of coolant flow is not needed at low RPM.

To date, the delivery capacity of the coolant pump has been designed in line with the greatest possible cooling requirement of the engine which, in the majority of cases, is not required.

As a result, the surplus quantity of coolant circulates unused through the thermostat in a small circuit. The cooling system is now also optimized in such a way as to avoid this power loss situation.

In addition, the new system makes it possible to achieve temperature ranges that are adapted to the engine load.



The coolant pump on the N52 is designed as an electrically driven centrifugal pump. The output of the wet-rotor electric motor is controlled electronically by the electronic module (EWPU) located under the connection cover of the motor.

The electronic module EWPU is connected via the bit-serial data interface to the ECM (DME). The ECM determines the necessary cooling capacity from the engine load, operating mode and the data from the temperature sensor and sends the corresponding instruction to the EWPU control unit.

The coolant in the system flows through the motor of the coolant pump, thus cooling both the motor as well as the electronic module.

The coolant lubricates the bearings of the electric coolant pump.

Particular care must be taken when performing servicing work to ensure that the pump does not run dry. When the pump is removed, it should be stored filled with coolant. The bearing points of the pump could seize if the pump were not filled with coolant. This could jeopardize subsequent start-up of the pump thus rendering the entire heat management system inoperative (the pump not starting up could cause serious engine damage). If the pump should ever run dry, the pump wheel should be turned by hand before finally connecting the coolant hoses. The system should then be immediately filled with coolant.

Particular care must be taken during assembly to ensure that the connector is clean and dry and the connections are undamaged. Diagnosis should be performed only with the approved adapter cables. The information provided in the repair instructions must be observed.

Bleeding (Venting) Cooling System
After performing any service work which requires draining of the coolant. The system must be bled to ensure that there are no air pockets present. The system can be bled using the DISplus/GT-1 or by following a special procedure. To bleed the system:

1. Fill system with coolant via the expansion tank (AGB). Top up coolant level to lower edge of expansion tank.
2. Close expansion tank.
3. Switch on ignition.
4. Set heating to maximum (temperature), switch on blower (lowest stage).
5. Press accelerator pedal module to floor for at least 10 seconds. The engine must NOT be started.
6. Bleeding via EWP takes approximately 12 minutes. Then check coolant level in expansion tank, top up to MAX marking if necessary.
7. Check cooling circuit and drain plugs for leaks.
8. If the procedure needs to be repeated several times, allow DME to completely de-energize (remove ignition key for app.. 3 minutes) and then repeat procedure as from item 3.

Note: Connect battery charger if battery charge level is low.

Heat Management

The engine control unit controls the coolant pump according to requirements: low output in connection with low cooling requirements and low outside temperatures; high output in connection with high cooling requirements and high outside temperatures.

The coolant pump may also be completely switched off under certain circumstances, e.g. to allow the coolant to heat up rapidly during the warm-up phase. However, this only occurs when no heating is required and the outside temperature is within the permitted range.

The coolant pump also operates differently than conventional pumps when controlling the engine temperature. To date, only the currently applied temperature could be controlled by the thermostat. The software in the engine control unit now features a calculation model that can take into account the development of the cylinder head temperature based on load.

In addition to the characteristic map control of the thermostat, the heat management system makes it possible to use various maps for the purpose of controlling the coolant pump. For instance, the engine control unit can adapt the engine temperature to match the current driving situation. This means that four different temperature ranges can be implemented:

- 112°C Economy (ECO) mode
- 105°C Normal mode
- 95°C High mode
- 80°C High + mapped thermostat mode

The coolant control sets a higher cylinder head temperature (112°C) if the ECM determines Economy mode based on the current operating conditions.

The engine is operated with relatively low fuel consumption in this temperature range as the internal friction is reduced.

An increase in temperature therefore favors lower fuel consumption in the low load range. In HIGH and mapped thermostat mode, the driver wishes to utilize the optimum power development of the engine. The cylinder head temperature is therefore reduced to 80°C.

This results in improved volumetric efficiency, thus increasing the engine torque. The engine control unit can therefore set a certain operating mode adapted to the respective driving situation. Consequently, it is possible to influence fuel consumption and power output by means of the cooling system.

Intelligent Heat Management

The previous section dealt with the various operating modes in connection with heat management. However, an electrically driven coolant pump makes available even further options. For instance, it is now possible to warm up the engine without the recirculating the coolant or to allow the pump to continue to operate after turning off the engine to facilitate heat dissipation.

The advantages offered by this type of pump are listed in the following table:

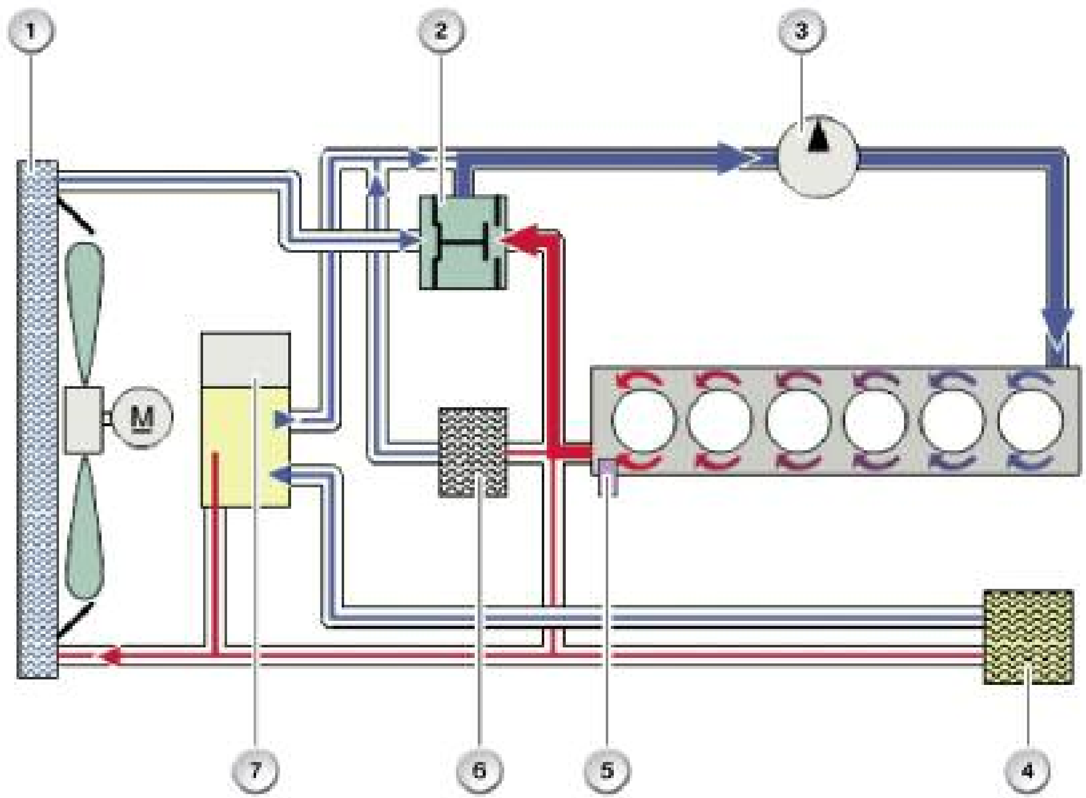
Fuel Consumption	• Faster warm-up as coolant is not recirculated (stationary) • Increased compression ratio through greater cooling capacity at full load as compared to the predecessor engine
Emissions	• Faster engine warm-up by drastically reduced pump speed (n => 0) and the resulting lower volumetric flow of coolant • Reduced friction • Reduced fuel consumption • Reduced exhaust emissions
Power output	• Component cooling independent of engine speed • Requirement-controlled coolant pump output • Avoidance of power loss
Comfort	• Optimum volumetric flow – Heating capacity increased as required – Residual heat with engine stationary
Component Protection	• EWP after-running = more effective heat dissipation from the hot engine

Cooling System Comparison (Belt Driven vs. Electric Coolant Pump)

The belt driven coolant pump circulates the coolant as a function of engine speed. The circulated coolant can only be influenced by the mapped thermostat for temperature control purposes.

The system switches between the small and large circuit. In other words, between the circuit which flows through the radiator (large circuit) and the circuit which flows only between the engine block , coolant pump and thermostat.

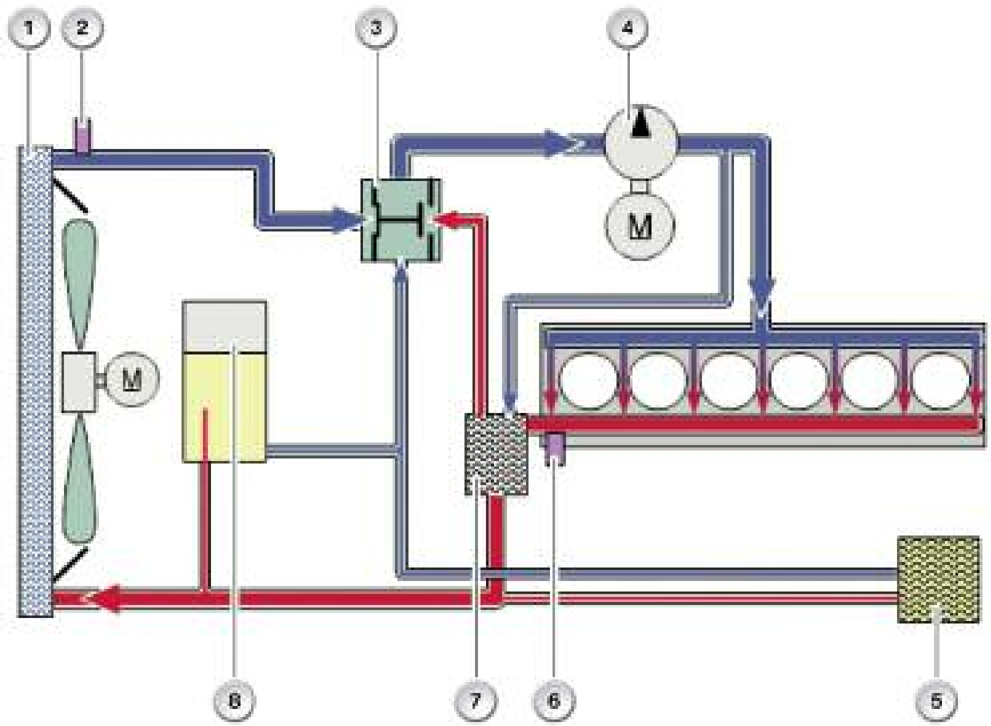
This means that the cooling capacity is dependent upon engine speed.



Index	Explanation	Index	Explanation
1	Radiator	5	Outlet temp sensor, cylinder head
2	Mapped Thermostat (KFT)	6	Engine oil to water heat exchanger
3	Belt driven coolant pump	7	Expansion tank
4	Heat exchanger for heating system		

The advantages of the conventional cooling system are still utilized in the cooling system with the electric coolant pump. However this system also provides further options.

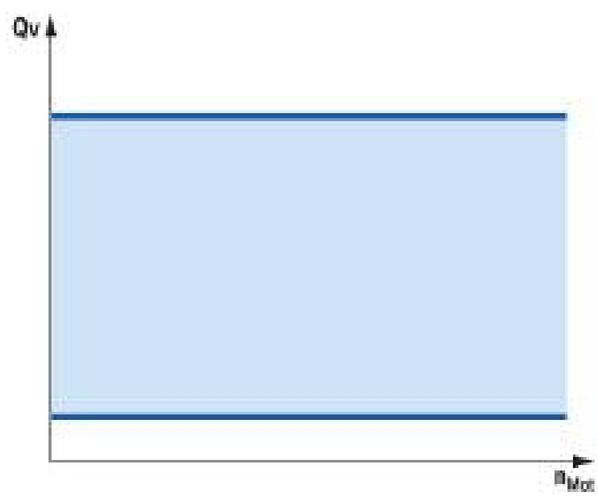
For instance, the cooling capacity of the system can now be adapted by means of freely variable volumetric coolant flow. It is possible to deactivate the coolant pump while the engine is warming up or to allow it to continue to operate when the engine has been turned off.



Index	Explanation	Index	Explanation
1	Radiator	5	Heat exchanger for heating system
2	Outlet temperature sensor, radiator	6	Outlet temp sensor, cylinder head
3	Mapped Thermostat (KFT)	7	Engine oil to water heat exchanger (MOWWT)
4	Electric coolant pump		Expansion tank

As shown in the graph to the right, this results in the field in which the speed related to the cooling capacity can be controlled independently. This field is limited by the MAX and MIN speed of the coolant pump.

The graph shows that a system with an electric coolant pump can deliver any volume of coolant independently of engine RPM. The “Qv” indicates coolant delivery volume and “nMot” refers to engine RPM.

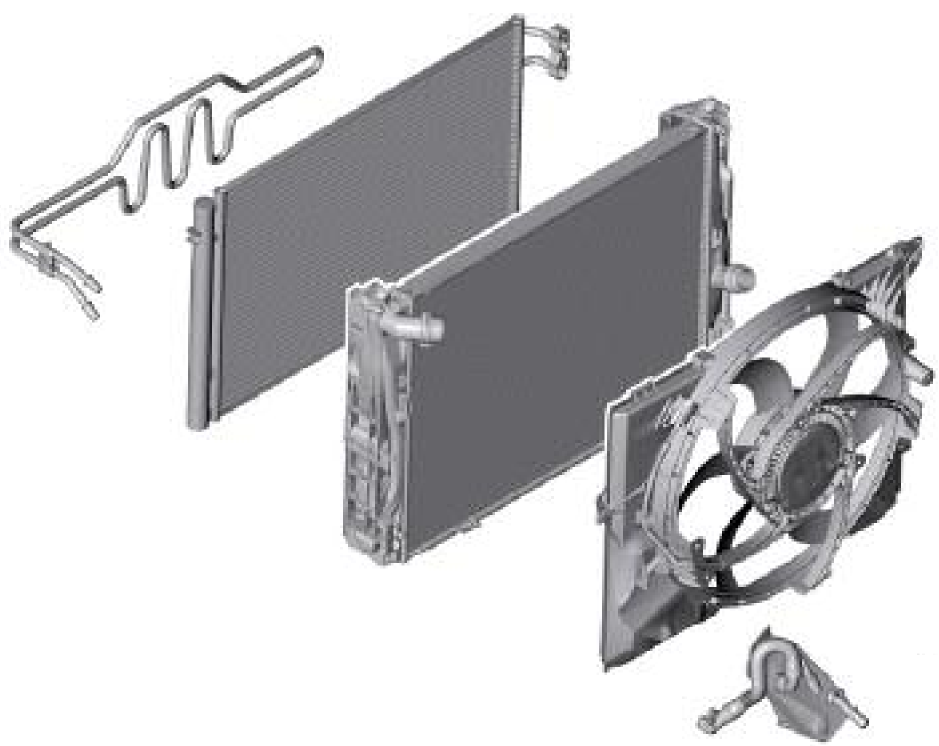


Cooling Fan

The electric cooling fan is controlled by the ECM. The ECM uses a remote power output final stage mounted on the fan housing. The output stage receives power from a 60 Amp fuse located in the power distribution box behind the glove box.

The electric fan is controlled via a PWM circuit from the ECM. The fan is activated based on the ECM calculation of:

- Coolant outlet temperature
- Calculated catalyst temperature
- Vehicle speed
- Battery voltage
- Air conditioning inputs such as AC pressure.



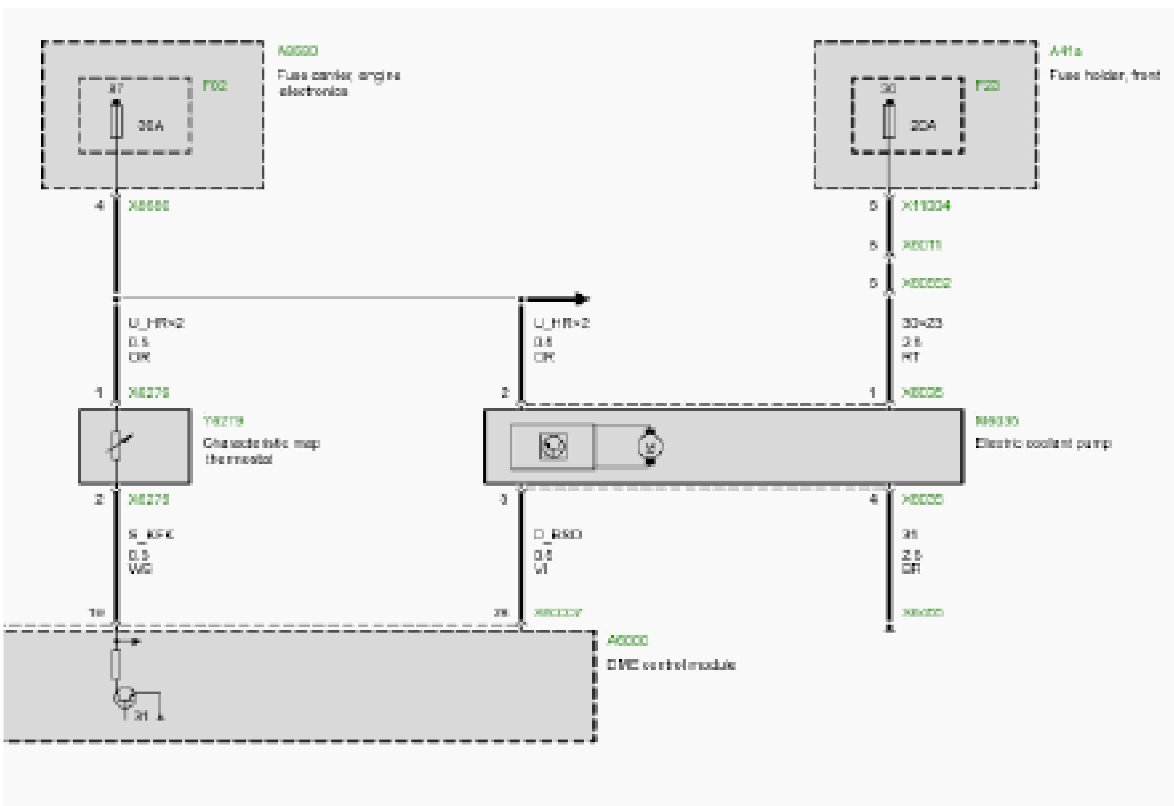
Index	Explanation	Index	Explanation
1	Power steering cooler	4	Fan shroud with electric fan
2	AC Condenser	5	Automatic transmission fluid cooler
3	Radiator		

Map Controlled Thermostat

The map controlled thermostat is activated by the ECM and works in conjunction with the heat management system on the N52 engine.

Due to the redesign of the cooling system, the thermostat is located externally near the electric coolant pump.

The thermostat is ground controlled by the ECM. Power is supplied by a 30 amp fuse which is part of the engine electronics fuses in the E-box.



Workshop Exercise - Cooling System

Using an instructor designated vehicle, perform a complete vehicle short test. Proceed with the cooling system bleeding procedure as outlined in the Group 17 repair instructions.

Note: Be sure to have battery charger connected while performing this procedure!

Connect the appropriate breakout box the the ECM. Using the oscilloscope, monitor the BSD interface between the ECM and the EWP. Initiate the bleeding procedure and monitor the signals on the BSD interface.

Using the service functions menu, go to cooling system - "venting" and enter into test plan.

Describe the proper steps to bleed the cooling system on an N52 engine:

What is the maximum/minimum delivery rate shown in the test module?

How does the ECM (DME) communicate the desired delivery rate to the EWPU?

Is it necessary to use the test plan in order to bleed the cooling system?

While waiting for the bleeding procedure to complete, observe the BSD signal on the oscilloscope:

What is the observed voltage on the BSD line?

Does the EWPU control unit show up on the "control unit functions" menu?

Are there any status items in the DME diagnosis screens?

Workshop Exercise - Cooling System

Using the breakout box on the ECM, locate the signal line to the electric fan. Measure the signal using the oscilloscope and record results below.

	Frequency	Duty Cycle	Voltage
Engine OFF, key at KL15			
Engine running, fan not active			
Fan Activated using component activation.			
Engine running at operating temperature			

Using the ETM and vehicle, locate the following components and record information and location in the table below:

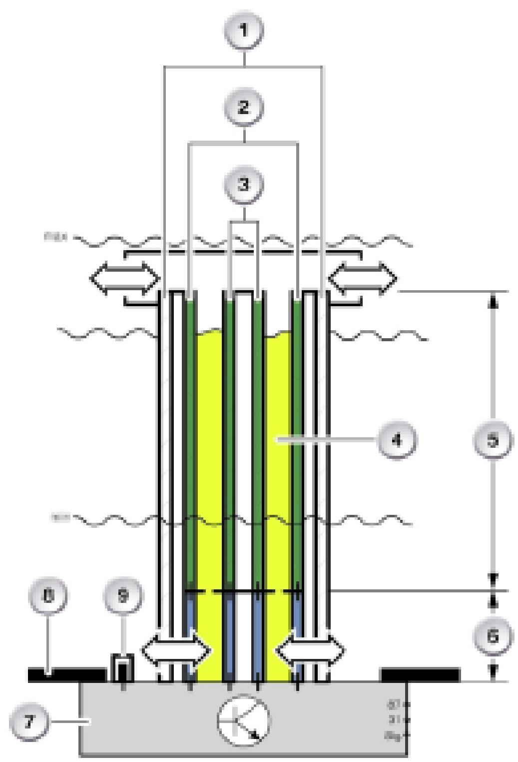
Item/Description	ETM Component # (and fuse rating)	Description of Location
Fuse for Electric Water Pump		
Fuse for Engine Thermostat		
Fuse for Engine Cooling Fan		
Coolant outlet temperature sensor		
Engine Coolant Temperature Sensor		
Engine Cooling Fan Controller		
Electric Coolant Pump (EWPU)		

Electronic Oil Condition Monitoring

There is no dipstick including the guide tube on the N52 engine. This represents a convenience function for the customer while enabling more accurate recording of the engine oil level.

The engine oil level is measured by an oil condition sensor (OZS) and indicated in the central information display (CID). The engine oil temperature and the oil condition are also registered or calculated by the oil condition sensor. The signal from the oil condition sensor is evaluated in the ECM. The evaluated signal is then routed via the PT-CAN, SGM and the K-CAN to the instrument cluster and to the CID.

Registering the engine oil level in this way ensures the engine oil level in the engine does not reach critically low levels thus protecting the engine from the associated damage. By registering the oil condition, it is also possible to determine when the next engine oil change is due. Over filling the engine with oil can cause leaks - a corresponding warning is therefore given.



Index	Explanation	Index	Explanation
1	Housing	6	Oil Condition Sensor
2	Outer Metal Tube	7	Sensor Electronics
3	Inner Metal Tube	8	Oil Pan
4	Engine Oil	9	Temperature Sensor
5	Oil Level Sensor		

Function of the Oil Condition Sensor

The sensor consists of two cylindrical capacitors arranged one above the other. The oil condition is determined by the lower, smaller capacitor (6). Two metal tubes (2 + 3), arranged one in the other, serve as the capacitor electrodes. The dielectric is the engine oil (4) between the electrodes. The electrical property of the engine oil changes as the wear or ageing increases and the fuel additives break down.

The capacitance of the capacitor (oil condition sensor) changes in line with the change in the electrical material properties of the engine oil (dielectric). This means that this capacitance value is processed in the evaluation electronics (7) integrated in the sensor to form a digital signal.

The digital sensor signal is transferred to the DME as an indication of the status of the engine oil. This actual value is used in the DME to calculate the next oil change service due.

The engine oil level is determined in the upper part of the sensor (5). This part of the sensor is located at the same level as the oil in the oil pan. As the oil level drops (dielectric), the capacitance of the capacitor changes accordingly. The electronic circuitry in the sensor processes this capacitance value to form a digital signal and transfers the signal to the DME.

A platinum temperature sensor (9) is installed at the base of the oil condition sensor for the purpose of measuring the engine oil temperature.

The engine oil level, engine oil temperature and engine oil condition are registered continuously as long as voltage is applied at terminal 15. The oil condition sensor is powered via terminal 87.

Faults/Evaluation

The electronic circuitry in the oil condition sensor features a self-diagnosis function. A corresponding error message is sent to the DME in the event of a fault in the oil condition sensor.

Electronic Oil Level Indicator

The oil level is measured in two stages:

- Static oil level measurement while the vehicle is stationary
- Dynamic oil level measurement during vehicle operation

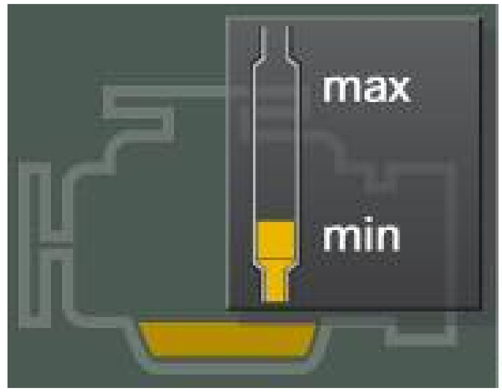
Static Oil Level Measurement at Engine OFF
This is only a reference measurement as the oil condition sensor (OZS) is flooded when the engine is turned off and can only detect the minimum oil level. The oil level is measured correctly only when the engine is running (see Dynamic oil level measurement).

After switching on the ignition, the static oil level measurement provides the driver with the opportunity of checking whether there is sufficient engine oil for safely and reliably starting the engine.

1. It is important that the vehicle is parked horizontally otherwise the oil level measurement may be incorrect.
2. Select on-board computer function "Service" > "Oil level".

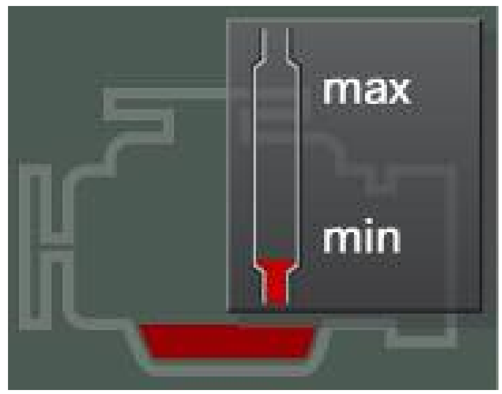
If there is sufficient engine oil for safe and reliable engine start, a graphic appears in the CID in the form of an engine with a green oil sump.

If the oil level is close to minimum, the graphic appears with a yellow oil sump and an oil dipstick that represents the low oil level in yellow.



A top-up request +1 liter additionally appears as a text message. The display will not change if less than 1 liter of oil is topped up. MAX is indicated only after topping up a quantity of 1 liter.

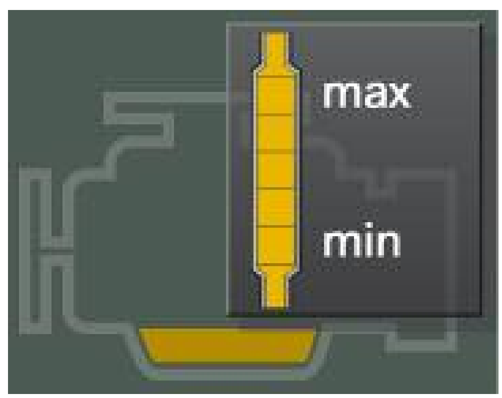
If the oil level drops below minimum, the graphic appears with a red oil sump and an oil dipstick that represents the low oil level in red.



A top-up request +1 liter will additionally appear as a text message.

The display will not change if less than 1 liter of oil is topped up. MAX is indicated only after topping up a quantity of 1 liter.

If the oil level is above maximum, the graphic appears with a yellow oil sump and an oil dipstick that represents the high oil level in yellow.



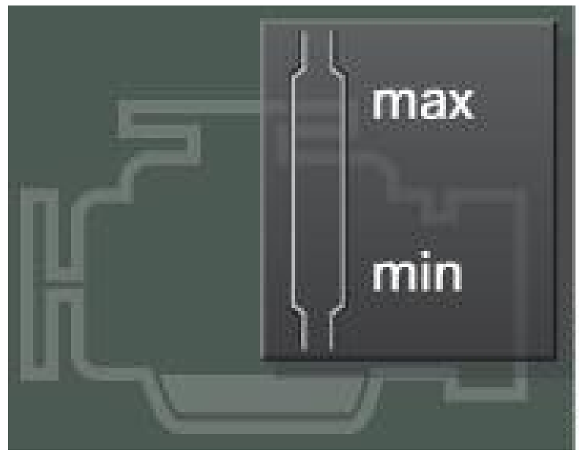
A text message is also displayed for the driver.

Dynamic oil level measurement during vehicle operation

Always perform the dynamic oil level measurement (app.. 5minutes driving time) after an oil change. The oil level could be misinterpreted as the oil level last stored is initially displayed after an oil change.

No oil level is initially stored after replacing or reprogramming the engine control unit. "Oil level below min" is therefore displayed. The correct oil level is indicated after running the engine for app.. 5 minutes.

1. Start engine.
2. Select on-board computer function - “Check oil level".
3. The oil level is measured. A clock symbol may appear while the level measurement is running. The clock symbol appears for up to 50 seconds after starting the engine when there is no measured value or the long-term value last stored is not within the tolerance range of the currently measured oil level.



Dynamic oil level measurement begins when following values are reached:

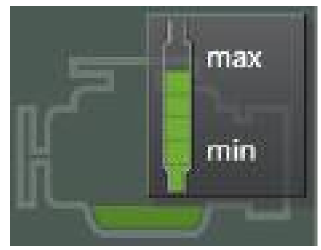
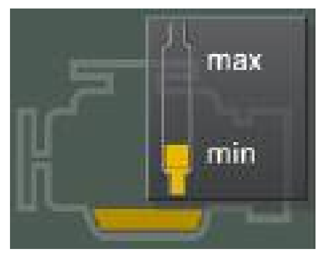
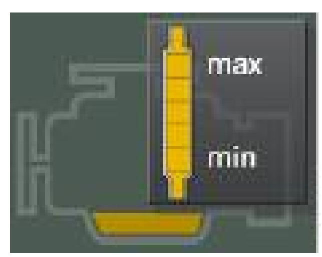
- Engine temperature > 60°C
- Engine speed > 1000 rpm
- Transverse and longitudinal acceleration < 4-5 m/s2

The transverse acceleration signal is supplied by the DSC. The longitudinal acceleration is calculated from the speed and time factors.

- Increase < 5% after covering a distance of app.. 200 m. The increase value is detected by the ambient pressure sensor in the DME.

On reaching this value, the oil level indicator is updated app.. 5 minutes after starting vehicle operation. The oil level is then continuously measured. The indicator is updated at 20 minute intervals. The "Check oil level" menu in connection with the dynamic oil level measurement is exited while driving (vehicle speed > 0) app.. 15 seconds after the oil level is displayed.

Display Options

Significance	Remark	Display
Oil OK with engine stationary	The oil level appears in the CID in the form of a graphic together with the "OK" message, indicating that the oil level is in the safe operating range.	
Oil level OK at idle speed	The oil level appears in the CID in the form of a graphic together with the "OK" message, indicating that the oil level is in the safe operating range. A further graphic showing a dipstick appears above the displayed graphic. It shows the oil level in green.	
Oil level too low	The oil level appears in the CID in the form of a graphic together with the request to top up with 1 liter of oil. If the oil is not topped up, this request is repeatedly indicated until the minimum oil level is exceeded.	
Oil level too high	The oil level appears in the CID in the form of a graphic together with the indication that the maximum oil level has been exceeded. The excess engine oil must be extracted in the workshop down to the maximum limit. If no oil is extracted, this request will be repeated until the oil level drops below the maximum limit. This represents an advantage that extends beyond the user friendliness of the monitoring system. Over filling of the engine that can cause leaks is indicated as a warning in the instrument cluster.	
Service	There is a problem with the measurement system if SERVICE appears in the display. In this case, the oil level is forecast from the oil consumption last measured and shown in the display. It is not necessary to immediately visit a workshop. The remaining kilometers are shown in the service menu. In the event of the instrument cluster failing, the oil level can also be read out with the diagnosis tester.	

Classroom Exercise - Review Questions

1. Describe the connector configuration of the MSV70 control module:

2. Describe the “phasing” function of Valvetronic:

3. Describe the proper procedure for bleeding the cooling system on the N52 engine?

4. Where are the PT-CAN resistors located in the E90?

5. What components/systems communicate with the ECM via the BSD circuit?

Classroom Exercise - Review Questions

6. What is different (new) about the crankcase ventilation system?

7. How are the DISA actuators controlled?

8. What is new regarding the fuel supply system?

9. What is the purpose of the LDM?

10. What components are connected to the ECM via BSD?