Reference Manual

E65
COMPLETE VEHICLE
(BOOK 2)

Technical Training

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Subject **Page**

Components

N62 ENGINE

Model: E65 - 745i / E66 - 745Li

Engine: N62B44

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

Objectives of The Module

After Completing this module, you will be able to:

- Describe the two stage oil supply.
- Distinguish the difference between the left and right drive chain tensioning assemblies.
- Explain the Bi-VANOS operation.
- Understand the function of the Variable intake manifold.
- Explain the cooling circuit flow.
- List what chamber A and chamber B is used for in the Bi-VANOS system.
- Identify the Secondary air components.
- Explain how the initial VANOS position is retained when oil pressure is not present.
- List the proper drive belt removal procedure.
- Describe the throttle valve functions.
- Identify the N62B44 designation.

N62 Engine

Purpose of The System

The N62B44 engine is a completely new development from the NG (New Generation) series and is available as a B44 (4.4 liter).

The development objectives were:

- Reduction in fuel consumption
- Reduction in emissions
- Increased power
- Improved torque and torque curve
- Improved engine acoustics

To achieve these objectives, enhancements were made in the following areas:

- Engine mechanicals
- Treatment of exhaust emissions
- Valve timing
- Engine management control
- Intake air flow

The most important features of the new N62 engine are:

- 8 cylinders in a 90° V configuration
- 2 four-valve cylinder heads
- Light-alloy design
- Newly-developed variable intake manifold
- Valvetronic system

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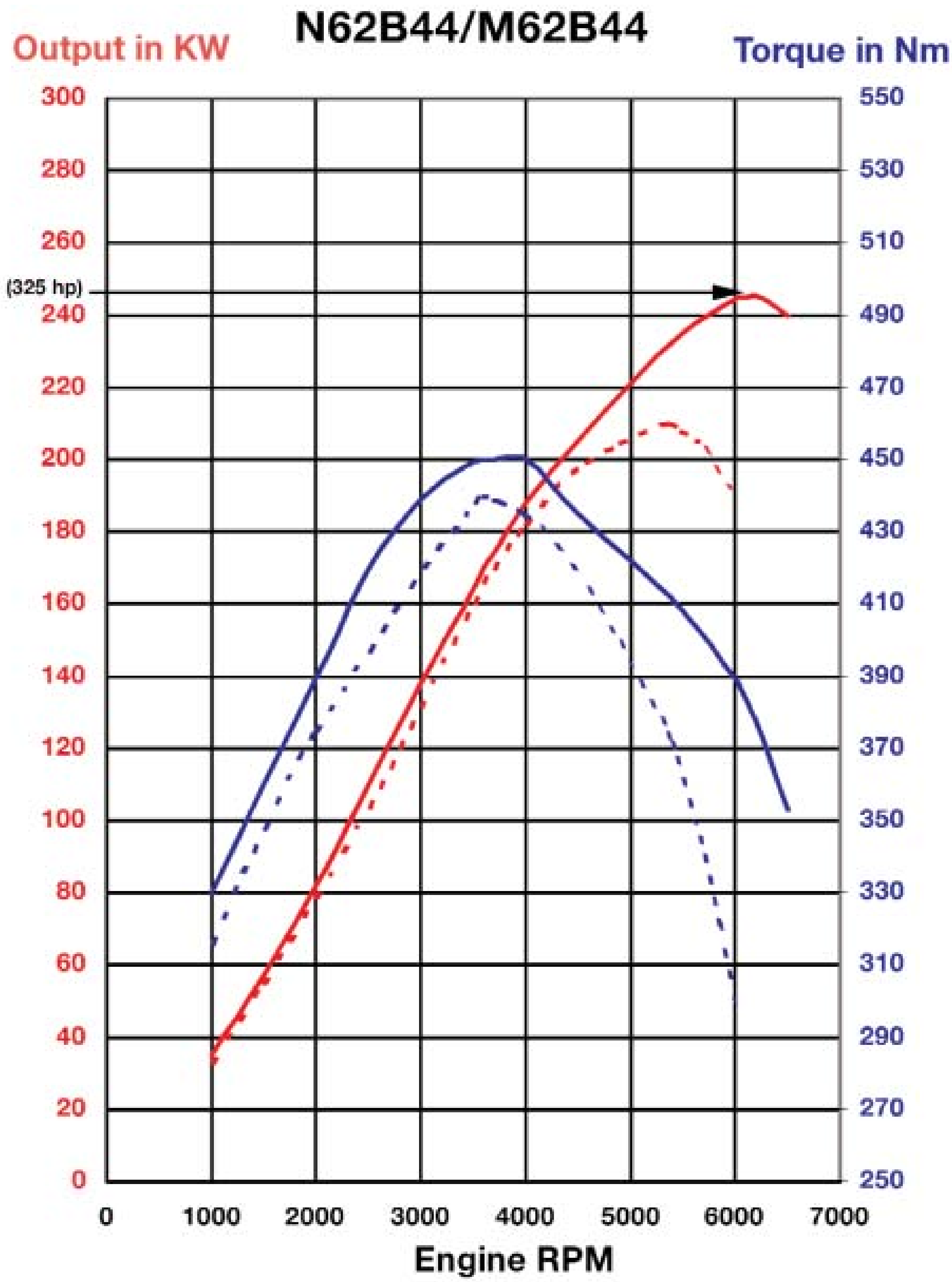
In conjunction with the Variable Intake Manifold, the Valvetronic system adapts the intake valve lift to ensure optimum cylinder filling. The throttle valve use is limited during engine operation to maintain a constant intake manifold vacuum.

The N62 is the best engine in its class. At this time there is no other engine on the market which uses comparable technology.

Technical Data

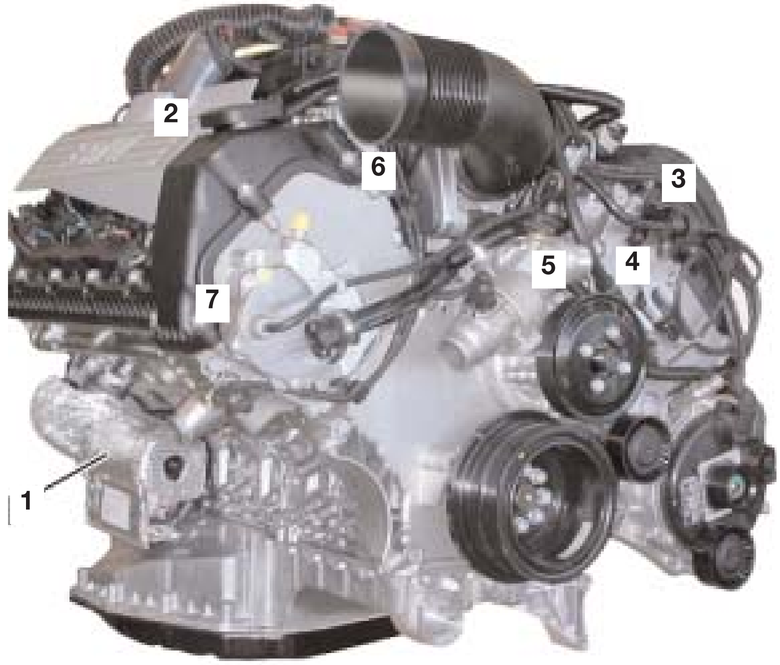
Engine	N62B44
Design	8 Cylinder V
V Angle	90°
Displacement (cm3)	4,398
Bore/Stroke (mm)	92/82.7
Cylinder Gap (mm)	98
Main Crankshaft Bearing Diameter (mm)	70
Output (kW) at speed (rpm)	325 6,100
Torque (Nm) at Speed (RPM)	330 3,600
Cut-off speed (RPM)	6.500
Compression Ratio	10.0
Valves / Cylinders	4
Intake Valve Diameter (mm)	35
Exhaust Valve Diameter (mm)	29
Intake Valve Lift (mm)	0.3 – 9.85
Exhaust Valve Lift (mm)	9.7
Cams Open Period (º crankshaft)	282/254
Engine Weight (kg)	213
Fuel	91 Octane
Firing Order	1-5-4-8-6-3-7-2
Knock Sensor	Yes
Variable Intake Manifold	Yes
Digital Motor Electronics	ME 9.2 with Valvetronic Control Unit
Complies with Exhaust Emission Regulations	EU-3 EU-4 LEV
Engine Length (mm)	704
Fuel Consumption Saving Compared with the M62	14%


N62B44/M62B44
Output in KW
Torque in Nm
300
280
260
(325 hp)
240
220
200
180
160
140
120
100
80
60
40
20
0
550
530
510
490
470
450
430
410
390
370
350
330
310
290
270
250
0
1000
2000
3000
4000
5000
6000
7000
Engine RPM

42-02-02

Engine Views

1. Starter Motor
2. Valvetronic Motor
3. Evaporative Emission Valve
4. VANOS Solenoid Valve
5. Thermostat Housing
6. Throttle Unit
7. Vacuum Pump



N62B44 Engine (Front View)

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1. Camshaft Position Sensor Cylinder Bank 5-8
2. Valvetronic Eccentric Shaft Position Sensor, Cylinder Bank 5-8
3. Valvetronic Eccentric Shaft Position Sensor, Cylinder Bank 1-4
4. Camshaft Position Sensor Cylinder Bank 1-4
5. Secondary Air Non-return Valves
6. Servomotor for Variable Intake Manifold

N62B44 Engine (Rear View)

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Fresh Air System

Air Routing

The intake air passes through the air intake duct to the air cleaner, through the throttle section into the variable intake manifold and on to the two cylinder head intake ducts.

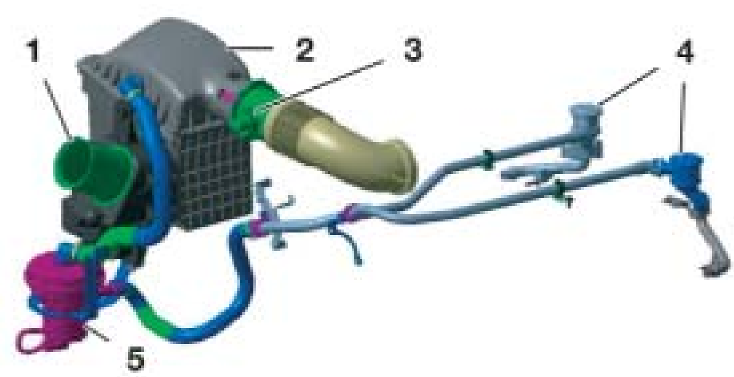
Increases in engine output and engine torque, as well as optimization of the engine torque curve, are largely dependent on an optimum engine volumetric efficiency over the entire engine speed range.

Long and short intake paths contribute to good volumetric efficiency in the lower and upper speed ranges. Long air intake paths ensure optimum volumetric efficiency in the lower to middle speed ranges. This optimizes the torque curve and increases the torque.

In order to optimize the power increase in the upper speed range, the engine requires short air intake paths for better cylinder filling. The air intake system has been completely redevelopd in order to eliminate this inconsistency in terms of air intake path length.

The air intake system consists of the following components:

1. Air Intake Duct
2. Air Cleaner Housing with Intake Air Silencer
3. Intake Pipe with HFM (Hot-Film Air-Mass Flow Sensor)
4. Secondary Air Valves
5. Secondary Air Pump



Air Intake System

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Throttle Valve

The throttle valve on the N62 is not necessary for engine load control. This is carried out by the intake valves variable lift adjustment.

- Throttle Valve Housing with Throttle Valve.
- Throttle Valve Actuator
- Two Throttle Valve Potentiometers

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Throttle Valve

The tasks of the throttle valve are:

Starting the engine

Airflow is controlled by the throttle valve during the starting procedure when the air temperature is between 20 ºC and 60 ºC, .

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 because this 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 function

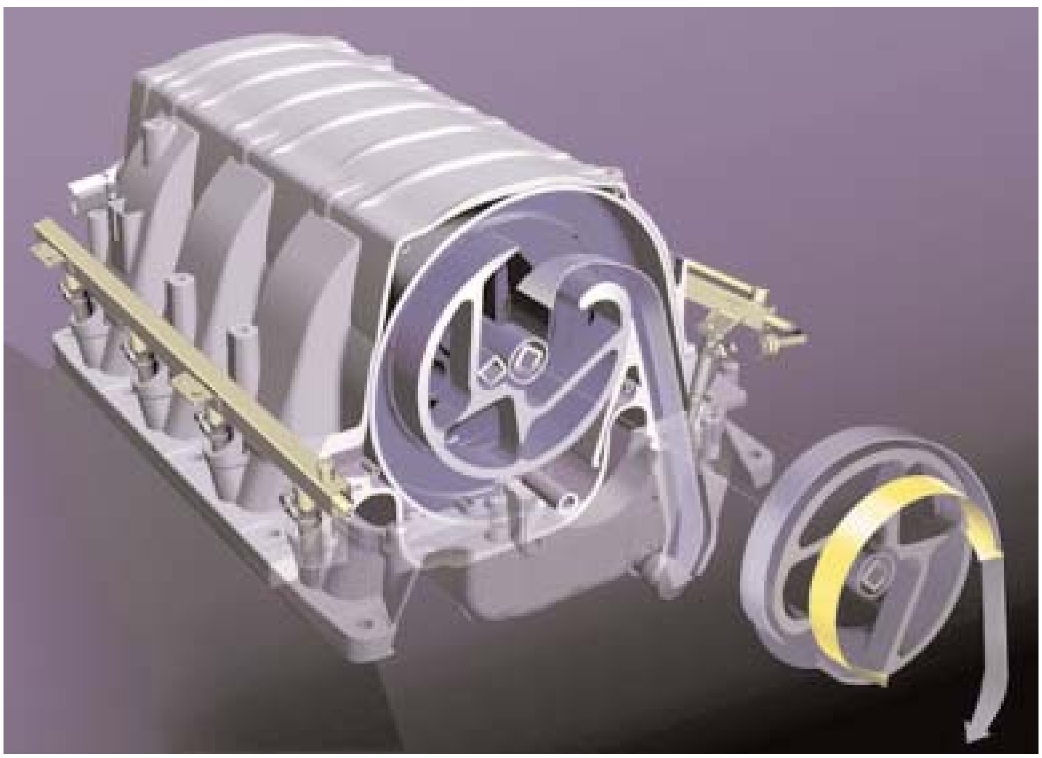
If the Valvetronic system should fail, the throttle valve implements conventional load control).

Intake Manifold

The N62 engine is equipped with a Variable Intake Manifold making it possible to reach a generous torque curve even at low engine speeds, without incurring losses in engine output at higher speeds. It ensures that the engine exhibits optimum volumetric efficiency through the entire range of speeds.

The new feature is the Variable Intake Manifold intake pipe length can be adjusted depending on the engine speed to provide efficient cylinder filling and scavenging. This is determined by the optimal matching of the intake pipe dimensions, the exhaust system and the valve timing.

The intake manifold is located in the engine "V" and is mounted on the cylinder head intake ports.



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Function

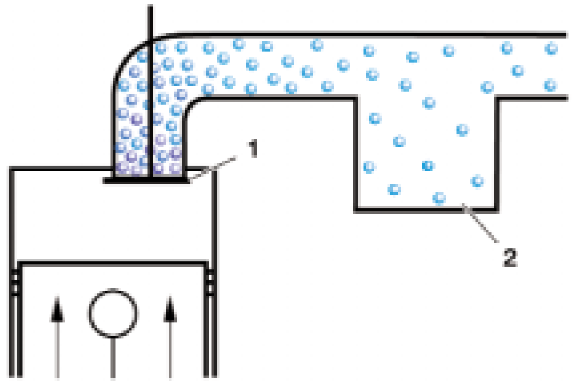
In order to understand how engine speed relates to volumetric efficiency, the physical processes within the intake pipe must be taken into consideration.

To ensure that there is good airflow to the engine cylinders, the intake pressure in front of the intake valve should ideally be high. This means that good airflow (high gas molecule density) in front of the intake valve is necessary.

This is only possible if the intake valve is closed and the mass inertia causes the intake air to flow in front of the closed intake valve. The air is compressed, the pressure and the air flow increase.

Intake air flows in front of the closed intake valve.

1. Closed intake valve
2. Intake manifold



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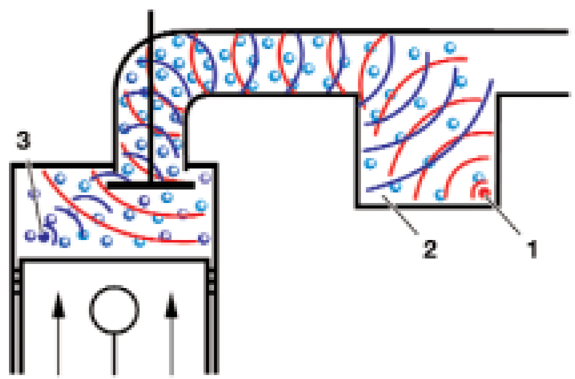
As soon as the intake valve is opened, the pressurized intake air flows into the cylinder, expands and draws the air molecules which follow into the cylinder. The suction waves form in the intake pipe (moving at sonic speed) in the opposite direction to the intake air.

These suction waves are reflected in the intake manifold and create pressure waves which then move once more at sonic speed in the direction of the intake valve.

Movement of the intake air with the intake valve open.

1. Pressure waves
2. Air manifold
3. Suction waves



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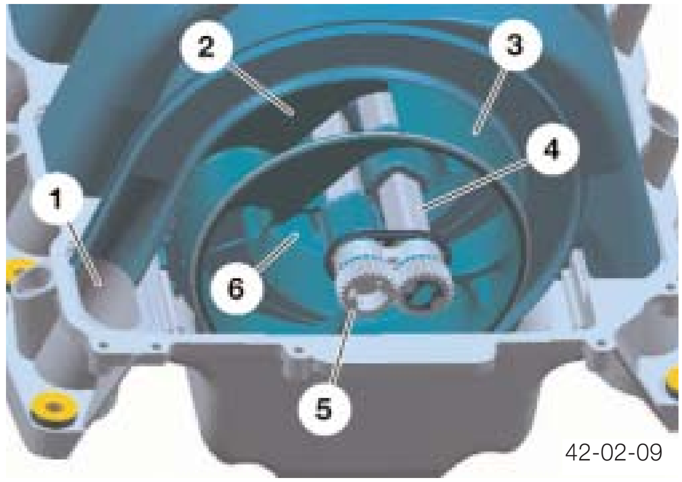
The intake pipe is at the optimum length when the pressure waves are at the intake valve shortly before it is closed. The increase in pressure in front of the intake valve results in increased air flow to the cylinders once more. This process is described as recharge effect.

The opening angle of the intake valve remains unchanged as the engine speed increases. The opening time, however, is reduced proportionately (with conventional, non-Valvetronic engines).

Since the suction waves and pressure waves expand at sonic speed, the suction path length must be adapted depending on the engine speed to ensure that the tip of the pressure wave reaches the intake valve before it is closed.

1. Intake Port
2. Funnel
3. Rotor
4. Shaft
5. Spur Gears
6. Manifold Volume



The Variable Intake Manifold

Each cylinder has its own intake pipe (1) which is connected to the manifold volume (6) via a rotor (3). The rotors are supported by one shaft (4) per cylinder bank.

The second shaft, from which the rotor for the opposite cylinder bank is adjusted, is turned by spur gears (5) in the opposite direction from the driven shaft.

The intake air flows via the manifold volume through the funnel (2) and on to the cylinders. The intake path length is set as the rotor turns.

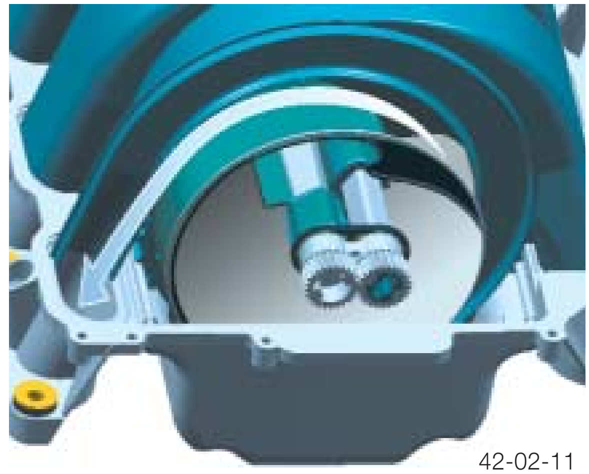
The intake path length can be adjusted according to the engine speed. Adjustment from the long to short intake path begins at 3,500 rpm. If the engine speed increases, the intake path length is progressively reduced, up to 6,200 rpm.

Notes:

The intake path length is determined by the funnel position. If the engine speed is less than 3,500 rpm, the funnel is in the longer intake path length position.

This means that the intake air must cover a longer path to reach the cylinders.

- *Intake manifold set to longer intake path.*



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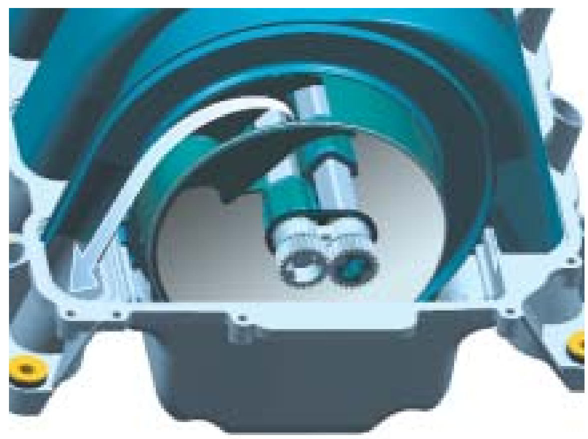
When an engine speed of 6,200 rpm is reached, the rotor is adjusted to the shorter intake path position. The intake path to the cylinders is now short.

The funnel can be progressively adjusted to any point between the long/short intake path positions.

- *Intake manifold set to short intake path.*



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Funnel adjustment is carried out by the drive unit, which is located on the rear of the intake manifold housing. The drive motor adjusts the drive shaft with funnels (cylinder bank 1-4). The second shaft with funnels for cylinder bank 5-8 is synchronously adjusted by the spur gears.

The drive motor is controlled by the ECM and provides feedback about the funnel position via an integral potentiometer.

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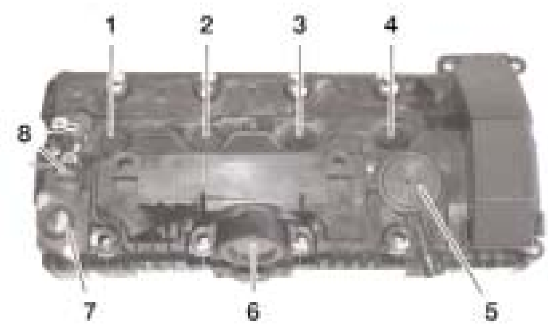
Crankcase Venting System

The crankcase vapors (a result of combustion blow-by gasses) are led out of the crankcase and back into the combustion chamber via the intake manifold. The blow-by gasses contain droplets of oil which must be separated. The oil is returned to the sump while the blow-by gasses are led into the intake pipe for combustion.

The engine performance is affected by the introduction of crankcase vapors into the combustion process, particularly in idle speed ranges. This influence is monitored by lambda regulation.

The crankcase vapors are carried from the crankcase and into the cylinder head covers through labyrinth separators (one per cylinder head). The oil which accumulates on the walls of the labyrinth separators flows into the cylinder head via a siphon and from there back to the sump.

1-4. Opening for Spark Plugs
5. Pressure Control Valve
6. Opening Valvetronic Motor
7. Opening Valvetronic Sensor Connector
8. Camshaft Sensor



Cylinder Head Cover

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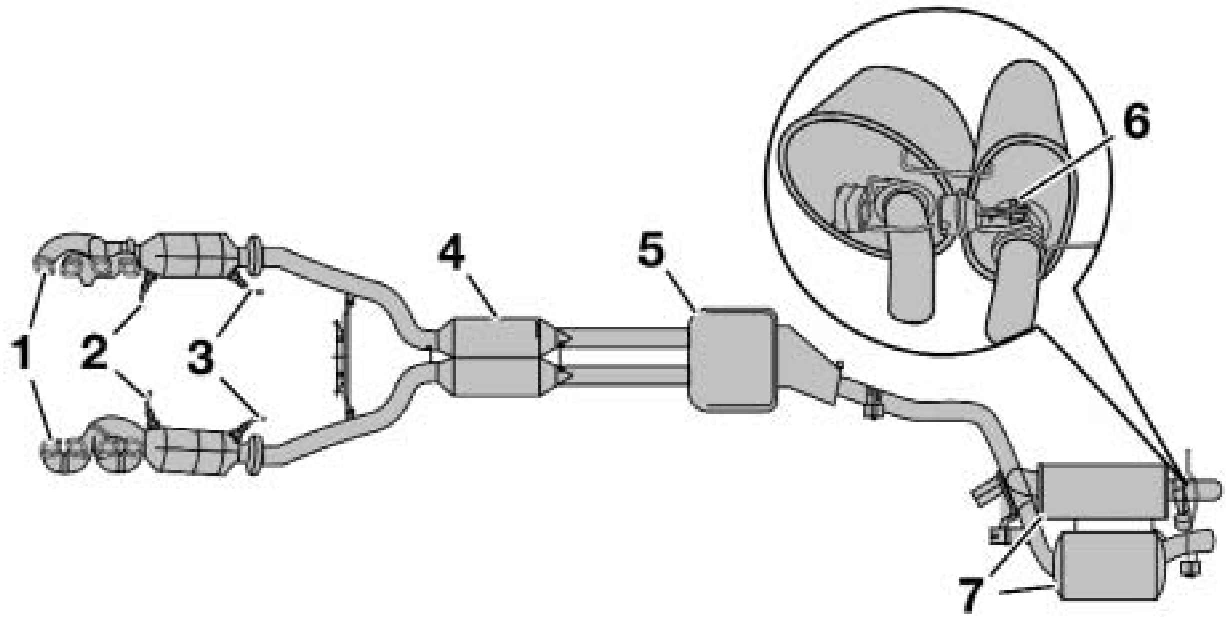
The remaining vapors are passed to the engine for combustion via the pressure control valve (5) in the intake manifold. One labyrinth separator with a pressure control valve is integrated in each of the two cylinder head covers.

The throttle valve is controlled so that there is always a 50 mbar vacuum in the intake manifold. The pressure control valve regulates the crankcase pressure to a low 0-30 mbar.

Exhaust System

The exhaust system is completely redesigned for the N62B44 engine. It has been optimized in terms of cylinder filling, scavenging, sound level and rapid catalytic converter light-off.



Exhaust System

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1. Manifold with Integrated Catalytic Converter
2. Broadband Planar Oxygen Sensors
3. Secondary Oxygen Sensors
4. Exhaust Pipe with Front Silencer
5. Center Silencer
6. Exhaust Gas Flap
7. Rear Silencers

Exhaust Manifold with Catalytic Converter

Each cylinder bank is equipped with a four into two into one exhaust manifold. The manifold and the catalytic converter housing together form one component. A ceramic-bed pre-catalytic converter and a ceramic-bed main catalytic converter are arranged one behind the other in the catalytic converter housing.

The mounting for the broadband planar oxygen sensors (Bosch LSU) and the secondary oxygen sensors is located in front of and behind the catalytic converter.

Silencers

- A 1.8 liter capacity front silencer has been fitted for each cylinder bank.
- A single 5.8 liter center silencer is fitted downstream of the two front silencers.
- The resonator type rear silencers have capacities of 12.6 and 16.6 liters.

Exhaust Gas Flap

The 12.6 liter rear silencer is fitted with an exhaust gas flap to keep noise to a minimum at engine idle speed and low rpm. The exhaust gas flap is opened allowing additional flow when:

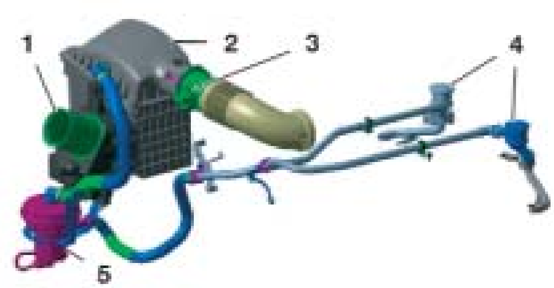
- The a transmission gear is engaged ***and***
- The engine speed is above 1,500 rpm

A vacuum-controlled diaphragm (actuator mounted on the silencer) opens and closes the exhaust gas flap. The exhaust gas flap is closed with vacuum, and is sprung open by the actuator (when vacuum is not present). The procedure is carried out using a solenoid valve which is electrically controlled by the ECM.

Secondary Air System

Blowing additional air (secondary air) into the cylinder head exhaust ducts during the warm-up phase results in a thermal secondary combustion which results in a reduction of the non-combusted hydrocarbons (HC) and carbon monoxide (CO) in the exhaust gas. The energy generated during this process heats up the catalytic converter faster during the warm-up phase, and increases it’s conversion rate.

1. Air Intake Duct
2. Air Cleaner housing with Intake Air Silencer
3. Intake Pipe with HFM (Hot-Film Air-Mass Sensor)
4. Non-return Valves
5. Secondary Air Pump



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Secondary Air System

Secondary Air Pump (SLP)

The electrically-operated secondary air pump is mounted to the vehicle body. The pump draws out filtered fresh air from the air cleaner housing during the warm-up phase and supplies it to the two secondary air Non-return Valves.

Once the engine has been started, the secondary air pump is supplied with voltage by the ECM via the secondary air pump relay. It remains switched on until the engine has taken in a certain amount of air.

The *ON* period may be a maximum of 90 seconds and it depends on the following engine operating conditions:

- Coolant temperature (from -10 ºC to approximately 60 ºC)
- Air temperature (NTC sensor in HFM)
- Engine speed

1. Cylinder Head Lead
2. Non-return Valve (SLV)
3. Secondary Air Pump Connection

View From Rear of The Cylinder Head

One non-return valve is mounted on each cylinder head (see also Engine Views).

The non-return valves are opened by the pressure generated from the secondary air pump. The secondary air is led through a pipe to the secondary air ducts (integral in the cylinder heads) for distribution into the exhaust ports.

The non-return valves are sprung closed when the secondary air pump is deactivated. This prevents exhaust vapors, pressure and condensation from flowing back into the secondary air pump.

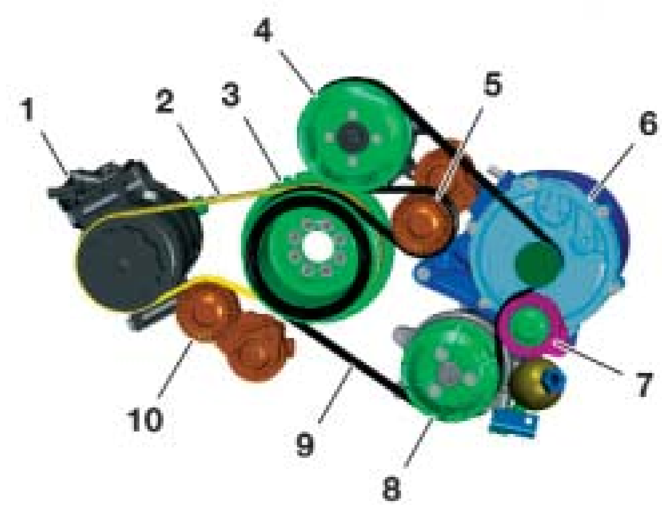
Ancillary Components and Drive Belts

Drive Belts

The belt drive has two components and is subdivided into the main and A/C drives. Both belts are driven by the crankshaft pulley.

A 4 rib belt is used to drive the air conditioning compressor and a 6 rib belt is used for the main drive. Each drive belt has a maintenance free tensioning unit with tensioning pulley and torsioner.

1. Air Conditioning Compressor
2. 4 Rib A/C Drive Belt
3. Crankshaft Pulley
4. Water Pump
5. Tensioning Unit Main Drive Belt
6. Alternator
7. Deflection Pulley
8. Power Steering Pump
9. 6 Rib Drive Belt
10. Tensioner Unit A/C Drive Belt



Ancillary Components and Drive Belts

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To remove the drive belt:

The tensioning pulley is pushed back using a Torx tool in the recess provided (1) and fixed in this position by inserting a locking pin as shown (2).

42-02-16

Alternator

Due to the high power capacity of 180 A, the alternator is cooled by the engine's cooling system to enhance heat dissipation. The brushless Bosch alternator is installed in an aluminum housing which is mounted to the engine block. The exterior alternator walls are surrounded with circulated engine coolant. The function and design of the alternator is the same as in the M62, with only minor modifications. The BSD interface (bit-serial data interface) for the ECM is new.

1. Watertight Housing
2. Rotor
3. Stator
4. Seal

Alternator 42-02-17

1. Coolant Return Flow
2. Coolant Inlet Flow

* Further details found in the cooling circuit section

Alternator Coolant Flow 42-02-18

Regulation

The alternator communicates with the Engine Control Module (ECM) via the BSD (bit-serial data interface). The alternator conveys data such as model and manufacturer. This is necessary to allow the engine management system to adapt it's calculations and specific control to the type of alternator fitted.

The ECM takes on the following functions:

- Activation/deactivation of the alternator.

- Informing the alternator regulator of the nominal voltage value to be set.

- Controlling the alternator's response to load.

- Diagnosing the data line between the alternator and the ECM.

- Storing alternator fault codes.

- Activating the charge indicator lamp in the instrument cluster.

The connection with the ECM makes it possible to equalize the alternator load torque for nearly all operating conditions. This supports the engine idling speed control and the battery load balance. In addition, the ECM receives information from the Power Module about the battery's calculated temperature and charge status. This means that alternator output can be adapted precisely to the temperature and load status of the battery which increases the battery service life.

The charge indicator display strategy has not changed in comparison with the alternators currently in use. Regulating the alternator output is particularly important when activating Valvetronic operating motors.

A temperature protection function is implemented in the voltage regulator. If the alternator overheats, the alternator voltage is reduced until an appropriate temperature has been reached.

The ECM can recognize the following faults:

- Mechanical faults such as blockages or belt drive failure.

- Electrical faults such as exciter diode defects or over/under voltage caused by regulation defects.

- Connection defects between the ECM and the alternator.

Coil breaks and short-circuits cannot be recognized. The basic alternator function is in operation even if the BSD interface fails.

Note: The alternator regulator voltage is influenced by the ECM - BSD interface. The battery charge voltage can therefore be up to 15.5 V, depending on the battery temperature. If a battery charge voltage of up to 15.5 V is measured, the regulator is not faulty. A high charge voltage indicates a low battery temperature.

Air Conditioning Compressor

The "clutch free" A/C compressor is manufactured by Denso. It functions continuously with the engine running. The compressor is a 7-cylinder swash plate type. The displacement can be reduced to less than 3% when air conditioning is not requested (no refrigerant is supplied to the refrigerant circuit).

There is an internal compressor refrigerant circuit to maintain lubrication. The IHKA electronics regulate the compressor output via an external control valve (1).

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Starter Motor

The starter motor is located on the right-hand side of the engine below the exhaust manifold, and is a compact planetary drive starter with a 1.8 kW output.

1. Starter motor with heat protective cover.

42-02-03

Power Steering Pump

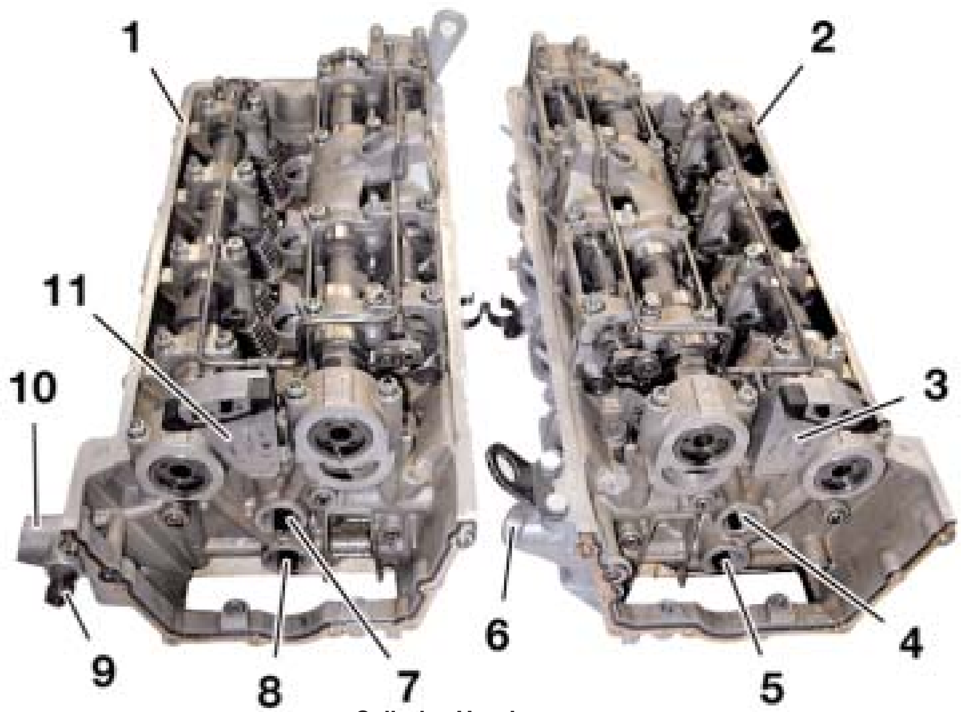
The power steering pump is a tandem radial piston pump on vehicles equipped with Dynamic Drive. A single vane pump is installed on vehicles without the Dynamic Drive.

Further information about the power steering pump can be found in the Chassis Dynamics section.

Cylinder Heads

The two N62 cylinder heads are a new development from BMW. They are fitted with the Valvetronic system. The secondary air ducts for subsequent exhaust gas treatment are integrated in the cylinder heads. The cylinder heads are cooled by the "cross-flow" principle.

The inlet camshaft and the Valvetronic eccentric shaft are jointly guided by a bridge support. The cylinder heads are made from aluminum and are manufactured using gravity die-casting. The upper timing chain housing is now an integral part of the cylinder head.



Cylinder Head 43-02-20

1. Cylinder Head for Cylinder Bank 1-4
2. Cylinder Head for Cylinder Bank 5-8
3. Upper Timing Chain Guide with Oil Jet
4. Mounting for VANOS Intake Solenoid
5. Mounting for VANOS Outlet Solenoid
6. Chain Tensioner Mount
7. Mounting VANOS Intake Solenoid
8. Mounting VANOS Outlet Solenoid
9. Oil Pressure Switch
10. Chain Tensioner Mount
11. Upper Timing Chain Guide with Oil Jet

Engine Covers

Each cylinder head has a plastic cover for the ignition coil cabling and top of the cylinder head. The covers "push fit" into rubber grommets on the cylinder head covers.

A sound absorption cover for the top of the engine also covers the two Valvetronic motors. This cover is fixed to the intake manifold housing using four bolts.

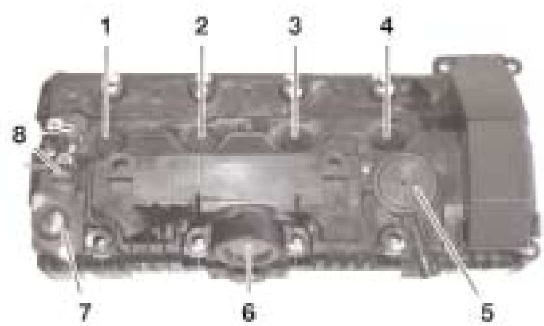
1. Cylinder Head Top Cover
2. Sound Absorption Engine Cover

42-02-21

Engine Covers

The cylinder head covers are made from plastic. The retaining sleeves for the ignition coils have molded-on gaskets. The sleeves must be replaced if any hardening or damage is visible on the gaskets. The sleeves are inserted into the cylinder head through the cylinder head cover (nos. 1through 4).

1-4. Opening for Spark Plugs
5. Pressure Control Valve
6. Opening for Valvetronic Motor
7. Opening for Valvetronic Sensor Connector
8. Camshaft Sensors (Intake and Exhaust)



Cylinder Head Cover

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Notes:

Cylinder Head Gaskets

The cylinder head gasket is a multi-layer steel gasket with a rubber coating. This type of gasket has previously been used on other engines.

The B44 head gasket has a 6 mm hole in a flap on the outlet side of the cylinder head gasket.

The cylinder head bolts for the N62 engine are M10x160 necked-down “stretch” bolts.

42-02-23

Note: These bolts should always be replaced when repairs are performed.

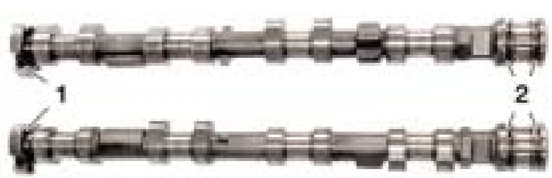
The lower part of the timing chain housing is bolted to the cylinder head using two M8x45 bolts.

42-02-22

Camshafts

The camshafts are made from chilled cast iron and are hollowed to reduce weight. The camshafts are weighted with counterbalances for equalizing imbalances in the valve gear.

1. Camshaft sensor wheels (sintered metal)
2. Thrust bearing area with oil ducts for the VANOS units



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Notes:

Valvetronic

Over the entire speed and load range, the gasoline engine needs a combustible fuel-air mixture within the ideal ratio (Lambda = 1). The mixture quantity must be altered to vary the speed and output. This variation is effected by the throttle valve. The mixture, which falls within the narrow range of Lambda = 1, is formed outside the combustion chamber using the fuel injection system (external mixture formation).

The mixture control is influenced by the throttle valve and is not optimal in all the different load ranges. This is particularly true in the idle to part-load ranges, since the throttle valve is only opened slightly in these ranges. The consequences are less than optimal cylinder filling, torque and increased fuel consumption.

Technical measures were previously introduced; such as the optimization of air/fuel mixing, improved valve overlap, introduction of DISA and the steady improvement of mixture control all depend on the throttle valve. This is where the new completely unique Valvetronic design comes in.

The Valvetronic system simultaneously varies the valve opening time and the valve opening lift between 0.3 mm and 9.85 mm, according to engine speed and load. This means that the air/fuel mixture volume is controlled according to engine requirements. This type of mixture and volume control makes the typical throttle valve control unnecessary.

Physical considerations:

On engines with throttle valve control, the throttle valve is slightly open in the idling and part-load ranges. This results in the formation of up to 500 mbar vacuum in the intake manifold, which prevents the engine from aspirating freely and in turn prevents optimum cylinder filling. The Valvetronic system with an open throttle valve largely counteracts this disadvantage. The air-mass flow to the intake valves is unrestricted. The full ambient pressure is available directly at the intake valves for cylinder filling and scavenging.

The Valvetronic system primarily controls the fill by adapting the valve opening time and the valve lift (short opening time/small valve lift = lower fill, and vice versa). During the valve opening phase the engine aspirates more freely via the intake valves even with small valve lifts vs. a throttle valve which is continuously blocked.

The slower cylinder filling from the intake valves with partial lift results in more turbulence in the combustion chamber, thus faster and better mixture control and more efficient combustion. At lower engine speeds this effect is intensified by opening the intake valves later, after top dead center (ATDC) using VANOS. This increases vacuum in the combustion chamber which accelerates filling and turbulence when the intake valves are opened.

In summary, the additional variability of the Valvetronic system results in optimization of cylinder filling and scavenging throughout the engine's entire operating range. This has a positive effect on output, torque and a decrease in fuel consumption and exhaust emissions.

Features:

- Valve lift adjustment
- VANOS for intake and outlet
- Variable intake manifold
- Mixture control and ignition control
- Other individual engine design measures

The main benefits of these features are:

- Improved cylinder filling with air/fuel mixture
- Improved mixture control before the cylinder inlet
- Improved combustion procedure

This results in:

- Improved engine idling
- Improved engine torque
- Improved engine torque curve
- Fewer pollutant emissions

These benefits result in a clear improvement in performance and fuel consumption reduction (14%) for the driver.

Principle of Operation

The Valvetronic system is a combination of VANOS and valve lift adjustment. This combination of abilities allows the ECM to control when the intake valves are opened and closed, and also the opening lift. The intake air flow is set by adjusting the valve lift while the throttle valve is fully opened. This improves cylinder filling still further and reduces fuel consumption.

Each cylinder head in the N62 engine has a Valvetronic assembly. This Valvetronic assembly consists of a bridge support with eccentric shaft, intermediate levers with retaining springs, drag lever and the intake camshaft.

In addition, the following components belong to the Valvetronic system:

- A Valvetronic motor for each cylinder head
- A Valvetronic control module
- A Valvetronic sensor for each cylinder head

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The intake valve lift can be adjusted to anywhere between 0.3 mm and 9.85 mm.

The cylinder heads are precision manufactured together to ensure precise flow rate and uniform distribution. The valve gear components on the intake side are precisely matched together to the tightest limits.

The bridge support, lower eccentric shaft and inlet camshaft bearings are matched together in the cylinder head once it is assembled. If the bridge support or the lower bearings are damaged, the entire assembly must be replaced.

Notes:

Valvetronic Motors

One Valvetronic motor is located on top of each cylinder head towards the inside of the engine "V". The motors are capable of traveling from minimum to maximum lift in 300 milli-seconds.

1. Cylinder Head Cover, Cylinder Bank 1-4
2. Valvetronic Motor for Eccentric Shaft Adjustment

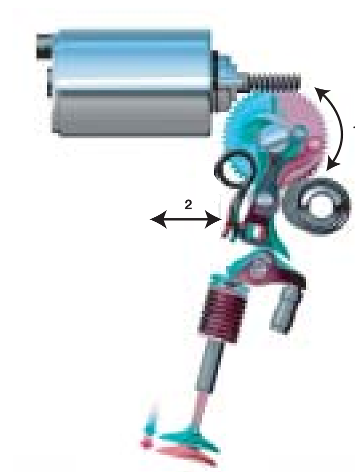
Valvetronic Motor

Note: The Valvetronic motor must first be removed in order to remove the cylinder head cover. The eccentric shaft must be in the minimum lift position and the motor must be wound out from the eccentric shaft. The worm gear could otherwise be damaged when separating the worm shaft and the worm wheel as the eccentric shaft springs back (due to the torque compensation spring).

If it is not possible to remove the motor, due to mechanical failure or sticking, the worm shaft can be moved using an Allen key to release the motor. A hole must be drilled in the rear plastic motor cover in order to access the motor shaft (worm shaft) using the Allen key. The motor can then no longer be used.

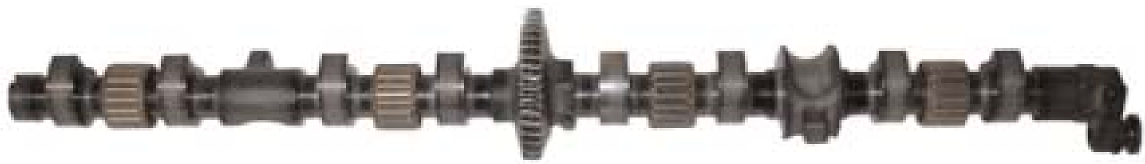
The Valvetronic motor worm gear rotates the eccentric shaft clockwise or counterclockwise at a very quick rate (1).

Due to the progressive "lobe" on the eccentric shaft, this rotation positions the intermediate lever (2) closer or further to the camshaft lobe.



Notes:

Eccentric Shafts



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The eccentric shafts (one per cylinder head) are driven by the Valvetronic motors and are supported by four caged needle bearing assemblies for a smooth rotation.

42-02-36

To assist in maintaining the set positions and counter the valve train torque, a torque compensation spring is mounted on the end of the shaft for tension.

Magnets are fitted in the (removable) magnetic wheel at the end of the eccentric shaft. Together with the position sensor, the Valvetronic Control Module determines the exact shaft position. The eccentric shaft sensor is mounted through the cylinder head cover (one per cylinder head) at the back.

The magnetic wheel is secured to the shaft by a bolt and is indexed by a tab (arrow) to prevent incorrect installation.

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Intermediate Lever and Roller Finger

The intermediate lever is positioned further (minimum valve opening) or closer (maximum valve opening) to the camshaft by the the progressive “lobe” on the eccentric shaft as it is rotated. This offers a variable ratio effect for valve actuation. The roller finger is used to actuate the intake valve.

43-02-33

The intermediate levers and roller fingers are matched (by classification) to ensure uniform valve lift.

Note: When disassembling/assembling the valvetrain, the intermediate levers and roller fingers must be returned to the original positions to prevent uneven cylinder charging which can result in rough idle and engine performance complaints.

Refer to the Repair Instructions for tolerance numbers!

Valve Lift

The Valvetronic motor worm gear rotates the eccentric shaft clockwise or counterclockwise at a very quick rate (1).

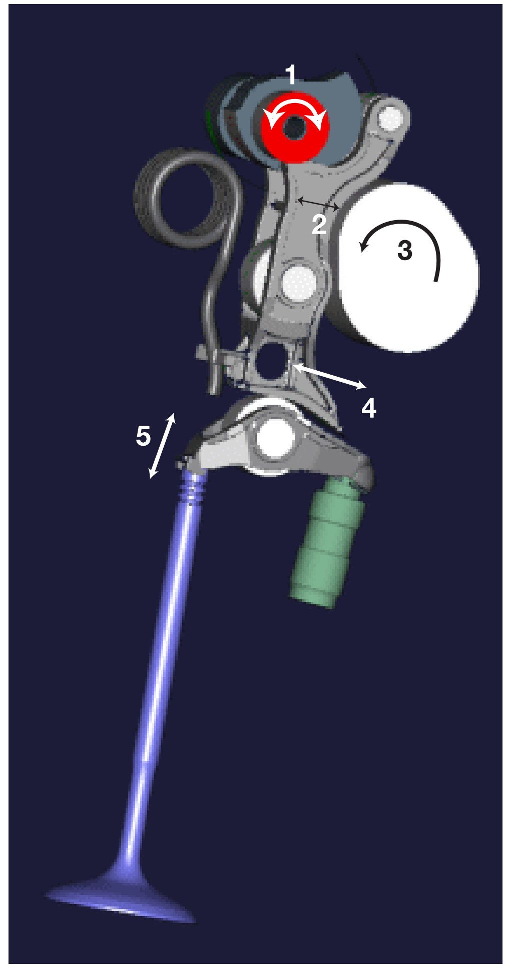
Due to the progressive "lobe" on the eccentric shaft, this rotation positions the intermediate lever (2) closer or further to the camshaft lobe.

As the camshaft is rotating (3), the cam lobe will pivot the intermediate lever (4) and the "heel" of the intermediate lever will depress the roller finger. A spring is located on each intermediate lever to maintain constant contact with the camshaft.

The roller finger is cushioned by the HVA and will open the intake valve (5).

The Valvetronic system varies the valve opening lift between 0.3 mm and 9.85 mm by rotating the eccentric shaft during engine operation to increase or decrease intake (flow) into the cylinder based on throttle request.

* This is an assembly that affects all of the intake valves (per cylinder head) to work in unison.

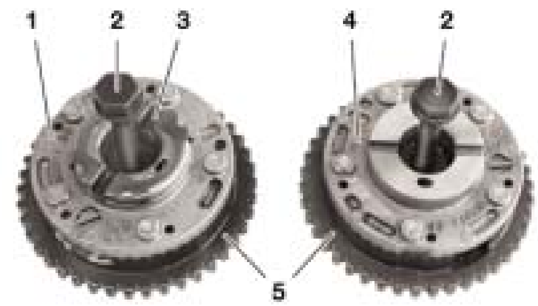


Notes:

Bi-VANOS (Variable Camshaft Adjustment)

The N62 features compact infinitely variable vane-type VANOS for the intake and exhaust camshafts. The VANOS unit is easy to remove and install. The VANOS unit is designed as an integral component of the chain drive and is secured to the respective camshaft with a central bolt. The camshaft adjustment rate is 60º (as compared with the crankshaft).

1. VANOS Unit Exhaust Side
2. VANOS Central Bolt
3. Spring Plate
4. VANOS Unit Intake Side
5. Toothed Chain Gear Teeth



VANOS Units 43-02-39

The VANOS unit gear teeth are visibly different to match the new toothed chain. The VANOS unit for the cylinders 1-4 exhaust shaft has mounting provisions for the vacuum pump drive. A spring plate is fitted between the VANOS unit and the vacuum pump drive to reduce wear (3). The ***VANOS units are labeled "In/Out"*** for intake and exhaust installation positions.

The VANOS units are supplied with oil via ports in the camshafts. The oil ports are located on the left and right of the thrust bearing. Depending on the individual VANOS adjustment direction, the VANOS is supplied with oil via either the rear oil ports (1 & 2) or the front oil ports (3 & 4). The oil moves through the camshaft to the VANOS units.

1&2. Rear Oil Duct with Four Holes
3&4. Front Oil Duct with Four Holes
5. Front Oil Duct Outlets
6&7. Hook Sealing Washer.

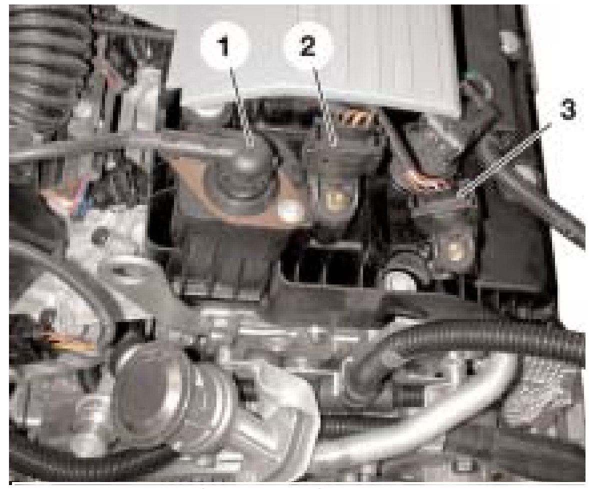
VANOS Oil Ports

Camshaft Sensors

The cam shaft sensors (Hall effect) are mounted through the cylinder head cover. There are two sensors per cylinder head to monitor the intake and exhaust camshaft positions.

The sensors monitor the impulse wheels attached to the ends of the camshafts.

1. Valvetronic Position Sensor
2. Intake Camshaft Position Sensor
3. Exhaust Camshaft Position Sensor



Camshaft Sensors

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Solenoid Valves

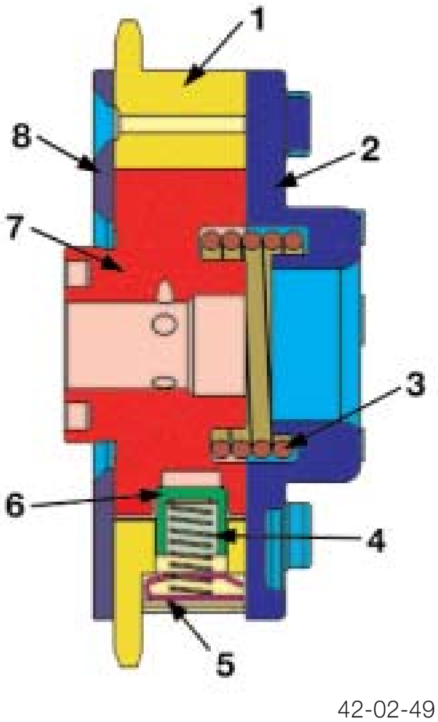
The VANOS solenoid valves are mounted through the upper timing case front cover. There are two solenoids per cylinder head to control the oil flow to the camshaft ports for the intake and exhaust VANOS units.

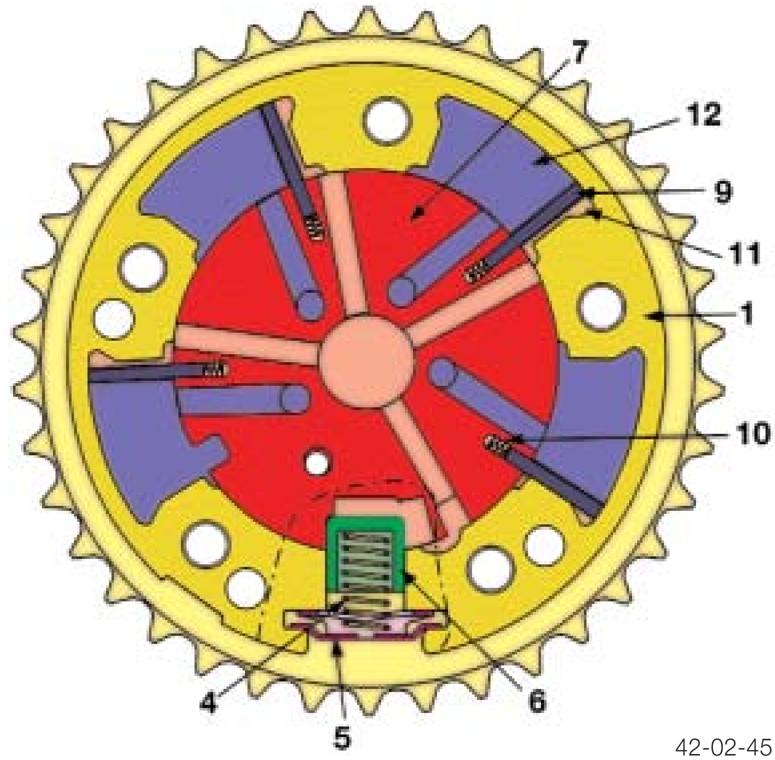
The 4/3 way proportional solenoid valve is activated by the ECM to direct oil flow. The solenoid valve is sealed to the front cover by a radial seal and secured by a retaining plate.

42-02-42

Notes:

VANOS Sectional Views





VANO'S Components

1. Housing with Sprocket
2. Front Plate
3. Torsion Plate
4. Lock Spring
5. Retaining Plate for Lock Spring
6. Spring Loaded Locking Pin
7. Hub
8. Black Plate
9. Blade
10. Spring
11. Pressure Chamber A
12. Pressure Chamber B

Mechanical Layout:

The figures above show a sectional view of one VANOS unit. The VANOS unit is secured by a central bolt through the hub (7) to the camshaft. The timing chain connects the crankshaft with the housing of the unit.

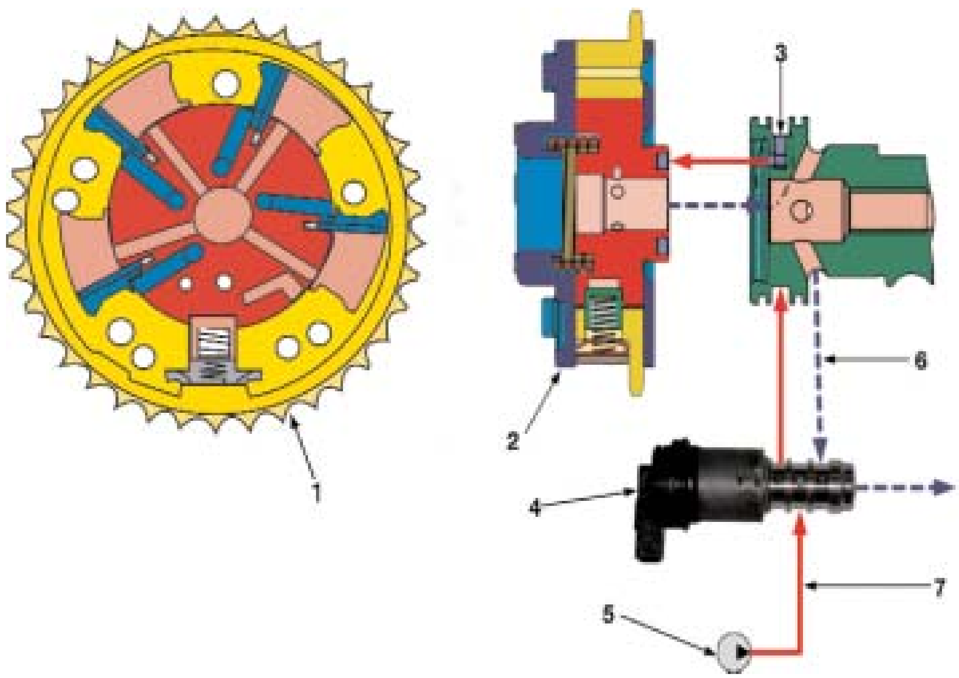
There is a recess in the hub in which the locking pin (6) engages without oil pressure (sprung). When the solenoid valve is activated to supply oil pressure to the VANOS unit, the locking pin is compressed and releases the VANOS for adjustment.

The internal blades (9) are spring loaded (10) to provide a seal between the oil pressure chambers (11 and 12). The torsion spring (3) acts against the camshaft torque.

Hydraulic Actuation:

When oil pressure is applied to chamber A, the blades are forced away from the VANOS housing (counterclockwise). The blades are keyed into the hub which results in the hub position being rotated in relation to the housing (with sprocket). The hub is secured to the camshaft which changes the camshaft to sprocket relationship (timing).

The example below shows the ***adjustment*** procedure together with the pressure progression based on the VANOS unit for the exhaust camshafts.



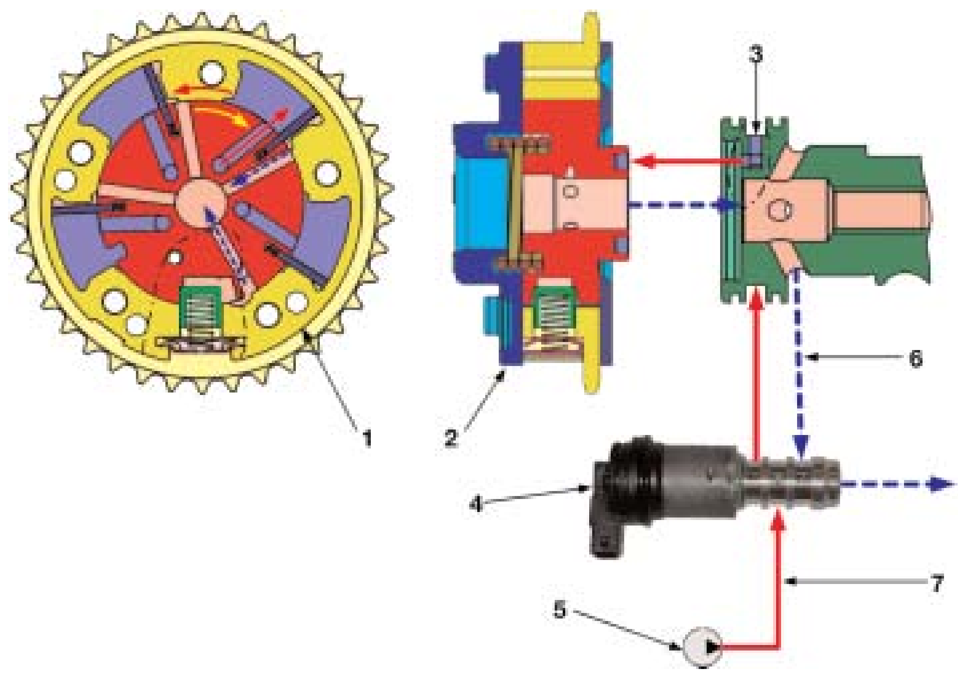
Hydraulic Actuation - Chamber A

1. Front View of Vanos Unit
2. Side View of Vanos Unit
3. Camshaft Oil Port (Chamber B)
4. Solenoid Valve
5. Engine Oil Pump
6. Supplied Oil from Pump (Switched Through Solenoid)
7. Supplied Oil Pressure (From Engine Oil Pump)

During this adjustment chamber B is open (through the solenoid) to allow the oil to drain back through the cylinder head (internal reservoir).

When the solenoid valve switches over, oil pressure is applied to chamber B. This forces the blades (and hub) in a clockwise direction back to the initial position, again changing the camshaft timing.

The example below shows the ***reset*** procedure together with the pressure progression based on the VANOS unit for the exhaust camshafts.



Hydraulic Actuation - Chamber B

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1. Front View of VANOS Unit
2. Side View of VANOS Unit
3. Camshaft Oil Port (Chamber B)
4. Solenoid Valve
5. Engine Oil Pump
6. Oil Return (Switched through Solenoid)
7. Supplied Oil Pressure (From Engine Oil Pump)

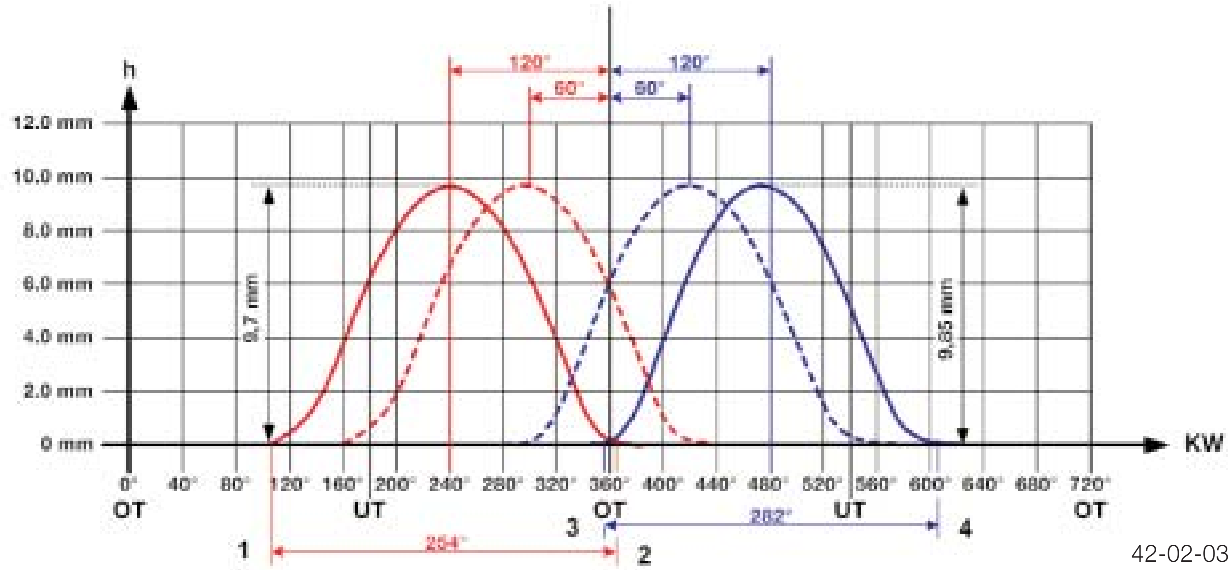
During this adjustment chamber A is open (through the solenoid) to allow the oil to drain back through the cylinder head (internal reservoir).

Notes:

The chart below shows the VANOS unit camshaft adjustment possibilities. The valve lift adjustment has also been incorporated.

The special feature of Valvetronic is that the air mass drawn in the cylinders can be easily determined by the valve lift and closing time. The air mass can then be limited, thus the term “load control”.

With the help of VANOS, the valve closing point can be easily selected within a defined range. With valve lift control, the opening duration and cross section of the valve opening can also be easily selected within a defined range.



42-02-03

Chart Exhaust & Intake Valve

1. Exhaust Valve Open
2. Exhaust Valve Closed
3. Intake Valve Open
4. Intake Valve Closed

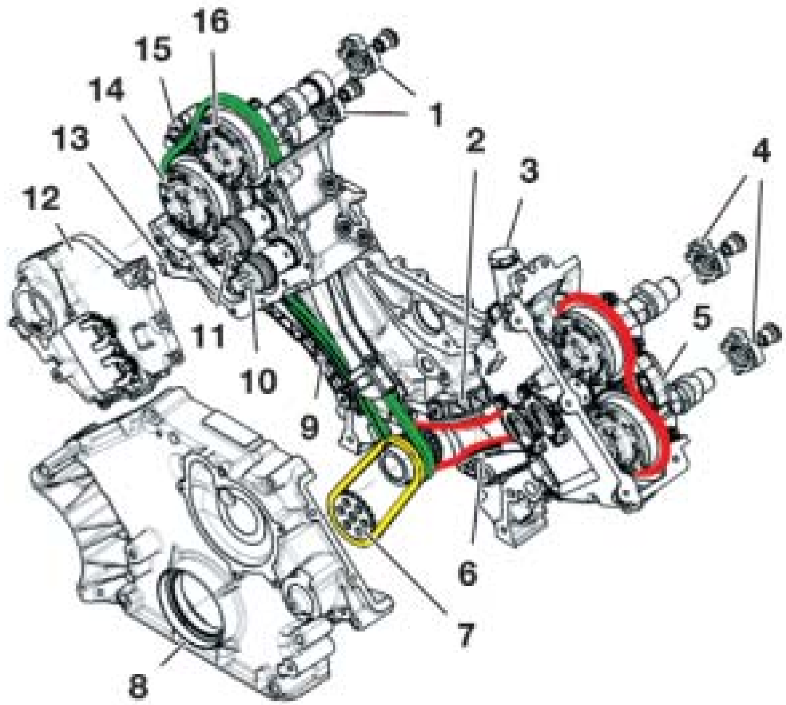
Vacuum pump

The N62 engine requires a vacuum pump for the vacuum assisted brake booster. With the throttle valve open while the car is being driven, additional vacuum is needed.

The N62 vacuum pump has a second vacuum connection (small hose) for the exhaust flap adjustment. The vacuum pump is driven by cylinders 1-4 exhaust camshaft via the VANOS unit. The pump is lubricated through an oil gallery from the cylinder head.

Chain Drive

The camshafts are driven by a toothed chain, one for each cylinder bank. The oil pump is driven by a separate roller chain.



Chain Drive

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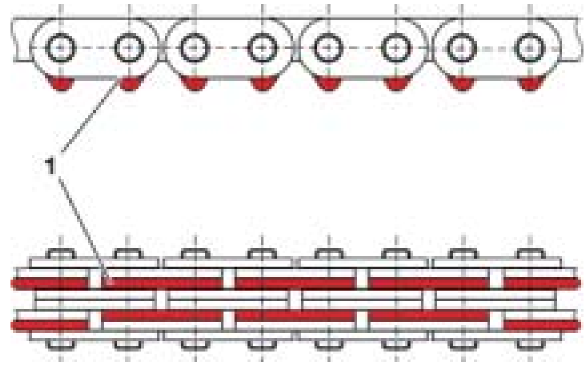
1. Sensor wheels for the camshaft position sensor, cylinder bank 1-4
2. Tensioner Rail, Cylinder 5-8
3. Chain Tensioner, Cylinder Bank 5-8
4. Sensor Wheel for the camshaft position sensor, cylinder bank 5-8
5. Upper timing chain guide with integrated oil jet
6. Guide rail
7. Sprocket for Oil Pump Drive
8. Timing case lower section
9. Tensioning rail, cylinder bank 1-4
10. Solenoid Valve, VANOS exhaust camshaft
11. Solenoid Valve, VANOS intake camshaft
12. Upper Timing Chain Cover
13. Chain Tensioner, Cylinder Bank 1-4
14. VANOS exhaust camshaft Bank 1-4
15. Upper Timing Chain guide with integrated oil jet
16. VANOS intake camshaft 1-4

Toothed Chain

The camshafts are driven by the crankshaft using newly developed maintenance free toothed chains.

The toothed chain gear wheels are located on the crankshaft and on the VANOS unit. Use of the new toothed chains (1) optimizes the drive chain rolling process and reduces noise.



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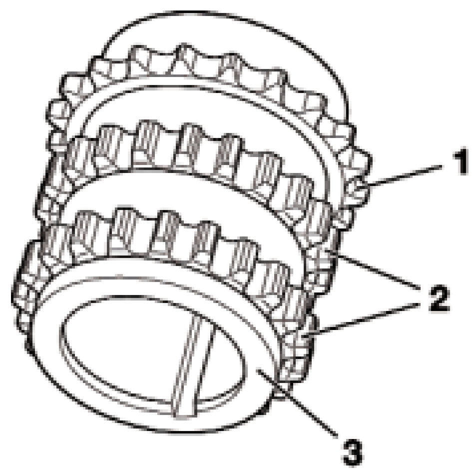
Crankshaft Sprocket

The crankshaft sprocket (3) has three sets of gear teeth:

1. One roller chain gear wheel for the oil pump drive.
2. Two toothed chain gear wheels for the camshaft drives.

Note: The sprocket will also be fitted to a 12-cylinder engine variant which will be available in the future. Please observe the installation instructions and the relevant labels (V8 Front/V12 Front) when installing the sprocket.



42-02-52

Chain Tensioner (cylinder bank 1-4)

A chain tensioner is mounted in the side of the cylinder head for each camshaft drive chain. There is a guide ball in the chain tensioner tip that moves in an arched groove in the tensioning rail.

The tensioner seal must be replaced each time the tensioner is disassembled. The tensioners are the same for both the left and the right cylinder heads.

1. Chain Tensioner
2. Tensioning Rail
3. Bearing Pin

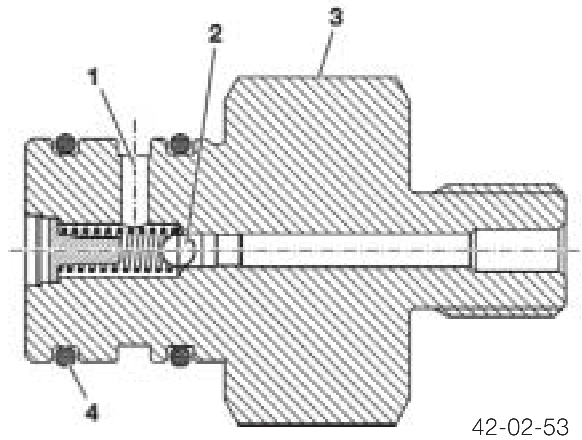
42-02-55

Chain Tensioner

Tensioning Rail Bearing Pin

The bearing pin for the cylinder bank 1-4 drive chain tensioning rail is hollowed. There is a ball (check) valve in the bearing pin. The valve opens at an oil pressure of 1 bar and allows engine oil to flow to the tensioning rail via a port (1).

1. Engine Oil Port to Tensioning Rail
2. Ball (check) Valve
3. Bearing Pin
4. Sealing Rings for Sealing the Tensioning Rail



42-02-53

Tensioning Rail Bearing Pin

Chain Tensioner (cylinder bank 5-8)

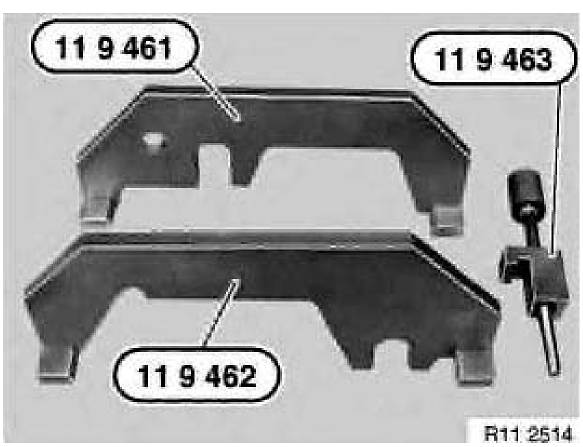
An oil jet has been fitted to lubricate the cylinder bank 5-8 drive chain. There is a valve in the oil jet which opens at a pressure of 1 bar and supplies the drive chain with engine oil.

1. Chain Tensioner
2. Tensioning Rail
3. Oil Jet

42-02-54

Chain Tensioner

Note: Refer to the Repair Instructions when using the Special Tools shown below to adjust the camshaft timing.



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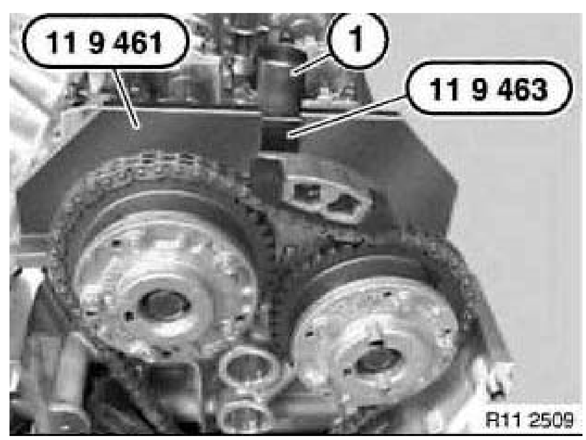

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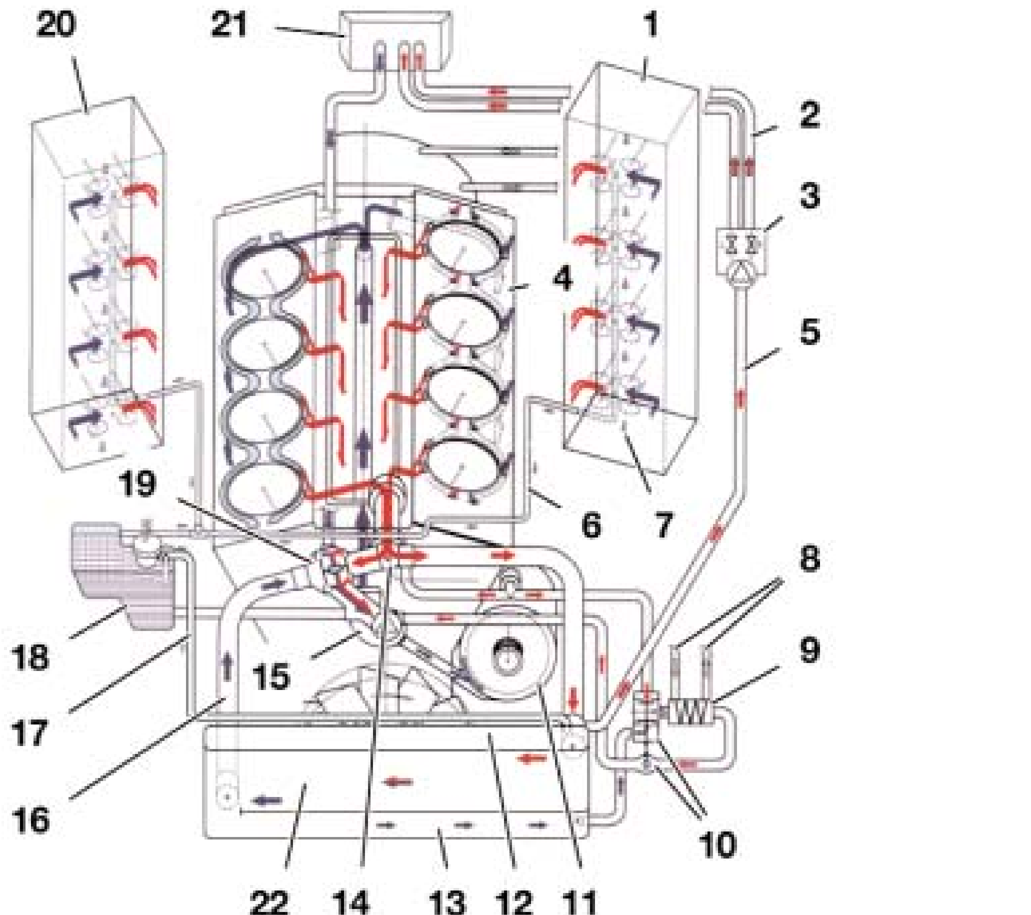
Cooling System

Coolant Circuit - 14 Liter Coolant Capacity



Cooling System (Circuit Flow)

1. Cylinder Head Bank 5-8
2. Coolant Supply (heater core)
3. Water valve with electric water pump
4. Cylinder Head Gasket
5. Coolant Supply Line
6. Cylinder Head Ventilation Lines
7. Hole (crankcase venting system)
8. Transmission oil lines
9. Oil/water heater exchanger for automatic transmission
10. Thermostat for transmission oil heat exchanger
11. Alternator Housing
12. Radiator
13. Radiator Partition (low temp section)
14. Temperature Sensor
15. Water Pump
16. Radiator Return Flow
17. Radiator Ventilation Line
18. Expansion Tank
19. Thermostat
20. Cylinder Head Bank 1-4
21. Vehicle Heater
22. Radiator (High Temperature Area)

Coolant Circuit

The coolant flow has been optimized allowing the engine to warm up as quickly as possible after a cold start as well as even and sufficient engine cooling while the engine is running. The cylinder heads are supplied with coolant in a cross-flow pattern. This ensures more even temperature distribution to all cylinders. The cooling system ventilation has been improved and is enhanced by using ventilation ports in the cylinder heads and in the radiator. The air in the cooling system accumulates in the expansion tank. When a pressure of 2 bar is reached in the expansion tank, the air is bled out by the pressure relief valve in the reservoir cap.

Note: The ventilation ports in the front of the cylinder heads provide quicker “self bleeding” during a routine coolant exchange. The complex cooling system and the small ventilation ports require that time should be allowed after the cooling system has been filled for the air to escape.

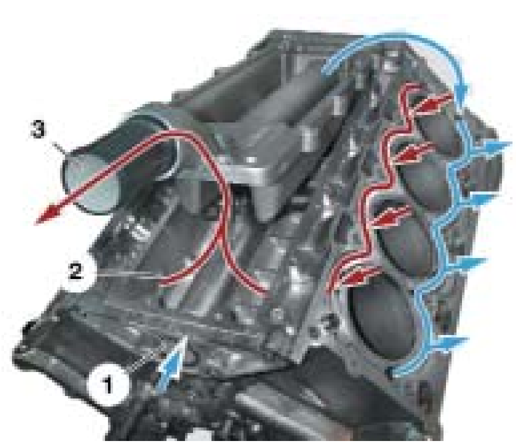
Coolant flow in the Engine Block

The coolant flows from the water pump through the feed pipe (1) in the engine's V and to the rear of the engine block. This area has a cast aluminum cover (see following illustration). From the rear of the engine, the coolant flows to the external cylinder walls and from there into the cylinder heads.

The coolant then flows from the cylinder heads into the engine block V and through the return connection (3) to the thermostat housing. When the coolant is cold it flows from the thermostat (closed) directly into the water pump and back to the engine (recirculating for faster warm up).

When the engine reaches operating temperature (85 ºC-110 ºC), the thermostat opens the entire cooling circuit to include the radiator.

1. Coolant from the water pump through the feed pipe to the rear of the engine.
2. Coolant from the cylinder walls to the thermostat housing.
3. Return connection to water pump/thermostat.



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Engine Block Coolant Flow

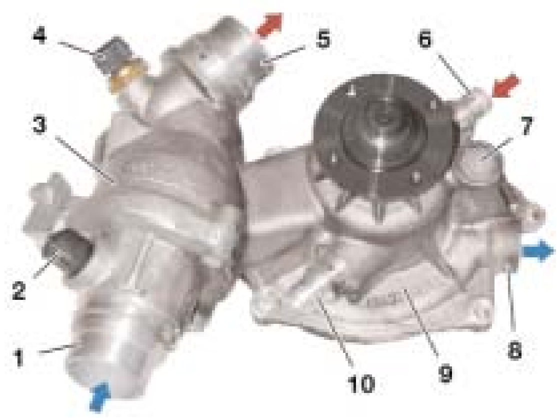
The coolant flows to the rear of the engine block, from there through the side channels to the cylinder walls and then into the cylinder heads (lower left picture). The cast aluminum cover at the rear of the engine block (with sealing bead) is shown on the lower right.

42-02-59

Water Pump/Thermostat Housing

The water pump is combined with the thermostat housing and is bolted to the timing case lower section.

1. Map-controlled themostat (radiator cool return flow).
2. Electrical connection for Thermostat Heating element.
3. Thermostat Mixing Chamber
4. Temperature Sensor (hot coolant from engine)
5. Radiator in-flow (hot coolant from engine)
6. Heat exchanger (transmission oil return flow)
7. Leakage Chamber (evaporation space)
8. Alternator in-flow (cool supply)
9. Water Pump
10. Expansion Tank Connection



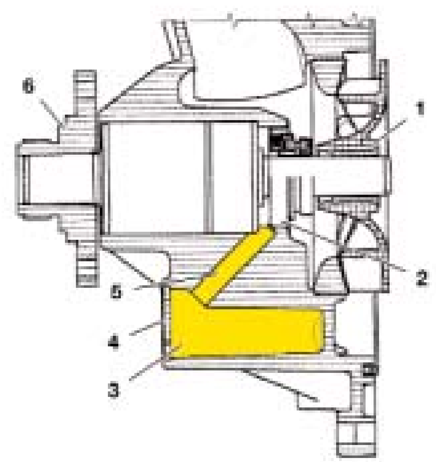
Water Pump / Thermostat Housing

Caution during installation of the water pump: The impeller is made from reinforced plastic.

Leakage Restraint System in the Water Pump

The water pump has a leakage restraint system for the functional leakage from the pump shaft piston ring type seal. The coolant which escapes through the pump shaft sliding ring seal usually accumulates and evaporates through a hold in the leakage chamber (evaporation area).

If the sliding ring seal is faulty, the leakage chamber fills completely with coolant. Sliding ring seal leakages can be detected by monitoring the fluid level in the leakage chamber (inspection hole).



1. Impeller
2. Sliding Ring Seal
3. Leakage Chamber / Evaporation Space
4. Leakage Chamber Cover
5. Delivery from the sliding ring seal to the leakage chamber
6. Hub of pulley and viscous clutch

Water Pump

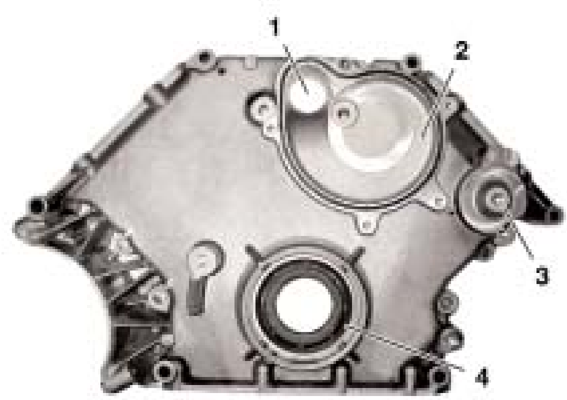
42-02-61

Note: In the past, fully functional water pumps were often replaced because the functional sliding ring seal leakage which is necessary for water pump operation resulted in evaporation residues being left on the external walls of the water pump.

The leakage restraint system has the advantage in that the coolant escaping from the sliding ring seal (normal, functional leakage) evaporates without a trace and cannot be mistakenly identified as a water pump defect during visual inspections.

Timing Chain Cover Lower Section

The waterpump mounts to the lower section to channel coolant to the engine block.



1. Coolant to Engine
2. Rear Water Pump Housing in Lower Section
3. Mount for Drive Belt Tensioner Pulley
4. Crankshaft Radial Seal

Timing Chain Cover Lower Section

42-02-62

Map-controlled Thermostat

The map-controlled thermostat allows the engine to be cooled relevant to operating conditions. This reduces fuel consumption by approximately 1-6%. The electrical connections, the design and the map-controlled thermostat response have been enhanced. The map-controlled thermostat function is the same as previous engines (M62).

1. Radiator Return Flow To Thermostat
2. Connection for Thermostat Heating Element
3. Temperature Sensor
4. Radiator in-flow (hot coolant from engine)

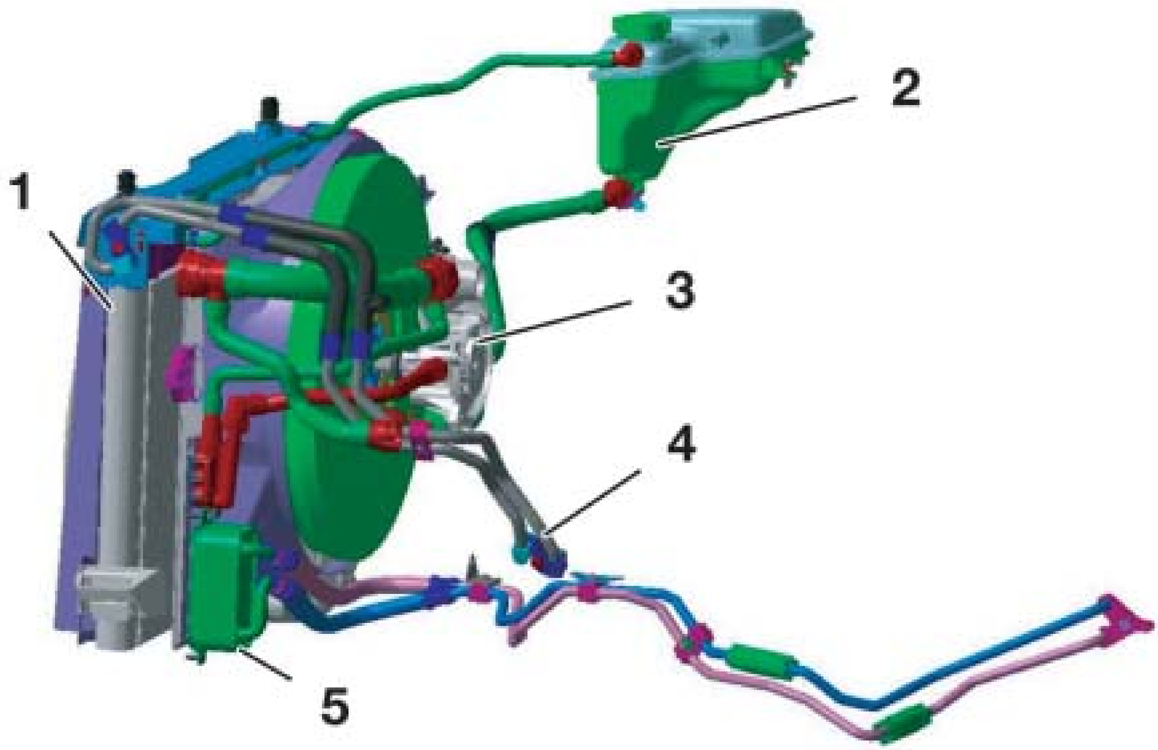
Maped-Controlled Thermostat

Cooling Module

The cooling module contains the following main cooling system components:

- Cooling radiator
- Air conditioning condenser
- Transmission oil/water heat exchanger
- Hydraulic fluid radiator
- Engine oil radiator
- Main electric fan
- Fan shroud for viscous coupling fan

All the components (with the exception of the transmission oil radiator) can be removed for repairs without disassembling any other coolant circuit. All connections have been fitted with the quick-release coupling which are used in current models.



Cooling Components

1. Cooling Radiator
2. Expansion Tank
3. Water Pump
4. Engine oil/air heat exchanger connection (hot countries only)
5. Transmission oil/coolant heat exchanger

Cooling Radiator

The radiator is made from aluminum and is divided into a high-temperature section and a low-temperature section by a partition wall (see coolant circuit diagram). The coolant first flows into the high-temperature section and then back to the engine, cooled.

Some of the coolant flows through an opening in the radiator partition wall to the low-temperature section where it is cooled further. The coolant then flows from the low-temperature section (when the ÖWT thermostat is open) into the oil/coolant heat exchanger.

Coolant Expansion Tank

The expansion tank is mounted on the right hand wheel housing (engine compartment). *Note:* The expansion tank should never be filled above the Max marking. Excess coolant is expelled by the pressure relief valve in the cap as it heats up. Avoid overfilling the expansion tank because the cooling circuit design ensures very good “self bleeding”.

Transmission Oil/Coolant Heat Exchanger

The transmission oil/coolant heat exchanger ensures that the transmission oil is heated up quickly and also that it is appropriately cooled. When the engine is cold, the transmission oil/coolant heat exchanger thermostat switches into the engine's recirculated coolant circuit. This allows the transmission oil to heat up as quickly as possible (with the engine coolant).

When the return flow water temperature reaches 82 ºC, the thermostat switches the transmission oil/coolant heat exchanger to the low-temperature coolant radiator circuit (refer to the cooling circuit diagram) to cool the transmission oil.

Electrically Operated Fan

The electric fan is integrated in the cooling module and is mounted directly in front of the radiator. The speed is regulated by the ECM.

Viscous Coupling Fan

The viscous coupling fan is driven by the water pump. The noise output and the performance of the fan coupling and the fan wheel have been optimized as compared with the E38M62. The viscous coupling fan is used as the final level of cooling and switches on at an air temperature of 92 ºC.

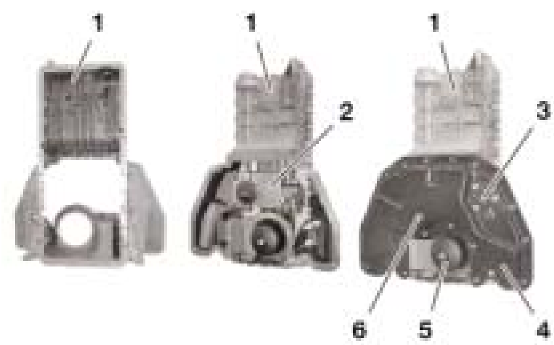
Notes:

Engine Block

Oil Sump

The oil sump consists of two parts. The upper section of the oil sump is made from cast aluminum and is sealed to the crankcase with a rubber-coated sheet steel gasket. This section of the oil sump has a cross shaped cut out oil filter element recess. The upper section of the oil sump is inter connected to the oil pump and is sealed with a sealing ring. The double panel (noise insulation) lower section of the oil sump is flanged to the upper section of the oil sump.

1. Upper Section of The Oil Sump
2. Oil Pump
3. Oil Level / Condition Sensor
4. Lower Section of The Oil Sump
5. Oil Filter Housing
6. Oil Drain Plug



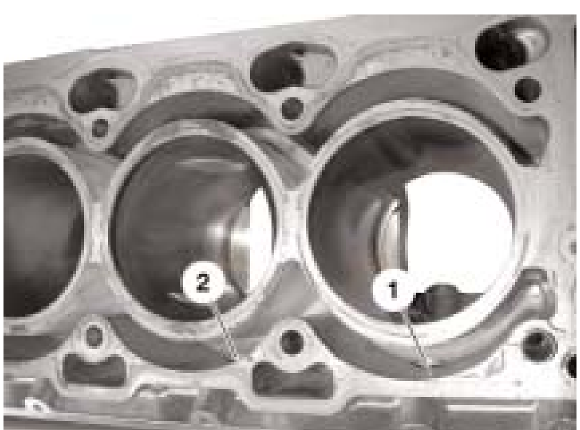
Oil Sump Components

42-03-65

Crankcase

The crankcase has a one-piece “open deck” design and is made entirely from AluSil. The cylinder walls are hardened using a specific procedure (exposure honing). Exposure honing involves treating the cylinders with a special “soft stripping”. This removes the aluminum from the cylinder surface and the hard silicone particles remain.

Open Deck = Exposed cylinder coolant chamber



42-02-67

42-03-66

1. Flow to engine “V” (return coolant collection area)

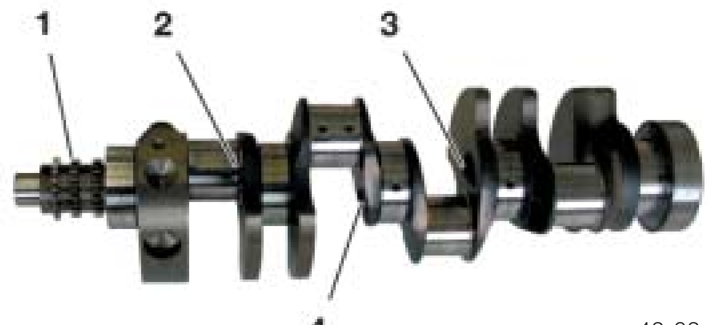
2. External cylinder bank wall

Crankshaft

The N62 uses an inductively hardened cast-iron crankshaft. The crankshaft has five main bearings (familiar 4 bolt cast iron caps) and is hollowed around bearing journals 2, 3, and 4 for weight reduction. The fifth bearing is also the “thrust” bearing.

The crankshaft stroke for the B44 is 82.7 mm.

1. Crankshaft Sprocket
2-4. Hollowed Area (Weight Reduction)



42-02-68

Crankshaft

Crankshaft Thrust Bearing

The thrust bearing halves are multiple pieces that are assembled as one part for the the number five main bearing at the rear of the engine. The bearing thickness conforms to the familiar triple classification system (yellow - green - white).


42-02-70

Piston and Connecting Rod

The reduced weight cast piston contains integrated valve reliefs in the piston crown. The pistons are made from high-temperature aluminum alloy equipped with three piston rings.

- First piston ring groove = square ring
- Second piston ring groove = taperface ring
- Third piston ring groove = three-part oil control ring


42-03-70

The forged steel connecting rod and cap is separated by the familiar “cracked” process. The connecting rod (large end) is angled at 30º allowing sufficient articulation in a very compact space. The pistons are cooled by oil jets spraying under the exhaust side of the piston crown.

Flywheel

The lightweight flywheel is made from a laminated plate. The starter ring gear is also the increment wheel for engine speed and crankshaft positioning/misfire detection.

The ring gear is riveted directly to the flexplate (6). The flywheel diameter is 320 mm.

Vibration Damper

The vibration damper is a torsional vibration absorber (axial design). The outer edge of the damper has a notch (1) to accept the locating tool when positioning the crankshaft for initial setting.

The locating tool inserts into the raised mount in the front cover (2). ***Refer to the Repair Instructions for the proper engine timing procedure.***

Engine Mounting

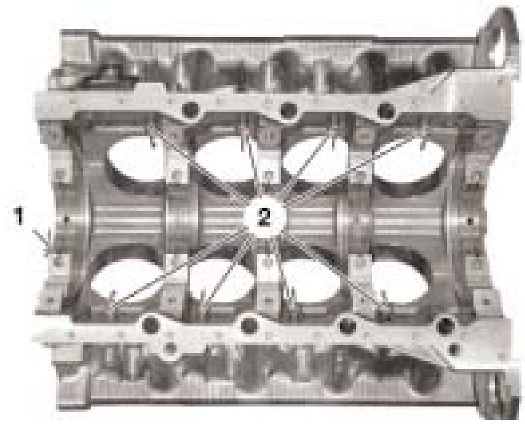
The engine is secured by two hydraulic damping mounts that are located on the front axle carrier (structure and function are the same as the E38/M62).

Notes:

Lubrication System

Crankcase with oil jets

1. Oil Jet for Drive Chain Cylinder Bank 5-8
2. Oil Jets for Piston Cooling



Crankcase with Oil Jets

42-02-71

The engine oil is supplied by the oil pump to the lubrication points in the engine block and is pumped into the cylinder heads. The following components in the crankcase and cylinder head are supplied with engine oil:

Crankcase

- Crankshaft bearings
- Oil jets for piston cooling
- Oil jet for the drive chain (bank 5-8)
- Tensioning rail for drive chain (bank 1-4)

Cylinder head

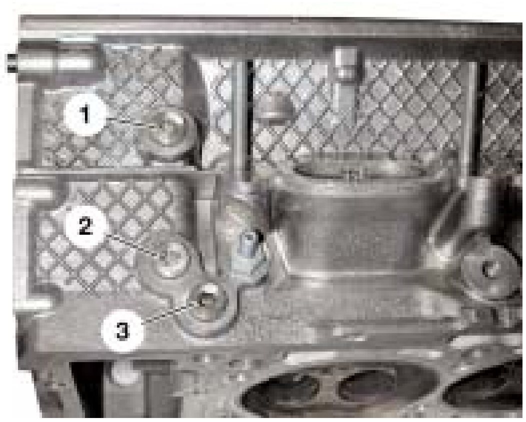
- Chain tensioner
- Guide rail on cylinder head
- Hydraulic valve adjustment elements (HVA)
- VANOS supply
- Camshaft bearings
- Overhead oil tubes for the valve gear

Oil Check Valves

Three oil check valves are inserted into each cylinder head from the outside. This prevents the engine oil from draining out of the cylinder head and the VANOS units.

The check valves are accessible from the outside, therefore; cylinder head removal is not necessary when changing the check valves.

1. Oil Check Valve for VANOS Intake
2. Oil Check Valve for VANOS Exhaust
3. Oil Check Valve for Cylinder Head Oil Supply



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Oil Check Valves

Note: The oil check valves are different in design and should not be mixed up on installation.

42-02-73

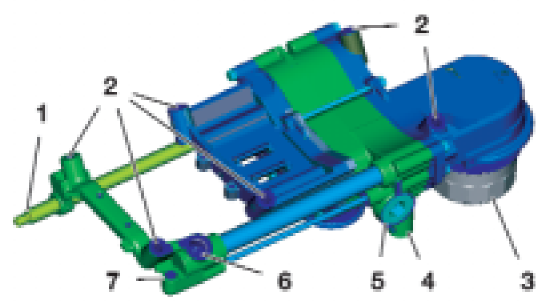
Oil Pressure Switch

The oil pressure switch is located on the side in the bank 1-4 cylinder head.

Oil Pump

The oil pump is mounted at an angle to the crankshaft bearing cap and is driven by the crankshaft using a roller chain. The oil pump is a two-stage gear oil pump with two parallel switched gear clusters.

1. Drive Shaft
2. Mounting Points
3. Oil Filter
4. Pressure Relief Valve (over 15 Bar)
5. Control Valve (Pump Stage/Pressure Control)
6. Oil supply from the oil pump to the engine
7. Oil pressure control tube from the engine to the control valve.



42-02-75

Oil Pump

The two pair of gear clusters are stacked one behind the other and work in two stages.

Stage two (both pump supply circuits) is only active in the lower engine speed range up to approx. 2,000 rpm to provide sufficient oil pressure for the VANOS at high oil temperatures.

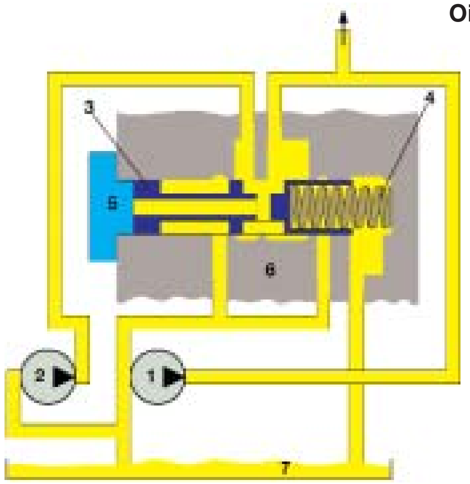
Stage two is deactivated hydraulically at a pressure of 2 bar.

42-02-76

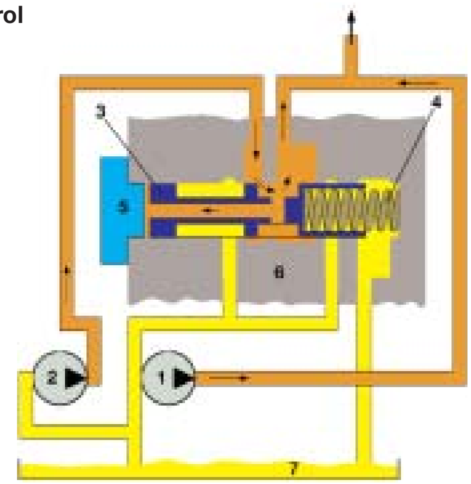
Oil Pressure Control

1. Oil Pump Stage 1
2. Oil Pump Stage 2
3. Pressure Control Valve Piston
4. Pressure Control Valve Spring
5. Sealing Plug
6. Oil Pump Housing
7. Oil Sump

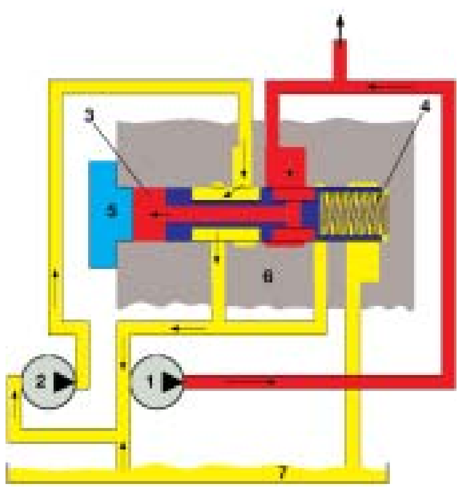
Oil Pressure Control



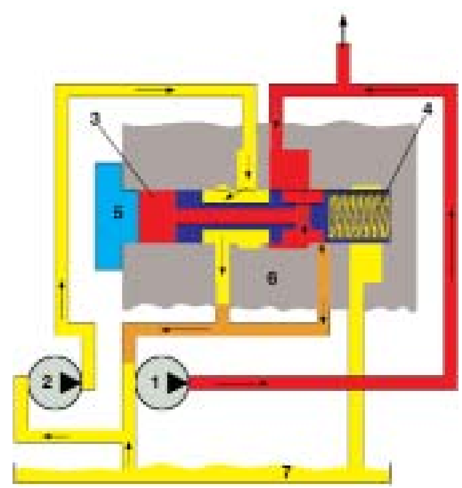
Oil pressure control valve in initial position, without pressure.



Stage two = Both pump supply circuits activated with oil pressure less than 2 bar.



Stage two deactivated = Oil pressure above 2 bar, pressure control valve opens channel for stage two to oil sump.



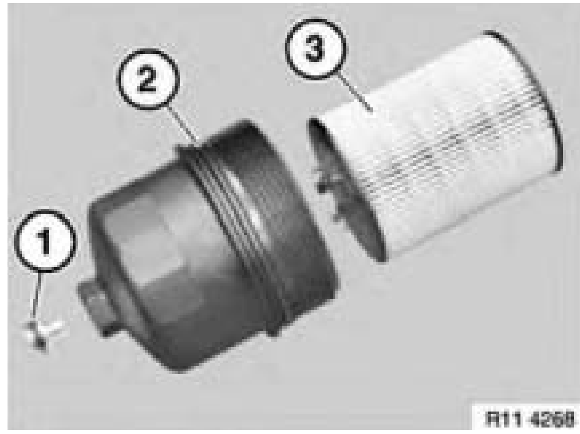
Main pressure control = Oil pressure above 6 bar, pressure control valve opens channel for stage one (slightly) to oil sump relieving excessive pressure.

Oil Filter

The canister type oil filter (3) is located under the engine by the oil sump. The support for the oil filter is integrated in the rear oil pump cover.

The oil filter housing (2 with o-ring) is threaded into the rear of the oil pump cover through an opening in the oil sump.

A drain plug is integrated in the oil filter housing for draining the filter assembly before the housing is removed (1 with o-ring).



42-02-77

The filter element support dome contains an over pressure relief valve. If the filter element is blocked, this valve bypasses unfiltered engine oil around the element to the supply lubrication to the engine.

Pressure Control

The oil pressure control valve in the oil pump has two functions:

1. Deactivates stage two oil pump circuit above 2 bar. Stage two is only active in the lower speed range. This is to ensure that there is always sufficient oil pressure for the VANOS units even at high oil temperatures and low speeds. The oil pump power consumption is reduced by deactivating stage two.

2. Monitoring the required oil pressure for the engine. The piston in the control valve is moved by a spring against the engine control pressure which is returning from the engine. This means that precise monitoring of the actual engine oil pressure is possible.

A separate pressure relief valve in the oil pump automatically opens at the maximum pressure of approximately 15 bar. This prevents damage in the oil pump especially at low oil temperatures.

Oil Cooling (if equipped)

An oil cooler is used in hot countries. The oil cooler is located in front of the radiator above the A/C condenser. The engine oil flows from the oil pump through a channel in the crankcase to a connection on the generator support. The generator support has an oil thermostat. A wax element in the oil thermostat continuously opens the inflow to the oil cooler when the oil temperature is between 100 ºC to 130 ºC.

Some of the engine oil always flows past the oil thermostat and through the engine without being cooled, even when the oil thermostat is fully open. This ensures a minimum amount of oil is supplied when the cooler is faulty. A modified generator support, without connections for the oil thermostat, is fitted to vehicles which do not have an oil cooler.

Technical Data - Lubrication System

The recommended oil is BMW High Performance 5W-30 Synthetic Oil
* P/N 07 51 0 017 866

Oil Capacity in Liters	Explanation
8.0	Filling Capacity for Service with Oil Filter Change

Oil Pressure	Explanation
1.0	Minimum Oil Pressure at 20ºC
4.0 - 8.0 Bar	Maximum Oil Pressure at 20ºC

Oil Delivery Capaci ty	Explanation
9-12 l/Min	At Idle Speed (700 rpm) at 20ºC
50-55 l/Min	At Maximum Engine Speed (6500 rpm) and 20ºC

Review Questions

1. What is the function of the throttle valve?

2. What are the conditions that will result in stage two oil supply?

3. What does the term “cracked” connecting rod mean?

4. What does the low temperature area refer to in the cooling system?

5. What is the difference between the left and right drive chain tensioning assemblies?

6. How is the funnel adjustment made on the 5-8 Variable intake manifold if only one actuating motor is used?

7. What is minimum and maximum valve lift provided by the Valvetronic system?

8. What is chamber A and chamber B used for in the Bi-VANOS system?

9. What retains the initial VANOS sprocket to hub position when oil pressure is not present?

10. How should the drive belt be removed?

Table of Contents

Subject **Page**

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

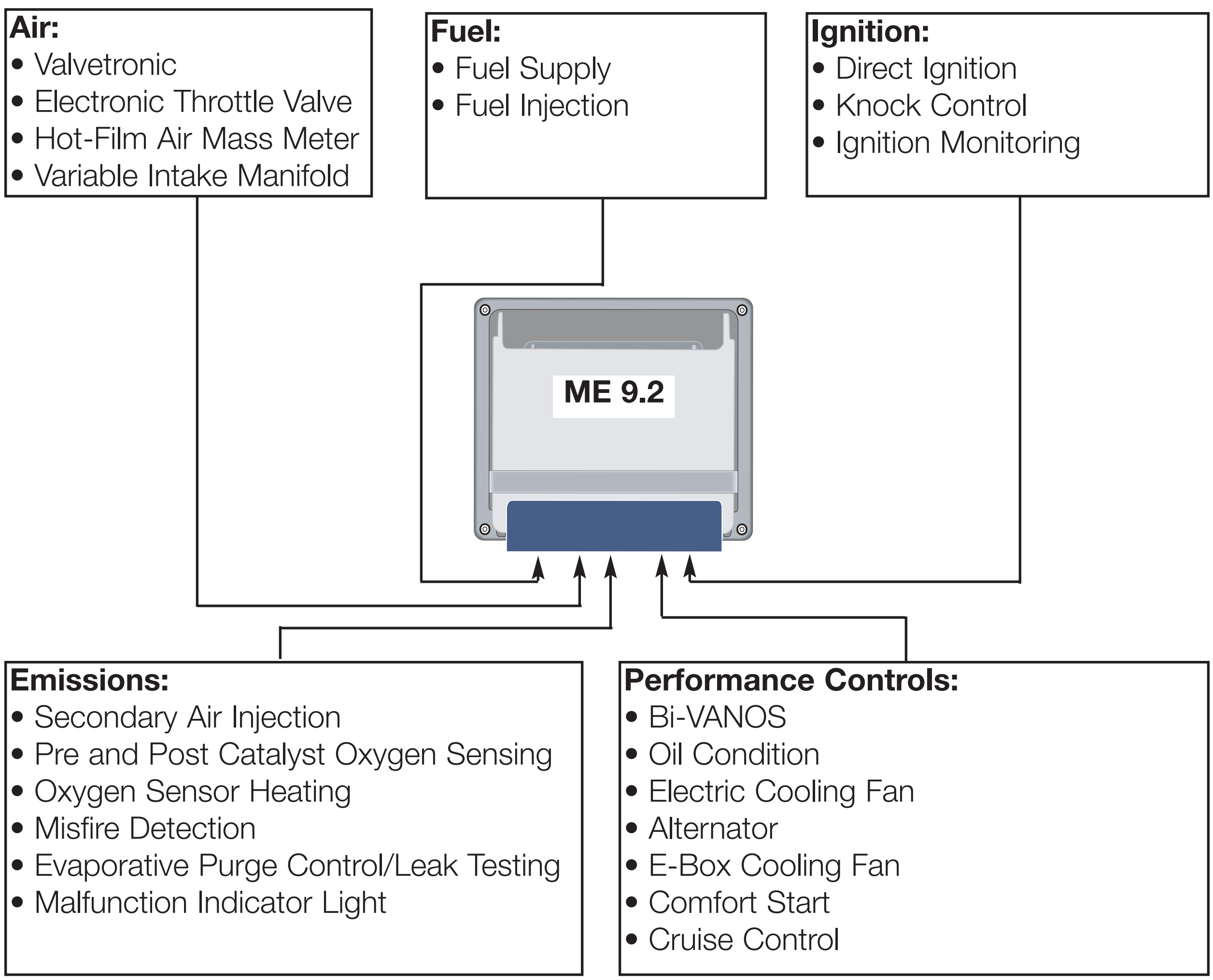
After completing this module, you will be able to:

- 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:

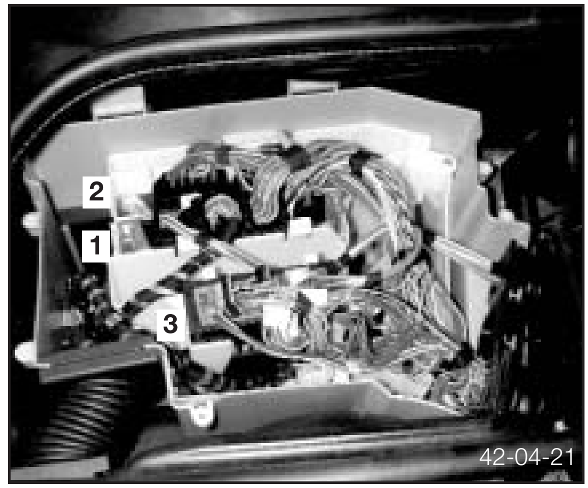


The basic engine management inputs, processes and outputs are not included in this module because they have not changed, refer to the ST055 Engine Electronics hand out for details.

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

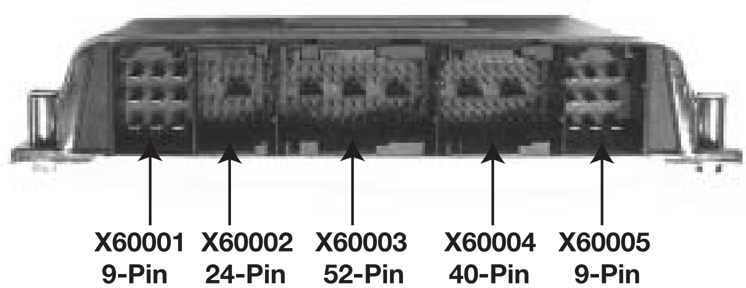


42-04-21

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.



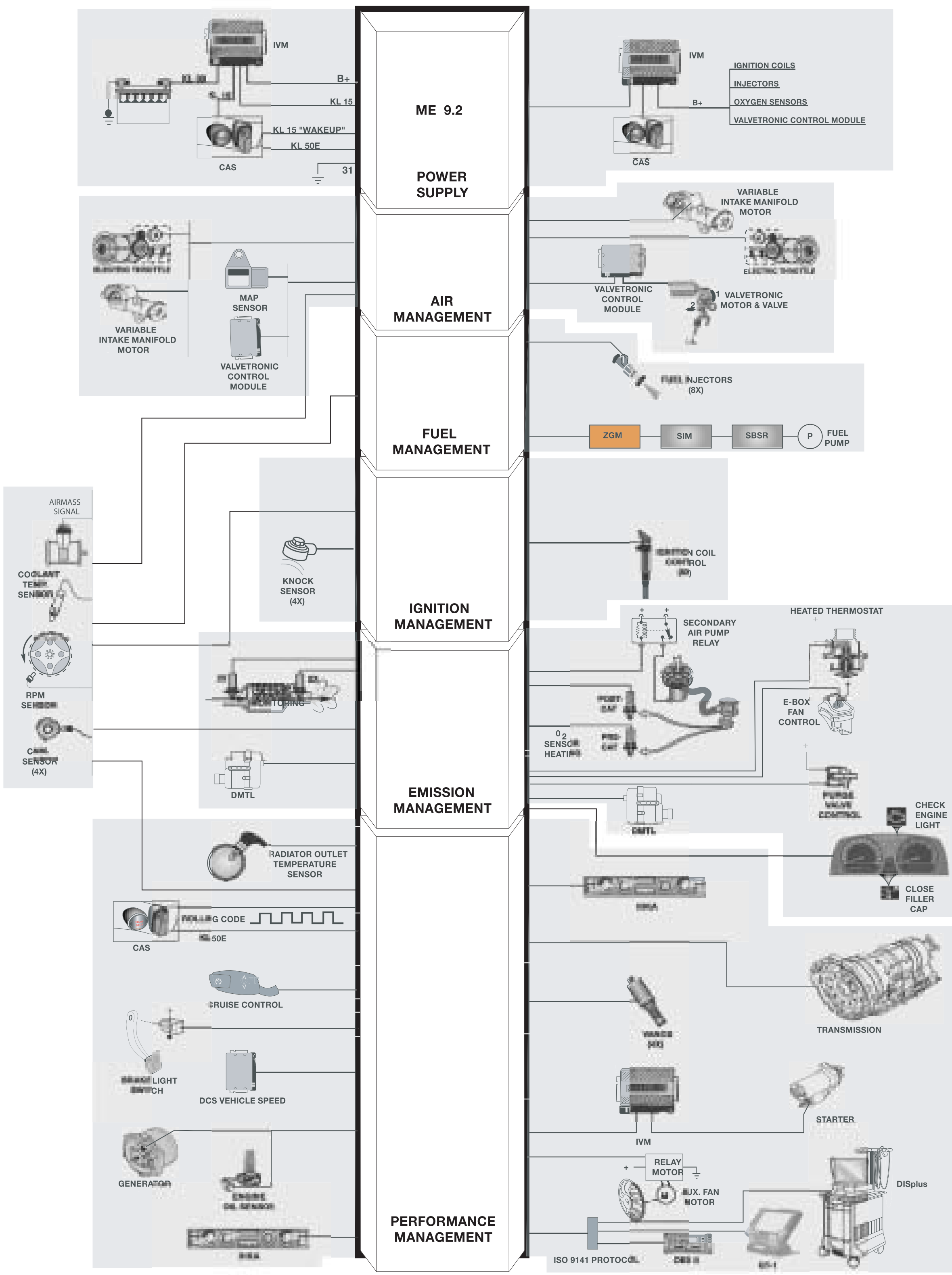
42-04-22

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).


W12 1 310

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.



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
AIRMASS SIGNAL
COOLANT TEMP SENSOR
RPM SENSOR
CAM SENSOR (4X)
KNOCK SENSOR (4X)
INJECTORS (8X)
ZGM
SIM
SBSR
P
FUEL PUMP
IGNITION COIL CONTROL
SECONDARY AIR PUMP RELAY
HEATED THERMOSTAT
E-BOX FAN CONTROL
O_2 SENSOR HEATING
MONITORING
DMTL
CHECK ENGINE LIGHT
CLOSE FILLER CAP
RADIATOR OUTLET TEMPERATURE SENSOR
ROLLING CODE
KL 50E
CRUISE CONTROL
LIGHT SWITCH
DCS VEHICLE SPEED
TRANSMISSION
STARTER
GENERATOR
RELAY MOTOR
AUX. FAN MOTOR
DISplus
ISO 9141 PROTOCOL

42-04-23

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:

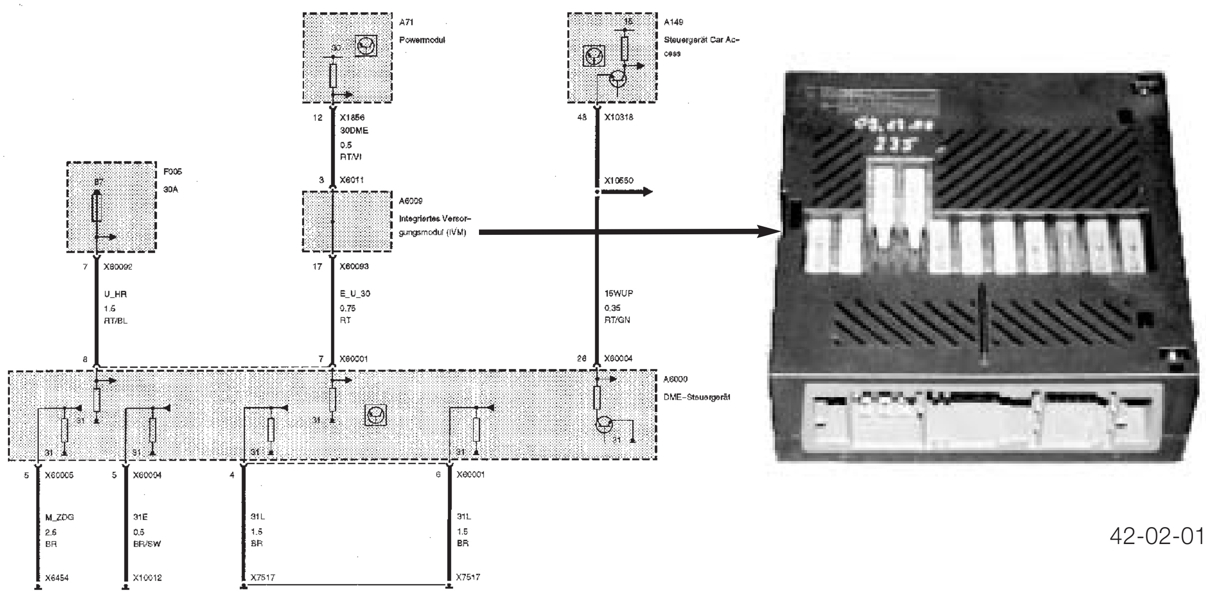
Switch
Starter Switch

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.

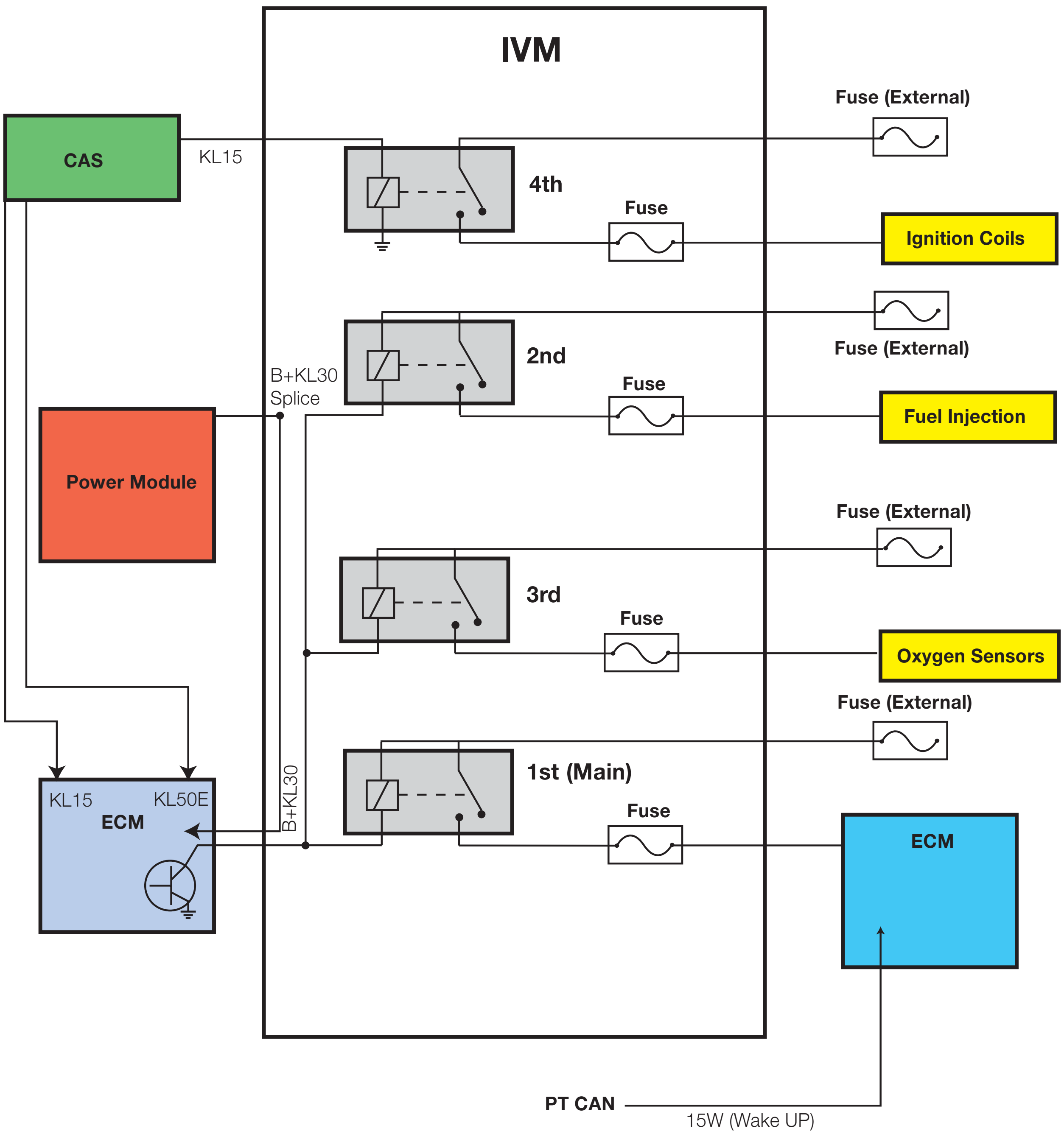
KL15 - Ignition Switch Signal: When the ignition is switched “on” the ECM is informed from the CAS Module that the engine is about to be started via a “wakeup” call (15w) over the PT CAN line. The ECM also receives a “hardwire” KL15 input from the CAS Module. The ECM activates a ground circuit to the 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.



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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.

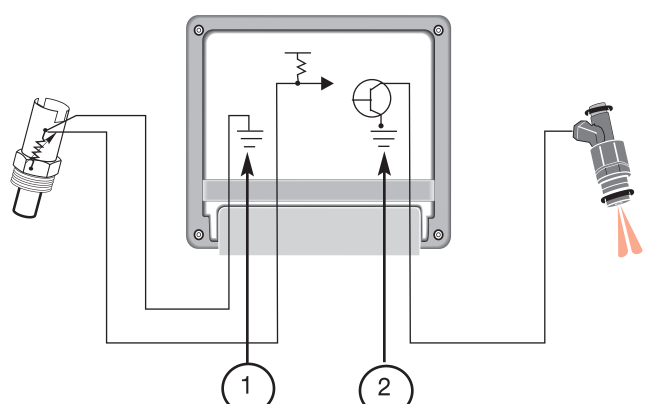

42-08-01

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).

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

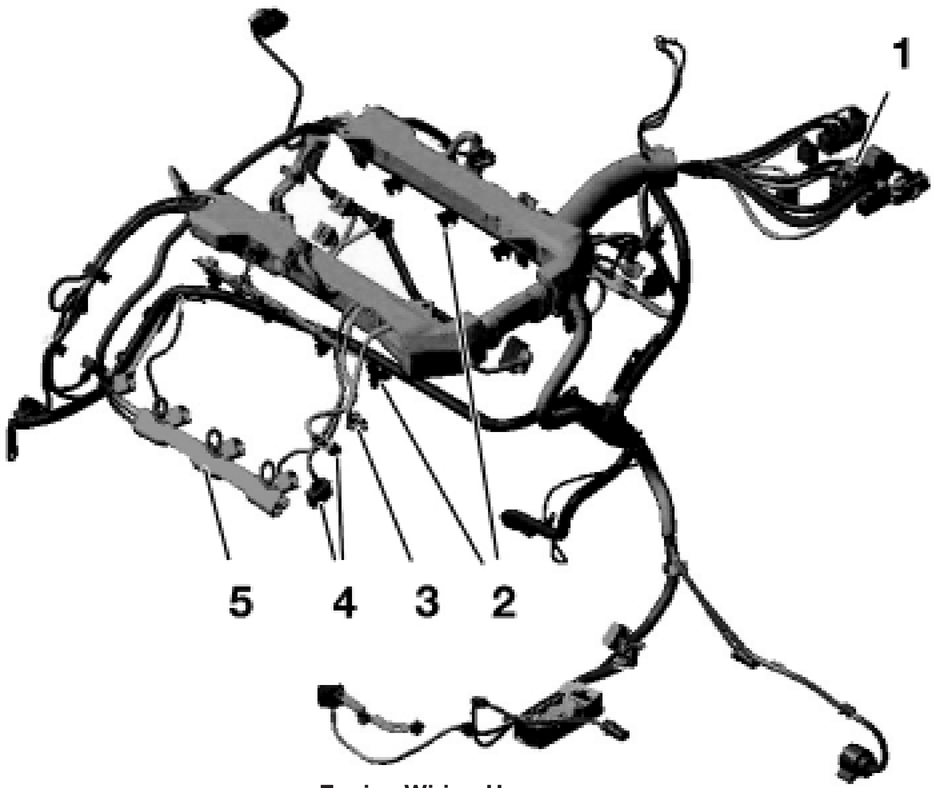
- Internally links a constant ground (1) to the engine sensors.

- 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.

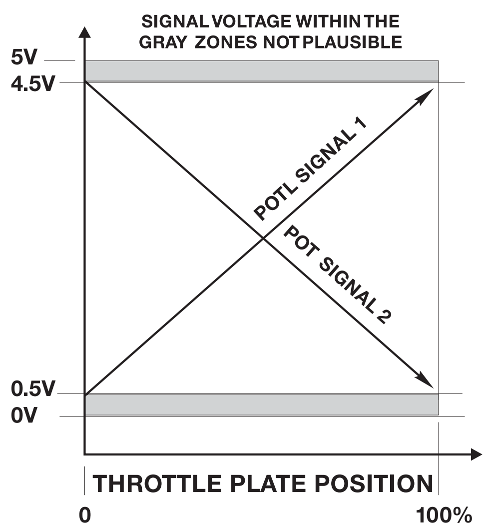
Electronic Throttle Valve 42-02-25

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:

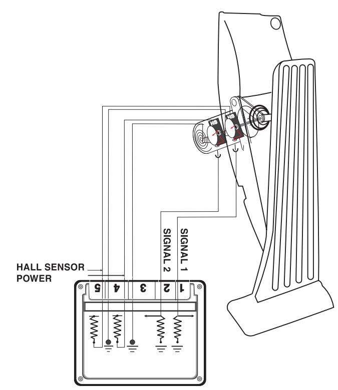
Accelerator Pedal Position (PWG): The accelerator pedal module provides two variable voltage signals to the ECM that represents accelerator pedal position and rate of movement. The ECM will activate the Valvetronic system.

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

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.



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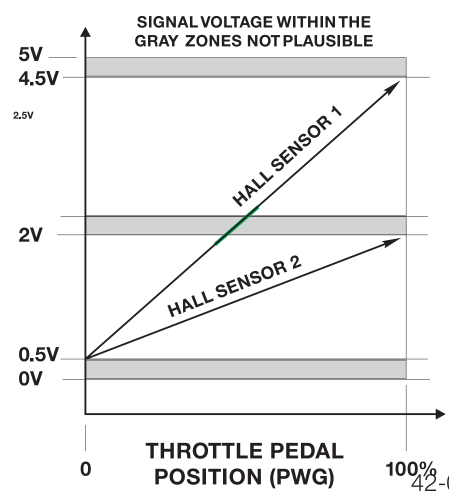

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Hot-Film Air Mass Meter (HFM): The air volume input signal is produced electronically by the HFM (1) which uses a heated metal film in the air flow stream. The HFM housing is mounted in the air inlet pipe between the air filter and the throttle valve.

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.

42-04-04

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.

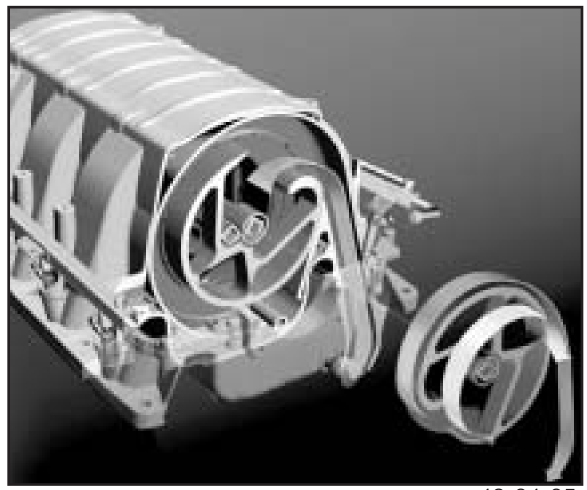
The ECM provides the power supply to the sensor which decreases in resistance as the temperature rises and vice versa. The ECM monitors an applied voltage to the sensor that will vary as air temperature changes the resistance value.

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

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.



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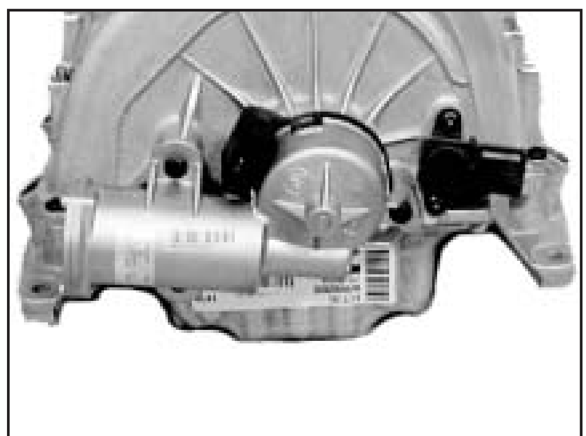
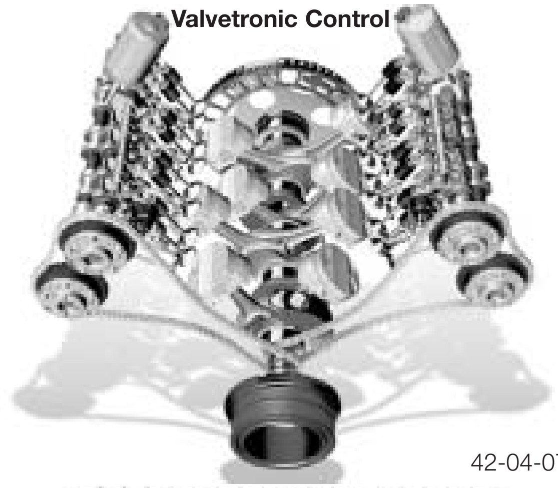


42-04-06

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



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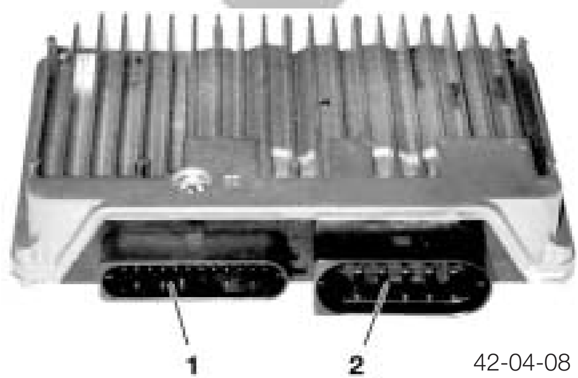
The Valvetronic control module adjusts the valve lift based on a request from the ECM. The Valvetronic control module (located in the E Box) adjusts the eccentric shaft motors by two internal power output stages.

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.



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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.

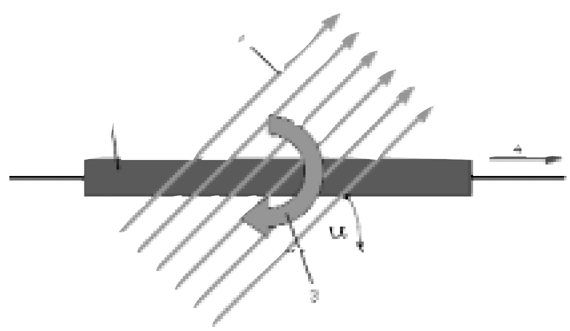
42-04-10

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

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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.

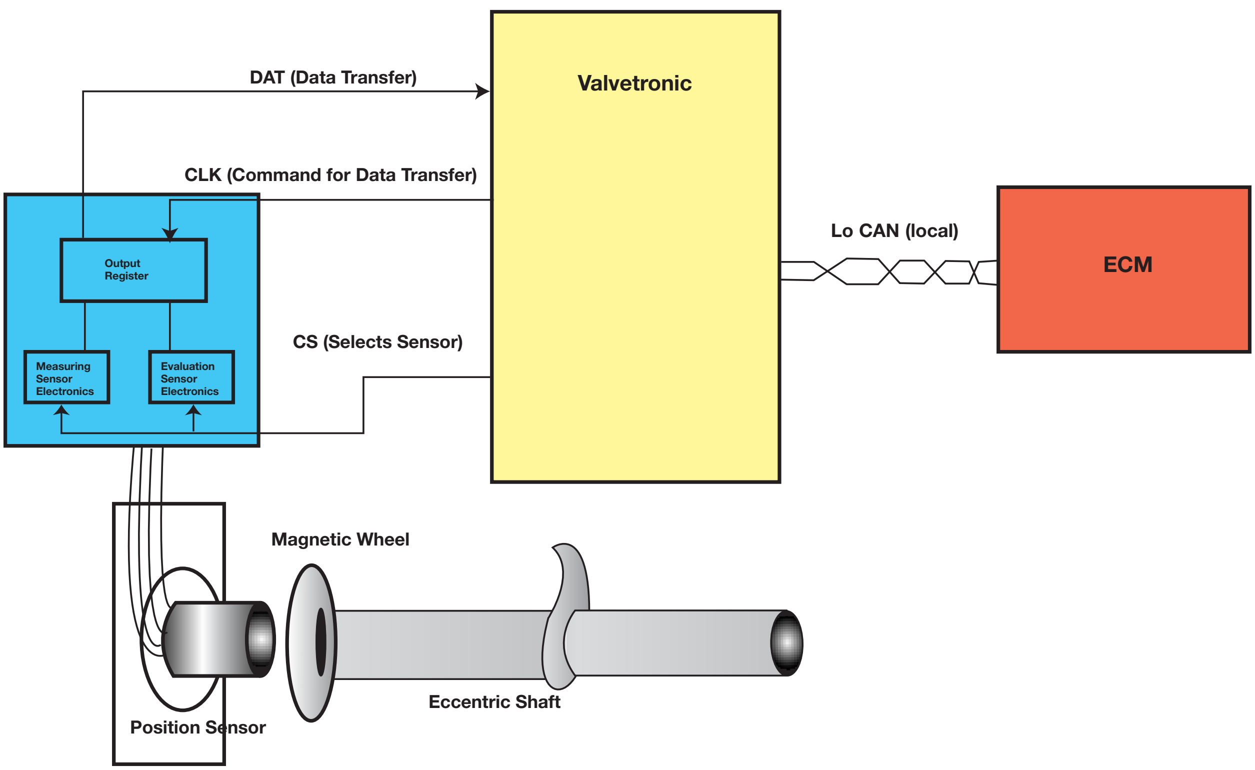
The position data “message” is transmitted via a serial interface from the eccentric shaft sensors to the Valvetronic control module. Each of the two sensors requires three interfaces for data transfer:

- 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).



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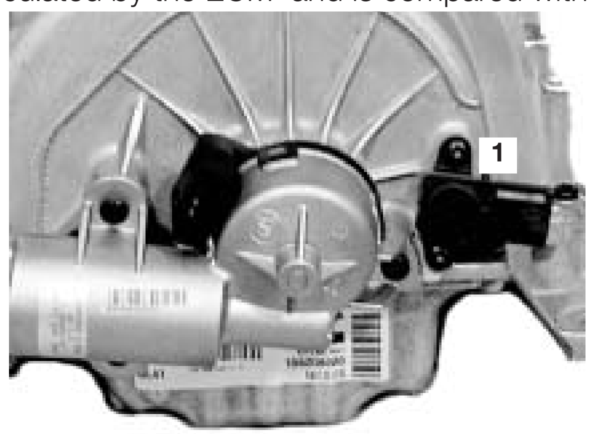
Ambient Pressure: The ambient pressure sensor is located in the ECM (integral). This sensor enables continuous measurement of the air pressure. The signal is used in the ECM to calculate the altitude correction for the mixture formation and as a reference value for the intake manifold pressure.

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.



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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

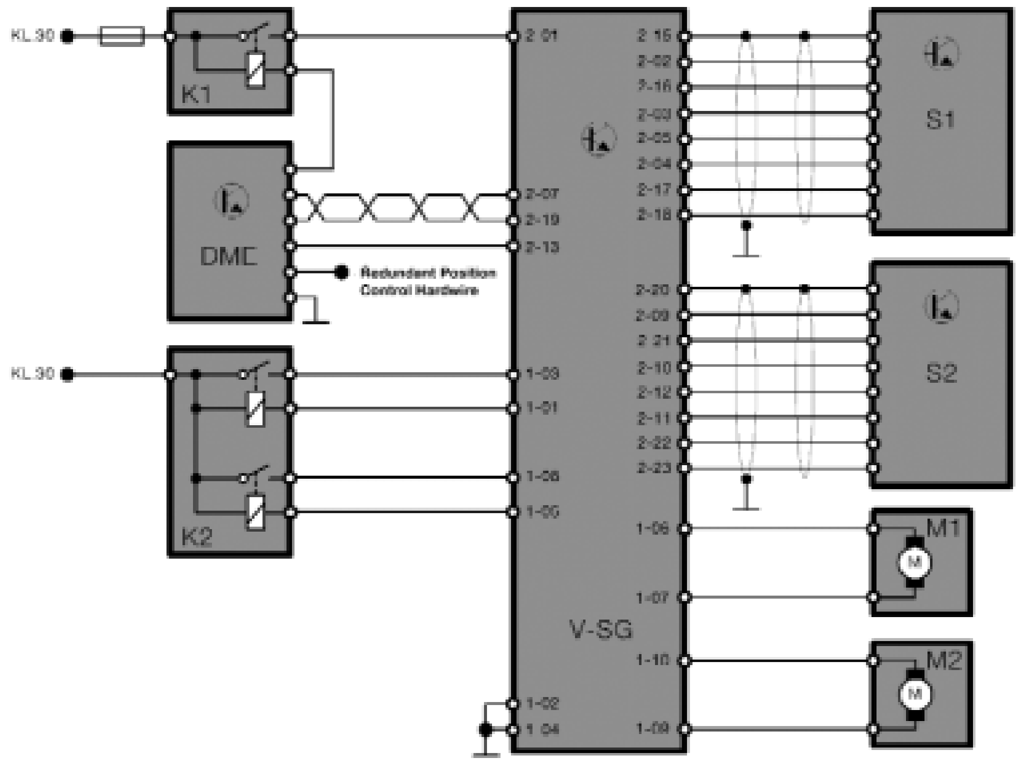
A Redundant Position Control Hard Wire is between the ECM and the Valvetronic control module. Only two messages can be transmitted using this wire:

- 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.

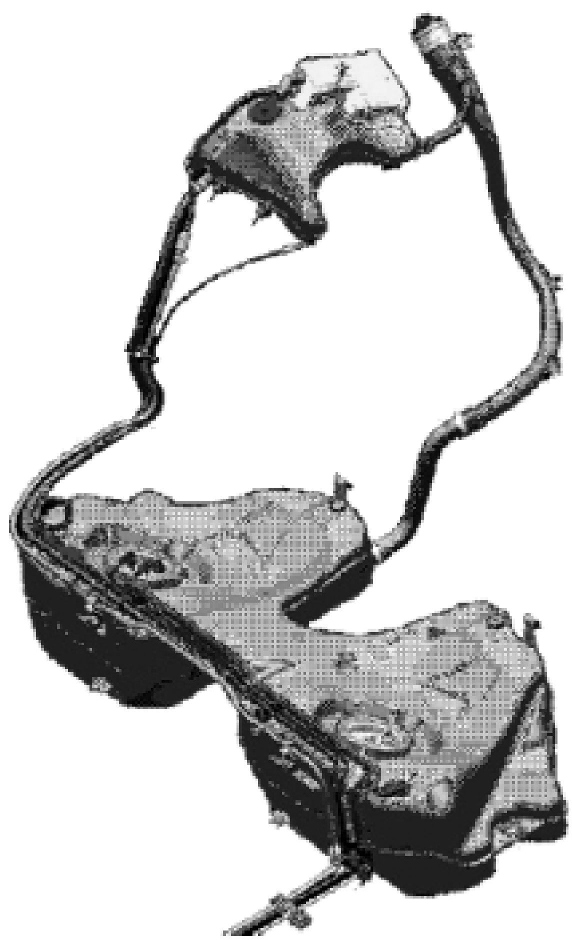
At temperatures below 20 ºC, the engine is started with the throttle valve fully opened using the Valvetronic for idle speed control (this has a positive effect on the starting characteristics).

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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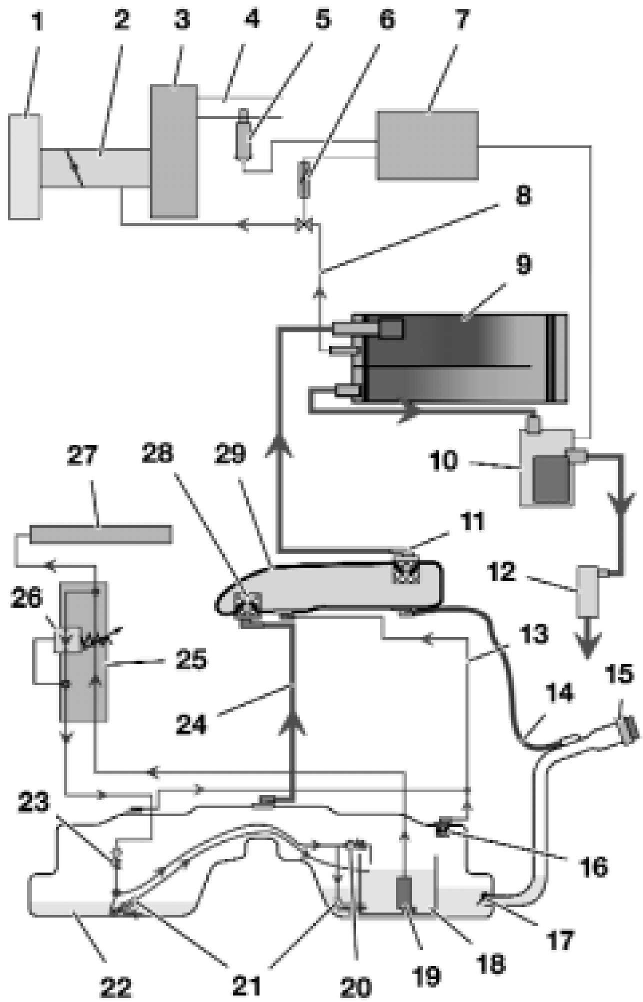


Fuel System

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

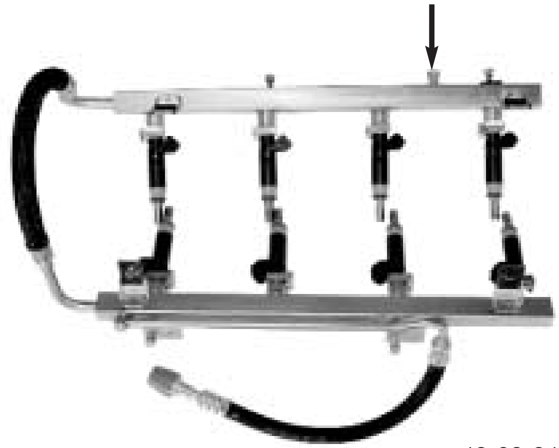
The fuel is delivered in accordance with fuel consumption by engine use controlled regulation. This produces the following benefits:

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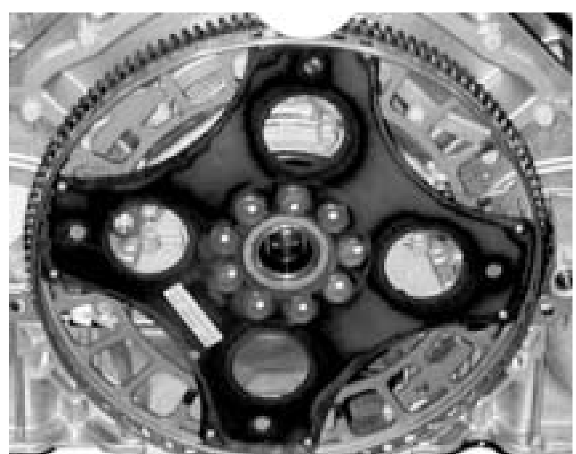
The Siemens fuel injection valves are the dual outlet “directional angle plate” type with a ***coil reisistance of approximately 12 ohms each.***

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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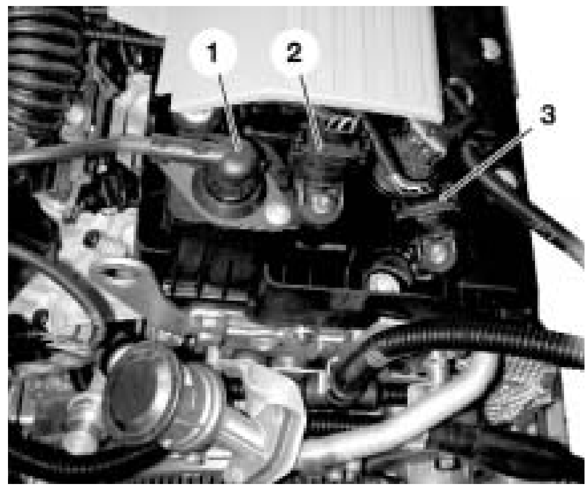
Notes:

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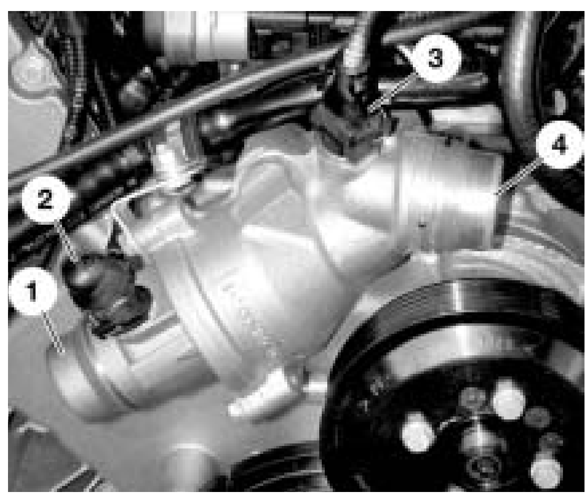
Engine Coolant Temperature: The Engine Coolant Temperature is provided to the ECM from a Negative Temperature Coefficient (NTC) type sensor. The ECM determines the correct fuel mixture and base ignition timing required for the engine temperature.

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

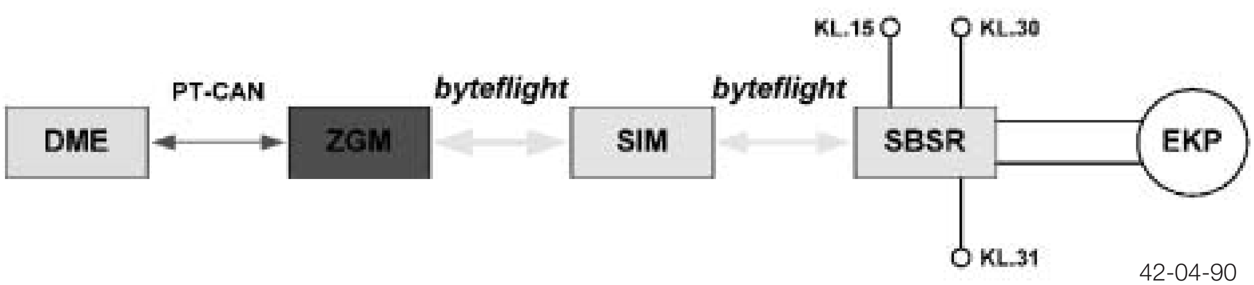
Fuel Management delivers fuel from the tank to the intake ports of the engine. To accomplish this, **fuel supply** must be available to the fuel injectors. Then the fuel must be **injected** in the precise amount and at the correct time. The ECM does not directly monitor fuel supply, although it does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

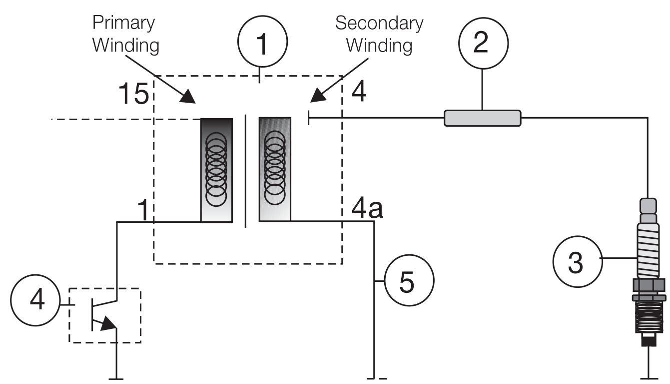
Table of Contents

Subject **Page**

Ignition Management

Ignition Coils: The high voltage supply required to ignite the mixture in the combustion chambers is determined by the stored energy in the ignition coils. The stored energy contributes to the ignition duration, ignition current and rate of high voltage increase. The Coil circuit including primary and secondary components consists of:

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



Ignition Coil

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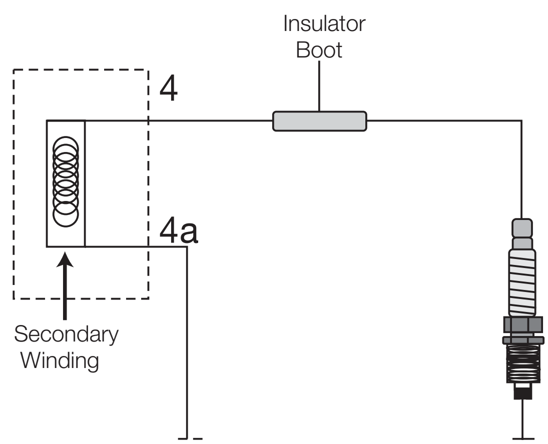
The Coil Assembly contains two copper windings insulated from each other. One winding is the primary winding, formed by a few turns of thick wire. The secondary winding is formed by a great many turns of thin wire.

The primary winding receives battery voltage from the Ignition Coil Relay (in the IVM) which is activated by the CAS Module. The ECM provides a ground path for the primary coil (Coil Terminal 1) by activating a Final Stage transistor. The length of time that current flows through the primary winding is the “dwell” which allows the coil to “saturate” or build up a magnetic field. After this storage process, the ECM will interrupt the primary circuit at the point of ignition by deactivating the Final Stage transistor. The magnetic field built up within the primary winding collapses and induces the ignition voltage in the secondary winding.

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

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



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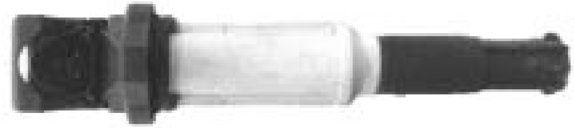
There is an individual ignition circuit and coil for each cylinder on the ME 9.2 system. The ME 9.2 uses "pencil type" ignition coils manufactured by Bremi. The eight individual ignition coils are integrated with the insulated connector (boot).

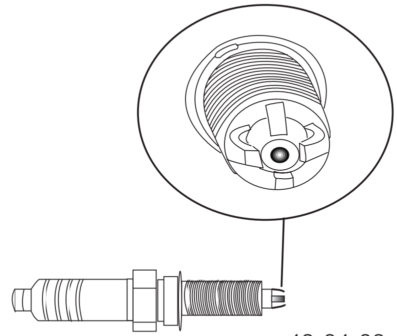


42-04-02

The coils are removed by lifting the swivel latch connector retainer to release the wiring harness, apply a slight twist and lift the assembly upwards. The primary ignition cables are routed on the top of the cylinder head covers.

Spark Plugs: The spark plugs introduce the ignition energy into the combustion chamber. The high voltage "arcs" across the air gap in the spark plug from the positive electrode to the negative electrodes. This creates a spark which ignites the combustible air/fuel mixture.

The spark plugs are located in the center of the combustion area (on the top of the cylinder heads) which is the most suitable point for igniting the compressed air/fuel mixture. The correct spark plugs for the ME 9.2 are the ***NGK BKR6EQUP*** quad electrode (non-adjustable gap).



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The Ignition System is monitored by the ECM via the Crankshaft Position/RPM Sensor. If a Misfire fault is present, the ECM will deactivate the corresponding fuel injector for that cylinder. Engine operation will still be possible.

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

There are four Knock Sensors bolted to the cylinder heads between cylinders 1 & 2, 3 & 4, 5 & 6 and 7 & 8. If the signal value exceeds the threshold, the ECM identifies the "knock" and retards the ignition timing for that cylinder.

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

42-04-04

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

Accelerator Pedal Position (PWG): As the accelerator pedal is actuated, the ECM will advance the ignition timing. The "full throttle" position indicates maximum acceleration to the ECM, the ignition will be advanced for maximum torque. For details about the sensor, refer to the Air Management section.

Hot-Film Air Mass Meter (HFM): The air volume input signal is used by the ECM to determine the amount of ignition timing advance. For details about the sensor, refer to the Air Management section.

Air Temperature: This signal allows the ECM to make a calculation of air density. The sensor is located in the HFM. The ECM will adjust the ignition timing based on air temperature. If the intake air is hot the ECM retards the ignition timing to reduce the risk of detonation. If the intake air is cooler, the ignition timing will be advanced. If this input is defective, a fault code will be set and the ignition timing will be set to a conservative basic setting. For details about the sensor, refer to the Air Management section.

Notes:

Principle of Operation

Ignition Management provides ignition to the combustion chambers with the required voltage at the correct time. Based on the combination of inputs, the ECM calculates and controls the **ignition timing** and **secondary output voltage** by regulating the activation and dwell of the **primary ignition circuit.** The ECM controls and monitors the primary ignition circuit as well as the secondary ignition output (Misfire Detection).

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

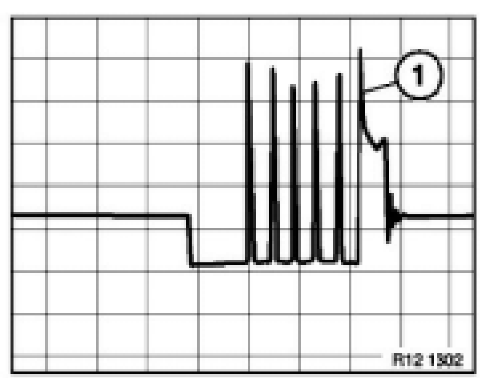
The Ignition Control is determined by the ECM (load dependent). The ECM will calculate the engine "load" based on a combination of the following:

The dwell time will be regulated based on battery voltage. When cranking, the voltage is low and the ECM will increase the dwell to compensate for saturation "lag time". When the engine is running and the battery voltage is higher, the ECM will decrease the dwell due to a faster saturation time.

The Crankshaft Position/RPM signals the ECM to start ignition in ***firing order (1-5-4-8-6-3-7-2)*** as well as providing information about the engine operation. This input is used in combination with other inputs to determine engine load which advances/retards the ignition timing. Without this input, the ECM will not activate the ignition.

Cold start is determined by the ECM based on the engine coolant temperature and rpm during start up. A cold engine will crank over slower than a warm engine, the ignition timing will range between top dead center to slightly retarded providing optimum starting.

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



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

Multiple Ignition Pulses ensure good spark quality during engine start up. The ECM will activate the ignition coils multiple times (1) per 720° of crankshaft revolution.

The ignition timing will be progressively advanced assisting the engine in coming up to speed. As the engine speed approaches idle rpm, the timing remains slightly advanced to boost torque. When the engine is at idle speed, minimum timing advance is required. This will allow faster engine and catalyst warm up. The multiple pulsing switches to single pulse when engine speed >1350 RPM (varied with engine temperature).

The timing will be advanced when the ECM observes low engine rpm and increasing accelerator/air volume inputs (acceleration torque). As the Valvetronic valve lift is increased, the ECM advances the timing based on the engine acceleration request (and at what rate). The ECM will fully advance timing for the “full throttle” position indicating maximum acceleration (torque).

The Air Flow Volume signal provides the measured amount of intake air volume. This input is used by the ECM to determine the amount of timing advance to properly combust the air/fuel mixture.

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

As the Valvetronic valve lift is decreased, the ECM decreases the ignition timing if the rpm is above idle speed (coasting). This feature lowers the engine torque for deceleration. When the engine rpm approaches idle speed, the timing is slightly advanced to prevent the engine from stalling. The amount of advance is dependent upon the engine temperature and the rate of deceleration.

Emission Optimized - IGNITION KEY OFF

“Emission Optimized Ignition Key Off” is a programmed feature of the CAS Module. After the CAS Module detects KL 15 is switched “off”, the ignition coil relay (in the IVM) stays active (CAS voltage supply) for two more individual coil firings. This means that just two cylinders are fired - not two revolutions.

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

When **KL15** is switched “off” the ECM removes the operating voltage from the fuel injection relay (in the IVM). The CAS Module will maintain power to the ignition coil relay for a few seconds to maintain ignition coil activation (by the ECM).

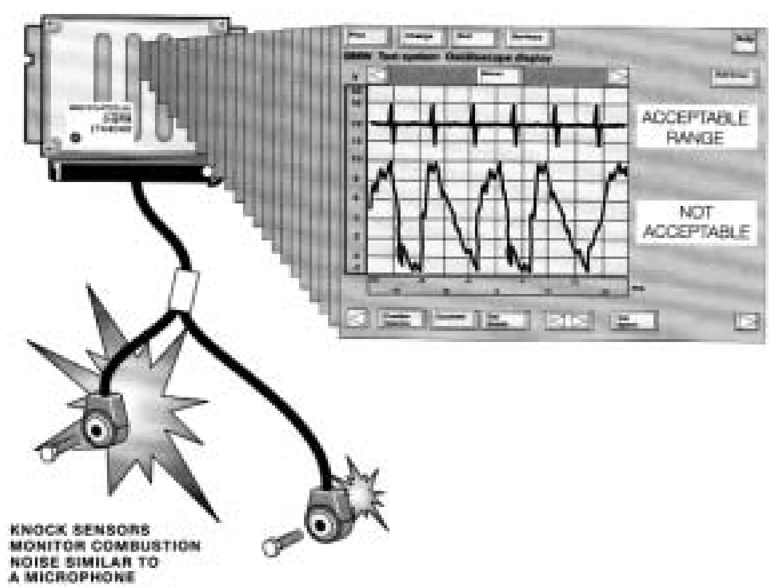
Knock Control

The use of Knock Control allows the ECM to further advance the ignition timing under load for increased torque. This system uses four Knock Sensors located between cylinders 1 & 2, cylinders 3 & 4, cylinders 5 & 6 and cylinders 7 & 8. Knock Control is only in affect when the engine temperature is greater than 35 ºC and there is a load on the engine. This will disregard false signals while idling or from a cold engine.

Based on the firing order, the ECM monitors the Knock Sensors after each ignition for a normal (low) signal. If the signal value exceeds the threshold, the ECM identifies the "knock" and retards the ignition timing (3º) for that cylinder the next time it is fired.

This process is repeated in 3º increments until the knock ceases. The ignition timing will be advanced again in increments right up to the knock limit and maintain the timing at that point.

If a fault is detected with the Knock Sensor(s) or circuits, the ECM deactivates Knock Control. The ignition timing will be set to a conservative basic setting (to reduce the risk of detonation) and a fault will be stored.



42-04-05

Emissions Management

Evaporative Emissions: The control of the evaporative fuel vapors (Hydrocarbons) from the fuel tank is important for the overall reduction in vehicle emissions.

The evaporative system has been combined with the ventilation of the fuel tank, which allows the tank to breath (equalization). The overall operation provides:

- An inlet vent, to an otherwise "sealed" fuel tank, for the entry of air to replace the fuel consumed during engine operation.

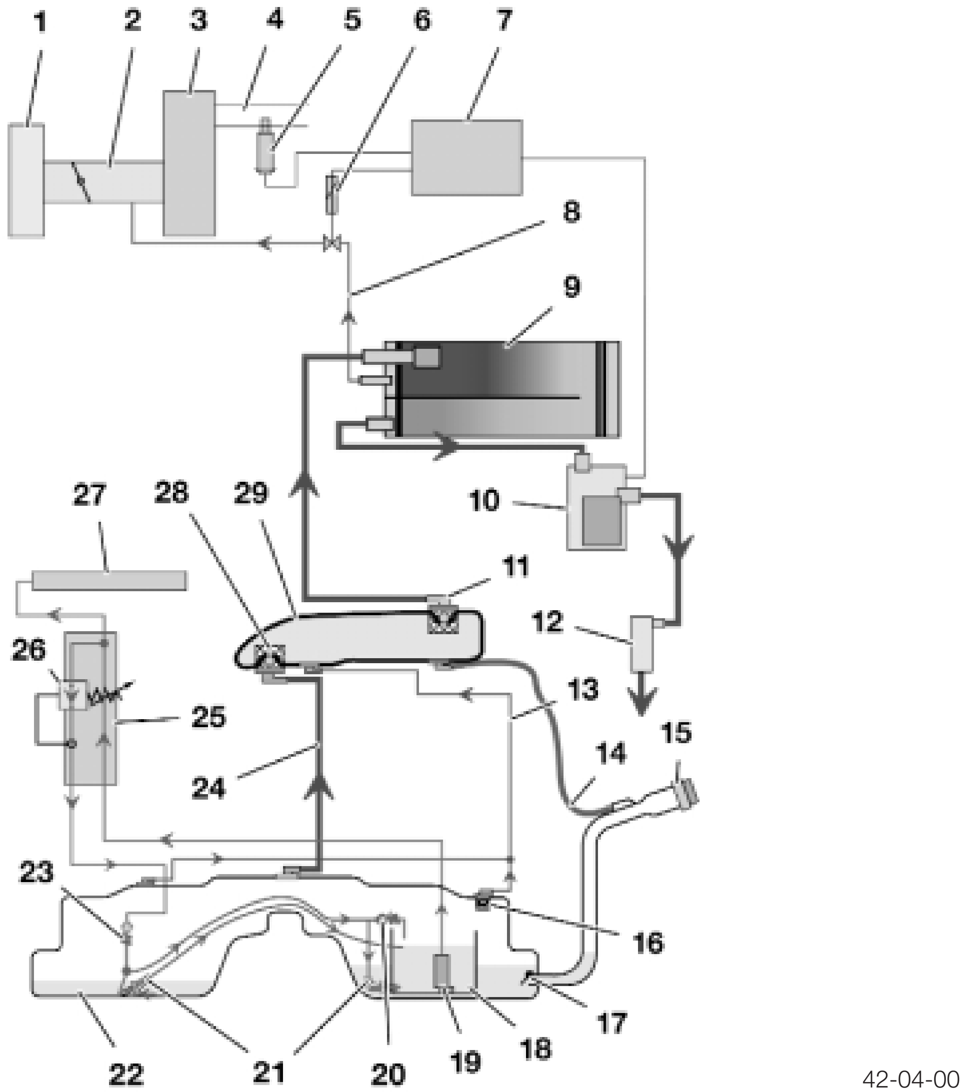
- An outlet vent with a storage canister to "trap and hold" fuel vapors that are produced by the expansion/evaporation of fuel in the tank, when the vehicle is stationary.

The canister is then "purged" using the engine vacuum to draw the fuel vapors into the combustion chamber. This "cleans" the canister allowing for additional storage. Like any other form of combustible fuel, the introduction of these vapors on a running engine must be controlled. The ECM controls the Evaporative Emission Valve which regulates purging of evaporative vapors.

On-Board Refueling Vapor Recovery (ORVR): The ORVR system recovers and stores hydrocarbon fuel vapor during refueling. Non ORVR vehicles vent fuel vapors from the tank venting line back to the filler neck and in many states reclaimed by a vacuum receiver on the filling station's fuel pump nozzle.

When refueling, the pressure of the fuel entering the tank forces the hydrocarbon vapors through the tank refuelling breather hose (24 on the following page) to the liquid/vapor expansion tank and into the active charcoal canister.

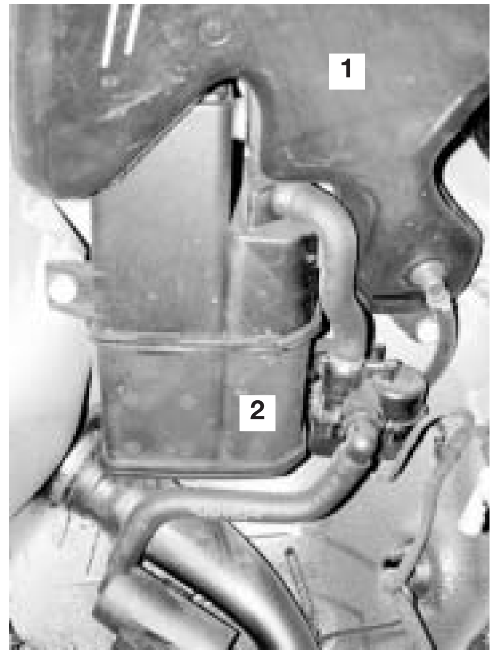
The HC vapors are stored in the active charcoal canister and the system can then “breath” through the DM TL and the air filter.



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 pump
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

Liquid/Vapor Expansion Tank: Fuel vapors are routed from the refuelling breather hose and the Service Ventilation hose to the Liquid/Vapor Expansion Tank (1) located in the right rear fender well.



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The vapors cool when exiting the fuel tank, condense and drain back to the fuel tank. The remaining vapors exit the Liquid/Vapor Expansion Tank to the Active Carbon Canister.

Active Carbon Canister: As the fuel 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 (passing through the DM TL and filter) allowing the fuel tank to “breath”.

When the engine is running, the canister is then "purged" using intake manifold vacuum to draw fresh air through the canister which extracts the hydrocarbon vapors into the combustion chamber. This cleans the canister for additional storage. The Active Carbon Canister (2) is combined with the DM TL Pump and is located in the right rear fender well.

Evaporative Emission Valve: This ECM controlled solenoid valve (located on the front of the engine) regulates the purge flow from the Active Carbon Canister through the air inlet pipe into the intake manifold.

The ECM Relay (in the IVM) 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. If the valve is “mechanically” defective, a driveability complaint could be encountered and a mixture related fault code will be set.


42-04-02

DMTL (Diagnosis Module - Evaporative Leakage Detection): This component ensures accurate fuel system leak detection for leaks as small as 0.5 mm (.020") 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 with the Active Carbon Canister.

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

2. When the ECM activates the DM TL for leak testing, it first activates only the pump motor. This pumps air through a restricted orifice (0.5 mm) which causes the electric motor to draw a specific amperage value (20-30 mA). This value is equivalent to the size of the restriction.

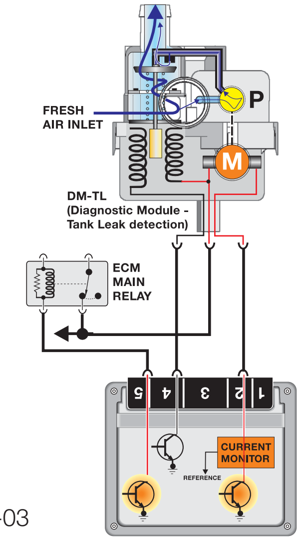
3. The solenoid valve is then energized which seals the evaporative system and directs the pump output to pressurize the evaporative system.

- A large leak is detected in the evaporative system if the amperage value is not achieved.

- A small leak is detected if the same reference amperage is achieved.

- The system is sealed if the amperage value is higher than the reference amperage.

1



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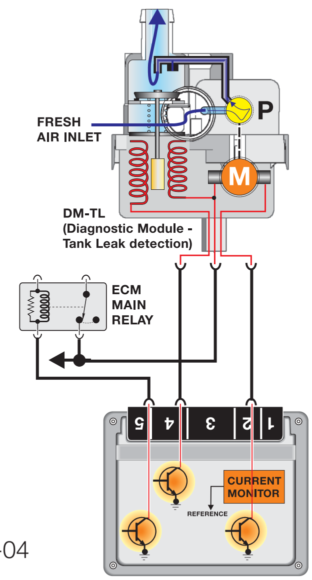

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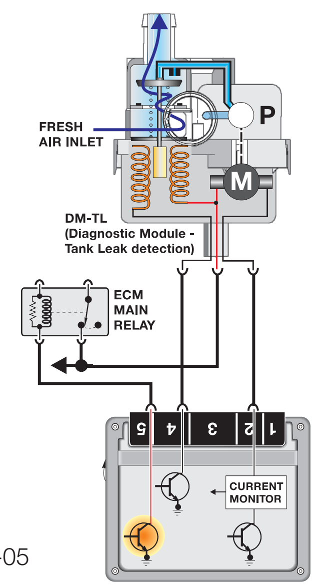


42-04-05

Exhaust Emissions: The combustion process of a gasoline powered engine produces Carbon Monoxide (CO), Hydrocarbons (HC) and Oxides of Nitrogen (NOx).

- *Carbon Monoxide* is a product of incomplete combustion under conditions of air deficiency. CO emissions are strongly dependent on the air/fuel ratio.

- *Hydrocarbons* are also a product of incomplete combustion which results in unburned fuel. HC emissions are dependent on air/fuel ratio and the ignition of the mixture.

- *Oxides of Nitrogen* are a product of peak combustion temperature (and temperature duration). NOx emissions are dependent on internal cylinder temperatures affected by the air/fuel ratio and ignition of the mixture.

Control of exhaust emissions is accomplished by the engine and engine management design as well as after-treatment.

- The ECM manages exhaust emissions by controlling the air/fuel ratio and ignition.

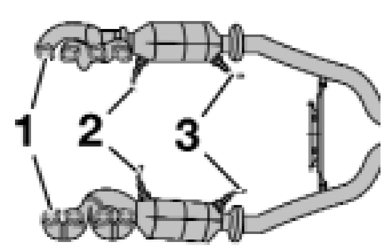
- The ECM controlled Secondary Air Injection further dilutes exhaust emissions leaving the engine and reduces the catalysts warm up time.

- The Catalytic Converter further reduces exhaust emissions leaving the engine.

Oxygen Sensors: The N62 engine is fitted with a total of four oxygen sensors. One planar broadband oxygen sensor (constant characteristic curve), which regulates the fuel-air mixture, is located upstream (2) of each of the two catalytic converters. The catalytic converter assemblies are integral with the exhaust manifolds (1).

There is a post catalytic converter sensor (Bosch LSH25) for each cylinder bank positioned downstream of the catalytic converter (3) which monitors the catalyst efficiency.

This monitoring means that if the exhaust gas concentration is too high, a fault code is stored. The post catalyst sensors can also detect an emission relevant fault in a pre-catalyst oxygen sensor.



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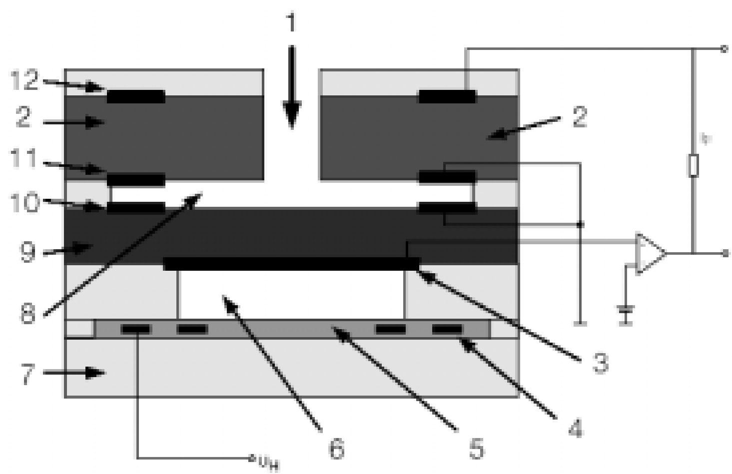
Bosch LSU Planar Wideband Oxygen Sensor: The N62 engine is equipped with new planar wideband oxygen sensors (pre-catalyst). The sensor is planar shaped (type of construction) which is more compact and is made up of thin layers of zirconium dioxide (ZrO_2) ceramic films. This modular lamination structure enables the integration of several functions including the heating element which ensures the minimum operating temperature (750 ºC) is reached rapidly.

In contrast to conventional oxygen sensors, the wideband features can measure not only at Lambda=1, but also in the rich and extremely lean range (Lambda=0.7 to complete atmospheric oxygen) very rapidly.

To operate effectively, the oxygen sensor requires ambient air as the "reference gas" inside the sensor. ***The ambient air reaches the inside of the sensor through the plug connection and through the harness.*** The plug connection socket must therefore be protected from contamination (wax, preservatives, engine degreasers, engine washing, etc.). In the event of the oxygen sensor malfunctioning, the connector should always be checked first with regard to contamination and cleaned if necessary. The plug connection must be disconnected and then reconnected to remove any oxidation from the connector pins.

1. Exhaust gas
2. Pump cell
3. Platinum electrode, reference cell
4. Heating element
5. Heating element
6. Reference air gap
7. Zirconium ceramic layer
8. Measuring gap
9. Reference Cell
10. Platinum electrode, reference cell
11. Platinum electrode, pump cell
12. Platinum electrode, pump cell



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Sensor Element Design

The pump cell (2) and reference cell (9) are made of zirconium dioxide and each coated with two porous platinum electrodes. They are arranged so that there is a measuring gap (8) of approx. 10 to 50 microns between them. This measuring gap is connected by an inlet opening to the exhaust gas (1). The pump cell is controlled by the ECM applying voltage to the electrodes to initiate oxygen ion pumping across the porous membrane of the reference cell, providing a quicker response time.

If the exhaust gas content is lean, the pump cell pumps oxygen away from the measuring gap to the outside. The direction of flow is reversed for rich exhaust gas content, then oxygen is pumped from the exhaust gas into the measuring gap. The pump current flow is proportional to the oxygen concentration (lean) or the oxygen requirement (rich). The pump is constantly working to maintain that the gas composition in the measuring gap is constantly at Lambda=1. The required current of the pump cell is evaluated by the ECM as a signal that represents oxygen content in the exhaust gas.

Oxygen Sensor Signals

The sensor conductivity is efficient when the oxygen sensor is hot (750º C). For this reason, the sensor contains a heating element. This reduces warm up time, and retains the heat during low engine speed when the exhaust temperature is cooler. The oxygen sensor heating elements receive power from the IVM (12 V) and the ground sypply is pulse width modulated by the ECM.

The monitored voltage signal is constantly changing due to combustion variations and normal exhaust pulsations.

- At a value of Lambda =1, the pump cell requires approx. 3 mA.
  The oxygen sensor signal voltage is approx. 1.5V
  The reference cell voltage is approx. 450mV

- At a Lambda value <1 (rich), the oxygen sensor signal voltage is approx. 0.3V

- At a Lambda value >1 (lean), the oxygen sensor signal voltage is approx. 4.3V

If necessary, the ECM will “correct” the air/fuel ratio by regulating the ms injection time. The ECM monitors the length of time the sensors are operating in the lean, rich and rest conditions. The evaluation period of the sensors is over a predefined number of oscillation cycles and pump cell amperage.

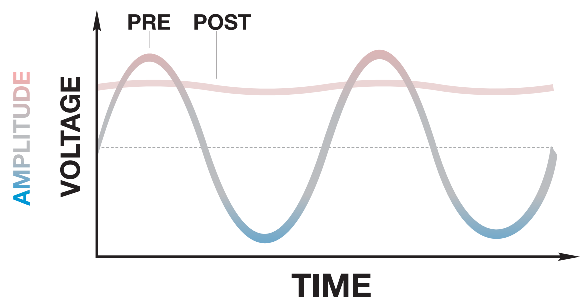
Catalytic Converter Monitoring: The efficiency of catalyst operation is determined by evaluating the oxygen storage capability of the ceramic monolyth catalytic converters using the pre and post oxygen sensor signals.

A properly operating catalyst consumes or stores most of the O_2 (oxygen) that is present in the exhaust gas (input to catalyst). The gases that flow into the catalyst are converted from CO, HC and NOx to CO_2, H_2O and N_2 respectively.

In order to determine if the catalysts are working correctly, post catalyst oxygen sensors are installed to monitor exhaust gas content exiting the catalysts. The signal of the post cat. O_2 sensor is evaluated over the course of several pre cat. O_2 sensor oscillations.

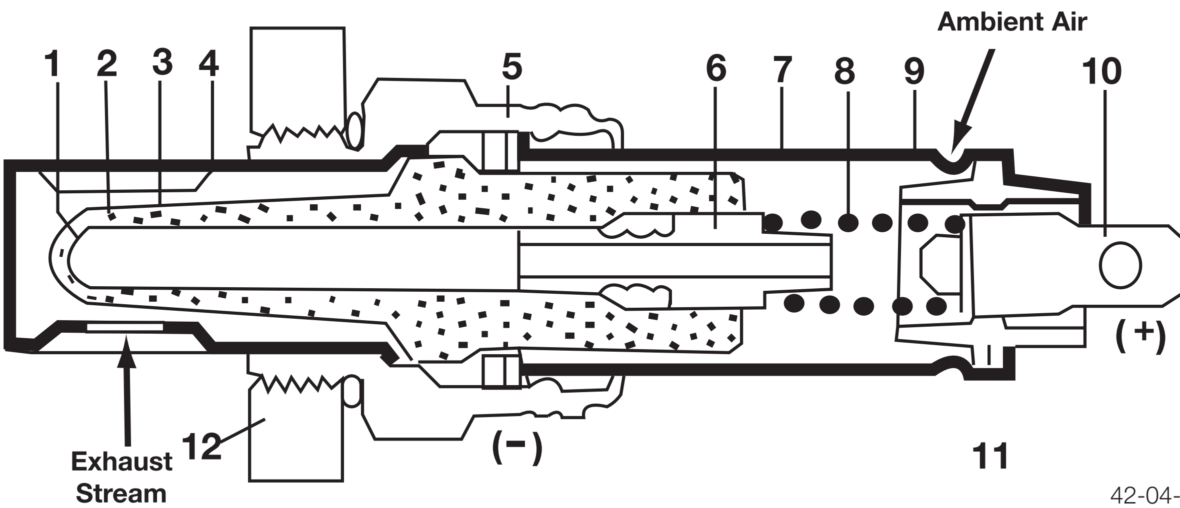
During the evaluation period, the signal of the post cat. sensor must remain within a relatively constant voltage range (700 - 800 mV).

The post cat. O2 voltage remains high with a very slight fluctuation. This indicates a further lack of oxygen when compared to the pre cat. sensor. If this signal decreased in voltage and/or increased in fluctuation, a fault code will be set for Catalyst Efficiency.



42-04-08

Bosch LSH 25 Oxygen Sensors: The post catalyst oxygen sensors produces a low voltage (0-1000 mV) proportional to the oxygen content exiting the catalytic converters.



42-04-09

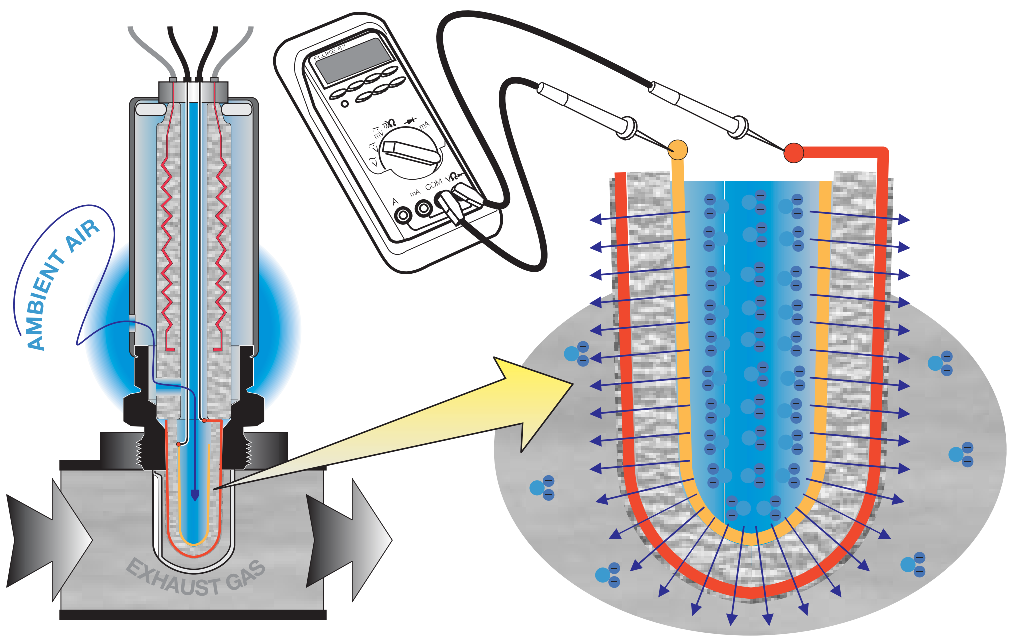
Oxygen Sensors

1. Electrode (+)
2. Electrode (-)
3. Porous Ceramic Coating (encasing electrolyte)
4. Protective Metal Cage (Ventilated)
5. Casing
6. Contact Sleeve
7. External Body (Ventilated)
8. Contact Spring
9. Vent Opening
10. Ouput Lead
11. Insulator
12. Exhaust Pipe Wall

The "tip" of the sensor contains a microporous platinum coating (electrodes) which conduct current. The platinum electrodes are separated by solid electrolyte which conducts oxygen ions. The platinum conductors are covered with a highly porous ceramic coating and the entire tip is encased in a ventilated metal "cage".

This assembly is submersed in the exhaust stream. The sensor body (external) has a small vent opening in the housing that allows ambient air to enter the inside of the tip.

The ambient air contains a constant level of oxygen content (21%) and the exhaust stream has a much lower oxygen content. The oxygen ions (which contain small electrical charges) are "purged" through the solid electrolyte by the hot exhaust gas flow. The electrical charges (low voltage) are conducted by the platinum electrodes to the sensor signal wire that is monitored by the ECM.



42-04-10

If the exhaust has a lower oxygen content (rich mixture), there will be a large ion "migration" through the sensor generating a higher voltage (950 mV).

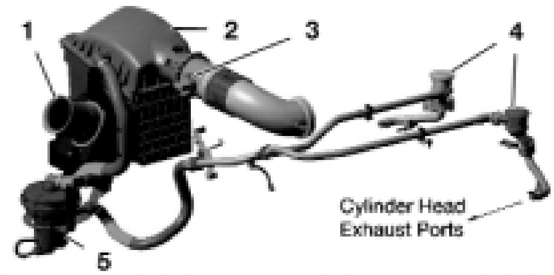
If the exhaust has a higher oxygen content (lean mixture), there will be a small ion "migration" through the sensor generating a lower voltage (080 mV).

This conductivity is efficient when the oxygen sensor is hot (250º - 300º C). For this reason, the sensor contains a heating element. This "heated" sensor reduces warm up time, and retains the heat during low engine speed when the exhaust temperature is cooler.

Secondary Air Injection: 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 Air Pump and Air Injection Valves direct fresh air through internal channels in the cylinder heads into the exhaust ports.

1. Air Intake Duct
2. Air Cleaner housing with Intake Air Silencer
3. Intake Pipe with HFM
   (Hot-Film Air Mass Flow Sensor)
4. Secondary Air Valves
5. Secondary Air Pump



43-04-05

Secondary Air System

Secondary Air Pump (SLP): The electrically-operated secondary air pump is mounted to the vehicle body. The pump draws out filtered fresh air from the air cleaner housing during the warm-up phase and supplies it to the two secondary air injection valves.

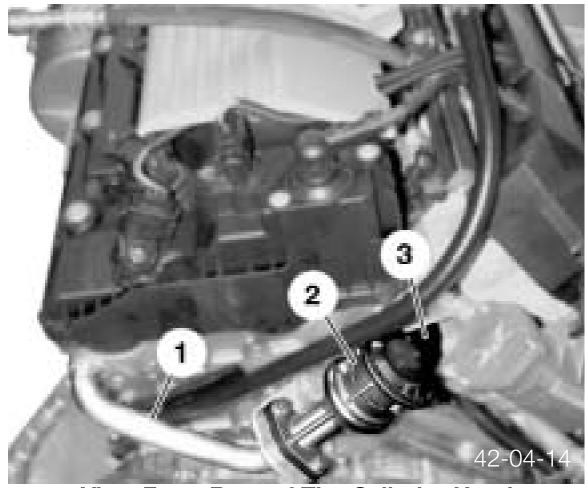
Once the engine has been started, the secondary air pump is supplied with voltage by the ***Secondary Air Pump Relay (located in front of the glovebox)*** which is activated by the ECM. It remains switched on until the engine has taken in a certain amount of air. The ***ON*** period may be a maximum of 90 seconds and it depends on the following engine operating conditions:

- Coolant temperature (from -10 ºC to approximately 60 ºC)
- Ambient air temperature (from the HFM)
- Engine speed

The power is supplied from the fuse junction (#102 - 50 Amp) located on the right inner fender of the engine compartment (under the remote charging post) for the relay to energize the SLP.

Non-return Valves (SLV): One non-return valve is mounted on each cylinder head.

1. Cylinder Head Lead
2. Non-return Valve (SLV)
3. Secondary Air Pump Connection



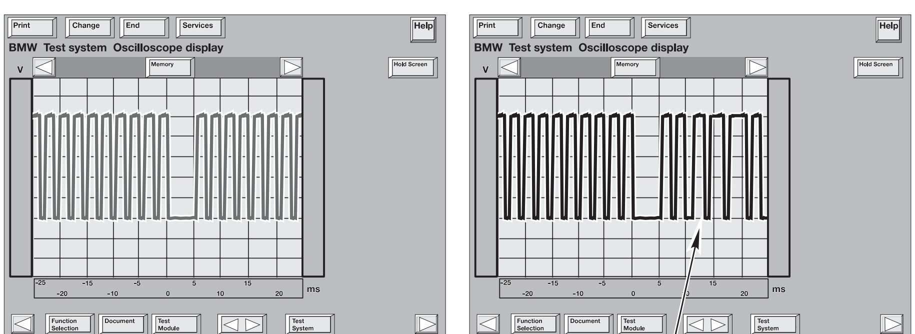
View From Rear of The Cylinder Head

The Non-return valves are opened by the air pressure generated from the secondary air pump. The secondary air is led through a pipe to the secondary air ducts (integral in the cylinder heads) for distribution into the exhaust ports. There are two outlets in each exhaust port next to the exhaust valve guides.

The Non-return valves are sprung closed as soon as the secondary air pump is switched off. This prevents exhaust vapors, pressure and condensation from flowing back to the secondary air pump.

Misfire Detection: As part of the OBD II regulations the ECM must determine misfire and also identify the specific cylinder(s), the severity of the misfire and whether it is emissions relevant or catalyst damaging based on monitoring crankshaft acceleration.

In order to accomplish these tasks the ECM monitors the crankshaft for acceleration by the impulse wheel segments of cylinder specific firing order. The misfire/engine roughness calculation is derived from the differences in the period duration of individual increment gear segments. If the expected period duration is greater than the permissible value a misfire fault for the particular cylinder is stored in the fault memory of the ECM.



SMOOTH RUNNING ENGINE (NOTE SQUARE WAVE SIGNAL)

ENGINE MISFIRE DETECTED

42-02-13

Depending on the level of misfire rate measured the ECM will illuminate the "Malfunction Indicator Light", deactivate the specific fuel injector to the particular cylinder and switch lambda operation to open-loop.

In order to eliminate misfire faults that can occur as a result of varying flywheel tolerances (manufacturing process) an internal adaptation of the flywheel is made. The adaptation is made during periods of decel fuel cut-off in order to avoid any rotational irregularities which the engine can cause during combustion. This adaptation is used to correct segment duration periods prior to evaluation for a misfire event.

If the sensor wheel adaptation has not been completed the misfire thresholds are limited to engine speed dependent values only and misfire detection is less sensitive. The crankshaft sensor adaptation is stored internally and if the limit is exceeded a fault will be set.

Notes:

Principle of Operation

Emissions Management controls evaporative and exhaust emissions. The ECM monitors the fuel storage system for **evaporative leakage** and controls the **purging** of evaporative fuel. The ECM monitors and controls the exhaust emissions by regulating the **combustible mixture** and after treating by injecting **fresh air** into the exhaust system. The catalytic converters further break down remaining combustible exhaust gases and is monitored by the ECM for **catalyst efficiency**.

The Evaporative Leakage Detection is performed on the fuel storage system by the DM TL pump which contains an integral DC motor that is activated by the ECM. The ECM monitors the pump motor operating current as the measurement for detecting leaks.

The DM TL generates a pressure of 20-30 mbar in the fuel tank and evaporative system. The electrical current required for this is calculated by the ECM serves as the indirect value for the tank pressure.

The DM TL carries out a reference measurement before each measurement. This is performed by building up a pressure for 10-15 seconds using an internal orifice of 0.5 mm as a reference and the ECM monitors the current required by the pump motor (20-30 mA).

If a lower pressure is detected in the pressure build-up (low current draw) as compared to the reference measurement, this indicates a leak in the fuel tank/evaporative system. If a higher pressure is detected (higher current draw), the system does not have a leak.

The pump also contains an ECM controlled change over valve that is energized closed during a Leak Diagnosis test. The ECM only initiates a leak diagnosis test every second time the criteria is met. The criteria is as follows:

- Engine **OFF** with ignition switched **OFF**.
- ECM still in active state or what is known as “follow up mode” (ECM Relay energized, ECM and components online for extended period after key off).
- Prior to Engine/Ignition switch OFF condition, vehicle must have been driven for a minimum of 20 minutes.
- Prior to minimum 20 minute drive, the vehicle must have been OFF for a minimum of 5 hours.
- No faults in the ECM for DM TL / tank venting system.

- Fuel Tank Capacity must be between **10 and 90%** (safe approximation between 1/4 - 3/4 of a tank).

- Ambient Air Temperature between **-7°C & 35°C**

- Altitude **< 2500m** (8,202 feet).

- Battery Voltage between **11.5 and 14.5 Volts**

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

PHASE 1 - REFERENCE MEASUREMENT

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

The ECM simultaneously monitors the pump motor current flow. The motor current raises quickly and levels off (stabilizes) due to the orifice restriction. The ECM stores the stabilized amperage value in memory. The stored amperage value is the electrical equivalent of a 0.5 mm (0.020”) leak.

PHASE 2 - LEAK DETECTION

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

The time taken for the measurement is:
- 60-220 seconds if there are no leaks
- 200-360 seconds if there is a leak measuring 0.5 mm (small leak)
- 30-80 seconds if there is a leak measuring over 1 mm (large leak)

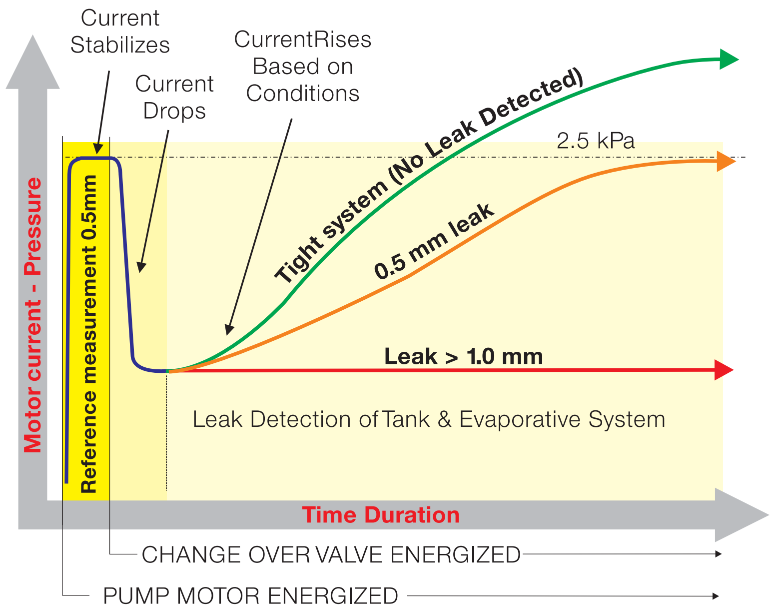
The evaporative emission valve is closed during the measurement. The time taken for the measurement is dependant on how much fuel there is in the tank.

Once the test is concluded, the ECM stops the pump motor and immediately de-energizes the change over valve. This allows the stored pressure to vent thorough the charcoal canister trapping hydrocarbon vapor and venting air to atmosphere through the filter.

Test Results

The time duration varies between 30 & 360 seconds depending on the resulting leak diagnosis test results (developed tank pressure "amperage" within a specific time period).

When the ECM detects a leak, a fault will be stored and the "Malfunction Indicator Light" will be illuminated. Depending on the amperage measurement detected by the ECM, the fault code displayed will be "small leak" or "large leak".



42-02-14

Refuelling While a Leak Diagnosis is Taking Place: The ECM detects refuelling during a leak diagnosis as a result of the pressure drop when the fuel filler cap is opened and the increase pressure while filling the tank is being filled.

In this case, the leakage diagnosis is interrupted. The solenoid valve in the DM TL is switched off and the tank pressure escapes through the activated carbon canister.

If refuelling does not take place immediately after the fuel filler cap has been opened, the system will detect a large leak and the a fault will be stored in the ECM. If refuelling is detected in the next driving cycle (increase in fuel level), the fault is cleared.

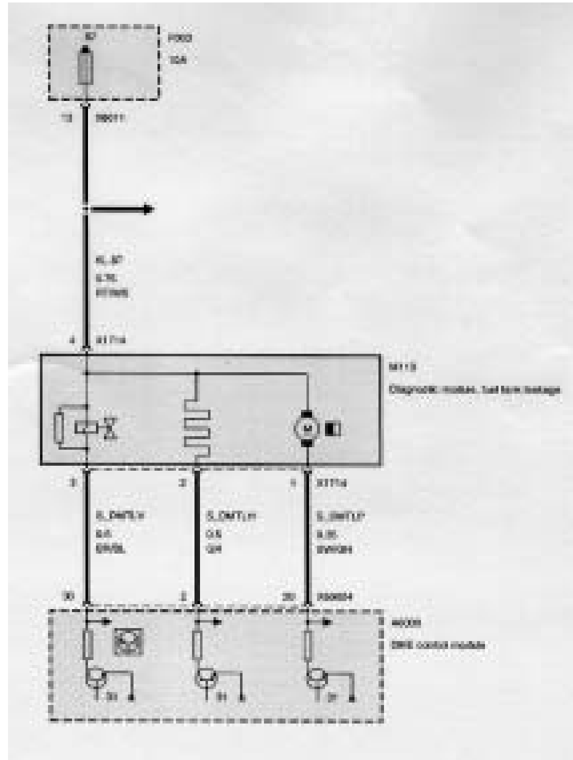
The ECM detects refueling from a change in the fuel tank sending unit level. If the filler cap was not properly installed, when the leakage test is performed and leakage is detected; the ***variable indicator lamp*** (shown to the right) and the **"Please Close Filler Cap"** Check Control message will be displayed.

If the filler cap is correctly installed and leakage is not present the next time the test is performed, the "Malfunction Indicator Light" will not be illuminated.


42-02-15

Starting with 2002 MY, a heating element was added to the DM TL pump to eliminate condensation.

The heater is provided battery voltage when KL15 is switched "on" and the ECM provides the ground path.



Catalyst Monitoring is performed by the ECM under oxygen sensor closed loop operation. The changing air/fuel ratio in the exhaust gas results in lambda oscillations at the pre-catalyst sensors. These oscillations are dampened by the oxygen storage activity of the catalysts and are reflected at the post catalyst sensors as a fairly stable signal (indicating oxygen has been consumed). Conditions for Catalyst Monitoring:

Requirements	**Status/Condition**
• Closed loop operation	YES
• Engine coolant temperature	Operating Temp.
• Vehicle road speed	3 - 50 MPH (5 to 80 km/h)
• Catalyst temperature (calculated)*	350°C to 650°C
• Valvetronic position deviation	Steady
• Engine speed deviation	Steady/stable engine speed
• Average lambda value deviation	Steady/stable load

* Catalyst temperature is an ECM calculated value based on load/air mass and time.

Note: The catalyst efficiency is monitored once per trip while the vehicle is in closed loop operation.

As part of the monitoring process, the pre and post O_2 sensor signals are evaluated by the ECM to determine the length of time each sensor is operating in the rich and lean range.

If the catalyst is defective the post O_2 sensor signal will reflect the pre O_2 sensor signal (minus a phase shift/time delay), since the catalyst is no longer able to store/comsume oxygen. The catalyst monitoring process is stopped once the predetermined number of cycles are completed, until the engine is shut-off and started again. After completing the next "customer driving cycle" whereby the specific conditions are met and a fault is again set, the "Malfunction Indicator Light" will be illuminated.

Secondary Air Injection Monitoring is performed by the ECM via the use of the pre-catalyst oxygen sensors. Once the air pump is active and is air injected into the exhaust system the oxygen sensor signals will indicate a lean condition. If the oxygen sensor signals do not change within a predefined time a fault will be set and identify the faulty bank(s). When diagnosing a Secondary Air Injection fault, in addition to the electric air pump and non-return valves always consider the following:

- Restricted air inlet to the pump.
- Restricted supply hoses to the non-return valves.
- Internal restrictions in the cylinder head passages into the exhaust ports.

Misfire Detection is part of the OBD II regulations the ECM must determine misfire and also identify the specific cylinder(s), the severity of the misfire and whether it is emissions relevant or catalyst damaging based on monitoring crankshaft acceleration.

Emission Increase:

- Within an interval of 1000 crankshaft revolutions, the ECM adds the detected misfire events for each cylinder. If the sum of all cylinder misfire incidents exceeds the predetermined value, a fault code will be stored.

- If more than one cylinder is misfiring, all misfiring cylinders will be specified and the individual fault codes for all misfiring cylinders and for multiple cylinder will be stored.

Catalyst Damage:

- Within an interval of 200 crankshaft revolutions the detected number of misfiring events is calculated for each cylinder. The ECM monitors this based on load/rpm. If the sum of cylinder misfire incidents exceeds a predetermined value, a fault code is stored and the "Malfunction Indicator Light" will be illuminated.

If the cylinder misfire count exceeds the predetermined threshold the ECM will take the following measures:

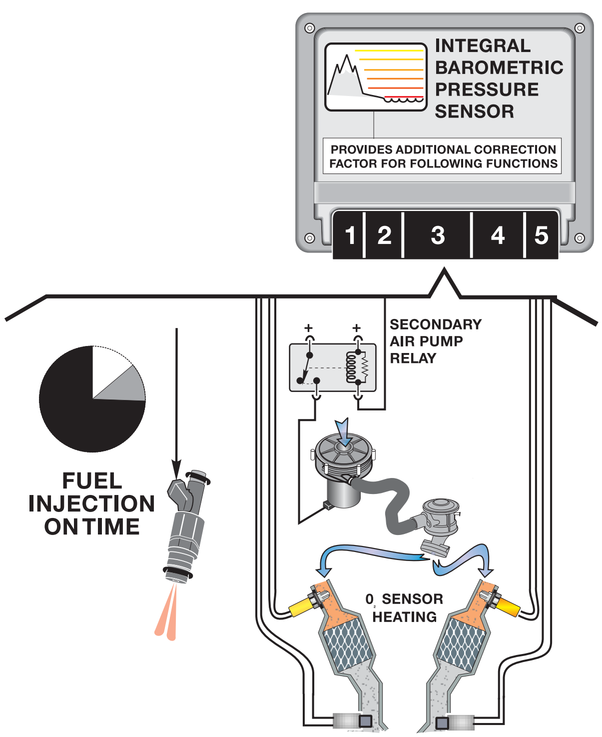
- The oxygen sensor control will be switched to open loop.
- The cylinder selective fault code is stored.
- If more than one cylinder is misfiring the fault code for all individual cylinders and for multiple cylinders will be stored.
- The fuel injector to the respective cylinder(s) is deactivated.

The Integrated Ambient Barometric Pressure Sensor of the ME 9.2 is part of the ECM and is not serviceable. The internal sensor is supplied with 5 volts. In return it provides a linear voltage of approx. 2.4 to 4.5 volts representative of barometric pressure (altitude).

The ME 9.2 monitors barometric pressure for the following reasons:

- The barometric pressure signal along with calculated air mass provides an additional correction factor to further refine injection "on" time.

- Provides a base value to calculate the air mass being injected into the exhaust system by the Secondary Air Injection System. This correction factor alters the secondary air injection "on" time, optimizing the necessary air flow into the exhaust system.



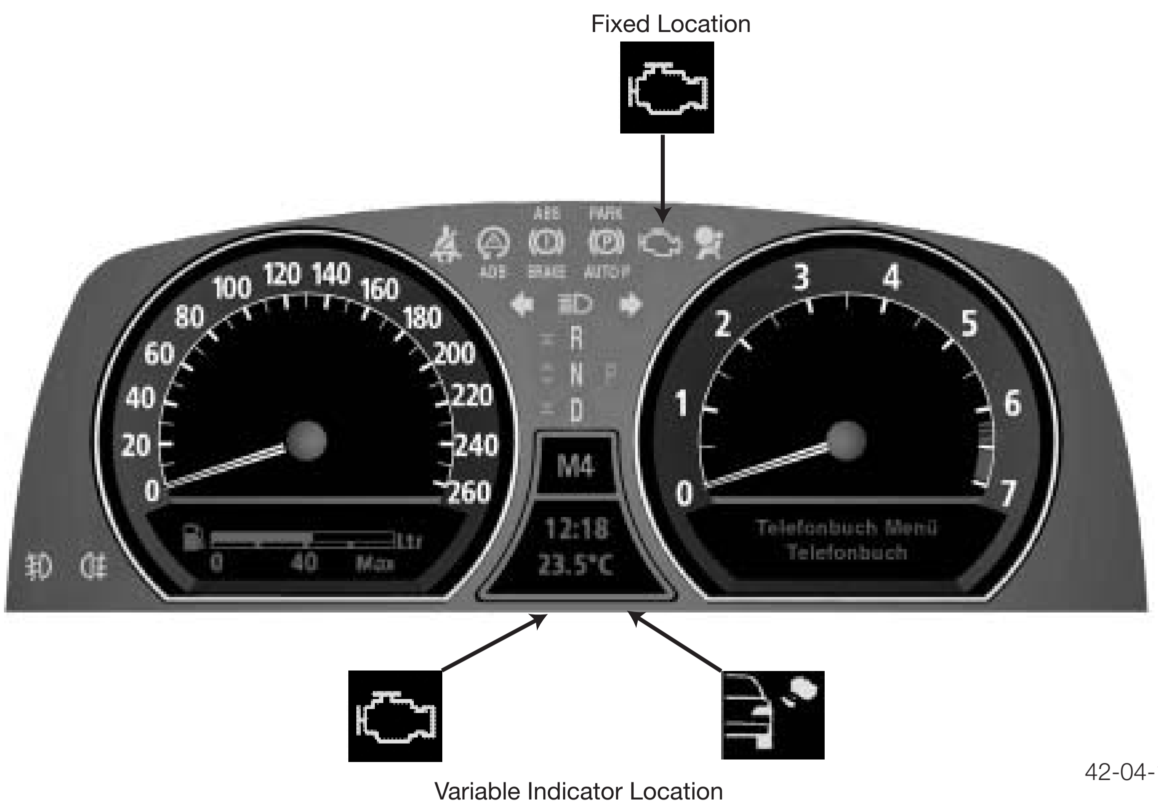
42-04-16

The Malfunction Indicator Light is illuminated when the OBD system (integral in the ECM) determines that a problem exists and a corresponding “Diagnostic Trouble Code” is stored in the ECM’s memory. The Malfunction Indicator appears both in the instrument cluster upper center section (fixed) and in the Check Control Display (variable indicator). This light informs the driver of the need for service with a Check Control message displayed.

After fixing the problem the fault code is deleted to turn off the light. If the conditions that caused a problem are no longer present, the OBD system can turn off the light automatically. If the OBD system evaluates the component or system three consecutive times and no longer detects the initial problem, the dashboard light will turn off automatically.

The Malfunction Indicator Light will illuminate for the following reasons:

- Pre-drive check when the ignition is switched on (in the fixed location)
- Increased emissions (both fixed and variable indicator locations with message displayed)
- Engine fault - drive with moderation (variable indicator location with message displayed)

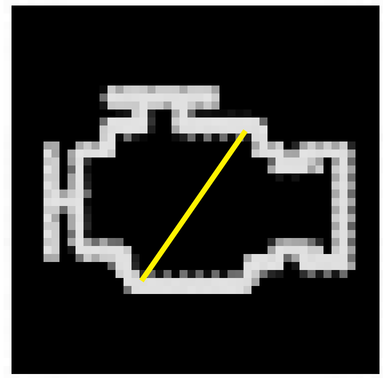


42-04-18

The Malfunction Indicator Light will illuminate with a “half shading” in the variable indicator location for the following reasons:

• Engine fault - with reduced power (with message displayed)

• ***Engine damage possible!*** (with message displayed)



42-04-18

Emissions Diagnosis

The "BMW Fast" (BMW fast access for service and testing) diagnosis concept is used in the E65 for ME 9.2 ECM. This concept is based on the "Keyword Protocol 2000" (KWP 2000) diagnosis protocol defined as part of the ISO 14230 standard. Diagnosis communication takes place entirely on the basis of a transport protocol on the CAN bus. The Diagnosis bus is connected to the Central Gateway Module (ZGM).

Vehicle Diagnosis Access Point

The diagnosis tool is connected to the vehicle at the OBD diagnosis connector (On-Board Diagnosis). The connector is located behind a small cover in the drivers side kick panel trim. There is a black plastic cap that bridges KL30 to the D-bus when the connector is not being used. This cap must be removed before installing the diagnosis cable.

The TxD lead is located in pin 7 of the OBD socket and is connected directly to the ZGM.

The ZGM detects by means of the data transmission speed whether a BMW diagnosis tool (DISplus, MoDiC, GT-1) or an aftermarket scanner is connected.

The ECM allows access to different data depending on the diagnosis tool connected.

42-04-20

Note: When using an OBD scan tool for diagnosis, the transmission speed is 10.4 KBit/s.

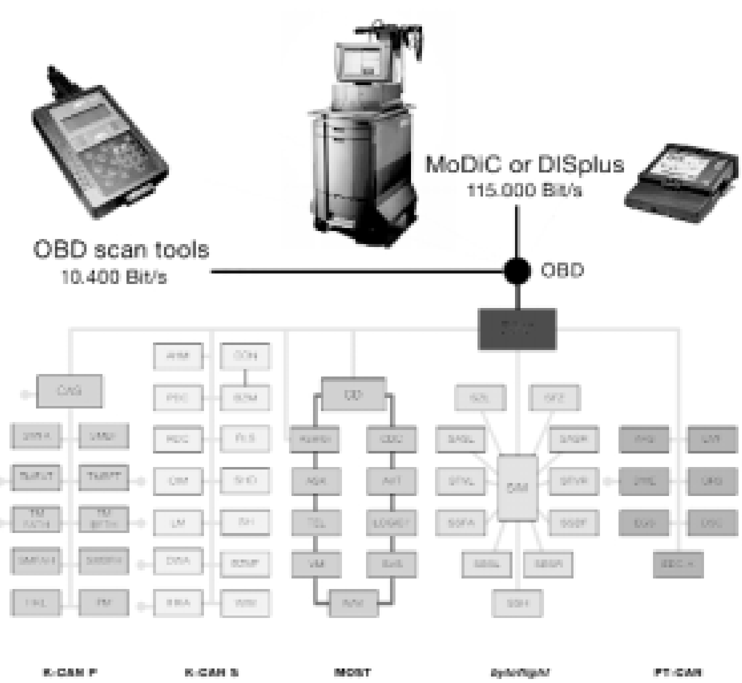
Diagnosis Bus

The aim of diagnosis is to enable a Technician to reliably identify a defective component. By the use of appropriate hardware and monitoring software, the microprocessor of the diagnosis tool is able to detect faults in the ECM and its peripherals.

Faults identified are stored in the fault memory and can be read out using the Diagnosis Program. Data transfer between the vehicle and the diagnosis tool takes place via the Diagnosis bus (D bus).

The new features of the diagnosis bus are:

- Faster data transmission speed of 115 kBd.
- Central diagnosis access point (OBD connector).
- Single diagnostic cable (TxD II) for the entire vehicle.
- Omission of the TxD1 cable.
- Access to diagnosis functions requires “Authorization”.
- Diagnosis protocol "KWP 2000" (Keyword Protocol 2000).
- Standardized diagnosis structure for all control units.



42-04-21

The ECM is not directly connected to the OBD diagnostic connector. The OBD diagnostic connector is connected to the ZGM. The ECM is connected to the ZGM (central gateway module) by the PT CAN bus. The ECM is also connected to the Valvetronic control module by the Lo CAN (local) bus. Valvetronic faults are stored in the ECM.

Performance Controls

Bi-VANOS Control (Variable Camshaft Adjustment)

Performance, torque, idle characteristics and exhaust emissions reduction are improved by Variable Camshaft Timing (Bi-VANOS). The VANOS units are mounted directly on the front of the camshafts and adjusts the timing of the **Intake and Exhaust** camshafts from retarded to advanced. The ECM controls the operation of the Bi-VANOS solenoids which regulates the oil pressure required to move the VANOS units. Engine RPM, load and temperature are used to determine Bi-VANOS activation.

42-04-00

The Bi-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 Bi-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 Bi-VANOS operation.

Solenoid Valves: The Bi-VANOS solenoid valves are mounted through the upper timing case front cover. There are two solenoids per cylinder head to control the oil flow to the camshaft ports for the intake and exhaust VANOS units.

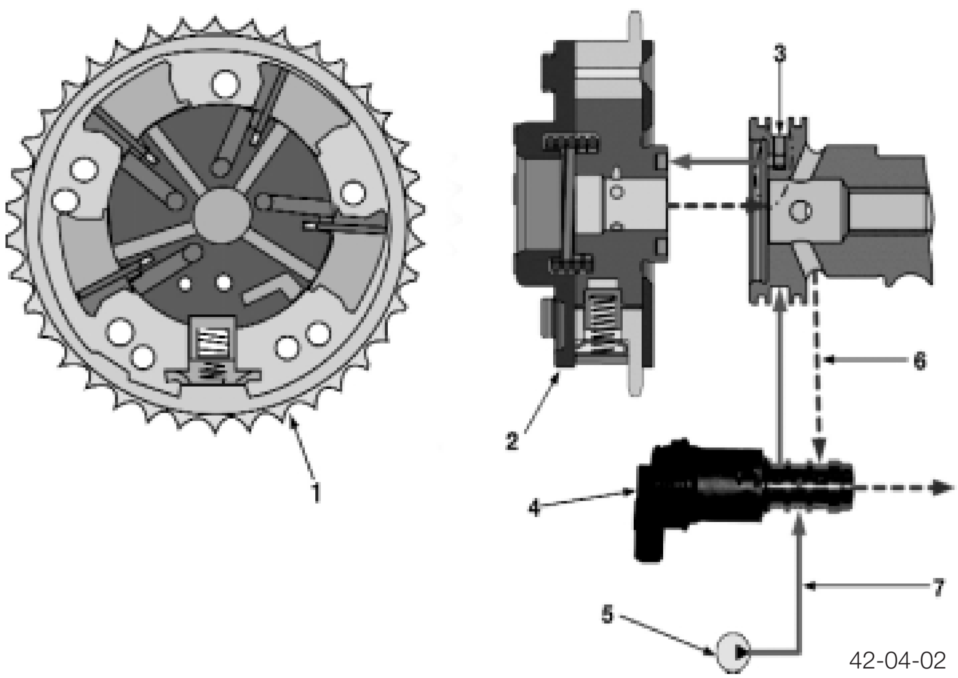
The 4/3 way proportional solenoid valve is activated by the ECM to direct oil flow. The solenoid valve is sealed to the front cover by a radial seal and secured by a retaining plate.

42-02-41

Hydraulic Actuation

When oil pressure is applied to chamber A, the blades are forced away from the VANOS housing (counterclockwise). The blades are keyed into the hub which results in the hub position being rotated in relation to the housing (with sprocket). The hub is secured to the camshaft which changes the camshaft to sprocket relationship (timing). The example below shows the ***adjustment*** procedure together with the pressure progression based on the VANOS unit for the exhaust camshaft.

1. Front View of VANOS Unit
2. Side View of VANOS Unit
3. Camshaft Oil Port (Chamber B)
4. Solenoid Valve
5. Engine Oil Pump
6. Supplied Oil (Switched Through Solenoid)
7. Supplied Oil Pressure (From Engine Oil Pump)



42-04-02

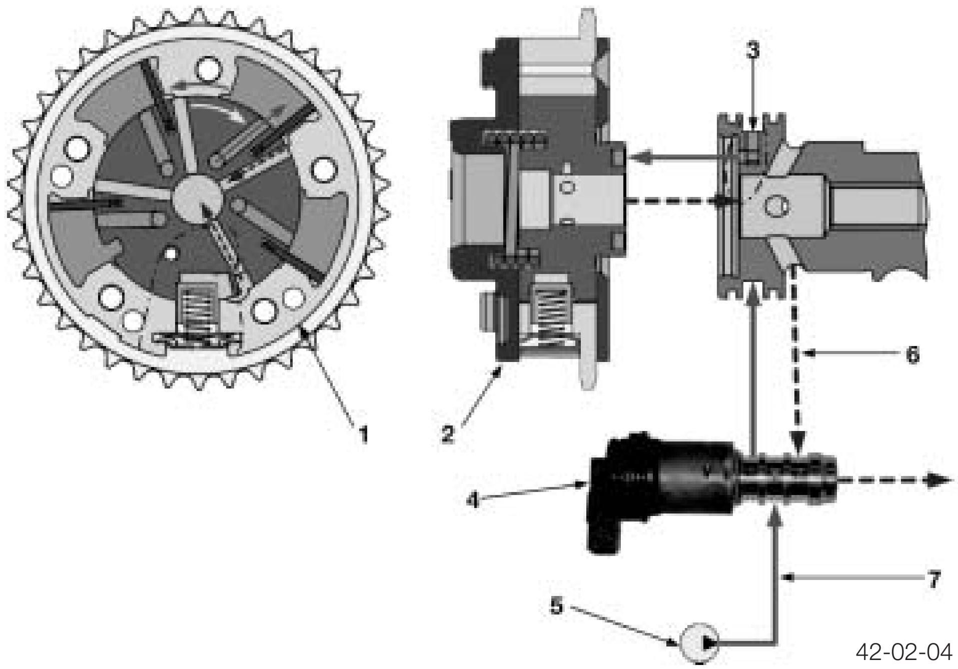
VANOS

During this adjustment chamber B is open (through the solenoid) to allow the oil to drain back through the cylinder head (internal reservoir).

When the solenoid valve switches over, oil pressure is applied to chamber B. This forces the blades (and hub) in a clockwise direction back to the initial position, again changing the camshaft timing.

The example below shows the ***reset*** procedure together with the pressure progression based on the VANOS unit for the exhaust camshafts.

1. Front View of VANOS Unit
2. Side View of VANOS Unit
3. Camshaft Oil Port (Chamber B)
4. Solenoid Valve
5. Engine Oil Pump
6. Oil Return (Switched through Solenoid)
7. Supplied Oil Pressure (From Engine Oil Pump)



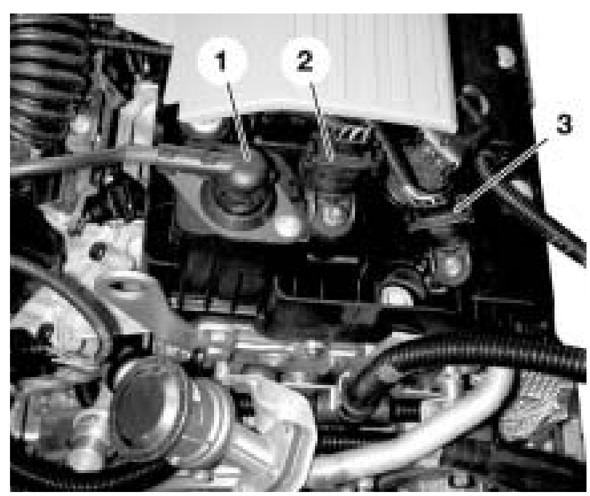
42-02-04

VANOS

During this adjustment chamber A is open (through the solenoid) to allow the oil to drain back through the cylinder head (internal reservoir).

Camshaft Sensors: The camshaft sensors (Hall effect) are mounted through the cylinder head cover. There are two sensors per cylinder head to monitor the intake and exhaust camshaft positions. The sensors monitor the impulse wheels attached to the ends of the camshafts.

1. Valvetronic Position Sensor
2. Intake Camshaft Position Sensor
3. Exhaust Camshaft Position Sensor

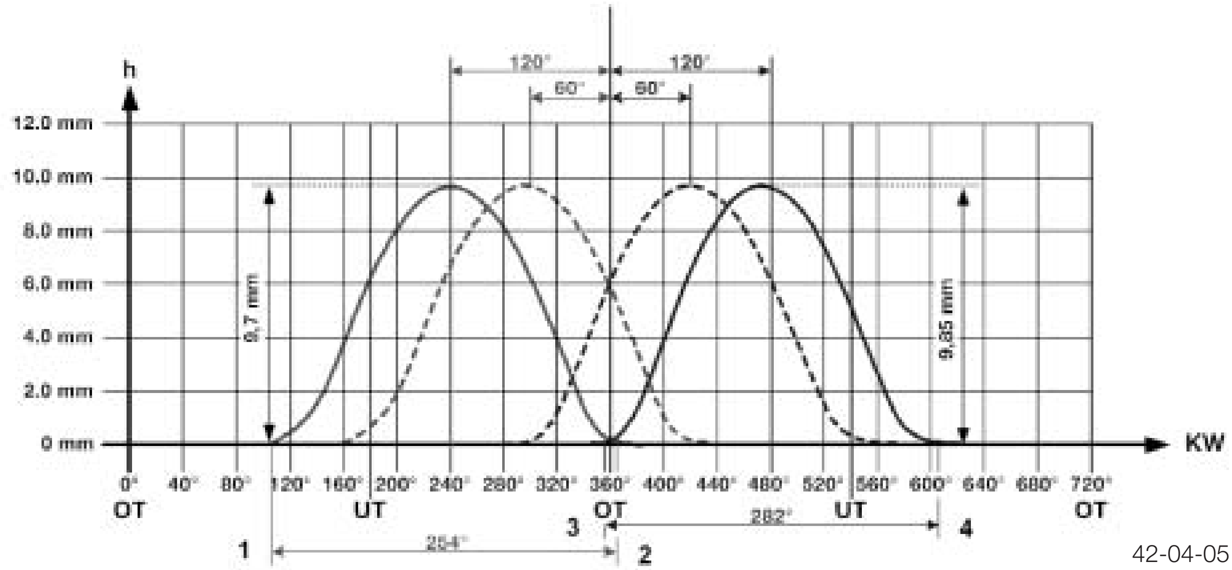


42-02-48

The chart below shows the Bi-VANOS unit camshaft adjustment possibilities. The valve lift adjustment has also been incorporated.

The special feature of Valvetronic is that the air mass drawn in the cylinders can be easily determined by the valve lift and closing time. The air mass can then be limited, thus the term “load control”.

With the help of VANOS, the closing point can be easily selected within a defined range. With valve lift control, the opening duration and cross section of the valve opening can also be easily selected within a defined range.



Exhaust & Intake Valve

1. Exhaust Valve Open
2. Exhaust Valve Closed
3. Intake Valve Open
4. Intake Valve Closed

Vacuum pump

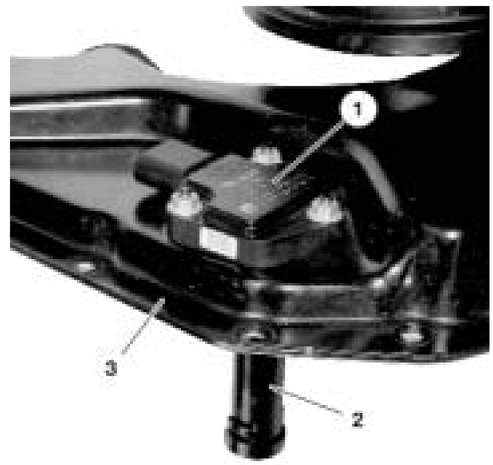
The N62 engine requires a vacuum pump for the vacuum assisted brake booster. With the throttle valve open while the car is being driven, additional vacuum is needed. The vacuum pump is driven by cylinders 1-4 exhaust camshaft via the VANOS unit. The pump is lubricated through an oil gallery from the cylinder head.

Oil Condition

An oil condition sensor records the exact engine oil level, oil temperature and the condition of the engine oil. Recording the engine oil level protects the engine from having a level which is too low which will result in engine damage. Recording the condition of the oil means that it is possible to determine exactly when an oil change is required.

Oil Condition Sensor (OZS): The electronic condition sensor is located in the engine sump mounted to the engine oil pan.

1. Electronic Sensor
2. Housing
3. Lower section of the oil sump (inverted view)

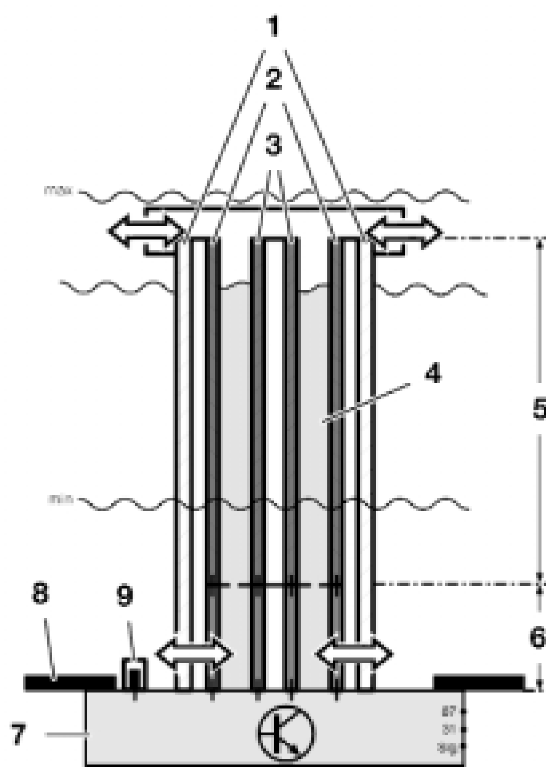


42-04-06

The sensor consists of two connected cylinder capacitors. The smaller capacitor (6) records the oil condition. Two metal tubes (2+3) act as capacitor electrodes located inside the sensor. The engine oil (4) dielectric is located between the electrodes.

With increased wear and additive deterioration, the electrical material properties of the engine oil change.

1. Housing
2. Outer metal tube
3. Inner metal tube
4. Engine oil
5. Oil level sensor
6. Oil condition sensor
7. Sensor electronics
8. Oil sump
9. Temperature sensor



42-04-07

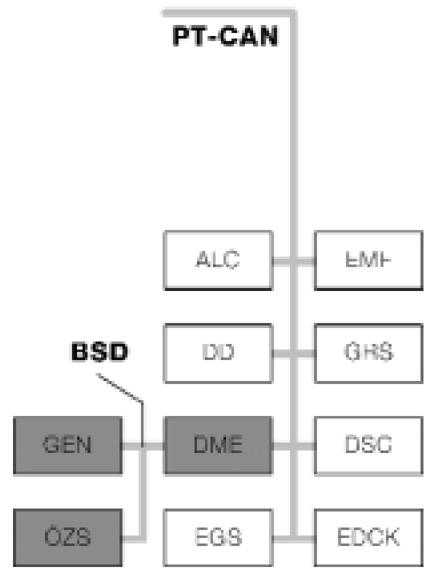
Oil Condition Sensor

The different electrical material properties of the engine oil (dielectric) change the capacitance of the oil condition sensor. This capacitance value is processed to a digital square wave signal in the evaluation electronics (7) which is integrated in the sensor. This signal is sent to the ECM over the BSD interface as a “statement” about the engine oil condition. The ECM processes this sensor value to calculate the next oil change service.

The engine oil level is determined in the upper section of the sensor (5). This part of the sensor is located on the top of the oil level in the oil sump. As the oil level lowers (dielectric), the capacitance of the sensor also changes. The sensor electronics process this capacitance value into a digital square wave signal which is also sent over the BSD interface to the ECM.

A platinum temperature sensor (9) is integrated at the base of the oil condition sensor to measure the oil temperature. The engine oil level, oil temperature and engine oil condition are constantly recorded when voltage is supplied (KL15). The oil condition sensor is supplied with voltage from the IVM.

The oil condition sensor electronics performs its own diagnostics. A fault in the OEZS results in a corresponding error message that is transmitted over the BSD interface to the ECM for fault storage.



42-04-08

Electric Cooling Fan

The variable speed electric cooling fan is controlled by the ECM. The ECM uses a remote power output final stage (mounted on the fan housing). The power output stage receives power from the fuse (50 amp) junction located on the right inner fender of the engine compartment (under the remote charging post). The electric fan is controlled by a pulse width modulated signal from the ECM.

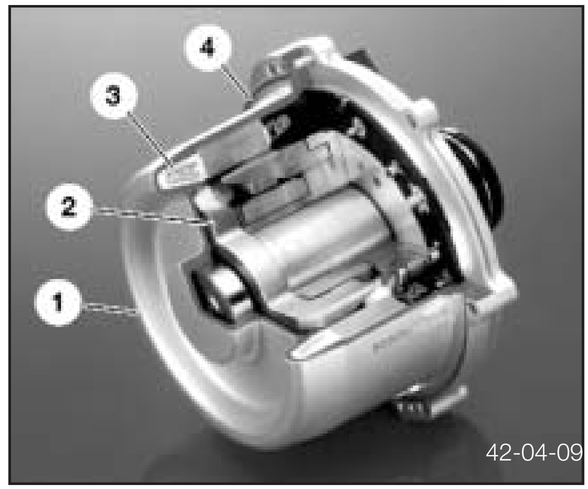
The fan is activated based on the ECM calculation of:

- Coolant outlet temperature (monitored by the Outlet Temperature Sensor in the thermostat housing)
- Catalyst temperature
- Vehicle speed
- Battery voltage
- Air Conditioning high side pressure (calculated by IHKA via a bus signal to the ECM)

Alternator

Due to the high power capacity of 180 A, the alternator is cooled by the engine's cooling system to enhance heat dissipation. The brushless Bosch alternator is installed in an aluminum housing which is mounted to the engine block. The exterior alternator walls are surrounded with circulated engine coolant. The function and design of the alternator is the same as in the M62, with only minor modifications. The BSD interface (bit-serial data interface) for the ECM is new.

1. Watertight Housing
2. Rotor
3. Stator
4. Seal



Altenator

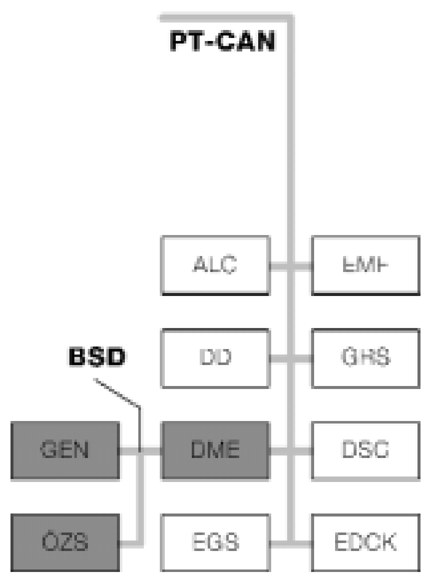
Regulation

The alternator can actively communicate with the ECM via the BSD (bit-serial data interface). The alternator conveys data to the ECM.

This is necessary to allow the ECM to adapt its calculations and specific control to the alternator output.

The connection with the ECM makes it possible to almost completely equalize the alternator load torque. This supports the engine idling speed control and the battery load balance.

In addition, the ECM receives information from the Power Module about the battery's calculated temperature and charge status. This means that alternator output can be adapted precisely to the temperature and load status of the battery which increases the battery service life.



42-04-08

The ECM takes on the following functions:

- Activation/deactivation of the alternator.
- Informing the alternator regulator of the nominal voltage value to be set.
- Controlling the alternator's response to load.
- Diagnosing the data line between the alternator and the ECM.
- Storing alternator fault codes.
- Activating the charge indicator lamp in the instrument cluster.

The charge indicator display strategy has not changed in comparison with the alternators currently in use. Regulating the alternator output is particularly important when activating Valvetronic operating motors.

A temperature protection function is implemented in the voltage regulator. If the alternator overheats, the alternator voltage is reduced until an appropriate temperature has been reached.

The ECM can recognize the following faults:

- Mechanical faults such as blockages or belt drive failure.
- Electrical faults such as exciter diode defects or over/under voltage caused by regulation defects.
- Connection defects between the ECM and the alternator.

Coil breaks and short-circuits cannot be recognized. The basic alternator function is in operation even if the BSD interface fails.

Note: The alternator regulator voltage is influenced by the ECM - BSD interface. The battery charge voltage can therefore be up to 15.5 V, depending on the battery temperature. If a battery charge voltage of up to 15.5 V is measured, the regulator is not faulty. A high charge voltage indicates a low battery temperature.

Electronic Box Cooling Fan

42-04-21

The E-box develops very high temperatures caused by engine heat and the energy dissipated by the control units. The ECM controls an electric cooling fan in the base of the electronic box to draw in cool air from the passenger compartment.

Since electronic control modules need to operate at a reduced temperature, the air temperature in the E-box must be kept as low as possible. Lower temperatures extend the life expectancy of electronic control modules.

Comfort Start

42-04-11

The comfort start makes easy engine starting possible because the starter remains automatically activated until the engine is running (rpm signal). Security is enhanced by using the CAS Module with coded keys and the ignition starting button (integral).

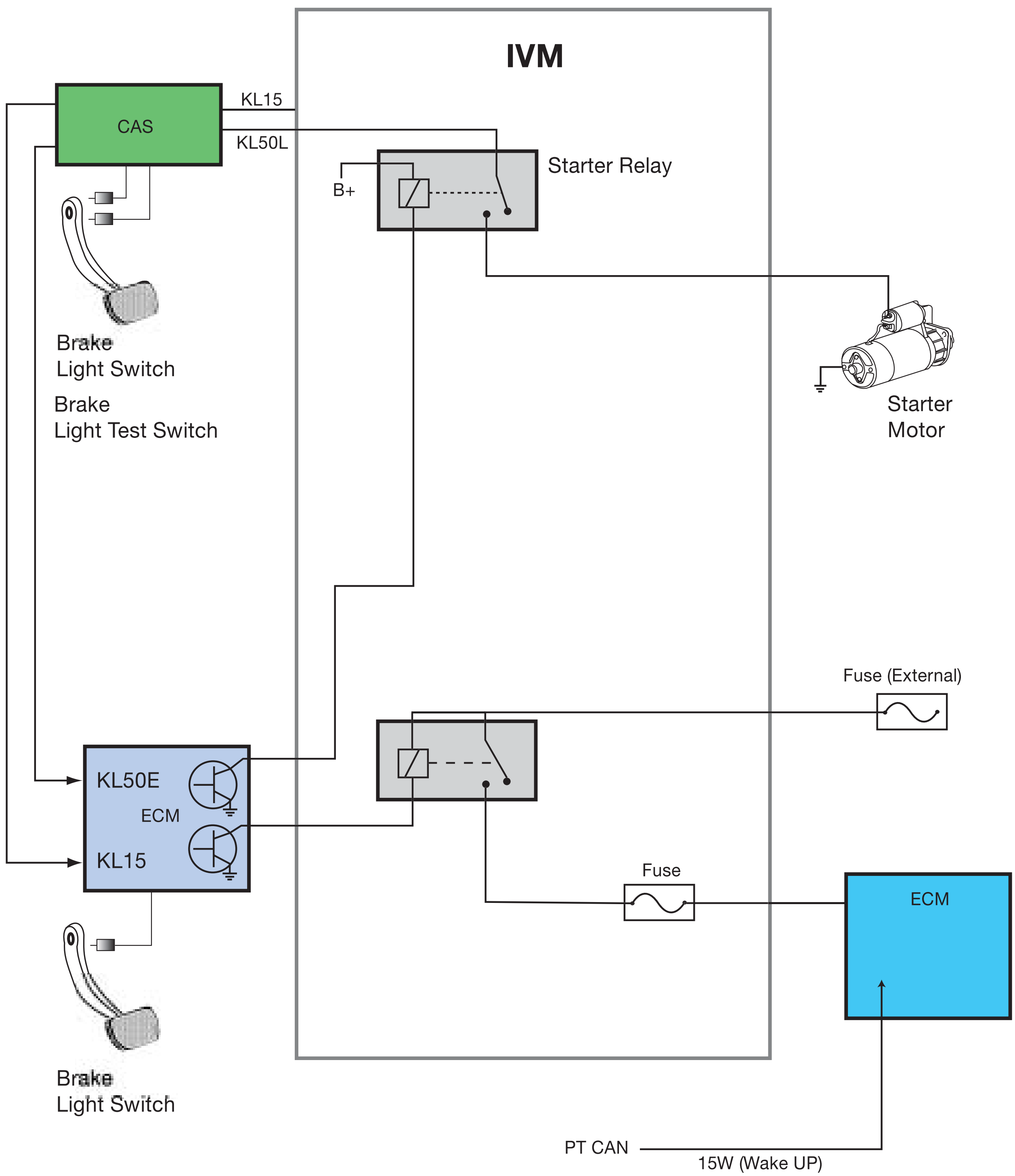
When starting to the engine, the CAS contains the data for the EWS code which is transferred to the ECM. The transmission of EWS data between the CAS and the ECM is over the data line D - EWS. Terminal R and terminal 15 is directed by the CAS for all electrical systems. The CAS also activates KL15 WUP (Wake UP) for control modules on the PT-CAN.

When KL15 WUP is activated, the control modules change from the state of rest into the operating condition. During the starting procedure, KL 50L for the comfort starting relay (in the IVM) and KL 50E is switched to the ECM for the starting request. The ECM will activate a ground signal to the comfort starting relay to energize the starter motor.

The brake light switch is monitored by the ECM for the comfort start feature as well as cruise control. An engine start is possible only if the brake pedal is pressed. For safety reasons, the CAS monitors both signals of the brake light switch (the actual brake light switch and the brake light test switch).

The selector lever of automatic transmission must be in position P or N. The position of the selector lever is detected from the direct hardwire signal or via a CAN signal.

Comfort Start - Block Diagram



Actuation Time of Terminal 50: The monitored actuating times of terminal 50 protects the starter against overloading. The actuation times of terminal 50 are:

- A maximum of 21 seconds. A repetition is possible immediately.
- The actuation time is reduced for each repetition by 2 seconds until the minimum actuation time of 3 seconds is reached.
- If the start/stop button is pressed for longer than the preceding actuation time, the actuation time is increased by 2 seconds again (up to a maximum of 21 seconds).

Switching off the Engine: The vehicle engine is switched off when the vehicle is stopped and the start/stop button is pressed. If the start/stop button is pressed for longer than 2 seconds, the vehicle engine is switched off and then the key is automatically released and pushed out with spring pressure ("convenience off").

Incorrect Operation and "Emergency On": To ensure the safety of the vehicle in the case of an accidental engine shutdown during driving, the "Emergency On" function is available. An engine shutdown during driving can be caused by accidentally pressing the start/stop button (the button must be pressed for at least 1 second or 3 times consecutively).

The "Emergency On" function enables the starter to be actuated again without brake operation at a vehicle speed above 5 km/h (3 mph). The "Emergency On" function also prevents terminal R from being switched off during driving.

Service Functions: When replacing the ECM and/or CAS Module, the following must be completed:

The Service Function "DME/DDE - CAS alignment" in the DISplus. After the alignment the two modules are rigidly assigned to each other and the vehicle.

Note: It is not possible to exchange these control modules with another vehicle for testing purposes.

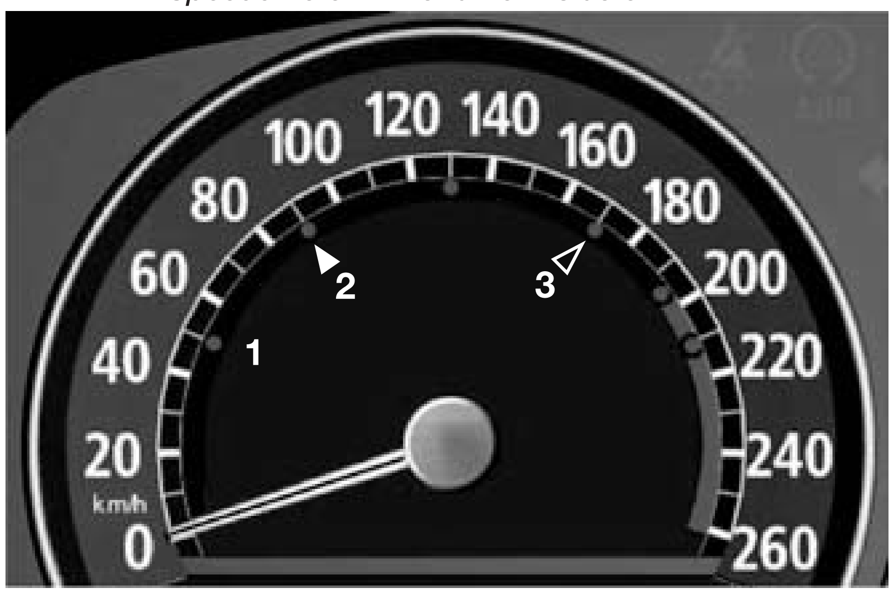
Cruise Control

The cruise control (FGR) is a function of the ECM and has multi-speed capability on the E65. This multi-speed function allows the driver to program and store multiple speed settings which can then be activated as required.

This means that speed settings such as 30, 50, or 65 mph can be selected directly at the touch of a button without having to drive the vehicle precisely at that speed beforehand. This is a considerable added convenience. Those preset cruise control speeds are programmed by the driver in advance and then activated when driving.

Speedometer in Instrument Cluster:

1. Preset speeds
2. Cruise control active: illuminated pointer
3. Cruise control not active: silhouette pointer



Briefly press/pull the lever to illuminate the cruise control mask in the speedometer. The memory will accept and store up to 6 preset speeds. When the cruise control is not active, the silhouette pointer indicates the last speed at which it was activated.

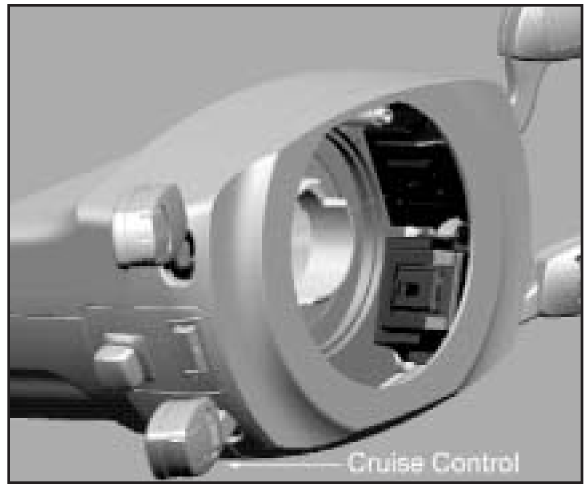
When the cruise control is active, the illuminated pointer indicates the speed that is currently being maintained. The cruise control can be activated at any speed from approximately 20 mph upwards.

When the ignition is switched OFF, the cruise control is switched off at the same time. Moving the lever up/dn will deactivate the cruise control and delete the mask in the speedometer. The cruise control function is overridden by braking, selecting transmission setting "N" or active DSC intervention.

Cruise Control Lever: The cruise control is operated by the left lower steering column lever.

When the lever is pressed forward to (but not beyond) the detent, the current road speed is stored and maintained.

Flicking the lever forwards increases the vehicle road speed by approx. 1 mph at a time. If the lever is pressed and held, the vehicle accelerates. When the lever is then released, the speed is stored and maintained.



42-04-13

When decelerating, flicking the lever backwards repeatedly reduces the vehicle road speed by approx. 1 mph at a time. When the multi-speed function is activated, the preset speed indicators on the speedometer can be hidden. This is done by pressing and holding the cruise control lever up or down for more than 3 seconds.

Programming/Deleting Preset Speeds

Programming of preset speeds should be performed while the vehicle is stationary with KL15 switched “on”. It is also possible to program the preset speeds while driving. However, altering the preset speed also alters the current speed being maintained.

To program a preset speed, the cruise control lever is pressed forwards or backwards beyond the detent. A pointer then appears on the speedometer that indicates the preset speed. To increase the preset speed, the cruise control lever must be pressed forward to the detent. To reduce the preset speed, the cruise control lever must be pulled backwards to the detent.

To store the preset speed, the slide switch (in the end of the lever) must be pressed and held in for at least 3 seconds. The stored preset speed is indicated by a pointer on the speedometer. A preset speed is deleted by selecting it using the cruise control lever and then pressing and holding the slide switch in for at least 3 seconds. The speed pointer then disappears.

Note: The preset cruise control speeds are a Vehicle Memory function.

Function	**Operated By**
Activate cruise control accelerate/set	Move lever forwards
Decelerate/set	Move lever backwards
Activate multi-speed function	Pressing lever forwards past detent
Select next higher preset speed	Pressing lever forwards past detent
Select next lower preset speed	Pressing lever backwards past detent
Cancel cruise control	Move lever up/down
Recall/set/delete preset speeds while cruise control active	Press slide switch inwards

Notes:

Review Questions

1. Describe the Integrated Voltage Supply Module (IVM) for the Fuel Injectors and Ignition Coils:

2. List the three signal operations required to detect Valvetronic Positon.

3. Describe how the Electric Fuel Pump is activated.

4. What type of Ignition Coils are used in the N62?

5. Where is the Active Charcoal Canister and DM TL located?

6. What are the advantages of the Bosch LSU Planar Wideband Oxygen Sensors?

7. List the functions of the Oil Condition Sensor.

8. Explain the Comfort Start feature.

9. How are the Cruise Control preset speeds programmed and deleted?

Table of Contents

N73B60 Engine - Workbook

Subject **Page**

N73B60 Engine

Disassembly - Components

N73B60 Engine

Model: E66 - 760Li

Production: MY 2003

This intent of this workbook is to assist you with key components for disassembly/reassembly in addition to the detailed information found in the Repair Instructions, Technical Data and Tightening Torques from the latest TIS information.

This section will be instructor led for a brief review of the N73 engine. You are encouraged to use this workbook with the latest TIS information to make notes during disassembly/reassembly of the engine. This will be valuable to you as supplementary information or a memory refresher when performing repairs in the future.

Note: For more in depth and detailed information about the N73 engine, refer to the ST047 2003 Systems Diagnosis training manual.

For additional and updated information, always refer to:

www.bmwcenternet.com
- TIS information/updates
- Service Information Bulletins
- DCS messages

Objectives:

After completion of this module you will be able to:

- Disassemble the N73 engine.
- Perform critical measurements and observations to determine engine condition.
- Correctly reassemble (including valve gear timing) the N73 engine.

N73B60 Engine

Purpose of the System

The N73 engine is a complete new BMW development from the NG Series (New Generation) as a B60 (6 liter). The N73B60 will be used in the E66 as a 760Li (USA).

KT-9765

The BMW 760Li will set new standards in terms of performance and driving dynamics in the 12-cylinder market segment as well as significantly reduce fuel consumption.

For the first time at BMW, Valvetronic technology (combination of Bi-VANOS and variable intake valve lift) is supplemented by direct injection (DI).

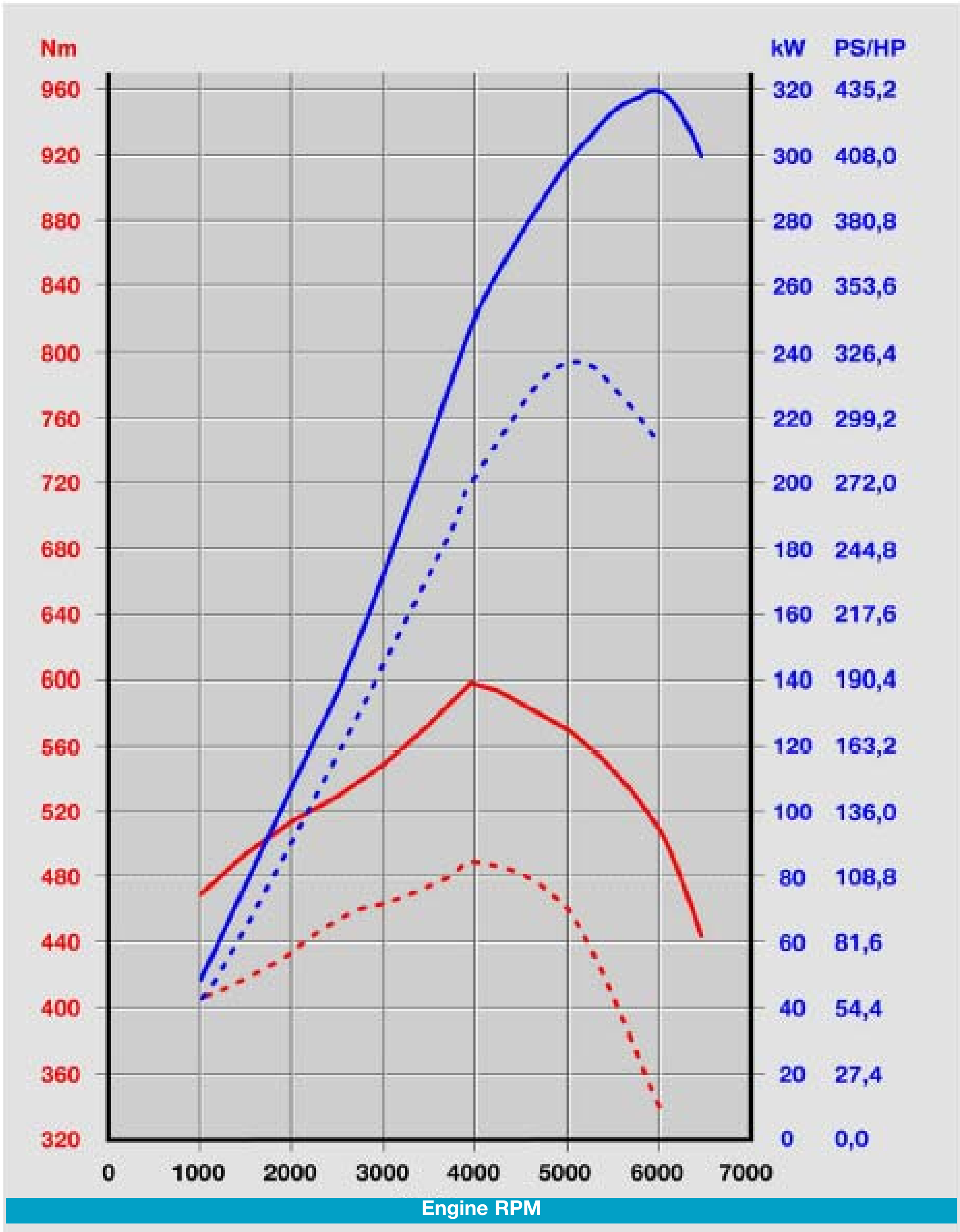
In addition, the N73 cylinder heads use 4 valve technology.

The combination of these cutting edge technologies provides low fuel consumption and maximum power output and torque, making the N73 the best engine in its class.

Technical Data

Technical Data Comparison	N73B60	M73B54
V-angle configuration	12 cyl. V / 60º	12 cyl. V / 60º
Displacement (cm 3)	5972	5379
Bore / Stroke (mm)	89 / 80	79 / 85
Cylinder spacing (mm)	98	91
Crankshaft main bearing diam. (mm)	70	75
Conrod big end diam. (mm)	54	48
Power output (kW/HP) at engine speed (rpm)	320 / 438 6000	240 / 326 5000
Torque (Nm) at engine speed (rpm)	600 3950	490 3900
Idle speed (rpm) Maximum engine speed (rpm)	550 6500	600 6500
Compression ratio	11.3 : 1	10 : 1
Valves per cylinder	4	2
Intake valve diam. (mm)	35	42
Exhaust valve diam. (mm)	29	36
Intake valve lift (mm)	0.3 - 9.85	10.3
Exhaust valve lift (mm)	9.7	10.3
Engine weight (kg)	280	-
Fuel requirement	Premium unleaded	Premium unleaded
Knock control	Yes	Yes
Injection pressure (bar)	50 - 120	3.5
Digital Motor Electronics (ECM)	2x MED 9.2.1 & Valvetronic ECU with 2x HDEV ECU	2x ME 5.2 & EML IIIs
Emission compliance level	LEV	LEV
Firing order	1-7-5-11-3-9-6-12-2-8-4-10	1-7-5-11-3-9-6-12-2-8-4-10
Fuel consumption savings compared with M73	12 %	-
Maxmimum regulated vehicle speed (km/h / mph)	250 / 155	250 / 155

Power and Torque Output - N73B60 / M73B54



N73B60 ———
M73B54 - - - - -

Intake Manifold

The intake system is a complete component constructed of magnesium in a shell type design and has separate manifold chambers for each cylinder bank.

1. Intake manifold pressure sensors
2. Captured gaskets
3. Pressure control valves for crankcase ventilation
4. Throttle valves

The individual parts of the intake system are bonded and bolted to each other, providing considerable weight reduction (separating the shell halves is not permitted).

The entire intake system is protected against corrosion by a dip coating procedure. The fastening bolts of the add on parts are also coated and must be replaced in the event of damage, to prevent corrosion and pitting.

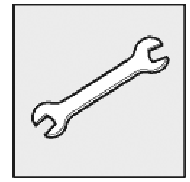
All of the gaskets (2) are secured by retainers (captured) to provide ease of installation. The intake system is isolated from the engine by rubber elements on the fastening bolts.

An intake manifold pressure sensor (1) is used for each cylinder bank. Recording the manifold differential pressure is necessary for the correct throttle position (synchronization) so that a manifold differential pressure of 50 mbar can be balanced on each bank.

Both sides of the induction system are fitted with a pressure control valve (3) for crankcase ventilation which is distributed to both banks.

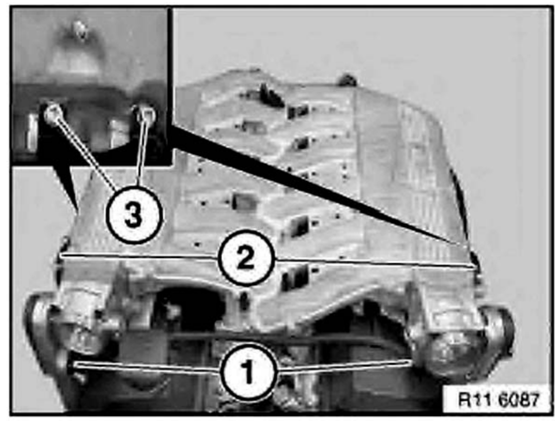
Note: When replacing the spark plugs, it is necessary to remove the entire intake system to avoid damaging the spark plugs during installation. The spark plugs must be replaced every 100,000 miles in US vehicles.

Intake Manifold - Removal



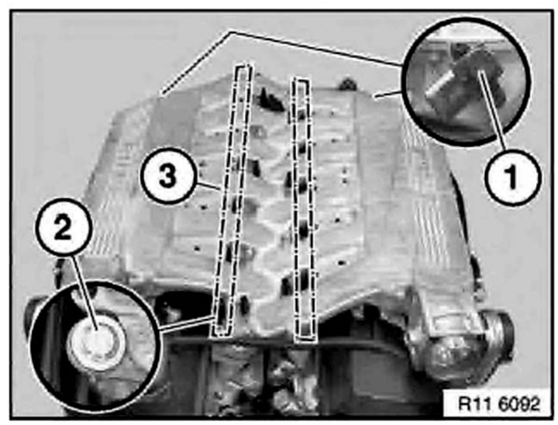
Top Diagram

- Remove plug connections on the throttle assemblies (1).
- Detach engine vent hoses from pressure control valves (2).
- Detach oustide braces for intake manifold (3 L/R).



Lower Diagram

- Remove plug connections on the intake manifold pressure sensors (1 L/R).
- Remove bolts (2) along sections (3).
- Lift intake manifold up to remove.



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Questions

How many attaching bolts are there? ________

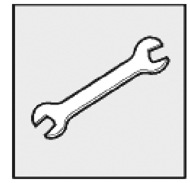
What is the tightening torque? ________ *Nm*

How are the intake manifold gaskets held in place? ________

Can the gaskets be reused? ________

Notes: ________

Cylinder Head Cover (right) - Removal

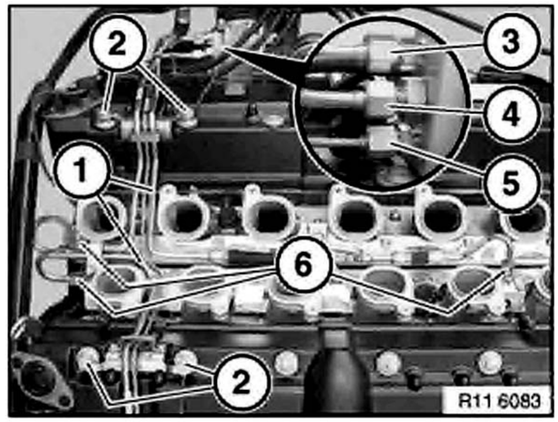


Caution: Do not bend any high pressure lines!

Top Diagram

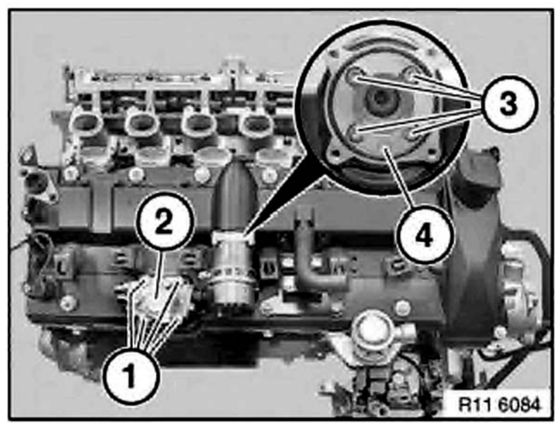
- Detach high pressure lines (1) at mounting points (2).

On high pressure pump:
- Detach feed line (3).
- Detach high pressure line (4).
- Detach leakage line (5).
- Detach high pressure lines from fuel rail (6).



Lower Diagram

- Remove Valvetronic motor.
- Remove mounting bolts (1) and high pressure pump (2).
- Remove bolts (3) and pull out spacer (4).
- Remove Non-Return Valves and cylinder head cover perimeter bolts.



002

Questions

What is the tightening torque for the coupling nuts on fuel lines 3-6?_____________Nm

What should you do to the spark plug domes (sleeves) before reinstalling them?

After removing the high pressure pump (2), what other component must be removed from the pump mounting base?____________________________

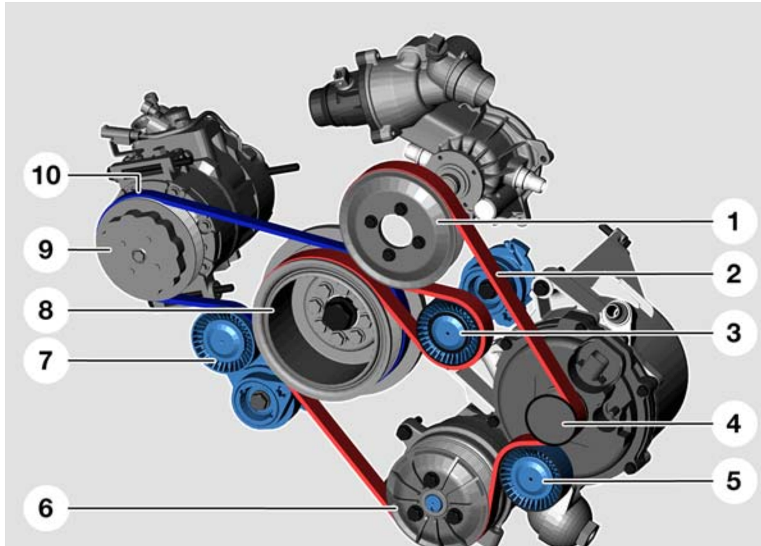
Why should caution be taken to not bend any of the high pressure fuel lines?________________________

DSC00579

Ancillary Components and Drive Belts - Removal

Remove the following components:

1. Water pump pulley
2. 6 rib main drive belt
3. Main drive belt tensioner
4. Alternator
5. Deflection pulley
6. Power steering and dynamic drive pump
7. A/C compressor drive belt tensioner
8. Crankshaft pulley
9. A/C compressor
10. 4 rib A/C compressor drive belt



KT-9644

To remove the drive belts:

The tensioning pulley is pushed back using a Torx tool in the recess provided (1) and fixed in this position by inserting a locking pin as shown (2).

42-02-16

The cooling module of the N73 includes an external engine oil cooler. The engine oil cooler is located in front of the engine coolant radiator above the A/C condenser.

The engine oil flows from the oil pump through a channel in the crankcase to a connection on the alternator support. The alternator support has an oil thermostat (arrow to the right).


DSC00629

A wax element in the oil thermostat opens the supply flow to the engine oil cooler from an oil temperature of 100 ºC to 130 ºC.

A partial amount of engine oil will permanently bypass the oil thermostat, even when it is fully open and flows uncooled through the engine.

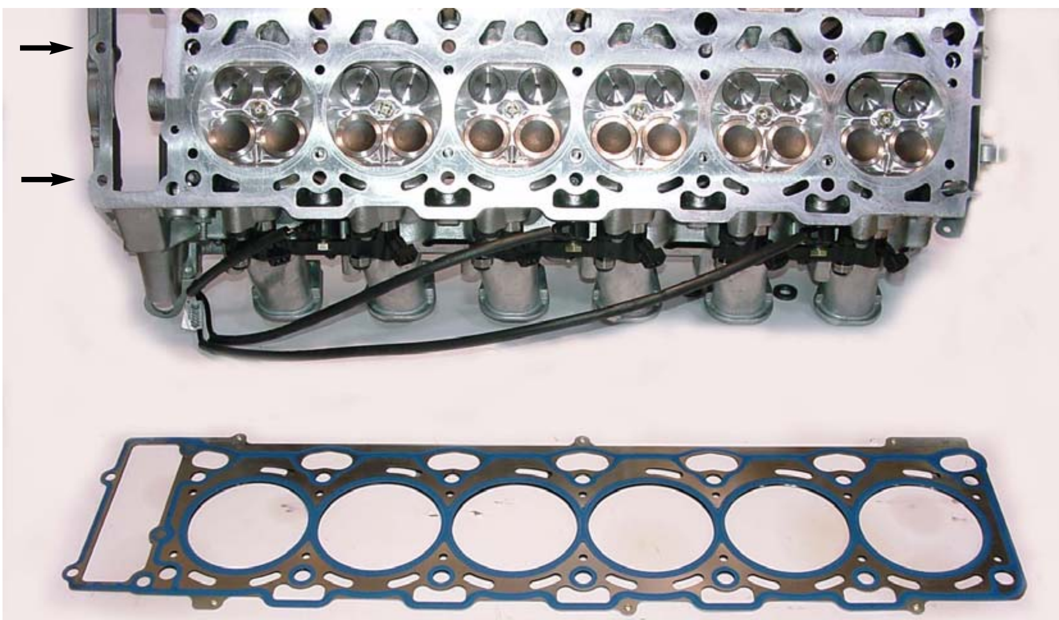
The engine oil cooler helps to keep the engine oil temperature below 150 ºC.

Cylinder Heads

The two N73 cylinder heads are a new development from BMW and have been adapted to the new direct injection system. The cylinder heads are equipped with Valvetronic valve gear and Bi-VANOS. The inlet camshaft and the Valvetronic eccentric shaft are jointly guided by a bridge support.

The ports for the high pressure fuel injectors are located on the intake side. The engine is equipped with a high pressure fuel pump for each cylinder head. Each cylinder head has a bucket-tappet drive on the exhaust camshaft for the high pressure fuel pump.

The secondary air ducts for subsequent exhaust gas treatment are integrated in the cylinder heads. The cylinder heads are cooled by the “cross-flow” principle. The cylinder heads are made from aluminum and are manufactured using gravity die-casting.



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Cylinder Head Gaskets

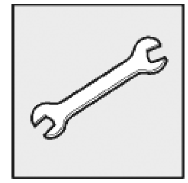
The cylinder head gasket is a triple layer steel gasket with rubber coating. This gasket version is already established in previous engines (N62).

The cylinder head bolts for the N73 engine are M10x160 necked-down “stretch” bolts.

Note: These bolts should always be replaced when repairs are performed.

The lower part of the timing chain housing is bolted to the cylinder head using two M8x45 bolts (arrows above).

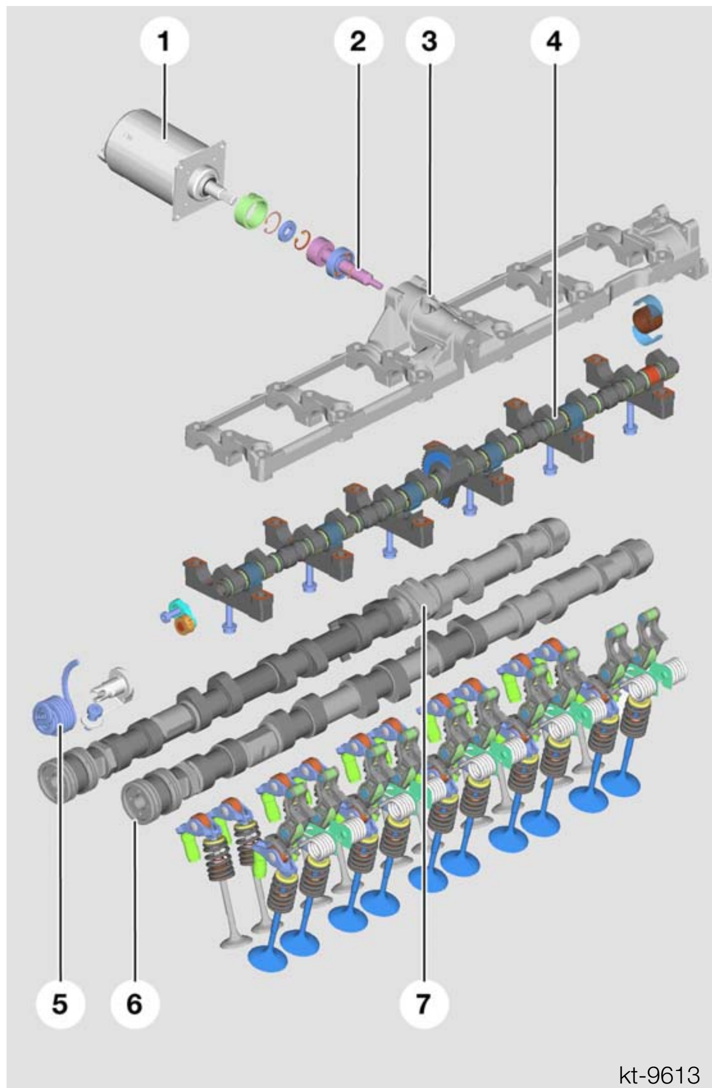
Cylinder Head - Preparation for Removal



- Rotate the engine and set up cylinder number 1 valve gear "timing" for cylinder head removal, remove the VANOS solenoids, front cover and Bi-VANOS units ***as per the Repair Instructions.***

Valvetronic

The Valvetronic system simultaneously varies the valve opening time and the intake valve opening lift between 0.3 mm and 9.85 mm, according to engine speed and load. This means that the air volume is controlled according to engine requirements. The valve gear is essentially the same as the N62 engine and has been adapted to the geometry of the N73 (with two more cylinders).



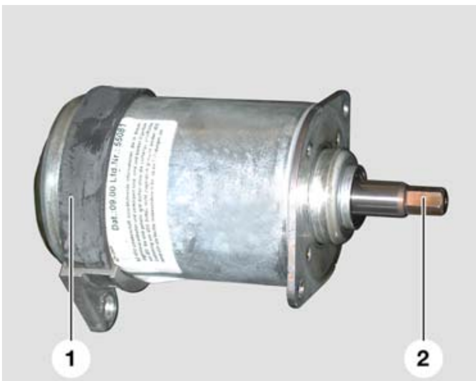
1. Valvetronic motor *
2. Intermediate shaft *
3. Bridge support *
4. Eccentric shaft
5. Torque compensation spring *
6. Intake camshaft
7. Exhaust camshaft with "triple" cam lobe for high pressure pump *

* Modifications have been made to these components making them different from the N62.

Note: To remove the cylinder head, it is necessary to remove the variable valve gear and eccentric shaft in order to gain access to the cylinder head bolts.

The Valvetronic motor is rubber mounted at the rear (1 lower left) to isolate it from the cylinder head cover. The Valvetronic motor is secured to the bridge support by the intermediate flange and has a hexagon drive (2 lower left), which engages into the intermediate shaft (7 lower right).

The intermediate shaft is mounted in the bridge support and is engaged by its spindle in the eccentric shaft teeth. This design provides ease of removal if the motor/gear fails.



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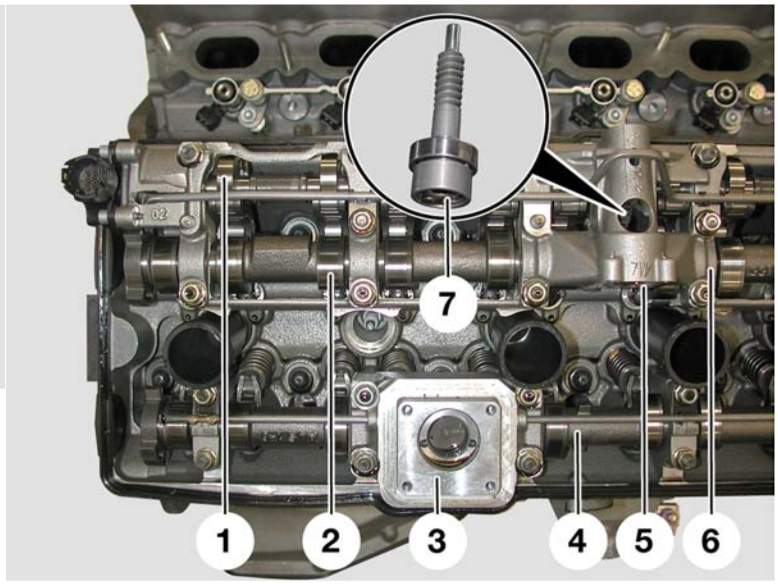

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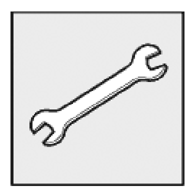
Diagram shown to the right:

1. Eccentric shaft
2. Intake camshaft
3. Mounting for high pressure fuel pump
4. Exhaust camshaft
5. Bridge support with receptacle for intermediate shaft and Valvetronic motor
6. Bridge support
7. Intermediate shaft

To remove the intermediate shaft, use the spanner tool #90 88 6 11 7 270 to unthread the locking collar (lower left). If you remove the outer snap ring (as shown lower right), the tensioning drive washer can be removed along with the tensioning ring behind it.

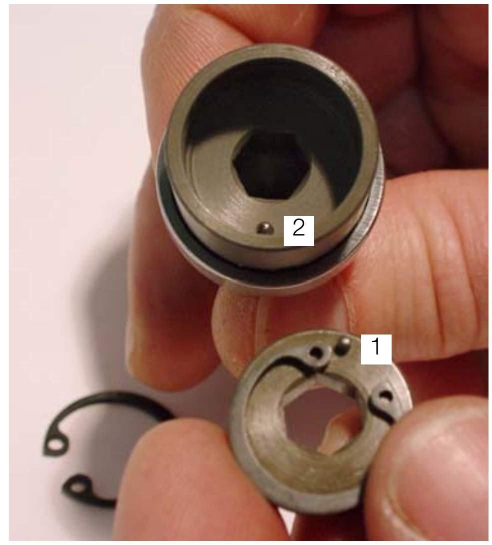


Note: When reinstalling the tension ring and tensioning drive washer, the ring eyelet must engage with the pin:

- On the drive washer (1)

and

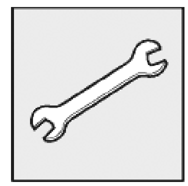
- In the intermediate shaft (2)



Test fit (insert) the Valvetronic motor hex shaft.

If it does not insert easily, remove the drive washer and flip the tension ring over to reassemble.

- Remove torque compensation spring and Valvetronic bridge support assembly *as per the Repair Instructions (N62 section can be used).*
- Remove bank 1 - 6 cylinder head.



Questions (N62 section can be used)

Can the N73 cylinder heads be machined? ______ *If so, what is the limit?* ____________

If so, how does this affect cylinder head gasket replacement? ____________

What is the correct torque procedure for the cylinder head bolts? ____________

How are the BI-VANOS units distinguished? ____________

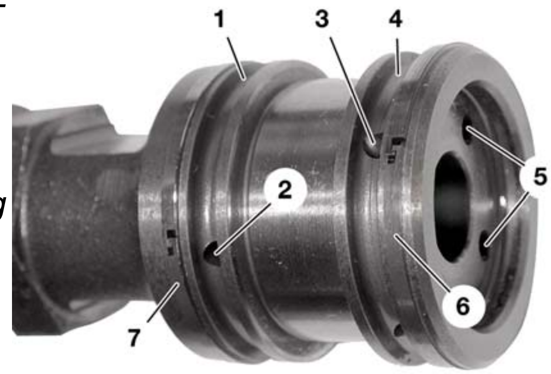
What special tools (numbers) are required for N73 valve gear timing?

How are the camshafts identified? ______________________________

What markings indicate correct camshaft bearing cap installation?
intake: ______________________________
exhaust: ______________________________

What is the correct postion for the hook sealing rings (6 & 7) when reassembling?

____

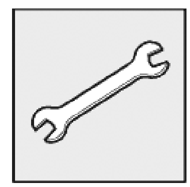


1&2. Rear Oil Duct with Four Holes
3&4. Front Oil Duct with Four Holes
5. Front Oil Duct Outlets
6&7. Hook Sealing Rings.

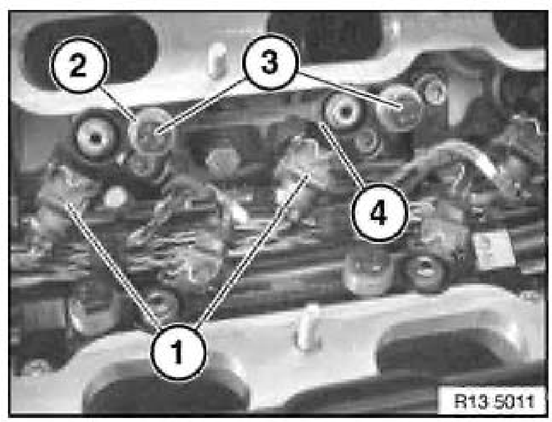
42-02-40

VANOS Oil Ports

Fuel Injector Removal

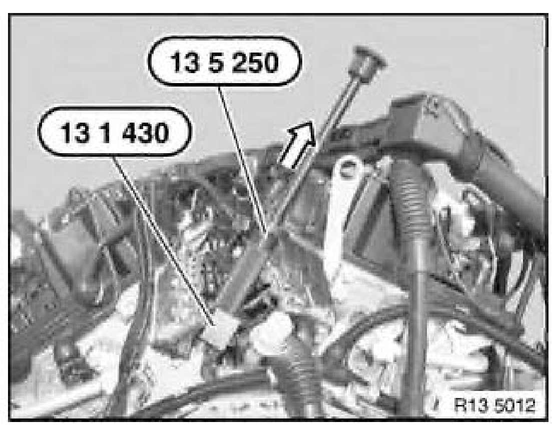


The fuel injector installed position and mounting pressure are maintained by a twin hold down fixture (one hold down fixture for every two fuel injectors).



The twin hold down fixtures are bolted to the cylinder head with spring washers, the correct mounting pressure is ensured by the contact pressure of the spring washers.

The high pressure fuel injectors are positioned on the intake side at a 30º angle to the cylinder head and reach directly into the combustion chamber between the two intake valves.



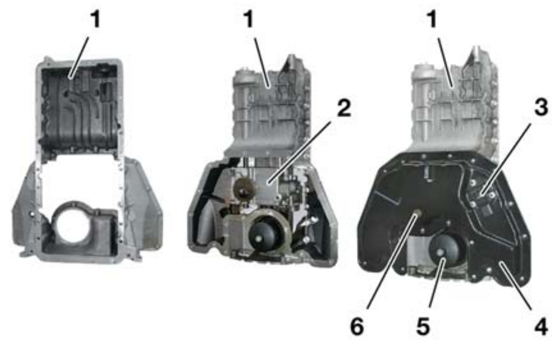
- Remove the fuel rail and disconnect plug connections (1).
- Remove bolts (3), nozzle holder (4), spring washers (2) and store exactly as removed for re-installation.
- Install special tool #13 1 430 and 13 5 250 on injector nozzles and drive out by slide hammering.

Engine Block

Oil Sump

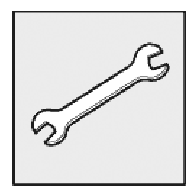
The oil sump consists of two parts. The upper section of the oil sump is made from cast aluminum and is sealed to the crankcase with a rubber-coated sheet steel gasket. This section of the oil sump has a cross shaped cut out oil filter element recess. The upper section of the oil sump is inter connected to the oil pump and is sealed with a sealing ring. The double panel (noise insulation) lower section of the oil sump is flanged to the upper section of the oil sump.

1. Upper Section of The Oil Sump
2. Oil Pump
3. Oil Level / Condition Sensor
4. Lower Section of The Oil Sump
5. Oil Filter Housing
6. Oil Drain Plug



42-03-65

Oil Sump Components



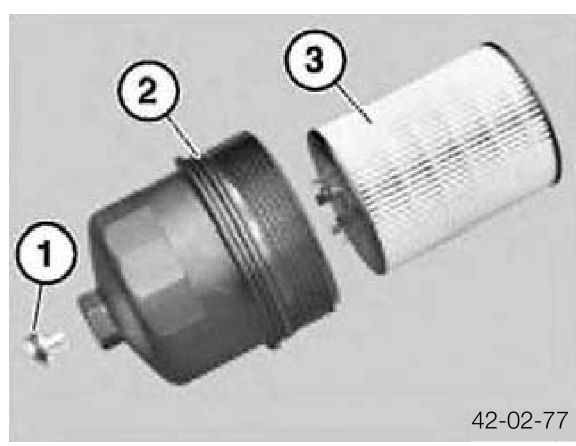
• Remove oil sump assembly and oil pump.

Oil Filter

The canister type oil filter (3) is located under the engine by the oil sump. The support for the oil filter is integrated in the rear oil pump cover. The oil filter housing (2 with o-ring) is threaded into the rear of the oil pump cover through an opening in the oil sump.

A drain plug is integrated in the oil filter housing for draining the filter assembly before the housing is removed (1 with o-ring).

The filter element support dome contains an over pressure relief valve. If the filter element is blocked, this valve allows a bypass of unfiltered engine oil around the element to supply lubrication to the engine.

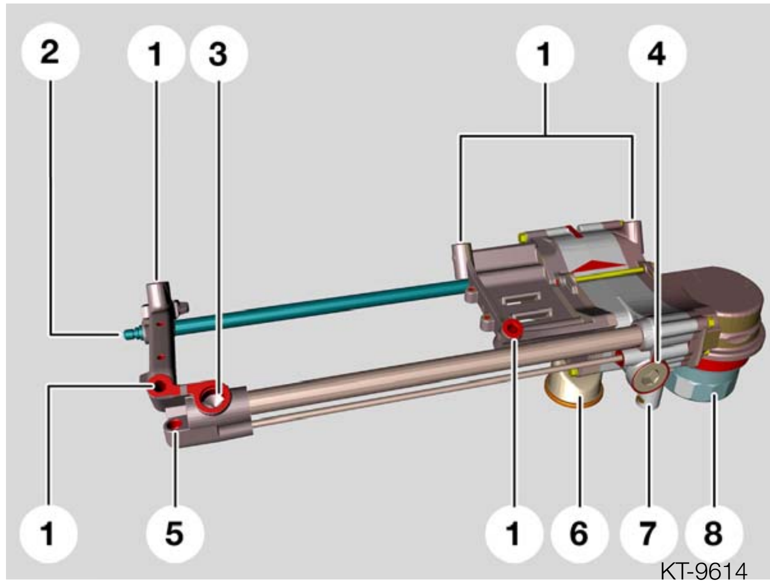


42-02-77

Oil Pump

The oil pump is mounted at an angle to the crankshaft bearing cap and is driven by the crankshaft using a roller chain. The oil pump is a two-stage gear oil pump with two gear clusters.

1. Mounting points
2. Oil pump drive shaft
3. Oil pressure from pump to engine
4. Control valve (Pump Stage/Pressure Control)
5. Oil pressure control tube from the engine to the control valve.
6. Oil pickup strainer
7. Pressure relief valve (over 15 Bar)
8. Oil filter



Oil Pump

Pressure Control

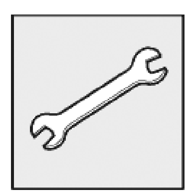
The oil pressure control valve in the oil pump has two functions:

1. Deactivates stage two oil pump circuit above 2 bar. Stage two is only active in the lower speed range. This is to ensure that there is always sufficient oil pressure for the VANOS units even at high oil temperatures and low speeds. The oil pump power consumption is reduced by deactivating stage two.

2. Monitoring the required oil pressure for the engine. The piston in the control valve is moved by a spring against the engine control pressure which is returning from the engine. This means that precise monitoring of the actual engine oil pressure is possible.

A separate pressure relief valve in the oil pump automatically opens at the maximum pressure of approximately 15 bar. This prevents damage in the oil pump especially at low oil temperatures.

- Disassemble oil pump for visual inspection.

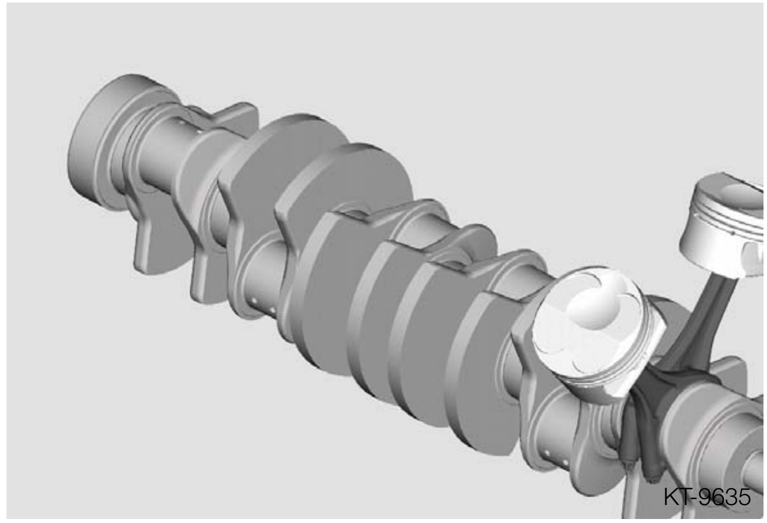


Crankshaft

The N73 uses a forged steel crankshaft (1 - front).

Each crankshaft throw has two counterweights for balancing the moving masses (12 counter-weights in total).

The crankshaft is supported by seven main bearings, the seventh is the thrust bearing.



Crankshaft

Crankshaft Thrust Bearing

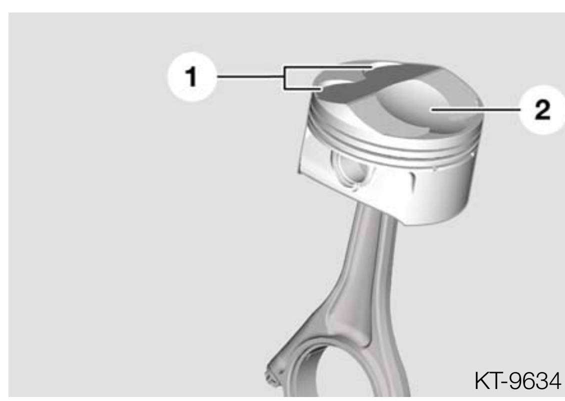
The thrust bearing halves are multiple pieces that are assembled as one part for the the number seven main bearing at the rear of the engine.

Piston and Connecting Rod

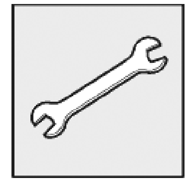
The iron coated cast aluminum alloy pistons are "domed" with valve reliefs in the crowns (1). The recess (2) directs the combustible mixture directly under the spark plug and prevents the combustion chamber from being divided into two parts.

Piston rings:
- First piston ring groove = square ring
- Second piston ring groove = taperface ring
- Third piston ring groove = two-part oil control ring

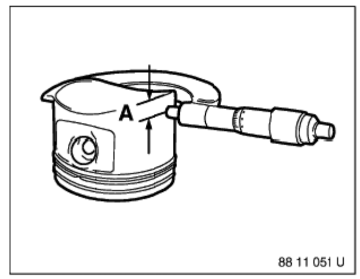
Note: Due to the shaping of the piston crown and the wrist pin offset, the pistons are cylinder bank specific (crown index arrow always points to the front of the engine).



The forged steel connecting rod and cap is separated by the familiar "cracked" process. The large end is angled at 30º allowing sufficient articulation in a very compact space. The pistons are cooled by oil jets spraying under the exhaust side of the piston crown.



- Remove piston/connecting rod assembly from any cylinder of the bank (caution - use care around the oil spray jet).
- Remove crankshaft thrust bearing cap for visual inspection.
- Measure the piston diameter.
- Measure the cylinder bore that the piston was removed from.

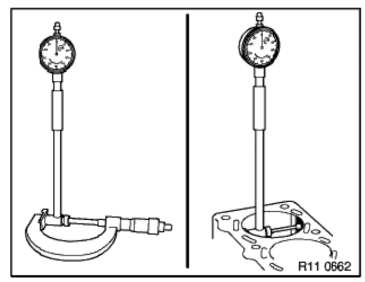


Questions (N62 section can be used)

What is the piston diameter? ______________

What are the cylinder bore measurements? Fill in the chart:

	Side to Side	Front to Back
Top		
Center		
Bottom		



What is the piston installation clearance on a "used" piston? ______________

What is the permissible total wear tolerance between piston and cylinder? ______________

What is the permitted out-of-round of a cylinder bore? ______________

What is the permitted conicity (taper) of a cylinder bore? ______________

How are the pistons identified for the cylinder bank? ______________

What is the correct way to install connecting rods (on the pistons) for cylinder bank 1 - 6?

____

____

Crankcase

The crankcase is a one-piece "open deck" design and is made entirely from AluSil. In mass production, the cylinder bores are finished by an etching procedure. This involves etching out a thin aluminium layer from the cylinder walls. By doing this, the high strength silicon crystals are exposed. The silicon crystals form a high strength running surface for the pistons.

Open Deck: Exposed cylinder coolant jacket

kt-9588

Lubrication System - Technical Data

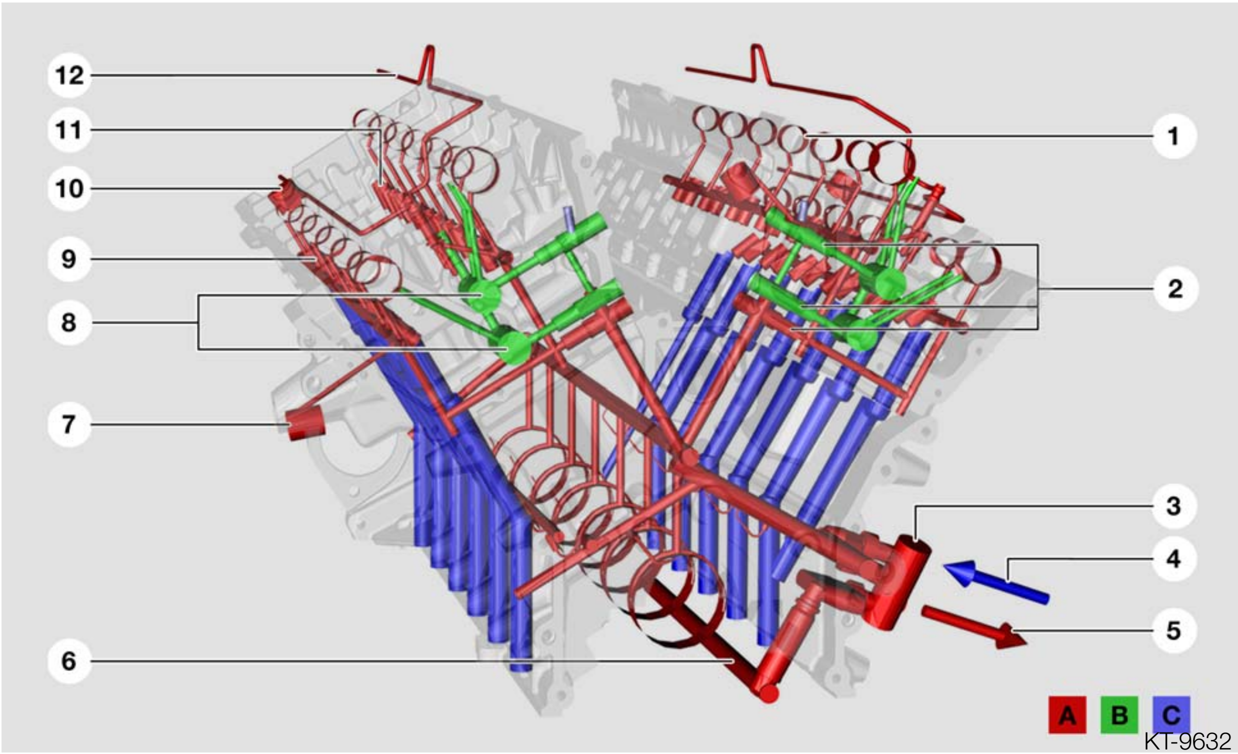
The recommended oil is BMW High Performance 5W-30 Synthetic Oil
* P/N 07 51 0 017 866

Oil Capacity in Liters (quarts)	Explanation
8.5 (9.0)	Filling capacity with oil filter change

Oil Pressure in Bar	Explanation
1.0	Minimum oil pressure @ 20° C
4.0 - 8.0	Maximum oil pressure @ 20° C

Oil Delivery Capacity	Explanation
9 - 12 liters/minute	At idle speed (550 rpm) @ 20° C
50 - 55 liters/minute	At maximum engine speed (6500 rpm) @ 20° C

Lubrication System



Oil Circuit (view from engine front)

A. Oil pressure from oil pump
B. Oil supply to VANOS units
C. Oil return
1. Oil supply to intake camshaft
2. Oil non-return valves
3. Oil circuit in oil thermostat
4. Oil return from oil cooler
5. Oil supply to oil cooler
6. Oil supply from oil pump
7. Oil supply , chain tensioner
8. Oil supply , VANOS solenoid valves
9. Oil supply to exhaust camshaft
10. Oil supply to high pressure injection pumps
11. Oil supply to HVA elements
12. Oil supply to Valvetronic eccentric shaft

The engine oil is supplied by the oil pump to the lubrication points in the engine block and is pumped into the cylinder heads. The following components in the crankcase and cylinder head are supplied with engine oil:

Crankcase

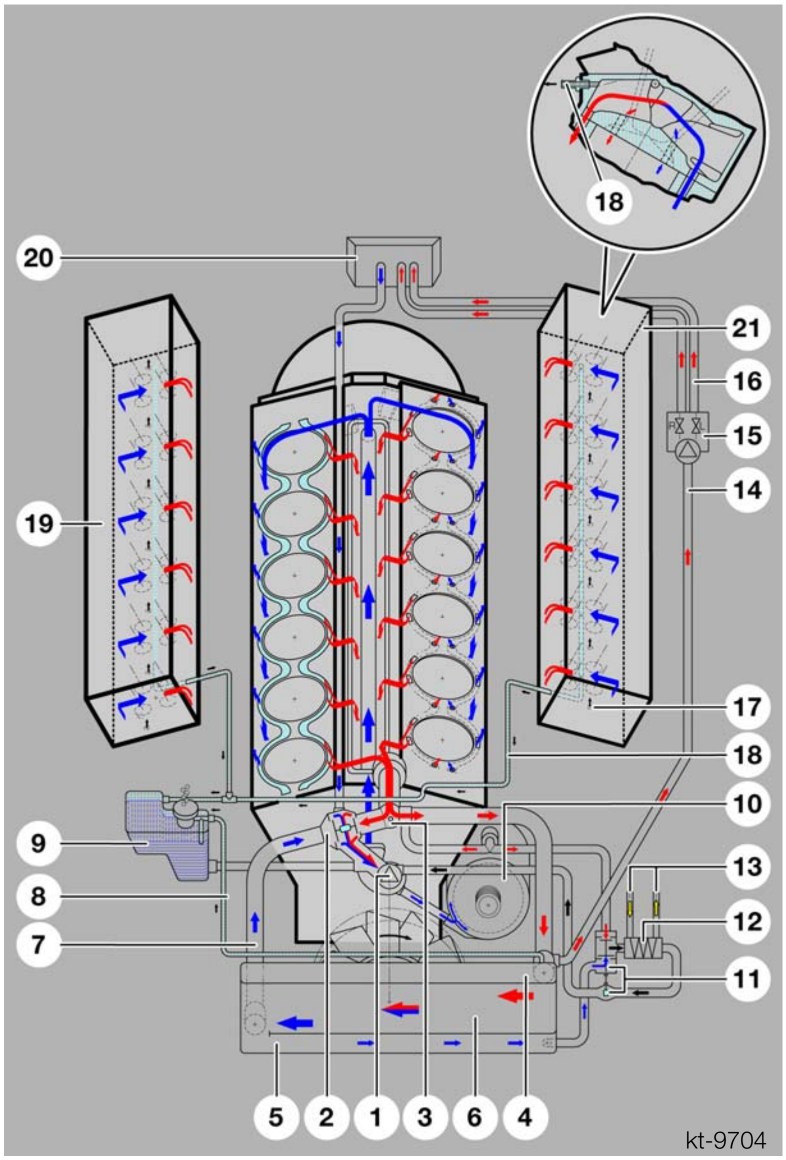
- Crankshaft bearings
- Oil jets for piston cooling
- Oil jet for the drive chain (bank 7-12)
- Tensioning rail for drive chain (bank 1-6)

Cylinder head

- Chain tensioner
- Guide rail on cylinder head
- Hydraulic valve adjustment elements (HVA)
- VANOS supply
- Camshaft bearings
- Overhead oil tubes for the valve gear

Cooling System

Coolant Circuit - 14.94 Liter (15.8 Quart) Capacity



Cooling System (Circuit Flow)

1. Water pump
2. Thermostat housing with MAP thermostat
3. Coolant temperature sensor
4. Radiator
5. Partition wall (low temperature area)
6. Radiator (high temperature area)
7. Return flow (cool)
8. Radiator vent line
9. Coolant reservoir
10. Water cooled alternator
11. Thermostat for transmission oil heat exchanger
12. Oil/water heater exchanger for automatic transmission
13. Transmission oil line connections
14. Heater supply hose (hot)
15. Water valves / electric pump
16. Heater inlet hoses
17. Holes (cylinder jacket venting)
18. Cylinder head vent hose
19. Cylinder head, bank 1-6
20. Heater core(s)
21. Cylinder head, bank 7-12

Coolant Circuit

The coolant flow has been optimized allowing the engine to warm up as quickly as possible after a cold start as well as even and sufficient engine cooling while the engine is running. The cylinder heads are supplied with coolant in a cross-flow pattern. This ensures more even temperature distribution to all cylinders.

The cooling system ventilation has been improved and is enhanced by using ventilation ports in the cylinder heads and in the radiator. The air in the cooling system accumulates in the reservoir/expansion tank. When a pressure of 2 bar is reached in the expansion tank, the air is bled out by the pressure relief valve in the reservoir cap.

Note: The ventilation ports in the front of the cylinder heads provide quicker “self bleeding” during a routine coolant exchange. The complex cooling system and the small ventilation ports require that time should be allowed after the cooling system has been filled for the air to escape.

Coolant flow in the Engine Block (similar to N62)

The coolant flows from the water pump through the feed pipe in the engine's V and to the rear of the engine block. This area has a cast aluminum cover. From the rear of the engine, the coolant flows to the external cylinder walls and from there into the cylinder heads.

The coolant then cross flows through the cylinder heads (exhaust to intake) into the engine block inner coolant jacket into the engine “V” and through the return connection to the thermostat housing. When the coolant is cold it flows from the thermostat (closed) directly into the water pump and back to the engine (recirculating for faster warm up).

When the engine reaches operating temperature (85 ºC-110 ºC), the thermostat opens the entire cooling circuit to include the radiator.

Notes:

The coolant flows to the rear of the engine block, from there through the side channels to the cylinder walls and then into the cylinder heads (lower left picture). The cast aluminum cover at the rear of the engine block (with sealing bead) is shown on the lower right.

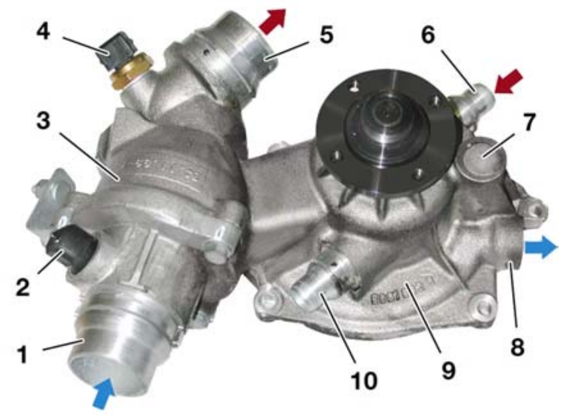
42-02-59

42-02-58

Water Pump/Thermostat Housing

The water pump is combined with the thermostat housing and is bolted to the timing case lower section.

1. Map-controlled themostat (radiator cool return flow).
2. Electrical connection for Thermostat Heating element.
3. Thermostat Mixing Chamber
4. Temperature Sensor (hot coolant from engine)
5. Radiator in-flow (hot coolant from engine)
6. Heat exchanger (transmission oil return flow)
7. Leakage Chamber (evaporation space)
8. Alternator in-flow (cool supply)
9. Water Pump
10. Expansion Tank Connection



42-02-60

Water Pump / Thermostat Housing

Caution during installation of the water pump: The impeller is made from reinforced plastic.

- Reassemble engine using your notes taken during disassembly in addition to the Repair Instructions.

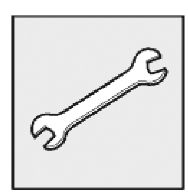


Table of Contents

MED 9.2.1 Engine Management System - Workbook

Subject **Page**

MED 9.2.1 Engine Management System

Model: E66 - 760Li

Production Date: MY 2003

Manufacturer: Bosch

Pin Connector: 134 Pins - 5 Modular Connectors per Control Module

This intent of this workbook is to assist you with diagnosis and testing in addition to the detailed information found in the the latest Diagnosis and TIS of the DISplus/GT1.

This section will be instructor led for a brief review of the MED 9.2.1 Engine Management System. You are encouraged to use this workbook with the latest Diagnosis and TIS information to make notes during diagnosis and testing of the ***new/unique components of the MED 9.2.1 system.*** This will be valuable to you as supplementary information or a memory refresher when performing diagnosis in the future.

Note: For more in depth and detailed information about the MED 9.2.1 Engine Management System, refer to the ST047 2003 Systems Diagnosis training manual.

For additional and updated information, always refer to:

www.bmwcenternet.com
- Diagnosis and TIS information/updates
- Service Information Bulletins
- DCS messages

Objectives:

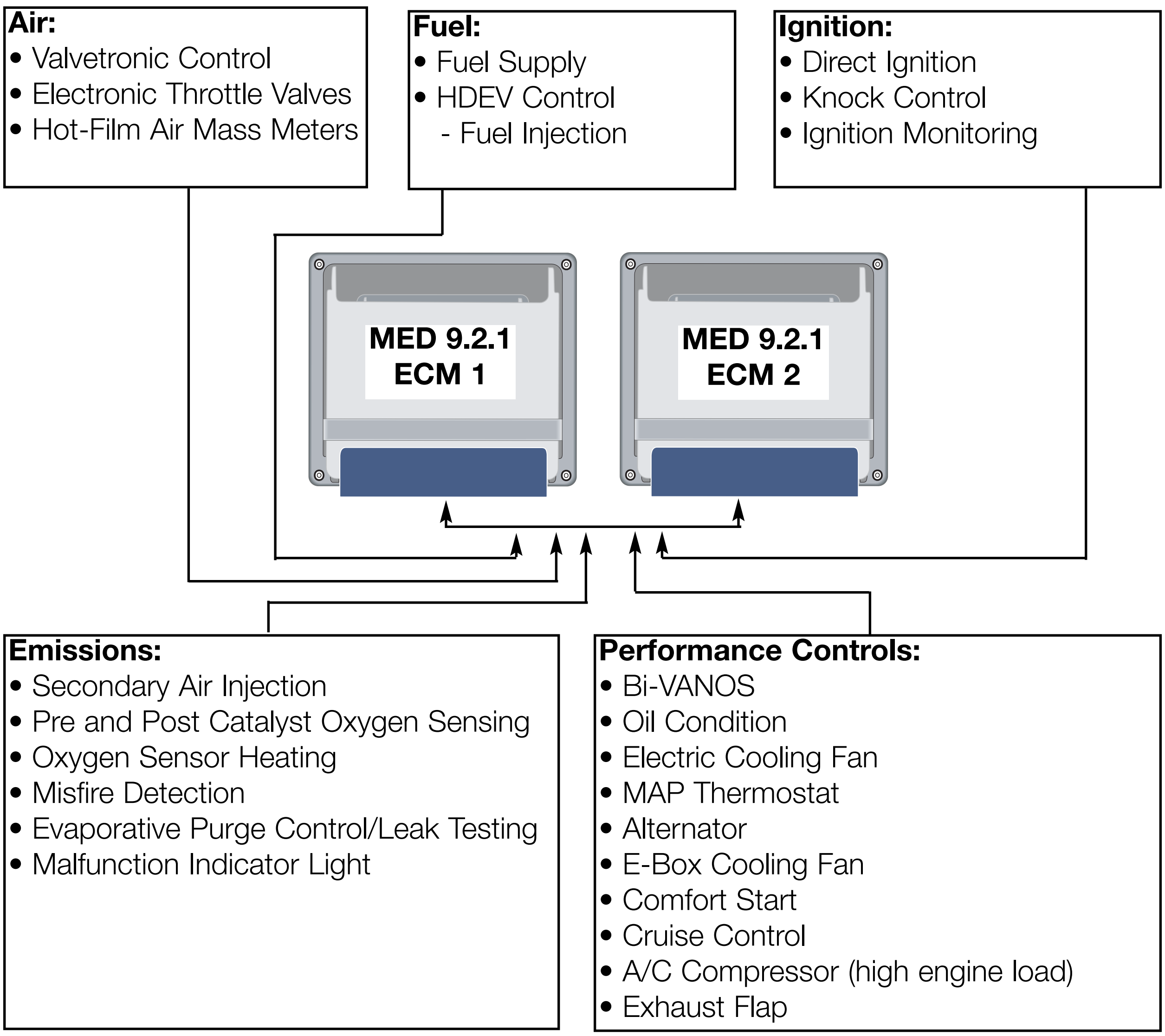
After completion of this module you will be able to test and diagnose the following:

- Integrated Voltage Supply Module
- Local-CAN bus
- Auxiliary Air Flaps
- Intake Manifold Pressure Sensors
- High Pressure Injection System
- Direct Injection System Control
- Bosch LSU Planar Wideband Oxygen Sensor
- Exhaust Flap

MED 9.2.1

Purpose of the System

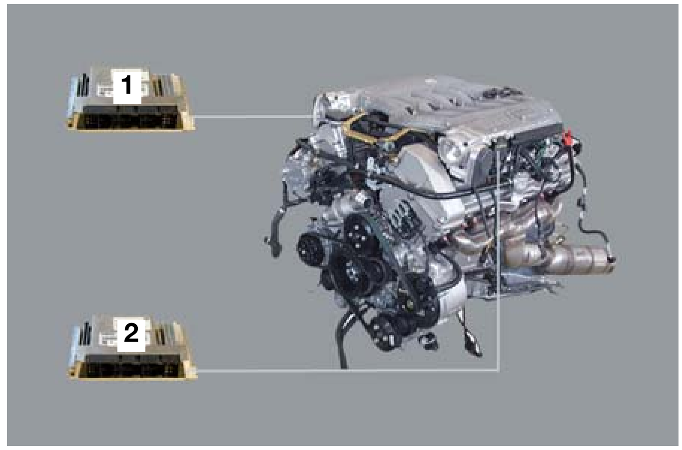
The MED 9.2.1 system manages the following functions:



The basic engine management inputs, processes and outputs are not included in this workbook because they have not changed, refer to the ST055 Engine Electronics hand out for details. Some components and functions are the same as the ME 9.2 Engine Management System found in the E65/E66. Refer to the ST042 E65 Part 2 hand out for details.

System Components

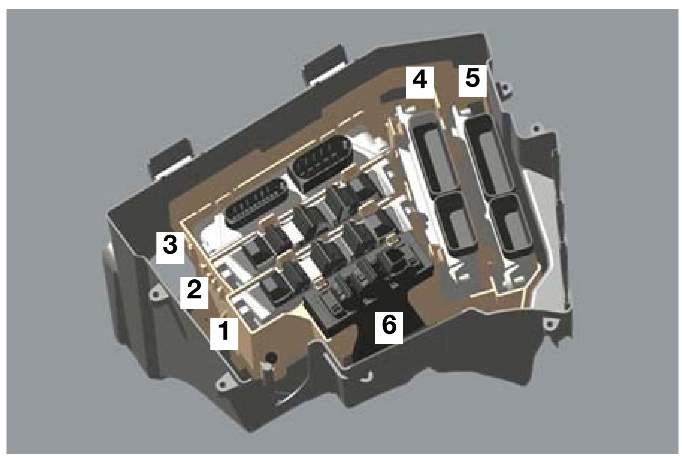
MED 9.2.1 Engine Control Modules - New Features: This Bosch Engine Management System is introduced for more stringent emission requirements as well as reducing fuel consumption and increasing driving performance. Flash EEPROMs (additional 1 MB flash memory) are used as the storage medium for program data, fault code memory as well as the adaptation values.



The 134 pin MED 9.2.1ECMs are manufactured by Bosch to BMW specifications. The ECM is the SKE (standard shell construction) housing and uses 5 modular connectors.

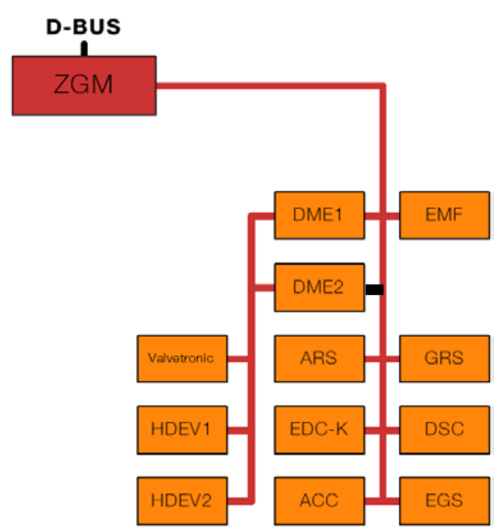
For testing, use the Universal Adapter Set (break-out box) Special Tool: ***# 90 88 6 121 300***

The ECMs work in combination with the Valvetronic Control Module. The N73 engine has a total of 5 control modules to manage the engine functions:



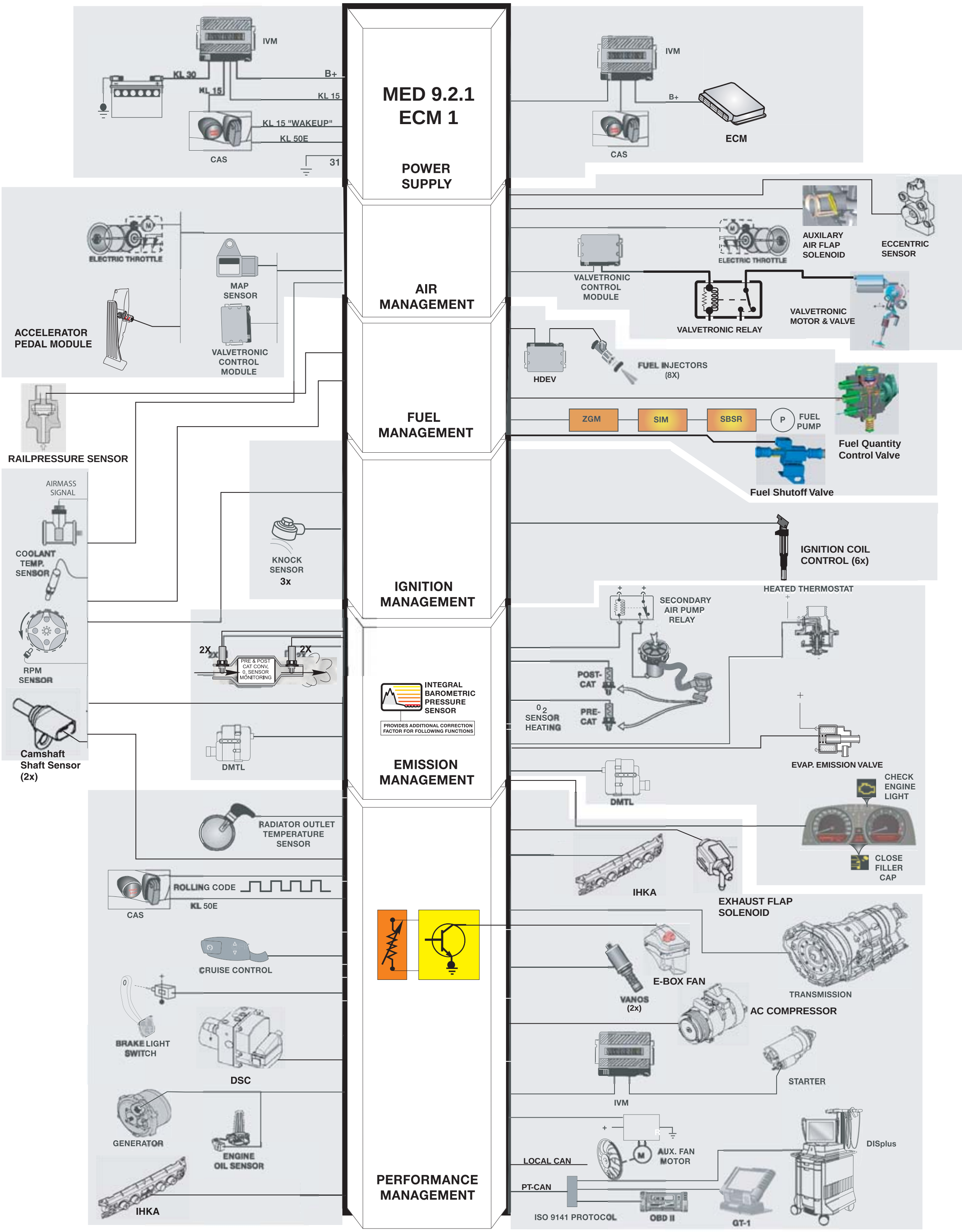
1. MED 9.2.1 ECM 2 - overall engine management
2. MED 9.2.1 ECM 1 - overall engine management
3. Valvetronic Control Module - intake valve lift
4. High pressure fuel injector control module (HDEV) - activates injector group for one bank
5. High pressure fuel injector control module (HDEV) - activates injector group for one bank

These modules are located in the electronic box in the engine compartment together with the Integrated Voltage Supply Module (6).

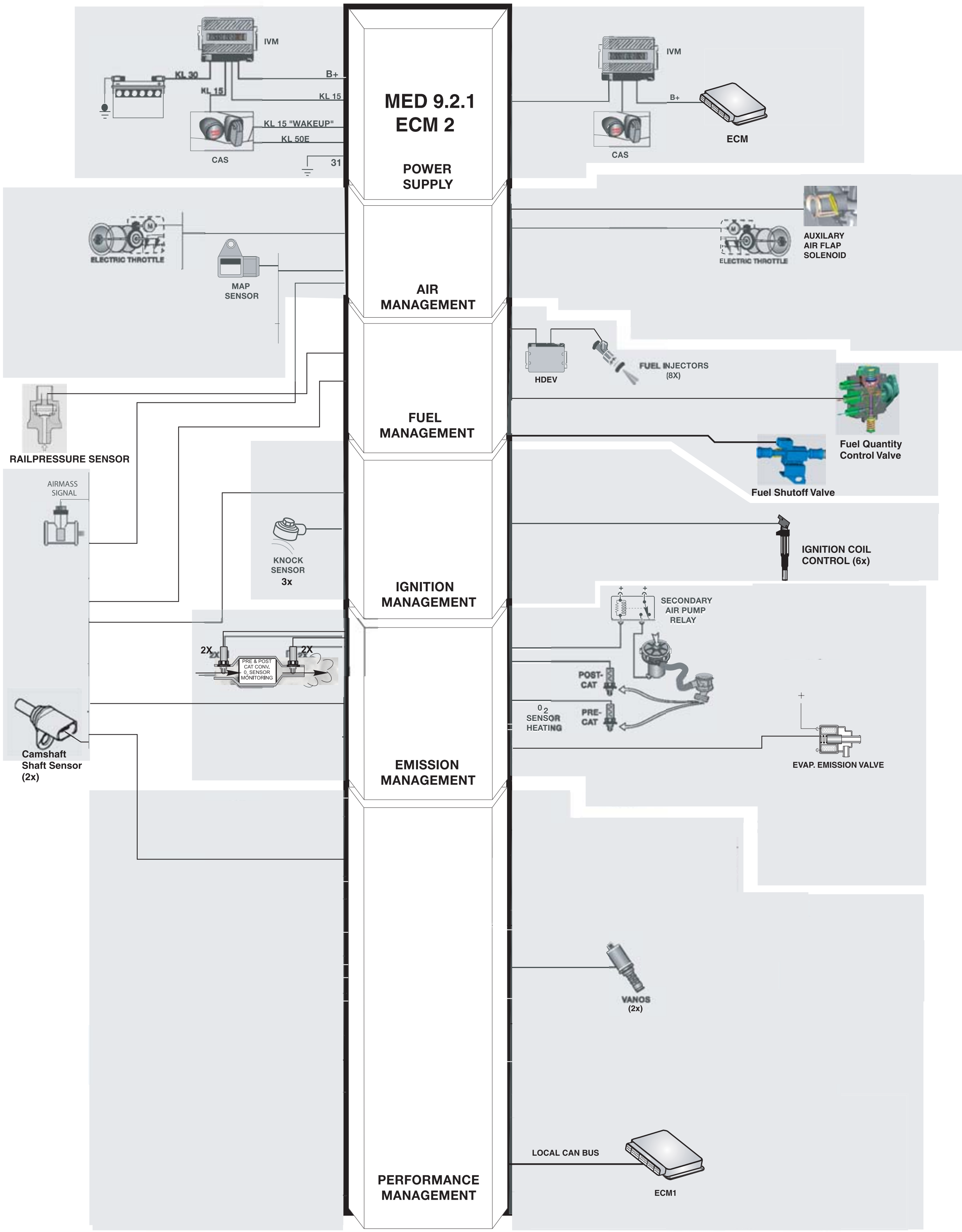


The ECM controls an electric cooling fan in the base of the electronic box to draw in cool air from the passenger compartment.

MED 9.2.1 ECM 1 Inputs - Processing - Outputs



MED 9.2.1 ECM 2 Inputs - Processing - Outputs



Principle of Operation

The ME 9.2 Engine Management System from the N62 engine provides the basis for the MED 9.2.1 Engine Management System.

The main distinguishing features of the MED 9.2.1 are:

- Extended computer capacity (additional 1 MB flash)
- Modified oxygen sensor chip which permits detailed diagnosis of the oxygen sensors
- One MED 9.2.1 control module for each cylinder bank
- Power is supplied to the high pressure fuel injectors for each cylinder bank by a high pressure fuel injector control module (HDEV)
- Omission of DISA and variable intake manifold activation (N62)
- Three knock sensors for each cylinder bank
- Activation of the auxiliary air flaps in the air cleaner housing
- Rail pressure sensor
- Fuel quantity control valve

An MED 9.2.1 control module is used for each cylinder bank. Both control modules are the same design and are classified into ECM 1 and ECM 2 by the programming. ECM 1 receives the input signals from a sensor or switch:

- Accelerator pedal module
- Oil condition sensor
- Alternator
- Coolant temperature
- Oil pressure

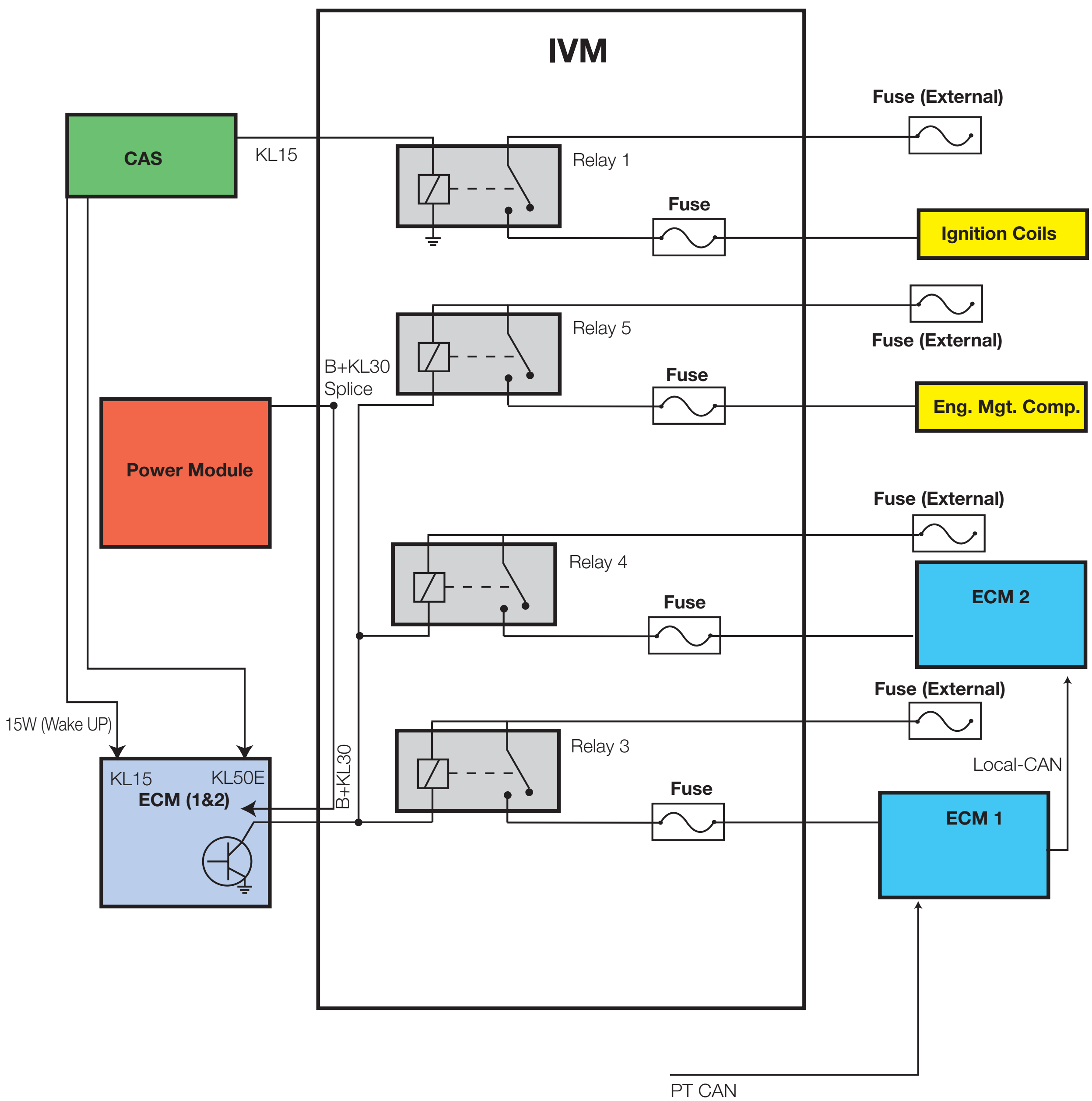
ECM 1 transmits these signals via the Local-CAN bus to ECM 2. All further input signals are transmitted directly to the control module responsible for the relevant cylinder bank (see overview pages 5 and 6).

Output signals which relate to not just one cylinder bank (e.g. electric fuel pump or exhaust flap) are transmitted by ECM 1 to the corresponding actuators. The crankshaft sensor signal is transmitted simultaneously to both control modules.

The MED 9.2.1 regulates the injected fuel quantity. For this purpose, the MED 9.2.1 receives the rail pressure sensor signals and regulates this pressure with the fuel quantity control valve according to the value defined by the program map. This ensures that a defined quantity of fuel is injected over the injection period.

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.



47-04-04

1. What pin and connector number of ECM 1 and ECM 2 supplies ground to the ECM (main) relays?

   ECM 1 ______________ ECM 2 ______________

2. What fuse(s) (numbers) supply operating voltage from relay 1 to the ignition coils of:

   Cylinder bank 1-6 ______________ Cylinder bank 7-12 ______________

3. If fuse 005 from relay 3 were defective, what control modules would be affected?

4. Relay 5 supplies operating voltage to what components?

5. What type of signal is found on pin 26 (X60204) of ECM 2? ______________

   Is this signal an input or output? ______________

   Where does this signal originate? ______________

   What is the voltage value? ______________

   Does ECM 1 receive this signal? ______________

6. What type of signal is found on pin 7 (X60201) of ECM 2? ______________

   Is this signal an input or output? ______________

   Where does this signal originate? ______________

   What is the voltage value? ______________

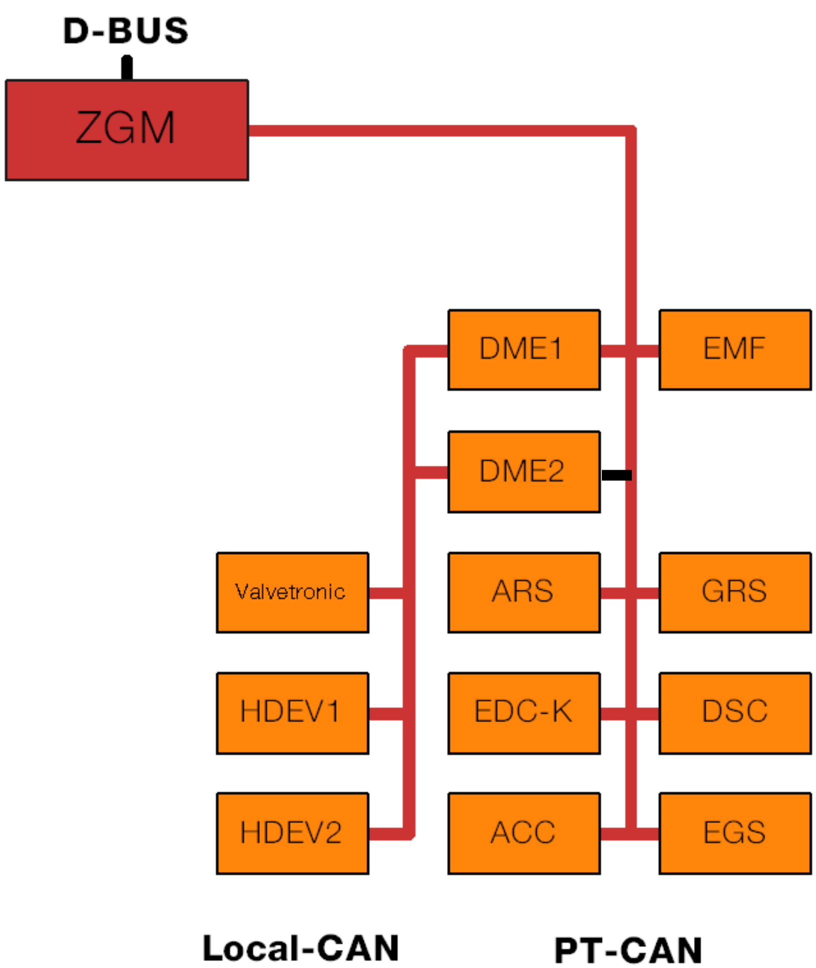
   Does ECM 1 receive this signal? ______________

Indirect Signals and Wiring

The ECMs are not directly connected to the OBD diagnostic connector. The OBD diagnostic connector is connected to the ZGM. Both ECMs are connected to the ZGM (central gateway module) by the PT-CAN bus. ECM 2 is also connected via the Local-CAN bus to ECM1. The ECMs are also connected to the Valvetronic control module and HDEV control modules by the Local-CAN bus. Valvetronic faults are stored in the ECMs.

The ECMs are classified into ECM 1 and ECM 2 by the wire harness connections (color coded) and location. ECM 1 receives the input signals from a sensor or switch and transmits these signals via the Local-CAN bus to ECM 2. All further input signals are transmitted directly (via hardwire harness) to the control module responsible for the relevant cylinder bank.

Output signals which are required for both cylinder banks are transmitted by ECM 1 to the corresponding actuators. The crankshaft sensor signal is transmitted simultaneously to both control modules.



KT-9715

PT-CAN

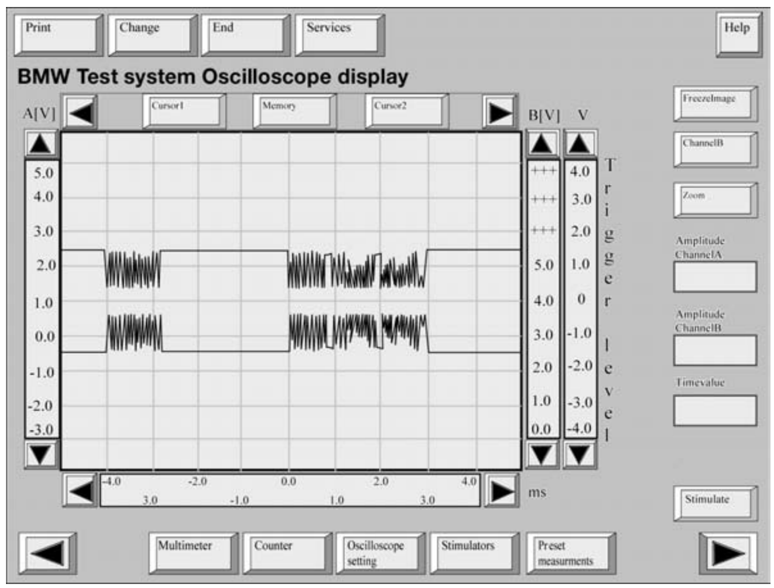
1. What are the circuit descriptions of the three wires that make up the PT-CAN bus?

______________________ ______________________ ______________________

2. Record the voltage levels on the PT-CAN bus (high and low) using the DISplus scope as shown - when the bus is:

Inactive - high ______ *low* ______ *Active - high* ______ *low* ______

Notes on setup: ______________



47 002

Local-CAN

1. What are the circuit descriptions of the two wires that make up the Local-CAN bus?

______________________ ______________________

2. Record the voltage levels on the Local-CAN bus (high and low) using the DISplus scope - when the bus is:

Inactive - high ______ *low* ______ *Active - high* ______ *low* ______

3. What pin and connector numbers did you test the Local-CAN bus circuit on ECM 1?

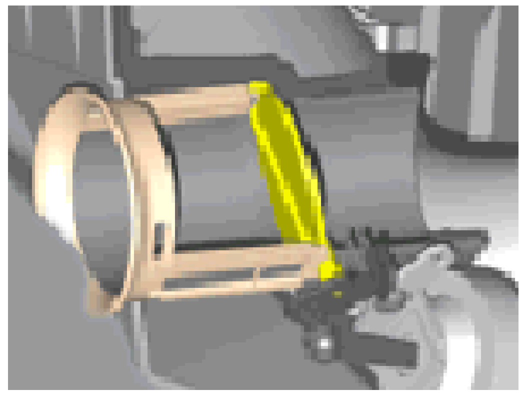
Pins ______________ *Connector* ______________

4. Are you able to test the Local-CAN bus for resistance? _________ *Value:* _________

Air Management

Auxiliary Air Flaps: Each air cleaner housing incorporates an auxiliary air flap in its side wall. The auxiliary air flaps supply the engine with enough air volume to attain the maximum performance. The auxiliary air flaps are closed in the lower rpm ranges so that only cooler ambient air is drawn in for hot idling and stop and go driving.

The auxiliary air flaps are actuated by vacuum diaphragms which are located inside the air cleaner housings. Both diaphragms are supplied with vacuum from a common solenoid valve.



The auxiliary air flaps are fully opened by the ECM:

- In driving position “D” with kickdown operation from 3500 rpm
- In driving position “S” from 3000 rpm and simultaneous full load recognition.

10-15% additional air is drawn in from the engine compartment when the auxiliary air flaps are open. It is not necessary to draw in additional cold air from outside the engine compartment since the engine compartment is adequately ventilated at full load.

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

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

This vacuum is set by the electronic throttle valves (4) and monitoring with the intake manifold pressure sensors.

Shown to the right is the intake manifold (upside down) with both sensors (1).

KT-9589

Auxiliary Air Flaps

1. *What are the pin and connector numbers at the ECM (1 or 2) for the auxiliary air flap vacuum solenoid?* ______

2. *Is there a Test Plan available for the auxiliary air flaps?* ______

3. *Select Control Unit Functions (MED 9.2.1), Diagnosis Requests. Is there a status under the "Part Functions" column for observing the "Messages and Results"?* ______

   Is there a "Component Activation" feature for the auxiliary air flaps? ______

Intake Manifold Pressure Sensors

1. *What are the pin and connector numbers at the ECM (1 or 2) for the pressure sensors?*

   Pins ______ *Connector* ______

2. *Is there a Test Plan available for the pressure sensors?* ______

3. *Select Control Unit Functions (MED 9.2.1), Diagnosis Requests. Is there a status under the "Part Functions" column for observing the "Messages and Results"?* ______

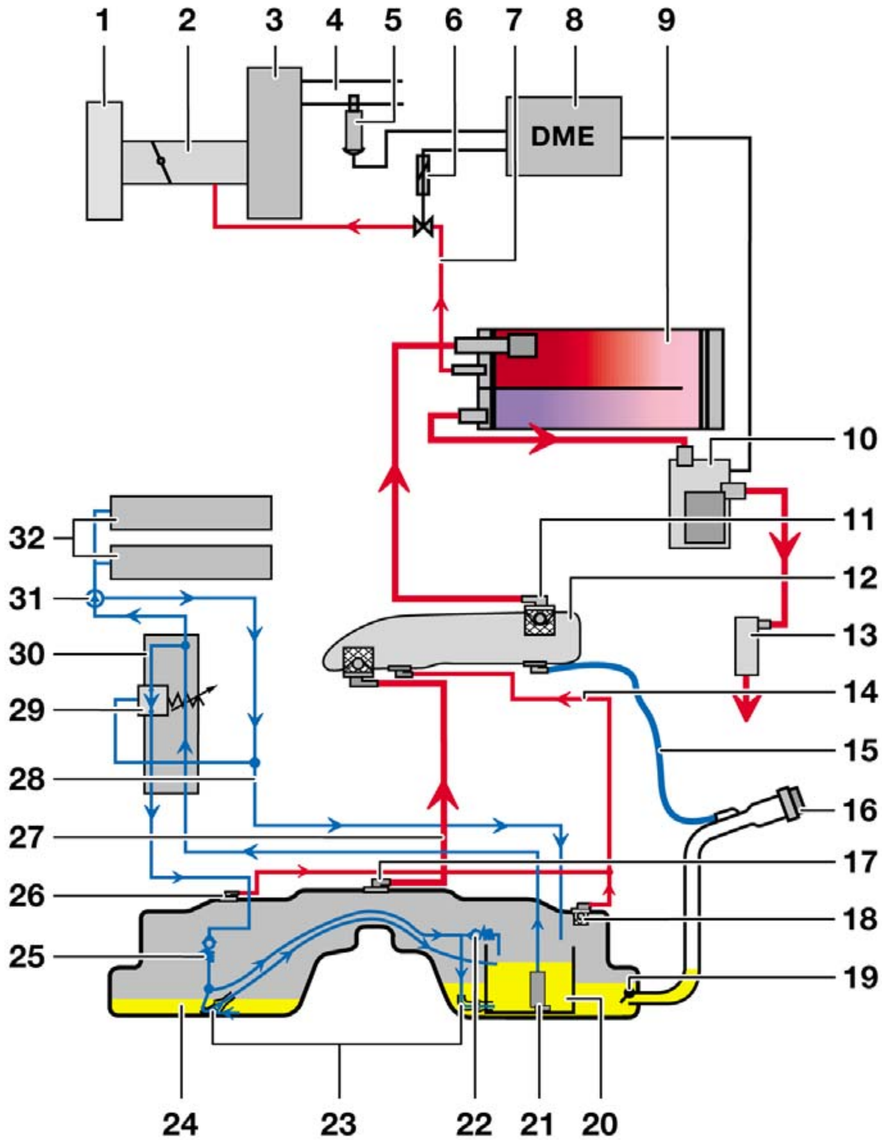
4. *What is the value at idle speed?* ______ *mbar*

5. *What is the voltage value at pin 2 (X60103) of ECM 1 at:*

   Idle speed ______ *2000 rpm* ______

6. *With the ignition off, unplug the electronic throttle valve (on the bank you are testing). Restart the engine and check the value at idle speed.* ______ *mbar*

Fuel Management



KT-9780

1. Air cleaner
2. Intake manifold
3. Engine
4. Exhaust system
5. Oxygen sensor
6. Evaporative emission valve (TEV)
7. Purge vapors
8. MED 9.2.1 ECM
9. Carbon Canister
10. Fuel tank leak diagnostic module (DM TL)
11. Roll-over valve
12. Liquid/vapor expansion tank
13. Dust filter
14. Service ventilation
15. Pressure test lead
16. Fuel tank filler cap
17. Filler vent valve
18. Service vent valve (float valve)
19. Anti-spitback flap
20. Surge chamber (fuel pump baffling)
21. Electric fuel pump (EKP)
22. Pressure relief valve
23. Suction jet pumps
24. Fuel Tank
25. Outlet protection valve
26. Service vent valve (float valve)
27. Refueling breather
28. Leakage line
29. Fuel pressure regulator (6 bar)
30. Fuel filter
31. High pressure fuel pump (HDP)
32. Fuel rails

Fuel Supply System: For the N73 engine, minor modifications have been made to the fuel supply system to adapt it to the direct injection system. The additional features are:

- Leakage line
- Electric fuel pump with increased delivery

The N73 in tank electric fuel pump is a roller cell type (EKP Bosch 3.1) with an increased delivery pressure of ***6 bar***. This pressure is required to adequately supply the high pressure fuel pumps.

Fuel Supply System Components:

- Fuel tank (24)
- Surge chamber (20)
- Fuel pump (21)
- Two suction jet pumps (23)
- Outlet protection valve (25)
- Pressure relief valve (22)
- Internal tank fuel lines
- Fuel filter with fuel pressure regulator (30&29)
- High pressure fuel pump (HDP)
- Fuel rails with injection valves (32)

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 high pressure fuel pumps (HDP). 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 ***6 bar*** and feeds the excess fuel in the return flow back into the tank.

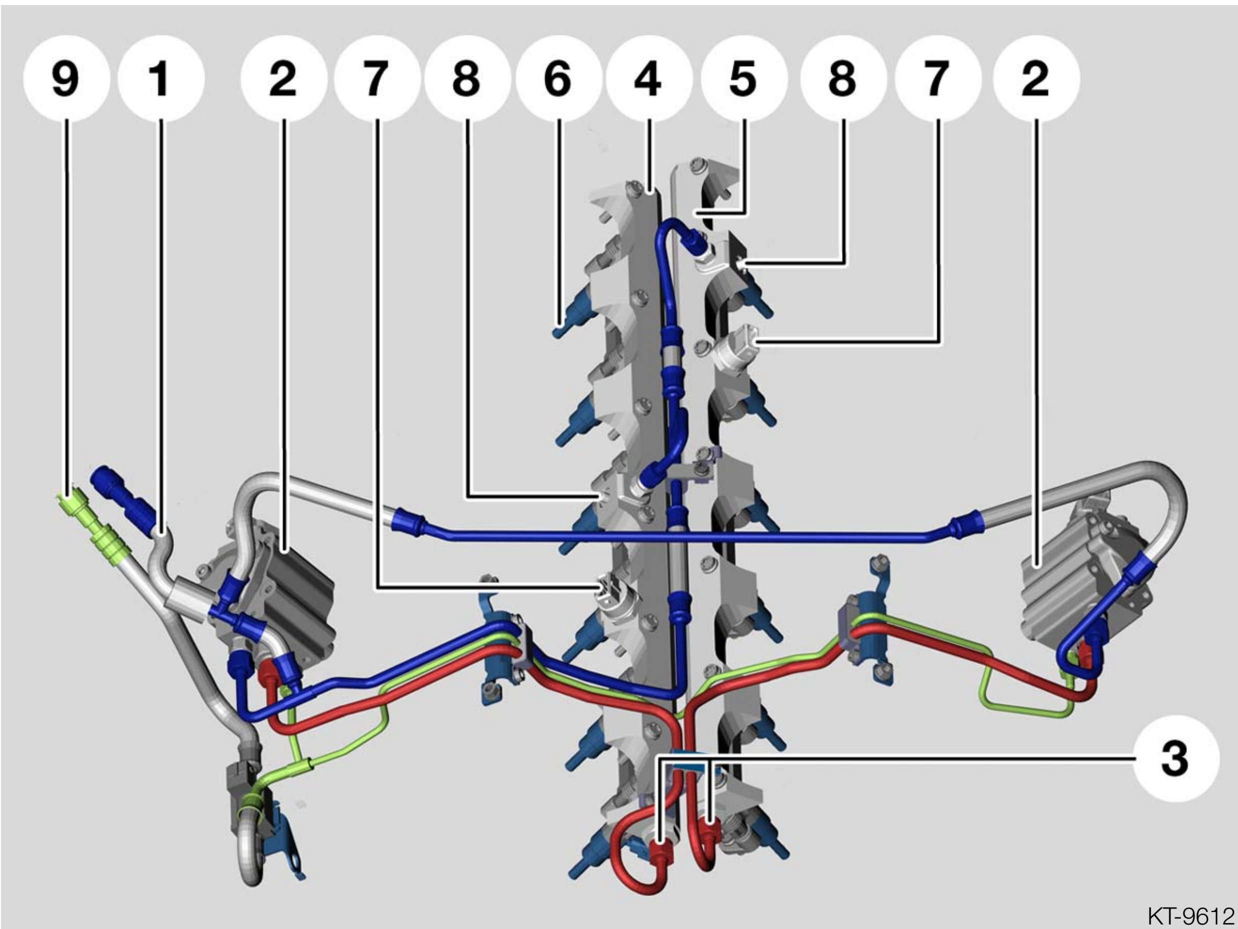
The pressure regulator valve in the return flow sets a return pressure of 1.0 - 1.5 bar. This pressure prevents fuel vapor locks in the return flow and also ensures operation of the two suction jet pumps.

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. 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.***

High Pressure Injection System: A BMW gasoline direct injection system is used for the first time in the N73 engine series. Each fuel rail is supplied with fuel by a high pressure pump (HDP), which is driven via a bucket tappet by a triple lobe cam on the exhaust camshaft.

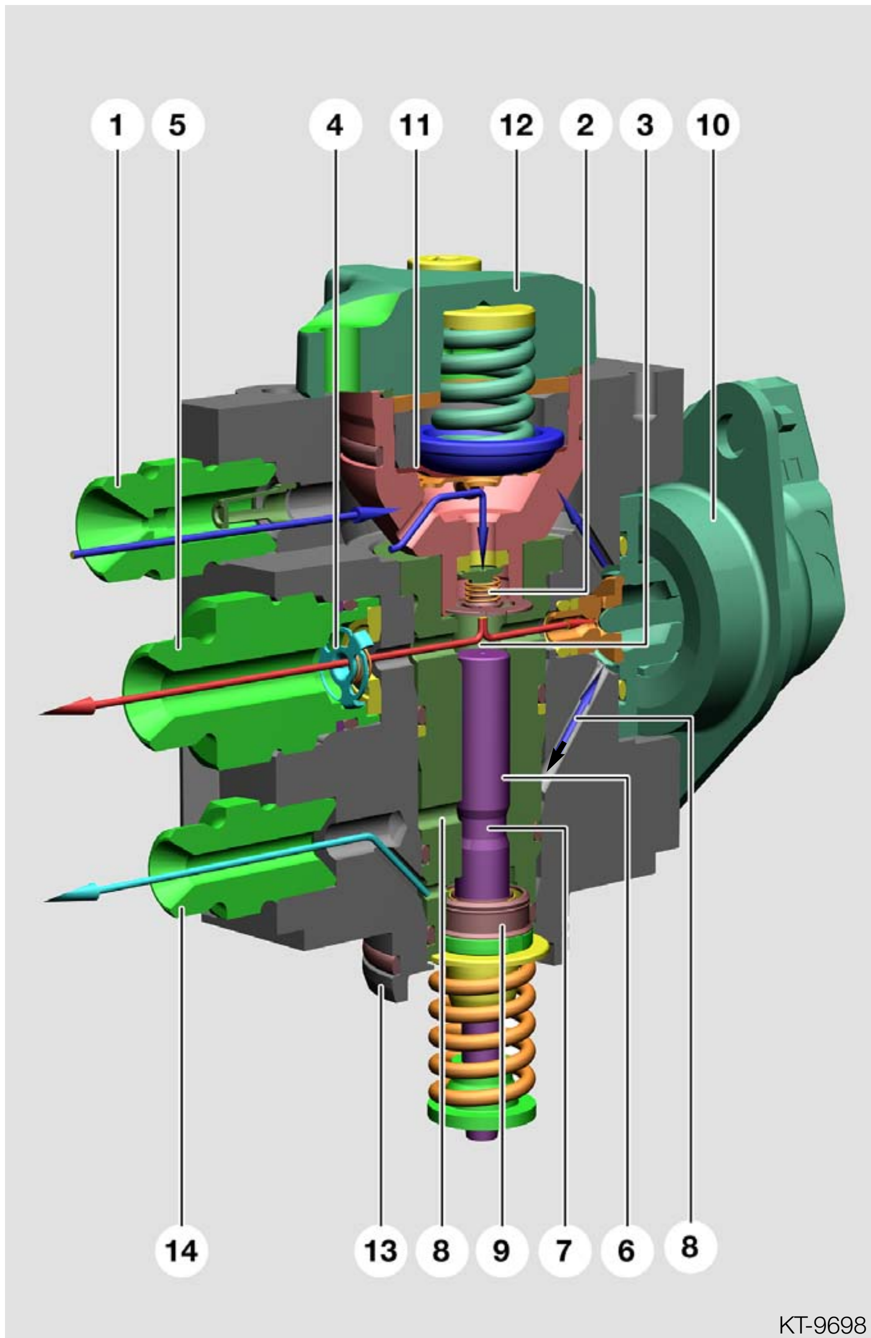
The two high pressure pumps are supplied with fuel by the electric fuel pump (EKP), which is located in the fuel tank. The high pressure fuel injectors are connected to a pressure rail (accumulator) for each cylinder bank. The two rails are not interconnected.



1. Supply line
2. High pressure pumps
3. High pressure lines
4. Fuel rail (7-12)
5. Fuel rail (1-6)
6. High pressure fuel injectors
7. Rail pressure sensors
8. Pressure limiting valves
9. Leakage line

High Pressure Pumps: A single cylinder high pressure pump is used for each cylinder bank. The pumps are mounted on the cylinder heads and driven via bucket tappets by triple cam lobes on the exhaust camshafts. Each pump has three connecting lines: feed line, high pressure line and leakage line.

1. Feed line
2. Inlet valve
3. High pressure chamber
4. Outlet valve
5. High pressure line
6. Pump plunger
7. Annular plunger groove
8. Feed area channel
9. Sealing ring
10. Fuel quantity control valve
11. Diaphragm
12. Pressure attenuator
13. Mounting flange
14. Leakage line



Fuel is delivered to each high pressure pump through the feed line at a pressure of 6 bar from the electric in tank fuel pump via a T-branch. In the pump, the fuel passes through the inlet valve (2) into the high pressure area (3).

As the pump plunger is forced up by the camshaft, the fuel is pressurized ***(up to 120 bar)*** in this area. The pressurized fuel is then forced out through the high pressure line to the fuel rail. The outlet valve (4) prevents back flow from the rail into the high pressure pump.

Due to the extreme pressure on and around the plunger shaft, a small amount of fuel (max. 1 litre per hour) flows past the plunger shaft against the sealing ring (9). This also serves as lubrication for the plunger shaft. The sealing ring provides a seal between the fuel side of the pump and the engine oil at the pump drive.

To relieve the pump pressure (up to 120 bar) at the sealing ring, the pressure is reduced in two stages, at which point the fuel returns through the leakage line to the tank. The pump pressure is reduced down to 6 bar at the annular groove (7) because it is connected by a channel (8) to the feed area of the pump. The fuel flow from this channel is regulated by the fuel quantity control valve (MSV).

Below the annular groove, some fuel flows past the pump plunger against the sealing ring. At this point the fuel pressure is virtually reduced to atmosheric pressure, which is sufficient to return the fuel through the leakage line to the tank.

Fuel Quantity Control Valves (MSV): The fuel quantity control valve (10) is installed in the high pressure pump to regulate the fuel delivery rate as required based on load and engine rpm. This valve opens a channel from the high pressure chamber (3) to the feed area allowing excess fuel to return to the feed area.

When the pump plunger is at it's lowest position, the valve is energized closed by the ECM. The valve is de-energized as soon as the injection pressure calculated by the ECM is reached during the upwards travel of the pump plunger. The valve is now opened to allow excess fuel to return to the feed area. This switching is repeated three times per camshaft revolution because the drive cam for the pump has three lobes.

The pulsations generated in the pump during the process are absorbed by the pressure attenuator spring (12). The pressure attenuator is sealed by a diaphragm (11) from the pump feed area.

In Tank Electric Fuel Pump

1. *Request the Test Plan for the in tank electric fuel pump. What can cause faults in the fuel supply control?*

2. *Select #4 "Fault in electric fuel pump". When the Test Plan requests you to check the wires and power supply to the fuel pump, can you find a quicker way to confirm this?*

3. *Is there a "Component activation" for the in tank electric fuel pump?*

   If yes, how can you confirm that it is operating?

High Pressure Pump with Fuel Quantity (volume) Control Valve

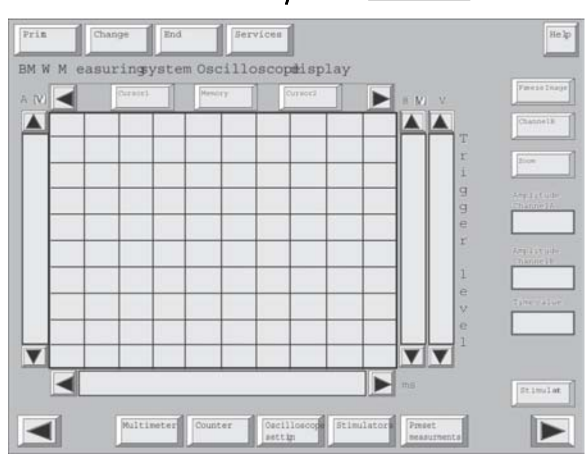
1. *Is there a Test Plan available for the high pressure pump/fuel volume control valve?*

2. *Select Control Unit Functions (MED 9.2.1), Diagnosis Requests. Is there a status under the "Part Functions" column for observing the fuel volume control valve?*

3. *What are the pin and connector numbers at the ECM (1 or 2) for the fuel volume control valve? Pin ____ Connector ____*

4. *Record the voltage value at this pin with the engine not running (ignition on). ____ V*
   Engine running at idle speed. ____ V

5. *Record the frequency at this pin with the engine running at idle speed. ____ Hz*
   at 2000 rpm. ____ Hz



6. *Use the MFK 2 cable to observe a scope pattern from the same pin and record that pattern on the right (engine at idle speed).*

   Hint: Start out with a scope setting of 10Hz at 50 V for MFK 2 (Channel B).

   Increase the engine speed to 2000 rpm and observe pattern.

Fuel Rails (pressure accumulator): The fuel is stored in the fuel rail at a pressure between 50 and 120 bar for distribution to the fuel injectors. The fuel rail connects to the injectors through brass coupling connections.

Due to length and position compensation between the rail and the fuel injectors, brass coupling connections are used in order that the fuel injector O-ring can float inside this coupling.

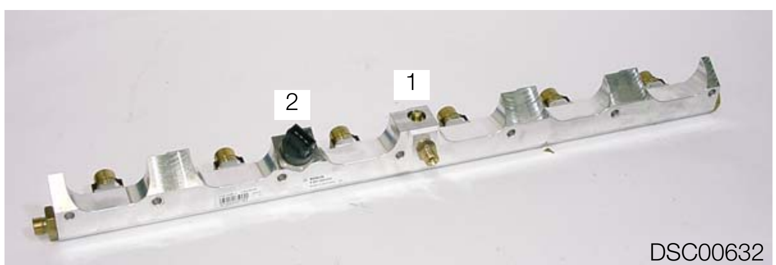
DSC00630

Pressure Limiting Valves: Each fuel rail contains an integral pressure limiting valve (1 below). This valve opens from a pressure of 125 bar to prevent damage to the injection system. The outlet of this valve is connected by a line to the high pressure pump fuel feed line. The valve can open briefly:

- When no fuel is required by the fuel injectors (fuel cutoff when vehicle is coasting)

or

- During the afterheating (hot soak) phase when the hot engine is turned off.



DSC00632

Rail Pressure Sensors: Each fuel rail incorporates a rail pressure sensor (2 above). The sensor is a pressure dependent resistor and the voltage (5 V) is supplied by the ECM. The increasing system pressure alters the sensor resistance.

According to the fuel pressure applied, the rail pressure sensor outputs a varying voltage signal as the rail pressure increases from 0.5 V (0 bar) to 4.5 V (140 bar). If the rail pressure sensor malfunctions, the fuel quantity control valve (on the HDP) is activated with a back up function (set value) by the ECM.

Fuel (rail) Pressure Sensor

1. What type of sensor is this? ____________________

*2. Is there a Test Plan available for the fuel pressure sensor?*____________________

3. Select Control Unit Functions (MED 9.2.1), Diagnosis Requests. Is there a status under the "Part Functions" column for observing the fuel pressure sensor? ____________________

4. What are the pin and connector numbers at the ECM (1 or 2) for the fuel pressure sensor? Pin ____________ *Connector* ____________

5. Record the voltage value at this pin with the engine not running (ignition on). ______ *V*
Engine running at idle speed. ______ *V*
Engine speed at 2000 rpm. ______ *V*

6. Shut the engine off and turn the ignition back on "KL15" (engine not running). Observe the voltage value at this pin for approximately one minute. What did you observe?

____

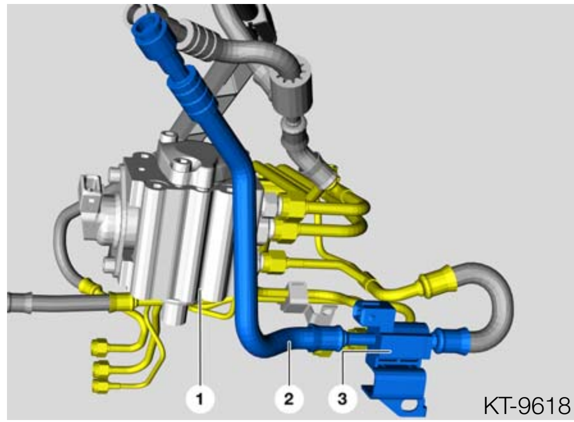
7. If the pressure limiting valve is defective, could the answers to questions 5 and 6 (above) indicate this? ____________________

Additional notes:

Return Shut-off Valve: The return shut-off valve prevents a pressure drop in the system while the engine is stopped and is located in the leakage line. When the engine is started, the valve is energized after a slight delay to prevent a pressure drop in the feed area of the high pressure pump (cavitation).

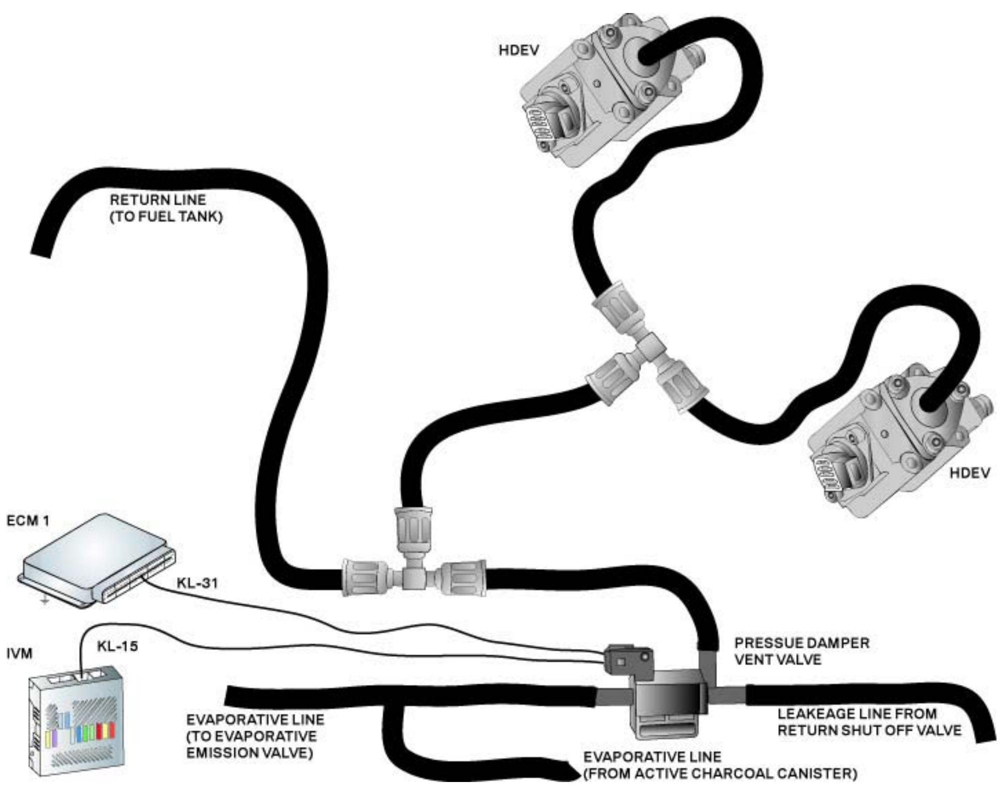
While the engine is running, this valve is supplied with system voltage (from the ECM Main Relay) and activated by the ECM providing a ground path which allows leakage fuel to return to the tank.

1. High pressure pump
2. Leakage line
3. Return shut-off valve



Pressure Damper Vent Valve: The Pressure Damper Vent Valve provides a controlled outlet for fuel/vapors that accumulate in the Pressure Attenuator (damper) chamber in the top of each High Pressure Pump. This is a 3/2 way electrically controlled valve (KL15 from the IVM, ground path provided by ECM 1) that provides:

- A circuit for fuel to return to the fuel tank when energized (KL15 on) *or*
- A circuit for fuel vapors to vent into the evaporative system when de-energized (KL15 off)



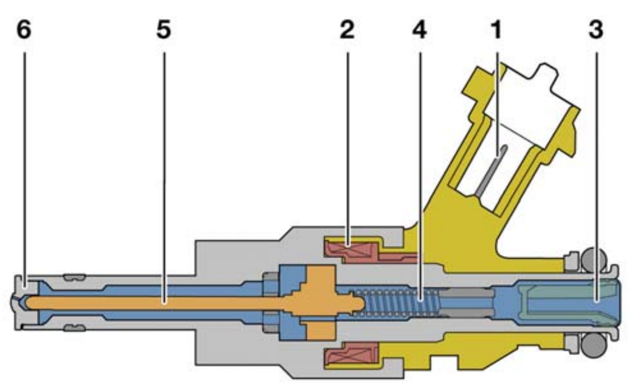
When the engine is running, a slight amount of fuel may accumulate in the Pressure Attenuator upper chambers due to natural leakage through the internal diaphram (extreme pressure). This fuel (circuit) is returned to the fuel tank by combining with the Leakage Line of the Return Shut-off Valve. The Pressure Damper Vent Valve provides a passage to combine these two circuits when the ignition is switched on (KL15) and isolates the Evaporative Emission circuit.

When the engine is not running, fuel vapors remain in these chambers and is routed into the Evaporative Emission circuit. This is accomplished by Pressure Damper Vent Valve blocking the passage from the Return Shut-off Valve (KL15 off) and opening a passage to the circuit leading from the Active Charcoal Canister to the Evaporative Emission Valve.

High Pressure Fuel Injectors (HDEV): The high pressure fuel injectors are designed essentially the same as conventional fuel injectors. They are secured by a taper in the cylinder head and sealed by a Teflon ring against the combustion chamber.

The O-ring seals the top of the injector and floats inside the brass coupling connections on the fuel rail. Each fuel injector incorporates a single hole nozzle with a spray angle of 70º to the piston crown.

1. Electrical connection
2. **Solenoid coil**
3. Fuel inlet port
4. Pressure spring
5. Nozzle needle
6. Single hole nozzle



KT-9744

To open the high pressure fuel injector, the nozzle needle is lifted off its seat when the solenoid coil is energized. Due to the high injection pressure (up to 120 bar), the pressure spring is designed to accommodate a pressure force of 30 newtons (5 newtons for conventional fuel injectors). The pressure spring forces the nozzle needle onto its seat during closing with sufficient contact pressure.

Return (flow) Shut-off Valve

1. Is there a Test Plan available for the return flow shut off valve? ______________

2. Select Control Unit Functions (MED 9.2.1), Diagnosis Requests. Is there a status under the "Part Functions" column for observing the return flow shut off valve? ______________

3. What are the pin and connector numbers at the ECM (1 or 2) for the return flow shut off valve? Pin ______________ *Connector* ______________

4. Measure and record the resistance value of this valve. ______________ *ohms*

5. Record the voltage value at this pin with the engine not running (ignition on). ________ *V*
Engine running at idle speed. ________ *V*
Engine speed at 2000 rpm. ________ *V*

6. Shut the engine off. Wait ten seconds and restart the engine. Observe the voltage value at this pin while the engine cranks and starts. What did you observe? ______________

High Pressure Fuel Injectors (HDEV)

1. What is the resistance value of a high pressure fuel injector? ________*ohms*

Visual identification of the high pressure fuel injector:

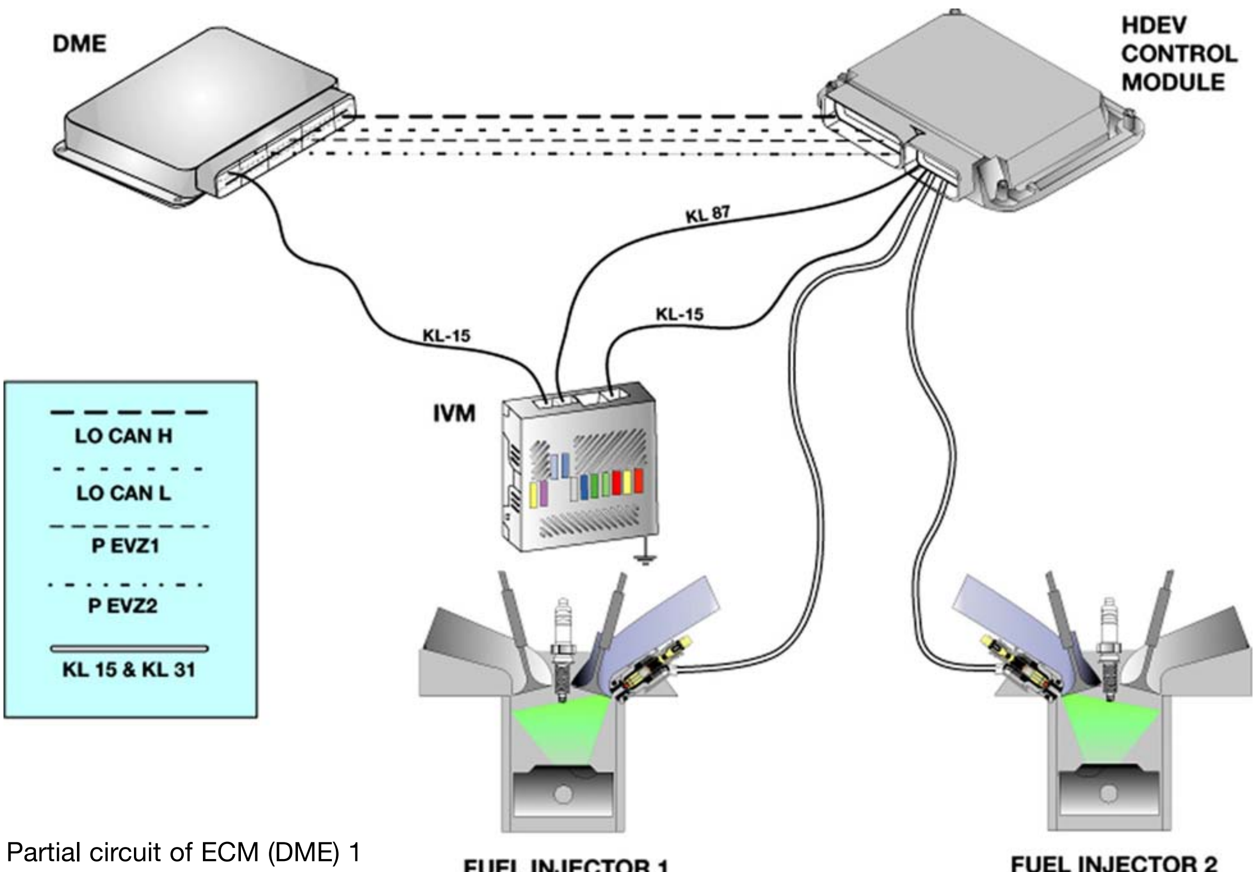
1. Teflon ring (combustion chamber seal)
2. Taper (seats against cylinder head)
3. O-ring (brass coupling seal in fuel rail)

Additional notes:

Direct Injection System Control

A high pressure fuel injector control module (HDEV) is used for each cylinder bank and is located in the engine compartment E box. The HDEV control module is supplied with system voltage from the ECM main relay (in the IVM). Data is transmitted from the ECMs to the HDEV control modules for each high pressure fuel injector via the Local-Can bus. The HDEVs activate the injectors individually.

Note: The high pressure fuel injectors are activated by the HDEV control modules with a voltage of 100 V and energized during the opening period with approx. 85 V.



Partial circuit of ECM (DME) 1
with two injectors shown

HDEV Control Modules: The HDEV control modules contain pulse width modulated final output stages with high performance capacitors to transform the system voltage up to 85 to 100 volts. Current flows in the output stages up to a specific cutoff value. This cutoff creates an induced voltage, e.g. 85 V, which is then charged to the high performance capacitors (boosters). The high pressure fuel injectors are actuated by this capacitor with 2.8 to 16 amps of current.

High Pressure Fuel Injector Control Module (HDEV)

1. Is there a Test Plan available for the HDEV? ______________________

2. Select Control Unit Functions (MED 9.2.1), Diagnosis Requests. Is there a status under the "Part Functions" column for observing the HDEV injector output? __________

3. What are the pin and connector numbers at the ECM (1 or 2) for the fuel injector output request? Connector __________ *Pins* __________ __________

__________ __________

__________ __________

4. Record the voltage value at one of these pins with:

The engine not running (ignition on). ____ *V*

Engine running at idle speed. ____ *V*

Rev engine up to 2000 rpm. ____ *V*

5. What are the pin and connector numbers at the HDEV (1 or 2) for the output control of <u>one</u> of the fuel injectors? Connector __________ *Pins* __________ __________

voltage ground

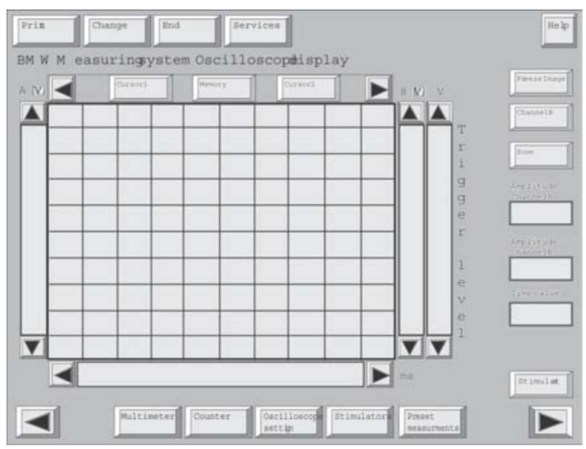
<u>Ask the Instructor for assistance:</u>

6. Using the <u>ground</u> pin of this fuel injector at the HDEV, record the voltage value with:

The engine not running (ignition on). ____ *V*

Engine running at idle speed. ____ *V*

Rev engine up to 2000 rpm. ____ *V*



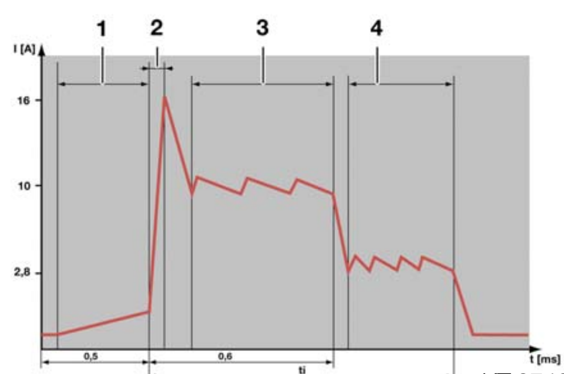
7. Use the MFK 2 cable to observe a scope pat-
tern from the same pin and record that pattern on the right (engine at idle speed).

Hint: Start out with a scope setting of 10Hz at 100 V for MFK 2 (Channel B).

Increase the engine speed to 2000 rpm and observe pattern.

HDEV activation (sample shown to the right):

1. Premagnetization time
2. Booster phase
3. Starting current phase
4. Holding current phase



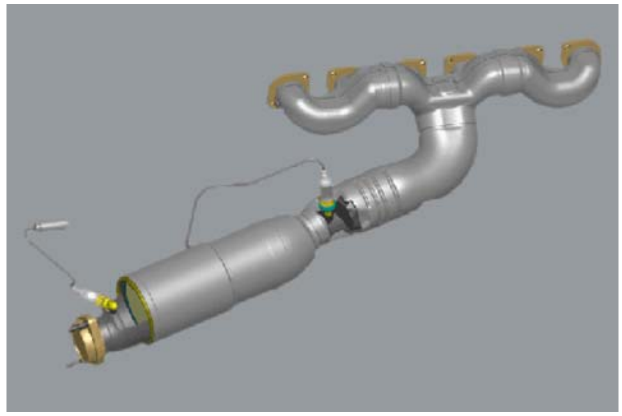
KT-9743

Emissions Management - N73B60 Low Emission Vehicle (LEV)

Oxygen Sensors: The N73 engine is fitted with a total of four oxygen sensors. One planar broadband oxygen sensor (constant characteristic curve), which regulates the fuel-air mixture, is located upstream of each of the two catalytic converters. The catalytic converter assemblies are integral with the exhaust manifolds.

There is a post catalytic converter sensor (Bosch LSH25) for each cylinder bank positioned downstream of the catalytic converter which monitors the catalyst efficiency.

This monitoring means that if the exhaust gas concentration is too high, a fault code is stored. The post catalyst sensors can also detect an emission relevant fault in a pre-catalyst oxygen sensor.


N73 Oxygen Sensors

Bosch LSU Planar Wideband Oxygen Sensor: The N73 engine is equipped with planar wideband oxygen sensors (pre-catalyst). The sensor is planar shaped (type of construction) which is more compact and is made up of thin layers of zirconium dioxide (ZrO_2) ceramic films. This modular lamination structure enables the integration of several functions including the heating element which ensures the minimum operating temperature (750 ºC) is reached rapidly.

In contrast to conventional oxygen sensors, the wideband features can measure not only at Lambda=1, but also in the rich and extremely lean range (Lambda=0.7 to complete atmospheric oxygen) very rapidly.

The pump cell and reference cell are made of zirconium dioxide and each coated with two porous platinum electrodes. They are arranged so that there is a measuring gap between them. This measuring gap is connected by an inlet opening to the exhaust gas. The pump cell is controlled by the ECMs applying voltage to the electrodes to initiate oxygen ion pumping across the porous membrane of the reference cell, providing a quicker response time.

The pump current flow is proportional to the oxygen concentration (lean) or the oxygen requirement (rich). The pump is constantly working to maintain that the gas composition in the measuring gap is constantly at Lambda=1.

Bosch LSU Planar Wideband Oxygen Sensor

1. Is there a Test Plan available for the LSU oxygen sensor? ______________________

2. Select Control Unit Functions (MED 9.2.1), Diagnosis Requests. Is there a status under the "Part Functions" column for observing the LSU oxygen sensor? ______________

List the status that apply to the oxygen sensor:

______________ ______________ ______________

______________ ______________ ______________

3. Using the DISplus voltmeter, connect MFK2 to the full circuit of the oxygen sensor. (for example: pin 13 to pin 20 at ECM 1 of LSU bank 1). Start engine and allow warmup.

Select Control Unit Functions (MED 9.2.1), Diagnosis Requests. Under the "Part Functions" column for the LSU oxygen sensor, select: Oxygen-sensor control, Oxygen-sensor controller, Lambda value, Additive lambda adaptation and Multiplicative lambda adaptation - now select "Display".

Ask the Instructor for assistance:

4. With the engine running and the voltmeter displayed, introduce a vacuum leak.

With the Minimum/Maximum feature selected, observe the voltage value and reconnect the hose.

What is the minimum? ______ *V* *maximum?* ______ *V*

5. Slowly disconnect the hose and allow the engine to run for approximately 1 - 2 minutes. Under the "Part Functions" column for the LSU oxygen sensor, record the values for:

Oxygen-sensor control ____________ *Additive lambda adaptation* ____________
Oxygen-sensor controller ____________ *Multiplicative lambda adaptation* ________
Lambda value ____________

Caution: Do not conduct this test for longer than 5 minutes! (allow engine to cool)

6. What do the values from question 5 indicate? ______________________________

____

____

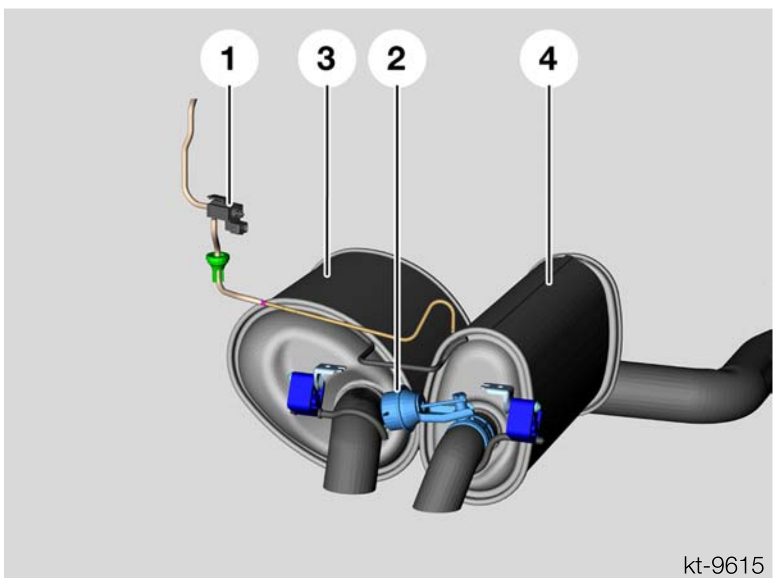
Performance Controls

Exhaust Flap: The 12.6 liter rear silencer (4) is fitted with an exhaust flap to keep noise to a minimum at engine idle speed and low rpm. The flap provides exhaust efficiency based on two effects:

- Minimization of the cross section (slight back pressure) and the outlet noise level at low exhaust flow rates
- Large cross-section with low backpressure at high speeds and loads

The exhaust flap is ***opened*** allowing additional flow when:

- The transmission gear is engaged ***and***
- The engine speed is approximately above 1,500 rpm



A vacuum controlled diaphragm (2 - actuator mounted on the silencer) opens and closes the exhaust gas flap. The vacuum is supplied from the camshaft driven vacuum pump.

The exhaust flap is opened with vacuum, and is sprung closed by the actuator (when vacuum is not present). The procedure is carried out using a solenoid valve (1) which is electrically controlled by the ECM and located in the left rear luggage compartment (below the light assembly).

Exhaust Flap

1. *Select Control Unit Functions (MED 9.2.1), Diagnosis Requests. Is there a status under the "Part Functions" column for observing the "Messages and Results"? ______________*

   Is there a "Component Activation" feature for the exhaust flap? ______________

2. *Is there a Test Plan available for the exhaust flap? ______________*

3. *If so, does the engine need to be run? ____________ Why? ______________*

---

4. *What are the pin and connector numbers at the ECM for the exhaust flap solenoid activation?*

   Pin ______________ Connector ______________

5. *Which ECM controls the exhaust flap (1 or 2)? ____________*

Additional notes:

Table of Contents

Subject **Page**

GA6HP26Z AUTOMATIC TRANSMISSION

Model: E65 - 745i / E66 - 745Li

Engine: N62B44

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

Objectives of The Module

After Completing this module, you will be able to:

- List the GA6HP26Z designation.
- Describe Stand By Control.
- Name the clutches used in the GA6HP26Z.
- Identify what is unique about 5th and 6th gear.
- Explain the Parking Lock function.
- Demonstrate how to use the Emergency Release.
- List the Mechatronic components.
- Name the two paths of communication for the Selector Lever.
- Explain the L mode.

GA6HP26Z Automatic Transmission

Purpose of The System

BMW has developed a new automatic six speed gearbox together with ZF (Zahnradfabrik Friedrichshafen), designated the GA6HP26Z for the E65. It represents a further development of transmission technology and features innovations used for the first time in BMW automatic gearboxes. This gearbox makes an important contribution to the "revolutionary" features of the E65 in the luxury class segment.

G = Gearbox
A = Automatic
6 = Number of gears (speeds)
HP = Hydraulic planetary gear
26 = size
Z = Gearbox manufacturer ZF
(Zahnradfabrik Friedrichshafen)

42-05-00

GA6HP26Z Auto Transmission

The GA6HP26Z is designed in two versions for the different E65 engines. There is a more powerful version available for the V-12 that differs with the following components:

- Power output and torque characteristics
- Torque converter
- Clutches with different numbers of steel discs and lined plates
- Lepelletier planetary gear train with a different number of planet gears

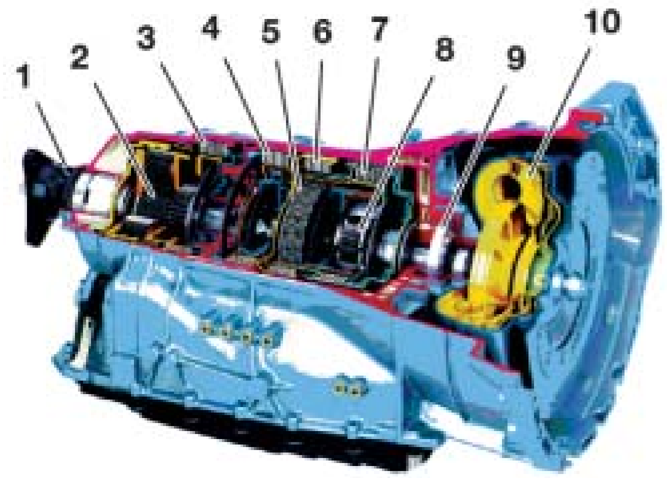
The gearbox used in the 745i is designed for a torque of 440 Nm. The more powerful version (760i) is designed for a power output of 320 kW/435 bhp and a torque of 600 Nm. The fundamental design and function of both gearbox versions are the same.

Mechanical Design of the Gearbox

The mechanical power transmission of the gearbox has been optimized with regard to gearshift comfort, quality and reduced fuel consumption. The engine torque is transferred to the gearbox by a torque converter with a controlled lockup clutch. The six forward gears and the reverse gear are produced by a Lepelletier planetary gear train. The gears are shifted by multi-disc clutches.

1. Output shaft
2. Double gear train
3. Clutch D
4. Clutch C
5. Clutch E
6. Clutch B
7. Clutch A
8. Single gear train
9. Oil pump

10 Torque converter with lockup clutch



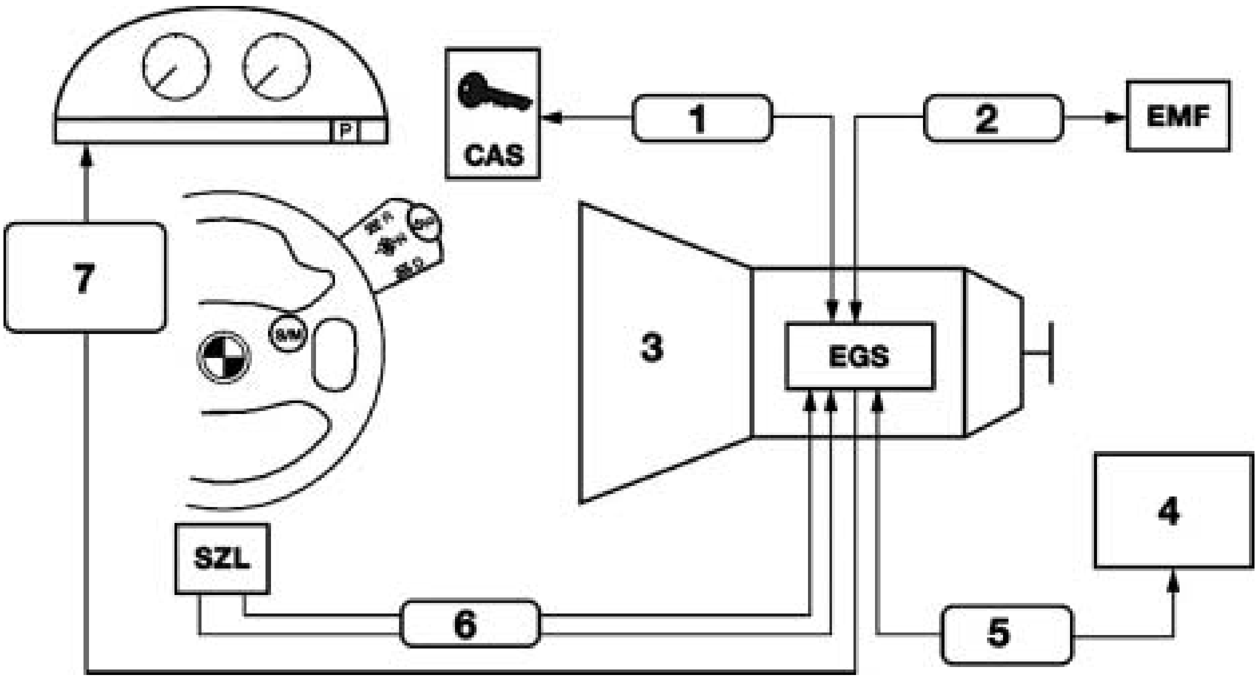
42-05-01

The new automatic gearbox has the following advantages:

- Designed as a 6-speed gearbox with an overdrive ratio in 5th and 6th gear, fuel consumption is reduced by up to 5 percent.
- The 6-speed gearbox allows for more gear spread, improving vehicle acceleration.
- The new 6-speed gearbox is approximately 30 kg lighter and 50 mm shorter as compared to the previously used gearbox (A5S560Z).
- The number of transmission components has been reduced from approx. 660 parts in a 5-speed gearbox to approx. 470 parts for the new 6-speed gearbox.
- The number of interfaces has been reduced by using the Mechatronics Module for the electronic transmission.

Transmission Control

The gearbox is controlled by the Mechatronic Module that is a combination of the valve body and electronic control module. The following system overview shows the main components of the electronic control system.



42-05-02

Transmission Control

1. Key signal, starter interlock
2. Redundancy (park lock, n)
3. Automatic gearbox
4. Controls in vehicle interior (for emergency release)
5. Mechanical emergency release for parking lock
6. Driver’s choice P,R,N,D,(L,-)
7. Shift pattern (shift gate)
   Position indicator P, R, N, D, L1...L6
   Shift lock indicator
   Error message

CAS - Car access system
EMF - Electromechanical parking brake
EGS - Electronic transmission control (in mechatronic module)
SZL - Steering column switch center

The driver's request is transmitted in the form of an electrical signal from the selector lever on the steering column or from several control buttons in the multifunction steering wheel. The signals are transferred over the CAN bus to the transmission control module. In the gearbox, the commands are implemented while evaluating various ambient conditions. The relevant positions are indicated in the instrument cluster.

Pure electronic transmission control (shift by wire) eliminates the conventional gearshift lever in the center console and all of the associated components. There are additional safety enhancements, for example the automatic parking lock is active when the ignition key is removed. In the event of faults or complete failure of electrical connections or system components, numerous measures are provided:

- An additional serial data link (hard wire) between the selector lever and Mechatronic
- The display of error messages in the instrument cluster and/or in the CC display
- The mechanical emergency park release

Technical Data: The following table lists the technical data of the gearbox versions.

Technical Data	Explanation
Gearbox Type	Passenger vehicle automatic gearbox with 6 forward gears and one reverse gear in standard arrangement
Transmission Data 745i	Max torque at 4200 rpm **440** Nm Max power output at 6600 rpm 230 KW / 313 bhp
Transmission Data 760i	Max. torque at 4200 rpm 600 Nm Max. power output at 5800 rpm 320 kW / 435 bhp
Converter	Slip-controlled torque converter lockup clutch in the gears 1 to 6 Max. permissible continous speed 7000 rpm
Transmission Ratios	1st gear 4.171 / 2nd gear 2.34/ 3rd gear 1.521 / 4th gear 1.143 / 5th gear 0.867 / 6th gear 0.697 / reverse gear 3.403
Control	Electrohydrualic with adaptive electronic control
Weight	84 to 90 kg with oil depending on version

42-05-03

Mechanical System Components

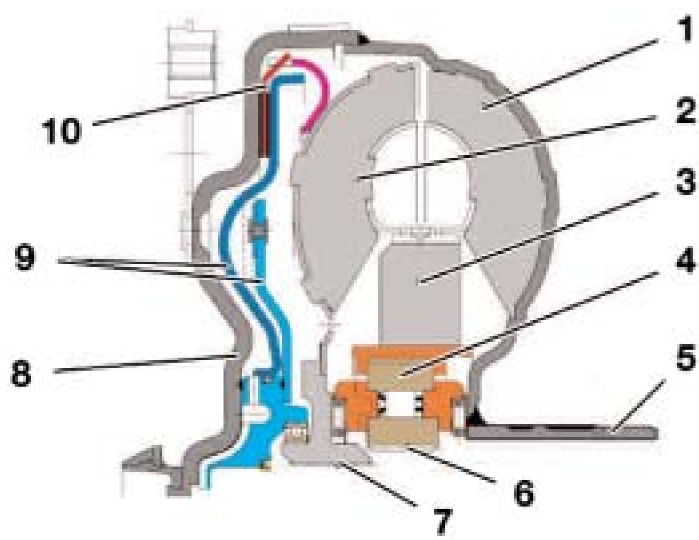
The new features/changes of the individual components as compared to previous BMW automatic transmissions will be covered. The component and functional description follows the power flow progression in the gearbox, from the torque converter to the output shaft.

Torque Converter and Lockup Clutch: The torque converter is the link for transmitting power from the engine to the gearbox. It converts high speed/low torque into low speed/high torque with a slight slip from the fluid coupling. The integral converter lockup clutch eliminates slip during the transfer of rotational speed.

The torque converter clutch is locked when the control module diverts oil pressure in the converter. The oil flow is reversed to depressurize the area in front of the clutch and apply pressure to the back side of the clutch pushing it against the converter housing. The clutch plate locks the turbine wheel directly to the converter housing allowing it to rotate as a unit without slip.

The lockup clutch is a two-friction surface clutch. It is slip-controlled in all forward gears (1 through 6). The operating points when the lockup clutch is engaged are increased which reduces fuel consumption.

1. Pump
2. Turbine
3. Stator
4. Overrunning Clutch
5. Torque Converter Hub
6. Stator Shaft
7. Turbine Shaft
8. Torque Converter Casing
9. Piston for lockup clutch
10. Lined clutch plate



Torque Converter & Lockup Clutch

The lockup clutch will not engage until the oil temperature is >35 ºC. The control of the lockup clutch depends on various factors such as:

- Load requirement signal
- Vehicle speed
- Engine load status
- Gearbox oil temperature
- Selected gearshift program

Examples:

- Control of the lockup clutch takes place in the XE program (extreme economy) in gears 1 through 6 at a speed of approx. >30 km/h when a load requirement of <50% is present. The lockup clutch is disengaged if the load requirement is >50%.

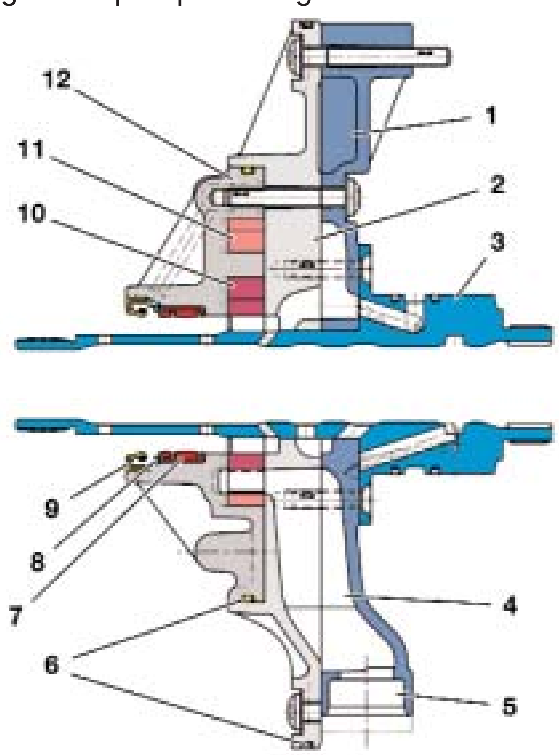
- The converter clutch is engaged from a speed of approx. 80 km/h in all forward gears. It is engaged at a speed of 20 km/h at full load or kick-down.

There are small oil channels in the lining of the lockup clutch. This oil circuit quickly reduces the temperature in the torque converter after the lock-up clutch engages.

The GA6HP26Z has a new feature of reducing the load on the engine when the vehicle is stationary and the brake pedal pressed. The turbine (input) shaft is uncoupled from the drive so that only a minimum load remains, reducing fuel consumption. The uncoupling phase is achieved by a control feature of the "A" clutch which is called ***Stand By Control (SBC).*** The pressure is reduced in the A clutch allowing the turbine shaft and torque converter to turn freely until acceleration is requested.

Oil Pump: The oil pump supplies the required oil pressure and lubricating oil for the automatic gearbox. It is a crescent-type pump and a delivery control valve is not required. The converter is supported by a needle bearing in the pump housing.

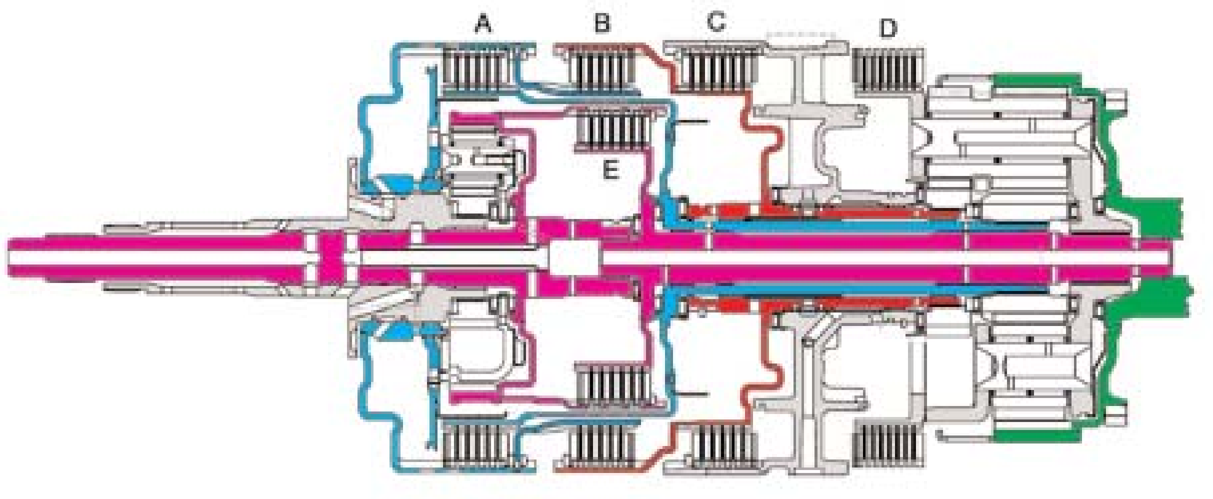
1. Intermediate Plate
2. Centering Plate
3. Stator shaft
4. Intake
5. To Oil Strainer (intake pipe)
6. O-ring
7. Bearing
8. Snap ring
9. Rotary shaft seal
10. Impeller
11. Internal Gear
12. Pump Housing



42-05-05

Oil Pump

Multi-disc Clutches: The GA6HP26Z gearbox requires only 5 clutches to engage 6 gears. The clutches are divided into drive clutches and brake clutches. Clutches A, B and E are drive clutches while clutches C and D are brake clutches. The A, B and E drive clutches are “dynamic pressure” balanced.



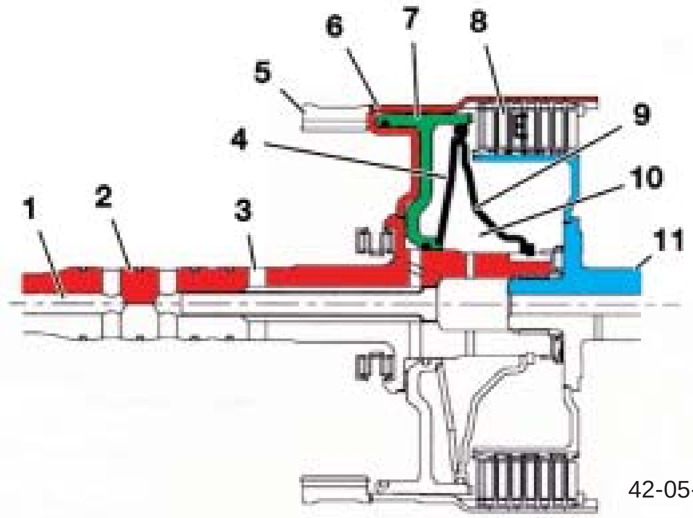
42-05-06

A Drive clutch **B Drive clutch** **C Brake clutch** **D Brake clutch** **E Drive clutch**

Dynamic Pressure Balance (Example: Clutch E)

Oil is applied to the clutch piston on both sides to avoid speed dependent pressure reduction in the clutch. This balance is achieved by the pressure plate (9) and the non-pressurized residual oil in the lubricating oil gallery (1) through which the area between the piston and pressure plate is filled with oil. This ensures the clutch disengages and engages exactly in all speed ranges while also improving gearshift comfort.

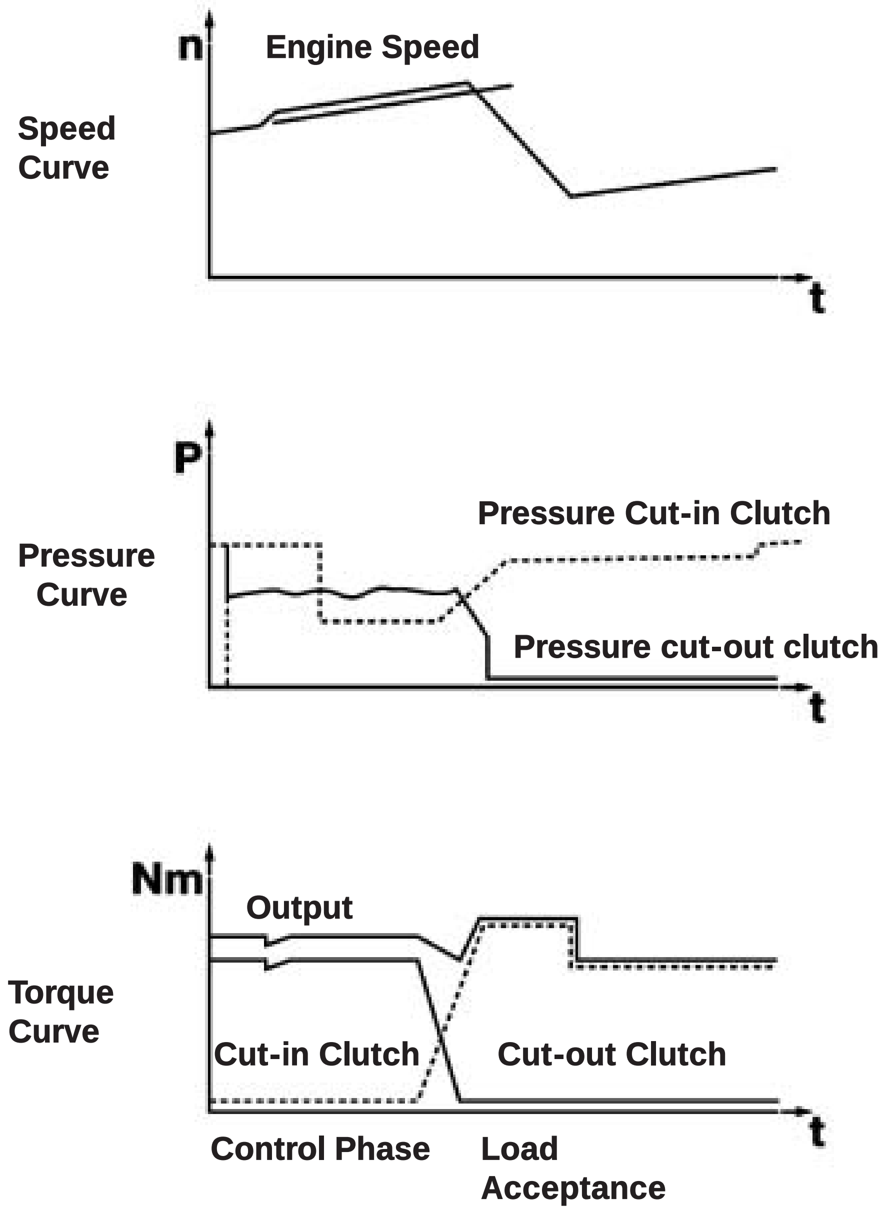
1. Lubrication Oil Gallery
2. Turbine shaft
3. Main pressure for clutch E
4. Disc Spring
5. Internal gear for single gear train
6. Cylinder E (outer disc carrier)
7. Piston E
8. Clutch assembly E
9. Pressure plate
10. Area for pressure compensation
11. Inner disc carrier E



42-05-07

Clutch E

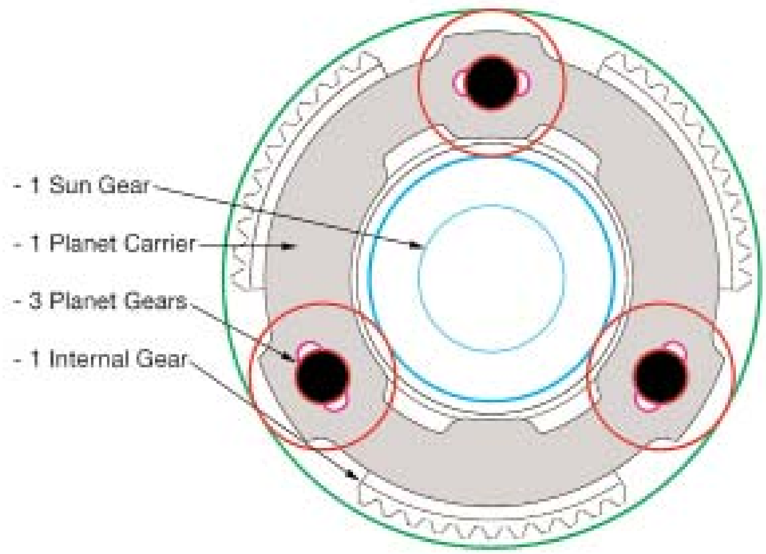
Free wheel gearshifts (using overrunning clutches) are not used in this transmission. In the GA6HP26Z gearbox, all gearshifts from 1st to 6th gear and from 6th to 1st gear are executed as overlap shifts. The overlap gearshift system saves weight and space. The electro-hydraulic gearshift is executed by valves in the valve body that are controlled by pressure regulators. The speed, pressure and torque curves are shown in the following diagrams.



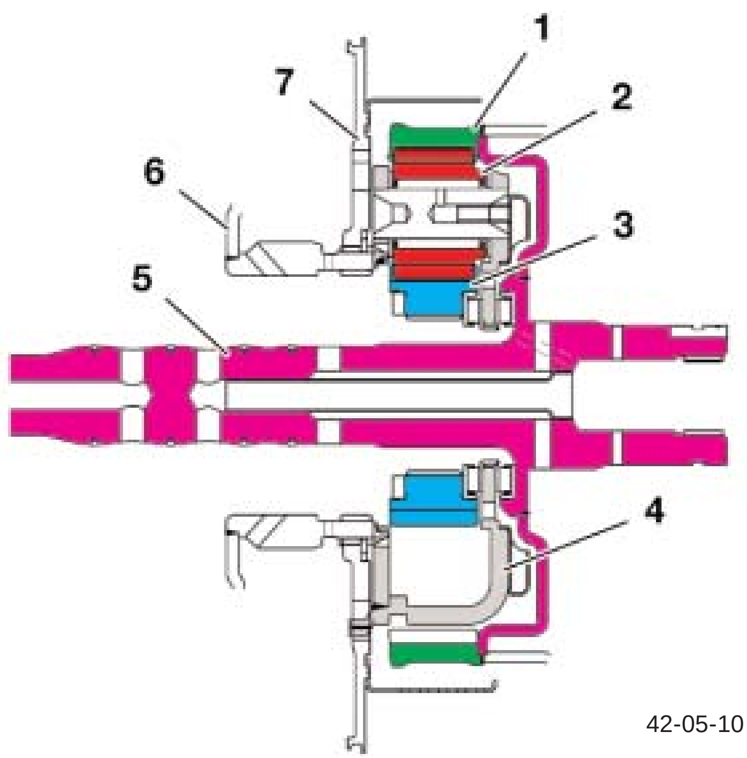
42-05-08

Lepelletier Planetary Gear Train: The Lepelletier planetary gear train provides six forward gears and one reverse gear using a lightweight design. The planetary gear train consists of a single carrier planetary gear train and a downstream double planetary gear train.

The single carrier planetary gear train consists of:

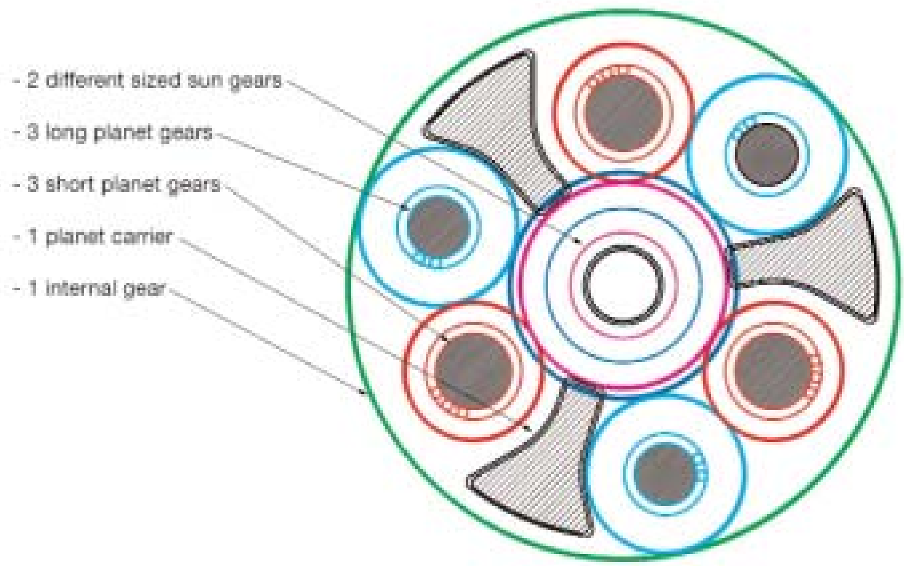


1. Internal gear 1
2. Planet gear
3. Planet carrier
4. Planet carrier
5. Turbine shaft
6. Cylinder A
7. Pressure plate A



Lepelletier Planetary Gear Train

Double Planetary Gear Train: The series connected double planetary gear train consists of:



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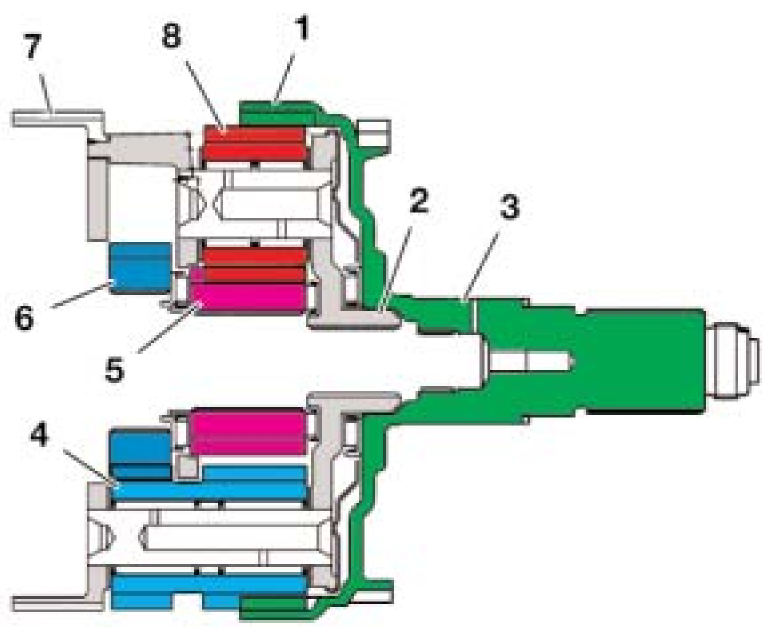


1. Internal gear 2
2. Planet carrier, clutch E
3. Output
4. Double planet gear (long)
5. Sun gear 3, clutch E
6. Sun gear 2, clutch A
7. Planet carrier 1
8. Planet gear (short)

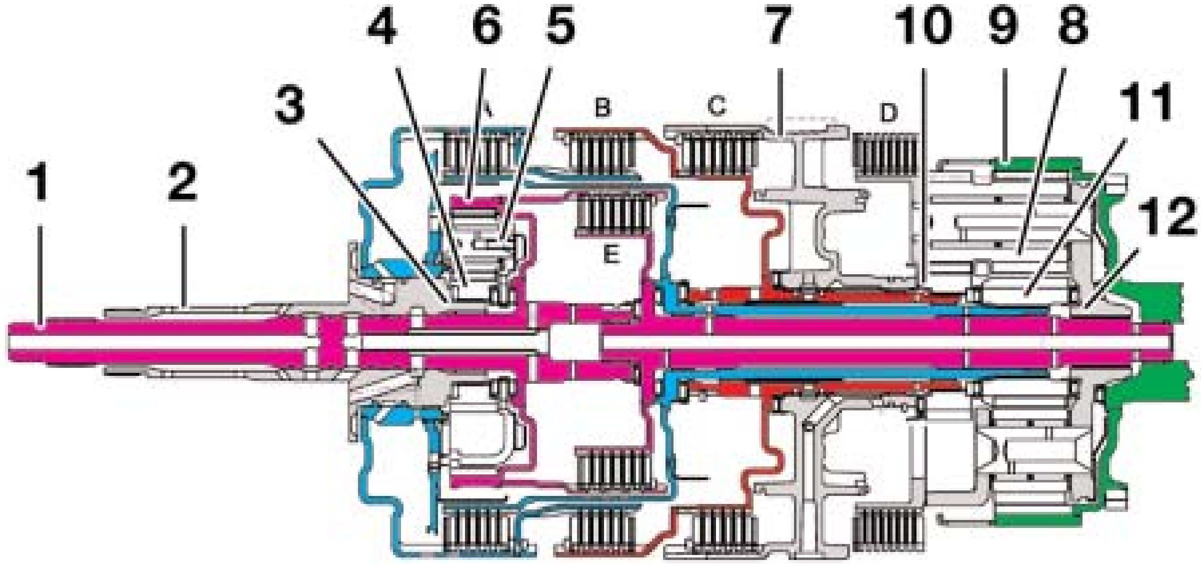
42-05-12

Double Planetary Gear Train

Power Transfer in the Planetary Gear Train

Principle of Operation

Neutral Position: The turbine shaft drives the internal gear for the front single planetary gear train and the outer disc carrier of clutch E. The internal gear drives the planet gears that roll on the fixed sun gear. The planet carrier of the gear train is driven together with the outer disc carrier of clutch A and the inner disc carrier of clutch B. This steps up the drive for clutch A and B.

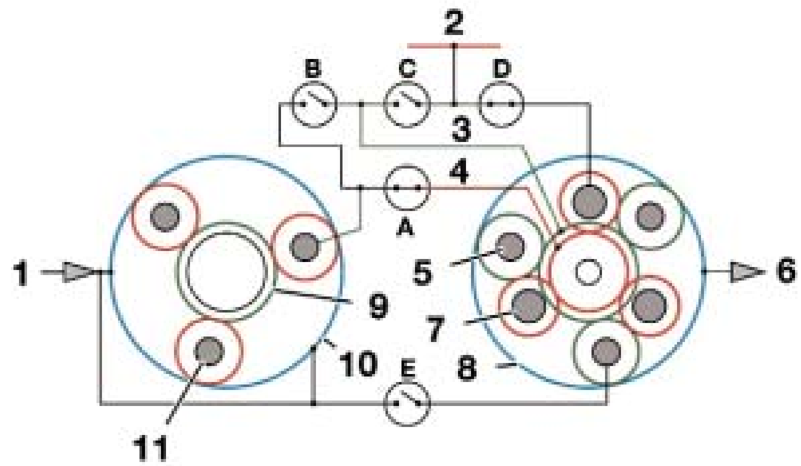


42-05-13

Power Transfer in the Planetary Gear Train

1. Turbine shaft
2. Stator shaft
3. Single gear train
4. Sun gear
5. Planet carrier
6. Internal gear
7. Fixed connection to housing
8. Double gear train
9. Internal gear 2
10. Sun gear 2
11. Sun gear 3
12. Double planet carrier

Power Flow in 1st Gear: Drive clutch A is engaged in 1st gear. The sun gear 3 in the double planetary gear train is driven and is meshed with the short planet gears. Due to clutch D being engaged, the double planet carrier is held by the gearbox housing. As a result, the internal drive gear is driven over the long planet gears (large gear reduction) in the direction of engine rotation.



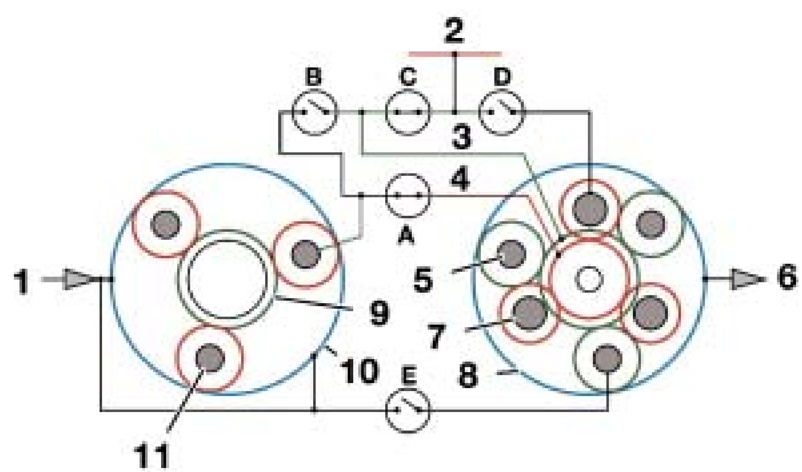
42-05-15

Planetary Gear Train

1. Drive (turbine shaft)
2. Gearbox housing
3. Sun gear 2
4. Sun gear 3
5. Planet gear, long
6. Output
7. Planet gear, short
8. Internal gear 2
9. Sun gear 1 (stator shaft)
10. Internal gear 1
11. Planet carrier

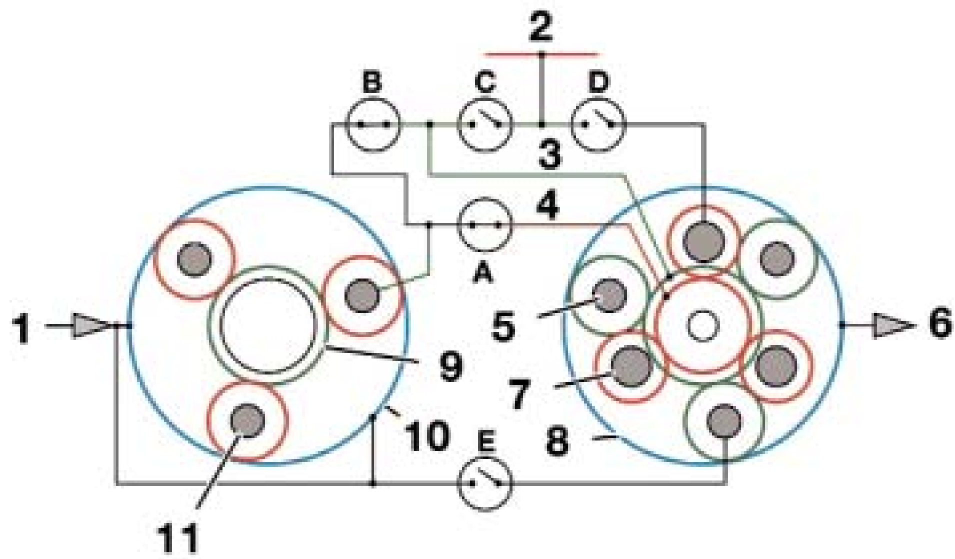
A - Drive clutch
B - Drive clutch
C - Brake clutch
D - Brake clutch
E - Drive clutch

Power Flow in 2nd Gear: Clutch A is also engaged in 2nd gear so that sun gear 3 (4) in the rear gear train is driven. Sun gear 2 (3) in the rear gear train is now blocked by clutch C. The long planet gears and the short planet gears move on rolling contact (reaction) with the fixed sun gear 2 and drive the double planet carrier as well as the internal gear 2 in the direction of engine rotation (gear up - ratio change).



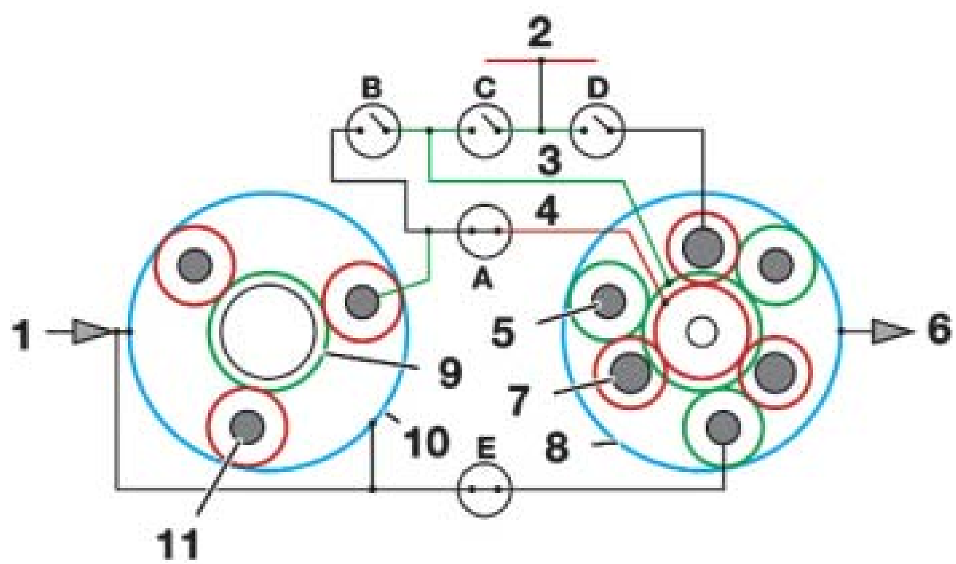
42-05-14

Power Flow in 3rd Gear: As in 1st and 2nd gear, drive clutch A is engaged. Drive clutch B is now also engaged. Both sun gears in the double planetary gear train are driven (reaction). As a result, the gear train moves as an assembly and the gear ratio is achieved only by the front single planetary gear train (gear up - ratio change).



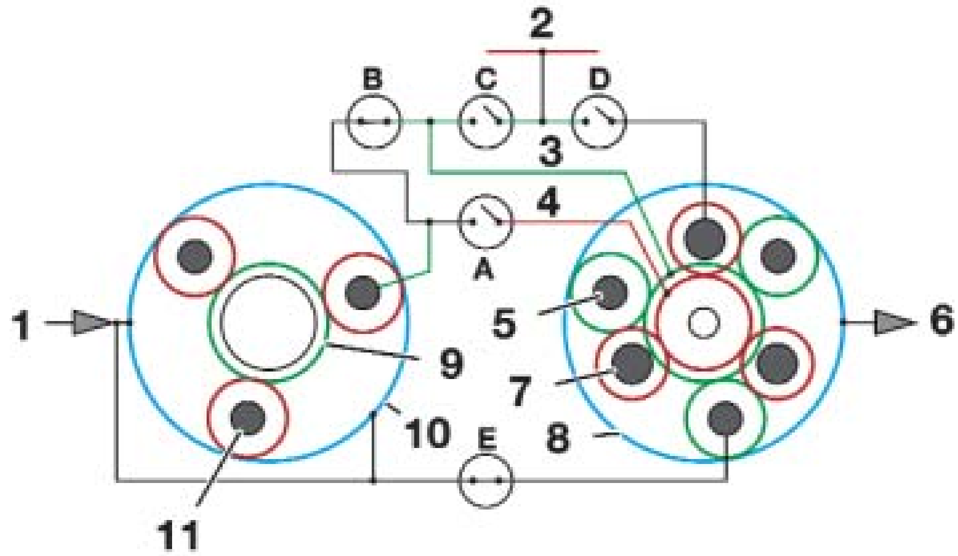
42-05-16

Power Flow in 4th Gear: Drive clutches A and E are engaged in 4th gear. Clutch A drives the sun gear 3 (4). Clutch E drives the planet carrier in the double planetary gear train. Together with the double planet carrier, the long planet gears and the short planet gears drive the internal gear 2 in the direction of engine rotation (gear up - ratio change).



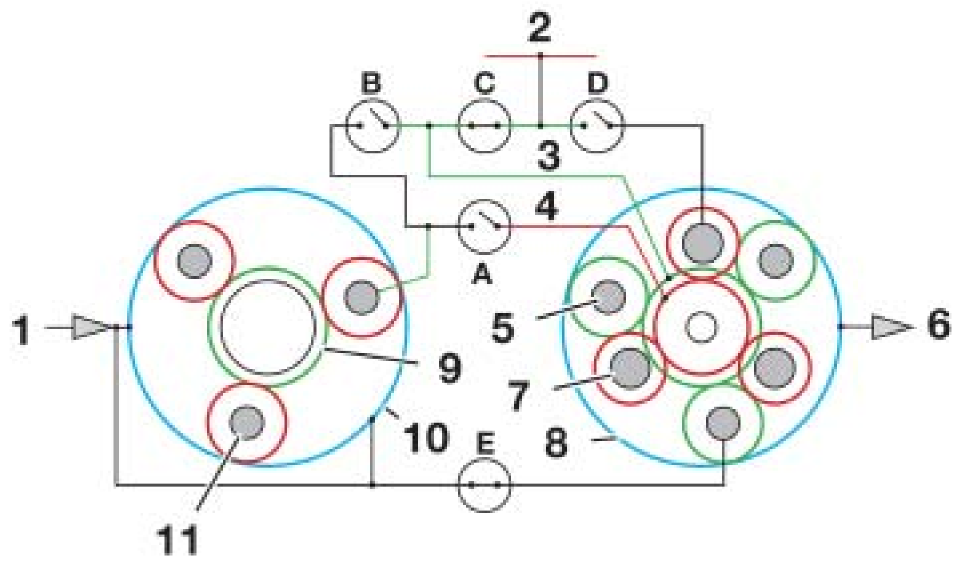
42-05-17

Power Flow in 5th Gear: Drive clutches B and E are engaged in 5th gear. The sun gear 2 (3) in the double planetary gear train is driven by clutch B and the planet carrier of the double planetary gear train by clutch E. Together with the double planet carrier, the long planet gears and the short planet gears drive the internal gear 2 in the direction of engine rotation. ***This results in a gear ratio with a slight overdrive.***



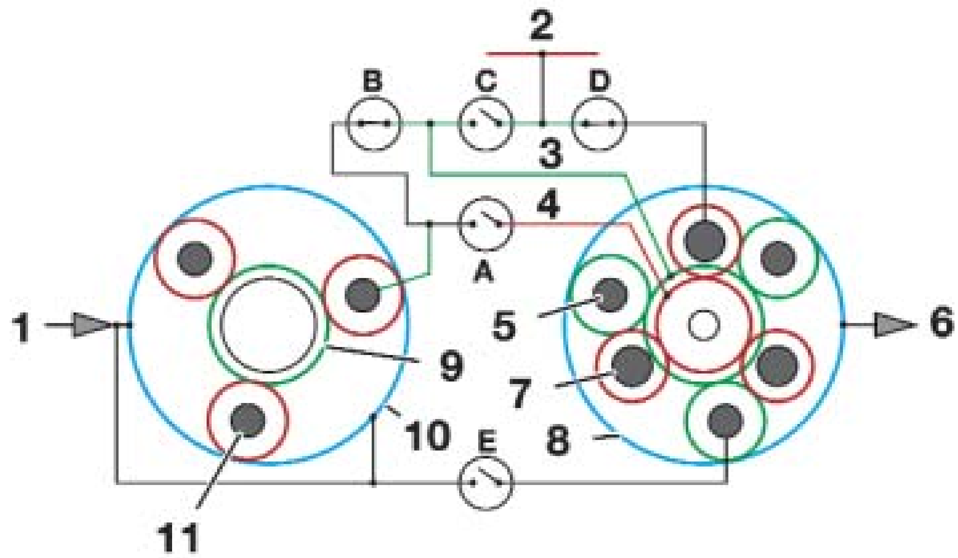
42-05-18

Power Flow in 6th Gear: In 6th gear, the sun gear 2 in the double planetary gear train is blocked by clutch C. The planet carrier is driven by the engaged clutch E. As a result, the long planet gears are forced to move by rolling contact (reaction) on the fixed sun gear 2 (3) and drive the internal gear in the direction of engine rotation. ***This results in a large gear ratio in overdrive.*** The single gear train is not operative in 6th gear.



42-05-19

Power Flow in Reverse Gear: The drive clutch B is closed in reverse gear. As a result, the sun gear 2 (3) in the double planetary gear train is driven while being in mesh with the long planet gears. The double planet carrier is supported by brake clutch D and the gearbox housing. The internal gear 2 (output shaft) can now be driven by the long planet gears in the *opposite direction* of engine rotation (large gear reduction).



42-05-20

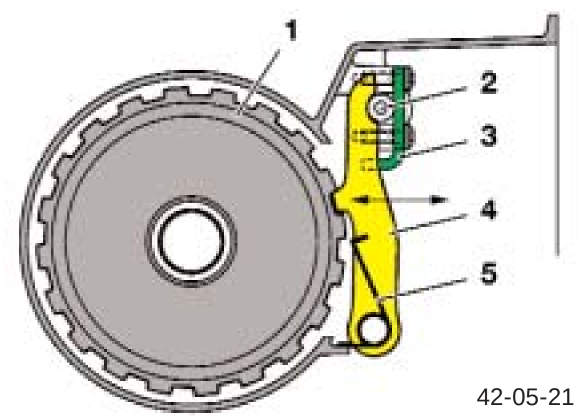
Notes:

Parking Lock

The parking lock secures the vehicle to prevent it from rolling away. When the vehicle is stationary it is electrically applied by a solenoid valve as requested from the selector lever.

The parking lock “locks” the output shaft of the gearbox when the linking rod (2) is extended to pivot the pawl (4) to engage in the gear teeth of the parking lock disc gear wheel (1). The parking lock will hold the vehicle on uphill or downhill gradients of up to 32% and will only engage at speeds below 2 km/h. The Mechatronic Control Module will prevent the parking lock from engaging at speeds above 2 km/h.

1. Parking lock disk (gear wheel)
2. Linking rod
3. Guide plate
4. Parking lock pawl
5. Lock pawl lifting spring



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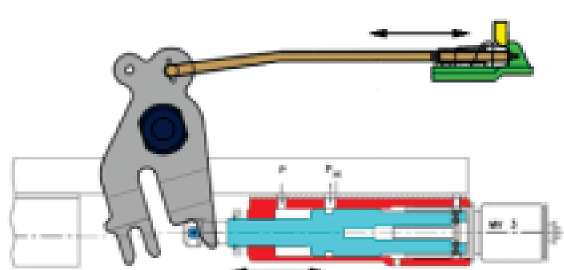
Parking Lock

Principle of Operation

In the electrical parking lock, a combination of mechanical lock engagement (as described above) and electric/hydraulic activation are used. The electrical components include magnetic solenoid valves (MV2 and MV3) mounted on the valve body. MV3 is mounted into the parking lock hydraulic cylinder.

Electrical activation of the parking lock is triggered by a push-button on the selector lever or by removing the ignition key. Activation of the solenoid valves is controlled by the Mechatronic Control Module.



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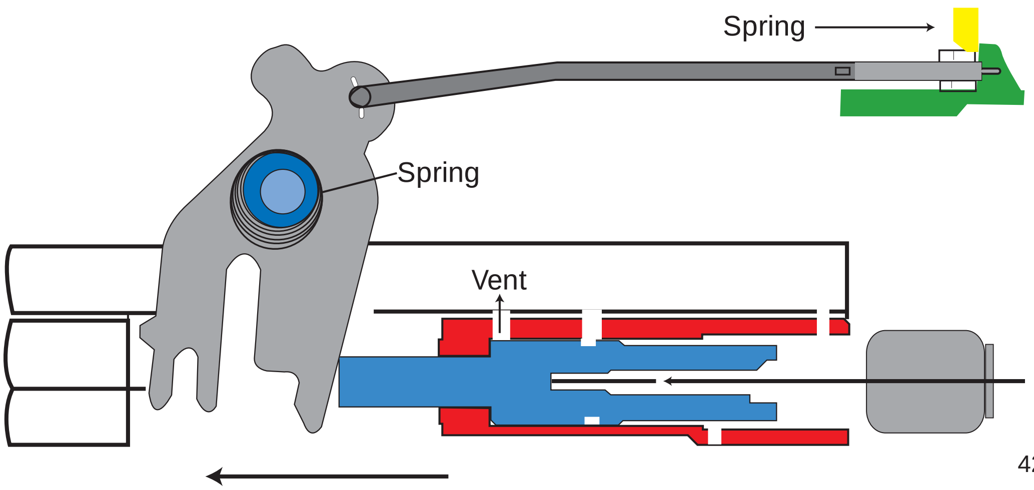
When the parking lock is engaged the solenoid valve (MV3) for the parking lock cylinder is deactivated, cancelling the electro-mechanical lock and the piston released. The solenoid valve (MV2) is also deactivated and the chamber of the parking lock cylinder is vented. The piston is pulled to the parking lock position by a preloaded barrel spring behind the operating lever. The linking rod is extended to pivot the pawl to engage in the parking lock disc.



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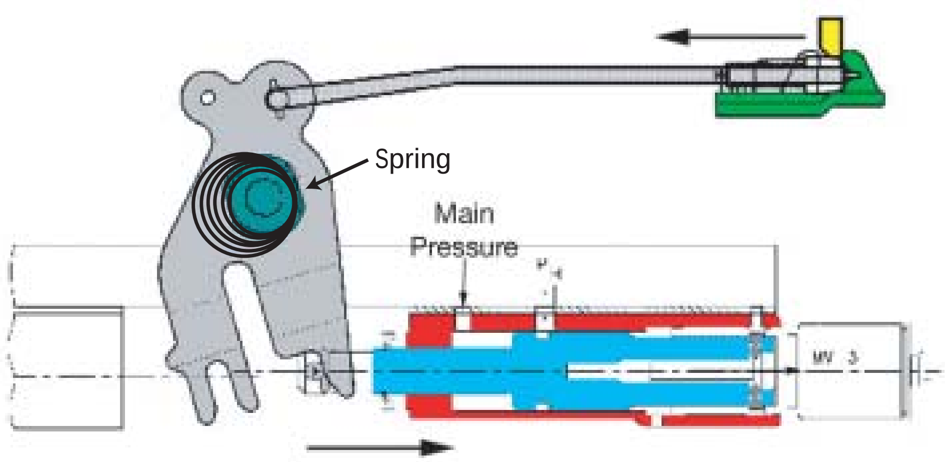
When the parking lock is disengaged (below) the MV2 solenoid valve is activated and the main pressure is applied in the chamber of the parking lock cylinder. This pushes the piston, operating lever and linking rod back to release the parking lock. The parking lock pawl is lifted by a spring to disengage from the gear teeth of the parking lock disc gear wheel. The MV3 solenoid valve for the parking lock cylinder is also activated. The piston is additionally held by locking (detent) balls in position “N” when the engine is not running.

The transmission can be shifted from the park position to position “N” only with the engine running (main pressure required). If engine operation is not possible, the parking lock can be released manually by an additional bowden cable.



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Examples:

- The parking lock is engaged by pressing the “P” push button on the selector lever when the speed signal is less than 2 km/h.

- The parking lock is automatically engaged when the ignition key is removed and the speed signal is 0.

- Position “N” is automatically engaged when the engine is turned off (ignition switched off) with the key remaining in the lock. The park position will be automatically engaged after approximately 30 minutes. Position “N” can remain engaged for a further 30 minutes if position N is selected again before the 30 minutes have elapsed.

- The parking lock is disengaged only by moving the selector lever in position R, D or N with the engine running and the brake pedal pressed.

Interaction Between Parking Lock and EMF: An electromechanical parking brake (EMF), is fitted in the E65. Based on the operating status of the EMF, it is possible to engage the parking lock when the engine is not running in the event of a fault in the EMF.

Interaction During EMF “AUTO HOLD” Function: The parking brake and parking lock is engaged when the driver leaves the vehicle with the engine running with position D or R engaged, seat is not occupied and the door is opened.

Interaction Between EMF and EGS in the Case of Fault: If the EMF cannot switch from the "hold" to "lock" mode, the parking lock is engaged following a plausibility check in the EGS control unit. The plausibility check determines whether position N is engaged, the speed is 0 km/h and the engine and ignition are off.

Notes:

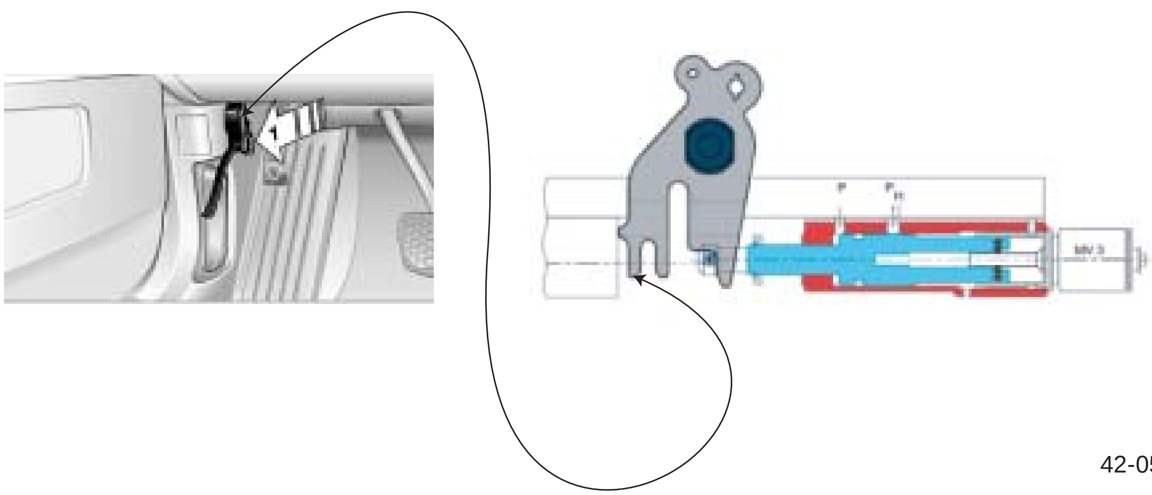
Emergency Release for Parking Lock

A mechanical emergency release is provided if the parking lock can not be automatically released (battery failure, engine, engine electrical system, transmission electrical system, etc.). This allows the vehicle to be towed or pushed as required.

To tow the vehicle, the emergency release must be operated even if the transmission control is fully operable. Depending on the type of fault, the N-hold function cannot be guaranteed during the entire time even if an output speed is recognized (corresponding information in the Owner's Handbook and Towing Instructions for BMW 7 Series).

The emergency release for the parking lock is located in the vehicle interior at the A-pillar in the footwell on the driver's side (1). On US vehicles, the emergency release can only be accessed with the vehicle key releasing the locked cover. ***Before performing this procedure, apply the brake pedal!***

A cable assembly is routed from the operating lever to the gearbox lever on the selector shaft. The emergency release should not be operated during normal vehicle operation. After being released, the "gearbox emergency released" message is displayed in the position indicator section of the instrument cluster.



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The emergency release must be reset to re-engage the parking lock after eliminating the fault. The gearbox lever moves during normal operation and must not be influenced by the cable assembly. Press on the red tab on the back side of the lever and guide the lever assembly back into the orignal position.

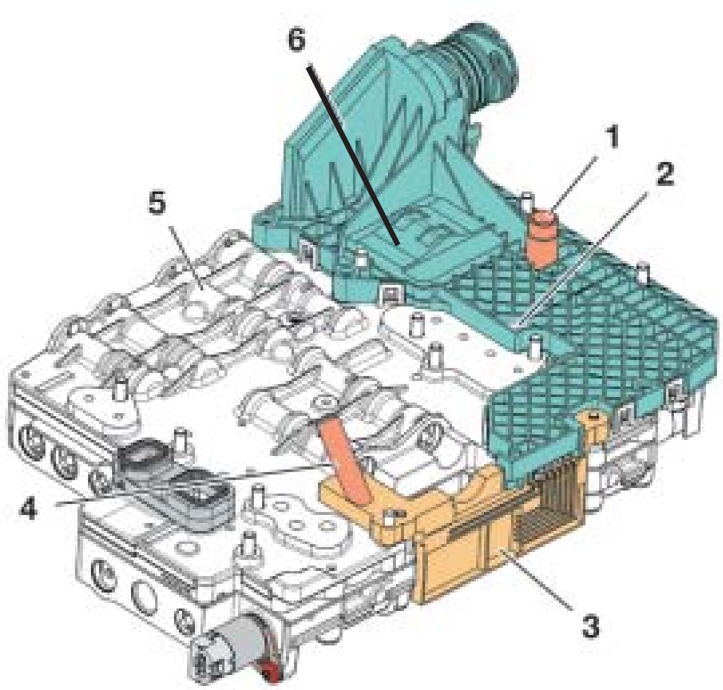
When the emergency release has been operated by mistake or not reset after repairs it is detected by a plausibility check of the actual position by the two park position sensors in the gearbox. In this case, the parking lock cannot be engaged automatically. The driver is informed by an error message in the instrument cluster (Check Control).

Electric-hydraulic Control

System Components

Mechatronic Module: The mechatronic module is a combination of the hydraulic valve body and electronic control module which are installed in the oil sump. This is the first time the mechatronic module is used in a BMW automatic transmission. This offers the advantages of improved shift quality, increased driving comfort and increased reliability due to the reduced number of electrical connections and interfaces.

The hydraulic valve body contains valves, springs, dampers and electric solenoid valves. ***The electronic control module manages the complete electronic control of the transmission and is an integral part of the valve body (replaceable as a complete unit).*** The electronic control module is completely sealed and oil tight.



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Electric-Hydraulic Control

1. Output speed sensor
2. Temperature sensor
3. Position switch
4. Turbine (input) speed sensor
5. Hydraulic module (valve body)
6. Electronic Control Module

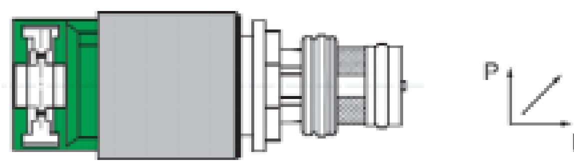
The electronic-hydraulic transmission gearshifts in the GA6HP26Z are controlled by 3 solenoid valves and 6 electronic pressure control valves. These components are not separately replaceable at this time.

Solenoid Valves (MV): Three solenoid valves are mounted on the valve body and are 3/2-way valves, i.e. valves with three hydraulic connections and two electrically switch positions. The solenoid valves are activated by the electronic control module.

Electronic Pressure Control Valves (EDS): The electronic pressure control valves convert electrical current into a proportional hydraulic pressure. They are regulated by the electronic control module to activate the hydraulic valves (in the valve body) to the pistons in the clutch assemblies. Two types of EDS valves are used:

EDS with rising characteristic curve

- EDS valves 1, 3 and 6 are identified by a green cap.
- The rising characteristic curve starts at 0 mA = 0 bar, up to 700 mA = 4.6 bar.
- Operating voltage - 12 V
- Resistance at 20 ºC = 5.05 Ohm



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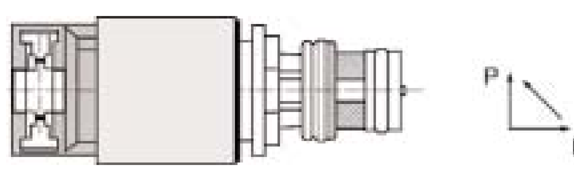
EDS with falling characteristic curve

- EDS valves 2, 4 and 5 are identified by a black cap.
- The falling characteristic curve starts at 700 mA = 0 bar, up to 0 mA = 4.6 bar.
- Operating voltage - 12 V
- Resistance at 20 ºC = 5.05 Ohm



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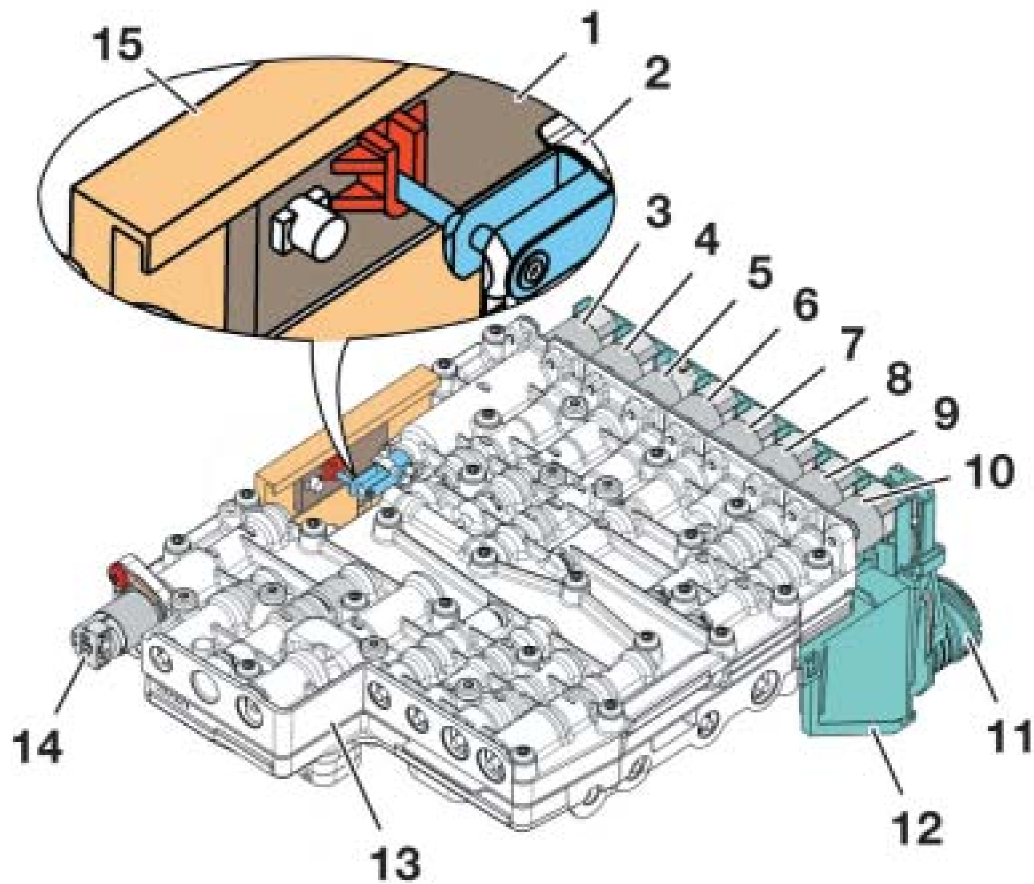
Location of Solenoid Valves and Pressure Control Valves

Note: Care must be taken when installing the Mechatronic module to ensure that the piston of the parking lock cylinder (2) is engaged in the position switch (15).



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Solenoid Valves and Pressure Control Valves

1. Position Switch Slide
2. Parking lock cylinder piston
3. Solenoid valve 3, parking lock cylinder
4. EDS
5. Solenoid valve 1
6. EDS 4
7. EDS 5
8. EDS 3
9. EDS 2
10. EDS 1
11. Electronic plug connector
12. Electronic module
13. Hydraulic module (valve body)
14. Solenoid valve 2
15. Position switch

Solenoid Valve and Clutch Logic

POS / gear	Solenoid valve logic									Clutch logic					
		MV		P-EDS						Drive clutches				Brake clutches	
	1	2	3	1	2	3	4	5	6	A	B	E	WK	C	D
P = Park							X	-X-							●
R = Reverse	X	X	X				X	-X-			●				●
N = Neutral	X	X	X				X	-X-							●
D, 1st gear	X	X	X	X			X	-X-	-X-	●			●		●
D, 2nd gear		X	X	X		X		-X-	-X-	●			●	●	
D, 3rd gear			X	X	X			-X-	-X-	●	●		●		
D, 4th gear	X		X	X			X	-X-	-X-	●		●	●		
D, 5th gear	X		X		X		X	-X-	-X-		●	●	●		
D, 6th gear	X		X			X	X	-X-	-X-			●	●	●	
	Shift valve 1	Parking lock valve	Parking lock cylinder	Clutch A	Clutch B	Brake C	Brake D / clutch E	System pressure (situation-related)	Gear logic control (situation-related)	Planet carrier Single gear train	Sun gear 1 (double gear train)	Carrier Double Gear Train	Situation-related control of converter lockup clutch	Sun gear 1 (double gear train)	Planet carrier (double gear train)

X Activated
-X- Situation-related control
● Engaged

42-06-30

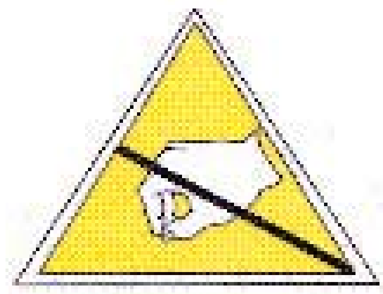
Notes:

Work Shop Hints

Note:

- The transmission requires ***oil replacement every 100,000 miles.***

- Contact the BMW Technical Hotline for additional assistance.



- Consult the Repair Information (in TIS) and the Service Information Bulletins regarding ***static electrical discharge*** before any repair attempts are made to the Mechatronic Module!

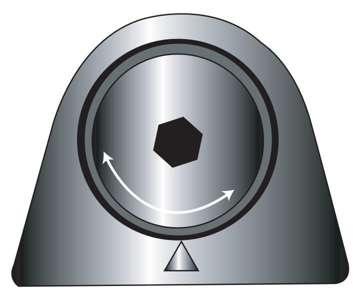
- The oil pan can only be removed at temperatures below 40 ºC. The oil pan is made of plastic which will distort at high temperatures.

- External seal replacement, torque converter replacement and replacing the Mechatronic as a unit assembly are the only recommended repairs at this time (aside from replacing the complete transmission). No repair attempts should be made to the valve body components (mechanical or electrical) or the electronic control module.

The drain plug is found in the rear of the oil pan. There are ***final alignment indications*** embossed in the drain plug and the oil pan.

When installing the drain plug, observe the tightening torque. The arrow (embossed in the oil pan) must locate within the range span (embossed in the plug) .

Do not overtighten the drain plug because the plug and oil pan will distort or crack!



42-05-52

The inlet oil filter and debris magnets are integral in the oil pan (replaced as a unit).

When installing the oil pan, observe the tightening torque of the bolts.

Do not overtighten the bolts because the oil pan will distort or crack!

42-05-54

The harness plug insulating sleeve must be removed prior to removing the Mechatronic Module from the transmission housing.

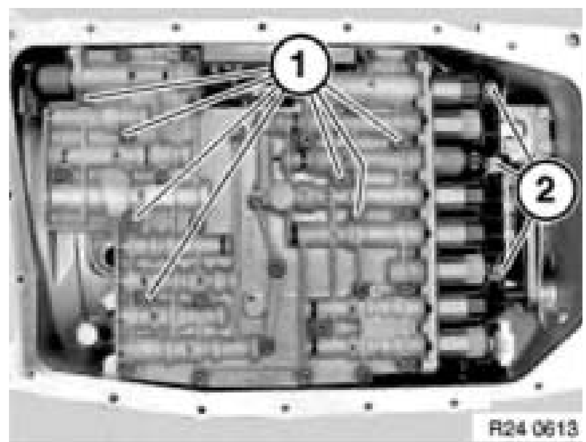
The sleeve is released by sliding the lock lever up as shown to the right. The sleeve is then pulled from the transmission housing.

After the sleeve is installed in the transmission housing, the lock lever must be slid down until it locks.

42-05-53

When unbolting the Mechatronic Module for replacement, ***only the Torx T40 bolts (1) and (2)*** in the diagram are to be loosened to remove the assembly from the transmission housing (as per the Repair Information).

1. = M6 x 58 mm
2. = M6 x 20 mm

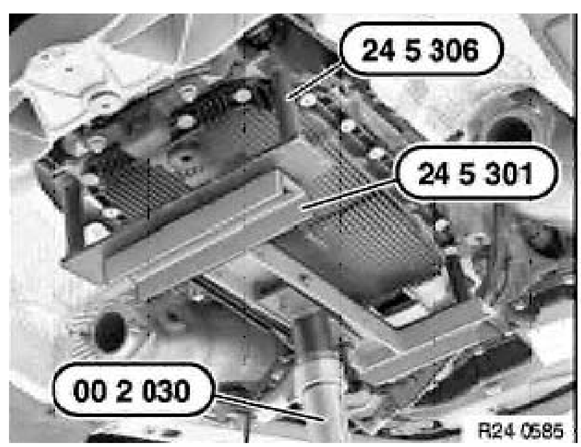


42-05-14

Mechatronic Removal

Consult the ***TIS for the correct tightening torque*** on installation. When installing the Mechatronic module, make sure that the piston of the parking lock cylinder and the control lever is engaged in the position switch.

Use the ***Transmission Support (Special Tool) PN 90 88 6 245 306*** in conjunction with 88 88 6 002 030 for removal/installation of the complete transmission.

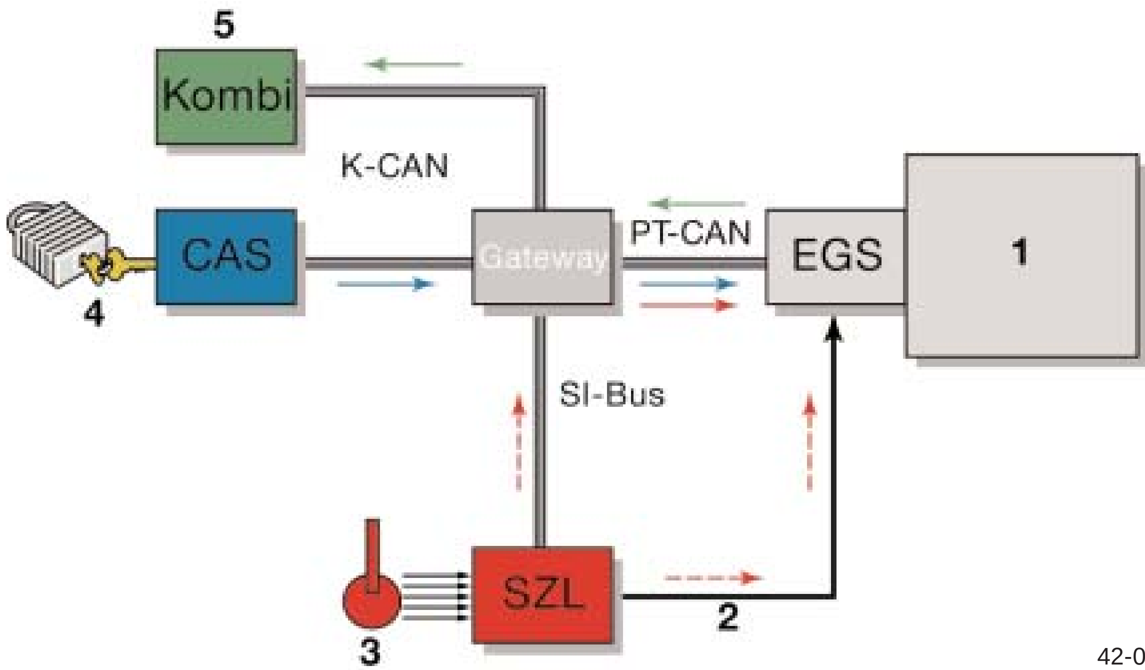


42-05-13

Transmission Removal

Electronic Transmission Control

The electronic transmission control module is an integral part of the Mechatronic Module. The electronic inputs are evaluated in the control module and electronic actuation is output to control the shifts and regulate shift quality. The control module is integrated in the E65 electrical system by the PT-CAN bus (power train) connection and a separate data link (hardwire) for signal transfer between components.



42-05-32

Electronic Transmission Control

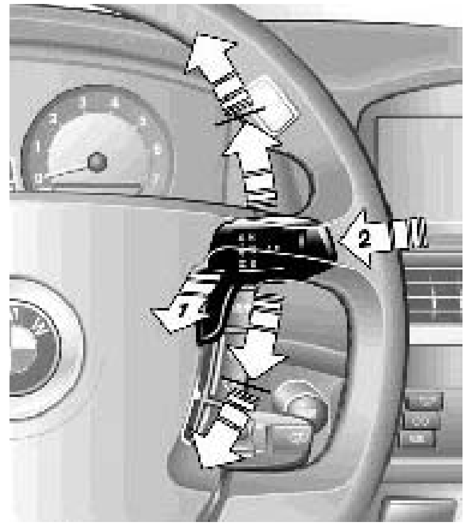
1. Automatic transmission
2. Serial, unidirectional line (hardwire)
3. Selector lever
4. Ignition Key
5. Display, position indicator
   CAS module-Car access system

Gateway-Central gateway module (ZGM)
EGS-Electronic transmission control module
SZL-Steering column switch center
PT-CAN (Powertrain)
K-CAN (Body)
SI-Bus-Safety and Information Bus, byteflight optical fiber

In addition to the bus line, the signal transfer between the steering column switch center (SZL) and the transmission control module additionally takes place over a unidirectional serial line (hardwire) for safety reasons. The central gateway module (ZGM) is a link in the data transfer from one bus to another.

The data required for gear shifts are injection timing, engine speed, Valvetronic position, engine temperature and engine intervention. These signals are transmitted between the ECM and transmission control module over the PT-CAN bus.

System Components



42-05-14

Selector Lever: The selector lever is located on upper right of the steering column. Shift position N, D and R are possible. The parking lock P is operated with a push button on the end of the selector lever (2).

All gearshifts are electrically controlled - ***there is no mechanical connection to the gearbox from this lever.*** The positions are indicated in the instrument cluster.

Selector Lever Positions in Automatic Mode

The shift pattern consists of positions R, N, D and the corresponding arrows. The selector lever can be moved from its mid-position by pulling back towards the driver (1). The lever can then be moved in a clockwise or counterclockwise direction and returns from each position automatically to the mid-position. Position P is separated from the shift pattern and is activated by pressing the push button at the end of the selector lever (2).

- **Position R:** With the brake pedal pressed, the selector lever must be pulled back and pressed as far as it will go in the counterclockwise direction (past detent).

- **Position N:** With position R engaged, N can be engaged by pulling the selector lever back and pressing it in the clockwise direction (up to but not beyond detent). When position D is engaged, position N can be engaged by pulling the selector lever back and pressing it in the counterclockise direction (up to but not beyond detent). When position P is engaged, position N can be engaged by pulling the selector lever back and pressing it in either direction.

- **Position D:** With the brake pedal pressed, the selector lever must be pulled back and pressed as far as it will go in the clockwise direction (past detent).

- **Position P:** Position P is engaged by pressing the push button integrated in the selector lever. The parking lock is released by depressing the brake pedal and engaging position R, N or D.

Special Features

- The transmission can be shifted from the park position to position "N" only with the engine running (main pressure required) and the brake pedal depressed.

Automated Functions

- The park position is automatically engaged when the ignition key is removed.

- Position N is engaged automatically when the engine is turned off and the ignition is switched off with the key remaining in the lock. The park position is then automatically engaged after approximately 30 minutes. Position N can remain engaged for an additional 30 minutes if position N is selected again before the 30 minutes have elapsed.

L/D Push Button in MFL: US vehicles are equipped with the L mode (limiting function) which allows the driver to suppress certain shifts (ascending or descending steep grades).

Starting from position D, the limitation mode is selected by pressing the L/D push button. Initially, the current gear is retained and the vehicle will not upshift to a higher gear.

42-05-15

The system returns to the automatic mode by pressing the L/D button again or pressing the selector lever to position D.

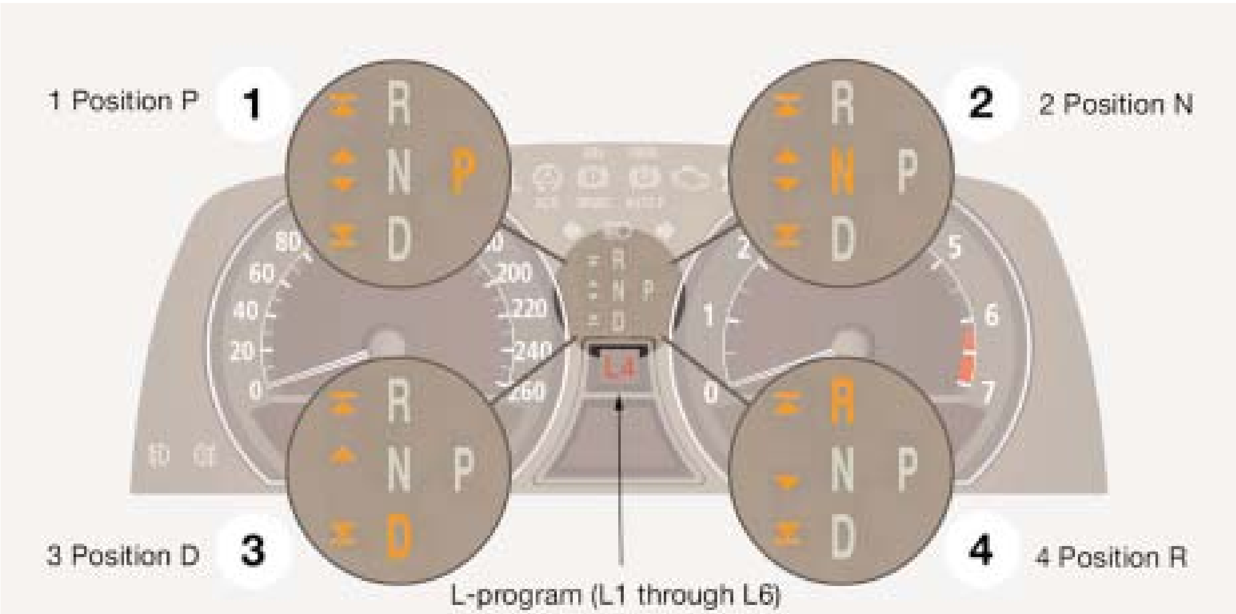
Example: Position D is engaged and the gearbox is in 4th gear. After pressing the L/D push button in the MFL, 4th gear is retained and is the upper limit. Gears 1 through 4 will be shifted automatically when the vehicle is driven.

There are two push buttons integrated in the steering wheel facing the driver (ten and two o'clock position as shown above). The limitation stages are manually downshifted by pressing either of these buttons when the L mode is selected. It is not possible to upshift the limitation stages. There is no forced upshift when reaching the maximum engine speed.

When the L mode is selected, the indicator in the instrument cluster will illuminate to indicate L1 through L6.

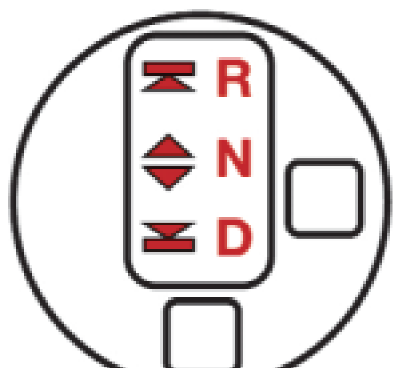
Impermissible shift requests, such as a down shift that will cause the engine to exceed the maximum speed are suppressed by the transmission control module and are indicated only temporarily in the instrument cluster.

Position Indication with Shift Pattern: The engaged position is only indicated in the instrument cluster. Depending on what position is selected, the corresponding selection is illuminated in the shift pattern. The arrows indicating the possible movement directions of the selector lever are also illuminated. An additional indication is provided in the L mode.



42-05-36

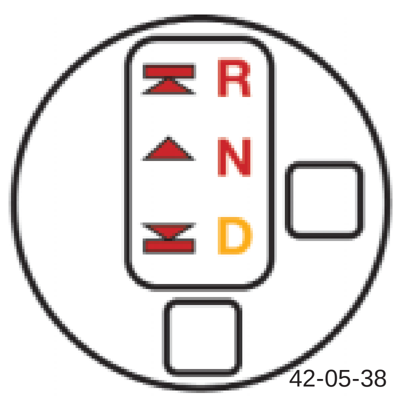
After switching on the ignition and starting the engine, the P or N positions and all of the arrows are indicated. In positions D or R, the single arrow for the shift direction to return to N is indicated (next to the N indicator).



42-05-37

Detailed explanations for Typical Indications:

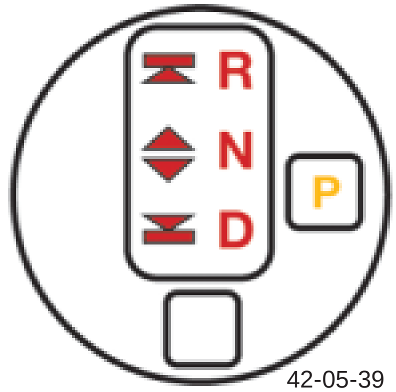
The ***shift pattern*** consists of the locator illumination for the R, N and D positions with the associated arrows. This is indicated when the ignition is "ON" and the transmission is not in position P.



42-05-38

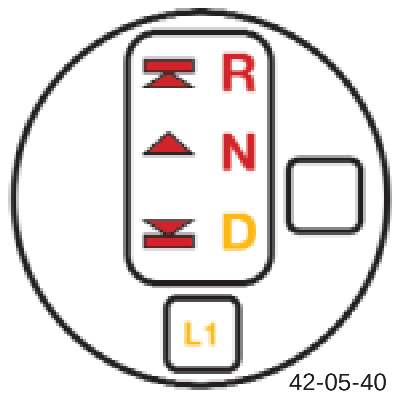
The ***position indicator*** for R, N or D is highlighted corresponding to the engaged gear position (position D is highlighted here). The positions are indicated when the ignition is "ON" and the transmission is not in position P.

Position P is separate from the actual shift pattern. P is indicated in the instrument cluster only when the park position is engaged and the ignition is “ON”.



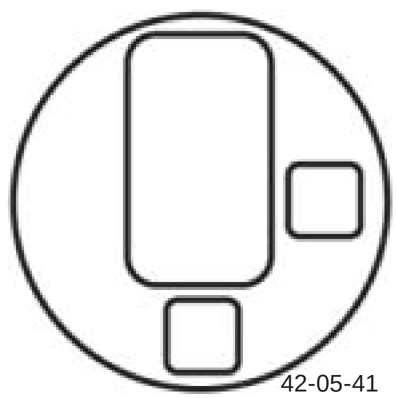
42-05-39

The ***L mode*** is indicated in a separate display and illuminates L1 through L6 when the L mode is selected. Impermissible shift requests, such as a down shift that will cause the engine to exceed the maximum speed are suppressed by the transmission control module and are indicated only temporarily.



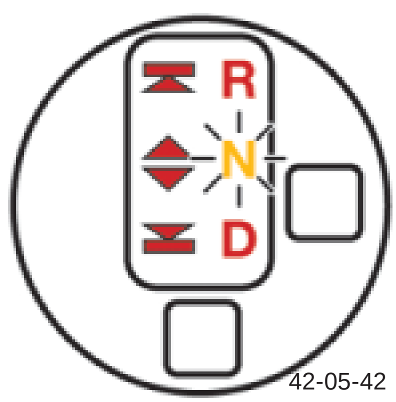
42-05-40

The indicator in the instrument cluster is ***blank*** when the P position is engaged and the bus is in sleep mode. This can also occur when position P is engaged and the bus wakes up, the CAN signals are valid but terminal 15 is OFF.



42-05-41

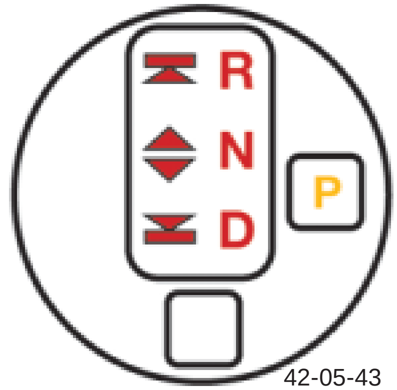
The N position indicator will begin to ***flash*** before the N-hold function elapses (30 min). Flashing takes place at a frequency of 1.5 Hz, controlled by the transmission control module.



42-05-42

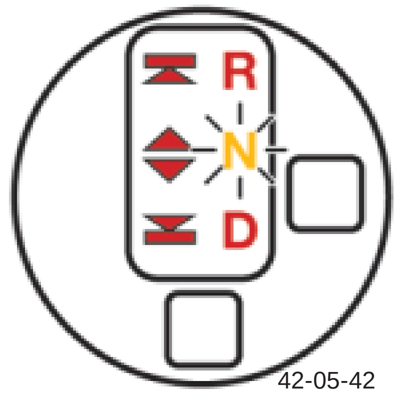
Detailed explanations for Fault Indications:

When the ***CAN signals are invalid*** and the activation line is "high", the shift pattern and P position indicator are illuminated when position P is engaged (Bus is awake).



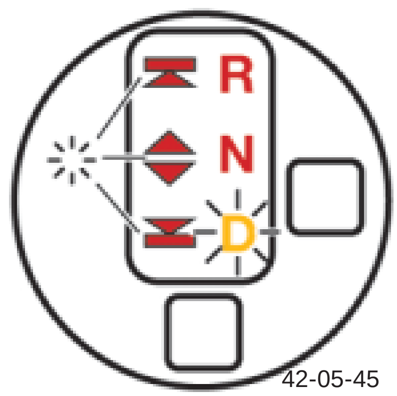
42-05-43

When the ignition is switched “ON” and the transmission control module ***does not detect the P position***, position N will flash in addition to the Check Control message “emergency release may be operated”. This can also occur if the Bus is awake, KL15 is ON and the Bus activation line is "high".



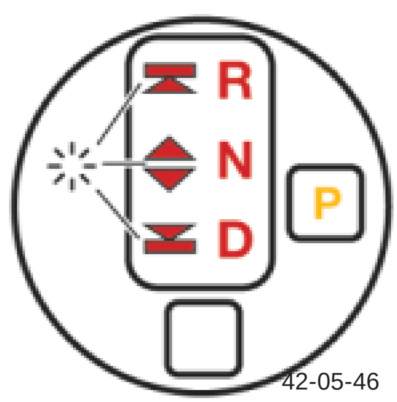
42-05-42

This display is illuminated when the transmission is in the ***mechanical emergency operation*** (with forward movement). The R and N illumination will remain on and all of the arrows along with the D position indicator will flash at a frequency 1.5 Hz.



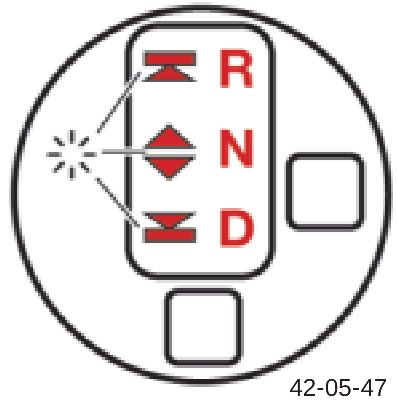
42-05-45

This display is illuminated when the transmission is in the ***mechanical emergency operation*** and in the P position. All of the arrows will flash at a frequency 1.5 Hz. The shift pattern locator illumination for R, N, D will remain on and the P position is indicated.



42-05-46

This display is illuminated when the transmission is in the ***mechanical or electrical emergency operation and the CAN communication is not functional.***



42-05-47

In the event of a transmission failure or a CAN bus error, the instrument cluster assumes control and will illuminate this display. All of the arrows will flash at a frequency 1.5 Hz. The shift pattern locator illumination for R, N and D will remain on and the P position indicator is switched off.

Notes:

Principle of Operation

The data required for gear shifts is transmitted between the ECM and transmission control module (EGS). The transmission control module requires additional information from the vehicle for operation. In addition, other control modules in the E65 require information about the electronic transmission status.

The PT-CAN bus is used for this purpose, below is a list of the the signals and components:

Signals	Transmitter	Receiver
Selector switch	SZL	EGS
Ignition terminal status	CAS	EGS
Central locking system	CAS	EGS
Transmission data (P/N)	EGS	CAS
Engine data	ECM	EGS
Wheel speeds	DSC	EGS
Deceleration request	EMF	EGS
Display, transmission data	EGS	Instrument cluster
Check Control message	EGS	Instrument cluster
Torque requirement	EGS	ECM
Battery voltage	Power module	EGS
Electric loads (30 min. N hold)	EGS	Power module

Note: The turbine (input) and output speeds of the gearbox are determined with Hall sensors that transfer the values directly to the electronic transmission control module. The position switch also transfers information directly over a hardwire.

As in previous transmission control modules, the "flash" programmable coding is for the new control module.

The processor of the transmission control module features a 440 KB internal flash memory. Approximately 370 KB of this is taken up by the basic transmission program. The remaining 70 KB contain the vehicle specific application data.

Interlock

The CAS module signals the "ignition key inserted or not inserted" status to the transmission control module. The parking lock is engaged in the transmission when "ignition key not inserted" is signalled. The parking lock can only be released when the ignition key is inserted, the engine is running, the brake pedal is depressed (Shiftlock) and R, N, or D is selected.

Starter Interlock

The engine will only start in position P or N. The CAS module evaluates two signals from the transmission control module to activate the starter:

- The gearbox P or N position (CAN signal)
- Position P over the hardware line from the P position sensors

The engine can still be started in position P in the event of a CAN signal fault. The engine can not be started if the emergency release is operated (not in P position). In addition to evaluating these two signals when the ignition is switched “OFF”, the transmission always rests in "hydraulic neutral" so the gearbox will not transfer power during an engine start.

Warm-up Program

The warm-up program is selected after every engine start when the engine temperature is below 60 ºC (approx.). The upshifts occur at a higher engine rpm allowing the engine and catalytic converters to reach operating temperature faster. The warm-up program is not in effect when the engine temperature is above 60 ºC or after 120 seconds of operation.

Downshift Inhibit

This function prevents a downshift when the maximum engine speed will be exceeded, preventing engine and transmission damage.

Reverse Interlock

This prevents shifting into reverse gear at a speed above 5 km/h. If the reverse gear is selected at a speed above 5 km/h, the gearbox will shift into neutral and N is indicated in the instrument cluster. Only when the vehicle has reached a speed of less than 5 km/h is it possible to select reverse gear by operating the selector lever again.

Adaptive Transmission Control

As in the previous automatic transmissions, there are different adaptation modes for the A-program (automatic - in selector lever position D) in the 6-speed automatic transmission.

Adaptive transmission control provides the following features:

- Shift points and shift pressures based on driver type
- Maintains shift quality over the lifetime of the transmission through adaptive pressure control
- Torque converter lock up clutch.

In the A-program, only the basic shift characteristic map XE (extreme economy) and the performance-oriented shift characteristic map E (economy) are selected. The A-program offers the driver comfortable gearshift characteristics with very smooth gear changes.

The control module simultaneously monitors engine speed, turbine (input) speed and output speed. This is necessary to determine the slip ratio and slip time during a shift. Slip ratio and slip time are influenced by production differences between transmissions and normal wear.

The control module performs the adaptive pressure control function by modifying the control of the EDS valves increasing the clutch apply pressures to compensate for internal slip. The adaptive pressure control function optimizes the shift quality and increases the life span of the clutch plates.

Pressure adaptation takes place automatically while driving. After performing repairs on the transmission, it is necessary to reset the pressure adaptation with the DISplus. A test drive should then be performed ensuring that the transmission is driven in all gears.

Driver Type Adaptation

In the 6-speed automatic transmission, the driver type adaptation is based on the values of kick-fast, cornering evaluation, brake evaluation and constant driving evaluation. The adaptation function evaluates the longitudinal and transverse dynamics from the standard controls such as accelerator pedal, brake and steering. The current driving status and driver's load choice are calculated from these values.

Based on these values, the adaptation offers a basic gearshift program. To achieve the most fuel economy and comfort, a conservative shift characteristic is selected for driving situations without specific power requirements.

For example, when driving in the highest possible gear and increased power is required, a downshift is not implemented before the engine outputs the full torque. The downshift thresholds are very low so that a maximum of 2 gears can be downshifted over the full pedal travel range. Since this is not the optimum for each situation, the vehicle operation assessment function automatically provides the most suitable basic gearshift strategy.

Kick-Fast

The kick-fast function can change the basic gearshift program depending on the rate of speed that the accelerator pedal is pressed. The accelerator pedal value is compared to a threshold in the control module. As a result, one of two possible functions is selected:

- XE, extreme economy
- E, economy

Moderate movement results in moderate shifts while a quick application of the throttle initiates performance shifts.

Cornering Evaluation

This feature is activated when the control module detects a variation in front and rear wheel speeds (while cornering) from the DSC control module. In addition, the DSC monitors the steering angle sensor, yaw rate and overall vehicle speed to further determine the cornering forces.

When curves are recognized, the control module prohibits up shifting until the wheel speed signals equalize indicating the vehicle is driving straight ahead. Downshifts in conjunction with high power while negotiating a curve can have a negative influence on the stability of the vehicle.

Brake Evaluation

Using the same evaluation method as kick-fast, brake evaluation provides driver type information. Overrun downshifts are triggered at various high speeds depending on the braking requirement.

The vehicle deceleration is determined by the change in the speed proportional signals (wheel speeds or transmission output speed) or the braking pressure in the brake system. The shift speed for the individual downshifts (determined from one of the characteristic curves), depends on the set drive mode, the initial speed at the start of braking and the determined deceleration or brake pressure.

Constant Driving Evaluation

Constant driving evaluation takes place when the driver maintains a constant accelerator pedal position and the vehicle speed does not change. When requested, a downshift takes place immediately in the A-program.

Winter Program

The winter program is activated for the best possible stability and driving safety on slippery roads in winter in addition to control interventions by DSC. Wheel slip is evaluated by the control module based on wheel speed signal data provided by the DSC system over the PT-CAN bus. The control module modifies shift characteristics to match winter mode for better traction.

When active, the transmission will start in second gear and the shift points are lowered. The purpose of this program is to improve the stability of the vehicle with slippery road conditions. Downshift requests that would cause wheel spin are suppressed.

Hill Recognition Function

The control module activates this feature when it detects a high engine load (constant driving resistance) condition at lower road speeds. When the vehicle is traveling up hill the shift points are raised to prevent repetitive up/down shifting.

The parameters that reside in the control module for this feature include vehicle weight, gearbox, differential ratio, rolling resistance and wind resistance.

To adapt for performance reduction of the engine at high altitude, the uphill adaptation is influenced by the altitude compensation function in the ECM.

Cruise Control Shift Strategy

The cruise control function supports speed controlled operation to achieve smooth overall driving characteristics. This function ensures that the acceleration requested of cruise control is achieved while ensuring comfort is not impaired by increased gearshifts.

When cruise control is activated by the ECM, the transmission control module is notified over the PT-CAN bus. The transmission control module activates the program for cruise control operation which minimizes locking/unlocking of the torque converter clutch and up/down shifting. Additionally, the cruise control can request a downshift if the vehicle speed exceeds the set speed limit when coasting downhill.

Notes:

Emergency Programs

The following designs of the GA6HP26Z are used to reduce faults:

- Reduction of system interfaces by using the Mechatronic (assembly)
- Redundant selector lever signals and monitoring (PT-CAN and hardwire)
- Multiple substitute programs

Substitute program 1: restricted gear selection

Substitute program 2: corresponds to previous emergency program with only forward, reverse, neutral and park positions possible

Actuator (MV and EDS) deactivation: hydraulic/mechanical emergency operation

Electrical Emergency Program

The electrical emergency program shifts the transmission into 5th or 3rd gear (speed and previous gear dependent) after a CAN bus failure. After restarting the engine, 3rd gear is engaged when selecting position D. After a CAN bus failure, positions P, R, N and D are selected via a separate serial line (hardwire).

Caution: The Shiftlock function is also deactivated, making it is possible to engage a gear without pressing the brake pedal. This is also indicated by a Check Control message.

When KL15 is switched “OFF”, position P will be engaged immediately at speeds below 2 km/h. This is because the "key inserted/key not inserted" signal is not detected. The N-hold function is not possible with "engine off" (***Caution*** in car wash systems).

The instrument cluster can not detect a position change. The position indicator in the instrument cluster is blanked out. The shift pattern with R, N, D remains and the arrows will flash.

Notes:

Mechanical Emergency Program

The following applies in the event of total failure of the transmission control:

- No interruption in power transfer while driving forward (no gear changes)

- When the vehicle is stationary and "engine off": the parking lock will be engaged

The transmission electronics may still be in operation during the mechanical emergency program, communication may also still be possible but the power supply to the actuators (MV and EDS) is deactivated. The hydraulic system of the gearbox is designed so that restricted operation is still possible.

It is not possible to reselect a drive position with the selector lever. This means the vehicle can only be driven forward within certain restrictions until the engine is switched off. ***A drive position can not be engaged after turning the ignition off and restarting the engine.***

Vehicle safety is ensured because the parking lock engages when it is depressurized. As soon as the pressure in the parking lock cylinder drops the parking lock system is pretensioned mechanically (operating lever spring). The mechanical parking lock will not engage at speeds > 5 km/h. ***Once engaged, the parking lock can only be released with the mechanical emergency release.***

When the mechanical emergency program occurs:

- While driving forward, it is still possible to continue driving in 3rd/5th gear (3rd gear when 1st, 2nd or 3rd gear was previously engaged, 5th gear when 4th, 5th or 6th gear was engaged). This is interrupted by turning off the engine, the parking lock will engage once the hydraulic pressure has dropped.

- While in reverse, the gearbox assumes the neutral position and the parking lock is engaged (< 5 km/h).

- While in hydraulic neutral, the parking lock will engage (< 5km/h).

- In position P, the gearbox remains in this status and the parking lock remains engaged.

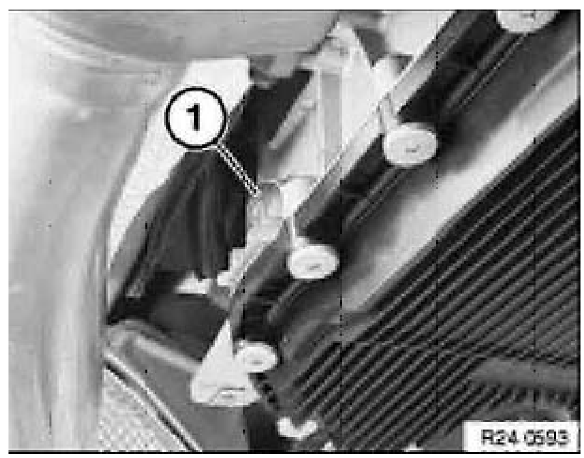
The driver is informed of the different emergency situations by the Check Control messages.

Feedback in the Event of a Failure

In the event of a total failure of the transmission control or the SZL, the selector lever operation can not be detected or implemented. In addition to the flashing shift pattern and the corresponding error symbols (shown to the right) in the instrument cluster, additional warnings will draw the driver's attention to the situation:

- Acoustic warning signal (gong)
- Acceleration limitation: This function reduces the start-off acceleration when the vehicle begins to move. This function is implemented by the ECM, depending on the restriction of the transmission control by a request or by PT-CAN timeout of the signals.

Workshop Hints



42-05-12

The GA6HP26Z automatic gearbox requires ***oil replacement every 100,000 miles.*** Only the approved oil must be used for replacement or after conducting repairs on the gearbox (consult the Operating Fluids information). Check oil level:

- The vehicle must be parked flat and level
- Check the oil level through fill plug (1) corresponding to the Repair Instructions (TIS)
- Observe the oil temperature *

* Diagnosis of this gearbox is carried out with the DISplus as part of the service and repair work.

42-05-16

A ***16 Pin Adapter Cable PN 90 88 6 246 080*** is used in conjunction with break out box 88 88 6 611 459 to adapt to transmission harness.

Check Control Messages

The E65 has different warning and information outputs depending on the driving situation and possible faults. The display provides more detailed information with longer and understandable texts in the control display. The message texts and characteristics are stored in the instrument cluster and are initiated by the transmission control module's evaluation of the fault. Only the transmission relevant faults and special messages are shown in the following charts.

Driving Situation Fault/consequences	**Check Control Message**	**Supplemental Information in the control display**
Temperature in gearbox high	Transmission Overheated! Drive moderately	Reverts to default shift program, reduce response. Avoid high speeds and engine loads.
Temperature in gearbox very high	Transmission Stop vehicle carefully	Transmission Overheated. Move selector lever to pos. P. Leave engine running. Allow trans. to cool then carefully cont. driving if problems persist, contact BMW Retail Center.
Selector lever CAN fault	Transmission fault! Drive moderately	Limited transmission operation Danger of complete trans. failure! Please contact the nearest BMW Center.
Key signal, invalid CAS, CAN fault, P-Magnet short to positive or open circuit, parking lock engaged incorrectly.	Trans. Range N only with engine on!	The transmission automatically shifts to P when the engine is switched off. Please contact your BMW Center as soon as possible.
Pos. P mechanical emergency operation active (also applies to emergency operation triggered in Pos. R and N)	Gearbox defective Transmission Fault!	The fault may be resolved by restarting engine. Contact the nearest BMW Center if necessary. Use emergency release to disengage park detent prior to towing or pushing vehicle.
Engine speed invalid ECM CAN fault	Transmission Failsafe! Drive moderately	Only P,R,N,D3 and D5 available Ranges may be engaged without depressing brake. Please contact the nearest BMW Retail Center. Have checked by nearest BMW Retail Center.

Driving Situation Fault/consequences	Check Control Message	Supplemental Information in the control display
Gear, monitoring and shift monitoring	Gearbox position R. Transmission range R. Fault!	Reverse gear cannot be engaged. It maybe impossible to select R. Reduce acceleration. Please contact The nearest BMW center.
Short to ground of an MV, EPS mechanical emergency operation and Pos. D Selector level signal fault (CAN and serial line)	Transmission range P,R, N Fault!	Only transmission range D is available. P engages auto. When engine is switched off Please contact the nearest BMW Retail Center.
V>3km/h, P-push-button invalid. p-sensor implausible	Trans. In P only when stationary!	
Signal from P-push-button invalid. P-sensor implausible	Transmission range P Fault!	Transmission range P may be unavailable. Engage parking brake when vehicle is stationary Please contact the nearest BMW Retail Center.
Parking lock does not engage, possible P-sensor fault, emergency release activated	Gearbox in position N! Transimission in position N!	Gearbox position P is engaged Transmission automatically shifts into P when the remote control unit is extracted from the ignition lock or once 30 minutes have elapsed.
Indicate in N-hold phase with door open or seat occupancy = 0 indication in H-hold phase with selector lever operation D,R, and N Detected	Transmission in position N!	Gearbox position P is engaged. Transmission automatically Shifts into P when the remote control unit is extracted from the ignition lock or 30 minutes have elapsed.
EGS CAN interface defective (gearbox fault probably) instrument cluster cannot receive valid display message from EGS. Passive message from Instrument cluster.	Transmission Fault! Drive Moderately	No transmission display. Poss. Reduction of gear selections. Possible to select new gears without depressing the brake. Please contact the nearest BMW Center.

Driving Situation Fault/consequences	**Check Control Message**	**Supplemental Information in the control display**
Indicate at terminal 15 on and door open or seat occupancy =0	Gearbox in position N! Transmission in position N!	Gearbox position P is engaged.
Shift lock note	To engage gear, brake	
Brake signal invalid Brake signal implausible	Gear engage without brake poss!	Before engaging gear, Press brake. When leaving the vehicle, switch off the engine. Accident hazzard! Please contact your BMW Retail Center as soon as possilble.
Indication in the event of sloppy operation or P-push-button faulty	Repeat gear selection	
Messege before N-hold phase elapse (30 minutes)	Transmission position P engaging!	To maintain transmission range N, press selecto lever within 10S to position N.
Gear monitoring Shift monitoring	Transmission Failsafe! Drive moderately	Transmission failsafe program activated. Possilbe reduced acceleration. Please contact the nearest BMW Center.
Ignition on and N engine = 0 and gearbox Pos. P and selector lever push to N	Pos. R, N, D Only within engine on.	

Review Questions

1. What does the GA6HP26Z designation stand for?

   G ______ HP ______ A ______ 26 ______ 6 ______ Z ______

2. Describe Stand By Control: ______

3. Name the clutches used in the GA6HP26Z:

4. What is unique about 5th and 6th gear (as compared to the others)? ______

5. What happens to the Parking Lock when engine operation is not possible?

6. What does the Emergency Release do? ______

7. The Mechatronic includes what components?

8. Name the two paths of communication for the Selector Lever: ______ & ______

9. What is the L/D Push Button for? ______

Table of Contents

Subject **Page**

SUSPENSION and STEERING

Model: E65 - 745i

Production Date: 11/2001

Objectives of The Module

After Completing this module, you will be able to:

- Identify the correct installation of the twin tube gas pressurized shock absorbers.
- Describe the alignment adjustments that can be performed.
- Understand the correct installation procedure for the “quick couplings” on the steering gear.
- Explain the Crash Element function.
- Locate the steering angle sensor.
- List the functions controlled by the CIM module.
- Install the wheel weights in the correct position.
- List the correct wheel bolt torque value.

Suspension and Steering

Purpose of The System

The E65 front suspension uses the double pivot spring strut axle design with tension rods (based on the E39 528i). The multi-link rear suspension with the integral axle is also used in the E65 to allow each wheel to move and flex individually without transmitting loads and forces through the sub-frame to the other wheel.

The suspension is equipped with coil springs on the front and rear (standard equipment) providing the best comfort possible.This suspension systems keep the vehicle level during hard acceleration, braking and cornering.

One of the factors that influenced the E65 suspension design was weight reduction. This results in improved fuel economy and handling characteristics (reduction of unsprung weight). The front and rear axle carriers, front and rear control arms, tension rods and front hub carrier assemblies are all made from aluminum. The weight is reduced by approximately 30% as compared to using steel components.

42-06-00

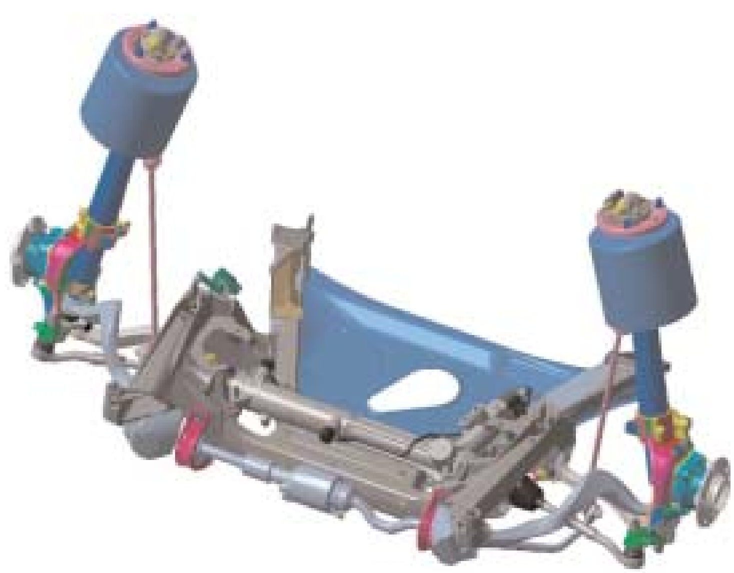
System Components

Front Axle: The traditional double pivot spring strut axle with tension rods is used. The double pivot refers to the lower mounting of the strut and hub carrier around which the wheel turns. The lower control arm and the tension rod form the two lower physical pivot points. The lower pivot point is actually an imaginary point formed by the extension of the control arm and tension rod.

This suspension system is preferred because of these excellent features:

- Constant tracking over the entire compression and extension travel of the suspension.
- Camber change (reaction) during compression.
- Straight-ahead driving with 0 mm kingpin offset (also reduces steering effort) even though wide tires are used.
- Anti-dive control (during braking).
- Fewer components (weight savings).

The double pivot front axle of the is bolted to the body sub-frame.



42-06-02

Front Axle Carrier: The materials used in the front axle carrier offer high tensile strength to support extreme loads. The front axle carrier is also manufactured from aluminum. It consists of cast alloy preformed sections which are welded into the extruded sections.

The front axle carrier accommodates the steering gear, control arms and tension struts, engine mounts, stabilizer bar, heat shield and the underbody panels.

An “thrust zone” panel is bolted on to increase the transverse rigidity of the front of the vehicle. This reinforcement has a positive effect on the handling, sound level and crash performance.

1. Thrust zone
2. Control arm
3. Tension rod
4. Hub carrier
5. Wheel bearing
6. Axle Carrier

42-06-03

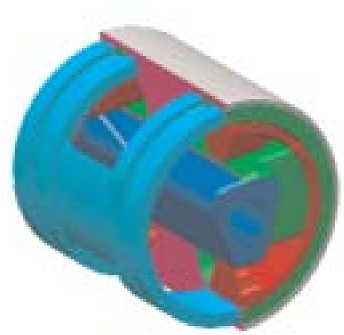
Front Axle Carrier

The benefits as a result of the improved front axle include increased agility, improved comfort by the reduction of unsprung weight, a reduction in fuel consumption by lowering the gross vehicle weight and better axle load distribution.

Control Arms: The control arm locations are similar to the E39 528i with a single control arm and tension rod per side. The layout of the arms combined with the tensioning rods located in front of the wheel center provides balanced steering during cornering.

The hydro mounts in the front of the tension rods contain hydraulic fluid in internal channeling to dampen wheel vibrations.

Small vibrations are cushioned by these mounts and isolated from the steering wheel.

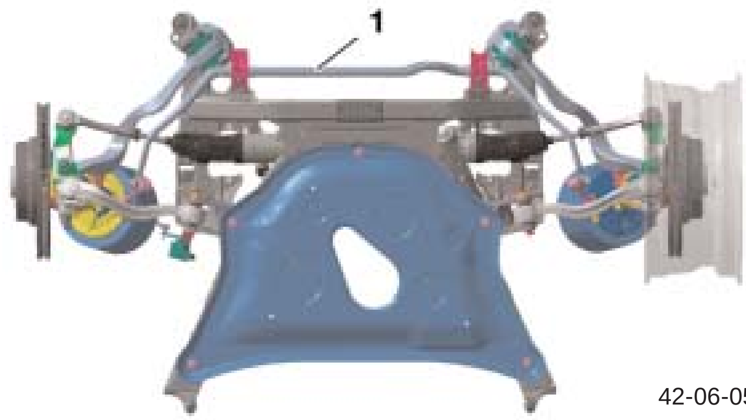


42-06-04

Stabilizer Bar: The standard stabilizer bar (1) is designed as a tubular stabilizer bar, which minimizes body "roll" during cornering. It is connected to the spring struts by links (rods) to provide the best performance leverage.

The connection on the spring strut is high mounted so that when driving straight ahead and hitting a bump on one side, the spring strut will not be turned (bump steer).

The active roll stabilizer bar (ARS) will be covered in Dynamic Drive.



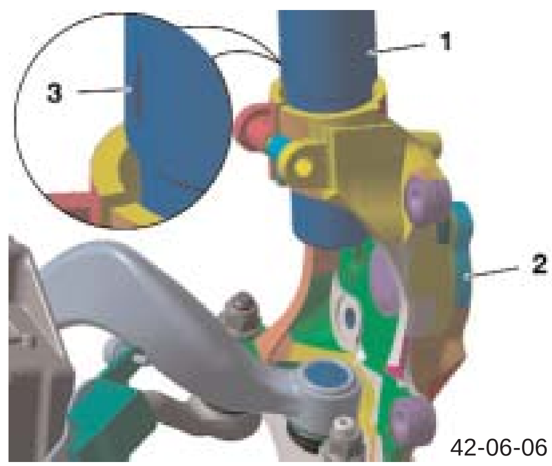
42-06-05

View from Bottom

Spring Strut, Hub Carrier and Wheel Bearing: The twin tube gas pressurized shock absorbers and the hub carrier are bolted together. The tube is made of aluminum and has a locating tab on the side which is used to align it into the hub carrier in the correct position.

The tube and hub carrier are produced in left and right versions and are identified by a label. The wheel bearing assembly is bolted onto the hub carrier.

1. Support tube
2. Hub carrier
3. Locating tab



42-06-06

Spring Strut, Hub Carrier, and Wheel Bearing

Upper Mount: The upper mount contains the spring strut support bearing and a centering pin (1) inserted to retain the factory preset camber.

The centering pin can be removed for minor camber adjustments (+/-18') provided by slots in the strut tower under the upper mount securing nuts .

The cable shown in the diagram is the connection for the EDC-K which will be covered in Dynamic Drive.

42-06-07

Technical Data

The following shows the alignment data in relation to the wheel sizes.

Wheels	**8 J x 18**
Caster angle (20º wheel lock)	**7º 56' ±30'**
Caster offset (mm)	**30’**
Camber	**-6' ±25'**
Total toe	**0º 10' ±8'**
Track differential angle (20º lock - inside wheel)	**-1º 27' ±30'**
Rim offset (mm)	**24**
Track (mm)	**1578**

Workshop Hints

Refer to the Repair Instructions for the following adjustments.

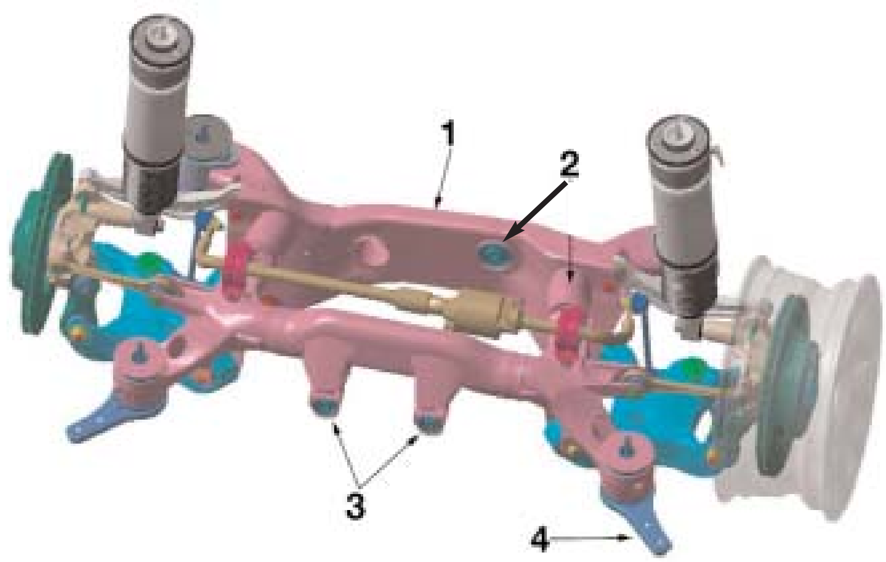
Toe Setting: The toe is set by loosening the external securing nuts and turning the inner track rods (left and right). Consult TIS for proper tightening torque on the securing nuts.

Camber Setting: The camber is set on the spring-strut support bearing. If it is necessary to adjust this in the workshop, the centering pin is removed and the camber correction is provided using the slots in the strut tower (adjustments of ±30' are possible).

Notes:

Rear Axle: The rear axle is designed with kinematics, aerodynamic features and also houses the differential. This suspension system incorporates anti-dive (when braking) and anti-squat (when accelerating) geometry which keeps the vehicle level.

Kinematics relates to the suspension system design type. The term implies flex, which in fact the system does. Under load (acceleration, turning, braking), the suspension changes its geometry to counteract changes induced by the increased loads. The suspension changes are pre-determined and built into the system.



42-06-08

Rear Axle

1. Rear cross member
2. Differential mounting, rear
3. Differential mounting, front
4. Thrust plate

Rear Axle Carrier: The rear axle carrier is a welded structure made of formed aluminum sections and cast aluminum joints. The differential is mounted in the rear axle carrier, with two mount points at the front and one at the rear.

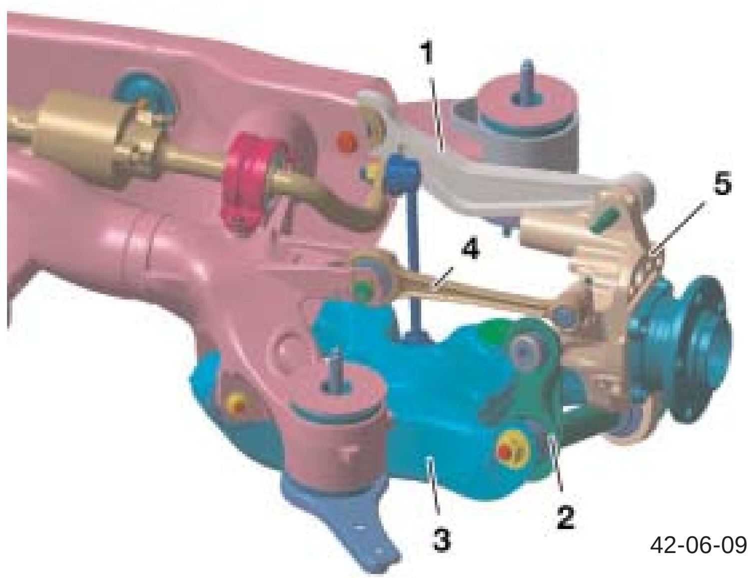
This offers advantages regarding sound and vibration characteristics. The rear rubber mount features kidney-shaped recesses allowing for vibrations in horizontal or vertical direction.

Note: The differential mounts must be installed in the correct position (direction indicated). Refer to the Repair Instructions for correct removal and installation.

Control Arms and Links: The control arms and links are aluminum and are geometrically adapted to the E65.

When the rear suspension is in the normal position, it is aligned parallel to the road and creates the desired air flow to the rear of the vehicle.

1. Upper control arm
2. Integral link
3. Lower traction strut
4. Upper traction strut
5. Hub carrier



Control Arms & Links

Stabilizer Bar: The stabilizer bar is designed as a tubular stabilizer bar, which minimizes body "roll" during cornering. It is connected by links between the rear axle carrier and the control arms. The connection at the control arm is an axial ball joint which is secured by a taper seat and Torx bolt. The active roll stabilizer bar (ARS) will be covered in Dynamic Drive.

Technical Data

	Steel Spring
Wheel	**8J x 18**
Tires	**245/55 R18**
Track width (mm)	**1582**
Total toe-in	**0º 18' ±10'**
Geometric axis deviation	**0º ±12'**
Camber	**-1º 30' ±20'**

Workshop Hints

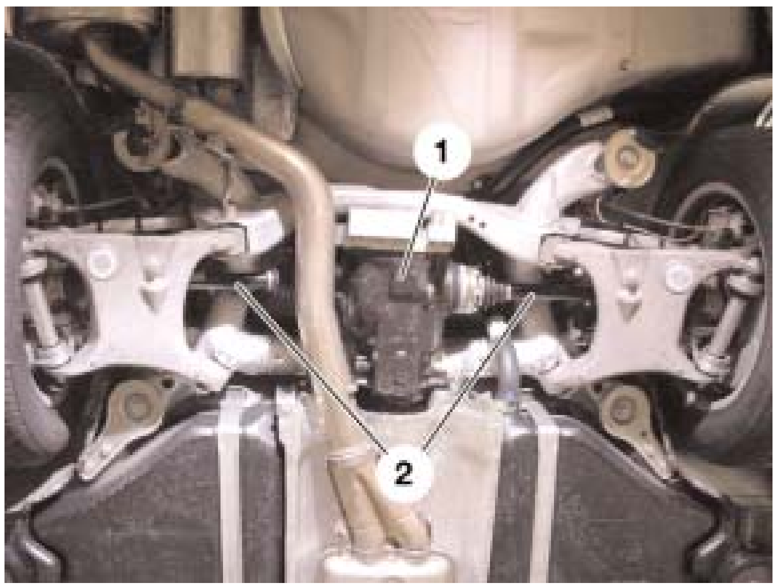
Refer to the Repair Instructions for the following adjustments.

Toe Adjustment: The toe is adjusted by an eccentric bolt at the front upper traction strut.

Camber Adjustment: The camber is adjusted by an eccentric bolt on the lower control arm at the connection to the axle carrier.

Differential and Axle Shafts: The compact final drive is an “open” differential (traction controlled by DSC) with a ratio of 3.38 : 1. The axle mounting bolts feature a special surface paint coating for corrosion resistance.

The oil fill and drain plugs contain integral seals and are also treated with the corrosion protection coating. The drive shaft is aluminum for weight reduction. The compact output shafts are also weight-optimized.



42-06-10

Differential & Output shafts

1. Differential Unit
2. Output (half) shafts

If the differential is damaged, internal repairs are not permitted. The differential is replaced as a complete unit. The only repair that can be performed is external seal replacement (output shaft seals and pinion seal). The differential does not require an oil change because it has a lifetime oil fill.

Steering

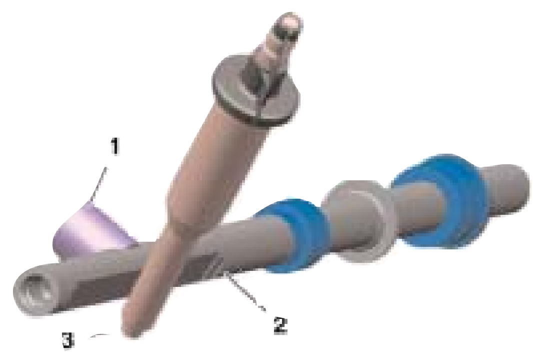
The E65 is equipped with a rack and pinion power assisted steering system with Servotronic. The adjustable steering column is all electric with the adjustment control located on the left on the steering column. The steering column is designed without a steering wheel lock, the anti-theft requirement is fulfilled by the parking lock in the automatic transmission.

As a driver protection feature, a newly designed telescopic crash element is mounted in the upper section of the steering column.

System Components

Steering Gear: The steering gear is bolted at 4 points to the front axle carrier. The gear ratio is variable from 47.0 to 59.0 mm rack movement per steering wheel revolution. This keeps the number of total steering wheel revolutions as low as possible when turning to full lock.

1. Thrust piece
2. Variable pitch gear tooth rack
3. Steering shaft



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Steering Gear

With larger dimensioning, the rack and pinion steering system is used in the E65. The thrust piece required for automatic play compensation is lengthened and equipped with a stronger spring. The thrust piece contains integral lubrication pockets where it contacts the rack for longevity and noise reduction.

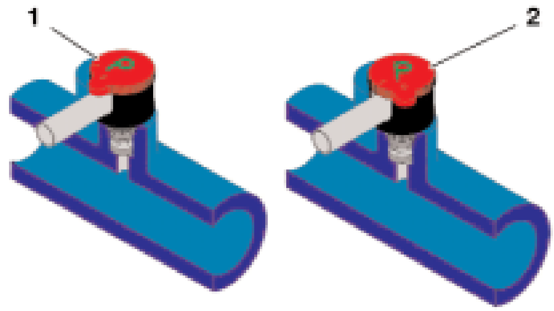
The gearing is pressed on the rack to increase resistance to stress. The rack is hollowed which saves weight (reduction of 280 g) and allows air equalization between the right and left bellows eliminating the external plastic tube.

Threadless plug “quick couplings” are used at the supply (1) and return (2) connections on the steering gear.

42-06-12

To release the quick coupling, turn the cap to position 2. The connection is then released by pressing with the thumb while at the same time pulling the quick coupling.

1. Operating position
2. Release position



Prior to reconnection, the cap must be reset to the locked operating position (1) and should be plugged into the connection only in this position.

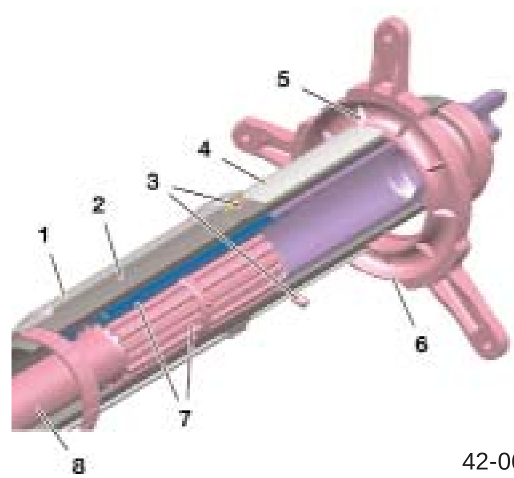
42-06-13

Power Steering Pump: Different power steering pumps are used depending on the vehicle equipment. Vehicles without dynamic drive are equipped with a vane type pump and standard oil reservoir.

A tandem pump is used when the vehicle is equipped with dynamic drive. This pump consists of a radial piston pump with a maximum output of 180 bar and a vane pump section with a maximum output of 135 bar. These vehicles are also equipped with large oil reservoir with oil level monitoring.

Steering Column: The upper steering column with crash element can be compressed telescopically by 70 mm when the steering column is subject to load in the event of a crash. This telescopic action is controlled by a crash element made of fiber glass reinforced plastic.

1. Steering column
2. Slide tube
3. Shear pins (3)
4. Crash element
5. Support webs for SZL
6. SZL carrier
7. Telescopic adjustable splines
8. Steering shaft



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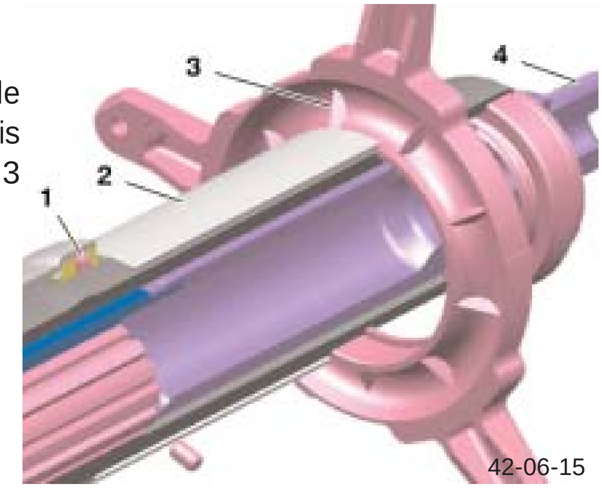
Steering column

The compression movement begins when the three plastic pins shear under an axial force of approximately 3 kN.

The telescopic adjustment splines inter-slide allowing compression when the crash element is deformed over a defined length (at a force of 3 to 7 kN).

1. Shear pins (3)
2. Crash element
3. Support webs for SZL
4. Splined shaft (steering wheel mount)



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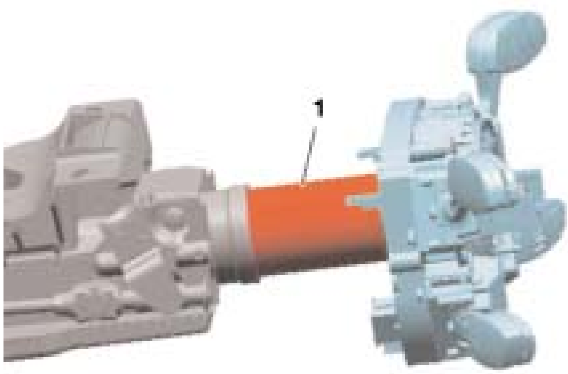
Crash Element Components

Crash Element (before and after compression):



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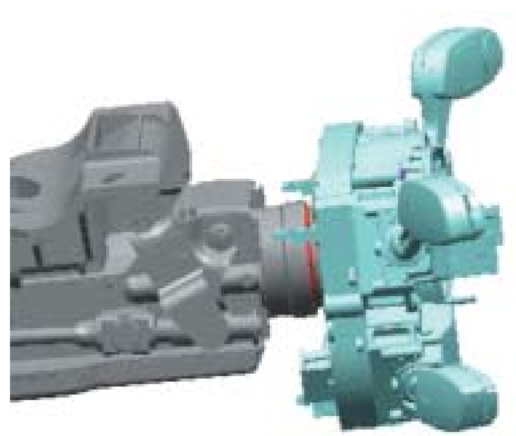

42-06-17

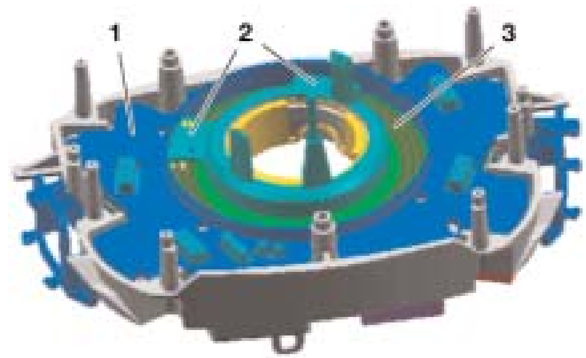
1 Crash element before **after**

Note: Never disassemble the steering column to perform repairs on the crash element! In the event of a defect (particularly a crash), replace the entire steering column.

Always set the steering wheel in the straight ahead position before removal/installation. Remove/install the steering column switch center (SZL) in the straight ahead position, also observe the marking on the locking tooth when installing the steering wheel.

Steering Angle Sensor: The steering angle sensor is integrated in the Steering Column Switch Center (SZL) module. The steering angle positions are transferred by Bus signals to other control modules.

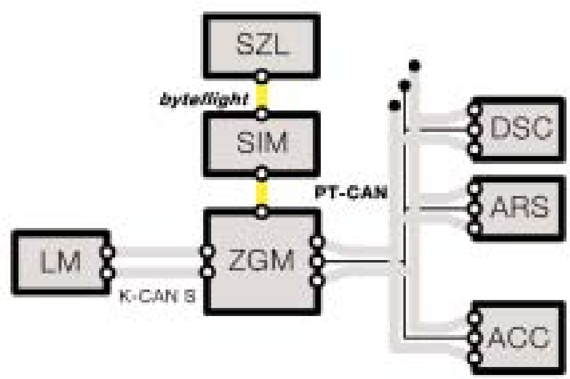
1. SZL - Steering column switch center module
2. Steering angle wiper contact
3. Steering angle wiper tracks



Steering Angle Sensor

The steering angle sensor is a 3.4 kOhm potentiometer with two wipers offset by 90 degrees. From the two wiper signals and a reference signal, the SZL calculates the steering angle sensor position and transfers it over the Byteflight and CAN Bus to other control modules. Shorts to B+ or ground are detected as faults.

SZL - Steering column switch center
DSC - Dynamic stability control
SIM - Safety integration module
ARS - Dynamic Drive
ZGM - Central gateway module



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Steering Angle Sensor Communication Link

Note: When replacing the SZL with the integrated steering angle sensor, the coil spring cassette must be installed in the center position with the wheels set in the straight ahead position. The wiper does not have an electrical reference point and steering angle matching must be performed with the DISplus after repairs.

After performing the steering angle matching, self-learning with the front wheel speed signals is necessary to determine the number of steering wheel turns. The number of steering wheel turns is necessary for determining the exact steering angle.

Chassis Integration Module (CIM): The CIM is located on the underside of the steering column.

The CIM controls the following functions:

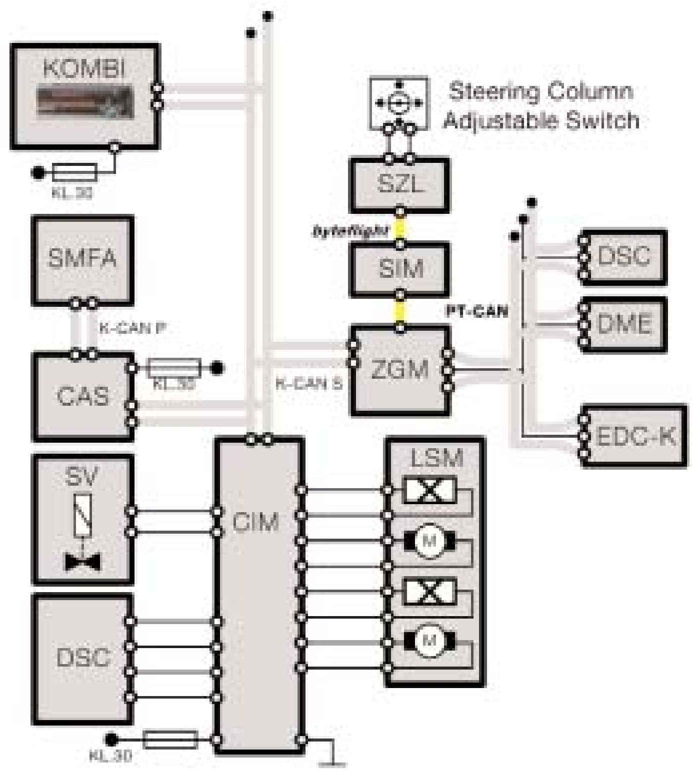
- Servotronic
- Electric steering column adjustment

1. Crash element
2. CIM module

42-06-20

CIM Location

The CIM is linked to the K-CAN S Bus for communication with other control modules. The ZGM provides the gateway for diagnostic communication.



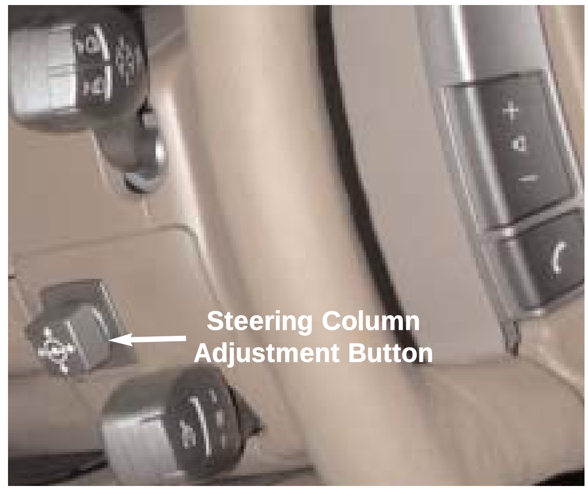
CIM Communication Link

SMFA	Seat memory, driver	SZL	Steering column switch center
CAS	Car access system	ZGM	Central gateway module
SV	Servotronic valve	LSM	Steering column motors
DSC	Dynamic stability control	CIM	Control module
DME	Digital motor electronics	EDC-K	Control module
SIM	Safety integration module		

Systems in the CIM Module - Steering Column Adjustment

The electric steering column adjustment system consist of the following components:

- CIM module
- 2 adjustment drive motors for forward/backward and up/down adjustment
- Hall sensors for position recognition



Principle of Operation

The steering column adjustment is electrically controlled by a button located on the left side of the steering column.

The electric steering column is adjusted by two motors in the up/down and in/out directions. The various positions are stored in the driver's seat module when one of the seat memory buttons are pressed.

The steering column is automatically moved to the uppermost forward position to provide easy entry and exit from the driver's seat.

There are no Check Control messages for the steering column adjustment because the driver receives immediate feedback in the event of a fault.

1. Up/down adjustment
2. Forward/backward adjustment
3. Steering column

Steering Column Adjustments

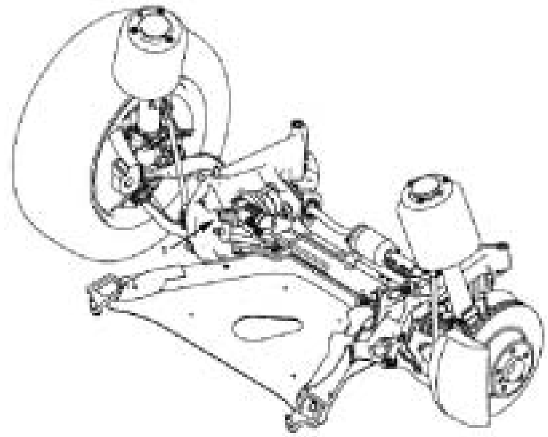
The CIM module will deactivate the steering column adjustment motors when overvoltage is detected (>16 V). The motors will be activated again when the voltage drops below 16 V for more than 2 seconds.

The motors are also protected from overheating by the CIM module. A temperature calculation is performed in the CIM based on activation time (in case of jamming) and the motors will be deactivated to allow a "cool down" time.

Systems in the CIM Module - Servotronic

The Servotronic system consist of the following components:

- CIM module
- Servotronic solenoid valve (1)



42-06-03

Principle of Operation

Servotronic provides speed dependent control of the power assisted steering. The flow of hydraulic oil is reduced (variable) by an electro-hydraulic pressure converter (solenoid valve) located on the steering rack (1). The degree of oil flow reduction is varied by the current supplied to the solenoid valve from the CIM control circuit.

In connection with EDC-K, the driver can influence the power assisted steering by choosing between ***two characteristic curves, comfort or sport.*** The comfort or sport request dictates the current supplied to the solenoid valve dependent on the vehicle speed.

Start Preconditions: The ignition “ON" signal is the only requirement and the solenoid valve is activated only when the engine is running. If a speed signal or steering angle input (movement) is not present within 5 seconds after starting the engine, the Servotronic switches over to the fast drive characteristic (power assist reduced).

This is the substitute value (without power) when there is a fault present. When a speed signal is received or steering angle input, the solenoid valve is activated by current from the CIM module control circuit to increase the power steering assist (speed variable).

Servotronic Initialization: A short initialization phase (approximately 1 second) is necessary to achieve the characteristic curve as fast as possible during the starting procedure. During this phase, vehicle standstill is detected. A current flow plausibility test is conducted and concluded within the initialization phase (test for short to B+ or ground).

Speed Acquisition: The speed signal is generated by the DSC module and is transferred over the PT-CAN and K-CAN Busses to the CIM module to calculate the acceleration. If the acceleration values are greater than 1.3 g, the speed is interpreted as being implausible and the CIM formulates a “failsafe” speed.

Determining Setpoint: Depending on the measured vehicle speed value, the Servotronic is adjusted every 100 ms in the comfort or sport characteristic curve. This provides a smooth transition in power assisted steering regulation.

Characteristic Curve Changeover: The transition between the comfort and sport characteristic curves is gradual in order to avoid jolts in the power steering during changeover. The time required for the changeover is dependent on the cyclic CAN message "comfort or sport" sent by the EDC-K. The comfort characteristic curve is used if the vehicle is not equipped with EDC-K.

Actual Value Acquisition: The voltage drop generated by the solenoid valve current during operation is monitored by the CIM for plausibility, comparing the actual value in relation to the Servotronic required.

Solenoid Valve Control: The solenoid valve is activated by a pulse width modulated signal (PWM) that has a period duration of 2.5 ms at 400 Hz. The pulse duty factor can be set in 2000 steps from 0 - 99.95%, at a time of 1.25 ms per step change.

Operation at the Controller: The Controller and Control Display form the interfaces to the driver. If the vehicle is equipped with EDC-K, the driver can set the chassis to sports tuning. The Servotronic will also switch to the sport steering characteristic curve.

The comfort characteristic provides greater power assist to the steering over the entire vehicle speed range.

The sport characteristic provides less assist over the speed range, giving the driver more “road feel” and feedback required for this driving style.

42-06-02

Servotronic Safety Requirements

The CIM will output the Check Control message "Servotronic failed" to make the driver aware of a fault. In addition, a fault code will be stored in the CIM module. If the fault is still present upon the next engine start, the Check Control message will re-appear.

Overvoltage: The CIM module will not apply power to the solenoid valve if a voltage value greater than 17 V is detected (failsafe).

Undervoltage: A momentary dip in voltage will self correct, the CIM functions will resume again after a delay time. The undervoltage fault code will not set during engine starting (crank signal).

- > 7.5 V CIM module operates normally

- 6.5 V...7.5 V Reset after 200 ms; CIM will assume sleep mode, woken by CAN Bus

- < 6.5 V Reset after 20 ms; CIM will assume sleep mode, woken by CAN Bus

Speed Signal Monitoring: The CIM module evaluates the vehicle speed signal for three different reasons and will produce different fault codes when faults are detected.

Timeout Vehicle Speed: The vehicle speed (V_DSC) is read cyclically (every 100 ms) by the CIM module via the K-CAN Bus. If an update is not received within 500 ms, the solenoid valve is deactivated. The sport characteristic (power assist reduced) will be in operation.

A CAN timeout fault code will be stored in the CIM after 10 failed messages. A Check Control message will be sent if an update is not received in 5 seconds. The timeout fault code is reset with the next engine start. The fault code counter will be cleared by a correctly received message within the 5 second monitoring period. When a general CAN fault is detected, the solenoid valve is deactivated and the speed monitoring is ignored.

Fault Value of Speed Message: The CIM is informed of speed faults detected by the DSC by a fault value. A Check Control message is sent and the solenoid valve is deactivated when the fault value is received ten times in succession.

Plausibility Check by Calculating the Acceleration: The acceleration is calculated based on the vehicle speed. The Servotronic is regulated to the speed up to an acceleration of 1.3 g. If the acceleration exceeds the value of 1.3 g:

- The speed is calculated internally during braking by deducting 4 km/h per 100 ms from the last speed and storing this value as the current speed.

- The speed is calculated internally during acceleration by adding 6 km/h per 100 ms to the last speed and storing this value as the current speed. As soon as an acceleration value less than 1.3 g is observed between the stored speed and the speed supplied on the Bus, the Servotronic regulation is resumed.

Solenoid Valve Circuit Monitoring: The circuit is monitored for shorts (B+ and ground) and breaks. If a fault is detected in the control circuit for the solenoid valve, the circuit and solenoid valve will be deactivated. Only minimum power assisted steering will be provided. This check is conducted within the initialization phase of 1 second. This function will repeat each time the ignition is cycled. The Servotronic will not operate during the engine start procedure if a fault is present for longer than 1 second.

Current Plausibility Check: The solenoid valve current is monitored by the CIM module and must be within a tolerance range. This takes place within the initialization phase and the output stage for the solenoid valve is deactivated if a fault is detected.

Damper Program Signal Status Monitoring: The EDC-K status is observed by the CIM module cyclically (every 200 ms) over the K-CAN Bus. The EDC-K provides the comfort or sport request. If a message is not received within 2 seconds, the comfort characteristic will be set and the fault code "timeout EDC-K status" will be stored. A Check Control message will not be sent.

Diagnosis Information

External Faults: All inputs, actuators and mechanical functions are monitored. Open or short circuits in the wires and actuators to the CIM module are monitored.

Internal Faults: The electronic function of the CIM module and the output stages are also monitored. When a fault occurs, the entire system is shut down and a fault code is stored. The cyclic CAN signal is also monitored.

Fault Generation: When a fault is detected in a function or component, that output function is deactivated. The fault information is stored in the fault code memory. If correct function of the component cannot be determined after a fault has occurred, the function will remain deactivated. After repairs, the fault can be deleted by the DISplus.

Wheels/Tires

The E65 is equipped with light alloy wheels including the spare wheel. The alloy wheels reduce unsprung weight and also provide an attractive, stylish appearance.

The 8J x 18 cast aluminum wheels shown to the right are standard equipment. The wheels are equipped with 245/45R-18 V rated all season tires.

42-06-24

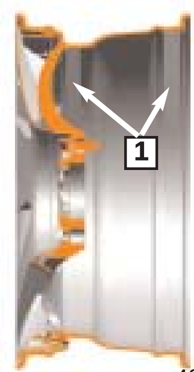
The ***optional*** cast aluminum wheels shown to the right are different sizes for the front and rear:

- Front Wheel = 9J x 19 with 245/45R -19 Performance tire
- Rear Wheel = 10J x 19 with 275/40R -19 Performance tire

42-06-25

Adhesive balance weights are used on the E65 wheels. The weights are installed on the inside of the rim on the designated precision cut areas for dynamic balancing.

1. Bonding surfaces for balance weights



42-06-26

Note: The wheel bolts are torqued to 140 Nm.

Table of Contents

Subject **Page**

BRAKES

Model: E65 - 745i

Production Date: 11/2001

Objectives of The Module

After Completing this module, you will be able to:

- Identify the front brake calipers.
- Explain the 2-Stage Brake Pad Wear Sensor.
- Demonstrate parking brake operation including “Auto Hold” activation.
- Understand the brake lining “seating” (special function) after the parking brake linings have been replaced.
- Explain how the EMF applies the parking brake.
- Demonstrate the EMF emergency release procedure.
- List and perform the procedure to resume operation after an emergency release.
- Describe Dynamic Braking.

Brakes

Purpose of The System

The brake power is designed for the weight and the driving performance of the E65. The E65 features a vacuum boosted dual-circuit hydraulic brake system with "front/back" distribution. The brake system offers the high safety reserve characteristic of BMW. The service life of the brake pads and discs as well as the noise characteristics have been improved. The front brake calipers are aluminum to reduce the unsprung weight. The 2-phase brake pad sensors on the left front and right rear convey signals to the DSC control module making it possible to calculate the total brake pad service life (Condition Based Service).

The electro-mechanical parking brake is automated and functions with the DSC hydraulic system. The stopping function is controlled by the DSC hydraulics when the engine is running and by the electro-mechanical drum brakes (integral in the rear rotors) when the engine is switched off. The parking brake is actuated by a push button. The driver has the opportunity to activate the "Automatic Hold" function which automatically applies and releases the brake. This prevents “creeping” in stop and go traffic and “roll back” before pulling away on an incline (Hill Hold).

The parking brake can only be released when the ignition is switched “ON" (childproof safety benefit). When the engine is switched off with the Automatic Hold function active, the electro-mechanical parking brake will be applied. In addition, the parking brake control module provides automatic wear compensation (adjustments are not necessary) and is diagnosable. The control module is located under the luggage compartment and has a manual emergency function in the event of a system failure.

42-06-00

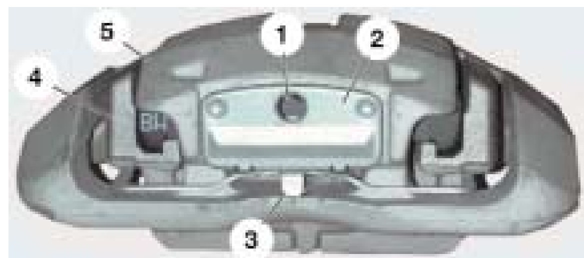
Service Brakes

System Components

Front Brake Calipers: The single piston floating front brake caliper housings are made of aluminum. The reinforcement frame surrounding the brake caliper prevents spreading from contact pressure on the brake disc.

The brake caliper mounting bracket is made of zinc-nickel coated cast iron. The coating satisfies both the increased corrosion protection requirements as well as the European directive for chromium free components (enforced from 7/2003 on).

A cover is installed to improve the appearance of the brake caliper and to support the retaining spring. The brake pad thickness can be measured through the inspection hole in the center.



1. Opening for measuring brake pad thickness
2. Cover
3. Retaining spring
4. Spheroidal cast iron mounting bracket
5. Aluminum housing

42-06-01

Front Brake Caliper

The single piston floating caliper code for the 745i is FNR-Al 60/30/348:

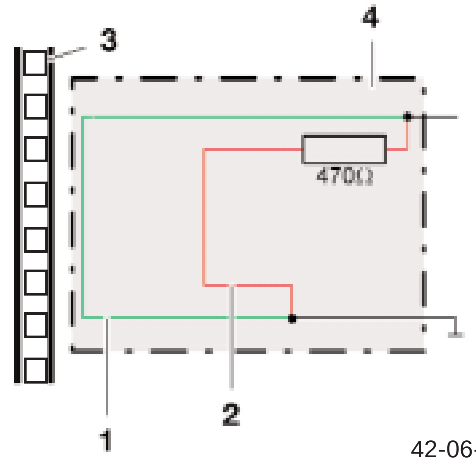
- FN - Supplier (Continental-Teves)
- R - Frame
- Al - Aluminum
- 60 - Piston Diameter (mm)
- 30 - Brake disc thickness (mm)
- 348 - Brake disc diameter (mm)

Rear Brake Calipers: The single piston floating rear brake calipers are made of zinc-nickel coated spheroidal cast iron. As on the front calipers, the coating satisfies both the increased corrosion protection requirements as well as the European directive for chromium free components (enforced from 7/2003 on). The single piston floating caliper code for the 745i is FN 46/24/345:

- FN - Supplier (Continental-Teves)
- 46 - Piston Diameter (mm)
- 24 - Brake disc thickness (mm)
- 345 - Brake disc diameter (mm)

2-Stage Brake Pad Wear Sensor: The 2-stage brake pad wear sensors located at the left front and right rear are monitored by the DSC control module for continuous calculation of the brake pad wear. In the first stage of wear through, the brake pad wear indicator operates in the same way as on previous models. A resistor (470 ohm) is integrated in the second wear through stage.

1. Stage 1 circuit (6 mm)
2. Stage 2 circuit with resistor (4 mm)
3. Brake disc
4. Brake pad wear sensor



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Brake Pad Wear Sensor

The control module monitors the wear status based on voltage change. The first stage of the wear indicator is activated with 6 mm (lining thickness) remaining and the second stage with 4 mm remaining.

With these two different voltages, the probable total service life of the brake pads is calculated by the DSC control module. The criteria considered by the DSC module to perform the remaining mileage calculation are: wheel speed, mileage, brake pressure, brake disc temperature and brake operating time. The remaining mileage of the brake pads can be read in the Control Display (Condition Based Service) as required.

After switching off the ignition, the calculated remaining mileage for the front and rear brake pads is stored and is the start value when the vehicle is in operation again. The service life is shown separately in the Control Display for the front axle and rear axle. The brake pad thickness can be measured through the “mounted” wheel using the Special Tool (refer to the Repair Instructions of TIS).

Brake Control: The brake system is controlled with a dual (8"/9") aluminum vacuum booster and a tandem master cylinder with a brake fluid reservoir. The brake booster is compact because the power assistance is enhanced by the engine driven vacuum pump.

Note: DOT4 brake fluid is recommended for all E65 models with a 2 year replacement interval.

Brake Discs: The E65 is equipped with vented brake discs on the front and rear axle made of high carbon cast iron. The brake disc surfaces are coated with Geomet to satisfy the increased corrosion protection requirements as well as the European directive for chromium free components (enforced from 7/2003 on).

Geomet is a zinc-aluminum surface coating (microfine scaled surface pattern) that is sprayed on and baked at 300 ºC. It is environmentally compatible and features outstanding corrosion protection properties. On the friction surface of the discs, the protective coating is worn down without any changes in the coefficient of friction. All other surfaces retain the corrosion resistant coating over the entire service life.

Note: An initial scraping sound is normal and will disappear after the first few braking applications.

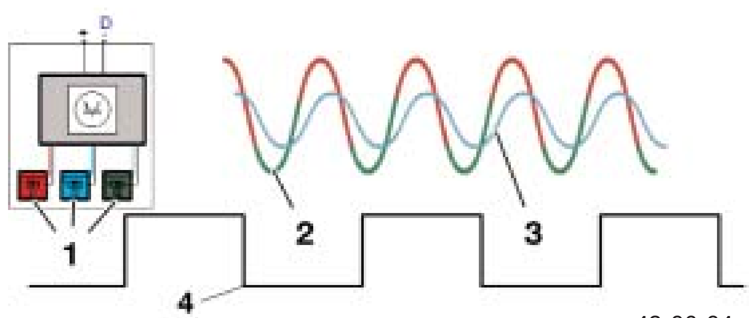
Brake Guard: The ventilated brake guards (plates) on the front and rear axle are made of aluminum and are shaped for effective water drainage. A rubber element is installed between the brake guard and wheel bearing to prevent noise transmission.

1. Rubber element
2. Wheel hub
3. Brake guard, rear axle

Brake Guard

Wheel Speed Sensors: Hall effect direction sensing wheel speed sensors are used on the E65. A special feature of this sensor is that forward and reverse rotation is detected. The sensor contains three Hall effect elements located next to each other in one housing. The signals of the first and third Hall element form a raw differential signal for determining the signal frequency (speed) and the air gap clearance to the impulse wheel.

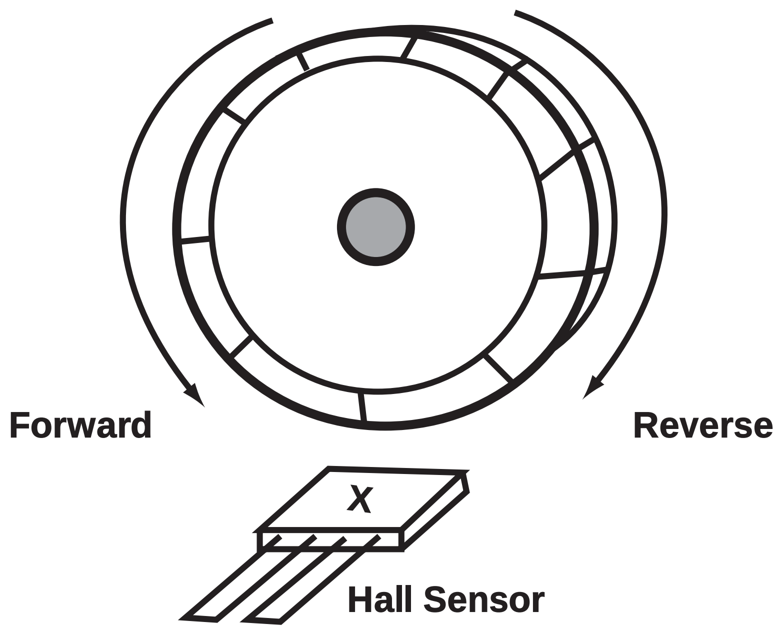
1. Hall-effect elements
2. Differential signal (magnetic)
3. Center Hall element signal (magnetic - rotational direction)
4. Output signal to DSC control module



42-06-04

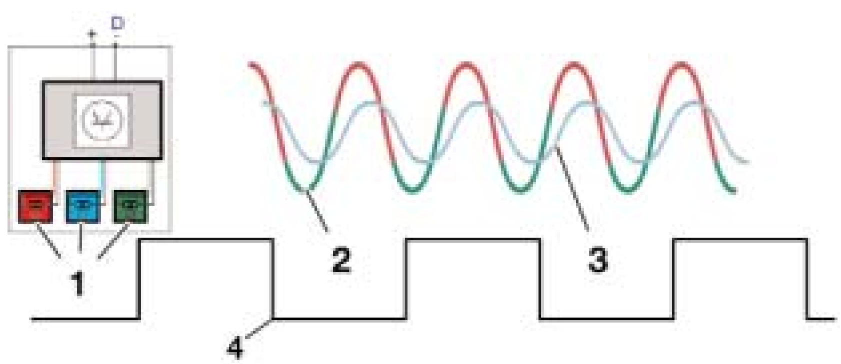
Wheel Speed Sensors

Clockwise or counterclockwise rotation is detected by the phase offset of the signal from the middle (second) element as compared to the differential signal. The phase will shift (left or right) depending on the impulse wheel's approach to the Hall element from the left or the right.



42-06-05

The direction of rotation phase (3) will shift to the left or to the right (as shown) of the differential signal (2). These signals are processed in the sensor and are represented in the output pulse width digital signal (4) that is monitored by the DSC control module.



42-06-06

This sensor contains two external wires and the digital signal is transmitted over the ***combined ground and data line*** (D) to the DSC control module. The second wire is the power supply for the wheel speed sensor.

The flow of current is the influencing factor, not the voltage level. This provides a reoccurring data message that uses two different amp ratings. The 14 mA level contains the information of speed, direction of rotation and air gap. The 7 mA level is the evaluation current for the fault code memory. When the vehicle is stationary, a pulse is sent every 740 ms to check the sensor circuit integrity.

Workshop Hints

The tightening torque requirements of the fastening bolts for the brake hoses have been changed (refer to TIS tightening torques).

After replacing the brake pads, the residual mileage stored in the DSC control module must be reset separately for each axle to a new start value using the DISplus.

When the DSC control module is replaced, the specified remaining mileage for the front and rear brake pads must be transferred into the new DSC control module using the DISplus.

Notes:

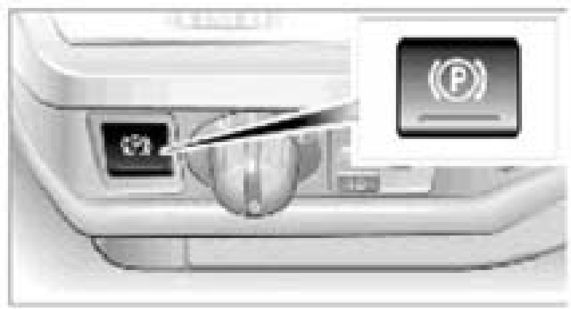
Parking Brake (EMF)

Purpose of The System

The Electro-mechanical Parking Brake (EMF) is used for the first time in series production. The EMF is used to secure a stationary vehicle, preventing it from rolling away by firmly locking the parking brake. The EMF is an automatic comfort oriented system that replaces the previous handbrake or foot operated parking brake. The driver can apply and release the parking brake by pressing a push button.

The system is designed for the characteristic requirements of the E65:

- Consideration for safety
- Optimum functionality
- Maximum system usage
- Best comfort and convenience



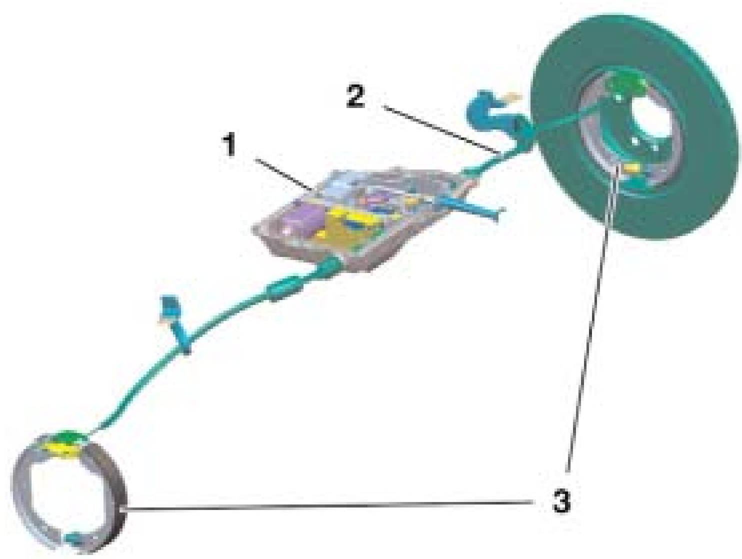
42-06-06

The Parking Brake push button is located in the instrument panel to the left of the headlight switch. The push button is an integral component of the Light Module.

The EMF mechanically locks the parking brake when the vehicle is stationary and provides an independent brake system as required by law (in addition to the service brakes).

The EMF system offers additional comfort and safety functions.

1. EMF actuator
2. Bowden cable
3. Drum brakes (integral in the rear brake discs)



EMF System 42-06-08

Basic Functions: There are two different parking brake functions depending on the operating status of the vehicle.

Locking (Brake Applied):

- With the engine running or the vehicle rolling, the parking brake function acts on the front and rear axle by the DSC hydraulically applying the service brakes.

- When the engine is not running and the vehicle is stationary, the electro-mechanical parking brake is applied.

Dynamic Braking:

- Braking required to decelerate a moving vehicle is identified by the DSC system when the parking brake push button is pressed while driving. The braking procedure is regulated by the DSC hydraulically applying the service brakes and takes place for as long as the push button is pressed.

Automatic Hold: This comfort function is selected using the controller or with the free programmable button on the multifunction steering wheel. After braking to a standstill, the vehicle is held by the DSC hydraulically applying the service brakes. The brakes are released by pressing the accelerator pedal. The hold and release function prevents “creeping” in stop and go traffic and “roll back” before pulling away on an incline (Hill Hold).

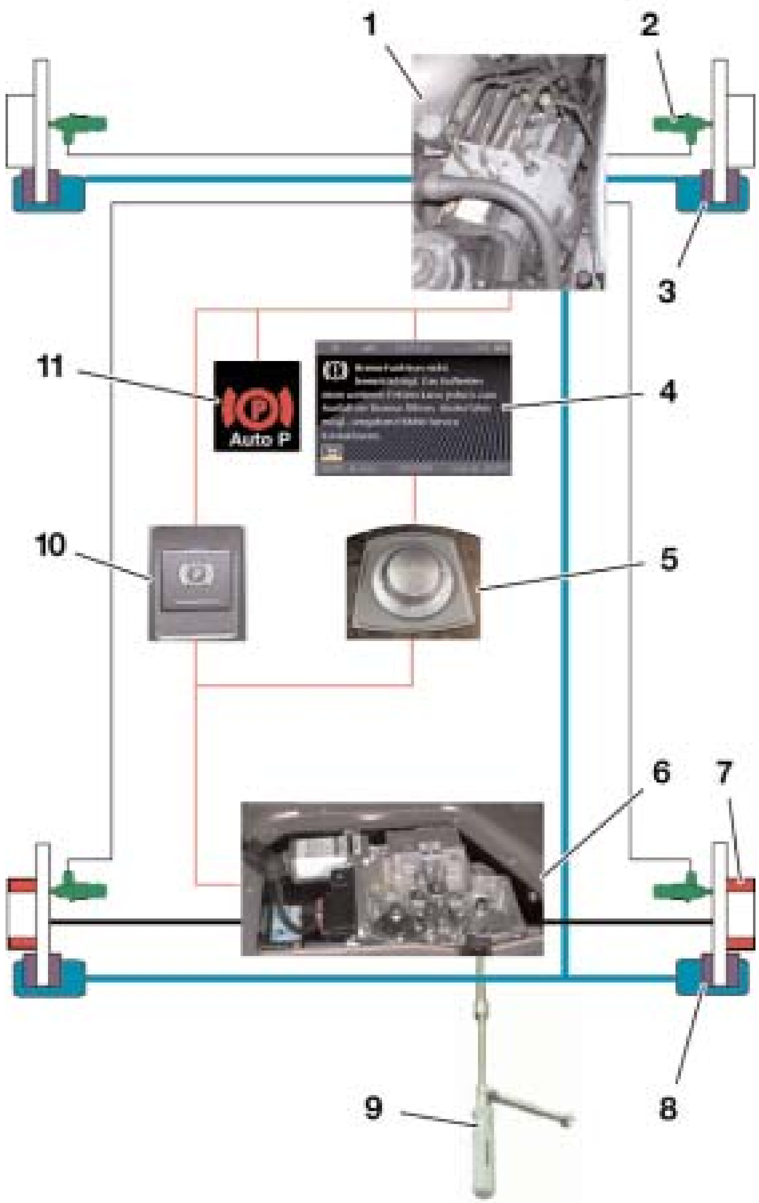
Brake Pedal “Feel”: The response of the brake pedal may change slightly (accompanied by an activation sound) because the parking brake function is activated using the brake system’s hydraulic circuits - this is normal.

Emergency Release: A mechanical emergency release is provided to release the parking brake in the event of an actuating unit failure or a dead battery. It is possible to release the mechanical actuating parking brake unit using the emergency release tool and an open end wrench found in the vehicle tool kit.

Note: In addition, refer to the automatic transmission section for the emergency mechanical parking lock release procedure.

Special Function: During vehicle operation, brake lining “seating” is conducted at defined intervals to ensure and maintain the effectiveness of the parking brake. The brake lining seating is performed to remove corrosion from the parking brake shoes and brake drums. The procedure automatically takes place approximately every 1000 km or once a month and is transparent to the driver.

System Components



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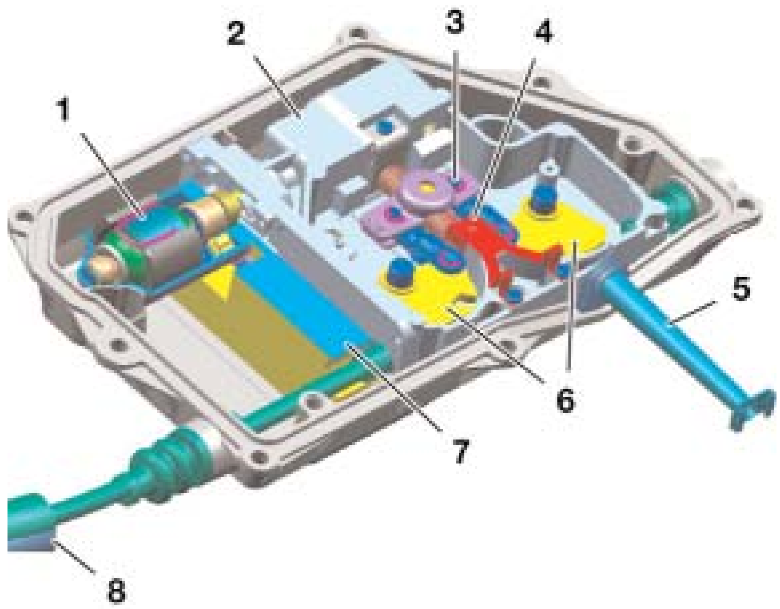
EMF Parking Brake

1. DSC module
2. Wheel speed sensors
3. Service brake, front axle
4. Control display
5. Controller
6. EMF actuating unit
7. Parking brake
8. Service brake, rear axle
9. Mechanical emergency release tools
10. Parking brake push button
11. Display in instrument cluster

Electro-mechanical Actuating Unit (EMF): The EMF receives the parking brake request and activates an electric actuator (motor) to tension the parking brake cables. The EMF actuating unit is located under the luggage compartment floor in front of the spare wheel recess.

1. Actuator (motor with 2 Hall sensors)
2. Gear mechanism
3. Balance arm
4. End stop
5. Guide tube for emergency operation (release)
6. Cable module
7. Control module
8. Bowden cable (one of two)



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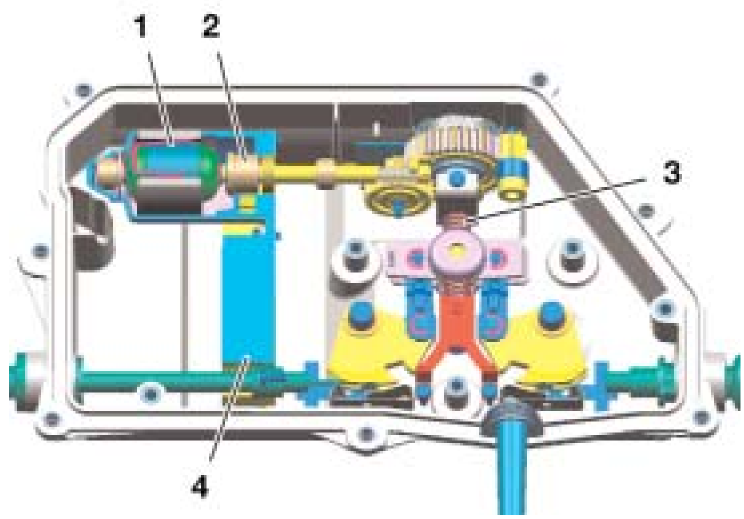
Electro-mechanical Actuating Unit

End Stop: The end stop is the "zero point" for the initial position which is required for the parking brake cable installation (release - no tension).

The balance arm rests against the end stop the first time the brake is released when the ignition is on (KL15).

Hall sensors are mounted on the motor to detect the speed and position. The control module detects the end stop by the increase in actuator motor current and the decrease in the motor speed (Hall sensors).

1. Electric motor
2. Hall sensors
3. Spindle (worm)
4. Control module



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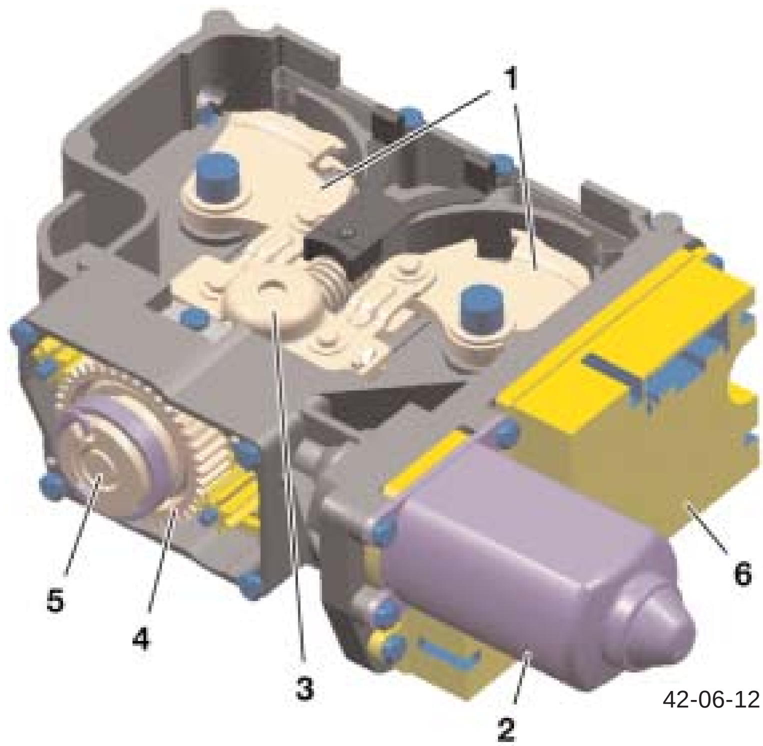
EMF Actuation

When activated, the spindle is turned by the motor using a gear drive mechanism to apply the parking brakes. The balance arm is pulled by the spindle (worm) and will compensate for the slight difference in side to side cable length. The balance arm is linked by connecting levers to pull the cable pulleys inwards towards the direction of the spindle rotation. The cables are attached to the cable pulleys which are pulled “in” to apply the parking brakes. Once the hold position is reached, the spindle worm gear ensures cable tension and will not release with out spindle rotation.

1. Cable pulley
2. Actuator motor
3. Balance arm
4. Gear drive mechanism
5. Spindle
6. Control module



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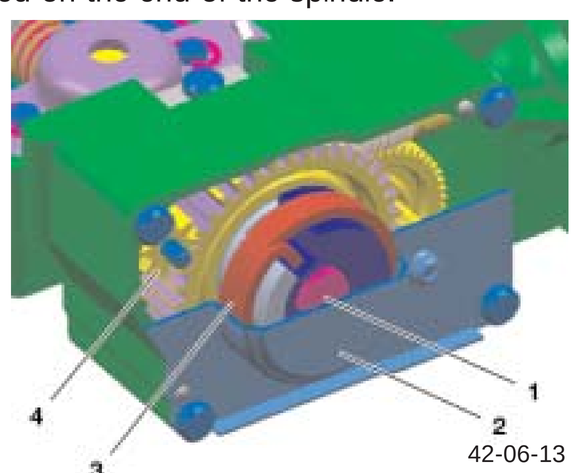
Cable Operation

Gear Drive Mechanism with Coil Spring: This is designed as a three stage (reduction) gear mechanism consisting of a worm, spur gear and spindle. The holding force for the parking brake is assisted by a coil spring mounted on the end of the spindle.

1. Spindle
2. Coil spring cover
3. Coil spring
4. Emergency release drive gear



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Gear Drive Mechanism

When the brake is released, the spindle is turned by the motor and gear drive mechanism in the opposite direction. The balance arm, connecting levers and cable pulleys are pushed outwards by the spindle (worm). The cables are also pushed “out” to release the parking brakes. To assist in the release, return springs are installed in the parking brake assemblies inside the brake discs.

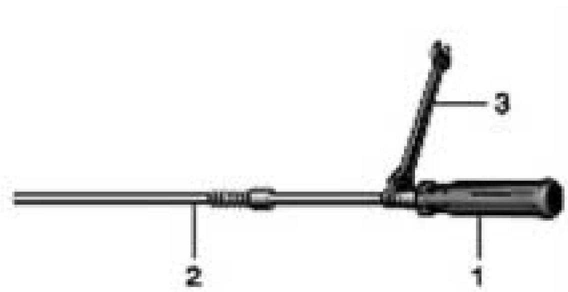
Note: With the manual emergency release, the spindle can be turned through the gear drive mechanism with the tools found in the vehicle tool kit to release the parking brake.

Workshop Hints

Emergency Release: The parking brake is manually released directly through the gear drive mechanism.

The tools in the vehicle tool kit to release the parking brake are:

1. Screwdriver handle
2. Emergency-release tool (spring loaded)
3. 10 mm open-end wrench



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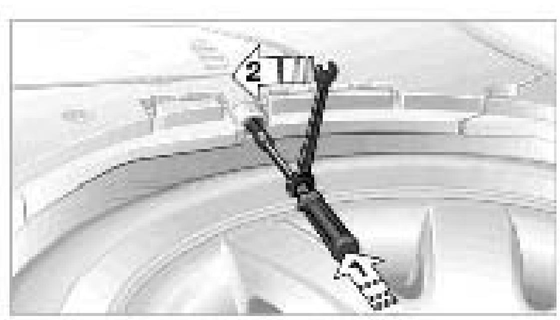
Emergency Release

Caution: Make sure the transmission is in the Park position before releasing the parking brake!

To release the brake, the extension rod is inserted through a guide tube located in the luggage compartment floor in front of the spare wheel recess (1). Maintain pressure on the tool.

Using the open end wrench and the screwdriver handle, turn the release tool in a counter-clockwise direction (2). The cable tension release will be felt during this procedure.



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Note: After a power failure/interruption, it is possible that the vehicle can not be moved after releasing the parking brake using the emergency release. The parking lock of the automatic transmission can still be engaged. Refer to the automatic transmission section for the emergency mechanical parking lock release procedure. ***The parking brake may only be used again if it is released manually after a power interruption. If this is not performed, the the parking brake may fail to operate correctly!***

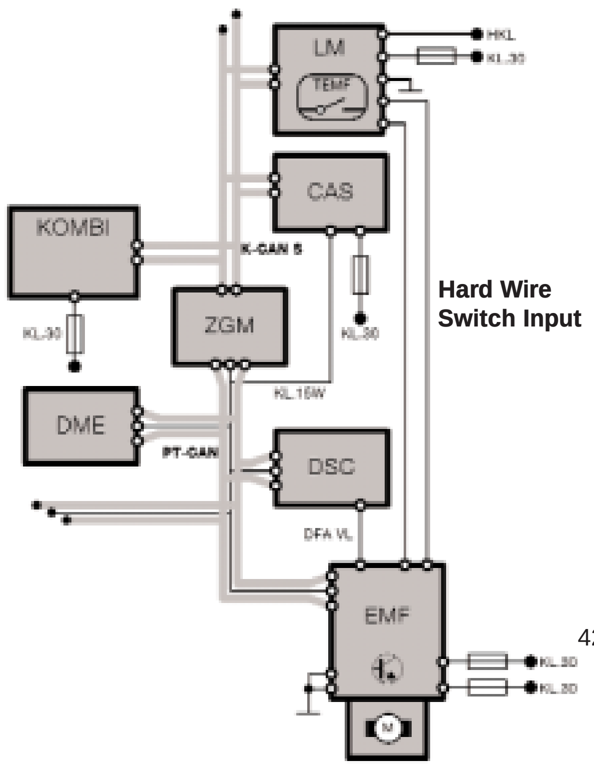
Resuming Operation after Emergency Release: When the voltage supply has been restored after the emergency release, the parking brake ***push button must be pressed 3 times at intervals of approx. 5 seconds to initialize the system.*** This procedure is also described in the Owner's Handbook and Towing Instructions for BMW 7 Series.

- ***1st press*** - The control module attempts to release the brake. Since the brake has been released mechanically by the emergency release, the motor cannot run back and blocks. The control module recognizes a disengaged setting.

- ***2nd press*** - The motor will move forward applying the parking brake. The control module detects an engaged setting. The “P” indicator light illuminates in red.

- ***3rd press*** - The motor will run backward releasing the parking brake and the “P” indicator light goes out. The parking brake is ready for operation.

Control Module: The parking brake control module (integral in the EMF) is linked to other control modules for communication by the PT-CAN and K-CAN Busses. Diagnostic communication is provide through the ZGM over the PT-CAN Bus.



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LM Light module
DSC Dynamic stability control
TEMF Parking brake push button
CAS Car access system
ZGM Central gateway module
DFA VL speed signal (seperate hard wire backup), left front wheel

When the parking brake push button is pressed with the engine running, a fixed brake pressure is built up by the DSC hydraulic unit and applied to the service brakes.

The force applied at the spindle is calculated in the parking brake control module. The control module first determines the current flow of the actuating motor accounting for the temperature of the motor coil (affecting resistance). Hall sensors are mounted on the motor to detect the speed and position. The actuating force is calculated by evaluating the speed reduction of the motor (speed is a function of torque).

Principle of Operation

Parking Brake Control

Two separate controls are provided to operate the parking brake functions.

1. ***The Push Button,*** located in the instrument panel to the left of the steering wheel is used for the basic function. This will apply and release the parking brake when the vehicle is stationary and provide "Dynamic Braking" when the vehicle is driven depending on the vehicle speed.

   When the vehicle is stationary, it functions as an ON/OFF (momentary) push button. Only in the Dynamic Braking mode, the brake is applied for as long as the button is pressed.

42-06-08

2. ***The action field in the menu of the control display*** provides a second control. The menu screen is activated and controlled by the driver to activate or deactivate the "Automatic Hold" parking brake function.

   This function can also be activated and deactivated with the free programmable button on the multifunction steering wheel (if set in the Control Display).

42-06-07

Indicator Lights

The driver is informed of the parking brake system status by an indicator light in the instrument cluster. When a fault is present, an additional message in the Control Display will provide more information. The parking brake control module communicates via the PT-CAN and K-CAN Busses. The light is activated as part of the pre-drive check when the ignition is switched on.

Parking brake indicator lamp

Function lamp

42-06-17

Indication

In the basic function, application of the parking brake is indicated by a red LED in the brake symbol and by the letter P on the inside. The letters "PARK" are illuminated in the indicator light for as long as the parking brake is applied.

The P symbol indicates that the requested status of "release" or "apply" is reached. When the parking brake is operated while driving (Dynamic Braking), an acoustic warning signal is additionally activated (multiple gong).

Automatic Hold Indication

Standby of the automatic hold function is indicated by the green lettering "AUTO-P" integrated in the light. The parking brake signal is additionally indicated when the automatic hold function is active and the vehicle is stopped. The parking brake symbol lights up in green because the hold function is activated by the DSC with all 4 wheel (service) brakes.

After the brake has been released when starting off (automatically), the green parking brake symbol goes out and only the green standby indication "AUTO-P" remains active. The transition from hydraulic to mechanical mode takes place automatically when the engine is switched off. The light changes from green to red indicating the parking brake is applied and the DSC (service brakes) are released.

Additional Indication

The driver is alerted of parking brake malfunctions by a yellow indicator light in the instrument cluster. In addition, the same symbol is illuminated in the variable indicator warning field and briefly explained by a text note.

In addition to the parking brake status, the variable indicator light is also made available to other control modules. It is only used by the parking brake control module for specific faults.

When the variable indicator light appears, the fault is explained in the Check Control display accompanied by additional information in the Control Display (Condition Based Service).

1. Parking brake indicator light
2. Check Control display
3. Variable indicator warning field

Indication Examples:

Instrument Cluster

System function	Indicator lamps
Parking brake released	
Parking brake applied	
Dynamic braking + Acoustic signal (gong)	
Automatic hold standby	
Automatic hold active	
System error	

Basic Parking Brake Function with the EMF

Situation: "Ignition ON" and the engine is not running. When the vehicle is stationary, the parking brake is released or applied by pressing the push button. The light in the instrument cluster is either not lit or is red. The lettering "PARK" is illuminated while the brake is released or applied. Pressing the button while the vehicle is rolling triggers the dynamic braking function.

Changing from the EMF to DSC: When the EMF is applied and the engine is started, the system changes over to the service brakes using the DSC. The EMF is not released ***until*** the service brakes are applied. The light is permanently red and the transfer is not indicated to the driver (transparent).

Changing from DSC to EMF: When automatic hold is activated ***or*** the ignition is switched "OFF" (even if automatic hold was not activated), the service brakes are released ***after*** the changeover to the EMF takes place. If automatic hold was activated, the indicator light changes from green to red. If the service brakes are applied, they will be released ***after*** the changeover to EMF. The indicator light will remain red during this changeover.

Parking Brake Function with DSC (Service Brakes)

Situation: "Engine Running". When the push button is pressed, the service brakes are released or applied by the DSC and the indicator light is either off or red. When the vehicle is moving and the push button is pressed, Dynamic Braking is applied.

The parking brake push button acts as a switch at speeds below 3 km/h, pressing the push button once will trigger an immediate function change. The brakes are released before starting off by pressing the push button. When attempting to start off without releasing the parking brake, the DSC will further increase the service brake pressure and a warning (gong) will alert the driver. ***When the parking brake is set and the driver exits the vehicle (CAN signal - driver's seat occupancy) with the engine running, the EMF parking brake will be applied in addition to the DSC service brakes.***

Ignition Key Removed (Rest Status)

When the parking brake is applied, the P-light remains on for a certain period indicating "brake hold" to the driver. ***The parking brake can be released at any time by pressing the push button until the ignition key is removed (car wash function).*** The rest status is assumed when the ignition key is removed. The parking brake can not be released when the ignition key removed (child safety). The ignition key must be inserted and the ignition switched on to release the parking brake.

Automatic Hold Function

The Automatic Hold function is activated by selecting “Auto P” in the Control Display (or MFL free programmable button) ***only when the engine is running and the hood is closed*** (or the hood contact switch is in the service position). It then remains operational until the next time the engine is switched off. When selected, the vehicle is automatically held by the service brakes each time it comes to a stop. This also applies when the Automatic Hold function is requested and the vehicle is stationary.

When the vehicle is stationary, the brake pressure that the driver applies from the brake pedal is "locked in". When the vehicle comes to a stop without operating the brake pedal (roll to a stop), hydraulic pressure is built up by the DSC pump. Increased pressure will be automatically supplied if the vehicle begins to roll (detected by the wheel speed sensors).

When the automatic transmission is engaged in a drive gear, the brakes will be automatically released by pressing on the accelerator pedal. The next time the vehicle stops it will be automatically held by the service brakes. The standby status of the automatic mode is indicated by the green lettering "Auto-P". When the vehicle is stationary, the parking brake symbol is additionally illuminated in green.

The Automatic Hold function is deactivated by selecting “OFF” in the Control Display (or MFL free programmable button). This will not change the current parking brake status. This means when the vehicle is stationary, it remains held hydraulically after selecting "Auto-P OFF". The parking brake indicator light will change from green to red and the "Auto-P" indicator will go out.

The Automatic Hold function is always aborted when the push button is pressed and must be reactivated by selecting “ON” in the Control Display (or MFL button). When the engine is switched “OFF” in the Automatic Hold function, the EMF will apply the parking brake.

The parking brake can be released at any time by pressing the push button until the ignition key is removed (car wash function). The parking brake will apply after the ignition key has been removed.

Automatic Hold Safety Control

Release of the Automatic Hold function by pressing the accelerator pedal is based on two safety functions.

Situation: Hood open. Automatic release of the service brakes when the accelerator pedal is pressed is inhibited when the hood is open (CAN signal - hood contact switch) while the engine is running.

In this situation, the parking brake can only be released by pressing the push button (Automatic Hold deactivation). When the hood is closed, the Automatic Hold must be selected again by the driver. This situation also applies when the luggage compartment (trunk) lid is open and Reverse is engaged.

Situation: The driver exits the vehicle. When the driver exits the vehicle (CAN signal - driver's seat occupancy) with the engine running, the automatic release of the service brakes by pressing the accelerator pedal is inhibited. The EMF parking brake will also be applied and the transmission will automatically shift to the P-position.

When the driver re-enters the vehicle (CAN signal - driver's seat occupancy), the brake pedal must be pressed and a transmission drive gear must be engaged to drive off. The brake light switch signal requests the EMF to release the parking brake. The Automatic Hold function must be selected again by the driver.

Dynamic Braking

Two separate controls are required by law for brake operation, the brake pedal and handbrake lever were previously used. In the E65, the footbrake and the push button in the dashboard fulfills the requirements.

When the vehicle is moving and the engine is “OFF”, the EMF parking brake is applied when pressure is maintained on the push button at speeds below 3 km/h. During this situation, the parking brake is applied for 0.8 seconds. For the next 2 seconds there is an increase in the braking power and the rate of deceleration is maintained as long as the push button is pressed.

The Dynamic Braking function is active while the vehicle is rolling at speeds above 3 km/h (when the ignition is in position KLR or KL15) when pressure is maintained on the push button. This maintains vehicle stability by preventing overbraking of the rear axle using DSC hydraulic pressure build-up application to the service brakes. The required brake pressure is made available as fast as possible by the DSC.

Since braking takes place hydraulically on all four wheels, higher deceleration rates are possible with minimum operating force as compared to the EMF parking brakes. This controlled braking contributes to increased vehicle safety. ***For safety reasons, traffic is warned when Dynamic Braking is active by the brake lights.***

To avoid incorrect operation, the "Release Parking Brake" display and gong draw the driver's attention to Dynamic Brake operation. ***This function should only be used in exceptional circumstances.***

When Dynamic Braking is activated until the vehicle comes to a stop, the vehicle will remain held by the service brakes and the red P-indicator light remains on. If the brake pedal is pressed during this operation, the DSC interprets this as a higher priority and will override the parking brake function.

Exiting the dynamic emergency braking function: After emergency braking the vehicle to a stop, the vehicle will remain held by the service brakes even after releasing the parking brake push button. The service brakes will not be released until the push button is pressed again.

Safety Concept

Fault Messages

The EMF and DSC control modules monitor the system for faults and alert the driver. A fault has different priorities depending on driving situations: vehicle stationary/moving and starting off/deceleration. To avoid damage, faults in the EMF actuating mechanism like cable breakage and stretch (actuating range exceeded) are detected by the Hall sensors in the motor.

If the EMF control module is defective, fault messages will not be available. The instrument cluster recognizes the absence of the normally active parking brake message (alive - enable) over the PT-CAN Bus and will display a fault message. The safety concept is based on a staged shut down strategy. In addition to the yellow warning light, information is available in the Control Display.

Fault	Availability	Availability	Availability	Back-up system
	Parking brake (mechanically) v=0	Dynamic braking (hydraulic) v>0	Automatic hold	
Can signal error	OK	OK	Not available	Service brake + auxiliary brake
DSC Hydraulics fault	OK	Not available	Not available	Service brake + auxiliary brake
Actuating mechanism fault	Not available	Ok	Not available	Park position automatic gearbox
Fault in parking brake control unit	Not available	Not available	Not available	Park position automatic gearbox and, if applicable service brake + auxiliary brake

General Parking Brake Fault Concept

Fault division between DSC and EMF control module: DSC faults that only affect the parking brake will result in a shut down of the hydraulic function (Dynamic Braking not possible). These are typically faults that result in a shut down of the ABS functions and Manual Emergency Mode will be assumed by the EMF. If the fault is only a CAN Bus fault, Dynamic Braking will be possible.

Shut Down Stage of "Manual Emergency Mode"

This will only apply when the EMF actuating unit is not in operation and is implemented for one of the following DSC faults:

- DSC control module defect
- Electrical defect (example: wiring harness)
- Sensor fault (brake pressure sensor, wheel speed sensors)
- EMF actuator fault, DSC hydraulic unit
- CAN communication fault

Shut Down Stage "Only Dynamic Braking Available"

This stage will provide Dynamic Braking by the DSC hydraulic service brakes in the event of an EMF actuating failure.

- Fault in the actuating motor Hall sensors
- Actuating motor fault
- Fault in control electronics
- Fault in actuating mechanism (mechanical)
- Electrical faults

Shut Down Stage "Total Shut Down"

- Parking brake control module failure
- Push button fault
- Electrical faults including voltage supply

All fault codes are stored in the EMF control module and is also informed of the DSC control module fault status.

Fault Regeneration

If a fault is detected, the system remains in the current stage until the ignition is switched "OFF". A shut down situation will not be deactivated until the faulty component is operating correctly. If the fault is not present during the next restart, the shut down stage is cancelled to resume normal operation. Component tests are carried out continually, even during the shut down situation.

The fault information remains stored in the fault code memory. If correct function of the component cannot be determined after a fault has occurred, the parking brake will remain in the safe, shut down state until the next workshop visit with the exception of: CAN time-out error, overvoltage and temperature protection. After properly repaired, the fault can be deleted with the DISplus.

Regeneration of CAN Faults

CAN timeout faults can be regenerated. The shut down stage is cancelled if the signal is received correctly for a certain period of time.

Monitoring and Fault Detection

Electrical faults monitoring: The wiring to the EMF control module including the actuator motor are monitored for breaks or shorts to B+ and ground.

Hydraulic interface monitoring: The DCS checks the plausibility of the deceleration request by the parking brake during Dynamic Braking and the hydraulic Hold Function. If the request and feedback do not agree within a defined time (5 seconds), the corresponding shut down stage is assumed and a fault code will be stored.

Input signals monitoring: In the event of a faulty input signal, the entire system is shut down with a Check Control error message and a stored fault code.

Parking brake push button monitoring: The push button signals are continually monitored (hardwired to the EMF control module). In the event of a push button plausibility fault, the entire parking brake system is shut down and the "Parking Brake Push Button Defective" fault code is stored. The DSC control module also checks the plausibility of the parking brake push button signals that are transmitted via the CAN Bus (from the EMF control module). If faulty, the "Parking Brake Push Button Signals via CAN Implausible" fault code is stored and partial shut down is carried out (Dynamic Braking is not possible).

Speed signals monitoring: Total shut down of the parking brake system will occur with the loss of all 3 speed inputs.

- The direct digital wheel speed signal (separate hard wire backup, front left) is continually checked for the plausibility of the signal edge change.
- The plausibility of the reference speed signal from the DSC over the PT-CAN Bus and the direct digital wheel speed signal is continually and mutually checked.
- The reference speed signal from the DSC is compared with the automatic transmission output speed.

  Fault codes:

  - Direct wheel speed signal implausible or faulted
  - DSC speeds implausible or no message
  - EGS automatic transmission output speed implausible or no message

Hall sensors monitoring: The plausibility of the actuating motor Hall sensors is continually checked. When there are deviations that are out of tolerance, partial shut down (only Dynamic Braking available) is implemented and the "Parking Brake Actuating Unit Defective, Plausibility of Hall Sensors" fault code will be set.

In addition, the plausibility of the position is checked during the actuating motor operation. When the Hall sensor signal is not received, the parking brake system is shut down and a fault code will be set.

EMF actuating unit monitoring: After the ignition is switched on and a fault is present, it will be detected before a required parking brake function is active.

EMF Self Diagnostics

The self diagnostic functions are divided into several modes. These modes are executed in priority for diagnosis. When the vehicle is stationary and self diagnosis is being executed, the parking brake function is fully operational. Fewer diagnostic modes are allowed while the vehicle is moving. A self diagnostic mode that will restrict or completely deactivate the parking brake function is executed only when the vehicle is stationary.

Certain faults in CAN communication will cause the manual emergency mode and the Automatic Hold will not function. The "manual level" is operational and the parking brake will still be applied and released by the EMF or DSC when the push button is pressed with the vehicle stationary. Dynamic Braking also remains available. The loss of the Automatic Hold function is indicated only with the variable parking brake indicator lamp.

Workshop Hints

Please familiarize yourself with the statements below regarding new procedures when making repairs to the Electro-mechanical Parking Brake. Consult the Repair Information in TIS for additional information on the following procedures:

The parking brake shoes are adjusted the same way as current BMW models by turning the adjuster with a screwdriver through the wheel bolt hole of the wheel hub.

Parking brake cable removal: To remove the parking brake cable assemblies, the EMF top cover must be removed and the end stop plate must be raised with a screwdriver. Using the brake release tool (found in the vehicle tool kit), release the parking brake completely so that the balance arm is turned back to the stop. This will allow the pulleys to rotate far enough so that the cable crimp can be disengaged from the recess in the pulley.

Parking brake initialization: The parking brake must be initialized with the DISplus after replacing the brake shoes. The brake cable “free play” is learned by the EMF control module from the Hall sensors in the actuating motor.

Parking brake lining seating: When the parking brake shoes are replaced, the new brake linings must be seated (bedded down) to achieve adequate holding power. A "Special Bedding Down Routine" is integrated in the parking brake software and can be accessed with the DISplus found under ***Service Functions - Chassis - Parking Brake - Workshop Braking-in.***

The parking brake indicator light in the instrument cluster will flash red (at a low frequency) to signal the standby status of the brake bedding down program. After activating the program, the ignition must not be switched off and the bedding down procedure must be carried out within 30 minutes.

If more than 30 minutes have lapsed, the parking brake button is pushed, or the ignition is turned off before the procedure is carried out, the brake bedding down program will be terminated. The system will resume the normal parking brake function.

The brake linings are seated by the EMF applying a reduced holding force. The braking force at the spindle during this procedure is 20% of the maximum actuating force.

The procedure is activated when the vehicle is stationary (for example: stopped at a traffic light). The brake shoes “scrub” when the vehicle starts off. The EMF releases the parking brakes when a speed of 15 km/h is reached or 30 seconds after the start of the seating procedure.

For safety reasons, the seating procedure is immediately terminated when any DSC function is required. The seating procedure is also terminated when the push button is pressed or the ignition is turned off.

Travel monitoring: Normal parking brake lining wear increases the actuating travel over the service life. Based on the reference point (stop in the EMF unit), the Hall sensors in the actuating motor allows the EMF control module to measure the travel range.

When the defined travel limit is exceeded, information is provided to the driver and a fault is stored in the EMF control module. This can also be checked using the DISplus found under ***Service Functions - Chassis - Parking Brake - Position Travel Check.***

Brake testing on a roller dynamometer: The E65 parking brake operation can be tested on a brake roller dynamometer. The parking brake test can be conducted with the engine running by pressing the parking brake push button. With the engine turned off, the parking brake test can activated by pressing the parking brake push button. The actuating unit will quickly apply and lock the parking brake.

Assembly Mode: Replacement EMFs are shipped in “assembly mode” to surpress activation until the brake cables and EMF are completely assembled and installed in the vehicle. This prevents unintentional operation of the EMF by the parking brake push button and can also be activated (for safety reasons) on an existing EMF in the vehicle when work is being performed.

Before initial operation, the assembly mode must be deactivated by using the DISplus found under: Service Functions - Chassis - Parking Brake - Assembly Mode.

When installing the EMF, make sure that the seal to the body and the seals for the parking brake cables are correctly installed.

Coding data: The coding data for the parking brake system is stored in the EMF control module (EEPROM) and the DSC control module (EEPROM). The coding data is entered by the DISplus when a control module is replaced.

Check Control and Control Display Fault Descriptions

	Parking brake lamp	
		
Cause	CC message	Control display information
Rest condition		
	Parking brake lamp	Variable indicator lamp
		
Cause	CC Message	Control display information
Held mechanically (up to 10km/h); parking brake Inoperative while driving; Parking brake can only be Operated manually	Parking brake inoperative while driving	Parking brake only be applied or released manually with the vehicle stationary. Parking brake without emergency function.
Mechanically released; parking brake can only be Operated manually	Parking brake automatic hold inoperative!	Parking brake not operated automatically when vehicle stopped/parked. Operate parking brake manually or use gearbox position P
Held mechanically or held hydraulically in dynamic braking mode when stationary; parking brake can only be operated manually	Parking brake Automatic Hold inoperative!	Parking brake not operative Automatic when vehicle Stopped/parked. Operate Parking brake manually or use gear box position P
Actuating unit failure while Driving; held hydraulic in dynamic braking mode when stationary	Parking brake automatic hold Inoperative/park with P	When driving off: release Parking brake with emergency release function if necessary. First engage gearbox position P! Use gearbox position P when parking

Parking brake overheated (only with engine off)	1. Parking brake overheated, avoid operation 2. Parking brake Overheated operation not possible	1. Parking brake overheated due to too frequent operation. Holding force reduced, risk of damage!. 2. Parking brake overheated due to frequent operation. Operation with vehicle Stationary no longer possible. Emergency braking function during vehicle operation still maintained.
Overheating; held hydraulically in Dynamic braking mode up to stop	Parking brake overheated, Operation not possible	Parking brake overheated due to Too frequent operation. Operation with vehicle stationary No longer possible. Emergency braking function During vehicle operation still maintained.
Parking brake overheated	1. Parking brake overheated. avoid operation 2. Parking brake Inoperative while driving!	1. Parking brake overheated due to frequent operation. Holding force reduced, risk of damage! 2. Parking brake can only be applied or released manually with the vehicle stationary. Parking brake without Emergency brake function.
	Parking brake lamp	Variable indicator lamp
	 KT-8139	 KT-8139
Cause	CC message	Control display function
Actuating unit failure	Parking brake inoperative / park with P	When driving off: release Parking brake with emergency Release function if necessary. First engage gearbox position P! When parking: use gearbox Position P.
Actuating unit failure on first Occurrence	1. Risk of damage to parking Brake! 2. Parking brake inoperative/park with P	When driving off: release parking brake with emergency Release function if necessary. First engage gearbox position P! When parking: use gearbox Position P.

Overheating (reversible)	Parking brake overheated, Operation not possible	Parking brake overheated due to frequent operation. Operation with vehicle stationary no longer possible. Emergency braking function during vehicle operation still maintained.
Released mechanically; parking brake inoperative While driving; parking brake can only be operated manually	Parking brake inoperative While driving	Parking brake can only be Applied or released manually with the vehicle stationary. Parking brake without emergency brake function.
Parking brake overheated	1. Parking brake overheated, avoid operation 2. Parking brake inoperative while driving	1. Parking brake overheated due to frequent operation Holding force reduced, Risk of damage! 2. Parking brake can only be applied to released manually with the vehicle stationary. Parking brake without emergency brake function.
Alive failure or total failure	Parking brake inoperative / park with P	Parking brake inoperative. To park: use gearbox position P. To start off: if necessary, release brake with emergency release function. First engage gearbox position P! Visit nearest BMW Service Center
Alive failure or total failure On first occurrence	1. Risk of damage to parking brake! 2. Parking brake inoperative, park with P	Parking brake inoperative. To park; use gearbox position P. to start off: if necessary, release brake with emergency release function. First engage gearbox position P! Visit nearest BMW Service Center

Notes:

	Parking brake lamp	Variable indicator Lamp
		
Cause	CC message	Control display information
Overheating (reversible), dynamic braking during vehicle operation	1. Release parking brake 2. Parking brake overheated operation not possible	Parking brake overheated due to frequent operation. Operation with vehicle stationary no longer possible. Emergency braking function During vehicle operation still maintained.
Dynamic braking during Vehicle operation	1. Release parking brake 2. Parking brake automatic hold inoperative	Parking brake not operated Automatically when vehicle Stopped/parked. Operate parking brake manually or use gearbox position P.
Failure during vehicle operation; dynamic braking during vehicle operation	1. Release parking brake 2. Parking brake inoperative/park with P	When driving off: release parking brake with emergency release function if necessary. First engage gearbox position P! when parking: use gearbox position P.

Notes:

	Parking brake lamp	Variable indicator lamp
	 KT-8141 Flashing  KT-8140	 KT-8139
Cause	CC message	Control display information
When stationary with engine off, while mechanically releasing or applying brake	Parking brake automatic hold inoperative!	Parking brake not operated
	Parking brake lamp	Variable indicator lamp
	 KT-8139 Flashing  KT-8141	 KT-8139
Cause	CC message	Control display information
Total failure due to redundancy fault in parking brake push-button; flashing at high frequency for a certain time when push-button pressed (rapid flashing with gong)	Parking brake inoperative/ Park with P	Parking brake inoperative. To park: use gearbox position P. To start off: if necessary, release brake with emergency release function. First engage gearbox position P! Visit nearest BMW Service Center.

	Parking brake lamp	Variable indicator lamp
	 KT-8141 flashing  KT-8139	 KT-8139
Cause	CC message	Control display information
When stationary (up to 10km/h) while mechanically releasing or applying brake; (slow flashing->coding data instrument cluster)	Parking brake inoperative while driving	Parking brake can only be Applied or released manually with the vehicle stationary. Parking brake without emergency brake function.

Notes:

Table of Contents

DRIVING DYNAMICS SYSTEMS

Model: E65 - 745i

Production Date: 11/2001

Objectives of The Module

After Completing this module, you will be able to:

- List the Driving Dynamics Systems.
- Demonstrate how to deactivate Dynamic Traction Control.
- Explain how EDC-K influences hydraulic damper operation.
- Identify the correct EDC-K solenoid valve resistance value.
- Describe the Dynamic Drive influence on the stabilizer bars.
- Name the Dynamic Drive components and locations.
- Understand the Valve Block sub-components and functions.
- Explain the Oscillating Motors hydraulic/mechanical operation.
- Describe “Failsafe” hydraulic flow.
- Demonstrate Dynamic Drive Commissioning.

Driving Dynamics Systems

Purpose of The Systems

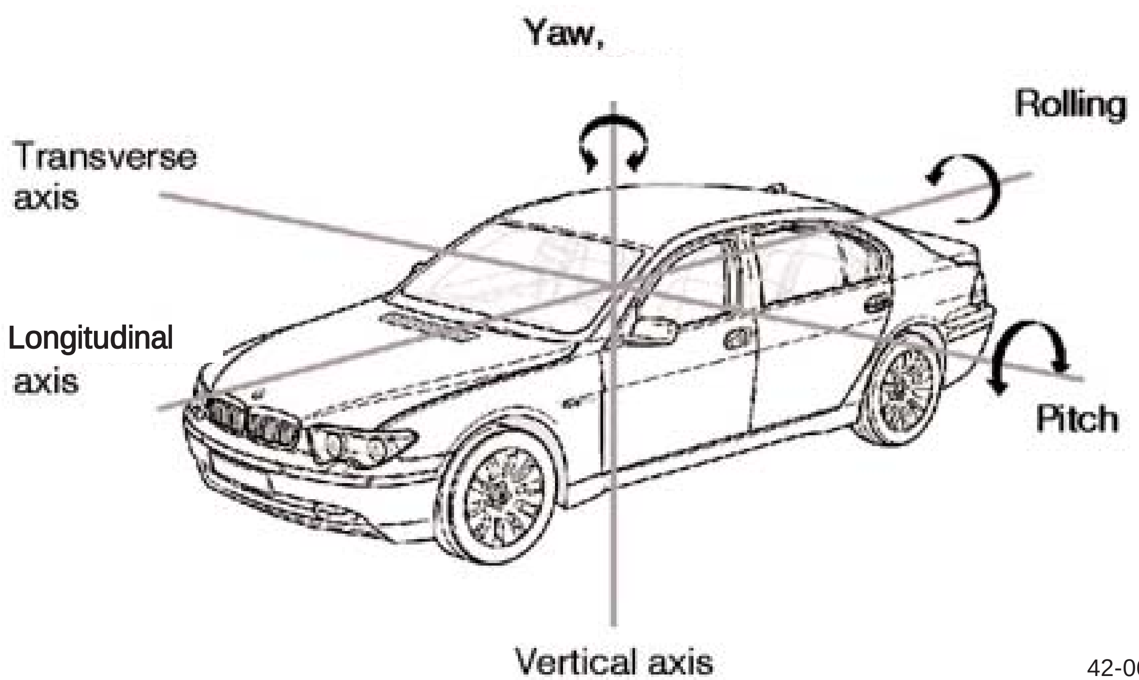
The E65 chassis offers the driver optimum ride comfort, driving safety, good agility and excellent handling. The chassis also adapts to changes in road conditions: traffic, ice, snow etc. Vehicle speed and changes in the direction of travel generate forces that have an effect on the chassis which requires the driver to react correctly to maintain safe driving.

The following forces occur while driving:

- Vertical forces - uneven road surfaces, bumps and potholes
- Lateral forces - centrifugal forces during cornering and crosswinds
- Longitudinal forces - acceleration, deceleration and braking

The following vehicle structure movements occur as a result of these forces:

- Around the transverse axis: pitch
- Around the longitudinal axis: roll
- Around the vertical axis: yaw



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Active Driving Dynamics Systems are integrated in the E65 chassis which support the driver both actively and passively by suppressing the effects of these forces as much as possible. The Driving Dynamics Systems include:

- Dynamic Stability Control (DSC) with subsystems

- Electronic Damping Control (EDC-K) continually adjustable system

- Dynamic Drive active roll stabilizer bar (ARS)

The Driving Dynamics Systems monitor the driving conditions using sensors. The sensor signals are transmitted to the control modules that interpret and evaluate the driving conditions. The control modules send output signals to actuators that will counter these forces providing adaptation for the road and driving situations.

Systems Indications

The indicator/warning lamps, Check Control, On-board Computer messages and Control Displays as well as the respective activation are described in the iDrive display and controls.

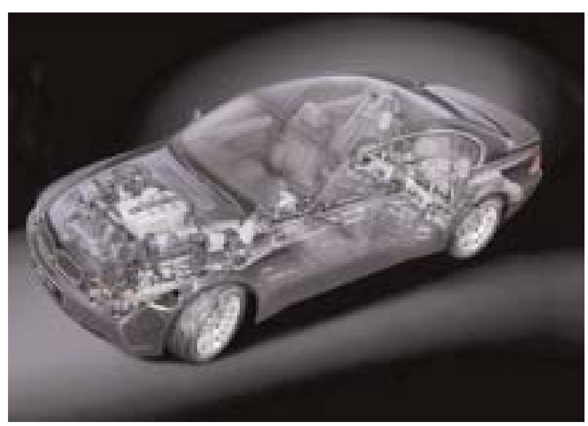
Dynamic Stability Control (DSC)

The DSC controls the vehicle stability in all driving conditions, counteracting the driving dynamics forces by using brake intervention or engine load control depending on the situation. DSC consists of the following subsystems:

- ABS Anti-Lock Braking System
- ASC Automatic Stability Control
- MSR Engine Drag Torque Reduction
- DBC Dynamic Brake Control
- CBC Cornering Brake Control

The following are new in the E65:

- FBS Fading Brake Support
- FLR Driving Performance Control
- DTC Dynamic Traction Control
- Parking Brake (hydraulic service brakes)



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Electronic Damping Control (EDC-K)

The continuous Electronic Damping Control (EDC-K) absorbs vertical forces while driving and dampens these forces to the chassis. The forces are measured by two vertical acceleration sensors on the front axle (left and right) and one at the rear axle (right). The front sensors are located in the wheel housings and the rear on the trunk tray underneath the trunk ventilation ports. The dampening characteristics are mapped in the control module to continuously regulate the EDC-K providing maximum comfort.

The EDC-K works with infinitely variable valves in the dampers to regulate the hydraulic fluid flow using electromagnetic control valves. EDC-K provides the actual damping force required at any time.

The steering angle sensor is used along with the front wheel speed sensors to determine the lateral acceleration. The controller provides the opportunity to select from two basic settings: Comfort or Sports.

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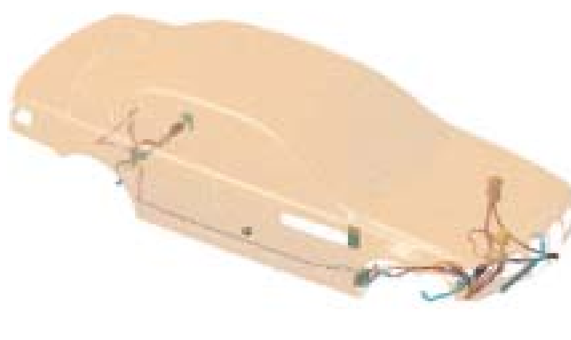
Dynamic Drive

Dynamic Drive controls two active stabilizer bars based on the lateral acceleration. The active stabilizers are split with a hydraulic actuator in between them so that the left and right sides can be turned in opposing directions. These active stabilizers set the stabilizing torque using hydraulic actuators so that:

- The rolling motion of the body is minimized or eliminated while cornering.
- The extent to which the body rolls on straight, uneven road surfaces is reduced.
- A high degree of agility and precision adjustment is achieved using the full speed range.
- An optimum self steering characteristic is produced.



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Dynamic Stability Control (DSC)

History

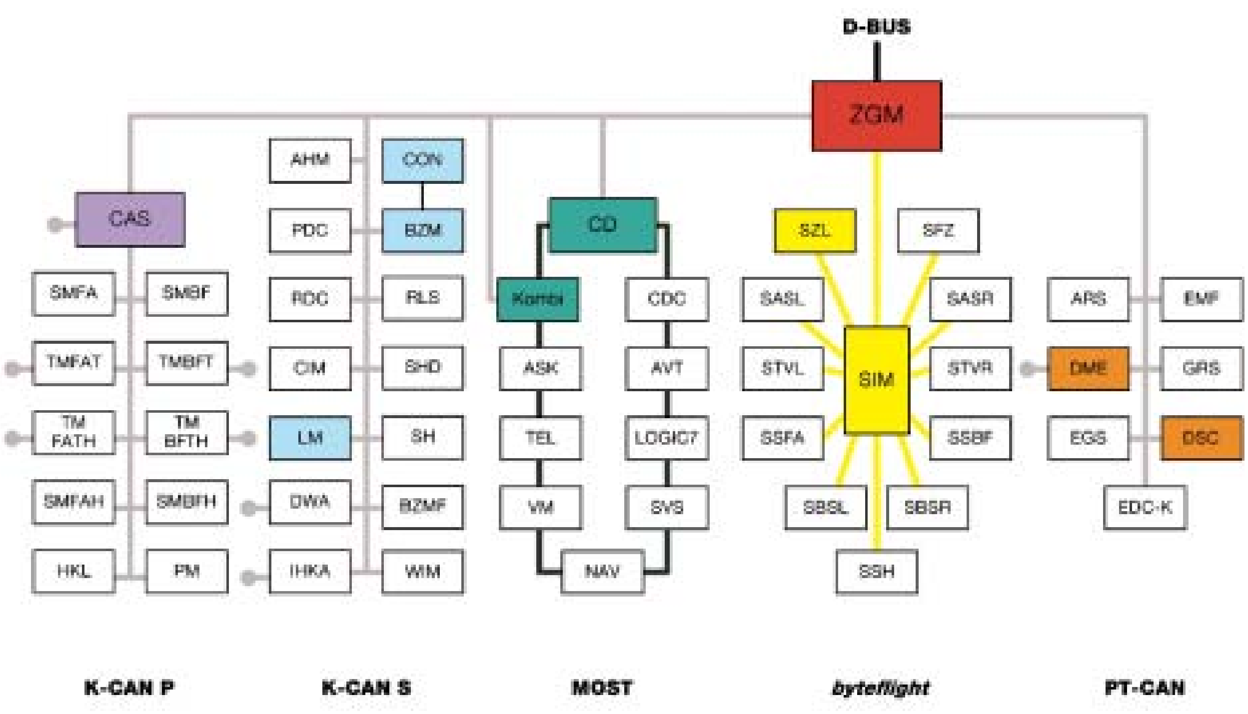
The history of wheel slip control systems used in BMWs is covered in the Chassis Dynamics course (ST056). DSC III was technically modified (deletion of the pre-charging unit), the functions were extended and renamed DSC 5.3. The DSC 5.3 was further developed into DSC 5.7 by adding these functions:

- Dynamic Brake Control (DBC)
- Dynamic Brake Support (DBS)
- Maximum Brake Support (MBS)

These functions have been used in Bosch systems since 1999. For the E65, DSC 5.7 is further developed and expanded to include the software functions to achieve improved system operation:

- FBS Fading Brake Support
- FLR Driving Performance Control
- Parking Brake (hydraulic service brakes)
- DTC Dynamic Traction Control

In addition, the evaluation of the 2-stage brake lining wear sensors is integrated in the DSC control module. The DSC system is connected to the PT-CAN Bus.



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Principle of Operation

DSC

DSC calculates the current driving conditions and corrects detected driving instability through active brake interventions. For example, in the event of vehicle oversteer, DSC initiates brake intervention at the front wheel furthest from the curve to create a stabilizing, opposing torque.

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In the event of vehicle understeer, active interventions at the wheels nearest to the curve provide a stabilizing counter torque. DSC stabilization is performed in all driving situations: normal running, acceleration and braking.

The DSC control module is combined with the hydraulic unit and is located on the right front strut tower in the engine compartment.

The DSC function can be deactivated by the Controller in the Control Display menu and the DSC light in the instrument cluster will illuminate to alert the driver. DSC can be reactivated by the Controller or automatically when the ignition is cycled.

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Anti-Lock Braking System (ABS)

The ABS system will operate under a full or failsafe state:

- ABS full system: the control module achieves a stabilizing effect on the driver's requests through active brake pressure increase at the individual wheels. Information from the wheel speed sensors, the yaw rate and steering angle sensors determine the vehicle speed. At vehicle speeds <60 km/h an individual control operation matching each situation shortens the braking distance.

- ABS failsafe level: the ABS adopts the failsafe level in the event of a sensor failure or a CAN Bus fault. In this case, the vehicle speed is determined by the wheel speed sensors. In addition, the “select low” control for rear axle stabilization will be applied and the active interventions during brake activation and MSR will be deactivated.

Automatic Stability Control (ASC)

ASC prevents the wheels from spinning during acceleration on all types of road surface. The ASC function is the same as models currently in use.

Engine Drag Torque Control (MSR)

When the accelerator pedal is abruptly released or in the event of unadapted downshifting to a lower gear, the MSR function maintains stability on the rear of the vehicle.

The MSR function is activated at vehicle speeds above 15 km/h to decrease strong load changes through a brief engine torque increase by increasing the Valvetronic lift, advancing the ignition timing, increasing the injected amount of fuel, etc.

Dynamic Brake Control (DBC)

The DBC function is designed to provide the maximum braking force available during rapid (panic) braking situations and includes the following subfunctions.

Dynamic Brake Support (DBS): DBS assists the driver in panic braking situations. This function is triggered by a sufficiently fast actuation of the brake pedal.

The brake pressure generated by the driver is increased by the hydraulic pump to the extent that the front and rear axles go into ABS control mode. The driver can achieve a full deceleration with low pedal force.

Fading Brake Support (FBS): FBS is a new subfunction of DBC that compensates for the brake force loss from an increase in brake temperature. The diminishing braking effect due to hot brakes requires the driver to press the brake pedal more firmly.

This increase in pressure is assumed by an activation of the DSC hydraulic pump. The temperature measurement is a virtual value which is calculated by the DSC control module based on wheel speed, brake pressure, braking time (length) and ambient temperature.

Cornering Brake Control (CBC)

The CBC function is activated in the event of medium to high lateral acceleration. If a vehicle drives into a curve under braking and threatens to oversteer, an increase in stability is achieved through a partial release of the rear wheel brake nearest the curve.

During corner braking, CBC provides the best possible directional stability through optimum brake force distribution. The hydraulic pressure in the rear brake calipers is controlled individually to prevent the vehicle from oversteering.

CBC controls the vehicle prior to ABS or DSC intervention. CBC also operates even when DSC is deactivated and CBC is deactivated in the event of an ABS failure.

Driving Performance Control (FLR)

FLR is a new subfunction of DSC that protects the brakes against overloading (misuse). When a temperature of over 600 ºC is determined, the engine power is reduced (max. engine torque 330 Nm) by the ECM. This engine torque reduction is stored as a fault (driving performance control active).

Dynamic Traction Control (DTC)

To improve propulsion, the ASC slip thresholds can be increased up to a speed of 45 mph (70 km/h). The permissible slip is doubled which offers advantages when driving on poor roads and in heavy snow (increased rear wheel spin is permissible).

When chassis dynamics increase as measured by the yaw rate sensor, the slip thresholds are reduced back to the normal mode for stability reasons.

The DTC function can be activated/deactivated by the Controller in the Control Display menu.

When the DTC traction mode is activated, the "DTC" light is illuminated above the DSC safety light (in the instrument cluster).

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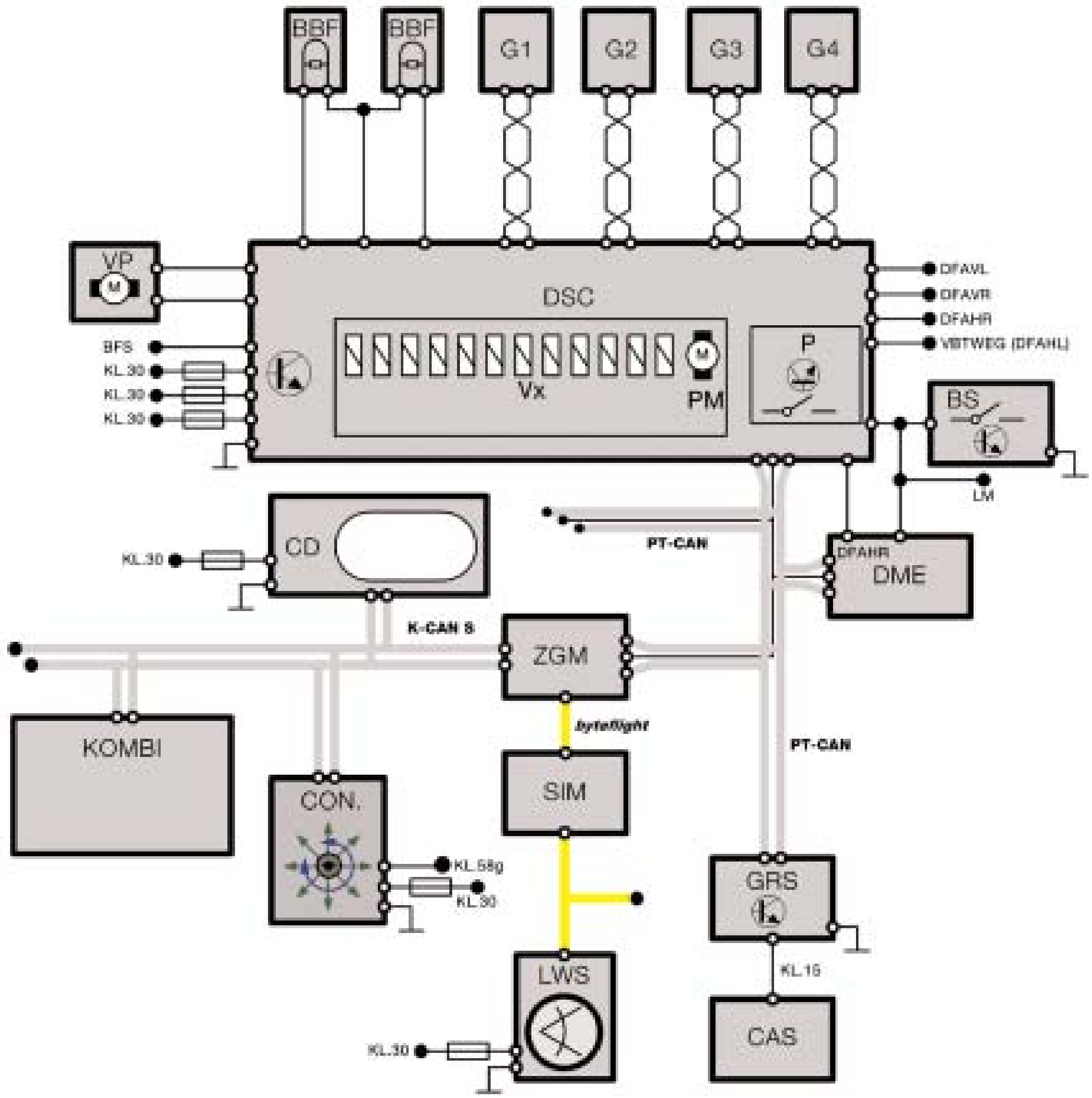
Parking Brake (Hydraulic Section)

DSC controls the hydraulic function of the Parking Brake. The "Automatic Hold" and "Dynamic Braking" functions affects a hydraulic braking operation on the front and rear service brakes (refer to the E65 Brakes Section).

System Components

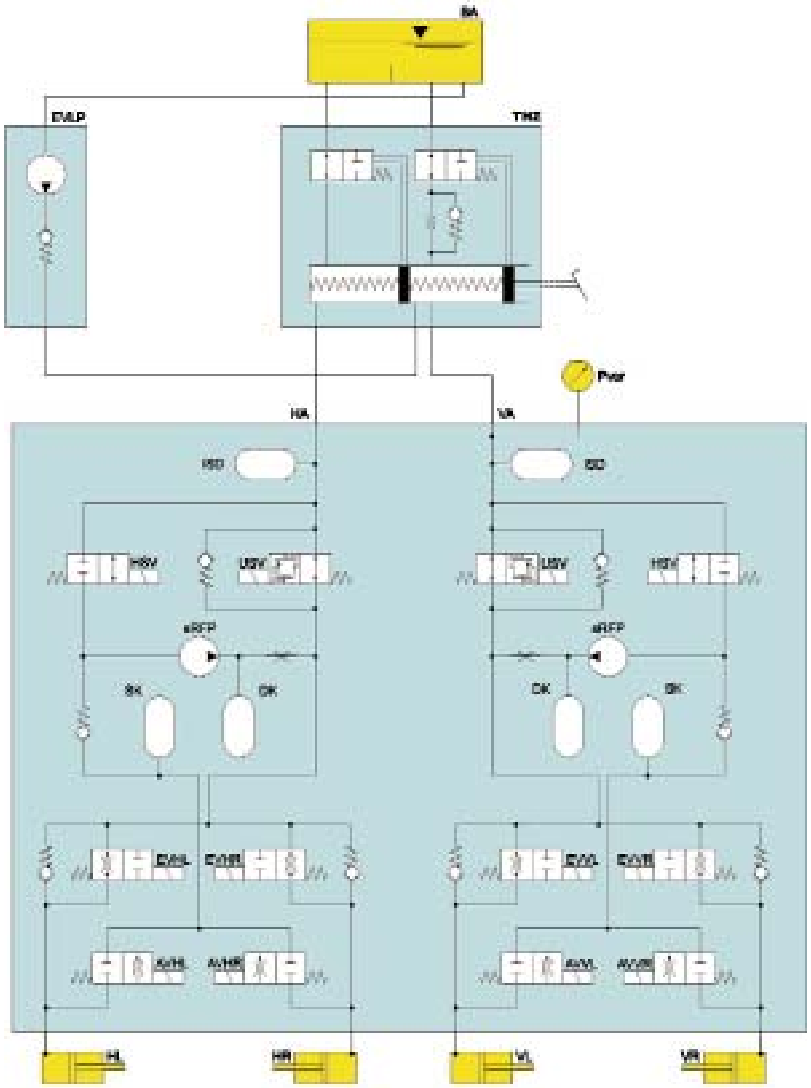


DSC Components

BBF - Brake lining sensors
VP - Precharging pump
DSC - DSC control module
Vx - Hydrualic control valves
VBTWEG - Mileage signal
CD - Control Display
ZGM - Central gateway module
Kombi - Instrument cluster
CAS - Car Access System
GRS - Yaw rate sensor with integrated transversal acceleration sensor

G1- G4 - Wheel speed sensors
BFS - Brake-fluid sensor
P - Pressure sensor
DFA - Speed-sensor output
BS - Brake-light switch
DME - Digital Motor Electronics (ECM)
SIM - Safety Information Module
CON.- Controller
LWS - Steering angle sensor

Hydraulic System Components



Hydraulic System Components

BA - Brake fluid reservoir
THZ - Tandem brake master cylinder
HA - Rear axle
VA - Front axle
Pvor - Pressure sensor
DK - Damper chamber
EVLP - Single precharging pump
Kombi - Instrument cluster
GRS - Yaw-rate sensor
CAS - Car Access System
HSV - High pressure switching valve
USV - Changeover valve
SK - Accumulator Chamber

sRFP - Self priming return pump
ISD - Integrated flow damper
EVHL - Inlet valve, left rear
EVHR - Inlet valve, right rear
EVVL - Inlet valve, left front
EVVR - Inlet valve, right front
AVHL - Outlet valve, left rear
AVHR - Outlet valve, right rear
AVVL - Outlet valve, left front
AVVR - Outlet valve, right front
HL/HR - Left rear / right rear
VL/VR - Left front / right front

Sensors

The DSC 5.7 receives input signals from the following sensors:

- Wheel speed sensors (4 active wheel speed sensors with direction of rotation detection)
- Steering angle sensor (located in the SLZ), made available over the PT-CAN Bus
- Brake fluid level warning switch (level monitoring in brake fluid reservoir)
- Brake light switch (BS)
- Rotation rate sensor - yaw (satellite of DSC on PT-CAN Bus)
- Transversal acceleration sensor (integrated in rotation rate sensor)

  The Rotation rate (yaw) sensor is located under the carpet in front of the passenger's seat in the passenger compartment.

42-06-09

- Pressure sensor (installed at the inlet of front brake circuit)

42-06-10

Notes:

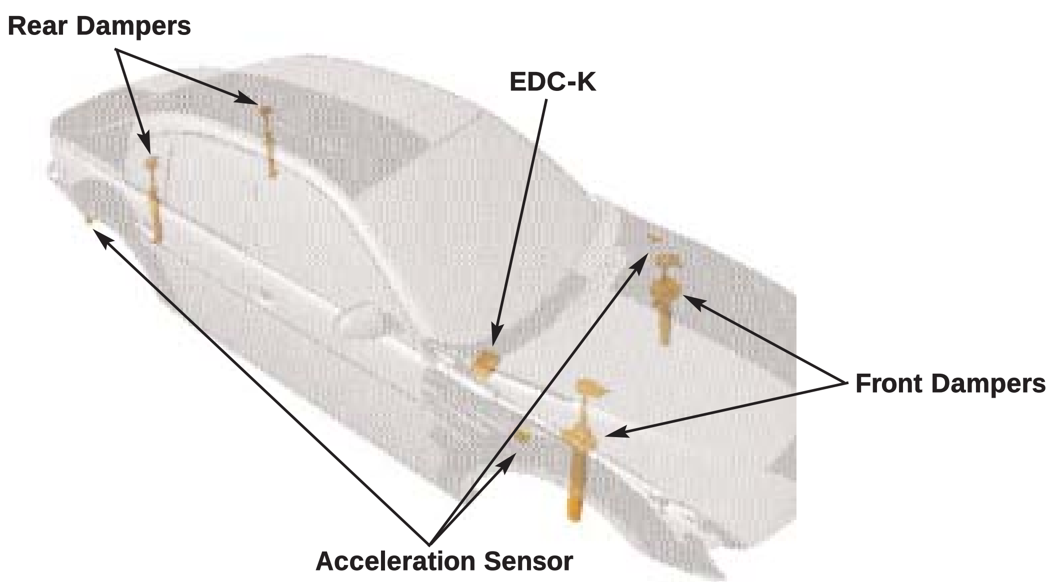
Electronic Damper Control - Continuous (EDC-K)

History

With EDC I in the 1987 E32, BMW AG was the first European manufacturer to introduce a fully automatic electronically adjustable damper system. EDC I provided manual selection during driving between hard, sport and soft damping. Since the market launch, this 2-stage system has been continuously enhanced and evolved into EDC III, it has set the standard for adjustable damper systems in the 5 and 7 Series.

EDC III evaluates the status of the road surface, vehicle load, driving speed and driver's request to automatically activate one of three damper programs: soft, medium or hard. The driver also has the option of selecting a comfort or sports program.

EDC-K is a further development of EDC III. The German abbreviation "K" stands for continuous damping force adjustment. The major change from EDC III is the damper valves and the activation control.



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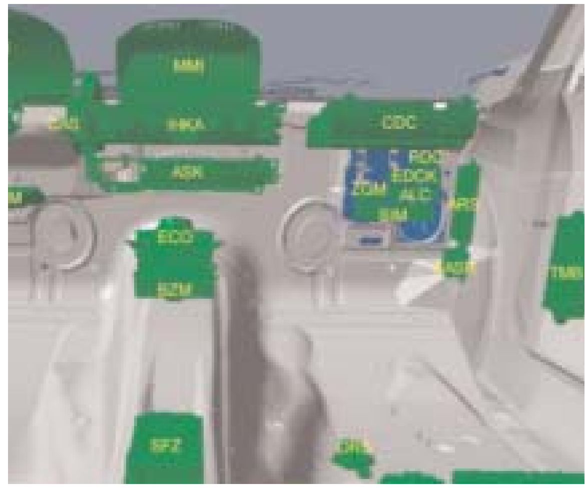
EDC-K operates with a continuously adjustable valve in each damper. The damping force is adjusted for individual piston speed. The damping force adapts continuously to the low frequency movement of the vehicle body, resulting in a significant increase in driving comfort. The driver has the option to select a comfort or sports setting by using the Controller in the Control Display menu.

The EDC-K system is an option offered under the Adaptive Ride Package.

System Components

EDC-K Control Module: The control module is located in front of the glovebox and is powered by B+, operating within a voltage range of 9 to 16V. In the event of undervoltage, the EDC-K system shuts down to prevent excessive battery draw.



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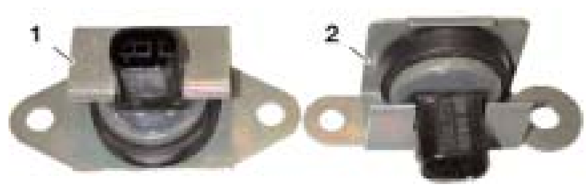
The control module incorporates various control functions that determines the current applied to the damper valves.

Vertical Acceleration Sensors: The three vertical acceleration sensors provide a varying voltage signal (0.2 - 4.5V) to the control module indicating the speed of body movement. The three sensors are identical and have a measuring range of ± 2.5 g.



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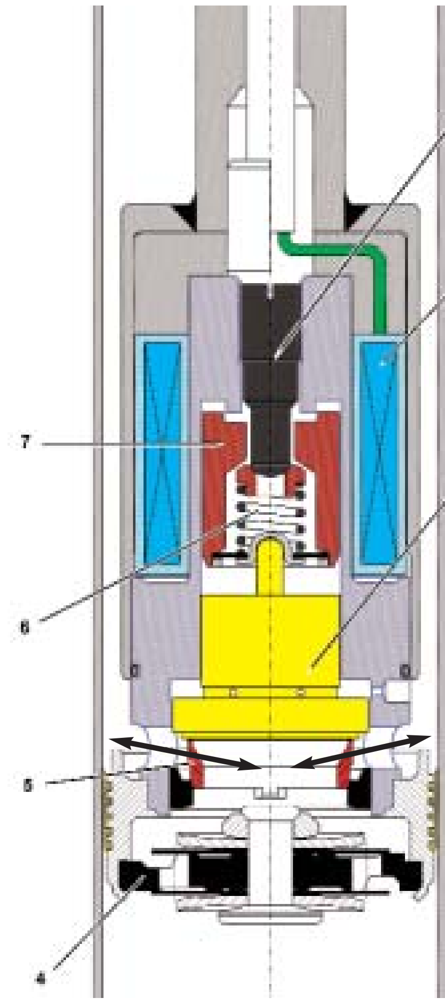
The front sensors (1) are mounted on the inside top of the wheel archs and the rear sensor (2) is mounted on the side of the rear wheel arch.

Electronically Adjustable Dampers: The front and rear axles are equipped with twin tube gas pressurized dampers supplied by Mannesmann Sachs Boge. The fully variable dampers are map controlled and do not have fixed stages.

Each damper incorporates an adjustable proportioning control valve on the piston. The wiring harness for this valve is routed through the hollow piston rod. Damper oil flows through this valve during compression and rebound. The control valve generates a pressure drop between the lower and upper chambers depending on the oil flow volume.

The front and rear axles are separately activated to achieve an optimum response for vibrations in all driving conditions. The valves are deactivated in the event of a control module failure or when the ignition is switched "OFF". The dampers automatically rest in the hardest setting (without power). On vehicles equipped with Dynamic Drive, the spring struts have different valve configurations on the front and rear axles. The dampers are de-energized when the vehicle is stationary. They are energized initially from 5 km/h.

1. Pre-tensioning screw
2. Solenoid coil
3. EDC-K Damper valve
4. Primary valve
5. Floating seat ring
6. Valve spring
7. Armature



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EDC-K Damper Valve - Detail

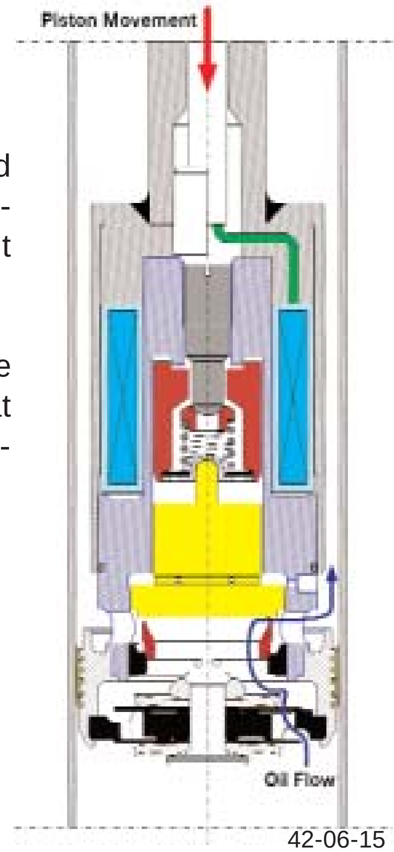
Infinitely Variable Control Valve: Without power, the maximum hydraulic resistance is set by the screw (1), which pre-tensions the valve spring (6). This is the hardest damper setting, also known as the failsafe (rest) setting.

The valve spring provides maximum tension on the armature (7), which presses down on the EDC-K Damper valve (3). This in turn presses down on the floating seat ring (5) which offers resistance to the oil flow by restricting the orifices (indicated by arrows).

When the solenoid coil (2) is energized by the EDC-K control module, the armature is magnetically pulled upwards against the valve spring tension. The armature will exert less pressure on the EDC-K Damper valve. The tension is decreased on the floating seat ring decreasing the orifice restriction. The oil flow will increase, resulting in softer damping.

When the solenoid coil receives maximum power, the effect will be the lightest tension on the floating seat ring. The orifices are unrestricted, providing the softest damping.

Damper Valve - Hydraulic Details



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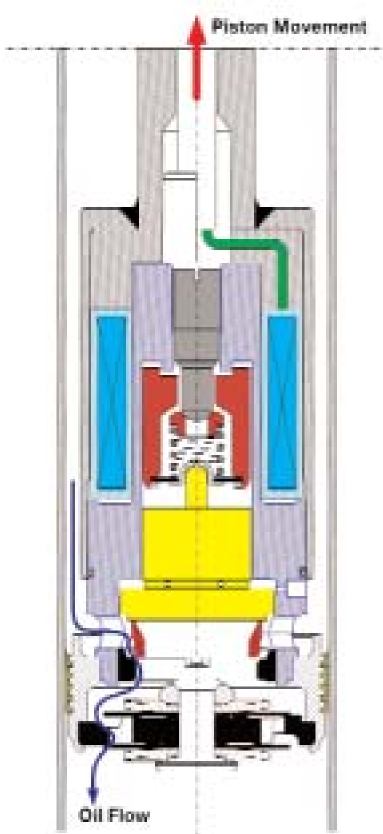
Compression Stage: The rod and attached piston is forced downwards in the damper cylinder. The oil in the cylinder provides lubrication and resistance to the piston movement (shown to the right).

The oil is forced through the primary valve which pushes the EDC-K Damper valve upwards. The floating seat ring rests at the bottom and the oil will flow through the orifices which control the rate (direction indicated by the arrow).



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Rebound Stage: The rod and attached piston is forced upwards in the damper cylinder. The oil in the cylinder provides resistance to the piston movement (shown to the left).

The oil will flow through the orifices forcing the floating seat ring up against the EDC-K Damper valve. The oil continues to flow through the primary valve to control the rate (direction indicated by the arrow).

The armature is controlled (electronically) by the EDC-K control module to regulate the EDC-K Damper valve and floating seat ring positions which varies the resistance to oil flow by restricting the orifices.

Principle of Operation

EDC-K is a microprocessor controlled damper adjusting system. The system consists of mechanical, hydraulic and electrical/electronic subsystems. Acceleration sensors record the driving/road surface conditions and the control module receives the sensor frequency signals for evaluation. The sensor signals are compared with each other for plausibility. The control module logic activates the damper valves according to internal programmed maps to dampen body and wheel movement as needed.

The driver can use the Controller and Control Display menu to select between comfort and sports programs. The system is diagnosable with the DISplus. In the event of sensor faults, the system is switched to a “safe state” by supplying fixed power to the damper valves. In the event of a system failure (no power), the dampers are mechanically sprung to the firmest setting.

The EDC-K function is divided into 3 blocks:

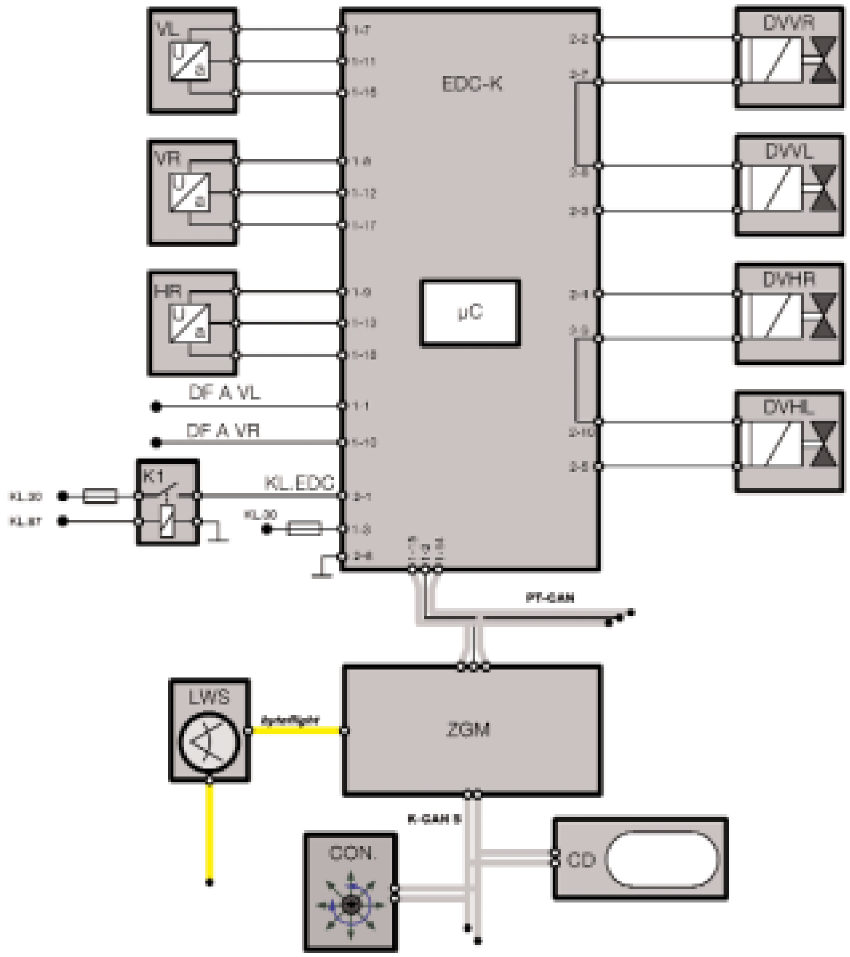
- Control Module
- Sensors and program selection option
- Actuators - 4 electronically adjustable dampers

The input signals for the system are generated by:

Sensor/Switch	Signal	Calculated Variable	Location
Acceleration sensors front axle, rear axle	Vertical acceleration front, rear	Vertical velocity, Compression/rebound travel	Sprint-strut dome FR, FL, RR
Steering angle sensor	Steering angle	Steering angle velocity	SZL
Wheel speed sensors FL/FR	Wheel speed	Driving speed, acceleration/braking	Wheel hubs FL/FR
Program selection	Comfort/sports program		Controller

In addition to the forces calculated in each measured movement, there are vertical, longitudinal, transversal, copy and tolerance control logic.

EDC-K Electronic System Overview



EDC-K Components

VL - Front left acceleration sensor	CD - Control Display
VR - Front right acceleration sensor	DVVR - Damper valve, front right
HR - Rear right accelerator sensor	DVVL - Damper valve, front left
DF A - Front left wheel speed sensor	DVHR - Damper valve, rear right
Con. - Controller	DVHL - Damper valve, rear left
LWS - Steering angle sensor	ZGM - Central gateway module

Vertical Dynamics Control

Vertical Dynamics Control responds to vertical (up/down) body movements based on wheel/body acceleration and speed. A distinction is made between a low frequency body vibration (approx. 1 Hz) and a high frequency wheel vibration (approx. 10 to 15 Hz). Because the body speed cannot be measured, a characteristic value is calculated from the acceleration signals. This value is adapted based on the vehicle speed, frequency ranges and road surfaces.

The higher frequency vibrations of the axle are calculated as the wheel dynamics value based on the wheel speed signal inputs. The value is determined from the irregularities of the wheel rotation when driving over bumps. This control operation takes place separately for both axles.

Longitudinal Dynamics Control

The Longitudinal Dynamics Control responds to acceleration and braking body movements (forward/backward). The vehicle speed signals are monitored by the control module: two direct wheel speed inputs from the DSC control module and three digital inputs from the PT-CAN Bus. Two of the signals on the PT-CAN Bus correspond to the 2 wheel speed signals from DSC and the third signal is the averaged vehicle speed.

The EDC-K control module assesses the plausibility of these signals. A Longitudinal Dynamics value is calculated from the wheel speed signal, which represents the level of acceleration or deceleration. The dampers are adjusted (on both axles) to the harder setting to counter act the longitudinal movement.

Transversal Dynamics Control

The Transversal Dynamics Control responds to transversal movement (dive and squat - front to back roll). This value is calculated from the steering angle sensor and the vehicle speed signals. The onset of “yaw” movement is detected very early from the steering angle sensor signal. A harder damper setting to support the vehicle as it enters a curve is activated at an early stage. The front and rear axles are separately controlled.

Copy Control

The Copy Control function responds to the compression and rebound of the body (encountering bounces on one side of the vehicle) while driving straight ahead. Through comfortable damper tuning, EDC-K responds to one sided unevenness due to the road surface. This prevents a side to side rolling motion while driving straight ahead.

Once vehicle "copying" is detected, a harder damping combination is applied to the front and rear axles. Detection is based on the evaluation of the right and left vertical acceleration signals from the front axle.

Tolerance Adaptation

The damper force is diminished as part of the operating time function. Diminishing damper forces are compensated by current (amperage) reductions which are calculated by the tolerance control. This also individually compensates for mechanical damper wear on each axle.

Control Strategy

All of the dampers are controled simultaneously until a single damper control in particular is required. For stability reasons, the smallest desired output current of the four damper controls (hardest damper setting) is set.

Plausibility Monitoring and Safety Concept

The EDC-K inputs and outputs are checked for plausibility. Depending on the type of fault, restricted operation of the damper control system will occur while a high degree of safety and comfort is maintained.

The control display informs the driver when an EDC-K system fault has occurred. There are two different shutdown options in the event of faults.

- In partial operation, medium damping is set by a fixed current at the front and rear axle valves.

- When the entire system is shut down, the de-energized valves instantly switch (spring loaded) and remain in the "hard damping" setting.

In the event of system faults, the chassis and suspension is set to a safe condition that is acceptable to the driver. The valves, sensors, electric circuits and EDC-K control module are fault monitored.

Notes:

System Faults and Reactions

Malfunction	Fault response
CAN steering angle signal correction Deviation > 10º	Fixed current, fault in memory, gong at end of trip
Acceleration sensors (front, left, right, rear)	Fixed current output for front axle, rear axle Fault in memory, gong at end of trip
Wheel speed front left/right	1) Control operation with replacement sensor 2) Fixed current output for front and rear axles
External voltage supply fault fluctuation (nominal should be 5 V +/- 10%)	Fixed current output for front axle, rear axle Fault in memory, gong at end of trip
Voltage supply to EDC control module between 2 V and 8 V	Valves de-energized, fault in memory, gong During trip
Valve failure	Valves de-energized, fault in memory, gong during trip
Voltage wake up, <2V standing & wake up>7V	Valves de-energized, fault in memory, gong during trip
No vehicle speed via CAN Bus	Fixed current, fault in memory, gong at end of trip
Control module EEPROM faulty	Fixed current, fault in memory
Control module - no alive message from EDC-K	Valves de-energized, fault in memory, gong during trip

CAN Interface

The steering angle value is prepared and is transmitted by the SZL over the CAN Bus. Both of the front wheel speed signals (including the direct DSC wheel speed signal), the vehicle speed reference value and the mileage reading are provided by the DSC control module over the CAN Bus to the EDC-K control module.

Power Supply

Low current supply to the damper valves results in hard damping and a high current results in soft damping. The EDC-K control module determines the setpoints and outputs pulse-width modulated (PWM) signals to the damper valves to regulate the current flow. Current flow limitation is ensured by an overcurrent detection and deactivation. All of the analog inputs are protected by diodes against positive and negative overvoltage. The following analog signals are processed by the EDC-K control module:

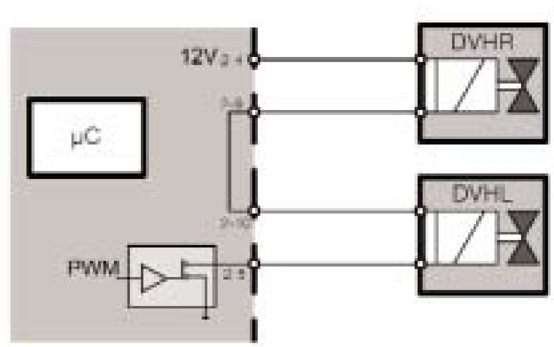
- Vehicle supply voltage
- EDC-K switched output voltage
- Damper valve voltage and current

Valve Activation/Output Stage Circuit

The solenoid valves have low resistance, approximately 2.2 ohms per valve at room temperature because high current is needed at a low voltage. The current is set in the 0 to 2 Amps range depending on the desired damping force. The setpoint value will not exceed 2 Amps to avoid valve damage. The solenoid valves are connected in series for each axle and are supplied with a ground (PWM for continuous adjustment) from the EDC-K control module.

Rear Axle EDC-K Valves Series Connection

uC = Microcontroller (EDC-K control module)
PWM = Pulse width modulation (output signal)
DVHR = Right rear damper valve
DVHL = Left rear damper valve



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Controller and Control Display Operation

Sports program: The driver can activate/deactivate the sports program by the Controller in the Control Display menu.

A firmer damping is set when the EDC-K request is set to "SPORT". EDC-K always reverts back to the comfort program each time the engine is restarted.

42-06-02

Notes:

Workshop Hints

Diagnosis

System monitoring and plausibility: For safety reasons, faults with one damper valve will result in deactivation of all damper valves. Fault detection takes place on each axle. To pinpoint which valve is faulty, use the DISplus to measure the resistance of the individual valves (per axle). The resistance of a good valve is 2.2 ohms ±10% at room temperature (20 ºC).

Acceleration sensors: The EDC-K control module does not distinguish individual malfunctions between the sensors. The power supply to the three sensors is connected in parallel in the control module (without isolation). A short circuit in the supply voltage to one of the sensors will also affect the supply to the other sensors.

A maximum of seven different faults can be stored for the acceleration sensors. The coding data will indicate the functions of the control module (vehicle and country specific).

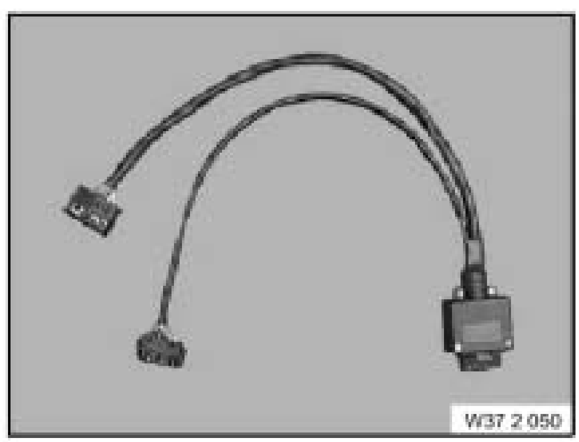
Notes on Service

When the steering angle sensor is removed, the steering wheel must be manually positioned to the straight ahead position and this position re-initialized in the SZL. The steering wheel straight ahead position is permanently monitored while driving.

EDC-K diagnosis detects electronic damper faults on the complete axle only. Mechanical testing of individual dampers can be carried out in the damper test. Mechanical wear causes the dampers to weaken over the service life, therefore a running time memory adapts the damper curves towards a harder setting (over time). Faulty dampers must be replaced together (in pairs) on a single axle. After a replacement, the running time memory for the front or rear axle must be reset with the DISplus.

A 10 Pin Adapter Cable is available to adapt the MFK cables to the EDC-K control module when using the DISplus (Test Plan).

Special Tool #90 88 6 372 050

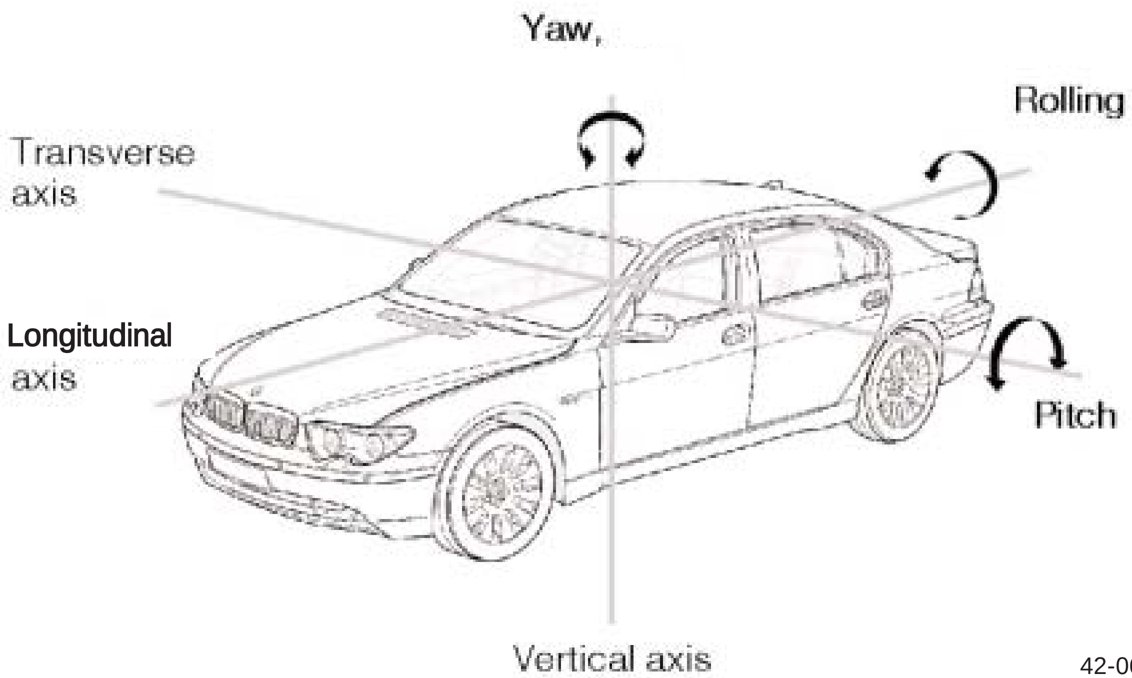


42-06-20

Dynamic Drive - Active Roll Stabilizer Bar (ARS)

Stabilizer Bars on the Front and Rear Axles

Body roll is built up over the vehicle's longitudinal axis as a result of the centrifugal force at the center of gravity. This force causes the vehicle body to lean towards the outside wheels while cornering and quickly draws the vehicle closer to the limits of driving dynamics. The tilt angle of the body and the increased wheel load is counteracted by the use of stabilizer bars.



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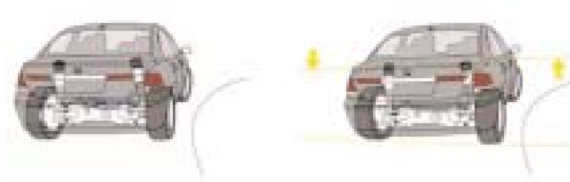
When cornering, the wheel on the outside of the corner compresses the spring, and the inner wheel extends the spring which causes the the stabilizer bar to turn (twist).

The forces on the mounting points of the stabilizer bar generate a torque that counteracts the body angle providing better load distribution on both wheels on the same axle.



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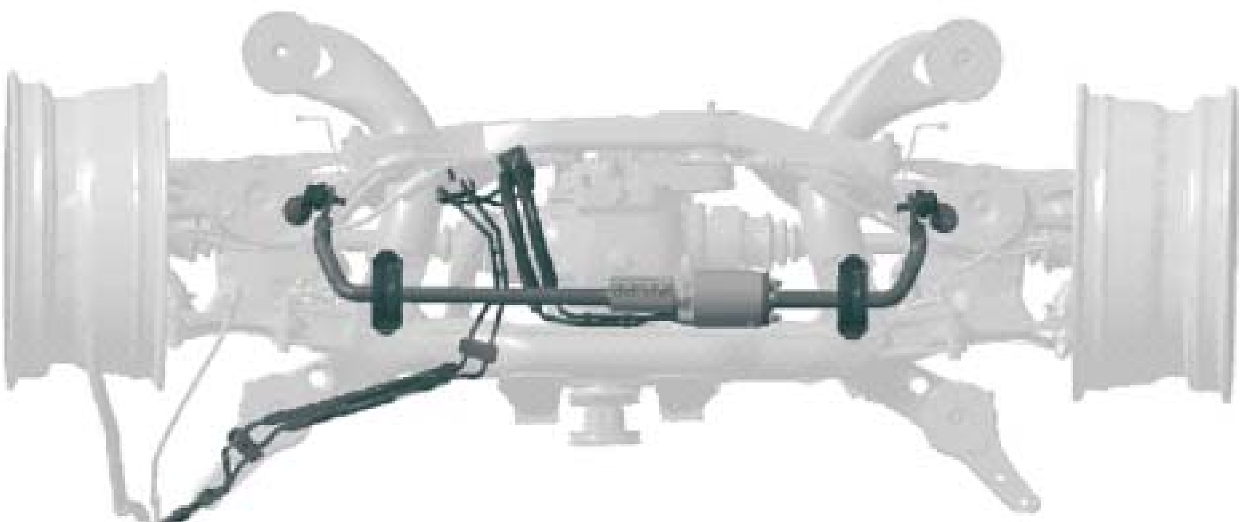
The suspension is firmer with a solid stabilizer bar. The disadvantage is that when you are driving straight ahead during a one-sided compression (bounce), this transmits a "copying" effect through the suspension, which reduces comfort.

Purpose of the System

The Dynamic Drive - Active Roll Stabilizer Bar (ARS) is a revolutionary step for chassis technology. ARS goes a long way towards removing the conflict between handling/agility and comfort. ARS has two stabilizer bars that have a positive effect on the body roll and handling, allowing softer springs and dampers to increase comfort.

Active Stabilizer Bar on the Rear Axle



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Dynamic Drive controls two active stabilizer bars on the axles depending on the lateral acceleration.

Oscillating Motor

42-06-22

The two separate stabilizer bars on each axle are mounted in roller bearings and are connected by a hydraulic oscillating motor.

One half of the stabilizer bar is connected to the oscillating motor shaft and the other is connected to the oscillating motor housing.

Active stabilizer bars introduce fewer forces into the body as compared to solid stabilizer bars-because the separate "halves" will not copy one sided suspension compressions (bounces).

The active stabilizer bars set the stabilizing torque, resulting in:

- Minimizing or completely eliminating body roll while cornering
- Reduction in the “copying effect” of the vehicle
- A high degree of agility and precision throughout the entire speed range
- Produces optimum self steering characteristics
- Improved suspension comfort (when driving straight ahead) because the stabilizer bar halves are independent and do not stiffen the basic suspension during a one-sided compression.

The distribution of the active body torque between the front and rear axle depends on the road speed. The following describes the different body torque distribution.

Self Steering Affect

The self steering affect is influenced by the distribution of the stabilizing torque on the axles. The greater the stabilizing torque on an axle, the lower the lateral forces will be that are transmitted on this axle. Two situations are described below with a different distribution of stabilizing torque on the axles:

Identical stabilizing torque on both axles: Handling is "NEUTRAL". The front wheels will apply about the same amount of lateral force to the road as the rear wheels (without drive torque). A vehicle that is tuned to neutral handling provides very agile handling and the steering reacts very quickly. The driver experiences precise handling.

Larger stabilizing torque on the front axle: Handling is "UNDERSTEERING". The front wheels cannot apply the same amount of lateral force to the road as the rear axle wheels. The vehicle tends to go straight requiring an increase in steering to make the vehicle turn.

Dynamic Drive sets the stabilizing torque on the front and rear axle to create a different handling characteristic for low and high speeds.

Road Speed	**Handling**
Low	Neutral
High	Understeer

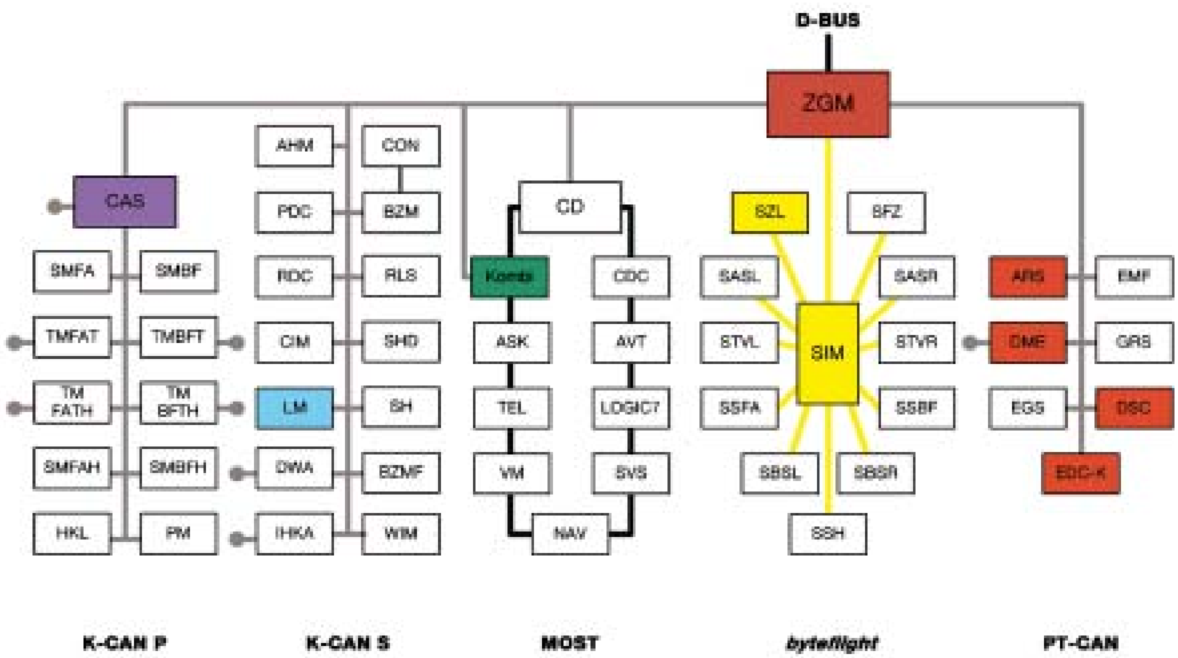
Passenger vehicles are designed for slight understeer depending on the speed range. Dynamic Drive is tuned to neutral in the lower speed range, requiring less steering to go around the same corner. This produces optimum handling and agility. In a higher speed range, Dynamic Drive is designed so that a larger active stabilizing torque will occur on the front axle as compared to the rear axle. ***This means that the vehicle with Dynamic Drive reduces over sensitive steering a higher speeds to enhance handling characteristics.***

System Dynamics

When the vehicle changes lanes, corners or changes direction quickly (winding roads), Dynamic Drive reacts very quickly. The system dynamics reaction time is shown in the following steps:

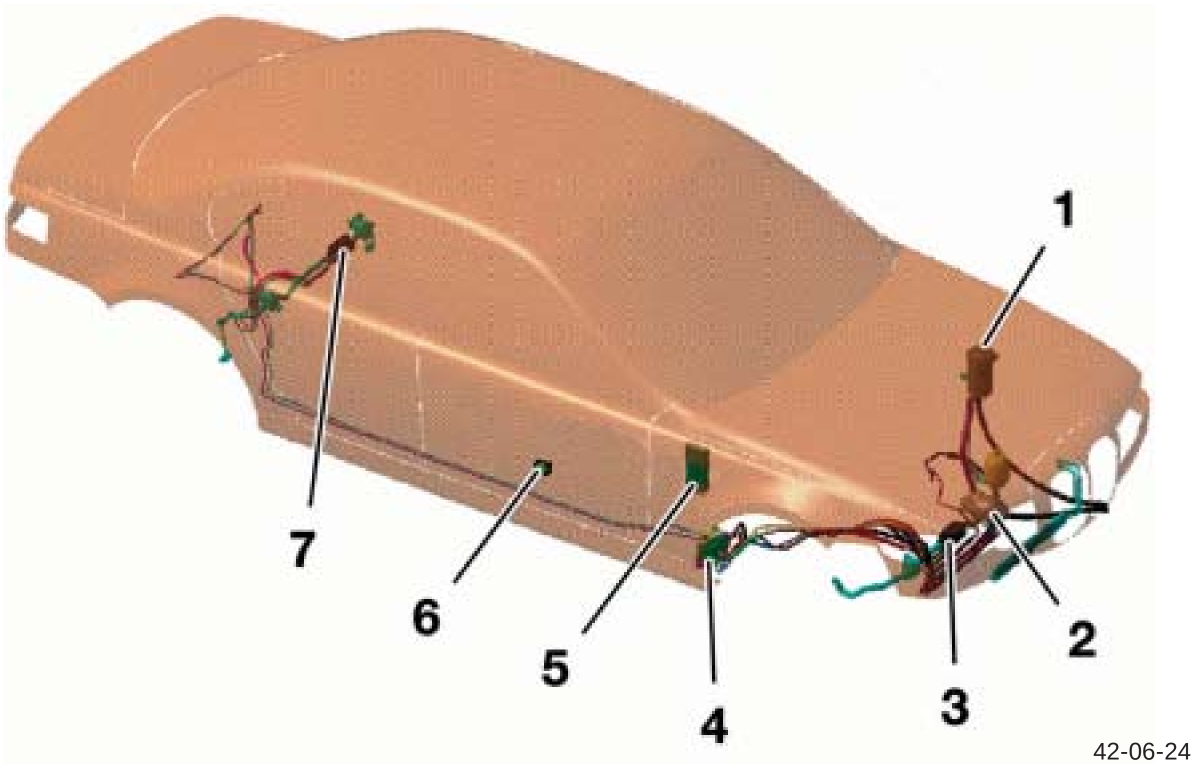
Process	Time
Signal detection by sensors, processing of sensor signals and valve control.	approx. 10 ms
Change of direction, switching over the torque direction, direction valve.	approx. 30 ms
Pressure build up (force per wheel).	
0 to 30 bar (0 to 350 N)	approx. 120 ms
0 to 180 bar (0 to 2100 N)	approx. 400 ms

Dynamic Drive Bus Structure



System Components

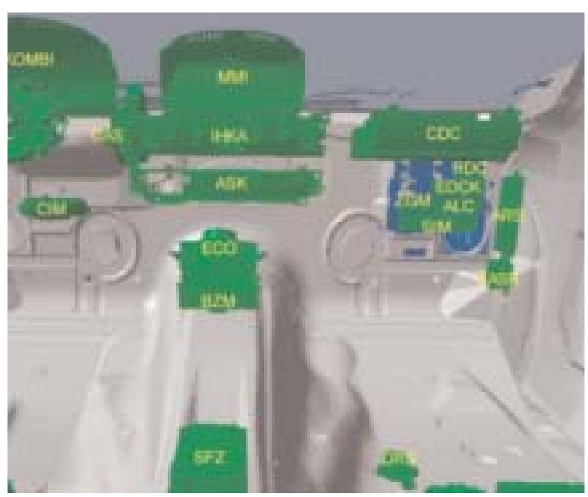
Dynamic Drive (ARS) consists of the following components:



Dynamic Drive (ARS)

1. Fluid reservoir
2. Tamdem pump
3. Front oscillating motor
4. Valve block
5. Control module
6. Transverse acceleration sensor
7. Rear oscillating motor

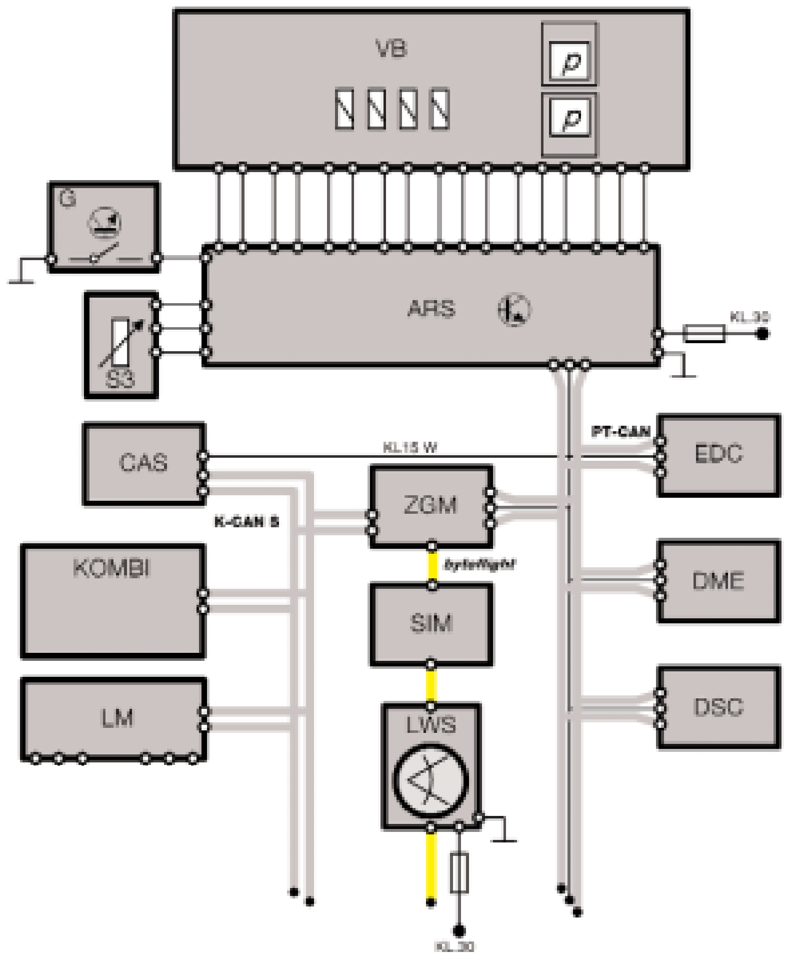
ARS Control Module: The control module is located on the right side "A" pillar in front of the glovebox and is powered by B+ through a 10 Amp fuse. The control module is activated by a CAN alarm lead from the CAS module when the ignition is switched "ON".



A vehicle authentication process takes place when the system is started. This compares the vehicle identification number from CAS with the vehicle identification number which is encoded in the ARS control module.

After the ignition is switched “ON”, the ARS hardware and software is self-checked. All of the outputs (magnetic valves) are checked for short circuits and breaks. When there is a fault, ARS switches the actuators to a safe driving condition. The control module will switch off in the event of undervoltage or overvoltage.

Dynamic Drive (ARS) Component Overview:



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Dynamic Drive Component Overview

ARS - Control module
VB - Valve block
P - Pressure sensors
G - Rotational rate (yaw) sensor
CAS - Car Access System
KOMBI - Instrument cluster
LM - Light switch center
LWS - Steering angle sensor

SIM - Safety integration module
ZGM - Central gateway module
EDC - Electronic damping module
DME - Digital engine electronics
DSC - Dynamic stability control
S3 - Lateral acceleration sensor

Inputs: The ARS control module requires dynamic driving input signals to calculate the required activation. The following input signals are monitored and checked for plausibility:

- Lateral acceleration
- PT-CAN Bus
- Front axle ARS circuit pressure
- Rear axle ARS circuit pressure
- Selector position recognition sensor (SSE)
- Fluid level sensor signal

The PT-CAN provides additional information about lateral dynamics:

- Vehicle speed signal (DSC)
- Steering wheel turning angle (Steering Angle Sensor)
- Yaw velocity - Transversal acceleration (Roational Rate Sensor)

These inputs allow the ARS control module to determine the stabilization requirement at the appropriate inertia moments. The reaction time is decreased by using the vehicle speed and steering angle inputs.

Outputs: All of the outputs are check by diagnostics and are short circuit protected. The outputs (and control) include the following:

- Pressure control valves for the front and rear axle ARS
- Directional valve
- Failsafe valve
- 5 V sensor voltage supply

The valves are controlled by pulse width modulation current. The individual coil current requirements are constantly checked for plausibility. The current measurements allows the pressures to be precisely set and electrical monitoring of the hydraulic the shift valves.

The PT-CAN sends a message to the ECM indicating how much engine power is required to drive the tandem hydraulic pump to activate the ARS stabilizer bars.

An “alive” data signal is provided and monitored by other control modules to detect the system status. All signal faults are permanently stored. Output faults include short circuits (B+ and ground) and open circuits.

Sensor System

Lateral Acceleration Sensor: The lateral acceleration sensor is located under the carpet in front of the passenger's seat (1). While cornering, the vehicle's lateral acceleration is measured (range is ±1.1 g).

Transversal acceleration (yaw velocity) is provided by the Rotation Rate Sensor (2) via the DSC control module.

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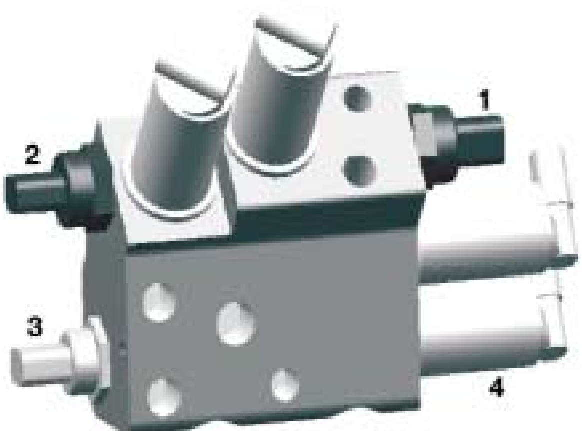
Front and Rear Axle Stabilizer Bar Pressure Sensors: The pressure sensors provide the ARS control module with the front (1 below left) and rear (2 below left) axle stabilizer bar hydraulic operating pressures. The sensors are mounted on the valve block assembly and the pressure values are initialized in the control module (during assembly line commissioning). The voltage value is proportional to the operating pressure (in bar shown below right).



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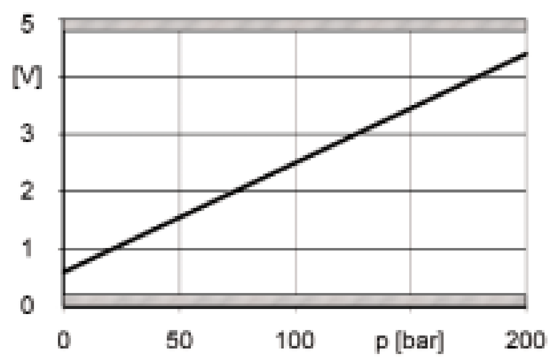

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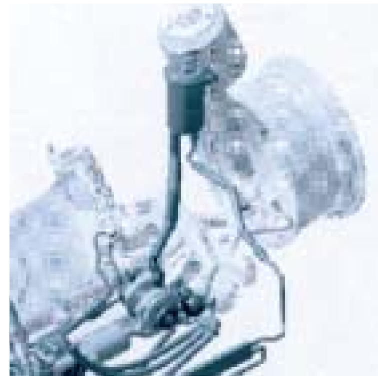
Selector Position Recognition Sensor (SSE): The SSE is mounted on the valve block assembly (3 above left). This sensor allows the ARS control module to detect the specific position of the directional valve (4 above left). The 2 positions detected are:

- Left hand control (direction of torsional twist)
- Right hand control (direction of torsional twist)

Fluid Level Sensor: The fluid level sensor allows the ARS control module to detect the fluid supply level in the reservoir (power steering reservoir) for the tandem pump. The fluid level sensor indicates when the fluid drops below the minimum level and triggers a warning message.



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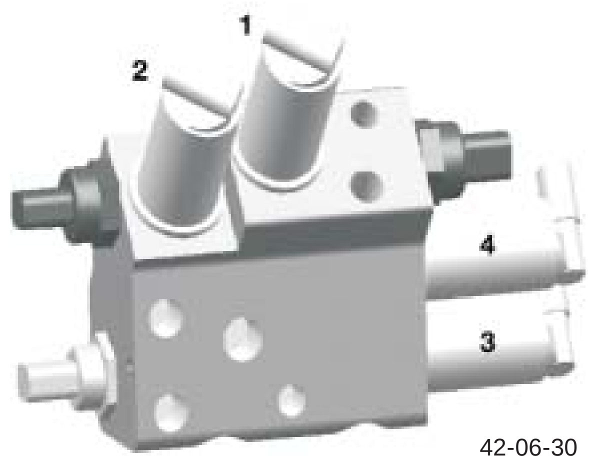
Normal fluid movement (slosh) will not trigger the sensor. Short/open circuits are not detected by the fluid level sensor circuit and a circuit break is interpreted as a loss of fluid.

Actuator System

Pressure Control Valves: There is a pressure control valve for both the front (1 below) and rear (2 below) axle hydraulic circuits. The valves adjust the front and rear axle stabilizer bar actuation pressures. When driving straight ahead, the pressure control valves are de-energized opening the valve diameters allowing the fluid to return to the reservoir (circulating).

When cornering, the valves are energized to readily increases the pressure in the oscillating motors to the setpoint value.

Depending on the lateral acceleration and the vehicle speed, the pressures for the front axle are regulated between 5 to 180 bar and 5 to 170 bar for the rear axle.



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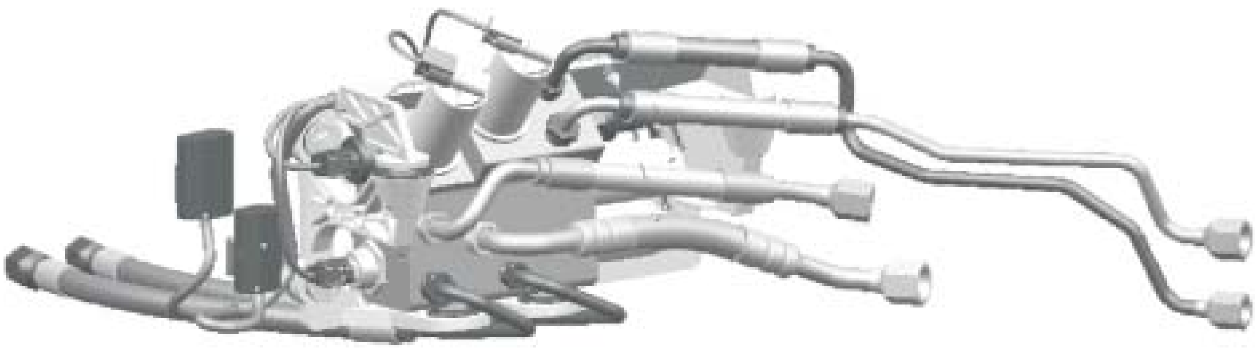
Directional Valve: The directional valve (3 above right) is electrically actuated by the ARS control module to control the direction of the hydraulic pressure for right and left hand twists.

Failsafe Valve: The failsafe valve (4 above right) is electrically actuated by the ARS control module to open the front axle hydraulic circuit to the oscillating motor. The circuit is closed when the failsafe valve is de-energized, decreasing the system pressure (circulating).

Check Valves: The check valves (internal in the valve block) allow the hydraulic fluid to be drawn from the reservoir preventing cavitation in the oscillating motor.

Valve Block: The valve block is an electrically controlled hydraulic distribution assembly and is located behind the right front wheel housing panel (at the base of the A-pillar).



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Valve Block Functions

- ***Distribution of hydraulic fluid flow to the oscillating motors:*** The pressure at the front axle oscillating motor is greater than or equal to the pressure at the rear axle oscillating motor.

- ***Measuring the actual pressure of the high pressure hydraulic fluid:*** There is a pressure sensor for both the front and rear axle oscillating motor hydraulic circuits on the valve block.

- ***Fast and precise regulation via the pressure control valves:*** Introduced pressure changes as a result of uneven roads are passively regulated to reduce noise as much as possible.

- ***Adjustment of the volume flow direction (left hand/right hand twist) via a directional valve:*** The directional valve position is detected by a selector position recognition sensor (SSE).

- ***Switch to Failsafe mode in the event of power supply failure or a fault is detected in the system:*** The front axle oscillating motor hydraulic circuit is closed off and hydraulic flow is diverted to the reservoir. The check valves will open to allow the hydraulic fluid to be drawn from the reservoir. The rear axle oscillating motor hydraulic circuit is also deactivated and hydraulic flow is diverted to the reservoir.

- ***Limiting the system pressure in the event of a fault:*** The Failsafe valve causes the circuit to close when de-energized, decreasing the system pressure (circulating).

Valve Block Sub-Components:

Components	Description
Pressure control valves	The pressure control valves are electrically actuated. They set the active pressure for the front and rear axle stabilizer bars. When driving straight ahead, the pressure control valves are de-energized and the valve diameters are open. The fluid can flow freely to the reservoir. The valves are energized when the vehicle is cornering. The pressure in the oscillating motors increases rapidly and is regulated to the setpoint value.
Directional valve	The directional valve is electrically actuated. It specifies the direction of the high pressure fluid (active pressure) and the return fluid pressure for the right hand and left hand twists.
SSE	There is a selector position recognition sensor (SSE) for monitoring the directional valve position in the directional valve.
Failsafe valve	The Failsafe valve is electrically actuated. It closes the front axle oscillating motor circuit, when de-energized. The system pressure is limited by the circulation position and causes a circulating flow.
Check valves	The check valves are located in the valve block. They allow the fluid to be drawn from the reservoir to prevent cavitations in the oscillating motor.
Pressure sensors	The stabilizer bar pressure sensor signals are used to monitor the hydromechanics. In addition, the pressure control pressure signals are used.

Active Stabilizer Bar (one assembly per axle): The active stabilizer bar consists an oscillating motor and two stabilizer bar halves with press fit roller bearings to mount the assembly to the axle carrier.

The oscillating motor and the oscillating motor housing joins the two halves of the stabilizer bar.

The rear axle Active Stabilizer Bar is shown on the right.

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The Active Stabilizer Bar assembly has three tasks:

- The oscillating motor decouples the two halves of the stabilizer bar.

- The oscillating motor guides the torque into the two halves of the stabilizer bar.

- In the event of system failure (Failsafe mode), the front axle stabilizer bar creates sufficient damping from the oscillating motor hydraulic fluid (hydraulic locking) to work like a conventional stabilizer bar.

Exception: If the oscillating motor chambers do not contain any fluid as a result of a leak, the front axle stabilizer bar will not dampen and rely on the spring strut assemblies.

Oscillating Motors: The oscillating motors are split chamber hydraulically controlled rotary actuators. This motor contains a total of four chambers, opposing chambers are connected with one another and receive the same hydraulic pressure.

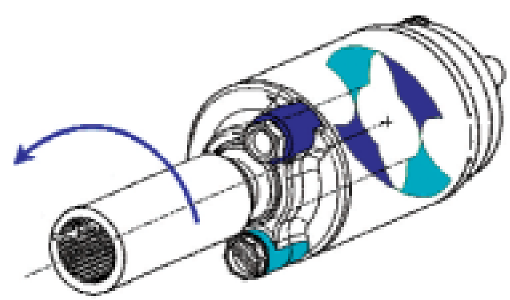
Two chambers are supplied with high pressure through an internal connection and the other two chambers are connected to the reservoir return line.

The pressure and drain (return) is switched between the two pairs for right or left hand torsional twists.

The different pressures result in the high and low forces that apply torque. One half of the stabilizer bar is connected to the shaft and the other half is connected to the housing.

The two halves will turn in opposite directions. As a result, the shaft will turn in an opposite direction of the housing.

The stabilizer bar is mounted to the axle carrier. The torque generated while cornering will force the body upwards on the outside of the curve and pull it down on the inside of the curve.



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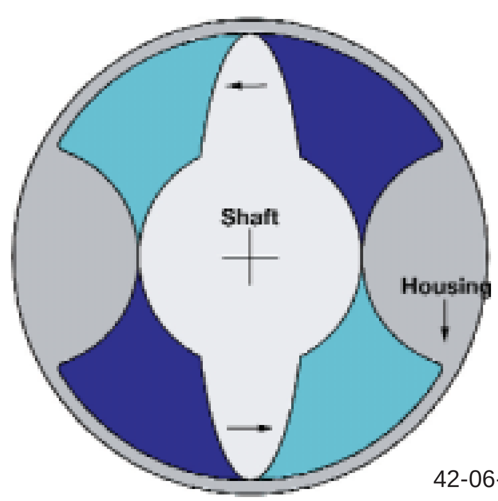

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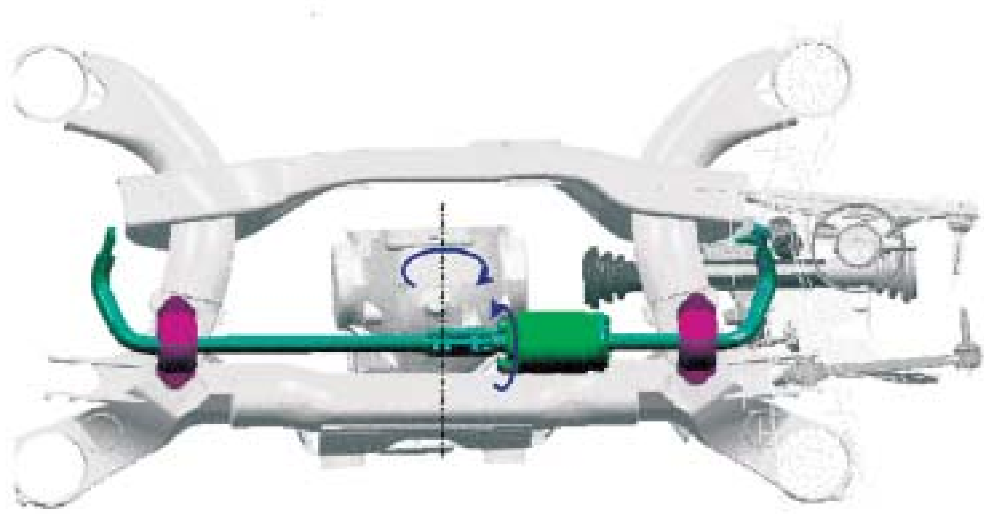

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The maximum torque influence on the front and rear axle occurs when there is a high degree of lateral acceleration (producing body roll). During this situation, the system pressure is 180 bar at the front axle and 170 bar at the rear axle. The front oscillating motor is smaller than the rear one and builds up a force of 600 Nm at 180 bar. The rear oscillating motor builds up a force of 800 Nm at 170 bar. The oscillating motors also act as torsional vibration dampers (hydraulic cushion).

During torsional twists, the fluid is displaced from two chambers returning through the lines and the valve block to the reservoir. The return path has a slight hydraulic resistance which creates damping. With failsafe (hydraulic blocking), the oscillating motor will turn as a unit because of the closed circuit hydraulic locking occurring internally (like a conventional stabilizer bar).

Tandem Pump: The tandem pump mounted on the engine and is driven by the ribbed V-belt. The pump assembly consists of a radial piston pump for Dynamic Drive and a vane pump for the power steering.

When the engine is idling, the pump speed is approx. 750 rpm providing a minimum flow rate of 4.5 l/min at 0 - 5 bar and 3.3 l/min at 180 bar.

This volume and pressure provides sufficient system dynamics when the engine is idling. At a pump speed of approx. 1165 rpm, the flow rate is limited to 7 l/min. Dynamic Drive and power steering share the fluid reservoir and fluid cooler.

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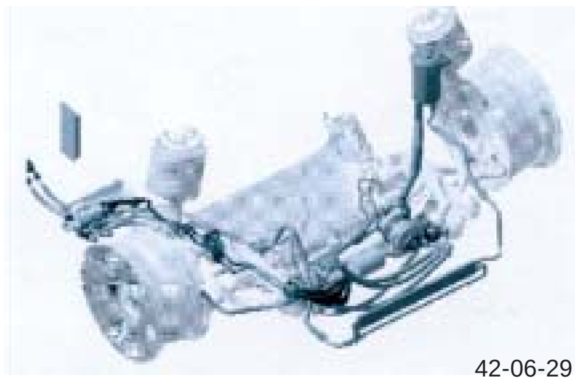
Fluid Reservoir: The fluid reservoir is identical on all E65 vehicles, whether equipped with Dynamic Drive or not. The fluid reservoir also supplies the power steering hydraulic circuit.

The reservoir contains a fluid filter (as on models in current use) and a fluid level sensor to detect when the fluid level drops below the minimum amount.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Fluid Cooler: The cooler ensures a long term fluid temperature of < 120 ºC and a short term fluid temperature of < 135 ºC in all hydromechanical components under all operating conditions.


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Hydraulic Lines and Hoses: The hydraulic lines and hoses are designed for extremely high pressures. The hydraulic component connections and fittings are designed with different dimensions and lengths to avoid improper installation.

Hydraulic noises transmitted to the vehicle interior predominantly occurs through the assemblies and connections. The lines and hoses must be properly positioned through the mounting supports (noise insulation) and not touch the body surface. The supply hose in the engine compartment has excess loops (and length) to also reduce hydraulic noise.

Principle of Operation

Dynamic Drive System Pre-drive Procedure

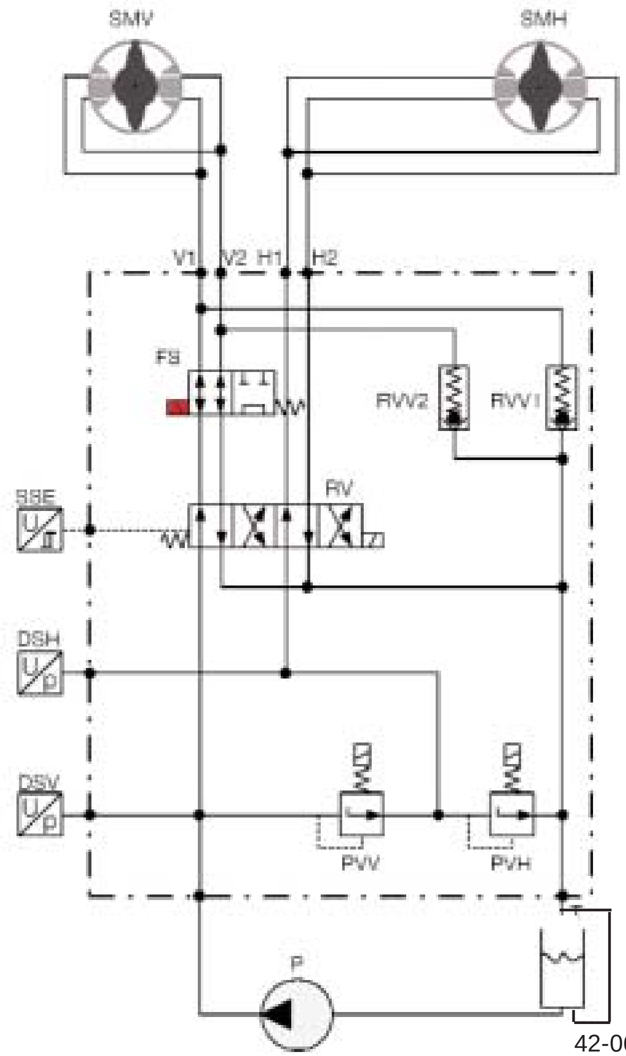
When the ignition is switched “ON”, the ARS control module self test is first performed. The electrical valve functions are conducted to detect short/open circuits in the valve solenoid coils, connectors and harness. The sensors are checked for short/open circuits in the harness, connectors or the internal electronics.

Finally, the hydraulic safety functions are checked before the vehicle moves as part of the "Pre-drive Check".

A test pressure (<60 bar) is set between the pump and the failsafe valve. This allows the ARS control module to check if the failsafe valve is actually in the de-energized failsafe position. When in this position, the system pressure is decreased (circulating).

When the failsafe valve is energized (FS as shown to the right) by the ARS control module, the front axle hydraulic circuit is open providing pressure to the oscillating motor (SMV).

The front axle pressure control valve function is tested simultaneously. If pressure does not build up at the front axle stabilizer bar, the Predrive Check criteria will not be met.



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The Dynamic Drive function is deactivated when the vehicle is stationary (inertia is not present) and all the valves are de-energized. This also applies when the vehicle is at a standstill on an incline (one sided load). Even though the lateral acceleration sensor provides a signal, the vehicle speed signal is not present.

When the vehicle speed is >15 km/h, the ARS function is started.

Straight Ahead Driving

When the engine is running, the tandem pump supplies hydraulic fluid to the system at a pressure of 3 to 5 bar. The front and rear axle stabilizer bar pressure valves are de-energized (open) and pressure is not applied to the oscillating motors. The hydraulic fluid circulates directly back to the reservoir for as long as the vehicle is driven straight ahead.

Cornering

When cornering, the signals from the lateral acceleration sensor are conveyed to the ARS control module. The control module outputs a pulse width modulated signal (PWM) to the front and rear axle stabilizer bar pressure valves. The stronger the lateral acceleration, the greater the signal (current flow). The increasing valve current will progressively close the valves forming a higher pressure in the stabilizer bar oscillating motors.

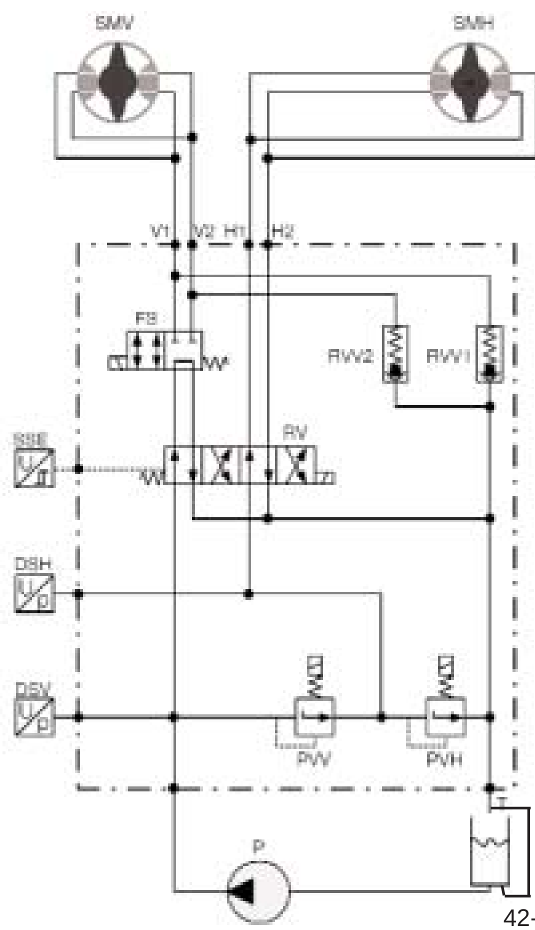
The pressure sensors provide the ARS control module with the stabilizer bar oscillating motor pressures. To direct the buildup pressure according to the corner (left hand or right hand twist), the directional valve is actuated by the control module. The SSE sensor detects the directional valve selector position.

Restricted Function

The system reverts to failsafe mode when a fault is detected. The control module stores the fault and indicates failsafe mode in the instrument cluster. The failsafe situation is shown to the right in the hydraulic overview diagram.

In the event of system failure, the failsafe valve (FS) is de-energized and sprung closed. The hydraulic fluid in the front stabilizer bar is sealed in, ensuring the stability and understeer effect of a conventional stabilizer bar.

The check valves (RVV1, RVV2) allow the hydraulic fluid to be drawn from the reservoir preventing cavitation in the oscillating motor when the vehicle is driven straight.



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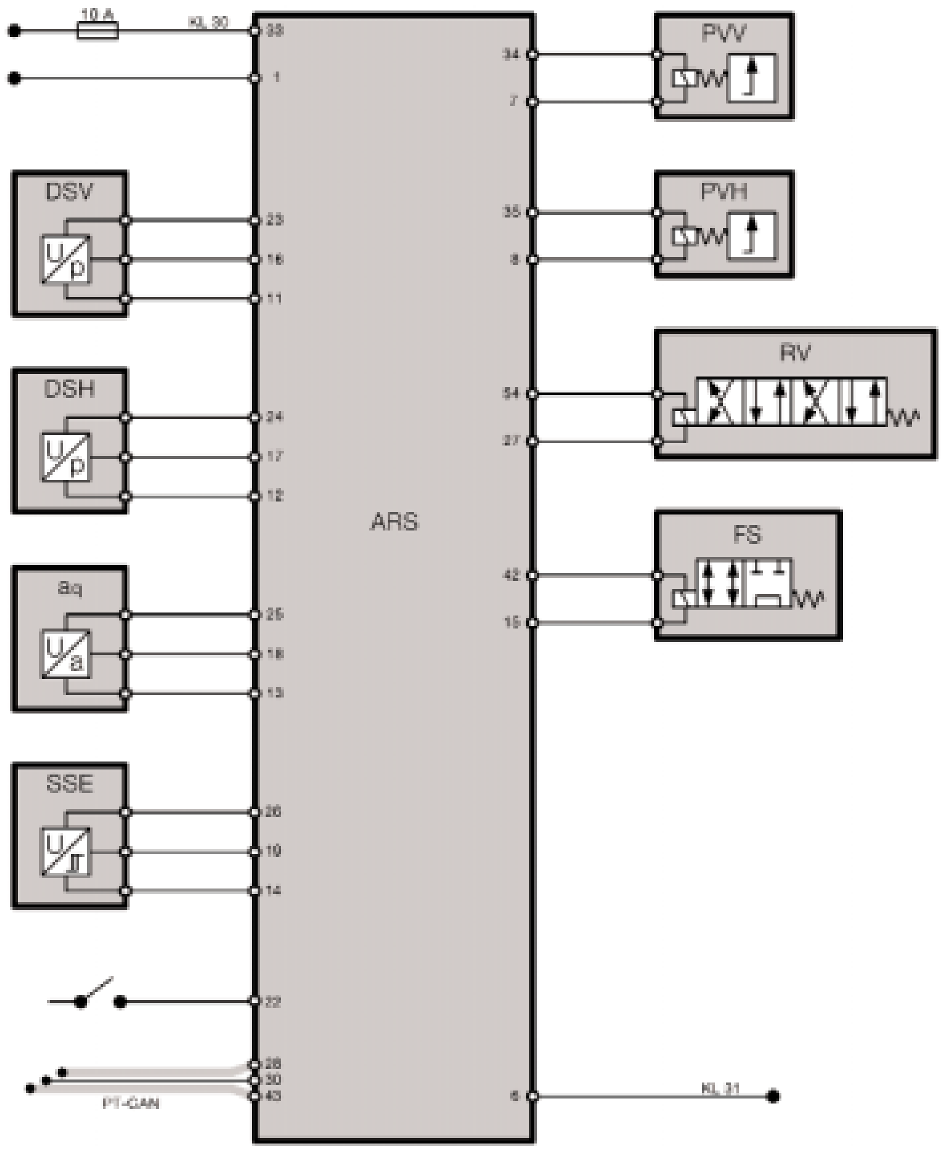
External Leakage

External leakage is detected by the front or rear pressure sensors and the ARS control module will deactivate Dynamic Drive (system failure).

ARS Block Diagram



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ARS

aq Lateral acceleration
ARS Active roll stabilizer bar control unit
SSE Selector position recogniton sensor
DSV Front axle pressure sensor
DSH Rear axle pressure sensor

PVV Front axle pressure control valve
PVH Rear axle pressure control valve
RV Directional valve
FS Fail-safe valve

Workshop Hints

Diagnosis

The following component faults can be detected:

Component	Type of fault	Fault detection via:
ARS control module	De-energized or faulty	Instrument cluster via omission of the Alive-Counter, vehicle identification number with authentication not recognized, watchdog
Pump	No pressure	Target-performance comparison pressures
Directional valve	Stuck in the ”energized” position (wire break)	Directional valve sensor
	Stuck in the “de-energized” position (wire break)	
Pressure control valve	Open (de-energized)	Front axle target-performance comparison pressure, current Measurement
	Closed (mechanical fault)	Front axle target-performance comparison pressure
Pressure control valve	Open (de-energized)	Rear axle target-performance comparison pressure and current measurement.
	Closed (mechanical fault)	Rear axle target-performance comparison pressure
Failsafe valve	Stuck open	Predrive-Check
	Stuck closed	Current measurement
Actuator Front/rear axle	Leaking (no moment)	Target-performance compliance pressure
	Blocked	Target-performance comparison pressure
CAN bus	Completely omitted (line out)	CAN-timeout
Steering angle	Implausible, or omitted	Plausible monitoring and fault detection CAN bus signals
Sensor	Completely omitted (line out)	Voltage monitoring
	Incorrect signal	Check plausibility via CAN signals
Fluid level sensor	No signal (line)	
Front axle Pressure sensor	No signal (line)	Front axle target-performance comparison pressure
	Incorrect signal	
Rear axle pressure sensor	No signal (line)	Voltage monitoring
	Incorrect signal	Target-performance comparison pressure
Directional valve sensor	No signal	Voltage monitoring
	Incorrect signal	SSE directional valve target – performance comparison

Depending on the fault, the system exhibits one of the reactions listed below:

System shut down (Failsafe mode)

The following faults lead to system shutdown and all output stages are de-energized

- Fault in the front axle stabilizer bar
- Fault on the front axle pressure sensor
- Fault with pressure build up (pump, pressure relief valve on the front axle)
- Fault in the control module
- Vehicle identification number is not conveyed by the CAS/is missing/is incorrect
- Directional valve positioning fault, faulty SSE
- Omitted PT-CAN signal

The de-energized failsafe valve blocks the chambers of the active stabilizer bar on the front axle. The fluid is only equalized via the internal oscillating motor and valve block leakage. The check valves in the valve block make it possible

Warning message	Handling instructions
Cornering stability. Take corners slowly	Directional stability system with unlimited Directional stability. No high road speeds When cornering. Drive on, contact BMW Center immediately

If there is a fluid loss in the ARS or the steering circuit, the fluid level sensor in the fluid level sensor in the fluid reservoir responds to this.

The driver is informed in order to avoid damaging the tandem pump by driving on.

Warning message	Handling instructions
Fluid loss. Stop carefully, switch off the engine	Fluid loss in the chassis and steering system. Do not drive on, contact BMW Center immediately

A 12 Pin Adapter Cable, ***Special Tool # 90 88 6 372 040*** is used in conjunction with the DISplus to adapt the MFK cables when diagnosing the ARS system.

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Restricted Control Comfort

Lateral acceleration is calculated from the vehicle speed and steering wheel angle (CAN signals). This signal is faster than the actual lateral acceleration and compensates for the hydromechanics time delay. If there is a fault with these two signals, the system reacts with delayed rolling compensation. This only happens with extremely fast steering, when cornering normally it is barely detectable.

If the lateral acceleration senor is faulty, the lateral acceleration is calculated solely from the can signals. The driver will not feel any restriction in function.

If there is a fault in the rear axle circuit and there is stabilizing on the front axle only, the driver feels that the vehicle is making larger rolling movements. Agility is reduced at road speeds <120 km/h.

The system also reacts this way if the Pre-drive Check brings up the “failsafe valve stuck open” message.

In the event of an electrical fault on the rear axle pressure sensor, there may be roll angle compensation defects. To be on the safe side, slightly more stabilization torque is transferred to the front axle than in the normal operating mode (this can be felt by the driver).

Warning message	Handling instructions
Cornering stability slightly restricted	Chassis stability slightly restricted when cornering. Drive on, contact BMW Center as soon as possible

Restricted System Monitoring

Dynamic Drive receives the following sensor signals from the DSC and SZL via the PT CAN Bus:

- Lateral acceleration
- Yaw velocity
- Road speed
- Steering wheel angle

These signals are used to check the lateral acceleration sensors.

Control comfort is restricted if the engine speed signal (DmE) fails.

In the event of a fault with the CAN signals and the yaw velocity, the system is missing two pieces of information. Since this information is used solely to check the other signals, the ARS function remains available with full control.

Although there is no restriction of the Dynamic Drive function, the driver will be shown the “chassis control comfort” display. The driver is instructed to drive to the workshop if possible.

Warning message	Handling instructions
Cornering stability slightly restricted	Chassis stability slightly restricted when cornering. Drive on, contact BMW Center as soon as possible.

A "dynamic" driver will notice the loss of the steering angle signal and the warning messages will be acknowledged. The warning message will disappear once it has been acknowledged. When the cause of the fault is corrected, the ARS control module will have full capacity.

Depending on how fast a fault is detected, there are two reset opportunities:

- When the ignition is off, all faults which have been corrected will be reset. You must wait until the sleep mode has been activated before switching the ignition back on.

- Faults that occur sporadically and can generally be traced back to CAN bus communication malfunctions, are automatically reset when driving straight ahead or when stationary. In this case, the driver may not be aware of the re-activation when driving or when the car is stationary.

  The faults are stored in memory with important additional information. The additional information includes the mileage when the fault occurred, details of whether the fault is present and the frequency of the fault occurance.

Note: When there is a Dynamic Drive failure, the DSC can not be deactivated or if it is already deactivated it will not switch back on automatically.

Dynamic Drive Commissioning

The commissioning procedure must be carried out using the DISplus after the hydraulic system was opened or a component was replaced (in particular the lateral acceleration sensor). This procedure is found under ***Service Functions - Chassis - Dynamic Drive - Start Startup - Test Plan*** and follow the on screen instructions. The following criteria must be met for matching the lateral acceleration sensor and the two pressure sensor offset values:

- The vehicle must stand level on all four wheels (on the ground).
- The vehicle must be unloaded.
- The engine must be idling at operating temperature.
- The doors must be closed and ***occupants are not allowed in the vehicle.***

Note: Stay clear of the moving chassis parts during the commissioning! The ground and side to side clearance must not be limited or obstructed and the doors must be closed. The arms of the lift hoist must not be situated underneath the vehicle. Vehicle will not be able to be driven (transmission will remain in “Park” during this procedure).

The commissioning is performed in five steps that are automatically carried out during the procedure:

1. Direction valve test (from 3 to 3.4 seconds)	First the direction valve is tested by evaluating the SSE signals.
2. Low pressure test (from 3.4 to 4.3 seconds)	The failsafe and direction valves are without power during this stage. Then tests are carried out with pressure control valves (with and without power) on the front and rear axle. The body is then tilted. The sides of the vehicle must be clear.
3. Front axle high pressure test (from 4.3 to 9.9 seconds)	Pressure of 180 bar is applied to the front axle oscillating motor. Air in the system, internal leaks and a blocked oscillating motor is detected.
4. Rear axle high pressure test (from 9.9 to 15 seconds)	Pressure of 170 bar is applied to the rear axle oscillating motor. Air in the system, internal leaks and a blocked oscillating motor is detected.
5. Pressure control valve test (from 15 to 25 seconds)	The characteristic curves of the front and rear axle are checked. (Target/actual value comparison) Faulty pressure control valve is detected.

Dynamic Drive Bleeding

After all work on the Dynamic Drive and the steering system in which hydraulic lines have been opened, the steering system must be bled and initial operation of the Dynamic Drive (commissioning) must be performed with the DISplus.

Procedure:

1. Check fluid level in the powersteering reservoir; if necessary, top up to the “MAX” level while the engine is stopped.

2. Start the engine. Turn the steering wheel left and right to the full lock twice.

3. Check the fluid level with the engine stopped; if necessary, top up to the “MAX” level.

4. Start the engine, connect vehicle to the DISplus.

5. Start the Commissioning procedure which is found under ***Service Functions - Chassis - Dynamic Drive - Start Startup - Test Plan*** and follow the on screen instructions.

Note: Refer to the Repair Instructions for details on the Dynamic Drive bleeding procedure.

Review Questions

1. What identifies the correct installation of the twin tube gas pressurized shock absorbers?

2. Explain the Crash Element function.

3. List the correct wheel bolt torque value.

4. Following a brake pad replacement, what must be performed to properly complete the repair?

5. How is the “Auto Hold” parking brake function activated?

6. Explain how the EMF applies the parking brake.

7. List the procedures to resume operation after an EMF emergency release.

8. Explain how EDC-K influences hydraulic damper operation.

9. Describe the Dynamic Drive influence on the stabilizer bars.

10. Describe “Failsafe” hydraulic flow (for the front axle).

Table of Contents

E65/66 Air Suspension

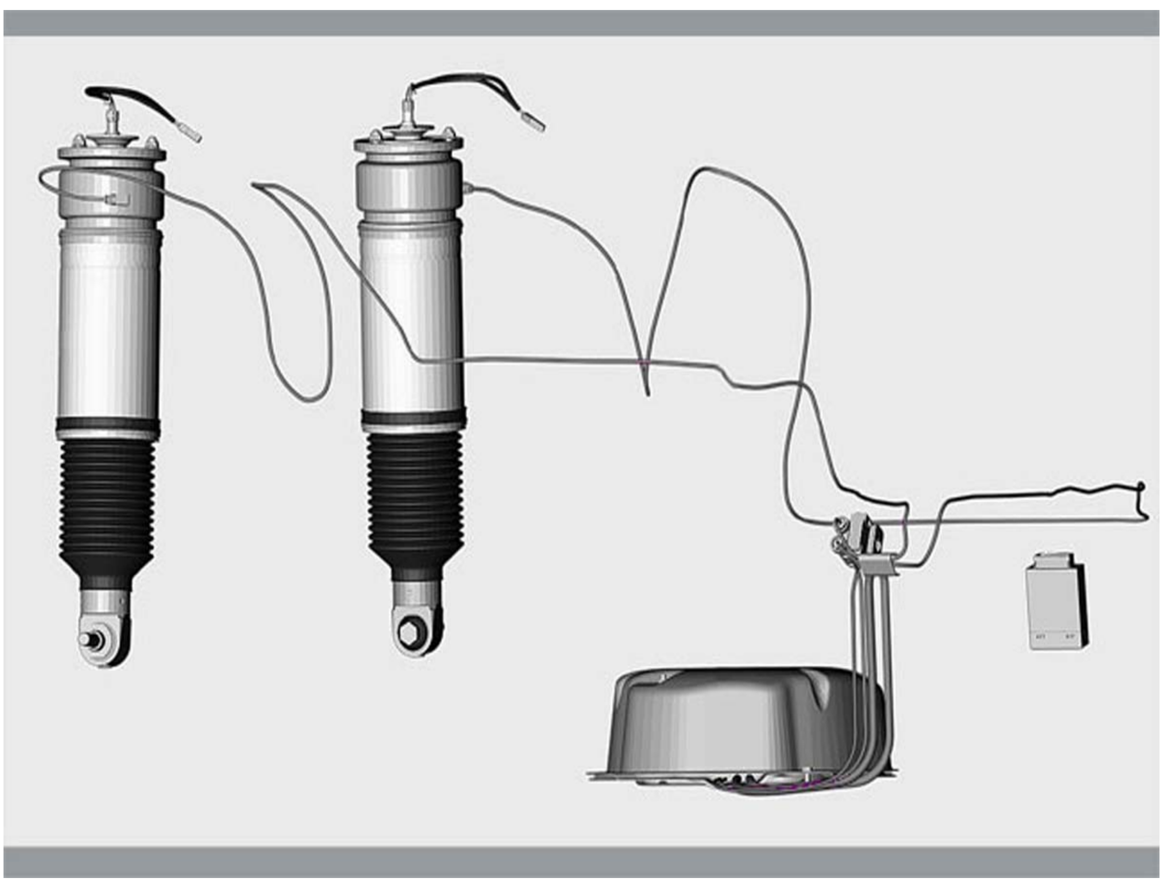
Subject **Page**

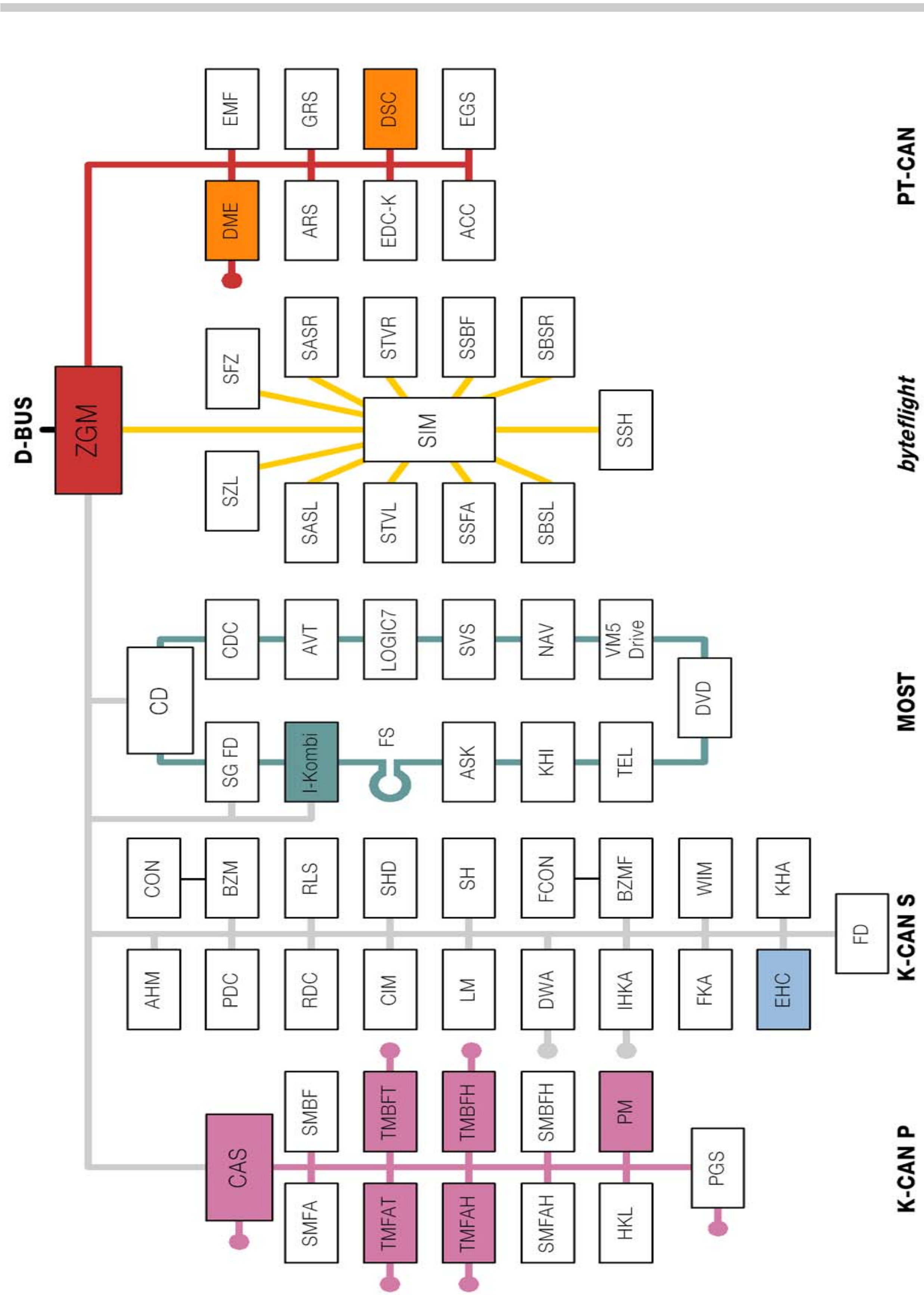
Single Axle Air Suspension (E65/E66)

Purpose of the System

The single axle air suspension system used on the the E65/E66 is a further enhancement of the previous single axle air suspension system used on the the E39 and X5. The components used are similar to the Single Axle EHC System on the E53. The E65/E66 Air suspension consists of the following components:

- Air Supply System (LVA)
- Control Unit (EHC)
- Two Air Springs
- Two Ride Height Sensors
- CC Display/Telltale Icon

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ZGM
PT-CAN
DME
EMF
ARS
GRS
EDC-K
DSC
ACC
EGS
byteflight
SIM
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SASR
STVL
STVR
SSFA
SSBF
SBSL
SBSR
SSH
MOST
CD
CDC
AVT
LOGIC7
SVS
NAV
VM5 Drive
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LM
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EHC
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SMBF
TMFAT
TMBFT
TMFAH
TMBFH
SMFAH
SMBFH
HKL
PM
PGS

Components (E65/E66)

Air Supply Unit (LVA)

The air supply unit is located in the spare tire recess and consists of the following components:

- Protective cover with internal acoustic insulation
- Lid
- Rubber-mounted component carrier
- Compressor Unit
- Compressor Relay (Replaceable)
- Solenoid Valve Block

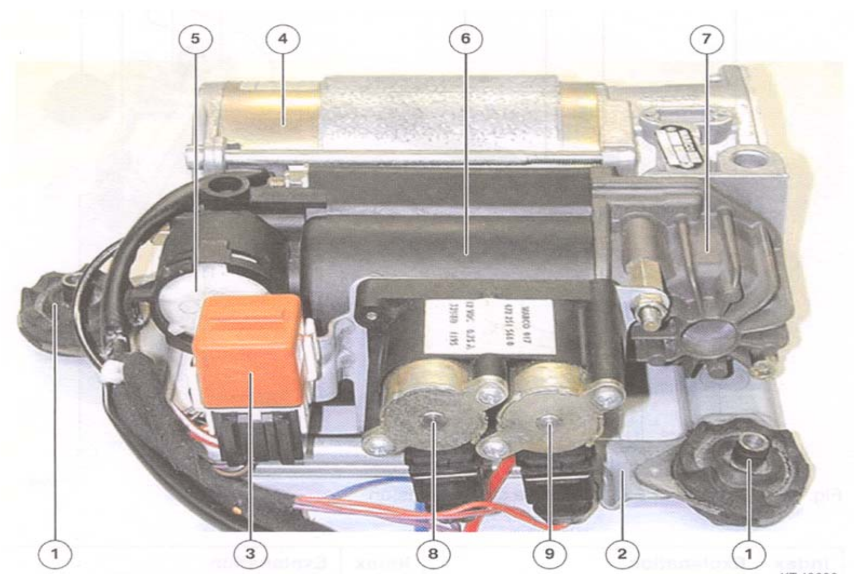


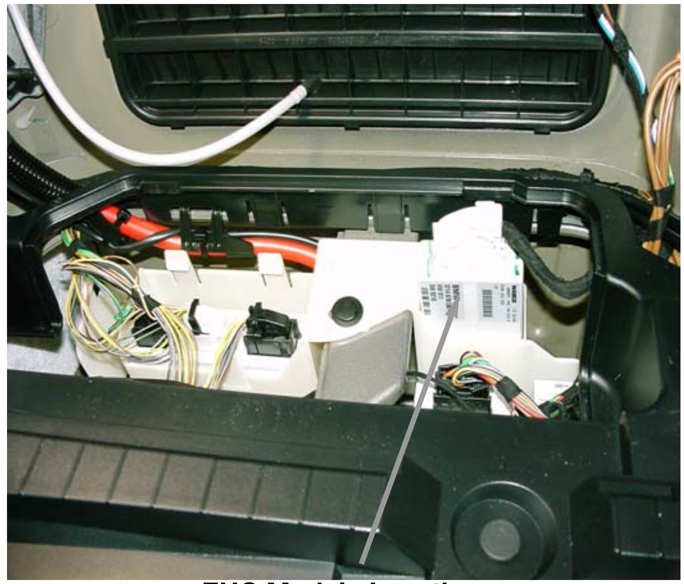
Fig. 11: Air supply unit, single-axle air suspension

Index	Explanation	Index	Explanation
1	Rubber Mount	6	Air Drier
2	Component Carrier	7	Compressor
3	Compressor Relay	8	Solenoid Valve, Right
4	Electric Motor	9	Solenoid Valve, Left
5	Air Cleaner		

Control Unit

The EHC control module is located in the right rear luggage compartment area in the module carrier next to the battery. On the E65/E66, the control module is connected to the K-CAN S. The EHC control module receives the following information:

- Vehicle Ride Height
- Load Cutout Signal
- Terminal 15 ON/OFF
- Vehicle Speed
- Lateral Acceleration
- “Engine Running” Signal
- Flap Status (Door, Hood, Trunk)



EHC Module Location

The Control unit decides on a case by case basis whether a control operation is required in order to compensate changes in load. It prevents intervention in the case of other causes. This makes it possible to adapt the frequency, specified height, tolerance thresholds and battery load optimally by means of the control operation to the relevant situation.

In addition to handling the self levelling suspension, the control module monitors the system components as well as storing and displaying faults. The control module has full diagnostic capability.

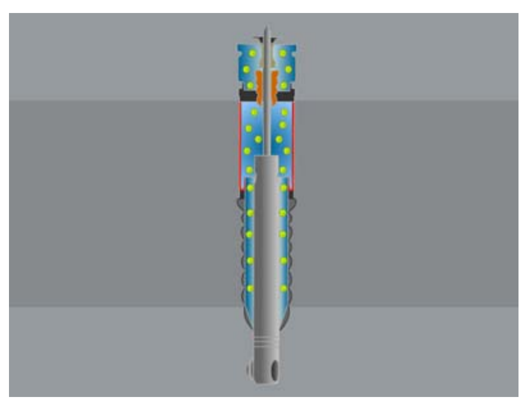
The EHC module is a 26 pin module with an ELO type connector. The module is connected to the K CAN S. The majority of the input messages are from K CAN S.

Air Springs

An identifying feature of the E65/E66 air spring is the internally guided air bellows. Internally guided means that the bellows is guided in an aluminum casing. The bellows is supported on this casing. This prevents the compression forces from weighing heavily on the bellows.

This process allows the bellows to be manufactured from a thin, flexible diaphragm which can react to minimal shocks and in this way provide a more comfortable suspension.

The diaphragm is composed of only one fabric layer embedded in rubber. The fibers within the fabric run longitudinally along the spring strut. The bellows is therefore known as an axial air bellows.



The bottom end of the air spring strut is enclosed in a bellows in order to protect the diaphragm against the mechanical effects of fouling (sand, dirt etc.). The lower end of the bellows incorporates small holes for pressure compensation in the space between the roll piston and bellows. The action of the bellows rolling in this space produces pressure differences.

The bellows together with the roll piston contains a volume of air that is sufficient for optimum suspension.

A residual pressure holding valve on the air spring strut prevents it from being depressurized. The air spring strut remains under pressure in the event of a loss of pressure in the system. The residual pressure is 3.25 +/- 0.75 bar. This ensures that the bellows is not damaged when the car is still being moved.

The residual pressure holding valve is secured with Loctite and must **NOT** be removed.

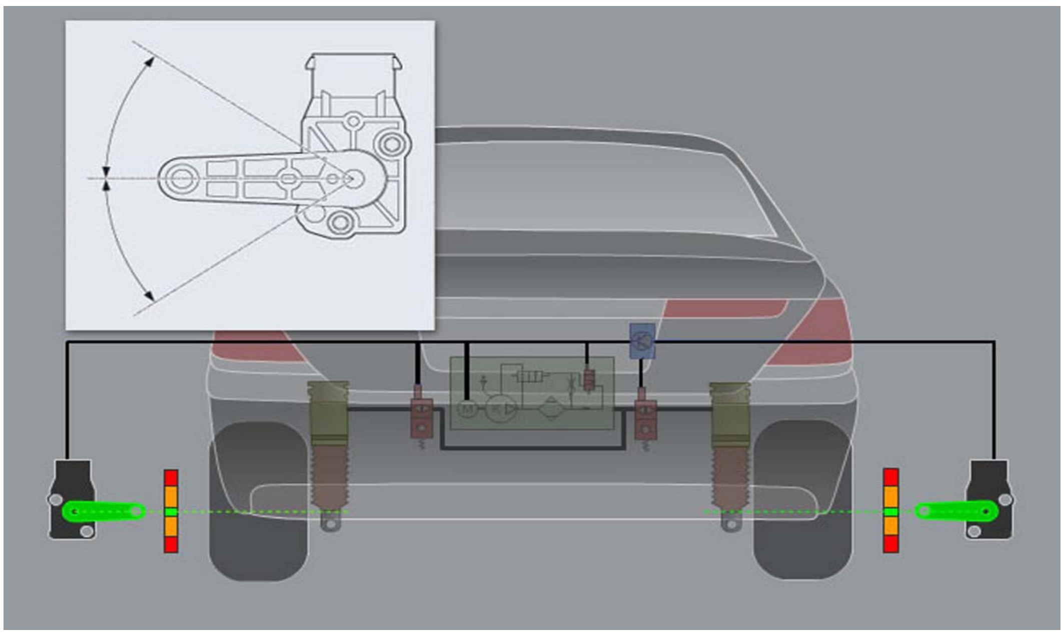
The air spring strut is initially filled at the manufacturer to 10 bar. This pressure is reduced to 3.5 bar when the spring strut is to be stored. Under this pressure, the strut is extended to maximum length.

The connection of the air spring struts to the air supply unit (distributor block) is located on the left of the luggage compartment under the flap on which the wheel nut wrench is mounted.

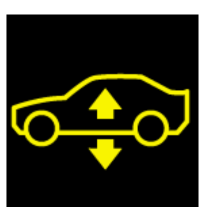
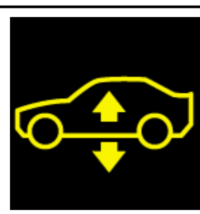
Ride Height Sensor

There are two ride height sensors, one for each rear wheel. The ride height sensor is actuated by a coupling rod and sends a signal to the EHC control unit.

The sensor is a hall sensor which sends a DC Analog output voltage to the EHC module. The voltage range is approximately .5 to 4.5 volts. The voltage increases with increasing vehicle height and the nominal voltage at normal ride height is approximately 2.5 volts. The right side rear sensor is a double sensor, the additional sensor is an input to the headlight leveling system and has it's own power supply, ground and signal wires.

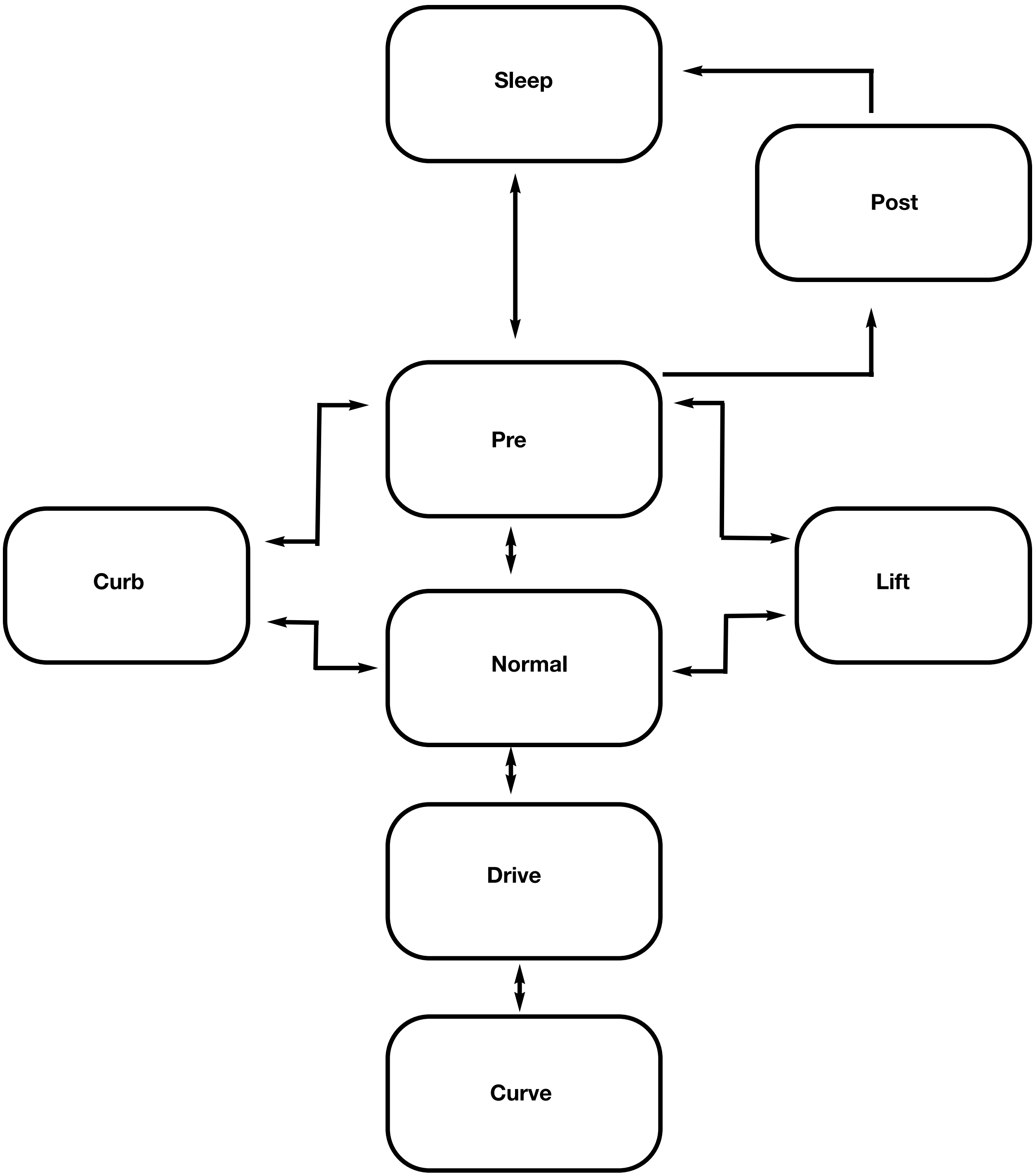


Check Control Messages

Control Unit	Cause	Variable Telltale Icon	Check Control Message	Information in Control Display
EHC	Alive failure or loss of functionality; transport or belt mode set		Level Control System failure	"Level Control system failure" Ground clearance and driving comfort reduced. Avoid high speed cornering. Have checked by BMW Service as soon as possible.
EHC	Level Control System sensor failure.		Level Control System Fault	"Level Control System fault" Possible reduction in driving comfort. Have problem checked by BMW Service.

Control Mode Flow Chart

The following chart demonstrates the control sequences of the E65/E66 with single axle rear air suspension.



Principle of Operation

Control Mode Overview

	E39/E53 EHC I (Single Axle)	E65/E66 (single Axle)	E53 EHC II (Dual Axle)
Sleep	X	X	X
Wake-up			X
Post		X	
Pre	X	X	X
Terminal 15 On			X
Normal	X	X	X
Drive	X	X	X
Curb	X	X	X
Curve	X	X	X
Lift	X	X	X
Twist			X
Trailer			X
Off-Road			X
Access			X

Control Modes

Ongoing control operations are not affected by transitions from one mode to another. However, in the case of load cutout OFF, control operations are always concluded in order to safeguard system deactivation. The control unit then sets the Sleep Mode.

Sleep

The vehicle is in Sleep mode, at the latest, when it has been parked for longer than 16 minutes with a door, hood or rear lid/hatch being operated or the terminal status changing. This is the initial state of the control system. No control operation is being performed in Sleep mode.

The control system goes into Pre-mode when a wake-up signal is received by the control unit.

Post Mode

The Post-mode is adopted in order to compensate any inclination or to adjust the ride height after driving and between the Pre-mode and Sleep mode.

The Post-mode is limited in time to 1 minute. The Post-mode is only executed if the engine has been running before the system switches into this mode. If the engine has not been previously running, the system switches directly from Pre-mode into Sleep mode.

The control operation is performed in a narrow tolerance band of +/- 6mm and is terminated at +/- 4mm. The fast signal filter is used.

In the event of an inclination (Kerb Mode), the control operation takes place for the nominal heights applicable in this situation.

Pre-Mode

The Pre-mode is activated by the "Load Cutoff" signal (e.g. by opening the door or unlocking with the remote control). The Pre-mode then stays set for 16 minutes and is restarted with a change in status.

The ride height of the vehicle is monitored and evaluated with a wide tolerance band.

In Pre-mode, the vehicle is only controlled to the nominal height if the level is significantly below the nominal height. The control tolerance band is -40mm from the mean value for the single axle air suspension and -20mm for the dual axle system. This control tolerance ensures that the vehicle is only controlled up in the case of large loads in order to increase the ground clearance prior to departure. Small loads give rise to small compression travel and this is compensated only when the engine is started. This control setting helps reduce the battery load.

With the single axle air suspension, the vehicle is controlled down when the mean value derived from both ride height signals is > 0mm and one side is in excess of +10mm. With twin axle air suspension, the vehicle is controlled down when one side is >15mm.

In this mode, only the mean value of the two height signals is considered when deciding whether there is an need for control operation.

The control operation is executed as long as pressure is available in the accumulator. When the accumulator is empty and the engine is turned off, the control operation is driven directly by the compressor. User-activated changes of ride level and filling of the accumulator are not possible.

Control operations which were started in other modes are continued with the inner tolerance bands applicable to these modes.

There is no inclination identification in Pre-mode.

Normal

The normal mode is the starting point for the vehicle's normal operating state. It is obtained by way of the engine running signal.

Ride level compensation, changing the vehicle's ride height and filling the accumulator are possible. The compressor starts up as required.

A narrower tolerance band than that in Pre-mode can be used because the battery capacity does not have to be protected. The fast filter is used with a narrow tolerance band of +/- 10mm. In this way, ride level compensation takes place outside a narrow band of 10+/-10mm. The faster filter allows the system to respond immediately to changes in ride level. Evaluation and control are performed separately for each wheel.

When a speed signal is recognized, the control unit switches into Drive mode. When the vehicle is stopped, the control unit remains in Drive mode. The system switches back into Normal mode when a door or the boot (trunk) lid is also opened. If none of the doors or the boot lid is opened, the vehicle cannot be loaded or unloaded.

This prevents a control operation happening when the vehicle (for example) is stopped at traffic lights and the ride height is above the mean axle due to the pitching motion on the rear axle.

Drive

The Drive mode is activated for E39/E53 single axle air suspension when a speed signal of >4km/h is recognized. The Drive mode is recognized from >1km/h for the E65/E66 single axle air suspension and for the E53 twin-axle air suspension system.

Low pass filters are used. In this way, only changes in ride height over a prolonged period of time (1000 seconds) are corrected. These are merely the changes in ride height, caused by vehicle compression and a reduction in vehicle mass due to fuel consumption. The high pass (fast) filter is used during the control operation. The slow filters are recognized at the end of the control operation. The slow filters are re-initialized at the end of the control operation. The markedly dynamic height signals caused by uneven road surfaces are filtered out.

Kerb (Curb) Mode

The Kerb mode prevents the inclination caused by the vehicle mounting an obstacle with one wheel from being compensated. Compensation would cause a renewed inclination of the vehicle and result in a renewed control operation after the vehicle comes off the obstacle.

The Kerb Mode is activated when the height difference between the left and right sides of the vehicle is > 32mm for the E65/E66 with single axle air suspension and >24mm for the E39/E53 with single axle air suspension and lasts longer than 0.9s. Twisting (also over both axles) > 45mm must occur for the E53 with twin axle air suspension.
There must be no speed signal present. The system switches from single wheel control to axle control.

The Kerb mode is quit when the difference between the left and right sides of the vehicle is < 28mm for the single axle air suspension and lasts longer than 0.9s when the speed is greater than > 1km/h.

If the system switches from Kerb mode to Sleep mode, this status is stored in the EEPROM.

If the vehicle is loaded or unloaded in Kerb mode, the mean value of the axle is calculated by the control unit. The value is calculated in the control unit from the changes in ride level of the spring travel on the left and right sides.

A change in ride level is initiated if the mean value of compression or rebound at the axle is outside the tolerance band of +/- 10mm. The left and right sides of the vehicle are raised or lowered in parallel. The height difference between the two sides is maintained.

Curve

Since rolling motions have a direct impact on the measured ride level, an unwanted control operation would be initiated during longer instances of cornering with an appropriate roll angle in spite of the slow filtering of the Drive mode. The control operations during cornering would cause displacement of the air volume from the outer side to the inner side of the curve. Once the curve is completed, this would produce an inclination which would result in a further control operation. The Curve mode prevents this control operation whereby when cornering is recognized slow filtering is stopped and a potential control operation that has started is terminated.

The Curve mode is activated for the E65/E66 single axle EHC and for the E53 twin axle suspension for a lateral acceleration of $> 2m/s^2$ and deactivated at $< 1.5\ m/s^2$.

The lateral acceleration is recorded by the rotation rate sensor.

Lift

The Lift mode is used to prevent control operations when a wheel is changed or during work on the vehicle while it is on a lifting platform.

This mode is recognized when the permitted rebound travel at one or more wheels is exceeded. For the E65/E66 the limit is > 55mm.

A "jack" situation is also recognized when the ride level is stored and the lowering speed drops below the value of 2 mm/s for 3 seconds.

If the vehicle has been raised slightly and the permitted rebound travel has not yet been achieved, the control operation attempts to readjust the ride height. If the vehicle is not lowered, a car jack situation is recognized after a specific period of time and this ride height is stored.

A reset is performed if the vehicle is again 10 mm below this stored ride height.

Transport

The Transport mode is set and cleared by means of a diagnosis activation. It serves to increase the ground clearance in order to ensure a safe transportation of vehicles on transporter trucks. The nominal height of the vehicle is raised in this mode by 30 mm.

When the Transport mode is activated, the air suspension symbol is indicated in the variable telltale in the instrument cluster and a text message is output in the Check Control Display.

Control operations do not take place in this mode because the vehicle mass does not change during transportation.

Belt

The Belt mode is set for mounting on the belt in order to avoid control operations.

When the Belt mode is activated, the air suspension symbol is indicated in the variable telltale in the instrument cluster and a text message is output in the Check Control display.

The Belt mode is cleared by means of a diagnostic activation only. The Belt mode can no longer be set.

New control units are supplied with the Belt mode set.

Control operations are not performed, the safety concept only operates with limited effect.

The Belt Mode is also known as "Band Mode" or "Assembly Line Mode".

Operating Principle

Initialization/Reset Performance

When the control unit is powered up after a reset (such as an undervoltage < 4.5 V or by a load cutoff), different tests and initializations are performed. This system is only enabled after the tests have been successfully completed and starts to execute the control programs on a cyclical basis.

Occurring faults are stored and displayed.

Control Sequence

In an ongoing control operation, the high pass filter (fast filter) is always used to prevent the controlled height from overshooting the nominal value. If a low pass filter (slow filter) were used to calculate the ride height, brief changes of ride height would be consumed. The low-pass filter is used while the vehicle is driven. This type of filtering filters out vibrations which are excited by the road surface.

The high pass filter is used to respond quickly to ride level deviations from setpoint. These take place while the vehicle is stationary in the event of large load changes.

Both sides of the vehicle are controlled individually, i.e. even the setpoint/actual value comparison for both sides is carried out individually. Exception: check for undershooting of the minimum height in Pre-mode and Curb mode: consideration of the left and right mean values in each case.

The following stipulations are applicable here:

- Raising before lowering
- Activation of all valves with control in the same direction
- Individual wheel deactivation

To ensure safe closing of the non-return valve in the air drier, the drain valve is actuated briefly for 200ms after the control operation has ended.

The permissible ON period of the components is monitored while control up operation are executed.

Safety Concept

The safety concept is intended to inhibit any system malfunction, particularly unintentional control operations, through monitoring of signals and function relevant parameters. If faults are detected, the system is switched over or shut down depending on the affected component. The driver is informed of existing faults via the display. Detected faults are stored for diagnostic purposes.

In order to ensure high system availability, existing faults, as far as possible, are cleared with terminal 15 ON. This is done by resetting the fault counter to zero. However, the fault memory content in the EEPROM is retained and can be read out for diagnostic purposes. The system is then operational again. The fast troubleshooting helps to detect existing faults before control operation can take place.

Only lowering is permitted if:

- The permissible supply voltage of 9 volts is undershot
- The permissible compressor running time of 480 seconds is exceeded.

A reset takes place if the voltage is in the OK range of 9 to 16 volts or after the compressor pause time of 100 seconds has elapsed.

Only raising is permitted if:

- The permissible control down period of 40 seconds is exceeded
- The reset takes place the next time the vehicle is driven or after the next control up operation.

No control operation takes place if:

- The permissible supply voltage of 16 volts is exceeded

The reset takes place as soon as the voltage is in the OK range.

Workshop Hints

Ride Height Measurement

When checking vehicle ride height with EHC, measure from the lower edge of the wheel opening to the center of the wheel hub.

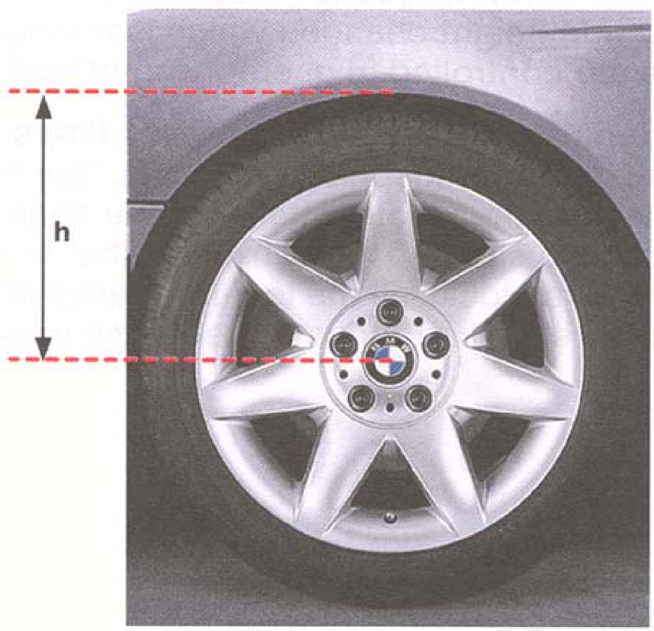


Fig. 23: Ride height measurement (h)

Diagnosis

Diagnostic items can be found in the “Control Unit Functions” path when using the DISplus or GT-1. The functions available are Identifcation (ID page), Read/Clear Fault Memory, Read Test Codes, Diagnosis Requests and Component Activation.

Service Functions

In the Diagnosis Program, there are numerous Service Functions that can be performed for the E65/E66 EHC system. By entering into the “Function Selection” program and following the “Chassis - Pneumatic Suspension” path all of the Service Functions are listed. The Service functions include Ride-Level Offset, Transport Mode and Band Mode.

Table of Contents

E65 SERVICE

Model: E65 - 745i / E66 - 745Li

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

Objectives of The Module

After Completing this module, you will be able to:

- Describe the sensor based service items.
- List the internally calculated service items.
- Identify the service indicators.
- Demonstrate how to extract Condition Based Service information from the Control Display.
- List the E65 key information read by the Key Reader.

E65 SERVICE

42-15-01

Introduction

Connected Service

The term "Connected Service" refers to "Networked service." Modern vehicles are already heavily networked internally by the single bus systems. Communication of vehicle occupants with the vehicle occurs via several control and display systems like the instrument cluster, on-board monitor with navigation system and on the E65 with the central Control Display.

This networking in constant progress is also revolutionizing the service process. It is called "Connected Service" and allows increasing communication and networking between the vehicle and the Retail Service Departments.

Customers can expect the following from the BMW Service in the future:

- Exactly planned appointments, no loss of information, early problem detection and flexible service.
- Fast handling of the service process without long waiting times for the service advisor, spare parts or vehicle.
- Departure from fixed items of inspection/repair, same high service quality, personal and individual advice.

Connected Service offers new possibilities. Vehicle specific service requirements are automatically assessed. Fixed inspection/maintenance schedules will be replaced by more flexible maintenance services.

The existing process will be further optimized, the appointment process will be faster and more effective and service advisors will have more time for individual consultation.

Overview of Technical Aspects

Connected Service is made up of several modules some of which are already available or are introduced starting with the E65.

The modules are:

Condition Based Service (CBS)

CBS defines vehicle specific maintenance requirements by sensor based monitoring of engine oil, air conditioning micro-filters and the front and rear brake linings. In addition, time dependent monitoring of the engine oil, brake fluid and coolant.

CBS also provides distance dependent monitoring of spark plugs as well as visual and functional checks. The service need display (SBA) is located in the instrument cluster and the details are displayed in the Control Display.

Coded Keys

42-15-24

The BMW keys have already been storing information for approximately 3 years. Since 1998 the chassis number and since 1999 the chassis number, mileage and status of the Service Interval Display (SIA) is stored.

42-15-18

The E65 keys (FBD keys or remote control service keys) store more information, such as check control messages and all CBS relevant data like: mileage, oil condition, brake pad wear and microfilter condition. The key is the "business card" of the vehicle.

Key Reader

The Key Reader allows readout of the data stored in the key when the vehicle is checked in for service. The required basic data of the vehicle and the data concerning all service requirements are automatically available.

Service Acceptance Module Software (SAM)

SAM is the software running at the service advisor work place. The software interprets and displays (processes) the data stored in the key.

SAM includes two future extension levels:

SAM 2 (Extension of SAM 1 - Future)

Associated with TeleService 1, it allows the remote transmission of vehicle data stored in the keys and access to the central service databases (central repair history).

SAM 3 (Extension of SAM 2 - Future)

Associated with TeleService 2, it allows the dealer to communicate with the vehicle for troubleshooting complex electronic problems.

TeleService (Future)

TeleService will be offered at two levels:

TeleService 1 will allow automatic or manual data transfer by cellular phone from the vehicle to a TeleService center. The Service Call transmits wear and fault information. Emergency service calls may be placed to an assistance service center. The transmission of information via SMS (Short Message Service) will allow collection of data from customers.

TeleService 2, will allow remote diagnosis of the vehicle electronics. Finally, Tele-Programming will allow the removal of faults, encoding and flash programming via the telephone interface.

Transfer and Analysis of Vehicle Operation and Service Data (FASTA)

FASTA increases product quality, gives input to Research and Development and is the basis for developing more accurate diagnostic tools and optimizing processes aimed at solving problems. In the workshop, the vehicle data is read with DISplus and transferred via network to the central FASTA vehicle related database at BMW.

Starting with the E46, FASTA was implemented for the first time for a select number of dealers in Europe and in the USA. This pilot phase now is over and FASTA is now being used for the launch of all new models and as an integral part of quality control.

Please refer to SIB # 07 08 01 & # 07 07 01 for further details.

Condition Based Service (CBS)

Purpose of the System

The current Service Interval Indicator systems (SIA3 and SIA4) determine maintenance intervals based on fuel consumption, which is done to assess the need to change the engine oil. The main determining factor for the maintenance interval currently is the condition of the engine oil. Other maintenance needs, including the replacement of wear and tear items, are arranged to coincide with due engine oil changes.

On the E65, BMW is measuring the need for maintenance of several critical components besides the engine oil, and independently of the engine oil. This would theoretically afford us the ability to bring a vehicle in for service whenever one of the measured components requires maintenance or replacement. However, customers would be inconvenienced because the maintenance intervals would be dramatically reduced.

Condition Based Service (CBS - further development of SIA) will strike a compromise between too frequent maintenance and too rigid intervals which call for the replacement of maintenance items that may still have substantial useful life left. ***The objective is to furnish economical maintenance by providing the ideal service for individual vehicles.***

Principle of Operation

Sensor Based (CBS) Schedules

The trend in the vehicle service business is to lengthen service intervals and reduce replacement of maintenance items. Additional measures have been taken to keep the vehicles in a roadworthy and comfortable condition.

Usage dependent maintenance of select wear and tear items is detected by physical and virtual sensors. This means that, in cases where the wear is not measured directly, the service due date will be determined by using auxiliary variables such as mileage, vehicle performance, temperature, etc.

Sensors built into certain components and control module algorithms take even more detailed account of the various conditions of vehicle use. The remaining times for selected maintenance tasks as well as any dates for State and/or Emissions Inspections (determined by the state in which the vehicle is registered) are individually displayed.

CBS thus determines the current and future maintenance requirements. The current status of Service items determined by CBS are shown in the Control Display. This data can also be read from the vehicle key by using the Key Reader, as the vehicle's current service status is automatically saved in the ignition key every time the key is used to operate the vehicle.

3 sensors detect the following wear conditions:

- Engine oil (sensor)
- Microfilter (virtual sensor)
- Front and rear brake linings (sensor as reference point)

The instrument cluster collects the values from the wear detection control modules and manages the internally defined service repair schedule. Data exchange is carried out on the bus systems.

Engine Oil Condition

The condition of the engine oil is detected by the oil condition sensor. Simultaneously, it also detects the engine oil level and the oil temperature.

The engine oil condition sensor is monitored by the ECM and is mounted in the lower oil sump.

The ECM contains an algorithm for evaluating the service due date. The following parameters are considered in the calculation:

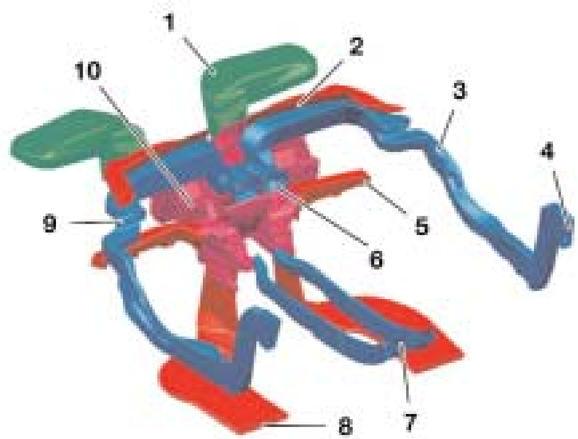
KT-7707

- The correct oil grade is installed
- Oil level
- Oil temperature
- Engine load
- Fuel consumption (ti signal)
- Mileage
- Date (time elapsed since the last oil change)

The remaining life to the next service is forwarded from the ECM to the instrument cluster by a bus message when the ignition is switched "ON." When the "engine oil" service is due, it is shown in the instrument cluster or the Control Display.

Note: The instrument cluster and the ECM must not be replaced simultaneously, otherwise all current oil maintenance schedule data will be lost.

Microfilters State of Wear



KT-8220

The air intake section of the air conditioning system includes a microfilter on the right and on the left. The microfilters (1) include an additional active carbon filter.

The condition of the microfilter is detected by the IHKA control module. It does not include a physical sensor to measure the level of contamination in the microfilter.

The IHKA uses an algorithm to calculate this from the following parameters:

- Ambient air temperature
- Heating use
- Driving speed
- Mileage
- Rain sensor signal
- Air recirculation settings
- Fan speed
- Date (time elapsed since the last oil change)

The remaining life to the next service is forwarded by the IHKA control module to the instrument cluster by a bus message when the ignition is switched "ON." When the "microfilter" service due date occurs, it is shown in the instrument cluster or the Control Display.

Note: The instrument cluster and the IHKA control module must not be replaced simultaneously, otherwise all current oil maintenance schedule data will be lost.

Front and Rear Brake Linings State of Wear

The brake lining state of wear on the front and rear axle is detected by 2-stage brake lining wear sensors. These are located on the left front and right rear brake pads.

The first stage (reference point for the calculation) of the wear indicator is activated when the thickness of the lining is 6 mm, and the second when it is down to 4 mm.

The brake lining wear sensors voltage signals are monitored by the DSC control module. The brake lining wear sensor operates in the first stage as on current models and a resistor was added for the second stage.

The algorithm is controlled by these two different voltages in the control module and determines the residual thickness of the brake lining. The residual wear of the brake lining is calculated from the following input parameters:

- Wheel speed
- Brake disc temperature
- Braking frequency
- Brake pressure
- Braking time
- Mileage (travel distance)

The residual wear of the brake lining on the front and rear axles is stored in the DSC control module when the ignition is switched “OFF” and is used as the starting value the next time the vehicle is started.

The residual distance to the next service is forwarded by the DSC control module to the instrument cluster by a bus message when the ignition is switched "ON." The "Front or Rear brake linings" service due date is displayed in the instrument cluster or the Control Display.

Note: The instrument cluster and the DSC control module must not be replaced simultaneously, otherwise all current oil maintenance schedule data will be lost.

Internal Calculation of CBS Service Volumes

For certain wear and tear items, sensors are not needed by the Condition Based Service. The wear items that are calculated and managed internally by the instrument cluster are:

- Brake fluid
- Coolant
- Spark plugs
- Visual and functional checks (vehicle check)
- Official State safety and/or emissions inspections

The maintenance of these items is performed at fixed intervals. The residual wear or the remaining time to next service is calculated by the instrument cluster using the travel/time parameters of: mileage, current date and internal distance counter. When a service item is due, it is shown in the instrument cluster or the Control Display.

Note: The internal distance counter plays a particular role. Unlike the Time/Date, this counter cannot be set by the driver.

However, battery down times (battery cut off by the distribution switch) also stop the trip distance counter which leads to longer time based service intervals. This will disrupt the CBS volumes for engine oil, microfilter, brake fluid and coolant.

To correct this, the internal counter status must be reset by the DISplus. The wear dependent items internally calculated by the instrument cluster are stored in the instrument cluster and in the CAS control module (redundancy).

Note: The instrument cluster and the CAS must not be replaced simultaneously, otherwise all current oil maintenance schedule data will be lost .

Service Indicators

Regarding CBS, there are three different service indicators:

- Service need display (SBA) in the instrument cluster (base of speedometer)
- Check Control display in the instrument cluster (base of tachometer)
- CBS indicator in the Control Display

Service Need Display (SBA)

The Service Need Display is the evolution of the SIA4 Service Interval display. When KL15 is "ON," the Service Need Display appears under the speedometer in the instrument cluster for 10 seconds in the place where the fuel tank level is normally displayed.

The first line corresponds to the mileage dependent service items. It specifies the mileage when the next service is due. If the mileage is exceeded (service overdue), it appears with a minus sign.

The second line corresponds to the time dependent service items and is displayed by a clock symbol. It specifies the weeks/months/ years when the next service is due. If the service is overdue, it appears with a minus sign.

42-15-01

The actual service item (with additional information) can be viewed in the Control Display.

Check Control Message

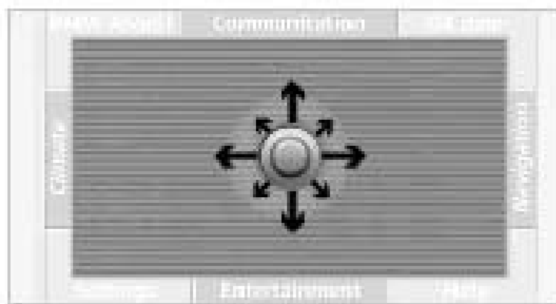
The CBS produces a Check Control message that indicates the brake lining wear at the front or rear axle. When the brake linings are worn, this is shown as follows:

- The general brake warning lamp and the variable control lamp come on in the instrument cluster.

- The variable control lamp shows the symbol of a car on a lifting platform.

42-15-17

In the base of the tachometer is a Check Control message that appears in short form: "Service, see Vehicle menu." For more detailed information, the user can access the Control Display.



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CBS Indicator in the Control Display

The Control Display provides additional information on service and maintenance procedures by selecting the “OB data” menu.

After releasing the Controller or returning to the central position, the "On-board data" menu appears.

Turn the Controller to the left until the bottom left button is highlighted (vehicle symbol).

Confirm your selection by pressing the Controller.

42-15-02

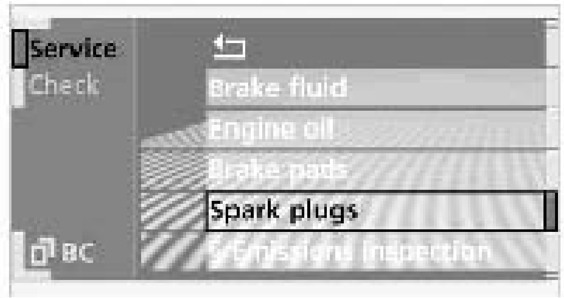
The CBS menu appears with the service items.

The Control Display shows a list of selected service and maintenance procedures, as well as legally-mandated official inspections.

42-15-03

Now you will see a service road in the Control Display. The service and maintenance procedures are displayed in different colors:

- Green: No service is currently required
- Yellow: Service daedline is approaching
- Red: Service deadline has already passed



42-15-04

The service items highlighted in red with the highest priority appear in the bottom part of the display.

You can scroll through the list of service and maintenance procedures from top to bottom by turning the Controller from right to left. You can leave the list of service items by pressing the button with the Up arrow symbol.

The service and maintenance items are:

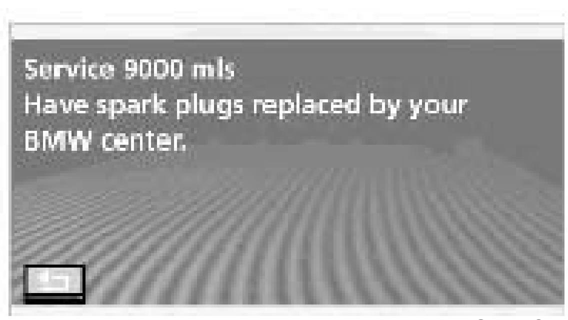
1. Engine oil
2. Front brake pads
3. Rear brake pads
4. Ventilation system microfilter
5. Brake fluid
6. Coolant
7. Spark plugs
8. Vehicle check
9. State Inspection
10. Emissions Inspection

To display the service and maintenance item information in the Control Display, turn the Controller to select the item and confirm your selection by pressing the Controller.

For the "Spark plugs" service and maintenance item, for example, the following information appears:

1. Service due 9000 mls, Have your BMW Center replace the spark plugs.

2. Button with arrow symbol



42-15-05

You can exit this menu by pressing the button with the arrow symbol at the bottom left. The lowest menu automatically closes after a short time (timeout) if you do not touch the controller. In the same way, you can access the full text for each service item.

To Enter and View Official Emissions and Vehicle Inspections Deadlines

Select “Emissions inspection” or “State inspection” and confirm your selection.

42-15-06

Turn the Controller to select an inspection date for entry.

Confirm the inspection date. The first part of the date entry is activated - here month.

Turn the Controller to reset. Press the Controller to store and move to the next entry - here year.

The system adopts the date when you store your entry. Press the Controller to select “CONFIRM”.

42-15-07

Note: This function is only available if the time in the Control Display has been correctly set.

When the deadline for the next emissions or state vehicle inspection is approaching, the remaining distance and time will appear briefly in the base of the speedometer when the ignition is switched on “KL15” (as shown on the right).

42-15-08

Resetting Service Items

When one or more service and maintenance items has been performed, these items must be reset (to the full service interval). This is achieved via the instrument cluster or DISplus.

To reset a service item, press the reset button (1) on the top left side of the instrument cluster for > 10 seconds.

KT-9270

This brings you directly to Reset mode.

A 4-line menu appears in the speedometer. At the top is the Back function, then the first three service and maintenance items sorted by priority. In addition, the residual wear or the remaining time are specified (possibly with a minus sign).

The "!" symbol means that you can reset this service and maintenance item, while a "0" indicates it is not able to be reset (the first 20% of the service interval is protected against premature/accidental reset).

1. Service items (in the speedometer)
2. Resettable service item (in the tachometer)

a. Back
b. Vehicle Check
c. Microfilters
d. Brake fluid
e. Back
f. RESET Vehicle Check

KT-8988

You can scroll through the service and maintenance items by pressing the reset button or the lower axial (FAS) button on the turn signal/high beam switch. When you have selected a service item, press the reset button for a few seconds to display a 2-line menu in the tachometer.

The Back function is at the top and the resettable service and maintenance item is below it. Now select the service and maintenance item with the reset button (or the axial button) and press the reset button again for a few seconds.

In a third menu line, the system confirms that the reset was successful. The whole interval for the service operation is highlighted in the Service Need Display.

Using the DISplus, the CBS resetting procedure is found under: ***Service Functions - Maintenance - CBS Reset.*** Two selections are possible:

CBS Reset Selection 1

Reset engine oil
Reset microfilter
Reset front brakes
Reset rear brakes
Reset vehicle check

CBS Reset Selection 2

Reset spark plugs
Reset brake fluid
Reset coolant
Correction motor vehicle inspection
Correction emissions inspection

Key Reader

The Key to a New Dimension

Starting with the E65, BMW opens a new dimension in customer service. Using the Key Reader, Service Reception uses the data stored in the vehicle key to provide the following benefits:

- Accelerate and facilitate service consultation.
- Routine tasks, such as collecting vehicle data, will be minimized.
- After accessing the data stored in the vehicle's key, service and maintenance requirements are determined for the individual vehicle (CBS).
- A customized service maintenance list will be printed out for specific operations (E65 no longer utilizes a conventional Service Maintenance Checklist).

KT-9275

The customer expects not only innovative products, but also a perfect mobility service. The Key Reader facilitates and accelerates service reception. As soon as the key is inserted, the reader accesses the stored vehicle data and the information is displayed on screen depending on the vehicle and model. ***Refer to SI # 04 04 02 for additional information.***

Key - Vehicle Data Holder and Business Card

The Key Reader automatically collects service relevant data from the vehicle key. The data is transmitted from the CAS module to the key.

The CAS is located in the instrument panel behind the key insertion unit (next to the start/stop button).

The CAS requests data from the instrument cluster over the K-CAN Bus and stores the time when the data was last written to the key.

KT-7836

1. Start/stop button 2. Key insertion unit

Under the following conditions, the data is re-transmitted to the key and stored there:

- Vehicle at standstill (no speed signal)
- Distance of at least 6 miles driven since last data storage
- Driving speed since last data storage exceeds 6 mph at least once

Note: There are circumstances under which the current vehicle data is not stored in the key, for example: the customer has provided the spare key, which has not been used recently.

For this reason, a service function is provided to store data in the key:

- ***Keep centerlock toggle switch in the unlock position and use the start/stop button to switch the vehicle on or off = Vehicle data is will be stored on the spare key.***

The following information is stored on the vehicle key:

Model Range	Model Year	Information on the Vehicle Key
E46, E38, E39 E52, E53	2000	General vehicle data: - Vehicle Identification Number - Current mileage - Build code
From E65	From series launch	General vehicle data: - Vehicle Identification Number - Current mileage - Vehicle type Other vehicle data: - Check Control message - Condition Based Service Data

Notes:

E65 Service Maintenance Checklist

As previously explained, ***Condition Based Service will determine which of the possible maintenance services listed below are required*** for a particular service visit. Please refer to ***SI # 00 05 01*** that outlines the proper service procedures.

Standard Operations

- o brief diagnostic test
- o verify Check Control messages
- o check indicator and warning lights
- o reset CBS display

Engine Oil

- o Change engine oil and oil filter. We recommend BMW High Performance 5W-30 Synthetic Oil, available under part number 07 51 0 017 866
- o after every 4th engine oil change: replace air cleaner filter element

Microfilter

- o replace

Front Brakes

- o Brake pads: replace; clean brake pad contact points in calipers
- o Brake discs: check surface and thickness

Rear Brakes

- o Brake pads: replace; clean brake pad contact points in calipers
- o Brake discs: check surface and thickness
- o Parking Brake: check condition, brake lining thickness and function

Vehicle Check

- o check operation of horn, headlight flasher and hazard warning lights
- o check instrument and control lighting, and heater/AC blower
- o check lighting system: turn signals, back-up, license plate, interior (incl. map reading lights), glovebox, flashlight, luggage area lights
- o safety belts: check condition and function

o check windshield wiper and jet positions

o body: check for corrosion

o tires: check tread depth, wear pattern, outer condition, inflation pressure (incl. spare)

o battery: check state of charge (“magic eye”) and recharge if required

o power steering reservoir: check fluid level

o visually inspect all SRS airbag units for torn covers, obvious damage or attachment of stickers

o function of rear-view mirrors

o coolant: check fluid level and concentration

o windshield washer system: check fluid level and protection level

o brake system connections and lines: check for leaks, damage and correct positioning

o underbody: all visible parts incl. transmission, rear axle, fuel tank, exhaust system: check for damage, leaks, corrosion

o steering components: check for clearance, leaks, damage and wear

o parking brake: check function

o Final Inspection: road test with check of
- brakes
- steering
- shock absorbers (external)
- transmission

Brake Fluid: replace every 2 years

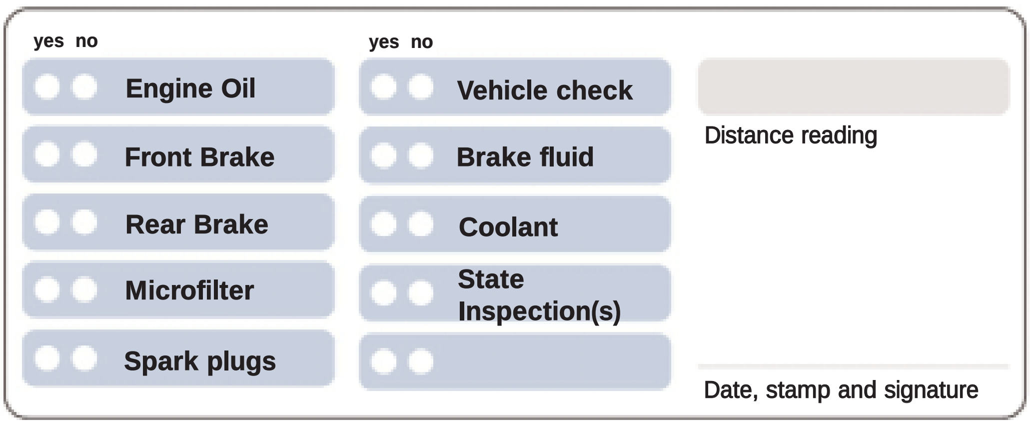
Coolant: replace every 4 years

Spark Plugs: replace every 100,000 miles

Automatic Transmission: replace ATF every 100,000 miles

Service Booklet

The Service booklet provides evidence of maintenance work. The innovation introduces a new appearance in the service and maintenance items. As in the past, it will show which service item and the mileage when the service is performed. The Retail Center appears with date, stamp and signature. This documentation must be checked in the "yes" or "no" to record and verify the indications in the Control Display (CBS).



KT-9282

Notes:

Review Questions

1. Describe the sensor based service and maintenance items.

2. List the internally calculated service and maintenance items:

3. What are the service indicators?

4. How is the Condition Based Service information extracted from the Control Display?

5. List the E65 key information read by the Key Reader: