E60 M5
Complete vehicle

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Participant's Manual
E60 M5 - Complete vehicle

S85B50 engine

Digital motor electronics (DME) S85B50

Sequential M gearbox (SMG 3)

Dynamic stability control (DSC)

Displays, indicators and controls

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E60 S85 - The New M5

Foreword

Identification badge: The M side gills

The new BMW M5 will be launched in October 2004. It will be the most powerful M5 of all time and the first to exhibit this power potential at first glance.

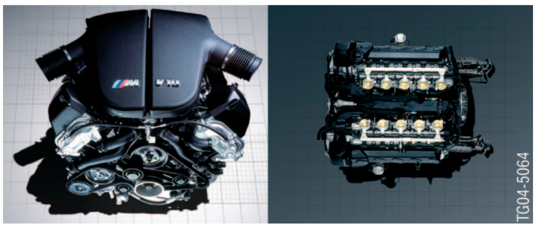
The basic concept, however, remains unchanged: The E60 M5 too combines - without compromise - the qualities of a luxury class Saloon with the power potential of a sports car. Its visual appearance, however, is intentionally somewhat less discreet as its predecessor. The front and rear aprons are now slightly more prominent and, together with the rear spoiler, 4-pipe exhaust system and 19" wheels, the in the meantime M5-characteristic side gills unmistakably identify the M5 at first glance - even from the side.

The highlight of the new M5 is, of course, the V10 engine derived from BMW-Williams Formula 1. With the governed limit at 8,250 rpm, it not only provides Formula 1 performance but also develops that typical Formula 1 sound.

Despite these features, the M5 still remains an understatement-product. Its exterior conveys a powerful yet still reserved appearance. At no point has its everyday suitability gained from the E60 series been lost.

The most important features in brief

10-cylinder Formula 1 engine



The V10 all-aluminium naturally-aspirated engine with 5 l displacement develops 400 bhp output. This output can be increased to over 500 bhp by pressing the power button on the centre console.

As in the Formula 1, the bedplate structure ensures low-vibration stability with matching rigidity. The engine is controlled by the Siemens MS_S65 engine management while the knock control is based on ionic current technology.

The 2-disc dry clutch also stems from Formula 1, while the gears are shifted with a 7-speed SMG 3 gearbox specifically adapted to the high speed concept.

Despite these impressive performance data, the E60 M5 conforms to the exhaust emission standard EU4.

Body and suspension

Prominent front and rear aprons, paired with side sills and a powerful rear spoiler clearly distinguish the M5 from the E60 Series. A rear diffuser - also a Formula 1 offshoot - provides an additional power boost on the rear axle.

With the push of a button, the new DSC on the M5 provides substantially greater lateral force for fans of the controlled drift. The rear axle lock is not fixed at 25% but rather provides variable control.

Control and individualization

The buttons on the shift lever can be used to vary the performance control systems. The accelerator pedal characteristic, EDC and Servotronic can be individually configured and selected by means of M-buttons on the steering wheel. The head-up display is specifically adapted to the M5 environment.

Technical data and competitors

	BMW M5 (E60)	**Mercedes E55 AMG**	**Audi RS6 plus**
Length (mm)	4855	4818	4858
Width (mm)	1846	1822	1850
Height (mm)	1469	1412	1425
Wheelbase (mm)	2889	2854	2759
Toe, front (mm)	1580	1583	1578
Toe, rear (mm)	1566	1551	1587
Unladen weight (kg)	1830	1835	1880
Payload (kg)	545	525	540
Luggage compartment capacity (l)	500	530	455
Engine / Valves per cylinder	V10 / 4	V8 / 3	V8 / 5
Displacement (ccm)	4999	5439 Compressor supercharging	4172 Bi-turbocharging
Engine output (bhp)	507	476	480
At engine speed (rpm)	7750	6100	6000 - 6400
Nominal torque (Nm)	520	700	560
At engine speed (rpm)	6100	2650 - 4000	1950 - 6000
Governed engine speed (rpm)	8.250	6.250	6.600
Transmission	7-speed SMG gearbox	5-speed automatic gearbox	5-speed automatic gearbox
Fuel consumption (l/100 km EU)	14,8	12.9	14.6
Fuel tank capacity/range (l/km)	70/473	80/620	82/561
Wheels and tyres	Front: 255/40 R19 on 8.5 J x 19 Rear: 285/35 R19 on 9.5 J x 19	Front: 245/40 R18 on 8 J x 18 Rear: 265/35 R18 on 9 J x 18	Front and rear: 255/35 R19 on 9 J x 19
0 - 100 km/h (s)	4.6	4.7	4.6
V max (km/h)	250 (governed)	250 (governed)	280 (governed)
Purchase price (Euro)	86,200.00	90,422.00	101,050.00

Contents
S85B50 Engine

Objectives
S85B50 Engine

Purpose of this Participant's Manual

The Participant's Manual is a document designed to accompany a seminar while at the same time serving as a source of reference.

This Participant's Manual describes new features and further developments of the S85B50 engine.

Introduction

The S85B50 is the first 10-cylinder engine from BMW for series production vehicles. The high speed layout of the S85 is a guarantee for a high degree of spontaneity in engine response and uniform power development. Due to the, for an in-line engine, very high top engine speed of 8,250 rpm, an extremely rigid engine block is necessary in order to withstand the vibrations and to satisfy the acoustic requirements.

For this reason, a bedplate structure was chosen for the engine block. The cylinder head is also designed as a one-piece unit in order to achieve the greatest possible rigidity and to reduce sealing surfaces.

The valve train especially the box-type tappets with hydraulic lash adjusters (HVA) have been optimized with regard to weight and friction.

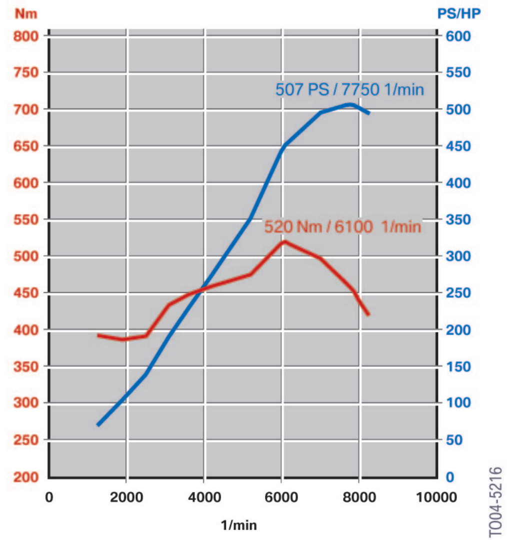
The high dynamics and spontaneity of the engine render necessary extremely fast adjustment of the VANOS. This is achieved by an oil pressure of 115 bar as well as new proportional valves and VANOS gear mechanisms.

The rapid engine response also necessitates the use of individual throttle valves that are operated side-specific.

The S85 is equipped with a double-disc clutch and dual-mass flywheel (ZMS) in order to transmit the high power to the transmission.

Technical data

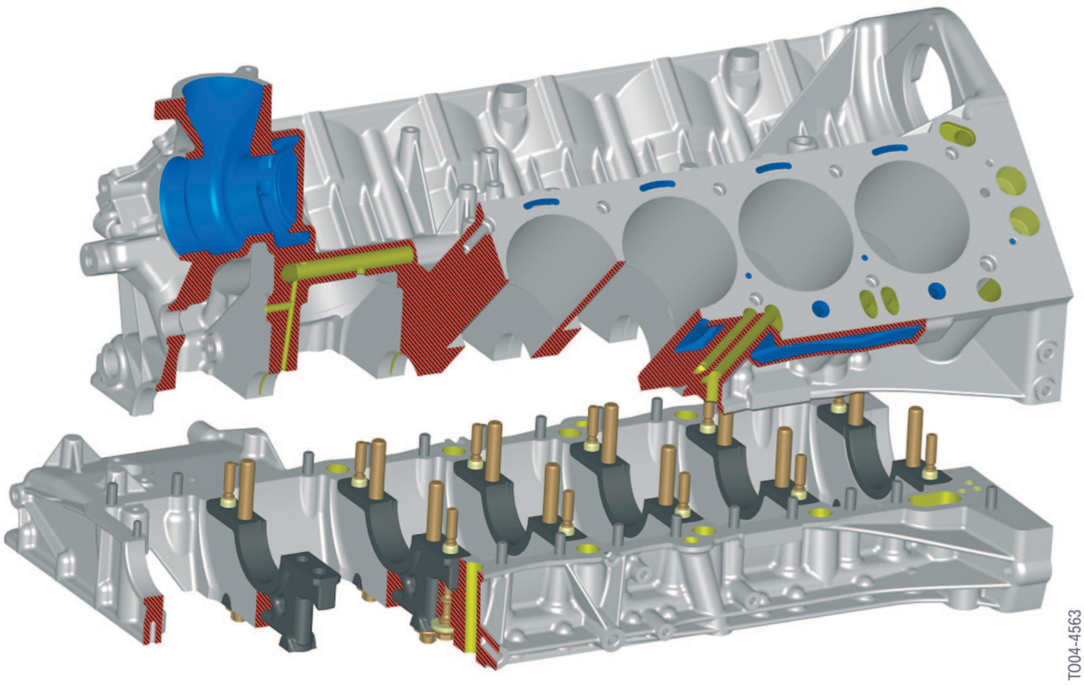
Engine designation	S85B50
Engine type	V10, 90°
Displacement	4,999 cm^3
Bore	92 mm
Stroke	75.2 mm
Power output	373 kW/507 bhp at 7,750 rpm
Torque	520 Nm at 6,100 rpm
Engine speed	8,250 rpm
Weight	240 kg



1 - S85B50 Power output diagram

S85B50

Engine block with bedplate



1 - Crankcase with bedplate (grey = aluminium, dark grey = cast iron, blue = water area, yellow = oil area)

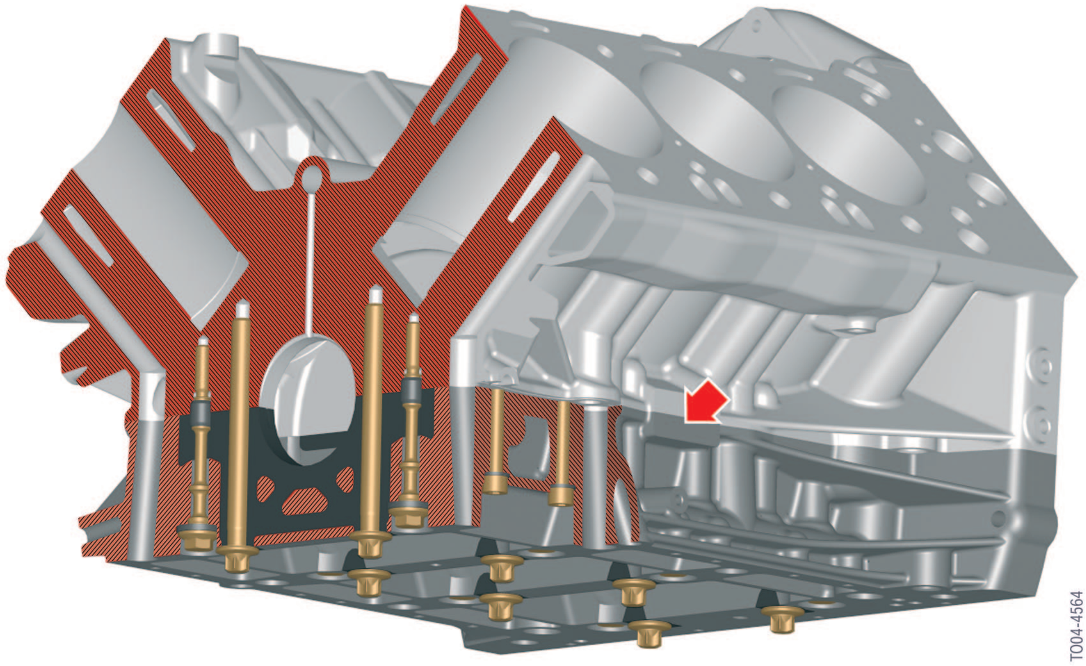
The lower bearings of the crankshaft in conventional crankcases are designed as individual bearing bridges.
In order to reliably take up the piston forces, these "main bearing bridges" are made of cast iron.
The bearing bridges are cast and are machined together with the crankcase following initial assembly.
In the case of the bedplate-type crankcase, the crankcase is split at the level of the crankshaft into the upper section of the crankcase and lower section of the crankcase, i.e. the bedplate.
In the split crankcase with bedplate, the crankshaft bearings are an integral part of a separate, stable frame, i.e. the bedplate.

The bedplate is machined together with the crankcase and, after assembling the crankshaft, mounted to the upper section of the crankcase.

Features

- The crankcase is additionally stiffened towards the oil pan by the complete bedplate. Consequently, the entire engine is on the whole more rigid and more resistant to torsion.
- The additional rigidity of the crankcase also improves the engine acoustics.
- The bedplate makes it possible to accommodate additional assemblies in the lower section of the engine.
- The bedplate facilitates simple and fast assembly of the crankshaft main bearings.

Bedplate screw connection



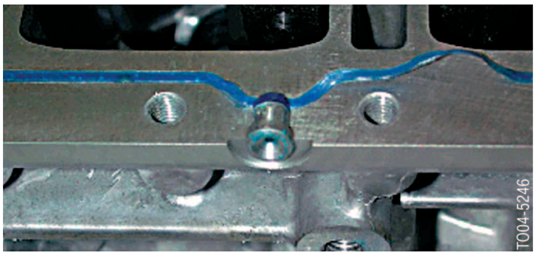
2 - Bedplate screw connection

The bedplate is secured to the upper section of the crankcase with the main bearing bolts. The positions are fixed with fitted sleeves (NG4) or screws with adapter sleeves (S85). The engine serial number is punched on the bedplate (see arrow).

To ensure trouble-free operation of the crankshaft, it is essential that the specified sequence of the bedplate screw connections is adhered to. Any deviations from this sequence can result in engine damage and leaks in the bedplate/crankcase.

The bedplate facilitates simple and fast assembly of the crankshaft main bearings.

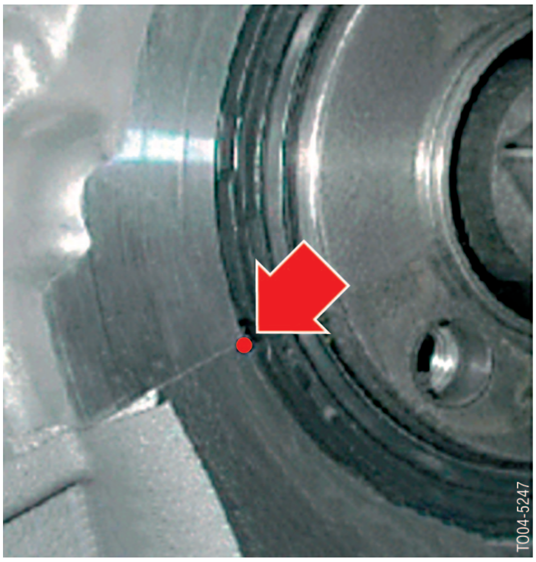
The bedplate must be sealed from the crankcase. Since the crankshaft bore is produced together with the bolted bedplate, a flat gasket cannot be used otherwise the crankshaft bore would be enlarged. For this reason, bedplate-type engines are sealed with a liquid sealing compound in a groove.



3 - Injection opening in crankcase for liquid sealant

After completely bolting the bedplate to the crankcase, the liquid sealant is injected via injection nozzles into the groove.

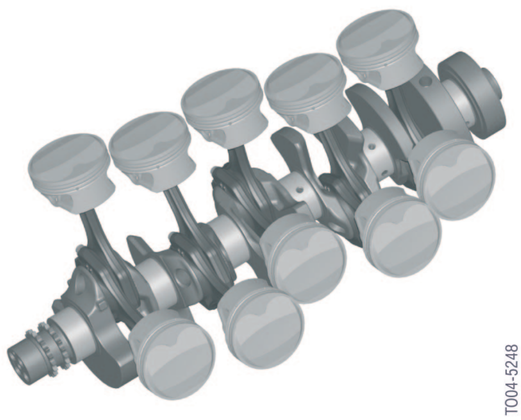
Bedplate sealing



4 - Sealant outlet

Primer is used to harden the liquid sealant at the outlet points.

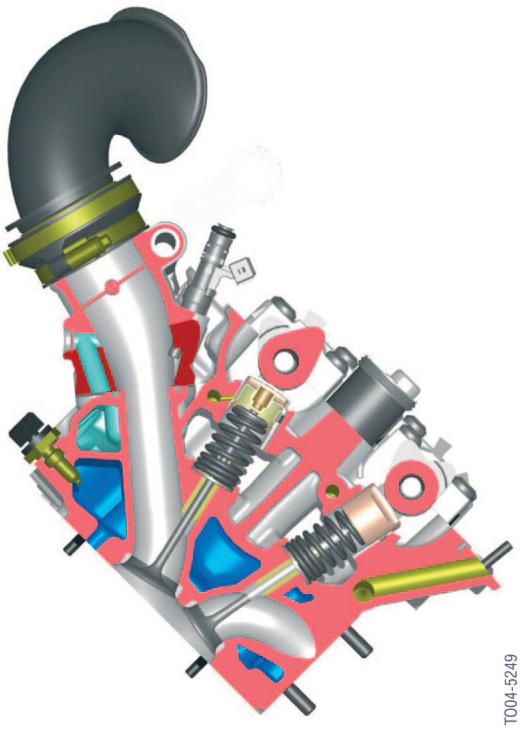
Crankshaft drive



5 - Crankshaft with connecting rods and pistons

The forged crankshaft has a crank pin sequence of 72°. The sprocket for the primary timing gear is produced as one part together with the crankshaft.
Both the pistons as well as the steel cracked connecting rods are asymmetric.

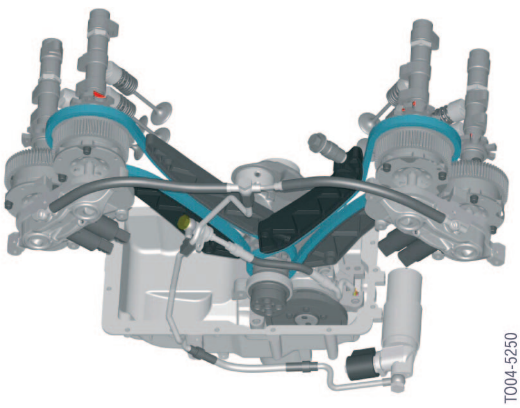
Cylinder head



6 - Cross section of cylinder head (red = cut edge, orange = secondary air channel, blue = water area, aqua = idle air port)

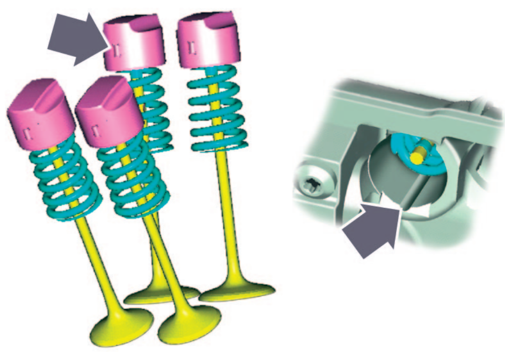
The one-piece design of the cylinder head offers advantages with regard to rigidity and a reduction in sealing surfaces.
Both the idle air port as well as the secondary air channel are integrated in the cylinder head.

Timing gear



7 - Timing gear S85

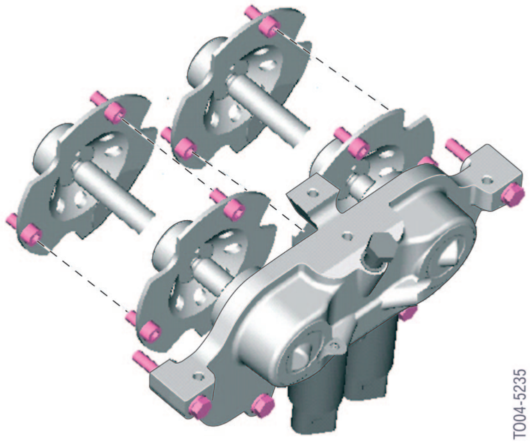
A timing chain with separate chain tensioner drives each intake camshaft (primary timing gear). A toothed drive belt provides the drive from the intake camshaft to the exhaust camshaft (secondary timing gear).



8 - Valve train

For weight and friction reasons, the shape of the hydraulic tappets in the S85 is based on the box-type tappet as known from motor racing engines. Since the tappets must not rotate in the cylinder head, anti-torsion needles which run in grooves milled into the cylinder head are fitted in the tappets.

VANOS



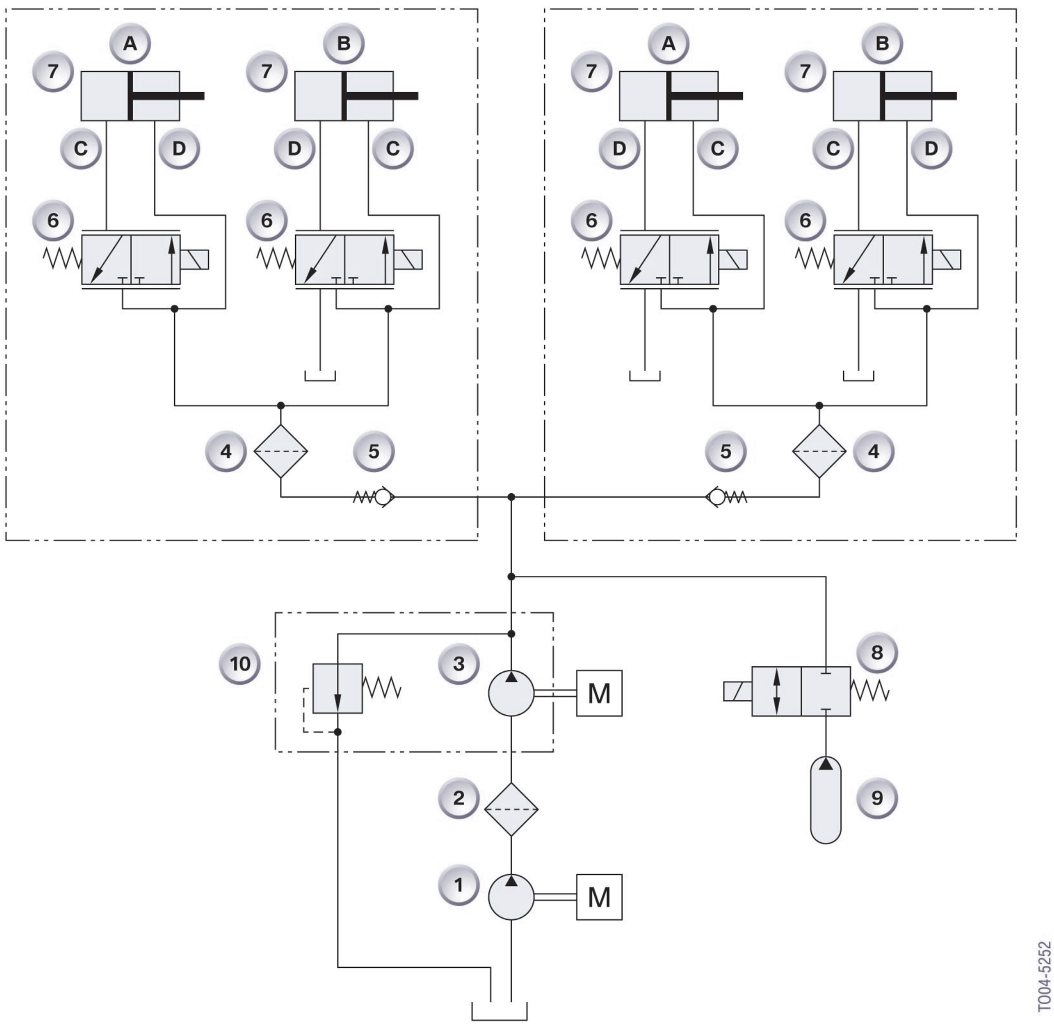
9 - VANOS control unit

As known from the S62, the VANOS system is used on the S85 to adjust both the intake camshaft as well as the exhaust camshaft. The intake camshafts have an adjustment range of 60° crankshaft angle and the exhaust camshafts 37° crankshaft angle.

The oil pressure of 115 bar is produced by a high pressure pump installed in the oil pan. The high pressure pump is driven through a gearwheel directly from the crankshaft.

The pressurized engine oil is routed via two delivery lines to the two VANOS control units and to the pressure accumulator.

The adjustment units feature two proportional valves that ensure infinitely variable control of the oil pressure. Compared to the directional control valves used formerly, proportional valves ensure shorter control times and greater operational reliability.



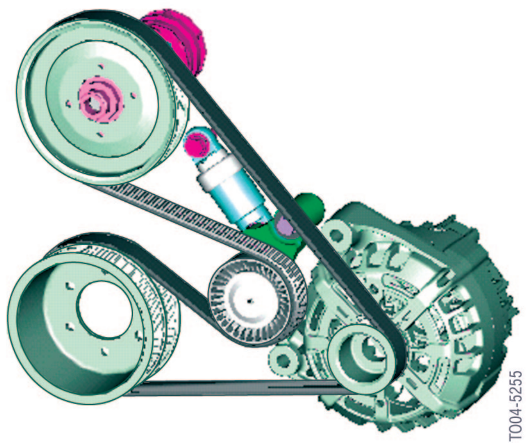
10 - Hydraulic diagram of VANOS actuator S85

Index	Explanation	Index	Explanation
A	Exhaust	4	Filter 50 µm
B	Intake	5	Check valve (optional)
C	Advance	6	Solenoid valve (3/2-way)
D	Retard	7	Adjustment piston, pressure accumulator
1	Engine oil pump (1-5 bar)	8	Pressure accumulator shut-off valve
2	Filter 80 µm	9	Pressure accumulator
3	High pressure pump 115 bar (HDP)	10	Pressure relief valve HDP VANOS hydraulic units (actuators)

The displacement range of the pistons in the VANOS control unit is converted into rotary motion by an infinitely variable gear mechanism integrated in the sprockets.

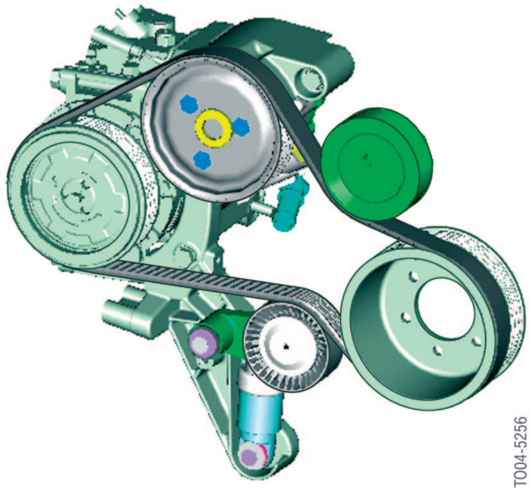
Belt drive

11 - Belt drive over complete side



12 - Main belt drive

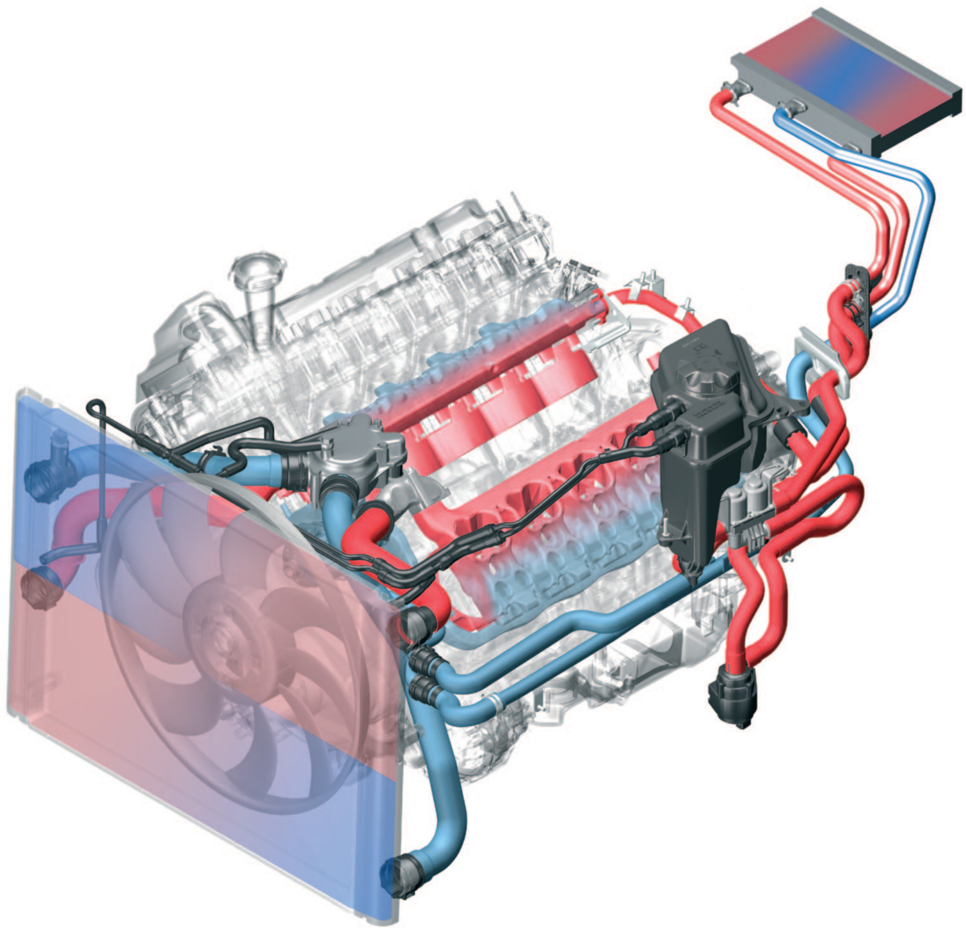
The water pump and alternator are driven by the main belt drive. The drive is provided by the pulley on the crankshaft.



13 - Secondary belt drive

The secondary belt drive comprises the power steering pump and A/C compressor. The drive is provided by the pulley on the crankshaft.

Cooling circuit



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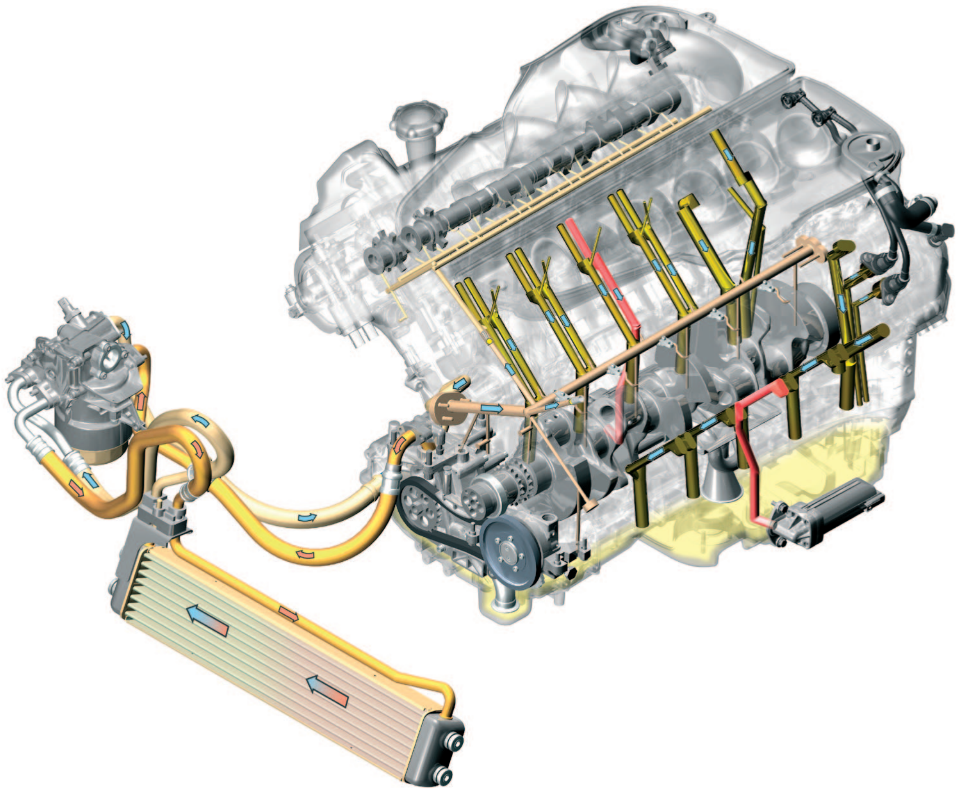
14 - Cooling circuit

Coolant flows both through the cylinder head as well as the engine block in the familiar cross-flow manner. A new feature, however, is that each cylinder head has its own radiator feed and the thermostat is located in the return flow line. The radiator is divided into an upper and lower water tank. Coolant that emerges from the cylinder head 1 - 5 flows through the upper water tank. The coolant from cylinder head 6 - 10 flows through the lower water tank.

The split cooler makes it necessary to provide three bleeder openings and two bleeder lines to ensure effective self-bleeding of the system.

The tap-off point for the heating system heat exchanger is located at the rear of the cylinder heads. The heating return line and the line to the expansion tank merge together at a T-piece ahead of the water pump.

Oil circuit lubrication



15 - S85 Oil circuit

The S85 is equipped with a quasi-dry sump. For this reason, a suction pump is used to pump the oil out of the oil pan in the area ahead of the rack and pinion power steering gear into the rear oil sump. From here, a controllable slide valve pump conveys the oil at a max. pressure of 5 bar into the oil filter. A thermostat that enables the path to the engine cooler is additionally located in the oil filter head. The oil is then routed from the oil filter into the engine. Here it is divided over three lines to the two cylinder heads and to the crankcase. A special feature of this system are the two electrically driven oil pumps that are located on the left and right of the oil pan.

The electric oil pumps start up at a transverse acceleration of 0.8 G and pump the oil from the cylinder heads which, under these centrifugal force conditions, would otherwise no longer flow back into the oil pan.

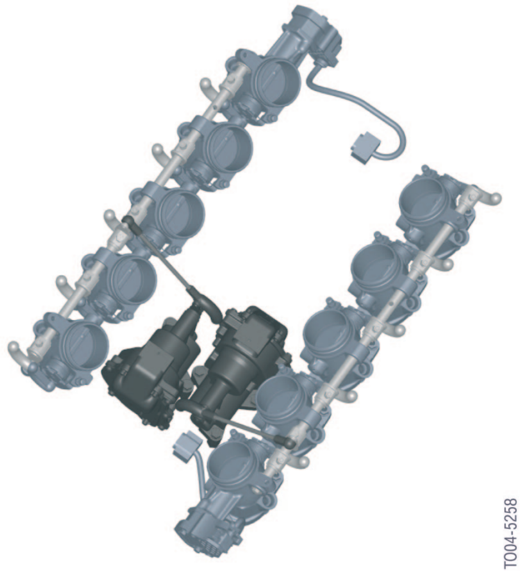
The crankcase is ventilated by a cyclone separator in the intake air manifold 6 - 10. The return flow line from the oil separator and the condensation return flow lines from the intake air manifolds are routed along the 6 - 10 side of the crankcase into the oil sump.

Intake air manifold

16 - Intake air manifolds S85

The S85 is equipped with a separate intake air manifold for each cylinder bank. The intake air manifolds are connected via hoses to the throttle valve assemblies.

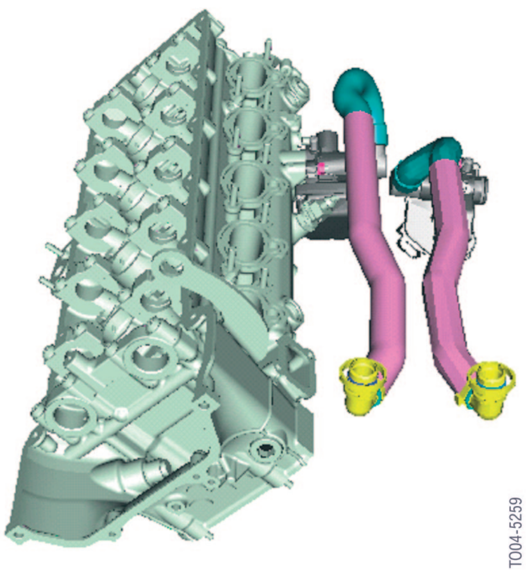
10 individual throttle valves control the air supply for the S85. The individual throttle valves of each cylinder bank are operated separately by an actuator unit and operating shaft. The actuator motors operate independently.



17 - S85 Throttle valves

The throttle valves are set with respect to each other (as on S54). There are no facilities for the synchronization of the cylinder banks with respect to each other as well as for setting the full load stop. The necessary corrections are undertaken by the engine management (see section entitled Engine Management MS_S65).

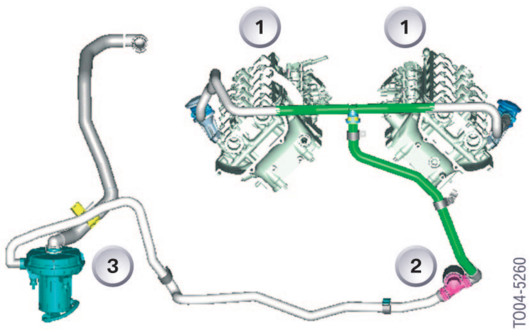
Idle control system



18 - Idle control system

The idle speed is controlled by two idle speed actuators that route the intake air from the intake air manifolds directly into the idle air port of the respective cylinder head. Each cylinder bank is controlled individually.

Secondary air system



19 - Secondary air system

Index	Explanation
1	Diaphragm valve
2	Secondary air actuator (US version only)
3	Secondary air pump

After the engine has been started, the electric secondary air pump mixes fresh air with the exhaust gas to bring about oxidation of the uncombusted hydrocarbons in the exhaust gas. As a result, the HC component in the exhaust gas is reduced and the light-off temperature of the near-engine main catalytic converters is reached at a faster rate. To conform to the stringent exhaust emission regulations in the USA, it is necessary to control the secondary air. This is achieved by an idle speed actuator in the secondary air line on the US version of the S85.

The secondary air is injected into the exhaust ports via vacuum-controlled diaphragm valves on the cylinder heads.

The vacuum necessary for activation of the secondary air valves is taken from the cylinder head 6 - 10 and switched by an electric changeover valve. A check valve prevents the return into the cylinder head.

The vacuum lines from the electric changeover valve to the secondary air valves are routed in the wiring harness duct.

Basic engine and add-on parts

Upper section of crankcase

The upper section of the crankcase is made from an aluminium alloy (GK Al-Si17Cu4Mg T5). The contact surfaces of the cylinders are machined in accordance with the Alusil process.

Bedplate

The bedplate consists of an aluminium frame (G AlSi7Mg0.3 T6) in which the grey cast iron bearing bridges (GGG 60) are cast. After casting, the component is subject to stress-relief annealing for 8 hours at a temperature of 525 °C, it is then quenched in water at 70 °C and aged for 5 hours at a temperature of 165 °C.

Crankcase

The crankcase comprises the bedplate and upper section of the crankcase. As already used on the N42, the seal is provided by a liquid sealant in a groove that is milled into the upper section of the crankcase.

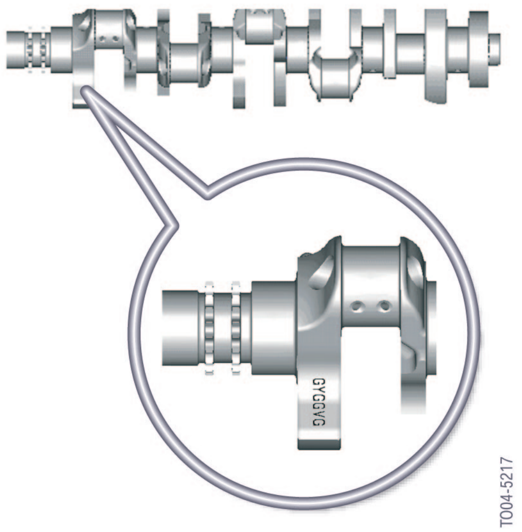
It is important that the assembly sequence is followed precisely in order to avoid stress in the crankcase when assembling the upper section and base plate:

1. Position the bedplate diagonally on the bearing blocks 1 and 6 by means of two M8x94 screws.
2. Provisionally fasten the bedplate with the ten M8x94 screws.
3. Tighten the M11x115 bolts to setting torque
4. Tighten the M11x115 bolts to specified rotary angle
5. Tighten the M8x94 bolts to setting torque
6. Tighten the M8x94 bolts to specified torque
7. Tighten the M8x60, M8x35 and M8x25 bolts to the specified torque

Cylinder head

The cylinder head is made from an aluminium alloy (GK AlSiMgCu0.5 wa).

Crankshaft/main bearings



1 - Main bearing classification (G = green; Y = yellow; V = violet)

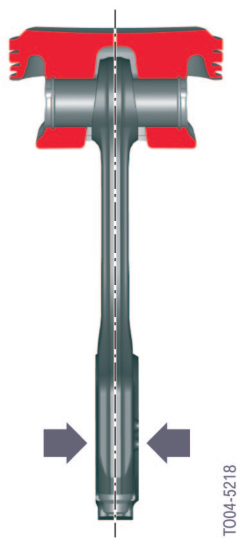
The crankshaft is forged from a high-strength steel 42CrMo4 and weighs 21.63 kg. After grinding the bearing points, the shaft is nitrocarburized.

The colour codes of the main bearing shells are stamped on the crank web of the first main bearing.

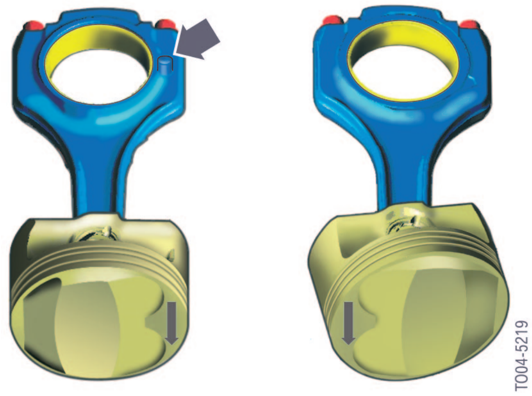
Connecting rods

The forged connecting rods of the S65 are made from the material 70MnVS4 BY. As on the S65, the large connecting rod eye of the connecting rods used on the S85 is cracked, thus achieving an unmistakable parting joint with outstanding fit accuracy. As on the NG engines, the small connecting rod eye is trapezoidal, enabling it to support the force over a large area. The connecting rods weigh 582 g and are produced to a tolerance of ± 2 g. No classification is necessary in view of this very close tolerance range. When assembling the connecting rods and pistons it is important to bear in mind that the connecting rod is asymmetrical and, in the same way as the piston, must be specifically installed with respect to forward direction.

The one-sided reduction of the thrust collar by 1.5 mm per connecting rod serves the purpose of shortening the lateral offset by a total of 3 mm and therefore reducing the total length of the engine by 3 mm. The installation direction is indicated by two elevations on the connecting rod.



2 - Asymmetry of connecting rod



3 - Installation direction of connecting rod

The specified tightening operation for the connecting rod bolts must be adhered to precisely. Tightening the bolts three times to the same tightening angle gives rise to a certain training effect (work hardening) in the connecting rod bolts, resulting in increased pretensioning force and simultaneously in pretensioning force spread. Disregard of or a mix-up in the bolt tightening instructions can lead to 100 % engine damage by connecting rod bolts working loose.

Pistons

The piston is cast from aluminium (Al Si12CuNiMg). Since an aluminium piston is an unfavourable friction partner for an aluminium cylinder, the piston skirt is coated with a galvanic ferrous layer (Ferrostan) at a layer thickness of approx. 10 µm. An additional approx. 2 µm tin layer serves as a running-in layer.

Camshaft

The camshaft mounted in nine bearings is a hollow chill casting (GGG 60). For the first time, the wheel for the camshaft sensor is cast on the camshaft on the S85. An M12x1 thread is integrated in the camshafts for the central screw connection of the VANOS gear mechanism.

Valve springs

Conical valve springs are used on the S85. The same springs are used for the intake and exhaust.

Valve cotters

The valve cotters are designed as single-row clamping-type cone cotters. In contrast to the three-row valve cotters, these clamping-type cone cotters prevent the valve turning during operation as neither a cleaning effect nor running-in is necessary thanks to the clean and efficient combustion and the very close production tolerances. An advantage of the clamping-type cone cotters is their low weight (approx. 50 % lighter than the three-row valve cotters).

In addition, the force of the valve spring is not transmitted positively but rather non-positively via the grooves in the valve stem. At a stem diameter of 5 mm, this arrangement protects the material more effectively.

Box-type tappets

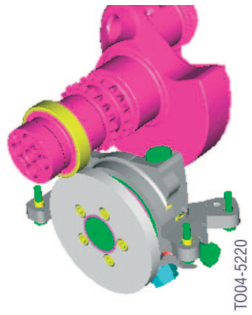
Compared to bucket tappets, box-type tappets permit a substantially greater crown curvature, resulting in decreased migration of the cam and tappet contact point. An alternative is concave grinding of the cams. This, however, involves higher production expenditure and produces a bucket tappet with a considerably larger diameter and therefore an additional weight of approx. 20 g per tappet. The valve timing gear of the S54 is still unsurpassed with regard to the moved masses, however, the box-type tappet of the S85 represents an optimum solution in terms of conflicting objectives such as ease of servicing, production engineering and moved masses.

Valves

Both the exhaust valve as well as the intake valve are designed as solid stem valves with a stem diameter of 5 mm. The intake valves are made from the valve steel X45CrSi9-3. The exhaust valve stem is also made from X45CrSi9-3 and is friction-welded to the valve head made from NiCr20TiAl.

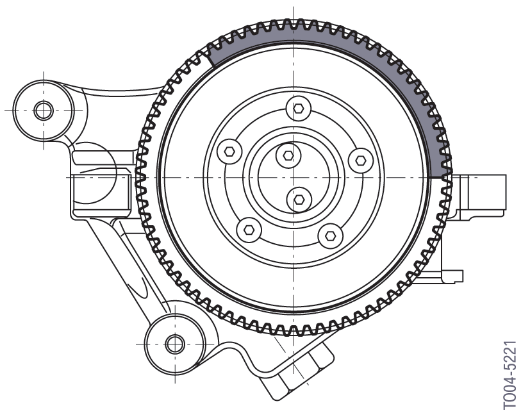
To improve the cylinder charge, the standard cylindrical runout is not formed on the exhaust valve in the area of the valve seat but rather the 70° bevel has a pointed runout. For this reason, the intake valve should be handled with great care as any "knock" could inevitably cause damage to the edges.

VANOS High pressure pump



4 - VANOS High pressure pump

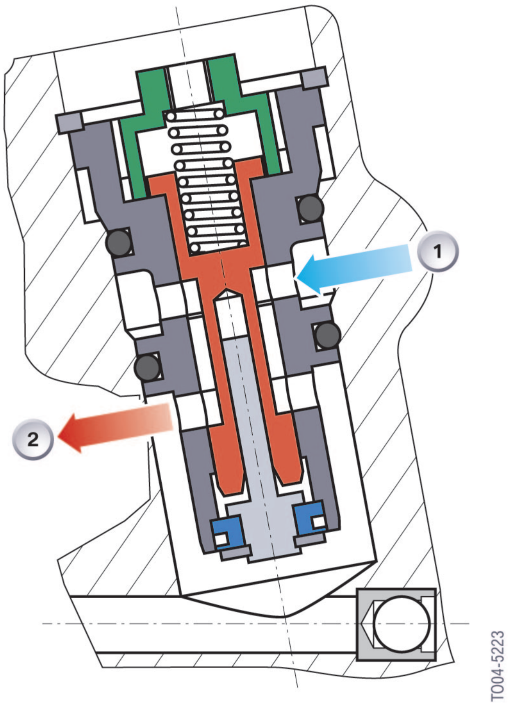
The high pressure pump is designed as a radial piston pump with five pump plungers. It is driven via a gear mechanism directly by the crankshaft. To avoid gearing noise, when mounting the sprocket of the high pressure pump, the coated part must face towards the crankshaft without any clearance. The correct gear clearance is then established automatically by the coating scraping off.



5 - Coated segment of high pressure pump gearwheel

The high pressure pump receives it oil supply from the bedplate. An 80 µm fine filter is installed in the transition hole from the bedplate to the high pressure pump. This filter has the sole purpose of holding back any impurities that may accumulate during series production and is not replaced during vehicle operation.

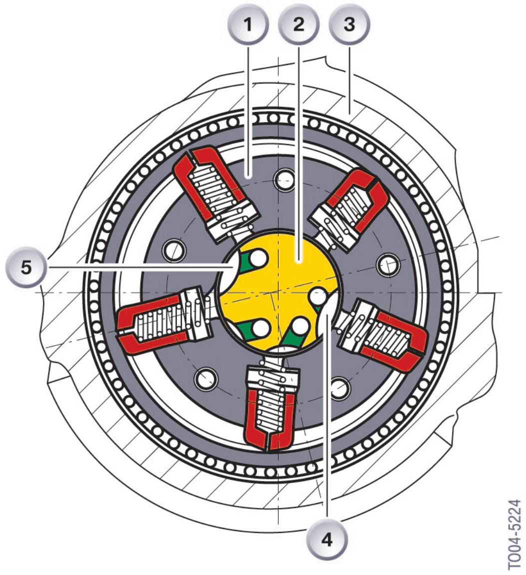
A feed valve in the high pressure pump ensures a constant supply of oil over the entire pressurized engine oil range.



6 - Feed valve in high pressure pump

Index	Explanation
1	Engine oil
2	Oil feed, high pressure pump

The high pressure pump consists of the fixed stator about which the rotor rotates. Five moving plungers are mounted in the rotor. The stator and rotor are installed off-centre in the pump housing. The plungers are guided radially as the rotor rotates thus producing the pump stroke motion.



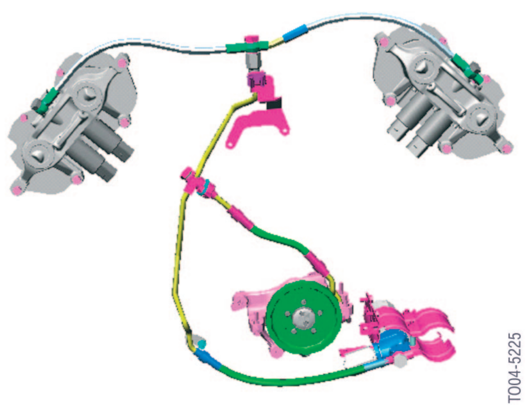
7 - High pressure radial piston pump with fixed stator 1 and moving rotor 2

Index	Explanation
1	Rotor
2	Stator
3	Pump housing
4	Engine oil is supplied by the stator and taken up by the pistons
5	Engine oil is compressed and returned to the stator at 100 bar

The pressure relief valve integrated in the high pressure pump opens in response to pressure peaks in the high pressure system and opens up a bypass to the oil pan.

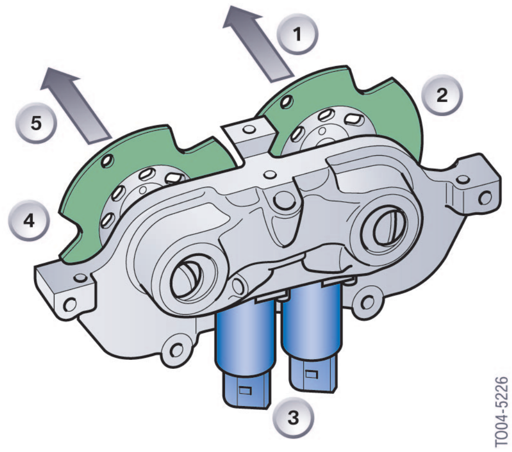
The oil pressurized at 115 bar is routed via three delivery lines to the two VANOS control units and to the pressure accumulator.

VANOS High pressure system



8 - High pressure line

VANOS Actuators



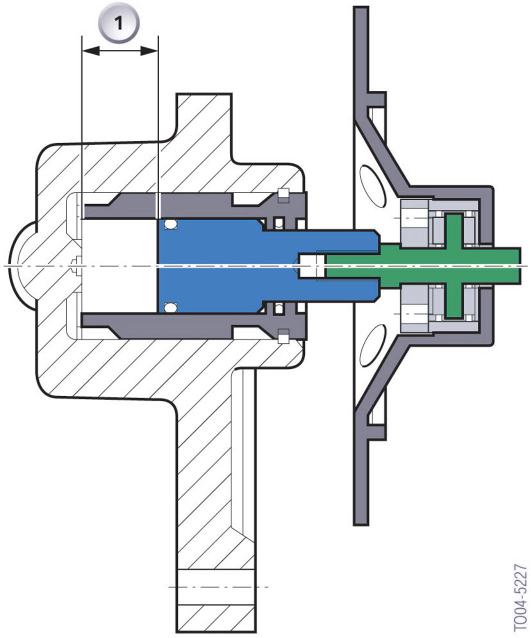
9 - Adjustment unit

Index	Explanation
1	Adjustment direction, advance
2	Intake
3	Plug contacts
4	Exhaust
5	Adjustment direction, retard

Separate adjustment units are provided for each cylinder bank for the purpose of adjusting the VANOS gear mechanism. These adjustment units are known as the actuators. The VANOS high pressure pump supplies them with oil under high pressure.

Since, due to the gearwheel connection the intake camshaft and exhaust camshaft rotate in opposing directions, the intake is adjusted towards advance and the exhaust towards retard when the plunger extends.

The adjustment pistons are designed as double-acting cylinders and differ with regard to the adjustment range for the intake and exhaust camshafts.

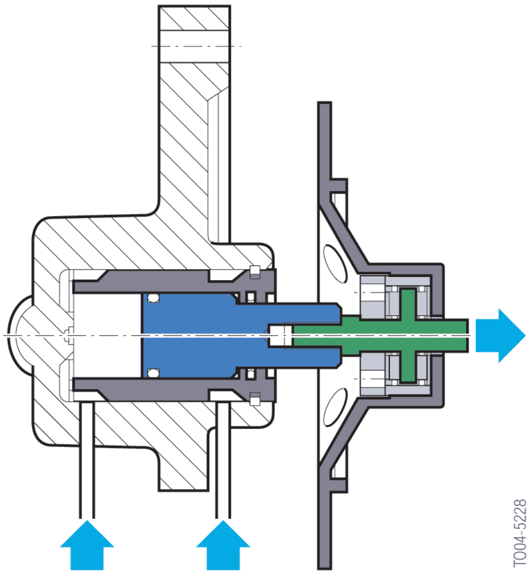


10 - Stroke of adjustment piston

Index	Explanation
1	Stroke

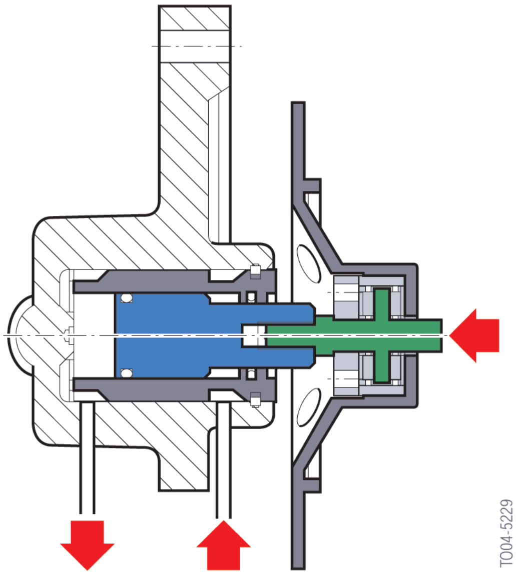
The stroke range on the exhaust side of maximum 14.25 mm corresponds to 18.5° camshaft angle = 37° crankshaft angle. The stroke on the intake side of maximum 25.25 mm corresponds to 30° camshaft angle = 60° crankshaft angle.

When extended into the two piston chambers, the adjustment pistons are subject to a system pressure of 100 bar. They therefore extend only due to the different piston surface areas. The oil from the small piston chamber is transferred into the high pressure circuit. The proportional valve must be fully actuated in order to extend the adjustment piston.



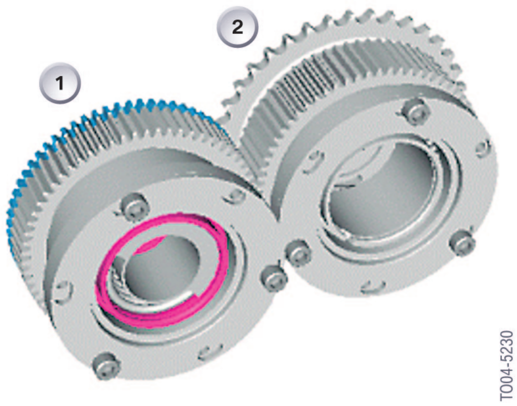
11 - Adjustment piston extending

The holding function and piston retraction are achieved by reducing the oil feed on the side with the largest piston surface area by partly actuating the proportional valve. The reduced oil feed decreases the oil pressure, thus initiating a change in the forces exerted on the adjustment pistons. The retraction movement of the adjustment pistons is supported by the camshafts as they push back the spline shafts in the hydraulic units due to the helical gearing in the VANOS gear mechanism.



12 - Adjustment piston retracting

VANOS gear mechanism

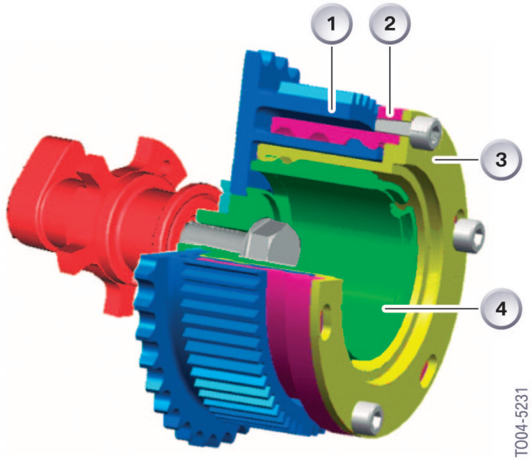


13 - VANOS gear mechanism

The VANOS gear mechanism connects the crankshaft with the intake camshafts as well as the exhaust camshafts. The gear mechanism also permits "torsion" of the camshafts. The gear mechanisms for the intake and exhaust sides differ in terms of the exterior structure of the gear and chain drive while the adjustment mechanism on the inner side is identical.

Index	Explanation
1	Exhaust
2	Intake

The gear mechanism is driven by the drive gearwheel that interacts with the helical gearing on the inner sleeve. The threaded connections for the gearing connects the inner sleeve to the outer sleeve. With (wide) helical gearing, the inner sleeve acts on the bearing assembly for the drive gearwheel that is firmly secured to the camshaft with the central bolt.



14 - Design of intake gear mechanism

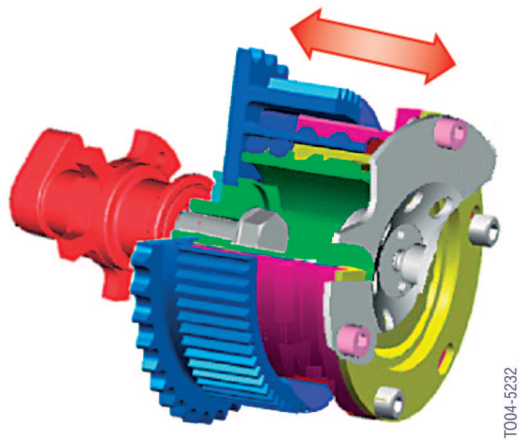
Index	Explanation
1	Drive gearwheel assembly
2	Inner sleeve
3	Outer sleeve
4	Bearing for drive gearwheel

The actuator (adjustment unit) is connected to the outer and inner sleeve by the screw connection of the gear mechanism. During adjustment, the inner sleeve and outer sleeve are pulled out of and pushed into the gear mechanism.

The inner sleeve is turned by the helical gearing on the "fixed" drive gearwheel (timing chain drive). Due to the non-positive screw connection of the outer sleeve, this sleeve also turns. In connection with a further helical gear, the outer sleeve now turns the bearing for the drive gearwheel and in turn the camshaft connected with the central bolt.

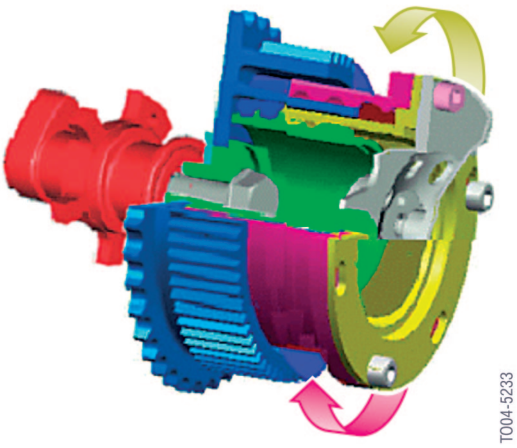
The gear units are mounted in their base position, i.e. pulled apart. The camshafts are adjusted when the gear units are pushed together.

The drive gearwheel and bearing for the drive gearwheel are connected by a torsion spring to assist the return movement.



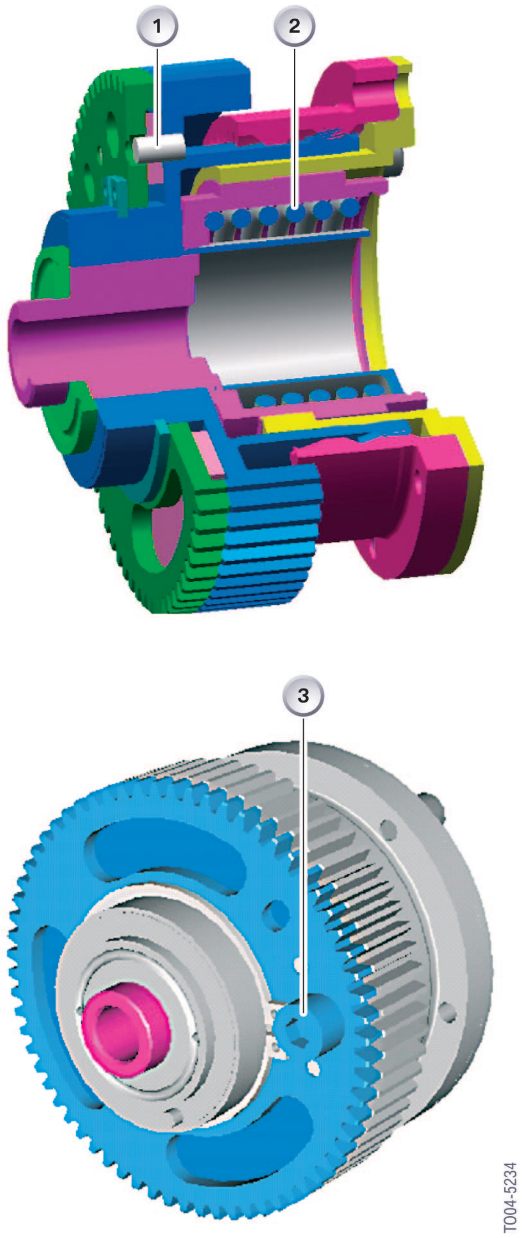
15 - Intake gear mechanism adjusted

The mounting screws for the gear mechanism are tightened only lightly when assembling the actuators. As a result, no force is transmitted from the outer sleeve to the inner sleeve when sliding the actuators onto the cylinder head (to facilitate the sliding movement of the gear unit). Due to the "fixed" drive gearwheel, the outer sleeve turns in the direction of engine rotation. At the same time the "fixed" bearing for the drive gearwheel turns the inner sleeve opposite the direction of engine rotation.



16 - Direction of rotation when sliding on the adjustment unit

The exhaust camshaft is driven by the intake camshaft in connection with a gear drive mechanism. The drive gearwheel is split in two in order to avoid gearing noises caused by a change in the driving tooth profile in connection with a change in load. A disc spring turns the two halves of the gearwheel in opposing directions (functional principle similar to dual-mass flywheel) so that both tooth profiles of the exhaust gearwheel always rest on the intake gearwheel under all load conditions.



17 - Exhaust-side sprocket with disc spring

Index	Explanation
1	Annular spring
2	Torsion spring
3	Lock screw

VANOS Pressure accumulator

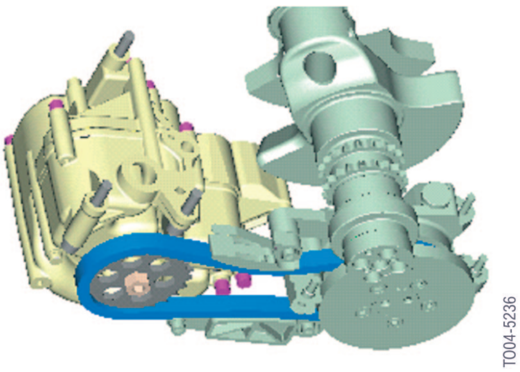
The pressure accumulator is preloaded with nitrogen. A piston separates the oil chamber from the gas chamber.

The VANOS operating pressure is 115 bar. The shut-off valve on the pressure accumulator is closed when the engine is turned off. A pressure of 80 bar remains in the pressure accumulator which is immediately made available the next time the engine is started.

⚠ The repair instructions must be observed when performing any work on the pressure accumulator! ◄

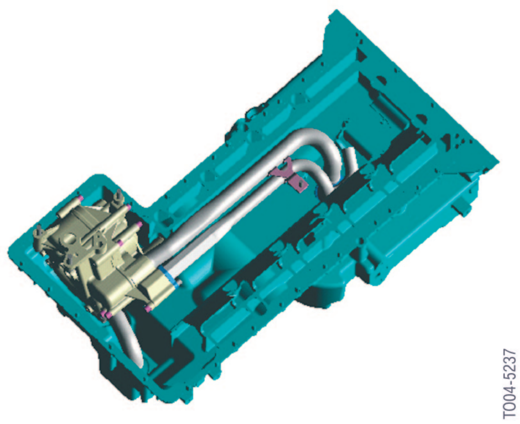
Oil pumps

The oil pump is driven by the VANOS high pressure pump in connection with a chain.

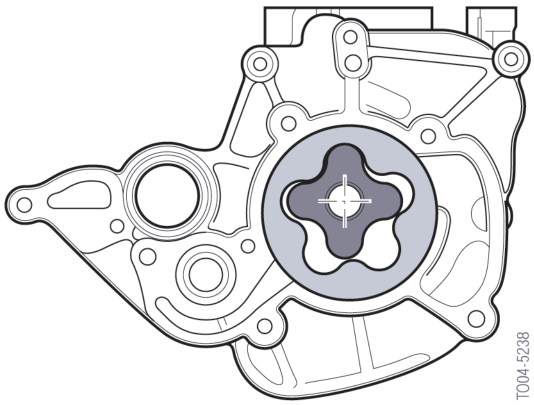


18 - Drive of oil pump

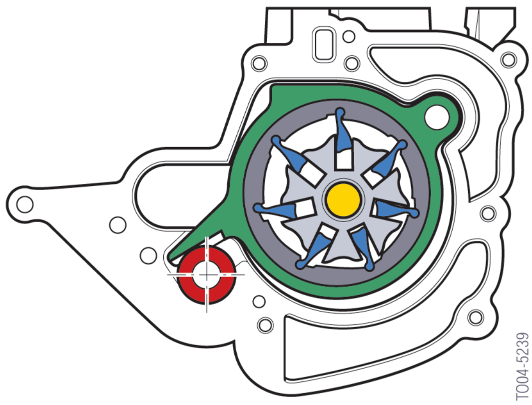
The oil pump housing accommodates two oil pumps. The one is a duocentric pump that pumps the oil from the front oil sump to the rear oil sump. The other is a slide-valve type pump which takes the oil from the rear sump and conveys it to the oil filter at a variable pressure of up to 5 bar.



19 - Oil pan with oil pump



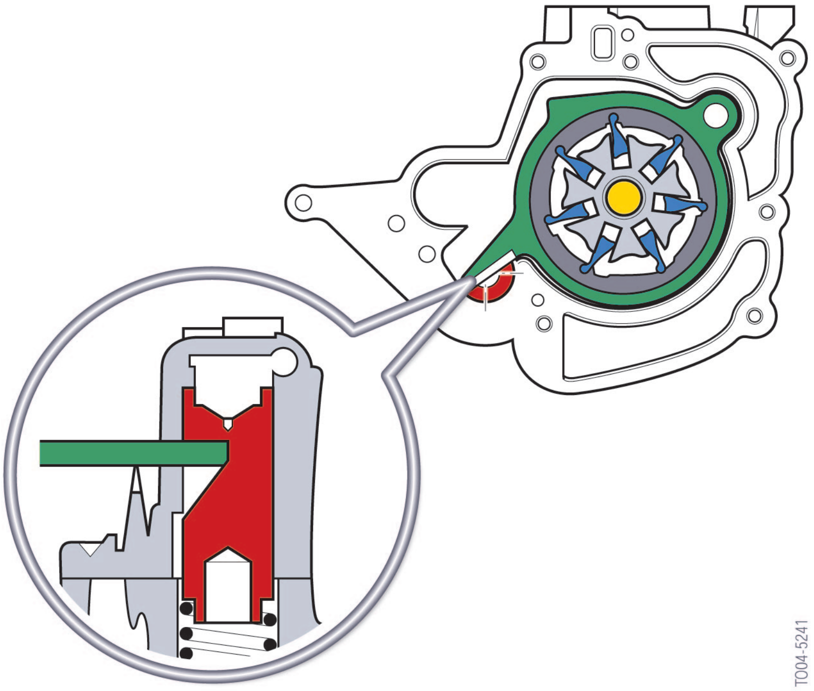
20 - Duocentric pump



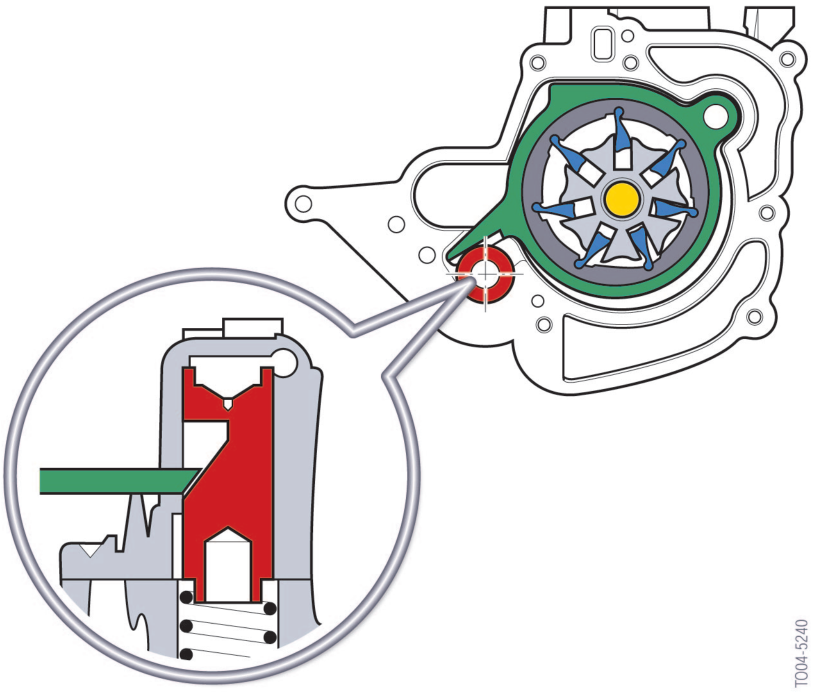
21 - Slide-valve type pump

The pump outlet is determined by the eccentricity of the pendulum-type slide valve. No oil is delivered when the pump runs centrally with respect to the rotor as all pump chambers are the same size.

The slide valve is displaced by an inclined piston. This piston is in equilibrium between the piston spring and the engine oil pressure. The greater the engine oil pressure, the more the piston is pressed against the spring and the more the slide valve turns in the direction of 0 delivery.



22 - Minimum delivery



23 - Maximum delivery

Electric oil pumps

When cornering at high speeds, the centrifugal force forces the engine oil into the outer cylinder head so that it can no longer flow back into the oil pan of its own accord.

It must therefore be pumped off by the respective oil pump and returned to the oil sump. The electric oil pumps are activated by the engine control unit that determines the cornering speed with a yaw rate sensor.

The electric oil pumps are protected by heat shields from the heat radiated from the exhaust manifolds.

Oil spray nozzles

Double-hook oil spray nozzles are used on the S85 for the purpose of cooling the piston crown.

The oil spray nozzle is equipped with an integrated pressure control valve.

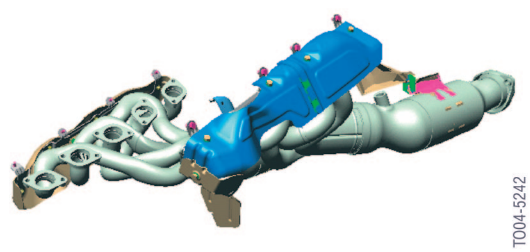
Opening pressure: 1.8 to 2.2 bar

Closing pressure: 1.3 to 1.9 bar

Oil filter housing

A thermostat that opens the path to the engine oil cooler is mounted in the head of the oil filter housing.

Exhaust manifold



24 - Exhaust manifold

The S 85 is equipped with a 5-in-1 exhaust manifold with near-engine catalytic converter for each cylinder bank. The pipes or runners of the manifold are made from stainless steel (X 15 Cr Ni Si 20-12) and have a wall thickness of 0.8 mm.

Intake air manifold

The S85 features a separate intake air manifold for each cylinder bank that is mounted with hose clips on the throttle valve assemblies.

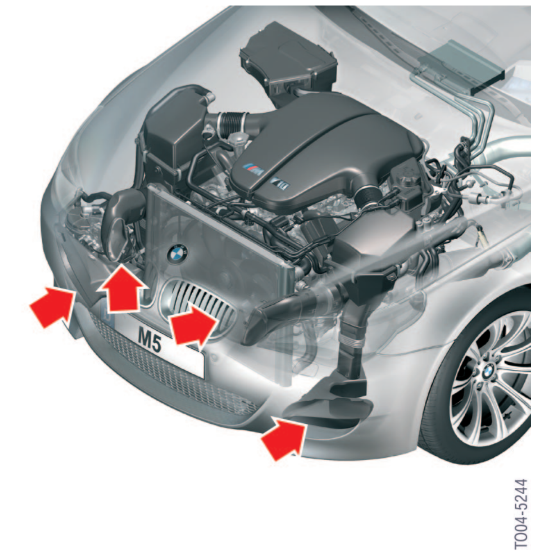
25 - Cyclone separator (1) in intake air manifold

Cyclone separators are installed in the intake air manifolds in the area of the fifth and tenth cylinder. The oil from the oil separators and the condensate from the manifolds merge in two channels in the crankcase behind the tenth cylinder and routed into the oil sump.

The design of the intake air manifold is similar to that mounted on the S54. The shells are also made from PA66 on the S85 but they are joined together by a butt-welding process.

Intake silencers

The air to the intake silencers is drawn in via two routes. One from the area behind the kidney grille and the other from the large air inlets in the bumper.



26 - Intake silencers with air ducting

The S85 requires four air ducts in order to achieve maximum output. A large cross section could not be realized for package space reasons. In addition, the upper intake ducts define the fording capability of the M5.

In the US version, the air cleaner element is additionally equipped with an activated carbon filter. This filter serves the purpose of ensuring no vapours containing hydrocarbons can escape from the intake area into the environment when the vehicle is stationary.

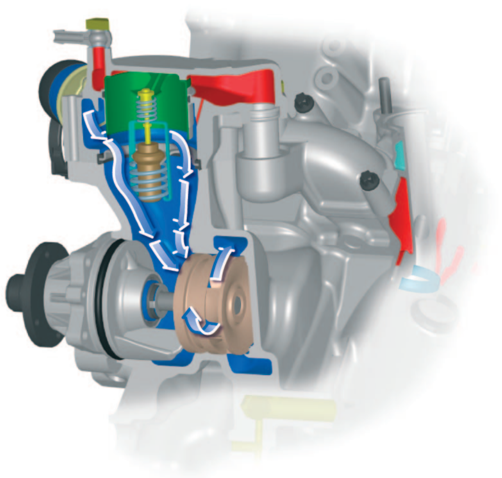
Radiator

The radiator of the S85 is divided into an upper and a lower water tank. The lower water tank serves the purpose of cooling the coolant from the cylinder side 1 - 5 while the upper tank is responsible for cooling the cylinder side 6 - 10. Due to this split design, it has been possible to reduce the pressure drop in the radiator from approx. 3 bar to approx. 1.4 bar.

Thermostat

Due to the two-section cooling concept, the thermostat on the S85 has been relocated in the return line. It is designed as a conventional thermostat that opens at a temperature of 79 °C.

The coolant from the cylinder heads enters the connection piece for the radiator feed and from here it is routed both via the double O-ring carrier into the thermostat as well as into the coolant supply hoses.



27 - Sectional view of thermostat housing

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DME S85B50

Objectives
DME S85B50

Purpose of this Participant's Manual

The Participant's Manual is a document designed to accompany a seminar while at the same time serving as a source of reference.

This Participant's manual describes new features and further developments of the digital motor electronics (DME) for the S85B50 engine.

Introduction

The S85B50 engine can develop a power output of 373 kW (507 bhp) and a maximum torque of 520 Nm.

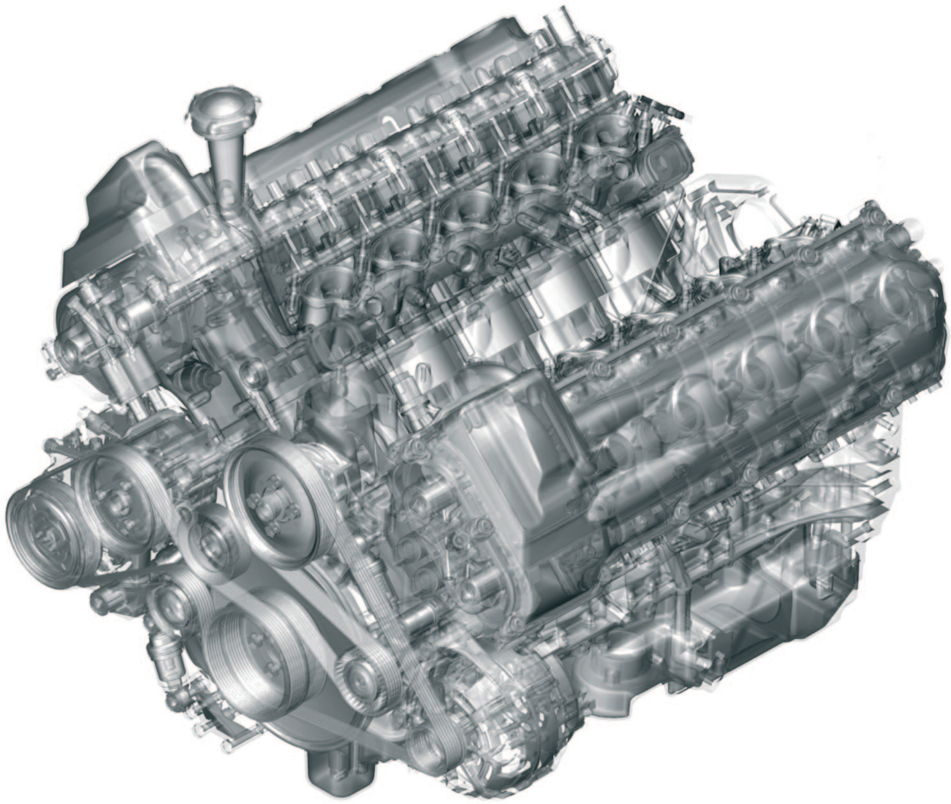
To ensure the available power is fully utilized at a maximum engine speed of 8,250 rpm while complying with legally stipulated exhaust emission regulations, the engine management MS_S65 further developed by Siemens on the basis of the MS_S54 was used for the first time.

The use of the MS_S65 with its expanded functions made it possible to precisely control the engine based on the high speed concept.

The S85B50 complies with the exhaust emission regulations

- Europe: EU4
- USA: US-LEV 2
- Japan: Japan LEV 2000.

System overview
DME S85B50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The MS_S65 is a further development of the MS_S54 (MS_S54 HP, M3 CSL) that was used to control the S54 in the E46 M3.

Additional functions used for the first time at BMW were implemented to facilitate the use of the S65 engine management on the S85B50:

- Two-stage selectivity of the maximum engine power output
- Transverse force-dependent control of the electric oil pumps
- Requirement-controlled fuel delivery with variable fuel pressure
- Knocking and misfiring detected by ionic current technology.

Functional Principle of the Digital Motor Electronics

Engine torque control

The EDR satellite serves the purpose of controlling the engine torque. The main control variable is the quantity of fresh air (air/ fuel mixture) supplied to the engine that can be varied by the position of the ten individual throttle valves and the two idle speed throttle valves.

For the control system, the V 10 engine is divided into two identical blocks (cylinder banks) each with five cylinders. Each cylinder bank has an idle speed throttle valve and five individual throttle valves.

The five individual throttle valves are mechanically coupled with each other per cylinder bank.

The position of the idle throttle valve and the position of the five individual throttle valves are controlled by two actuators per cylinder bank an idle speed actuator (LLS) and an electric throttle valve actuator (EDR).

The entire intake air control system therefore consists of four actuator motors for the throttle valves.

For safety reasons, each throttle valve is equipped with a return spring that closes the throttle valves in the event of the respective actuator failing.

All four actuator motors are controlled by the central engine management (DME).

The DME calculates the target load signal for both cylinder banks from the input variables such as driver's load choice via the pedal value sensor, coolant temperature and from interventions of other control units (DSC, ACC, ...). The DME then determines a set position for the throttle valves (set angle) from this target load signal. Initially, the potential of the idle throttle valves is exhausted before the individual throttle valves are opened to allow a substantially greater volume of air to be drawn in.

Communication with the actuator motors takes place via the CAN busses. The two EDR are addressed via a separate CAN-bus and the two LLS via a common LLS-SMG CAN-bus.

In order to set the engine power output corresponding to the input variables, the DME specifies for the actuators a target value relating to the throttle valve angle which the actuators then assume.

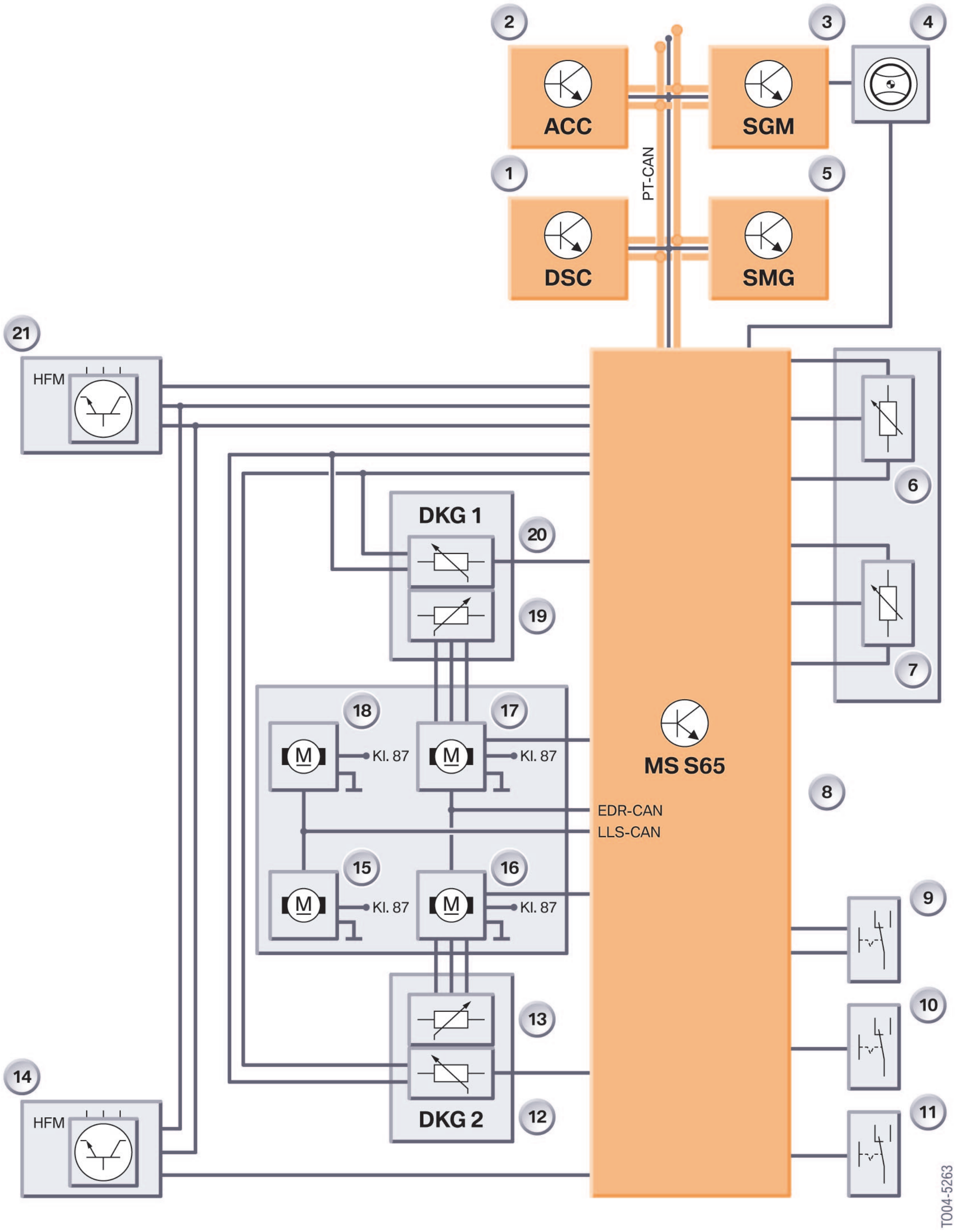
One of the two Hall sensors of the throttle valve sensor 1 (DKG 1) is made available to the electric throttle valve actuator 1 (EDR 1) for the purpose of controlling the individual throttle valves.

The second Hall sensor of DKG 1 is powered and read directly by the DME and only serves the purpose of monitoring the control of the EDR 1. (the same applies to actuator 2 (EDR 2)).

The two idle actuators feature an internal incremental angle transducer for controlling the throttle valve angle of the idle speed throttle valves. The sensor value is sent back to the DME via the CAN-bus.

The DME determines the current actual load signal from the directly read throttle valve sensors and the feedback signals of the LLS in order to check the setting of the throttle valves. The plausibility of this load signal is checked against the signals of the two hot-film air mass meters (HFM) that measure the intake air masses per cylinder bank.

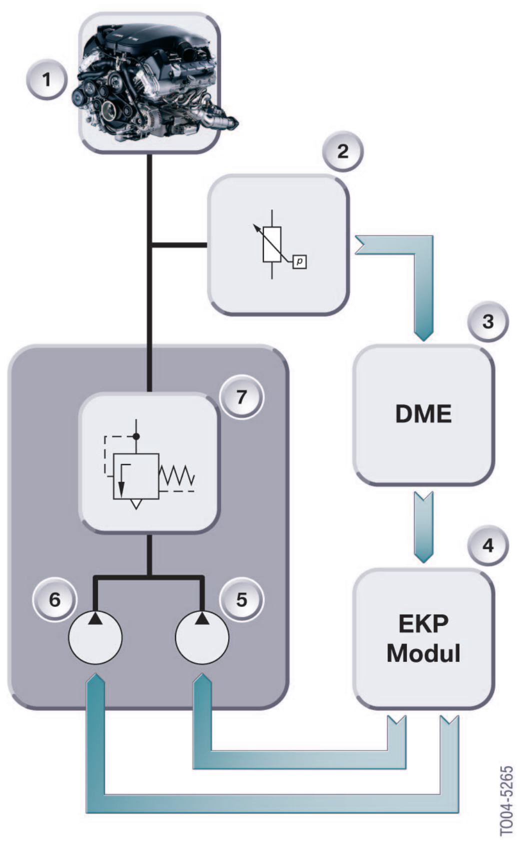
If the deviations between the target and actual load signal are too great, the plausibility is additionally checked against the signal from the oxygen sensor. The DME responds with a corresponding fault reaction.



1 - System circuit diagram EDR

Index	Explanation	Index	Explanation
1	Dynamic stability control (DSC)	12	Throttle valve sensor (DKG)
2	Active cruise control (ACC)	13	Inverted throttle valve sensor (DKG)
3	Safety and gateway module (SGM)	14	Hot-film air mass meter (HFM)
4	Steering wheel	15	Idle speed actuator (LLS)
5	Sequential M gearbox (SMG)	16	Electric throttle valve actuator (EDR)
6	Pedal position sensor (PWG)	17	Electric throttle valve actuator (EDR)
7	Pedal position sensor (PWG)	18	Idle speed actuator (LLS)
8	Digital Motor Electronics (DME)	19	Inverted throttle valve sensor (DKG)
9	Brake light switch	20	Throttle valve sensor (DKG)
10	Clutch switch	21	Hot-film air mass meter (HFM)
11	Transmission switch, idle speed		

Requirement-oriented fuel delivery with variable pressure



2 - System circuit diagram of pressure control circuit

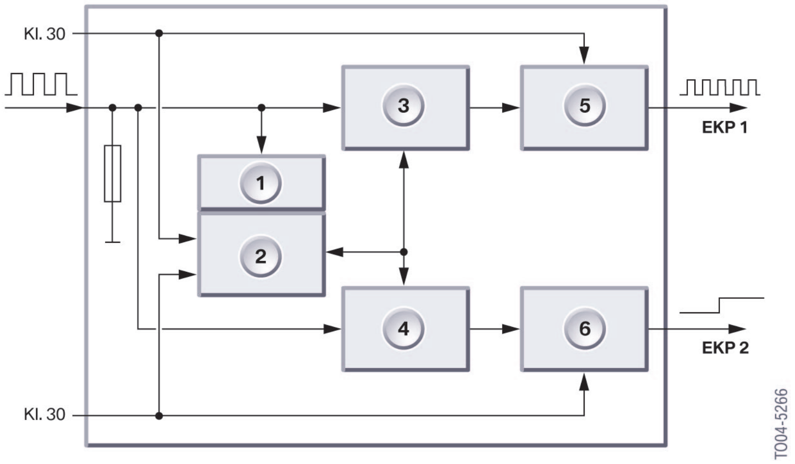
Index	Explanation
1	Engine
2	Pressure sensor
3	Digital Motor Electronics (DME)
4	EKP module
5	Electric fuel pump (EKP 1)
6	Electric fuel pump (EKP 2)
7	Pressure regulator in fuel tank

In order to be able to make fuel at variable pressure available to the engine corresponding to the load status, the DME activates the fuel pumps by means of the EKP module such that the required target pressure is set irrespective of the quantity of fuel currently used. The target pressure varies between 3 and 6 bar and can be checked with a test module based on the target curve.

Manual measurement is no longer necessary. The fuel control circuit consists of the following components:

- Electric fuel pumps (EKP)
- EKP module
- Fuel tank with components and line system
- Fuel pressure sensor
- Digital motor electronics (DME) with the control logic.

Activation of the fuel pumps



3 - Block diagram of EKP module

Index	Explanation	Index	Explanation
1	Activation	4	Control logic EKP 2
2	Power supply	5	Output stage EKP 1
3	Control logic EKP 1	6	Output stage EKP 2

The DME controls the EKP 1 corresponding to requirements via the electric fuel pump EKP.

The EKP 2 cuts in non-regulated in the high load range. The pressure regulator in the tank is activated in a variable mode in order to set the fuel pressure to the target value with the activated second pump.

The PWM interface is a single-wire interface, via which the DME activates the EKP module and therefore varies the delivery capacity of the electric fuel pump EKP.

The task of the EKP module is to clock the electric fuel pump (EKP) via the output stage with precisely this pulse duty factor. The deviation of the pulse duty factor between the input and output PWM signal must not be greater than 3 %.

This tolerance applies over the entire service life of the EKP module. The second electric fuel pump EKP additionally cuts in on reaching a pulse duty factor of 100 %.

Ionic current measurement

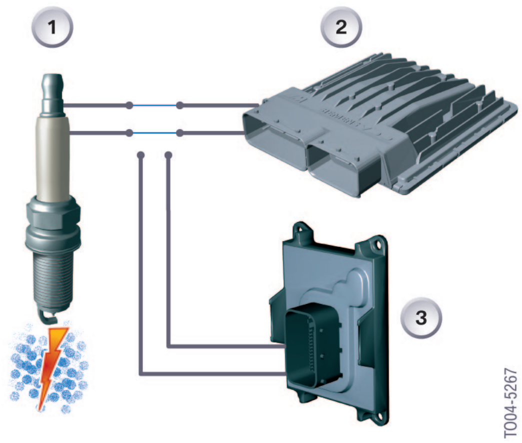
For optimized engine management in terms of exhaust emission and fuel consumption, it is necessary to establish as accurately as possible the composition of the combustion mixture under all engine operating conditions.

A method for achieving this aim is the so-called ionic current measurement. Ionic current measurement can be used for knock combustion control and detecting irregular idle speed (misfiring detection).

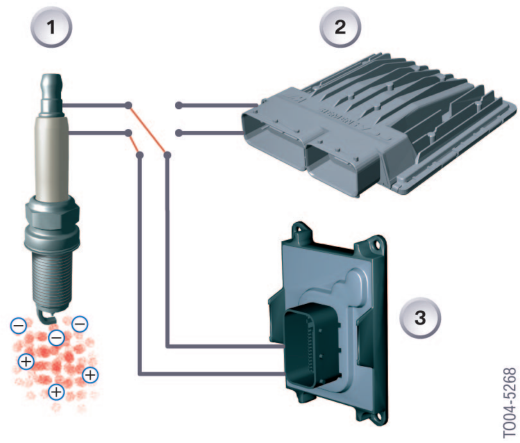
The ignition spark is triggered by the engine control unit.

A low voltage is applied between the electrodes of the spark plug immediately after the end of the ignition spark and the resulting current (ionic current) is measured.

The ionic current is measured and evaluated by the ionic current control unit.



4 - Ignition



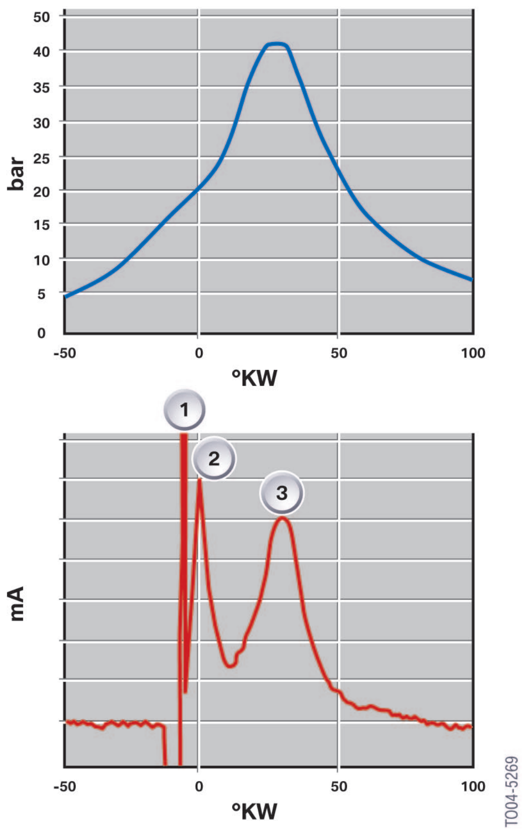
5 - Ionic current measurement

Index	Explanation
1	Spark plugs
2	Engine control unit
3	Ionic current control unit

The combustion progression in the combustion chamber can be represented by the combustion chamber or cylinder pressure curve.

Ionic current representation

The ionic current progression (curve) is directly dependent on the cylinder pressure and the ions in the cylinder.



6 - Pressure curve (top) and ionic current (bottom)

Index	Explanation
1	Ionic current maximum by induction of ignition coil
2	Ionic current maximum due to ignition (flame front directly in area of spark plugs)
3	The ionic current progression is a function of the pressure curve

Generally applicable:

Poor combustion => low cylinder pressure

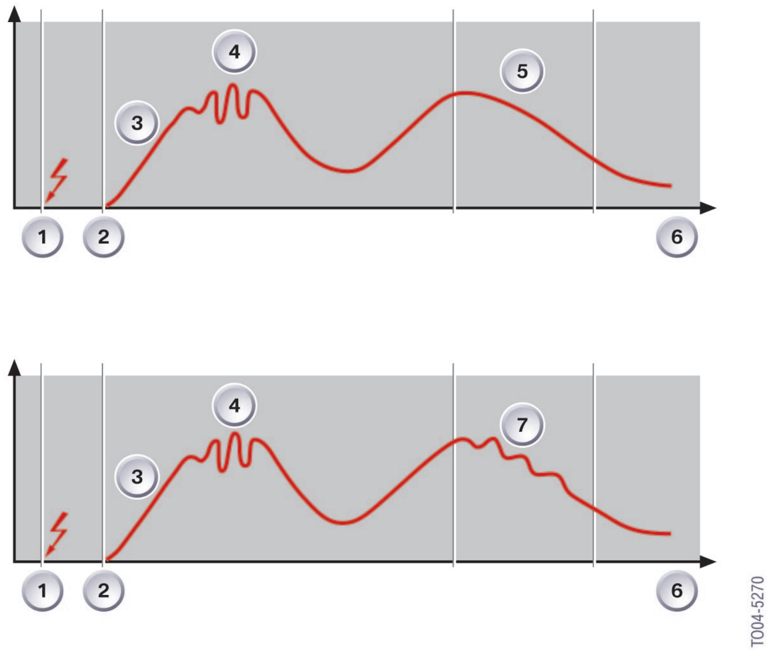
Good combustion => high cylinder pressure

Free ions additionally split off or separate due to pressure peaks that occur in the combustion chamber during knocking combustion. This results in a change in the ionic current progression (curve).

The ionic current is measured and evaluated in the ionic current control unit.

The resulting corrections to the engine control are executed in the engine control unit.

Comparison of ionic current curves



7 - Normal and knocking combustion

Index	Explanation	Index	Explanation
1	Firing point	5	No knocking
2	End of ignition	6	Time
3	Ionic current	7	Knocking
4	Flame front signal		

Selectivity of maximum engine power output

The POWER button is a ground switch that is pressed once to enable the maximum engine power output.

The modes that can be selected with the button are P400 and P500.

The P500 Sport mode which also selects a progressive accelerator pedal characteristic can be configured only in the "M-Drive" menu and selected via the "M" button on the multifunction steering wheel.

The P400 setting is assumed automatically when the vehicle is restarted.

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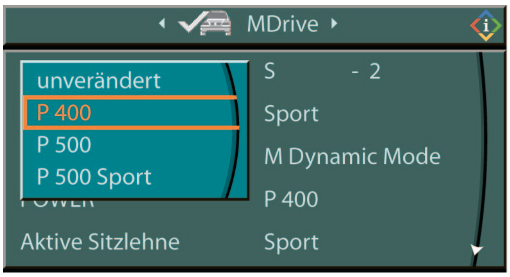
8 - POWER button



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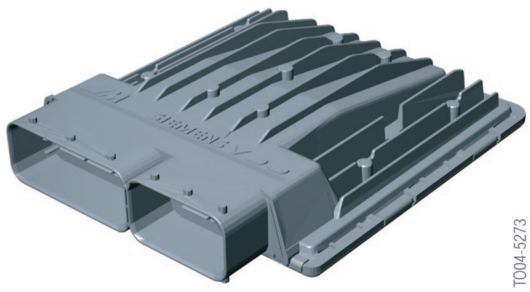
9 - M-Drive menu

Digital Motor Electronics (DME)

DME control unit Siemens MS_S65



1 - MS_S65

As on the E60 production vehicle, together with the intelligent battery sensor IBS and the alternator, the engine management in the E60 M5 is responsible for the energy management and the requirement-oriented service BOS).

One engine control units controls both cylinder banks.

The firing order is:
1-6-5-10-2-7-3-8-4-9.

The MS_S65 is equipped with 6 plug-in modules (combined in two compact connectors) that are grouped according to functions.

The ignition output stage as well as the knocking combustion and misfiring detection stage have been relocated to the ionic current control unit.

The transverse acceleration signal is evaluated by the DSC for the purpose of drawing off oil.

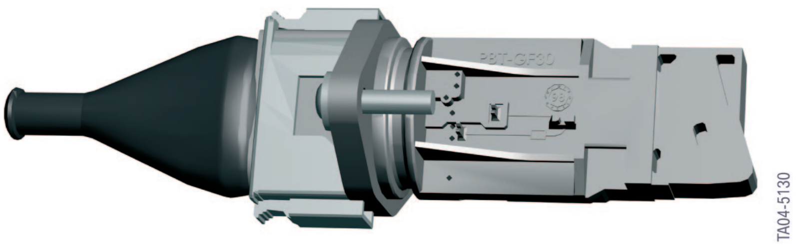
Date interfaces:

1. PT-CAN
2. Idle air actuator/SMG-CAN
3. Throttle valves CAN (DK-CAN)
4. BSD-BUS (alternator and IBS)
5. Interface to CAS.

Hot-film air mass meter (HFM)

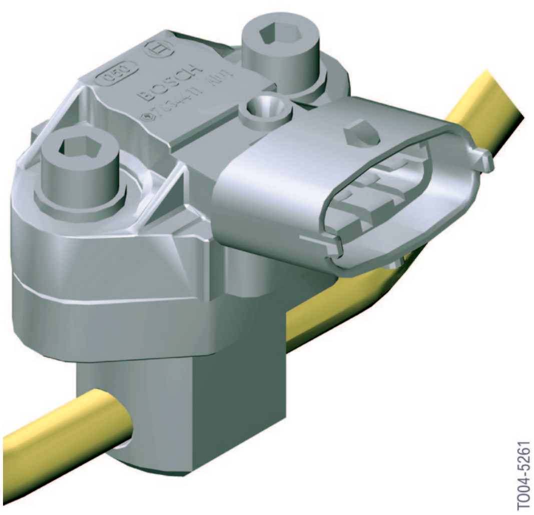
A hot-film air mass meter supplied by Bosch, HFM 5.0 with CL bypass, is used for each cylinder bank for the purpose of determining the intake air mass and its temperature.

The hot-film air mass meter HFM is designed as a plug-in module and is located in the intake silencer.



2 - HFM 5.0 with CL bypass

Fuel pressure sensor



3 - Fuel pressure sensor

The fuel pressure sensor is located in the front left wheel arch.

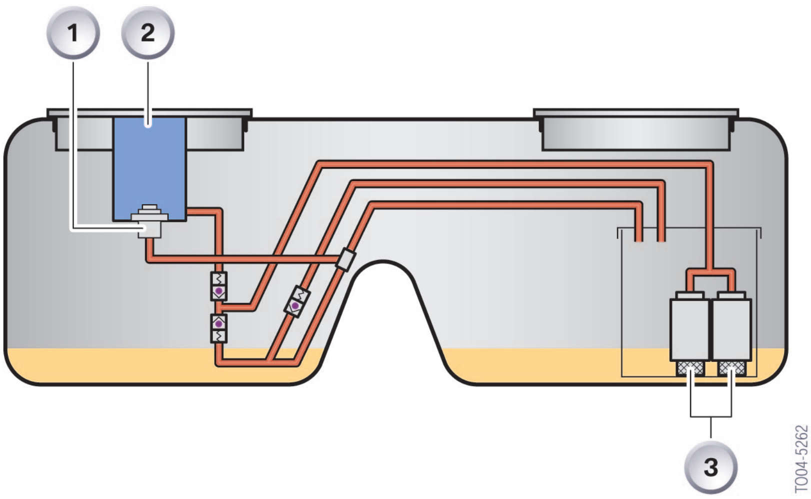
This sensor measures the current fuel pressure and transfers the value to the engine management.

Electric fuel pump (EKP)

The fuel tank contains two fuel pumps that are designed as vane pumps.

Both pumps are integrated in the right-hand half of the fuel tank.

The fuel filter and the pressure regulator are positioned in the left half of the fuel tank.



4 - Fuel tank with components

Index	Explanation	Index	Explanation
1	Pressure regulator	3	EKP 1 and 2
2	Fuel filter		

EKP module

As on the E60 Series (8-cylinder and diesel), the EKP module is located on the rear right in the luggage compartment. The power output stage of this control unit has been adapted to the additional pump and the modified control logic.

Ionic current control unit

The two ionic current control units supplied by the manufacturer Helbako are mounted on the front of the cylinder head covers of the respective cylinder bank.

5 - Ionic current control unit

Crankshaft sensor

The crankshaft sensor registers the engine speed at the incremental wheel of the ring gear. The position of the crankshaft is determined by a tooth gap.

The incremental wheel on the ring gear has a pitch of 60 - 2 teeth.

The sensor is designed as an inductive sensor.

Camshaft sensor

Each camshaft is monitored by an individual Hall sensor.

The sensor wheel is cast onto the camshafts.

Oil condition sensor (QLT)

The oil condition sensor has been adapted from the N62 and the software correspondingly adapted.

Oil pressure switch

The signal from this switch is transferred to the DME where it is evaluated. In the event of a deviation from the specified value, the DME sends a corresponding message to the CID which in turn displays an associated check control message.

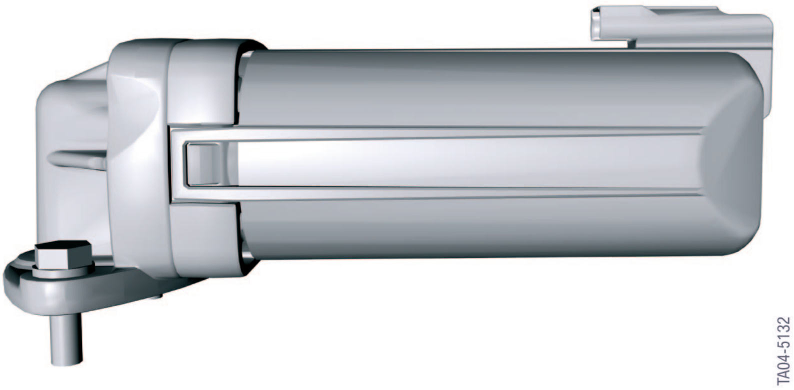
Oil extraction pump

Two independent return pumps are installed on the S85B50.

Different from the predecessor model, these pumps are activated as from a centrifugal force of 0.8 G.

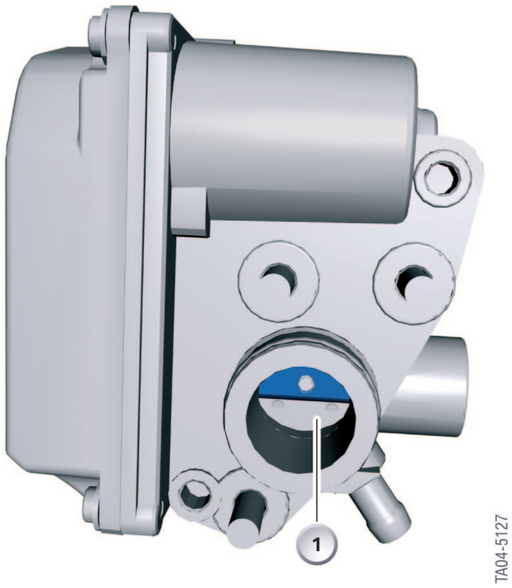
The pumps extract the engine oil that remains in the cylinder head and conveys it to the oil sump.

The DSC informs the DME of the current transverse force via the PT-CAN.

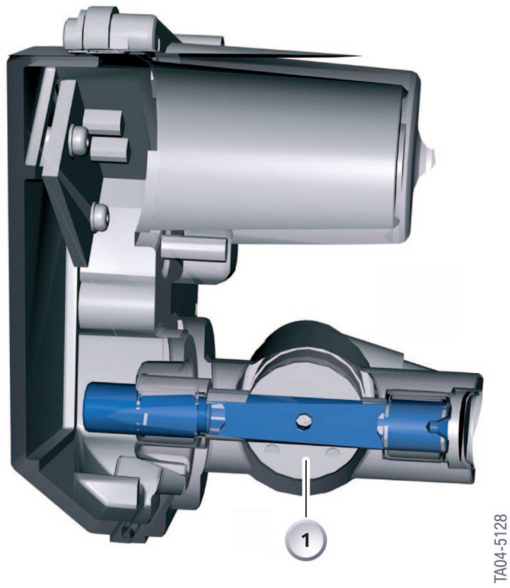


6 - Oil extraction pump

Idle speed actuator (LLS)



7 - Idle speed actuator



8 - Idle speed actuator (sectional view)

Index	Explanation
1	Throttle valve

The two idle speed actuators LLS are designed as throttle valve actuators and are located in the V-area.

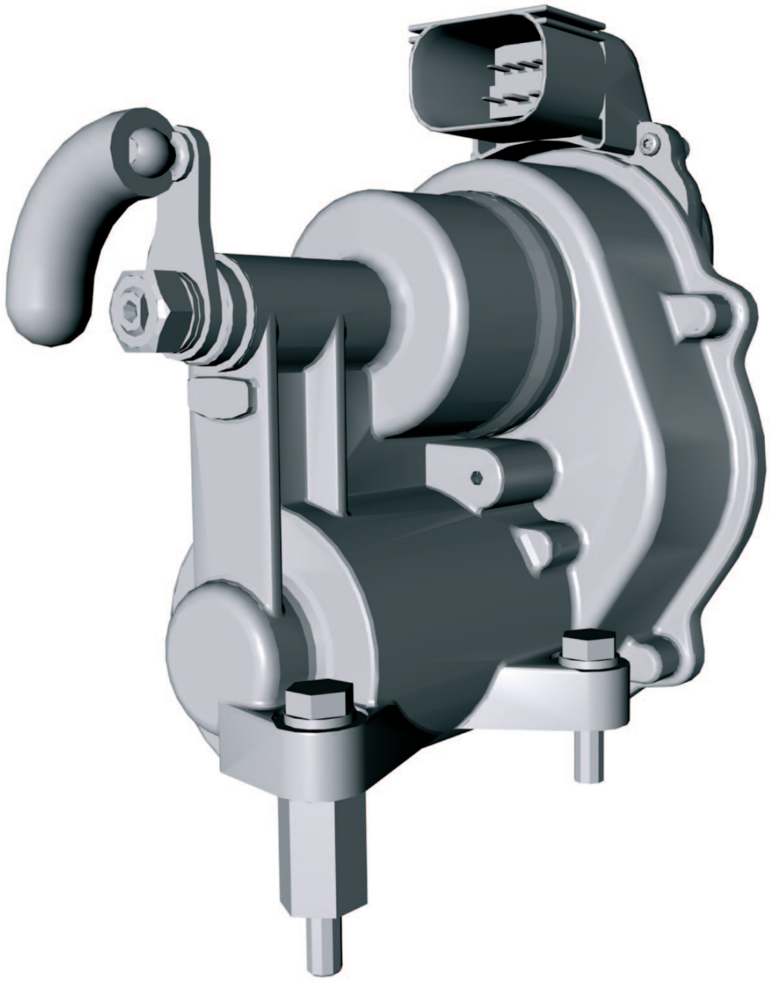
The idle speed actuators communicate with the DME via the LLS/SMG-CAN.

The idle speed actuators are initialized automatically when the engine is stationary and the ignition is ON.

Throttle valve actuator motor

One actuator motor (EDR) moves five mechanically coupled throttle valves on each cylinder bank.

Each EDR consists of an actuator motor with gear mechanism and electronic control module. The communication with the DME via CAN, the control and activation of the actuator motor and the internal diagnosis functions are controlled by the electronic control module.



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9 - Electric throttle valve actuator (EDR)

Throttle valve sensor (DKG)

Two potentiometers are activated per cylinder bank:

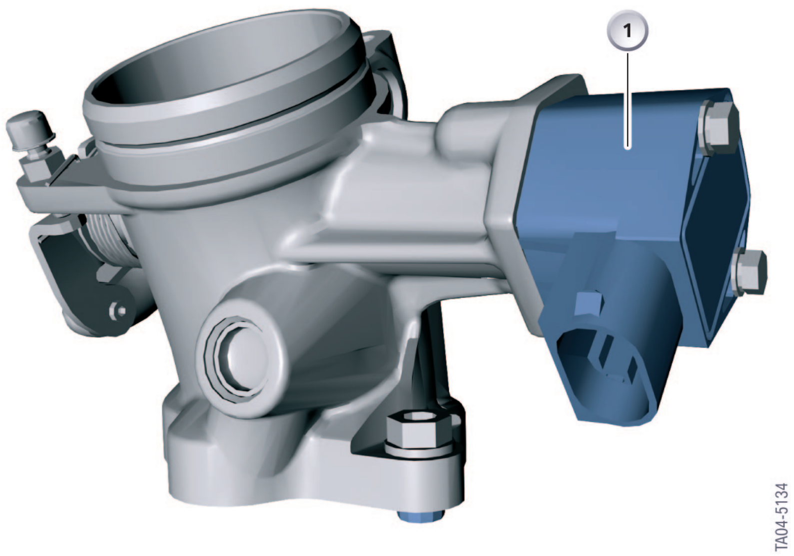
- One potentiometer for the position control. It is powered and read by the EDR satellite. The read value is transferred via the CAN to the DME. In the event of failure, the affected unit is switched off.
- A further potentiometer is responsible for monitoring. It is powered and read by the DME.

Both throttle valve sensors 1 and 2 are designed as double Hall sensors. These four sensors detect the position (angle) of the throttle valves of cylinder bank 1 and 2.

The two Hall sensors integrated in one housing feature an inverted characteristic curve (one raising, one falling).

The EDR uses the sensor with the raising characteristic for position control purposes.

The DME uses the redundant sensor with falling characteristic to monitor the throttle valve control.



10 - Throttle valve sensor (1)

Secondary air pump

The electric secondary air pump is maintenance-free. The integrated filter does not need to be changed.

The pump is activated by the DME. The delivery capacity is always at 100 % and is not controlled.

Mini HFM for secondary air system

11 - Mini HFM

A mini HFM measures the secondary air mass in the intake pipe of the secondary air pump.

This monitoring facility has proven necessary in view of the ever lower exhaust emission values.

Primary oxygen sensor (control sensor)

The familiar oxygen sensors LSU 4.9 with continuous characteristic are used as the primary oxygen sensors (control sensors).

They are installed in the intake funnel of the near-engine catalytic converters.

Secondary oxygen sensor (monitor sensor)

The secondary oxygen sensors (monitor sensors) are the already familiar discontinuous characteristic sensors LSH 25.

Exhaust gas temperature sensor

The exhaust temperature sensors are designed as NTC measuring elements.

The sensor can detect temperatures of up to approx. 1,200 °C.

This sensor is mainly used to protect the catalytic converters.

Pressure accumulator shut-off valve (VANOS)

The shut-off valve ensures that the high pressure engine oil remains in the pressure accumulator after turning off the engine.

The valve is therefore closed when no power is applied and is opened on request by the DME (no proportional opening).

Electric throttle valve actuators (EDR)

The two EDRs can be used individually.

Following replacement, the limit stops must be initialized by actively switching terminal 15 for at least 1 minute without starting the engine.

The DME controls the synchronization with respect to each other.

Individual throttle valve

The individual throttle valves can be adjusted individually with respect to each other

DME programming

The control unit can be reprogrammed up to 63 times.

VANOS Pressure accumulator

The repair instructions must be followed precisely when working on the VANOS system!

Ionic current technology

The information provided in the repair instructions must be followed precisely when replacing the spark plugs as the spark plugs are an integral part of the ionic current measuring circuit.

Contents
Sequential M gearbox SMG 3

Objectives
Sequential M gearbox SMG 3

Purpose of this Participant's Manual

The Participant's Manual is a document designed to accompany a seminar while at the same time serving as a source of reference.

This Participant's Manual describes the new features and further developments of the sequential M gearbox (SMG 3).

New 7-speed SMG

A new 7-speed sequential M gearbox (SMG) has been developed for the E60 M5. The SMG 3 is designated SMG Getrag 247.

In addition to the special functions such as launch control, hill ascent assistant, drive logic and tyre teach-in function, the SMG 3 is the first sequential M gearbox that has been specifically developed for automated operation. The central gearshift shaft has been replaced by individual selector rods.

The hydraulic gearshift unit is a part of the gearbox casing and is no longer designed as an add-on part. Compared to the SMG 2 the gearshift times have been shortened by 20 %.

Essentially, these shorter gearshift times have been achieved by individual selector rod operation and the use of carbon fibre friction cones in the synchronizer rings that facilitate shorter synchronization times through their higher load bearing capacity.

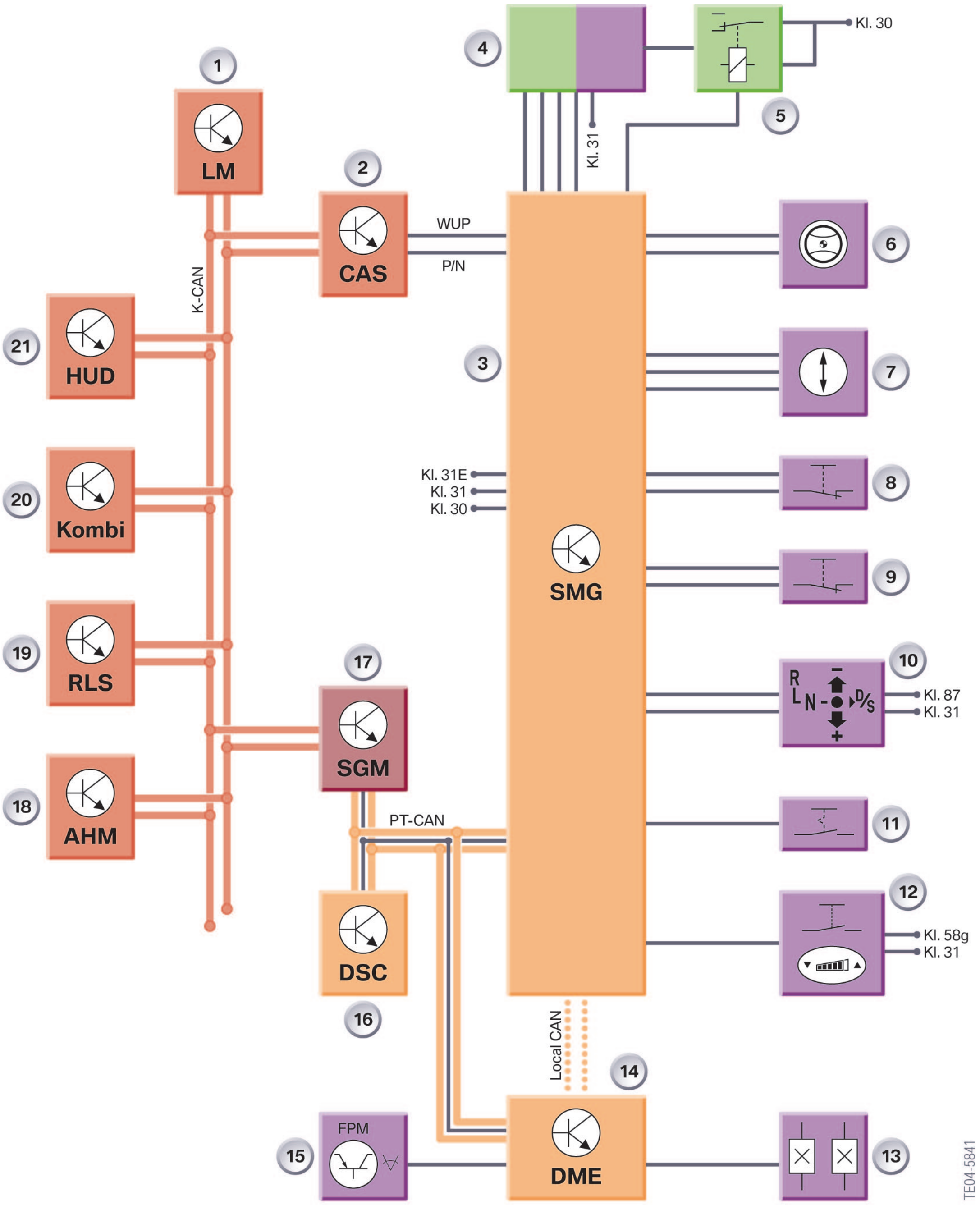
Initialization procedures designed to ensure the system functions precisely may also be necessary after performing work on the vehicle that is not directly related to the gearbox.

⚠ It is essential that the information provided in the repair instructions is complied with for this purpose. ◄

The power is transmitted from the engine to the gearbox by a dual-mass flywheel supplied by LUK and a two-disc dry clutch supplied by Fichtel und Sachs.

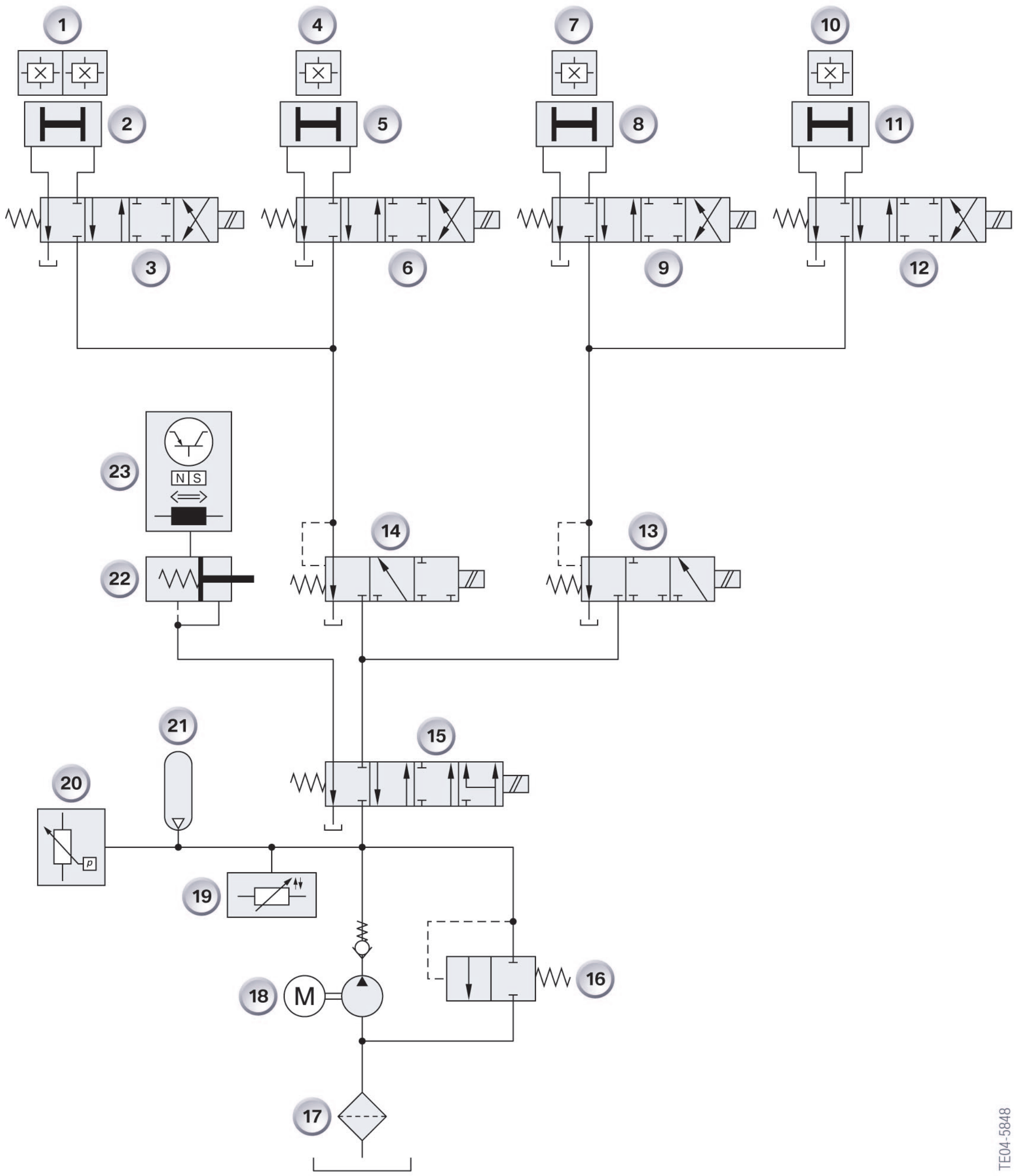
The new SMG 3

1 - Selector lever and head-up display in the E60 M5



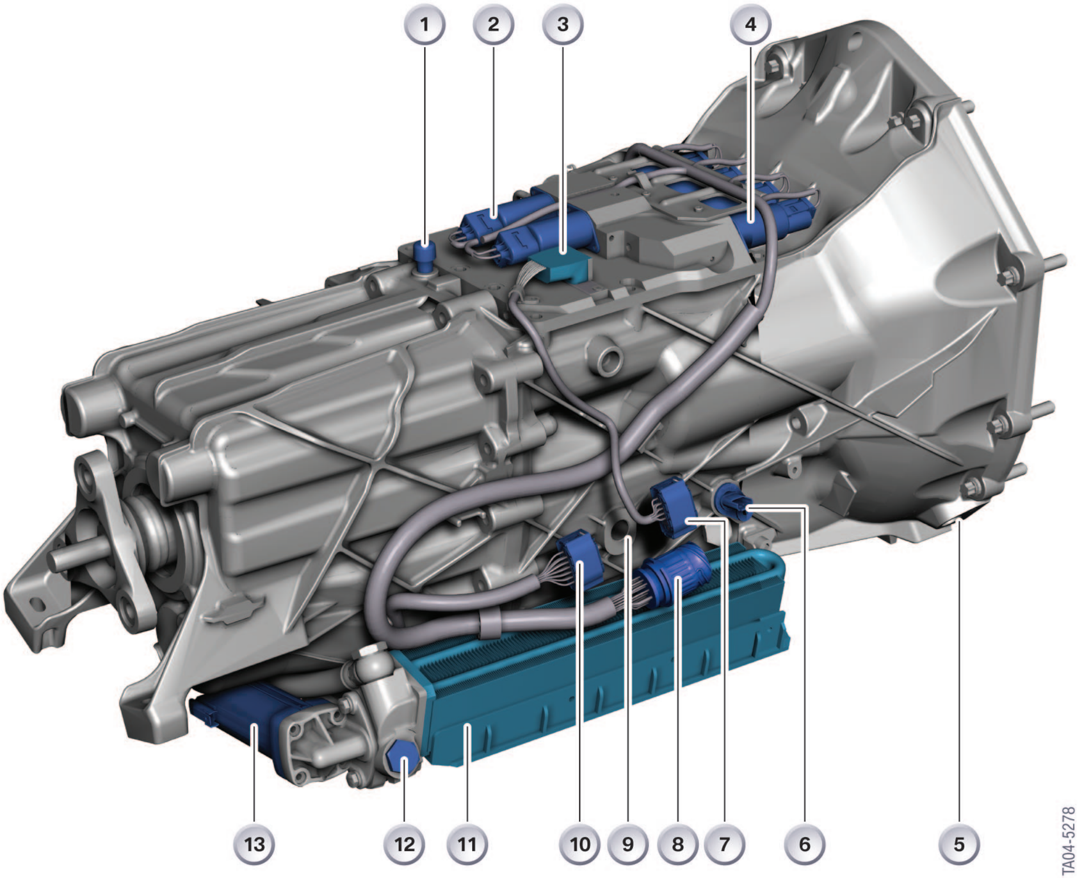
2 - Schematic circuit diagram SMG

Index	Explanation
1	Light module
2	Car access system (CAS)
3	SMG control unit
4	Sequential M transmission
5	Pump relay
6	Multifunction steering wheel (MFL)
7	Longitudinal acceleration sensor
8	Bonnet contact switch
9	Bonnet contact switch
10	Selector lever indicator
11	Door contact switch
12	Drivelogic switch
13	Brake-light switch
14	DME control unit
15	Accelerator pedal module
16	DSC control unit
17	Safety and gateway module (SGM)
18	Trailer module
19	Rain/driving light sensor (RLS)
20	Instrument cluster
21	Head-up display



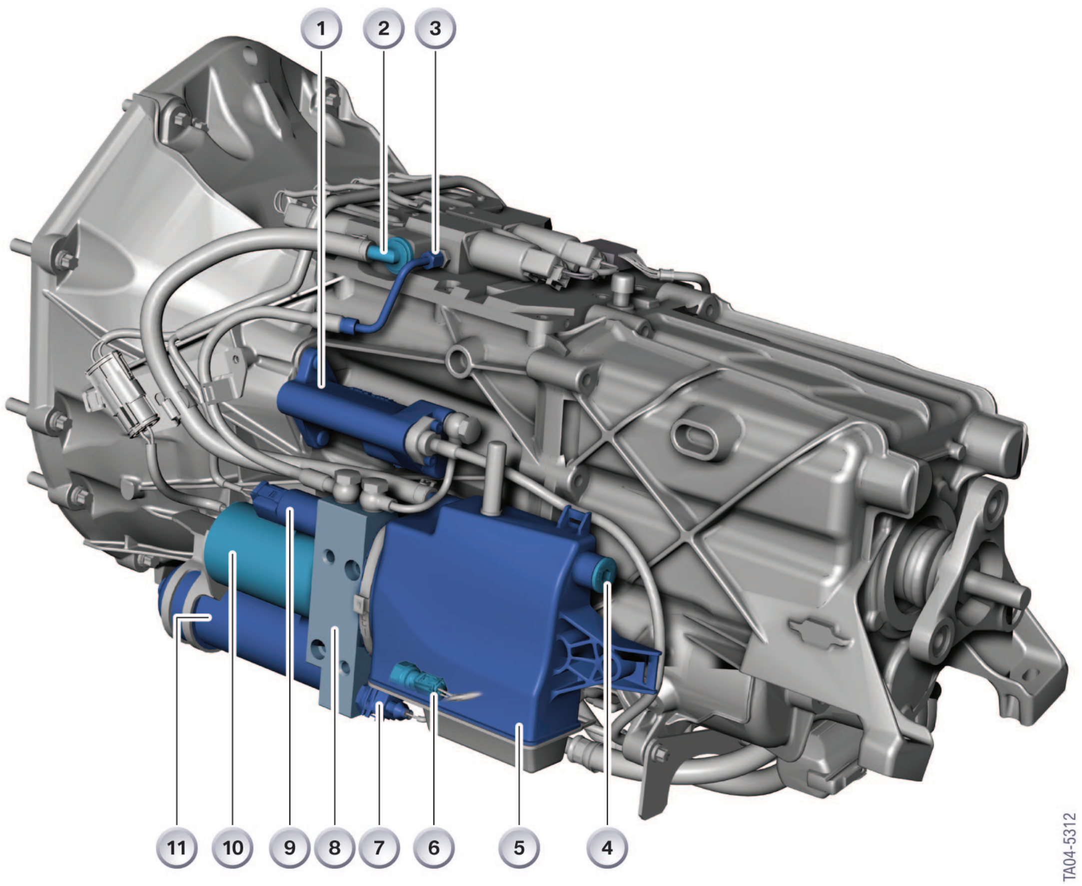
3 - Hydraulic circuit diagram SMG 3

Index	Explanation
1	Hall sensors, selector rod R/1 (redundant)
2	Working piston
3	Shift range valve
4	Hall sensors, selector rod 5/3
5	Working piston
6	Shift range valve
7	Hall sensors, selector rod 2/4
8	Working piston
9	Shift range valve
10	Hall sensors, selector rod 6/7
11	Working piston
12	Shift range valve
13	Proportional valve
14	Proportional valve
15	Proportional valve
16	Shift range valve
17	Edge-type filter
18	Electric motor with hydraulic pump
19	Temperature sensor
20	Pressure sensor
21	Pressure accumulator
22	Clutch slave cylinder
23	PLCD sensor



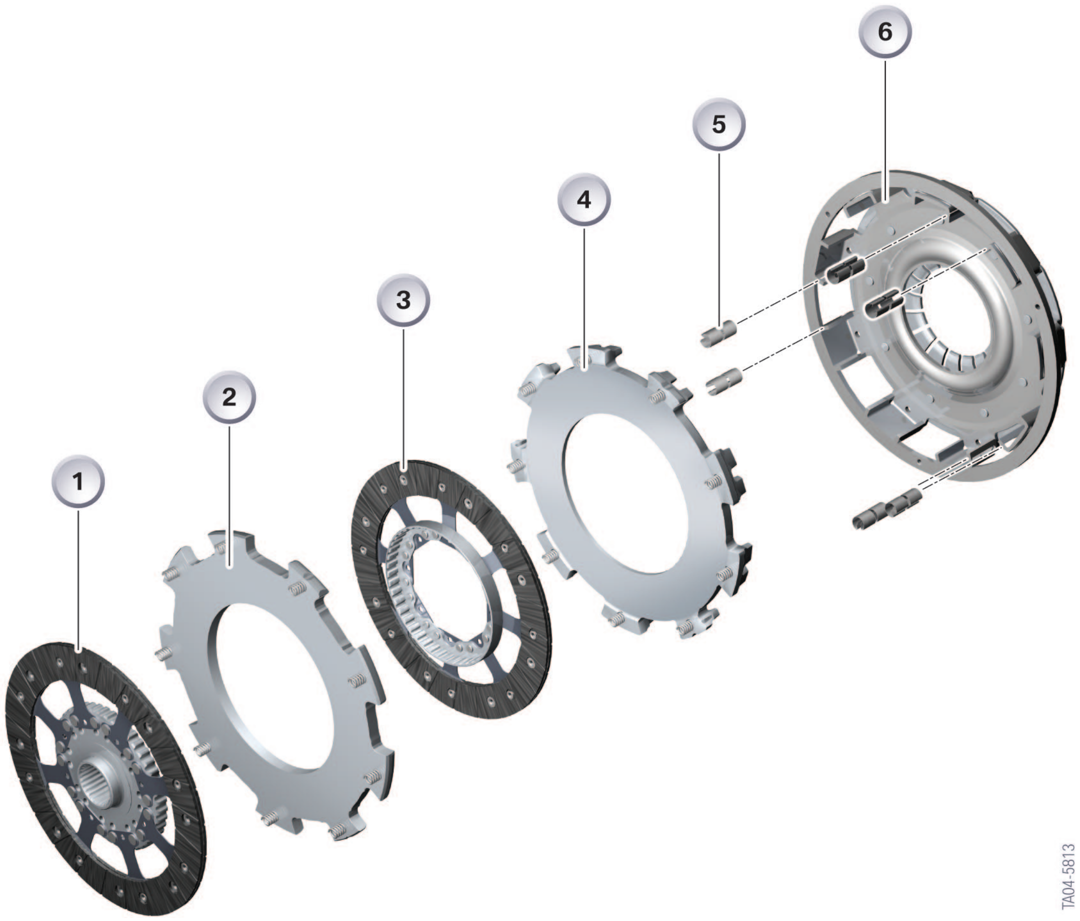
4 - SMG 3

Index	Explanation
1	Gearbox breather
2	Proportional valves
3	Sensor strip
4	Shift range valves
5	Crankshaft sensor
6	Speed sensor, countershaft
7	Connection to sensor strip
8	Connection for valves and electric motor
9	Oil level plug
10	Connection - clutch slave cylinder, temperature/pressure sensor
11	Gearbox oil cooler
12	Oil filter
13	Oil pump



5 - SMG 3

Index	Explanation
1	Clutch slave cylinder
2	Return line
3	High-pressure line
4	Oil level/filler plug
5	Reservoir
6	Pressure sensor
7	Temperature sensor
8	Hydraulic block with oil pump
9	Proportional valve
10	Electric motor
11	Pressure accumulator



6 - Two-disc clutch

Index	Explanation
1	Drive plate
2	Intermediate plate
3	Drive plate
4	Contact plate
5	Formed spring
6	Pressure plate

Special functions

Tow-start

The following procedure must be implemented to activate this function:

- With the brake pedal depressed, turn the ignition key to terminal 15
- Select position "N"
- Tow-start/pus-start the vehicle
- Shift selector lever to "S+" and hold in this position.

The transmission control engages the gear corresponding to the speed and activates the clutch.

Hill ascent assistant

Compared to the SMG 2, the hill ascent assistant function has now been automated. This means the hill ascent assistant no longer needs to be selected manually with the minus shift paddle on the steering wheel and the brake depressed as was the case with the SMG 2 but it is now activated automatically when the transmission system recognizes any other position than "N".

The hill ascent assistant in the SMG 3 is now an active system that makes use of the DSC to control the vehicle via the wheel brakes on uphill/downhill gradients (clutch load reduction).

⚠ Further information on the hill ascent assistant can be found in the Participant's Manual "DSC MK60E5". ◄

Launch control

The following procedure must be implemented to activate the launch control function:

- Vehicle stationary/engine running
- DSC in "OFF" position
- SMG in "S6" position
- Hold selector lever in "Minus" position
- Fully depress accelerator pedal and hold in this position
- Release selector lever.

The engine speed is controlled at 4,000 rpm in this function. After releasing the selector lever, the clutch is applied with defined slip in order to achieve the best acceleration values.

The SMG uses the front wheel speeds to calculate and release the slip of the rear wheels.

If the clutch monitoring logic detects clutch overheating, the clutch is fully engaged (100 %) in order to protect the components.

Teaching in the axle difference

The teach-in function for the axle difference must be initiated manually after a change in the dynamic rolling circumference (tyre change, snow chains, etc.) of one or several wheels on the vehicle to ensure correct operation of the transmission control system.

These differences are also adapted automatically but with a considerable time delay.

This function is initiated manually as follows:

- Vehicle speed between 30 and 150 km/h
- Transmission in position "N"
- Brakes not applied
- Pull both shift paddles on steering wheel for 2 seconds.

Clutch overload protection (KÜS)

The clutch overload protection function (KÜS) protects the clutch from thermal overload.

The clutch overload protection function makes use of an arithmetic logic in the SMG control unit that can calculate the thermal load of the clutch based on the slip and contact force.

In the first stage, the clutch overload protection function reduces the slip at the clutch. The customer would refer to this as a "harsh gearshift".

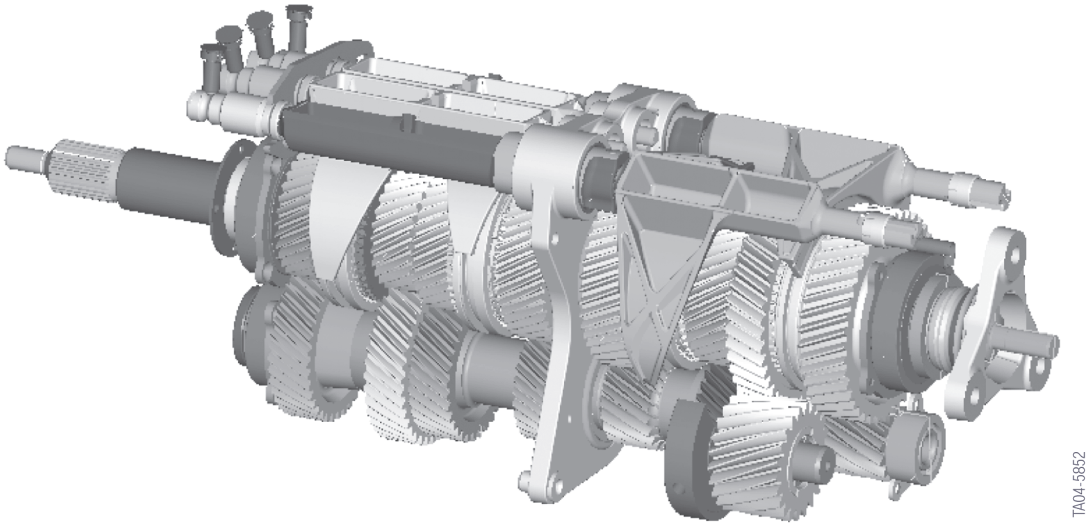
The anti-jolt function is activated as a further protection measure. As a result, the thermal input at the clutch discs is reduced and the driver's attention is drawn to the overload situation.

If the temperature continues to increase, a warning is triggered in order to repeatedly draw the driver's attention to the overload situation. Start-off in 2nd gear is automatically inhibited when the gearbox warning is triggered in order to minimise the clutch slip.

Transmission ratio of the SMG 3

The SMG 3 is designed as an overdrive gearbox as can be clearly seen in the overview of gear ratios.

A special feature of this gearbox is that the main shaft is mounted in three bearing assemblies. The third bearing assembly has been realized by an end shield bolted in the gearbox casing.

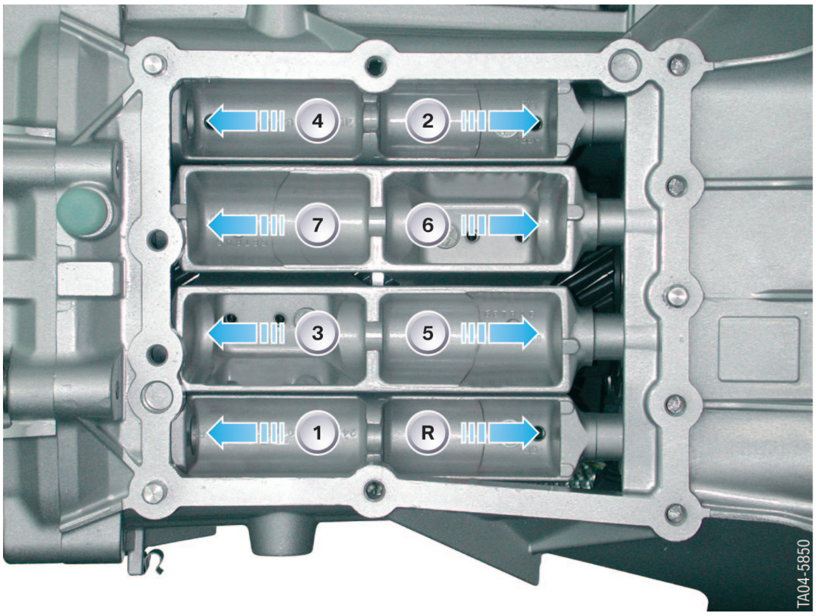


1 - Gear wheel arrangement of the SMG 3

Transmission ratio

Explanation	Transmission ratio	Explanation	Transmission ratio
1st gear	3.985	5th gear	1.159
2nd gear	2.652	6th gear	1.00
3rd gear	1.806	7th gear	0.833
4th gear	1.392	Reverse	3.985

Gearshift pattern



2 - Selector rods (top view)

Index	Explanation	Index	Explanation
R	Reverse	4	4th gear
1	1st gear	5	5th gear
2	2nd gear	6	6th gear
3	3rd gear	7	7th gear

Signals and parameters

Gear recognition

The engaged gear is determined in a contactless arrangement by means of the Hall sensors on the actuators of the individual selector rods. The position of the working pistons is detected.

Reversing light

The redundant sensor system of the 1/R selector rod detects reverse gear when engaged and correspondingly informs the transmission control.

The transmission control informs the lights switching centre that reverse gear is engaged.

Gearbox oil temperature

The gearbox oil temperature is determined indirectly via the hydraulic oil temperature sensor as both temperatures have a linear deviation with respect to each other.

The SMG control unit uses this temperature value to operate the electric gear oil pump.

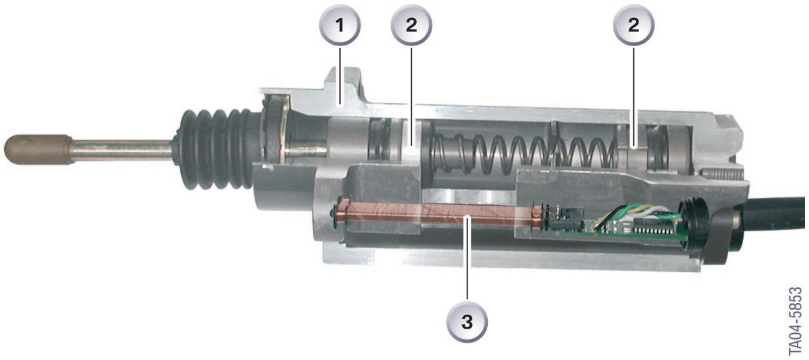
Input speed

The gearbox input speed is determined by a sensor. This sensor acquires the speed at the tooth flanks of the gear wheel on the countershaft.

Clutch slave cylinder

The clutch slave cylinder consists of two pistons and a spring between the two piston elements. The second piston is moved hydraulically. The second piston makes it possible to bleed the clutch slave cylinder in installed position without having to open any screws.

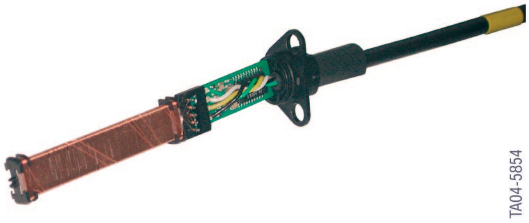
A PLCD sensor (Permanentmagnetic Linear Contactless Displacement) is arranged separately in the housing of the clutch slave cylinder. This sensor determines the exact position of the release piston.



3 - Clutch slave cylinder

Index	Explanation	Index	Explanation
1	Housing of clutch slave cylinder	3	PLCD sensor
2	Pistons		

The PLCD sensor essentially consists of a special core made of soft magnetic material. The entire length of the core is enclosed by a coil (primary coil) with a further, short evaluator coil at each end.



4 - PLCD sensor

A permanent magnet approaching the sensor causes local magnetic saturation and therefore virtual division of the core.

A voltage, depending on the position of the saturated area, is induced in the evaluator coils when an appropriate alternating current is applied to the primary coil. Consequently, the length of the virtual parts of the core and therefore the position of the saturated area can be determined in this way.

The SMG control unit powers the sensor and correspondingly processes, evaluates and converts the signals.

The alternating voltage necessary for this purpose is supplied by the ASIC (Application-Specific Integrated Circuit) integrated in the PLCD sensors.

Selector lever

The tasks of the selector lever are:

- To select the ranges D-N-R
- To change the operating modes D <-> S
- To activate launch control
- To activate the tow start function.

Eight Hall sensors determine the selector lever positions which are sent individually to the transmission control.

All selector lever positions are based on a redundant design where a sensor switches to ground and the corresponding redundant sensor switches in positive direction to ensure reliable detection even in the case of failure.

Gearshift paddles

The gearshift paddles can be used to perform the following functions:

- Upshift and downshift (+/-)
- Change of operating mode from "D" to "S"
- Manual initiation of wheel circumference teach-in function (the hill ascent assistant no longer needs to be activated manually).

Drivelogic

The Drivelogic selector switch can be used to choose between six gearshift programs in sequential mode and five shift programs in Drive mode.

The shift speed and therefore the shift hardness are preselected in sequential mode.

The shift points can be influenced by the setting in Drive mode.

Brake light switch

For redundancy reasons, the SMG control unit receives the signal from the brake light switch and the brake light test switch.

The signal from the brake light switch is used for:

- Shiftlock function
- Brake detection
- Engine start
- Disengaging gear
- DSC activation.

The signal is made available via the CAN.

Steering angle

The signal is tapped off from the CAN. This value influences the automatic function of the gearbox (gearshift suppression).

Longitudinal acceleration/gradient

This value is determined by the longitudinal acceleration sensor in the right footwell. It is used for the purpose of calculating the gradient.

Wake-up

The SGM control unit assumes standby mode as soon as the vehicle is unlocked. As a result, the hydraulic unit generates sufficient pressure to disengage the clutch if necessary.

Bonnet contact switch

Two switches determine the bonnet status. The driver is warned if the bonnet is open. The vehicle can only start off immediately after engaging the drive stage as the status is unclear for the SMG.

Door contact

This signal should not be confused with the wake-up signal.

Information on the door status is sent via the CAN to the SMG control unit. The gear is automatically disengaged when the door is opened.

Trailer operation

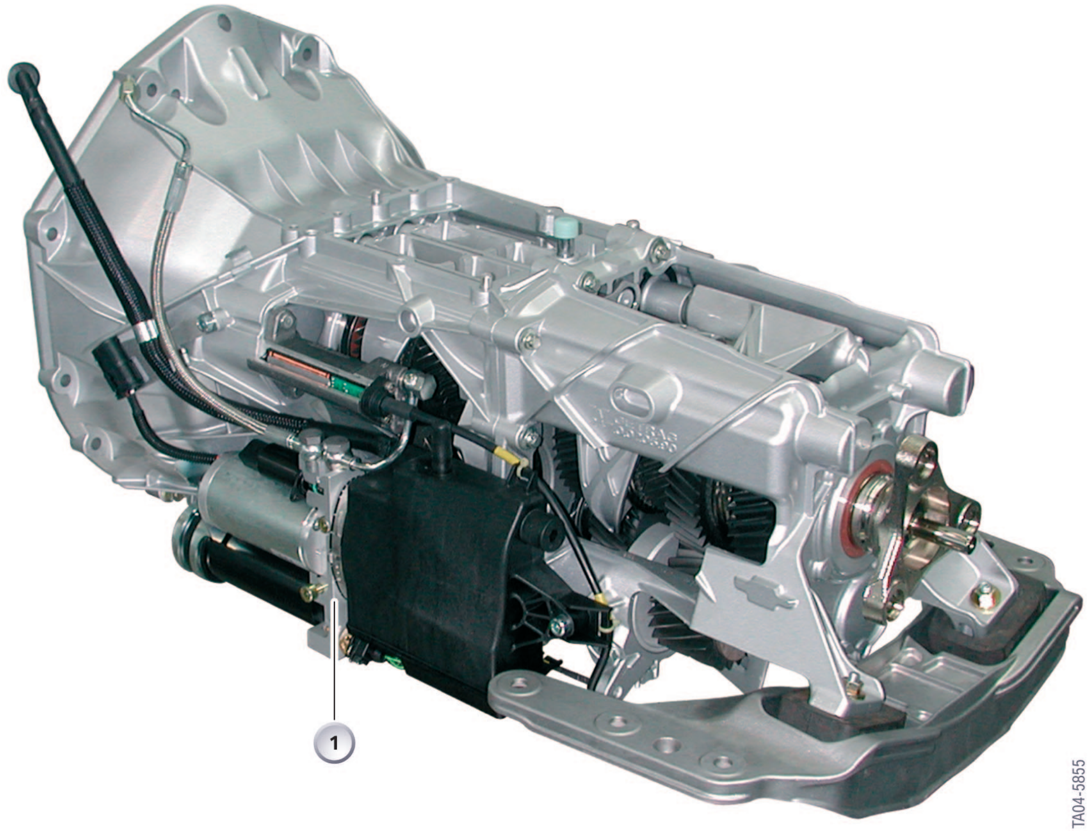
The SMG control unit is informed via the CAN-bus when the vehicle is used to tow a trailer, consequently activating the shift characteristic maps for trailer operation.

Engine speed

For redundancy reasons, this signal is made available via the CAN-bus as well as a hardware signal. It is used to control the clutch and to establish whether the engine is running.

Within the safety concept, the engine speed signal is used to monitor the current status.

Hydraulic system



5 - SMG with hydraulic unit

Index	Explanation
1	Hydraulic unit

A DC motor drives the hydrostatic pump. The pump conveys the hydraulic oil via a non-return valve into a pressure system while energy is stored in a hydraulic accumulator.

The operating pressure is 75 bar. The maximum pressure is 90 bar which is applied only during initialization procedures.

The maximum shift force is approx. 2,500 N.

Initialization

As on the SMG 2, the SMG control unit must newly adapt and store various parameters after a component has been replaced in the area of the clutch or gearbox as well as after programming.

Clutch teach-in function

This function is used to adapt the clutch to the characteristics stored in the control unit. The clutch grab point is taught-in with the engine running.

The clutch is released and, after the input shaft has stopped, initially, the clutch moves quickly close to the grab point and then slowly approaches the grab point.

This procedure is terminated if a transmission input speed is already measured during the fast approach phase as there is obviously a fault in the system (e.g. bleeding).

If a valid value is measured during the slow approach of the clutch towards the grab point this value is stored in the SMG control unit.

Adaptations

It is necessary to check the gearbox mechanism after replacing a gearbox, components of a gearbox or the SMG control unit. The following adaptations are provided in the GT1/DISplus.

The most important adaptations in the gearbox are:

- Shift range mid-points
- Valve characteristics
- Transmission characteristics
- Longitudinal acceleration sensor offset.

Shift range mid-points

This function ensures a gear can be **disengaged** without previous adaptation of the transmission characteristics.

Valve characteristics

The shift range valves in the hydraulic system are designed as proportional valves. Due to the tolerance scatter in series production, it is necessary to teach in the offset current of these valves.

The current at which the corresponding selector rod begins to move is determined. This value is stored as the offset current in the SMG control unit.

The current consumption of the proportional valves is determined in both switching directions.

Transmission characteristics

In this adaptation phase, the selector rods are moved to the end positions and the actual values determined.

The measured values indicate whether a gear is engaged.

The selector rod for reverse gear is additionally monitored by a redundant sensor whose values are also stored.

In addition, the hydraulic pressure is read off at this selector rod and the selector rod is monitored to ensure it remains in the end position.

Longitudinal acceleration sensor

The measured value of the longitudinal acceleration sensor has a constant offset. This value is determined when the vehicle is at rest in horizontal position and therefore the longitudinal acceleration is zero.

The actual values are permanently sampled. As soon as a sample value deviates by more than a reference value, external influences are assumed and the adaptation procedure is terminated to ensure no falsified acceleration values are measured during vehicle operation.

Pressure accumulator preload

A function for checking the accumulator prepressure has been implemented to facilitate diagnosis for service applications.

The diagnostic procedure evaluates the time required to discharge the accumulator. The pressure sensor of the hydraulic unit is used to measure the pressure.

The SMG control unit still measures the time required for filling. If a shorter period of time is required to reach the cutoff pressure this indicates that the nitrogen, which the accumulator must contain as the preload medium, has leaked out of the accumulator.

The shut-off valve on the pressure accumulator is monitored separately.

Contents
Dynamic Stability Control MK60E5

Objectives
Dynamic Stability Control MK60E5

Purpose of this Participant's Manual

The Participant's Manual is a document designed to accompany a seminar while at the same time serving as a source of reference.

This Participant's Manual describes the new features and further developments of the dynamic stability control (DSC) MK60E5.

MK60E5 from Continental Teves

The E60 M5 is equipped with the Continental Teves Dynamic Stability Control System (DSC+) MK60E5.

This system offers the customer further functions that were not yet realized with the previous systems.

New functions

- Brake readiness
- Dry braking
- Hill ascent assistant.

Features of the MK60E5

The features of this system distinctly enhance comfort during control intervention while facilitating even more precise individual wheel braking in connection with the analogue control valves.

With this system it has been possible to reduce the required braking distance to a minimum.

The E60 M5 can realize a braking distance of < 36 m from a speed of 100 km/h.

System overview
Dynamic Stability Control MK60E5

Further development of the MK60psi

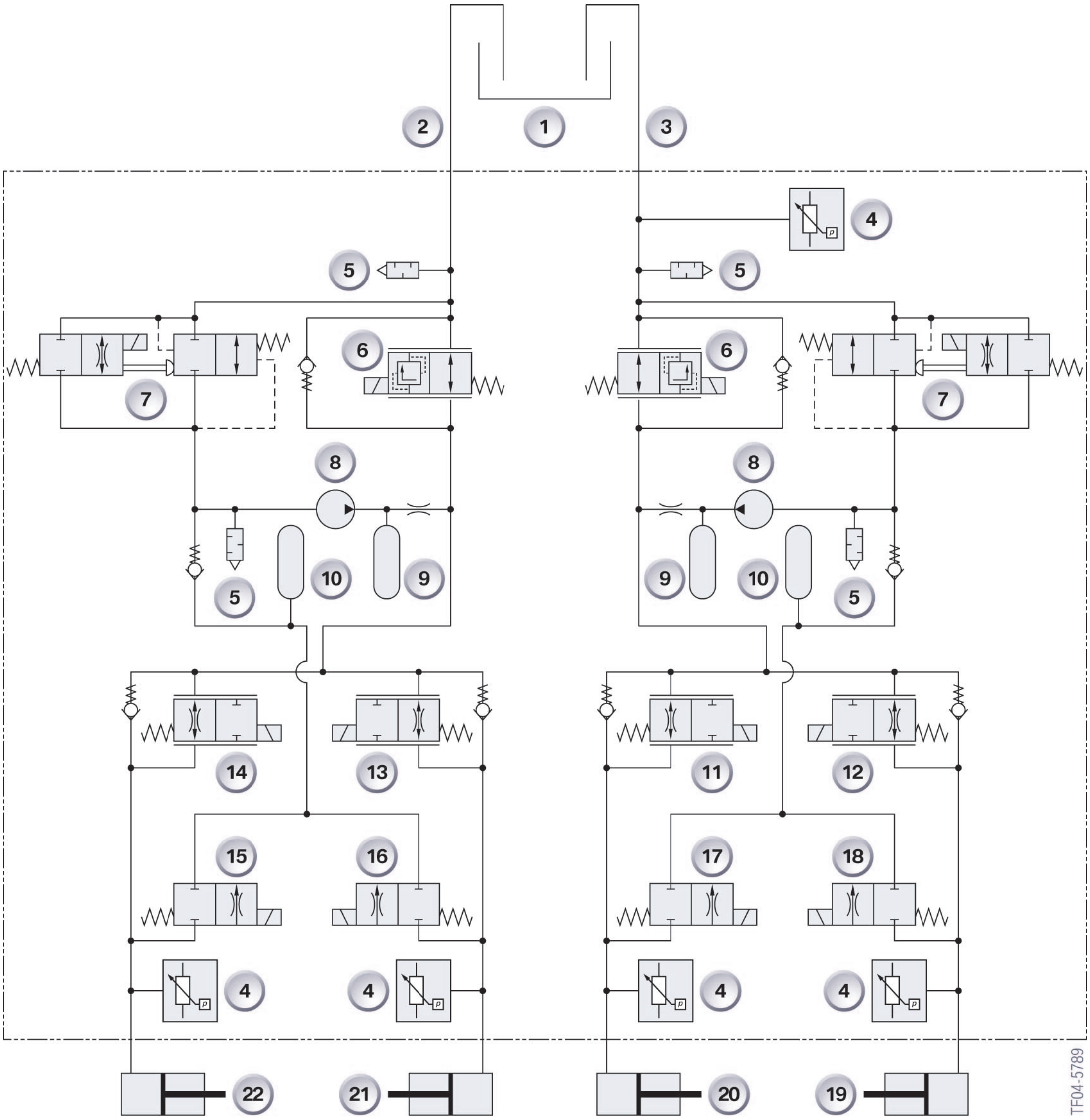
The MK60E5 is a further development of the MK60psi, which is currently used in the E87.

The abbreviation "psi" stands for "pressure sensor integrated" i.e. the two pressure sensors of the tandem master brake cylinder (THZ) have been combined to form one plausibility sensor and integrated in the hydraulic unit.

The designation "E5" in MK60E5 signifies the 5 pressure sensors that are integrated in the hydraulic unit: One pressure sensor that measures the pressure from the tandem master brake cylinder THZ and four further sensors that measure the braking pressure of the respective wheel brake.

As in the DSC 8.0, the tyre failure indicator (RPA) is integrated in the DSC functions.

Hydraulics diagram DSC MK60E5



1 - Hydraulics diagram DSC MK60E5

Index	Explanation
1	Brake fluid reservoir
2	Rear axle
3	Front axle (hydraulic connection)
4	Pressure sensor, push rod circuit
5	Pulsation damper
6	Isolating valve
7	Electric changeover valve
8	Self-priming return pump
9	Damper chamber
10	Accumulator chamber
11	Front left inlet valve with orifice plate, analogue
12	Front right inlet valve with orifice plate, analogue
13	Rear right inlet valve, analogue
14	Rear left inlet valve, analogue
15	Rear left outlet valve
16	Rear right outlet valve
17	Front left outlet valve
18	Front right outlet valve
19	Front right wheel brake
20	Front left wheel brake
21	Rear right wheel brake
22	Rear left wheel brake

DSC Additional Functions

Compared to the standard DSC features, the MK60E5 in the E60 M5 has been upgraded by the following additional functions:

- M Dynamic Mode (MDM)
- Brake readiness
- Dry braking
- Hill ascent assistant.

The following functions are not required on the M5:

- Performance control (FLR)
- Soft stop
- Fading brake support (FBS)
- Dynamic traction control (DTC).

Operating modes of the MK60E5

In principle, the MK60E5 has 3 different operating modes:

- DSC ON
- DSC OFF
- M Dynamic mode.

There is no DTC function in connection with the M5. However, similar to DTC mode, corresponding control thresholds are raised by activating the MDM.

M Dynamic Mode can be activated only via the M-Drive.

M Dynamic Mode (MDM)

MDM gives the performance-oriented driver the option of driving the car with controlled float angle and longitudinal slip without DSC intervening. The control system intervenes only when the physical limits are exceeded.

The control thresholds are not static but rather, as the speed increases, they approach the thresholds of DSC ON mode.

The stability control thresholds are identical as from a speed of approx. 200 km/h in order not to overtax the driver in the high speed range.

Brake readiness

The brake response time is shortened during full brake application by applying the brake pads to the discs while rapidly restricting the throttle.

This function ensures that a pressure of approx. 3 bar is applied for a period of up to 300 ms to the wheel brakes in order to apply the brake pads already before the expected application of the brakes. This function facilitates even more rapid response of the brakes. The function is active as from a speed of 30 km/h.

Dry braking

The brake response characteristics are improved in wet conditions by removing the water film on the brake discs.

The DSC detects rain and therefore wet brake discs through the permanent operation of the windscreen wiper motor.

The dry braking function applies approx. 3 bar hydraulic pressure to the wheel brakes under these conditions. This procedure is repeated every 2-3 km for a period of approx. 3 s when the accelerator pedal is sufficiently depressed (> 10 %), the vehicle speed is ≥ 90 km/h and the brakes were not applied over the last 2-3 km.

Hill ascent assistant

Assistance is provided when driving off on uphill gradients by briefly maintaining a specific brake pressure in the wheel brakes.

This function is active only when the transmission is not in "N" position and the handbrake is released.

DSC ON/OFF has no influence in this case.

The tilt angle (uphill and downhill gradient) is calculated from the measured value of the longitudinal acceleration sensor.

The DSC calculates the necessary holding pressure based on the uphill or downhill gradient.

After releasing the brake paddle, the braking pressure is immediately decreased to the calculated holding pressure which is then reduced in stages after a maximum time delay of 0.7 s. The vehicle will start off after approx. 1 s if the driver does not press the accelerator pedal.

The longitudinal acceleration sensor is assigned to the SMG system.

This function is also active on an incline with reverse gear engaged.

Condition Based Service (CBS)

As in the E60 Series, the MK60E5 calculates and evaluates the condition of the brake pads.

In contrast to the E60 Series, the M5 is equipped with two brake pad sensors on the front axle.

Differences compared to the MK60psi

The main differences in the design of the MK60E5 compared to the MK60psi are:

- Analogue valves
- 4 pressure sensors for individual braking pressure acquisition at each wheel.

Sensors

Sensor system	Principle	Manufacturer
Active wheel speed sensors	Magnetoresistive principle	Teves
Steering angle sensor (LWS) in steering column switch cluster (SZL)	Basic sensor, potentiometer technology	
Yaw rate sensor	Double tuning fork principle	
Lateral acceleration sensor	Capacitive principle	VTI
5 pressure sensors	Piezoresistive (change in resistance in piezo)	
Brake light switch	Hall principle	
Brake fluid level switch	Reed contact switch	

Control unit

- Add-on control unit
- Integrated semiconductor relay (motor and valve relay).

Hydraulic unit

- Teves MK60E5
- Front axle
  - 2 analogue inlet valves
  - 2 high-speed outlet valves
    - 1 isolating valve
    - 1 changeover valve
- Rear axle
  - 2 analogue inlet valves
  - 2 high-speed outlet valves
    - 1 isolating valve
    - 1 changeover valve.

Pressure generation

- Pump with two differential piston pump elements
- Operated by means of common eccentric shaft
- 250 W pump motor
- ASC and DSC mode: Self-priming return pump.

Engine intervention

- Ignition timing adjustment
- Charge control.

Interfaces

- CAN-bus interface (F-CAN, PT-CAN).

Contents
Displays, Indicators and Controls

Objectives
Displays, Indicators and Controls

Purpose of this Participant's Manual

The Participant's Manual is a document designed to accompany a seminar while at the same time serving as a source of reference.

This Participant's Manual describes the new features and further developments of the displays, indicators and controls in the E60 M5.

Additional Functions

Compared to the 545i, the E60 M5 provides the driver with additional functions relating to the displays, indicators and controls as well as for setting the individual systems.

In the following, the individual elements are presented as they will be realized at series launch.

The Owner's Handbook provides general information on how to use the controls.

Differences compared to the E60

The M5 instrument cluster is based on the instrument cluster of the E60 545i. The changes to the visual appearance and the additional functions are described in detail in the chapter System Components.

The head-up display (HUD) has been adopted from the E60 as the additional functions relate to the HUD software.

The "M-Drive" menu item in the central information display (CID) has been created simply by corresponding software adaptations.

The M-Drive settings are stored key-specific in the engine management and are called up accordingly. The engine management can store up to 10 different settings in the memory.

Displays and indicators in the E60 M5

Instrument cluster

The instrument cluster in the M5 is based on that of the E60 Series. Corresponding adaptations have been implemented in the visual appearance and scope of functions for use in the M5.

The additional functions are:

- Oil level indication in the on-board computer
- Lighting at terminal 15 ON
- Oil temperature gauge in rev counter
- SMG display with Drivelogic display.

The M5 instrument cluster additionally features the following indicator lamps:

- MDM for DSC dynamic mode
- M-Drive configuration is activated
- Light ON.

1 - Instrument cluster

Head-up display (HUD)

The "M-view" has been added to the head-up display. This expansion feature, however, is implemented only in the software of the HUD control unit.

The M-view can be configured in the "Display Settings" menu in the i-Drive or with the M-Drive and activated via the M-Drive Manager.

The head-up display in the M-view can show the following information:

- All warnings
- Engine speed with shift lights in the speed indicator (not the absolute value)
- Road speed
- Engaged gear.

2 - Head-up display in M-design

Oil level indicator

The M5 is equipped with an electronic oil level indicator. The oil level is indicated in the information field of the on-board computer (BC) in the instrument cluster.

The average speed information was removed from the BC menu to accommodate the oil level indication in the on-board computer.

The display is selected with the BC control. The sensor is the quality and condition sensor (QLT) from the E65. The entire measurement logic is resident in the engine management MS_S65.

3 - Oil level indicator

Index	Explanation
1	Oil level
2	Maximum mark
3	Minimum mark

The long-term value last stored is shown after starting the engine.

Basically there are two different measuring methods: Long-term measurement and quick measurement

Long-term measurement

The engine management permanently measures the oil level and derives the mean value from the measurement results which is then shown in the on-board computer.

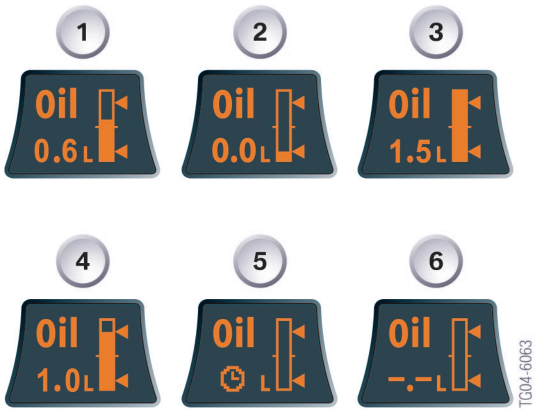
The DME requires an engine operating time of approx. 10 minutes to establish a long-term value.

Quick measurement

The quick measurement method provides the option of measuring the oil level with only a short time delay (e.g. topping up oil, oil service).

The quick measurement must be initiated manually by pressing and holding the BC button (approx. 2 seconds) in the oil level indication setting.

The displayed value indicates the quantity of oil above the minimum level. The value should be between MIN 0.0 l and MAX 1.0 l.



4 - Oil level indication

Index	Explanation
1	0.6 l Minimum
2	Minimum
3	Overfilled (bar full and 1.5 l displayed)
4	Maximum
5	Oil level measurement running
6	No measured value stored and measurement criteria not met

Display: 1.5 l means overfilled, the bar indicator is additionally filled above Maximum. Values from 1.0 to 1.4 are suppressed.

Perform quick measurement

- Park vehicle in horizontal position
- Engine running at idle speed
- Oil temperature above 70 °C
- Select engine oil level indicator in on-board computer
- Press and hold BC button > 2 s.

The oil level display changes and shows only two dashes (see Fig.) and a clock symbol. The clock symbol indicates that the oil level is being measured. The clock symbol would disappear if the engine speed is now increased. The measurement is continued as soon as the measurement criteria are met again.

The pure measuring time is approx. 60 s.

The long-term value last stored is deleted with initiation of the quick measurement.

Abbreviations

ACC	Active cruise control
BC	On-board computer
BSD	Bit-serial data interface
CAS	Car access system
DME	Digital motor electronics
DSC	Dynamic stability control
DTC	Dynamic traction control
EKP	Electric fuel pump
FBS	Fading brake support
FLR	Driving performance control
HDP	High pressure pump
HFM	Hot-film air mass sensor
HVA	Hydraulic valve lash adjustment
IBS	Intelligent battery sensor
KÜS	Clutch overload protection
KW	Crankshaft
	Short wave
LLS	Idle actuator
LWS	Steering angle sensor
MDM	M Dynamic mode
MFL	Multifunction steering wheel
PLCD	Permanent magnetic linear contactless displacement
PT-CAN	Power Train Controller Area Network
RLS	Rain/driving light sensor
RPA	Tyre puncture warning
SZL	Steering column switch cluster
THZ	Tandem-brake master cylinder
ZMS	Dual-mass flywheel

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