Reference Manual

E60 M5
COMPLETE VEHICLE

Technical Training

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E60 M5 Complete Vehicle

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Initial Print Date: 09/05 Revision Date:

M5 Complete Vehicle

Model: E60

Production: from 9/2005

OBJECTIVES

After completion of this module you will be able to:

- Familiarize yourself with the history behind the M5
- Note differences between the regular production 5 Series and the M5
- Understand the operation of the active backrest width adjustment system

Introduction

The new BMW M5 will be launched in October 2005 in the US market. 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 sedan 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, and the 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.

Based on the E28 5 Series, this M5 was the first car to combine the everyday usability of a sedan with the performance of a sports car. The introduction of the first M5 was not only the fastest sedan at the time but also heralded the birth of a whole new segment.

Cylinders: Six in-line

Capacity: 3453 cc

0–62: 6.5 seconds

Top speed: 152 mph

Performance: 286 bhp

Torque: 340 Nm

Quick Facts:

Hand built in Dingolfing.

US version had 30 bhp less due to the changes that allowed it to run on unleaded fuel with a catalytic converter (when compared with the European version).

M5 Heritage - E34

The successor to the E28 came with one of the most powerful straight-six engines ever built by BMW. The exterior appearance was more individual: muscular front and rear aprons, contrasting side skirts and a unique wheel design. The E34 M5 far exceeded the sales figures of its predecessor.

Cylinders: Six in-line

Capacity: 3795 cc

0–62: 5.9 seconds

Top speed: 155 mph (electronically limited)

Performance: 340 bhp

Torque: 400 Nm

M5 Heritage - E39

The E39 M5 effortlessly combined the concept of a luxury saloon with sports car technology and in so doing, attained the unanimous respect of enthusiasts and journalists. With the launch of E39, the traditionally understated appearance became more athletic and confident. The addition of muscular front and rear aprons coupled with more pronounced side skirts and 18-inch wheels served to reinforce the M5's sporty intentions. The E39 M5 was also the second M model to receive the now trade-mark M four-tailpipes (M Roadster was the first).

Cylinders: V8

Capacity: 4941 cc

0–62: 5.3 seconds

Top speed: 155 mph (electronically limited)

Performance: 396 bhp

Torque: 516 Nm

M5 Heritage - E60

The new BMW M5 will be launched in October 2005 in the US market. It will be the most powerful M5 of all time and the first to exhibit this power potential at first glance.

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.

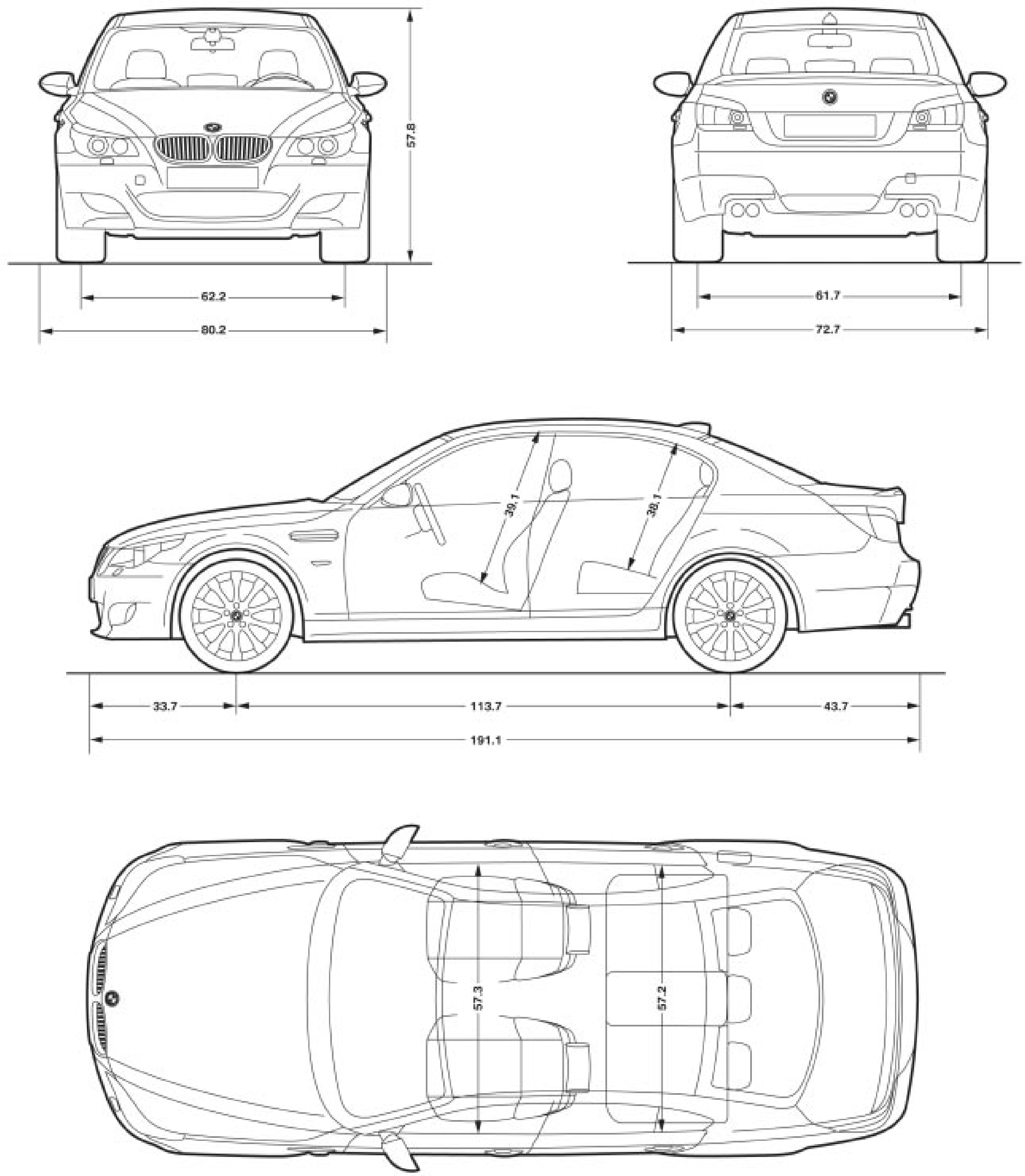
The highlight of the new M5 is, of course, the V10 engine derived from BMW-Williams Formula 1. With the governed limit at 8,250 rpm, it not only provides Formula 1 performance but also develops that typical Formula 1 sound.

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

Technical Data

	BMW M5 (E60)	BMW M5 (E39)
Length (in / mm)	191.1 / 4,854	188.3 / 4,783
Width (in / mm)	72.7 / 1,846	70.9 / 1,800
Height (in / mm)	57.8 / 1,469	56.6 / 1,437
Wheelbase (in / mm)	113.7 / 2889	111.4 / 2,830
Track, front (in / mm)	62.2 / 1,580	59.6 / 1,515
Track, rear (in / mm)	61.7 / 1,566	60.1 / 1,527
Unladen weight (lbs / kg)	4,012/ 1,820	3,946 / 1,790
Weight distribution (front / rear %)	52.2 / 47.8	52.1 / 47.9
Luggage compartment capacity (cu. ft / l)	17.7 / 500	16.2 / 460
Engine / Valves per cylinder	V10 / 4	V8 / 4
Compression ratio	12 : 1	11 : 1
Displacement (ccm)	4999	4941
Engine output (bhp)	500 @7,750 rpm	394 @6,600rpm
Maximum torque (lb-ft / Nm)	383 / 520 @6,100 rpm	368 / 500 @3,800rpm
Governed engine speed (rpm)	8,250	7,000
Max speed (mph)	155 (governed)	155 (governed)
0 - 60 mph	4.5 seconds	4.8 seconds
Fuel tank capacity (gal / l)	18.5 / 70	18.5 / 70
Transmission	7-speed SMG gearbox	6-speed Manual gearbox
Wheels and tires	Front: 255/40 Z R 19 on 8.5 J x 19 Rear: 285/35 Z R19 on 9.5 J x 19	Front: 245/40 Z R18 on 8J x 18 Rear: 275/35 R18 on 9.5 J x 18

Vehicle Data Views



Body

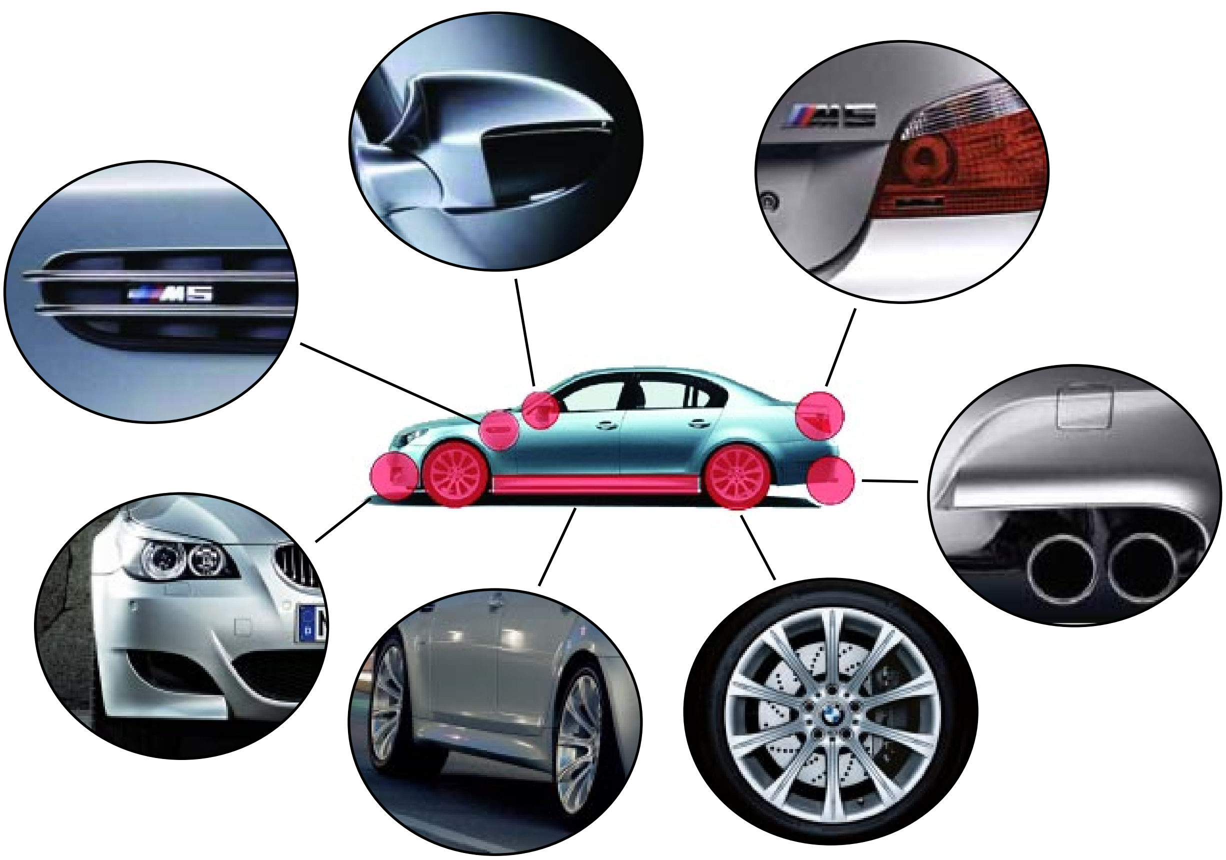
The E60 M5 combines - without compromise - the qualities of a luxury class sedan with the power potential of a sports car. Its visual appearance, however, is intentionally somewhat less discreet as its predecessor.

Features that make the E60 M5 stand out when compared to the 5 Series sedan are:

- Front and rear bumpers are now slightly more prominent
- A rear spoiler has been added
- Rear diffuser
- The signature twin dual pipe exhaust system
- 19" wheels
- M5-characteristic side gills

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 production series been lost.

The body structure of the M5 is taken from the production 5 Series vehicle. It utilizes GRAV technology (the entire front end of the vehicle is made of aluminum, not steel).



Exterior Design

The exterior design of the M5 has a number of spectacular original features in comparison to the production version.

Air inlets in the bumpers instead of fog lights

Lowered apron has an integrated front spoiler.

In conjunction with sealing the engine compartment, the front bumper reduces lift on the M5's front axle by 50% in comparison to the standard car.

The front spoiler, the diffuser, the rear spoiler lip and the special underside paneling provide the required down force in the M5.

The highly visible and stylish grills in the side panel at the front are more than mere decoration and serve to create a through-flow of air.

A special M-design door mirror.
The sill also emphasizes the sporty line.

Special, extra-wide 285/35 ZR 19 tires on specifically styled $9^1/_2$ inch rims at the rear and 255/40 ZR 19 tires on $8^1/_2$ inch rims on the front axle also adds to the sporty look.

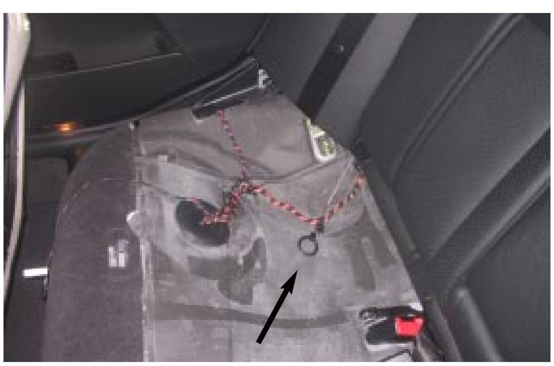
The rear bumper of the vehicle does not only make the vehicle appear more sporty but includes an air diffuser to better improve the aerodynamics of the vehicle.

The M5 also continues with the signature M dual twin exhaust pipes started with the M Roaster.

When compared with the production 5 Series, the front and rear bumper and side skirt have been changed.

The rear deck lid comes with a spoiler.

The rear deck lid no longer has a cylinder lock for trunk opening with a key. In case of an electrical failure, there is a mechanical release under the rear seat. It is an eylet/loop with a bowden cable that connects to the trunk actuator mechanism.



Mechanical Release for Trunk

Interior Design

The cockpit of the new BMW M5 is tailored to the requirements of the M driver, who looks for sports car performance and precision ergonomics. The redesigned instruments in the dashboard combined with the SMG gearshift paddles on the Multi-function steering wheel and the presence of the MDrive button serve to create the unique M ambience.

Distinctive M Instrument Cluster.
The instrument cluster has been especially designed for the BMW M5. Chrome rings surround the two circular displays for the speedometer and rev counter. The scales are white and permanently illuminated, while the indicator needles glow in traditional M red.

This conveys a unique, almost race-car like ambience. Arranged between the two circular gauges are the displays for SMG mode, current gear and engine oil level.

Center Console

Illuminated Selector Lever
The SMG selector lever is illuminated. The gearshift pattern on the selector lever handle is permanently illuminated, and the current gear is highlighted.

Next to the selector lever are the buttons for the dynamic system settings: DME, DSC, EDC, and SMG Drivelogic.

Automatic Air Conditioning
The IHKA system is installed in the M5 as standard equipment.

Same as the production based 5 Series, minor adjustments can be made utilizing the iDrive menu for climate control.

Central Information Display with Navigation
Navigation is standard equipment on the M5 which includes the Top Hi-Fi (Logic7)audio system and the acclaimed iDrive system.

Front Seats

The standard M Sports seats provide excellent levels of lateral support to the driver and front passenger. This includes individual backrest width adjustment for optimum fit, and adjustable thigh support, seat heating with three settings as well as an adjustable lumbar support. Up to three personal settings can also be stored in Memory and accessed when required.

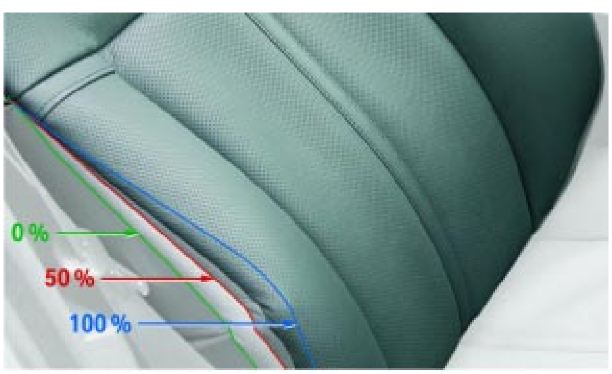
Interior View of the E60 M5

M Multi-Function Seat (Optional)

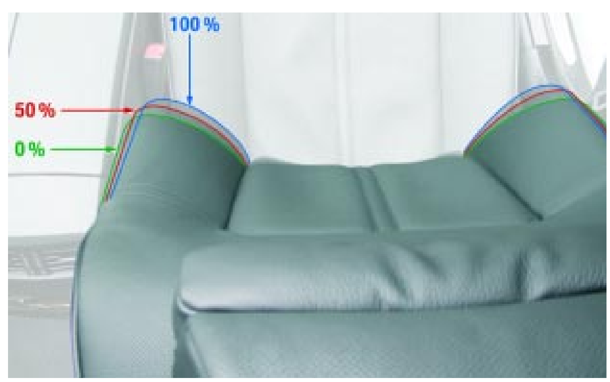
Enhanced driving enjoyment with innovative seat system

Backrest width adjustment system serves the purpose of optimally adapting the side sections of the backrest to the individual upper body of the occupants with the aim of achieving improved support of the upper body when cornering.

BMW M GmbH has developed the active backrest width adjustment in M-vehicles for performance-oriented drivers. The active backrest width adjustment (ALBV) changes the setting of the side sections of the backrest dynamically when cornering. The dynamic setting of the backrest is dependent on various parameters.



Side View of Forward Adjustment Ranges



View of Backrest Adjustment Ranges

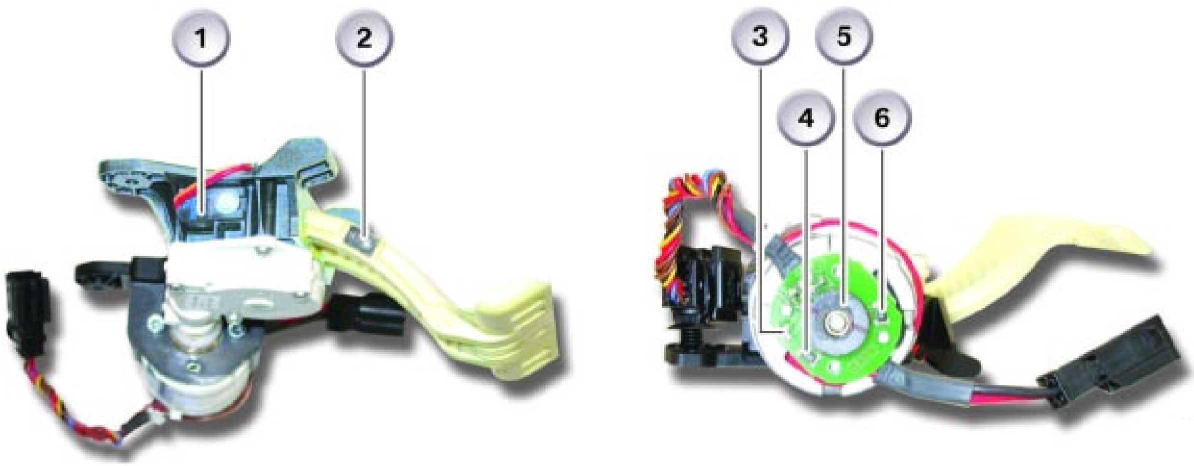
Due to the centrifugal forces exerted on the upper body, forces acting towards the outer edge of a bend occur when driving through corners dynamically. The upper body is displaced towards the outer edge of the bend.

The active backrest width adjustment system activates the respective side section of the backrest to counteract the forces and to keep the upper body stable in the seat. The driver can concentrate fully on steering.

System Components

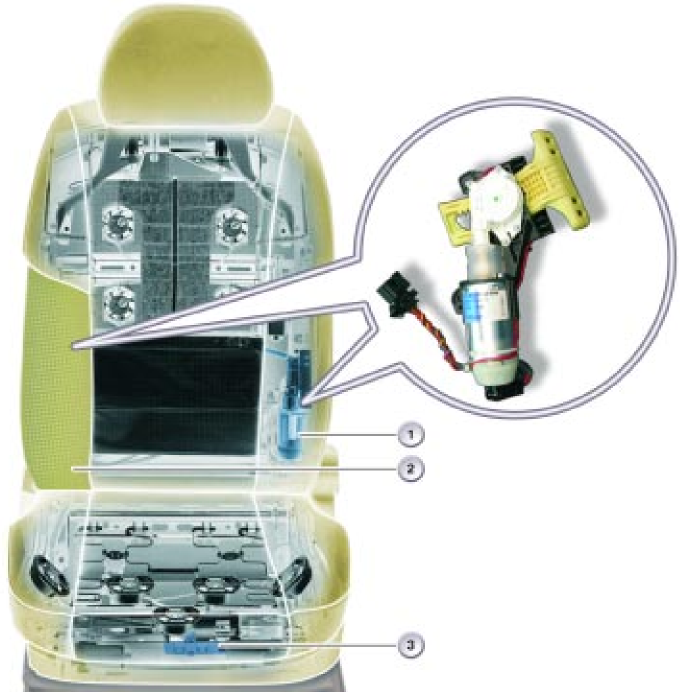
Drive Unit
The drive unit consists of a DC motor with a step-down gear mechanism flanged to it. The gear mechanism engages in the adjustment assembly on which the side sections of the backrest are mounted. The side sections of the backrest are adjusted from maximum open (0 %) to maximum closed (100 %) by the adjustment assembly.

An electric motor is driven by a PWM signal (pulse-width modulation) for this purpose. The adjustment speed can be influenced corresponding to the pulse width. At maximum closing speed, the side section of the backrest is adjusted from completely open (0 %) to completely closed (100 %) within approx. 1 second.



Actuators of the Active Backrest Width Adjustment with Sensors

Index	Explanation	Index	Explanation
1	End Position Sensor	4	Hall Sensor 1
2	Contact for End Position Sensor	5	Magnetic Ring
3	Temperature Sensor Connection	6	Hall Sensor 2



Index	Explanation
1	Both Drive Unit
2	Adjustable Backrest Section
3	ALBV Control Unit

Comfort Seat with Active Backrest

The drive units are controlled with following pulse width corresponding to the characteristic curve.

Characteristic curve	Adjustment range in %	Pulse width modulation in %
Comfort	50 -100	50
Normal	0 - 100	65
Sports	0 - 100	80
Sports*	0 - 100	85

* A modified characteristic curve for PWM control is used in the sports setting on MGmbH vehicles.

The drive unit additionally features various sensors. The end position sensor, a two-wire Hall sensor, recognizes the fully opened backrest width (0 %).

Two Hall sensors, offset by 120 degrees, are additionally installed for determining the direction of rotation and position. The signals of the Hall sensors are counted up or down, enabling the ALBV control unit to determine the direction of rotation and position. The Hall sensors are monitored by the ALBV control unit and sampled every 200 ms.

A temperature sensor is additionally installed in the drive unit. At excessively high temperatures, the drive unit is no longer activated until the temperature has dropped below a permissible value.

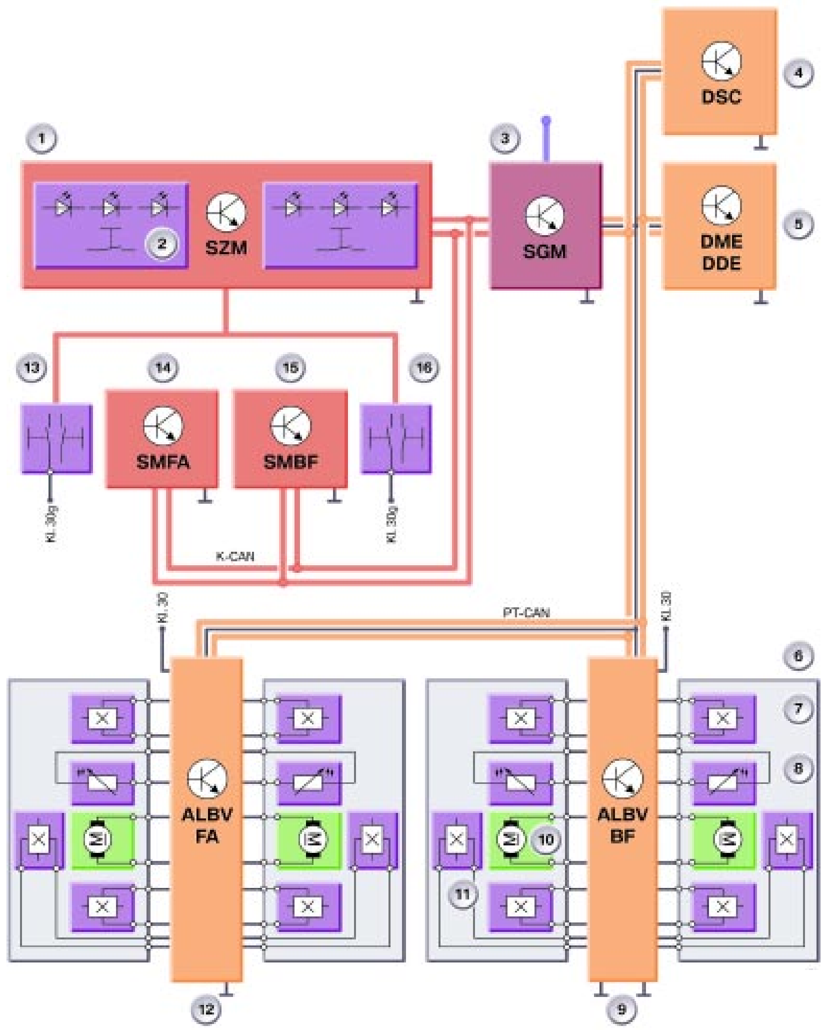
The active backrest width adjustment system consists of the control units:

- Active backrest width adjustment, driver (ALBV FA)
- Active backrest width adjustment, front passenger (ALBV BF)

Both control units are located in the respective driver's or front passenger's seat. The control units feature a PT-CAN bus link. This connection to the PT-CAN is necessary in view of the high number of parameters relating to the vehicle dynamics from the DSC and DME control unit and the short response time of the system.

NOTES

System Circuit Diagram ALBV



Index	Explanation	Index	Explanation
1	Center console switch cluster SZM	9	Control unit for active backrest adjustment, front passenger ALBV BF
2	Button for active backrest width adjustment	10	Servomotor
3	Safety and gateway module SGM	11	2 Hall sensors for direction of rotation and position recognition
4	Dynamic stability control DSC	12	Control unit for active backrest adjustment, driver ALBV FA
5	Digital diesel electronics/digital motor electronics DME/DDE	13	Backrest width adjustment switch, driver
6	Drive units for active backrest width adjustment (2 per seat)	14	Driver's seat module
7	End position sensor	15	Passenger's seat module
8	Temperature sensor	16	Backrest width adjustment switch, front passenger

Principles of Operation

System Activation

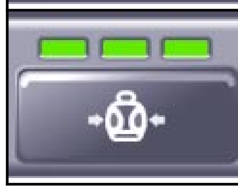
The active backrest width adjustment system cannot be activated before the engine is running. There are buttons for the driver's and front passenger's side located in the center console switch cluster (SZM) to switch on the system.

A green LED lights when the button is pressed with the engine running. The indicator switches to two LEDs or three LEDs when the button is pressed again.

The active backrest width adjustment system is switched off immediately if the button is pressed for longer than 1.2 seconds and all LEDs go out.

Each of these LEDs represents a specific characteristic map that is stored in the ALBV FA / ALBV BF.

The actuators for setting the side sections of the backrest are actuated corresponding to the selected characteristic map. The actuators are controlled by means of a PWM signal (pulse-width modulation).

	ALBV OFF
	Comfort
	Normal
	Sport

The ALBV system features the following functions:

- Basic Function
  - – Active backrest width adjustment
- Additional Functions
  - – Easy-entry for driver's and front passenger's side
  - – Backrest width adjustment
  - – Readjustment of the backrest width
  - – Soft start/stop of the drive unit for backrest width adjustment
  - – Backrest width memory function
  - – Special features in M-Drive mode

Basic Function
After activation of a corresponding characteristic curve (comfort, normal, sports) the outer (closest to the curve) side section of the backrest is controlled during vehicle operation depending on various parameters.

The side sections of the backrest are adjusted to such an extent as to take up the transverse forces and to keep the position of the upper body stable in the seat.

Various control units make available information on the PT-CAN to the ALBV control units for the purpose of controlling the respective side sections. The DSC control unit provides the most important information.

The following information is made available:

- Road Speed – The mean value of the signals of all four wheel speed sensors is determined and sent as the road speed signal on the PT-CAN.
- Longitudinal and transverse acceleration – The longitudinal and transverse acceleration is calculated in the DSC control unit from the signals of the Y sensor 2.
- Yaw Rate – The yaw rate, i.e. the rotation about the vertical axis, is also calculated in the DSC control unit from the signals of the Y sensor 2.
- Steering Angle – The steering angle is determined by the steering angle sensor in the steering column switch cluster SZL. The SZL sends a data telegram via the F-CAN to the DSC control unit.
- Steering Angle Speed – The steering angle speed is also determined by the steering angle sensor and sent via the SZL to the DSC control unit.

Further information from the DME/DDE and driver's/front passenger's seat modules

- Engine speed information – The DME/DDE sends an engine speed signal so that the ALBV control unit recognizes that the engine is running and the system can be activated.
- Memory information – The backrest width memory is integrated in the seat memory located in the respective driver's/front passenger's seat module. The seat module initiates the backrest width memory by means of a K-CAN telegram.

Convenience Entry/Exit Aid

To make it easier for the driver and passenger to get in and out of the vehicle the side sections of the backrest are completely opened (0 %) and held in this position. The side sections of the driver's seat backrest are opened under the following conditions:

- Terminal R OFF
- Terminal R ON and driver's door opened
- Driver's door open and terminal 15 OFF

The side sections of the front passenger's seat backrest are opened under the following conditions:

- The front passenger's door is opened and the seat belt not buckled.

Note: The easy-entry facility is deactivated when the active backrest width adjustment is enabled, i.e. the engine is running and the side sections of the backrest are in the position last stored.

Backrest Width Adjustment

The backrest width can be preset manually by means of a seat adjustment switch on the control panel.

The customer has the option of setting the backrest width to his/her individual requirements. Adjustment is possible as from terminal 30.

The switches for backrest width adjustment are connected via the K-bus to the center console switch cluster (SZM). The SZM is connected via the K-CAN to the SGM and the PT-CAN.

After selecting a characteristic curve for the active backrest width adjustment, only the presetting between completely open (0 %) and half closed (50 %) is possible otherwise subsequent adjustment would no longer be possible if the side sections of the backrest were completely closed (100 %).

Only the open backrest side section can be adjusted during control of the active backrest width.

Control Panel for Seat Adjustment

Index	Explanation
1	Backrest Width Open
2	Backrest Width Close
3	Memory Button

Readjustment of the Backrest Width
Readjustment is intended to balance out the asymmetry in the side sections of the backrest after manual adjustment of the backrest width or after assuming a memory position.

Readjustment takes place when the electronic circuitry in the ALBV control unit recognizes a difference of >5 Hall pulses between the left and right actuator motors.

Readjustment takes place 1 second after the end of the backrest width adjustment procedure. If the adjustment was not successful, the procedure is repeated after 2 seconds.

No readjustment takes place while the active backrest width adjustment is in operation.

Soft Start/Stop of Drive Unit
A special control facility is responsible for starting and stopping the electric motor. The controlled start function minimizes starting current peaks and avoids mechanical noise during the adjustment procedure.

The controlled soft stop function prevents overrunning of the drive unit.

Backrest Width Memory
The backrest width memory is located in the respective driver's and passenger's seat module. With the aid of the memory buttons in the seat control panel, two positions can be stored for each personalized key in the backrest width adjustment memory.

The setting of the driver's seat last selected is additionally stored in the current key under following conditions:

- 10 seconds after manual backrest width adjustment
- When retrieving a memory position
- When switching terminals from 15 to R M-Drive

Service Information

Initialization of the Drive Units
An initialization procedure must be performed to ensure smooth operation after replacing a control unit or a drive unit.

As part of this initialization procedure, the zero position of the drive units is defined by the signal from the end position sensors. For this purpose, the drives are moved to the fully opened position and the switch pressed and held for at least 15 seconds.

Initialization can be performed with the aid of the BMW diagnosis system.

Service functions => Body => • Active backrest width adjustment

Rear Seats

The rear seat have been modified slightly in order to improve seat positioning during hard cornering maneuvers.

The M5 still boasts having split 60/40 rear seatbacks for extra storage capability and an armrest with built in cup holders.

Rear Seat Arrangement

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Subject Page

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S85 Engine

Model: E60 M5 and E63/E64 M6

Production: All

OBJECTIVES

After completion of this module you will be able to:

- Understand the construction of the S85 V-10 engine
- Identify and locate S85 engine components
- Perform basic engine services on the S85 engine

Introduction

For the first time in a road-going BMW, a new Formula 1 inspired V-10 has been developed for the new M5 and M6. The new S85 engine benefits from the knowledge gained from F1 racing development.

The all aluminum V-10 produces in excess of 500 horsepower at 7750 RPM. One of the concepts adapted from F1 is the “High RPM Power Concept” which allows the S85 to achieve a maximum RPM of 8250.

Other features of the S85 include a light alloy, 2-piece crankcase which uses a bedplate design for additional reinforcement. The familiar High-Pressure Double VANOS is carried over from previous BMW Motorsport engine designs.

The S85 is naturally aspirated and “breathes” through 10 individual throttle assemblies which are actuated by two throttle motors (One per bank).

Together with all of the other engine concepts in this design, the S85 propels the new M5 and M6 to sub-5 second 0-60 mph times. The M5 offers the best power to weight ratio in comparison with the other vehicles in it’s class.

Motorsport Engine History

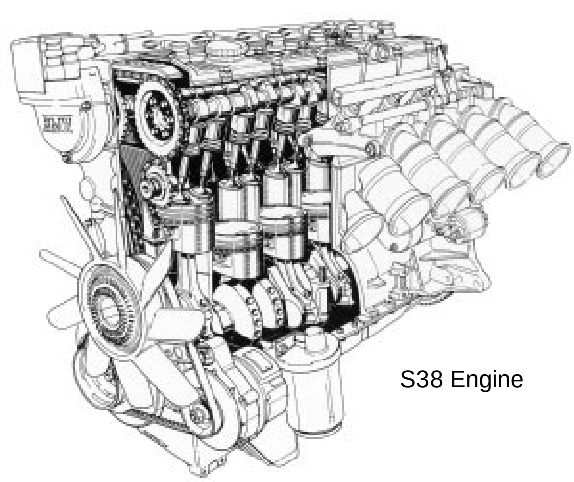
Since 1972, BMW M GmbH, the “motorsport” division of BMW has been turning out some of the most powerful and legendary engine packages in the auto industry. The letter “M” has been referred to as “the most powerful letter in the world”. Customers who are familiar with the “M” badge know that when the buy an M-car, they have come to expect something special under the hood.

S38 (M88)

The first BMW motorsport engine was the inline 6-cylinder known then as the M88. This engine was introduced with the legendary M1 in 1978. Since then, the M88 engine has been known as the S38 in production vehicles. In the M1, the M88 produced 277hp which was impressive for a 6-cylinder engine in 1978.

The S38 engine, which was a slightly “de-tuned” version of the M88, was first introduced into the US market in the E28 M5 in 1988. The 256 hp S38 featured some of the BMW motorsport philosophy which is still in use today. Innovations such as individual throttles, 4 valves per cylinder, lightweight valvetrain and steel crankshaft are still in use on current M engines.

The E24 M6 also took advantage of the S38 engine technology through its production life. The M6 was available in the US in 1987 and 1988.

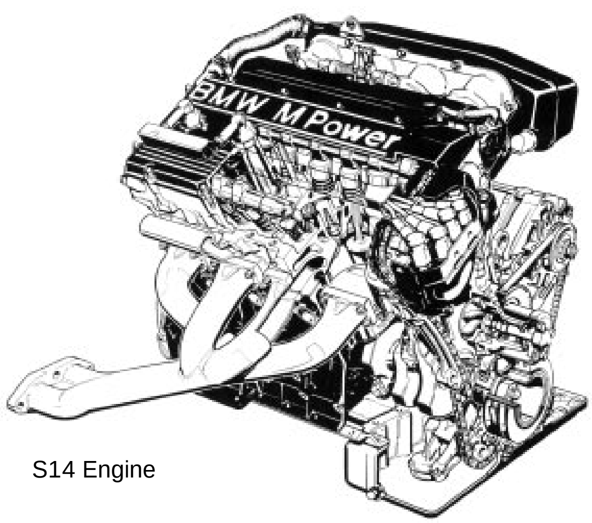


S38 Engine

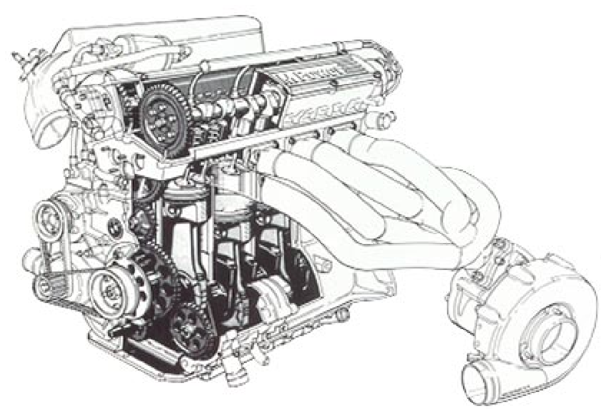
S14

Introduced a year before the M5, BMW also produced a "Motorsport" version of the E30. The first M3 featured a Formula One derived race bred powerplant that came to be known as the S14. The S14 was a 2.3 liter, 4-cylinder engine capable of 192 hp at 6750 rpm. Considering that this is a "naturally aspired" engine, a 4-cylinder engine producing 192 horsepower was impressive especially in 1987.

The S14 engine was a further development of the 4-cylinder engine which was used to propel the BMW Brabham F1 car to the 1983 F1 World Championship. The Formula 1 engine (M12/M13) was derived from the "stock block" M10 engine. The M12/M13 F1 engine displaced 1.5 liters and was turbocharged and capable of producing in excess of 1100 bhp. This is an impressive feat for an engine which was developed from a stock powerplant. The extensive research and development of the Formula 1 engine led to the ultimate production of the S14.



S14 Engine

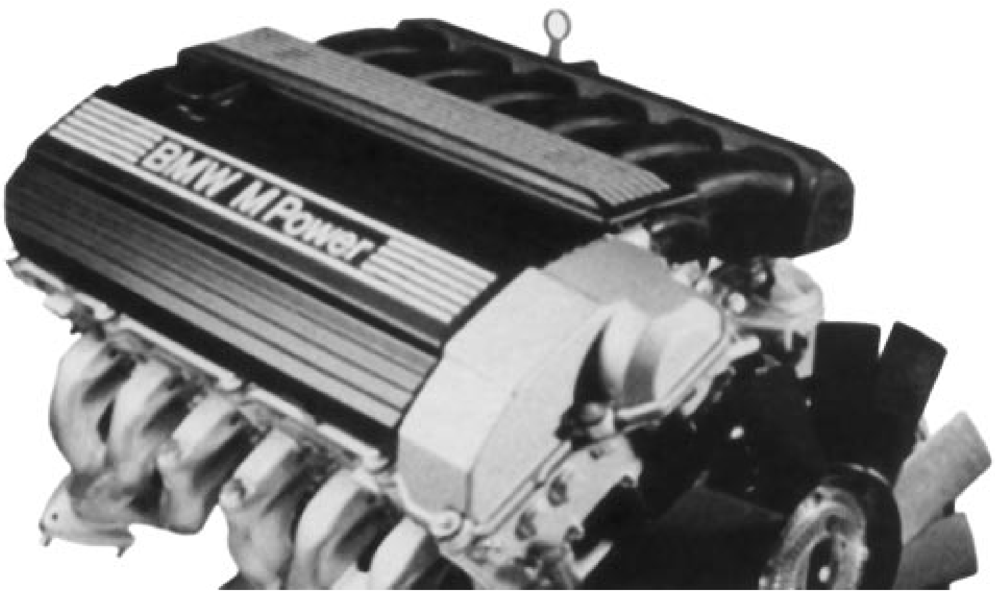


M12/13 F1 Engine

S50 (US)

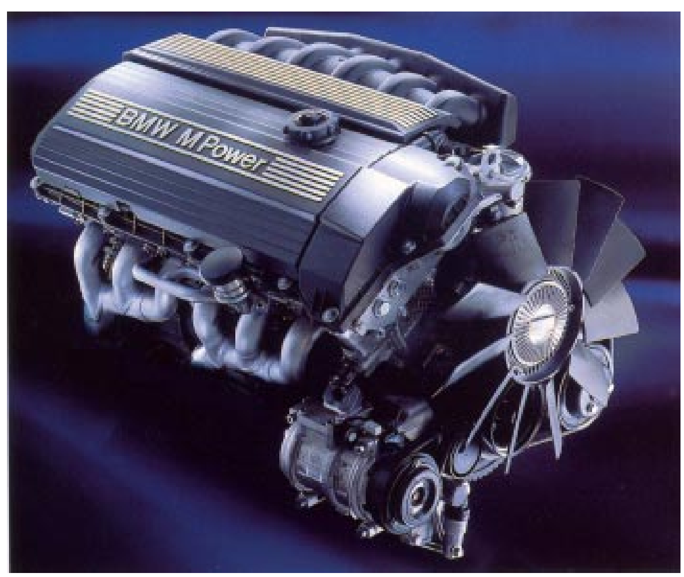
The E30 M3 was discontinued in 1991. The next generation M3 would not be available until 1995. The E36 M3 was based on the new 3 series coupe introduced in 1991. This was the first time that a 6-cylinder was available in the M3.

The new S50 (US) engine was derived from the M50TU already in use at that time. The new M3 engine produced 240 hp and differed considerably from the European version. The S50 (US) engine was only available for one year (1995). In order to comply with OBD II regulations, the S50 was discontinued in favor of the S52 in 1996. The S52 was a 3.2 liter engine using Siemens engine management.



S52

In 1996, the M3 received the new S52 3.2 liter engine which produced 240 hp. This was the first OBDII compliant "M" engine and also the first to use Siemens engine management instead of Bosch.



The engine was based on the M52 production engine and used much of the same technology as the previous (S50US) engine. The S52 was also used in the new "M" Roadster and Coupe. The S52 would be in use until 2001, when it was replaced by the S54

S54

The S54 would be the powerplant of choice for the 3rd generation M3. The new in-line 6-cylinder “Motorsport” engine marked a major leap in engine technology for that time. For the first time in a production “M” car, the S54 achieved the elusive goal of 100 hp per liter. With 333 hp at 7900 RPM, S54 propelled the E46 M3 to 0-60 times of 4.8 seconds.

The S54 was the first Motorsport 6-cylinder to use the “High-Pressure Double VANOS” system. Some of the other engine highlights include:

- 11.5 to 1 compression
- 6 - individual throttle assemblies with electronic throttle control
- A unique lightweight valve actuating mechanism
- Forged steel crankshaft with “nitro-carburized” heat treatment
- “Semi-dry sump” lubrication system
- Light weight one-piece cylinder head
- High-strength cast iron engine block

Together with the Motorsport designed engine management system, the S54 also meets the required LEV emission standards as well.

S62

Another first time achievement for the Motorsport division, was the introduction of the first V-8 "M" engine. The 5 liter S62 was also the most powerful production "M" engine with an output of 394 hp.

The S62 was first used in the third generation M5, the E39. Also, the S62 was used in the Z8 which marks only the second time in which an "M" engine was used in a non-"M" vehicle. The first time being the S70 in the E31 850Csi.

Features of the S62 engine include:

- 8 individual throttle controlled electronically via two throttle motors
- Hi-pressure Double VANOS
- Lightweight aluminum block and cylinder heads
- Lightweight valvetrain
- "Semi-dry sump" oiling system

BMW Motorsport Engine Summary

Designation	# of cyl.	Displacement (Liters)	Output (horsepower)	Vehicle (year)	Comments
S14	I-4	2.3	192 hp	E30 M3 (87-91)	First 4-cylinder Motorsport engine
S38 (M88)	I-6	3.5 (M1) 3.5 (E28/E24) 3.6 (E34)	277hp 256 hp 310hp	M1 (1978-81) E28 (88) E24 (87-88) E34 (91-93)	First production Motorsport engine.
S50US	I-6	3.0	240 hp	E36 M3 (95)	Used in 1995 only
S52	I-6	3.2	240 hp	E36 M3 (96-99) E36/7 M Roadster E36/7 M Coupe	OBD II compliant
S54	I-6	3.2	333 hp	E46 M3 (01-05)	Adjustable Valvetrain
S62	V-8	5.0	394 hp	E39 M5 (00-04) E52 Z8	First V-8 motorsport engine
S85	V-10	5.0	500 hp	E60 M5 (07-) E63/E64 M6 (07-)	First V-10 motorsport engine
S70	V-12	5.6	375 hp	E31 850CSl (94-95)	Used in the 850Csi
M12/M13	I-4	1.5	over 1100 hp	Brabham BMW F1 BT53 1983	1983 Formula 1 championship winning engine
P84/5	V-10	3.0	over 900 hp	BMW Williams F1	Formula 1 V-10 engine

Formula One Engine

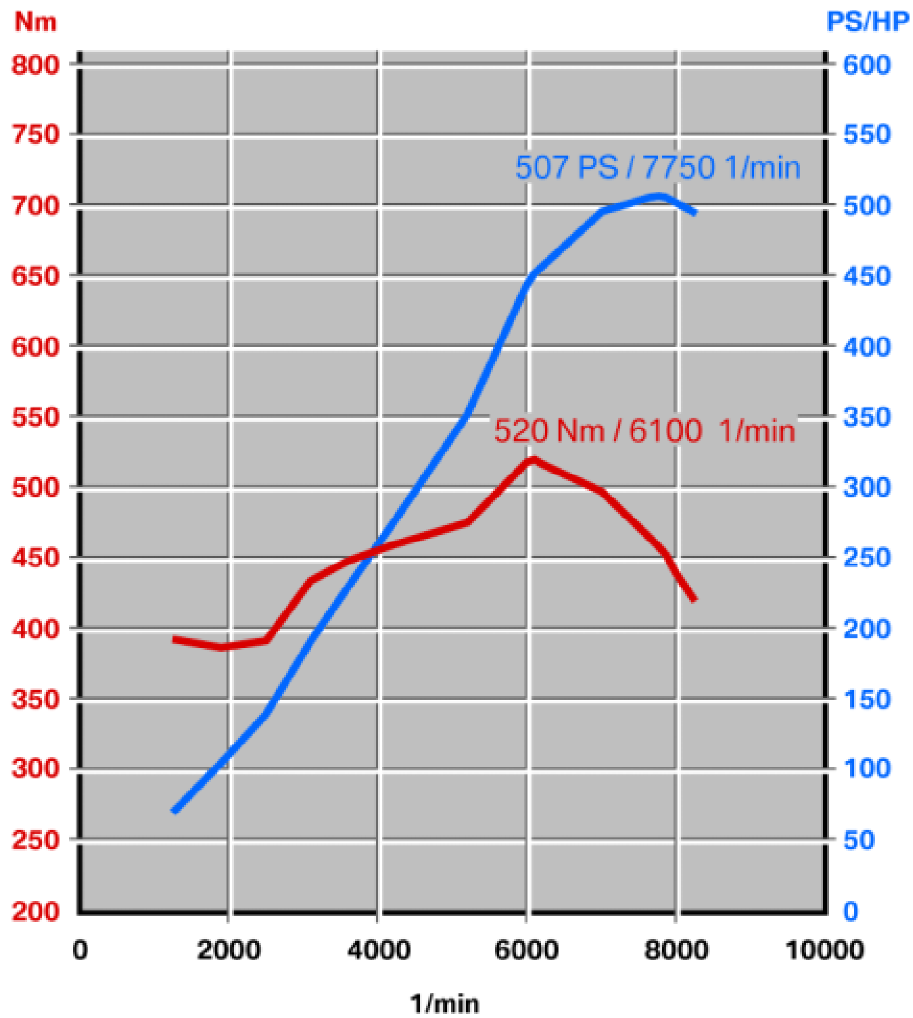
The S85 engine has benefitted greatly from the lessons learned in Formula 1. The F1 counterpart of the S85 is known as the P84/5. This is a 3 liter V-10 which consists of approximately 5000 parts and requires around 100 hours of assembly time.

The engine block and cylinder heads are constructed of aluminum alloy and are designed to withstand the demands and stresses of an F1 race. The titanium connecting rods are just one example of components which allow the P84/5 to reach engine speeds of more than 19,000 RPM.

Some interesting facts of the F1 V-10:

- During the design of the F1 V-10 approximately 1000 technical drawing are created.
- The total engine weighs less than 195 pounds.
- The exhaust temperature can reach up to 16,200 degrees Fahrenheit
- The air temperature in the pneumatic valve system can reach 4,500 degrees F.
- Before the recent changes in F1 rules regarding engines, BMW produced about 200 engines per race season.
- The P84/5 engine propels the FW27 F1 car to 120mph in five seconds.
- At 19,000 RPM the following events occur in one second - The engine rotates 316.7 revolutions, the ignition system fires 1,583 times, 9,500 engine speed measurements are made, the pistons covers a distance of 75 yards and nearly 140 gallons of air are drawn into the engine.

Engine Statistics

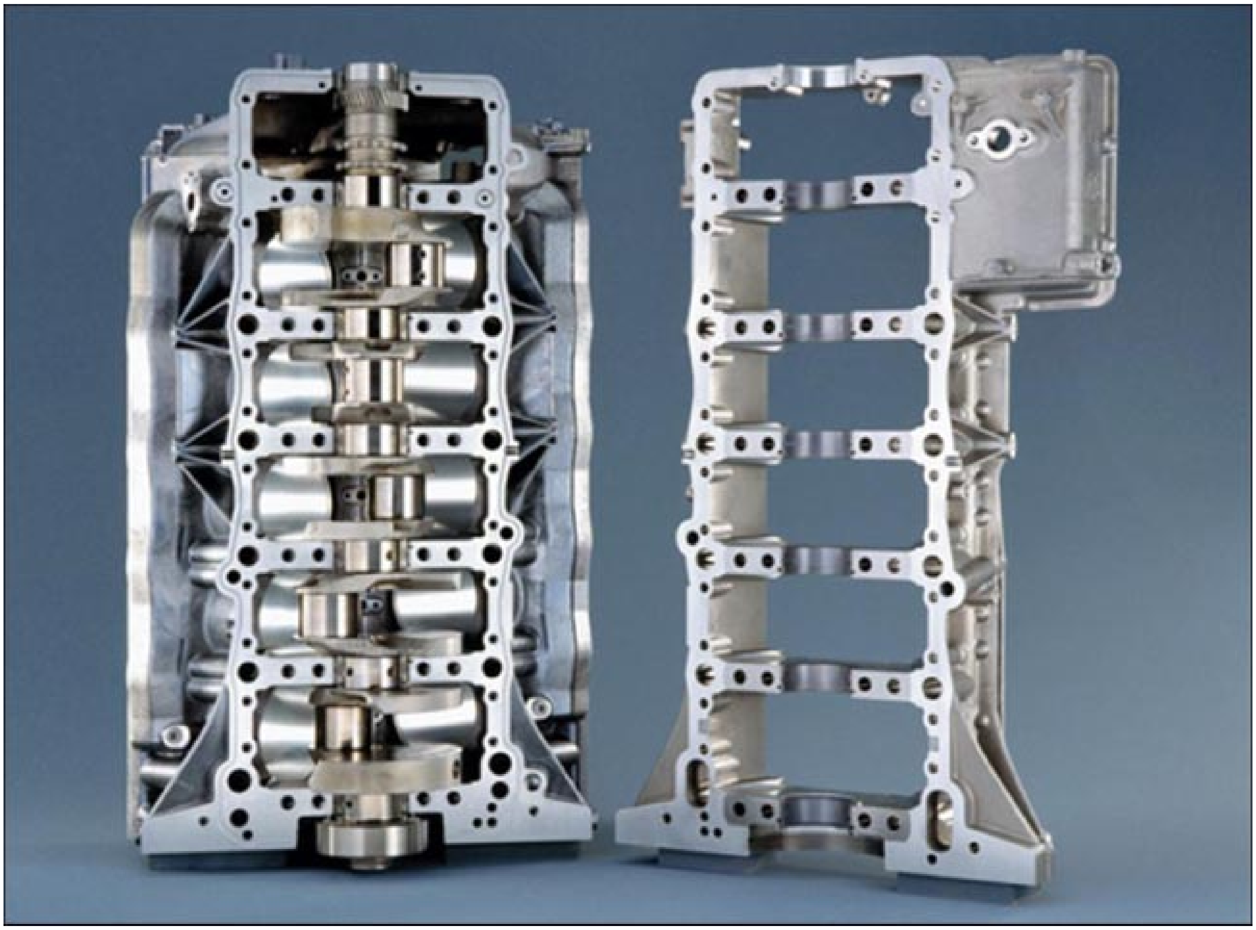


Description	S85 V-10	P84/5 F1 V-10
Engine Configuration	90 Degree V-10, 4 valves per cylinder	90 Degree V-10, 4 valves per cylinder
Displacement	4,999 cm^3 (5.0 Liter)	2,999 cm^3 (3.0 Liter)
Bore and Stroke	92mm X 75.2 mm	Unknown
Horsepower	373kW (500bhp) @7750	900 hp +
Torque	520Nm @ 6100RPM	Unknown
Maximum engine RPM	8250	19,200
Compression	12 to 1	Unknown

Components

Engine Block and Bedplate

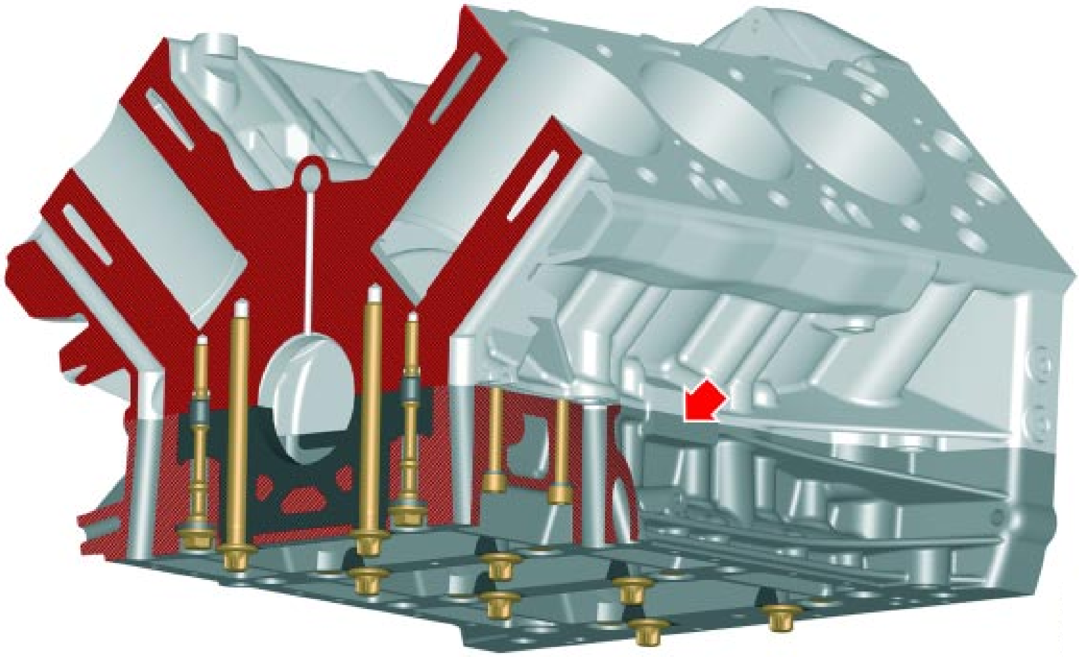
Similar in design to the N52 engine, the S85 takes advantage of the additional stiffening properties of the 2-piece crankcase.



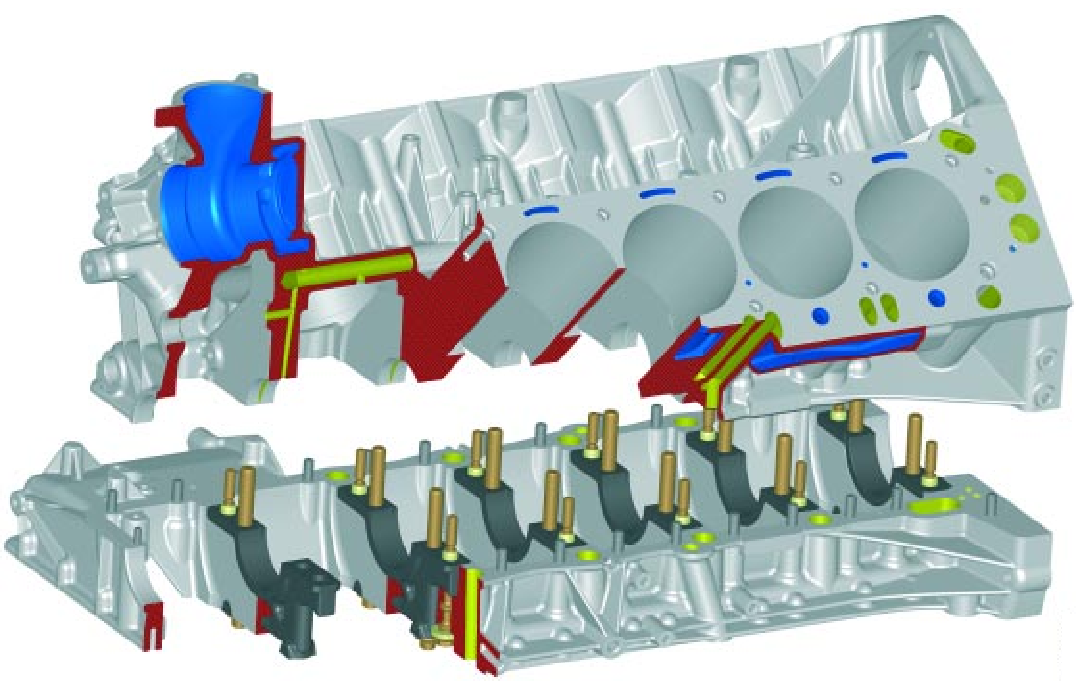
The 10 cylinder crankcase uses the familiar Alusil construction which is split at the crankshaft centerline. The bedplate is machined together with the crankcase and is mounted to the upper section of the crankcase when the engine is assembled. This design contributes to improved torsional stiffness. Better engine acoustics (NVH) are also attributed to the improved stiffness.

Some of the other benefits of the bedplate include the ability to accommodate additional assemblies and to facilitate the assembly of the crankshaft main bearings.

The bedplate assembly contains cast iron bearing bridges which take up additional forces from the pistons and connecting rods. The engine serial number is stamped on the bedplate assembly.

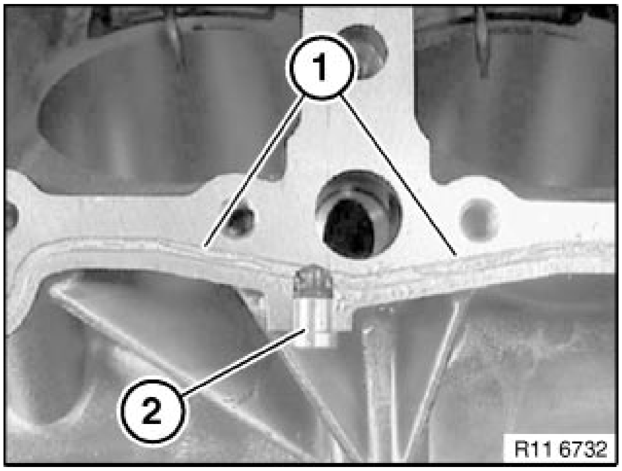


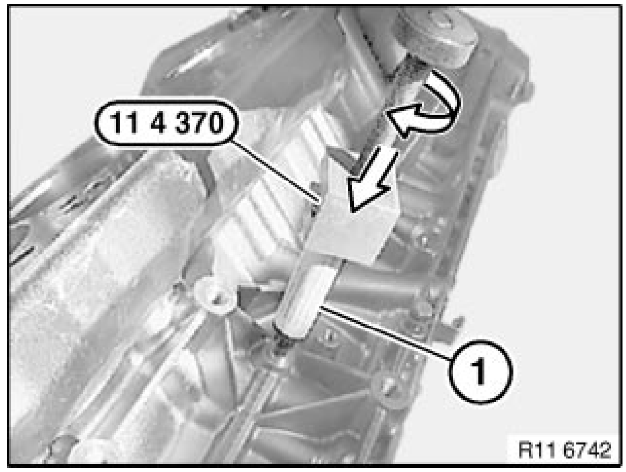
The bedplate is secured to the upper section of the crankcase with the main bearing bolts. The positions are fixed with fitted sleeves. Strict adherence to the bolt tightening procedure is necessary to prevent engine failure.



Bedplate Sealing

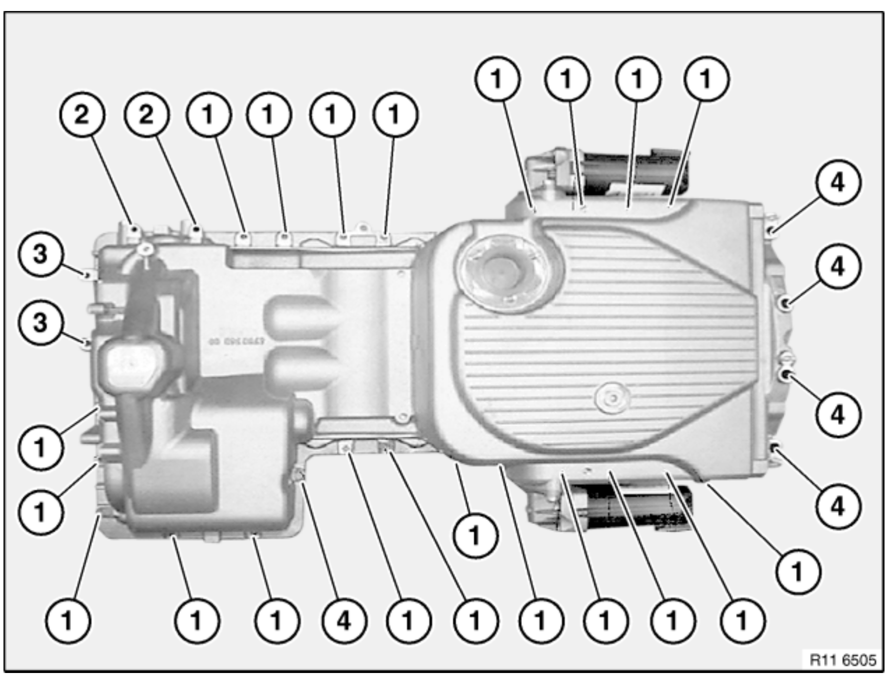
As with the N52 engine, the S85 uses the same technique for bedplate sealing. There is a machined groove (1) in the upper part of the crankcase. A liquid sealant is injected into the groove through ports (2) on each side of the crankcase.





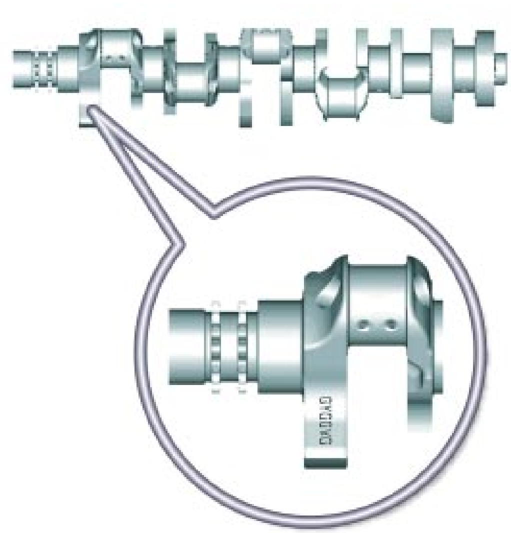
Oil Pan

The oil pan is an all aluminum one-piece design. Due to the configuration of the front subframe crossmember, the pan has a front and rear sump. The oil pan provides the mounting for the electric oil pumps and the oil lines. When removing and installing the oil pan, note the location of the oil pan bolts. There are 4 different types of bolts, each requiring a specific installation location.



Crankshaft

The S85 crankshaft is forged steel and has 5 crankpins (journal) each offset 72 degrees apart. The crankshaft is also “nitro-carburized” for increased surface hardness.



The sprocket for the primary chain drive is integrally cast as part of the crankshaft. Also, the drive sprocket for that VANOS high pressure pump is bolted to the crankshaft snout.

The color codes for the main bearing classification are stamped onto the crankshaft.

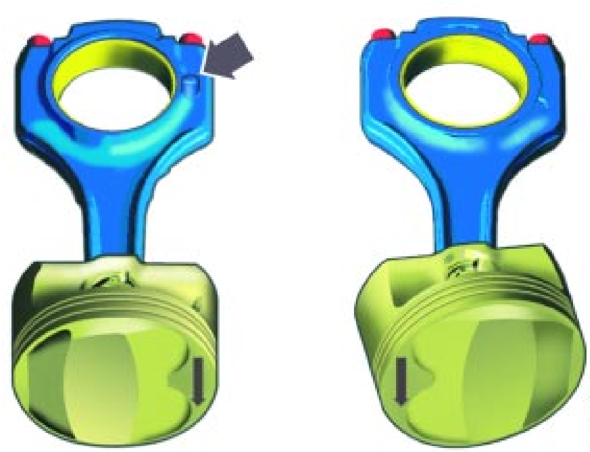
Connecting Rods

The connecting rods are forged steel and use the “cracked” configuration on the “big end”. For weight reduction, the small end of the connecting rod is trapezoidal and uses a tapered piston pin.

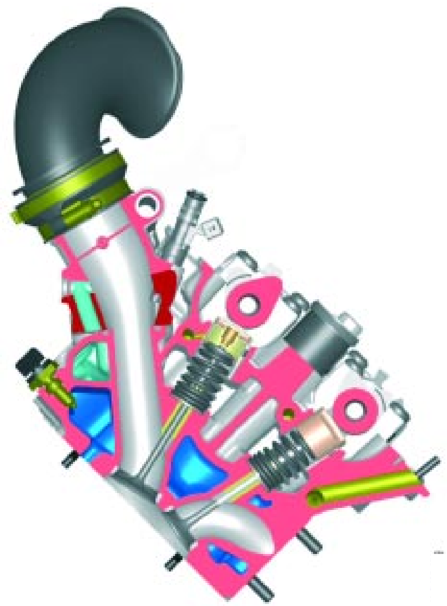
The connecting rods weigh 582 grams +/- 2 grams. The rods are also of asymmetrical construction which allows for a narrower connecting rod. The narrower rods contribute to the overall reduction in engine length. The rods can only be installed one way. Refer to repair instructions during installation.

Pistons

The pistons are cast from aluminum alloy. To promote the optimum friction partner with the cylinder bore, the piston skirt is coated. There is a galvanic ferrous layer at a thickness of approximately 10 microns. There is an additional tin layer of 2 microns that act as the run-in layer.



Cylinder Head and Valvetrain



The cylinder head is an aluminum one-piece design to improve overall rigidity. The idle air port and secondary air channel are integrated into the head.

The familiar 4-valve per cylinder arrangement is used on the S85. However there are some additional refinements carried over from racing applications.

Cylinder Head Cover
The cylinder head cover is cast aluminum with provisions for mounting the ionic current control units as well as the camshaft sensors and components for the crankcase ventilation system.

Valves
Both the intake and exhaust valves are designed as solid valves with a 5mm stem diameter. The reduced stem diameter not only reduces weight, but also improves airflow qualities.

The intake valve is a one-piece design made from a steel alloy (X45CrSi9-3). In contrast, the exhaust valve is a two piece design. The stem is made from the same steel alloy as the intake valve and is friction welded to the valve head, which is made from different alloy (NiCr20TiAl).

The valve guides are not replaceable. The cylinder head cannot be machined

Valve Springs
The valve springs are the conical design familiar from past engine designs.

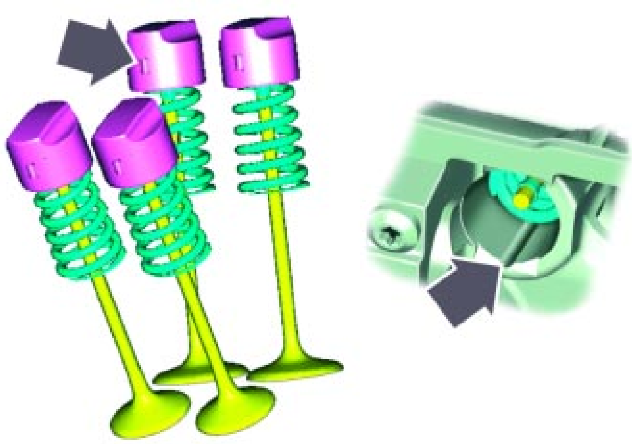
Valve Keepers (Cotters)

The valve keepers are a single row design rather than the three row design. The single row design is a "clamping type" which prevent the valve from turning during engine operation. The valve turning method is not needed due to the clean efficient combustion and close production tolerances.

The single row keeper is also 50% lighter than the three row design. In addition, the single row design provides less stress on the 5mm valve stems for increased reliability.

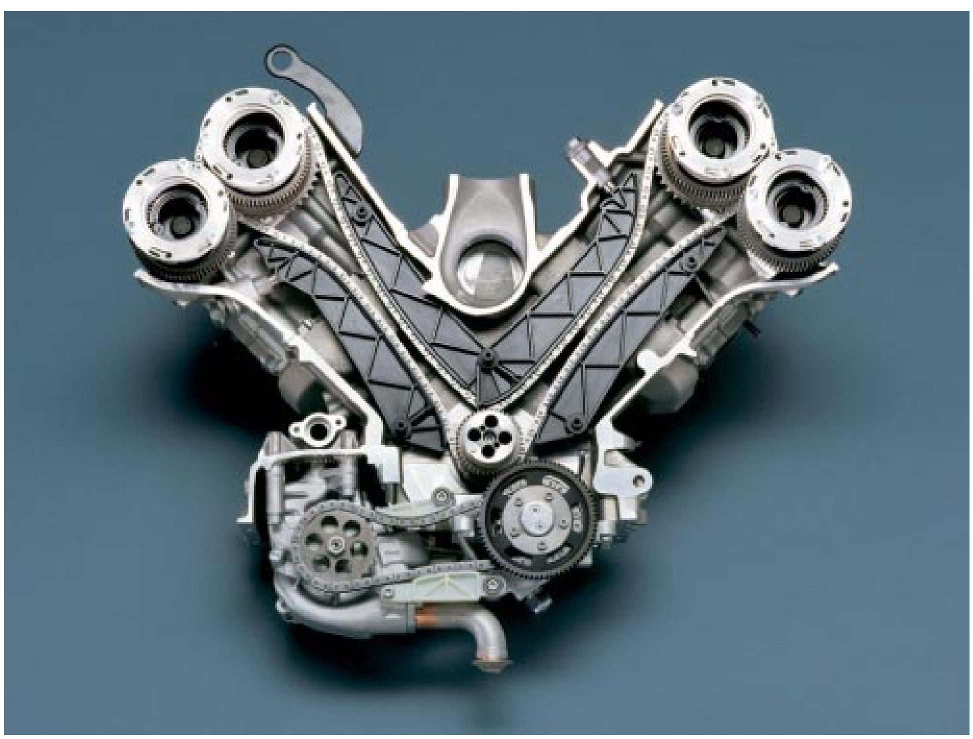
Hydraulic Valve Actuators (HVA)

The HVA assemblies are differently configured from past designs to save weight and improve the frictional characteristics. The new tappet design is referred to as the "box" type tappet. This style of tappet has been used in racing applications. The box tappet does not rotate in the cylinder head, therefore a groove is milled to prevent rotation. A corresponding "anti-torsion" pin is part of the tappet.



Camshaft
The camshaft is a “hollow chill” casting (GGG60). In contrast to previous designs, the camshaft sensor trigger wheel is cast as one piece with the camshaft. An M12X1 thread is integrated into the camshaft for the VANOS gear mounting.

Camshaft Drive
The primary camshaft drive is provided by two timing chains to drive the intake camshafts (one chain for each intake camshaft). The exhaust camshafts are driven by a “gear-to-gear” connection between the intake camshaft sprocket and the exhaust camshaft sprocket.

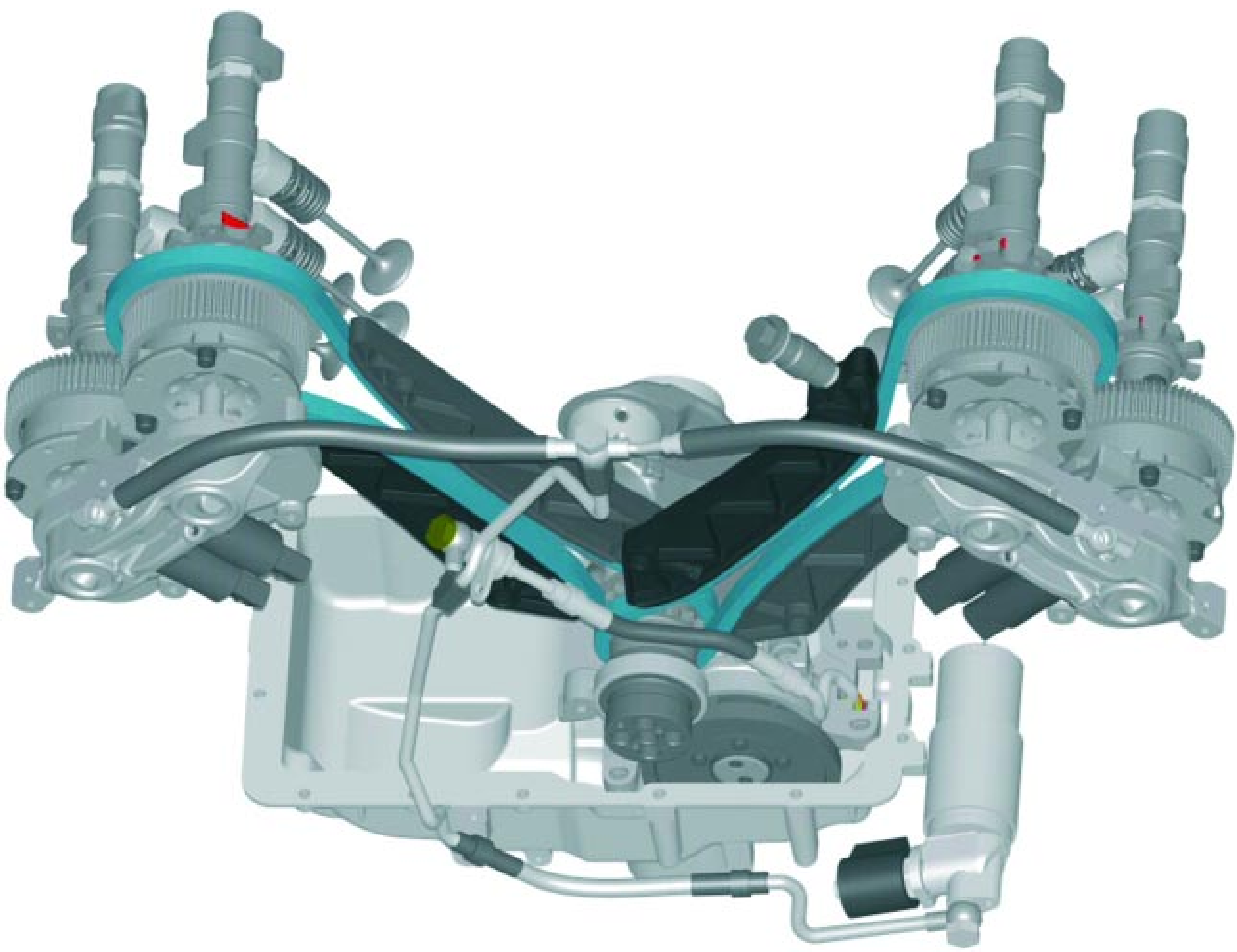


VANOS

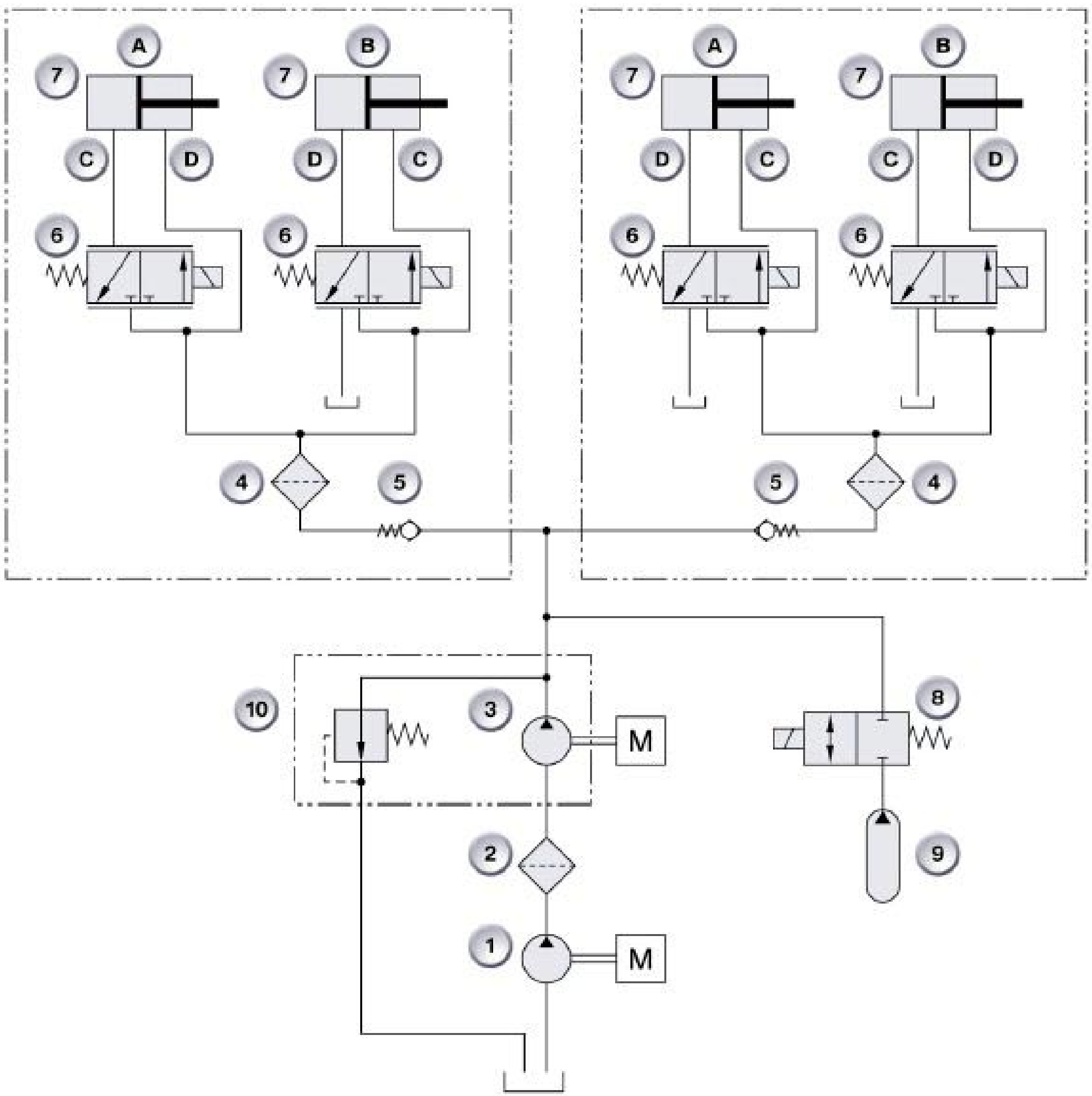
The VANOS system on the S85 is carried over from previous “M-engine” designs with some minor changes. The adjustment range of the intake camshafts is 60 degrees of crankshaft angle and the exhaust camshaft can be adjusted up to 37 degrees (crankshaft).

The S85 VANOS system is operated on the “high-pressure” concept which uses up to 115 bar for VANOS operation.

The VANOS high pressure pump is driven directly from the crankshaft via a gear-to-gear connection. The pressurized oil is routed from the pump via two delivery lines to the two VANOS units. A “T-connection” provides high pressure oil to the pressure accumulator.



VANOS Hydraulic Schematic

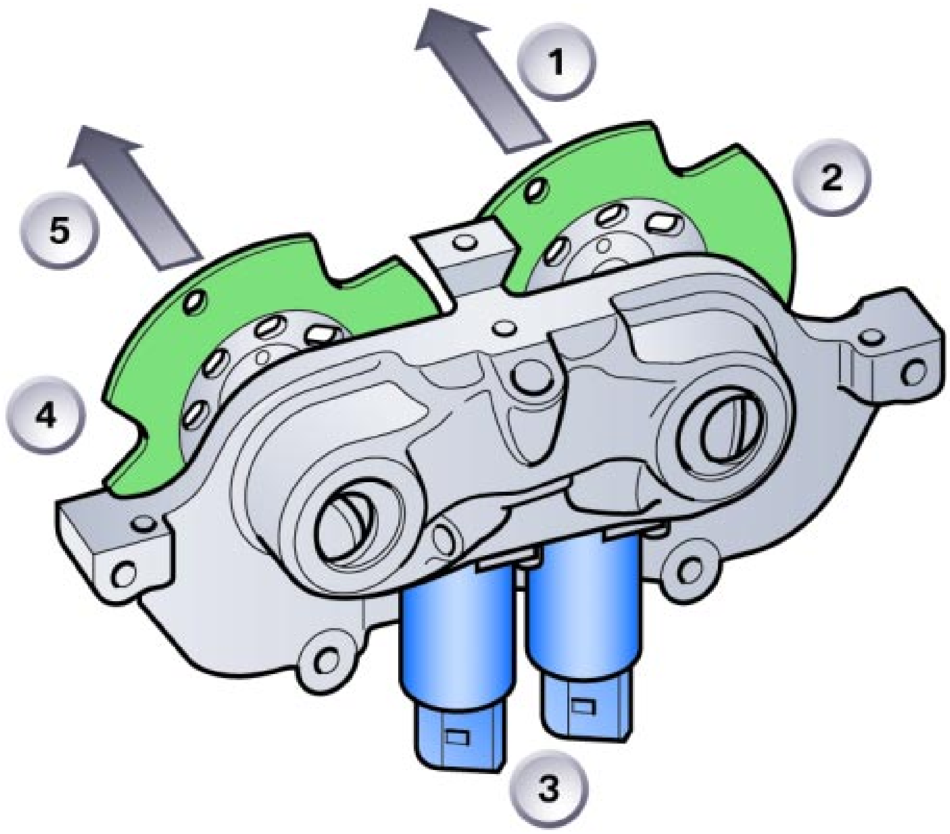


Index	Explanation	Index	Explanation
A	Exhaust	4	Filter (50 micron)
B	Intake	5	Check valve (optional)
C	Advance	6	Proportional valve (3/2-way)
D	Retard	7	Adjustment piston, pressure accumulator
1	Engine oil pump (1-5 bar)	8	Pressure accumulator shut-off valve
2	Filter (80 micron)	9	Pressure accumulator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

VANOS Actuators

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 the exhaust camshaft is driven via a gear-to-gear connection, the intake and exhaust camshaft rotate in opposing directions, the intake is adjusted towards advance and the exhaust towards retard when the plunger extends.



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

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

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 millimeter corresponds to 30° camshaft angle (60° crankshaft angle).

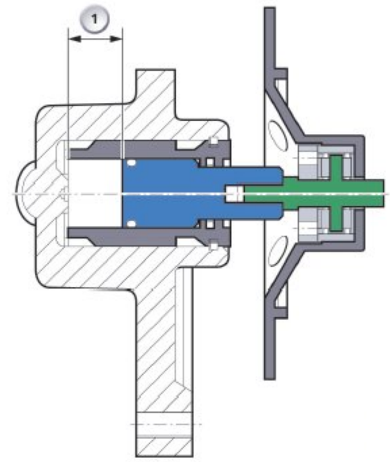
When extended into the two piston chambers, the adjustment pistons are subject to a system pressure of 115 bar. They therefore extend only due to the different piston surface areas.

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.

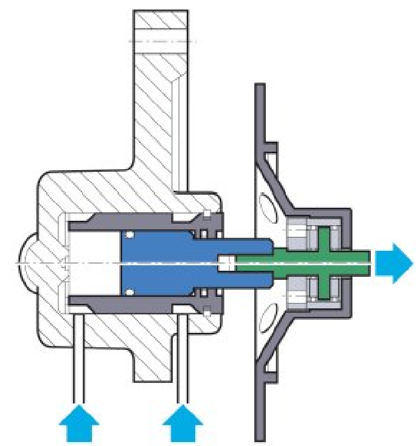
The holding function and piston retraction are achieved by reducing the oil feed on the side with the largest piston surface area by partly actuating the proportional valve.

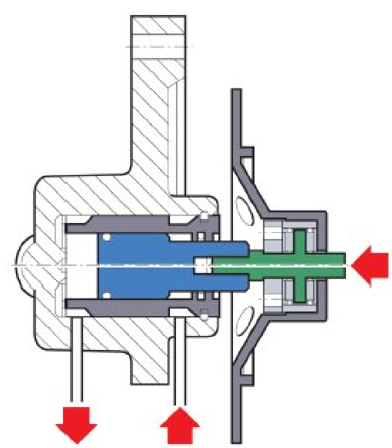
The reduced oil feed decreases the oil pressure, thus initiating a change in the forces exerted on the adjustment pistons.

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.



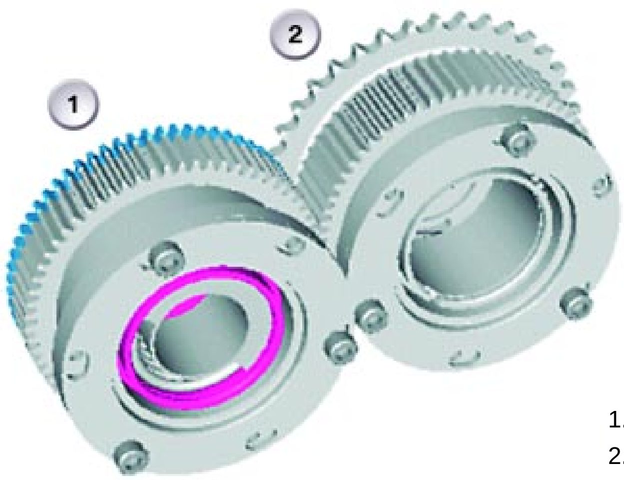
1. Stroke range of adjustment piston





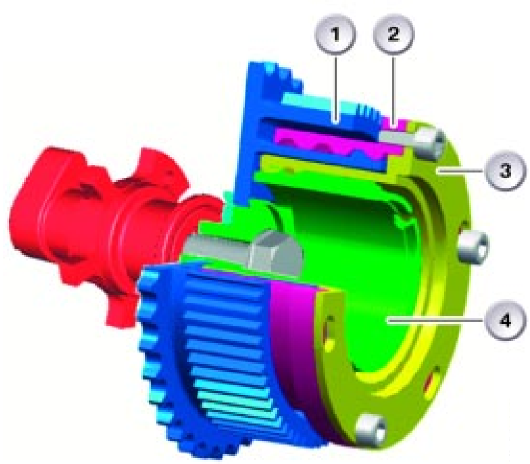
VANOS Gear Mechanism

The VANOS gear mechanism (transmission) connects the crankshaft with the intake camshafts via a chain sprocket. The intake VANOS gear mechanism also provides the drive mechanism for the exhaust camshaft via a gear-to-gear connection. 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.



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.

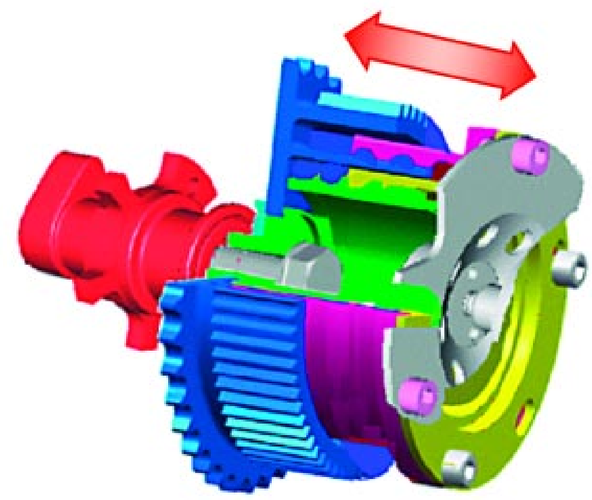


Index	Explanation	Index	Explanation
1	Drive gearwheel assembly	3	Outer sleeve
2	Inner sleeve	4	Bearing for drive gearwheel

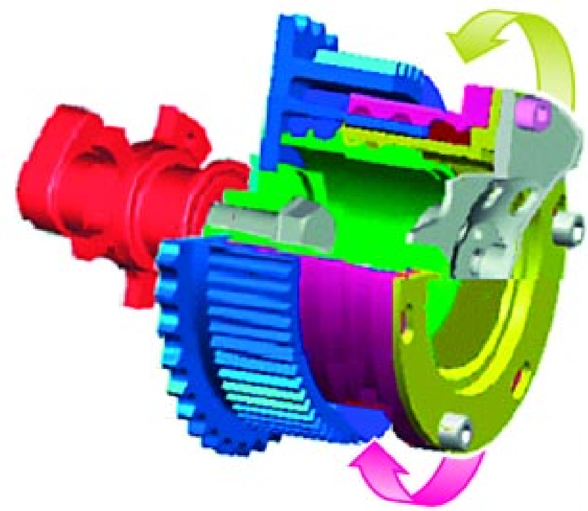
The actuator (adjustment unit) is connected to the outer and inner sleeve by the screw connection of the gear mechanism. During adjustment, the inner sleeve and outer sleeve are pulled out of and pushed into the gear mechanism.

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.



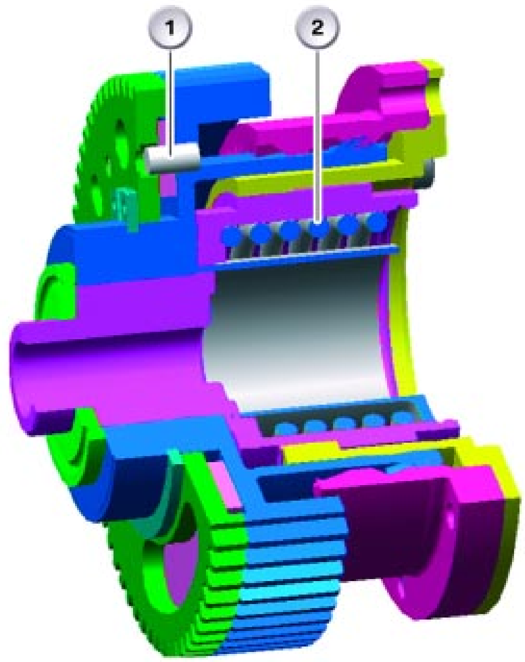
Intake gear mechanism adjustment direction

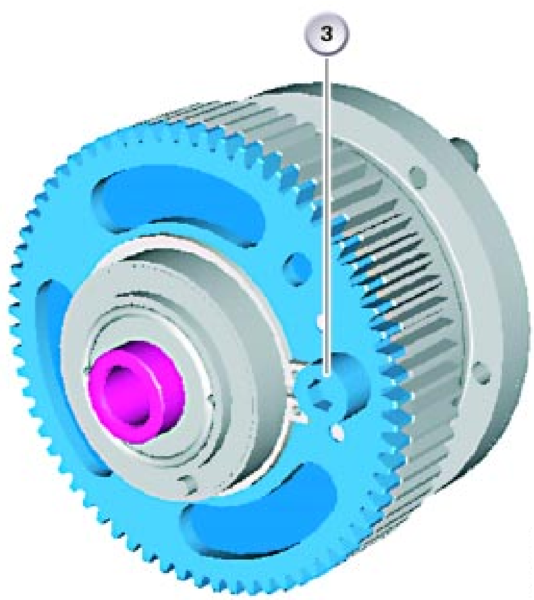


DIrection of rotation during adjustment

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.

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.

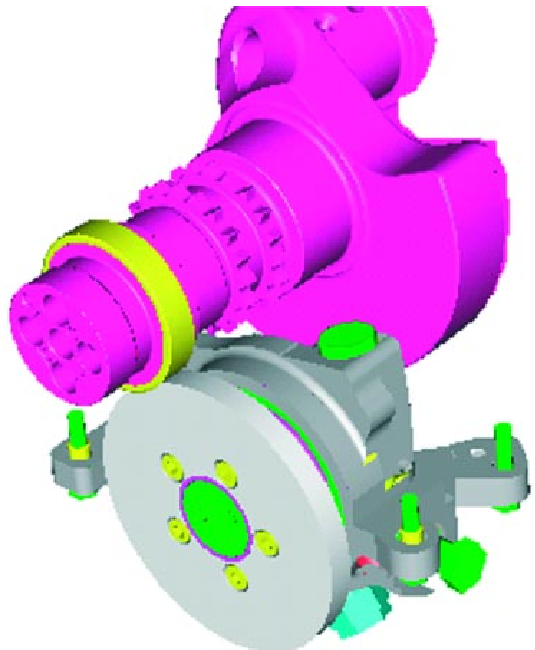




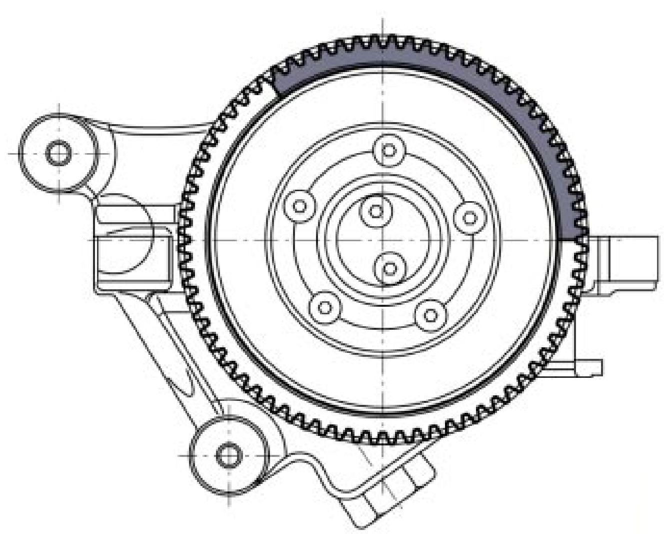
Index	Explanation	Index	Explanation
1	Annular spring	3	Lock screw
2	Torsion spring	4	

VANOS High Pressure Pump

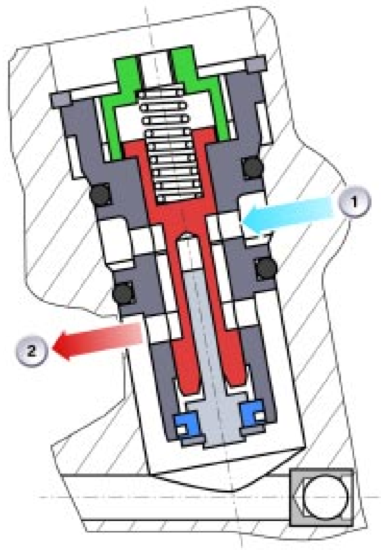
The high pressure pump is designed as a radial piston pump with five pump plungers. It is driven via a gear mechanism directly by the crankshaft. To avoid gearing noise, when mounting the sprocket of the high pressure pump, the coated part must face towards the crankshaft without any clearance. The correct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



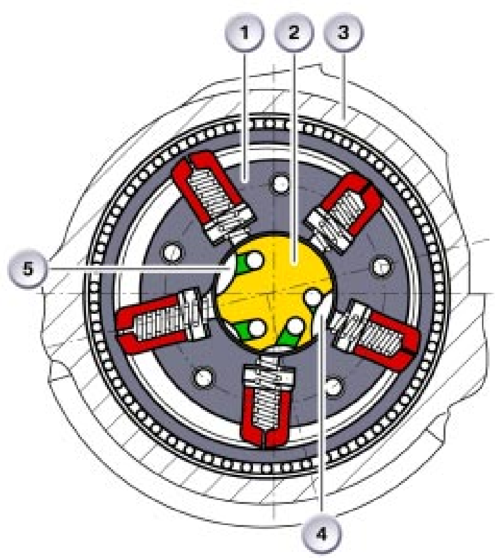
The high pressure pump receives it oil supply from the bedplate. An 80 micron fine filter is installed in the transition hole from the bedplate to the high pressure pump. This filter has the sole purpose of holding back any impurities that may accumulate during series production and is not replaced during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



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



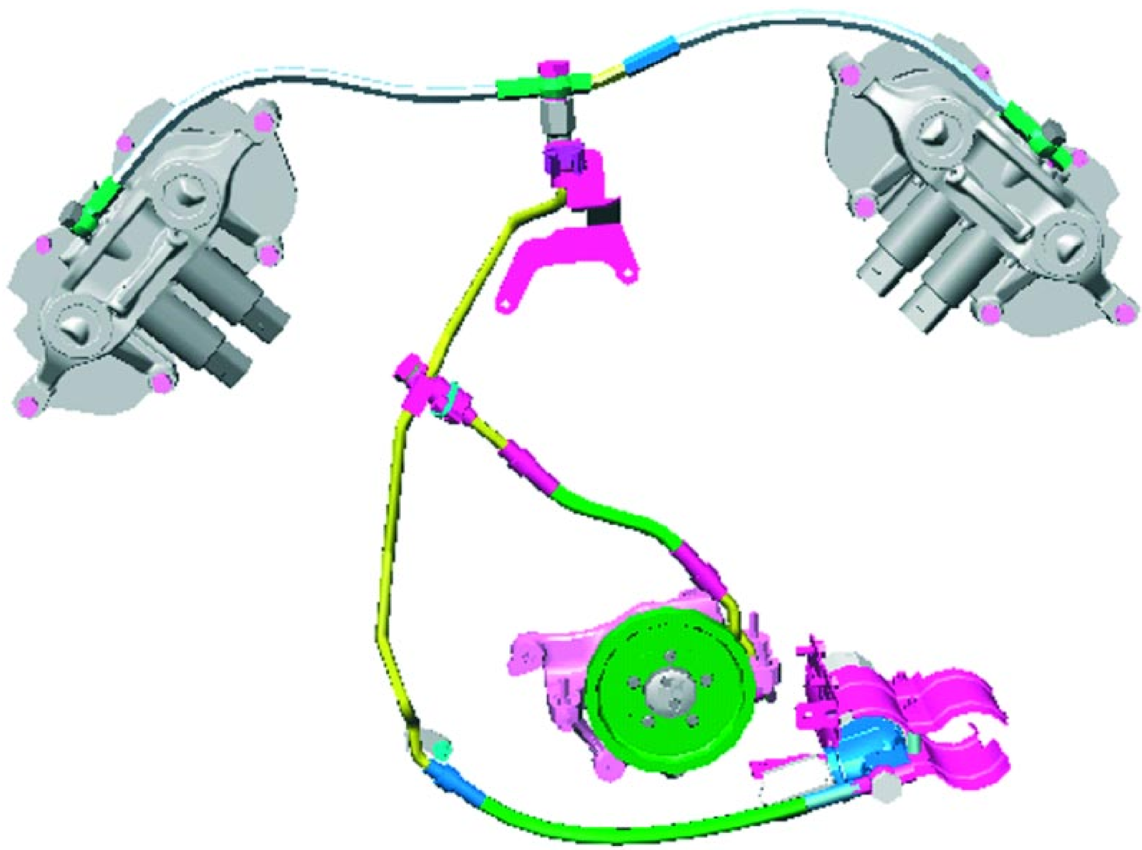
The high pressure pump consists of the fixed stator about which the rotor rotates. Five moving plungers are mounted in the rotor. The stator and rotor are installed off-center in the pump housing. The plungers are guided radially as the rotor rotates thus producing the pump stroke motion.



Index	Explanation	Index	Explanation
1	Rotor	4	Engine oil is supplied by the stator and taken up by the pistons
2	Stator	5	Engine oil is compressed and returned to the stator at 115 bar.
3	Pump housing		

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.



Intake Plenum (Manifold)

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

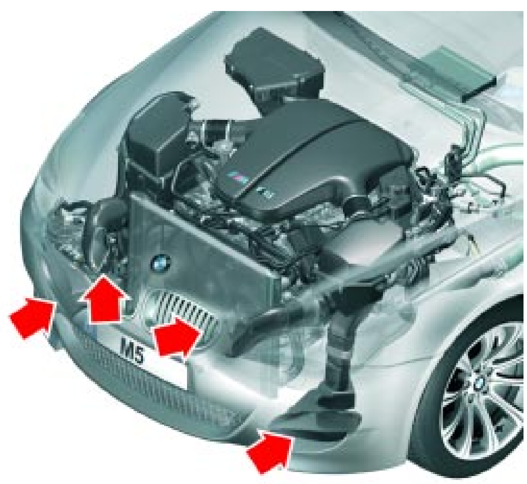
1. Cyclone separator

Cyclone separators are installed in the intake air plenums 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.



The S85 requires four air ducts in order to achieve maximum output. A large cross section is not possible due to space reasons.

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

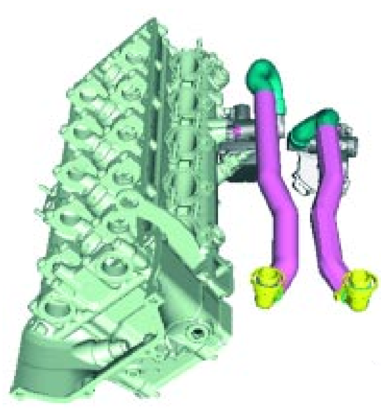
Throttle Valves

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.

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

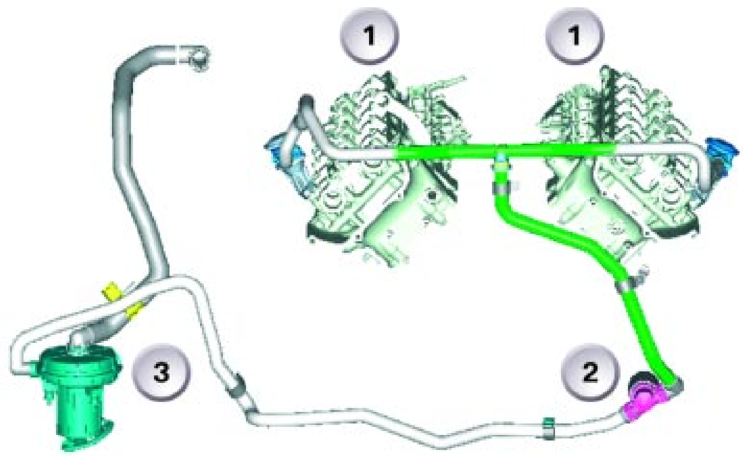
The idle speed is controlled by two idle speed actuators that route the intake air from the intake air manifolds directly into the idle air port of the respective cylinder head. Each cylinder bank is controlled individually.



Secondary Air System

In order to comply with LEV II standards, the S85 uses a secondary air system. The secondary air system helps reduce HC emissions during the cold start period. The catalyst warm-up time is also reduced.

The secondary air is injected into the exhaust ports via pressure controlled diaphragm valves on the cylinder heads. The air from the secondary air pump is routed through channels in the cylinder heads.



Index	Explanation	Index	Explanation
1	Diaphragm valve	3	Secondary air pump
2	Hose junction		

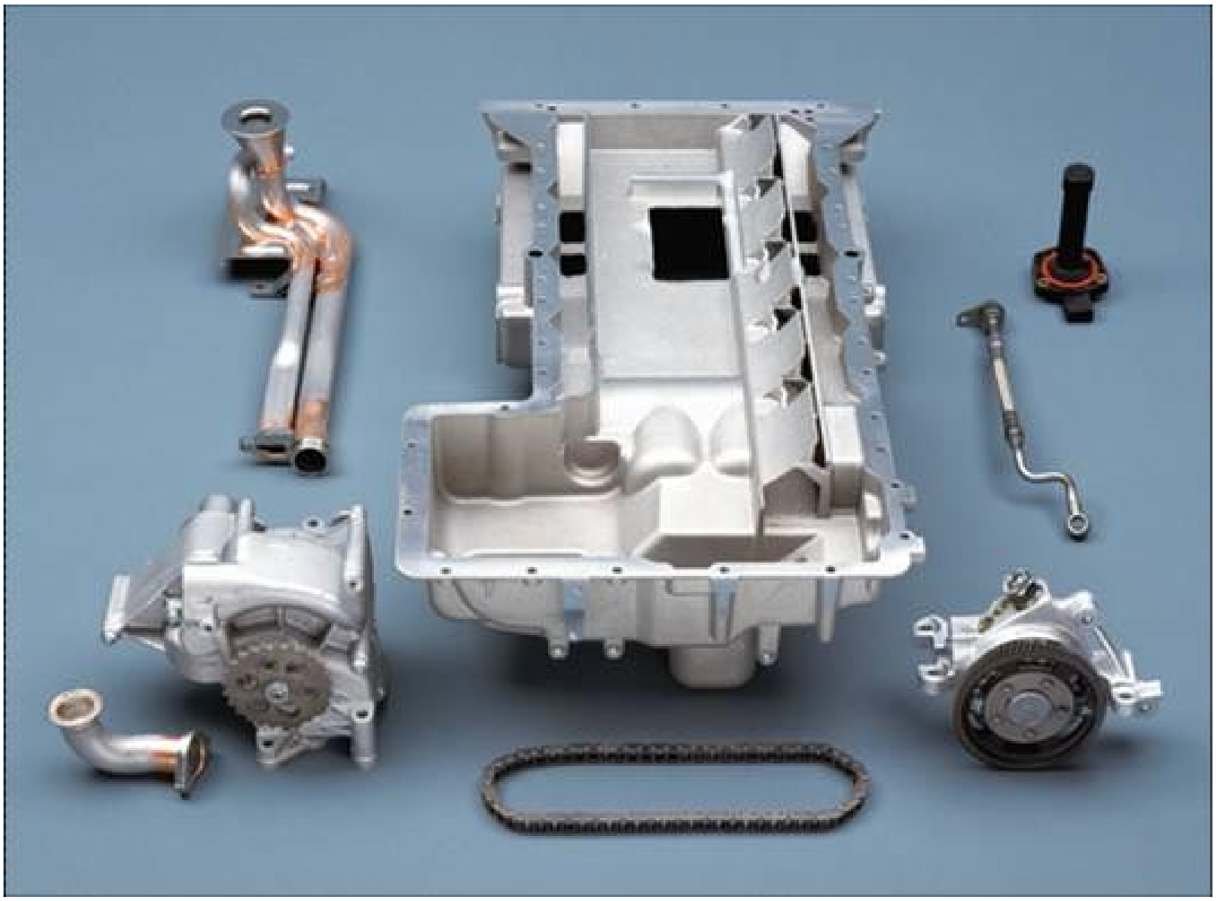
Exhaust System

The S85 is equipped with stainless steel exhaust manifolds. The manifolds are "hydroformed" and feature equal length tubes with a wall thickness of 0.8 mm. The tubes are configured as a 5-into-1 design with one "near-engine" catalyst per cylinder bank.

There are 2 pre-catalyst oxygen sensors for mixture control which are Bosch LSU 4.9. The two post-catalyst O2 sensors are Bosch LSF25. In addition there are 2 exhaust gas temperature sensors (one for each bank) for catalyst protection.

Lubrication System

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 maximum 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.

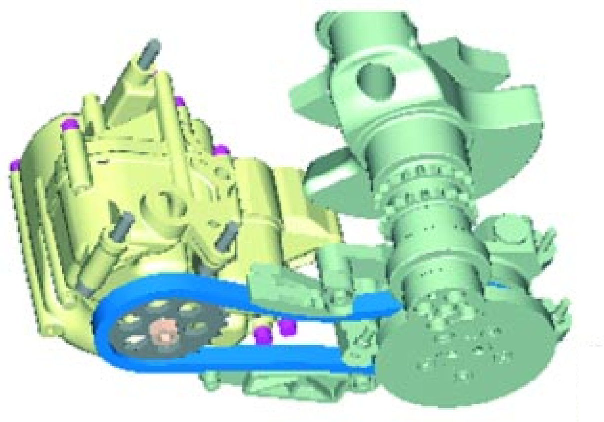
A special feature of this system are the two electrically driven oil pumps that are located on the left and right of the oil pan. The electric oil pumps start up at a transverse acceleration of 0.8 G and pump the oil from the cylinder heads which, under these centrifugal force conditions, would otherwise no longer flow back into the oil pan.

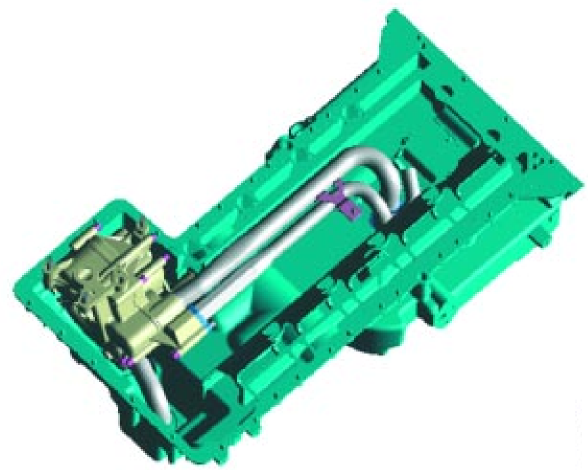
The crankcase is ventilated each with by a cyclone separator in the intake air manifold. The return flow line from the oil separator and the condensation return flow lines from the intake air manifolds are routed along the 6-10 cylinder bank of the crankcase into the oil sump.

Oil Pumps

Due to the race-inspired design of the S85 engine. the lubrication system has been adapted to meet the oiling needs during all operating conditions.

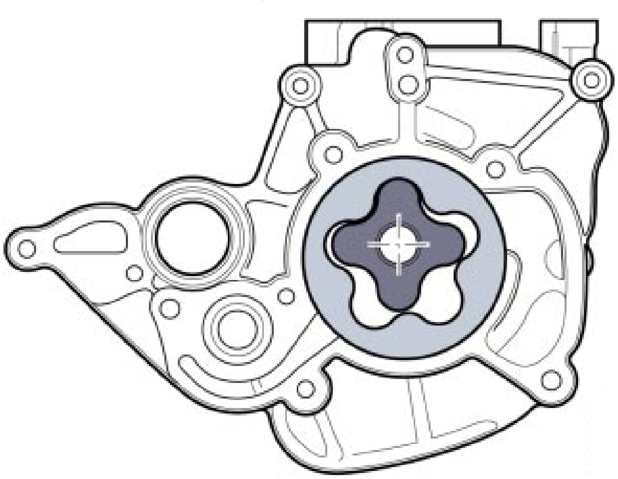
The primary oil pump is driven from a chain connected to the high pressure VANOS pump (which is driven via the gear-to-gear connection with the crankshaft). The oil pump housing accommodates two oil pumps. One of the pumps is a duocentric design which pumps oil from the front oil sump to the rear oil sump. This ensures that oil is in the rear sump at all times especially during hard braking.



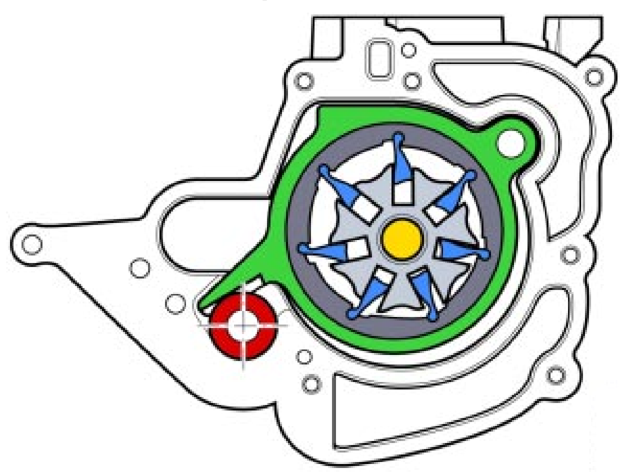


The other pump is a slide-valve design which has a variable displacement capability. The slide valve pump takes the oil from the rear sump and conveys it to the oil filter at a variable pressure of up to 5 bar.

Duocentric Oil Pump



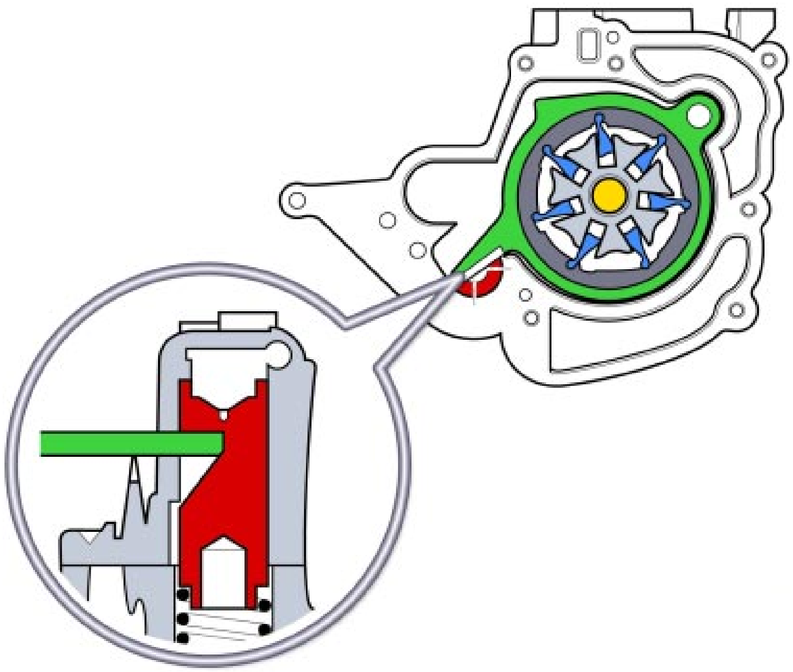
Slide Valve Oil Pump

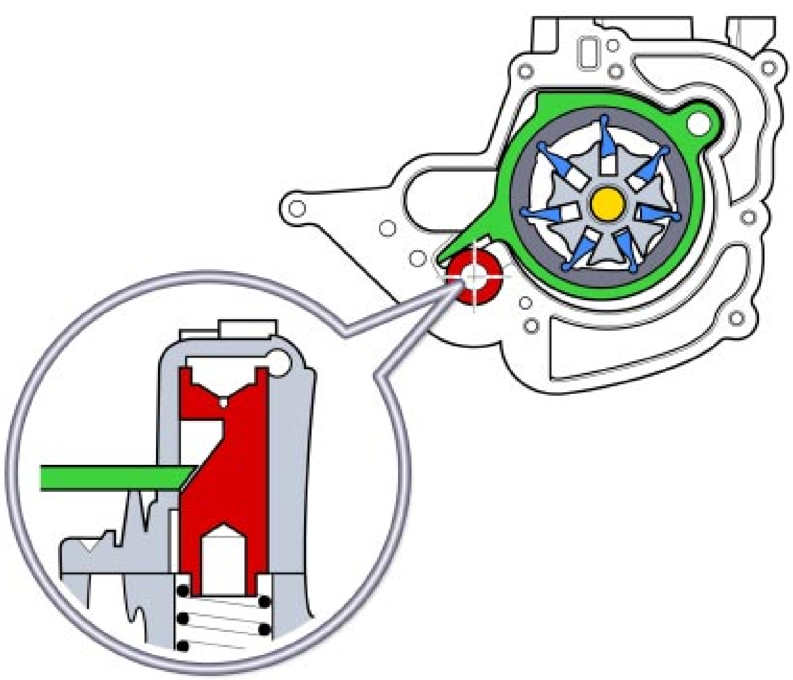


The pump outlet is determined by the eccentricity of the pendulum-type slide valve. No oil is delivered when the pump runs centrally with respect to the rotor as all pump chambers are the same size.

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.



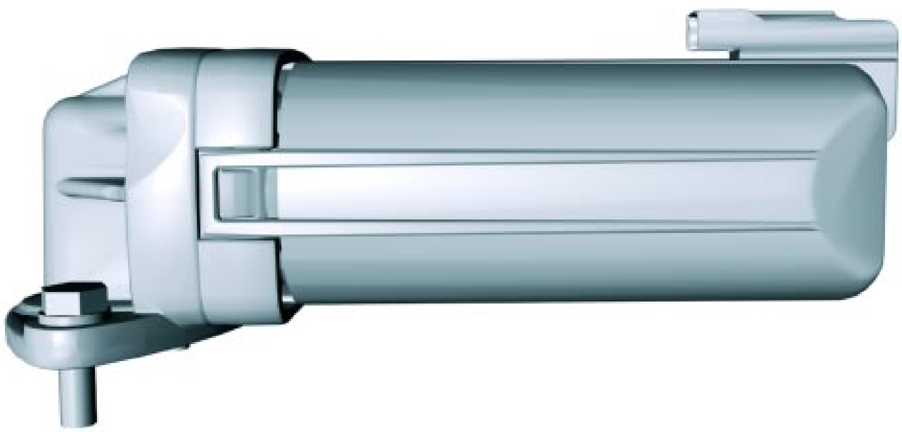


Electric Oil Pumps

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.

The filter housing is located behind the front bumper on the right side, near the secondary air pump.

The underbody panels must be removed during an oil service to access the oil filter.

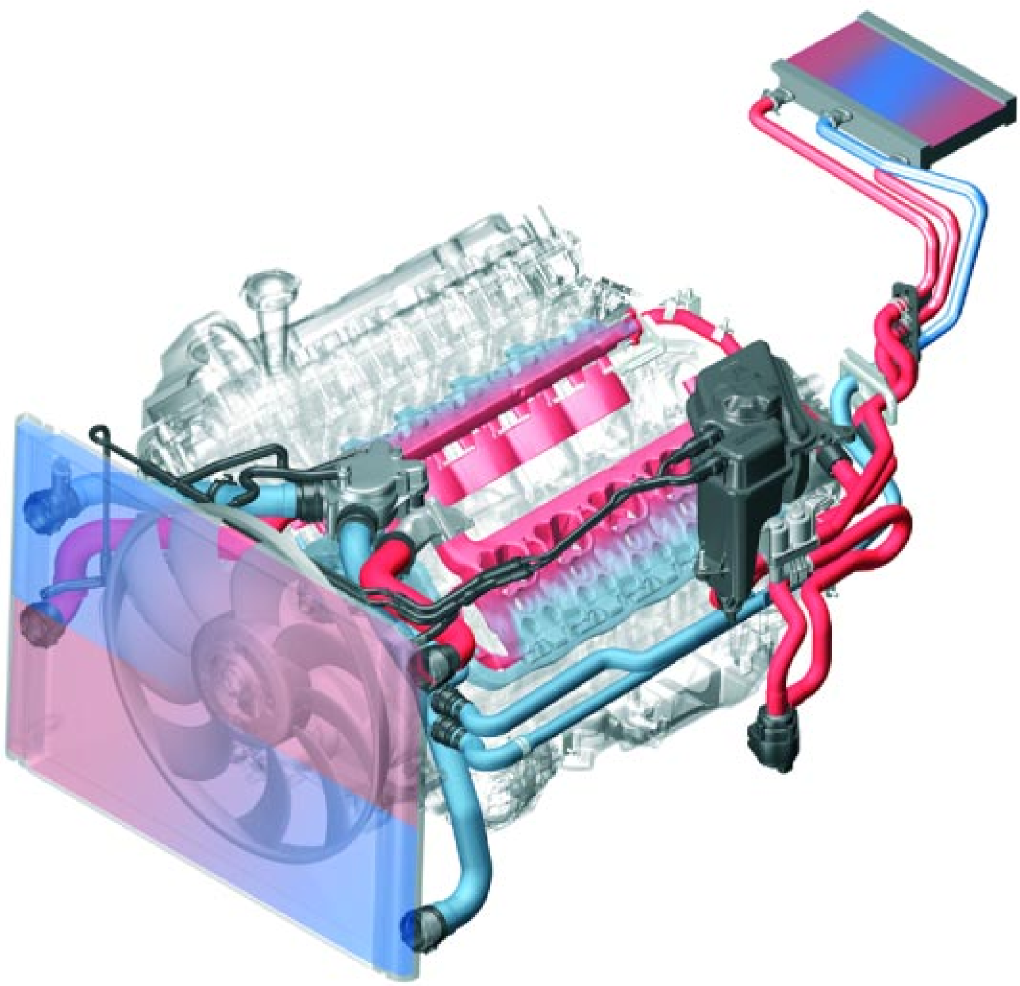
Cooling System

The cooling system uses the cross-flow technique, however there are some changes over previous systems. For instance, each cylinder head has it's own radiator feed and the coolant thermostat is located in the return flow line.

The radiator is divided into an upper and lower water tank. Coolant emerges from the Bank II (6-10) cylinder head through the upper water tank. Bank I (1-5) flows through the lower water tank.

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

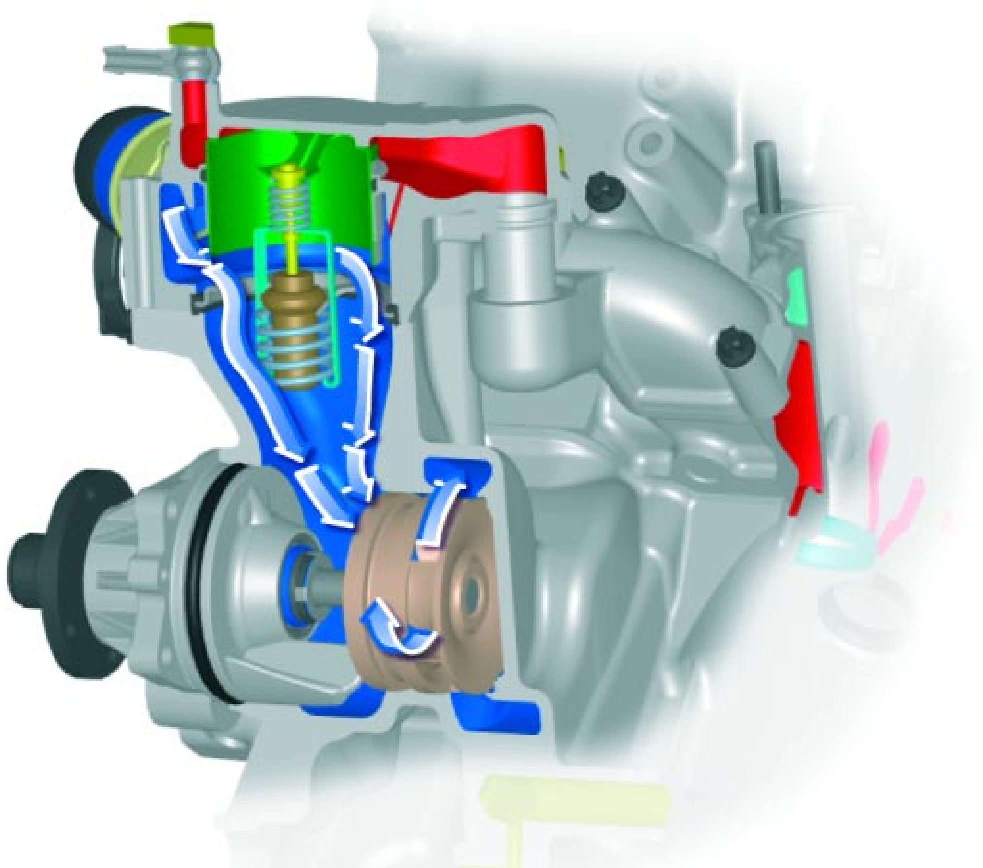
The tap-off point for the heating system is located at the rear of the cylinder heads. The heating return line and the line to the expansion tank merge at a "T-connection" ahead of the water pump.



Radiator

The radiator of the S85 is divided into an upper and a lower tank. The lower tank serves the purpose of cooling the coolant from Bank I (Cyl 1-5) while the upper water tank is responsible for cooling the cylinder Bank II (Cyl 6-10).

Due to the split design, it has been possible to reduce the pressure drop in the radiator from approximately 3 bar to approximately 1.4 bar.



Thermostat

Due to the two-part cooling concept, the thermostat has been relocated to the return line. It is designed as a conventional thermostat that opens at a temperature of 79ºC.

The coolant from the cylinder head enters the outlet 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.

Water Pump

The water pump is belt driven and it is located directly below the thermostat housing.

Classroom Exercise - Review Questions

1. Where are the color codes for the main bearing classification?

2. What is unique about the valve and valve keepers?

3. What are the advantages of a “box type” tappet?

4. What is unique about the camshaft drive mechanisms?

5. What drives the VANOS high pressure pump?

Classroom Exercise - Review Questions

6. Describe the oiling system on the S85: (i.e. how many pumps, what are the functions of the oil pumps etc.)

7. Where is the oil filter located?

8. What is unique about the cooling system?

9. Describe the construction of the crankcase:

10. What is meant by an “asymmetrical” connecting rod?

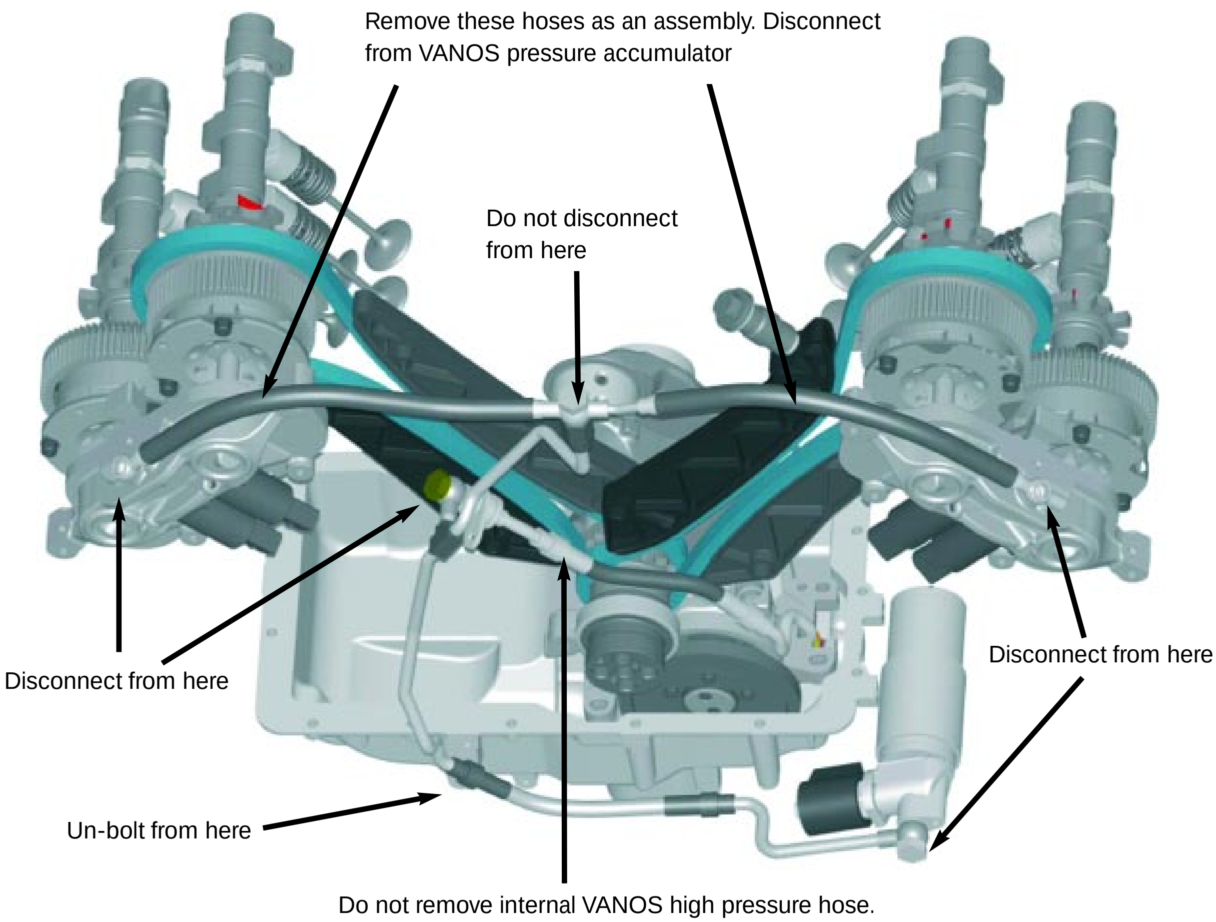
Workshop Exercise - Engine Disassembly

Using the instructor designated S85 engine trainer, remove the left and right intake air manifolds (plenum). Remove plastic trim covers from the cylinder head covers. Remove ignition coils and ionic current control units. Then proceed to remove ***both*** *cylinder head covers using proper repair procedures.*

What should be noted regarding the spark plug tubes?

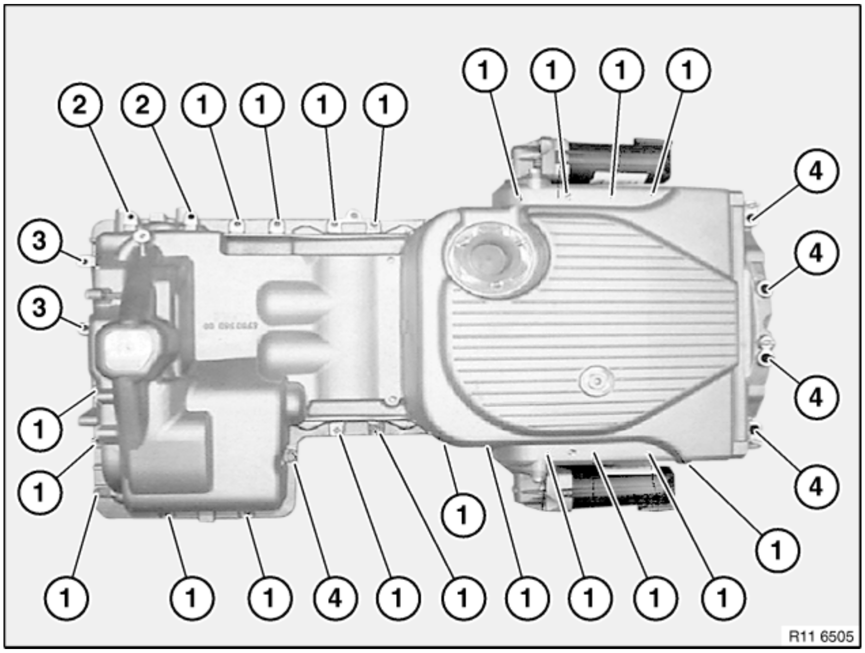
What is the purpose of the ground strap between the cylinder head cover and the engine block?

Proceed and remove VANOS high pressure hoses and the VANOS pressure accumulator. (Do not remove internal VANOS high pressure hose)



Workshop Exercise - Engine Disassembly

Invert engine on stand to remove oil pan. Pay close attention to bolt arrangement.



Complete chart below by filling in oil pan bolt descriptions:

Bolt #	Bolt Description (type and amount)
1	
2	
3	
4	

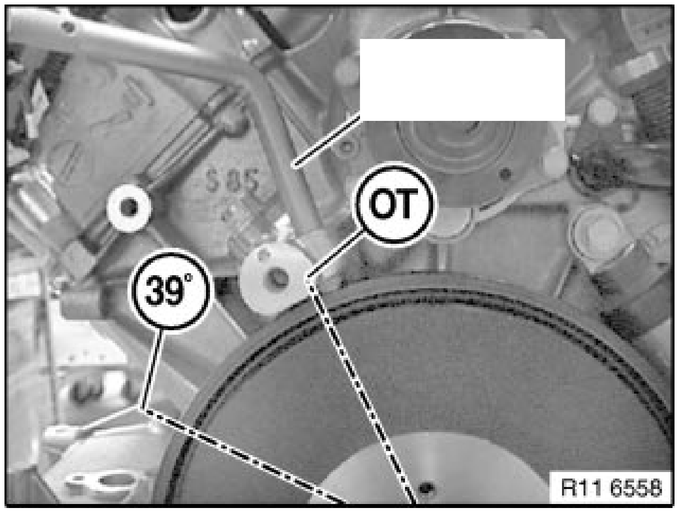
Once oil pan removal is complete, remove engine oil pump and VANOS high pressure pump.

What is the purpose of the shims under the VANOS high pressure pump?

What is the specification for VANOS pump gear backlash?

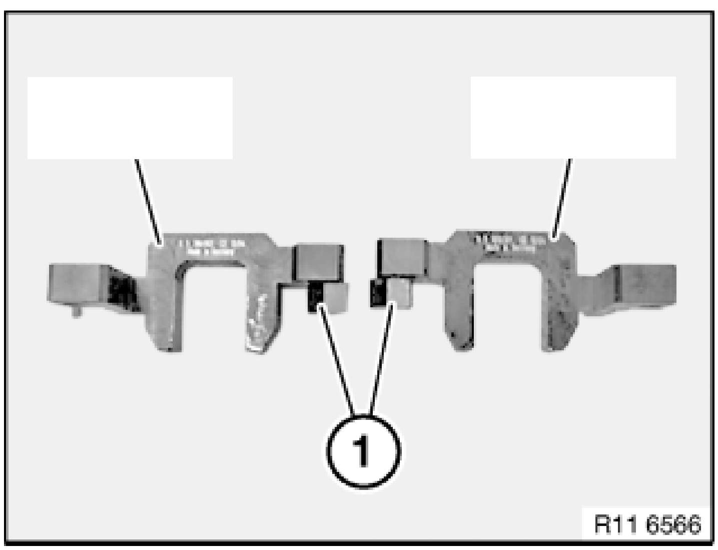
Workshop Exercise - Engine Disassembly

Invert engine to upright position and prepare to CHECK camshaft timing. Rotate engine to #1 cylinder at TDC (on compression stroke). Check to see if the numbers on the camshaft (dihedron) are facing upwards.



Lock engine in place at "OT" position using special tool. Fill in the special tool number in space provided above.

Proceed to check the INTAKE camshaft timing using special tools.



Write the part numbers in the spaces provided for the special tools shown above.

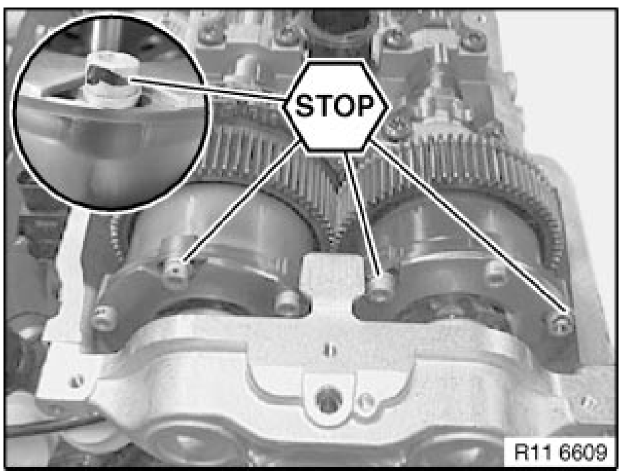
In the above illustration, what is the purpose of the spacers (1)?

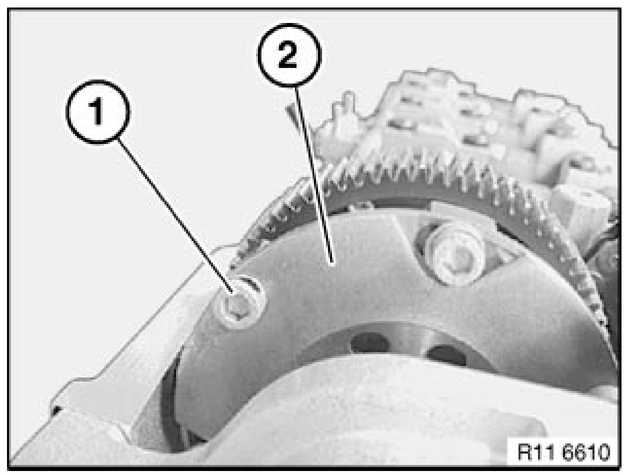
Workshop Exercise - Engine Disassembly

Rotate the engine to the 39 degree position and lock in place with special tool. Check the EXHAUST camshaft using the special tools.

When checking the camshaft timing (intake and exhaust), what is the maximum allowable protrusion of the special tool?

After checking the camshaft timing, proceed with removal of BOTH VANOS actuating units. Pay special attention to the removal procedure. ***Do NOT loosen bolts with washers or the cam timing will be affected (if the engine is rotated).***





Remove 6 bolts (reference #1 on graphic) on each VANOS adjusting unit, rotate engine to access all bolts on both banks. Proceed with removal of both VANOS adjusting units as per repair instructions.

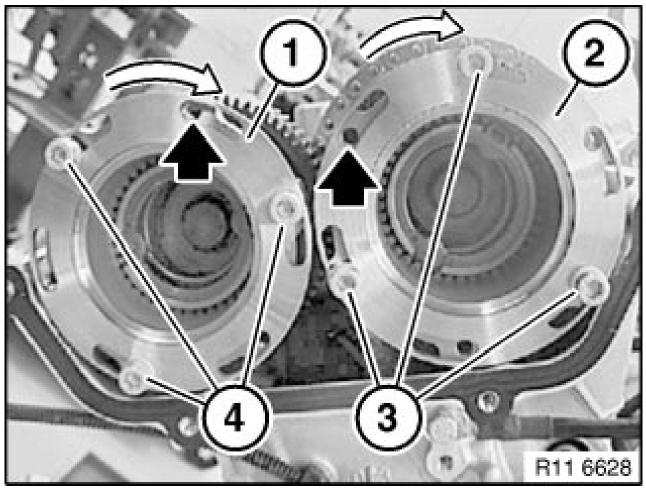
Once complete, return the engine to the #1 TDC position and proceed with removal of the bank I cylinder head (cyl 1-5).

Are the VANOS adjusting units bank specific? (can they be swapped from bank to bank?) Why or why not?

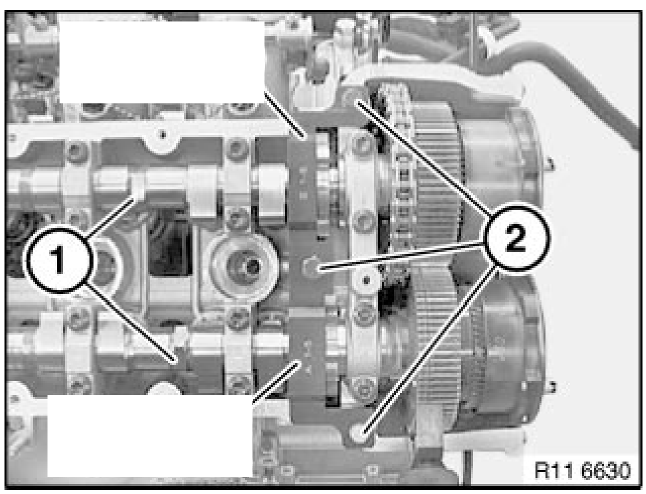
Workshop Exercise - Engine Disassembly

Remove both intake and exhaust VANOS gear (transmission) and both camshafts to facilitate cylinder head removal.

Install all necessary special tools to remove both VANOS gears.



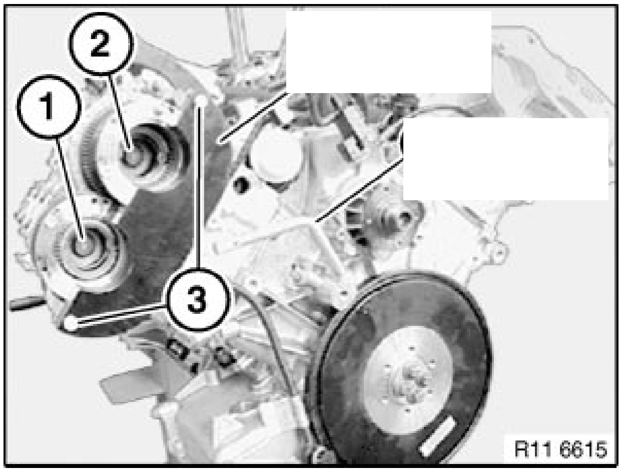
Loosen bolts (3 and 4) but do not remove. Rotate inner sleeve of VANOS gear to the left most stop (refer to graphic above - 1 and 2). Re-tighten bolts (3 and 4) to approximately 5 Nm.

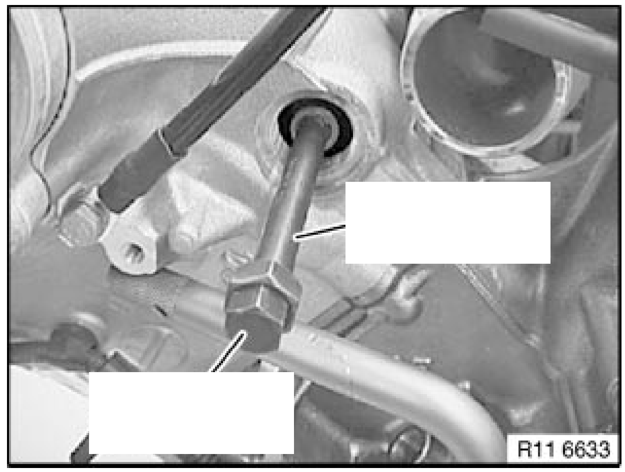


Install special tools as shown above, write correct tool numbers in spaces provided. Be sure to fully tighten all bolts (see 2 above).

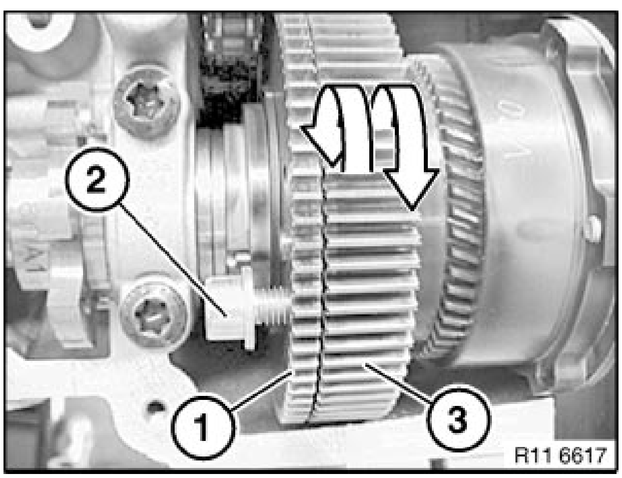
Workshop Exercise - Engine Disassembly

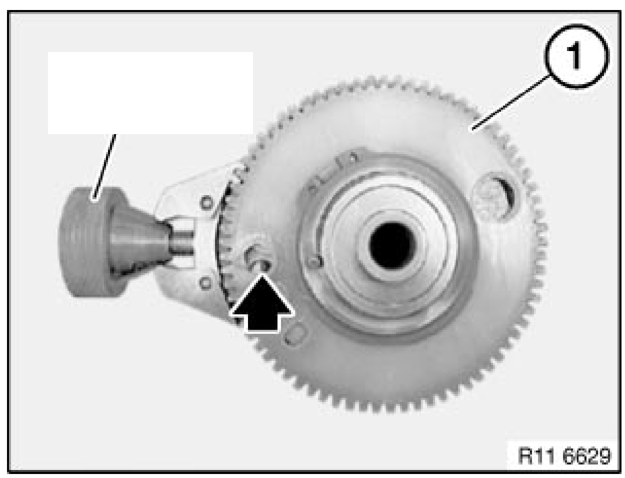
Install special tools as shown. Remove the right side chain tensioner and the bolt for the chain rail (on the cylinder head only). Fill in special tool numbers in the spaces provided below.





Install M8 X18mm lock bolt (2) on the exhaust VANOS gear as shown below. Tighten fully to prevent slippage of split gear mechanism (1 and 3).





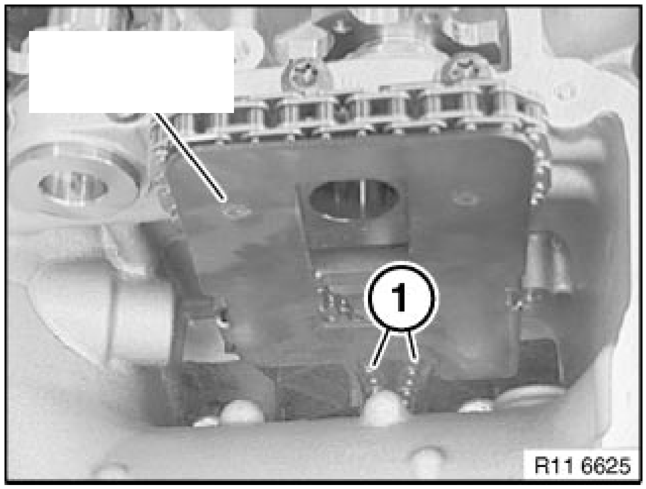
What is the purpose of the M8 x 18mm lock bolt?

What is the purpose of the special tool shown above (#1on right)? Record the part number of the tool in the space provided.

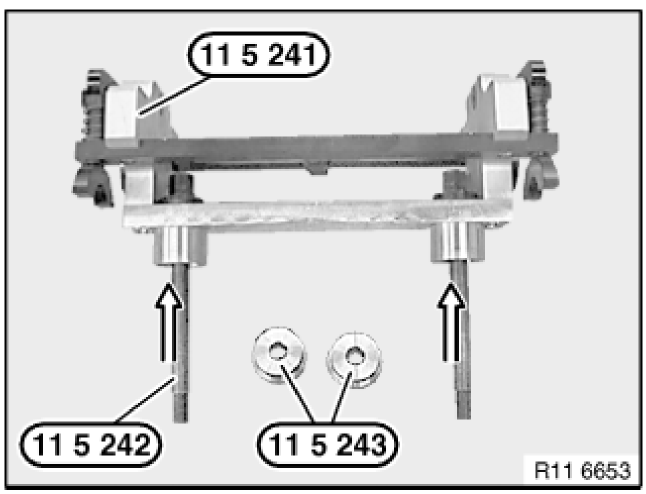
Workshop Exercise - Engine Disassembly

Remove both central bolts on the intake and exhaust VANOS gears. Remove exhaust VANOS gear first and set aside. Remove intake VANOS gear without dropping the timing chain.

Install special tool as shown below. Write in the correct tool number in the spaces provided.



Proceed with removal of the intake and exhaust camshaft using special tools.

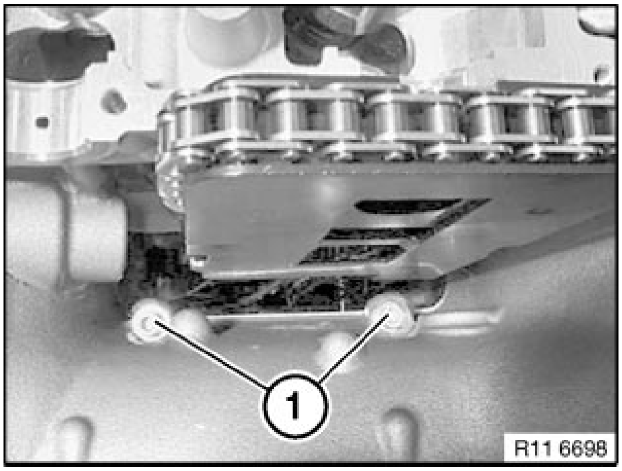


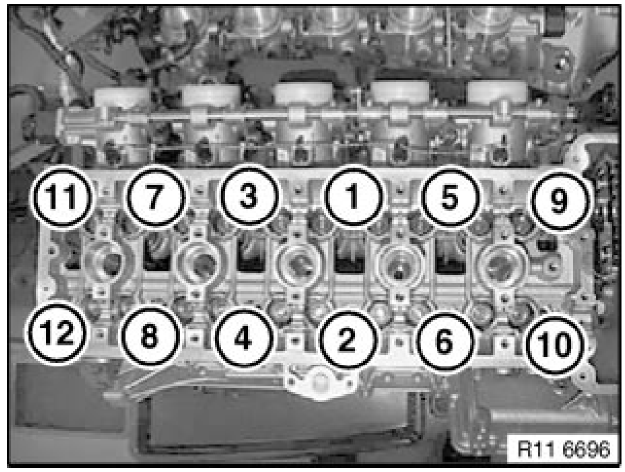
IMPORTANT!!!

When removing the intake camshaft, there are special tool inserts (115243) which should be installed into the camshaft removal tool (115241).
When removing the exhaust camshaft, the inserts (115243) should be removed from the tool.

Workshop Exercise - Engine Disassembly

Once the intake and exhaust camshafts are removed, remove the tappets (HVA) and proceed with head bolt removal. Loosen bolts in proper sequence (from 12 to 1). Retrieve all cylinder head bolt washers when removing head bolts.





Remove cylinder head and inspect piston installation for reference. Note coolant and oil passages.

What is the minimum thickness of the cylinder head? ______________________

Is it possible to machine the cylinder head sealing surface? ______________________

Re-install the cylinder head and tighten the head bolts in proper sequence (1-12). Since this is a trainer engine, do not tighten head bolts to full torque.

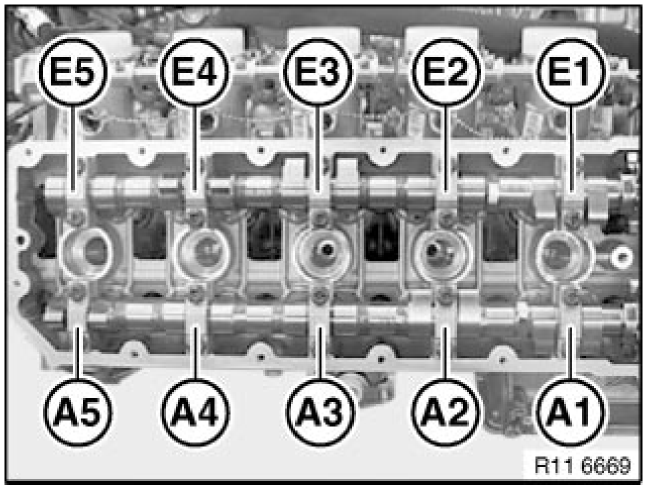
Fill in the chart below with the proper head bolt torque specifications.

Torque Specification (M10 X1.5X110 bolt)	**Measurement**
Joining Torque >	
Torque Angle >	
Torque Angle >	
Torque Specification (M6 bolt on front of cyl head)	**Measurement**
Torque	

Workshop Exercise - Engine Disassembly

Re-install tappets (HVA) noting the location of the “anti-torsion” pin. Proceed with installation of the intake and exhaust camshafts, starting with the exhaust camshaft.

Be sure to install camshafts with the numbers facing upwards and aligned to cam timing tools. Install camshaft bearing caps in proper order as shown below.



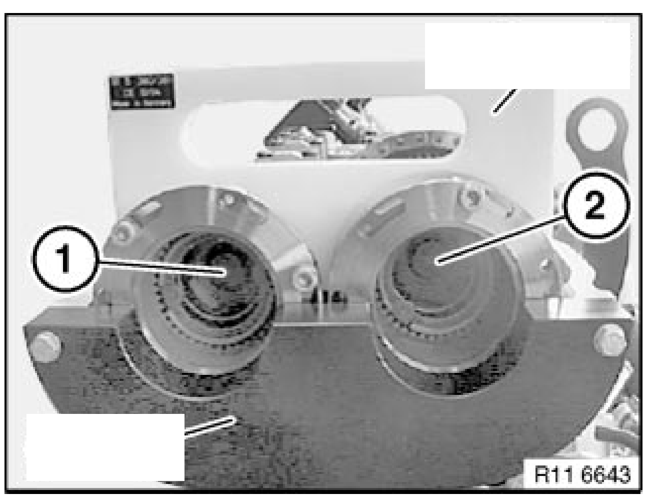
Depress camshafts with special tool and secure bearing caps. Do not tighten the camshaft bearing caps to full specification on the trainer engine.

Once the camshaft installation is complete, proceed with the installation of the intake and exhaust VANOS gears. Install intake VANOS gear first.

Ensure that the timing chain does not bind during installation.

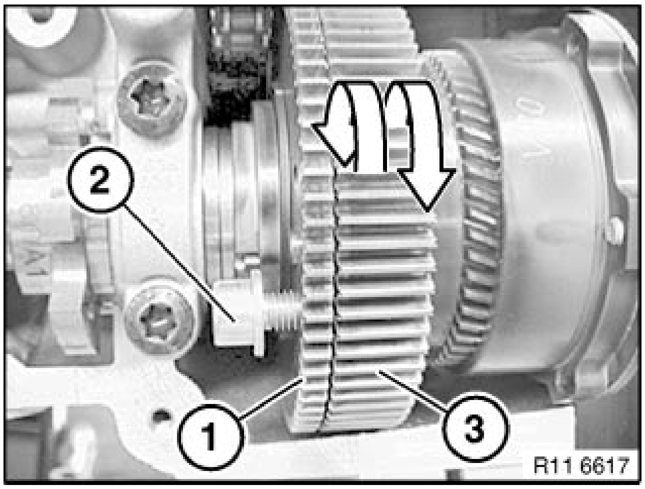
Install special tools as shown below. Be sure that the camshaft locking tools are still in place before tightening the camshaft central bolts.

Tighten camshaft central bolts to the proper specification and remove special tools.

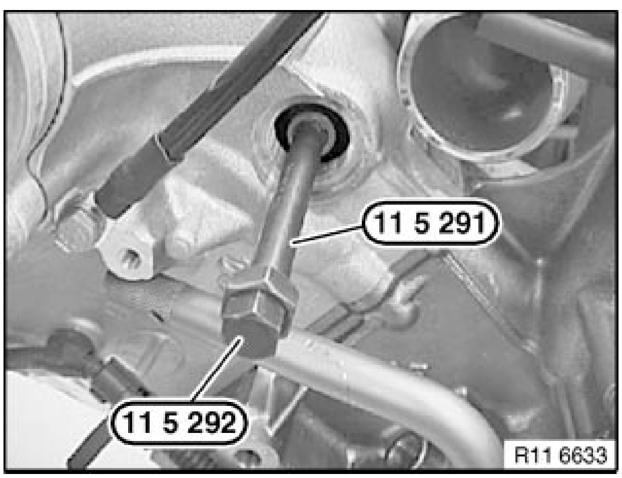


Workshop Exercise - Engine Disassembly

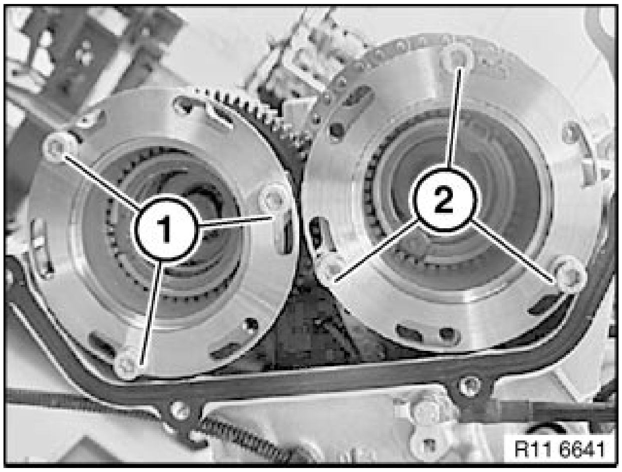
Note: Before proceeding, remove M8 X 18mm lock bolt (2) as shown below.

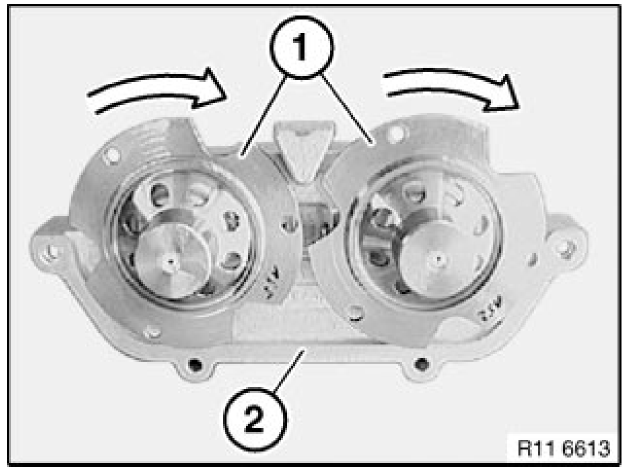


Re-install bolt for timing chain guide rail and install timing chain tensioner. Proceed with installation of the VANOS units.

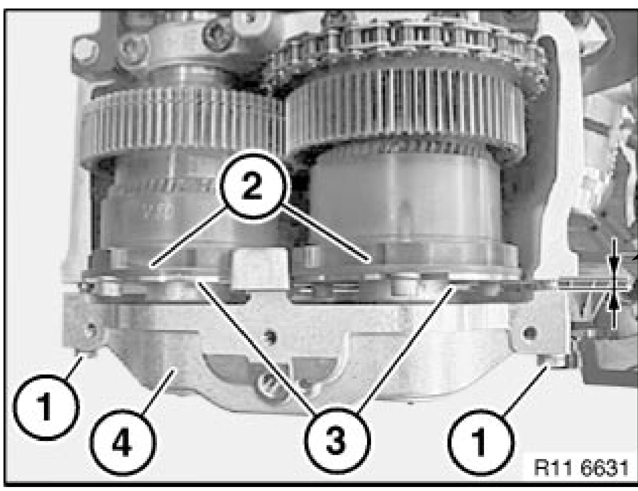


Workshop Exercise - Engine Disassembly





Loosen bolts (see above left picture1 and 2) 90 degrees. Before installing VANOS adjusting unit, ensure that the thrust plates (see above right - 1) are fully retracted and rotate freely without binding.



Note: There should be an gap of approximately 8mm at this point during installation.

*Install VANOS adjusting unit (with gasket). Position the adjustment unit using the outer bolts (1), but **do not tighten** bolts. Ensure that the VANOS gears (2) are fully extended. Align thrust plates (3) and make sure that the thrust plates are flush with the VANOS gears. Install the (exposed) hex (Allen) bolts, tighten and then loosen 90 degrees.*

Before tightening the bolts (1) for the VANOS unit, ensure that all of the hex (allen) bolts (with and without washers) are loose. Tighten bolts (1) in increments of 1/2 turn.

While tightening bolts (1) observe that the outer sleeves will rotate and retract 8mm.

Workshop Exercise - Engine Disassembly

Once the VANOS adjusting unit has been seated and all bolts tightened. Proceed with the final installation and tightening of the hex (allen) bolts.

Note: Do not rotate engine unless the hex (allen) bolts are tight. Before rotating the engine, tighten the exposed bolts. Failure to do so will alter camshaft timing.

Tighten all bolts (with and without washers) to 10Nm. Rotate the engine through 120 degree increments to access all bolts.

Continue with installation of the Bank ll (6-10) VANOS unit by following the same steps.

At this point, CHECK the camshaft timing. If not correct, proceed with necessary steps to ADJUST camshaft timing.

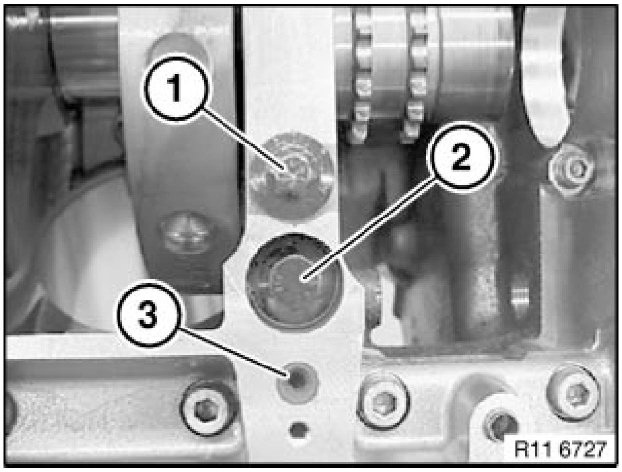
Re-install cylinder head covers, ignition coils and the ionic current control units.

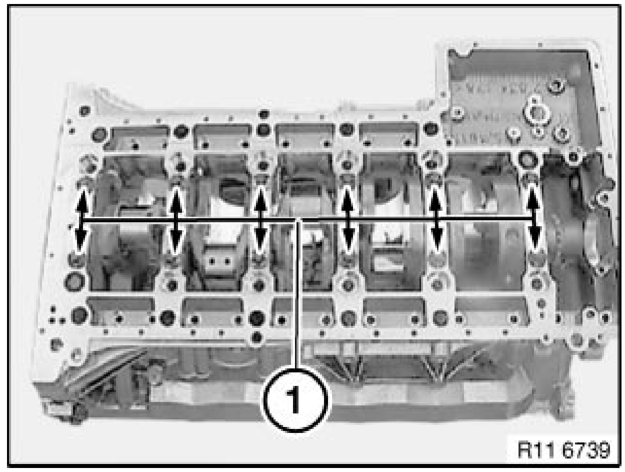
What is the correct torque specification for the cylinder head cover bolts?

What should be noted regarding the installation of the ionic current control units?

Workshop Exercise - Engine Disassembly

Invert engine for access to bedplate. Proceed with removal of bedplate assembly.





First remove all M8 fit bolts (#2 - above left) completely from engine. Next, remove the M11 main cap bolts (#1- above right). Then proceed by removing the remainder of the hex (allen) bolts.

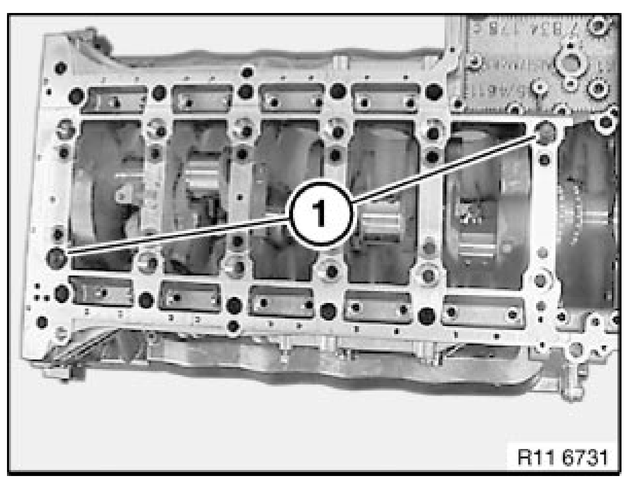
Then remove the bedplate, paying close attention to the main bearing installation position. Take this opportunity to review engine construction, look over oil passages and bedplate sealing grooves etc.

Proceed with re-installation of bedplate.

Note: Bedplate does note use locating dowels, the M8 "fit" bolts provide the locating reference for the bedplate. Therefore proper installation is critical to prevent engine damage.

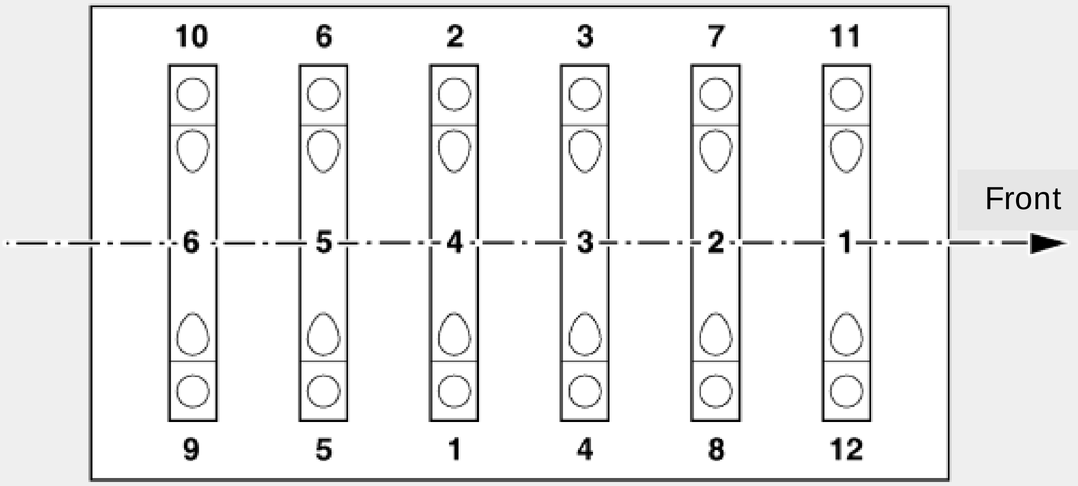
Install bedplate as shown on right. Install two M8 fit bolts diagonally as shown on right.

Tighten only the two M8 bolts to 8 Nm.



Workshop Exercise - Engine Disassembly

Bank 1 Cylinders 1-5 (as viewed from underneath)



Bank 2 Cylinders 6-10 (as viewed from underneath)

Proceed and install all, M11 main bearing cap bolts. And tighten in sequence (on the trainer engine only tighten to 30Nm).

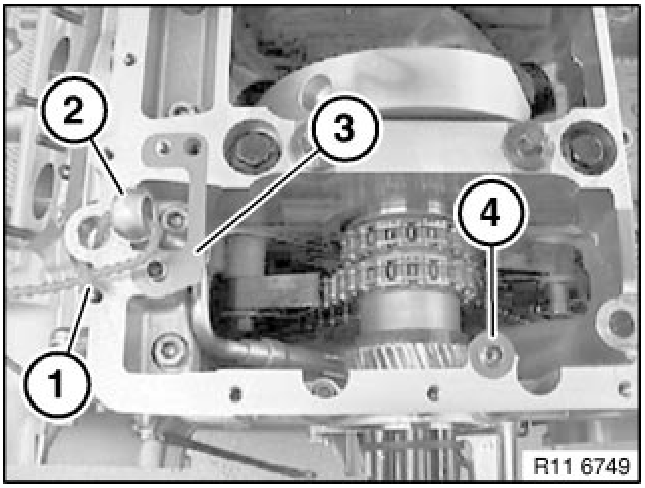
What is the difference in the tightening procedure between “old” main cap bolts and “new” main cap bolts?

Install the M8 “fit” bolts and tighten in sequence (For trainer engine only tighten to 15Nm)

Install remaining bolts, tighten in sequence. (minimum torque).

Workshop Exercise - Engine Disassembly

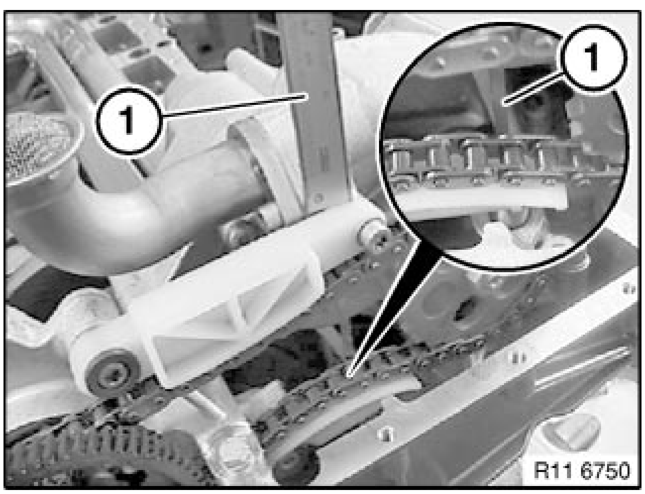
After bedplate installation is complete, proceed with the installation of the engine oil pump and VANOS high pressure pump.



Re-install VANOS pump, note installation position of the shims (3 and 4 above).

What special tool is used to check the “backlash” of the VANOS pump gear? And, what is the backlash specification?

Re-install engine oil pump as per repair instructions. Measure travel of chain tensioner piston as shown.



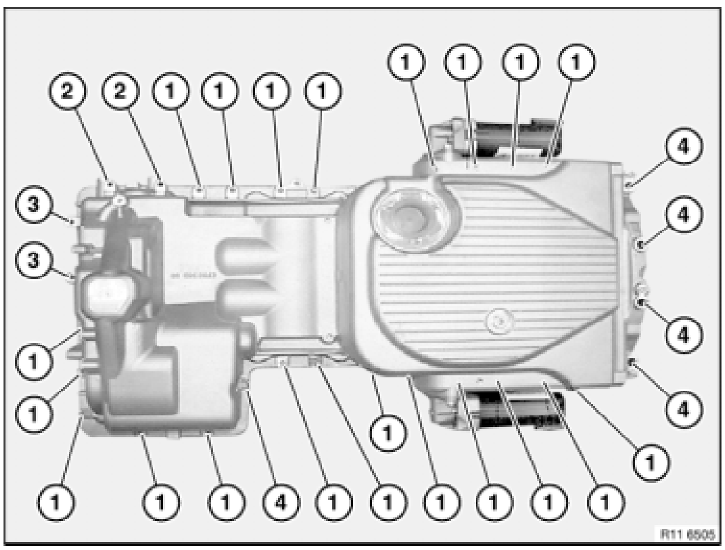
What is the specification for the travel of the chain tensioner?

Workshop Exercise - Engine Disassembly

What is the specification for the travel of the chain tensioner?

If the chain tensioner travel is out of specification, how is it adjusted?

Re-install oil pan and observe proper bolt installation. Record bolt descriptions and bolt torque in the chart below.



Bolt #	Bolt Description (type and amount)	Torque Specification
1	M6 X 22 Hex Bolt (10mm) 23 bolts total	
2	M6 X 40 Hex Bolt (10mm) 2 bolts total	
3	M6 X 75 Hex screw T30 Torx 2 bolt total	
4	M6 X 22 Hex Screw T30 Torx 5 bolts total	

Re-attach VANOS high pressure hoses.

Re-install trim covers and intake plenum.

Check over engine and re-install any additional items such as harmonic balancer etc.

Classroom Exercise - Review Questions

1. Is it possible to remove the cylinder head without removing the camshafts? (Why or Why not?)

2. What is the difference between TDC and the “39 degree” position?

3. What is the purpose of the “split gear” on the exhaust VANOS gear?

4. When removing the exhaust camshaft, what should be done to the special tool 115 241 and why?

Classroom Exercise - Review Questions

5. What bolts should be replaced when performing the R&R of the VANOS gears?

6. What is the purpose of the M8 “fit” bolts on the bedplate assembly?

Notes:

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MS_S65 Engine Management System

Model: All with S85 engine

Production: All

OBJECTIVES

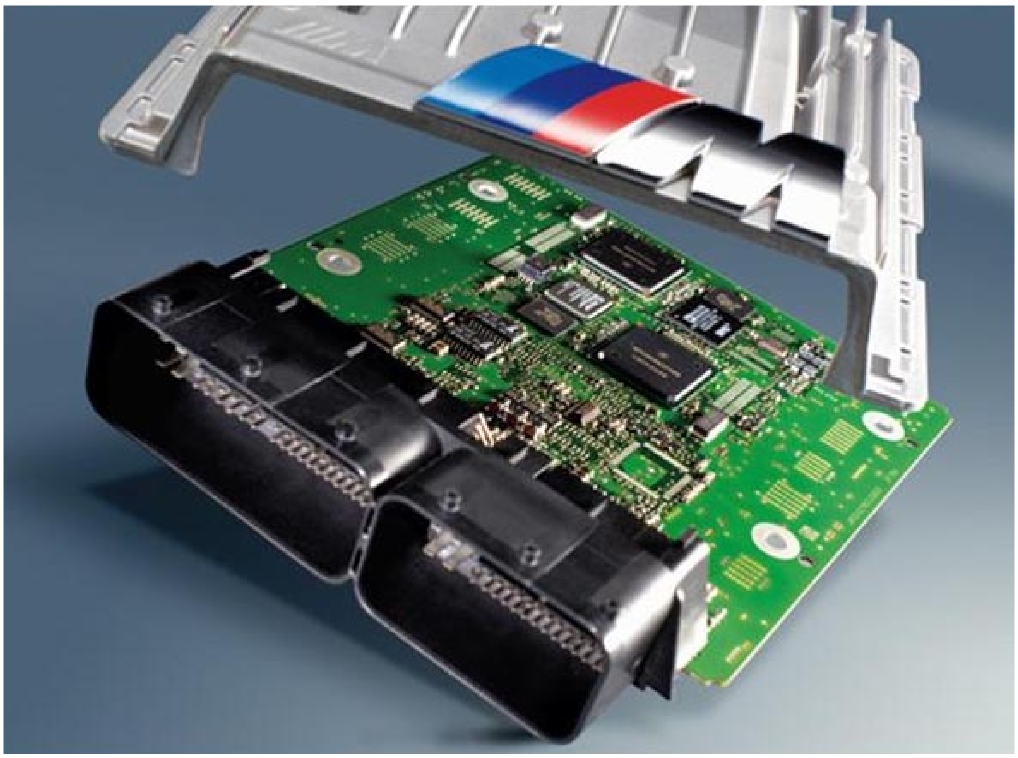
After completion of this module you will be able to:

- Understand the construction of the S85 V-10 engine
- Identify and locate components related to MS_S65 engine management
- Perform basic procedures related to MS_S65 engine management
- Diagnose concerns related to MS_S65 engine management

Introduction

In order to meet the demands of the S85 engine, the new Siemens MS_S65 engine management system has been developed in conjunction with the BMW Motorsport division. The high-revving S85 engine package still manages to comply with the EPA LEV 2 standards while maintaining reasonable fuel economy.

This is only possible in conjunction with "world-class" engine management. The DME control unit in the MSS65 engine system boasts the most powerful ECM to date. The MSS65 system is a further development of the current MSS54 engine management with some notable improvements.

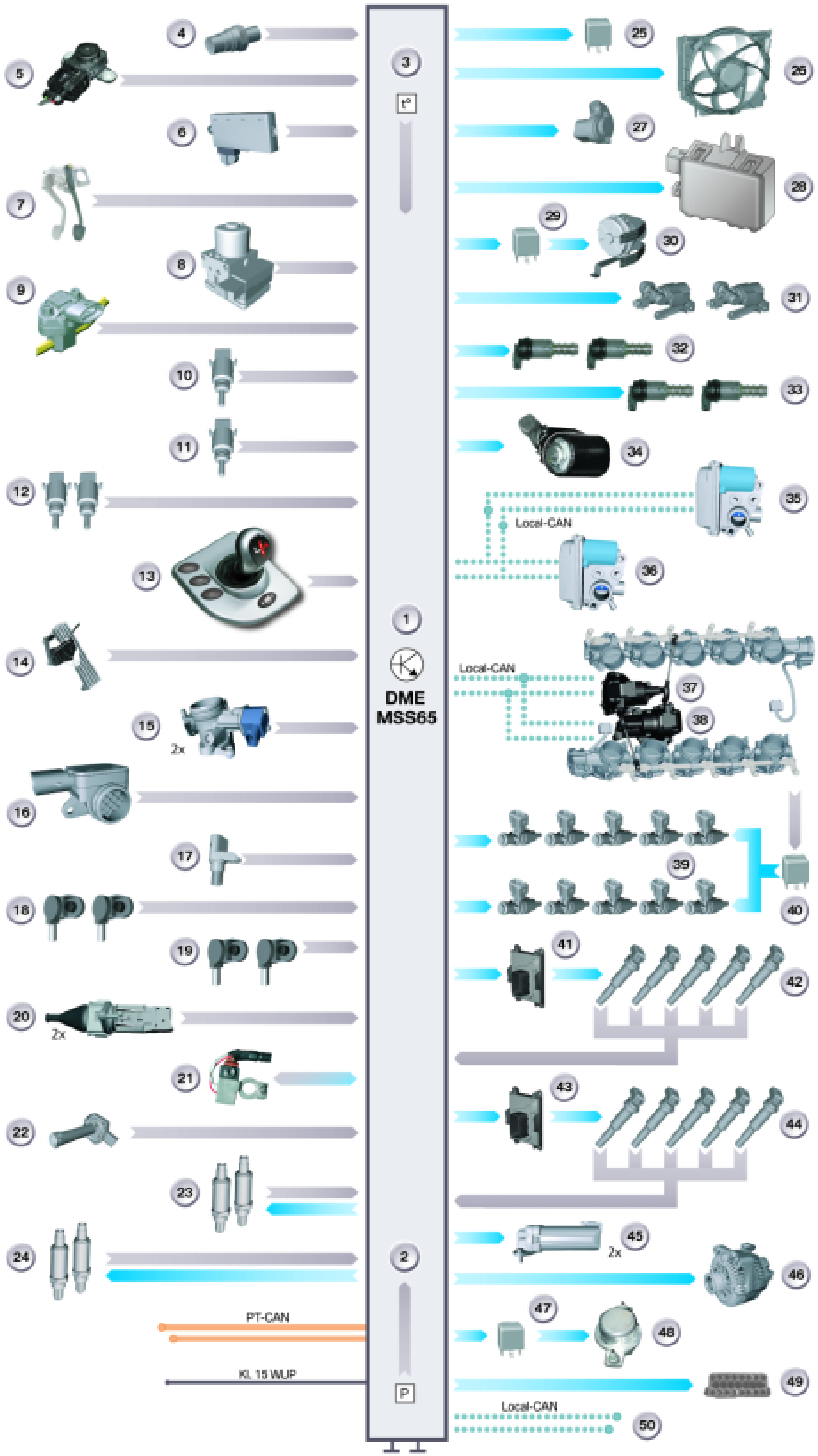


The ECM uses a multi-layer circuit board with over 1000 individual parts. There are three 32 bit processors which allow a combined capability of over 200 million engine calculations per second.
The ECM is also responsible for monitoring over 50 input signals.

Some of the functions of the new engine management include:

- Control and synchronization of 10 individual throttles
- Control of 2 electric oil "scavenging" pumps during cornering
- Demand oriented fuel delivery controlled by engine management
- The use of "ionic current measurement" for knock control and misfire detection

MS_S65 System Overview



Legend for MS_S65 System Overview

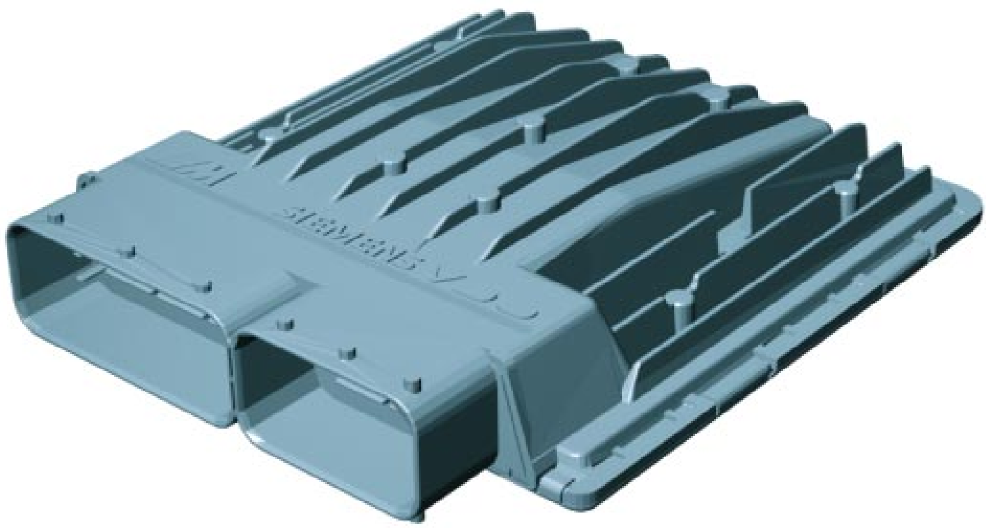
Index	Explanation	Index	Explanation
1	Engine Control Module (DME)	26	Engine Cooling Fan with Final Stage
2	Ambient Pressure Sensor	27	E-Box Cooling Fan
3	Ambient Temperature Sensor	28	EKP Module
4	Oil Pressure Switch	29	Secondary Air Pump Relay
5	Differential Pressure Sensor (X2)	30	Secondary Air Pump
6	Car Access System (CAS)	31	Fuel Tank Vent Valve (Purge Valve I and II)
7	Brake Light Switch (BLS)	32	VANOS Solenoids Bank I
8	Dynamic Stability Control (DSC)	33	VANOS Solenoids Bank II
9	Fuel Pressure Sensor	34	VANOS Pressure Accumulator
10	Radiator Outlet Temperature Sensor	35	Idle Control Valve (LLS) Bank I
11	Coolant Temperature Sensor	36	Idle Control Valve (LLS) Bank II
12	Exhaust Gas Temperature Sensor (Bank I and II)	37	Throttle Control Motor (EDR) Bank I
13	Power Button	38	Throttle Control Motor (EDR) Bank I
14	Accelerator Pedal Module	39	Fuel Injectors (Bank I and II)
15	Throttle Valve Sensor (I and II)	40	Fuel Injector Relay
16	Mini HFM (for secondary air system)	41	Ionic Current Control Unit (Bank I)
17	Crankshaft Position Sensor	42	Ignition Coils (Bank I)
18	Camshaft Position Sensors (Bank I)	43	Ionic Current Control Unit (Bank II)
19	Camshaft Position Sensors (Bank II)	44	Ignition Coils (Bank II)
20	Hot Film Air Mass Meter (Bank I and II)	45	Electric Oil Pumps (I and II)
21	Intelligent Battery Sensor (IBS)	46	Alternator
22	Oil Condition Sensor (OZS)	47	Vacuum Pump Relay
23	Pre-Catalyst Oxygen Sensor (Bank I and II)	48	Vacuum Pump
24	Post-Catalyst Oxygen Sensor (Bank I and II)	49	DLC (Diagnostic Connector)
25	ECM (DME) Main Relay	50	Local CAN (Lo-CAN) to SMG

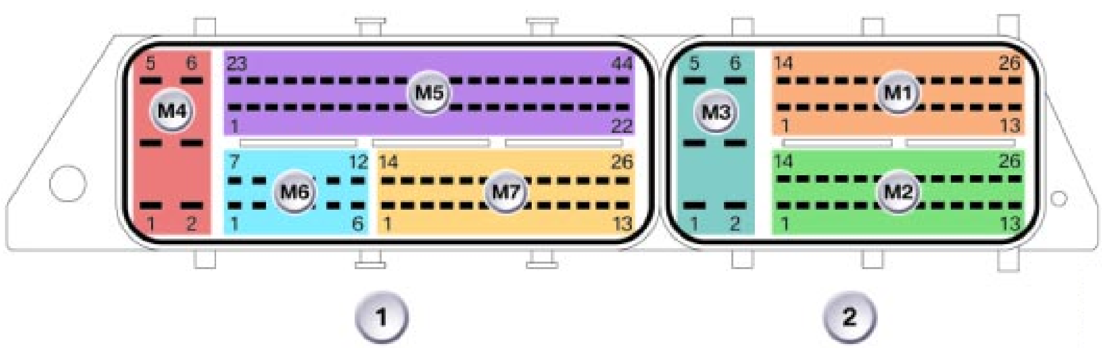
Components

Control Module

The MS_S65 engine control module is manufactured by Siemens/VDO. The “MS S” designation indicates that it is a Siemens/Motorsport engine management system.

The control module features an all-aluminum housing with a new modular connector configuration. The control unit has two main connectors, one with 4 modular “sub” connectors and the other with 3 for a total of 7 “sub” connectors.

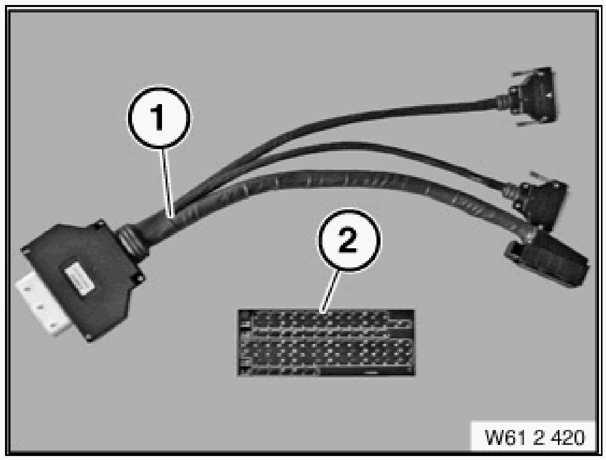


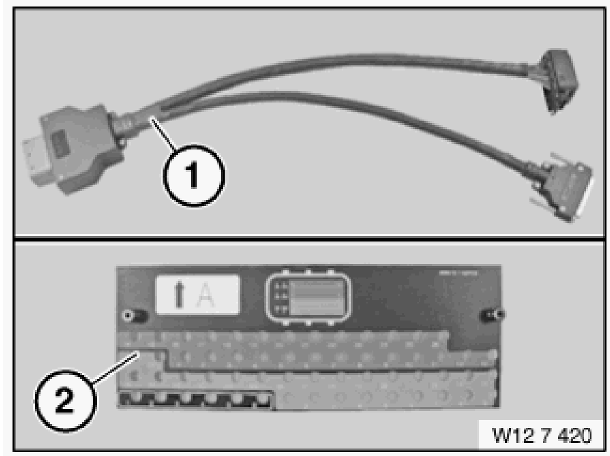


Index	Explanation	Index	Explanation
1	Connector X60004 to X60007	M4	Connector module 4 (6 pins)
2	Connector X60001 to X60003	M5	Connector module 5 (44 pins)
M1	Connector module 1 (26 pins)	M6	Connector module 6 (12 pins)
M2	Connector module 2 (26 pins)	M7	Connector module 7 (26 pins)
M3	Connector module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

Processor Power

The computing power has been increased to meet the needs of the “high-revving” S85 powerplant. The ECM is capable of more than 200 million calculation per second. This is accomplished with three - 32 bit processors and a multi-layer circuit board with over 1000 individual parts.



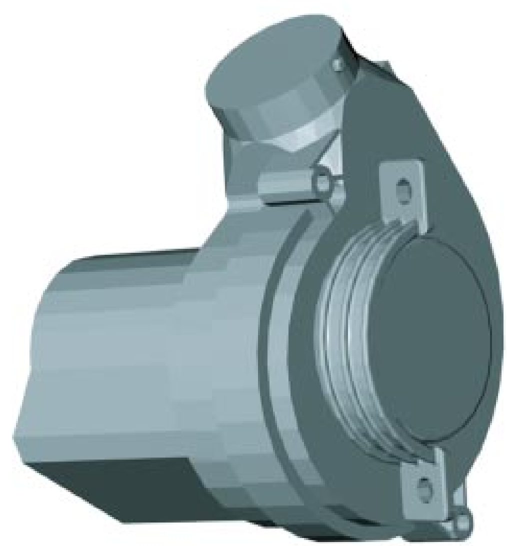


Adapter Cables

The MS_S65 ECM requires the use of special breakout box adapter cables. These are carried over from the MSV70 engine management. These adapter are used with overlays to properly identify the pin connections during diagnosis.

E-Box Fan

The E Box fan is controlled by ECM. The ECM contains an integral NTC temperature sensor for the purpose of monitoring the E box temperature and activating the fan.



When the temperature in the E-Box exceeds predetermined values, the ECM provides a switched ground for the E Box fan to cool the E box located control modules.

With every engine start-up, the ECM briefly activates the fan ensuring continued fan motor operation for the service life of the vehicle. This feature is intended to prevent fan motor “lock up” from lack of use due to pitting or corrosion over time.

Power Supply

Terminal 30 (KL30) Battery Voltage

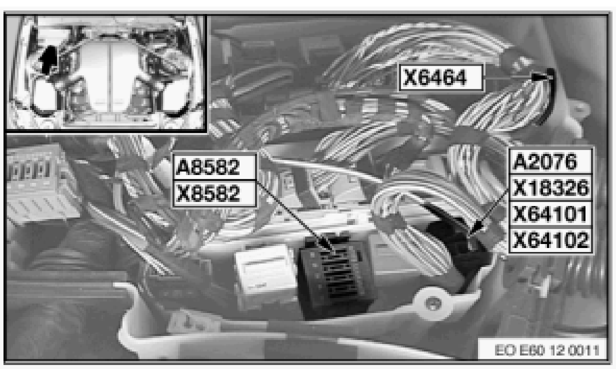
The B+ power supply to the ECM comes from a 7.5amp fuse. On the M5 and M6, KL30 comes from fuse #26 (F26) which is located in the front fuse holder behind the glove box.

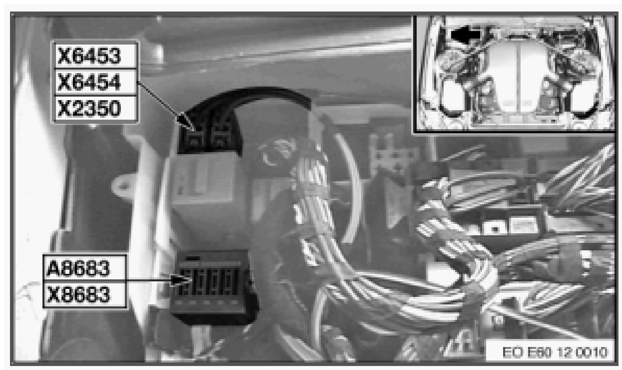
Engine Fuses

The engine electronics fuses are located in the E-box. However, there are now three separate fuse carriers in the E-Box. These fuses are supplied by KL87 from the ECM main relay.

The three fuse carriers are designated A8582, A8683 and A8680. The fuses in these carriers are designated as follows:

Fuse Carrier	Fuses
A8582	F02, F03, F04, F05
A8683	F001, F002, F003, F004, F005
A8680	F1a





Terminal 15 (KL15)

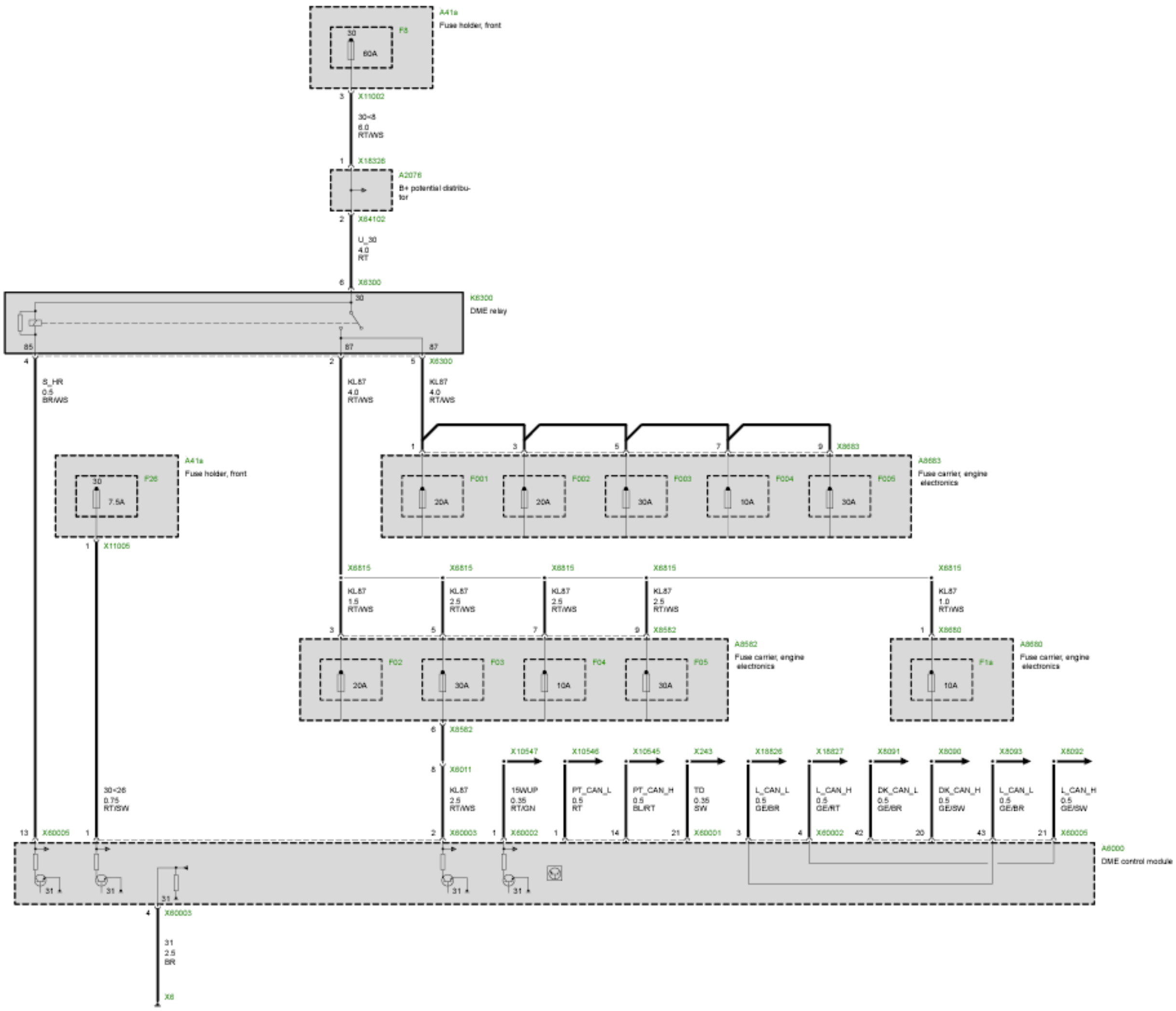
As with previous vehicles equipped with PT-CAN, the ECM receives a KL15w via the bus network and a “hardwire” KL15 wake-up signal directly from the CAS.

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

Ground (KL31)

There is a KL31 connection to the ECM at connector X60003 pin #4.

Power Supply Schematic



Interfaces

The M5 and M6 continue to use the familiar PT-CAN bus. However, there are two new “local” CAN bus networks. One is for the throttle motor control (DK-CAN) and the other for the idle system control (LL-CAN). The LL-CAN is also connected to the SMG as well.

The Bit-serial data interface (BSD) connects the ECM to the oil condition sensor (OZS), intelligent battery sensor (IBS) and the generator.

Air Management

Throttle System

As with previous “M” engine designs, there are individual throttles for each cylinder. The throttles are “bank” controlled via two EDR actuators (1 per bank). The 5 throttle valves on each bank are mechanically coupled with each other. Also, each cylinder bank has an idle control valve. Therefore, there are a total of 4 actuators for engine intake air control.

The two throttle actuator motors (EDR) and two idle control actuators (LLS) are connected to the ECM via separate local CAN bus systems. The throttle valve actuators are connected to the DK CAN and the idle speed actuators are connected to the LLS/SMG CAN.

Throttle Valve Actuator

One actuator motor (EDR actuator) moves five mechanically coupled throttle valves on each cylinder bank. Each actuator consists of an electric motor with a gear mechanism and internal electronics.

The electronic control module within the EDR actuator allow the ECM (DME) to control, monitor and diagnose the throttles via the DK CAN connection.

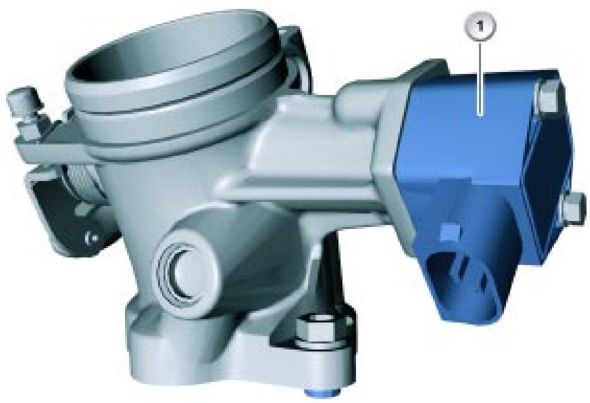
Due to the CAN connection between the actuators, synchronization of both banks can be carried out electronically.

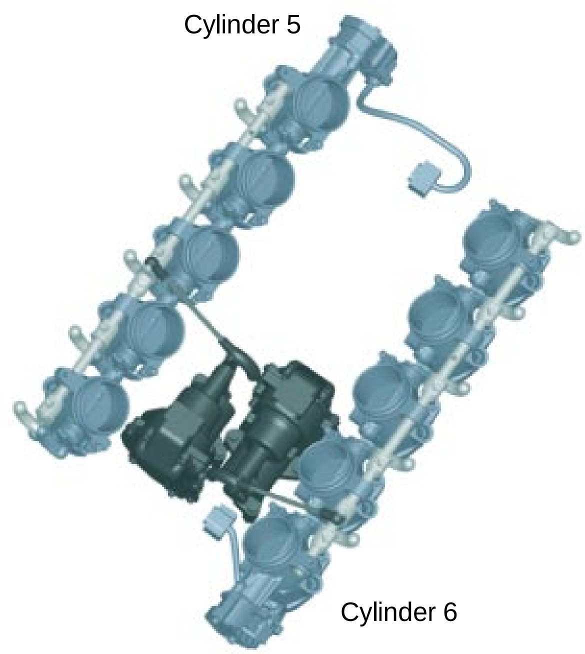
In addition to the DK CAN connection, there is a so-called “Enable line” (S_DK1/S_DK2) between the DME and throttle-valve actuator. Across this “Enable line”, the DME can switch off the throttle-valve actuator if there are communication faults on the DK CAN.

Pin 4 on the throttle-valve actuator of bank 1 is switched to ground. This makes it possible to detect which throttle-valve actuator is fitted on which bank.

Throttle Valve Position Sensor (DKG)

There is one throttle valve position sensor (DKG) per bank. Each sensor contains 2 throttle position sensors (hall type) as well as internal electronics. The internal electronics make it possible for the throttle valve position sensor to communicate with the ECM (DME) via a local CAN bus. The local CAN bus is referred to as DK CAN which uses the familiar three wire configuration.





One throttle valve position sensor is located on the throttle housing for cylinder 5 (bank I) and the other is located on the throttle housing for cylinder 6 (bank II). Each sensor contains 2 feedback hall sensors to detect throttle plate position.

One of the hall sensors is monitored by the EDR actuator which also supplies B+ power and ground (B-) for the sensor. The throttle position value is then sent to the ECM via the local CAN (DK CAN). The sensor signal is “inverted” which means that the signal decreases as the throttle opens. In the event of failure, the affected EDR actuator unit is switched off.

A second hall sensor is responsible for monitoring (plausibility). It is powered and read by the ECM (DME). This hall sensor sends the signal with the “rising” characteristic in which the signal voltage increases as the throttle opens.

DK-CAN

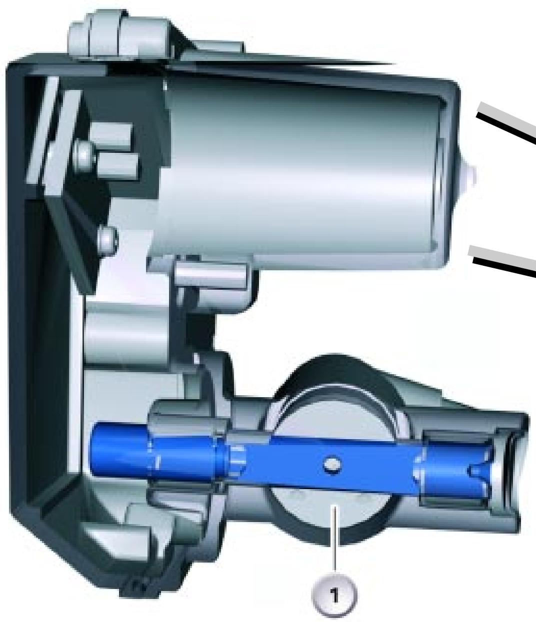
The total resistance of the DK-CAN is 120 Ohms. There are two - 240 Ohm resistors, one in each EDR motor. The resistors are in parallel between DK-CAN-Hi and DK-CAN-Lo for a total resistance of 120 Ohms.

Idle Speed Actuator (LLS)

The two idle speed actuators use a “throttle type” design and are in the “V-area” between the cylinder heads. In addition to the internal electric motor to control the idle valve “throttle plate, the LLS contains an incremental angle transducer for monitoring the position of the idle valve (plate).

This information is processed internally (in LLS) and communicated to the ECM via LLS/SMG-CAN. The idle speed actuators are initialized automatically when the engine is stationary and the ignition is ON.

At idle and low load conditions, the intake air is controlled by the 2 idle speed actuators. The idle actuators are controlled via the local CAN bus which connects the ECM (DME), the SMG and the 2 actuators (one LLS per bank).

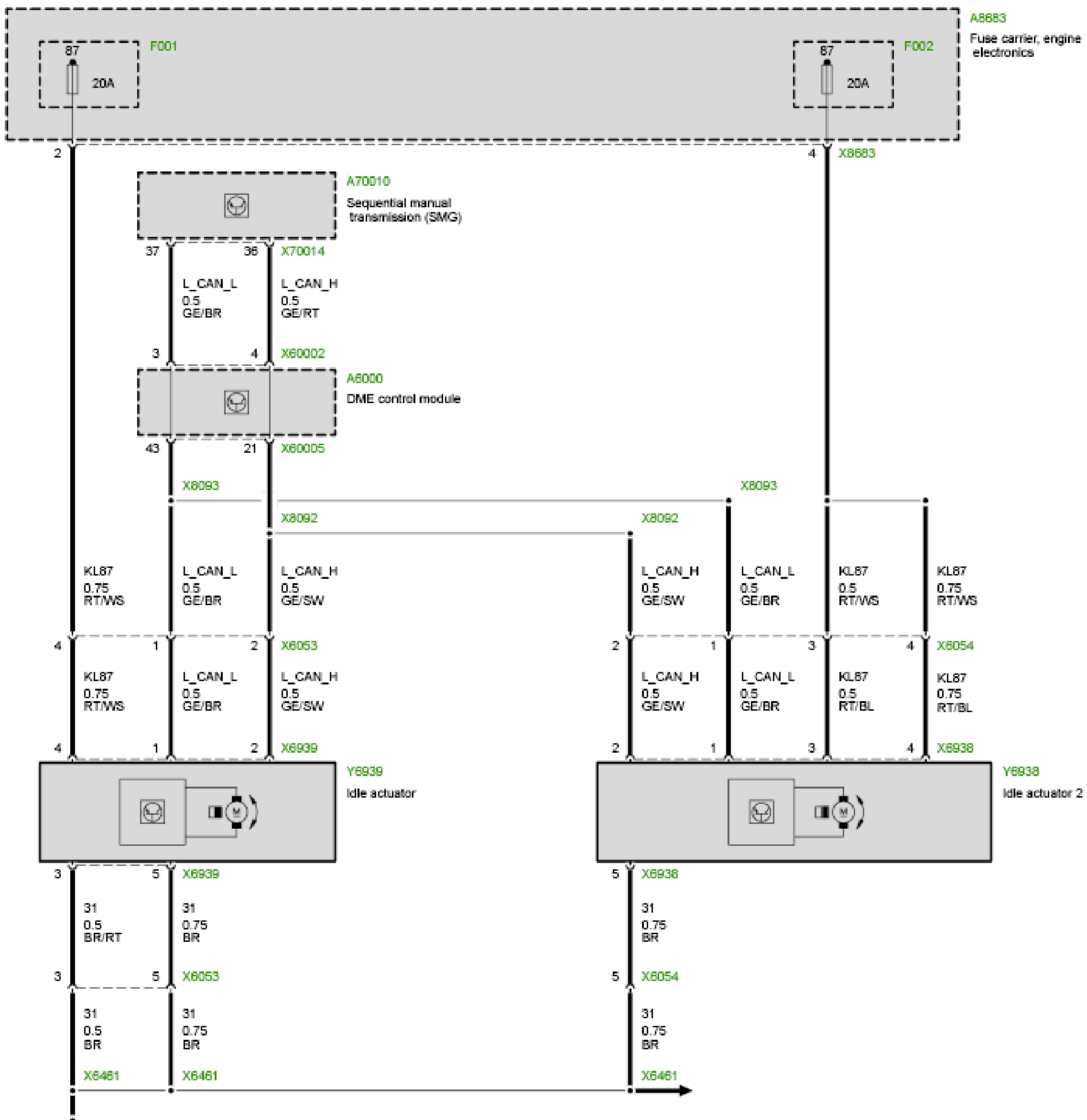


The engine control module determines the current actual load signal from the throttle valve sensors (DKG) and feedback signals from the LLS actuators in order the check the setting of the throttle valves. The plausibility of the load signal is checked against the signals of the two hot-film air mass meters.

If the deviations between the target and actual load signals show any discrepancies, the plausibility is checked against the O2 sensors as well. The ECM will respond the the appropriate fault code if the situation falls outside the programmed parameters.

Similar to past systems the engine speed is controlled by the idle valves (LLS) until a certain load requirement is reached. This means that the potential for the idle throttle valves (LLS) will be exhausted before the individual throttle valves are opened. This allows an overall greater volume of air to be drawn into the engine.

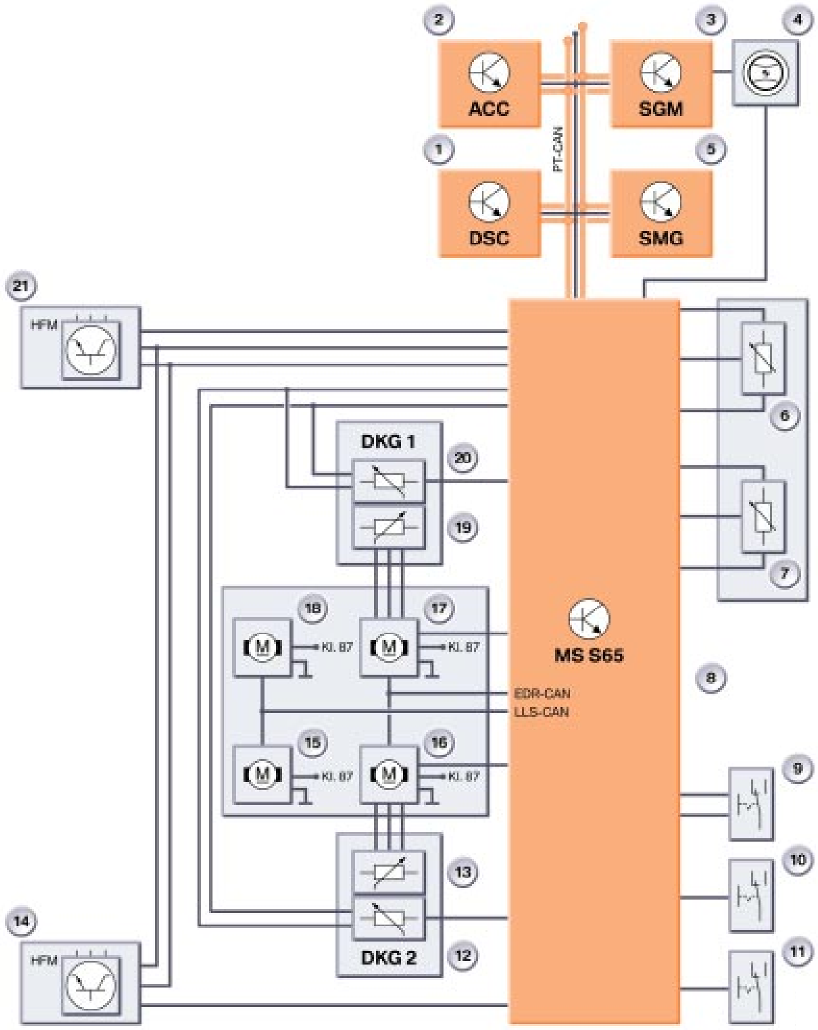
Idle System Schematic



LL-CAN

The total resistance of the LL-CAN is 120 Ohms. There are two - 240 Ohm resistors, one in each idle actuator. The resistors are in parallel between LL-CAN-Hi and LL-CAN-Lo for a total resistance of 120 Ohms.

Throttle System Overview

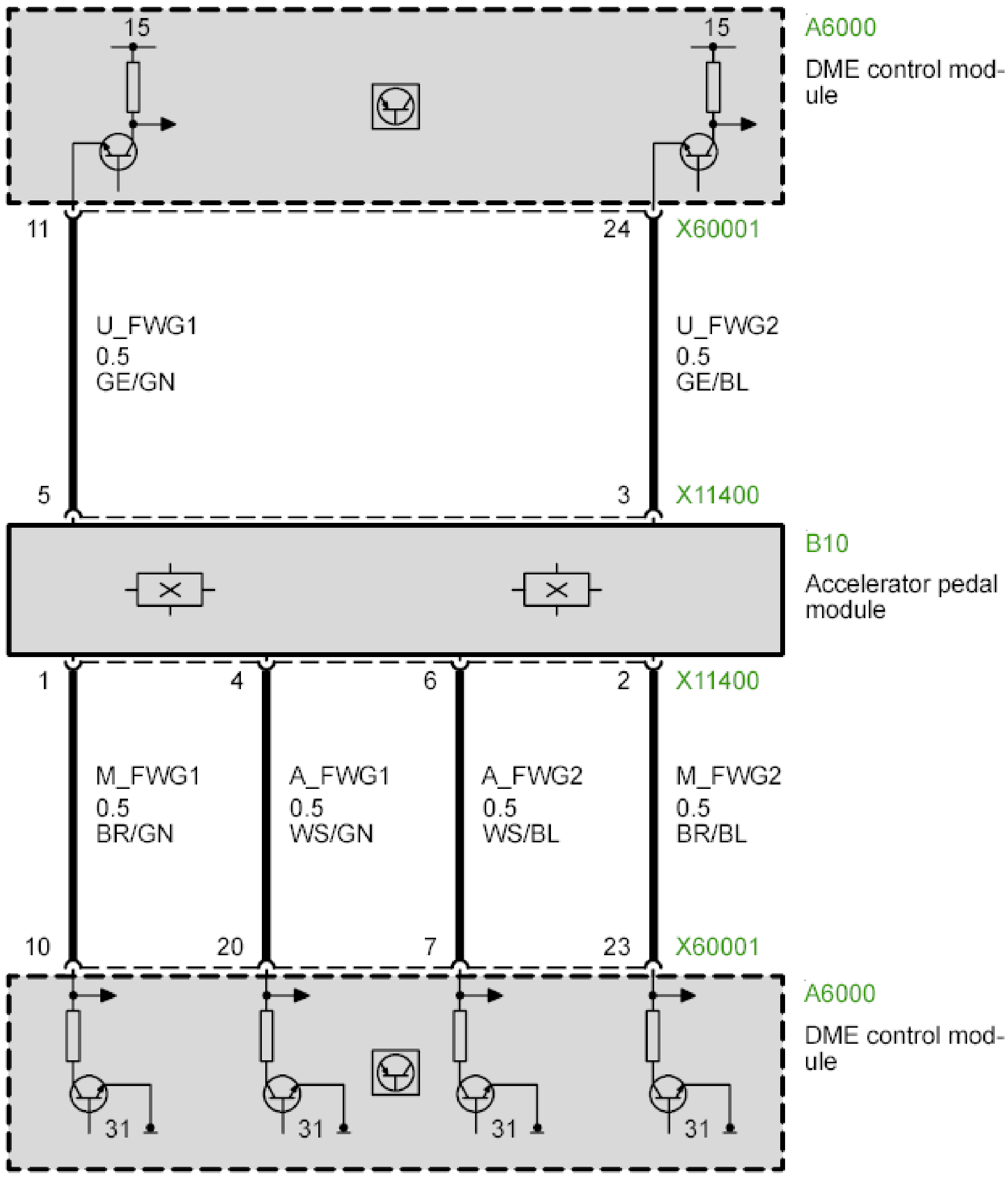


Index	Explanation	Index	Explanation
1	DSC	12	Throttle valve sensor
2	Active Cruise Control	13	Throttle valve sensor, inverted
3	SGM	14	HFM
4	Steering wheel	15	Idle speed actuator
5	SMG	16	EDR
6	Accelerator pedal sensor	17	EDR
7	Accelerator pedal sensor	18	Idle speed actuator
8	DME	19	Throttle valve sensor, inverted
9	Brake light switch	20	Throttle valve sensor
10	Clutch switch	21	HFM
11	Transmission switch, idle speed		

Accelerator Pedal Module

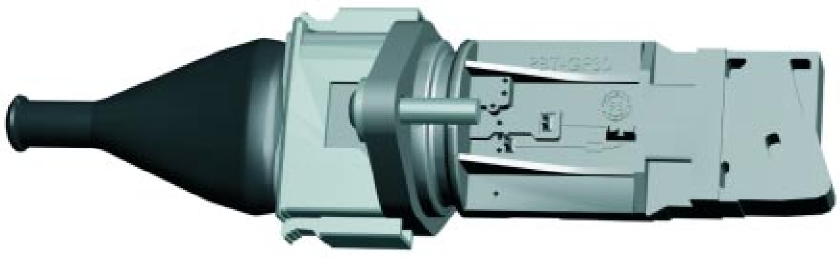
The accelerator pedal module provides the input for the driver's request. The accelerator pedal module contains dual Hall sensors which the ECM monitors for plausibility. The ECM provides an independent voltage and ground supply for each hall sensor. Each Hall sensor is provided with 5 volts and ground. As the accelerator pedal is moved from rest to full throttle, the sensors produce a variable voltage signal.

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



Hot Film Air Mass Meter (HFM)

The HFM is a Bosch type (HFM 5.0) with a CL bypass. There is one HFM for each bank. They are located in the intake silencers and incorporate the “plug-in” design.



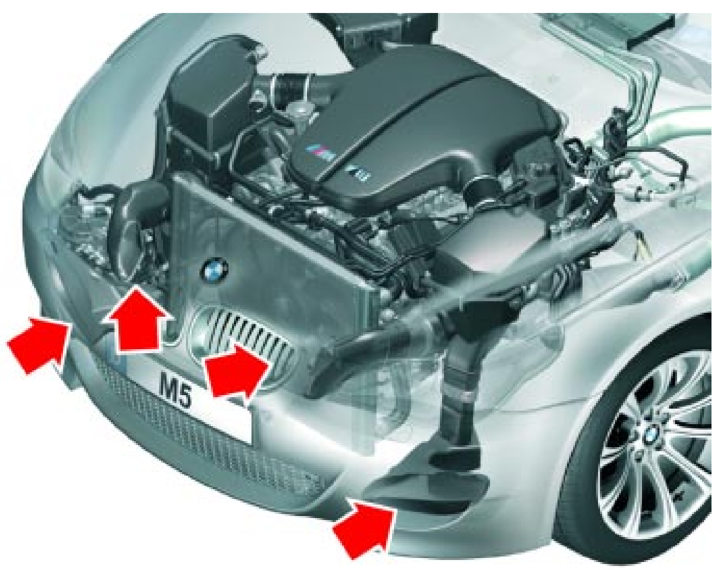
Intake Air Temperature Sensor

The intake air temperature sensor is integrated into the HFM housing. The sensor is an NTC type which receives 5 volt reference and ground from the ECM. The HFM sends a varying 5 volt analog signal to the ECM.

Intake Silencers

The air to the intake silencers (air filter housing), is drawn in via two pathways. One is from the area behind the kidney grille and the other from the large air inlets in the bumper.

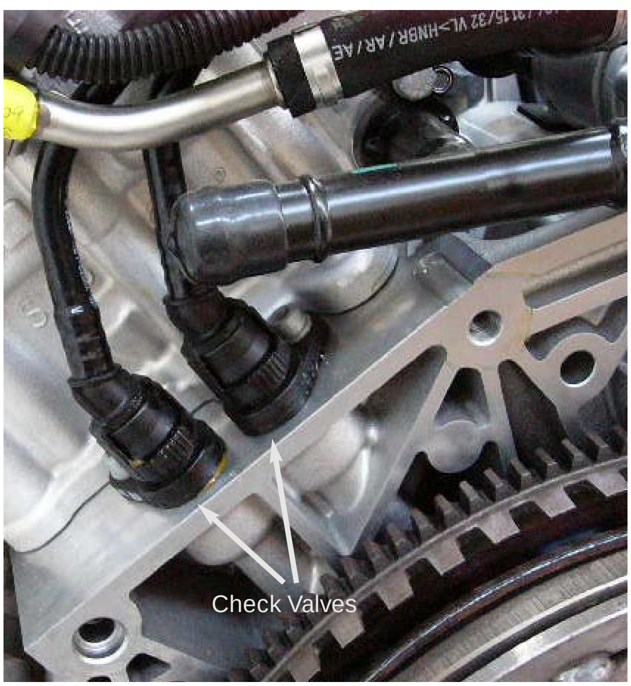
The S85 requires 4 air ducts in order to achieve maximum output. For space reasons, there are 4 inlets to the air filter housings, rather than 2 large ones.



Crankcase Ventilation

The crankcase ventilation system on the S85 is used to separate liquid oil from crankcase gasses. The cyclone separators are integrated into the left and right intake plenums. The liquid oil from the separators is returned to the crankcase via two plastic hoses which are routed to the oil sump. The lines feed into two check valves behind cylinder 10.

There are also 2 check valves (one in each valve cover) which also allow any accumulated oil to drain back from the intake plenum housings.



Vacuum Pump

Although the S85 does not use Valvetronic, the assistance of an external vacuum pump is required under various operating conditions. In some operating modes, especially with a cold engine, when the catalyst heating function is active there is insufficient partial engine vacuum available for brake power assistance. There is also reduced engine vacuum when using “race track” (M-Dynamic) mode or when the vehicle is rolling with KL15 on and the engine off.

To make up for this limited vacuum period, there is a supplemental electric vacuum pump. The electric vacuum pump is controlled via the ECM (DME). The pump is installed on the left in the engine compartment under the left microfilter housing.

The vacuum pump is designed as a vane-type pump. The prevailing partial vacuum is measured by a partial vacuum sensor.

The vacuum pump is switched on at -250 mbar and switched off at -600 mbar.

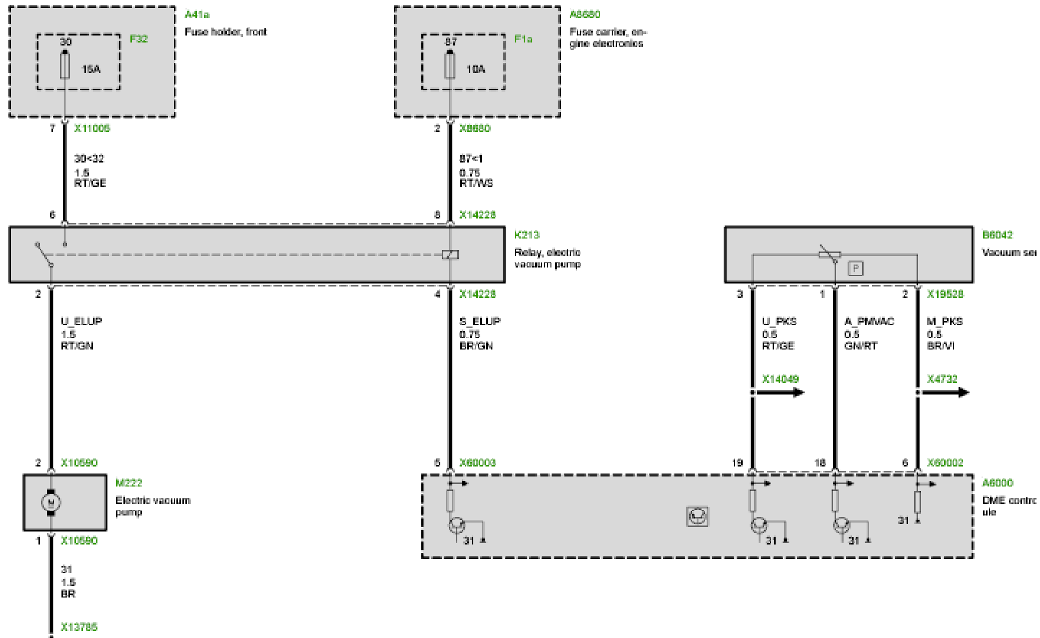
1. Pressure Sensor
2. Vacuum Pump

An external pressure sensor (see schematic on opposing page), signals the pressure difference from the brake booster compared to the ambient pressure from the internal ambient pressure sensor in the ECM (DME).

When vacuum is required, the ECM activates the relay which in turn then actuates the electric vacuum pump. The cut-in and cut-out thresholds are controlled as a function of the differential pressure and the vehicle speed.

The software in the ECM is configured such that the correct vacuum is available in the brake booster under all driving conditions.

With relatively little vacuum in the brake booster, the engine must be running or the vehicle must be rolling with terminal 15 on in order to activate the electric vacuum pump.



A test module is provided in DIS for the electric vacuum pump. The differential pressure sensor on the brake booster is used for the purpose of monitoring the pump.
The plausibility is checked by the pressure difference between the vacuum and ambient pressure calculated internally in the ECM. It is evaluated and, in the case of fault, shown in the instrument cluster and displayed as a CC message (check control).

If the electric vacuum pump is found to be defective during the self-diagnosis procedure, the safety concept manager (SK manager) intervenes and shuts down cylinder bank II (Cylinders 6-10). The smaller opening cross section in the intake duct of cylinder bank 6-10 thus ensures adequate vacuum in the brake booster.

In the case of fault the safety concept manager triggers an "engine" symbol as well as a CC message (check control) "engine malfunction/power loss" in the instrument cluster.

Emergency Programs

The fault code "electric vacuum pump for Mastervac" (Mastervac = brake booster) is stored in the fault code memory in connection with the fault types "short to positive", "short to ground" and "line break". The following actions are initiated:

- Maximum torque 200 Nm
- Maximum engine speed 3500 rpm
- Maximum vehicle speed 150 km/h

The following actions are initiated in connection with the fault "pump not running":

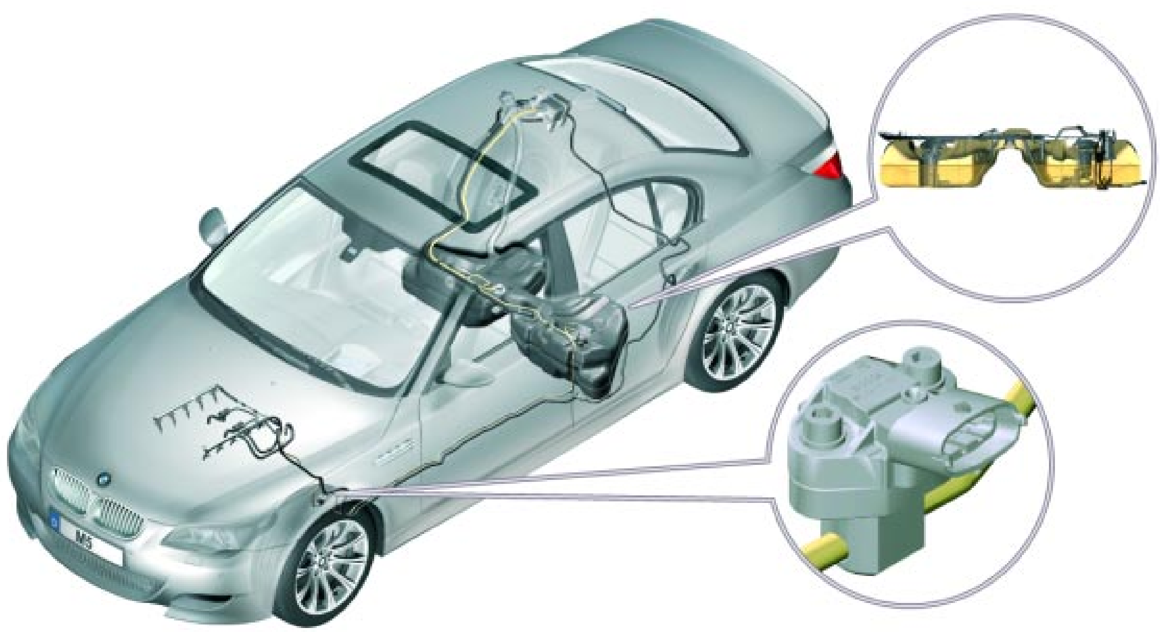
- Maximum torque 100 Nm
- Maximum engine speed 2000 rpm
- Maximum vehicle speed 50 km/h

Fuel Supply and Management

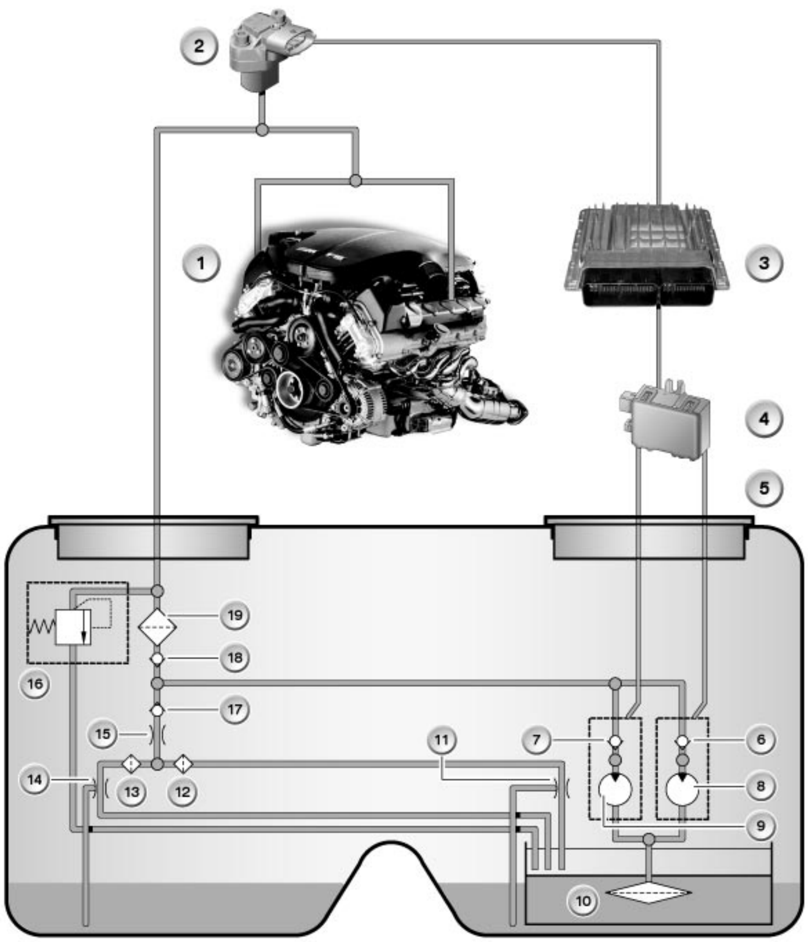
The fuel system on the S85 engine is a “demand-oriented” system which uses a variable fuel pressure delivery concept. The fuel pressure can be varied between 3 and 6 bar. This method of fuel delivery allows maximum delivery when needed, but also reduces HC losses from the fuel tank by keeping the overall fuel volume to the minimum. Additional benefits include increased service life of the fuel pump.

The fuel control circuit consists of the following components:

- Electric fuel pumps (2-EKP)
- EKP module
- Fuel tank with components and line system
- Fuel pressure sensor
- Digital motor electronics (DME) with the control logic



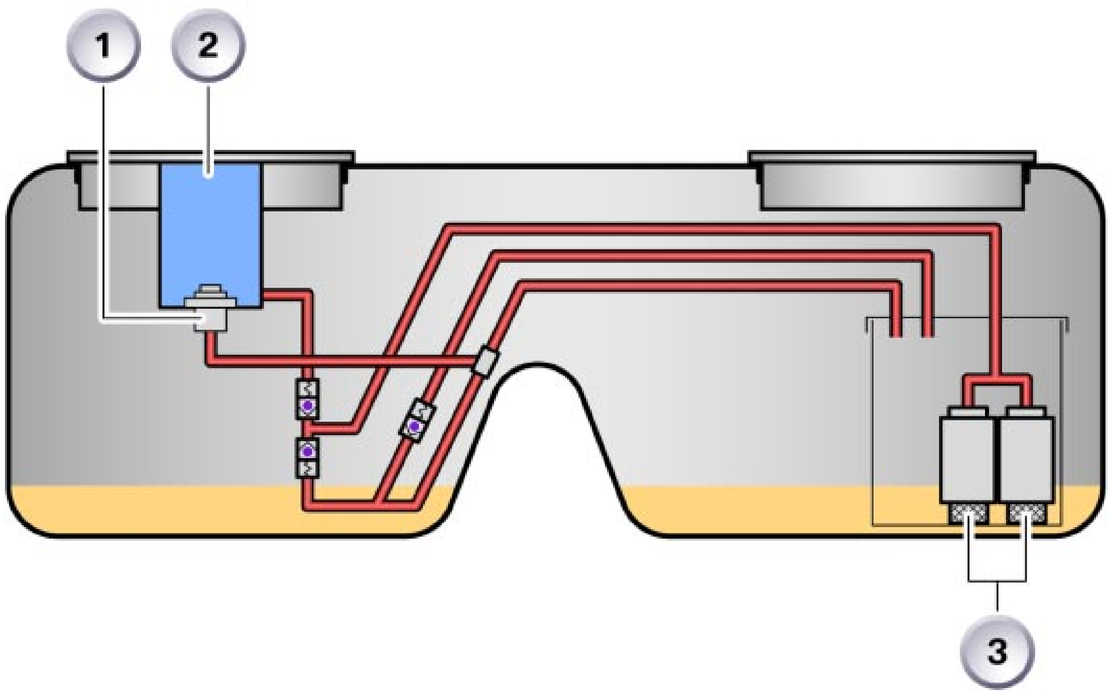
Fuel System Overview



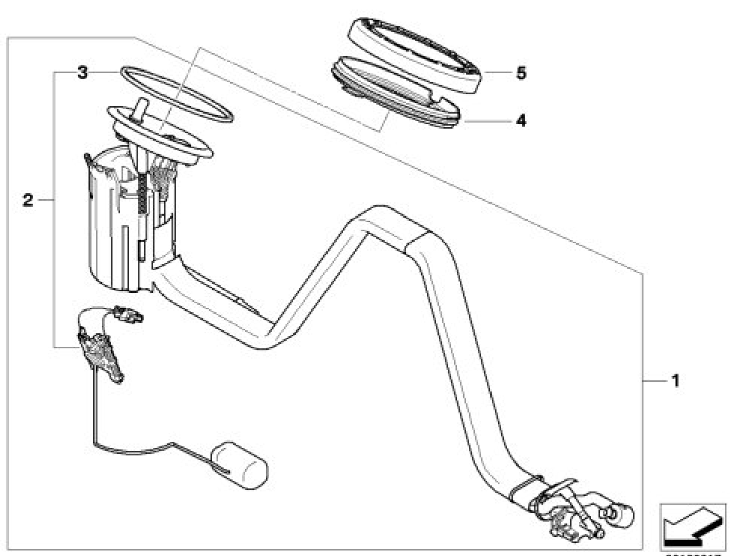
Index	Explanation	Index	Explanation
1	S85 Engine	11	Suction jet pump 1
2	Fuel pressure sensor	12	Strainer
3	Engine control unit (ECM)	13	Strainer
4	EKP Control unit	14	Suction jet pump 2
5	Fuel tank	15	Restrictor
6	Check valve	16	Fuel pressure regulator
7	Check valve	17	Check valve
8	Fuel pump 1 (EKP1)	18	Check valve
9	Fuel pump 2 (EKP2)	19	Fuel filter
10	Surge chamber (with mesh screen)		

Fuel Pumps

The fuel tank has been modified from the standard production E60 to accommodate two fuel pumps. Both pumps are a vane type which are located on the right hand side of the fuel tank.



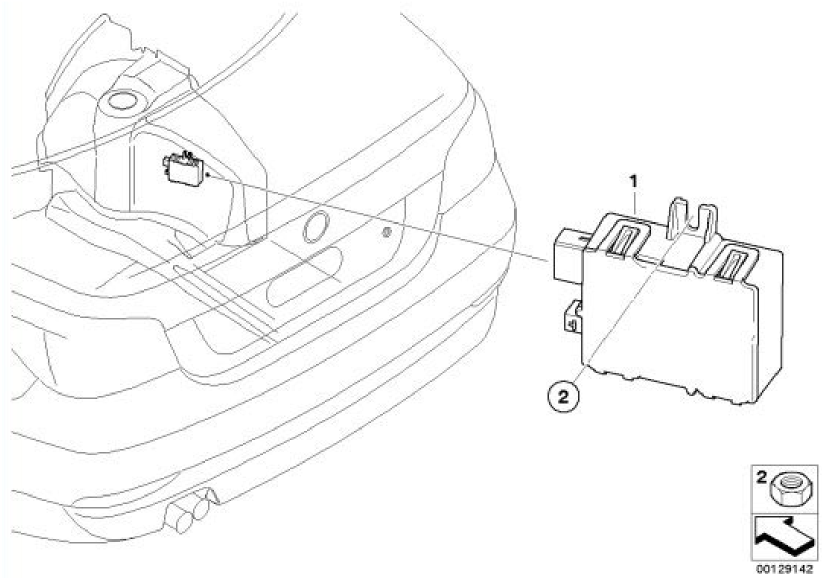
Index	Explanation	Index	Explanation
1	Fuel pressure regulator	3	Fuel pump 1 and 2 (EKP 1 and EKP 2)
2	Fuel filter		



EKP Module

The EKP module is located in the luggage compartment on the right side.

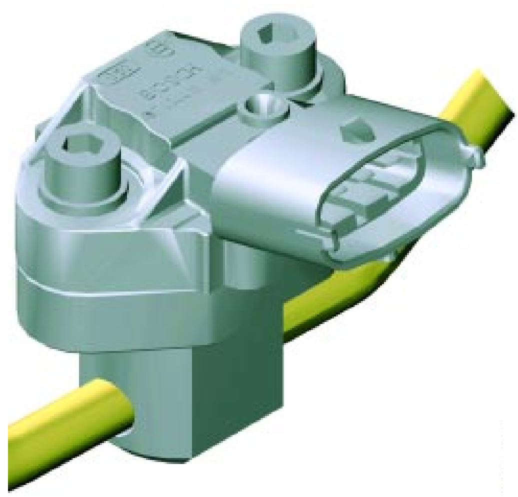
The output stage of the EKP module has been modified to accommodate two fuel pump output circuits and the associated control logic.



Fuel Pressure Sensor

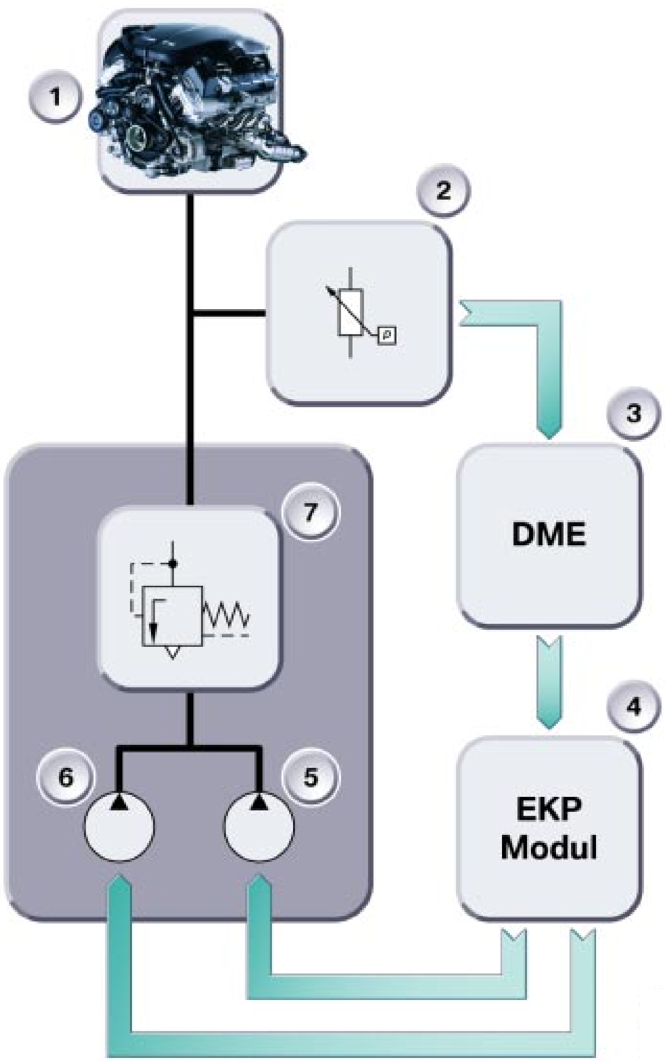
The fuel pressure sensor is located in the front left wheel arch. The sensor is used to measure the current fuel pressure and transfers the pressure value to the engine management.

The fuel pressure sensor renders manual fuel pressure testing unnecessary. Fuel pressure values can now be displayed using the BMW diagnostic equipment.



Fuel System Operation

The ECM (DME) is responsible for control of 2 in-tank fuel pumps which are connected to the fuel system in parallel. The first fuel pump (EKP1) covers the fuel required by the engine up to about 60%. EKP1 is operated via a variable duty cycle by the EKP control unit. The fuel pressure is varied by the speed of the pump (not the mechanical fuel pressure regulator).



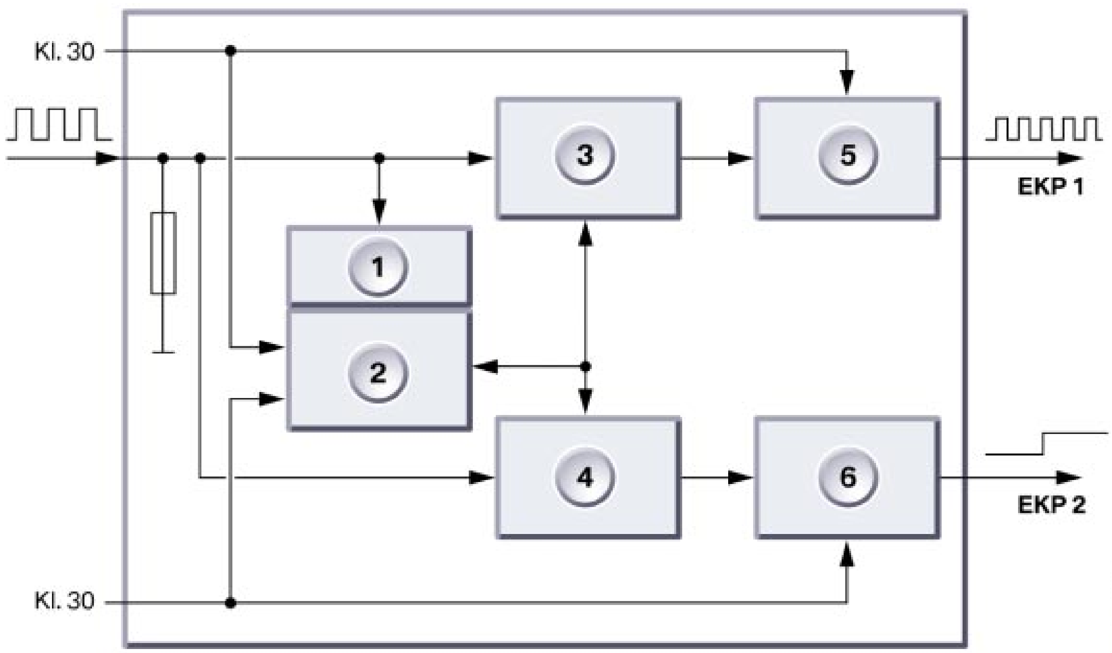
Index	Explanation	Index	Explanation
1	S85 Engine	5	EKP 1
2	Pressure sensor	6	EKP 2
3	ECM (DME)	7	Fuel pressure regulator (6 bar)
4	EKP Control module		

The fuel pressure sensor is needed to provide the ECM with the proper information to provide adequate pressure control.

From approximately 5000 RPM (also load dependent), the second fuel pump (EKP2) is switched on at 100%. EKP 1 is also switched to 100% as well. At this point, the fuel pressure regulator (mechanical) is responsible for setting maximum fuel pressure to 6 bar.

The EKP module is controlled by the ECM over a single wire PWM interface. The pulse width of the signal dictates the delivery capacity of the electric fuel pump. 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%.



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

Emergency Program

If faults are detected in the fuel supply system, the fuel system is run in emergency mode. At this point, both pumps are operated with 100% activation.

Fuel Injectors

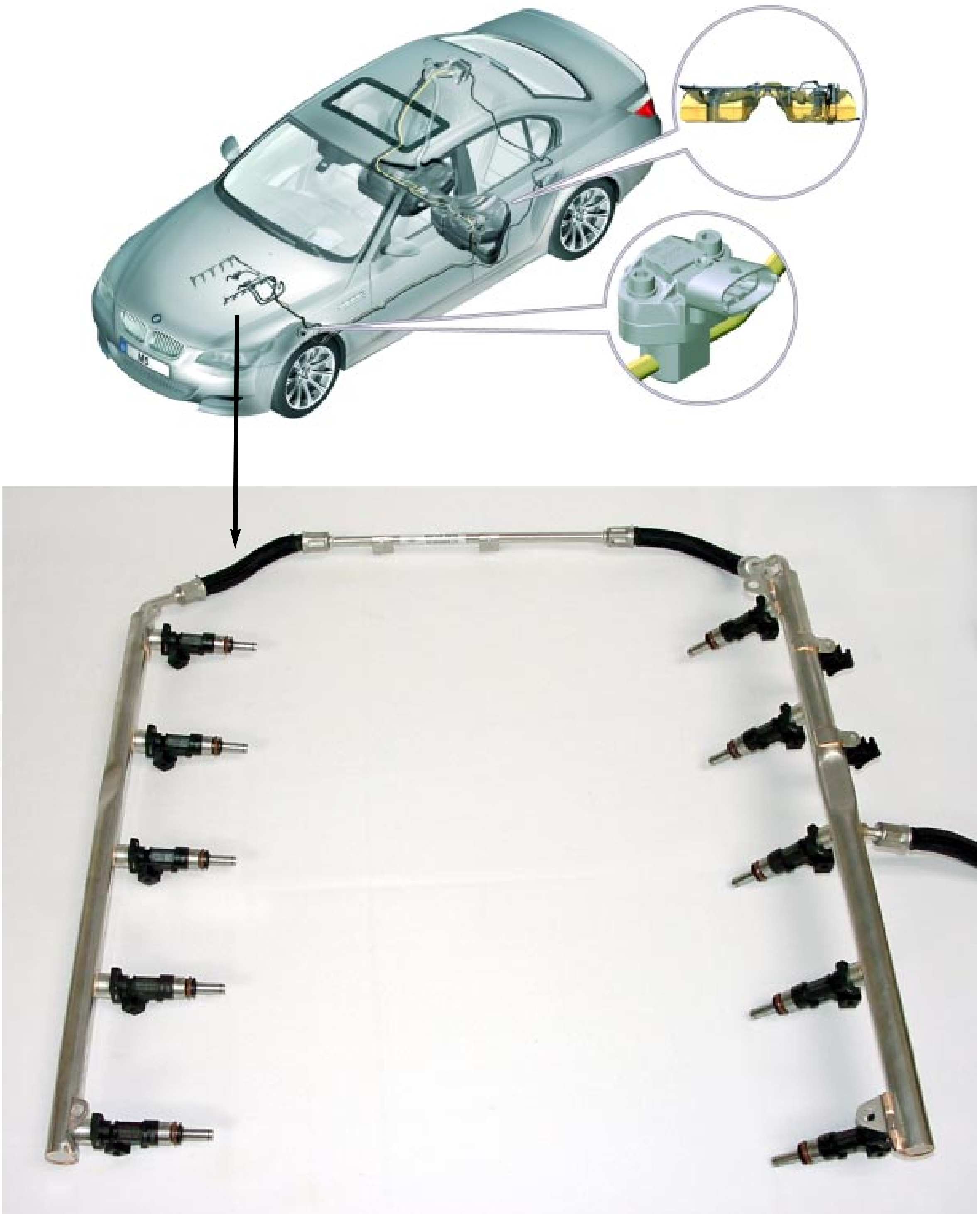
The injectors are mounted into machined bores located in the throttle housings. This design allows the injectors to be closely mounted to the intake valves.

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

Power supply for the fuel injectors is from Terminal 87 of the fuel injector relay which is controlled by the CAS.

Fuel Rail

The fuel rail is a non-return design which does **NOT** include a service port for diagnosis. Fuel pressure is measured by the ECM via a fuel pressure sensor. The sensor is located in the driver's side front wheel arch.



Workshop Exercise - Fuel System

Using the DISplus/GT-1, obtain the diagnosis requests for the fuel system and locate the current fuel pressure data. Complete the chart below with the requested information:

Operating condition	Fuel Pressure (bar)
Starting/cranking	
Idle	
Throttle blip > 5000 rpm	

Based on the schematic above, is it possible to code/program the EKP control unit? (Why or Why not)

Workshop Exercise - Fuel System

Monitor the fuel pump activation line (T_EKP) between the ECM and EKP module using an oscilloscope and measuring system functions. Complete the chart below with the requested information:

Operating condition	Voltage	Frequency	Duty Cycle
Starting/cranking			
Idle			
Throttle blip > 5000 rpm			

Monitor voltage on the fuel pump voltage supply lines to pumps 1 and 2. Measure at the EKP module located in the luggage compartment. Use the MIN/MAX function to assist in your measurement. Complete the chart below by filling in the requested information:

Operating condition	Voltage Pump 1	Voltage Pump 2
Starting/cranking		
Idle		
Throttle blip > 5000 rpm		

List the part number of the test cable used for the EKP module:

Ignition Management

The ignition system on the MS-S65 engine management uses several inputs to control ignition functions. There are some changes as compared to previous BMW engine management systems. The knock sensors have been eliminated in favor of a new "ionic current" measuring system. The new "ionic current" monitoring system is also capable of detecting misfires as well.

Ignition Coil

As with most recent ignition coil designs, the "pencil" or "rod" type ignition coils are in use with the S85 engine.

The ignition coils are manufactured by Bremi or Bosch. The ignition coils are triggered by the ionic current control units based on signals from the ECM.

The Zener diode in the secondary winding has been eliminated to allow ionic current measurement.

Spark Plugs

With the introduction of the new ionic current monitoring technology, the spark plugs for the S85 have been specially manufactured by NGK.

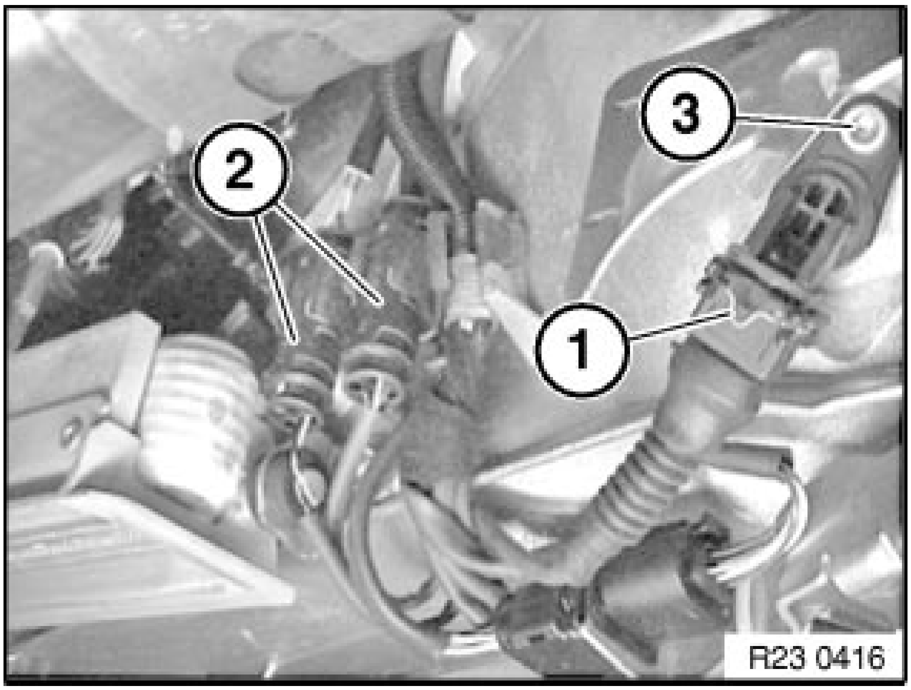
The new (LKR8AP) spark plug uses a two-prong ground electrode, with a center electrode which has a laser welded platinum ring . The plug also features a very long reach (26.5mm) and a 12 mm thread.

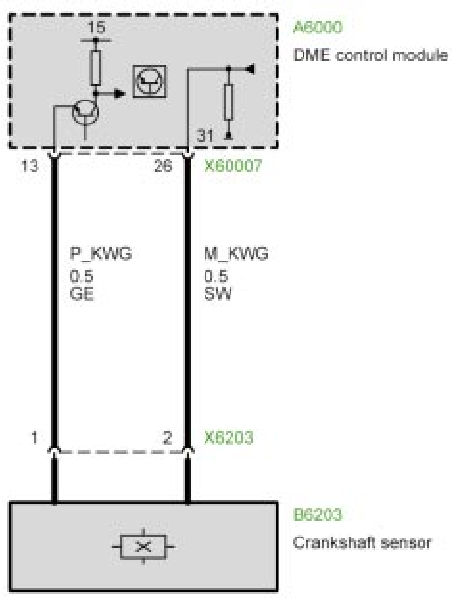
The spark plug now carries out two functions:

- To provide a gap between the spark plug electrodes
- To act as a sensor for ionic current monitoring

Crankshaft Position Sensor

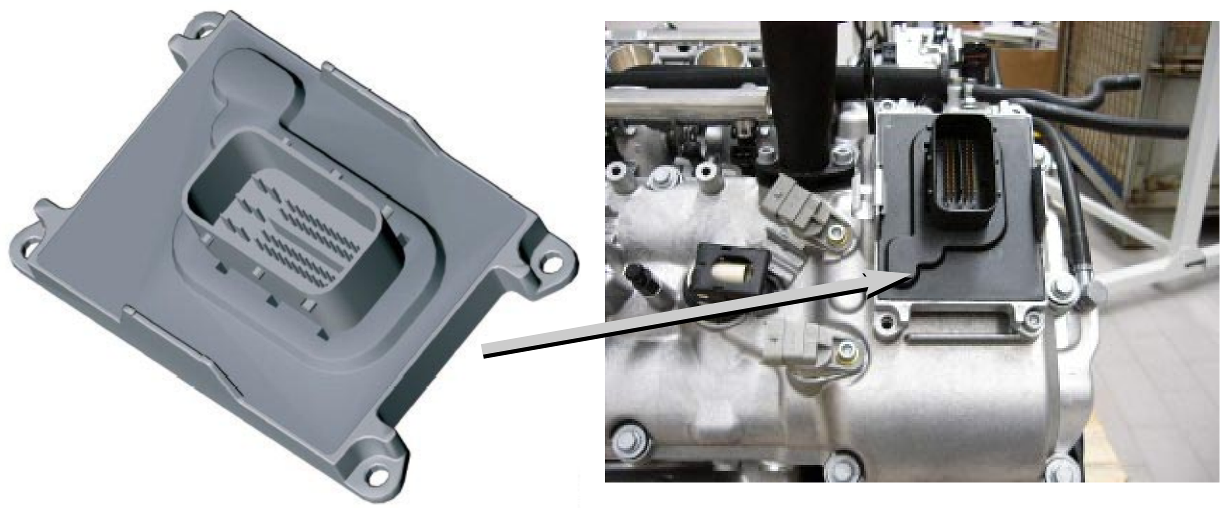
This sensor provides the crankshaft position and engine speed (RPM) signal to the ECM for Fuel Pump and Injector operation. This is a “Hall Effect” type sensor mounted on the transmission bell housing (3). The impulse wheel is mounted on the outer circumference of the flywheel. The impulse wheel contains 58 teeth with a gap of two missing teeth. The gap of two missing teeth provides a reference point that the ECM recognizes as crankshaft position.



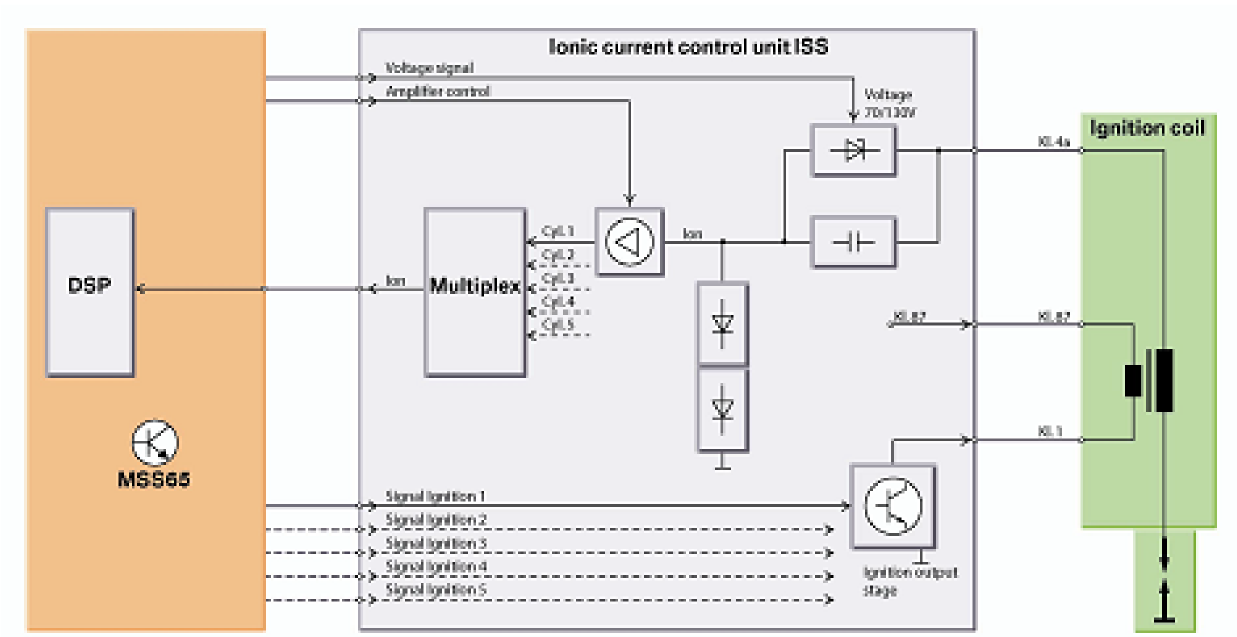


Ionic Current Control Units

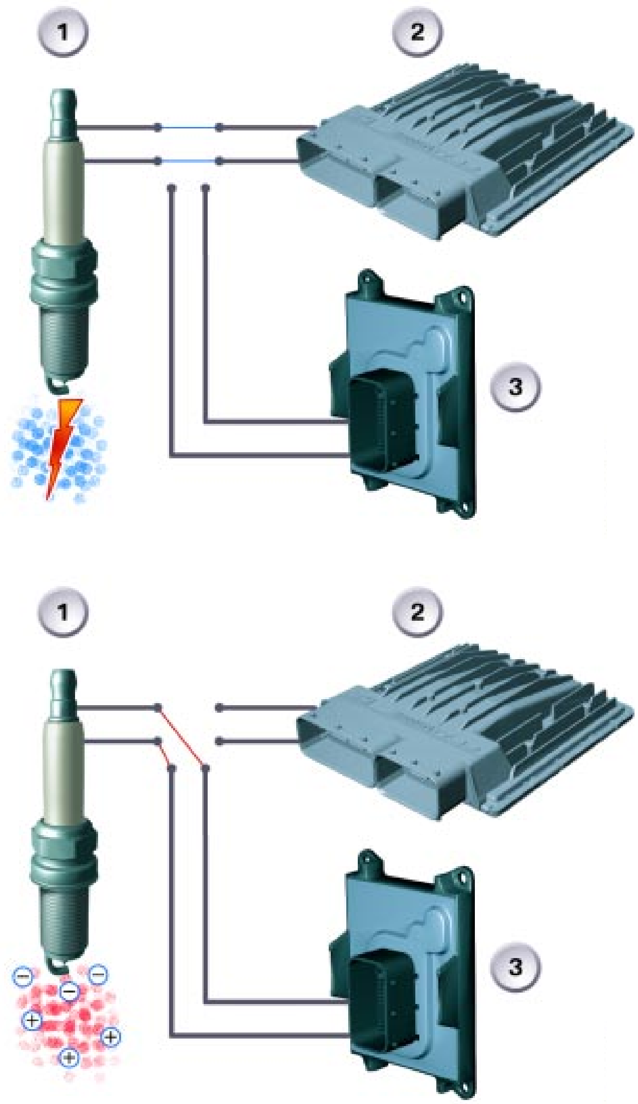
There are 2 ionic current control units which are located at the front of the engine on top of the respective cylinder head cover. These units are manufactured by Helbako and are responsible for control of the ignition coils via signals from the ECM (DME).



In addition to ignition coil control, the ionic current control unit is used to measure ionic current during the combustion period (after ignition). These measurements are used by the engine management to monitor knock as well as misfiring.



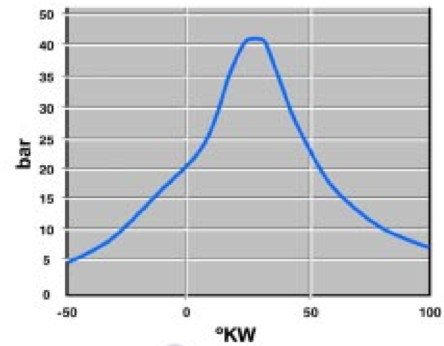
Ionic Current Overview

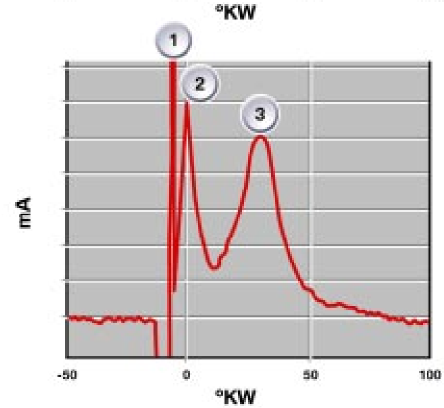


Index	Explanation
1	Spark plugs
2	Engine control unit
3	Ionic current control unit

Ionic Current Measurement

Ionic current monitoring technology holds many benefits for the detection of misfires and engine knock. Currently, misfires are detected by monitoring the crankshaft for speed fluctuations. This method is limited on very smooth running engines, particularly on those with more than 8-cylinders.





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

Ionic current technology makes it possible to monitor both misfires as well as engine knock. This is done mostly with existing hardware. The spark plug is now assigned a dual role. In addition to supplying the air gap which makes ignition possible, the spark plug is now used as a “current probe” to measure ionization during combustion.

Once the ignition phase has ended, the combustion phase begins with a uniform flame front across the combustion chamber. During the combustion period, heat and pressure ionize particles in the combustion chamber in the area of the spark plug electrodes.

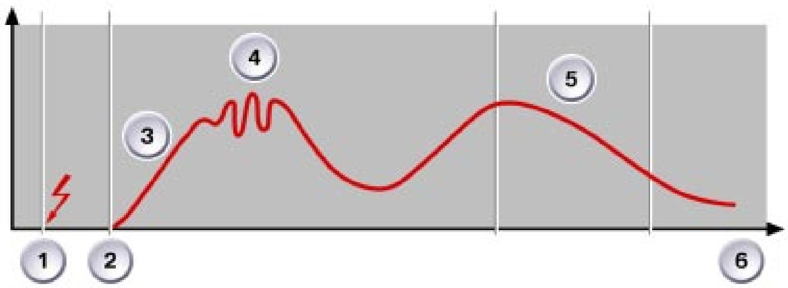
These ions can be measured to give an indication of cylinder pressure. The cylinder pressure peaks can be interpreted to show combustion quality.

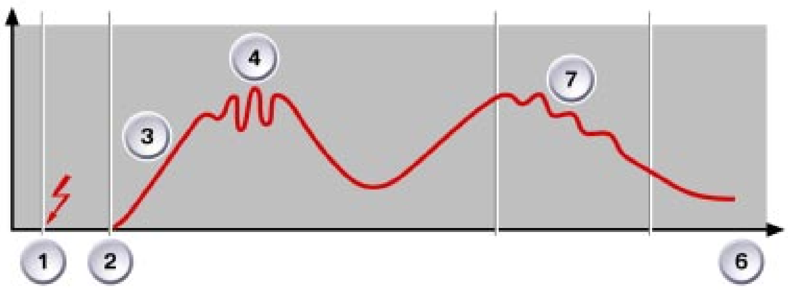
Ionic current progression is directly dependent on the cylinder pressure and the ions in the cylinder. In other words, the ***quantity*** of ions is dependent upon the ***quality*** of combustion.

The ionic current is measured after ignition occurs. 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 and the ECM (DME).

The combustion progression in the combustion chamber can be represented by the combustion chamber or cylinder pressure curve. As a general rule :

- Poor combustion = low cylinder pressure
- Good combustion = high cylinder pressure





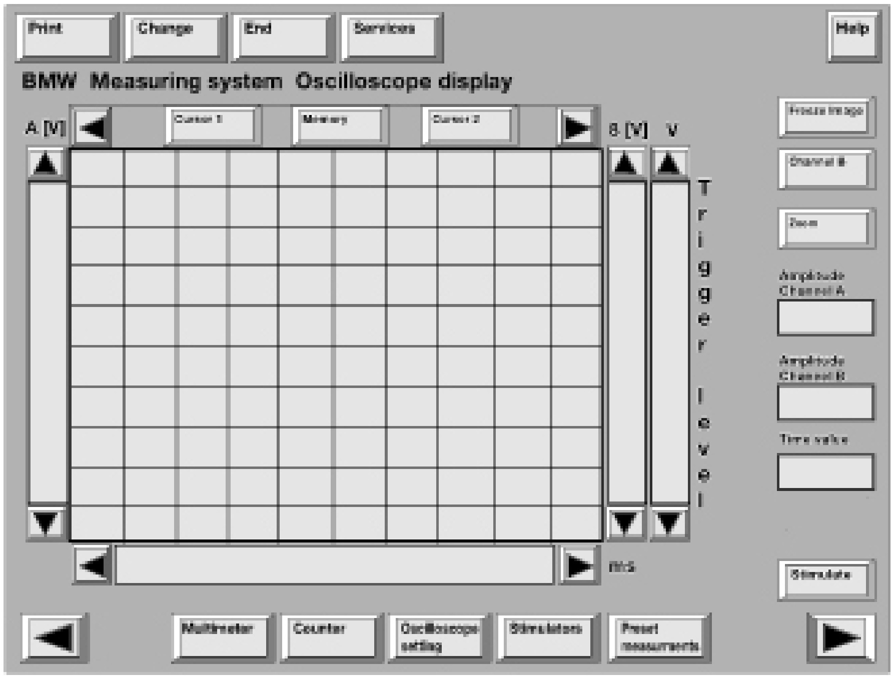
Index	Explanation	Index	Explanation
1	Firing Point	5	No knocking
2	End of Ignition	6	Time
3	Ionic Current	7	Knocking
4	Flame front signal		

During various combustion events, free ions additionally split off or separate due to abnormal pressure peaks that occur in the combustion chamber when knocking or detonation occurs. 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 ECM will make necessary corrections to control knocking. This method of knock detection eliminates the need for knock sensors. Also, the possibility for erroneous knock signals is eliminated.

Workshop Exercise - Ionic Current Ignition System

Using MFK2, obtain the primary ignition pattern for cylinder 6 and sketch the pattern below.



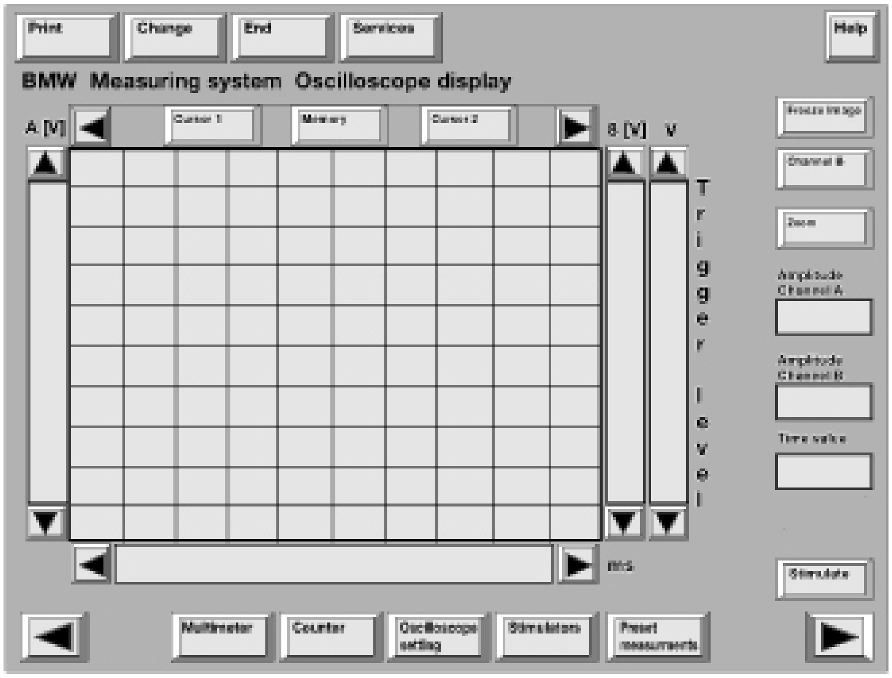
Is there anything unique regarding the primary ignition pattern?

What is the resistance of the primary winding of the ignition coil?

Where are the “final stage” transistors located?

Workshop Exercise - Ionic Current Ignition System

Proceed and check the secondary ignition pattern for cylinder 6 and sketch the pattern below.



Is there anything unique regarding the secondary ignition pattern?

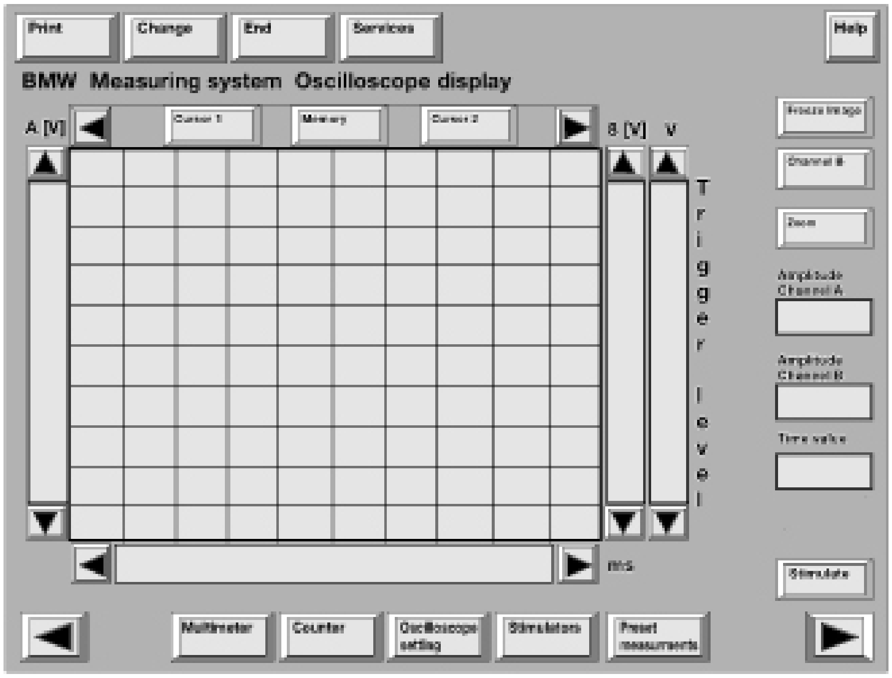
Measure the resistance of the secondary winding of the ignition coil:

What is the observed resistance?

What is the purpose of the ignition coil modifications?

Workshop Exercise - Ionic Current Ignition System

Connect breakout box to ionic current control unit. Using an ETM for reference, monitor the ignition coil control line between the ECM and the ionic current control unit. Sketch the pattern below:

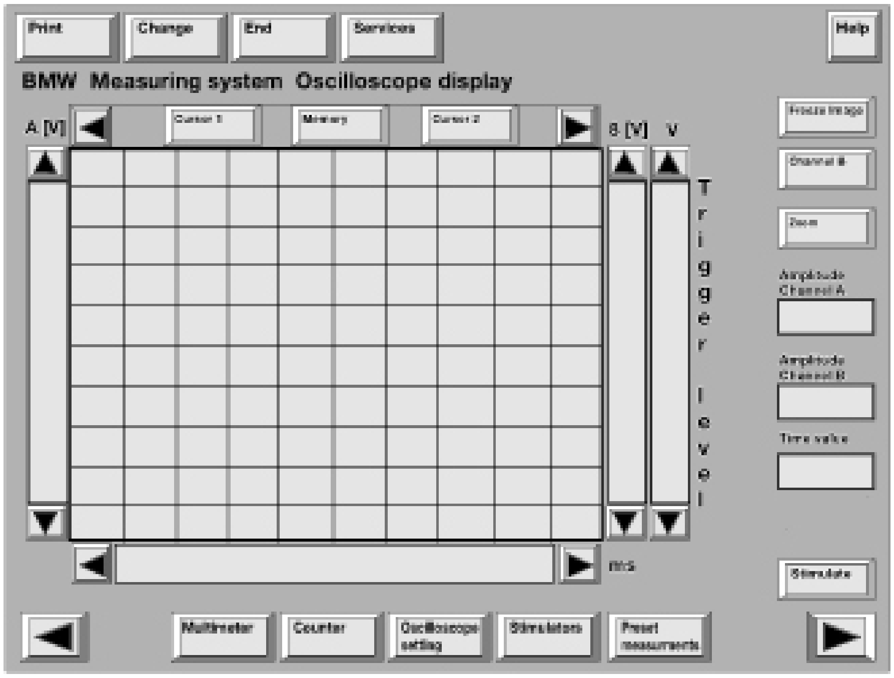


What is the purpose of the “ignition control line”?

What happens to this signal when the RPM is increased?

Workshop Exercise - Ionic Current Ignition System

Obtain the scope pattern for the ionic voltage signal (between the coil and ionic current control unit). Sketch pattern below.



What is the maximum observed voltage?

What does this signal represent?

What modifications have been made to the coil to allow this circuit to be possible?

What would occur if this signal were interrupted?

Emission Management

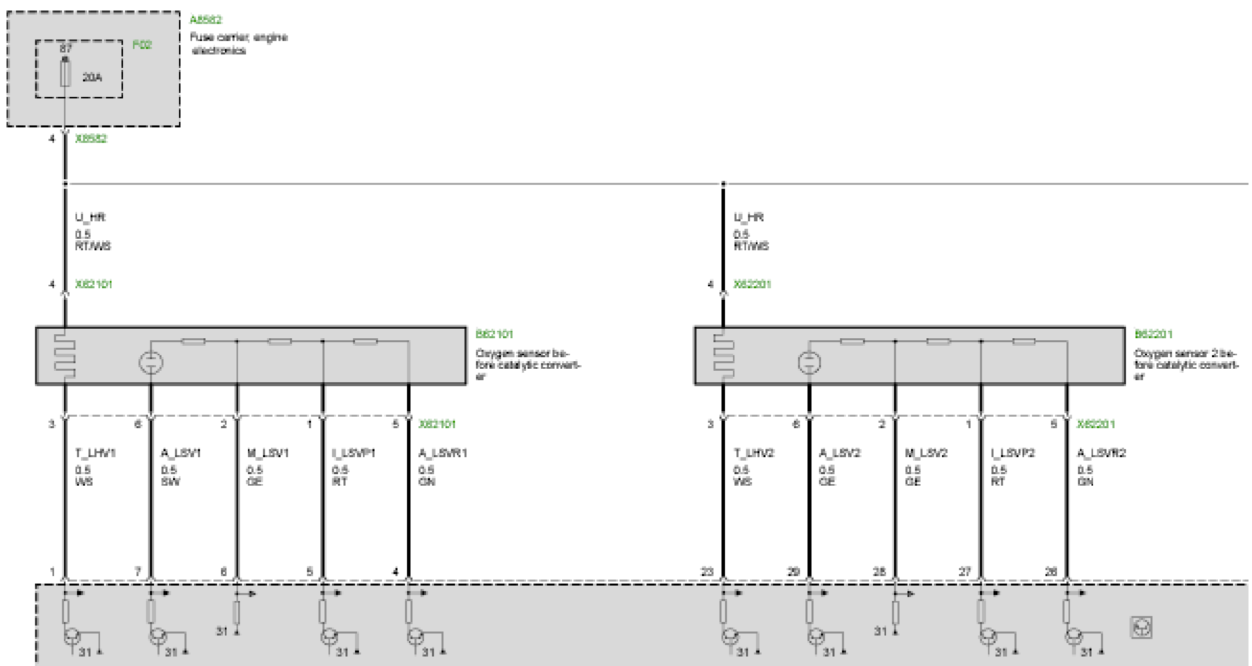
The S85 engine with MS_S65 engine management complies with LEV II standards.

Bosch LSU Oxygen Sensor

A “wide-band planar” oxygen sensor used on the S85. The new Bosch LSU 4.9 sensor is carried over from the N62TU and N52 engines. Compared with the LSU 4.2 oxygen sensor previously used, the LSU sensor is twice as fast. Full operational readiness is achieved after 10 seconds (LSU 4.2 20 seconds).

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

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

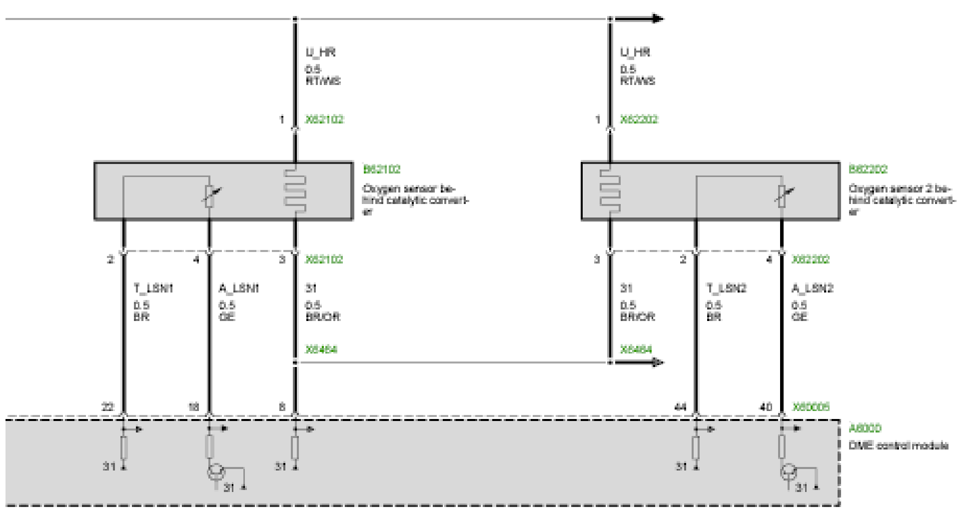


Post Catalyst Oxygen Sensor

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

The new planar 4.2 sensors offer:

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



Secondary Air System

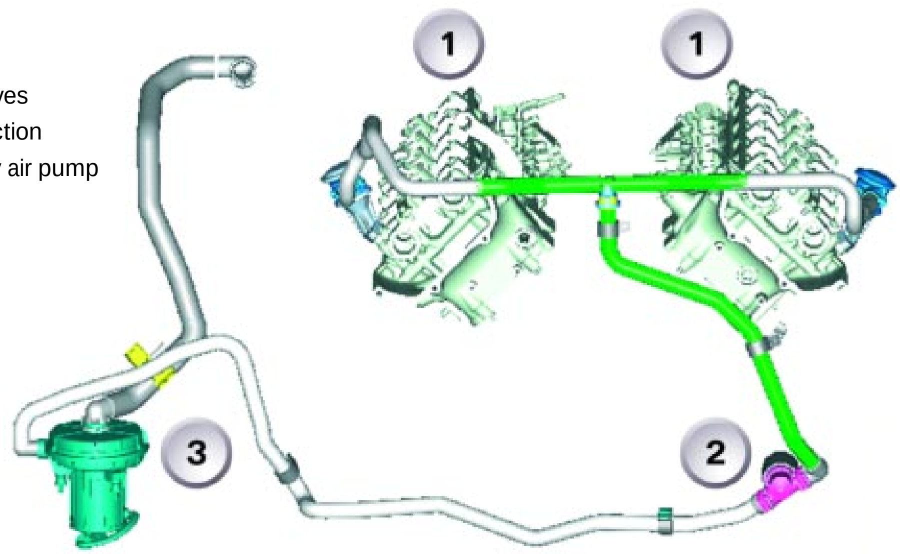
Injecting ambient air into the exhaust stream after a cold engine start reduces the warm up time of the catalysts and reduces HC and CO emissions. The ECM controls and monitors the Secondary Air Injection.

An Electric Secondary Air Pump and Air Injection Valve direct fresh air through an internal channel in the cylinder head into the exhaust ports. The Air Injection Valve is opened by air pressure (from the pump) and is closed by an internal spring.

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

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

1. Check Valves
2. Hose Junction
3. Secondary air pump



Mini Hot Film Air Mass Sensor (HFM)

A compact mini hot film air mass sensor (HFM manufactured by Siemens) is used in the secondary air system for the S85 engine in the M5 and M6.

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

When the mini HFM detects no air mass or insufficient air mass, a fault is stored in the ECM and the Malfunction Indicator Light (MIL) is activated. The mini HFM has a compact pipe shaped design with O-ring connections.

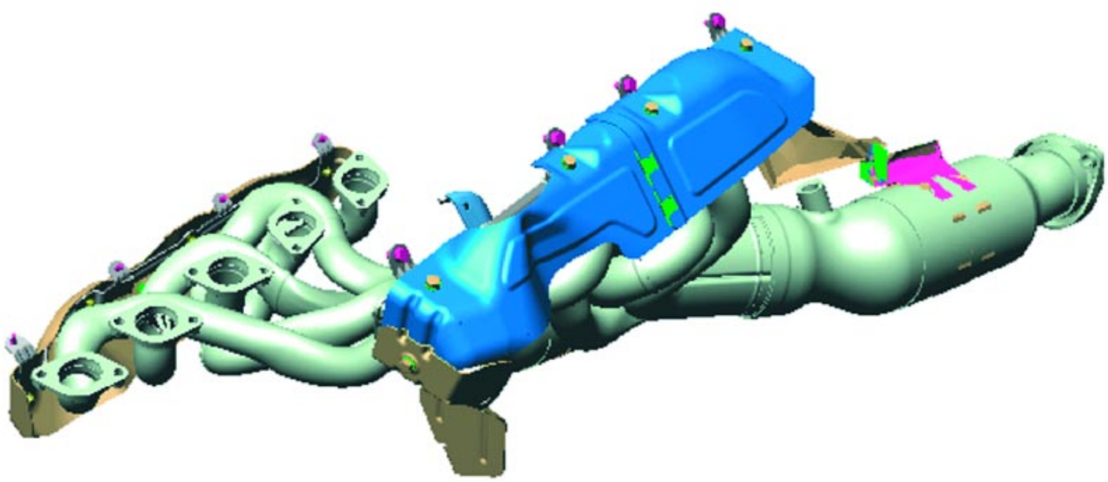
On-Board Refueling Vapor Recovery

The ORVR system on the M5 is identical to the production E60. This system recovers and stores hydrocarbon fuel vapor that was previously released during refueling. Non ORVR vehicles vent fuel vapors from the tank venting line back to the filler neck and in many states reclaimed by a vacuum receiver on the filling station's fuel pump nozzle.

When refueling an ORVR equipped vehicle, the pressure of the fuel entering the tank forces the hydrocarbon vapors through the larger tank vent line to the liquid / vapor separator, through the rollover valve and into the charcoal canister. The HC is stored in the charcoal canister, and the system can then "breath" through the DM-TL and the air filter. The vent line to the filler neck is smaller, but still necessary for checking the filler cap/neck during Evaporative Leak Testing.

Exhaust Manifold

The tubular stainless steel exhaust manifolds contain the familiar "near engine" catalytic converters. The manifolds also provide the mounting for the pre and post catalyst oxygen sensors. The manifold also has provisions for the exhaust gas temperature sensor.



Exhaust gas temperature sensor

The exhaust temperature sensors are designed as NTC measuring elements. The sensor can detect temperatures of up to approximately. 1,200°C. This sensor is mainly used to protect the catalytic converters.

Charcoal Canister
As the hydrocarbon vapors enter the canister, they will be absorbed by the active carbon.

The remaining air will be vented to the atmosphere through the end of the canister, DM-TL and filter, allowing the fuel tank to “breath”.

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

The Carbon Canister with DM-TL and air filter are located at the behind the right rear wheel.

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

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

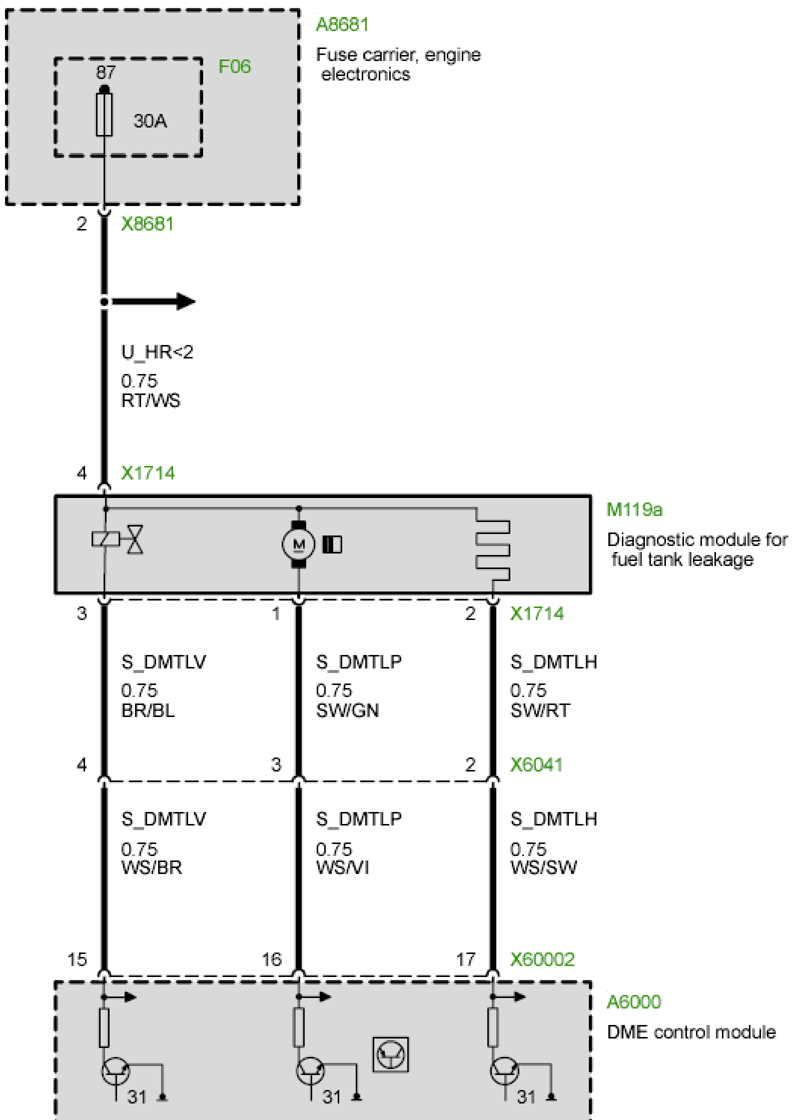
If the valve is “mechanically” defective, a driveability complaint could be encountered and a mixture related fault code will be set.

Evaporative Leakage Detection (DM-TL)

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

The pump also contains an ECM controlled change over valve that is energized closed during a Leak Diagnosis test. The change over valve is open during all other periods of operation allowing the fuel system to “breath” through the inlet filter. The DM-TL pump is located behind the right rear wheel attached to the Carbon Canister.

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



Performance Controls

VANOS

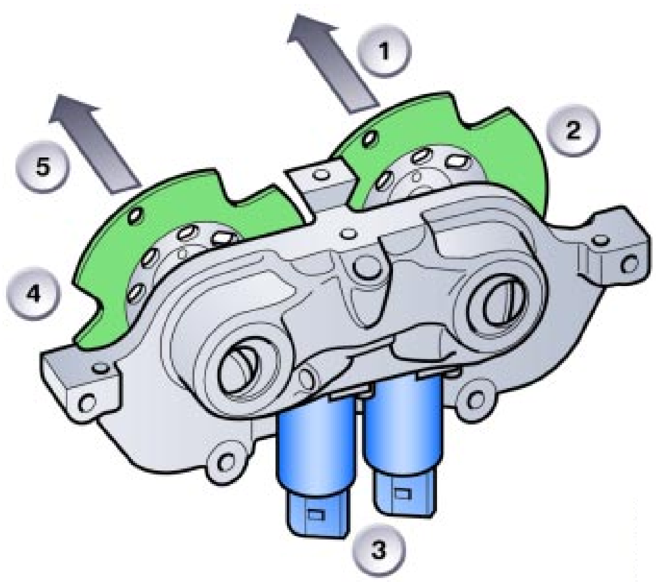
The VANOS used on the S85 is the “high-pressure” Bi-VANOS designed specifically for motorsport applications. The system is designed to allow for rapid and accurate camshaft timing changes. This is made possible due to a very high operating pressure. The operating pressure in this VANOS system is 115 bar.

The VANOS system of the S85 consists of the following components:

- Two VANOS actuating units (one for each bank)
- Two sets of VANOS transmissions (one set for each bank).
- High pressure radial piston pump
- Pressure accumulator with solenoid valve
- High pressure lines

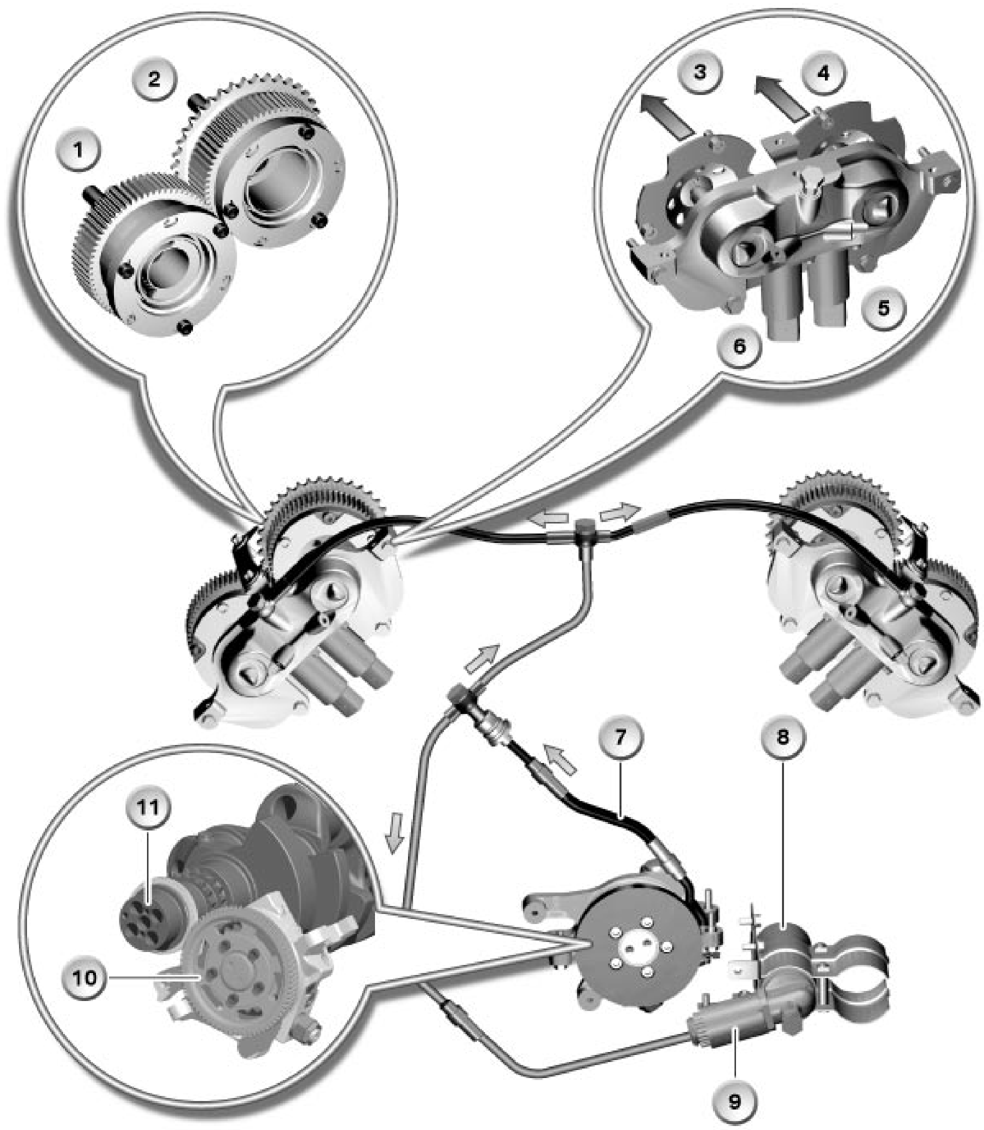
VANOS Actuating Unit

The actuating unit consists of the adjustment pistons and solenoid valves. The adjustment pistons provide axial movement when oil pressure is applied. The solenoid valves, which are controlled by the ECM, direct oil flow to control piston movement.



Index	Explanation	Index	Explanation
1	Adjustment direction, advance	4	Exhaust
2	Intake (adjustment piston)	5	Adjustment direction, retard
3	Solenoid valves		

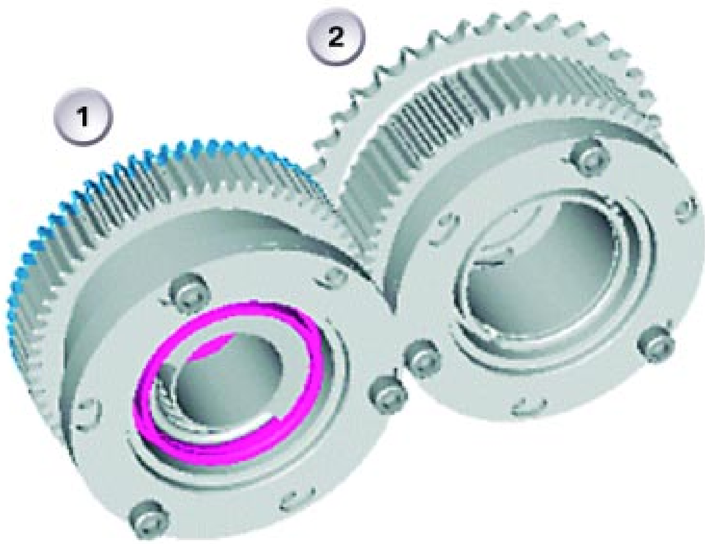
VANOS Overview



Index	Explanation	Index	Explanation
1	VANOS transmission (exhaust cam)	7	High pressure line for oil pump (in engine)
2	VANOS transmission (intake cam)	8	VANOS accumulator
3	“Retard” adjustment, exhaust camshaft	9	Pressure accumulator valve
4	“Advance” adjustment, intake camshaft	10	VANOS Radial high pressure pump
5	VANOS solenoid valve, intake	11	Drive sprocket
6	VANOS solenoid valve, exhaust		

VANOS Transmission

The VANOS transmission contains the “helical” cut gearing to provide the torsion or “twisting action” of the camshafts. The intake camshaft is driven by the primary chain drive from the crankshaft. The exhaust camshaft is driven by the gear-to-gear connection with the intake camshaft sprocket.



The VANOS transmissions provide the minimum and maximum “spread angle” for the camshafts. The intake camshafts have a spread angle of 60° relative to the crankshaft, and the exhaust camshafts have a spread angle of 37° relative to the crankshaft.

Due to the gear-to-gear connection between the intake and exhaust “sprockets”. The camshafts rotate in opposite directions. This means that the “retard” and “advance” movements are in different directions between the intake and exhaust camshafts.

Pressure Accumulator

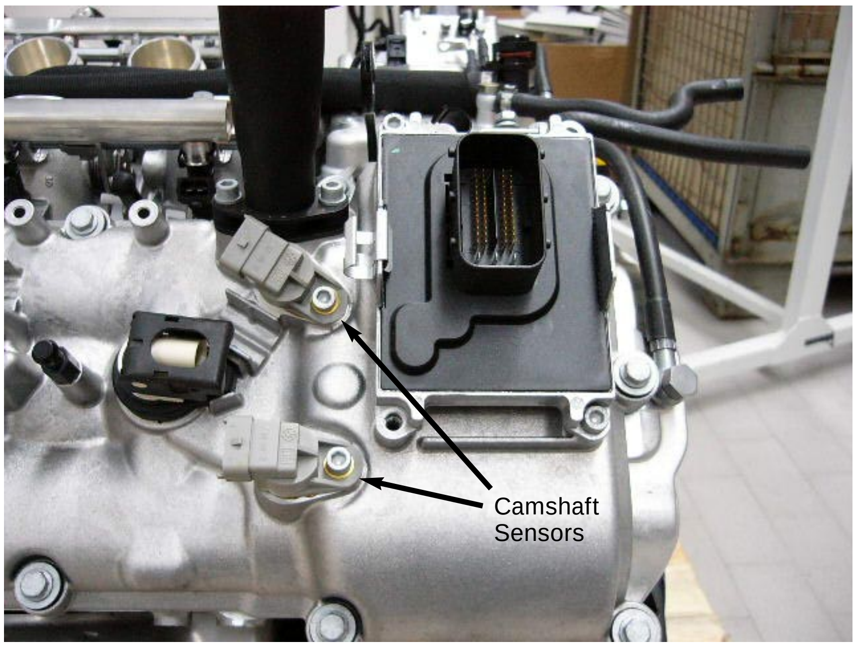
The pressure accumulator is pre-charged with nitrogen at a pressure of 40 bar. The oil chamber is separated from the gas chamber by a piston. The operating pressure of the VANOS is approximately 70 bar. When the engine is switched off, the pressure accumulator valve on the VANOS accumulator closes. A pressure of approximately 70 bar remains in the pressure accumulator and is immediately available the next time the engine is started. This prevents the VANOS adjustment units from producing a clacking noise when the engine is started.

Switching on and switching off conditions for the pressure accumulator valve:

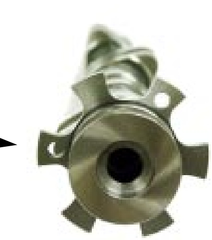
- Engine start: pressure accumulator valve OPEN
- End of engine start: pressure accumulator valve CLOSED
- Oil pressure in VANOS built up: pressure accumulator valve OPEN
- Switch off the engine: pressure accumulator valve CLOSED

Pressure Accumulator Shut-off Valve (VANOS)
The shut-off valve, which is controlled by the ECM, 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).

Camshaft Sensors
The hall-effect camshaft sensors are located on top of the valve cover. The provide the ECM with information regarding camshaft position. The sensors monitor trigger wheels which are integrally cast on the camshafts.



Camshaft Trigger Wheels
The trigger wheels for the camshaft sensors are integrally cast onto the camshafts.



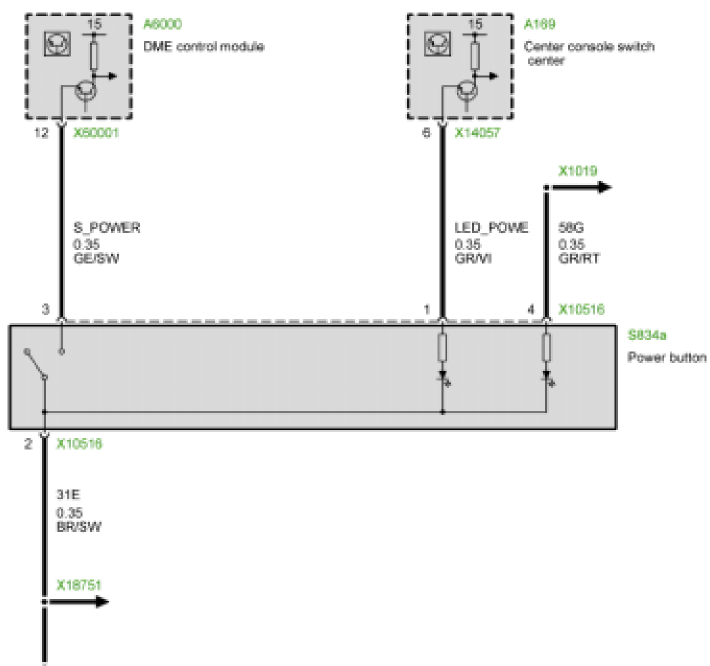
Power Button

The POWER button is a provides a ground input to the ECM to allow selectivity of 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.

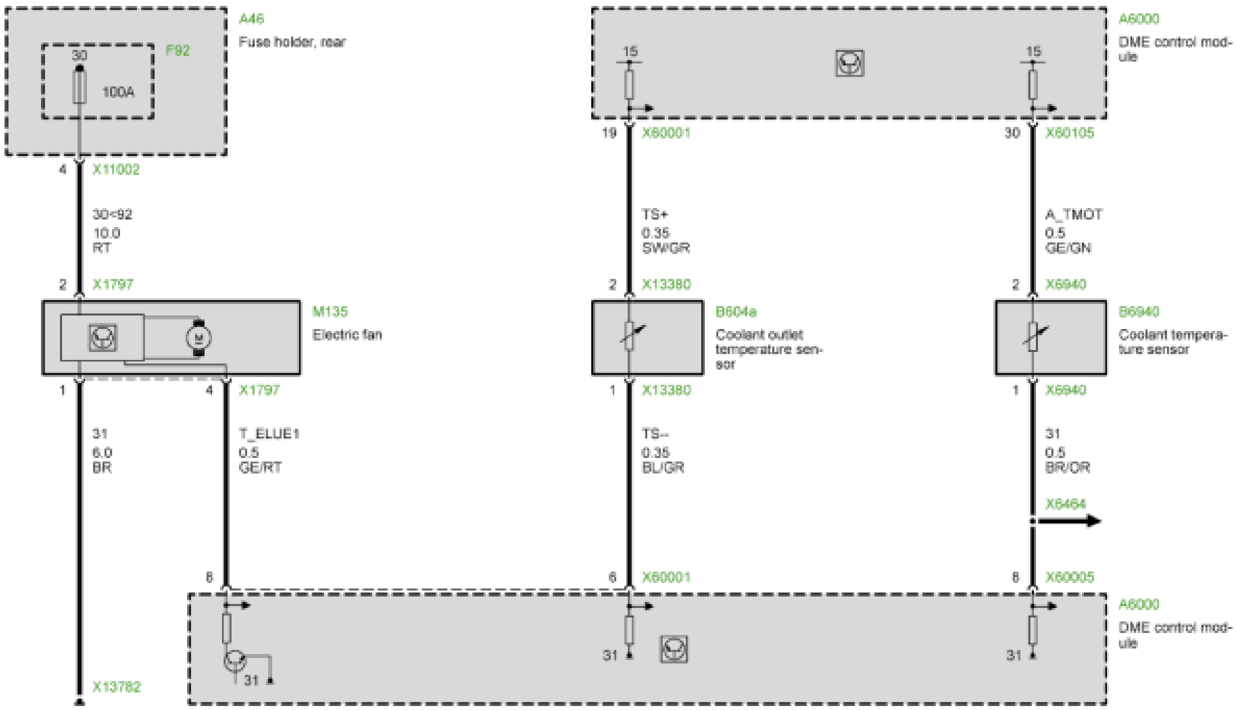
The P400 setting is assumed automatically when the vehicle is restarted.

The DME receives the ground input from the switch. The SZM is responsible for the illumination of the “On” LED. Switch illumination is provided by the KL58g circuit.



Cooling System

The cooling system on the S85 is not influenced by the ECM. In other words, the coolant thermostat is **not** electrically heated by the ECM. However, the ECM still provides control for the electric cooling fan as in past models.



The cooling fan is controlled by the ECM through an output stage which receives a PWM signal. The ECM varies the PWM signal based on the following factors:

- Coolant outlet temperature
- Calculated (and measured) catalyst temperature
- Vehicle speed
- Battery voltage
- Air conditioning inputs (such as AC pressure)

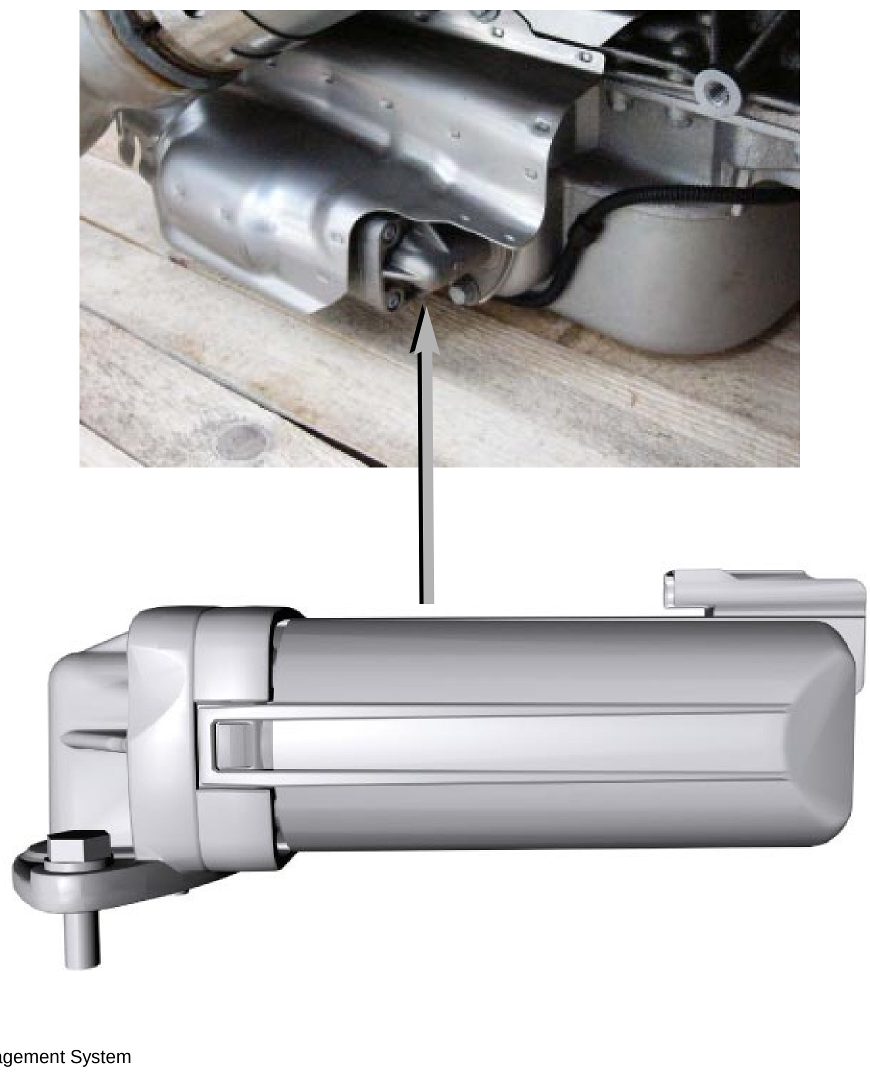
Lubrication System

The lubrication system on the S85 uses “lateral force compensation”. This system is used to counteract the forces encountered during extreme cornering. This oiling system is unusually elaborate for a passenger car.

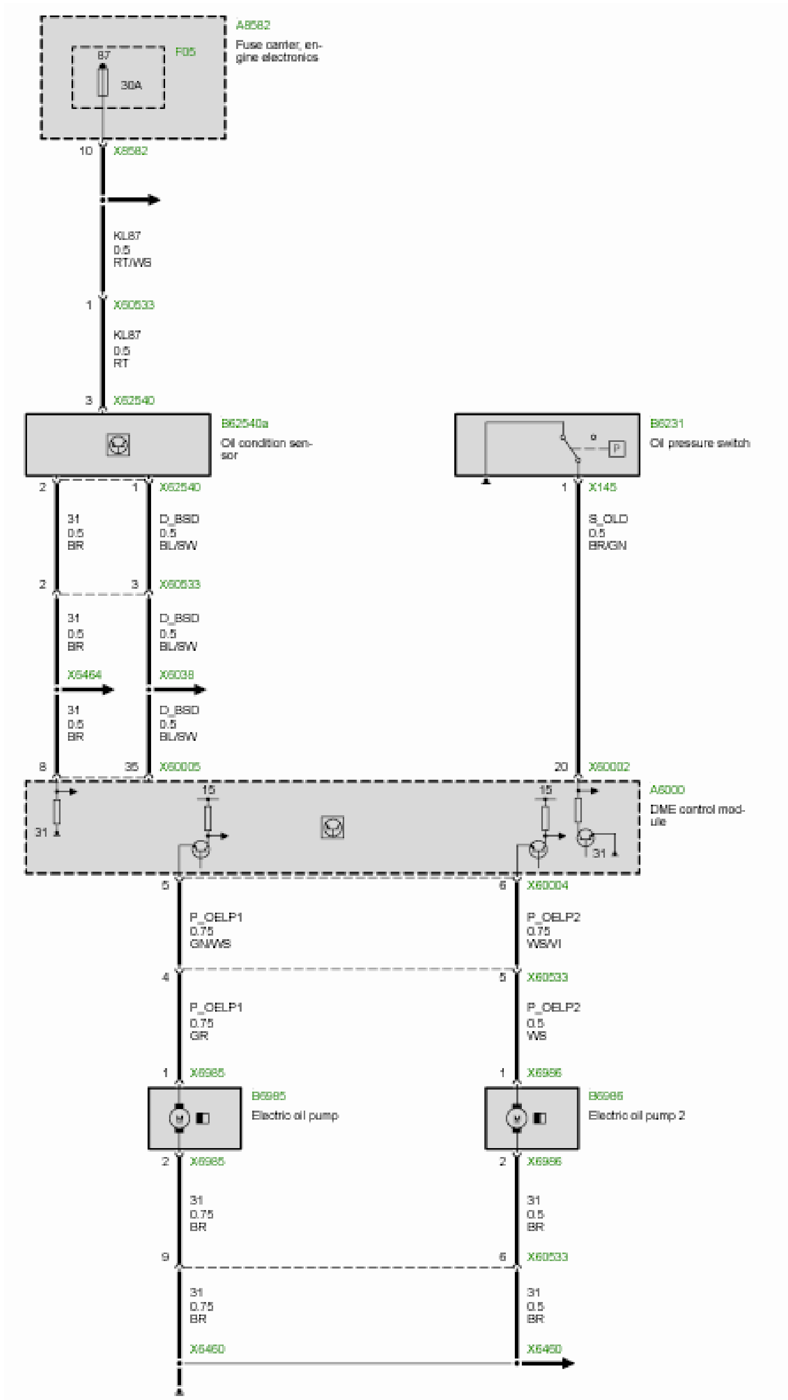
There are a total of 4 oil pumps (not including one for VANOS), that supply the S85 engine with lubrication. Of the four oil pumps used for lubrication, two of them are mechanically driven from the crankshaft by a chain drive. The other two oil pumps are electrically controlled by the ECM.

Since the E60 M5 is capable of cornering forces in excess of 1g, a potential for a loss of lubrication could be experienced. This extreme force will hold oil in the cylinder head on the cylinder bank which is on the outside of the turn which in turn could present the potential for oil starvation at the oil pump inlet.

To prevent this, there are two electrically operated “duo-centric” oil pumps located on the left and right sides of the oil sump. The ECM receives lateral acceleration information from the Dynamic Stability Control via the PT-CAN connection. If the lateral acceleration exceeds 0.8g, the ECM activates two electric oil pumps which transport oil from the cylinder head to the main oil sump.



Lubrication System Schematic



Oil Pressure Switch

The oil pressure switch is a ground input to the ECM. The status of the oil pressure switch is evaluated in the ECM. Any deviations from the specified value will cause the ECM to send a corresponding message to the CID. An associated check control message will also be displayed.

Oil Level Indicator

The M5 is equipped with an electronic oil level indicator. The display is selected with the BC control.

The oil level is indicated in the information field of the on-board computer (BC) in the instrument cluster.

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

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

Basically there are two different measuring methods:

- Long-term Measurement
- Quick Measurement

Index	Explanation
1	Oil Level
2	Maximum Level Mark
3	Minimum Level Mark

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

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

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.

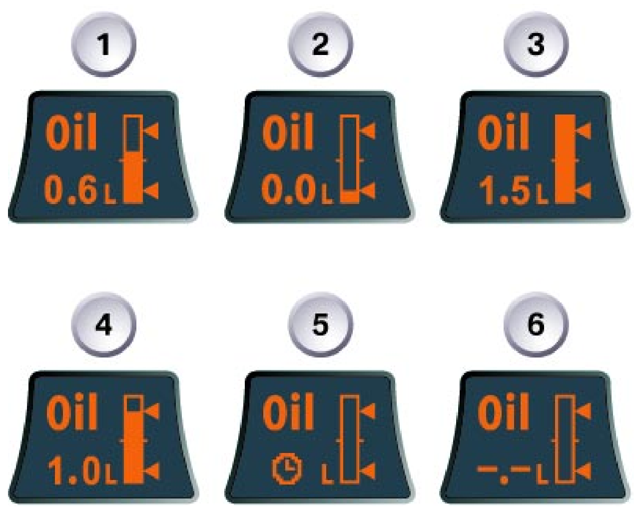
Display: 1.5 l means overfilled, the bar indicator is additionally filled above Maximum.

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 below) 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 approximately 60 s. The long-term value last stored is deleted with initiation of the quick measurement.



Index	Explanation	Index	Explanation
1	Oil level correct (0.6 liter minimum)	4	Oil level at maximum
2	Oil level at minimum	5	Rapid measurement in progress
3	Overfilled (bar full and 1.5 liter shown)	6	No value can calculated at the moment

Classroom Exercise - Review Questions

1. With regard to the “Ionic current measurement” technology, what components are no longer necessary on the S85 (and why)?

2. What (2) functions is the spark plug responsible for on the S85 engine?

3. When the vehicle is started, what “Power” mode is selected automatically (by default)?

4. Where are the CAN terminating resistors located on the DK-CAN and the LL-CAN?

5. What component(s) is responsible for the triggering of the ignition coils?

Classroom Exercise - Review Questions

6. How is the fuel pressure checked on the S85 engine?

7. What is the purpose of the two electric oil pumps?

8. How are the fuel pumps controlled on the S85?

9. Does the camshaft trigger wheel need to be adjusted? (why or why not?)

10. What is the purpose of the electric vacuum pump?

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Initial Print Date: 09/05 Revision Date:

Chassis & Suspension

Model: E60 M5

Production: from 9/2005

OBJECTIVES

After completion of this module you will be able to:

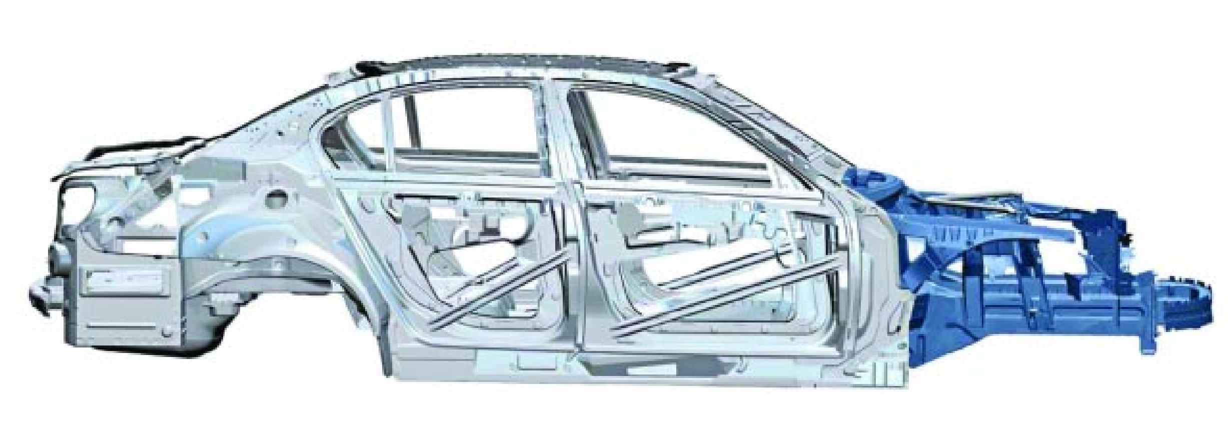
- Familiarize yourself with the suspension system used in the vehicle
- Familiarize yourself with the brake on the vehicle
- Understand the changes to the DSC system

Chassis & Suspension

The E60 M5 utilizes the same body construction as the production based 5 Series E60. The main body is made of steel and the front end utilizes the familiar GRAV technology.

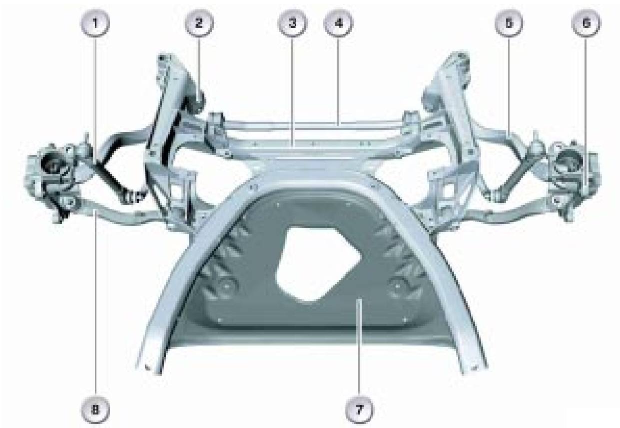
GRAV is an acronym of "gewichtsreduzierter Aluminiumvorderbau" and this lightweight aluminium front end enhances the lightweight design of the car. Almost the entire front end is made of aluminium.

The transition to steel in the composite construction starts in the vicinity of the engine bulkhead. The reduced weight of the front end in particular contributes much to the ideal axle-load distribution of 50:50.



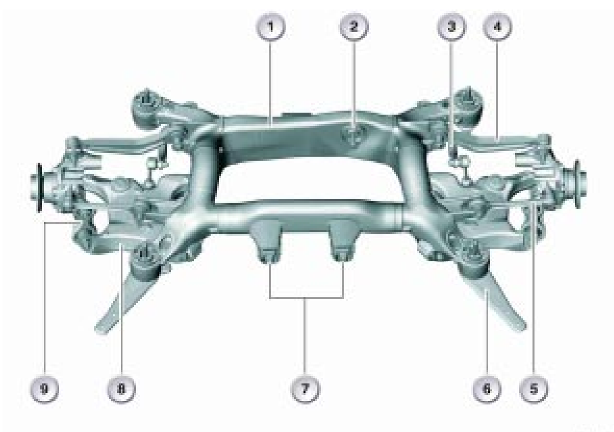
The suspension system used on the E60 M5 is carried over from the production based E60 5Series sedans.

The control arms and transverse links are made of aluminium and ensure high-precision tracking of the wheels. The highly innovative design principle with the special layout of the leading links and control arms ensures high-precision steering. The low axle loads, especially in the area of the front axle, also provide for a high degree of agility and familiar BMW handling characteristics.



Front Axle

Index	Explanation
1	Stabilizer Link
2	Hydro-Mount
3	Front Axle Carrier
4	Stabilizer Bar (No ARS)
5	Tension Strut
6	Swivel Bearing
7	Reinforcement Plate
8	Control Arm



Rear Axle

Index	Explanation
1	Axle Carrier
2	Differential Bearing, rear
3	Stabilizer Bar
4	Control Arm
5	Traction Strut
6	Thrust Rod
7	Differential Bearing, front
8	Swinging Arm
9	Integral Link

EDC-K

The continuously variable electronic damping control (EDC-K) system used in the E65/6 is used in the E60 M5.

The continuous Electronic Damping Control (EDC-K) absorbs vertical forces while driving and dampens these forces to the chassis.

The forces are measured by two vertical acceleration sensors on the front axle (left and right) and one at the rear axle (right). The front sensors are located in the wheel housings and the rear on the trunk tray underneath the trunk ventilation ports. The dampening characteristics are mapped in the control module to continuously regulate the EDC-K providing maximum comfort.

The EDC-K works with infinitely variable valves in the dampers to regulate the hydraulic fluid flow using electromagnetic control valves. EDC-K provides the actual damping force required at any time.

The steering angle sensor is used along with the front wheel speed sensors to determine the lateral acceleration. The controller provides the opportunity to select from three basic settings:

“Comfort” - Comfort-oriented coordination of shock absorbers and steering

“Normal“ - Offers a balanced mixture of the comfort and the sports program

“Sport” - Consistently sporty coordination of shock absorbers and steering.

Selecting Program

To select between the three programs available, press the EDC button repeatedly:

"Comfort": no LED lights up in the button.

"Normal": one LED lights up in the button.

"Sport": both LEDs light up in the button.

The last selected program is active each time the engine is started.

You can also activate your preferred program with the button on the steering wheel.

Brakes

Braking distances equal to top sports car levels. The new BMW M5 owes its enormous braking power to double piston aluminium brake calipers and perforated, ventilated compound (floating) brake rotors.

Front Brake Rotors

Brake rotor measurements front:

374 x 36 mm

Brake rotor measurements rear:

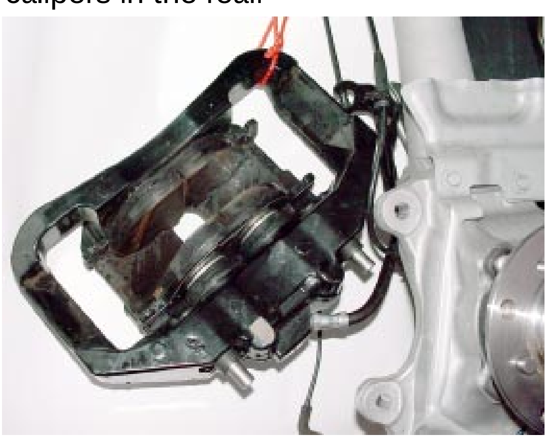
370 x 24 mm

Rear Brake Rotors

The braking distance for the M5 is approximately 118ft from 62 mph to a full stop.

Calipers

The M5 utilizes dual piston brake calipers in the front and conventional single piston calipers in the rear.



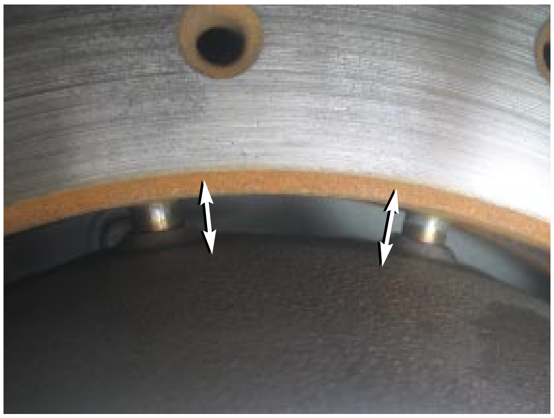
Dual Piston Front Brake Caliper

(close-up view)

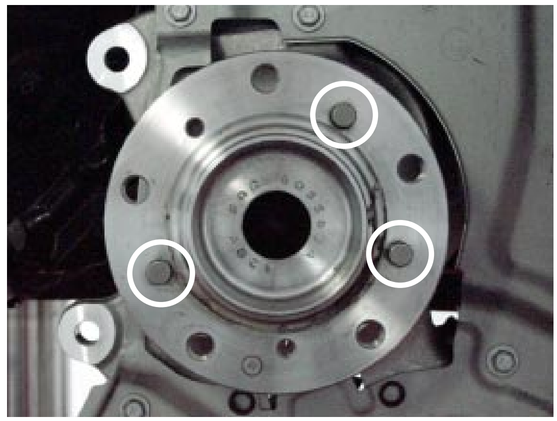
Rotors

Both the front and rear rotors are cross drilled floating type. These ensure optimized heat dissipation, improved response, as well as reduction of unsprung masses.

The rotor has an aluminum center section (hub) with pins embedded in a radial pattern that are “connected” to the rotor surface utilizing a free moving or floating configuration. This allows the rotor surface to contract and expand with the changes in temperature.



Detail of Rotor Attachment Pins



Detail of Rotor Alignment Pins on Hub

The rotor is attached to the hub with two allen style screws and three alignment pins located on the hub.

The rotor outer ring is cast and holes are drilled out to improve braking. The drilled surface allows gases that form between the brake pad and rotor to escape. Otherwise, there would be a thin film of “brake gases” between the surface of the rotor and the brake pads.

Rear Brake Pads (“gasses”)

Brake pads are made by gluing the friction material to a backing plate (metal). These are then baked in an oven to allow the glue to cure. While the brakes are heated, gasses are released and travel through the brake pads to the surface. This can be seen on any new brake pads as a lighter upper section of the brake pad (see picture to the left).

DSC MK60E5

Introduction

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

The MK60E5 is a further development of the MK60psi, which is currently used in the E90. 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.

This system offers functions that were not yet available with the previous system.

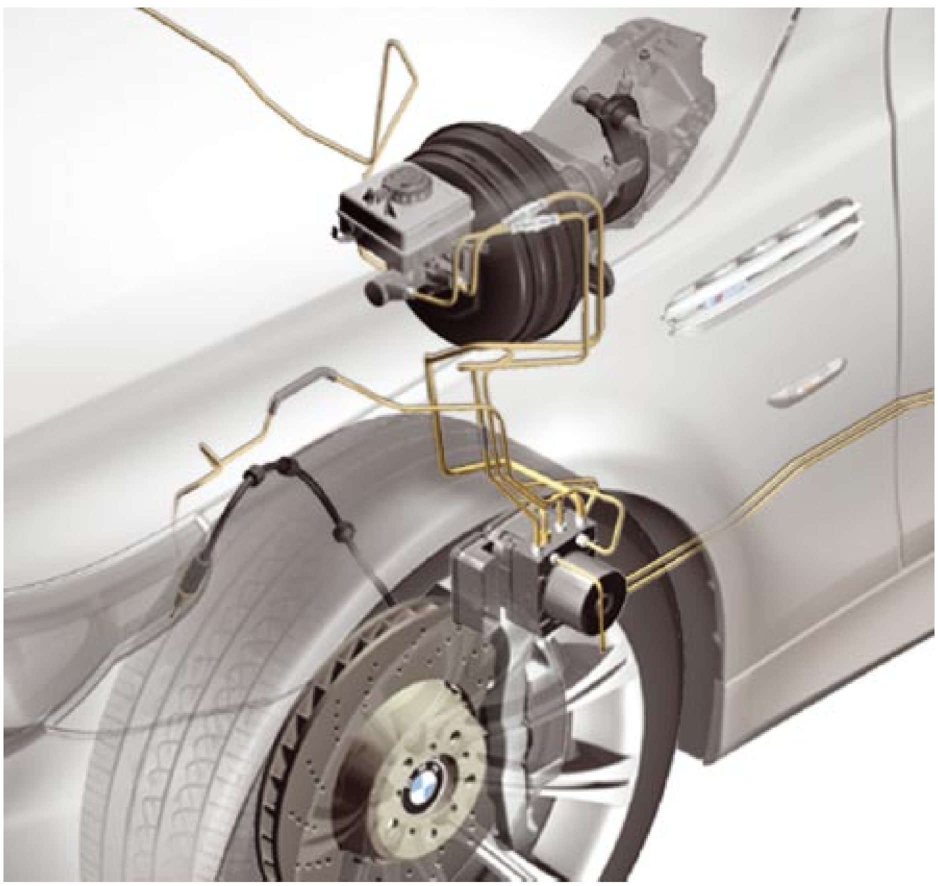
New Functions:

- Brake Readiness
- Dry Braking
- Hill Ascent Assistant.

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.

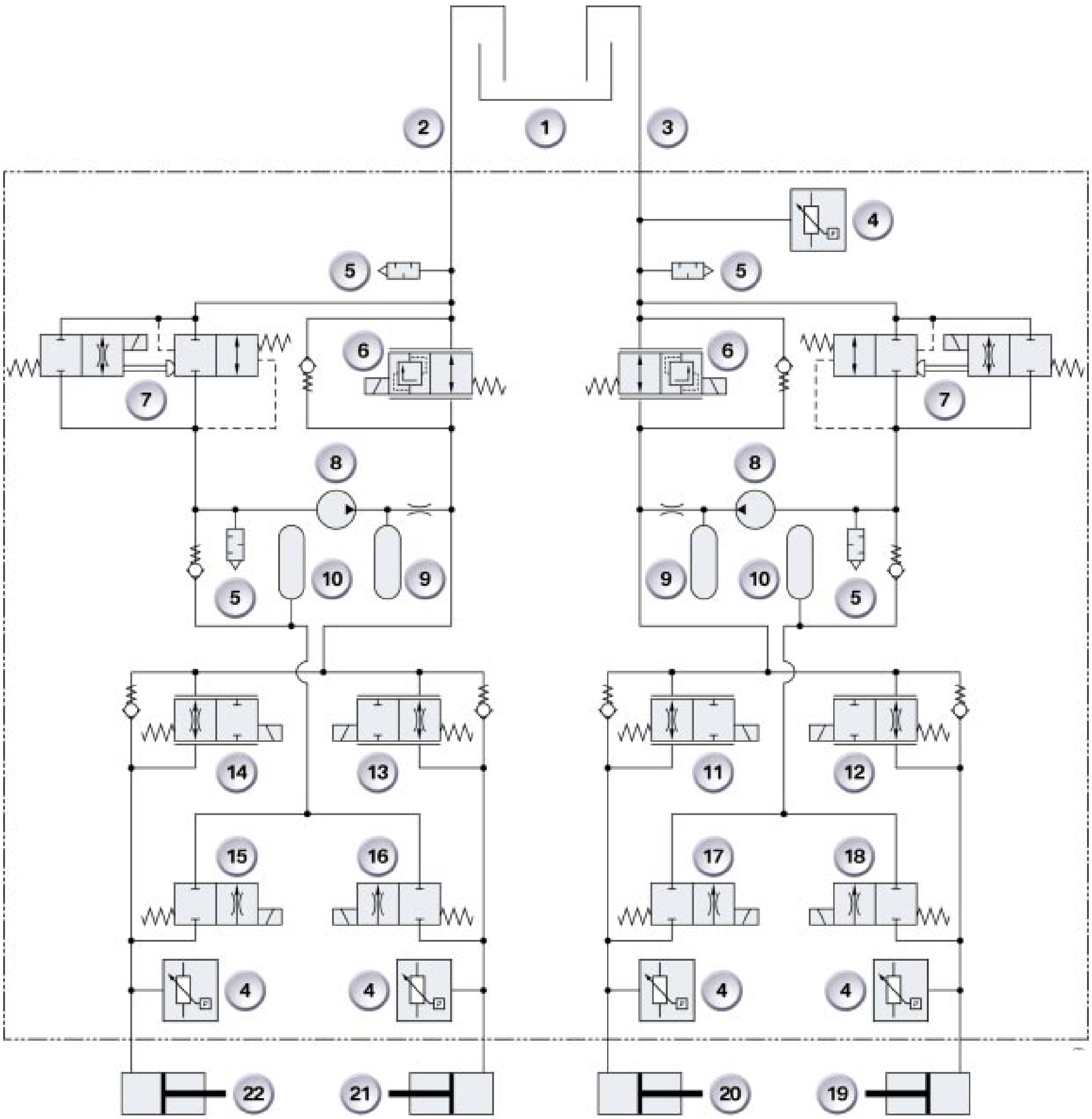
This system has made it possible to reduce the required braking distance less than previous systems. The E60 M5 has a braking distance of less than 118 feet from a speed of 62 mph (< 36 m from 100 km/h).

The tire failure indicator (RPA) is integrated in the DSC functions.



Mounting Location of DSC Control Unit and Hydraulic Unit

DSC MK60E Hydraulics Diagram



Legend for DSC MK60E Hydraulics Diagram

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, analog
12	Front Right Inlet Valve with Orifice Plate, analog
13	Rear Right Inlet Valve, analog
14	Rear Left Inlet Valve, analog
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

System Components

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

- Analog 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

The control unit is mounted behind the left front wheel well cover and is attached to the hydraulic unit. It consists of:

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

Hydraulic Unit

The Teves MK60E5 hydraulic unit consists of:

- 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).

Features

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

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

The following functions are not used 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
- MDynamic 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.

MDynamic 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 approximately 125 mph (200 km/h) in order not to overtax the driver in the high speed range.

Note: MDynamic Mode can be activated only via the M-Drive.

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 19 mph (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 approximately 3 seconds 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 seconds. The vehicle will start off after approximately 1 seconds if the driver does not press the accelerator pedal.

The longitudinal acceleration sensor is assigned to the SMG system. The DSC control unit receives this signal over the bus network.

Note: 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.

Variable M Differential

The variable M differential from the E46 M3 is utilized in the E60 M5 . The variable, rev-sensing locking differential on the rear axle delivers a key traction advantage, even in very demanding driving situations.

For example: When the friction coefficients (surface traction) for the two drive wheels are very different from each other.

By utilizing the internal sheer pump, the locking effect between the left and right wheels can be up to 100%. This markedly improves handling and stability, enhancing both safety and driving enjoyment. Sporty drivers in particular enjoy the advantages of the differential lock – it enhances the positive aspects of rear-wheel drive when driving at higher speeds and on surfaces with poor traction.

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SMG III

Model: E60 M5

Production: from 9/2005

OBJECTIVES

After completion of this module you will be able to:

- Recognize the designation of the new gearbox
- Understand the operation of the gearbox
- Identify components used in the SMG 3 system

Introduction

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

The SMG 3 is the first sequential M gearbox that has been specifically developed for automated operation. Previous sequential gearboxes were conventional manual transmissions with an adapted hydraulic gearshift unit attached.

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
- The use of carbon fibre friction cones in the synchronizer rings that facilitate shorter synchronization times through their higher load bearing capacity
- Redesign of the transmission pinion placement (first gear pinion is not next to second gear pinion - they do not share the same synchronizer)

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”.

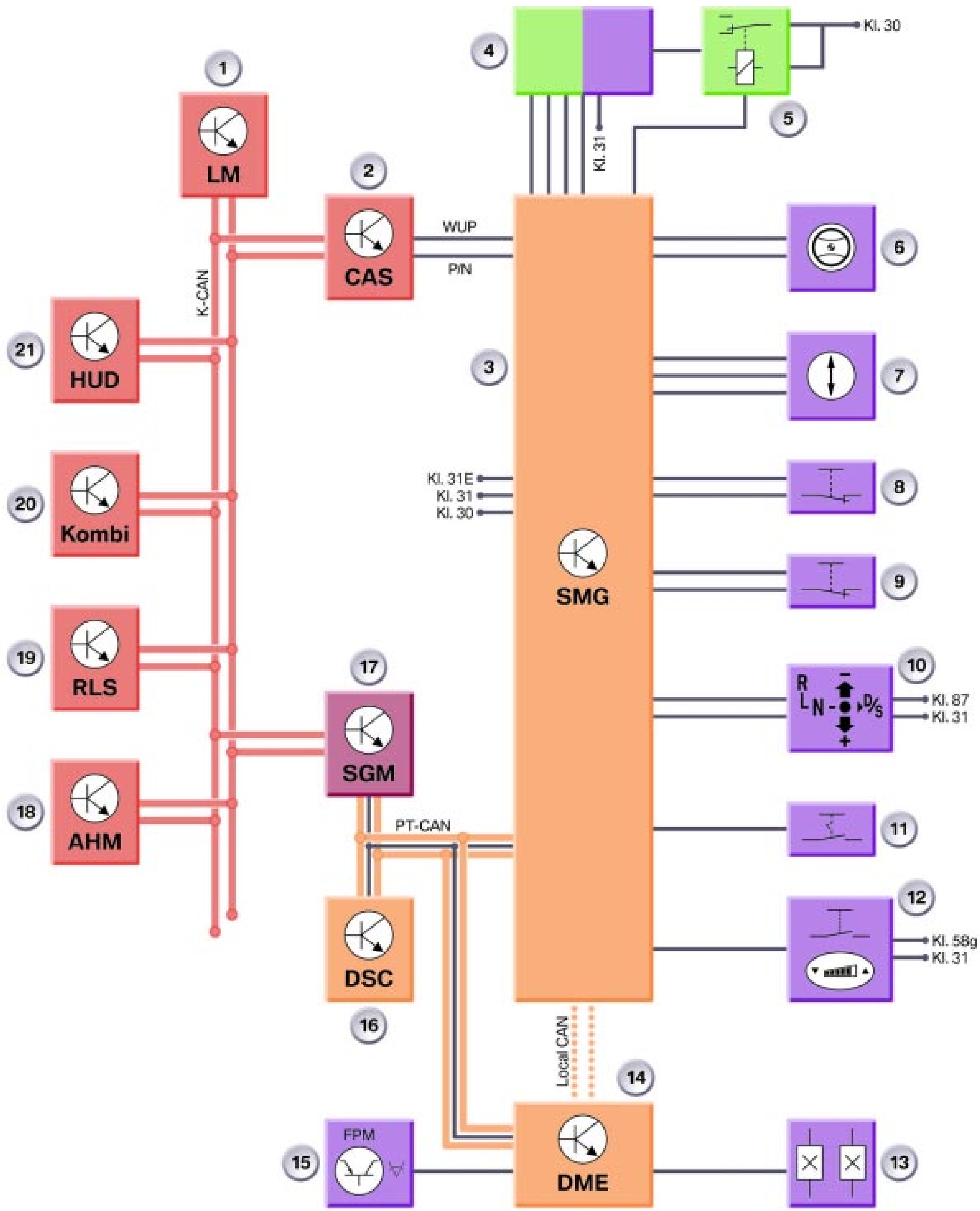
In addition, the system also has the ability for the following special features:

- Launch control
- Hill ascent assistant
- Drivelogic
- Tire teach-in function,

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.

NOTES PAGE

SMG III System Overview



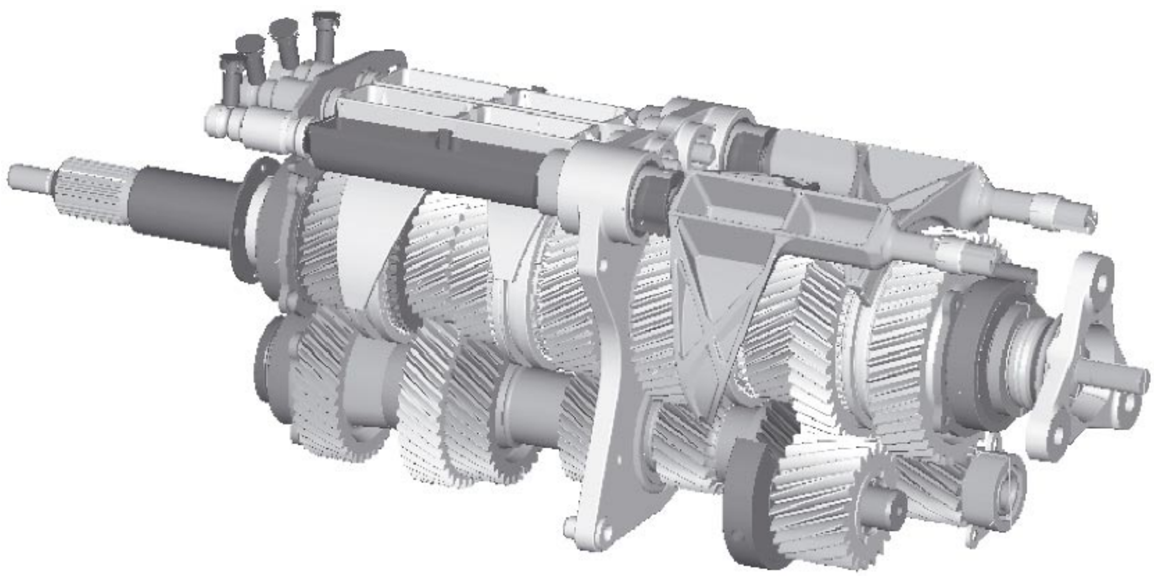
Legend for SMG III System Overview

Index	Explanation
1	Light Module
2	Car Access System 2 (CAS 2)
3	SMG Control Unit
4	Sequential M Transmission
5	Pump Relay
6	Multi-Function Steering Wheel (MFL)
7	Longitudinal Acceleration Sensor
8	Hood Contact Switch
9	Hood Contact Switch
10	Selector Lever Indicator
11	Door Contact Switch
12	Drivelogic Switch
13	Brake Light Switch
14	Engine Control Module
15	Pedal Position Sensor (PWG)
16	DSC Control Unit (MK60E5)
17	Body Gateway Module (KGM)
18	Trailer Module (not for US)
19	Rain/Light Sensor (RLS)
20	Instrument Cluster
21	Head-Up Display

System Components

SMG Getrag 247 Gearbox

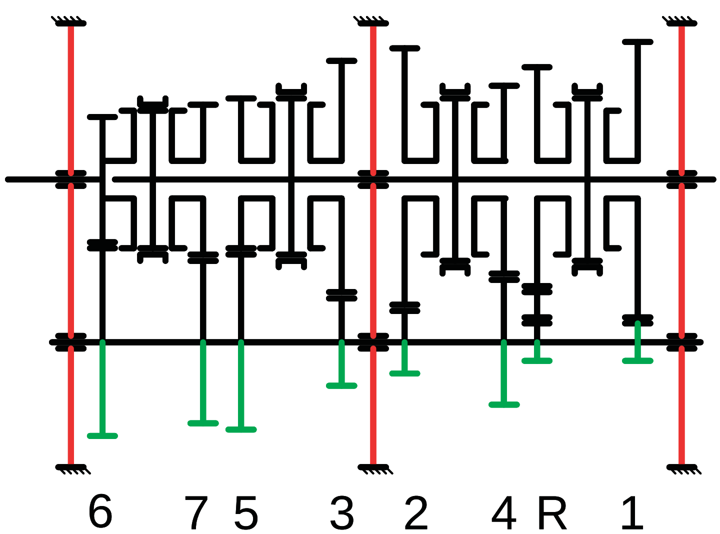
A special feature of this gearbox is that the main shaft is mounted in three bearing assemblies. The third bearing assembly has been realized by an end shield bolted in the gearbox casing.



Pinion Arrangement of the SMG Getrag 247

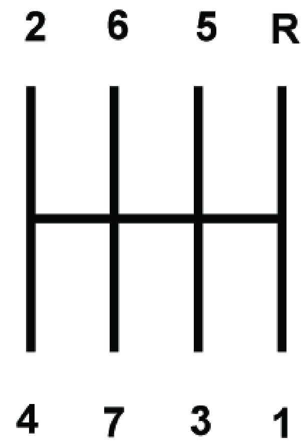
Powerflow

The diagram below illustrates the powerflow of the gearbox.



Gearshift Pattern
Besides the gearbox being designed solely for a sequential shifting mechanism (making a manual shift version impossible), the shift pattern would make it impractical for manual shifting.

Selector Rods (top view)



Shift Pattern

Gear Recognition Hall Sensors

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.

Oil Temperature Sensor

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.

Oil Pressure Sensor

The Hydraulic pressure sensor is located inside the hydraulic unit. It is used to determine operating pressure values.

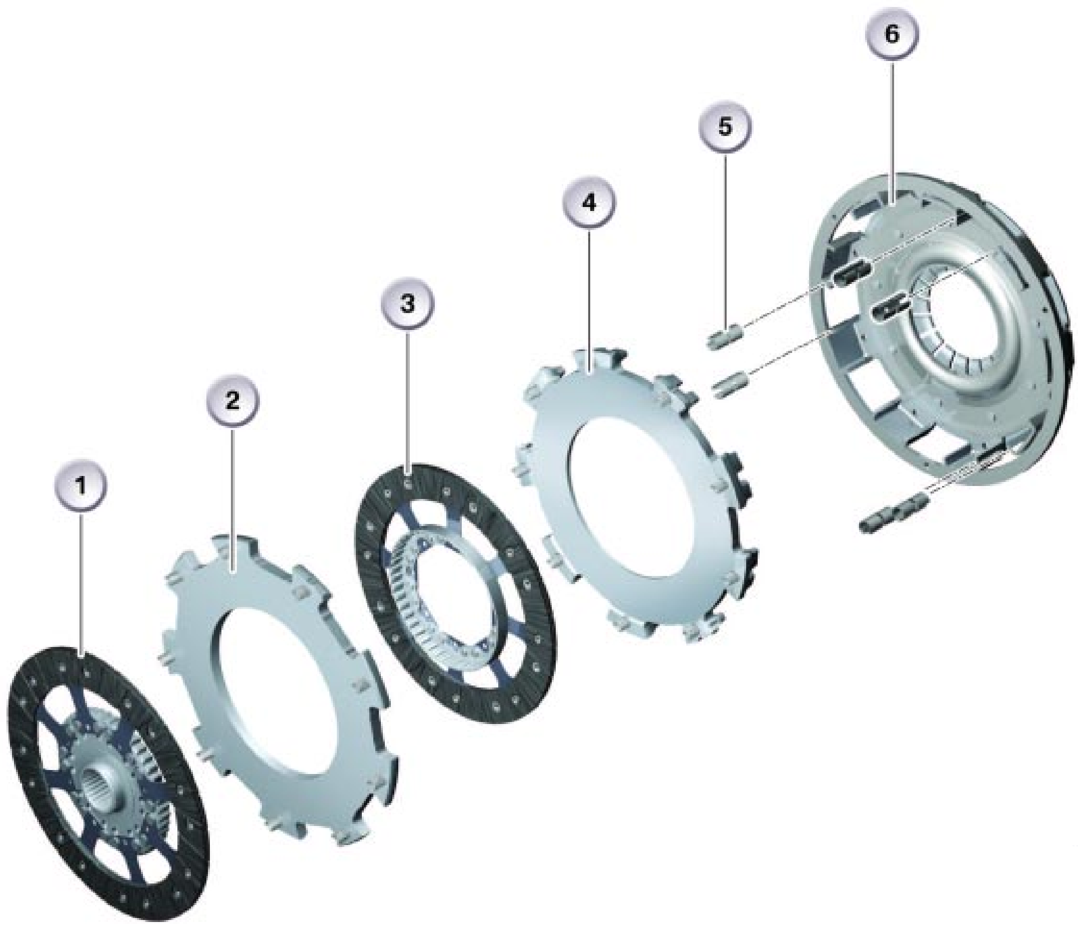
Normal operating pressure is 75 Bar (90 Bar is only used during the learn-in/adaptation)

Input Speed Sensor

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

Clutch

The E60 M5 utilizes a two disc dry clutch setup to transfer power from the engine to the gearbox.



Two Disc Clutch

Index	Explanation
1	Drive Plate
2	Intermediate Plate
3	Drive Plate
4	Contact Plate
5	Formed Spring
6	Pressure Plate

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.

Gearshift Lever

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.

Drivelogic Switch

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.

Steering Angle Sensor

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

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).

Gearshift Lever

Longitudinal Acceleration/Gradient Sensor

The longitudinal acceleration and gradient values are determined by the longitudinal acceleration sensor in the right footwell. This signal is used for the purpose of calculating the gradient.

Brake Light Switch

For redundancy , 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.

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.

Hood Contact Sensors

Two Hall sensors mounted on the hood latches determine the hood status.

Similar to the E46 M3 equipped with an SMG gearbox, the driver is warned if the hood is open. The vehicle can only start off if the hood contact status are both closed. If the status cannot be determined, the vehicle will not engage into gear.

Door Contact

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.

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

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.

Reverse 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 center that reverse gear is engaged.

Hydraulic System

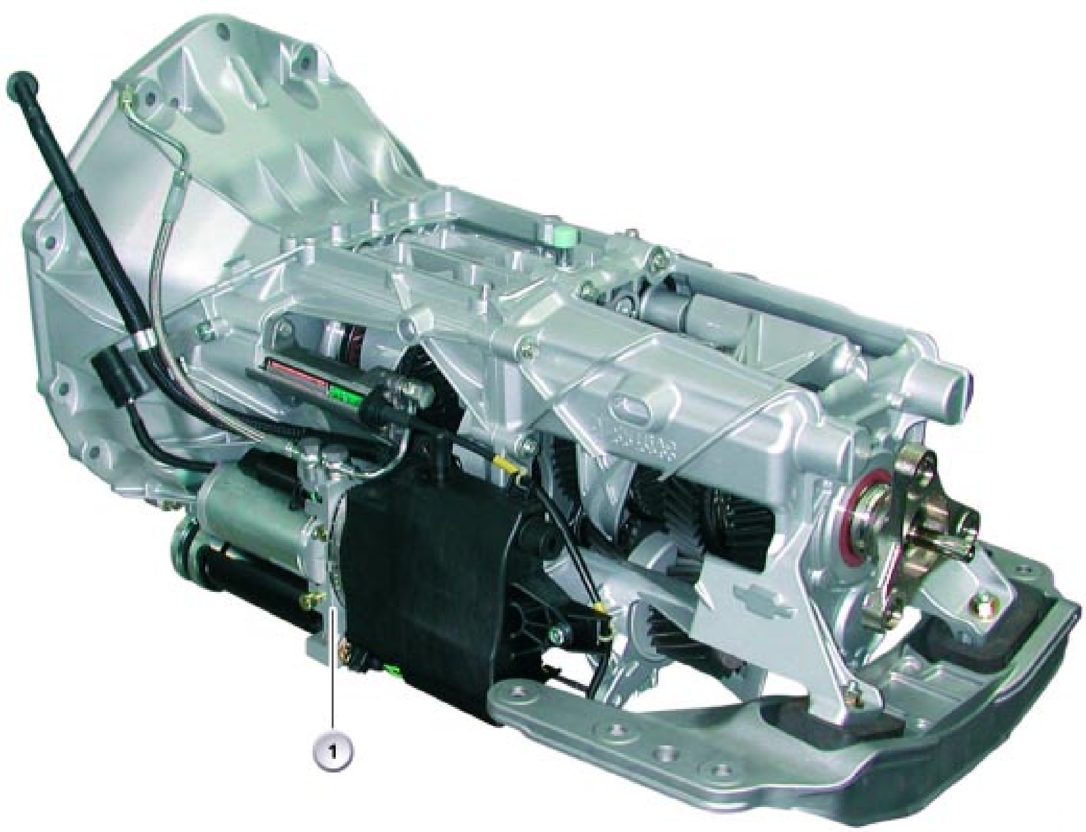
A DC motor drives the hydrostatic pump. The pump conveys the hydraulic oil via a non-return valve into a pressure system while energy is stored in a hydraulic accumulator.

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.

Inside the hydraulic unit are the following components:

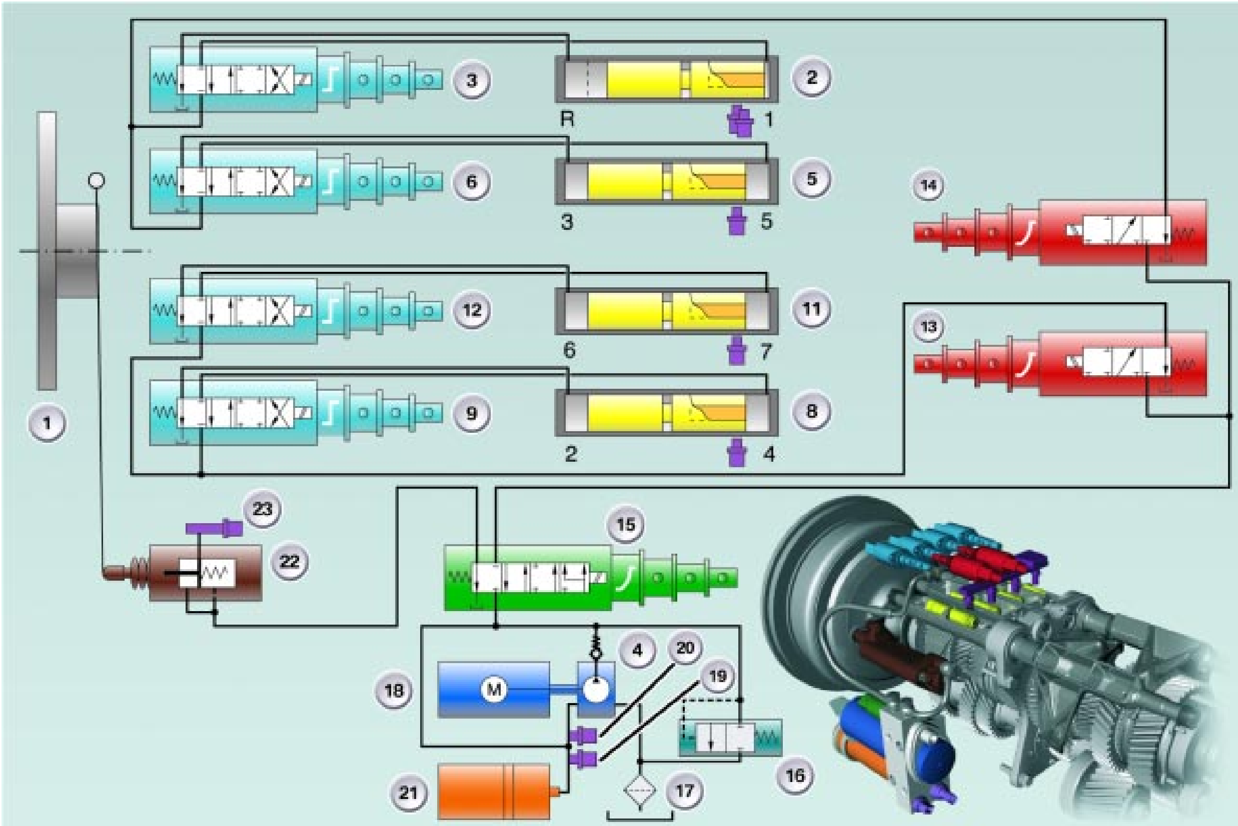
- Pressure Accumulator
- Hydraulic Pressure Sensor
- Solenoid Valve for the Clutch
- Hydraulic Pump with Electric Motor
- Hydraulic Temperature Sensor
- Pressure Limiter Valve
- Regulator Block
- Clutch Slave Cylinder with PLCD Sensor
- Expansion Tank
- Check Valve
- Filter



SMG with Hydraulic Unit

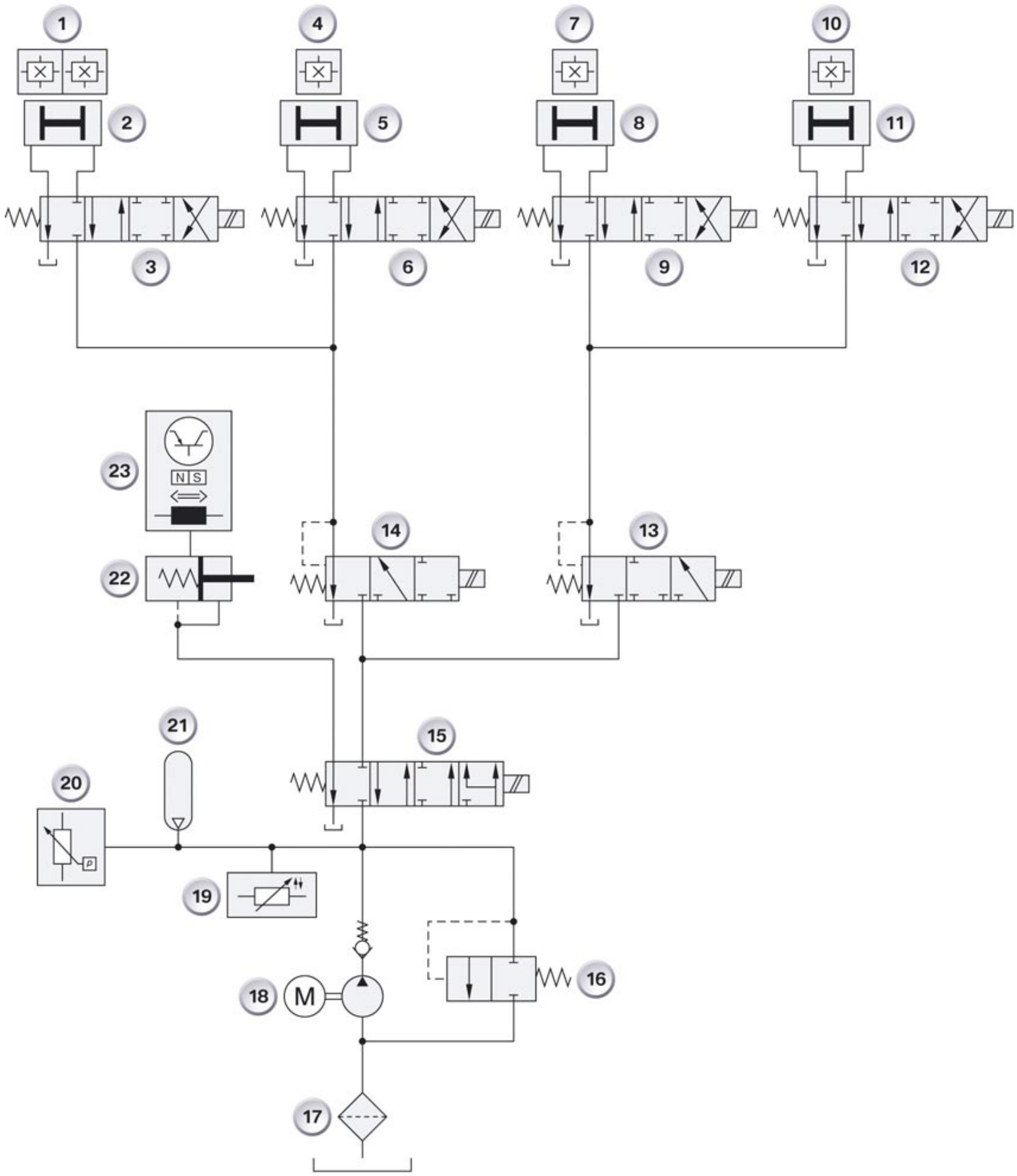
Index	Explanation
1	Hydraulic Unit

SMG III Hydraulic System Overview



Index	Explanation	Index	Explanation
1	Clutch	14	Proportional Valve
2	Working Piston (R / 1)	15	Proportional Valve
3	Shift Range Valve (R / 1)	16	Pressure Limiter Valve
4	Hydraulic Pump	17	Edge-Type Filter
5	Working Piston (3 / 5)	18	Electric Motor
6	Shift Range Valve (3 / 5)	19	Temperature Sensor
8	Working Piston (2 / 4)	20	Pressure Sensor
9	Shift Range Valve (2 / 4)	21	Pressure Accumulator
11	Working Piston (6 / 7)	22	Clutch Slave Cylinder
12	Shift Range Valve (6 / 7)	23	PLCD Sensor
13	Proportional Valve		

SMG III Hydraulic System Overview



Legend for SMG III Hydraulic System Overview

Index	Explanation
1	Hall sensors, selector rod R/1 (redundant)
2	Working Piston (R / 1)
3	Shift Range Valve (R / 1)
4	Hall sensors, selector rod 5/3
5	Working Piston (3 / 5)
6	Shift Range Valve (3 / 5)
7	Hall sensors, selector rod 2/4
8	Working Piston (2 / 4)
9	Shift Range Valve (2 / 4)
10	Hall sensors, selector rod 6/7
11	Working Piston (6 / 7)
12	Shift Range Valve (6 / 7)
13	Proportional valve
14	Proportional valve
15	Proportional valve
16	Pressure Limiter 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

Pressure Accumulator

The pressure accumulator is fitted on the bottom left of the transmission. The pressure accumulator supplies enough hydraulic power for the gearshift.

Hydraulic Pressure Sensor

The hydraulic pressure sensor is fitted directly to the hydraulic block of the hydraulic control unit. The hydraulic pressure sensor reports the current hydraulic pressure to the SMG control unit. The hydraulic pump is switched on and off accordingly.

Solenoid Valve for the Clutch

The solenoid valve for the clutch is used for actuating the clutch slave cylinder.

Hydraulic Pump with Electric Motor

The hydraulic pump with electric motor builds up to 90 bar system pressure for the gearshift. The hydraulic pump with electric motor is actuated via the SMG control unit.

Hydraulic Temperature Sensor

The hydraulic temperature sensor measures the temperature of the hydraulic fluid at the hydraulic pump.

The signal is used for actuation of the transmission functions in the SMG control unit. The signal is transmitted by a direct wire from the hydraulic temperature sensor to the SMG control unit.

Pressure Limiter Valve

The pressure limiter valve prevent the oil pressure in the hydraulic control unit from becoming too high.

Regulator Block

The regulator block is installed in the center of the transmission housing close to the clutch housing.

The regulator block consists of the following components:

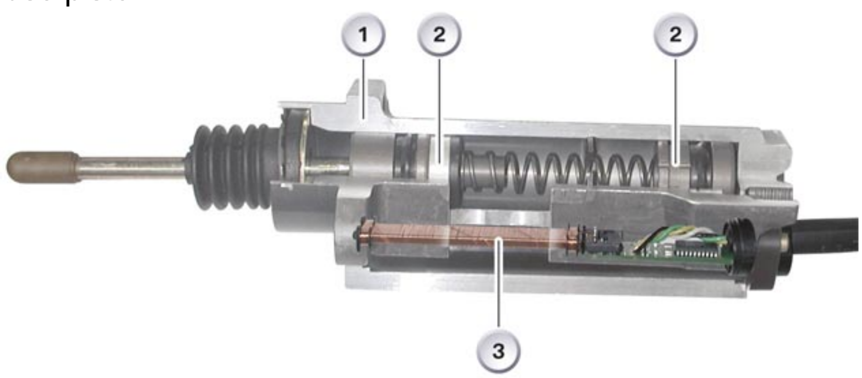
- 4 shift travel valves for actuating the hydraulic shift cylinders
- 2 pressure control valves for modulation of the shift force
- 4 hydraulic shift cylinders for moving the shift rods in the longitudinal axis
- 4 transmission position sensors for recording the selected gear (shift rod sensor R/1 is designed as a double version.)

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 (Permanent-magnetic Linear Contactless Displacement) is arranged separately in the housing of the clutch slave cylinder. This sensor determines the exact position of the release piston.



Clutch Slave Cylinder

Index	Explanation	Index	Explanation
1	Housing of Clutch Slave Cylinder	3	PLCD Sensor
2	Pistons		

PLCD Sensor

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.

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 the measurement is supplied by the ASIC (Application Specific Integrated Circuit) integrated in the PLCD sensors.

Expansion Tank

The expansion tank ensures that there is always sufficient hydraulic fluid available for the system.

Check Valve

The check valve at the outlet to the hydraulic pump prevents the hydraulic pressure from reducing when the hydraulic pump is inactive.

Filter

A filter is installed at the inlet end of the hydraulic pump. The filter prevents impurities from entering the solenoid valve (functional failure). It is not necessary to clean the filter.

Features

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.

Gear	Ratio	Gear	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

Drivelogic

Each time you change between the Sequential mode and the Drive mode, the driving program last selected in the respective mode is active.

The exception to this is after the first change from the Sequential to the Drive mode. In this case, driving program 3 is active.

In Drive Mode
Five driving programs, from relaxed 1 to sporty/highly dynamic 5 are available for selection.

In Sequential Mode
You can choose from six driving program from balanced/dynamic 1 to sporty/purist 6.

Each time the engine is started, driving program 3 is activated.

The sporty/purist driving program 6 is only available with the DSC Dynamic Stability Control deactivated. When DSC is activated, the system switches from driving program 6 to 5.

Note: To maintain vehicle stability, always drive with the DSC switched on when possible.

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/push-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).

Note: Further information on the hill ascent assistant can be found in the Chassis and Suspension Section under "DSC MK60E5".

Hill Hold Feature (similar to regular production E60 - shown)

Launch Control
Launch control has been carried over from the E46 M3.

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 minimize the clutch slip.

Service Information

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.

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 (tire 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.

Pressure Accumulator Preload

A function for checking the accumulator preload is available 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.

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.

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E60 M5 Driver Information Systems

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Initial Print Date: 09/05 Revision Date:

Driver Information Systems

Model: E60 M5

Production: from 9/2005

OBJECTIVES

After completion of this module you will be able to:

- Recognize the differences in Driver Instrumentation when compared to the base 5 Series production vehicle
- Recognize and navigate through the MDrive settings
- Know what information is displayed on the HUD
- Know how to perform an oil level check and what types of measurement or available

Introduction

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.

The M5 instrument cluster is based on the instrument cluster of the E60 545i. There are changes to the visual appearance and functions.

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 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.

System Components

Instrument Cluster

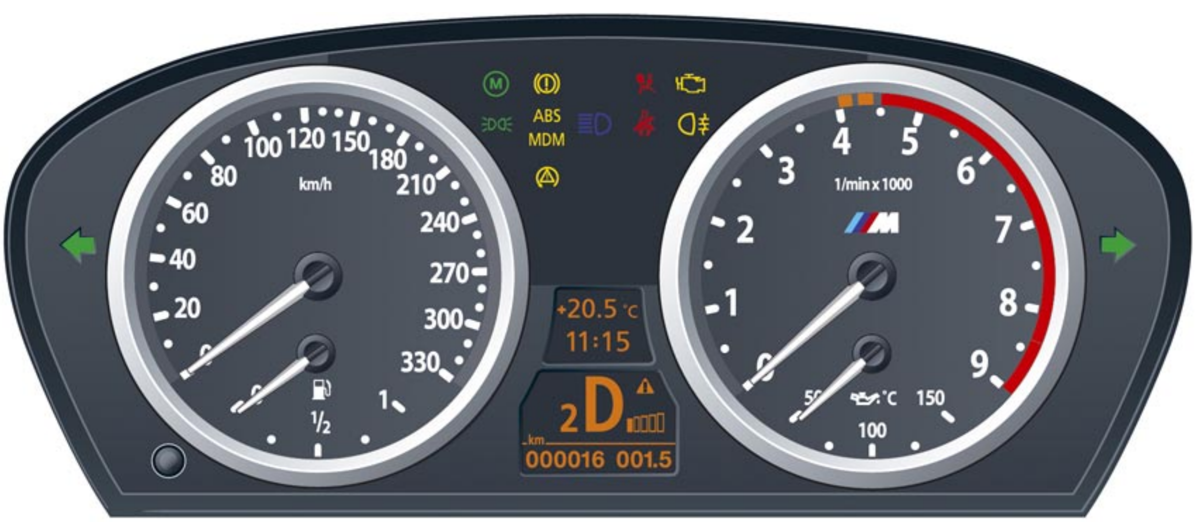
The instrument cluster in the M5 is based on that of the E60 Series. Corresponding adaptations have been implemented in the visual appearance and scope of functions for use in the M5.

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.



Central Information Display - MDrive Menu

There is a new menu in the iDrive system that allows the driver (key dependent) to customize certain system settings in the vehicle when the entering the Sport Mode via the M button on the steering wheel (presetting the characteristics).

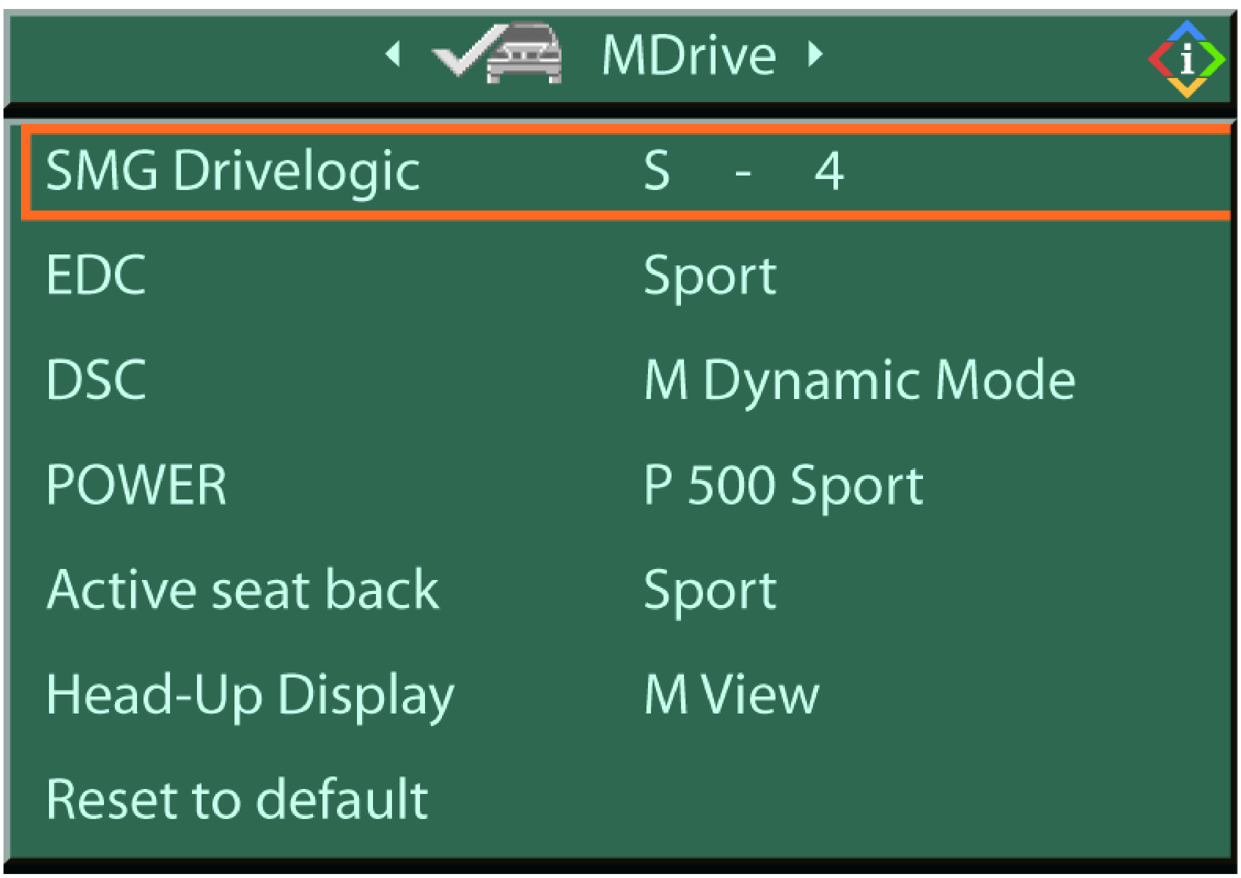
This feature is referred to as MDrive.

To access the MDrive menu use the following path in the iDrive system:

Main Menu => i Menu => Vehicle Settings => MDrive Menu

The following options can be preset in the menu:

- SMG Drivelogic
- EDC
- DSC
- Power
- Active Backrest
- Head-Up Display
- Reset to Default



Activating Settings
Press the MDrive button on the steering wheel.

The indicator lamp in the instrument cluster lights up. The settings made on the Control Display for the functions contained in MDrive are active.

Deactivating Settings
Pressing the MDrive button on the steering wheel a second time deactivates MDrive.

Even with MDrive activated, you can change individual settings outside MDrive, e.g. with the buttons in the center console. To reactivate all settings made for MDrive on the Control Display press the button twice.

Driving Area of Vehicle

Note: If the indicator lamp flashes after pressing the button, then MDrive was unable to react, as the ABS Anti-lock Brake System or DSC Dynamic Stability Control is currently controlling the vehicle stability. Press the button again when the indicator lamp no longer flashes.

SMG Drivelogic

You can pre-select or activate your preferred driving program with the MDrive button on the steering wheel for the SMG gearbox.

Selecting "SMG Drivelogic" and press the controller (the first setting is selected).

Turning the controller will set Drive mode, Sequential mode, or "Unchanged".

"D" Drive Mode signifies the gearbox will go to the automatic mode.

"S" Sequential Mode signifies the gearbox will go to the manual mode.

"Unchanged" signifies the gearbox retain whatever the current settings are when the MDrive button on the steering wheel is selected.

After selecting the Drive mode, the Program mode can be pre-selected.

Here, the driver can choose from program numbers 1(balanced/dynamic) to 6 (sporty/purist).

Note: The sporty/purist driving program 6 is only available with the DSC Dynamic Stability Control deactivated. When DSC is activated, the system switches from driving program 6 to 5.

EDC Electronic Damping

You can pre-select or activate your preferred driving program with the MDrive button on the steering wheel for the SMG gearbox.

You can choose from three programs:

"Comfort" Program - Select the "Comfort" program if you want comfort-oriented coordination of shock absorbers and steering.

"Normal" Program - The "Normal" program offers a balanced mixture of the comfort and the sports program.

"Sport" Program - Select the "Sport" program if you want a consistently sporty coordination of shock absorbers and steering.

DSC

The preselection of the DSC setting for the MDrive program offers 4 options:

"Unchanged" signifies the gearbox retain whatever the current settings are when the MDrive button on the steering wheel is selected.

"Off" signifies that the DSC system will be entirely disabled.

"On" signifies that the DSC system will be on.

"M Dynamic Mode" signifies that the DSC system's MDM program will be activated.

DSC - M Dynamic Mode (MDM)

The M Dynamic Mode is a mode of the Dynamic Stability Control (DSC). It enables driving with greater longitudinal and lateral acceleration on dry road surfaces, however with limited vehicle stability. The system does not provide stabilizing intervention by reducing the engine output and braking at the wheels until the absolute driving limit is reached. Steering corrections by the driver may also be required in this driving state.

The M Dynamic Mode is deactivated each time the engine is started.

MDM indicator lamp The indicator lamp goes out shortly after the engine is started. The indicator lamp stays lit: M Dynamic Mode is activated. The indicator lamp lights up continuously and the DSC indicator lamp flashes: the M Dynamic Mode is active and controls the drive and braking forces.

Note: To Deactivate MDM again, press the button on the steering wheel again; the MDM indicator lamp goes out.

WARNING!!!

With the M Dynamic Mode activated, stabilizing interventions are only carried out to a reduced degree. To maintain vehicle stability, drive with DSC activated and the M Dynamic Mode deactivated whenever possible.

Power - M Engine Dynamic Control

With M Engine Dynamic Control you can influence how sporty the reaction of your vehicle to accelerator pedal movements is to be. Three programs are available for engine control.

"P 400" Program - In the "P 400" program the engine reacts gently to the movement of the accelerator pedal. This is, for example, ideal for city driving or driving on snow. In the process, the fuel consumption is minimal and the engine output is reduced.

"P 500" Program - The "P 500" program provides maximum performance and more spontaneous reaction of the engine to accelerator pedal movements.

"P 500 Sport" Program - In the "P 500 Sport" program the engine reacts especially spontaneously and uncompromisingly sporty with maximum performance to accelerator pedal movements.

Program Selection

Each time the engine is started, the "P 400" program is activated.

Press the POWER button to activate the "P 500" program. Pressing the POWER button repeatedly switches between the programs "P 400" and "P 500".

Note: You can only activate the "P 500 Sport" program with MDrive. For the programs "P 500" and "P 500 Sport" the LED in the POWER button lights up.

Active Seat Backrest

First set a comfortable backrest width. Based on the backrest width set, the lateral support is automatically adapted to the current driving situation.

The adaptation of the backrest width and the speed of the adjustment vary depending on the program. You can select from among three programs from comfort to sport. The "Sport" program provides for increased lateral support on both sides when driving through a quick succession of alternating curves.

Three programs are available under active seat backrest control are:

"Comfort" program

"Normal" program

"Sport" program

Head-Up Display (HUD)

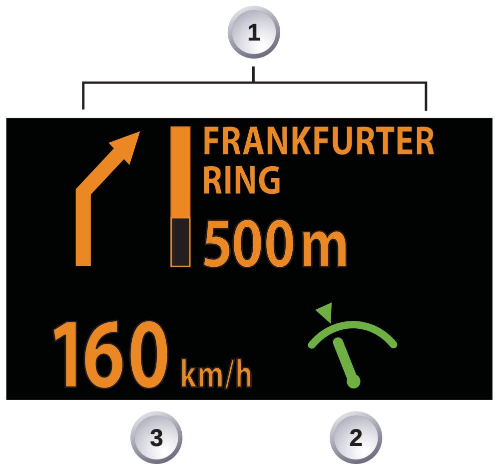
The "M-view" has been added to the Head-Up Display. This expansion feature, however, is implemented only in the software of the HUD control unit.

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.

M-View



Default View

Index	Explanation
1	Current Engine Speed Highlighted
2	Advance Warning Field
3	Red Warning Field
4	Speed
5	Gear Display

Index	Explanation
1	Navigation Instructions
2	Cruise Control Status
3	Speed

Note: The visibility of the displays in the Head-Up Display is influenced by:

- **Sunglasses with certain polarization filters**
- **Certain seating positions**
- **Objects on the cover of the Head-Up Display**
- **Wet road surface and unfavorable lighting conditions**

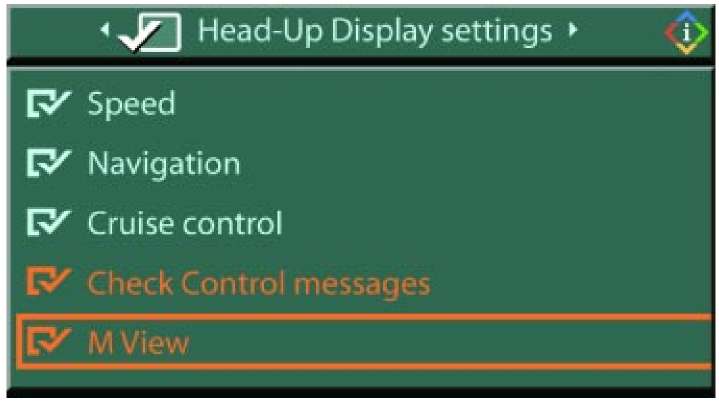
Enabling M-View

To select M-View you have to utilize the display settings Menu of the iDrive system.

With the engine running or the ignition switched on:

Press the button to activate or deactivate the Head-Up Display.

1. Press the button.
   (This opens the start menu.)
2. Press the controller
   (Opens the i-Menu)
3. Select "Display settings"
   and press the controller.
4. Select "Head-Up Display"
   and press the controller.
5. Select desired information of
   Head-Up Display.
6. Press the controller.



When M View is selected,not all information usually selectable for the HUD are not available. Information unavailable in the M view appears on the Control Display in gray and cannot be selected.

The settings are stored for the remote key currently in use.

Note: The M view for the Head-Up Display can also be programmed into the MDrive button on the steering wheel.

Setting Brightness

The brightness of the display is automatically adapted to the ambient lighting conditions. However, you can change the base setting. With the low beams switched on, the brightness can also be adjusted with the knurled wheel of the instrument lighting.

To adjust brightness:

1. Open the start menu.
2. Press the controller to open the menu.
3. Select "Display settings" and press the controller.
4. Select "Brightness" and press the controller.
5. Move the controller to the left to select "Head-Up Display".
6. Turn the controller until the desired setting is selected.

The setting is stored for the remote control currently in use.

Reset to Default

This option allows all the setting in MDrive to revert to factory or default settings.

Oil Level Indicator

The M5 is equipped with an electronic oil level indicator. The display is selected with the BC control.

The oil level is indicated in the information field of the on-board computer (BC) in the instrument cluster.

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

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

Basically there are two different measuring methods:

- Long-term Measurement
- Quick Measurement

Oil Level Indicator

Index	Explanation
1	Oil Level
2	Maximum Level Mark
3	Minimum Level Mark

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

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

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.

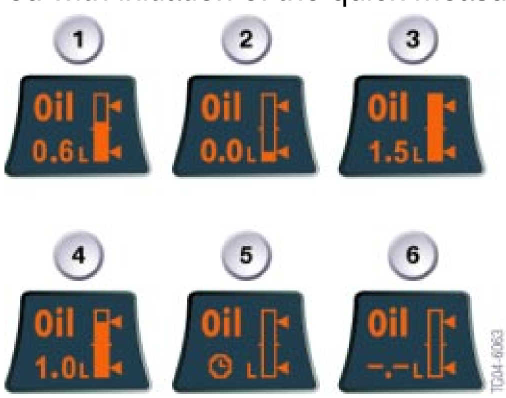
Display: 1.5 l means overfilled, the bar indicator is additionally filled above Maximum.

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 below) 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 approximately 60 s. The long-term value last stored is deleted with initiation of the quick measurement.



Index	Explanation
1	0.6 Liter Minimum
2	Minimum Level
3	Overfilled (bar full and 1.5 Liter displayed)
4	Maximum Level
5	Oil Level Measurement Running
6	No Measured Value Stores and Measurement Criteria not Met