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M Drivetrain

Model: E60 M5, E63/E64 M6 and E9X M3

Production: From Start of Production

OBJECTIVES

After completion of this module you will be able to:

- Understand the operation of the M DCT transmission
- Understand the operation of the SMG 3 and M DCT transmission
- Identify components used in the SMG 3
- Identify components used in the M DCT transmission
- Understand the operation of the M Variable differential

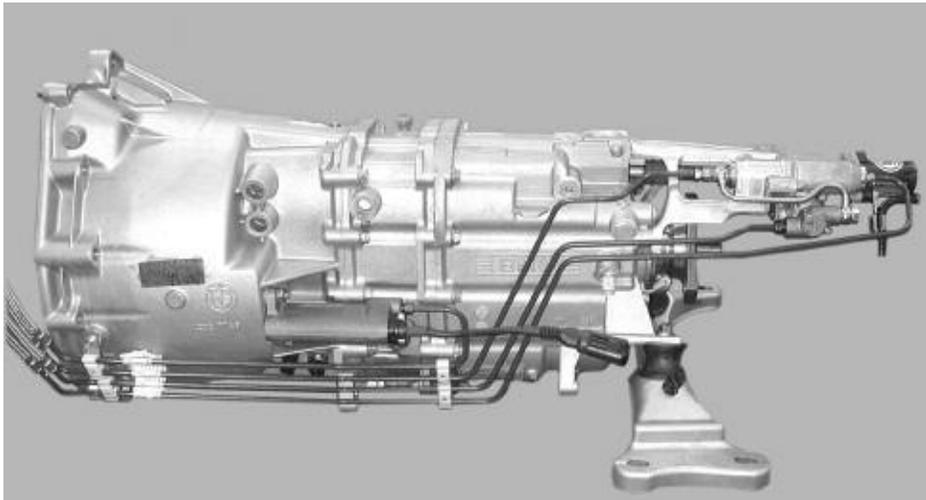
History

In 1996, BMW M introduced a manual transmission that was capable of shifting gears automatically without the use of a conventional clutch pedal or mechanical shifter lever. The system was called the SMG I. Derived from Formula 1 racing technology; SMG stands for Sequential Manual Gearbox.

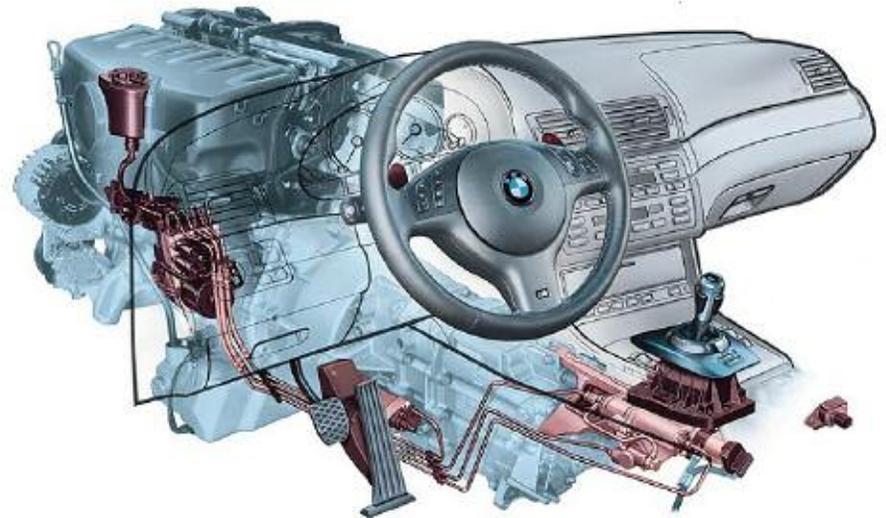
The U.S. received the first SMG in the 2001 E46 M3. This system was referred to as SMG 2. The six-speed manual gearbox manufactured by Getrag, operated in automated "A" mode and

performed similar to an automatic transmission or in sequential "S" mode, which allows the operator to shift manually through the gears.

In sequential mode, the driver shifts up and down through the gears by simply operating the shifter lever or a pair of paddle shifters mounted on either side of the steering wheel. Individual gear selection is realized by electrical/hydraulic actuation of both, the gearbox selector forks and the (conventional) clutch assembly.



E46 M3 SMG 2 Gearbox



E46 M3 SMG 2 Shift/Clutch Mechanism

Every function of the system is realized via a network of sensors and actuators that are monitored by the SMG 2 and Digital Motor Electronics modules through the use of its own SMG Controller Area Network (CAN) Bus.

With the development of the E60 M5 and later the E63/E64 M6 BMW introduced the SMG 3. This is a seven speed sequential gearbox with Drivelogic referred to as the SMG Getrag 247 Gearbox. (See E60 M5 section of M Drivetrain.)

BMW also offered a ZF version of the SMG 3 gearbox on some non M vehicles like the E46, E60 550i, E64 645i and E85 Z4.

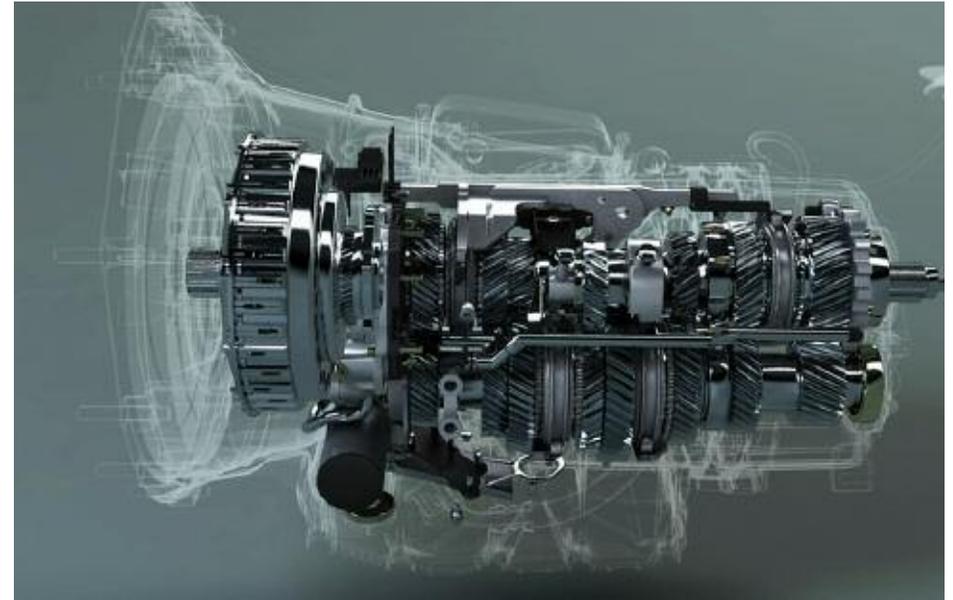


E60 M5 SMG 3

The most exciting and latest version of the sequential gearbox from BMW is the new M Double-Clutch Transmission with Drivelogic (M DCTDrivelogic). Designed by Getrag and introduced in the US with the launch of the E93 M3. This seven speed, double wet clutch transmission takes SMG to the next level.

M DCT has five driving programs in Automatic Mode and six driving programs in Sequential Mode. A new electronic gear selector lever and steering wheel paddle shifters move seamlessly through the pre-selected gears to enjoy uninterrupted drive torque.

M DCT combines the smoothness and comfort of an automatic with the direct connection to the engine of the manual transmission.



E9X M3 M DCT transmission cut away view

E60 M5

The SMG 3 was developed for the M5 and is designated SMG Getrag 247. The E60 M5 and the E63/E64 M6 use the 7-speed sequential M gearbox (SMG 3).

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.



SMG3 gearbox cut away view

Compared to the SMG 2 the gearshift times have been shortened by 20%.

Essentially, these shorter gearshift times have been achieved by:

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

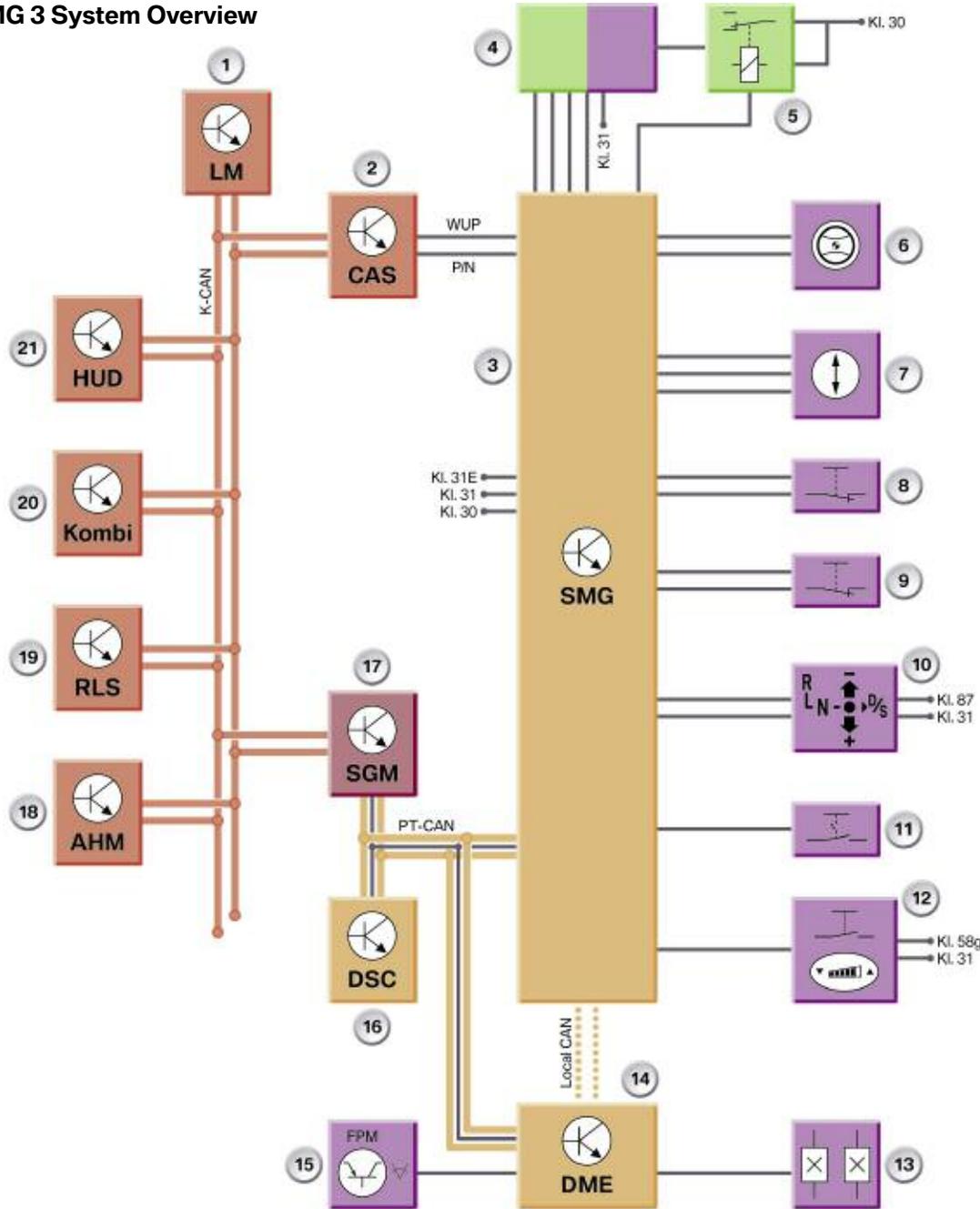
The power is transmitted from the engine to the gearbox via a dual-mass flywheel supplied by “LUK” and a two-disc dry clutch supplied by “Fichtel und Sachs”.

The system also has the following special features:

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

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

SMG 3 System Overview

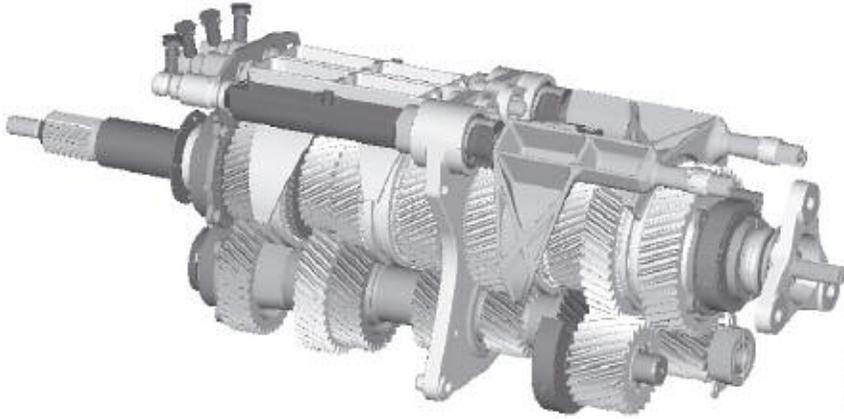


Index	Explanation
1	Light Module
2	Car Access System 2 (CAS 2)
3	SMG Control Unit
4	Sequential M Transmission
5	Pump Relay
6	Multi-Function Steering Wheel (MFL)
7	Longitudinal Acceleration Sensor
8	Hood Contact Switch
9	Hood Contact Switch
10	Selector Lever Indicator
11	Door Contact Switch
12	Drivelogic 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

Components

SMG Getrag 247 Gearbox

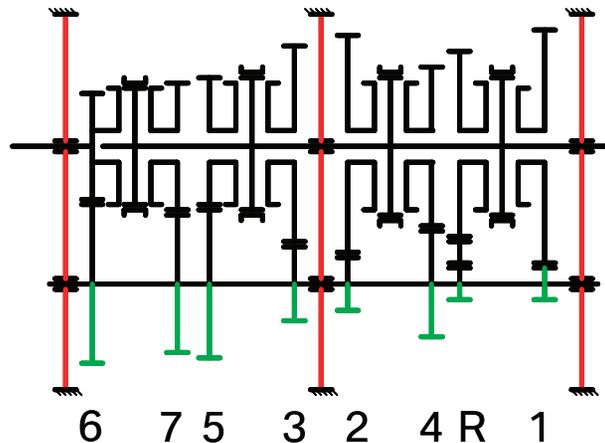
A special feature of this gearbox is that the main shaft is mounted in three bearing assemblies. The third bearing assembly has been realized by an end shield bolted in the gearbox casing.



Pinion Arrangement of the SMG Getrag 247

■ Powerflow

The diagram below illustrates the powerflow of the gearbox.

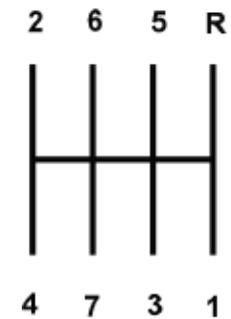


Gearshift Pattern

Besides the gearbox being designed solely for a sequential shifting mechanism, the shift pattern would make it impractical for manual shifting. (A manual shift version of SMG-3 is impossible.)



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)

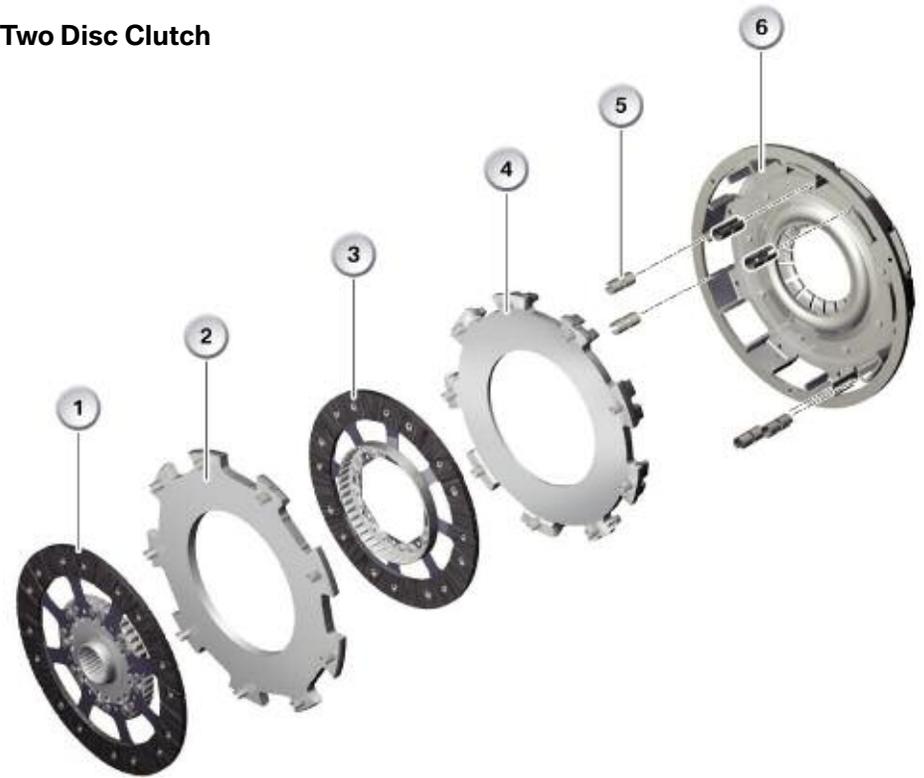
Input Speed Sensor

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 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

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

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

Gearshift Lever



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 Paddles

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.

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:

- Shift lock 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 hardwire 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 nonreturn 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:

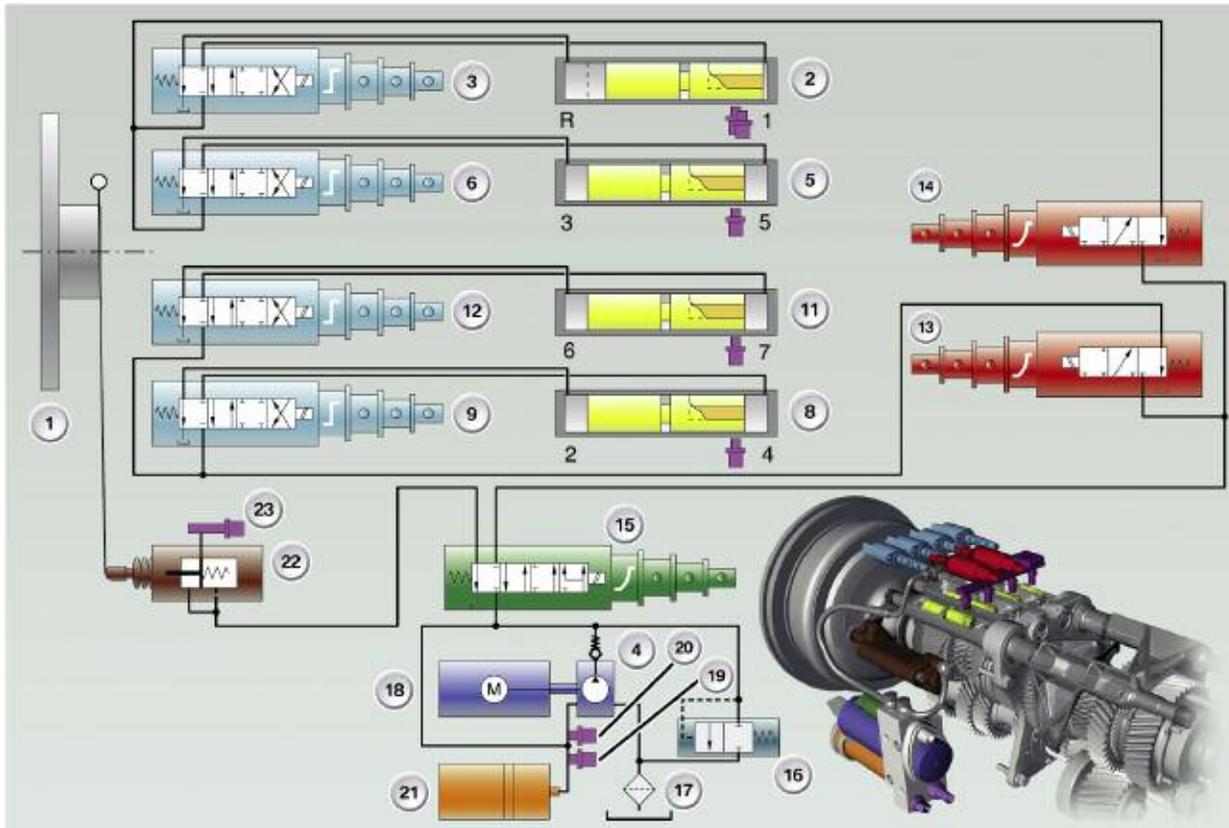
- Pressure Accumulator
- Hydraulic Pressure Sensor
- Solenoid Valve for the Clutch
- Pressure Limiter Valve
- Regulator Block
- Clutch Slave Cylinder with PLCD Sensor
- Expansion Tank
- Hydraulic Pump with Electric Motor
- Check Valve
- Hydraulic Temperature Sensor
- Filter

SMG with Hydraulic Unit



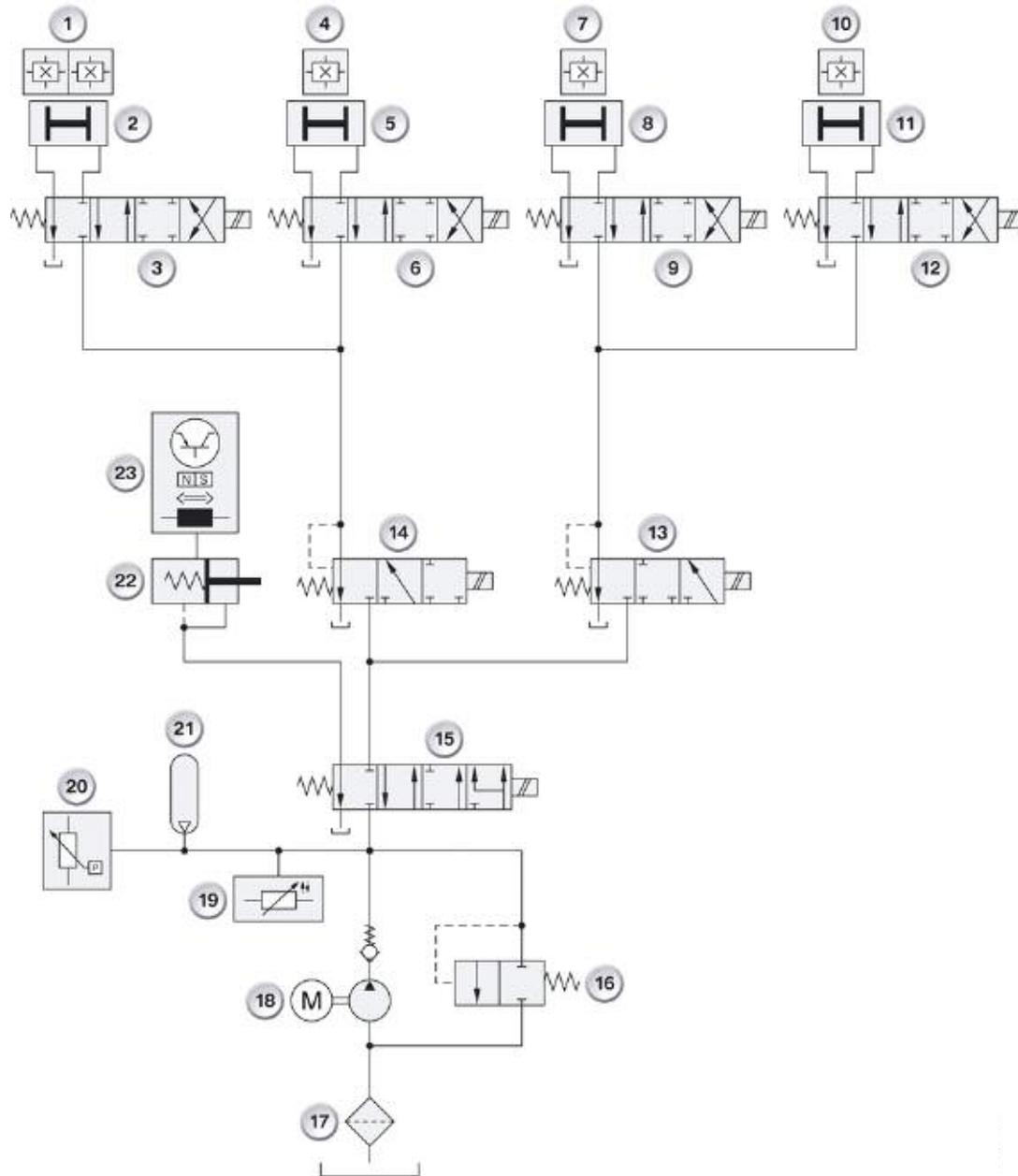
Index	Explanation
1	Hydraulic Unit

SMG 3 Hydraulic System Overview



Index	Explanation
1	Clutch
2	Working Piston (R / 1)
3	Shift Range Valve (R / 1)
4	Hydraulic Pump
5	Working Piston (3 / 5)
6	Shift Range Valve (3 / 5)
8	Working Piston (2 / 4)
9	Shift Range Valve (2 / 4)
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
19	Temperature Sensor
20	Pressure Sensor
21	Pressure Accumulator
22	Clutch Slave Cylinder
23	PLCD Sensor

SMG 3 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 prevents 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.)

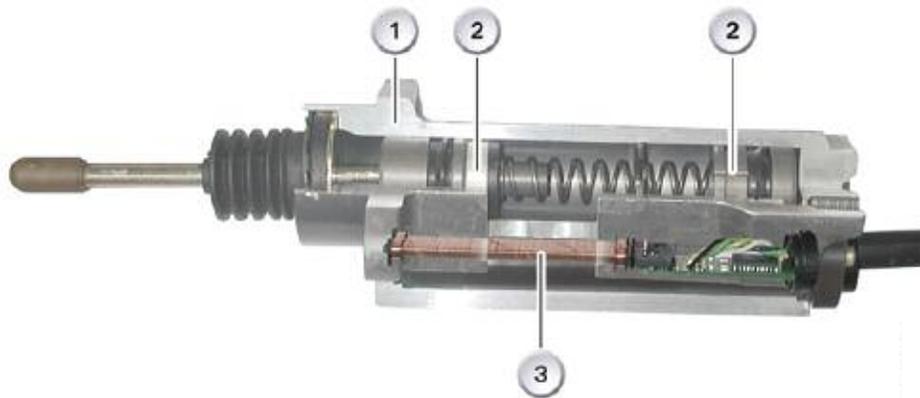
Clutch Slave Cylinder

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 below.

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.



Transmission program selection button is located next to the shifter.

■ 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. It is now activated automatically when the transmission system recognizes any position other 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".



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 ISTA/GT1 diagnostic equipment.

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.

M DCT Transmission

BMW has introduced the new generation of sequential transmissions. The M Double-Clutch Transmission with Drivelogic (M DKG) GS7D36SG is available as an option on the entire E9x M3 series and is referred to as M DCT Drivelogic.

The M double-clutch transmission combines the benefits of a sequential M transmission with that of an automatic. Like the SMG, it can be used in automatic mode "Drive" and in manual mode "Sequential".

There are 5 Drivelogic programs in automatic "Drive" mode and 6 Drivelogic programs in "Sequential" mode. In sequential mode shifting can either be done with the new electronic sports shift lever, exclusive to the BMW M3, or with paddle shifters on the steering wheel. The main characteristic of this system is that

there is no longer an interruption in driving force during the shifting operation from gear to gear.

Shifting is controlled by the M DCT electronics and executed by the M DCT hydraulic components. These are combined into one mechatronics module and integrated into the transmission. The M DCT has a dedicated system to directly lubricate all of the relevant transmission components. The transmission oil temperature is regulated by a special two stage cooling system.

An electric automatic parking lock has been integrated into the system. Selection of the driving programs and gears are controlled using the (M GWS) electric gear selector switch. Different driving modes and settings can be selected through the controller and the fifth settings menu of the CID (option dependent).

E92M3 with the M Double-Clutch Transmission (M DCT)

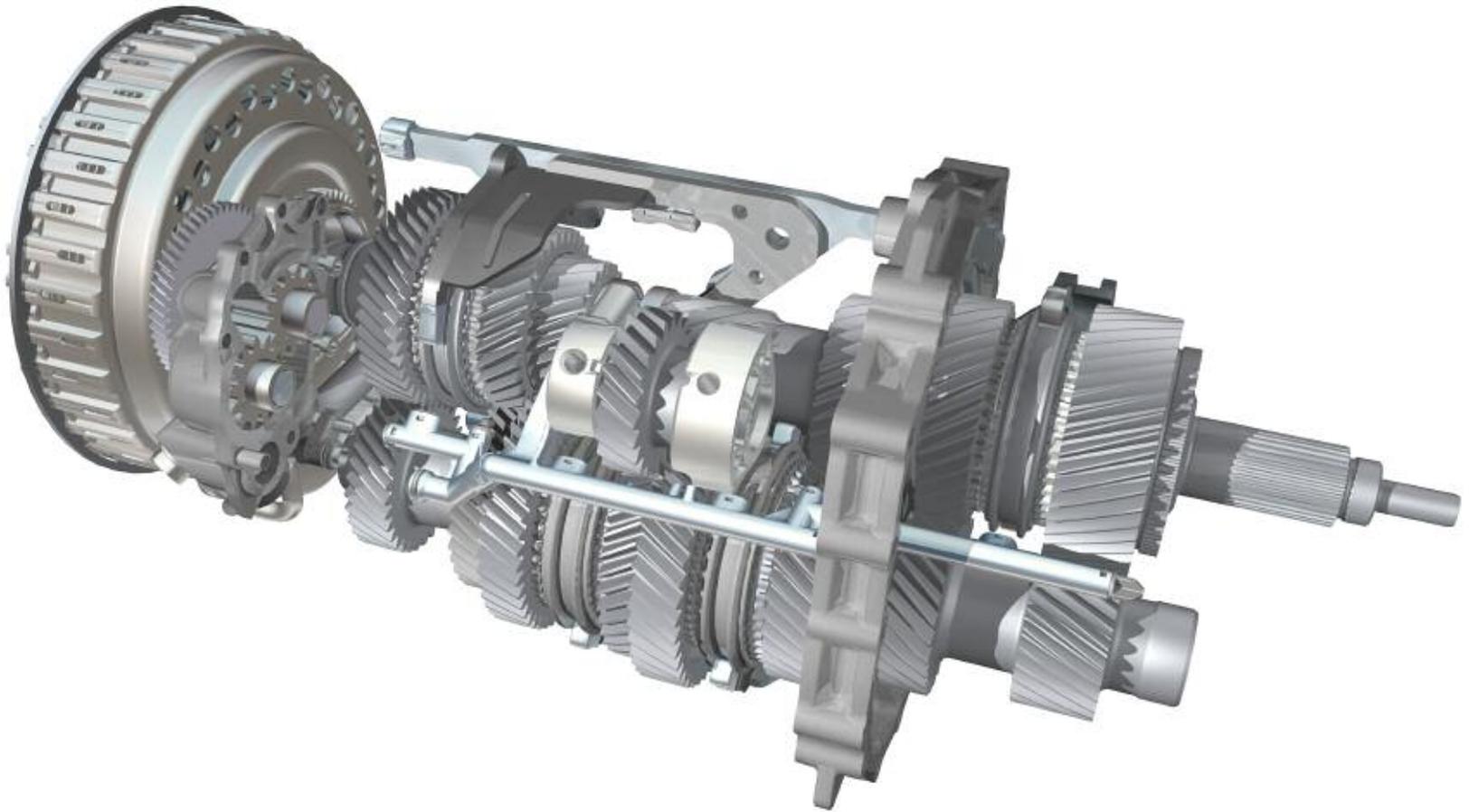


Special Features

M Double-Clutch Transmission features:

- hydraulically operated double (wet) clutches
- integrated mechatronics module, that consists of the M DCT electronics and the M DCT hydraulic components
- internal direct lubrication of key transmission areas and components

- special two-stage oil cooling system
- new M DCT electronic gear selector switch M GWS
- automatic parking lock mechanism
- drive shaft length has been adapted (shortened) to fit the M DCT transmission
- fully variable M limited-slip differential with a modified gear ratio of 3.154 (without M DCT 3.846) and modified housing cover.



M DCT Applications

Transmission	Model	Engine/torque	Transmittable torque rating
GS7D36SG	E90 M3 E92 M3 E93 M3	S65B4000 400 Nm	520 Nm

SMG/DCT History

Series	Model	Engine	Transmission Description	Transmission Denomination	Introduced
E36	M3	S50B32	1st generation Sequential M transmission (Not for US)	GS6S420BG	10/1996
E46	M3	S54B3200	2nd generation Sequential M transmission	GS6S420BG	03/2001 06/2003
E85	Z4	M54B25/30	Sequential manual transmission	GS6S37BZ	04/2003
E6X	525i, 530i, 530i	M54B25/30 N52B3000	Sequential manual transmission	GS6S37BZ	09/2003
E6X	545i, 645Ci 550i, 650i	N62B4400 N62B4801	Sequential manual transmission	GS6S53BZ	09/2003
E6X	M5/M6	S85B5000	3rd generation Sequential M transmission	GS7S47BG	09/2005
E89	Z4	N54B3000	(Non M version) Double-Clutch Transmission (DCT)	GS7D36SG	05/2009

Principle of Operation

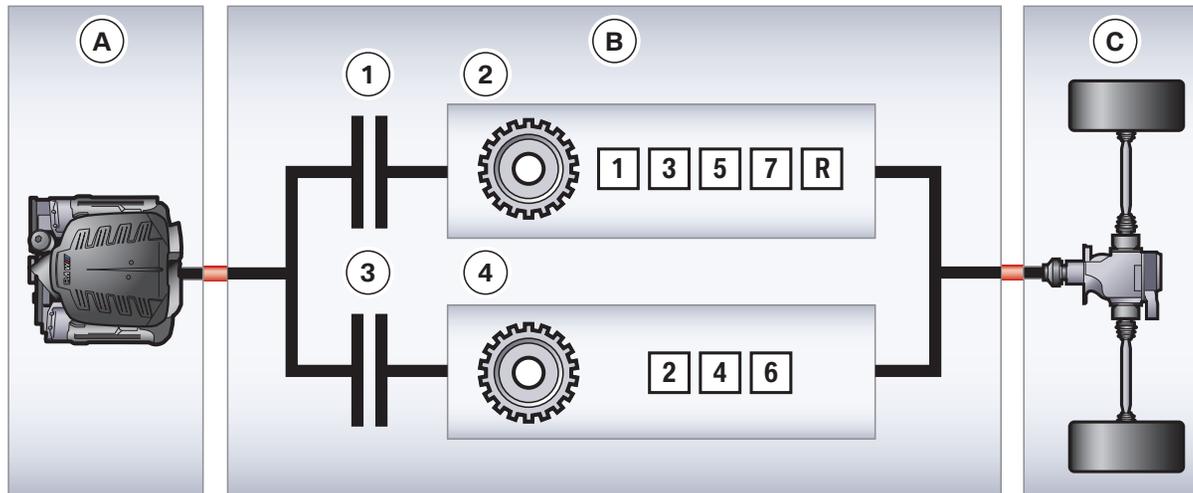
The M DCT consists of two sub-transmissions, each with its own clutch. Clutch 1 with sub-transmission 1 and clutch 2 with sub-transmission 2. Sub-transmission 1 consists of the gears 1, 3, 5, 7 and Reverse while sub-transmission 2 consists of gears 2, 4 and 6. This means that the your next gear is always pre-selected in the other sub-transmission, regardless of whether you are shifting up or down (with the exception of "R").

For example, while still in the acceleration phase of the currently selected gear, if on sub-transmission 1 the next logical gear on

sub-transmission 2 is engaged in advance, in a process similar to the Shift Overlap function of an automatic transmission.

Precise control of the clutches when upshifting will allow the driving force to be transferred very quickly and smoothly from sub-transmission 1 to sub-transmission 2 without an interruption in driving power. This results in significant benefits not only for the available driving force but also in terms of shift comfort.

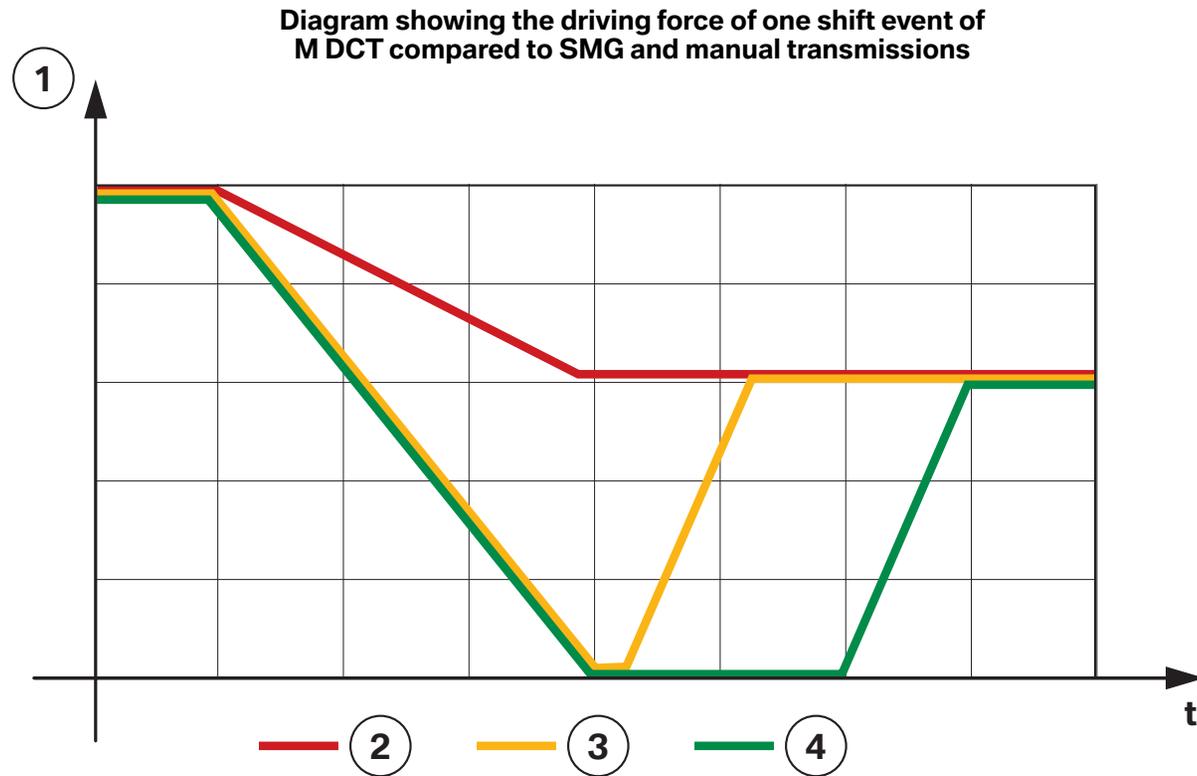
By combining the seamless driving force and comfort of the automatic with the direct connection to the engine as a manual, M DCT provides the benefits of both transmissions.



Simplified drawing of the M DCT functional principle

Index	Explanation	Index	Explanation
A	Engine S65	1	Clutch 1
B	Double-clutch transmission	2	Sub-transmission 1
C	Live axle	3	Clutch 2
		4	Sub-transmission 2

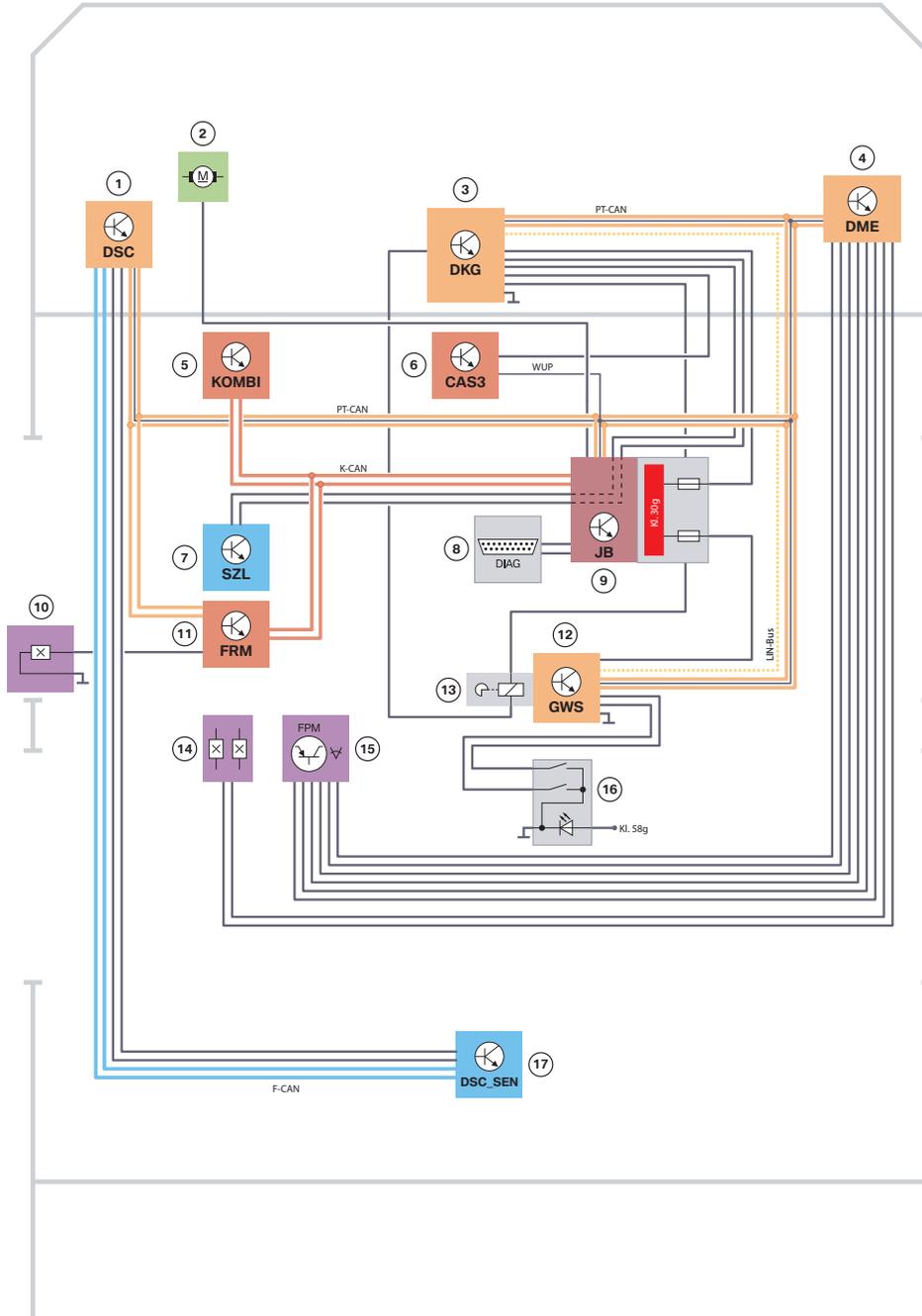
Comparison of the M DCT to the Manual and SMG



Index	Explanation	Index	Explanation
1	Driving force	4	Manual transmission
2	Double-clutch transmission (M DCT)	t	Time (one shift event)
3	Automated transmission (SMG)		

Note: Smooth gear changing without loss of driving force becomes clear when compared to the previous manual and SMG transmission

System Overview



Index	Explanation
1	DSC control unit (Dynamic Stability Control)
2	Auxiliary water pump
3	M DCT electronics (integrated into the Mechatronics module)
4	DME/ECM (Digital Engine Electronics)
5	Instrument cluster
6	CAS control unit (Car Access System)
7	Steering column switch cluster
8	Diagnostics interface
9	Junction box electronics
10	Door contact switch
11	Footwell module
12	M gear selector switch (M GWS)
13	Parking lock electromagnet
14	Brake light switch
15	Accelerator pedal module
16	Drivelogic program selector button
17	DSC sensor unit

Operation and Power Flow

Operation

The driving force is guided into the transmission by a central input shaft (1) through wet clutches 1 and 2, which are integrated into the transmission.

Clutch 1 (2) transmits the power to inner input shaft 1 (5).

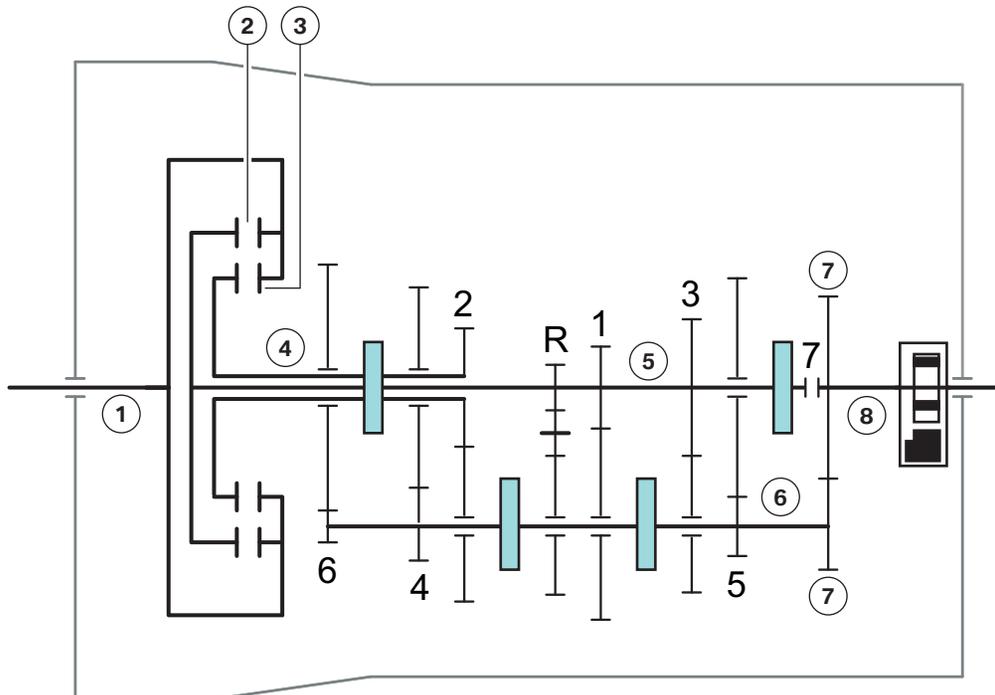
Clutch 2 (3) transmits the power to inner input shaft 2 (4).

The torque is then transferred to the output shaft (8) via the countershaft (6).

The constant gears (7) are always engaged regardless of the gear selected. The countershaft and the output shaft are also always engaged.

The respective gear pairs are selected via the sliding clutches (9). The 7th gear is the direct gear, the sliding clutch connects inner input shaft 1 directly to the output shaft.

The parking lock (10) is located directly on the output shaft.



Index	Explanation
1	Central input shaft with clutch input
2	Clutch 1
3	Clutch 2
4	Inner input shaft 2
5	Inner input shaft 1
6	Countershaft
7	Constant gears
8	Output shaft
9	Sliding clutches
10	Parking lock

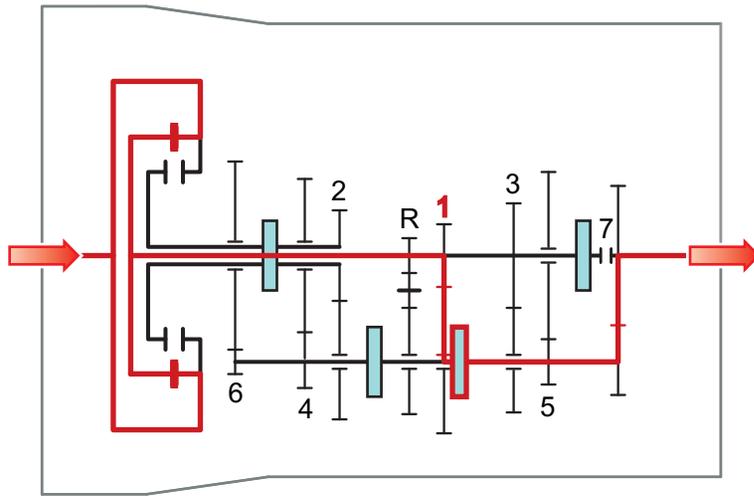
Schematic Structure of the M DCT



Shifting Operation From 1st to 2nd Gear

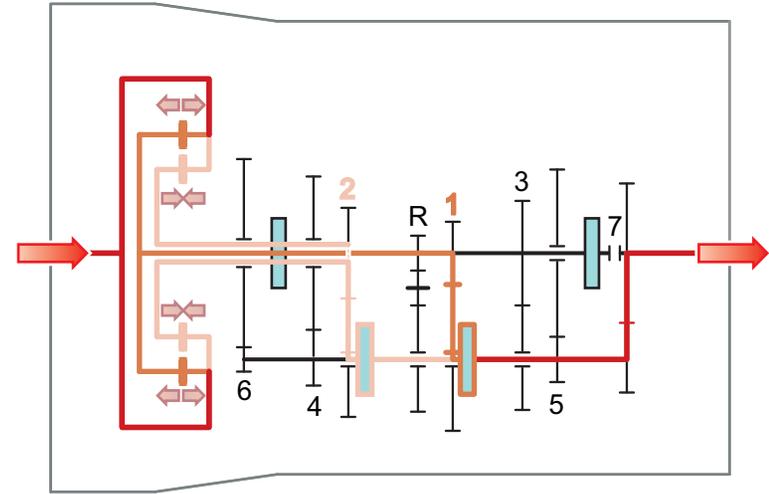
The following is a diagram demonstrating the shifting operation from 1st to 2nd gear with regulated transmission of the driving force between clutch 1 and clutch 2.

2nd gear is already pre-selected, while the driver accelerates in first gear (not shown). During the first phase, clutch 2 begins to engage as clutch 1 begins to disengage.



M DCT power flow route 1st gear

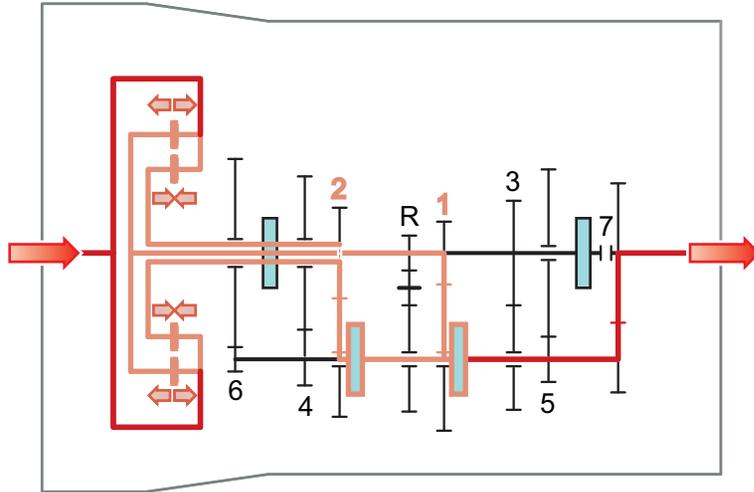
The greater portion of the driving force is still being transferred by clutch 1. The pressure on clutch 1 is still significantly higher than the increasing pressure on clutch 2.



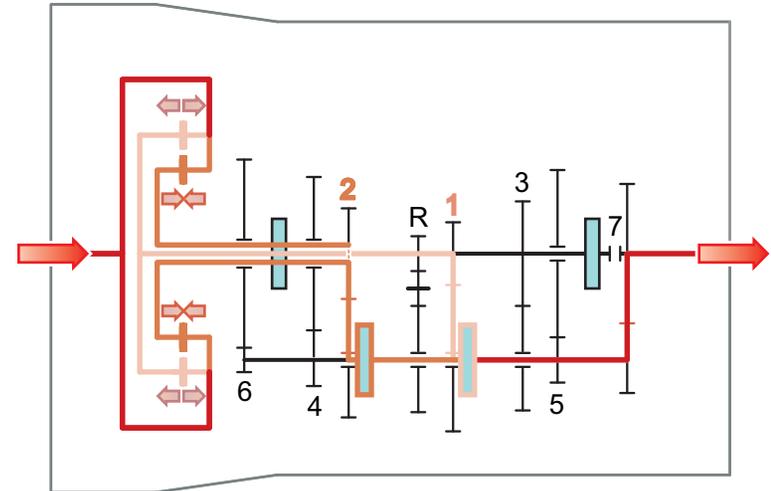
M DCT gear shift from 1st to 2nd gear, first phase

During the second phase, the driving force is distributed proportionally to clutch 2, which is engaging and clutch 1 which is disengaging. In this diagram both clutches have nearly the same pressure.

During the 3rd phase, clutch 2 carries the greater portion of the driving force, while clutch 1 disengages further. The pressure on clutch 2 is now significantly higher than the decreasing pressure on clutch 1.

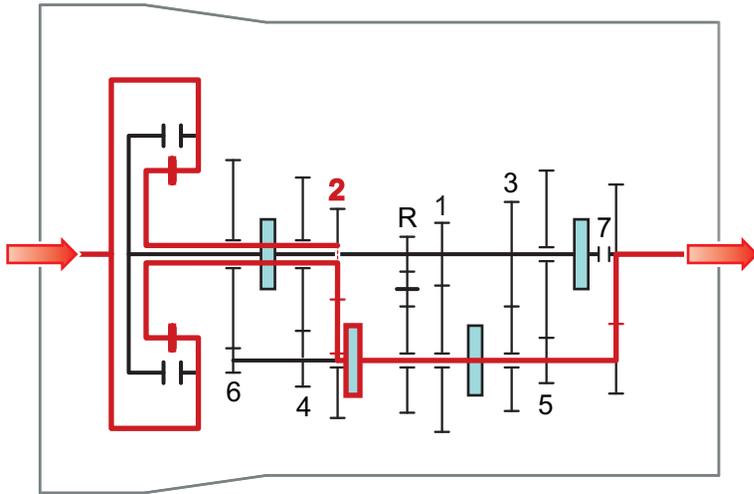


M DCT gear shift from 1st to 2nd gear, second phase



M DCT gear shift from 1st to 2nd gear, third phase

During the 3rd phase, clutch 2 carries the greater portion of the driving force, while clutch 1 disengages further. The pressure on clutch 2 is now significantly higher than the decreasing pressure on clutch 1.



2nd gear power flow

Note: For further information regarding the power flow of the M DCT transmission refer to the M DCT training material available in TIS and ICP.

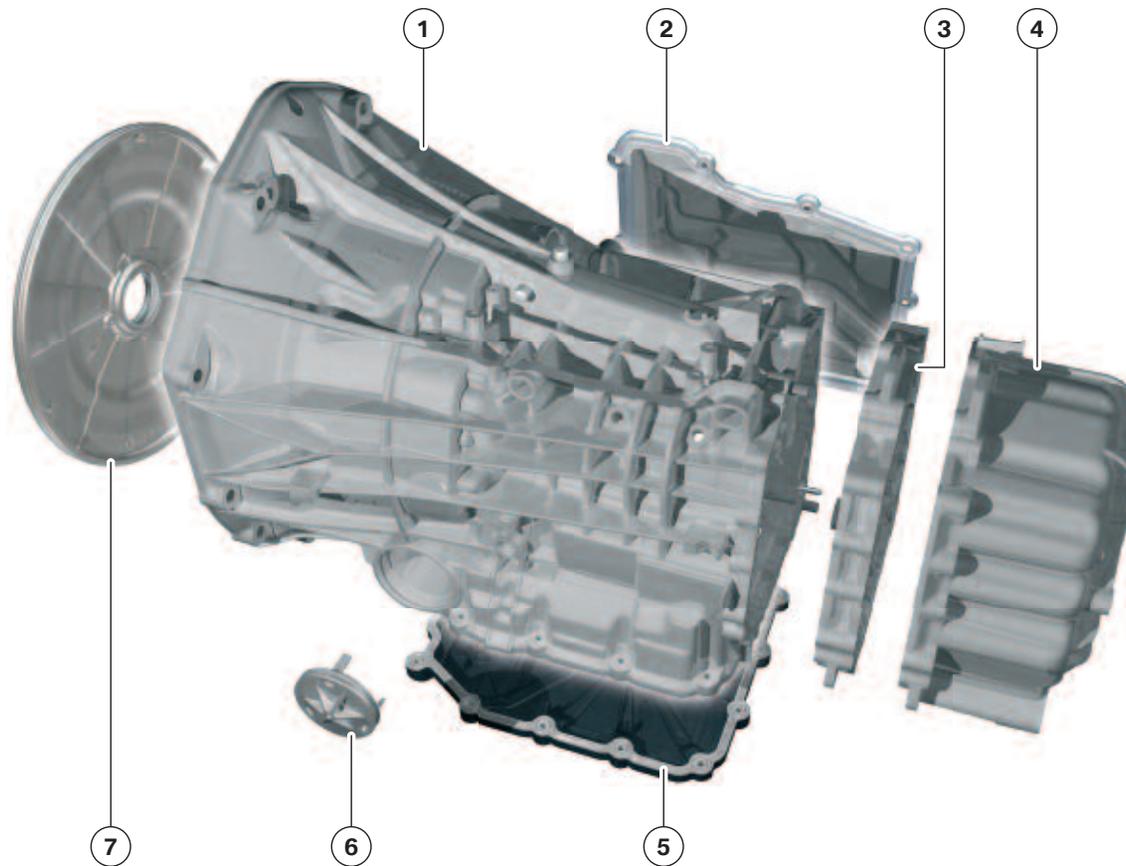
System Components

Housing Structure

The GS7D36SG transmission housing consists of three main components:

- the transmission housing
- the intermediate case
- the rear housing cover

The main opening at the front is closed with the clutch cover. The case openings on the right side are closed with the mechatronics/hydraulic components cover. The lower openings are closed with the oil sump cover and on the left side with the oil filter cover.



Index	Explanation
1	Transmission housing
2	Cover for the Mechatronics module or hydraulic components cover
3	Intermediate case
4	Rear housing cover
5	Sump
6	Oil filter cover
7	Clutch cover

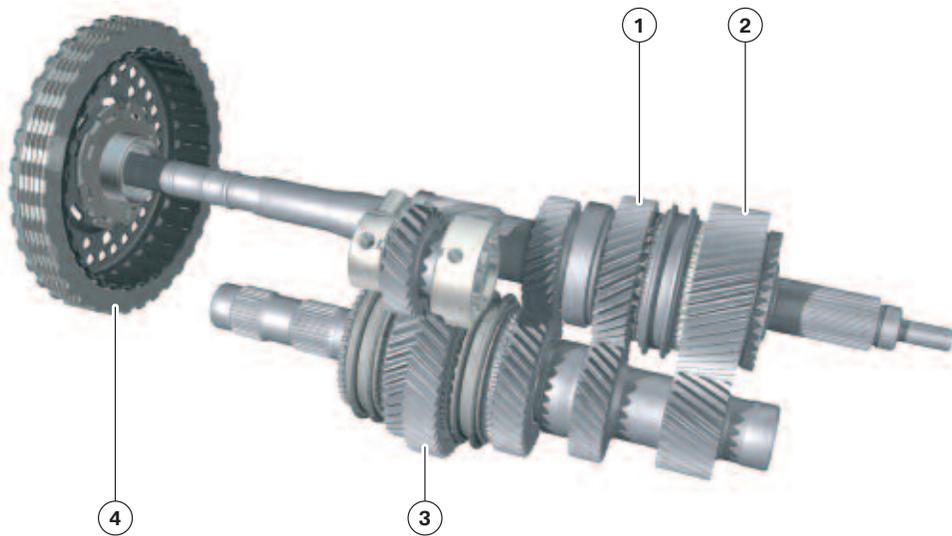
M DCT Housing Structure

Internal Structure

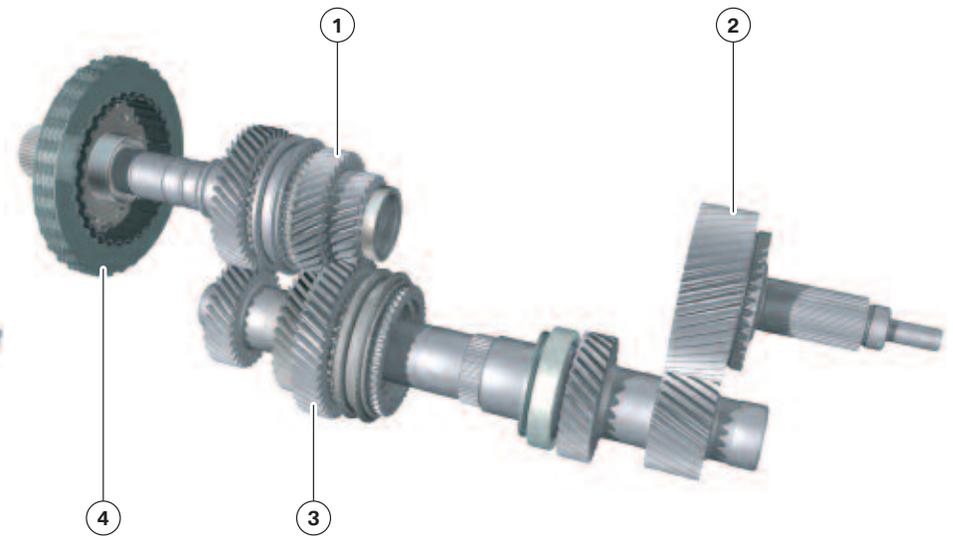
In the M DCT, driving force is transmitted in gears 1, 3, 5, 7 and R from clutch 1 to inner input shaft 1 and sub-transmission 1.

In gears 2, 4 and 6 the driving force is transmitted from clutch 2 to inner input shaft 2 and sub-transmission 2.

M DCT Sub-transmission 1



M DCT Sub-transmission 2



Index	Explanation	Index	Explanation
1	Inner input shaft 1 (left) Inner input shaft 2 (right)	3	Countershaft
2	Output shaft	4	Clutch 1 (left) Clutch 2 (right)

Clutch 1, clutch 2, input shaft 1, input shaft 2, the countershaft and the output shaft form the total gear set of the double-clutch transmission.

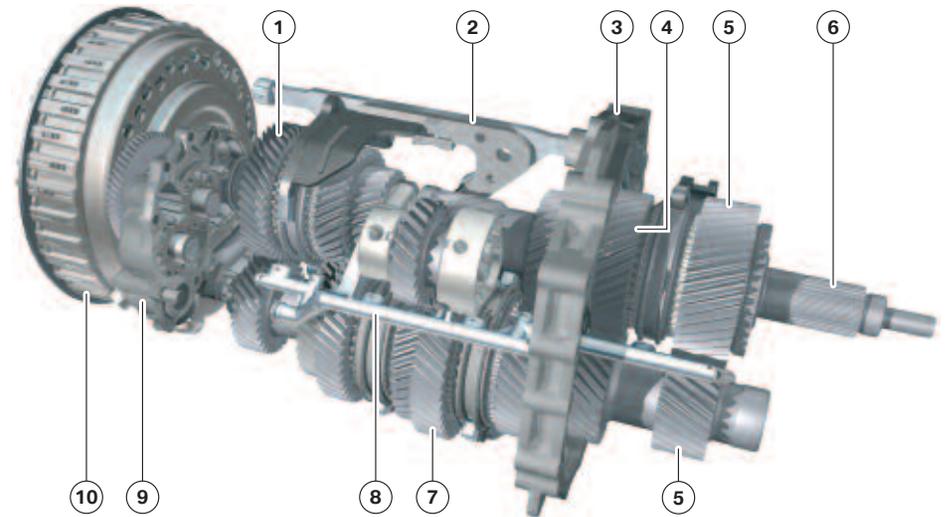
There are four hydraulically operated selector rods and four sliding clutches, with one selector rod and one sliding clutch for each gear pair 4/6, 2/R, 1/3 and 5/7. Gears 1, 2, 3 and Reverse are equipped with double taper synchronization and gears 4, 5, 6 and 7 with single taper synchronization.

Carbon friction material is used for taper friction lining on all gears. The gear set assembly is mounted on three bearings that are evenly distributed along the length of the transmission shafts.



M DCT sub-transmission 1 and sub-transmission 2 joined together with selector linkage

The driving force is transmitted from the dual-mass flywheel over the central input shaft and the external double-clutch housing into the M DCT. The oil pump drive gear is connected at this point to the central input shaft.



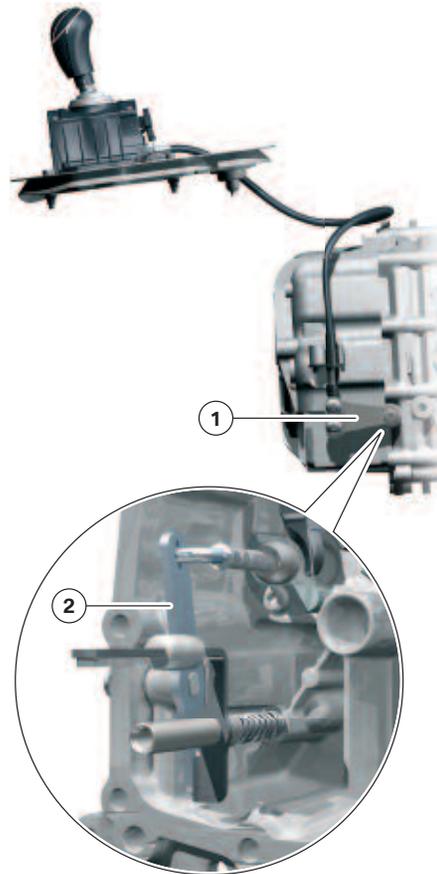
M DCT complete gear set

Index	Explanation	Index	Explanation
1	Inner input shaft 2	6	Output shaft
2	Selector linkage	7	Countershaft
3	Intermediate case	8	Lubricating pipe
4	Inner input shaft 1	9	Oil pump (sectional view)
5	Constant	10	External double-clutch housing (Driving force input)

Automatic Parking Lock

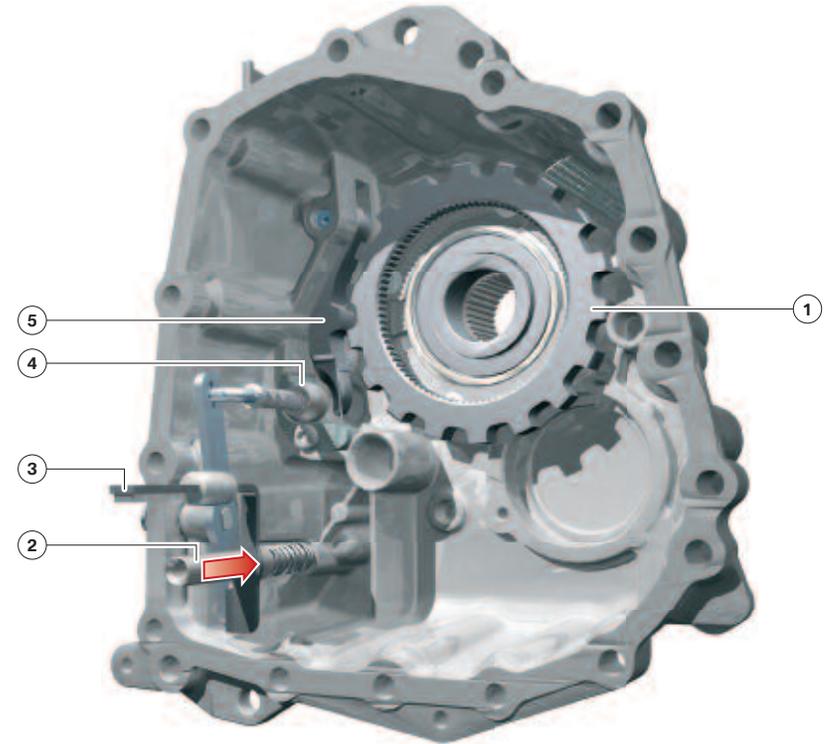
This is the first time that an integrated automatic parking lock has been used in an M vehicle. When the engine is turned off, there is no mechanical connection between engine and drive wheels (clutches are at zero pressure and disengaged).

Index	Explanation
1	External parking lock lever
2	Inner parking lock lever



There is no parking lock button on the selector lever of the M GWS. The parking lock position is determined by the M DCT electronics. The parking lock is engaged with the use of a parking lock electromagnet. This electromagnet is built into the gear selector switch housing and is activated directly by the M DCT electronics. It transfers its movement (stroke) to a Bowden cable. The parking lock Bowden cable transfers the movement directly to the external parking lock lever on the transmission and then to the inner parking lock lever.

M DCT inner structure of the parking lock mechanism



Index	Explanation	Index	Explanation
1	Parking lock wheel	4	Pressure cone for operating the locking pawls
2	Parking lock hydraulic pistons and direction of pressure (red arrow)	5	Spring-loaded parking lock pawl
3	Magnet for parking lock sensors		

Note: The parking lock Bowden cable does not need to be adjusted.

The parking lock disengages hydraulically in the transmission. To engage the parking lock using the electromagnet, the parking lock hydraulic components must be at zero pressure.

The parking lock will always be automatically engaged once the engine has been turned off, except in "N".

When in "N", the parking lock is engaged:

- when vehicle remote control is not in the ignition lock (Comfort Access)
- when removing the remote control from the ignition lock
- 30 minutes after the engine has been turned off.

Note: At the car wash, before stopping the engine you must deliberately shift to "N" and leave the transmitter in the ignition lock. (With Comfort Access it must remain in the car or be inserted in the ignition lock).

Emergency Release of Parking Lock

In an emergency, the parking lock can be released by operating the emergency release mechanism. This is achieved releasing the mechanical connection between the GWS and M DCT. (See "Service Information")

CAUTION!!! If the parking lock is released the vehicle may roll.

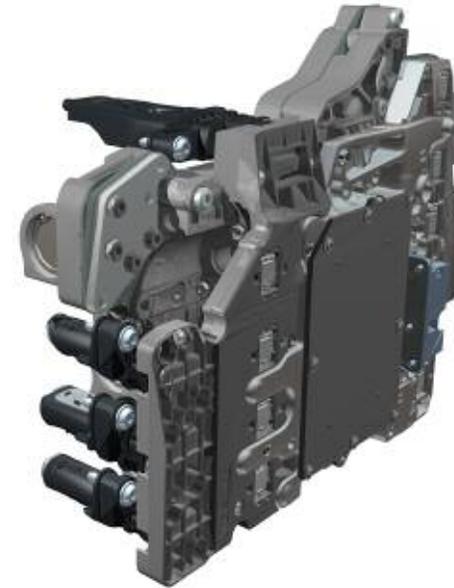
Note: The emergency release is described in detail in the Owner's Manual for the vehicle and in the Repair Instructions.

Mechatronics Module

The mechatronics module integrated into the M DCT transmission housing consists of the M DCT electronics and the M DCT hydraulic components.

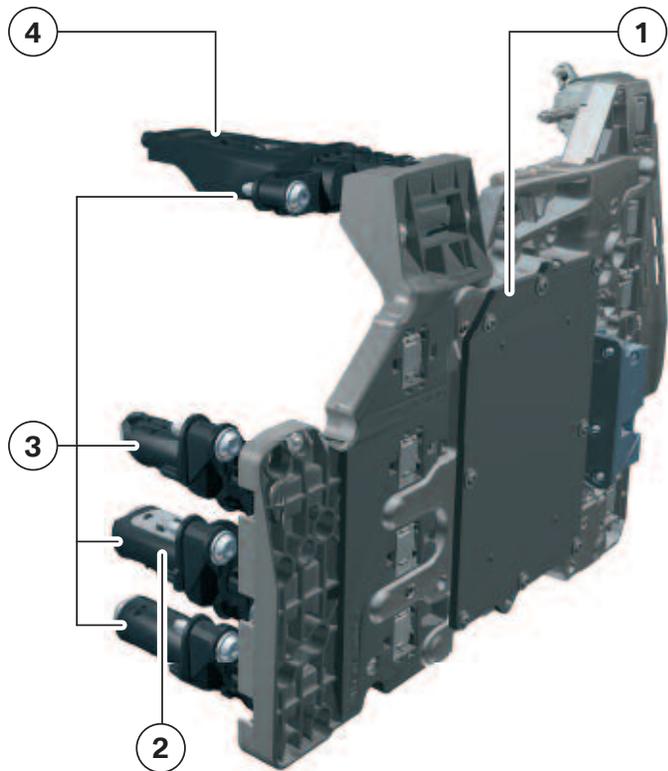
The selector rod position sensors are mounted directly on the M DCT electronics. The speed sensors for inner input shafts 1 and 2 are integrated in the upper position sensors.

The parking lock sensors are integrated in the second position sensor from the bottom.



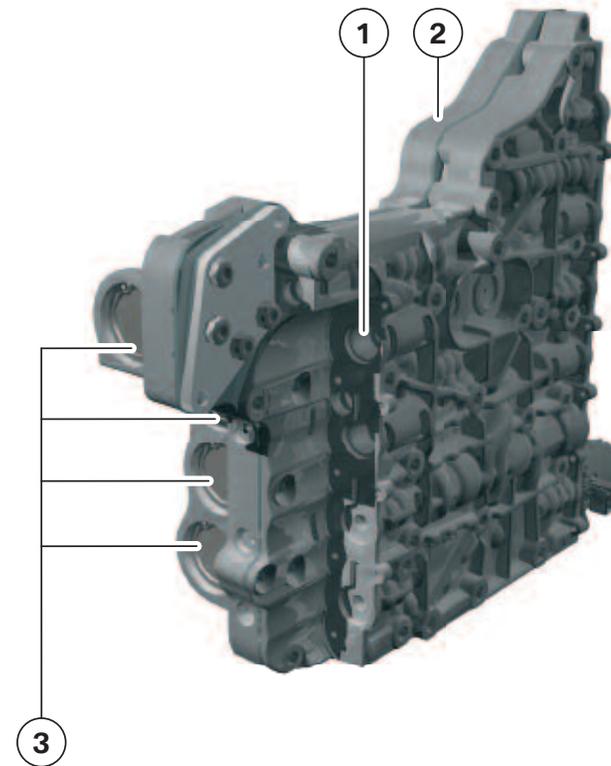
M DCT Mechatronics Module

M DCT Electronic Components



Index	Explanation
1	M DCT electronics
2	Integrated parking lock sensors
3	Selector rod position sensors
4	Integrated shaft speed sensors

M DCT Hydraulic Components

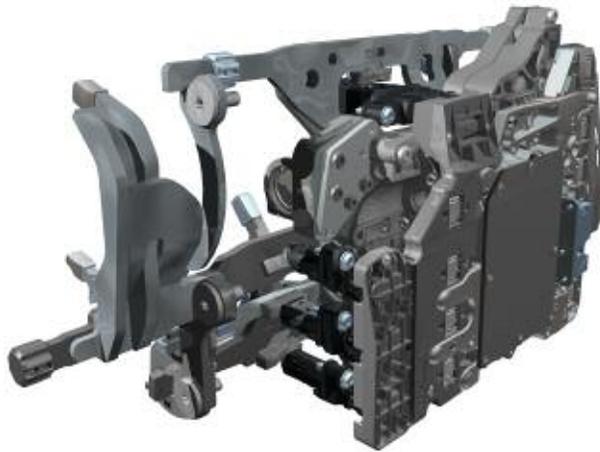


Index	Explanation
1	Take up shift valve
2	M DCT hydraulic components
3	Shift cylinders

The eight individual gears are engaged by four hydraulic cylinders and four individual selector rods. The selector rod positions are detected without the need for direct contact with the use of the selector rod position sensors.



View of selector rod side of M DCT mechatronics module



M DCT mechatronics module with selector rods installed

■ **Torque Intervention**

The M DCT mechatronics module sends a torque requirement to the engine control module on the PT-CAN in order to achieve a torque intervention when shifting gear under load or when coasting. This is negative when upshifting so that the engine speed is reduced. When downshifting the torque intervention is positive, in order to increase the engine speed. Gear shifting is supported by the engine control module through this torque intervention strategy.

■ **LIN-bus Module**

There is a LIN-bus connection in the M DCT electronics for redundant communication with the gear selector switch (GWS).

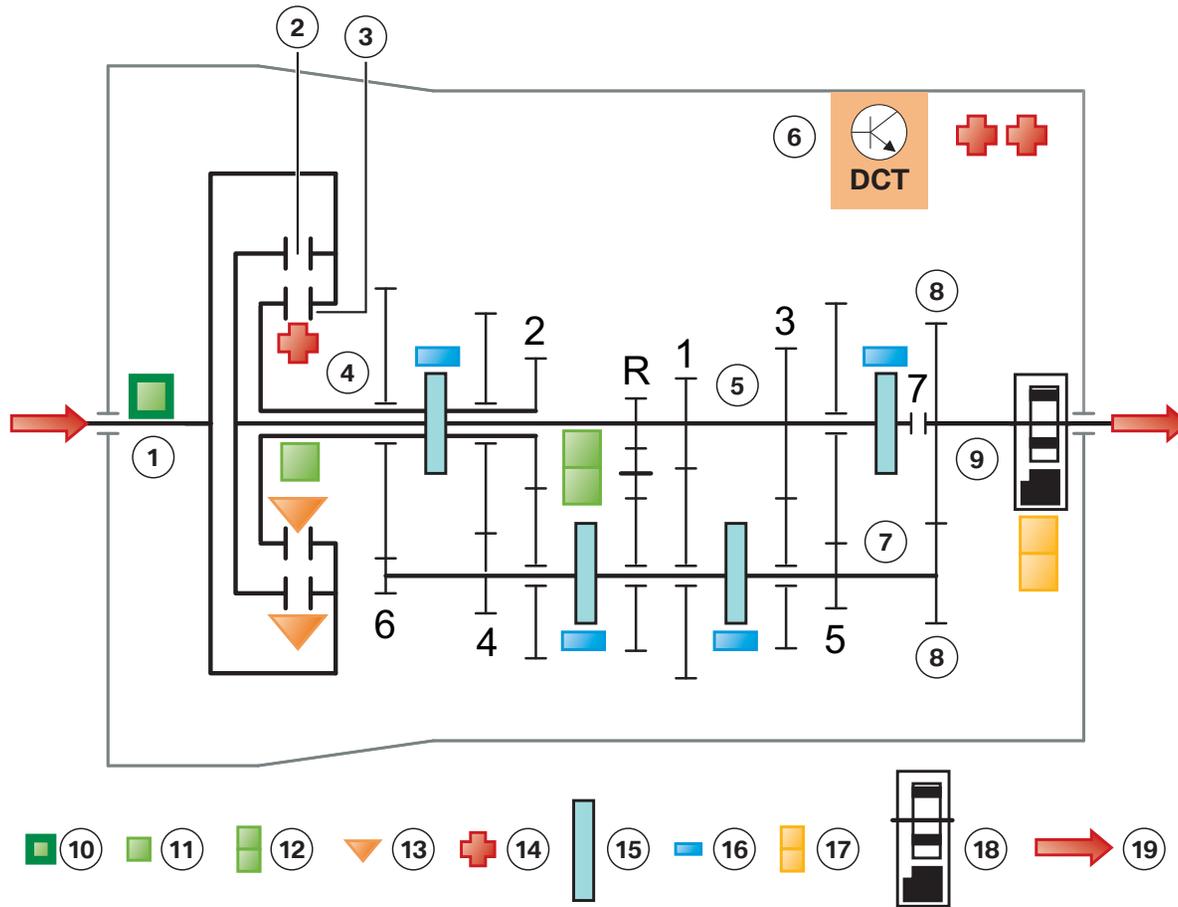
M DCT Transmission Sensors

The following sensors are mounted in the transmission and their signals are sent directly to the M DCT electronics:

- Input shaft 1 speed (Hall) sensor monitors rotation and direction of transmission shaft 1.
- Input shaft 2 speed (Hall) sensor without rotation direction detection for the transmission shaft 2.
- Clutch oil pressure (Piezo) sensors for clutch 1 and 2.
- 3 temperature sensors (NTC), one for the ejected clutch oil and two redundant temperature sensors for the M DCT electronics.
- 4 linear (Hall) sensors monitor the selector rod position.
- 1 double (redundant) parking lock (Hall) sensor.

The oil sump temperature is measured using a complex temperature map and checked against the temperature of the clutch oil by the M DCT electronics.

M DCT basic layout with clutches, shafts, M DCT electronics and sensors



Note: The engine speed signal is provided from the DME through the PT-CAN to the M DCT electronics.

Index	Explanation
1	Central input shaft
2	Clutch 1
3	Clutch 2
4	Inner input shaft 2
5	Inner input shaft 1
6	M DCT electronics
7	Countershaft
8	Constant gear wheel
9	Output shaft
10	Input engine speed (Hall) sensor
11	Gear rotation speed sensor for the inner input shaft 2 (Hall)
12	Gear rotation speed sensor with rotation direction detection of inner input shaft 1 (Hall)
13	Clutch oil pressure (Piezo) sensors
14	Oil temperature sensors (NTC)
15	Sliding clutches
16	Linear position (Hall) sensors
17	Parking lock (Hall) sensor (redundant)
18	Parking lock
19	Power flow input, output and direction

M-Gear Selector Switch (M GWS)

The double clutch transmission in the E9x M3 has an M specific gear selector switch. It is operated in a similar way to the one in the E6x M5/M6 with the sequential transmission (SMG).



M DCT M Gear Selector Switch (M GWS)

Index	Explanation	Index	Explanation
1	Selector lever	3	Drivelogic program selector button
2	Button to increase the Drivelogic program	4	Button to reduce the Drivelogic program

The M GWS consists of the selector lever with indicator, the housing with control module and the external but electrically connected Drivelogic program selector button.

■ Selector Lever Indicator and Function

The shift pattern, driving program, gear selection indicator on the selector lever are all similar to that of the E6x M5/M6 with SMG. The main difference is that the selector lever on the gear selector switch in the E9x M3 no longer snaps into the "N" and "R" positions, instead it only snaps into "R".

The M GWS selector lever is self centering as it returns back to its normal starting position on its own, after the driver selects the desired gear. Reverse gear is an exception; because once the shifter lever is moved left and into the "R" position the gear must be manually unselected by the driver.

The shift pattern, driving program, gear selection indicator on the selector lever are all displayed in red, depending on the position of the selector lever and driving program selected.

The indicator displays the currently selected driving program and the gear selection options. The indicator consists of the locating light that indicates the shift pattern and the function indicator lamp. These are two different red position LEDs that show the currently selected driving program and the gear selection options.

The function indicator lamp in the M GWS is controlled by the M DCT electronics. The function indicator lamp is monitored, read back and compared with the required indicator for plausibility.

In addition to the PT-CAN connection; there is a LIN-bus connection built in to the M GWS for redundant communication with the M DCT electronics.

Note: For further information regarding the M-Gear Selector Switch refer to the M DCT training material available in TIS and ICP or the vehicle's owners manual.

Selector Lever in the Start Position

Except for when in the position "R", the selector lever always returns to the start position. When starting the engine the parking lock is always engaged and the clutches are both disengaged (zero oil pressure). The engine can be turned on regardless of the gear it was in when it was turned off.

The selector lever indicator is displayed in red when in the start position. Driving program "D" Drive (automatic gear mode) is selected by briefly pushing the selector lever to the right, causing the M DCT, when in automatic gear mode, to change gears automatically into first (second) gear. The selector lever indicator "D/S" option is also displayed in red to indicate the start position.



M GWS selector lever during and after starting the engine

The M GWS one-touch function is pushed to the right once to start automatic gear mode



Driving Program "S" (Sequential Mode)

By pressing the selector briefly to the right a second time the M DCT changes from automatic to sequential mode "S".

If, while driving in 2nd to 6th gear, the driving program "S" is selected, then in addition to the "D/S", the "+" and "-" will light up in red.

The driver can now change to the next higher gear by briefly moving the selector lever backwards a notch or downshift by moving it briefly forward a notch.

A desired gear shift may only be executed within the range of permissible engine speeds. There is no automatic up-shifting once the maximum speed has been reached.

In automatic "Drive" mode, as soon as the selector lever is moved towards the front, the back or a shift paddle on the steering wheel is activated, the M DCT switches to sequential mode.



The M GWS pushed to the right twice to start sequential mode

In sequential mode there are two additional indicators, one for 1st gear and one for 7th gear.

■ Downshifting

In 1st gear the "-" is no longer lit up in red, because it is no longer possible to downshift.



M GWS in sequential mode downshifting

■ Upshifting

In 7th gear the "+" is no longer lit up in red, because it is not possible to shift higher.



M GWS in sequential mode, upshifting

Gear Selection "N" Neutral

The driver can consciously shift into neutral by pressing the selector lever briefly to the left.

"N" will light up in red in the selector lever indicator. This is useful for example in a car wash.



Note: At the car wash, before stopping the engine you must deliberately shift to "N" and leave the transmitter in the ignition lock. (With Comfort Access it must remain in the car or be inserted in the ignition lock).

Gear Selection "R" Reverse Gear

When in this shift position, reverse gear is selected and the "R" will light up in red.

If the engine is turned on while the selector lever position is in "R", the start position of the selector lever will flash red at one second intervals. This signals the driver that the Reverse gear is selected and that he must first return the shift lever to the (self centering) start position, in order to select a new gear or driving program.

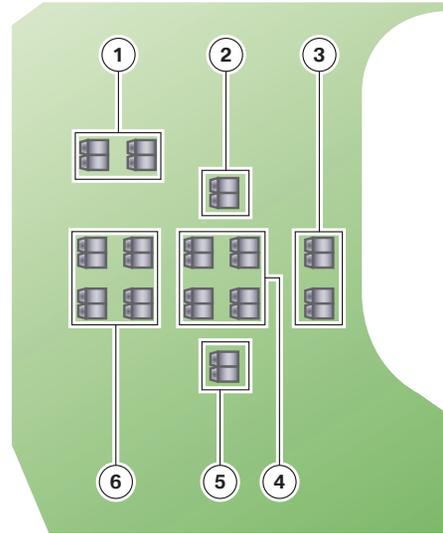


M GWS Shifter Sensor System

The selector lever position is detected with the use of Hall sensors. These are available mostly in groups of 2 or 4. In total there are 14 Hall sensors. This ensures maximum fault handling and diagnostic capacity.

M GWS arrangement of Hall sensors for determining the selector lever position

Index	Explanation
1	Gear selection "R" reverse gear
2	"-" downshifting
3	Driving program "D/S" automatic or sequential mode
4	Selector lever start position
5	"+" upshifting
6	Gear selection "N" neutral



Interface to the M DCT

The selector lever position is transmitted through the PT-CAN and a LIN-bus. In the event of a failure of one of the two communication lines, a signal is still sent to the M DCT.

Interface	From	To	Message
PT-CAN	M GWS	M DCT	Operation of the selector lever
PT-CAN	M DCT	M GWS	Show gearbox data
LIN-bus	M GWS	M DCT	Operation of the selector lever
LIN-bus	M DCT	M GWS	Show gearbox data

The M GWS wake up is done by a high signal on the PT-CAN wake-up line.

The M GWS itself has no active wake-up capabilities. The indicator on the selector Lever is active as soon as bus communication is active on the PT-CAN or the LIN-bus.

Drivelogic Program Selection

The controls and indicators in the vehicle are similar to the SMG 2 and SMG 3 vehicles.

The Drivelogic program switch gives you the option of choosing between six driving programs in sequential mode and five driving programs in drive mode.

The selected driving program is displayed as a bar chart in the instrument cluster.

In sequential mode the switching speed is affected which has a direct effect on the shifting firmness.

The sixth shift program can only be selected when the DSC function is de-activated.

In drive mode the shift points and the shifting speed are affected, as a higher shift program means a higher gear changeover speed and thus a higher shifting speed.

In addition to the Drivelogic program selection, the shift time is also dependent on the position of the accelerator pedal and how quickly it is operated.

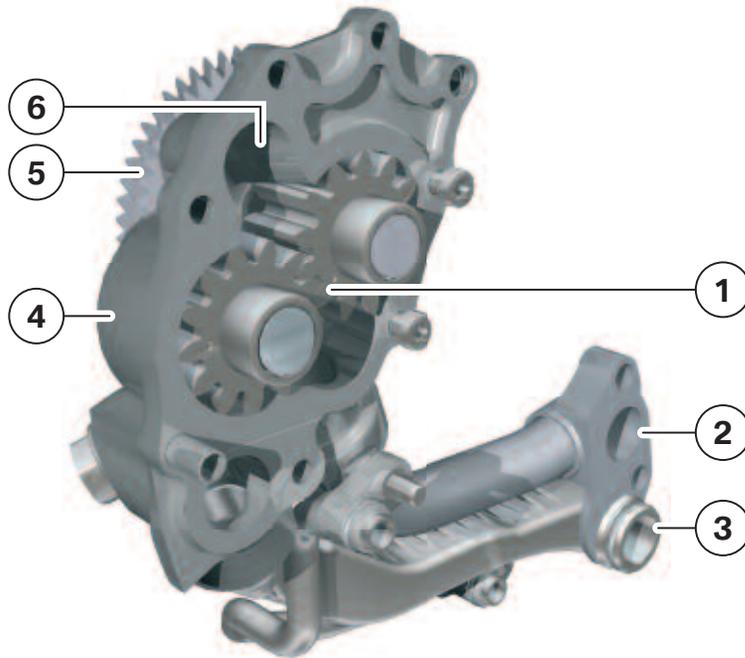
Lubrication System

Pressure and Flow Regulation

A gear driven pump is integrated into the M DCT transmission and is responsible for circulating the oil through the unit.

The transmission oil pump is driven by a gear on the drive input side which connects to the center input shaft of the M DCT. The engine must be running for the oil pressure to build up.

M DCT oil pump without sealing cover



Index	Explanation	Index	Explanation
1	Oil pump gears	4	M DCT gear oil pump housing
2	Oil pressure pipe to the hydraulic control unit	5	Drive gear
3	Oil return pipe	6	Oil intake side (oil supply)

Note: Because transmission oil pressure cannot be built up when the engine is not running, a M DCT vehicle should never be push-started.

The operating pressure is determined by a regulated control valve depending on the load and the function selected. The system is protected by a pressure relief valve in the pump.

The pressure is regulated according to the following priorities:

- Clutch engagement and disengagement
- Gear changes
- Cooling the clutch
- Lubrication cycle

The transmission oil pressure should be high enough to:

- Be able to engage the clutches reliably.
- Allow the gear selector rod to reach the required control shift speed.

The normal operating pressure range is between 5 and 20 bar, although it can be increased up to 30 bar if necessary to maintain proper transmission operation.

At maximum shifting force, the pressure required to operate the selector rods can be the same as the operating pressure.

The pressure required for the clutches is limited to 18 bar. The clutch is regulated by an integrated proportioning valve.

Overpressure protection is ensured by a pressure relief valve.

Clutch cooling is map-controlled using a proportional valve.

Note: The M DCT Drivelogic transmission has a new long-term rated oil, DCT Oil-1, which requires no replacement unless specified for a repair.

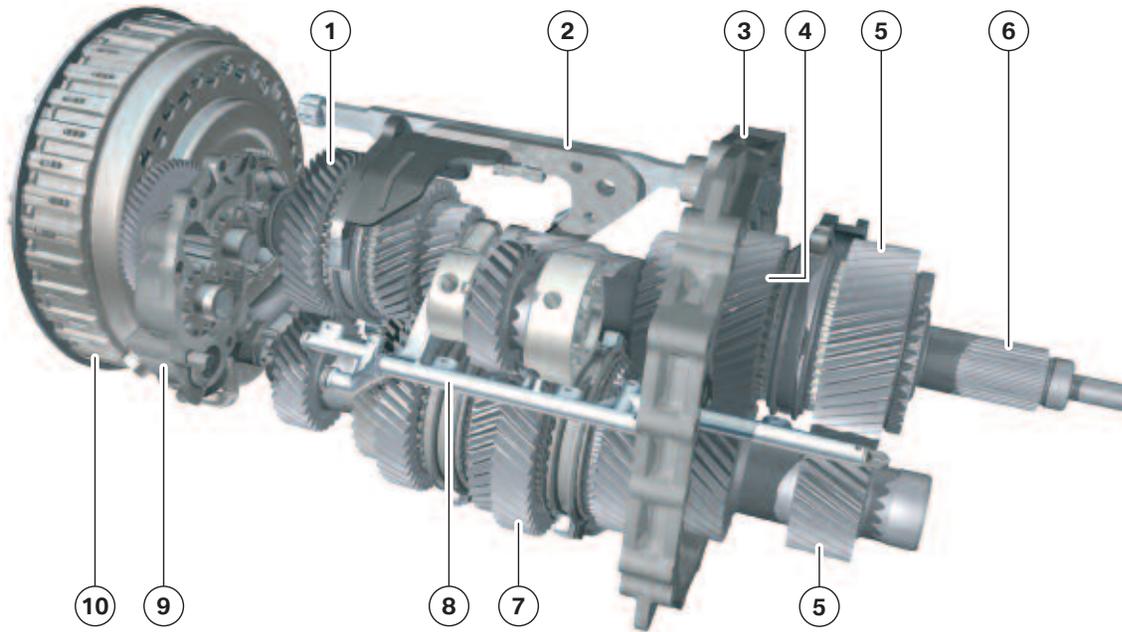
Oil-spray Lubrication

The M DCT transmission applies direct lubrication with the use of an internal lubricating pipe fitted with individual nozzles and aimed at pre-determined areas of the gear train.

Hydraulic Emergency Operation

If there is a fault, the M DCT has a hydraulic emergency operation mode. For example, if the power supply fails, the active gear remains selected and the active clutch engaged. This makes it possible to drive to the next possible vehicle storage location or parking area. The clutch disengages only when the engine speed goes below the minimum rpm and then it remains disengaged.

M DCT gear set with lubricating pipe



M DCT gear set lubricating pipe



Index	Explanation	Index	Explanation
1	Inner input shaft 2	6	Output shaft
2	Selector linkage	7	Countershaft
3	Intermediate case	8	Lubricating pipe
4	Inner input shaft 1	9	Oil pump (sectional view)
5	Constant	10	Dual clutch housing and oil pump drive gear

Two-stage Transmission Oil Cooling

Oil to Coolant Cooling

The M DCT transmission oil cooling circuit consists of an oil to coolant heat exchanger, an oil to air heat exchanger, a transmission oil thermostat and the relevant cooler lines. The oil to coolant heat exchanger is part of the engine cooling system of the vehicle.

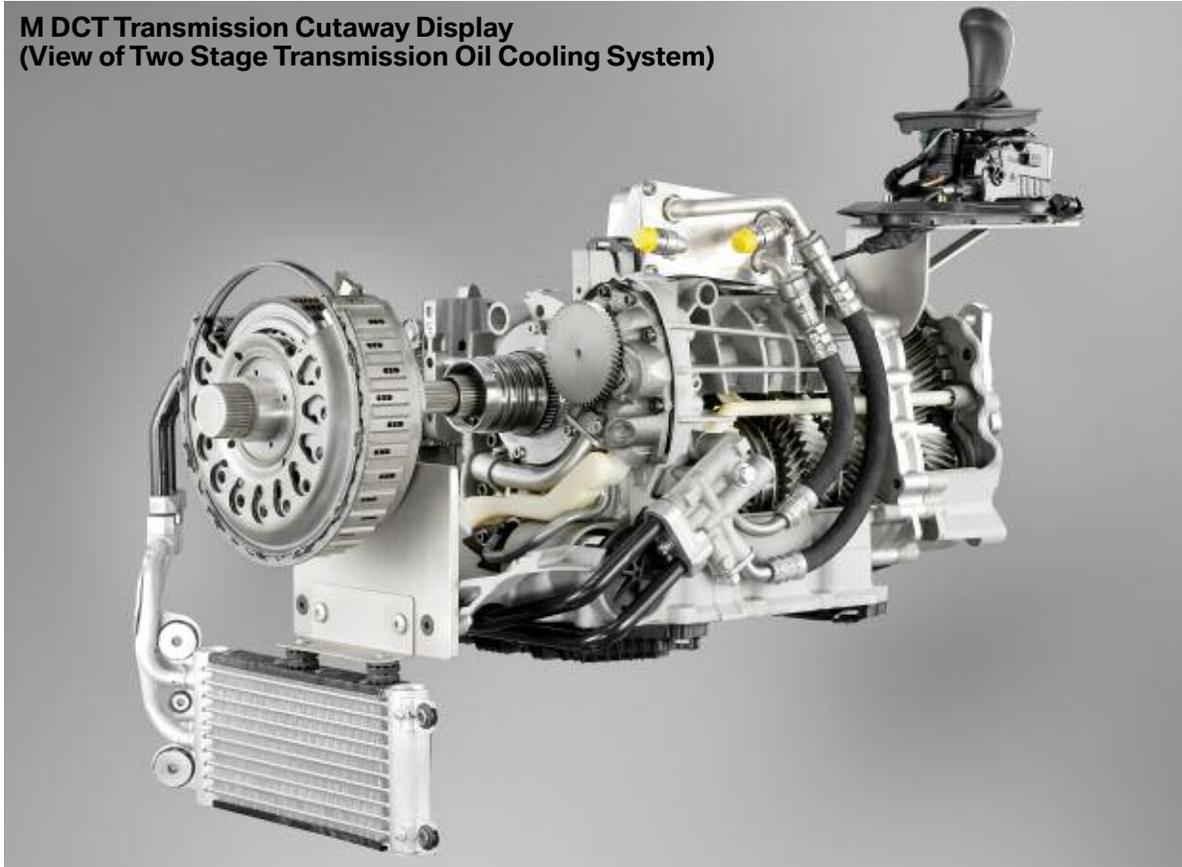
Mounted on the transmission housing it allows the oil to flow directly from the M DCT into the oil to coolant heat exchanger.

Engine coolant directly from the cylinder head is pumped to the oil to coolant heat exchanger by the auxiliary coolant pump and then

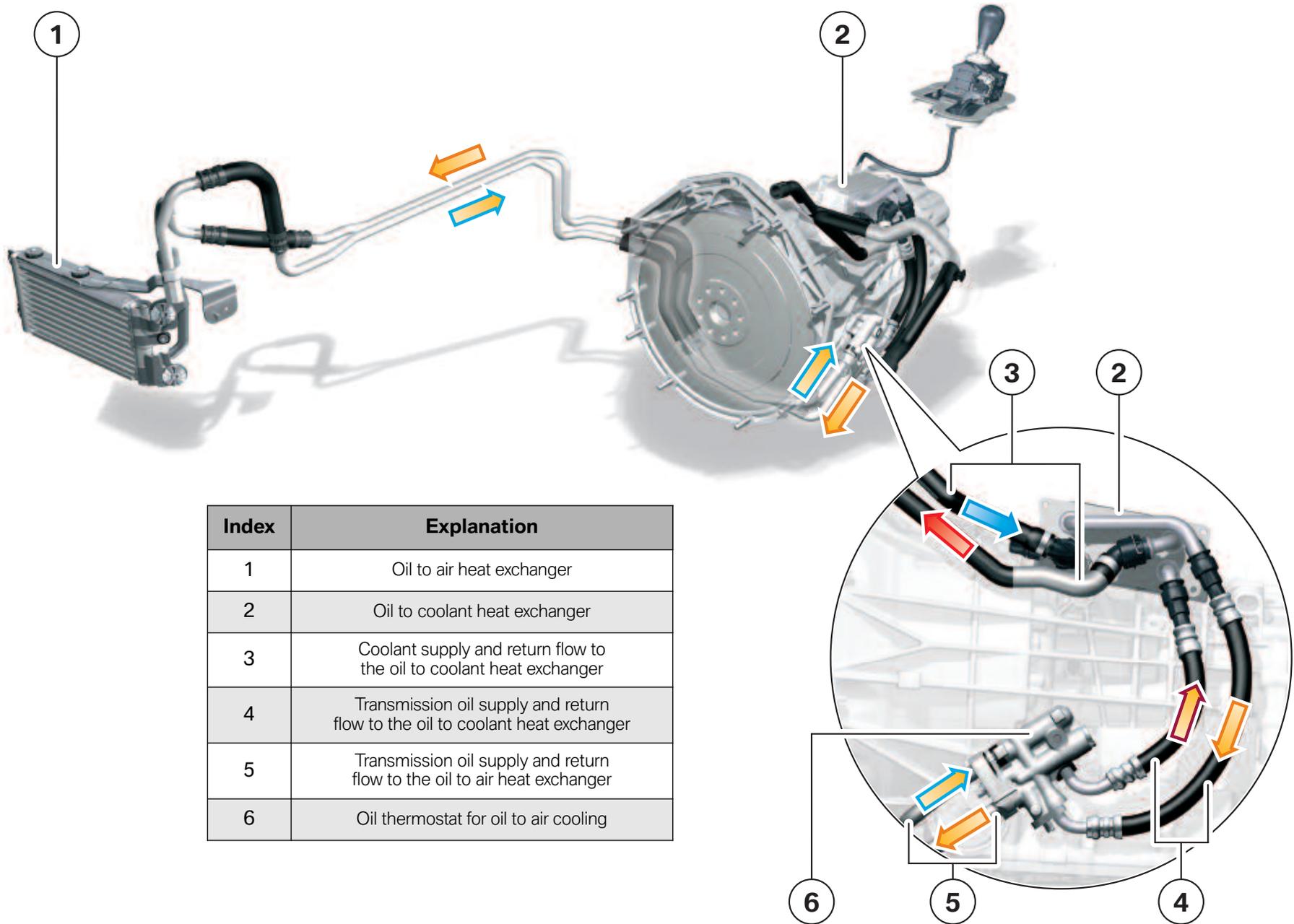
circulated back to the engine cooling system. The M DCT electronics can switch on the auxiliary coolant pump as needed. The auxiliary coolant pump, which is normally used to enhance the efficiency of the heating system, is used here to warm up the M DCT transmission. This design shortens the warm up time and maintains the transmission oil in the desired operating temperature range.

After the oil to coolant heat exchanger has brought the temperature of the transmission oil to above 95°C/203°F, an oil thermostat directs the transmission oil to the oil to air heat exchanger located at the front of the vehicle.

**M DCT Transmission Cutaway Display
(View of Two Stage Transmission Oil Cooling System)**



M DCT Two Stage Transmission Oil Cooling (view of system components)



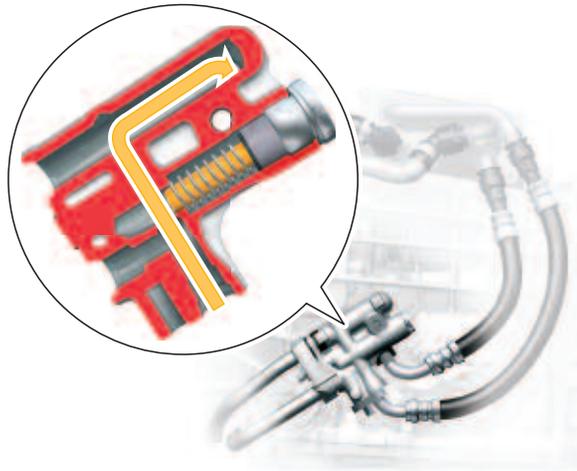
Index	Explanation
1	Oil to air heat exchanger
2	Oil to coolant heat exchanger
3	Coolant supply and return flow to the oil to coolant heat exchanger
4	Transmission oil supply and return flow to the oil to coolant heat exchanger
5	Transmission oil supply and return flow to the oil to air heat exchanger
6	Oil thermostat for oil to air cooling

Oil to Air Cooling

An oil thermostat is used to direct the oil flow through the oil to air heat exchanger. There is a by-pass passage in bore of the oil thermostat which is located between the supply and the return flow from the oil to air heat exchanger.

■ Oil “Warm-up”

When the oil temperature is below 95°C (203°F), the oil by-pass passage is opened by the thermal control valve in the oil thermostat. Oil flows out of the oil to coolant heat exchanger directly through the oil thermostat and back into the M DCT. This by-passes the oil to air heat exchanger completely and allows the system to reach operating temperature.

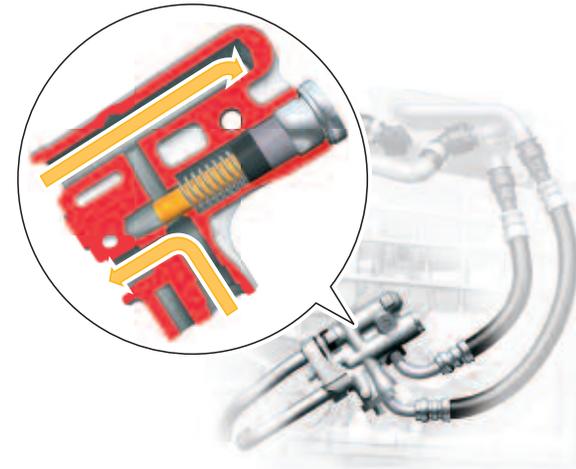


The M DCT oil thermostat closes at an oil temperature below 95 °C

■ Oil “Cooling”

When the oil temperature is above 95°C (203°F), the oil by-pass passage is closed by the thermal control valve in the oil thermostat. The hot oil is now directed to the oil to air heat exchanger for cooling before it flows back into the M DCT.

This design enhances the overall thermal efficiency of the oil to air heat exchanger while maintaining the proper transmission oil operating temperature.



The M DCT oil thermostat opens at an oil temperature above 95 °C

Note: In the event that the transmission oil temperature increases above the allowable limit, the engine torque is reduced and the maximum rpm is limited as a safety measure.

Service Information

Parking Lock

The parking lock Bowden cable does not need to be adjusted.

■ Parking Lock Emergency Release

To manually release the electrical parking lock:

- Removed the shifter boot is to gain access to the release mechanism.
- Using the screw driver from the vehicle tool kit or (similar tool), unclip the release mechanism cover.
- Insert the screw driver/tool in the release mechanism to the left of the shifter.
- Move the release toward the rear of the vehicle and observe the shifter indicator light illuminate the "N" position.



CAUTION!!!

The vehicle will roll with the emergency parking lock released.

The emergency release is described in detail in the vehicle's Owner's Manual and in the Repair Instructions.

Note: Releasing the parking lock using the emergency release can cause a fault code entry in the M DCT electronics.

Car Wash

At the car wash, before stopping the engine, you must actively switch to "N". Vehicles with "Comfort Access" must leave the transmitter in the vehicle or in the ignition lock.

Transmission Oil

■ M DCT Oil Type

"BMW DCT Oil-1" is a long-term oil that was especially designed for the M DCT transmission.

■ Oil Change Interval

The M DCT Drivelogic transmission has a new long-term rated oil, DCT Oil-1, which requires no replacement unless specified for a repair. (See SI B 00 01 07)

Transmission Oil Cooling

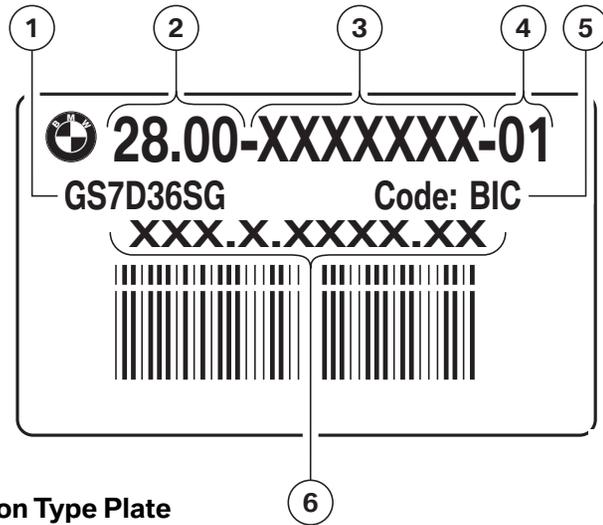
In the event that the transmission oil temperature increases above the allowable limit, the engine torque is reduced and the maximum rpm is limited as a safety measure.

CAUTION!!!

Because system oil pressure cannot be built up when the engine is not running, push starting a M DCT vehicle is not recommended.

Identifying the Transmission

This double-clutch transmission has an "S" as the seventh character of its transmission designation, which stands for Sport gear ratio (e.g. GS7D36"S"G).



Transmission Type Plate

Index	Explanation
1	Transmission designation in accordance with BMW GS 90007
2	Subassembly
3	BMW item number
4	Revision index
5	Transmission code
6	GETRAG item number

Service Functions

The following Service Functions are currently available on the BMW diagnostic equipment (ISTA/GT1) for the M DCT transmission:

- Clutch adaptation
- Transmission adaptation
- Oil calibration
- Parking lock hook test
- Learning the valves characteristics curves
- Mechatronic module data synchronization

■ Clutch Adaptation

The Clutch adaptation teaches the clutch engagement points for each clutch and saves the data in the M DCT control module.

Clutch adaptation should always be performed after the following service procedures :

- Clutch replacement
- Mechatronic module replacement
- Replacing the speed sensor or oil temperature sensor
- Replacing the oil pump
- If any work was done to the internal transmission components

■ Transmission Adaptation

The transmission adaptation service function ensures that the neutral positions and mechanical end stops will be learned and saved in the M DCT transmission control module.

Transmission adaptation should always be performed after the following service procedure:

- After replacement of the mechatronic module

■ Oil Calibration

This service function relates to the control and monitoring of the M DCT transmission oil temperature, which governs the function of specific components and relevant transmission controls.

The “Oil Calibration” should always be performed after the following service procedures:

- Clutch replacement
- Mechatronic module replacement
- Replacing the speed sensor or oil temperature sensor
- Replacing the oil pump
- If any work was done to the internal transmission components
- After a change or repair of the parking lock linkage
- If any work was done to the Gear Selector

CAUTION!!!

Transmission oil can exceed the temperature 40°C /104°F. Always exercise caution and follow proper safety procedures.

■ Parking Lock Hook Test

This service function tests and operates the parking lock hook with the gear selector. The parking lock will be selected hydraulically and must be held in place with the parking lock hook.

The “Parking Lock Hook Test” should always be performed after the following service procedures:

- Clutch replacement
- Mechatronic module replacement
- Replacing the speed sensor or oil temperature sensor

- Replacing the oil pump
- If any work was done to the internal transmission components
- After a change or repair of the parking lock linkage
- If any work was done to the Gear Selector
- Replacing the complete transmission

■ Learning the Valves Characteristic Curves

With this service function the characteristic curves of the valves PV1 and PV2 from the clutch control will be learned and saved in the transmission control module.

Learning of the valves characteristic curves should always be performed after completing the following service procedures:

- Clutch replacement
- Mechatronic module replacement
- Replacing the speed sensor or oil temperature sensor
- Replacing the oil pump

■ Mechatronic module data synchronization

With this service function the mechatronic data of the transmission will be assigned from the old mechatronic module to the new mechatronic module.

Data synchronization of the mechatronic module should always be performed after completing the following service procedure:

- Change of the mechatronic module

Possible Fault Messages

The following is an overview of possible fault indicators and the associated Check Control Messages.

High Transmission Oil Temperature

There are two transmission oil temperature messages which generate appropriate responses:

1. When the transmission oil temperature has overheated (oil sump or clutch) and in the case of certain valve faults.

Check Control Message 104	Information in the CID
Transmission Temperature. Drive Carefully! 	Transmission Temperature Risk of transmission overheating. Shift program with restricted vehicle operation active. Avoid high engine loads.
Reaction: The engine torque is reduced. The shift program is adjusted to lower the temperature.	
Action: Check driving profile and environmental conditions. Look for a possible fault in the transmission oil cooling system. It may be necessary to check the M DCT using BMW Diagnostic Equipment.	

2. When the transmission oil temperature has overheated (oil sump or clutch).

Check Control Message 105	Information in the CID
Transmission Temperature Drive Carefully! 	Transmission has Overheated Stop and shift the transmission position into "P" after it has cooled down, drive on carefully. If overheating re-occurs, visit your nearest BMW Service Center to check this.
Reaction: The engine torque is greatly reduced. The current gear remains engaged until you reach a standstill. After reaching a standstill, the parking lock is engaged.	
Action: Look for a fault in the transmission oil cooling system. Check the M DCT transmission using BMW Diagnostic Equipment.	

Internal Transmission Faults (Implausible sensor, valve readings and limit value infringements)

Check Control Message 368 may be displayed:

- If Implausible temperature values or a temporary pressure limit reading of negative pressure or overpressure.
- In the event of an electrical defect with the temperature sensors (wire open circuit or short circuit).
- When Implausible input from (engine) speed or sub-transmission speed.

Check Control Message 368	Information in the CID
Transmission fault. 	Transmission Fault The journey can be continued. Visit your nearest BMW Service Center to check this.
Reaction: None.	
Action: Check the M DCT using BMW Diagnostic Equipment.	

Check Control Message 365 may display:

- In the event that the temperature sensors and pressure sensors do not detect cooling oil flow, for example, because a valve has jammed while other valve problems or sensor failure are being experienced.
- With persistent pressure limit infringements.
- In the event of mechanical selector rod problems or sensor faults (position sensors for the selector rods).
- Because the temperature measured in the M DCT electronics does not match the value range of the other temperature sensors.

Check Control Message 365	Information in the CID
Faulty transmission. Drive Carefully! 	Transmission Fault Emergency program activated. Visit your nearest BMW Service Center to check this.
Reaction: A clutch may be blocked. Clutch 1 (the gears R, 1, 3, 5 and 7 can no longer be selected) or clutch 2 (the gears 2, 4 and 6 can no longer be selected). Individual or gear pairs are blocked.	
Action: Check the M DCT using BMW Diagnostic Equipment.	

Check Control Message 254 may display:

- In the event of a failure of certain control valves.

Check Control Message 254	Information in the CID
Faulty transmission. Drive Carefully! 	Transmission Fault Reduced acceleration may occur. Visit your nearest BMW Service Center to check this.
Reaction: The journey can be continued with limited engine performance.	
Action: Check the M DCT using BMW Diagnostics Equipment.	

Check Control Message 307 may display:

- If the transmission oil temperature increases or overheats and the ratio of the oil sump temperature to clutch temperature is implausible.
- In the event of PT-CAN failure or a communication fault.
- When there is accelerator pedal fault message or implausible reading.

Check Control Message 307	Information in the CID
Faulty transmission. Drive Carefully! 	Transmission Fault Some functions may be faulty. Gear can be engaged without braking. Drive carefully! Visit your nearest BMW Service to check this.
Reaction: Only 2nd and R gears are available.	
Action: Check the M DCT using BMW Diagnostic Equipment.	

Faults Related to Implausible Readings (with the brakes, parking lock or gear selector switch [GWS])

Check Control Message 250 may display:

- When there is a fault with the brake light switch or implausible reading.
- In the event of unrealistic driving conditions, such as excessive deceleration without brake operation.
- lengthy simultaneous accelerator pedal and brake pedal operation, for more than 1 min.

Check Control Message 250	Information in the CID
<p>Gear can be engaged without braking.</p> 	<p>Important!</p> <p>It is still necessary to step on the brakes before shifting into gear. The journey can be continued. Turn off the engine before leaving the vehicle. Have it checked by your BMW Service Center as soon as possible.</p>
<p>Reaction:</p> <ul style="list-style-type: none"> • If the brake light switch is defective, starting the engine may not be possible. 	
<p>Action:</p> <ul style="list-style-type: none"> • Check driving profile, vehicle may need to be checked using BMW Diagnostic equipment. 	

Check Control Message 302 may display:

- If the parking lock cannot be engaged electromechanically.

Check Control Message 302	Information in the CID
<p>Transmission position "P" is not selected.</p> 	<p>Transmission Position</p> <p>Position "P" is not selected.</p> <p>Caution! The vehicle may roll in this condition.</p>
<p>Reaction:</p> <ul style="list-style-type: none"> • Inoperative parking lock function, the vehicle must be secured with the hand brake/parking brake when switching off the engine. 	
<p>Action:</p> <ul style="list-style-type: none"> • Check for proper functioning parking lock electromagnet in the M GWS. • Check the routing path of the Bowden cable between the parking lock electro magnet in the M GWS and the parking lock lever on the M DC • Check for proper functioning parking lock lever on the M DCT. • Check M DCT using BMW Diagnostic Equipment. 	

Check Control Message 175 may display:

- In the event of a parking lock sensor fault.

Check Control Message 175	Information in the CID
Transmission position "P" is faulty. 	Faulty Transmission Transmission position "P" may not be possible. When at a standstill activate the parking brake. Visit your nearest BMW Service Center to check this.
Reaction: Parking lock may not be selected.	
Action: Check if the parking lock is selected. Check the M DCT using BMW Diagnostic Equipment.	

Check Control Message 541 may display:

- In the event that the parking lock cannot be disengaged hydraulically.

Check Control Message 541	Information in the CID
Transmission position "P" is faulty. 	Faulty Transmission To pull away, unlock the parking lock manually, see Vehicle Owner's Manual. Visit your nearest BMW Service Center to check this.
Reaction: Parking lock must be disengaged via the emergency release.	
Action: After emergency release, check the M DCT using BMW Diagnostic Equipment.	

Check Control Message 394 may display:

- In the event of a M GWS malfunction.

Check Control Message 394	Information in the CID
<p>Selector lever may be faulty.</p> 	<p>Selector Lever is Faulty The journey can be continued. If necessary repeat gearshift request.</p>
<p>Reaction: One or more M GWS functions may be faulty.</p>	
<p>Action:</p> <ul style="list-style-type: none"> • Repeat driving program selection on the M GWS or use the gearshift paddles on the steering wheel. • Check the M GWS using BMW Diagnostic Equipment. 	

Invalid Bus Message

Check Control Message 419 may display:

- PT-CAN message, invalid engine torque.

Check Control Message 419	Information in the CID
<p>Faulty drive</p> 	<p>Faulty Drive The journey can be continued. Reduced acceleration. Visit your nearest BMW Service Center to check this.</p>
<p>Reaction: Clutch is not operating smoothly. Shifting between gears is not smooth.</p>	
<p>Action: Check vehicle by using BMW Diagnostic Equipment.</p>	

Variable M Differential

The variable M differential from the E46 M3 is utilized in the E60 M5 as well in the E9x M3. 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 shear 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 which enhances the positive aspects of rear-wheel drive when driving at higher speeds and on surfaces with poor traction.

E46 Rear Axle Differential

The rear axle differential was developed specifically for the E46 M3. The rear axle differential is designated “210” (ring gear diameter in mm).

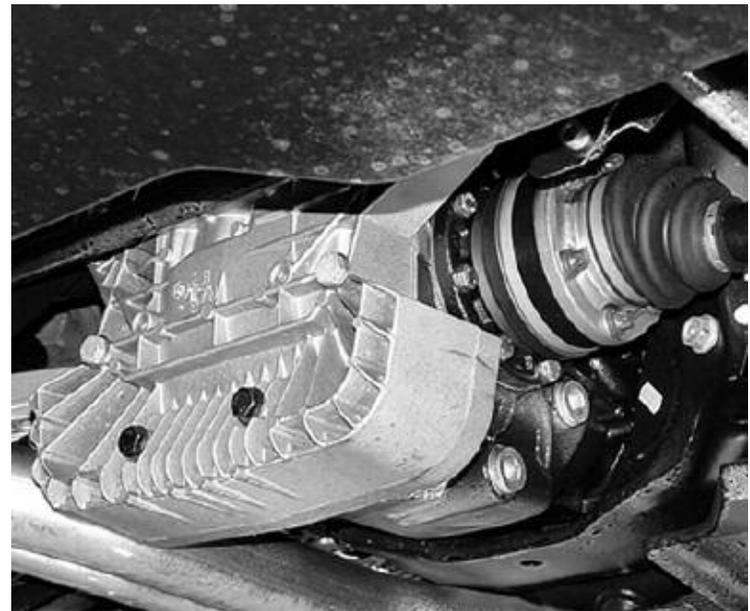
The mounting points of the rear axle carrier for the differential have been modified compared to the E46/2.

The rear axle differential is bolted to the rear axle carrier at two mounting points on the rear axle differential casing.

The rear axle carrier is connected to the body at the same points as the E46/2. For all BMW vehicles, this mounting arrangement is known as double-flexible rear axle mounting.

The cover of the rear axle differential is made of pressure die cast aluminum. Special arranged cooling fins reduce the temperature of the oil in the differential.

The technical innovations of the variable M-differential lock developed by BMW M in cooperation with GKN Viscodrive GmbH.



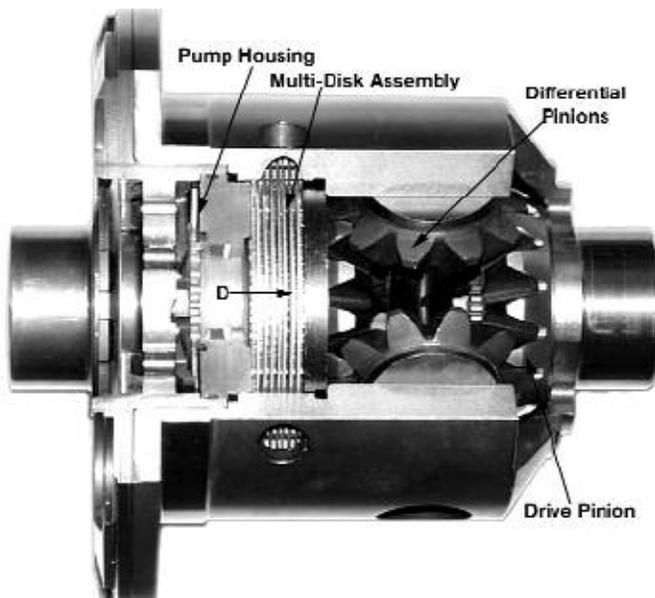
E46 M3 Differential

Variable M-differential Lock

To date, torque-sensing limited slip differentials with a constant basic locking torque have been used in M vehicles. The differential lock value for current M vehicles is 25%. However, if traction is very low, e.g. on snow, the advantages with this differential lock concept are limited due to the restricted support torque.

A variable differential lock was used for the first time in the E46 M3. Compared to the conventional torque-sensing differential lock, the variable M-differential lock is capable of providing traction advantages even under extreme conditions.

When there is a speed difference between both wheels, a shear pump located on the ring gear side generates a pressure. A working piston transmits this controlled pressure on the basis of the differential speed of the drive wheels to the multi-disc clutches so that the drive torque is transmitted to the wheel with the most “grip”.



The pump pressure and locking power increase as the speed difference between the two wheels increase. If the differential speed between both wheels decreases, the pump pressure is also reduced and the locking power diminishes.

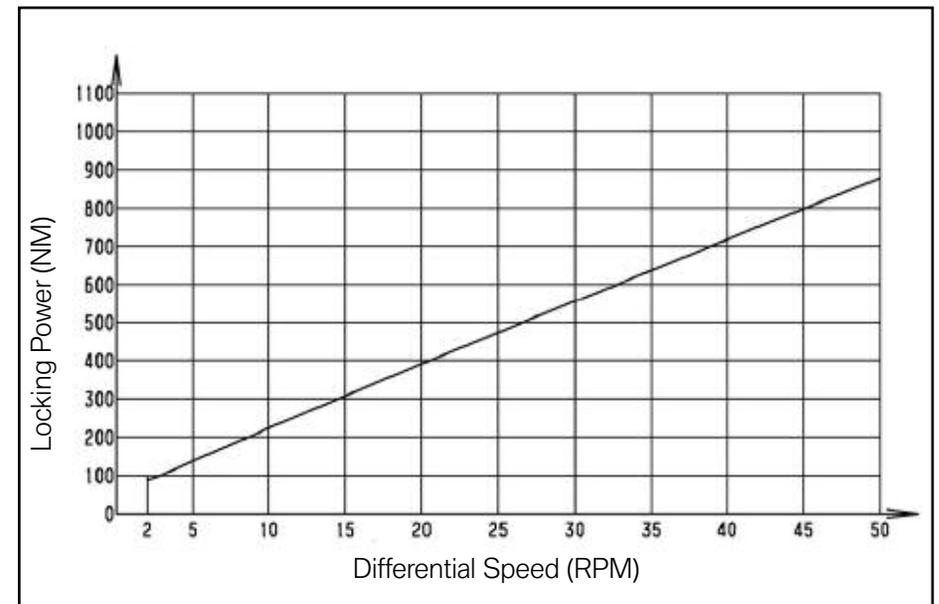
The Pump Unit

The pump unit is sealed (cannot be dismantled) and is filled with high viscosity silicone oil.

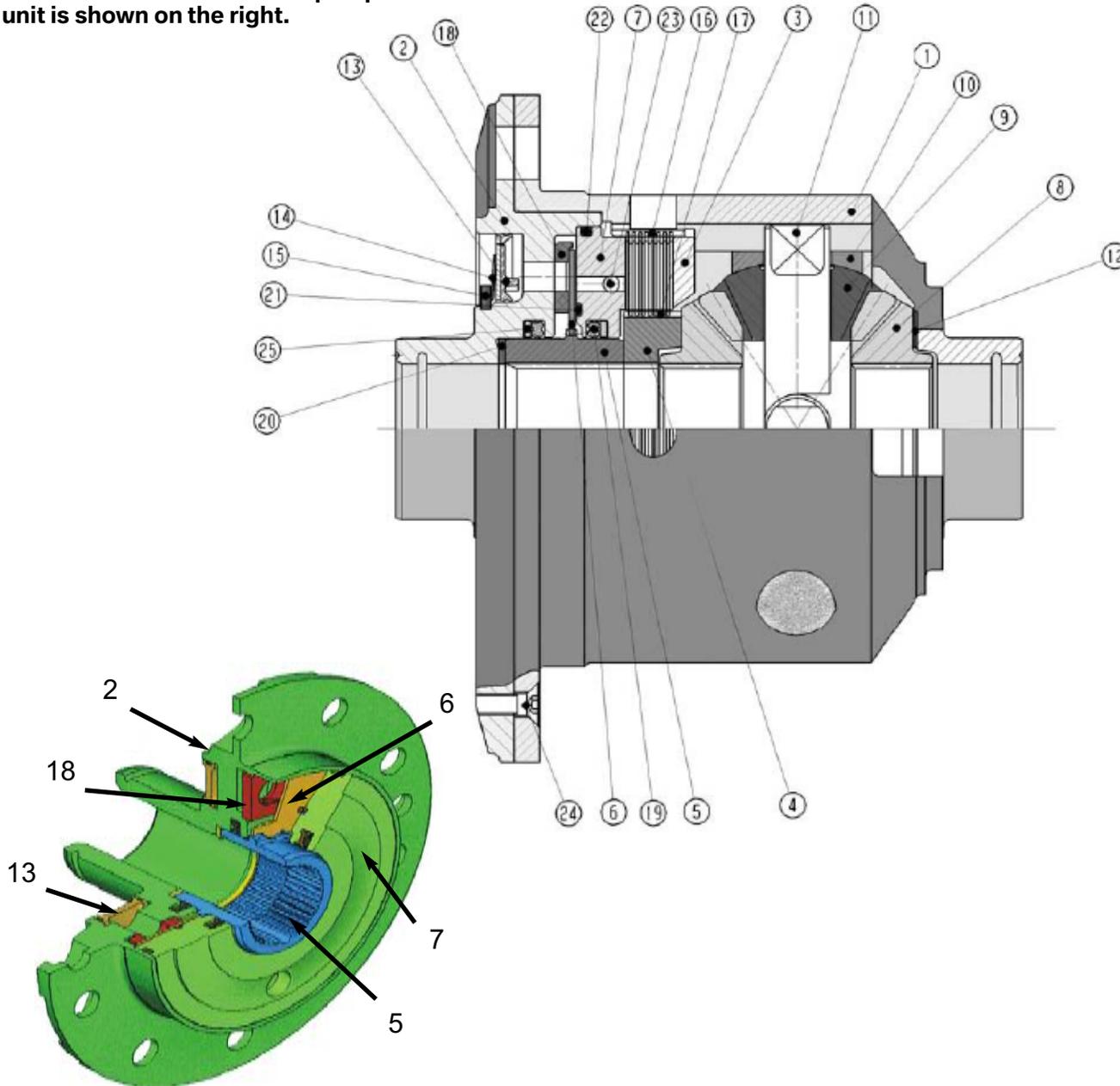
As a result of the speed difference between the drive wheels, shear forces occur in the silicone oil in the pump unit between a channel filled with silicone oil and a pump disc located above it.

These shear forces generate a pressure that is dependent on the differential speed of the drive pinions.

The pressure is built up by a piston (max. 38 bar on E46 M3) that presses the multi-disc clutches together achieving a variable differential lock effect dependent on the differential speed.



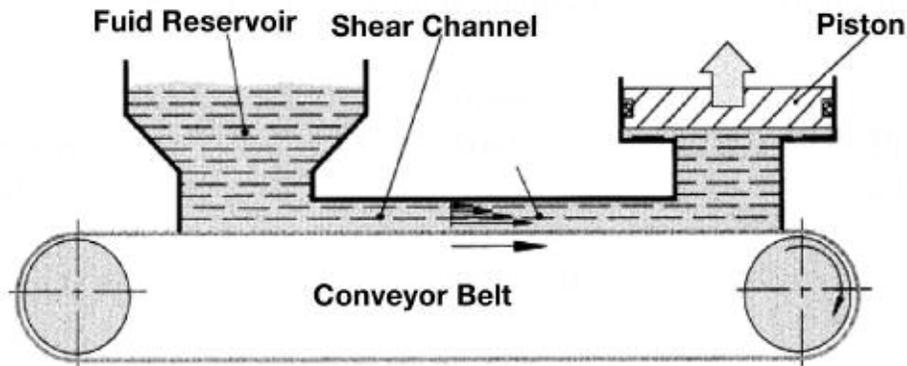
Sectional view of a shear pump unit is shown on the right.



Index	Explanation
1	Differential Case
2	Differential Cover
3	Differential Ring
4	Inner Disc Carrier
5	Displacement Disk Carrier
6	Displacement Disk
7	Pistons
8	Drive Pinion
9	Differential Bevel Pinion
10	Ball Disk
11	Differential Axle
12	Thrust Washer
13	Differential Piston
14	Disc Spring
15	Retaining Ring
16	Outer Friction Disc
17	Inner Friction Disc
18	Control Disc
19	Four-Lip Ring
20	Thrust Washer
21	O-Ring
22	O-Ring
23	Ball
24	Countersunk Screw
25	Support Ring

Principle of Operation

The conveyor belt model illustrates the functional principle of the shear pump. As the conveyor belt moves, the viscous friction in the laterally sealed shear channel conveys the fluid in the direction of movement.



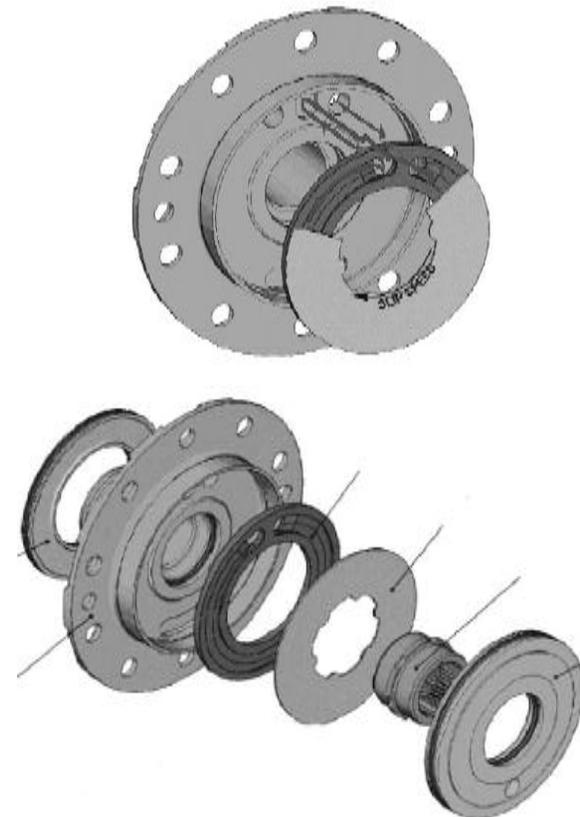
By transferring the operation principle to a rotary system, the conveyor belt becomes a displacement disc driven by the Hub. The shear channel is then a circular groove in the control disk. The control disk is located in the pump housing.

Transfer ports that are connected to outlet holes in the pump housing are provided at the ends of the shear channel.

Silicone oil is conveyed through the outlet holes from the equalization chamber (fluid reservoir) into the pressure chamber. Piston exerts a pressure on the friction discs.

The arrows shown below represent the flow of silicone oil between the displacement disc and the control disc. The silicone oil is transferred from the reservoir on the outside of the pump housing to the pressure chamber between displacement discs and the piston.

The arrangement of the pump elements and specific routing of the silicone oil in a gap between the piston and displacement disc ensures the pressure generated acts on the piston.



NOTES

PAGE