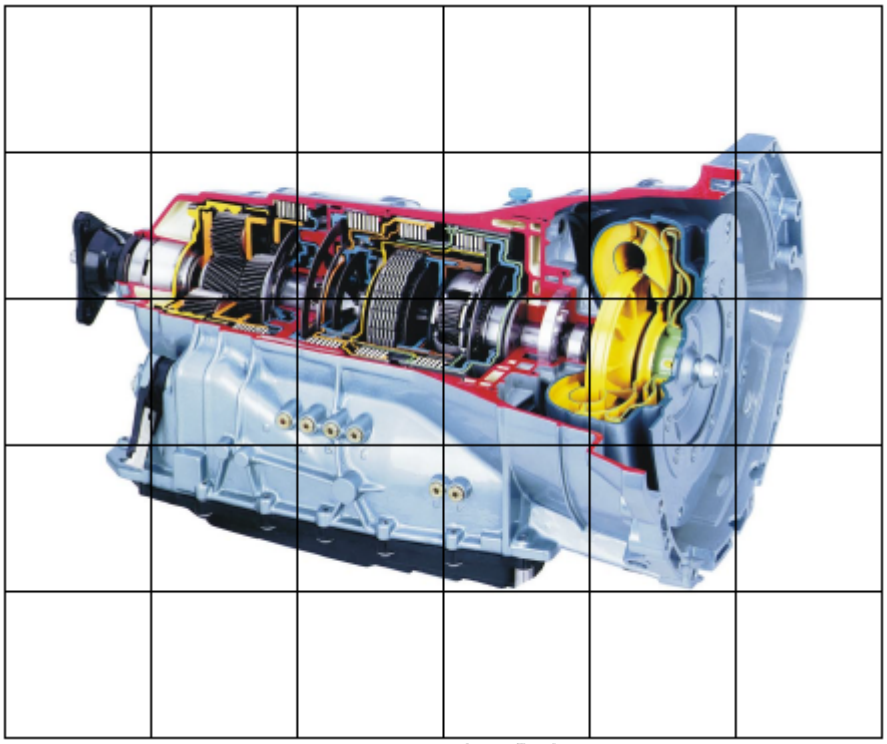
Automatic Gearbox GA6HP26Z/Power Train



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Introduction GA6HP26Z

Introduction of the new automatic gearbox

Together with the company ZF (Zahnradfabrik Friedrichshafen), BMW has developed a new automatic gearbox with the designation GA6HP26Z for the E65.

In many aspects it represents a further development of transmission technology and features innovations used for the first time at BMW.

In view of its innovations and further developments, the gearbox make an important contribution to the "revolutionary" claims of the E65 in the luxury class segment.

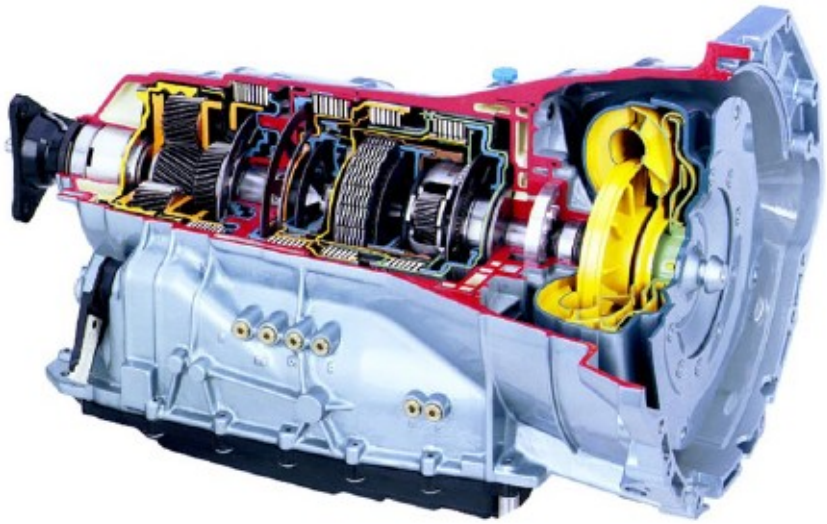

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Fig. 1: Automatic gearbox GA6HP26Z

- Gearbox versions

The GA6HP26Z was designed in two versions catering for the different E65 motorizations. There is a less powerful and a more powerful version that differ with regard to the following aspects:

- Power output and torque layout

- Torque converter

- Clutches with different numbers and steel discs and lined plates and

- Lepelletier planetary gear train with different number of planet gears

The less powerful version of the gearbox is designed for a power output of 230 kW/312 bhp and a torque of 440 Nm. It will therefore be used in the 735i and 745i. The more powerful version is designed for a power output of 320 kW/435 bhp and a torque of 600 Nm. It will be fitted in the 730d and 760i. The fundamental design and function of both gearbox versions are the same.

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- Mechanical design of the gearbox

The mechanical power transmission of the gearbox has been optimized with regard to gearshift comfort, fuel consumption reduction and product quality.

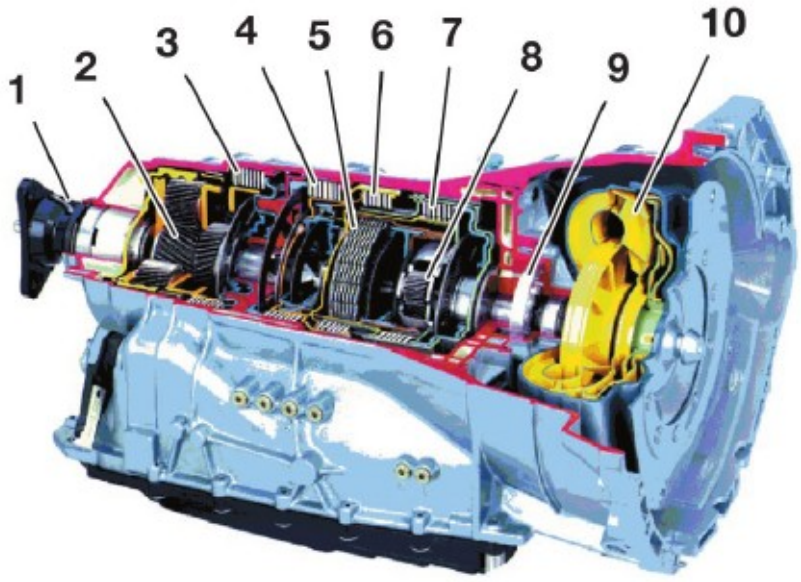

Fig. 2: Mechanical design of the GA6HP26Z

Index	Explanation	Index	Explanation
1	Output shaft	6	Clutch B
2	Double gear train	7	Clutch A
3	Clutch D	8	Single gear train
4	Clutch C	9	Oil pump
5	Clutch E	10	Torque converter with converter lockup clutch

The torque developed by the engine is transferred to the gearbox via a torque converter with a controlled converter lockup clutch. The gears are shifted by means of multi-disc clutches. The six forward gears, used for the first time in BMW automatic gearboxes, and the reverse gear are produced by a Lepelletier planetary gear train.

- Transmission control

The gearbox is controlled by a so-called mechatronics module that is made up of a combination of hydraulic gearshift unit and electronic control unit. The following system overview shows the main components of the electronic control system.

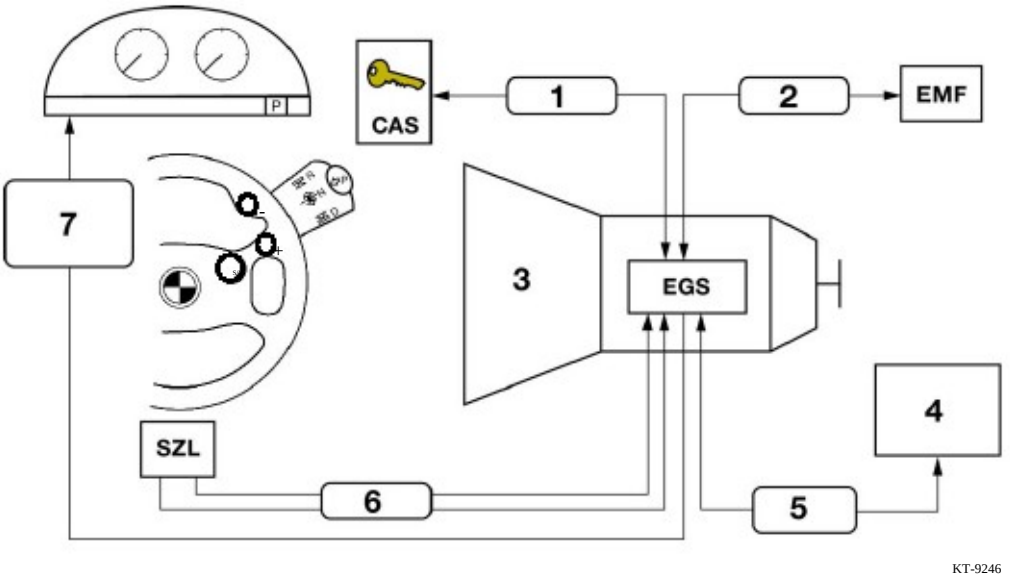

Fig. 3: Electronic transmission control GA6HP26Z

Index	Explanation
1	Key signal, starter interlock
2	Redundancy (parking lock, n_{out})
3	Automatic gearbox
4	Controls in vehicle interior (for emergency release)
5	Mechanical emergency release for parking lock
6	Driver's choice P R, N, D, (S, M, +, -),
7	Shift pattern (shift gate) Position indicator P R, N, D, S, M1...M6, Shift lock indicator Error messages
CAS	Car access system
EMF	Electromechanical parking brake
EGS	Electronic transmission control (in mechatronics module)
SZL	Steering column switch centre

The driver's choice is transmitted in the form of an electrical signal from a selector lever on the steering column or from several control buttons in the multifunction steering wheel and transferred via a CAN bus to the transmission control. In the gearbox, the commands are implemented while evaluating various ambient conditions. The relevant positions are indicated in the instrument cluster.

Pure electronic transmission control (shift by wire) realized in this way renders the conventional gearshift lever in the centre console and the associated components unnecessary.

The automatic parking lock which is active, for instance, when the ignition key is removed represents a further important increase in comfort and convenience.

In the event of faults or complete failure of electrical connections or system components, numerous measures are provided, such as, for instance, an additional serial data link between the selector lever and gearbox control unit, the display of error messages in the instrument cluster or in the new E65 display or the mechanical emergency release feature in the event of breakdown.

- Advantages of the new gearbox

The new automatic gearbox GA6HP26Z is characterized by the following advantages:

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- Designed as a 6-speed gearbox with a long 6th gear, fuel consumption is reduced by up to 5 percent.

- Compared to the 5-speed gearbox, the 6-speed gearbox allows for a more optimum spread of the gears, consequently improving vehicle acceleration.

- Compared to the A5S560Z, the new 6-speed gearbox is approx. 30 kg lighter and approx. 50 mm shorter.

- The number of transmission components has been reduced from approx. 660 parts in a 5-speed gearbox to approx. 470 parts for the new 6-speed gearbox.

- The number of interfaces has been reduced by using the mechatronics module and the pure electronic transmission control.

- Phase-in dates

Series launch of the gearbox GA6HP26Z in the E65 is planned as shown in the following table.

Version	Model	Series launch
Less powerful version	735i, 745i	from 7/01
More powerful version	760i, 730d	from 9/02 (760i)

- Technical data

The following table lists the technical data of the gearbox versions.

Technical data	Explanation
Gearbox type	passenger vehicle automatic gearbox with 6 forward gears and one reverse gear in standard arrangement
Transmission data - less powerful version	max. torque at 4200 rpm 440 Nm max. power output at 6600 rpm 230 kW / 313 bhp
Transmission data - more powerful version	max. torque at 4200 rpm 600 Nm max. power output at 5800 rpm 320 kW / 435 bhp
Torque converter	slip-controlled torque converter lockup clutch in the gears 1 to 6 max. permissible continuous speed 7000 rpm
Transmission ratios	1st gear 4. 71 / 2nd gear 2.34 / 3rd gear 1.521 /1 4th gear 1. 43 / 5th gear 0.867 / 6th gear 0.691 /1 reverse gear 3.403
Control	electrohydraulic with adaptive electronic control
Weight	84 to 90 kg with oil depending on version
Towing capability	500 km at up to 70 km/h

Component and functional descriptions

Only the new features/changes of the individual components compared to the information previously provided in the publications on BMW Automatic Gearboxes are described in the following.

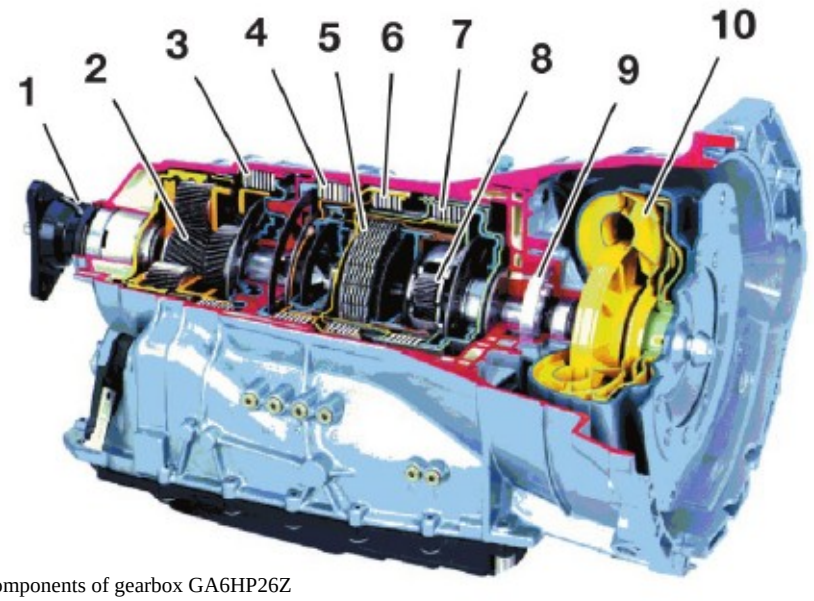

Fig. 4: Components of gearbox GA6HP26Z

Index	Explanation	Index	Explanation
1	Output shaft	6	Clutch B
2	Double gear train	7	Clutch A
3	Clutch D	8	Single gear train
4	Clutch C	9	Oil pump
5	Clutch E	10	Torque converter with converter lockup clutch

The component and functional description follows the power transmission progression in the gearbox, i.e. from the torque converter with converter lockup clutch up to the output shaft. The component arrangements are shown in the illustration above.

Torque converter and converter lockup clutch

The torque converter acts as the linking element for power transmission between the engine and gearbox. As is the case with other automatic gearboxes, it has the task of converting high speed/low torque into low speed/high torque. The converter lockup clutch is used for the purpose of eliminating slip during rotary speed transmission.

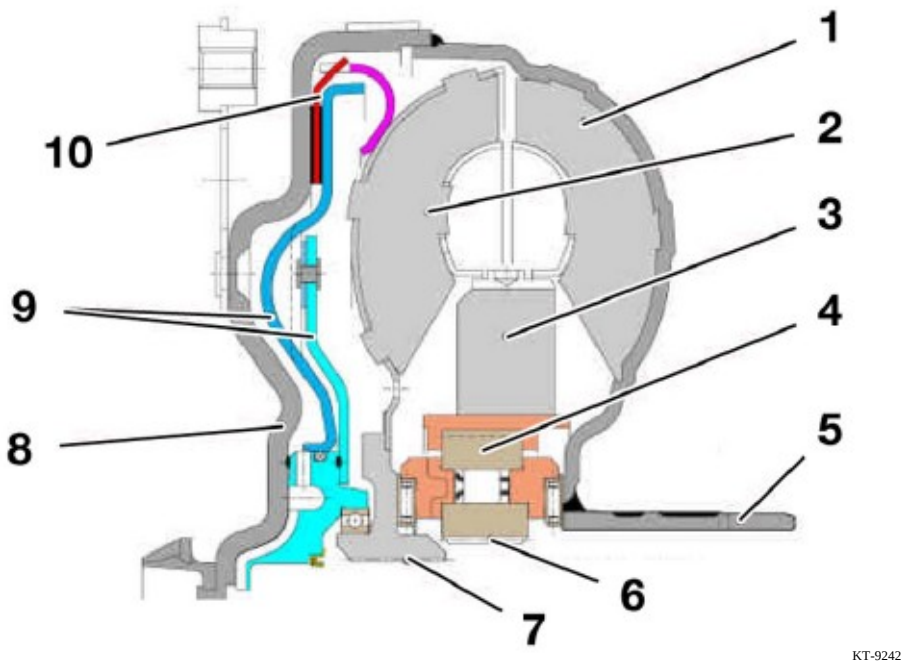

Fig. 5: GA6HP26Z, torque converter and converter lockup clutch

Index	Explanation	Index	Explanation
1	Pump	6	Stator shaft
2	Turbine	7	Turbine shaft
3	Stator	8	Torque converter casing
4	Overrunning clutch	9	Piston for converter lockup clutch
5	Torque converter hub	10	Lined plate

New features/changes

In the same way as on the gearbox A5S560Z, the converter lockup clutch is designed as a two-friction surface clutch. It is slip-controlled in the gears 1 to 6. Consequently, the operating points with the converter lockup clutch disengaged are reduced thus also reducing fuel consumption.

The converter lockup clutch is not closed or engaged up to a gear oil temperature of 35 ºC.

At other operating points, the control of the converter lockup clutch depends on various factors such as

- load requirement signal

- engine load status

- vehicle speed

- gearbox oil temperature

- selected gearshift program

For this reason, it is not possible to provide a general statement as to when control of the converter lockup clutch begins or when it engages.

Examples:

- Control of the converter lockup clutch takes place in the XE program "extreme economy" in the gears 1 to 6 as from a speed of approx. 30 km/h when a load requirement signal of up to 50% is applied. The converter lockup clutch is disengaged if the load requirement is more than 50%.

- The torque converter clutch is engaged as from a speed of approx. 80 km/h in all forward gears. It is already engaged at a speed of 20 km/h at full load or kick-down.

Similar to the gearbox A5S325Z, on the new automatic gearbox, there are small oil channels (galleries) in the linings of the converter lockup clutch. The oil circuit created in this way quickly reduces the temperature in the torque converter after the converter lock-up clutch engages.

The size of the torque converters for the new automatic gearbox differs depending on the relevant motorization.

Disengagement of the torque converter when stationary is a new feature. Instead of having the engine run against the torque converter when the vehicle is stationary (foot on brake), the torque converter is uncoupled from the drive so that only a minimum load remains and fuel consumption is reduced. The uncoupling phase is achieved by a control feature in clutch A (No. 7 in Fig. 1) dependent on the load signal and output speed.

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Oil pump

The oil pump supplies the required oil pressure and lubricating oil for the automatic gearbox. As on other gearboxes, it is designed as a crescent-type pump and has a delivery capacity of approx. 16 cm^3 per revolution. A delivery control valve is not fitted. The converter in the pump is mounted in a needle bearing.

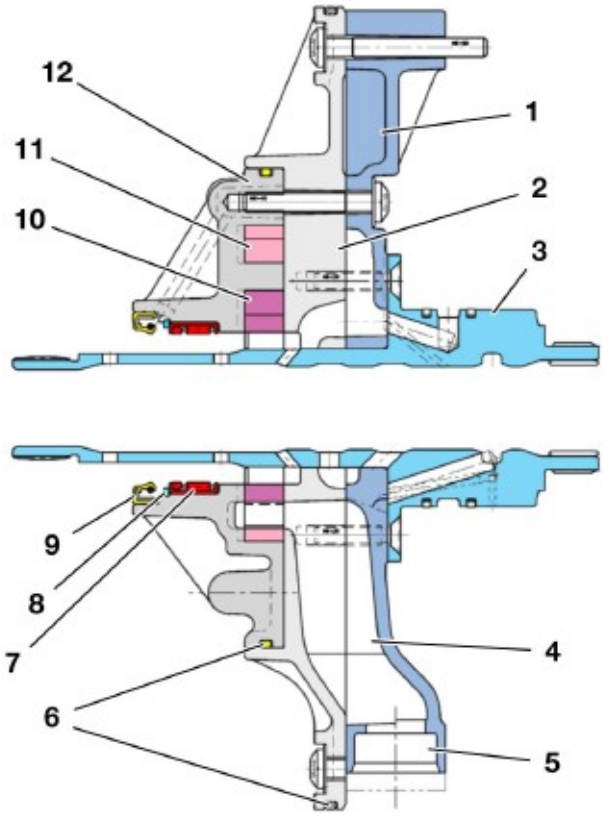

Fig. 6: GA6HP26Z, oil pump

Index	Explanation	Index	Explanation
1	Intermediate plate	7	Bearing
2	Centring plate	8	Snap ring
3	Stator shaft	9	Rotary shaft seal
4	Intake	10	Impeller
5	To oil strainer (intake pipe)	11	Internal gear
6	O-ring	12	Pump housing

Multi-disc clutches

The new gearbox GA6HP26Z requires only 5 clutches to shift 6 gears. The gearbox A5S560Z featured 7 clutches for shifting 5 gears. The clutches are divided into drive clutches and brake clutches.

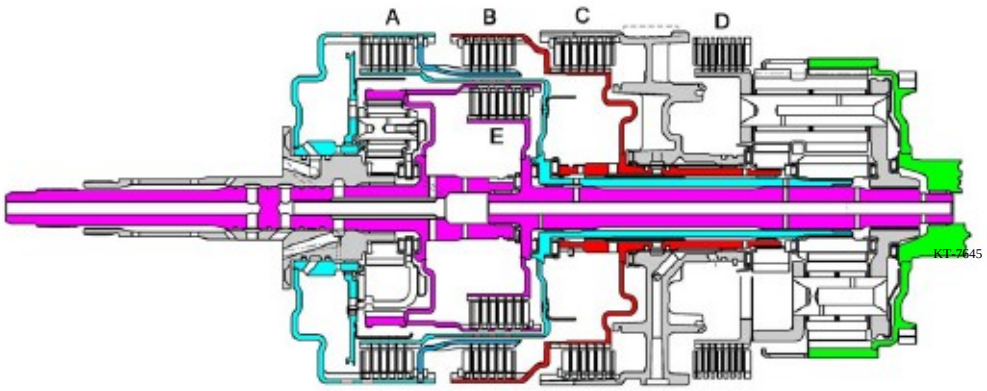

Fig. 7: GA6HP26Z, multi-disc clutches

Index	Explanation	Index	Explanation
A	Drive clutch	D	Brake clutch
B	Drive clutch	E	Drive clutch
C	Brake clutch		

Clutches A, B and E are drive clutches while clutches C and D are brake clutches.

The drive clutches A, B and E are balanced with respect to the dynamic pressure.

In the new gearbox, all gearshifts from 1st to 6th gear and from 6th to 1st gear are executed as overlap shifts. Free-wheel gearshifts are no longer required as on the A5S560Z where the shift from 1st to 2nd and 2nd to 3rd took place via overrunning clutches. The overlap gearshift system saves weight and space.

The electrohydraulic gearshift is executed by valves in the hydraulic shift unit that are controlled by pressure regulators.

Lepelletier planetary gear train

The new Lepelletier planetary gear train is used in the gearbox GA6HP26Z. Six forward gears and one reverse gear are possible with this planetary gear train.

This Lepelletier gear train facilitates a more lightweight design than the Wilson gear train previously used in the gearbox A5S560Z.

The planetary gear train consists of a single carrier planetary gear train and a downstream double planetary gear train.

The single carrier planetary gear train is made up of:

- 1 sun gear
- 3 planet gears
- 1 planet carrier
- 1 internal gear

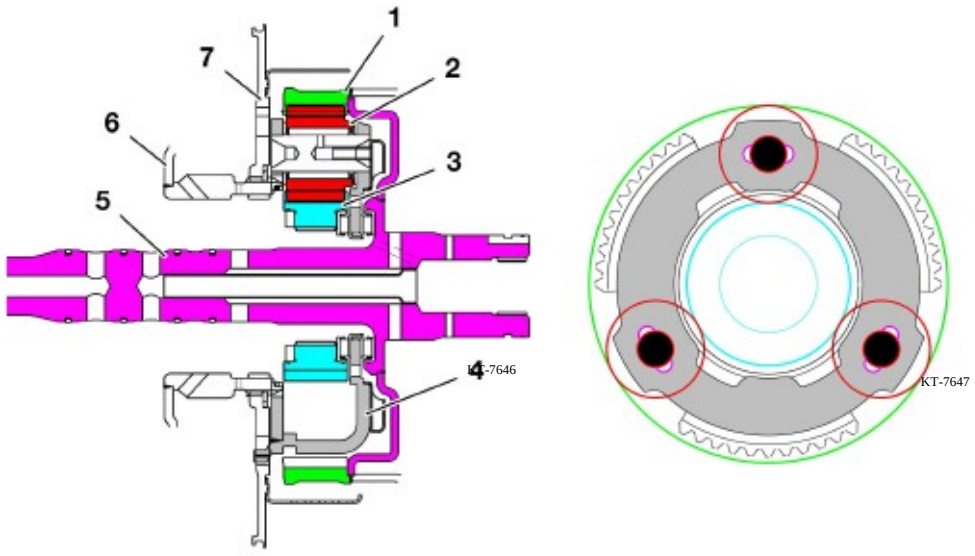

Fig. 8: GA6HP26Z, single carrier planetary gear train

Index	Explanation	Index	Explanation
1	Internal gear 1	5	Turbine shaft
2	Planet gear	6	Cylinder A
3	Sun gear 1	7	Pressure plate A
4	Planet carrier		

The subsequently connected double planetary gear train is made up of:

- 2 differently sized sun gears
- 3 short planet gears
- 3 long planet gears
- 1 planet carrier
- 1 internal gear

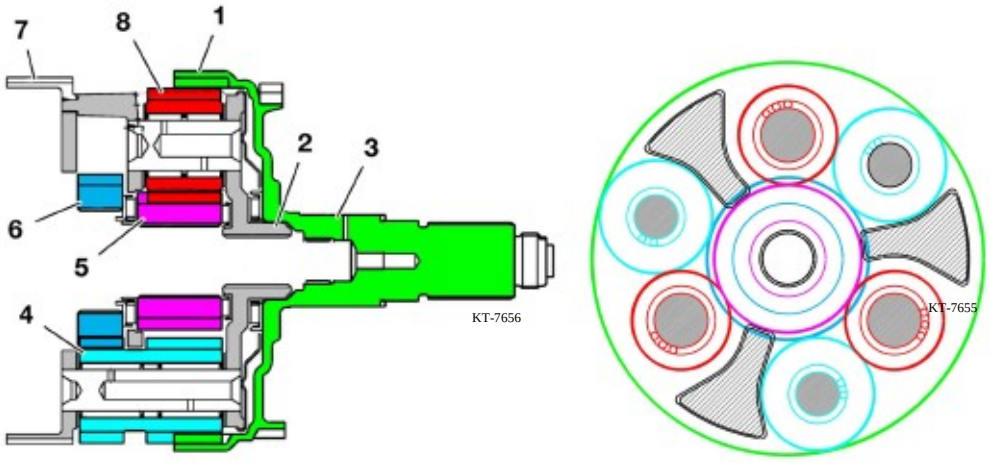

Fig. 9: GA6HP26Z, double planetary gear train

Index	Explanation	Index	Explanation
1	Internal gear 2	5	Sun gear 3, clutch E
2	Planet carrier, clutch E	6	Sun gear 2, clutch A
3	Output	7	Planet carrier 1
4	Double planet gear (long)	8	Planet gear (short)

Parking lock

The parking lock is a facility that secures the vehicle to prevent it rolling away. When the vehicle is stationary it is applied via the selector lever, depending on the version, by purely mechanical means or, as is the case in this new gearbox, electrically via an actuating magnet.

The parking lock blocks the output shaft of the gearbox by means of a pawl (4) that engages in the gearing of the parking lock gearwheel (1).

The parking lock is designed such that the vehicle is always reliably held on uphill or downhill gradients of up to 32% and at a speed below 2 km/h. The parking lock must not engage at driving speeds above 5 km/h.

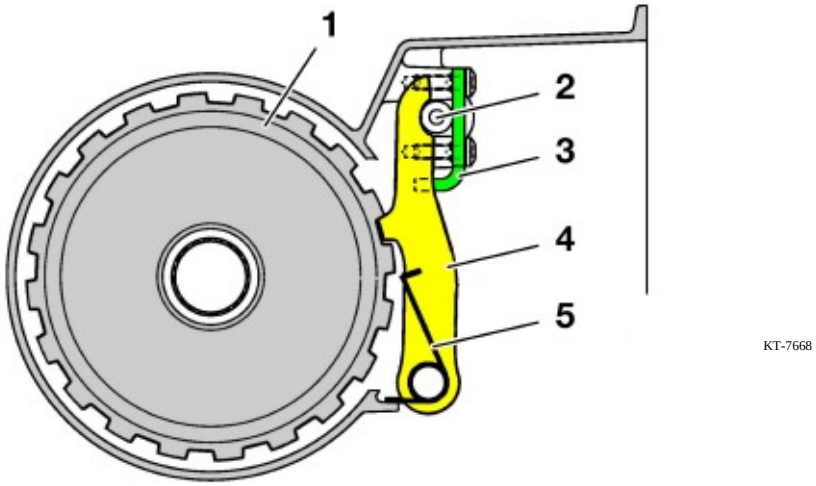

Fig. 10: GA6HP26Z, parking lock

Index	Explanation	Index	Explanation
1	Parking lock gearwheel	4	Parking lock pawl
2	Linking rod	5	Leg spring
3	Guide plate		

- Function

In the electrical version of the parking lock, a differentiation must be made between mechanical engagement of the lock and corresponding electrical activation.

The parking lock is engaged in the gearbox by means of a mechanical spring system, see graphic above.

The notched disc in the gearbox is replaced by a parking disc, a parking lock cylinder, a solenoid valve and an electric magnet.

Electrical activation of the parking lock is triggered by a push-button on the selector lever or by the radio remote control key transmitter. Activation by the solenoid valve and electric magnet is controlled by the EGS control unit.

The solenoid valve is located in the hydraulic shift unit and the electric magnet on the cylinder for the parking lock.

The electric magnet for the parking lock cylinder is switched off when the parking lock is engaged. Consequently, the mechanical lock is cancelled and the piston released. The solenoid valve in the shift unit is also switched off. The valve assumes its rest position and the cylinder chamber of the parking lock cylinder is vented. The piston is pulled in the direction of the parking lock by a preloaded leg spring on the parking disc and engaged by the linking rod secured to the parking disc.

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On leaving the parked position, the solenoid valve in the shift unit is switched on and the main pressure is applied in the cylinder chamber of the parking lock cylinder thus pushing back the piston to release the parking lock.

The electric magnet on the parking lock cylinder is also switched. Consequently, the piston is additionally locked by the locking balls, i.e. held only in position N when the engine is stationary.

In certain situations, e.g. in the event of power failure in the emergency program, the parking lock can be released manually by means of an additional bowden cable on the parking disc.

Examples:

- The parking lock is engaged manually by pressing the P-push-button on the selector lever when the speed signal is less than 2 km/h.

- The parking lock is engaged automatically when the ignition key is removed and the speed signal is 0.

- The parking lock is also engaged automatically when the engine is running and gear position D, N or R is engaged, the driver's door is open and the driver's seat is not occupied.

- The parking lock is disengaged only by moving the selector lever in position R, D or N with the engine running and the foot brake pressed.

- Interaction between parking brake and EMF

An electromechanical parking brake, EMF is fitted in the E65., Based on the information exchange relating to the operating statuses of the EMF and parking brake it is possible in the event of a fault in the EMF to engage the parking brake when the engine is stationary.

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Note:

The Trainer's Guide "Chassis" contains the functional description of the EMF.

Interaction during normal operation

The parking brake is engaged when the driver leaves the vehicle with the engine running, position D or R engaged, speed signal 0 km/h, seat detected as not occupied and the door as open. The function is deactivated if the signal from the driver's door or the seat occupancy facility is detected as faulty.

Interaction between EMF and EGS in the case of fault

If, due to a fault, the EMF cannot switch from "hold" to "lock" mode, the parking lock is engaged following a plausibility check in the EGS control unit.

The plausibility check determines whether position N is engaged, the speed is 0 km/h and the engine and ignition are off.

Mechatronics module

The mechatronics module is a combination of a hydraulic shift unit and electronic control unit and is installed in the oil pan. The mechatronics module is used in this form for the first time in a BMW automatic gearbox.

The hydraulic shift unit (hydraulics module) contains the mechanical components of the transmission control such as valves and dampers that serve as actuators.

The electronic control unit (electronics module) contains the complete electronic control unit of the transmission system.

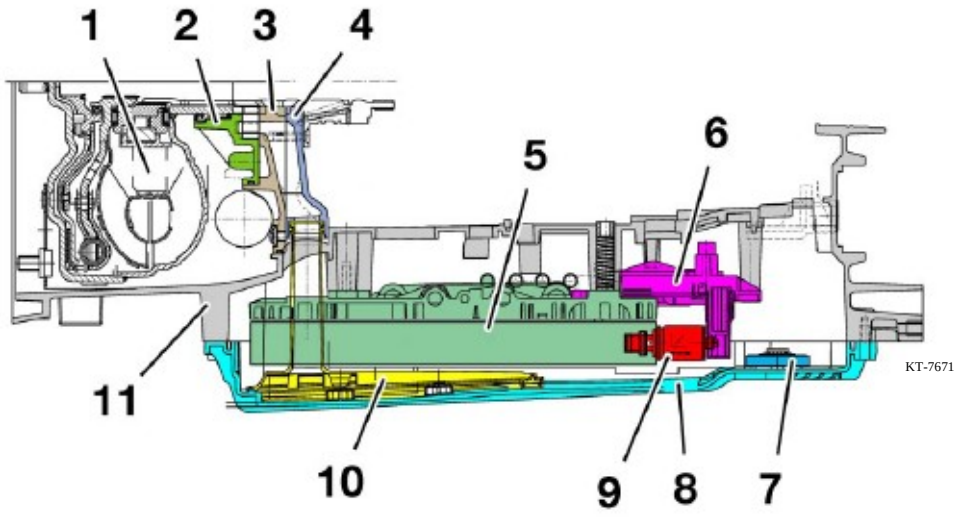

Fig. 11: GA6HP26Z, mechatronics module (sectional view)

Index	Explanation	Index	Explanation
1	Torque converter	7	Magnet
2	Pump	8	Oil pan
3	Centring plate	9	Pressure regulator
4	Intermediate plate	10	Oil sieve with intake pipe (integrated in oil pan)
5	Hydraulics module	11	Gearbox casing
6	Electronics module		

Advantages of the mechatronics module:

- Low tolerances thus improved design matching of gearshift operations

- Increased driving comfort

- Optimized shift quality

- Higher degree of reliability due to reduced number of plug contacts and less interfaces

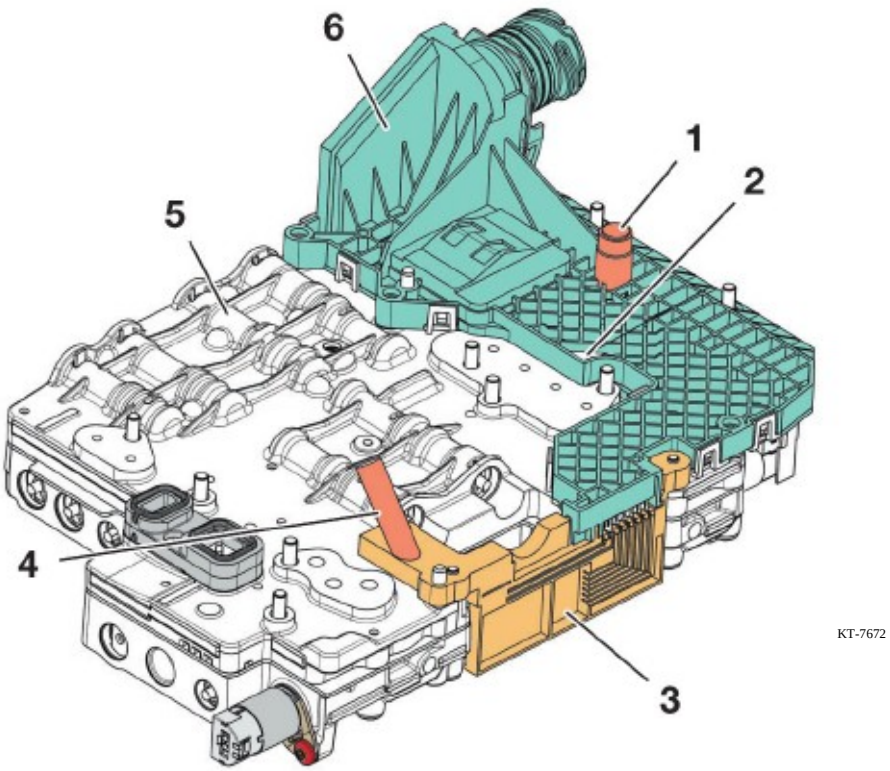

Fig. 12: GA6HP26Z, mechatronics module

Index	Explanation	Index	Explanation
1	Speed sensor, turbine	4	Speed sensor, output
2	Hydraulics module	5	Temperature sensor
3	Electronics module	6	Position switch

Automatic mode and Steptronic

- Operation in automatic mode

In the E65, the selector lever is located on the steering column. Shift position N, D and R are possible. The parking lock P is operated with a push-button on the selector lever.

All gearshifts take place electrically controlled - there is no mechanical connection to the gearbox. A cable assembly is provided for emergency operation of the parking lock.

The positions are indicated in the instrument cluster only.

Selecting lever positions in automatic mode

The shift pattern consists of the positions R, N, D and the corresponding arrows. The selector lever can be moved from its mid-position in clockwise or anticlockwise direction and returns from each position automatically to the mid-position.

Position P is separated from the shift pattern and is activated by pressing the push-button at the end of the selector lever.

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Fig. 13: Selecting selector lever positions

Pos. R: with the foot brake pressed, the selector must be pressed as far as it will go in anticlockwise direction.

Pos. N: with position R engaged, N can be engaged by flicking (one-touch function) the selector lever in clockwise direction.
If position D is engaged, position N can only be engaged by flicking the lever in anticlockwise direction. If position P is engaged, position N can be engaged by flicking the lever in both directions.

Pos. D: with the foot brake pressed, the selector lever must be pressed as far as it will go in clockwise direction.

Pos. P: position P is engaged by pressing the push-button integrated in the selector lever. The parking lock is released not by pressing this push-button again but rather by engaging position R, N or D.

Automated functions

The park position is engaged automatically when the ignition key is removed.

Position N is engaged automatically when the engine is turned off and the ignition switched off with the key remaining inserted in the lock. The park position is then engaged automatically after approx. 30 minutes. Position N can remain engaged for a further 30 minutes if position N is selected again before the 30 minutes have elapsed.

Special features

It is possible to shift from the park position to neutral position only with the engine running (exception: emergency release).

- S-program and Steptronic

The auxiliary functions S-program (sports) and M-program (Steptronic) can be activated with an additional push-button in the right-hand switch block of the multifunction steering wheel, MFL.

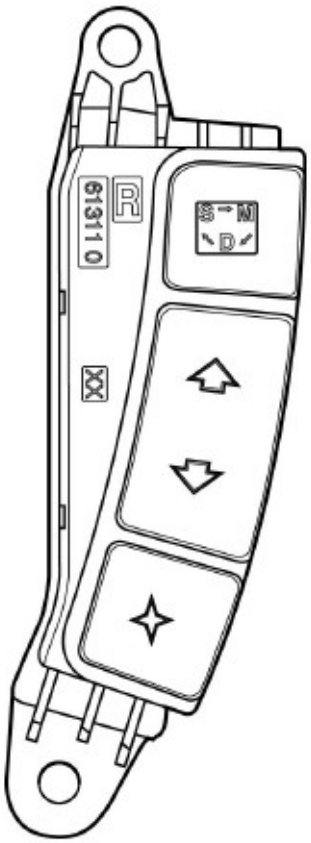

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Fig. 14: S/M/D push-button in MFL switch block

Initially, the S-program is selected by pressing the S/M/D push-button in position D. The program change is indicated with an "S" in the instrument cluster.

Steptronic mode is selected by pressing the S/M/D push-button once again. Depending on the engaged gear, this is indicated in the instrument cluster by a "M1" to "M6."

The system returns to position D (automatic mode) by pressing the S/M/D push-button in Steptronic mode. A return to automatic mode is also possible by pressing the selector lever in clockwise direction to position D.

There are four further push-buttons for Steptronic integrated in the steering wheel, i.e. two for "-" on the side facing the driver and two for "+" on the side facing away from the driver.

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Fig. 15: Steptronic push-buttons in the MFL

Index	Explanation
1	"-" push-buttons for downshifts
2	"+" push-buttons for upshifts (rear side of MFL)

The driver can shift down gears manually by pressing the "-" buttons in Steptronic mode. He can shift up manually by pressing the "+" buttons.

Impermissible shift requirements, e.g. when exceeding or falling short of the required engine speed, are suppressed by the transmission control and indicated only temporarily in the instrument cluster.

- Special feature for US vehicles

For US vehicles a variant is available without the S-program (sports) and without the M-program (Steptronic). Instead, these vehicles are equipped with a so-called L-program (limiting function).

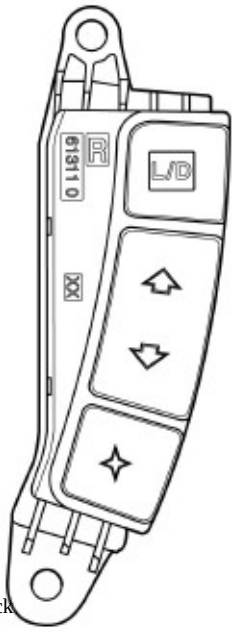

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Fig. 16: L/D push-button in MFL switch block

Starting from position D, limitation mode is selected by pressing the L/D push-button. The limitation stages are downshifted by pressing the "-" buttons in the MFL. The "+" push-buttons required for the Steptronic are nor provided.

The system returns to automatic mode by pressing the L/D button once again or pressing the selector lever to position D.

Functional description of the L-program

The L-program can be selected by pressing the L/D push-button in position D only. Initially, the current gear is retained and is simultaneously the upper limitation stage.

Example:

Position D is engaged and the gearbox is in 4th gear. After pressing the L/D push-button in the multifunction steering wheel, 4th gear is retained and is simultaneously the upper limitation stage. The gears 1 to 4 are shifted automatically.

The limitation stages can be downshifted by pressing the "-" buttons. It is not possible to upshift the limitation stages. There is no forced upshift on reaching the maximum engine speed.

When L-mode is assumed, the indicator in the instrument cluster changes from D to L1 to L6. In the same way as in Steptronic mode, requested gearshifts that are not executed are indicated only temporarily.

- Position indication with shift pattern

The engaged position is indicated in the instrument cluster only. Depending on what position is selected, the corresponding position selection is highlighted in the shift pattern. The arrows indicating the possible movement directions of the selector lever are also lit. An additional indication is provided in the S, M and L-program.

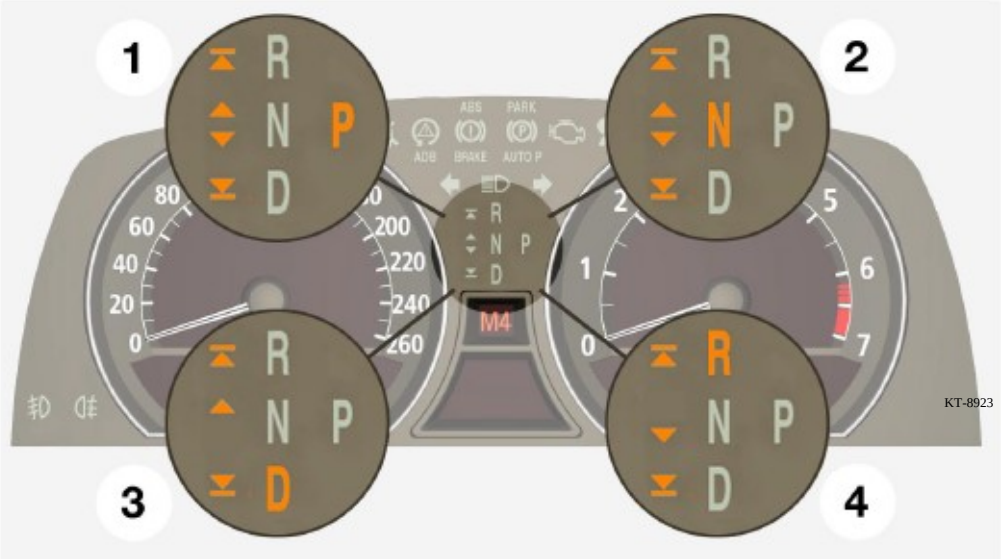

Fig. 17: Program indication of the automatic gearbox

Index	Explanation
1	Position P
2	Position N
3	Position D
4	Position R

- Starter interlock

It is only possible to start the engine in position P or N. The car access system (CAS) with ignition starter switch evaluated two signals from the transmission control unit EGS for the purpose of activating the starter interlock.

- The gearbox position P or N as CAN signal

- Position P via the hardware line from the P-sensors

It is therefore always still possible to start in position P even in the event of the CAN signal failing. The engine can no longer be started if the emergency release is also operated.

In addition to evaluating these two signals, at ignition OFF the, transmission always assumes "hydraulic neutral" so that there is never power transmission in the gearbox during engine start.

- Interlock and key-lock

The CAS control unit signals the status "ignition key inserted/ ignition key not inserted" to the EGS control unit.

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Interlock

The parking lock is engaged in the gearbox if "ignition key not inserted" is signalled. The parking lock can only be released with the ignition key inserted and the engine running as only in this case does the parking lock have available the hydraulic pressure it requires to release.

Key-lock

The ignition key can only be removed when the CAS control unit registers a vehicle speed less than 1 km/h.

Electronic transmission control unit

The electronic transmission control unit is an integral part of the mechatronics module that is installed in the oil pan of the gearbox. The electronic inputs are evaluated in the control unit and electronic actuating variables are output. The control unit is integrated in the E65 electrical system via a CAN bus connection and a separate data link.

- CAN bus and serial line

The signal transfer between the individual components takes place via the CAN bus (see graphic below).

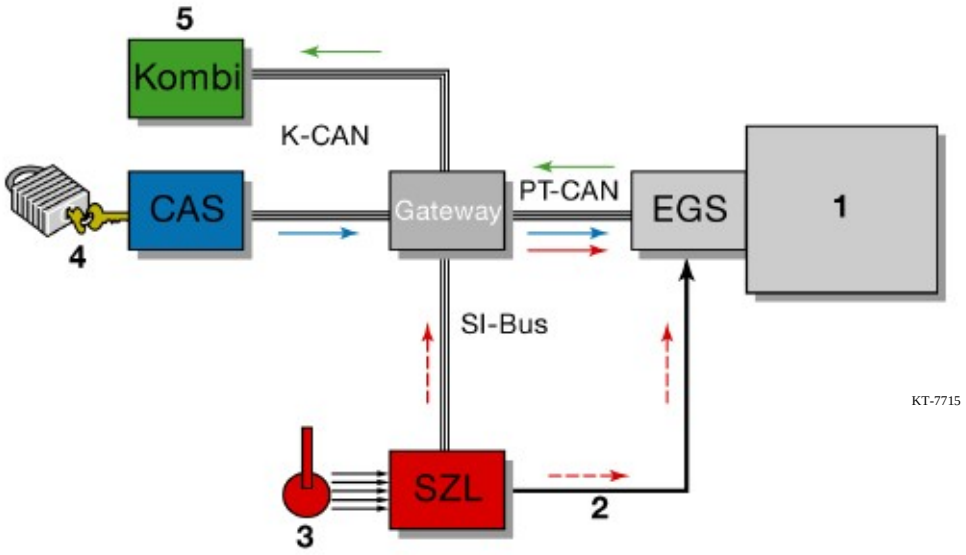

Fig. 18: GA6HP26Z, CAN bus and serial line

Index	Explanation	Index	Explanation
1	Automatic gearbox	Gateway	Central gateway module, ZGM
2	Serial, unidirectional line	EGS	Electronic transmission control
3	Selector lever	SZL	Steering column switch centre
4	Key	PT-CAN	Power train CAN
5	Display	K-CAN	Body CAN
CAS	Car access system	SI-Bus	Safety and information bus, byteflight optical fibre

For safety reasons, in addition to the bus line, the signal transfer between the steering column switch centre (SZL) and the electronic transmission control (EGS) additionally takes place via a unidirectional serial line from the SZL to the EGS. The serial line must exhibit comparable reliability as the CAN connection.

The CAN bus features mechanisms (check sums etc.) that ensure data transmission with a high degree of reliability. The central gateway module (ZGM) is a link in the data transfer chain for data transfer from one bus to another, e.g. from K-CAN to PT-CAN.

The data that the transmission control unit requires for shifting gears, such as injection timing, engine speed, throttle valve angle, engine temperature and engine intervention, are transmitted from the ZGM via the PT-CAN bus to the transmission control unit. The solenoid valves and the pressure actuator are activated directly by the mechatronics module.

Signals that are sent via the PT-CAN bus to the EGS control unit and from the EGS control unit to the other control units are:

Signals	Transmitter	Receiver
Selector switch	SZL	EGS
Terminal status	CAS	EGS
Central locking system	CAS	EGS
Transmission data	EGS	CAS
Engine data	DME/DDE	EGS
Wheel speeds	DSC	EGS
Deceleration request	EMF	EGS
Display, transmission data	EGS	Instrument cluster
Check control message	EGS	Instrument cluster
Torque requirement	EGS	DME
Battery voltage	Power module	EGS
Electric loads	EGS	Power module

The turbine and output speeds of the gearbox are determined with Hall sensors that transfer their values directly to the mechatronics module. The position switch also transfers directly to the mechatronics module.

In the same way as in the gearboxes A5S440Z or A5S325Z, the programming options of the gearbox control units via flash code are also possible in this new gearbox. The programming procedure has been largely adopted from the DME programming and adapted to the functionality of the transmission control units.

The processor of the transmission control unit features a 440 KB internal flash memory. Approx. 370 KB of this are taken up by the basic transmission program. The remaining approx. 70 KB contain the vehicle-specific application data.

Note

Pressure adaptation takes place automatically while driving. After conducting repairs on the gearbox or replacing the gearbox, it is necessary to reset the pressure adaptation with the tester. A test drive should then be carried out for the purpose of driving through all gears.

- Warm-up program

The warm-up program is selected after every engine start at an engine temperature below approx. 60 ºC. The gears are held longer, i.e. extended further, during the warm-up program. In this way, the engine and catalytic converter reach their operating temperature faster.

The warm-up program is exited on exceeding an engine temperature of approx. 60 ºC or after approx. 120 seconds.

- Downshift inhibitor

This function prevents a downshift when this would mean that the maximum engine speed would be exceeded. It therefore avoids damage being incurred to the engine and gearbox.

- Reverse interlock

This function prevents shifting into reverse gear at a driving speed above 5 km/h. If the driver selects reverse gear at a speed above 5 km/h, the gearbox will assume the neutral position and N is indicated accordingly in the instrument cluster.

Only when the vehicle has reached a speed of less than 5 km/h is it possible to select reverse gear by operating the selector lever once again.

- Block diagram

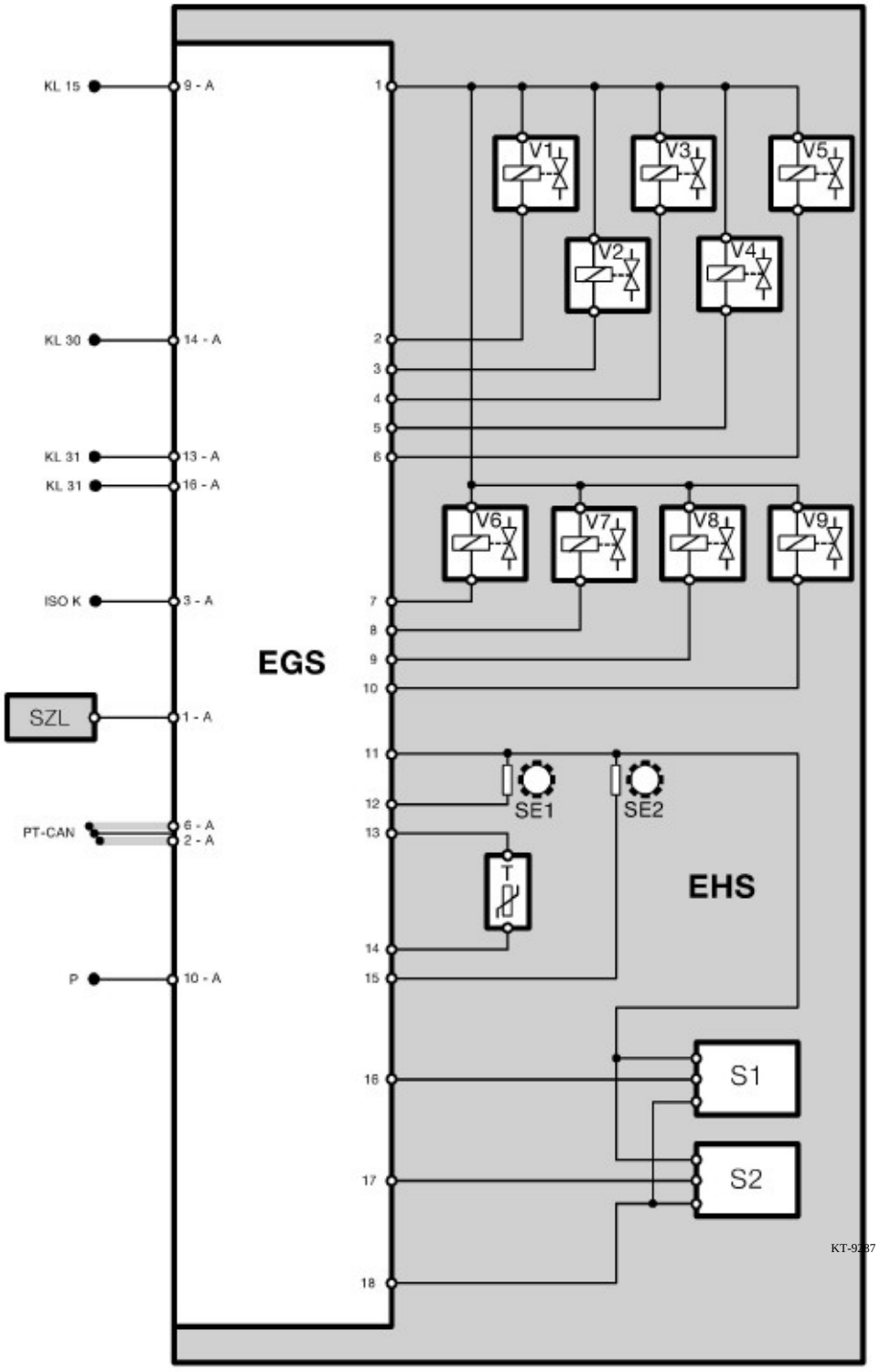

Fig. 19: Block diagram, electronic transmission control unit

- Pin assignments

Pin assignments at gearbox connector

PIN	Assignment	Remark
1-A	Serial line	Availability line from steering column switch centre
2-A	CAN L	CAN low
3-A	ISO K	K-line (e.g. application)
4-A	Not used	
5-A	Not used	
6-A	CAN H	CAN high
7-A	Not used	
8-A	Not used	
9-A	Terminal 15	Wake-up signal, terminal 15
10-A	P-signal	P-line for starter interlock
11-A	Not used	
12-A	Not used	
13-A	Terminal 31-1	Ground
14-A	Terminal 30	Supply from EGS
15-A	Not used	
16-A	Terminal 31-2	Ground 2

Internal pin assignments

The internal pin assignments in the mechatronics module, right side in block diagram, are listed here for the sake of completeness only. The connections are not accessible for service (module-internal).

PIN	Assignment	Remark
1	DR/MV	Positive supply for pressure actuator and solenoid valves
2	MV1	Negative for solenoid valve 1
3	MV2	Negative for solenoid valve 2
4	EDS2	Negative for pressure actuator 2
5	EDS4	Negative for pressure actuator 4
6	P-Magnet	Negative for parking lock valve
7	EDS1	Negative for pressure actuator 1
8	EDS3	Negative for pressure actuator 3
9	EDS5	Negative for pressure actuator 5
10	EDS6	Negative for pressure actuator 6
11	Sensor+	Positive supply for output, turbine speed sensors and position switch
12	N_T	Input, turbine speed
13	T_oil+	Positive supply, temperature sensor
14	T_oil-	Input, oil temperature
15	N_AB	Input, output speed
16	P-Sensor1	Input, park position
17	P-Sensor2	Input, park position
18	Sensor-	Input, park position

Electronic-hydraulic control

The electronic-hydraulic transmission control (EGS) installed in connection with the GA6HP26Z features 3 solenoid valves and 6 electronic pressure control valves. The gearshifts in the gearbox are controlled with the aid of the valves.

- Solenoid valves (MV)

3 solenoid valves are fitted on the hydraulic gearshift unit. They are designed as 3/2-way valves, i.e. valves with 3 connections and 2 switch positions.

The solenoid valves are driven by the electronic transmission control and have the settings "open" or "closed" therefore making it possible to switch over the hydraulic valves.

- Electronic pressure control valves (EDS)

The electronic pressure control valves convert electrical current into a proportional hydraulic pressure. They are driven by the electronics module and activate the hydraulic valves belonging to the gearshift elements.

Two types of electronic pressure control valves are fitted:

EDS with rising characteristic curve

- The EDS with rising characteristic curve are the electronic pressure control valves 1, 3 and 6. They can be recognized by their green cap.

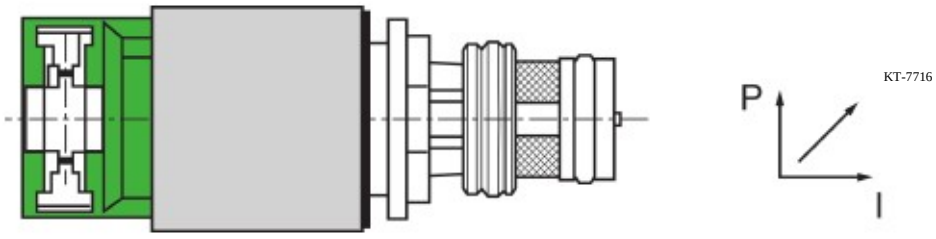

Fig. 20: EDS with rising characteristic curve (0 mA = 0 bar / 700 mA = 4.6 bar)

- Technical data:

1. Pressure range 0 to 4.6 bar

2. Operating voltage 12 V

3. Resistance at 20 ºC 5.05 Ohm

EDS with falling characteristic curve

- The EDS with falling characteristic curve are the electronic pressure control valves 2, 4 and 5. They can be recognized by their black cap.

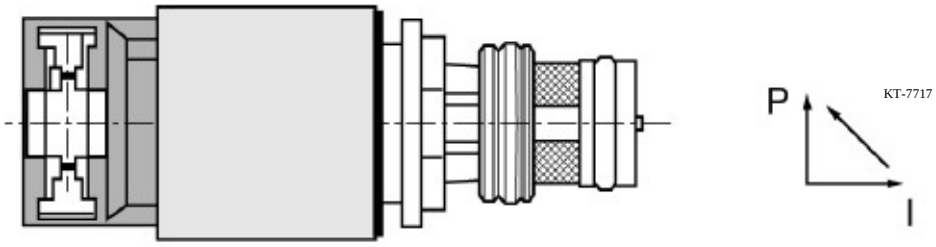

Fig. 21: EDS with falling characteristic curve (700 mA = 0 bar / 0 mA = 4.6 bar)

- Technical data:

1. Pressure range 4.6 to 0 bar

2. Operating voltage 12 V

3. Resistance at 20 ºC 5.05 Ohm

- Location of solenoid valves and pressure control valves

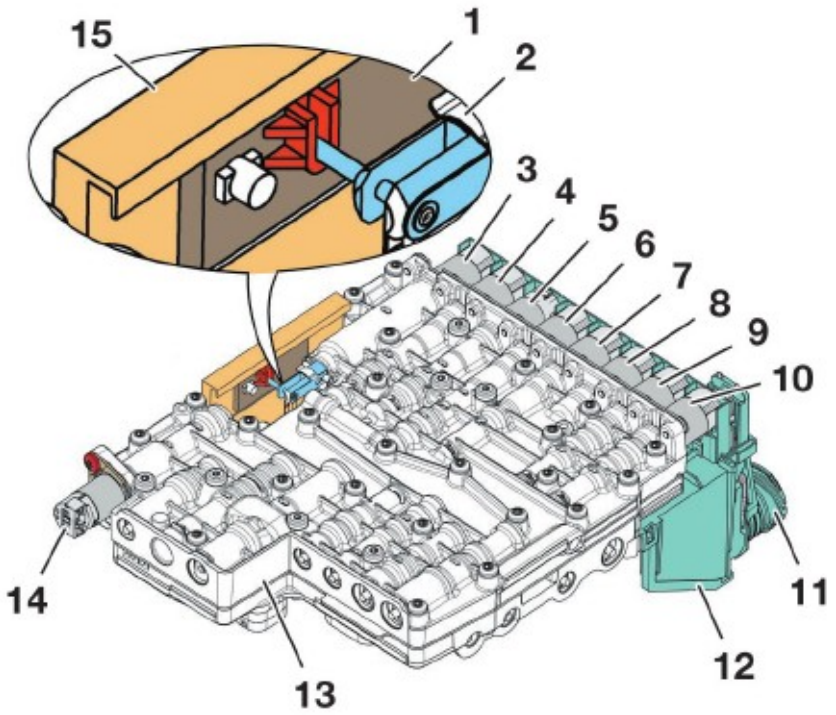

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Fig. 22: Location of solenoid valves and pressure control valves

Index	Explanation	Index	Explanation
1	Slide	9	EDS 2
2	Actuating magnet	10	EDS 1
3	Solenoid valve 3, parking lock cylinder	11	Gearbox connector
4	EDS 6	12	Electronics module
5	Solenoid valve 1	13	Hydraulics module
6	EDS 4	14	Solenoid valve 2
7	EDS 5	15	Position switch
8	EDS 3		

Note

Particular care must be taken when installing the hydraulics module and electronics module to ensure that the piston of the parking lock cylinder is engaged in the position switch.

- Solenoid valve and clutch logic

Clutch logic	Brake clutch	D	●	●	●	●						Planet carrier (double gear train)
		C					●				●	Sun gear 1 (double gear train)
	Drive clutches	WK				●	●	●	●	●	●	Situation-related control of converter lockup clutch
		E							●	●	●	Carrier, double gear train
		B		●				●		●		Sun gear 1 (double gear train)
		A				●	●	●	●			Planet carrier, single gear train
Solenoid valve logic	P-EDS	6				-x-	-x-	-x-	-x-	-x-	-x-	Gear logic control (situation-related)
		5	-x-	-x-	-x-	-x-	-x-	-x-	-x-	-x-	-x-	System pressure (situation-related)
		4	x	x	x	x			x	x	x	Brake D / clutch E
		3					x				x	Brake C
		2						x		x		Clutch B
		1				x	x	x	x			Clutch A
	MV	3		x	x	x	x	x	x	x	x	Parking lock cylinder
		2		x	x	x	x					Parking lock valve
		1		x	x	x	x		x	x	x	Shift valve 1
POS / gear			P = Park	R = Reverse	N = Neutral	D, 1st gear	D, 2nd gear	D, 3rd gear	D, 4th gear	D, 5th gear	D, 6th gear	

x Activated
-x- Situation-related control
q Engaged

Adaptive transmission control

- Introduction

In the same way as for the previous automatic gearboxes, there are different adaptation modes for the A-program (automatic in selector lever position D) and S-program (sports) also for the new 6-speed automatic gearbox.

In the A-program, only the basic shift characteristic map XE ("extreme economy") and the performance-oriented shift characteristic map E ("economy") are selected.

The A-program offers the driver comfort-oriented gearshift characteristics with a relatively smooth shift layout.

In the S-program, the basic shift characteristic map S ("sports") and the performance-oriented shift characteristic map XS ("extreme sport") are selected.

The S-program offers the driver dynamic adaptation characteristics (sports-oriented handling) in which individual function evaluations such as kick-fast, and brake evaluation are defined more distinctively.

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- Driver type adaptation

In the new 6-speed automatic gearbox, the driver type adaptation is based on the values of kick-fast, cornering evaluation - brake evaluation and constant driving evaluation.

Kick-fast

The kick-fast function can change the basic gearshift program depending on the speed at which the accelerator pedal is depressed.

For this purpose the determined accelerator pedal value is compared to a threshold resident in the control unit.

As a result of this comparison, one of the four following functions is proposed:

XE (extreme economy), E (economy), S (sport), XS (extreme sport).

Cornering evaluation

Cornering evaluation responds to the transverse acceleration of the vehicle with an indirect adaptation of the driver type over the driver type scale. The transverse acceleration is evaluated as an indirect statement indicating the preferred driving dynamics and should on no account lead to an immediate shift response. Downshifts in conjunction with high power flow requirements in transverse direction can have a negative influence on the stability of the vehicle.

The transverse acceleration is calculated from the speed signals of the wheels on both axles while also taking into consideration the yaw rate and the vehicle speed.

Brake evaluation

Using the same method for evaluating kick-fast, brake evaluation provides a driver type category.

The deceleration is determined on an adjustable time scale and compared with a limit value curve. One of the driver types (XE, E, S or XS) is output depending on the selected operating mode, D or S program and the average driver type.

Constant driving evaluation

Constant driving evaluation takes place when the driver maintains a constant accelerator pedal position and the vehicle speed does not change.

An immediate downshift takes place in the A-program, i.e. in the XE and E shift characteristic map.

The downshift takes place slightly delayed in the S-program, i.e. in the shift characteristic map S and XS.

- Winter program

The winter program is triggered and also switched off automatically.

It makes available a defensive gearshift characteristic for the highest possible stability and driving safety on slippery roads in winter. The stable gear layout provides the best possible support for running gear control interventions by ASC or DSC.

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Downshift requests resulting in tractive forces that would cause wheel spin are suppressed with the exception of the downshift requests required by the driver explicitly.

Functions that could lead to vehicle instability are inhibited for as long as the winter program is active.

- Uphill/downhill/trailer function

The uphill/downhill/trailer function adapts the gearshift strategy to the increased tractive power requirements in that it builds up the corresponding tractive power reserves.
Consequently, the tendency both to alternating upshifts and downshifts during speed-controlled operation as well as unnecessary frequent gearshifts during vehicle operation are suppressed or drastically reduced. A driving resistance observation facility constantly determines the deviation of the current driving resistance compared to a reference defined by the vehicle parameters resident in the data record of the control unit.
The vehicle parameters include vehicle weight, gearbox, axle transmission ratio, rolling and wind resistance.

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- Cornering function

The cornering function has two tasks: on the one hand, it prevents upshifts for the purpose of supporting the sense of dynamic driving and, on the other hand, prevents downshifts that would strain the power transmission potential of the drive axle.

- Cruise control shift strategy

The task of the cruise control function is to support speed-controlled vehicle operation as best as possible in the sense of achieving smooth overall characteristics.

On the one hand, this function ensures that the acceleration or tractive power (uphill driving) requested by the cruise control is achieved while, on the other hand, ensuring comfort is not impaired in the form of increased gearshift operations or alternating upshifts and downshifts.

- Shift strategy in connection with ACC

In active control mode, the ACC controller (active cruise control) undertakes the task of longitudinal dynamic vehicle control and, instead of the driver, it controls the engine and service brake within certain limits.

In this case, the controller uses the current transmission ratio of the drive train based on the required acceleration to calculate the specified value and communicates it to the engine as the torque requirement. In turn, the engine implements the requirement within its physical limits and outputs a corresponding virtual accelerator pedal value.

The ACC recognizes different operating situations such as constant driving control, control in following mode, acceptance of any set speeds, cornering control, uphill driving control etc. These control phases must be supported by the transmission system with individually adapted shift strategies. The strategy must take into consideration both the specific features of the controller as well as the subjective driver's choice with regard to the shift characteristics.

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Check control messages

With the previous check control only the indication "transmission emergency program" could be output in the event of faults in the transmission control.

A new concept in connection with the E65 allows for differentiated output of warning and action information dependent on the driving situation and possible faults.

The display of more detailed information with longer and clearly understandable texts in the control display (CD) provide the driver with a higher degree of transparency with regard to the technology used. The message texts and the message characteristics are stored in the instrument cluster and are initiated by the EGS on the basis of an identification number. Apart from a few fault-related exceptions, the individual message conditions are evaluated by the EGS.

The complete message texts, graphic symbols and the message characteristic are defined in the publication Instrument cluster E65.

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Emergency programs

- Introduction

The following measures are designed to reduce the possible causes of breakdown:

- Reduction of system interfaces (mechatronics)
- Redundant generation and monitoring of selector lever signals
- Graduated substitute programs

Substitute program 1:	restricted gear selection and comfort
Substitute program 2:	corresponds to previous emergency program (only forward, reverse, neutral and park position possible)
Actuator deactivation:	hydraulic/mechanical emergency operation

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- Electrical emergency program

Under certain circumstances, the electrical emergency program shifts 5th or 3rd gear after CAN bus failure.

After an engine start procedure, 3rd gear is engaged on selecting position D. After a CAN bus failure, positions P R, N, and D can be selected via a separate serial line.

To ensure a new driver's choice D, R or N is accepted, initially, the mid-position must have been detected after recognizing position D or R.

It is no longer possible to select the S-program and Steptronic. The shift lock function is also deactivated. Consequently, it is possible to engage gear without pressing the brake. (Indication provided by "passive" CC message.)

At terminal 15 off, position P is engaged immediately at speeds below 2 km/h as the "key inserted/key not inserted" signal is no longer detected; this means position P is engaged after "engine off". The N-hold function is therefore no longer possible at "engine off." (Caution in car wash systems)

The instrument cluster can no longer detect a position change. The position indicator in the instrument cluster is blanked out. The shift pattern with R, N, D remains and the arrows flash.

- Mechanical emergency program

The following generally applies in the event of total failure of the transmission control:

- No interruption in power transmission while driving forward

- Vehicle stationary and "engine off:" parking lock must be engaged

The EGS may still be in operation during the mechanical emergency program, communication to the outside may also still be possible but the power supply to the actuators is disconnected. The hydraulic system of the gearbox is designed such that only greatly restricted operation is still possible in the mechanical gearbox emergency program. It is no longer possible to select a drive position with the selector lever.

This means the vehicle can only be driven forward within certain restrictions. A drive position can no longer be engaged after turning off and restarting the engine.

Safe shut-down of the vehicle is always ensured as the parking lock is engaged when depressurized. As soon as the pressure in the parking lock cylinder drops the parking lock system is pretensioned mechanically. Since the mechanical parking brake system is still retained with the parking lock wheel and pawl, mechanical engagement does not take place before a speed $v < 5$ km/h is reached.

However, the parking lock can only be released with the mechanical emergency release facility.

If the mechanical emergency program occurs ...

- ... while driving forward, thanks to a hydraulic hold function it is still possible to continue driving in 3rd/5th gear (3rd gear when 1st, 2nd or 3rd gear was previously engaged, 5th gear when 4th, 5th or 6th gear was engaged).
  It is only possible to interrupt the power transmission by turning off the engine.
  The parking lock can be engaged once the hydraulic pressure has dropped.

- ... while reversing, the gearbox assumes the neutral position and the parking lock is engaged. The parking lock can only engage, however, at a speed lower than 5 km/h.

- ... while in hydraulic neutral, the parking lock is engaged. The parking lock can only engage, however, at a speed lower than 5 km/h.

- ... in position P the gearbox remains in this status and the, parking lock remains engaged.

The driver is informed of the different emergency situations by corresponding CC messages.

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- Feedback in the event of total failure

Since, in the event of total failure of the transmission control or of the SZL, a driver's choice (selector lever operation) can no longer be detected or implemented, in addition to the flashing shift pattern and the corresponding error messages in the instrument cluster, further measures are intended to draw the driver's attention to the new situation.

- Acoustic warning signal
- Limitation of start-off acceleration:

  The aim of this function is to reduce the start-off acceleration such that the driver can respond in good time should the vehicle begin to move in a, for him, unexpected direction.

  This function is implemented in the engine control system, triggered, depending on the restriction of the transmission control, by an active EGS request or by CAN timeout of the EGS signals.

Troubleshooting and diagnosis

Introduction

A large number of customer complaints are attributed to faulty operating conditions. It is therefore very important to check the ambient conditions at the beginning of diagnosis.

Test drive in the presence of the customer

- What is the problem?
- In what situation (engine speed, driving speed, load and drive stage or gear)?
- How does the customer operate the vehicle (e.g. hectically, very economically or perhaps also misuse)?
- What external influences affect the vehicle (temperature, road surface)?
- Shift selector lever through all positions and check that the indicator in the instrument cluster agrees with the selector lever.

Check oil level and oil quality

- The vehicle must be parked on flat and even ground
- Check the oil level corresponding to the workshop manual
- Observe the oil temperature

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Diagnosis of this gearbox can also be carried out with DIS and MoDiC as part of service and repair work.

Gearbox operation can be checked by means of the fault code memory, test programs or control unit functions. The procedure is the same as for all standard automatic gearboxes.

Service information

The automatic gearbox GA6HP26Z has a lifetime oil filling. The gearbox therefore requires no oil change during its entire service life.

Only the approved oil Shell M 1375-2 must be used after conducting repairs on the gearbox.

The permissible operating temperature is between -30 ºC and +130 ºC oil sump temperature.

- Emergency release for parking lock

A mechanical emergency release is provided for the situation that the parking lock can no longer be released by hydraulic means (failure of battery, engine, engine electrical system, gearbox electrical system etc.) to ensure the vehicle can be towed or pushed as required.

To tow the vehicle, the emergency release must be operated even if the transmission control is fully operable as, depending on the type of fault, the N-hold function cannot be guaranteed during the entire time even if an output speed is recognized (see corresponding information in the Owner's Handbook).

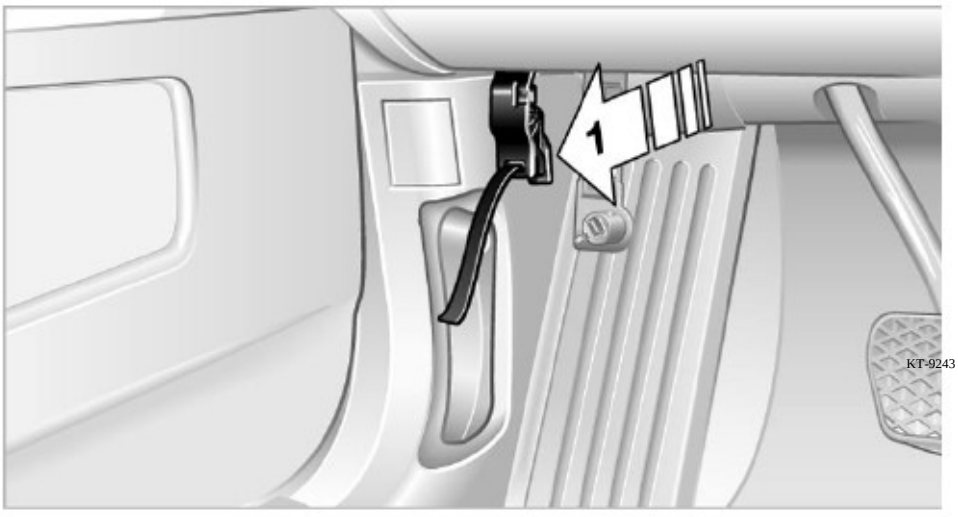

Fig. 23: Emergency release for parking brake with operating lever 1

The emergency release for the parking brake is located in the vehicle interior at the A-pillar in the footwell on the driver's side. It can be operated from the driver's seat (foot on brake pedal!). A cable assembly leads from the operating lever to the gearbox lever on the selector shaft.

The emergency release is not operated during normal vehicle operation. After being released, a hold function holds the parking brake in the operating lever status "gearbox emergency released."

The emergency release must be reset after re-engaging the parking lock or after eliminating the defect. The gearbox lever must move freely during normal operation, it must not be influenced by the cable assembly.

To ensure the driver's attention is drawn to the status in which the emergency release is operated, the release lever is designed such that it is inevitably conspicuous when in the released state.

The situation where the emergency release has been operated by mistake or not reset after repairs is detected in normal operation by a plausibility check between the setpoint and actual position by means of the two P-sensors in the gearbox. In this case, the parking lock cannot be engaged by the gearbox function. The driver is informed of this status by a corresponding error message in the instrument cluster (CC message).

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EU vehicles

Since the vehicle does not have a steering column lock, the mechanical emergency release for the parking lock must be located under a cover. This cover must not be transparent and may only be detachable with the aid of a screwdriver or similar tool.

US vehicles

To fulfil the interlock requirements for US vehicles, the emergency release should be designed such that it can only be accessed and operated with the vehicle key. It must not be possible to remove the key from the lock of the cover for as long as the parking lock is emergency released.

- Repair information

The gearbox is only released for the repair stages 1 and 2, release of repair stage 3 is not envisaged.

Important: the oil pan must only be removed at temperatures below 40 ºC. The oil pan is made of plastic. It can distort at higher temperatures.

Only the screws marked green in the drawing are to be released for the purpose of removing the mechatronics module.

The screws marked blue in the drawing for separating the hydraulics module from the electronics module must not be loosened. Initially, the electronics module, hydraulics module and pressure actuator will not be available as spare parts.

The screws marked red in the drawing must not be loosened as the hydraulics module must not be disassembled.

- q M5 screws (electronics module to hydraulics module) 6x
- q M6 screws (mechatronics module to gearbox casing) 9x
- q M5 screws (hydraulic module) 18x

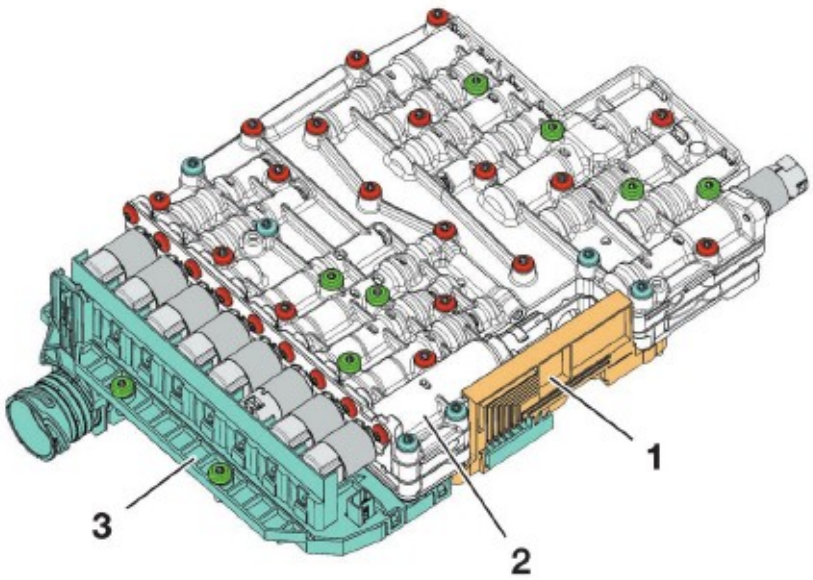

Fig. 24: GA6HP26Z, mechatronics module

Index	Explanation	Index	Explanation
1	Position switch	3	Electronics module
2	Hydraulics module		

- Towing and tow start

The vehicle can be towed up to a distance of 500 km at a speed of up to 70 km/h.

Tow starting is also not possible with this automatic gearbox.

LAUNCH

Power transmission

Axle drive, shafts

The axle drive of the E65 has a different gear ratio than the axle drive of the E38. Provisions are not made for repairs. In case of damage, the complete axle drive is replaced.
The only exception is the replacement of seals. It has a lifetime oil filling so that no oil change is required.

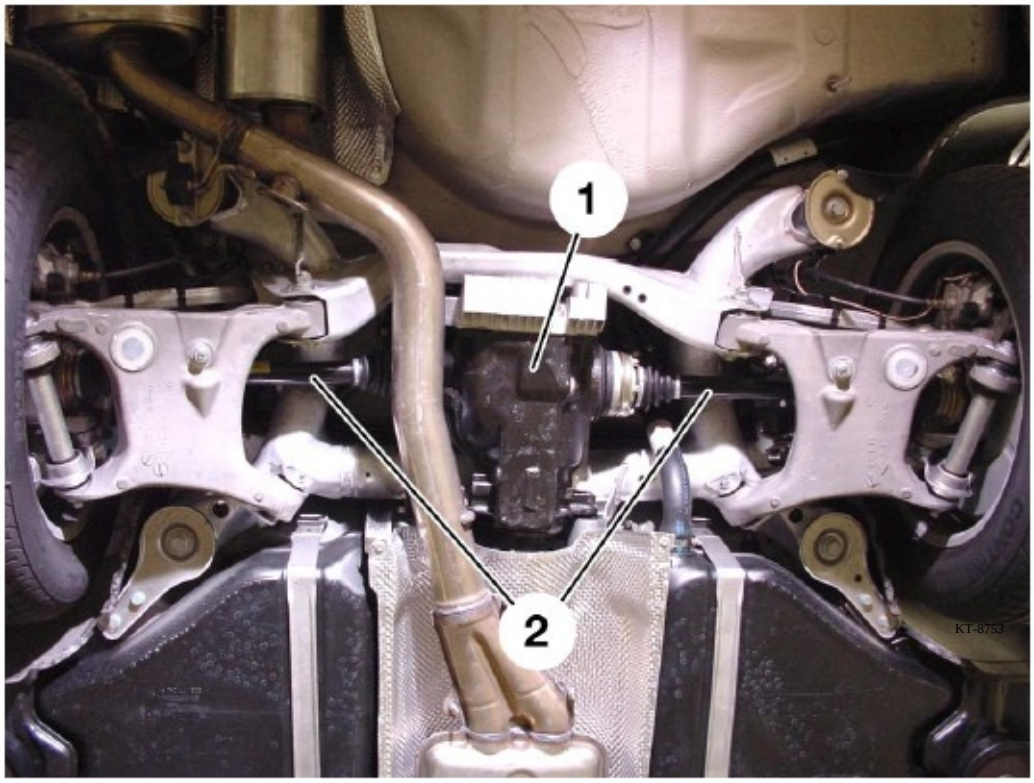

Fig. 25: Axle drive

Index	Explanation
1	Axle drive
2	Output shafts

Since no underbody coating is used for the first time on the E65, the screws of the axle drive feature a special surface paint coating. The oil filler and oil drain plugs with integrated seals are also treated with these corrosion protection measures.

The propeller shaft is made of aluminium to reduce weight. It is similar in design to that of the E39.
The compact output shafts are also weight-optimized.

LAUNCH

Glossary

The new gearbox designation GA6HP26Z

Index	Explanation
G	Gearbox
A	Automatic
6	Number of gears (speeds)
HP	Hydraulic planetary gear
26	Size
Z	Gearbox manufacture ZF (Zahnradfabrik Friedrichshafen)

Abbreviations used in this Trainer's Guide

Index	Explanation
AGS	Adaptive transmission control
CAN	Controller area network
CAS	Car access system
CC	Check control
CCM	Check control module
CD	Control display
EDS	Electronic pressure control valve
EGS	Electronic transmission control
EMF	Electromechanical parking brake
GSE	Transmission control
K-CAN	Body CAN
LSZ	Light switch centre
MV	Solenoid valve
P-Magnet	Parking lock magnet
PT-CAN	Power train CAN
SBC	Standby control (creep prevention)
SZL	Steering column switch centre
WK	Torque converter lockup clutch
ZGM	Central gateway module