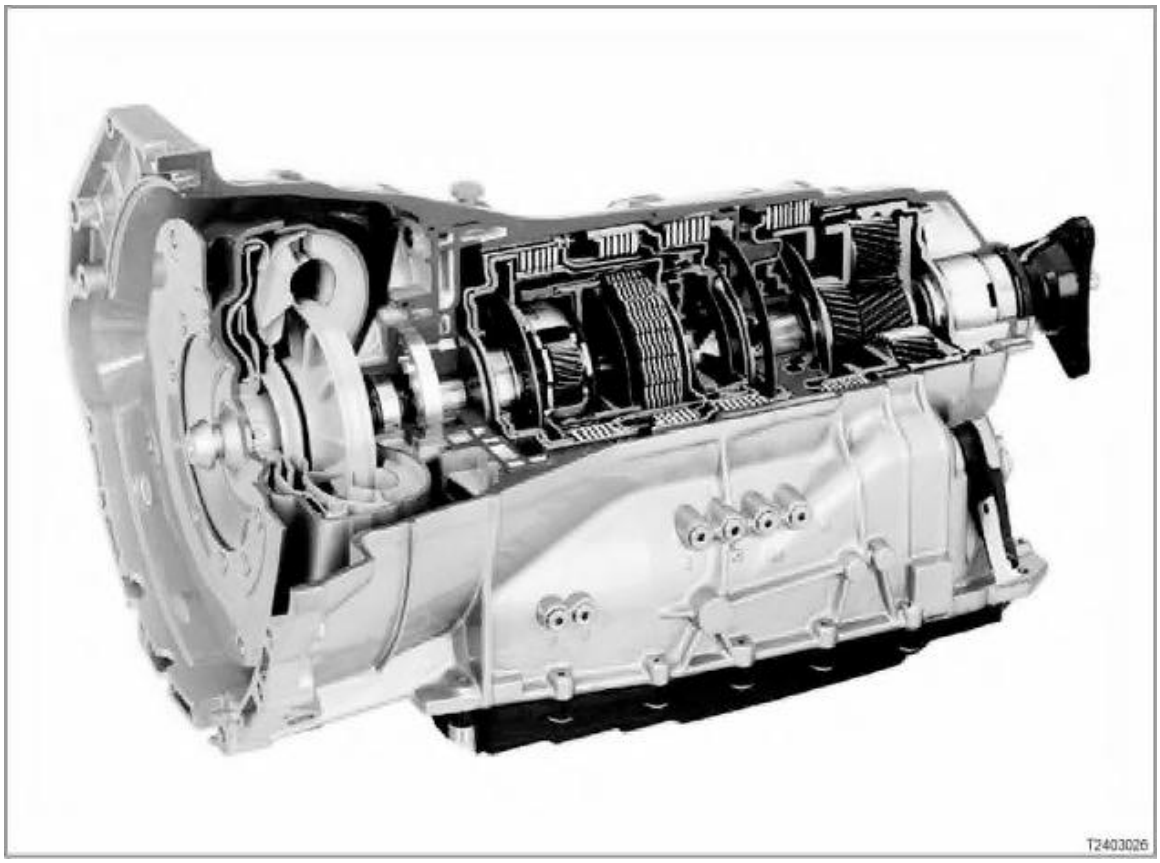
6-speed automatic transmission

E60, E53



Introduction

The 6-speed automatic transmissions GA6HP19Z and GA6HP26Z have been jointly developed by BMW and ZF (Zahnradfabrik Friedrichshafen). The 6-speed automatic transmission GA6HP26Z is already in service in the E65. [System overview ...]

Both automatic transmissions are available as special equipment (option 205). The automatic transmissions are paired to the engines as follows:

E60 engine and transmission

Engine	GA6HP19Z	GA6HP26Z
M54B22	X	
M54B25	X	
M54B30	X	
N62B44		X
M57D30TU		X

E53 engine and transmission

Engine	GA6HP26Z

N62B44	Standard equipment
M57D30TU	X

The two automatic transmissions differ in the following points:

- Different torque converter
- Clutches with different number of steel and lined plates

In order to absorb the higher torque of the N62B44 and M57D30TU engines, the automatic transmission GA6HP26Z is of a more powerful design.

With the Steptronic, the automatic transmissions can also be shifted manually using the selector lever on the centre console (no "shift-by-wire" as on the E65, but rather a mechanical connection).

Brief description of components

The automatic transmission consists of the following components:

- **Torque converter with converter lockup clutch**

  The torque of the engine is transmitted to the automatic transmission in 2 ways:

  1. Hydraulically via the torque converter

     The torque converter transmits the torque from the engine to the transmission as follows: High engine speeds and low engine torque are converted into low speeds and high torque.

  2. Mechanically via the converter lockup clutch

     When the converter lockup clutch is closed, the impeller and turbine wheel are non-positively linked without the influence of friction. This prevents power loss within the torque converter and optimises fuel consumption.

     The converter lockup clutch ensures that a mechanical link is established between the output shaft of the engine and the input shaft of the transmission. The opening and closing of the converter lockup clutch is regulated in 1st to 6th gear.

     Up to a transmission oil temperature of approx. 35 °C, the converter lockup clutch is neither regulated nor closed.
     At other operating points, how the converter lockup clutch is regulated depends on other factors such as:

     - Engine load
     - Vehicle road speed
     - Transmission oil temperature
     - Selected shift program

- **Oil pump**

  The oil pump is an internal gear pump. The torque converter drives the oil pump using the speed of the engine.

  The oil supplied by the oil pump has the following tasks:

  - To cool the torque converter
  - To lubricate the transmission
  - To actuate the pistons in the transmission's multi-plate clutch
  - To control the gearshifts

- **Multi-plate clutches**

  The automatic transmission requires 5 multi-plate clutches to shift between the 6 gears: 3 input clutches

and 2 brake clutches. [more ...]

- **Lepelletier planetary gear set**

  The automatic transmission is equipped with a Lepelletier planetary gear set. A Lepelletier planetary gear set is a Ravigneaux set (double planetary gear set) with a single preceding planetary gear set. [more ...]

- **Mechatronics module**

  The automatic transmission is controlled by the mechatronics module. The mechatronics module is a combination of hydraulic unit and electronics module.

  The hydraulic unit is the hydraulic section of the transmission control and regulates the valves (e.g. electronic pressure control valves).
  The electronics module contains the EGS control unit (EGS = electronic transmission control), the sensors and the electrical connections within the transmission.

  The mechatronics module is controlled from the selector lever as follows:

  - Electrically: shift pulses from Steptronic
  - Mechanically: parking lock, position switch

  [more ...]

- **Selector lever, drive positions and selector lever position displays**

  The selector lever has the positions

  P for Park

  R for Reverse

  N for Neutral

  D for Drive (= automatic mode)

  M/S "M" for manual mode = Steptronic, "S" for Sport program = automatic mode with sporty map

  Briefly pressing the selector lever to "-" in manual mode causes the transmission to shift down. Briefly pressing it to "+" causes an upshift.
  The selector lever position display is located in the selector lever trim. [more ...]

- **Instrument cluster display**

  The selected drive position and transmission program are displayed in the instrument cluster (controlled by the electronic transmission control).

  > E60

  Check-Control messages are displayed in the LC display as variable indicator lamps (red and yellow) in the form of symbols. The following Check-Control messages can be shown:

  - Transmission too hot or overheating (yellow or red indicator lamp)
  - Selector lever position "P" not engaged (yellow indicator lamp)
  - Emergency program, transmission fault (yellow or red indicator lamp)

  > E53

  On the E53, the vehicle electrical system distinguishes between the "High" version and the "Low" version.

  Only 2 warnings (overheating and emergency program) are displayed.

  - Vehicle electrical system, "High" version

    Warnings are only given with text.

  - Vehicle electrical system, "Low" version

Warnings are only given with symbols.

- **Check-Control messages in Central Information Display (CID) (E60 only)**

  The CID displays detailed information about the Check-Control messages in the instrument cluster.
  The instrument cluster assumes control on these messages from the body CAN.
  In addition to the visual display, the Check Control also alerts the driver with acoustic signals. Depending on the importance of the associated message, a single or double gong with varying volume and tone will sound.
  The instrument cluster controls these warnings by means of the K-CAN. The acoustic warnings are emitted by the multi-audio system controller (M-ASK).

The electronic transmission control needs signals from the following components:

- **Brake light switch**

  The signal from the brake light switch is needed for the function of the selector lever lock and the adaptive transmission control.

- **Accelerator pedal module**

  The signal from the accelerator pedal module is needed for the adaptive transmission control.

- **Dynamic Stability Control (DSC)**

  The DSC optimises both driving stability when pulling away or accelerating and traction. Within the limitations of the laws of physics, DSC compensates for driving conditions such as over/understeering. This is achieved by signals concerning driving dynamics, e.g. wheel speed, lateral acceleration, vehicle speed, steering wheel position being sent to the DSC control unit.
  DSC transmits the processed signals regarding cornering, acceleration and winter identification to the EGS control unit.

- **Digital engine electronics (DME)/digital diesel electronics (DDE)**

  The transmission is actuated by the DME or DDE sending information about the engine's current operating status (e.g. engine speed or torque) to the electronic transmission control (EGS).
  The EGS in turn sends information about the current operating status of the transmission back to the DME or DDE and intervenes as necessary in the actuation of the engine .

System functions

The automatic transmission has the following system functions:

- Adaptive transmission control
- Overlap control
- Starter inhibitor
- Parking lock
- Warming-up program
- Engine intervention
- Downshift inhibitor
- Reverse gear inhibitor
- Selector lever lock (shiftlock)
- Standstill decoupling
- Removal lock (interlock)
- Rock free from snow function
- Emergency program

Adaptive transmission control

As with automatic transmissions to date, the automatic transmissions GA6HP19Z and GA6HP26Z offer the choice between a comfort program and a sport program.

The adaptive transmission control (component of electronic transmission control) adapts the shift characteristics of the comfort program and sport program to the driver's wish and the driving situation. In both programs, the adaptive transmission control changes from a basic map to a performance-orientated map, as required:

- Comfort program in selector lever position "D"

  The comfort program is based on 2 characteristic maps: The XE map (extreme economy) and the E map (economy). The EGS control unit normally selects the economical XE map (= basic map). In case of particular demands (e.g. load requirements), the system will change to the performance-orientated E map. If the input signals change in favour of a more "gentle" driving style, the system will change back to the more economical XE map.

- Sport program in selector lever position "M/S"

  The sport program effects dynamic, sporty shift characteristics. In the sport program, there is the basic S map (sport) and the performance-orientated XS map (extreme sport). If an extremely dynamic driving style is called for, the system will change from the S map to the performance-orientated XS map.

The adaptive transmission control takes the following demands into account: driver type, driving uphill or trailer towing, driving downhill, braking deceleration and automatic upshifts, winter program

- **Adaptation to driver type**

  The adaptation to the driver type is made using the values kick-fast, cornering detection, brake evaluation and constant-speed travel.

  The driver-type adaptation is restarted each time the vehicle pulls away from a standstill.

  Kick-fast

  If the accelerator pedal is depressed rapidly, the shift program is changed accordingly. This is achieved by the detected accelerator-pedal value being compared with threshold values in the EGS control unit. The result of this comparison is the proposal of one of the two possible adaptation programs (XE or E in comfort program, S or XS in sport program).

  Cornering detection

  Cornering detection reacts to the vehicle's lateral acceleration with an indirect adaptation to the driver type. Lateral acceleration is considered an indirect statement of the preferred driving dynamics and does not cause an immediate gearshift reaction (downshifts when cornering could negatively affect driving stability).

  The lateral acceleration is calculated by means of signals from the wheel speed sensors on the front and rear axles and from the yaw rate and the road speed.

  Brake evaluation

  The braking action is evaluated in a similar way to "kick-fast".
  The braking deceleration is measured and compared with threshold values in the EGS control unit. The result of this comparison is the proposal of one of the two possible adaptation programs (XE or E in comfort program, S or XS in sport program).

- **Driving uphill or trailer towing**

  These functions are based on a comparison of actual car acceleration with a nominal value. From the current engine operating situation, the acceleration with normal load on a level surface is calculated. If the actual acceleration is significantly lower than the theoretical value, the function "Driving uphill or trailer towing" is activated.
  The associated shift maps allow a high-revving driving style. Undesirable upshifts and frequent up/downshifts are eliminated or greatly reduced.

- **Driving downhill**

  If the EGS control unit detects downhill driving, it will automatically shift down a gear if the vehicle's speed picks up. This enhances the engine's braking effect. A downshift is only effected if the engine speed is below the maximum speed of the lower gear.
  The EGS control unit detects downhill driving on the basis of signals from the throttle valve potentiometer (load), wheel speed sensor (road speed) and brake light switch (brake activation).

- **Braking deceleration and automatic upshift**

  To decelerate the vehicle, the driver takes his foot from the accelerator pedal and applies the brake as necessary. The gearshift map triggers an upshift when the throttle is closed. These gearshifts are not needed in conjunction with brake applications as they prevent the engine's braking effect from being utilised.
  The intention to apply the brakes can often be anticipated from the rapid closure of the throttle to zero. If such an action is detected, the upshift is suppressed for as long as the accelerator pedal is in the zero position and the vehicle is in overrun mode.

- **Winter program (only with selector lever in position "D")**

  The winter program is automatically activated if the drive wheels start to spin even at a low rate of acceleration. The winter program provides enhanced traction by not using 1st gear and executes early upshifts to prevent such reactions when load is changed. The winter program is deactivated if the wheels do **not** spin for several seconds despite high drive torque.

Overlap control

Overlap control provides gentle shift characteristics as follows: With overlap control, several multi-plate clutches are in use at the same time. Here, pressure is reduced in the active multi-plate clutch and at the same time built up in the clutch that is about to be activated. The reduction and build-up of pressure is maintained until a synchronised speed is reached. At this point, the hydraulic pressure for the multi-plate clutch to be activated can be built up completely. Overlap control is active for all gearshifts from 1st to 6th gear and from 6th to 1st gear.

Starter inhibitor

It is only possible to start the engine when the selector lever is in position "P" or "N".

> E60 starter inhibitor

The CAS (Car Access System) evaluates the following signals from the EGS (electronic transmission control) for the start:

- Selector lever position "P" or "N" as CAN message via the powertrain CAN
- Selector lever position "P" or "N" as signal via the direct wire

In principle, the CAN message is used. If this is faulty or invalid, the circuit switches to the signal from the direct wire.

> E53 starter inhibitor

The EWS (electronic immobiliser) evaluates the following signal from the EGS (electronic transmission control) for the start:

- Selector lever position "P" or "N" as signal via the direct wire

Parking lock

The parking lock blocks the transmission output shaft and so prevents the vehicle from rolling. When the vehicle is stationary, the parking lock is engaged purely mechanically via the selector lever (Bowden cable from selector lever to mechatronics module). The parking lock is designed to provide a reliable brake on gradients up to 32 %.

Warming-up program

The warming-up program is activated after each engine start with the engine temperature lower than approx. 60 °C. In the warming-up program, the automatic transmission remains in the perfomance-orientated XE or XS map until a certain temperature has been reached. Gearshifts are made at higher engine speeds, allowing the engine and catalytic converter to reach their operating temperatures more quickly.

Engine intervention

During the gearshift, the EGS control unit emits signals to influence the digital engine electronics (DME) or digital diesel electronics (DDE).

The DME then retards the ignition timing for a few milliseconds.

The DDE reduces the fuel quantity for a few milliseconds by reducing the injection period.

This action briefly reduces the torque, improves shift quality, reduces the load on the transmission and shortens the shifting time.

Downshift inhibitor

A downshift inhibitor prevents the transmission shifting to a lower gear until the engine speed is below the maximum speed for the next gear down. The engine speed signal is transmitted by the DME/DDE to the EGS control unit.
The downshift inhibitor prevents damage to the engine and transmission.

Reverse gear inhibitor

The reverse gear inhibitor electronically prevents reverse gear from being engaged when the vehicle is moving forwards at speeds above 5 km/h (3 mph). When this speed is exceeded, the corresponding solenoid valves are no longer actuated. This prevents multi-plate clutches B and D (for reverse gear) from being charged.

Selector lever lock (shiftlock)

The selector lever is locked in positions "P" and "N" by an electromagnet. The electromagnet is actuated by the EGS control unit. The selector lever lock is engaged when selector lever position "P" or "N" is detected and the ignition (terminal 15) is ON. When the vehicle's speed is less than 5 km/h (3 mph), it is only possible to move the selector lever from "P" or "N" when the brake is engaged and the engine speed is no higher than 2500 rpm.

Standstill decoupling
Standstill decoupling of the torque converter decouples the torque converter from the power train when the vehicle is stationary so that only a minimum of load is retained and fuel consumption is reduced. The decoupling phase is realised by clutch A within the transmission being regulated, depending on the load signal and output speed.

Removal lock (interlock)

The ignition lock is mechanically linked to the selector lever by a Bowden cable (as on the E38). The removal lock only allows the ignition key to be removed when the selector lever is in position "P". The other way around, the selector lever can only be moved from position "P" when the ignition key is in the ignition lock and turned at least to ignition ON.

Rock free from snow function

To rock the vehicle free from snow, it is possible to shift between selector lever positions "D" and "R" without the selector lever lock (effective in "N"). With the engine running, the gearshift must be completed within 0.5 seconds.

Emergency program

The emergency program is activated if the transmission management should fail or detect a malfunction that could lead to critical driving conditions. In the emergency program, the vehicle remains operational, albeit with limitations.

If the electronic transmission control fails (without current), the following forward gears can be engaged:

Failure in 1st-3rd gear ==> emergency 3rd gear

Failure in 4th-6th gear ==> emergency 5th gear

3rd gear will be engaged after a restart.

Operation

The different automatic transmission drive positions are selected with the selector lever.
When driving, there are the following possibilities:

- **D = Automatic mode**

  When the selector lever is in position "D", gears are selected by the adaptive transmission control.

- **DS = Automatic mode, sport program**

  When the selector lever is moved to the left from position "D" into the shift gate "M/S", the automatic transmission's sport-orientated shift programs are activated. The display in the instrument cluster changes from "D" to "DS".

- **M1 to M6 = Steptronic**

  If the selector lever is in shift gate "M/S" and is briefly moved to "-" or "+", the electronic circuitry changes to Steptronic and manual mode is activated. The display in the instrument cluster changes from "DS" to "M1" to "M6".
  In manual (Steptronic) mode, the transmission management will only execute upshifts or downshifts at appropriate engine and road speeds. Gearshifts that would result in an excessively high or low engine speed are suppressed. If an impermissible gearshift is requested, the display in the instrument cluster briefly changes to the gear selected and then back to the current gear.

- **Upshift only up to the gear required**
  A gear can be stored by repeatedly moving the selector lever to "+" or "-" and then holding it in the one-touch position. The transmission management changes gear in sequence up (or down) to the required gear. The selector lever must be held in position until the required gear has been reached.

Notes for service staff

Service staff should note the following points:

- Service notes: [more ...]
- Diagnostics: ---
- Encoding/programming: ---
- Car and Key Memory: ---

Subject to change.