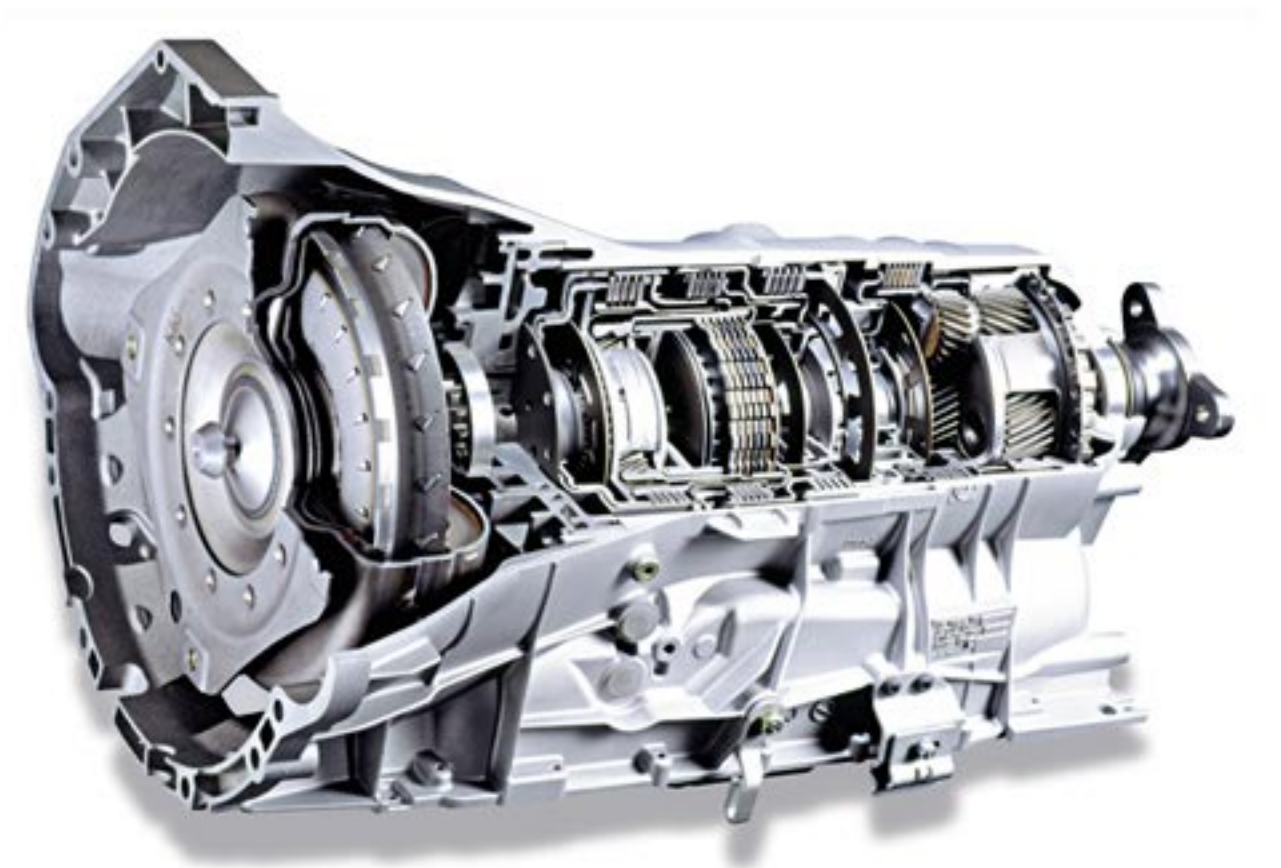
Reference Manual

ELECTRONIC TRANSMISSIONS



Technical Training

Table of Contents

Transmission Fundamentals

Subject **Page**

Initial Print Date:1/15/03 Revision Date:

Model: All with BMW Automatic Transmission

Production: All

Objectives:

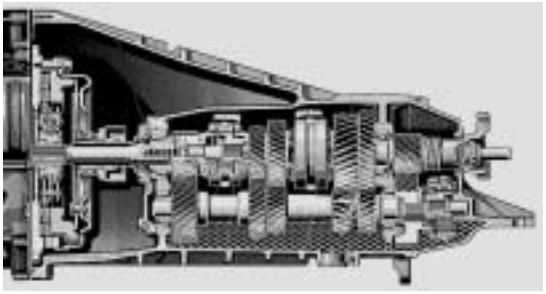
After completion of this module you will be able to:

- Recognize automatic transmission advantages.
- Identify BMW Automatic Transmissions.
- Understand Basic Transmission Hydraulics.
- Understand Transmission Fluid Application.
- Understand the Operation of Multi Plate Clutches and Brakes.
- Understand Torque Converter Operation.
- Understand Basic Planetary Gear Sets and Basic Power Flow.

Standard/Automatic Transmission Comparison

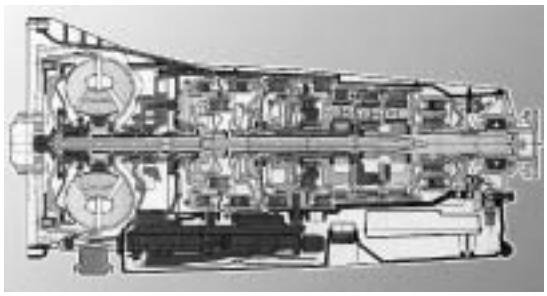
In today's modern vehicles, the automatic transmission has become a vital part of the powertrain. Automatic transmissions provide overall better fuel economy and efficiency while adapting to changing road conditions and driving habits. Standard transmissions offer more driver interaction with the vehicle, however automatic transmissions reduce driver fatigue and increase safety by shifting automatically. Automatic transmissions also offer improved driveability in stop and go traffic. If there is a disadvantage to an automatic transmission, it would be complexity and cost of manufacturing.

Standard Transmission



- Drive torque must be interrupted to change gears.
- Higher loads on driveline from abrupt clutch application.
- Clutch must be disengaged when vehicle is stopped to prevent stalling.
- High radial loads on housing.
- Gear set design requires more space than planetary type.
- Requires some Maintenance (clutch).
- Requires driver intervention for shifting.

Automatic Transmission



- Gear teeth are in constant mesh due to planetary design.
- Smoother application of drive torque reduces loads on driveline.
- Due to fluid coupling in the torque converter, transmission can stay in gear when vehicle is stopped.
- Minimal radial loads on housing.
- Compact design of gear set. Space requirement is minimized.
- Maintenance free operation. (Lifetime fluid and no clutch).
- Automatic shifting reduces driver fatigue and increases safety.

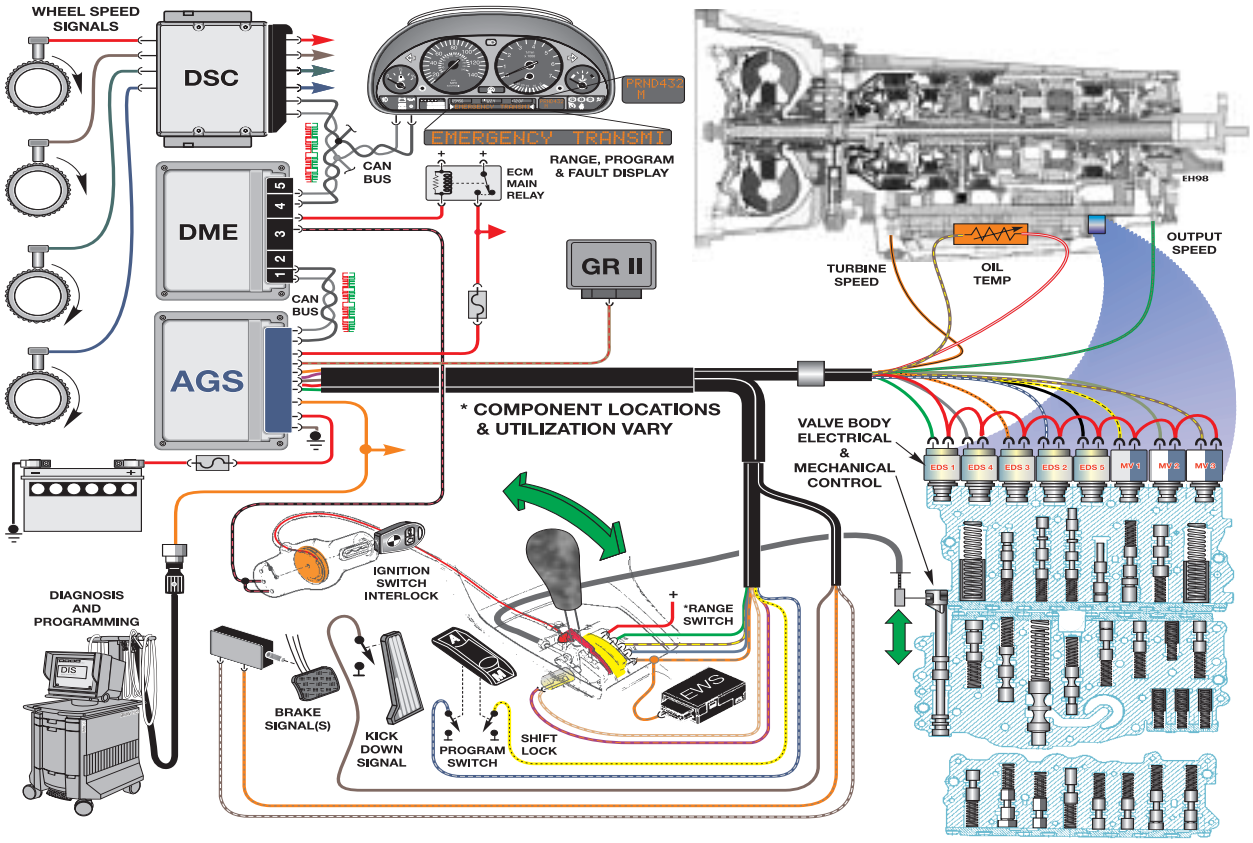
Hydraulic Transmission vs. Electro-hydraulic Transmission

Since the introduction of the automatic transmission there have been numerous refinements to improve shift comfort as well as fuel economy. Early automatic transmissions used only hydraulic control, there was no electronic intervention. In 1986 BMW introduced their first EH (Electro-Hydraulic) transmission into production vehicles.

The acronym EGS is used by BMW for its electronic transmission control system. EGS stands for "Electronic Transmission Control" which comes from the German words "**E**lektronisch **G**etriebe **S**teurung". In order to comply with SAE terminology we will refer to the EGS control module as the TCM "**T**ransmission **C**ontrol **M**odule".

EH controlled transmissions allow for optimized shift points by closely monitoring changing conditions. Engine speed, road speed and throttle angle are some of the inputs that are monitored by the TCM to determine optimal shift points. The TCM will then process this information and control shift point via electronic solenoids mounted on the valve body.

With the introduction of Adaptive Transmission Control, shift comfort and fuel economy was further improved. The TCM now monitors throttle angle deviations, wheel speeds and CAN Bus information to fine tune shift points.



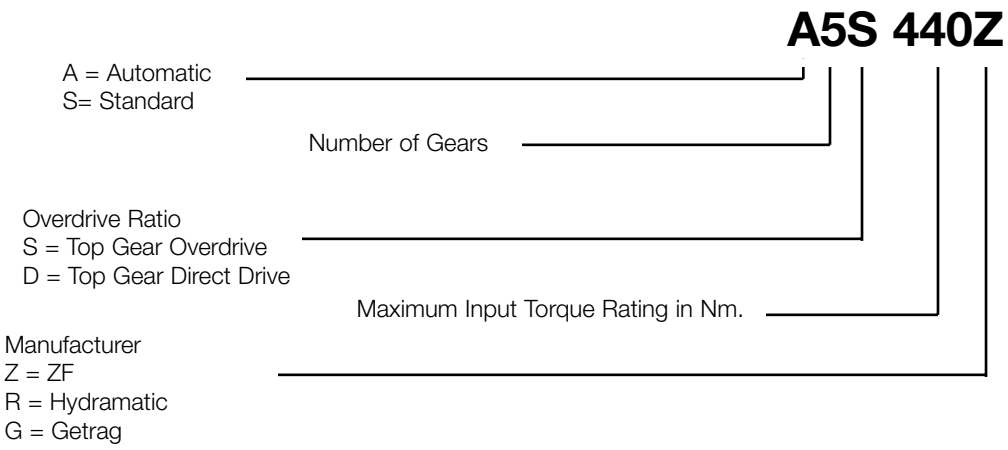
Transmission Identification

BMW automatic transmission are manufactured by two suppliers for the US market:

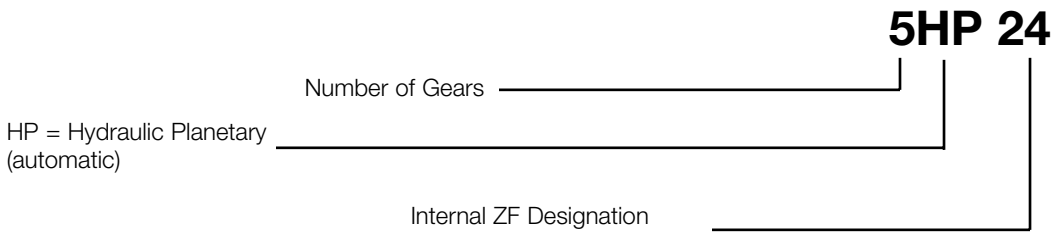
- **Zahnradfabrik Friedrichshafen:** Commonly referred to as ZF. ZF manufactures both manual and automatic transmissions.
- **GM Powertrain - Hydramatic:** Hydramatic is a manufacturing division of General Motors located in Strasbourg France. Hydramatic supplies automatic transmissions to BMW for four and six-cylinder vehicles.

BMW has developed an internal numbering system for their transmissions for parts ordering, information research and identification. Also each manufacturer uses their own internal identification system. Here is a breakdown of these identification codes:

BMW Identification Code Breakdown



ZF Identification Code Breakdown



Hydramatic Transmissions have internal designations as well, however there are not used often.

Transmission Hydraulics

Transmission Fluid (Oil)

The automatic transmission provides pressure regulated hydraulic fluid which is filtered for all of the transmissions functional requirements. All BMW automatic transmissions are designed to operate with specific fluids. Use of non-approved oil will cause malfunctions and irreparable transmission damage which is not covered by BMW warranty.

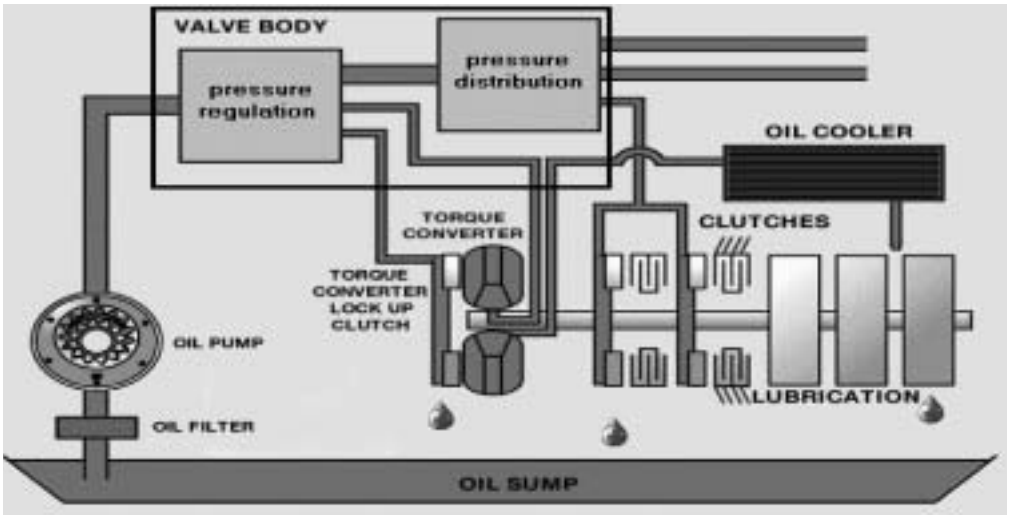
The transmission fluid provides the following functions:

- Lubricates mechanical components (planetary gears, bearings etc.).
- Removes heat and transfers heat to transmission cooling system. (Heat Exchanger).
- Removes debris and contaminants to sump and filter when circulated.
- Provides a transfer of kinetic energy in the torque converter.
- Allows hydraulic operation of mechanical components (clutches, brakes) via control of the valve body.

Also, transmission fluid has various properties to prevent oxidation and breakdown from heat and friction. Each type of transmission fluid has properties specific for each transmission application.

Fluid level is crucial in the proper operation of an automatic transmission. Improper fluid levels will cause improper operation and eventually irreparable transmission damage. Improper fluid level can cause:

- A low fluid level can cause an interruption in oil flow during fast acceleration or hard braking which can cause gear shift malfunctions.
- An excessively high fluid level can cause the rotating mechanical components to paddle in the oil. This produces foam which introduces air into the hydraulic system.
- A low fluid level can also cause transmission overheating causing premature transmission failure.



Transmission Fluid Application

There are numerous types of transmission fluid used in BMW transmissions. With the exception of the early transmissions (4HP22/24, A4S310/270R and the A5S310Z) all current BMW transmissions use "Lifetime Fill" transmission fluid. There is no maintenance required for these transmissions. It is important to use the correct fluid. Incorrect use of the transmission fluid can cause non-warrantable transmission damage.

When performing repairs on transmissions with lifetime fluid, it is important to drain the transmission fluid in to a clean container for re-use. New fluid should only be used for transmission replacement and for topping off after repairs.

Also, transmission fluid level is vital to the proper operation of the transmission. Refer to BMW Service Bulletin B 24 01 98 for proper fluid level checking procedures.

When servicing or repairing BMW automatic transmissions, refer to TIS for fluid capacities. For fluid types refer to the "Operating Fluids Manual".

Transmission	Fluid Type	BMW Part #	Container	SIB Ref.
4HP22 **4HP24**	Dexron III Mercon	Available Commercially (Castrol or Texaco)	N/A	
A5S310Z 530i/iT (E34)	Dexron III	Available Commercially (Castrol or Texaco)	N/A	
M3 (E36)	ESSO LT 71141	83 22 9 407 807	20 liter contalner	B 24 03 95
A5S325Z	ESSO LT 71141	83 22 9 407 807	20 liter contalner	
A5S440Z	ESSO LT 71141	83 22 9 407 807	20 liter container	
A5S560Z 740 (E32), 540 (E34) 840Ci (E31- 6/93-12/94) 740i/iL-750iL (E38)	Shell LA2634	83 22 9 407 765	5 liter container	B 24 11 92
540i (3/96-12/96) 850Ci (10/94-6/97)	ESSO LT 71141	83 22 9 407 807	20 liter container	B 24 02 94
A4S310R **A4S270R** **(THM-R1)**	Dexron III Mercon	Available Commercially (Castrol or Texaco)	N/A	
A5S360R **A5S390R**	Texaco ETL 7045E Texaco ETL 8072B	83 22 0 026 922 83 22 0 024 359	25 liter container 25 liter container	
GA6HP26Z	Shell M1375.4	83 22 0 142 516		

Torque Converter

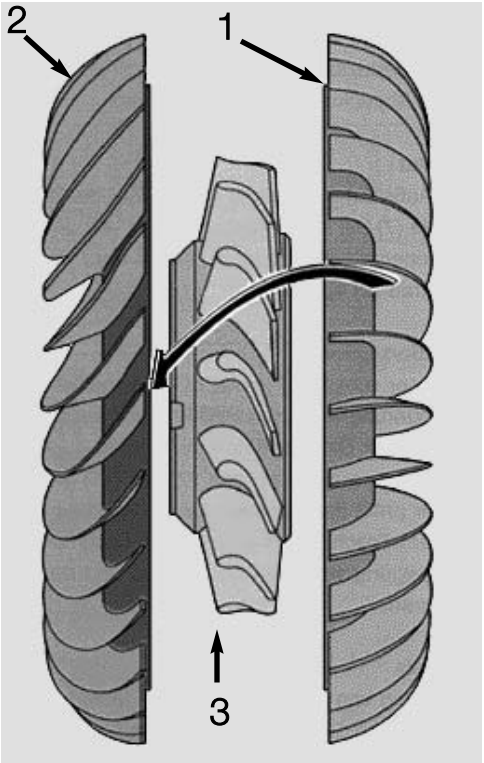
In standard transmissions the crankshaft is linked to the transmission input shaft via the clutch assembly. Power flows from the crankshaft through the flywheel. The pressure plate transfers power to the clutch disc which is splined to the transmission input shaft. The pressure plate is used to disconnect (or interrupt) power flow to the transmission input shaft. Because the engine is mechanically connected to the driveline, powerflow must be interrupted when the vehicle is stationary. Otherwise the engine would stall.

In automatic transmissions, there is a fluid coupling between the engine and transmission. This fluid coupling is more commonly referred to as the torque converter. In the torque converter there is no rigid connection between the engine and transmission (Except for lock up clutch). In order to understand the operation of the torque converter, we must first start with the components.

The breakdown of the components are as follows:

- The Impeller (1), which is rigidly connected to the torque converter housing.
- The Turbine (2) which is splined to the input shaft (turbine shaft) of the transmission.
- The Stator (3) which has a one-way clutch. The inner race of the one-way clutch is splined to a stationary shaft attached to the transmission.

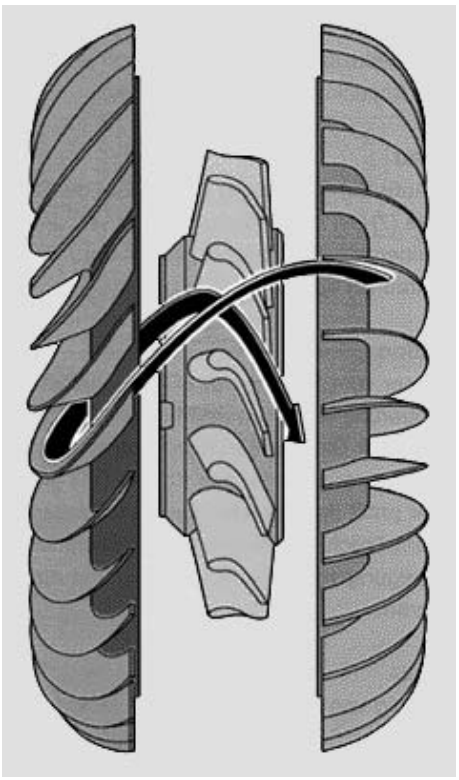
The addition of the stator allows the fluid coupling to be referred to as a torque converter. The stator provides for a multiplication of torque at low speeds. Without the stator there would be no multiplication of torque.



When the engine is running, the impeller which is directly connected to the converter housing, rotates at engine speed. Fluid is directed from the impeller blades to the turbine blades. The fluid drives the turbine which is splined to the input (turbine) shaft of the transmission. This functions the same way as a waterfall acting on a paddle wheel. The ratio of the impeller speed to turbine speed is approximately 1.1 to 1. This ratio is improved to 1:1 with the addition of the torque converter clutch which is discussed later.

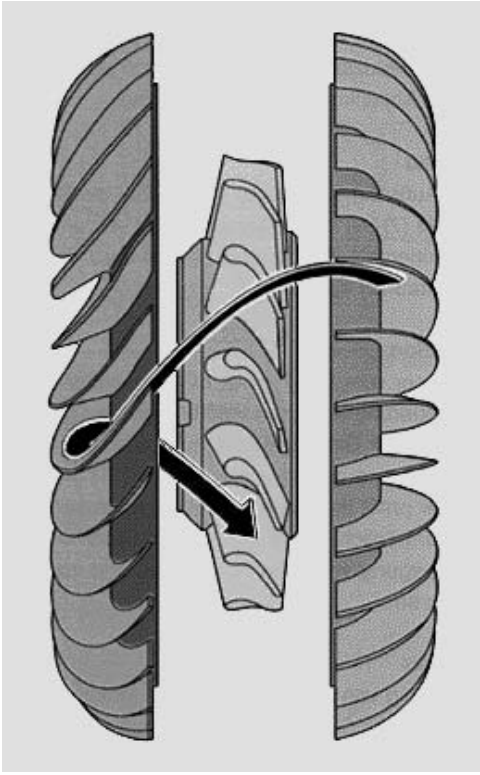
Torque Converter

Torque Converter Operation At Low Speeds



1. At low engine speeds there is a large difference in rotational speed between the impeller and the tur bine
2. Fluid flow is directed from the impeller to the tur bine. Fluid strikes the vanes of the turbine. The turbine is driven forward in the direction of engine rotation.
3. Fluid flow is then directed back towards the impeller.
4. Before the fluid reaches the impeller, the fluid strikes the vanes of the stator.
5. When the fluid strikes the stator, the one way clutch prevents the stator from rotating.
6. The fluid is then re-directed by the curved vanes of the stator. The fluid is now flowing in the same direction as the impeller.
7. The fluid that is acting on the impeller increases the force on the the impeller which multiplies torque.

Torque Converter Operation at High Speed



1. As engine speed increases, the turbine speed speed approaches the speed of the impeller.
2. The fluid flow is directed from the turbine to the back side of the impeller blades.
3. The one-way clutch in the stator unlocks and the stator blades turn in the direction of engine rotation.
4. Fluid is no longer re-directed and torque multiplication no longer takes place.
5. This is referred to as “Coupling Speed”. The turbine never reaches the same speed as the impeller as fluid flow would come to a halt. Ratio is approximately 1.1 to 1.

Torque Converter Clutch

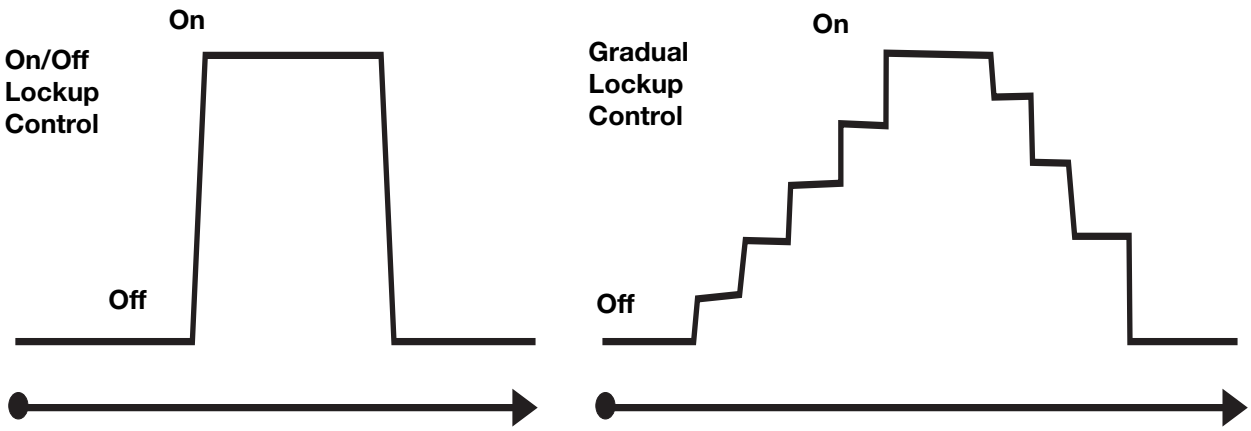
Since the efficiency of the torque converter at coupling speed is approximately 1.1 to 1, fuel economy is compromised. To offset this a torque converter clutch was added on EH controlled transmissions. The torque converter clutch locks the turbine to the converter housing. This creates a mechanical coupling with a ratio of 1:1. This can only be achieved at higher engine speeds, the torque converter clutch must be disengaged at low engine speeds to prevent stalling.

There are two methods for controlling the torque converter clutch on BMW transmissions:

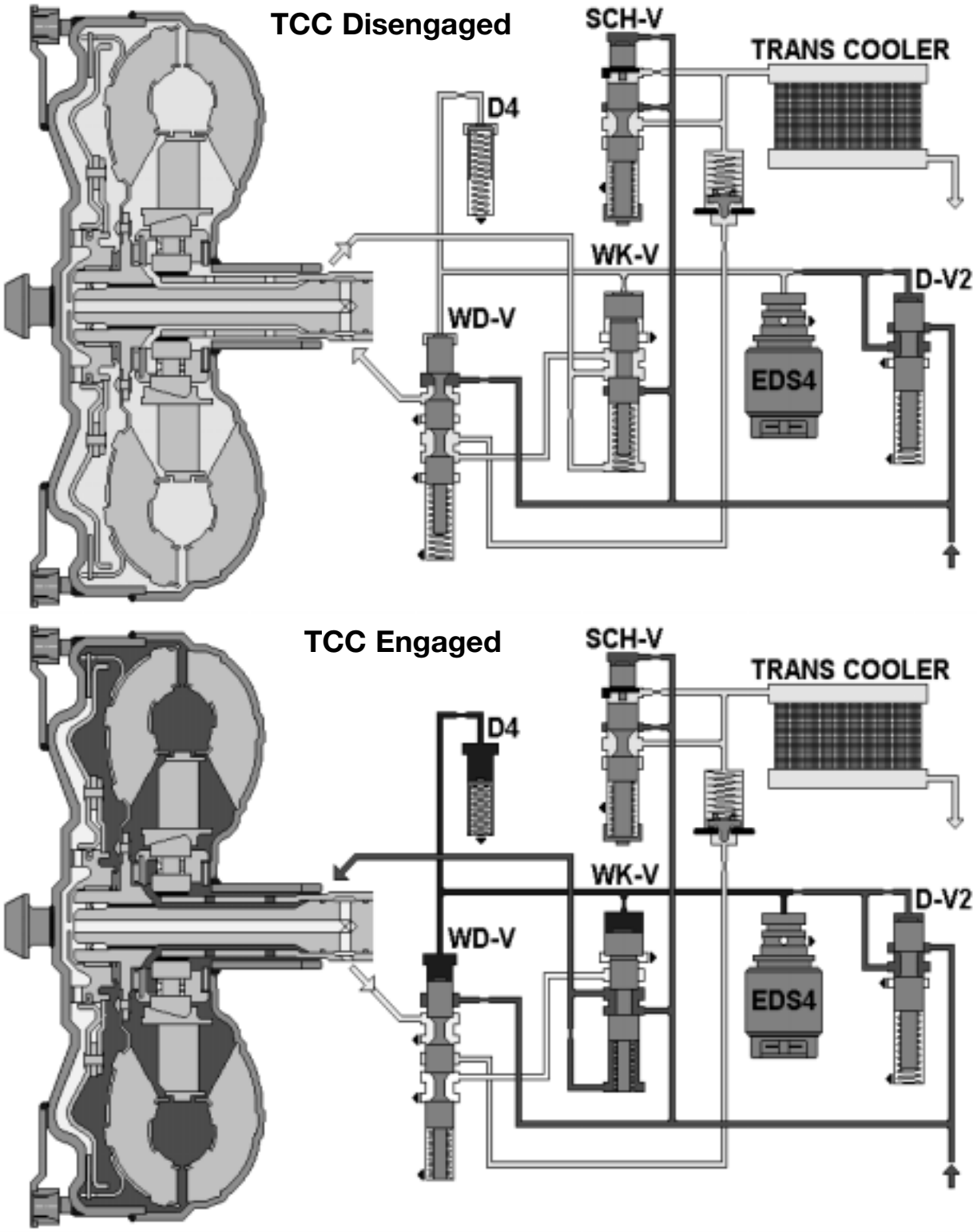
- **A4S310/270R, 4HP22/24 EH, A5S310Z** - These transmission use an on/off control method to lock and unlock the torque converter. The TCC is either completely engaged or completely disengaged. This method of engagement provides an abrupt sensation when the TCC is locking and unlocking. This abrupt sensation can be unpleasant and undesirable to some drivers.

- **A5S560Z, A5S440Z, A5S325Z, GA6HP26Z,A5S360/390R** - These transmissions use a gradual approach to TCC control. The TCC is gradually applied and released, this method reduces the abrupt feel of the on/off type TCC. The TCC solenoid is controlled by pulse width modulation. This allows fluid to be gradually introduced and released to the TCC.

The TCC is spring loaded to the engaged position. Pressurized fluid releases the TCC, when the pressurized fluid is released, the TCC is engaged. Depending on transmission application, the TCC can be engaged in 3rd, 4th or 5th gear. The TCC must be disengaged at low speeds to prevent stalling.

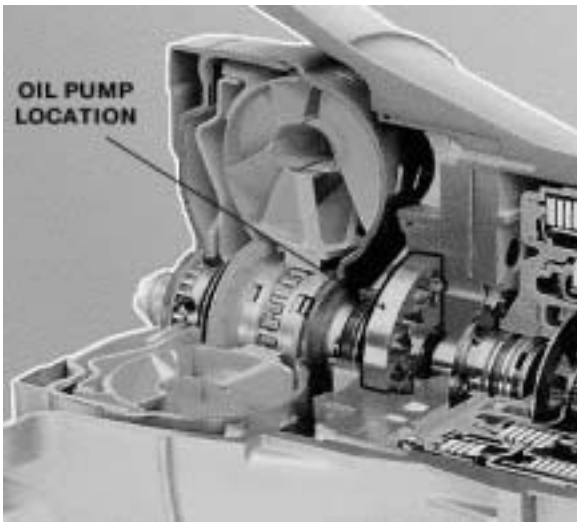


Example of TCC oil control circuit from the A5S440/560Z transmission.



Oil Pump

The transmission oil pump is used to circulate oil and provide pressure for hydraulic operation.



The pump is driven by the torque converter shell and rotates with engine. Fluid is drawn from the sump through the filter and distributed to the various transmission hydraulic systems.

The output pressure is regulated to an operating pressure of approximately 25 bar.

Currently there are two types of oil pumps used in BMW transmissions; Crescent type and Vane type.

Crescent Type Oil Pump (All except A5S360/390R)

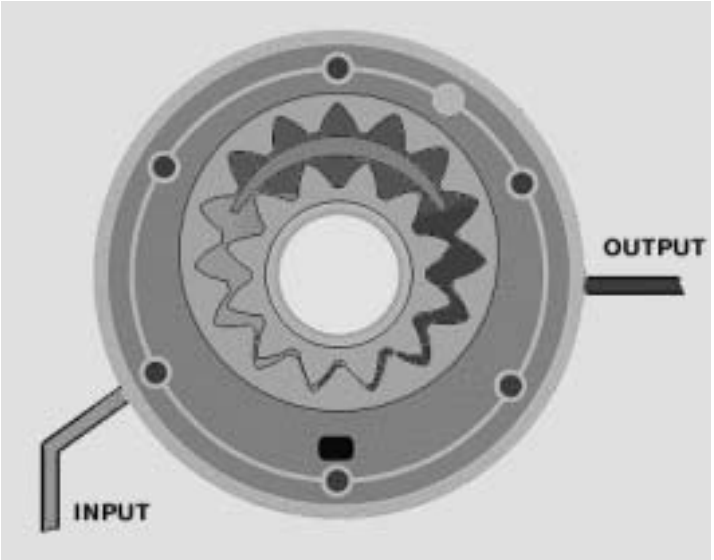
The crescent type is an internal gear pump containing a drive gear and a driven gear. The inner gear is driven by the torque converter and acts as the impeller. The outer gear is driven by the inner gear.

The gap between the teeth varies from the input, through the crescent and to the output of the pump.

A low pressure area is created on the input side of the pump by the widening gap between the gear teeth.

The oil is drawn to the crescent and transferred to the output side of the pump, where the pressure is increased by the narrowing gap between the gear teeth.

The output pressure of the pump is controlled by spring loaded pressure regulator.

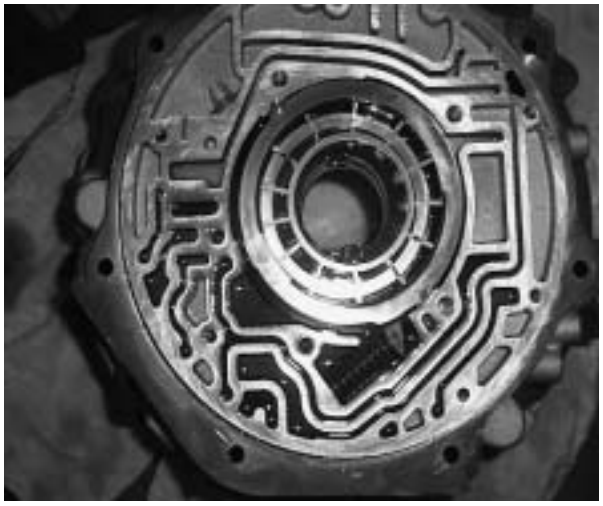


Oil Volume Control

On the A5S440Z transmission, oil pump output volume is controlled based on engine RPM. High oil volume is initially required at start up to quickly fill the transmission requirements. As engine RPM increases, the volume is greater than is required. The Oil Volume Control Damper regulates the pump output volume based on engine RPM. This helps improve fuel economy by reducing the load on the engine at high RPM.

Vane Type Pump (A5S360/390R)

The new A5S360/390R (GM5) transmission uses a vane type pump. The torque converter drives the pump rotor and 13 vanes.



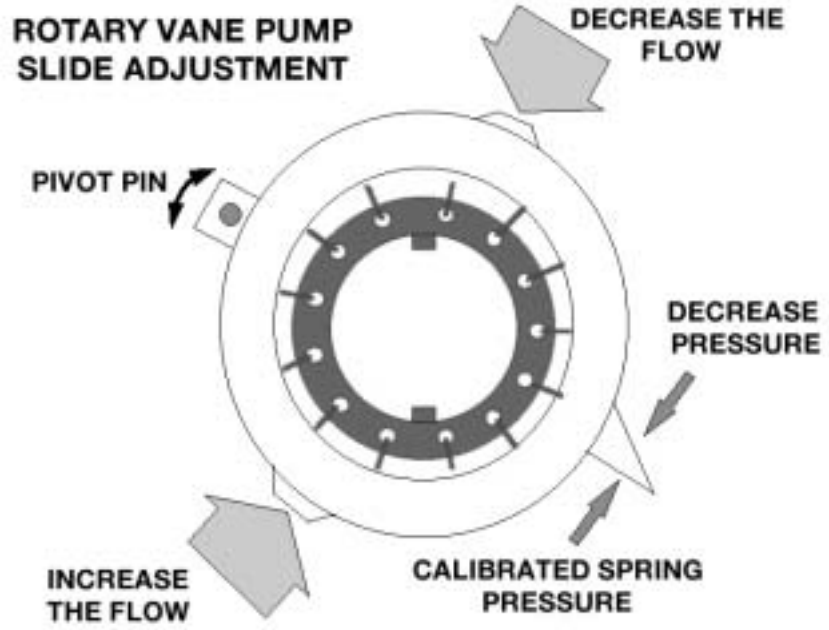
The rotor and vanes are placed inside a slide mechanism. As the rotor spins, the vanes sweep oil from the pump intake to the output along the mating surface on the vane ends and the interior surface of the slide.

The slide is mounted on a pivot pin. As it pivots, it changes the eccentricity of the rotor to slide mating surface. This in turn will alter the output oil volume. This provides the same function as the Oil Control Volume Damper on the A5S440Z.

The slide's position is influenced by a calibrated spring and hydraulic control pressure from the main pressure regulator solenoid on the valve body.

The benefit of changing the slide position is to optimize pump output volume to meet the the following operating conditions:

- Provide maximum volume during engine start-up. This condition provides a fast priming action of the pump for immediate lubrication and for hydraulic pressure operation.
- Regulated output volume at higher engine speeds. Maximum pump volume is not required at all times.



Hydraulic Control Components

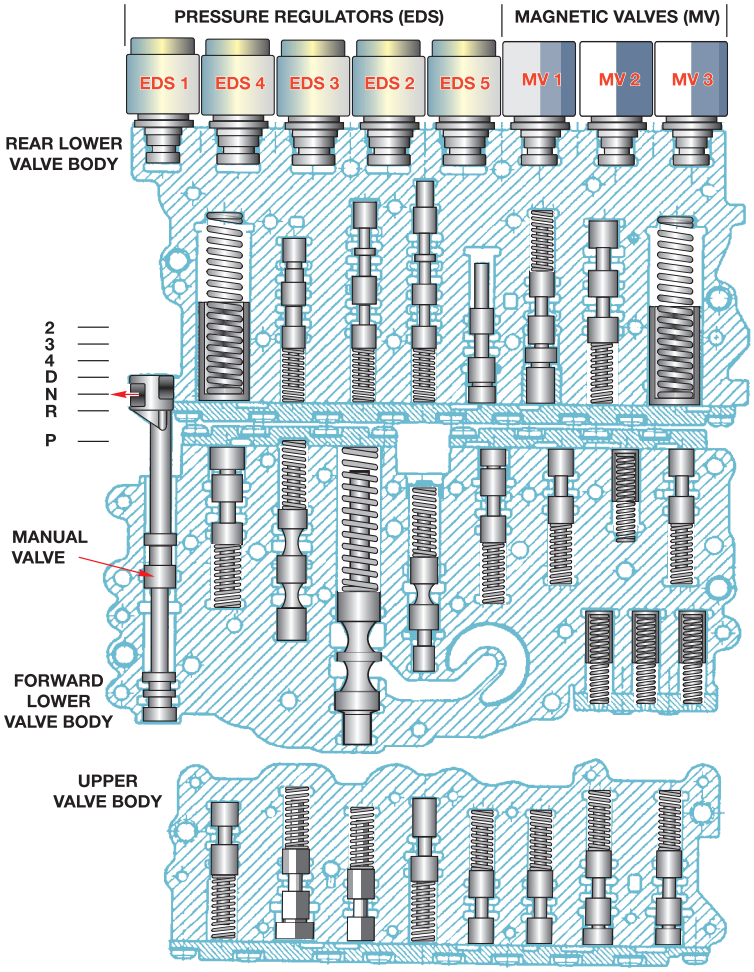
Electro/Hydraulic Valve Body

The valve body assembly is the main shift control element in the transmission. In non-EH transmissions the valve body was only hydraulically controlled. In the current EH (electro-hydraulic) transmissions the valve body is similar in design, but now also housing a number of shift solenoids which are controlled by the TCM.

The valve body consists of a number of sub-assemblies. Each sub-assembly contains a number of spool valves which are hydraulically controlled. Most spool valves are opposed by spring pressure. The spool valves are used to direct hydraulic fluid flow to the various shift elements in the transmission. There is also a manual valve which is connected to the shift assembly by a cable. The manual valve allows the drivers to select the basic operating mode (or ratio).

The valve body is responsible for the following:

- Regulating Main Pressure
- Controlling fluid flow to shift elements for Upshifts and Downshifts.
- Providing for manual operation by driver via manual valve.
- Reverse Lockout
- Failsafe Operation
- Shift Comfort through:
  Overlap Shift Control (ZF)
  Pressure Accumulators (GM)
- Torque Converter Control
- Distribution of lubrication.

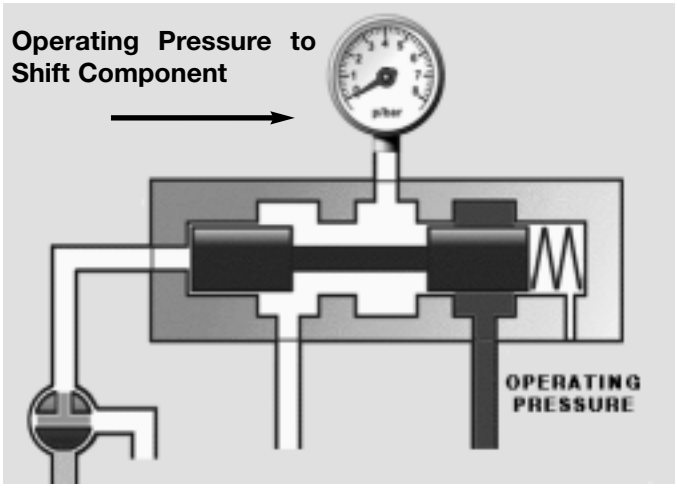


Shift Valves

Shift valves are used to direct application pressure to the various shift elements. Shift valves are regulated by spring pressure and control pressure for the shift solenoids. Shift valves come in various configurations depending upon application and transmission type. The most basic is the 3/2 shift valve. The 3/2 shift valve has 2 positions which are switched through one or two control pressures.

With no control pressure from shift solenoid present, the shift valve is moved to its end travel (left) by spring pressure.

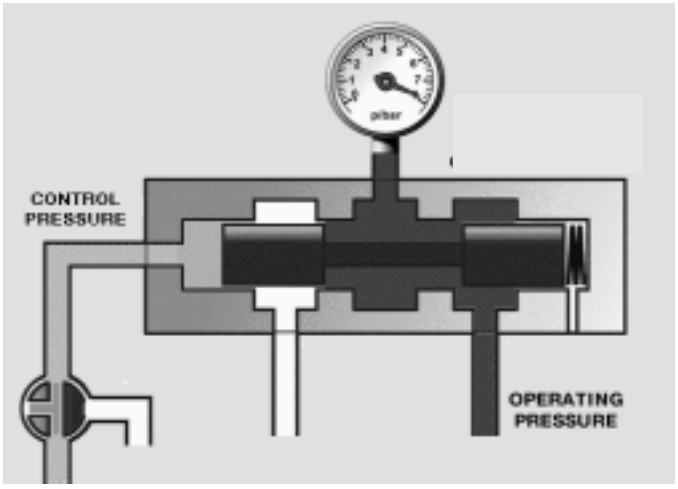
Operating pressure is blocked to the shift component. Also in this position any application pressure is drained from the shift component.



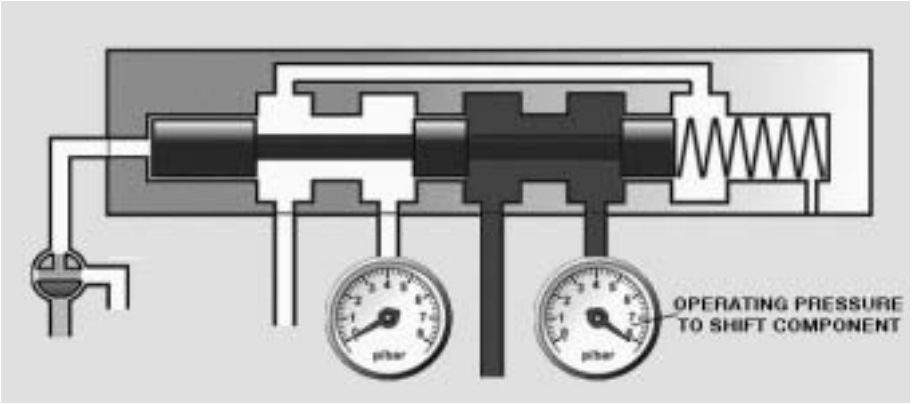
Once the control pressure is applied to the 3/2 shift valve, the shift valve moves to the right.

This allows operating pressure to reach the shift component.

When the control pressure is again reduced, spring pressure returns the 3/2 shift valve to the rest position. This drains and operating pressure from the shift component.



The example shown at right is a 4/2 shift valve. The operation is similar to the 3/2 valve. The primary difference is that the 4/2 shift valve affects 2 shift components.



Pressure Regulation

Pressurized oil from the pump must be regulated for use within the transmission. Otherwise, the high pressure directly from the pump would influence shift quality. The shifts would be more abrupt and harsh. In order to “fine tune” the pressures within the transmission, there is a pressure regulating valve and a pressure regulating solenoid. The pressure regulating valve is located in the oil pump housing or the valve body dependent upon transmission type.

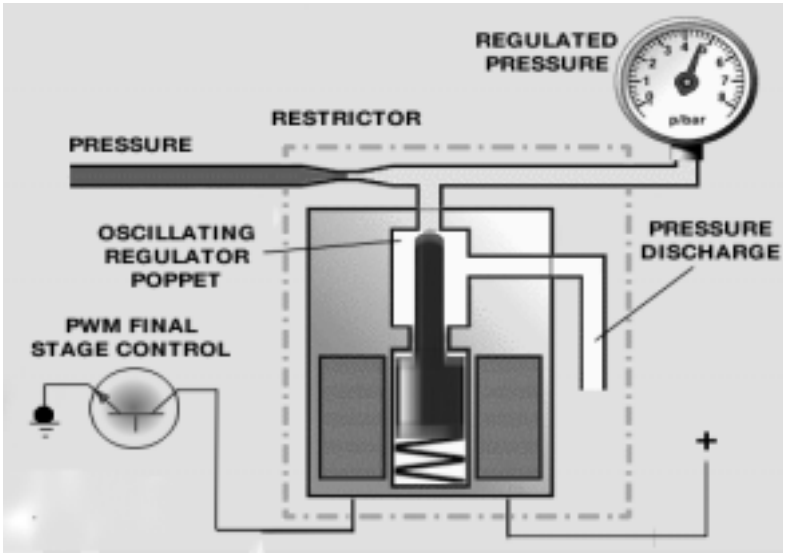
The pressure regulating solenoid is a pulse width modulated (PWM) solenoid. Current is controlled by the TCM. The pressure regulating solenoid is normally closed, there is maximum line pressure available when minimum (or no) current is applied to the pressure regulating solenoid. Depending upon application, pressure regulating solenoid can be PWM with B- or B+ control. GM transmissions use B+ control with a constant ground supply. ZF transmissions uses B- control with a constant B+ supply.

There are also pressure regulators used in ZF transmissions that are used to control shift pressures. The A5S440Z and A5S560Z both use EDS solenoids for “Overlap Shift Control” this will be explained later in this text.

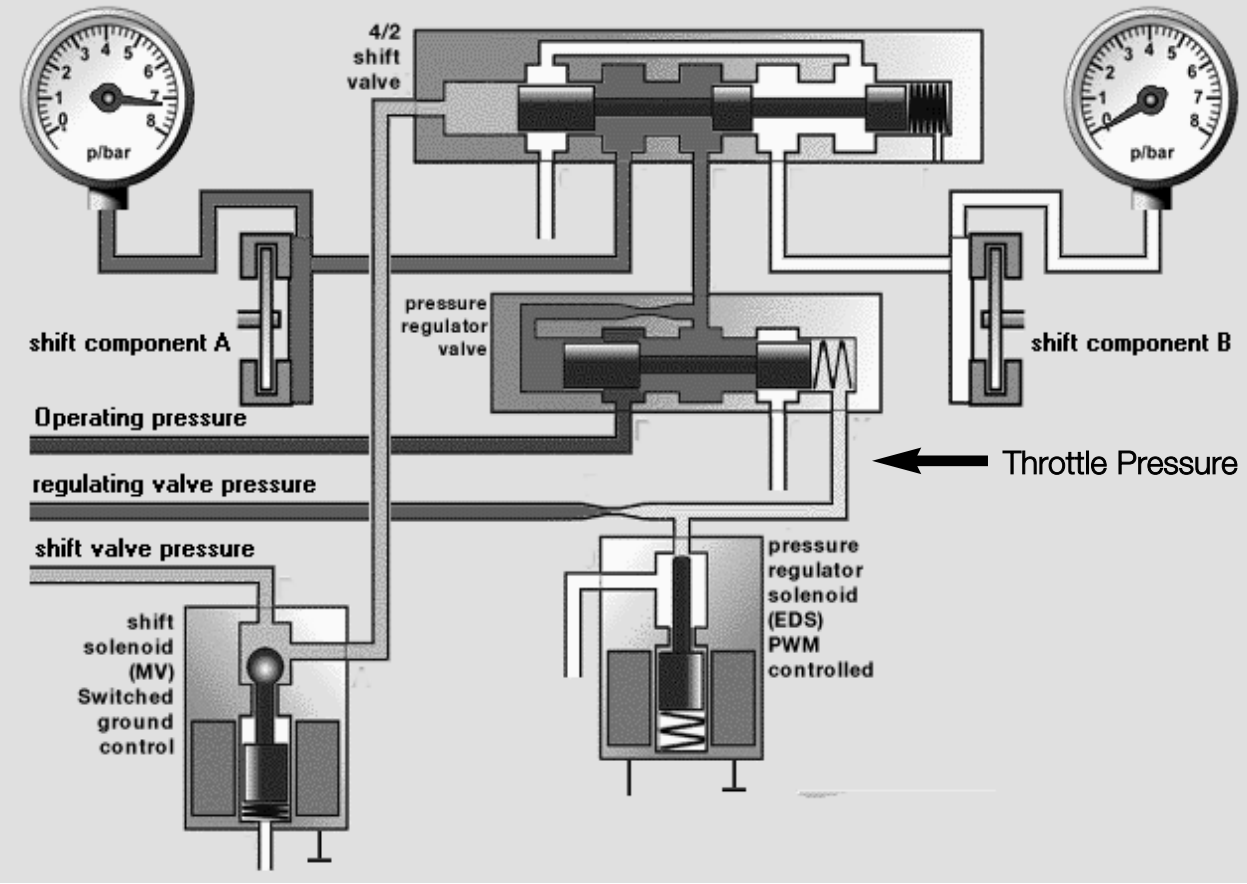
There are a few different names for pressure regulating solenoids depending upon the transmission type and manufacturer:

- ZF transmissions use the following terms - EDS solenoid (valve), or MV (magnetic valve).
- Hydramatic (GM) transmissions use the following terms: DR solenoid, Force Motor Solenoid or Variable Bleed Solenoid.

Transmission operating pressures are regulated based on engine speed, throttle angle and engine load. The regulated pressure from the pressure regulating solenoid is referred to as throttle pressure. This pressure is fed to the main pressure regulating valve.



Pressure Regulation



As the diagram shows, regulating valve pressure is fed to the pressure regulating solenoid. This pressure is then regulated to create throttle pressure. Throttle pressure is modified based on throttle angle, engine speed and engine load. Throttle pressure is then fed to the pressure regulating valve. As throttle pressure increases, the regulating valve piston is moved to the left (with respect to the diagram). As the regulating valve piston is moved to the left , operating pressure is increased to the 4/2 shift valve. The operating pressure to the 4/'2 shift valve will be fed to Shift Component A or Shift Component B depending the position on the 4/2 shift valve. The operating pressure to the shift components will be increased or decreased depending upon the throttle valve pressure. As engine speed and load are increased, the operating pressure will be increased to provide higher clamping forces on the shift components.

When there is no electrical power present to the pressure regulator solenoid, throttle pressure will be a maximum. Therefore maximum operating pressure will be available at the 4/2 shift valve. This condition would exist if the transmission was operating in failsafe mode.

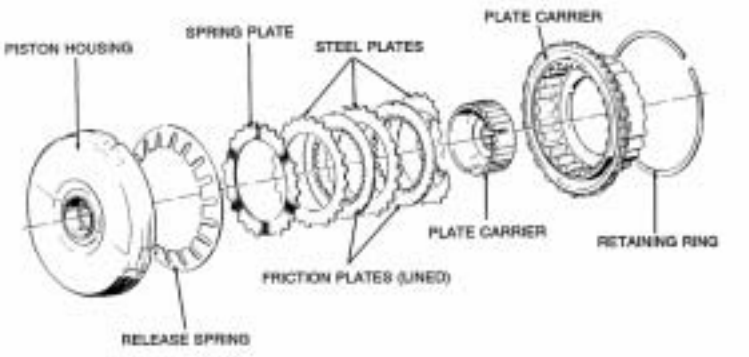
Apply Components

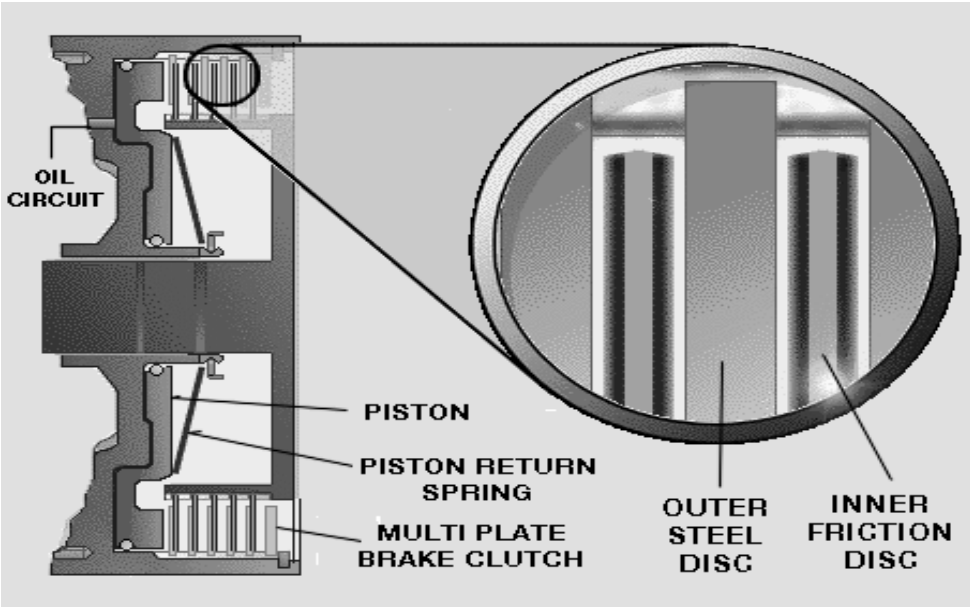
Multi - Plate Clutches and Brakes

Multi Plate Clutches and Brakes are used to drive or hold members of the planetary gear set. As a general rule, Multi Plate Clutches connect one planetary member to another. Multi Plate Brakes connect a planetary member to the case to hold it stationary.

The clutches and brakes consist of a number of friction discs and steel discs. The friction discs are coated with a friction material and have engaging lugs (splines) on the inner perimeter. The steel discs are steel on both sides and have engaging lugs located on the outer perimeter. The engaging lugs on the friction discs are usually engaged with a planetary member. The engaging lugs on the steel discs are usually engaged with the clutch piston housing.

In addition to the friction and steel discs, there is also an apply piston, housing and return spring. Once hydraulic fluid is applied to the clutch assembly, the friction discs and steel discs will be locked together. Once hydraulic pressure is released, the return spring will cause the clutch piston to return to its rest position which will unlock the clutch assembly.





Multi - Plate Clutch Operation

In order to carry out a shift in ratio, fluid needs to be applied or released from the Multi - Plate Clutch (or Brake). As shown in the example at the right, the following sequence occurs:

1. Fluid from a shift valve in the valve body is applied to the clutch assembly. (Figure A)
2. Fluid pressure builds behind the apply piston and overcomes the resistance from the diaphragm spring. (Figure A)
3. The friction and steel discs are compressed together and become locked, prevent ing any slippage between them. (Figure A)
4. Two planetary members are now locked together.
5. When fluid pressure is released, the steel and friction discs are allowed to unlock. (Figure B)
6. The diaphragm spring pushes against the apply piston and returns the piston back to the rest position. (Figure C)
7. The check ball in the apply piston is unseated by centrifugal force which allows the clutch to drain completely.

Figure A

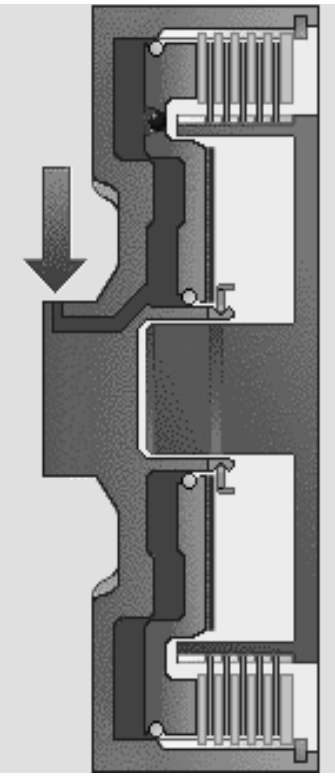


Figure B

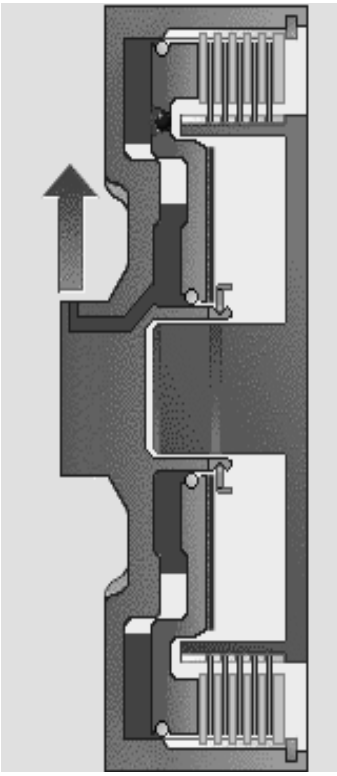
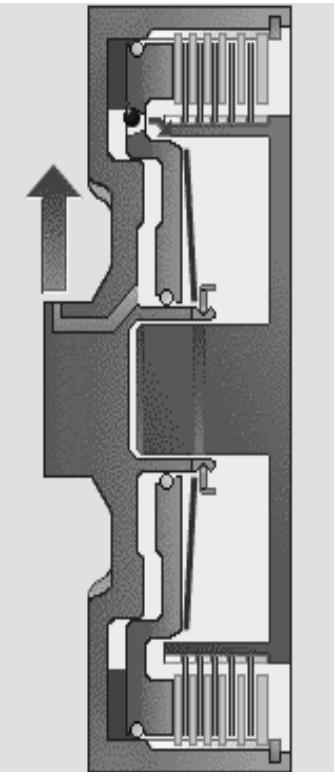


Figure C



Band Brakes

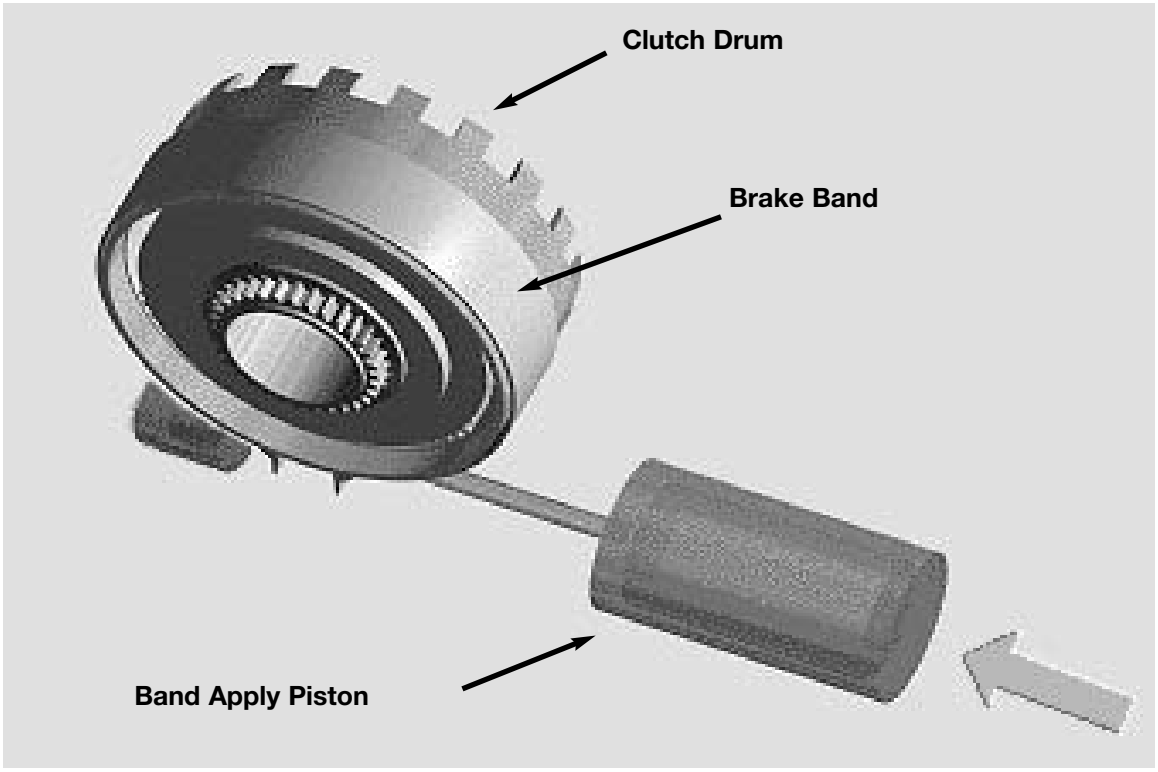
On some BMW transmissions there is a band type brake used for some applications. The A4S270/310R and the A5S310Z use a band type brake. The brake band is a circular band with friction material bonded to the inner surface. The band wraps around a particular planetary component (clutch drum) and locks that component to the transmission case. The brake band is applied and released by the clutch apply piston.

The brake band is not adjustable on the A5S310Z, however there is some adjustment allowed when needed on the A4S270/310R. Refer to repair instructions for proper procedures.

The brake band functions in the following manner on BMW transmissions:

- A4S270/310R - The brake band is active (applied) in first and second gear. The brake band holds the reaction sun drum stationary. The reaction sun drum is splined to the reaction sun gear.

- A5S310Z - The brake band is active (applied) in second, third and fifth gear. The brake band holds the forward sun gear to the case.



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Transmission Fundamentals

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One-Way Clutches (Freewheel)

The one way clutch consists of an inner and outer ring with a locking device between the two. The one way clutch is designed to lock in one direction and to allow free rotation in the other direction. Currently there are two types of one way clutches used in BMW transmissions:

- Roller type which consists of spring loaded rollers between the inner and outer race of the one way clutch. (Roller type is also used without springs on some applications)

- Sprag type which consists of asymmetrically shaped wedges located between the inner and outer race of the one way clutch.

Roller Type One Way Clutch

Sprag Type One Way Clutch

In both versions of the one way clutch (freewheel), rotation is only allowed in one direction. Using the diagrams above, imagine that the inner races were locked stationary. The outer race would only be allowed to turn counter clock wise. In the clock wise direction, the outer race of both versions would be locked. In the roller type, the helper springs would push the rollers up the ramp on the outer race. This would force the rollers in to the smaller area which would cause the outer race to lock, In the sprag type, the asymmetrical wedges would lock between the inner and outer race.

The one way clutches are used in the transmission to prevent an interruption of drive torque during certain gear shifts and to allow engine braking during coasting. Also there is a one way clutch in the stator of the torque converter.

Planetary Gear Set

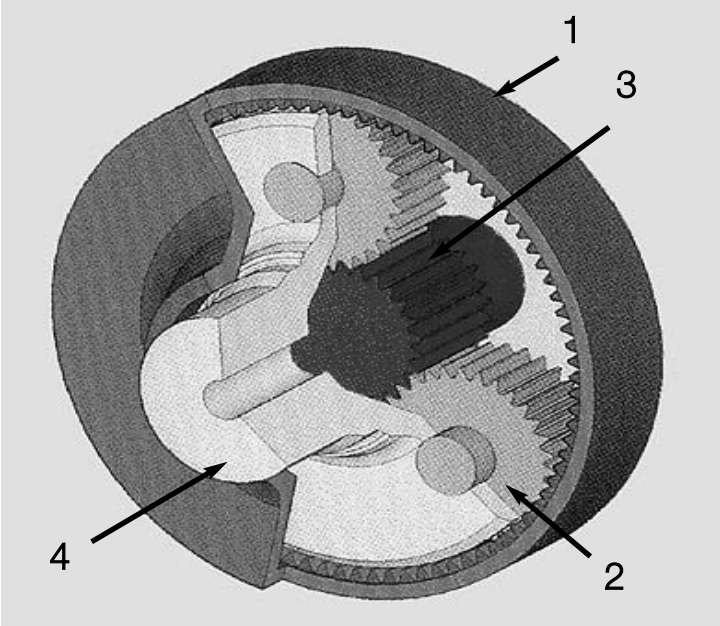
Planetary gear seats are compact gear units that receive input drive torque and provide the required output ratios for all forward gears and reverse gear. The planetary gear set consists of four main components:

1: Internal Ring Gear

2: Planetary Gears (pinions)

3: Sun Gear

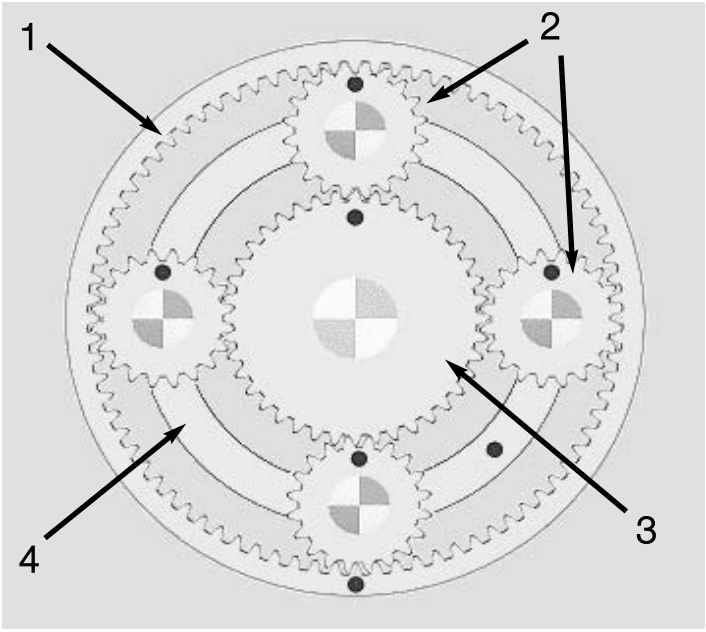
4: Planetary Gear Carrier



Various ratios are obtained by driving or holding different components in the planetary gear set. The example shown at right is a simple planetary gear set. Today's modern transmissions use a combination of multiple planetary gear sets referred to as a compound planetary gear set.

Advantages of Planetary Design

There are distinct advantages to the planetary gear set in comparison with a standard transmission gear set. Primarily, drive torque does not need to be interrupted to change gears. The planetary members are in constant mesh and there are more teeth engaged in any given ratio. This allows more torque to be transferred through the transmission.



Basic Power Flow

In the example shown at left, let's follow through an example of powerflow in reverse gear:

The Planetary gear carrier (4) is held stationary. The sun gear (3) is driven in a clockwise direction. The planetary pinions (2) are driven counter-clockwise, which in turn drives the internal ring gear (1) counter clockwise as well.

Compound Planetary Gear Sets

Compound planetary gear sets use multiple planetary components which are a variation on the simple planetary gear set. Since the inception of the simple planetary gear set, there have been numerous compound gear sets introduced. BMW transmissions use the following gear sets:

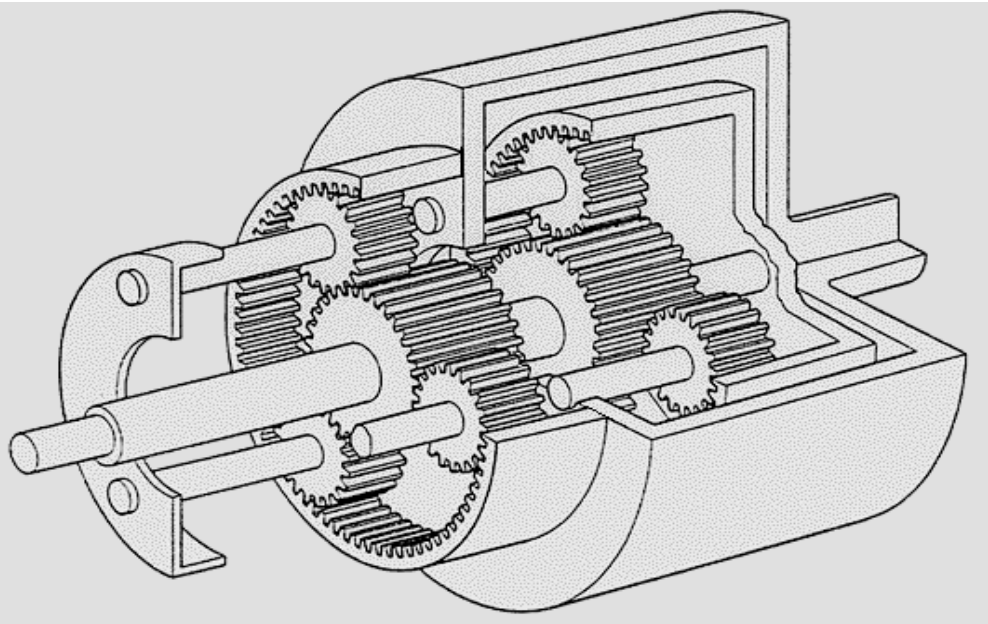
- Simpson Gear Set - used on 4HP22 and 4HP24
- Ravigneax Gear Set - used on A4S270R, A4S310R, A5S310Z, A5S325Z, A5S360R and A5S390R.
- Wilson Gear Set - used on A5S440Z and A5S560Z
- Lepelletier Gear Set - used on the GA6HP26Z.

Simpson Gear Set

The Simpson Gear Set is one of the early variations on the simple set. It is capable of 3 forward gears and one reverse. On BMW transmissions, the Simpson Gear set is used in the 4HP transmission which is a four speed automatic. Fourth gear (overdrive) is obtained by the addition of an auxiliary gear set (simple).

Characteristics of the Simpson Gear set are as follows:

- Two Internal Ring Gears, one rear input ring and one attached to the rear planetary carrier.
- Two Planetary carriers, each containing three planetary pinions.
- One common Sun gear, which meshes with both sets of planetary pinions.



Ravigneaux Gear Set

A new variation on the planetary design is the Ravigneaux gear set. This gear set is capable of 4 forward gears and one reverse. However, depending upon application it may be used with an auxiliary gear set. Here are some examples:

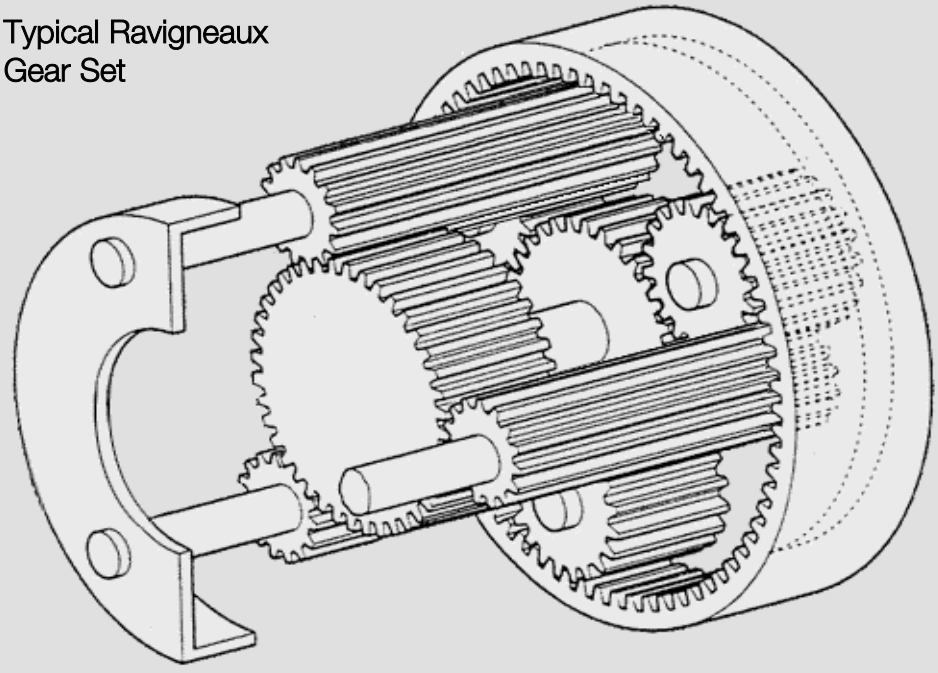
- A4S310/270R uses the Ravigneax set for 3 forward gears and one reverse. Overdrive is obtained by the auxiliary gear set.
- A5S310Z uses a combination of the Ravigneaux gear set and the auxiliary gear set to obtain 5 forward gear and one reverse. First, second and reverse gears are achieved by using a combination of both gear sets.
- The A5S360/390R uses a modified version of the ravigneaux set that provides five forward gears and one reverse. There is no auxiliary gear set used.

Characteristics of the Ravigneaux Gear Set are:

- One planetary carrier which is common to both sets of planetary pinions. *
- Two sets of planetary pinions, one long set with small diameter and one short set with large diameter. *
- Two sun gears, one input sun gear and one reaction sun gear. *
- One common ring gear. *

* Note: The Ravigneaux Gear Set shown below is a typical representation. There are a few variations of this arrangement used on BMW transmissions.

Typical Ravigneaux Gear Set



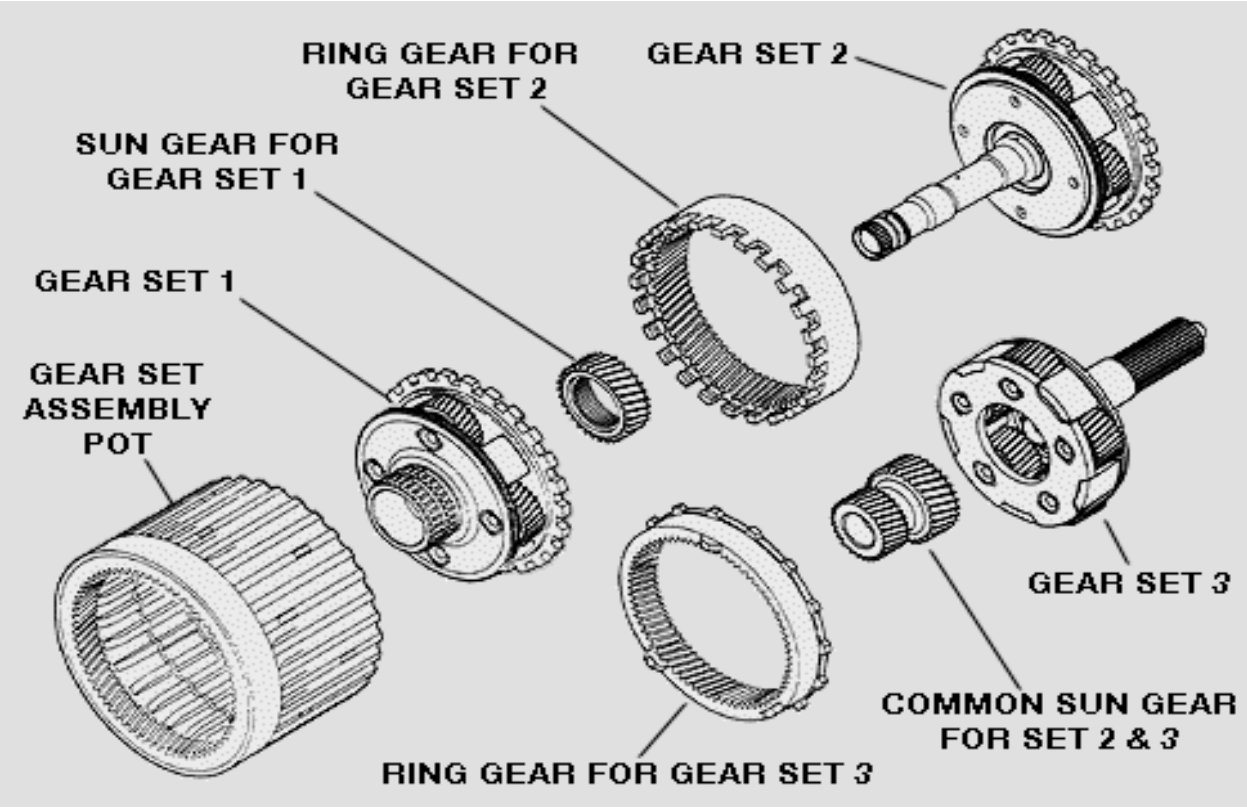
Wilson Gear Set

On BMW transmissions, the Wilson gear set is only used on the A5S440Z and A5S560Z. The Wilson Gear Set consists of three planetary gear sets.

The ring gear of the first gear set, the planetary carrier of the second gear set and the ring gear of the third planetary gear set and directly connected to the “Pot”. The “Pot” is a cylindrical device that slides over all of the components to unitize the individual gear sets into an assembly.

The characteristics of the Wilson Gear Set are:

- Three planetary carriers.
- Three ring gears, with ring gear 1 and 3 meshed to “Pot” assembly.
- Three sun gears, sun gear 2 and 3 are common. (Attached). Sun gears 2 and 3 are also referred to as the “Double Sun Gear”

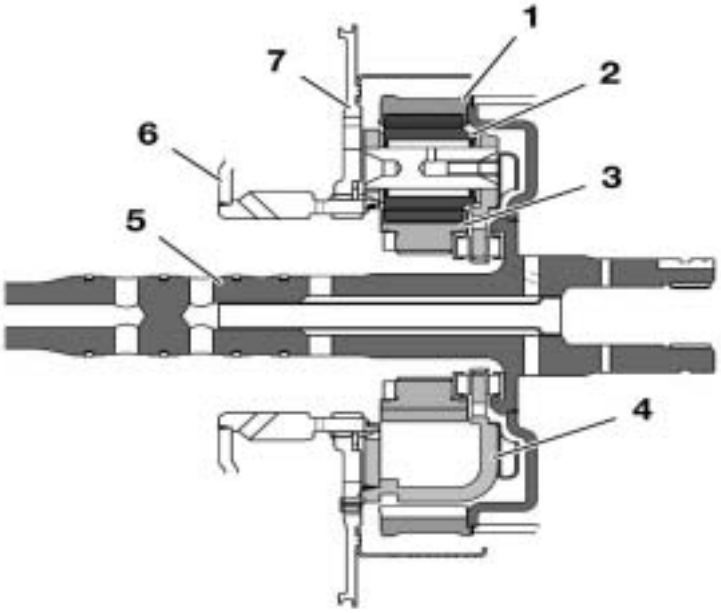


Lepelletier Gear Set

The Lepelletier Gear Set was introduced to BMW on the ZF GA6HP26Z. This gear set allows for 6 forward speeds and one reverse gear using a light weight design. The planetary gear train consists of a single carrier planetary gear train and a downstream double planetary gear train.

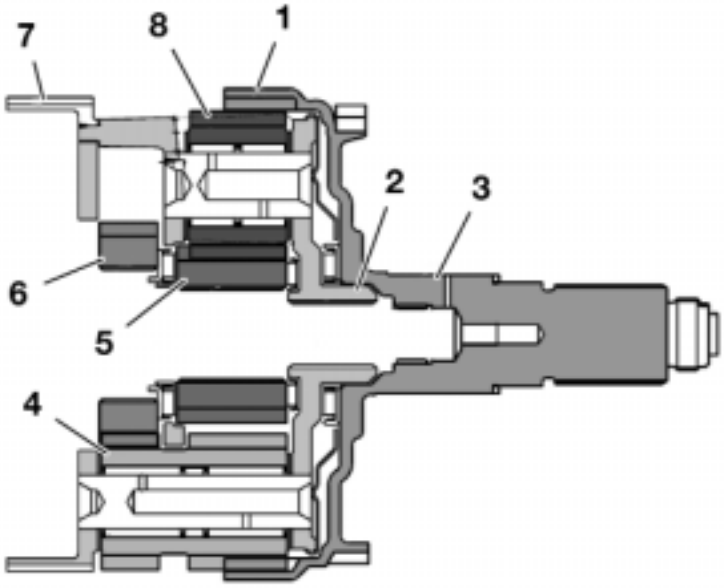
Lepelletier Gear Set

1. Internal Ring Gear 1
2. Planet Gear (pinion)
3. Planet Carrier
4. Planet Carrier
5. Turbine Shaft
6. Cylinder A
7. Pressure Plate A



Double Planetary Set

1. Internal Gear 2
2. Planet Carrier Clutch E
3. Output
4. Double Planet Gear Long
5. Sun Gear 3, Clutch E
6. Sun Gear 2, Clutch A
7. Planer carrier 1
8. Planet Gear (short)

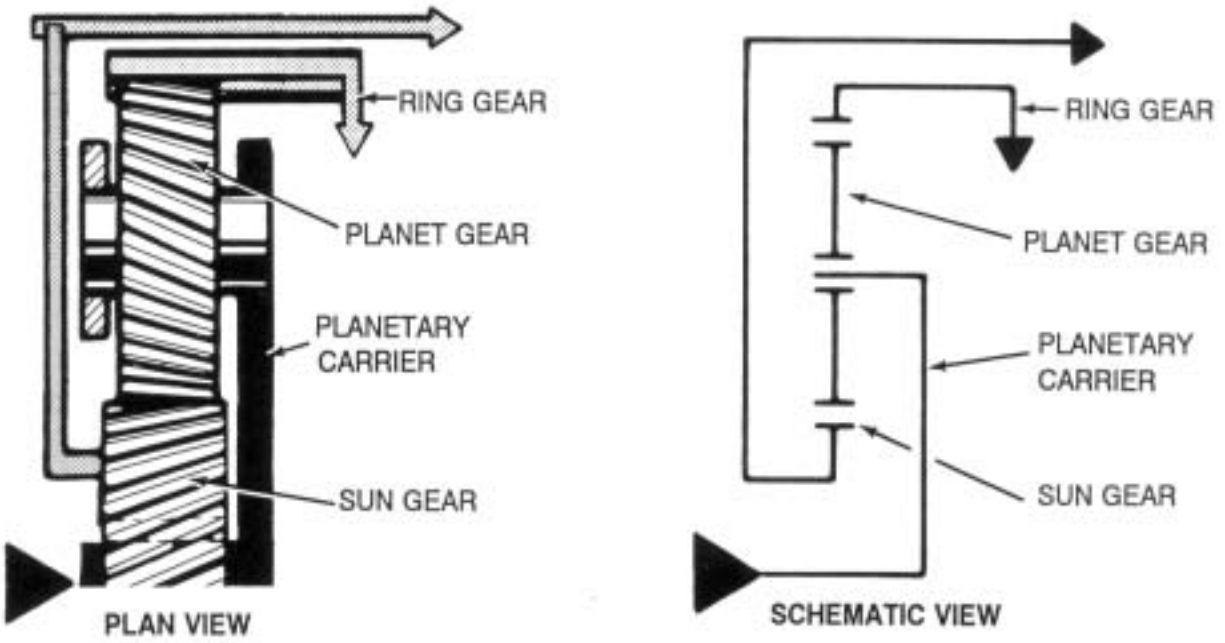


Planetary Gear Set Operation

In order to understand planetary gear set operation, it is important to understand some basic rules of operation.

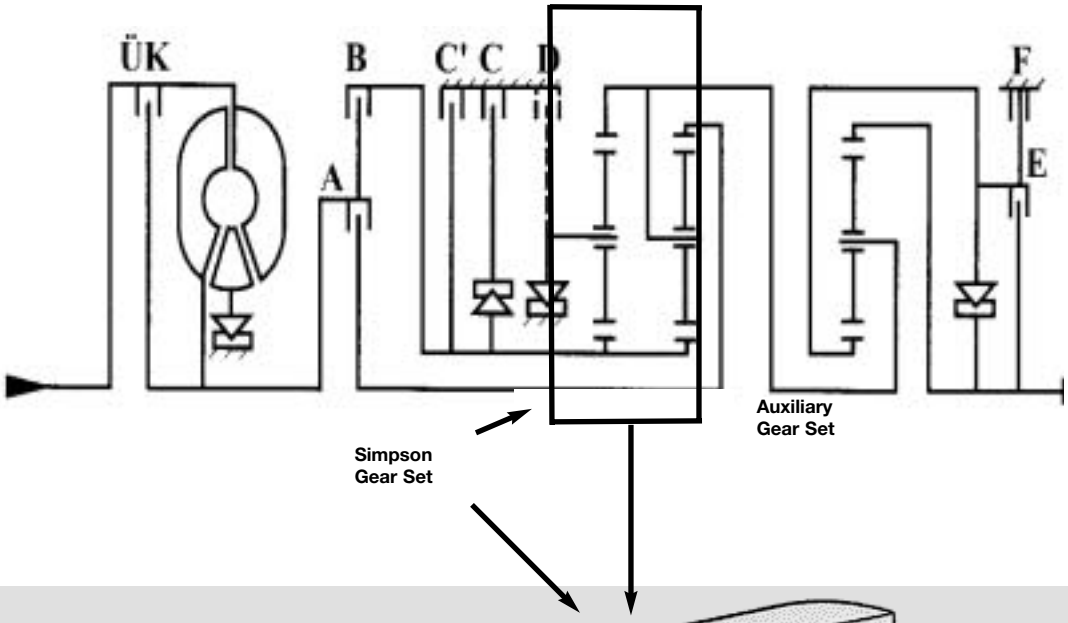
- It is assumed that engine rotation is clockwise when referring to power flow chart s and diagrams.
- Planetary pinions will always rotate in the same direction as the internal ring gear.
- When the sun gear is driven clockwise and the planetary carrier is held stationary the internal ring gear will rotate counter clockwise (reverse gear).
- When two or more planetary members are locked together, the assembly will rotate together. The ratio from input to output is 1:1.
- When the sun gear is held stationary and the planetary carrier is driven clockwise, the ring gear will be driven clockwise in an overdrive ratio. (i.e. .75:1)

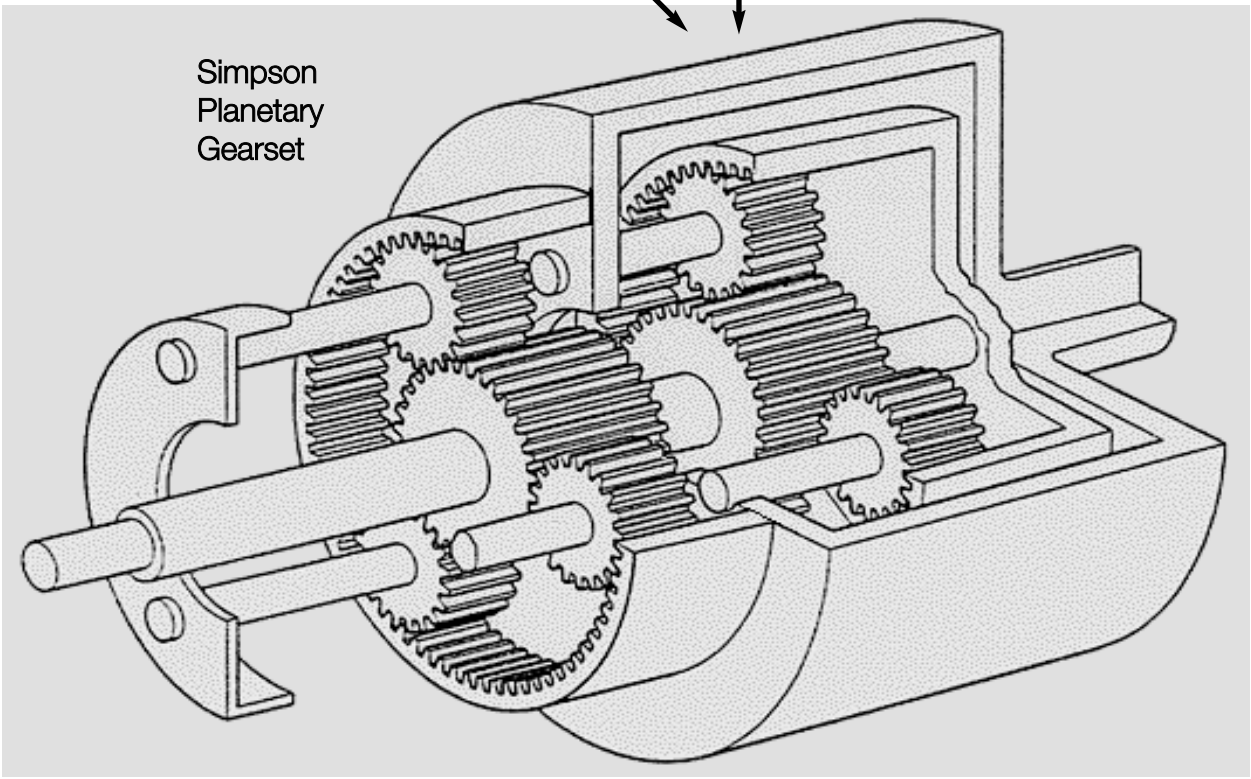
When trying to understand powerflow schematics, it is important to be able to draw a comparison between the actual planetary components and the schematic symbols. The diagram below outlines the relationship between these components and the powerflow schematic. The schematic is a representation of a cross section of the transmission, but you only see the top half of the cross section. The transmission is shown as though it has been quartered lengthwise.



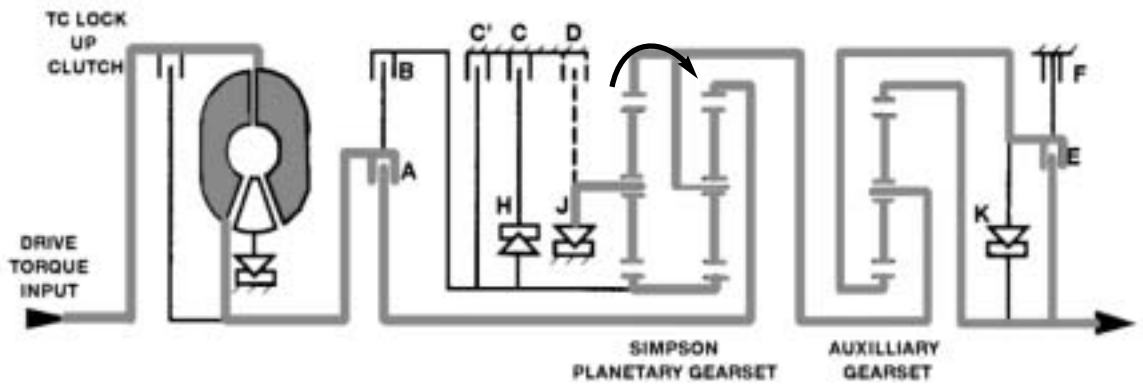
Power Flow Schematic

In order to understand power flow schematics, a relationship must be drawn between the actual components and the schematic representation. In our example, we are going to use the 4HP22/24 powerflow schematic. The 4HP22/24 transmission uses a Simpson Planetary Gearset and an auxiliary gearset. The auxiliary gear set is a simple planetary gearset.





Power Flow Schematic

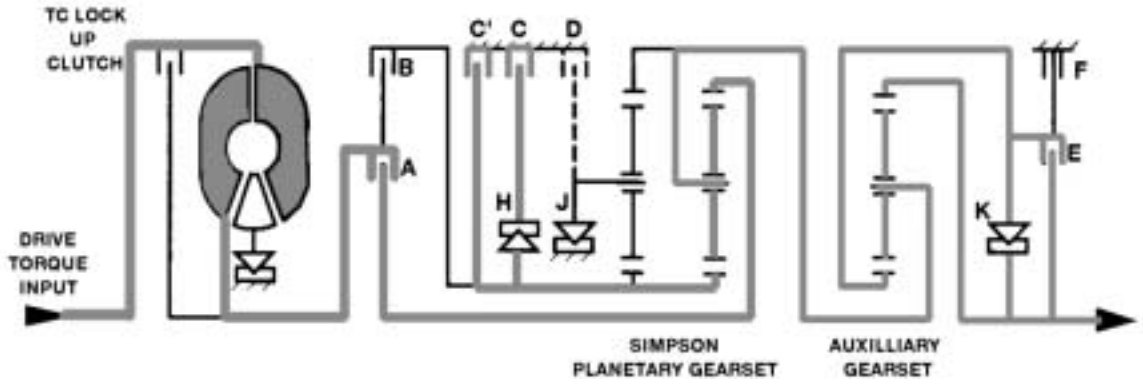


Power flow in first gear - Drive torque is applied to the torque converter impeller and transferred to the turbine. The turbine shaft rotates clockwise (CW). The "A" clutch locks the turbine shaft to the rear input ring gear. The rear input ring gear rotates CW driving the rear planet pinions CW. The planetary pinions drive the common sun gear CCW, which in turn drive the front planet pinions CW. The front planetary carrier is held from rotating CCW by one way clutch "J". The front planetary pinions which are rotating CW drive the front ring gear/rear carrier CW. The rear planetary carrier is rotating CW and is driving the planetary carrier from the auxiliary gear set. The "E" clutch in the auxiliary gear set is holding the Sun gear and the ring gear together. Therefore the auxiliary gear set is locked in a 1:1 ratio.

One Way Clutch "J" is locked prevent the front planetary carrier from rotating CCW. One Way Clutch "H" is not used and One Way Clutch "K" is locked. One way clutch "K" is used to prevent an interruption in power flow before the "E" clutch is locked during the 4-3 shift.

POSITION GEAR	D				3			2		1	R
	1	2	3	4	1	2	3	1	2	1	R
Clutch A	X	X	X	X	X	X	X	X	X	X	
Clutch B			X	X			X				X
Clutch C'		X				X			X		
Clutch C		X	X	X		X	X		X		
One Way Clutch H		X				X			X		
Clutch D										X	X
One Way Clutch J	X				X			X		X	
Clutch E	X	X	X		X	X	X	X	X	X	X
One Way Clutch K	X	X	X		X	X	X	X	X	X	X
Clutch F				X							

Second Gear

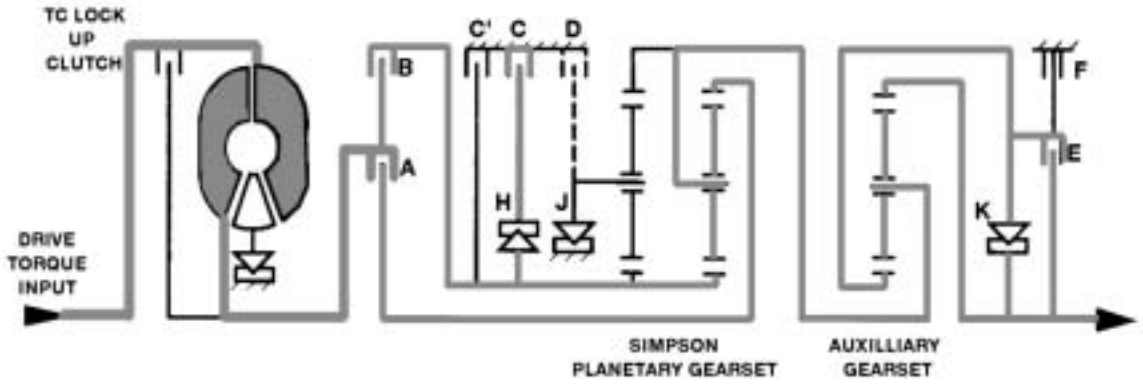


Second Gear - Drive torque is applied to the torque converter impeller and transferred to the turbine. The turbine shaft rotates clockwise (CW). The "A" clutch locks the turbine shaft to the rear input ring gear. The rear input ring gear rotates CW driving the rear planet pinions CW. The sun gear is held stationary by the C' clutch. The rear planet pinions rotate around the fixed sun gear CW. The rear planetary carrier will rotate CW. The rear planetary carrier will drive the auxiliary gear set will will rotate as a complete unit. The auxiliary gear set is locked in a 1:1 ratio due to the "E" clutch locking the sun and ring gear together.

The "C" clutch is locking the outer race of the "H" freewheel to the case. This is used for the 3/2 downshift. Freewheel "J" is not active and Freewheel "K" is locked.

POSITION GEAR	D				3			2		1	R
	1	2	3	4	1	2	3	1	2	1	R
Clutch A	X	X	X	X	X	X	X	X	X	X	
Clutch B			X	X			X				X
Clutch C'		X				X			X		
Clutch C		X	X	X		X	X		X		
One Way Clutch H		X				X			X		
Clutch D										X	X
One Way Clutch J	X				X			X		X	
Clutch E	X	X	X		X	X	X	X	X	X	X
One Way Clutch K	X	X	X		X	X	X	X	X	X	X
Clutch F				X							

Third Gear

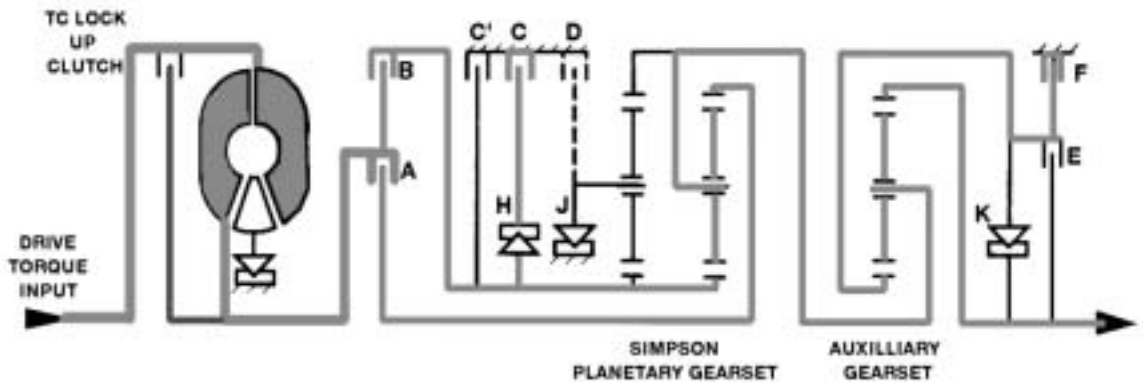


Third Gear - Drive torque is applied to the torque converter impeller and transferred to the turbine. The turbine shaft rotates clockwise (CW). The “A” clutch and the “B” clutch are locked, this causes the rear input ring gear to be locked to the sun gear in the Simpson Gear set. The Simpson gear set is locked in a 1:1 ratio. The “E” clutch is locked which locks the ring gear to the sun gear in the Simpson gear set. The entire transmission planetary system is now locked in a 1:1 ratio.

Freewheel “H” is overrun and freewheel “J” is not used. Freewheel “K” continues to be locked.

POSITION GEAR	D				3			2		1	R
	1	2	3	4	1	2	3	1	2	1	R
Clutch A	X	X	X	X	X	X	X	X	X	X	
Clutch B			X	X			X				X
Clutch C'		X				X			X		
Clutch C		X	X	X		X	X		X		
One Way Clutch H		X				X			X		
Clutch D										X	X
One Way Clutch J	X				X			X		X	
Clutch E	X	X	X		X	X	X	X	X	X	X
One Way Clutch K	X	X	X		X	X	X	X	X	X	X
Clutch F				X							

Fourth Gear

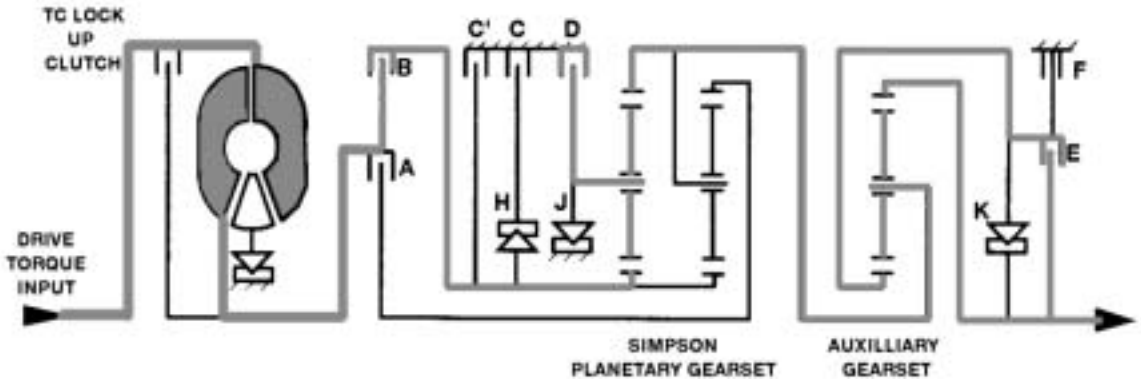


Fourth Gear - Drive torque is applied to the torque converter impeller and transferred to the turbine. The turbine shaft rotates clockwise (CW). (The turbine shaft can also be driven by the lock up clutch when engaged). The “A” clutch and the “B” clutch are locked, this causes the rear input ring gear to be locked to the sun gear in the Simpson Gear set. The Simpson gear set is locked in a 1:1 ratio. The “F” clutch is locked which locks the sun gear in the auxiliary gear set to the case. The Simpson gear set drives the planetary carrier CW. The planet pinions walk around the fixed sun gear in a CW direction. This causes the ring gear to rotate CW as well. The ring gear, which is the output of the transmission is driven in a overdrive ratio.

Freewheel “H” and “K” are overrun. Freewheel “J” is not used.

POSITION GEAR	D				3			2		1	R
	1	2	3	4	1	2	3	1	2	1	R
Clutch A	X	X	X	X	X	X	X	X	X	X	
Clutch B			X	X			X				X
Clutch C'		X				X			X		
Clutch C		X	X	X		X	X		X		
One Way Clutch H		X				X			X		
Clutch D										X	X
One Way Clutch J	X				X			X		X	
Clutch E	X	X	X		X	X	X	X	X	X	X
One Way Clutch K	X	X	X		X	X	X	X	X	X	X
Clutch F				X							

Reverse Gear



Reverse Gear - Drive torque is applied to the torque converter impeller and transferred to the turbine. The turbine shaft rotates clockwise (CW). The "B" clutch is locked which drives the sun gear in the Simpson gear set CW. The sun gear drives the planet pinions CCW. The planetary carrier is held stationary by the "D" clutch. The planet pinions cause the front ring gear to rotate CCW. The front ring gear (and rear carrier) drive the auxiliary gear set CCW which rotates at a ratio of 1:1 due to the "E" clutch locking the sun and ring gear of the auxiliary gear set.

Freewheel "H" and "J" are not used. Freewheel "K" is locked.

POSITION GEAR	D				3			2		1	R
	1	2	3	4	1	2	3	1	2	1	R
Clutch A	X	X	X	X	X	X	X	X	X	X	
Clutch B			X	X			X				X
Clutch C'		X				X			X		
Clutch C		X	X	X		X	X		X		
One Way Clutch H		X				X			X		
Clutch D										X	X
One Way Clutch J	X				X			X		X	
Clutch E	X	X	X		X	X	X	X	X	X	X
One Way Clutch K	X	X	X		X	X	X	X	X	X	X
Clutch F				X							

Shift Control

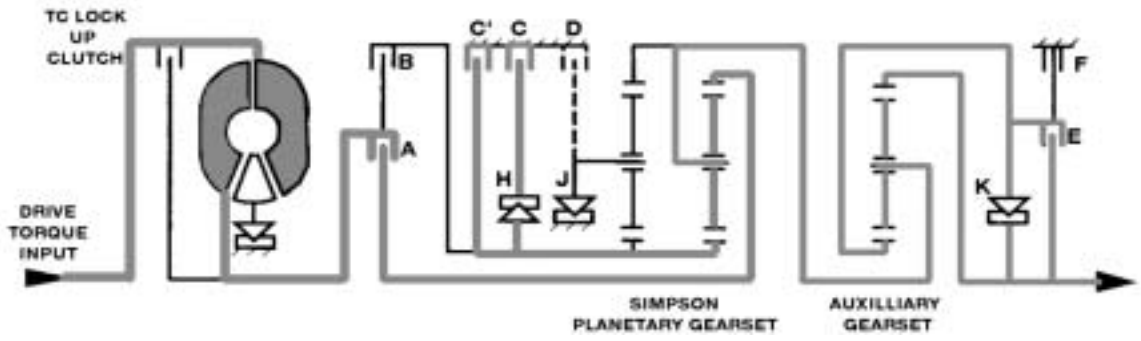
Freewheel Shifting

In order to prevent an interruption in power flow, freewheel (One Way Clutches) are used to lock members of the planetary gear set. Certain transmissions such as the 4HP22/24, A4S270/310R and the A5S360R use freewheel shifting on all gear shifts. Transmissions such as A5S310Z, A5S440Z, A5S560Z and GA6HP26Z use freewheel shifting for only specific shifts. Other shifts in these transmissions use overlap shifting technology.

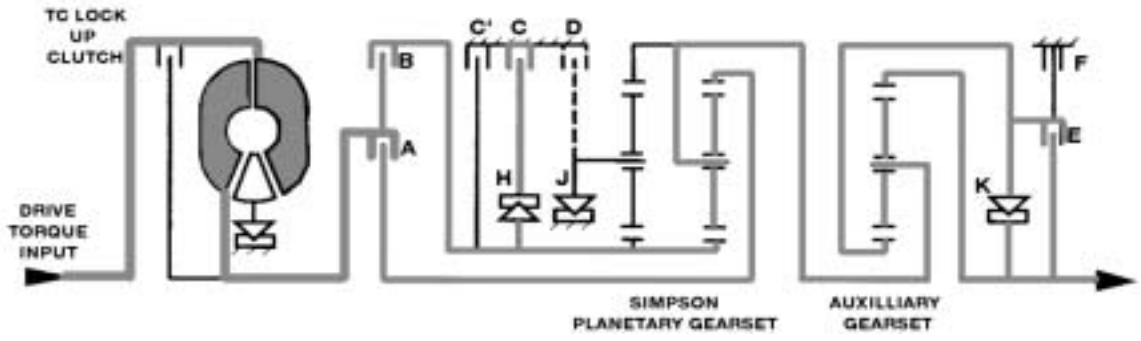
The demonstrate how the freewheel is used, we will examine freewheel “H” in the 4HP22/24 transmission.

In third gear, the sun gear is rotating clockwise. Freewheel “H” is overrun (unlocked) allowing the sun gear to rotate. Clutch “C” is active which locks the outer race of freewheel “H” to the case. During a 3/2 downshift, clutch “B” is released. The sun gear is held from rotating counter clockwise by freewheel “H” and the C’ clutch. Freewheel “H” is used to stop the counter clockwise rotation of the sun gear before the C’ clutch can engage. This prevents an interruption of power flow during the 3/2 downshift. If freewheel “H” fails to operate, there would be an increase in engine RPM from 3rd to 2nd gear.

Second Gear



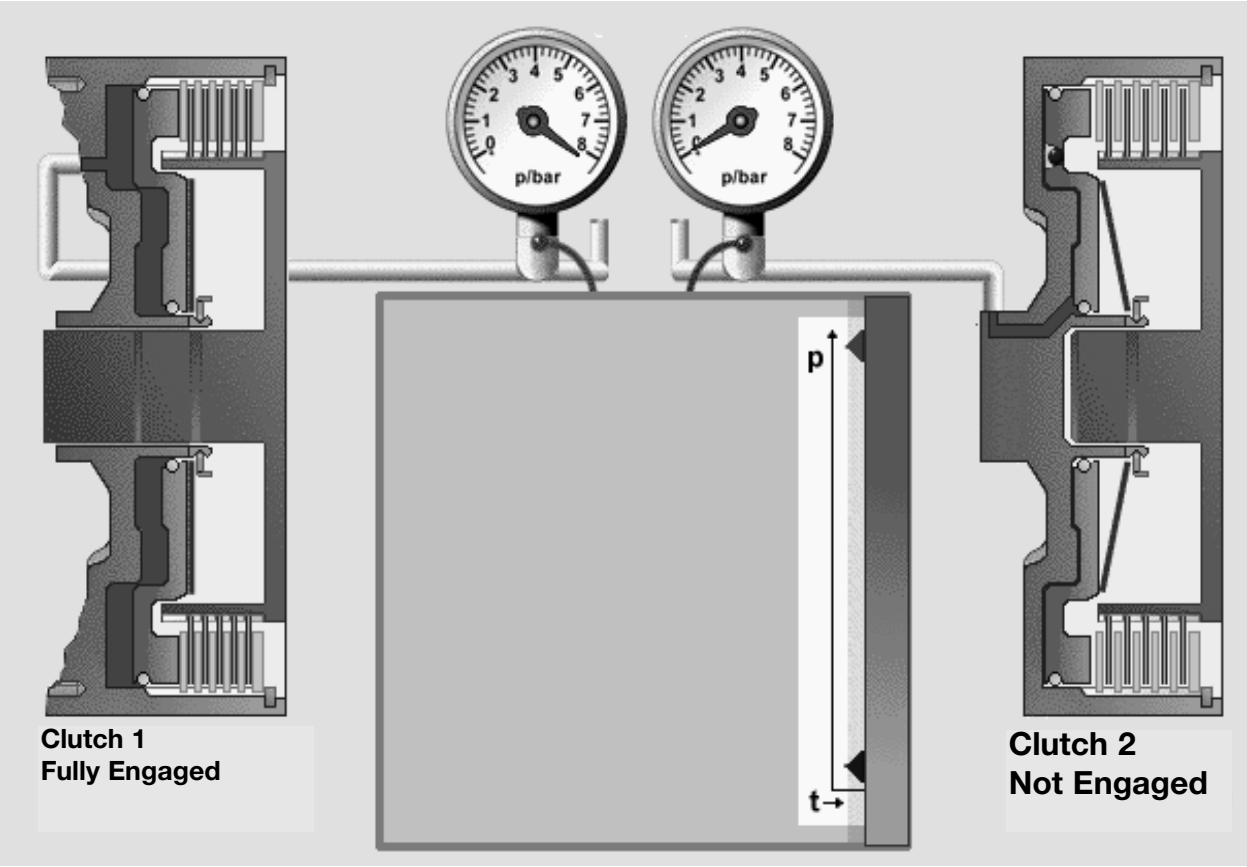
Third Gear



Overlap Shift Control

Overlap shift technology is currently used on ZF transmissions. The A5S310Z, A5S440Z, A5S560Z and the GA6HP26Z use overlap shift technology on most gear changes. The advantages of this design allows for the reduction of the use of One Way Clutches (free-wheel) and a significant improvement in shift quality.

During an overlap shift, the releasing clutch pressure is reduced at the same rate that the engaging clutch pressure is increased. The result is a smooth transfer or torque between gear ratios.

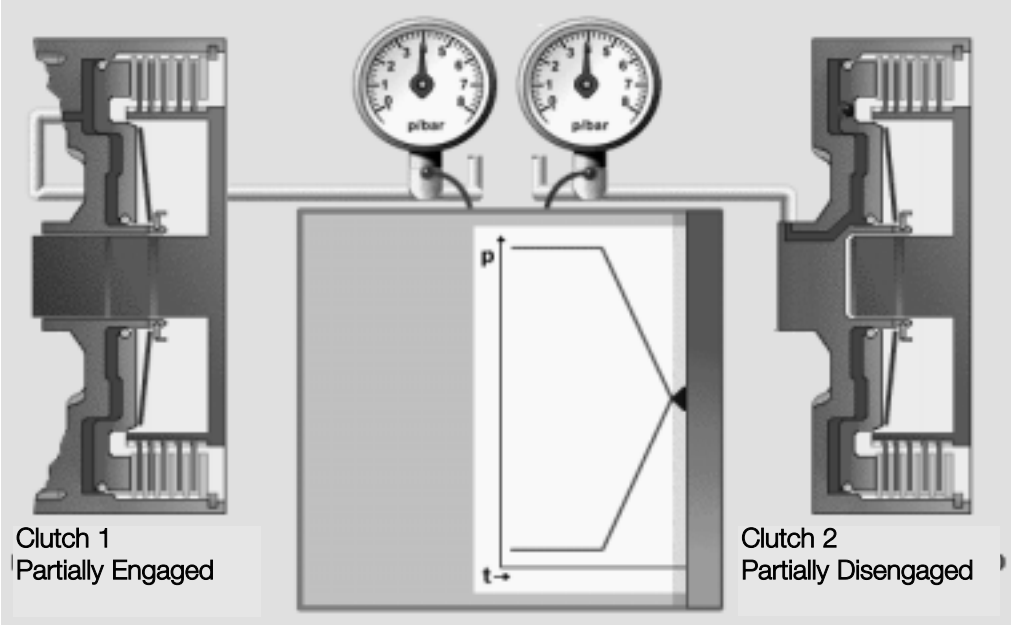


As shown in the diagram above, Clutch 1 is fully engaged with maximum pressure. Clutch 2 is fully released.

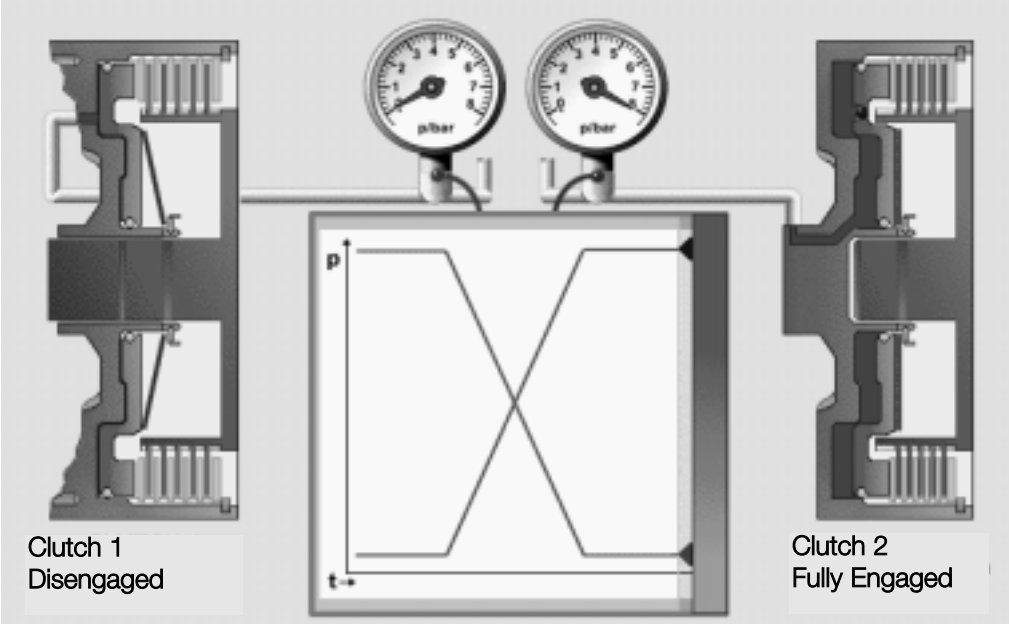
During overlap shifting, the TCM closely monitors the rotational speeds of the turbine (input) shaft and output shaft. The TCM then uses the EDS solenoids to control pressures during shifting to provide the optimum shift timing and overlap control.

Overlap Shifting

During the transition of overlap, the clutches run through a slip zone. The torque is gradually transferred from the clutch that is releasing to the clutch that is engaging.



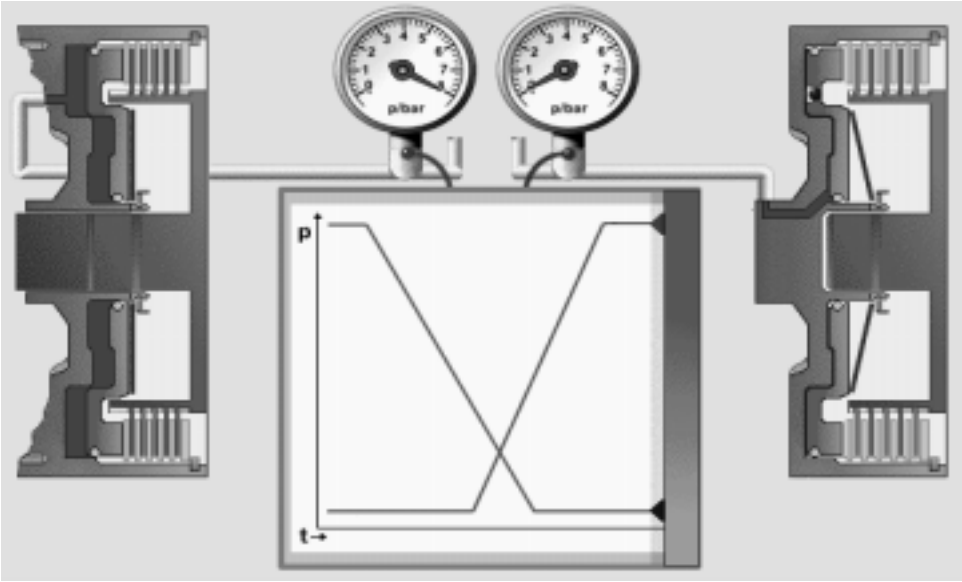
The new gear engages the moment the torque level exceeds that of the first clutch. This is described as overlap. If the overlap is correct, (zero overlap) the engaging clutch takes over as much torque as the disengaging clutch releases. The result is a seemingly unnoticed shift of the best quality.



Negative Overlap

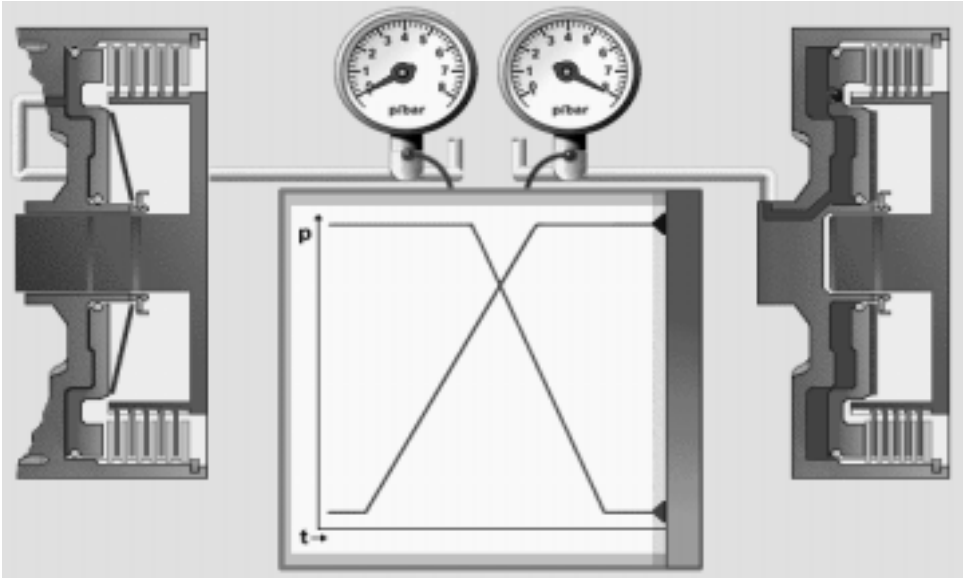
Negative overlap occurs when the engaging clutch takes over too late or the releasing clutch drops pressure too early.

The result is that the drive torque is briefly interrupted. When the engine is operating under load, the engine speed increases due to the interruption. When coasting the engine speed drops.



Positive Overlap

If positive overlap occurs, the engaging clutch takes over too early or the releasing clutch pressure drops too late. The gear set would become momentarily blocked if this condition occurs during an upshift. When this occurs the ratio of the gear set becomes 1:1 momentarily. The result is a loss in drive torque during a gear shift.



Transmission Control Module

The TCM receives inputs, processes information and actuates the output elements to provide optimal shift points. The TCM is programmed for maximum shift comfort and fuel economy. The TCM on most BMW vehicles is located in the E-Box next to the ECM (DME).

There are several types of TCM housings:

- 35 Pin TCM (TCU) - used on the 4HP transmissions
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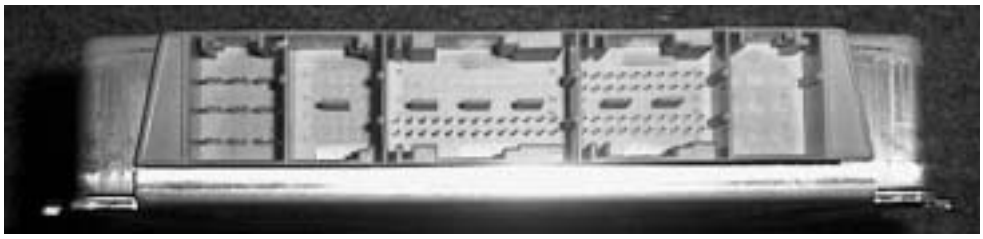
- 88 Pin TCM used on all others up to 98
- 134 Pin TCM used on all BMW transmission from the 99 model year.
  (Note- the 134 pin TCM was introduced on the 98 Models equipped with the A5S440Z).

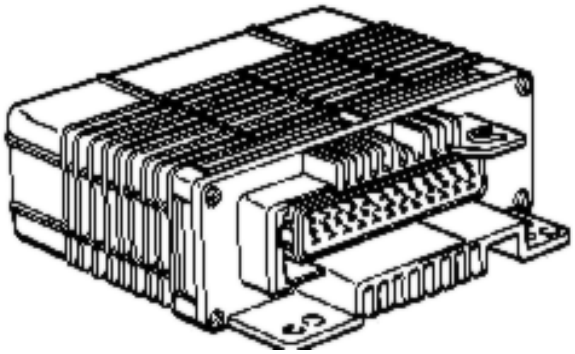
The 134 Pin TCM is also referred to as SKE (Standard Shell Construction). The SKE housing uses 5 separate connectors. On transmission applications only three connectors 1, 3 and 4) are used. Connectors 2 and 5 are blank and are NOT used. The connectors are blue in color to avoid confusion with the ECM (DME) connectors which are black.

134 Pin TCM with SKE housing

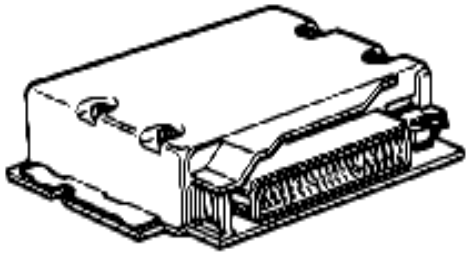


Connectors 1 2 3 4 5

55 Pin TCM



88 Pin TCM



Review Questions

1. Place the letter of the transmission fluid next to the correct transmission:

   A. ESSO LT 71141 B. Shell LA2634 C. Texaco ETL 7045

   D. Texaco ETL 8072B E. Dexron III/Mercon F. MTF LT-1

   A5S440Z _____ A5S390R _____ 4HP22 EH _____

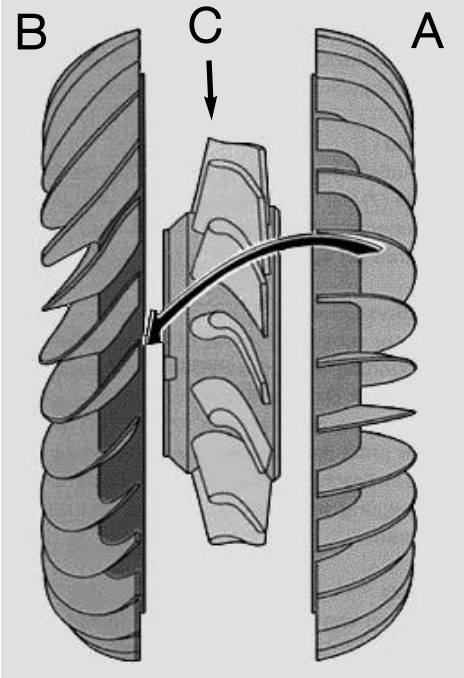
   A4S270R _____ A5S560Z (E32) _____ A5S325Z _____

2. Name the following components of a torque converter:

   A. _____

   B. _____

   C. _____



3. When at high engine speeds, the one way clutch in the stator of the torque converter is locked.

   A. True B. False

4. Which of the following transmissions use a Vane Type oil pump?

   A. A5S560Z B. A5S325Z C. A4S270R D. A5S360R

5. Which of the following transmissions use a *gradual* application of the torque converter clutch?

   A. A5S310Z B. A5S560Z C. A4S270R D. 4HP24 EH

6. Which of the following transmissions use the Wilson Gear Set?

   A. A5S440Z B. A5S360R C. A5S310Z D. A4S310R

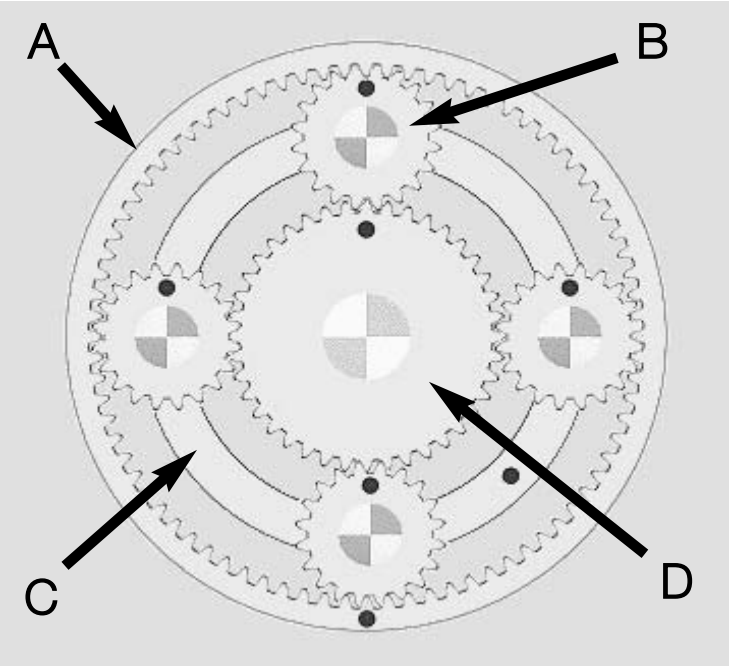
7. Name the following components of a planetary gear set:

   A. _____

   B. _____

   C. _____

   D. _____



8. Which of the following transmissions uses overlap shift control?

   A. A5S360R B. 4HP22/24 C. A4S310R D. A5S560Z

9. Which of the following statements below best describes Negative Overlap?

   A. The engaging clutch takes over too early and/or the releasing clutch pressure releases too late.

   B. The engaging clutch takes over too late and/or the releasing clutch pressure drops too early.

   C. The engaging clutch takes over too early and/ or the releasing clutch pressure drops too early.

   D. The releasing clutch pressure is reduced at the same rate as the engaging clutch pressure.

10. Which of the following statements is NOT true regarding the operation of the torque converter?

    A. The impeller is connected to the input shaft via splines.

    B. The turbine is driven by fluid from the impeller.

    C. The stator re-directs fluid to the impeller at low speeds.

    D. The one-way clutch in the stator overruns (unlocks) at high speed.

11. List the two types of One-Way Clutches used in BMW automatic transmissions:

    _____ _____

12. Place the letter of the gear set next to the appropriate transmission.

    A. Simpson B. Wilson C. Lepeletier D. Ravigneaux

    A4S270/310R _____ A5S360/390R _____

    A5S440Z _____ A5S560Z _____

    4HP22/24 _____ GA6HP26Z _____

    A5S310Z _____ A5S325Z _____

Table of Contents

Electronic Transmission Control

Subject **Page**

Initial Print Date: 1/15/03 Revision Date:

Model: All with BMW Automatic Transmission

Production: All

Objectives:

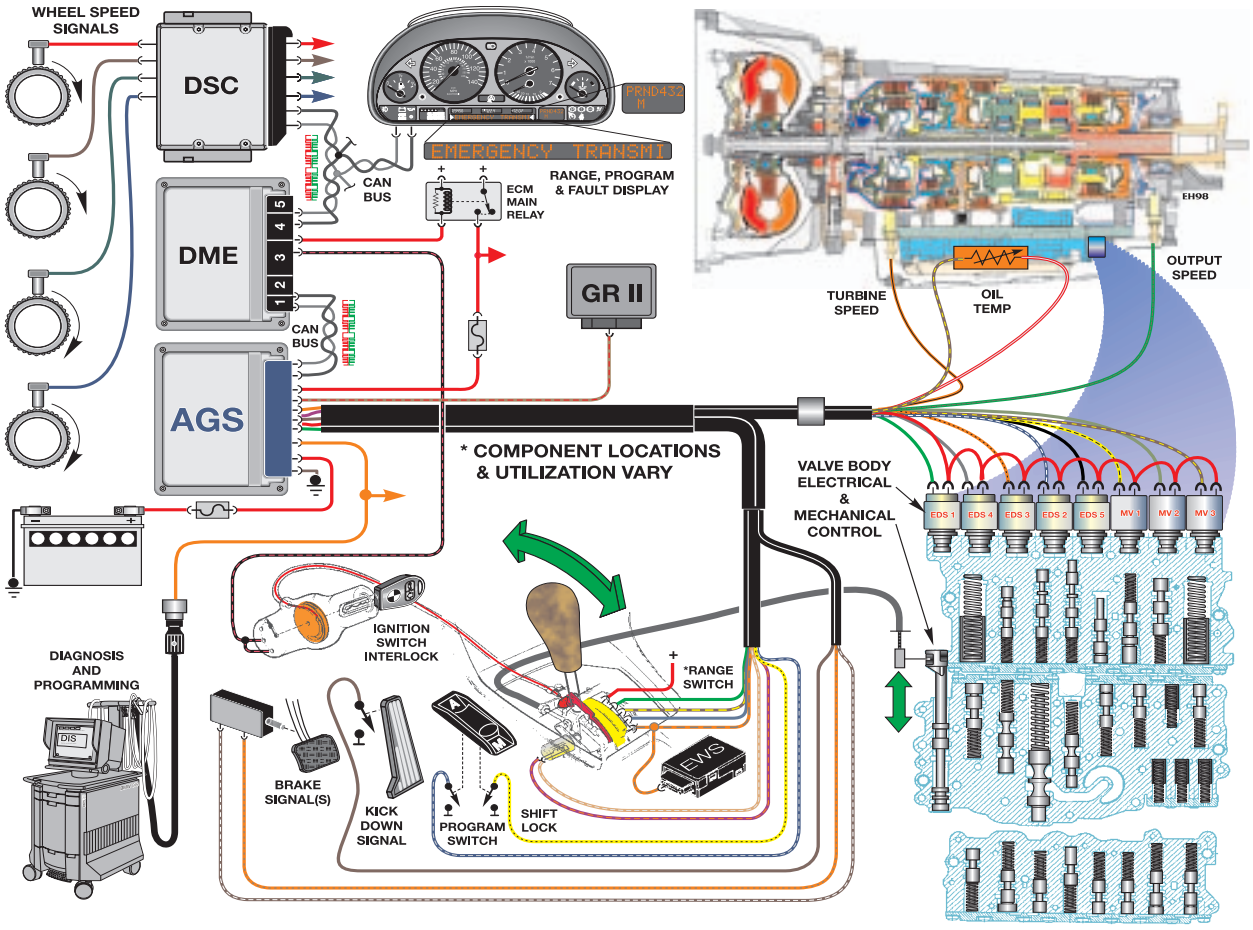
After completion of this module you will be able to:

- Identify BMW EH Automatic Transmissions.
- Identify Electronic Transmission Control Components
- Understand Electronic Transmission Operation
- Diagnose Transmission related faults using the DISplus or GT-1
- Understand service items and special tools.

Purpose of the System

Electronically controlled transmissions were introduced on BMW products in 1986 on 5 and 7 series vehicles. Currently EH (Electro-hydraulic) transmissions are offered on almost every production model (Except E46 M3 and E39 M5). EH transmissions offer the following benefits the to driver:

- Increased driving safety by reducing fatigue. All shifts are automatic as opposed to manual transmissions which require more driver interaction.
- Increased fuel economy through use of lock up torque converter.
- Increased fuel economy through optimized shift points.
- Improved shift comfort by use of “Overlap Shift” technology (ZF).
- More available features through the use of CAN bus technology.



The EH Control System is designed to work in conjunction with the engine electronics for precise shift control. The TCM receives information on engine RPM, load and throttle position to provide optimum shift points to maximize fuel economy and driver comfort.

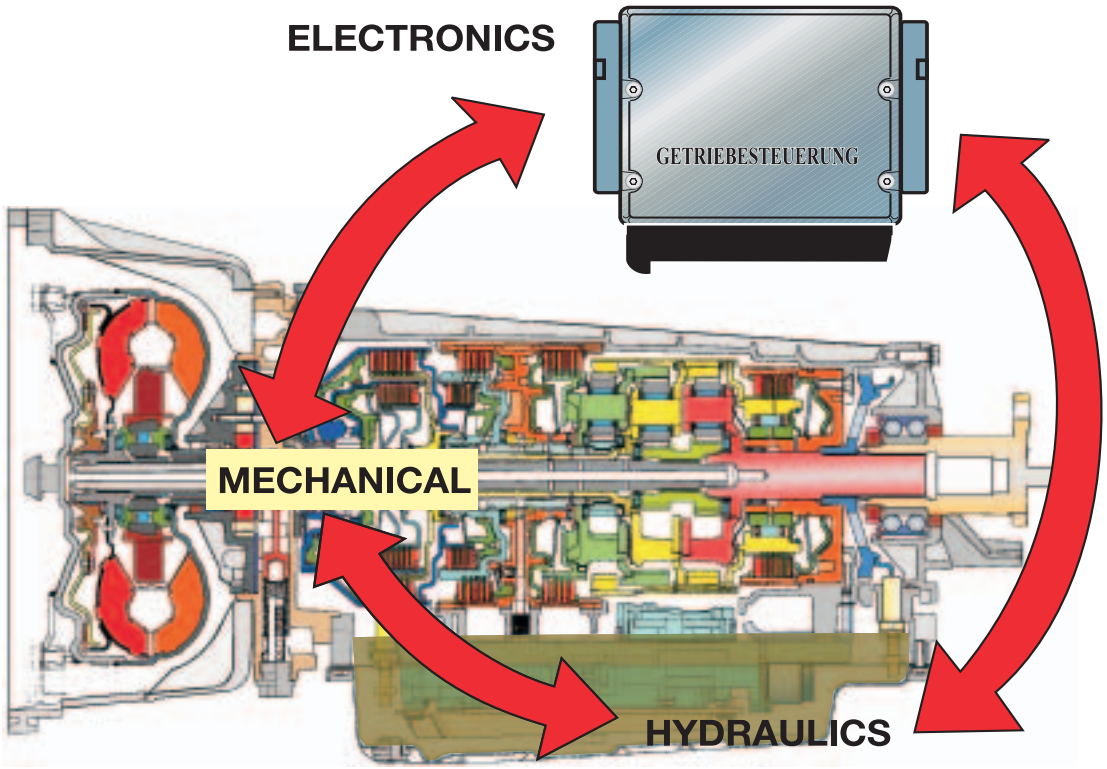
The function of an EGS System is to:

- Monitor all operating conditions through input signals
- Continually assess operating conditions by processing input data and select the appropriate operating program for current conditions.
- Activate transmission system components and to communicate with other drivetrain control systems.
- Respond to driver selected driving program (Economy, Sport or Manual).

In addition to providing shift control, the TCM also adapts to changing conditions within the transmission by monitoring slip ratios and modifying line pressure. This increases the life of the transmission and reduces maintenance and adjustments. The TCM controls the operation of the Lock-Up Torque Converter which further increases economy.

On current models, the TCM also has the capability of adapting to driver habits and responds to changing environmental conditions. Items such as rate of throttle input and kickdown requests are monitored to select the most appropriate shift program.

The EGS system is also required to maintain occupant safety, safeguard drivetrain damage, improve vehicle emissions and operate in failsafe mode when a malfunction occurs.



Transmission Version and Control Systems

Each BMW Electro-hydraulic transmission has a corresponding control system. They are designated “GS” which stands for Transmission Control. This acronym is from the German words **G**etriebe **S**teurung. Each transmission can have more than one control system, this depends upon application (model year, series etc.). Below is a listing of ZF control systems used on BMW vehicles, Hydramatic control systems are shown on the opposing page.

ZF Control Systems

Transmission BMW ID #	Manufacturer ID	Model/Year	Control System	Engine
4HP22 (EH)	4HP22 (EH)	86 535i 86 635i 86 735i	GS 1.2X GS 1.2X GS 1.2X	M30 M30 M30
4HP24 (EH)	4HP24 (EH)	88-9/91 750iL (E32) 92-94 750iL (E32) 90-94 850i/Ci (E31)	GS 1.27 GS 1.29 GS 1.29	M70 M70 M70
A5S310Z	5HP18	93 530i/iT (E34) 94 530i/iT (E34) 95 M3 (E36) 96-99 M3 (E36)	GS 7.3 GS 7.32 GS 7.11 GS 8.32	M60 M60 S50 (US) S52
A5S325Z	5HP19	00 323i/Ci/CiC (3/00-8/00) 01 323iT (from 4/01) 01-02 325i/Ci/CiC from 9/00 00-01 330i/Ci/CiC from 6/00 01- 525 from 3/01 01- 530 from 3/01 03 Z4 (E85) 2.5i and 3.0i	GS 8.60 GS 8.60 GS 8.60.4 GS 8.60.4 GS 8.60.4 GS 8.60.4 GS 8.60.4	M52 TU M52 TU M54 M54 M54 M54 M54
A5S440Z	5HP24	97 840Ci (E31) from 9/96 97 540i (E39) 1/97-8/97 97 740i/iL (1/97 - 4/97) 97 740i/iL (5/97-8/97) 98-03 540i 98-01 740i/iL 00- X5 4.4i	GS 8.55 (CAN index 50) GS 8.55 (CAN index 50) GS 8.55 (CAN index 50) GS 8.55 (CAN index 60) GS 8.60.2 (CAN index 60) GS 8.60.2 (CAN index 60) GS 8.60.2	M62 M62 M62 M62 M62, M62 TU 99-02 M62, M62 TU 99-01 M62TU
A5S560Z	5HP30	93-94 740i/iL (E32) 93 540i (E34) 94-95 540i (E34) 94-95 840Ci (E31) 95 740i/iL (E38) 95-01 750iL (E38) 96-97 740i/iL (-1/97) 96 840Ci (E31) 95-97 850Ci	GS 9.2 GS 9.2 GS 9.22 GS 9.22 GS 9.22 GS 9.22.1 GS 9.22.1 GS 9.22.1 GS 9.22.1	M60 M60 M60 M60 M60 M73/M73TU M62 M62 M73
GA6HP26Z	GA6HP26Z GA6HP26Z	02- 745Li (E65/E66) 03- 760Li (E66)	GS 19 GS 19	N62 N73

Hydramatic Control Systems

Transmission BMW ID #	Manufacturer ID #	Model/Year	Control System	Engine
A4S310R (THM-R1)	4L30-E(A4S310R) >>>	90-92 525i (E34) 93-95 525i (E34) 92 325i,is,ic (E36) 93-95325i,is,ic (E36) 92-95 318ti (E36)	GS 4.14 GS 4.16 GS 4.14 GS 4.16 GS 4.14 & GS 4.16	M50 M50 TU M50 M50 TU M42
A4S270R	4L30-E(A4S270R) >>>	96-98 328i (is,ic -97) 96-98 318i (is,ic-97) 96-98 318ti (E36/5) 96-98 Z3 1.9 (E36/7) 96-98 Z3 2.8 97-98 528i (E39)	GS 8.34 GS 8.34 GS 8.34 GS 8.34 GS 8.34 GS 8.34	M52 M44 M44 M44 M52 M52
A5S360R (GM5)	5L40-E (A5S360R) >>	99-00 323i/Ci (7/98-3/00) 99-00 328i/Ci (6/98-5/00) 99-00 528i (E39) 9/99-8/00 99-00 Z3 (E36/7) 2.3/2.8	GS 20 GS 20 GS 20 GS 20	M52 TU M52 TU M52 TU M52 TU
A5S390R (GM5)	5L40-E (A5S390R) >>	00-03 X5 3.0i (4/00 -) 01 325iT (8/00-3/01) 01-03 325xi/xiT & 330Xi (-8/00) 01 525i/iT (9/00-3/01) 01 530i (9/00-3/01) 01-02 Z3 2.5/3.0 (6/00-)	GS 20 GS 20 GS 20 GS 20 GS 20 GS 20	M54 M54 M54 M54 M54 M54

GS 20 TCM (Siemens)

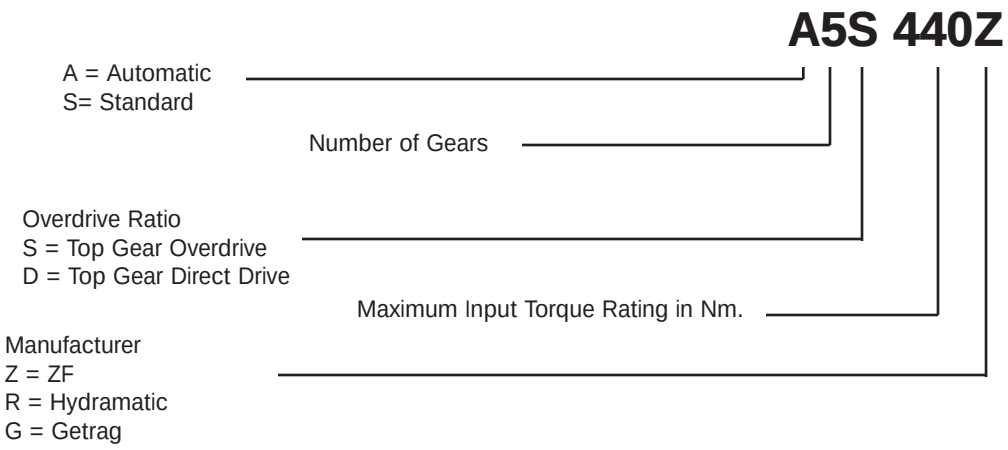
Transmission Identification

BMW automatic transmission are manufactured by two suppliers for the US market:

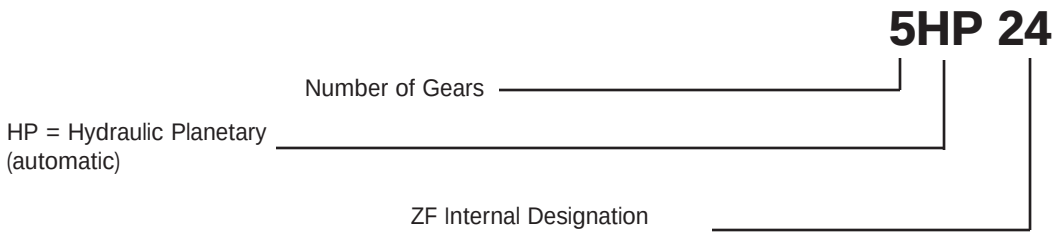
- **Zahnradfabrik Friedrichshafen:** Commonly referred to as ZF. ZF manufactures both manual as well as automatic transmissions.
- **GM Powertrain - Hydramatic:** Hydramatic is a manufacturing division of General Motors located in Strasbourg, France. Hydramatic supplies automatic transmissions to BMW for four and six-cylinder vehicles.

BMW has developed an internal numbering system for their transmissions for ordering parts, information research and identification. Also, each transmission manufacturer uses an internal identification system. Here is a breakdown of these identification codes:

BMW Identification Code Breakdown



ZF Identification Code Breakdown



Hydramatic Transmissions have internal designations , however they are not used often. The internal code for the A4S310/270R is 4L30-E and the A5S360/390R is 5L40-E.

Transmission ID Tag Location

In order to identify BMW transmissions there are identification tags located externally on the transmission case. The tag contains information such as Manufacturer, Serial number, transmission type etc. This information is needed when ordering parts, referencing bulletins and calling for technical assistance.

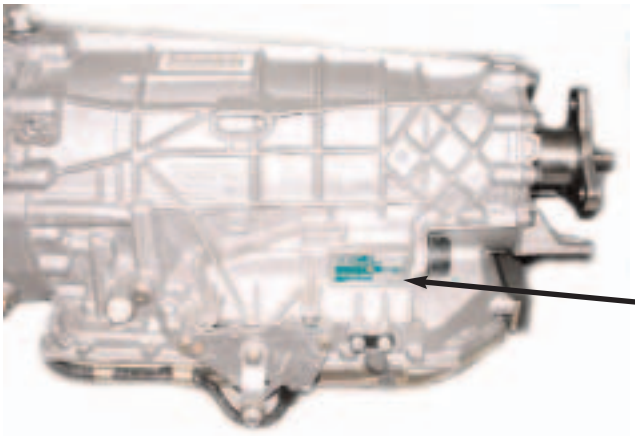
- **ZF - Tag is Located on -**

  1. Right hand side (passenger side) of transmission case. (5HP30 and 5HP18)

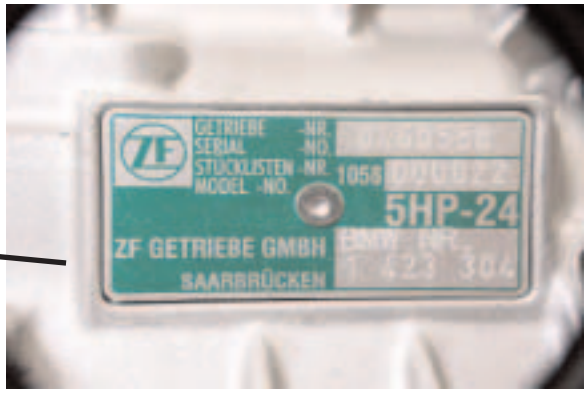
  2. Left hand side (drivers side) of transmission case. (6HP26Z, 5HP24 and all 4HP)

  3. Rear under output shaft. (5HP19)

ID Tag Location 5HP19

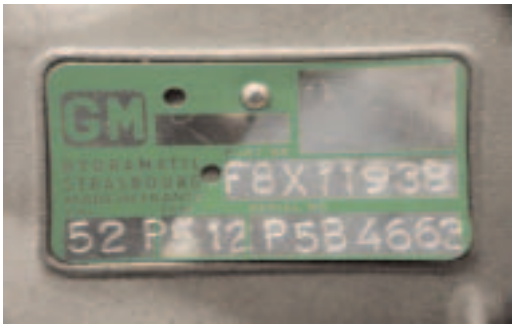


ID Tag Location 5HP24

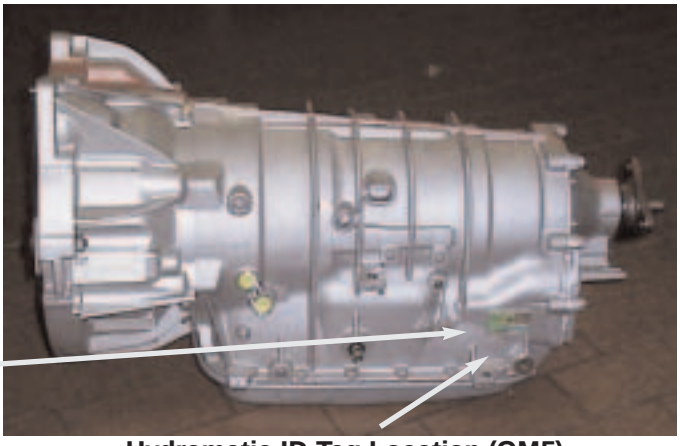


Typical ZF Tag

- **GM -** Located on left hand side (drivers side) of transmission case.

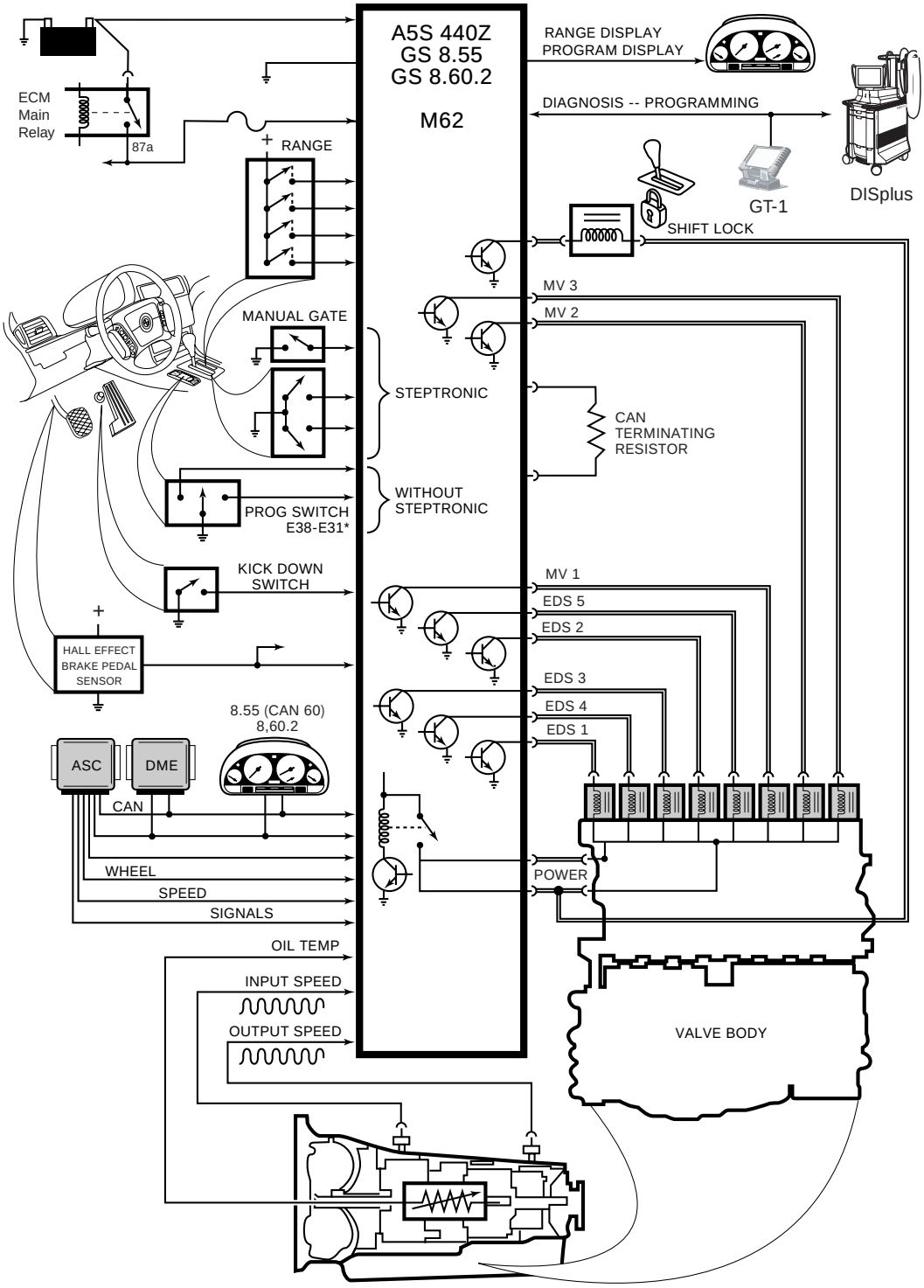


GM ID Tag (GM 5)



Hydramatic ID Tag Location (GM5)

System Components (Electrical)



Transmission Control Module

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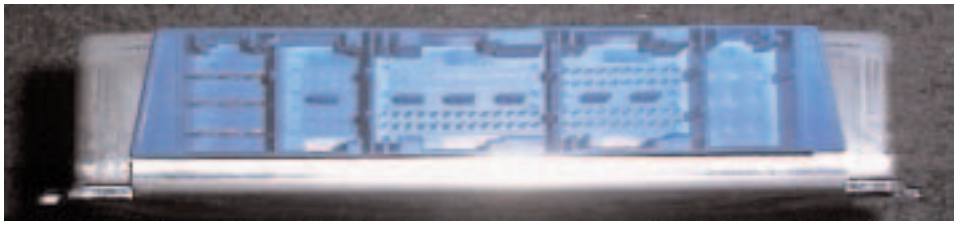
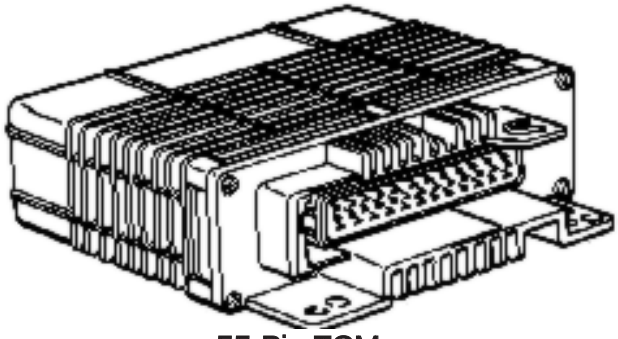
!34 Pin control modules are supplied by Bosch for ZF transmissions and Siemens for Hydramatic transmissions. Bosch and Siemens control modules are NOT interchangeable.

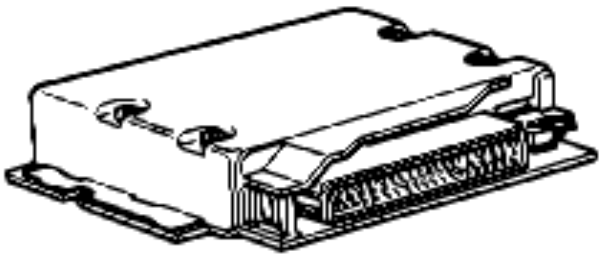
134 Pin TCM
with SKE housing



Connectors 1 2 3 4 5



55 Pin TCM



88 Pin TCM

Turbine Speed Sensor

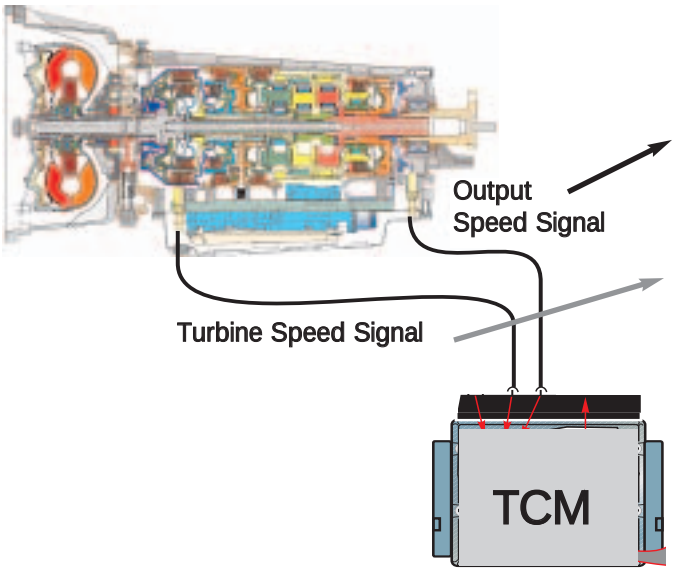
The Turbine Speed Sensor is used to provide input (turbine) shaft speed information to the TCM (EGS). The input shaft speed signal is used in conjunction with the output shaft speed signal to determine gear range and slip time information for processing in the TCM. Not all BMW transmissions use a turbine speed sensor. Some TCM's use the TD (engine speed) signal to determine input shaft speed. All transmissions with the exception of the A5S325Z use an inductive type sensor which generates an AC analog signal. The A5S325Z currently uses a Hall Effect Turbine Speed Sensor which will send a digital square wave signal to the TCM.

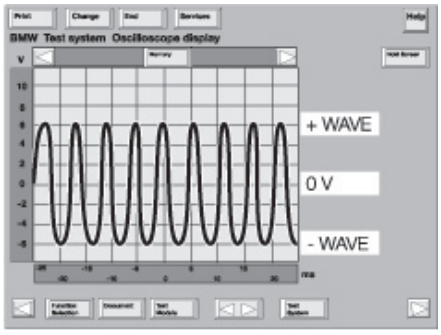
4HP22/24 (EH), A4S310/270R: These transmissions do not use a Turbine Speed Sensor. The TD signal is used to determine input shaft speed. The TD signal is an output signal of the DME control unit.

A5S310Z, A5S325Z, A5S440Z, A5S560Z, A5S360/390R: These transmission use a turbine speed sensor. The TD signal is also used with the turbine speed signal to allow the TCM to monitor Torque Converter Clutch operation. The TCM can control torque converter clutch slippage and also monitor for faults.

Output Shaft Speed Sensor

The Output Shaft Speed Sensor is used to provide output shaft speed information to the TCM. The output shaft speed signal is used in conjunction with the turbine speed signal to provide the TCM with information on gear ranges and slip times.
All BMW electronic transmissions have an output shaft speed sensor. The output shaft speed sensor is an inductive type which will generate an AC analog signal to the TCM. The frequency and amplitude of the signal will increase as output shaft speed increases. The exact location of the output shaft speed sensor varies by transmission model.





Typical Speed Sensor Signal

Transmission Oil Temp Sensor

The TCM is provided with transmission oil temperature information via a temperature sensor. On most BMW transmissions, the sensor is an NTC element which is part of the transmission internal wiring harness.

4HP22/24 (EH): These transmissions do not use a transmission oil temperature sensor. There are no transmission oil temperature influenced features on the 4HP transmissions.

All Except A5S360/390R, GA6HP26Z: The transmission fluid temp sensor is part of the transmission internal wiring harness. On these transmissions, the sensor cannot be replaced separately. The harness must be replaced.

A5S360/390R transmission: the sensor is a separate, replaceable sensor that can be unplugged from the harness.

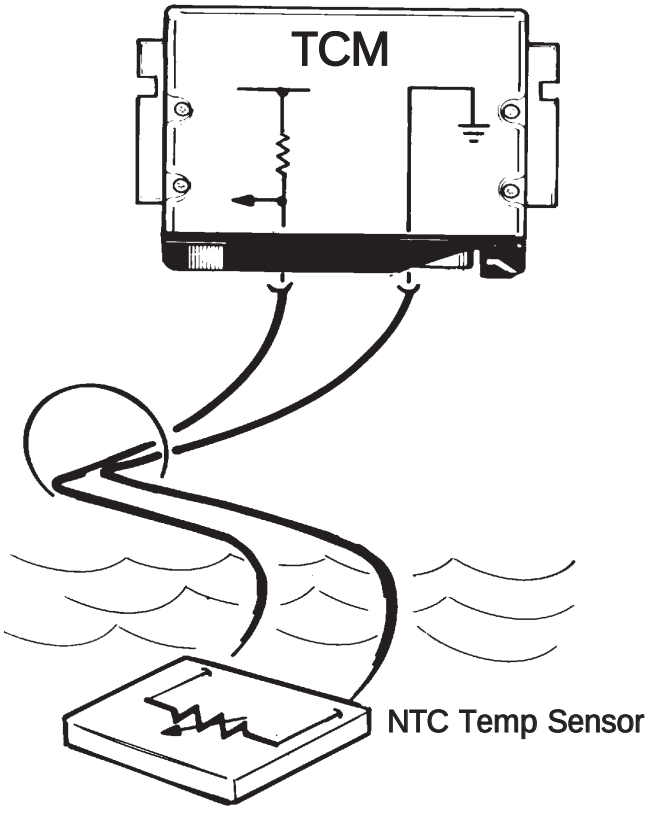
GA6HP26Z: the sensor is located in the Mechatronics Module, which is located inside of the transmission.

Note: The Mechatronics Module is not currently serviceable at this time. Contact the BMW Technical Hotline in the event of a failure. Do not attempt any repair or replacement of the Mechatronics Module.

The transmission oil temperature information is used to:

- Initiate the Warm Up Program
- To inhibit TCC operation until a specified temperature has been reached.
- For determining fluid level when used with diagnostic equipment.

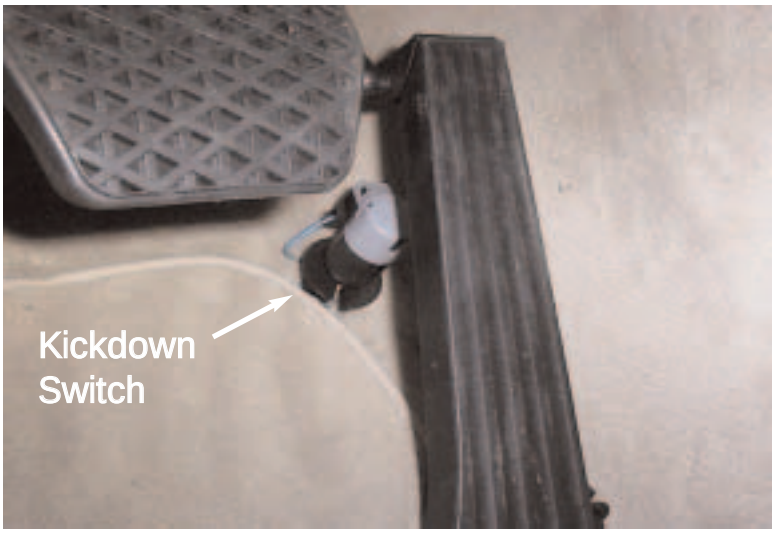
The transmission oil temperature sensor is connected to the TCM via a 5 Volt reference and a circuit ground. As transmission oil temperature increases, the circuit resistance and voltage decrease proportionately.



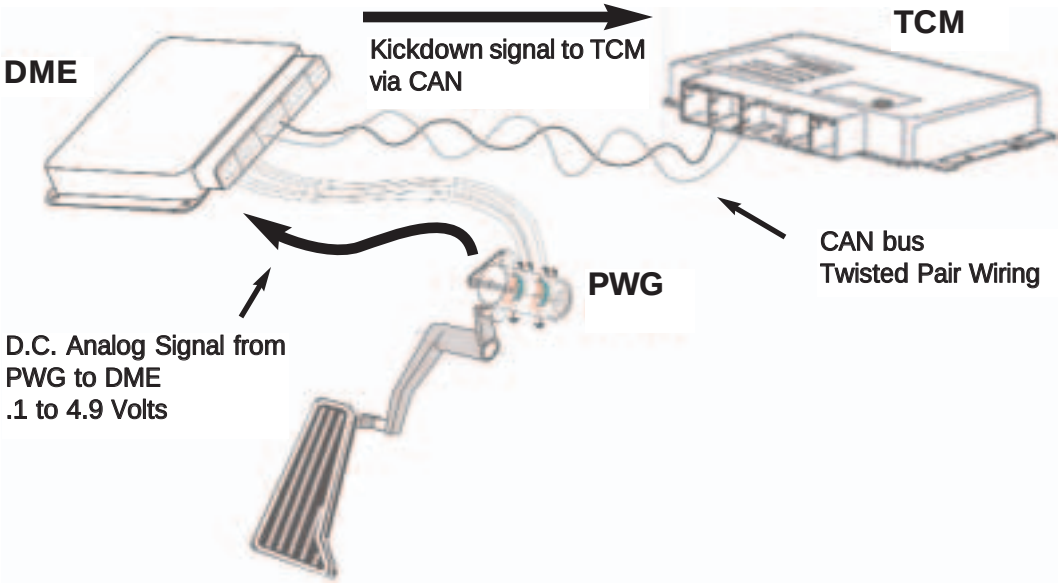
Kickdown Switch

The TCM receives a kickdown request via one of two possible methods:

- The kickdown signal is a direct ground input to the TCM. The kickdown input is provided by a kickdown switch located under the accelerator pedal.
  This method is used on most BMW vehicles without electronic throttle control systems (except M52TU with MDK).



- The kickdown request is provided by the ECM (DME) via the CAN bus. The kick down request originates from the PWG. There is no separate switch in the PWG. When the PWG voltage reaches approximately 4.5 volts, the ECM will process a kickdown request to the TCM via CAN. The PWG contains a kickdown detent to simulate the feel of a kickdown switch.
  This method is used on the M62TU, M54, M73, M73TU, N73 and N62 engines.



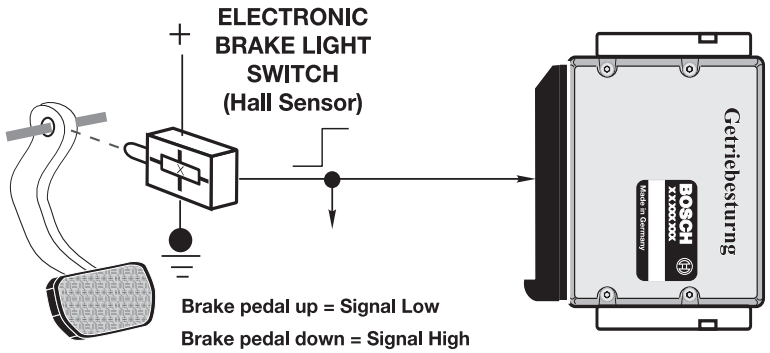
Brake Switch

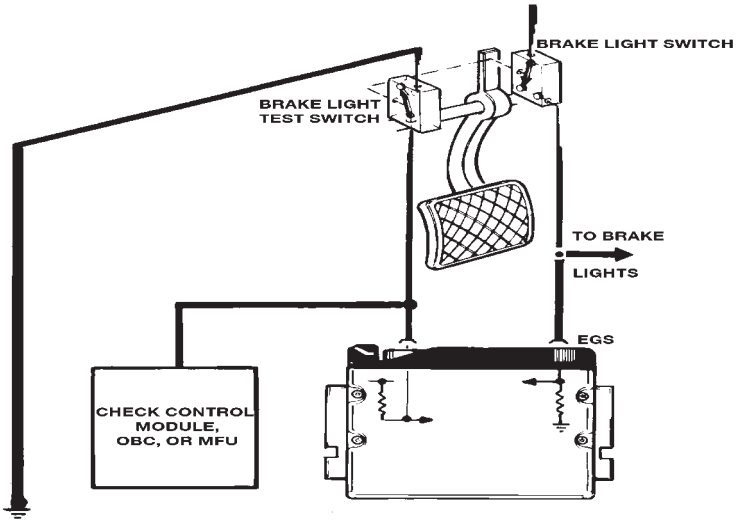
The brake switch is located on the brake pedal linkage. The brake switch signal is an input to the TCM which is used for:

- De-activation of the shift lock solenoid. When the ignition key is turned to KL15 the shift lock is active. The shift lock solenoid is de-activated when the brakes are applied.
- De-activate the Torque Converter . The TCC is deactivated whenever the brake is applied. (only on Hydramatic Transmissions).

There are two types of brake switches used on BMW vehicles:

- On early vehicles such as E32, E34, E36, E24, E28 and E31 the brake switch is a double-contact mechanical switch. There is a brake light circuit and a brake test circuit. The brake test circuit is used for a plausibility check to indicate faults within the brake light circuit.
- On the E38, E39, E46, E65/66, E85 and E53 the brake switch is a hall effect type switch. The electronic switch is also monitored for faults and plausibility.

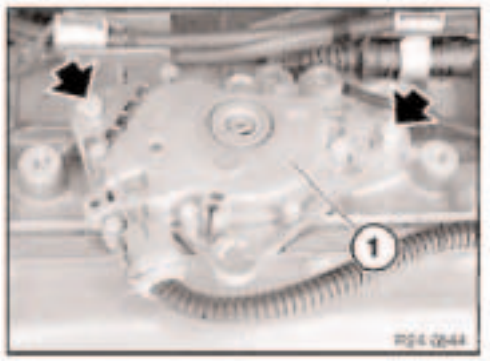




Transmission Range Selector Switch

The range selector switch is an input to the TCM. The input is used by the TCM to determine the position of the manual valve. The range switch uses the familiar “coded input” signal to determine selector lever position. On all transmissions except the A5S360/390R, the range switch uses a 4 wire configuration to determine 7 range selector positions. The A5S360/390R uses a five wire arrangement.

Most range switches are located on the transmission case with some exceptions. The E36 with the A4S270/310R the range switch is located is the center console on the selector lever assembly. The E39 with A4S270R the range switch is located on the transmission case and is adjustable. The range selector switch on the A5S360/390R is located inside the transmission housing. GA6HP26Z is part of the Mechatronics Module.



Range Switch A5S440Z

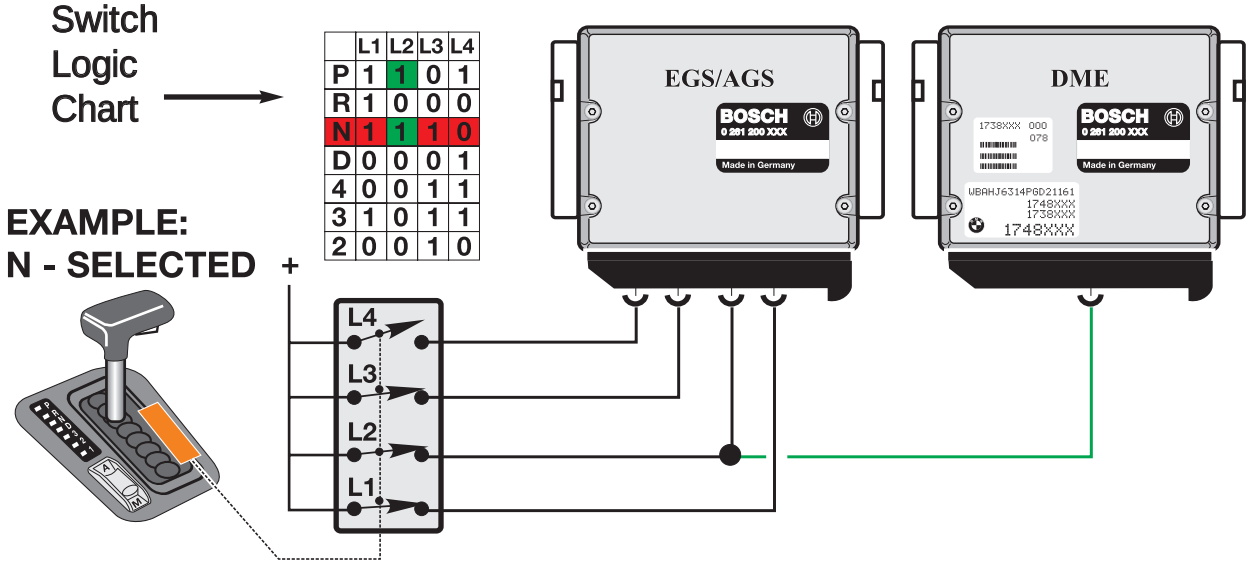
The range switch can be checked by using “Status Requests” in the DISplus or GT-1.
A multimeter or an oscilloscope can also be used to check the range switch. If the reading on “Status Requests” does not match the actual selector lever position, there will be various transmission malfunctions.

Always refer to the proper ETM when diagnosing the range selector switch. Use the switch logic chart to diagnose faults in the switch.

In the example below, the range switch is in neutral. Using the logic chart, switches L1, L2 and L3 are closed providing B+ voltage to the corresponding pins of the TCM. Switch L4 is open and no voltage is sent to the TCM. Malfunctions in the range switch or wiring can cause various shifting complaints and possible No-Start complaints.

Switch Logic Chart →

	L1	L2	L3	L4
P	1	1	0	1
R	1	0	0	0
N	1	1	1	0
D	0	0	0	1
4	0	0	1	1
3	1	0	1	1
2	0	0	1	0

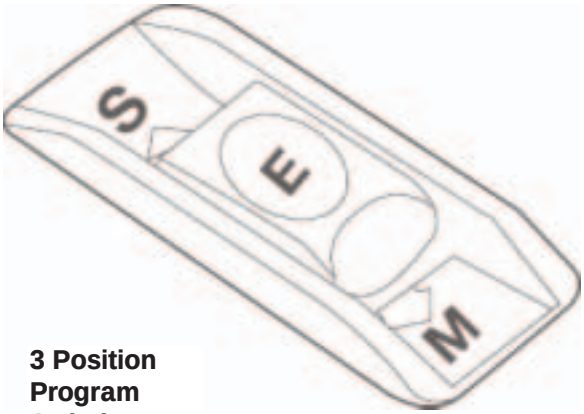


Transmission Program Switch

The transmission program switch is used to switch between various operating modes of the transmission. The normal default mode of the TCM is Economy which is indicated in the program display as “E”. Economy mode allows the transmission to operate in the most efficient mode. Shift priorities are for maximum economy and shift comfort. On some vehicles the program switch is designated “A” for economy mode. Program switches come in 2 or 3 position configurations. Early vehicles with the 4HP (Early E7) used a rotary program switch.

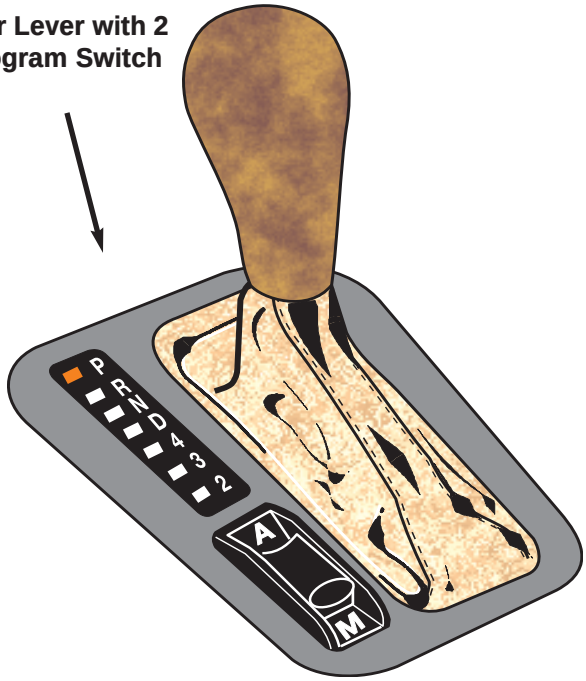
The TCM can also be switched to “Manual Mode” which on some vehicles is designated “Winter Mode”. Manual mode is used to start the vehicle off in a higher gear when encountering slippery conditions. The program display will indicate “M” (manual) or an asterisk symbol for “Winter Mode”.

Sport Mode is the third operating mode that is available. Sport mode allows for a slightly delayed and more aggressive shift. Sport mode is obtained a number of ways. On vehicles with 2 position program switches, moving the selector lever out of drive to 4,3, or 2 with the program switch in Economy will allow Sport mode. On vehicles with 3 position program switches, Sport mode can be obtained by switching to “S”.



3 Position Program Switch

E38 Selector Lever with 2 Position Program Switch



Steptronic Components

The Steptronic system uses additional components not found on a conventional system. These components consist of a manual switch and an Up/Down microswitch. Otherwise, the Steptronic system uses the same transmission and TCM.

The TCM monitors the Steptronic shifter position from P through D via the conventional range selector switch located on the transmission. The Range Selector Switch provides positions P through D to the TCM because the automatic gate of the shifter only travels through these positions.

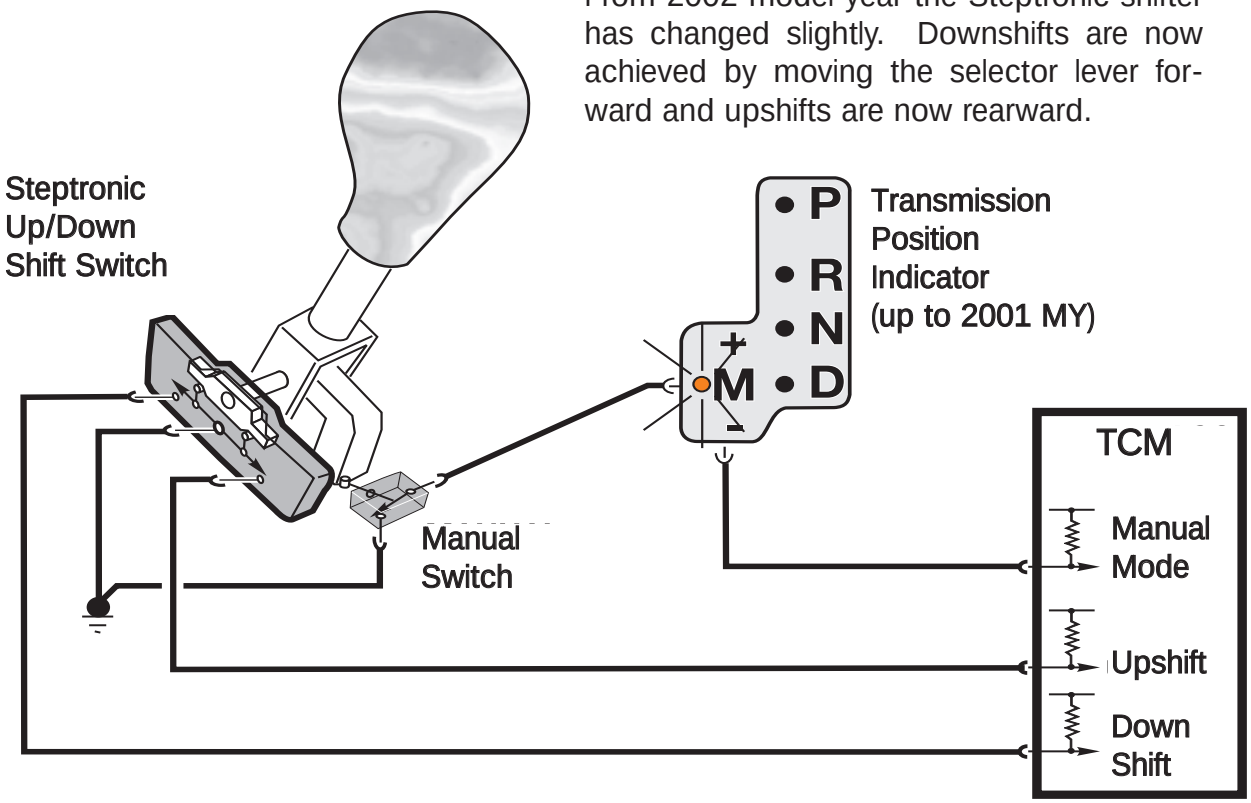
When the Steptronic Shifter is moved to the left 15 degrees into the manual gate, the TCM receives a ground input from the manual gate switch. The ground signal is provided to the TCM through the Transmission Position Indicator. The transmission position indicator also provides range position signaling to the range position indicator in the shift console.

Steptronic was introduced on the E31 850Ci (10/94) and the 840Ci (1/96). Steptronic was subsequently introduced into the E38, E39, E46, E36/7 and the E53.

The Steptronic system can be diagnosed through “Status Requests” with the DISplus or GT-1.

Refer to TRI Bulletin B 24 75 96 for more information on Steptronic.

From 2002 model year the Steptronic shifter has changed slightly. Downshifts are now achieved by moving the selector lever forward and upshifts are now rearward.

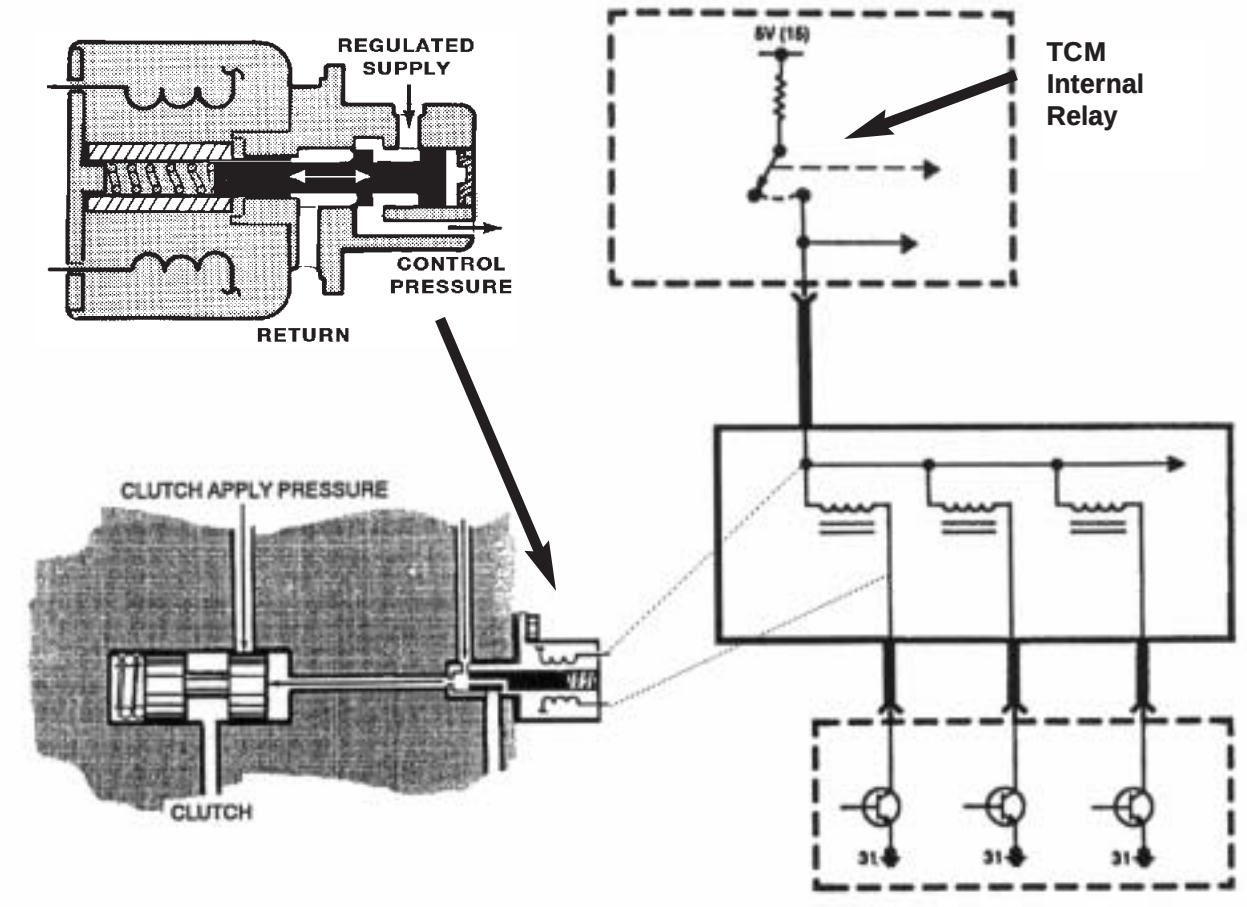


Magnetic Valves

Magnetic Valves (MV) are used to electronically control hydraulic fluid flow to the various shift elements within the transmission. Magnetic valves are located on the valvebody and replaceable as separate components. In ZF transmissions, MV valves are designated MV1, MV2, MV3 etc. In Hydramatic transmissions, they are designated Shift Valve A, Shift Valve B, Shift Valve C etc.

The magnetic valves are controlled by the TCM. They are supplied power by an internal TCM relay and are ground controlled. The TCM switches one or more of the MV's on or off in various combinations to achieve various shifts. Most transmission have 2 or 3 MV's to control shifting.

In addition to controlling shifts within the transmission, magnetic valves are also used for overlap shifting and pressure regulation on some transmission applications. For example MV4 and MV5 are used for overlap shifting in the A5S310Z. MV5 is used for pressure regulation on the 4HP22/24EH transmissions. When used for pressure regulation, the magnetic valves are pulse width modulated by the TCM.



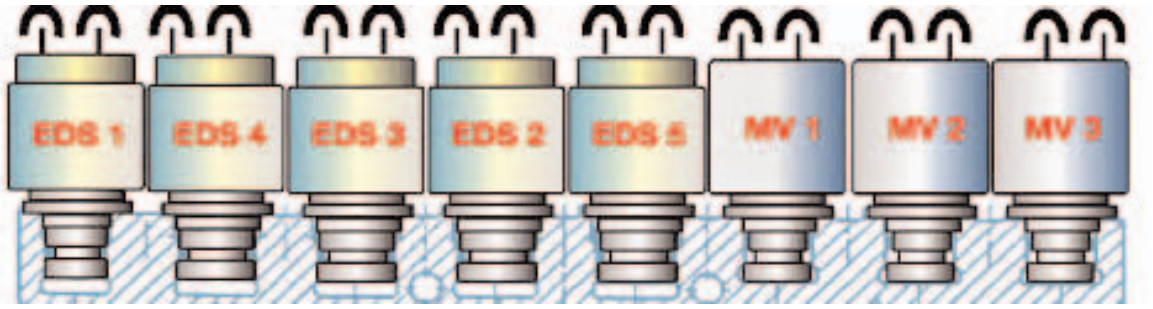
Pressure Regulating Solenoids

Pressure Regulating Solenoids are used to modify line pressure for use in the transmission. There are numerous terms for these solenoids depending upon transmission type and manufacturer. ZF transmissions use the term EDS, while Hydramatic Transmissions use the term DR solenoid, Force Motor Solenoid and Variable Bleed Solenoid (VBS).

EDS valves are used for main line pressure regulation, TCC application and Overlap Shift Pressure Control on the A5S440Z and A5S560Z. All pressure regulating solenoid are controlled by Pulse Width Modulation.

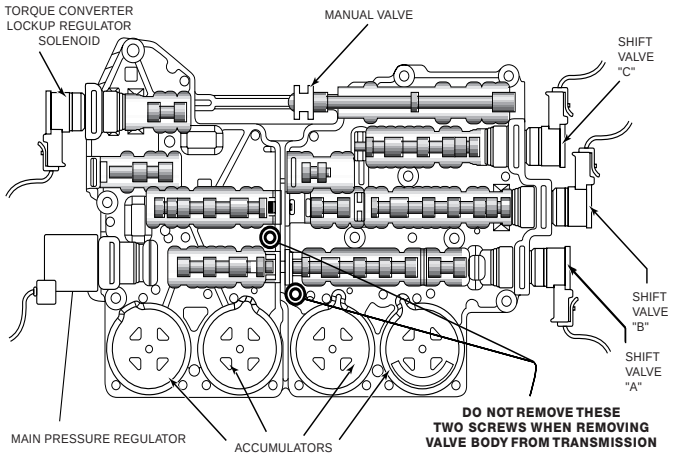
Using the example in the picture below, this is a section of the A5S440Z/560Z valve body. The EDS valves are used for the following:

- EDS 1 is used for main line pressure regulation
- EDS 2, 3 and 5 are used Overlap Shift Pressure Control
- EDS 4 is used for TCC application. (GWK) Gradually applied TCC.

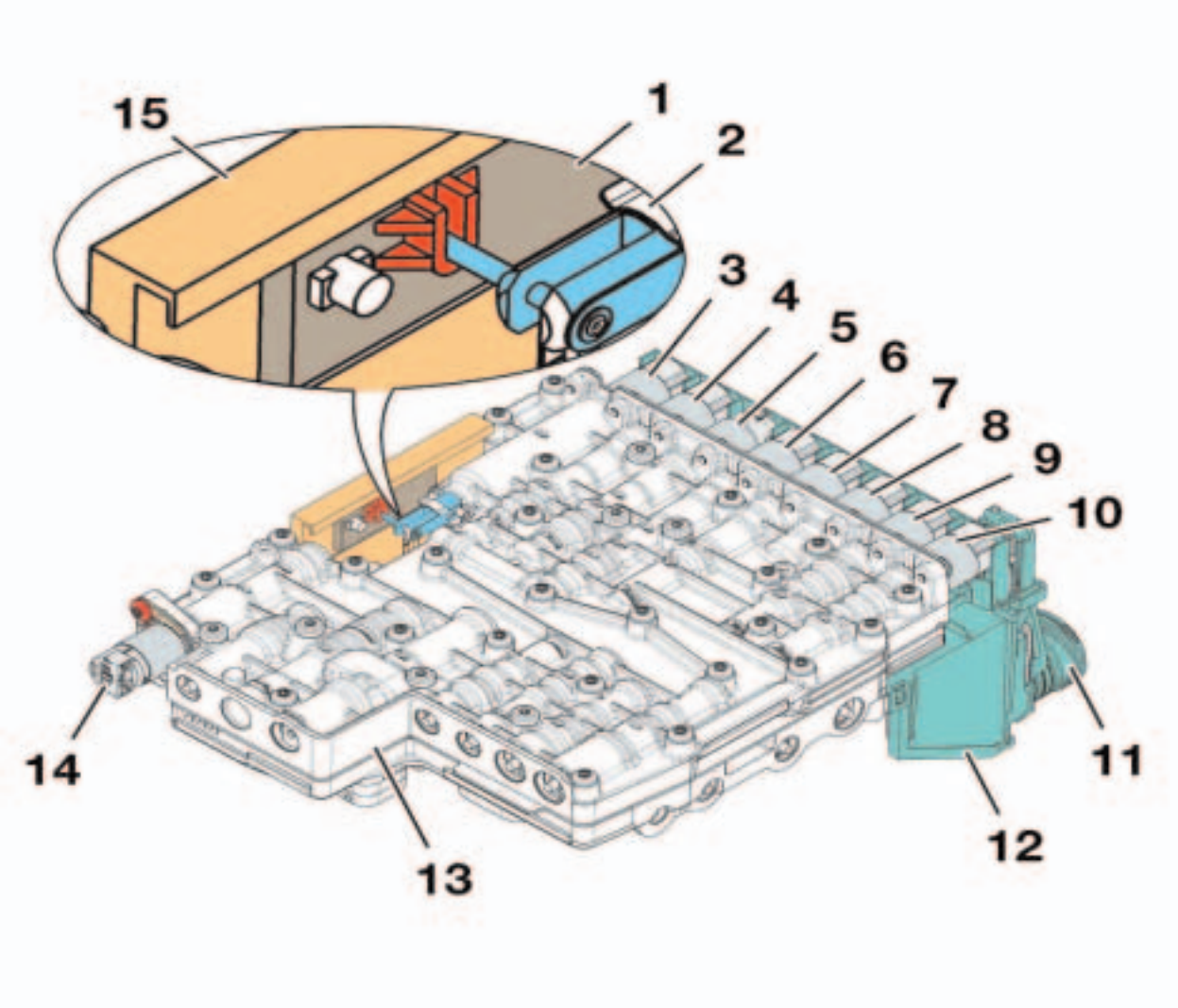


Hydramatic Pressure Regulator

The valve body shown at the right is from the A5S360/390R. Note the location of the main pressure regulator. Depending upon the reference text, the pressure regulator is also known as the Force Motor Solenoid , Variable Bleed Solenoid or PC Solenoid.



Mechatronics Module GA 6HP26Z



1	Position Slide Switch	**9**	EDS 2
2	Parking Lock Cylinder Piston	**10**	EDS 1
3	Solenoid Valve 3, parking lock Cylinder	**11**	Electronic Plug Connector
4	EDS	**12**	Electronic Module
5	Solenoid Valve 1	**13**	Hydraulic Module (Valve body)
6	EDS 4	**14**	Solenoid Valve 2
7	EDS 5	**15**	Position Switch
8	EDS 3		

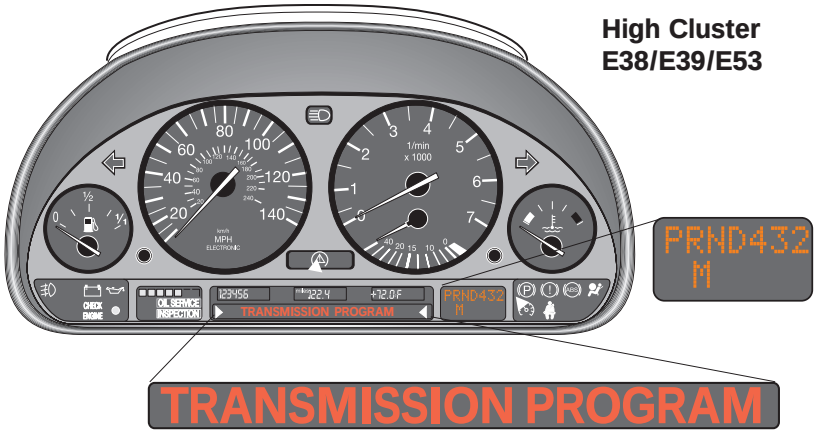
Instrument Cluster

The cluster is used to report information to the driver regarding transmission status. There are three items of information needed by the driver:

- **Transmission Range** - this indicates the position of the range selector lever. The driver needs to know whether the transmission is in P, R, N, D, 4, 3, or 2.
- **Transmission Program** - this indicates the mode of operation. There are 3 modes, Economy, Manual and Sport .
- **Transmission Fault Information** - the driver needs to know of there is a malfunction in the transmission. Depending upon application, transmission faults can be indicated by an icon or by a “Transmission Program” message in the instrument cluster display matrix.

E46 Trans Indicator

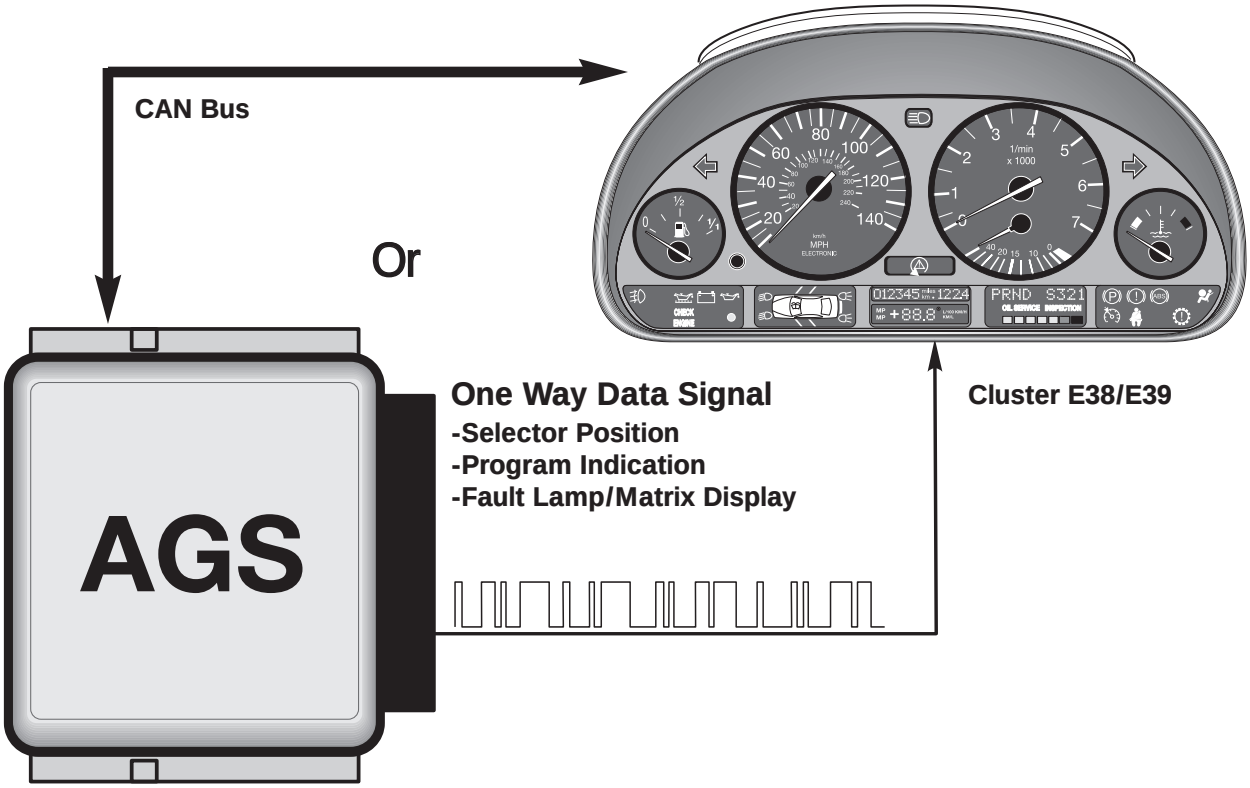
High Cluster
E38/E39/E53

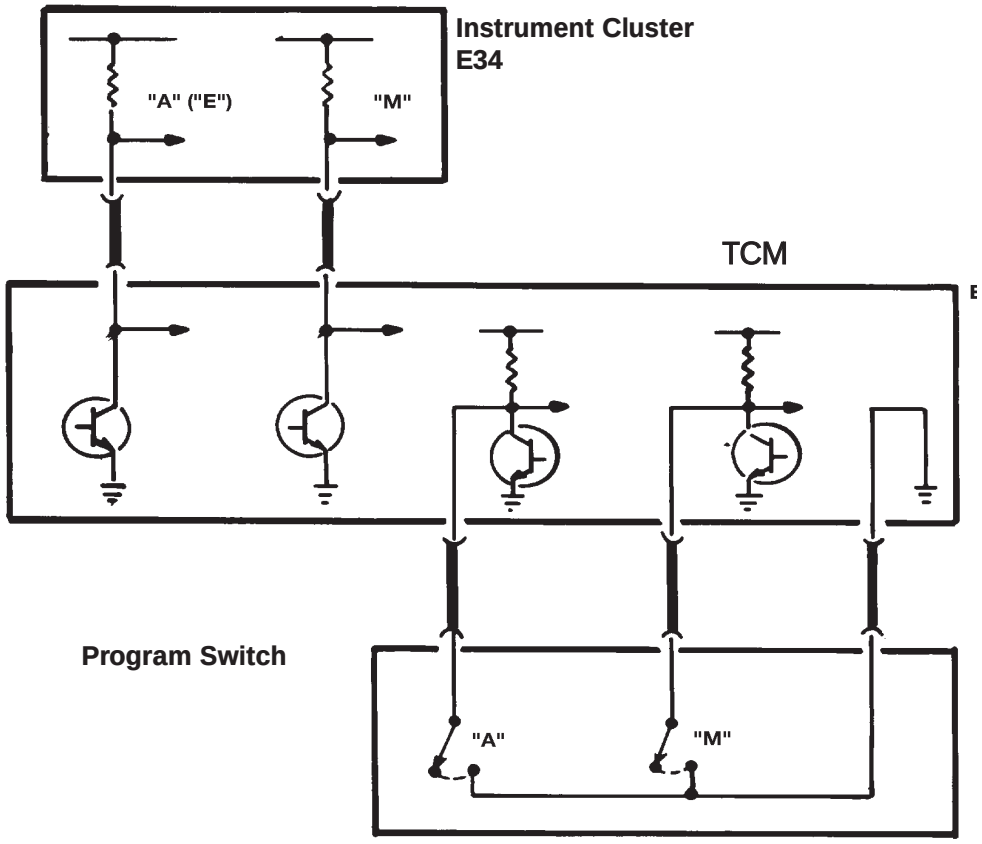


Depending upon vehicle model and transmission, these pieces of information arrive at the cluster through different methods.

- The most current method for this information to arrive at the cluster is through the CAN bus. The cluster processes this information from the TCM via CAN.
- On early E38 and E39 vehicles these is a “One Way Data Signal” from the TCM to the cluster. There is a one way serial data line that transfers this information to the cluster. On later vehicles, the cluster was introduced to the CAN bus and this method was no longer used. This was used on the E38 vehicles to 5/97 and E39 vehicles to 8/97 production.
- Early vehicles such as E32, E34, E36 etc. used a various combination of methods to transfer this data. Some clusters use the “Coded Input” method for the program indicator. Fault indication is done by a ground circuit through the TCM. Transmission range indication is achieved by a direct connection between the range switch and cluster or by a coded input to cluster.

There will be a FC6 in the Kombi when the TCM goes into failsafe mode.
When attempting to diagnose any of these circuits, always refer to the proper ETM.


CAN Bus
Or
AGS
One Way Data Signal
-Selector Position
-Program Indication
-Fault Lamp/Matrix Display
Cluster E38/E39


Instrument Cluster
E34
"A" ("E")
"M"
TCM
Program Switch
"A"
"M"

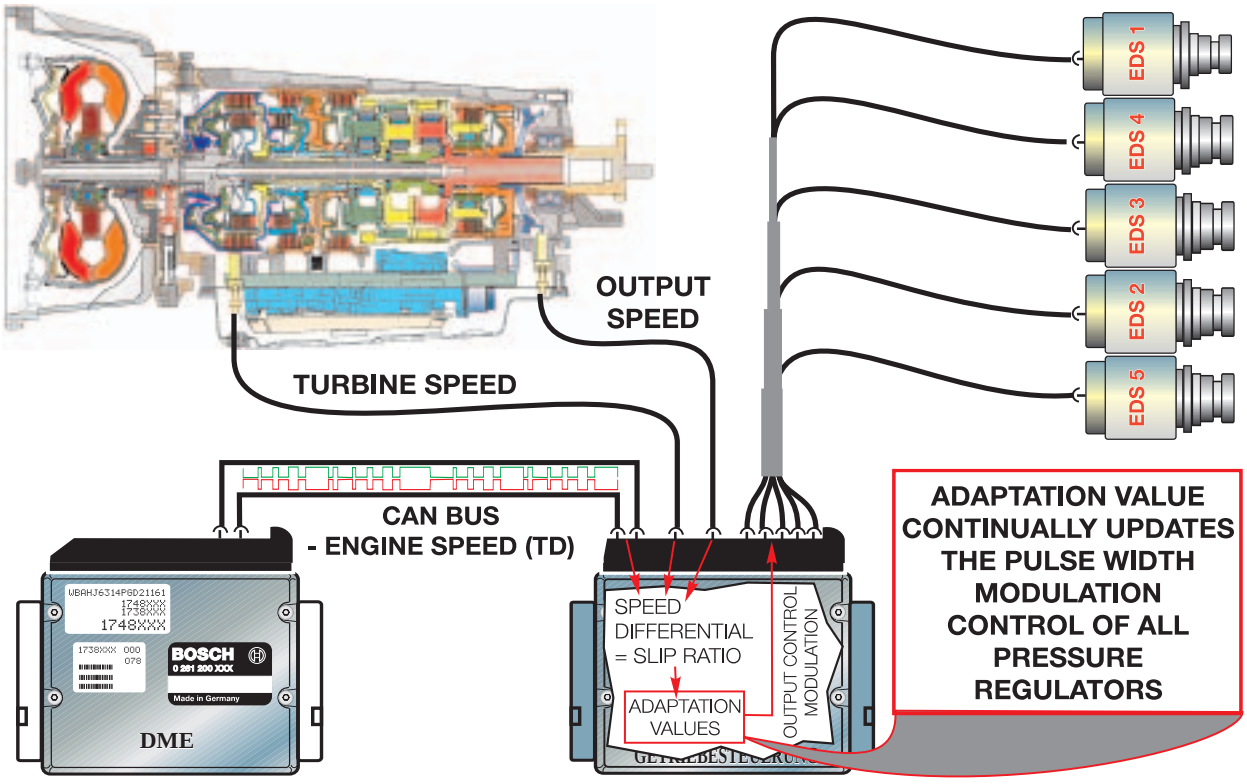
Transmission Features and Principles of Operation

Adaptive Hydraulic Pressure Control

Pressure adaptation has been a feature of ZF automatic transmissions since the 4HP22EH. The TCM will maximize shift quality by adapting to transmission wear over time. The TCM will adjust transmission shift pressures to compensate for wear in the multi-plate clutches. This is accomplished by monitoring the input and output speeds of the transmission. When the transmission shifts, the TCM monitors the time that it takes to accomplish the shift. The time change in gear ratio is monitored and compared to an internal time value in the TCM. If the ratio change takes more time than the stored value, the TCM will compensate by adjusting the transmission shift pressures via the EDS valve solenoids. The adaptation value is stored in the TCM. This adaptation values can only be cleared by the diagnostic tester (DIS plus or GT-1).

Note: DO NOT clear adaptation values unless directed to do so by technical assistance. Clearing pressure adaptations should not be done to resolve a customer complaint. The only time that you would need to do so is after a transmission or valve body replacement or software change.

Also it is important not to confuse pressure adaptation with AGS features. AGS features will be discussed later in this chapter. AGS features are not stored on a long term basis and will not be cleared when the pressure adaptations are cleared. Note: Driving style is NOT stored.



Downshift Protection

Downshift protection is a feature that prevents unwanted or improper downshifting. If the range selector were moved to a lower gear at a high road speed, engine damage could occur from an unintended over-rev. This feature will prevent engine over-rev by delaying or preventing the unwanted downshift until the proper road speed is achieved. The result is increased safety by preventing unwanted deceleration slip.

Reverse Lockout

The TCM will lockout reverse above 3 MPH to prevent drivetrain damage. The range selector lever will go into the reverse detent, but reverse will not engage. This is achieved by the TCM through hydraulic intervention. The transmission will appear to be in neutral.

Note: Reverse Lockout is not operative when in failsafe.

Engine Warm Up Cycle

The transmission shift points are modified after cold start to raise engine RPM during shifting. This allows for a faster engine warm up and reduction of catalyst warm up time. The TCM uses the transmission oil temperature information to determine the implementation of this function.

The warm up phase program will be terminated if any of the following conditions exist:

- The vehicle exceeds 25 MPH or
- Transmission oil temperature exceeds 60 Degrees Celsius or
- A Maximum of three minutes is exceeded.

ASC/DSC Shift Intervention

During ASC/DSC regulation upshifts are inhibited to enhance the effectiveness of traction-al control. Depending upon vehicle model, this action can take place via the CAN bus or a dedicated shift intervention signal wire. On later model vehicles where the ASC/DSC module is connected to the CAN bus, the shift intervention signal is sent to the TCM via CAN.

Torque Reduction

In order to allow a smoother shift and reduce load on the transmission, engine torque is reduced during shifting. This is accomplished by a signal that is sent from the TCM (EGS) to the ECM (DME) during shifting. The ECM will retard timing momentarily during the shift for a few milliseconds. This timing change is transparent to the driver. Depending upon application, the torque reduction signal is sent over a dedicated wire or a signal over the CAN bus.

Emergency Program

When a malfunction occurs within the transmission, the Emergency program (failsafe mode) will be initiated. The Emergency Program will prevent unintended gear engagement and ensure driver safety. The following will occur during Failsafe Operation:

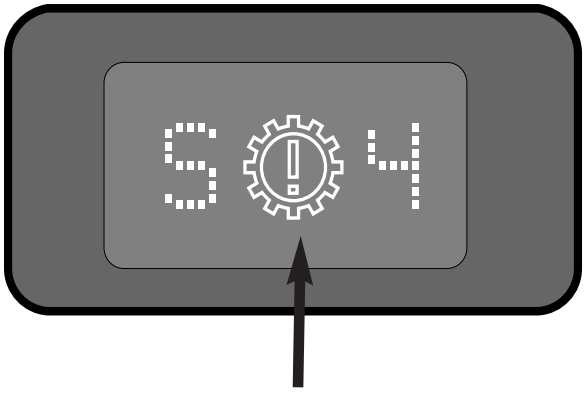
- All shift solenoids are de-energized via TCM internal relay.
- The pressure regulation solenoid is de-energized resulting in maximum line pressure.
- The Torque Converter Clutch is de-activated.
- The Reverse Lockout function is cancelled.
- Shift lock solenoid is de-energized.
- Fault indicators are active.

The fault indicator varies depending upon model, year and cluster type etc. High version instrument cluster will display a message in the matrix display. Vehicles with low version clusters will display a fault symbol in the cluster.

During failsafe mode the transmission will be shifted into a higher gear to allow the vehicle to be driven to a service location. Depending upon application, the transmission will shift into 3rd or 4th gear (on a 4spd) and 4th or 5th gear (on a 5 spd). For example the A5S360R transmission will go into 5th gear when there is a malfunction and 4th when there is a power failure to the TCM. Since pressure regulation ceases, the shift to failsafe mode will be abrupt or harsh, unless the transmission is already in the failsafe gear.

On newer OBD II compliant vehicles, the MIL light will also be illuminated by the ECM (DME).

Note: When diagnosing transmission related complaints, it is possible to have an erroneous fault indicator warning. Faults in the cluster can cause a false indication or "Trans Program" message. One indication of this scenario would be a transmission fault message in the cluster with no transmission faults stored in the TCM.

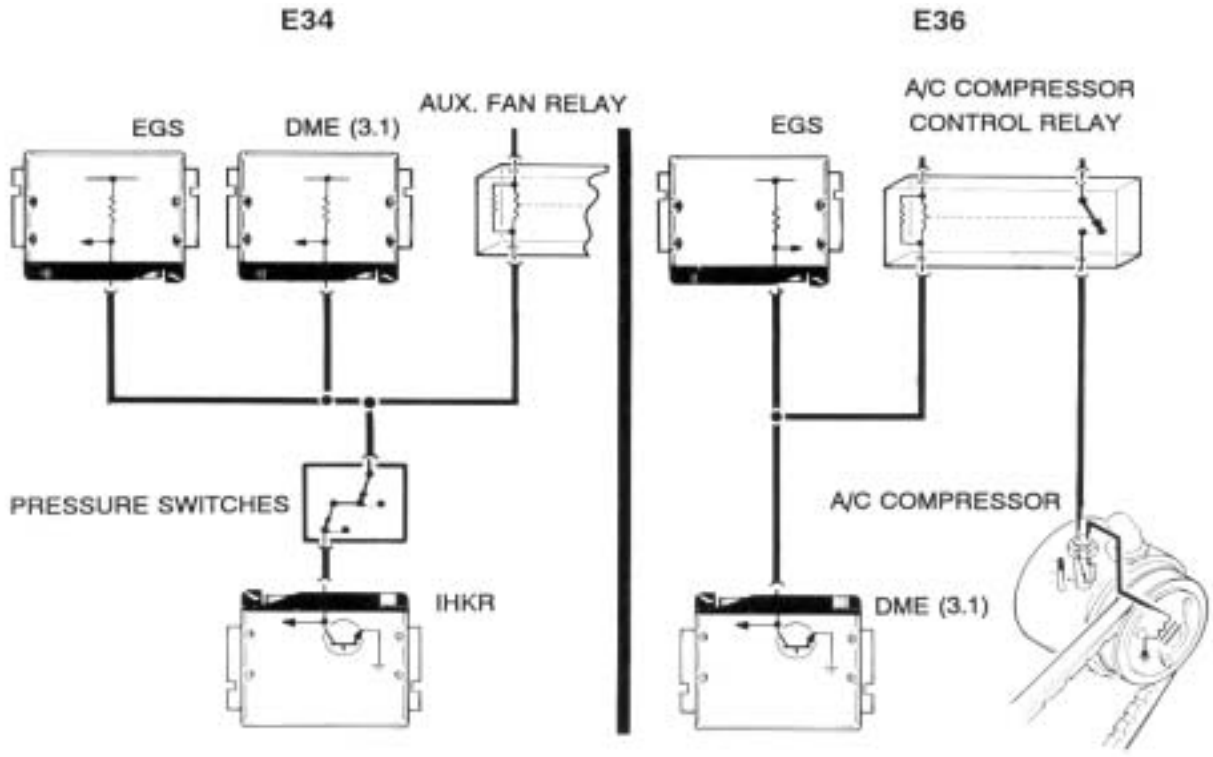


E46 Transmission Fault Indicator

AC Compressor Load Sensing (Hydramatic Transmissions)

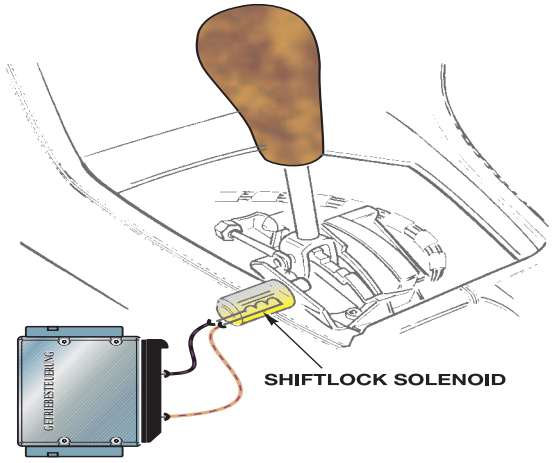
When the AC Compressor is switched on, additional load is placed on the engine. To compensate for the additional load, the TCM modifies line pressure and shift points. On the THMR-1, the TCM receives these signals via a direct connection to the AC compressor control circuit.

On vehicles equipped with CAN bus technology, the “AC on” signal is sent to the TCM from the DME as a CAN bus message.



Shift Lock

The shift lock solenoid is mounted on the selector lever assembly and locks the selector lever in Park or Neutral when the ignition is ON. This prevent the selection of a gear unless the brake pedal is depressed. The solenoid is activated by a switched ground from the TCM. Power is supplied by the TCM internal relay.
During failsafe operation, the shift lock is disabled. On later models, the shift lock will also be active when the TD signal is present and the shifter will remain locked above an engine speed of 2500 RPM regardless of brake application.



Torque Converter Clutch

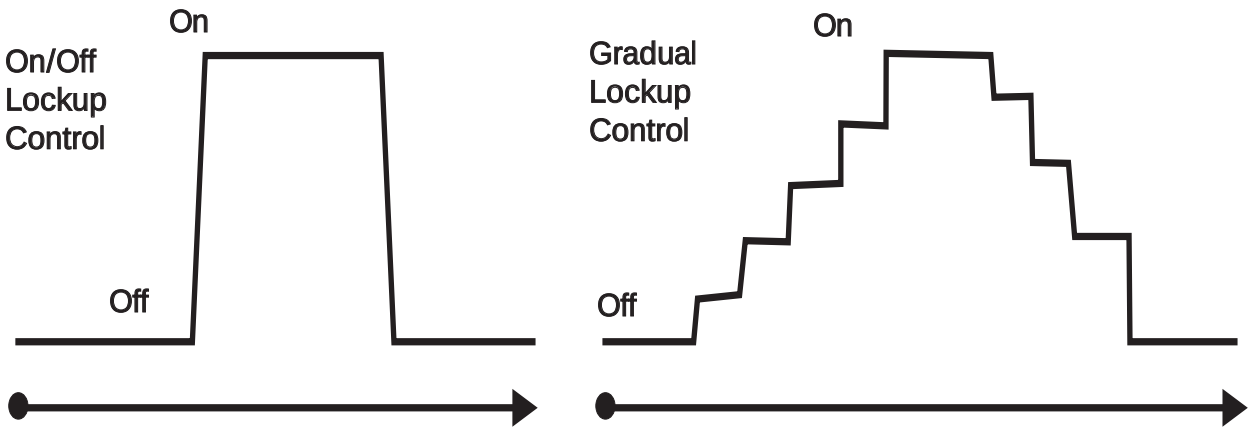
Since the efficiency of the torque converter at coupling speed is approximately 1.1 to 1, fuel economy is compromised. To offset this a torque converter clutch was added on EH controlled transmissions. The torque converter clutch locks the turbine to the converter housing. This creates a mechanical coupling with a ratio of 1:1. This can only be achieved at higher engine speeds, the torque converter clutch must be disengaged at low engine speeds to prevent stalling.

There are two methods for controlling the torque converter clutch on BMW transmissions:

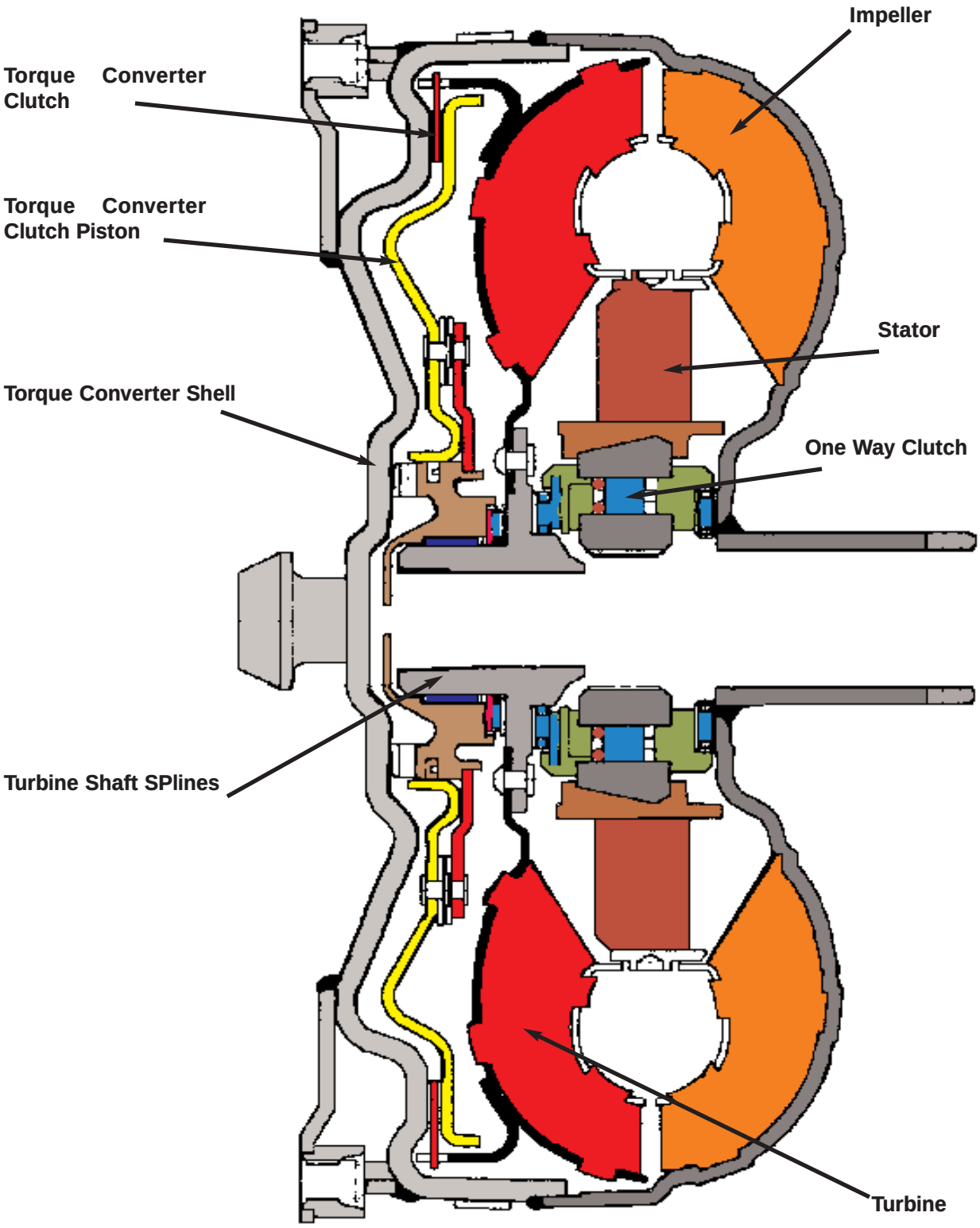
- **A4S310/270R, 4HP22/24 EH, A5S310Z** - These transmissions use an on/off control method to lock and unlock the torque converter. The Torque Converter Clutch is either completely engaged or disengaged. This method of engagement provides an abrupt sensation when the TCC is locking and unlocking. This abrupt sensation can be undesirable to some drivers.

- **A5S560Z, A5S440Z, A5S325Z, GA6HP26Z,A5S360/390R** - These transmissions use a gradual approach to TCC control. The TCC is gradually applied and released, this method reduces the abrupt feel of the on/off type TCC. The TCC solenoid is controlled by pulse width modulation. This allows fluid to be gradually introduced and released to the TCC.

The TCC is spring loaded to the engaged position. Pressurized fluid releases the TCC, when the pressurized fluid is released, the TCC is engaged. Depending on transmission application, the TCC can be engaged in 3rd, 4th or 5th gear. The TCC must be disengaged at low speeds to prevent stalling.



Lock-Up Torque Converter



Shift Solenoid Control

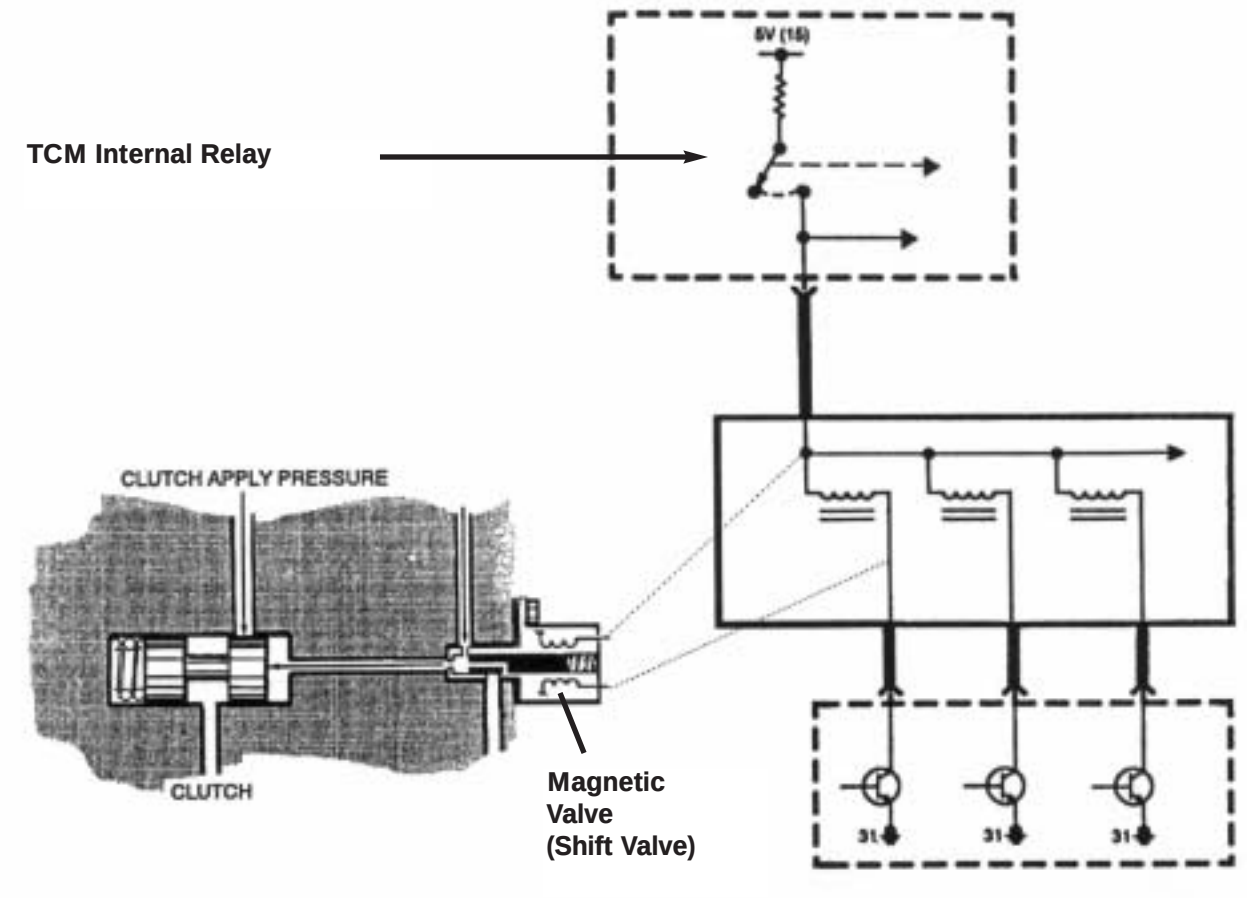
Magnetic valves are used to direct the flow of transmission fluid to control shift elements in the transmission. Another Term for “Magnetic Valve” is “Shift Valve”. Magnetic valves (MV) are solenoids controlled by the TCM. They can be switched by B+ or B-.

On ZF transmissions, magnetic valves are designated MV1, MV2, MV3 etc. On GM transmissions they are designated Shift Valve A, Shift Valve B, Shift Valve C etc.

Either valve can be checked for proper resistance using a multi-meter, DISplus or GT-1. Also, the “Activate Components” function can be used to check the Magnetic valves. Most all magnetic valves are switched on/off instead of Pulse Width Modulation (PWM).

All magnetic valves (except THM R-1 to 12/95) are supplied power from an internal relay located in the TCM. The magnetic valves are switched on and off by final stage transistors in the TCM. During failsafe operation, power to all MV’s is switched off by the internal relay.

Magnetic valves are located on the valve body. They can be replaced individually. Refer to proper repair instructions for installation and removal procedures.



Pressure Regulation

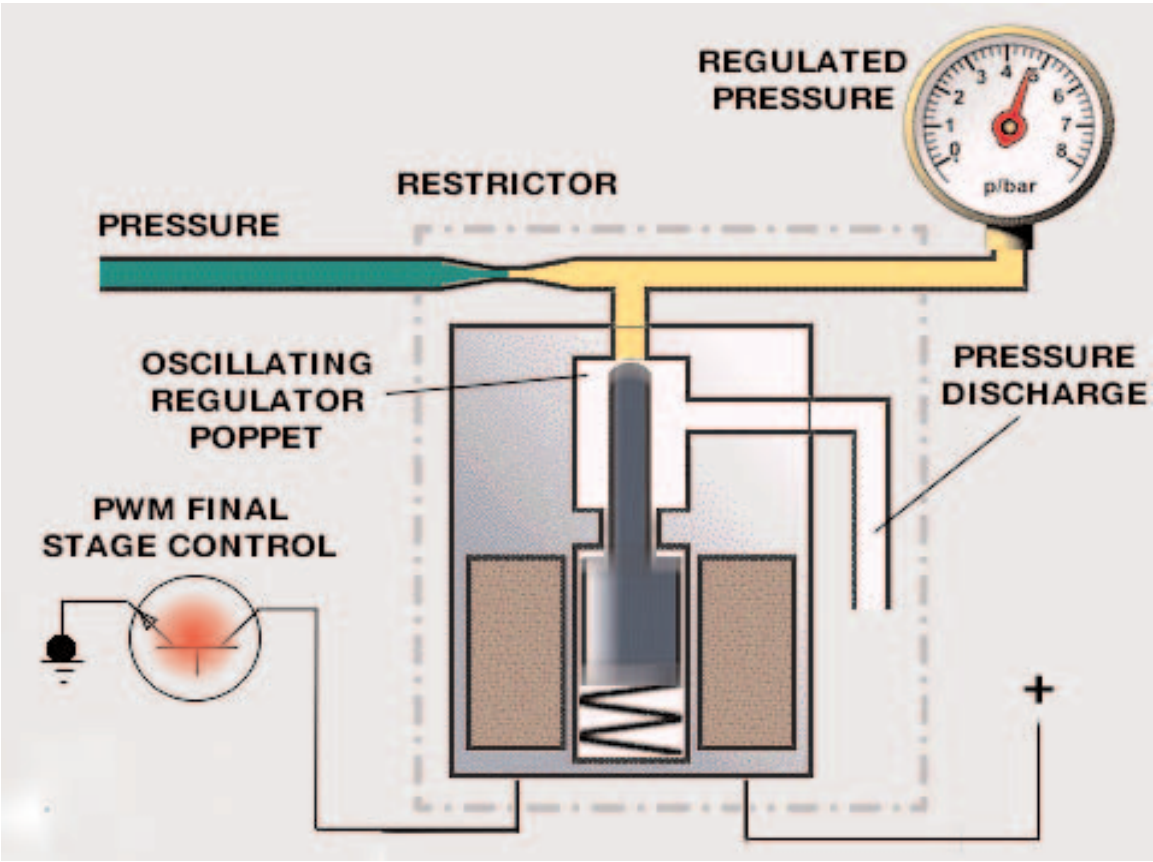
Pressure regulating solenoids modify line pressure for hydraulic operation. Solenoids for pressure regulation are referred to as EDS valves in ZF transmissions. GM transmissions have a few terms such as Force Motor Solenoid, Variable Bleed Solenoid, and DR solenoid. Regardless of the name used, they are all used to control main line pressure based on throttle position and engine load.

On ZF transmissions, EDS valves are also used to control “Overlap Shifting”. This allows for improved shift comfort by controlling pressures during shifting.

Depending upon transmission application, pressure regulating solenoids can be controlled using Pulse Width Modulation on B+ or B-.

The TCM will increase line pressure by regulating current flow to the pressure regulator. Current flow is controlled by pulse width modulation. When the duty cycle is low, the current flow to the solenoid is low. This allows spring pressure to close the valve. Therefore maximum line pressure is achieved. As the duty cycle increases, the current flow also increases. The valve opening increases, which allows pressure to be released through the pressure discharge which in turn decreases line pressure.

Main line pressure is also increased during failsafe operation and when needed during “Adaptive Hydraulic Pressure Control” functions. Mainline pressure will also default to maximum pressure when power to the TCM is switched off.



Shift Programs

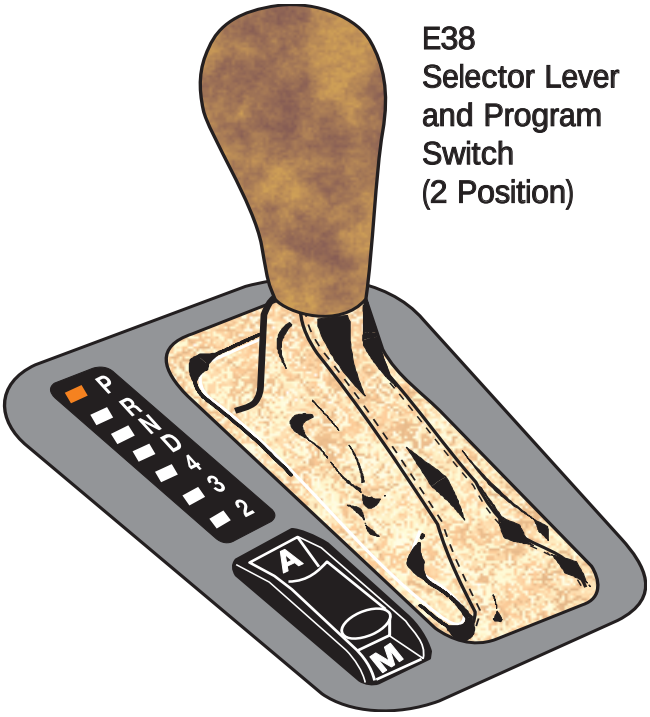
BMW EH transmissions have selectable shift programs (or modes) to suit driver needs and operating conditions. There are 3 basic shift programs available:

- **Economy Program -** The economy program is the default program which is adopted every time the vehicle is started. When in economy mode, the operating priority is for maximum economy and shift comfort. Shifts will take place at low engine RPM and road speed. The economy mode is indicated by an **"A"** on the program switch. The cluster will display an **"E"** to indicate economy mode.
- **Manual Mode (Winter Mode)** - Manual mode is used to start out the vehicle in a higher gear on slippery surfaces when more traction is needed. A higher gear will reduce torque to the rear wheels. Manual mode can also be used to select a lower gear when needed such as when climbing a hill. Depending upon vehicle applica tion an **"M"** will appear in the cluster when in Manual Mode or an asterisk (*****) symbol will appear in the instrument cluster to indicate Winter Mode.
- **Sport Mode** - Sport Mode provides raised shift points and a more aggressive shift program for the "Enthusiastic" BMW driver. The cluster will display an **"S"** when in sport mode.

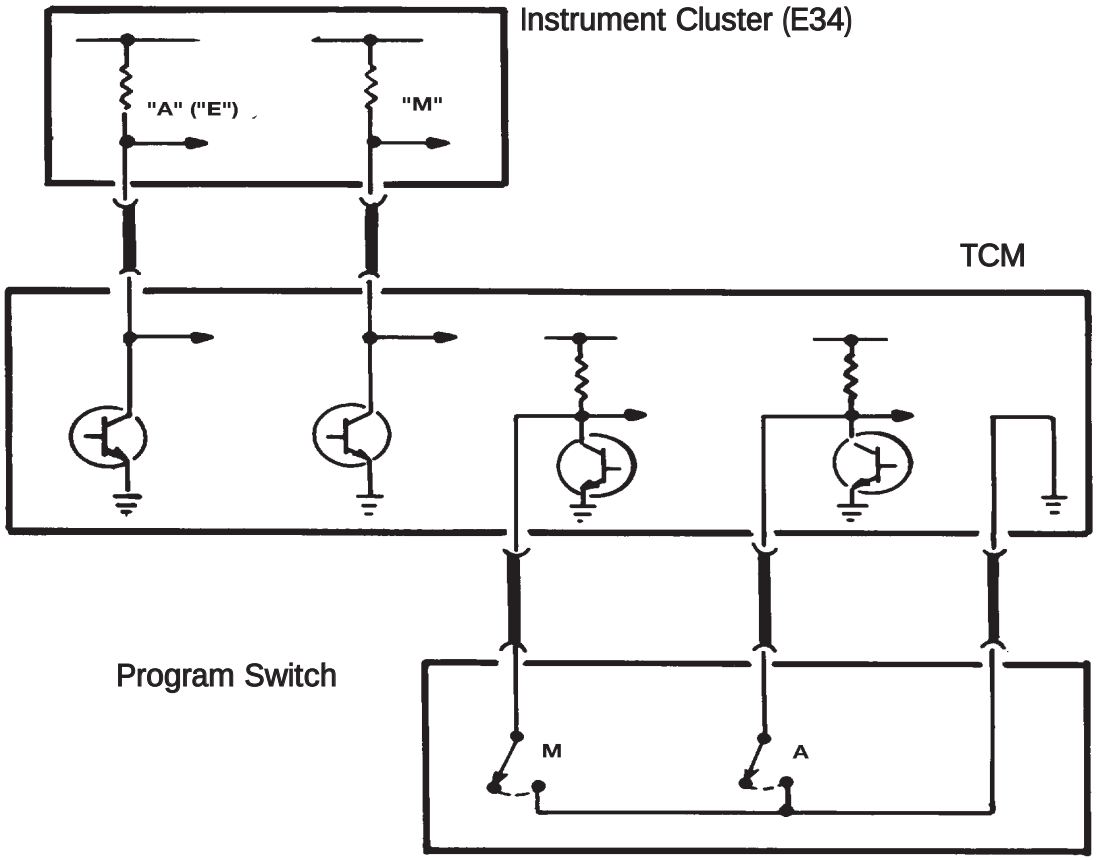
Regardless of vehicle application, the program switch provides a momentary ground to the TCM to switch between modes. There have been numerous designs of the program switch since it's introduction. The program switch configurations are as follows:

- **2 Position Slide Switch** - This switch has the "A" and the "M" selection. Sport mode is achieved by moving the selector lever from "D" to 4, 3 or 2 when in the Economy Mode. The 2 Position slide switch is used on most models. These vehicles usually have a range and program display located in the instrument cluster.
- **2 Position Rocker Switch -** This switch operates the same as the slide switch, but it is used exclusively on the E36. The E36 does not have a program indicator in the cluster. The rocker switch will illuminate, indicating the current program.
- **3 Position Slide Switch** - This switch has the added position for sport mode. The shifter does not have to be moved out of drive (D) to be in sport mode. This switch is used on the E36 M3 and the 4HP22/24 EH (Version Late E-7).
- **3 Position Rotary Switch** - This switch is used only on the Early 4HP22 EH trans missions (Version Early E-7).
- **No Program Switch -** On some vehicles with AGS features, there is no program switch. Shift modes are obtained by moving the shift lever out of "D" range or automatically by adaptive shift functions. (Example E39)

3 Position Program Switch



E38
Selector Lever
and Program
Switch
(2 Position)



Steptronic Shift Modes

The Steptronic shifting system was introduced to the BMW model line on the 95 E31 850Ci (from 10/94). Steptronic was subsequently added to other BMW models and is available on all BMW models with automatic transmissions. Other than a few additional components in the shifter mechanism, Steptronic equipped vehicles use the same transmission and TCM as non-Steptronic equipped vehicles.

Since the introduction of Steptronic, there have been several variations in Steptronic function. Regardless of version, the Steptronic system provides the driver with two modes of operation:

- To operate the transmission in fully automatic mode as with a non-Steptronic transmission.

- To operate the transmission in the manual shift mode by tilting the shift lever forward or backward when in the manual gate.

The Steptronic shift lever console contains and automatic and a manual shift gate. The automatic gate contains the gear lever positions P/R/N/D. When the lever is placed in “D” all of the shifting takes place based on the shift map programming in the TCM. To enter the manual gate the shift lever is moved 15 degrees to the left. Depending upon application, there are three possible configurations of the manual gate:

- On the E31 850Ci, the gate is marked as “M” only. There is a plus and minus sign for manual shifting. Upshifts are achieved by momentarily moving the shifter forward. Downshifts are achieved by moving the shifter rearward. When placing the shifter into the “M” gate, the transmission will adopt the current gear that is engaged. The transmission will stay in that gear until an upshift or down shift request is made.

- On all other vehicles until the 2002 model year, the gate is marked M/S. There is also a plus and minus sign for manual shifting. When placing the shifter into the M/S gate, the transmission will adopt Sport mode. All shifts will still be automatic. Full manual mode is achieved when an upshift or downshift request is made. Upshifts are achieved by moving the shifter forward momentarily and downshifts are achieved by moving the shifter rearward.

- On all models with Steptronic from 2002, the only change is to the manual shifting modes. In order to be consistent with SMG operation, the positions were reversed. Upshifts are now achieved by moving the shifter rearward and downshifts are now forward. Otherwise, Steptronic operation is identical to the previous models.

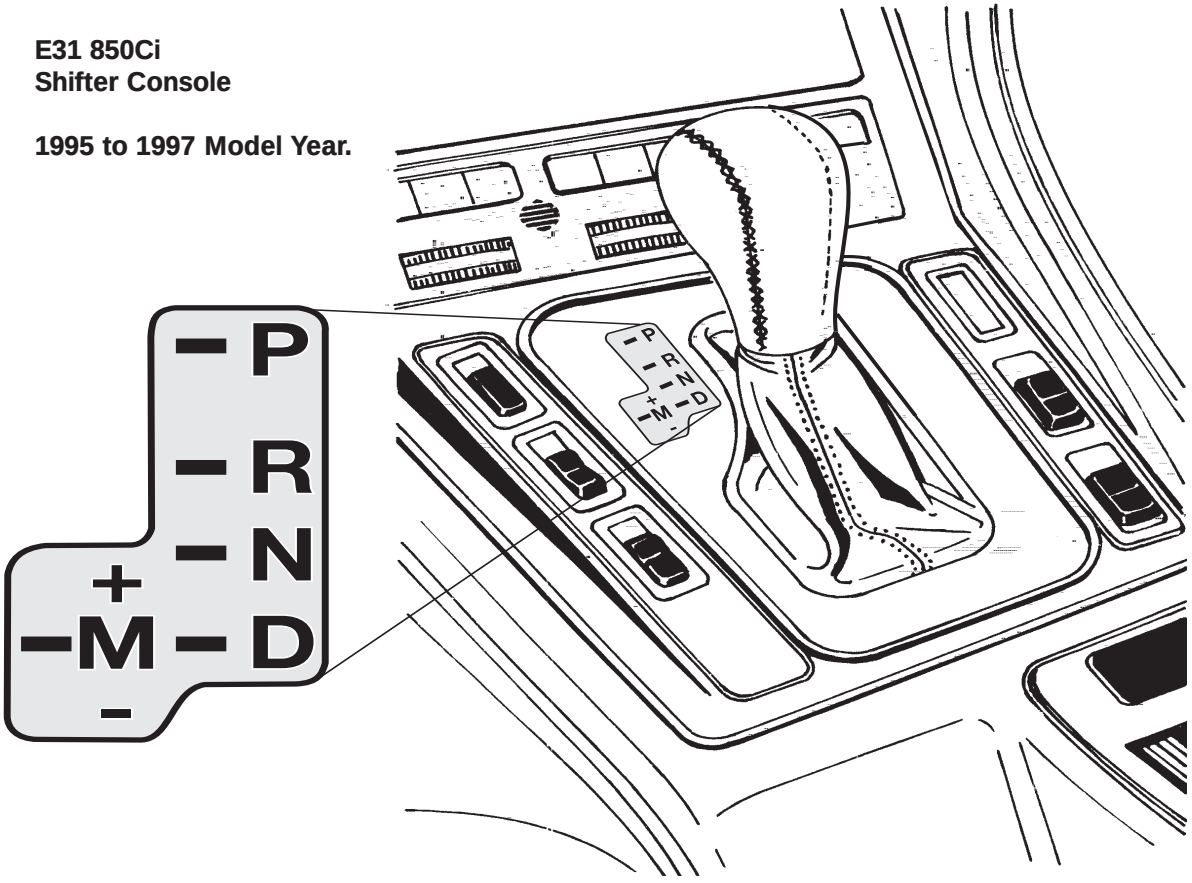
Automatic Functions in Manual Mode

When in manual mode there are certain functions which occur automatically to prevent drivetrain damage and improve driveability:

- **Engine Overspeed Prevention:** To prevent engine over-rev, the TCM will upshift automatically just prior to max engine cutoff.
- **Kickdown:** If plausible, the TCM will automatically shift down to the next lower when a kickdown request is received.
- **Decelerating:** If in 5th gear and coasting to a stop, the TCM will automatically down shift to 4th gear at approximately 31 mph and then 3rd gear at approximately 19 mph. The automatic downshift allows for an acceptable gear when re-accelerating. (6 cylinder models will shift to 2nd gear when stopping vehicle)
- **Implausible Gear Requests:** Certain shift requests are ignored by the TCM. For example, requesting a downshift at a high rate of speed would be ignored. Any shift request that would cause the engine to exceed the maximum RPM limit would not be allowed. Also starting out in a high gear is also not allowed. Only 1st, 2nd or third gear is allowed when accelerating from a stop.

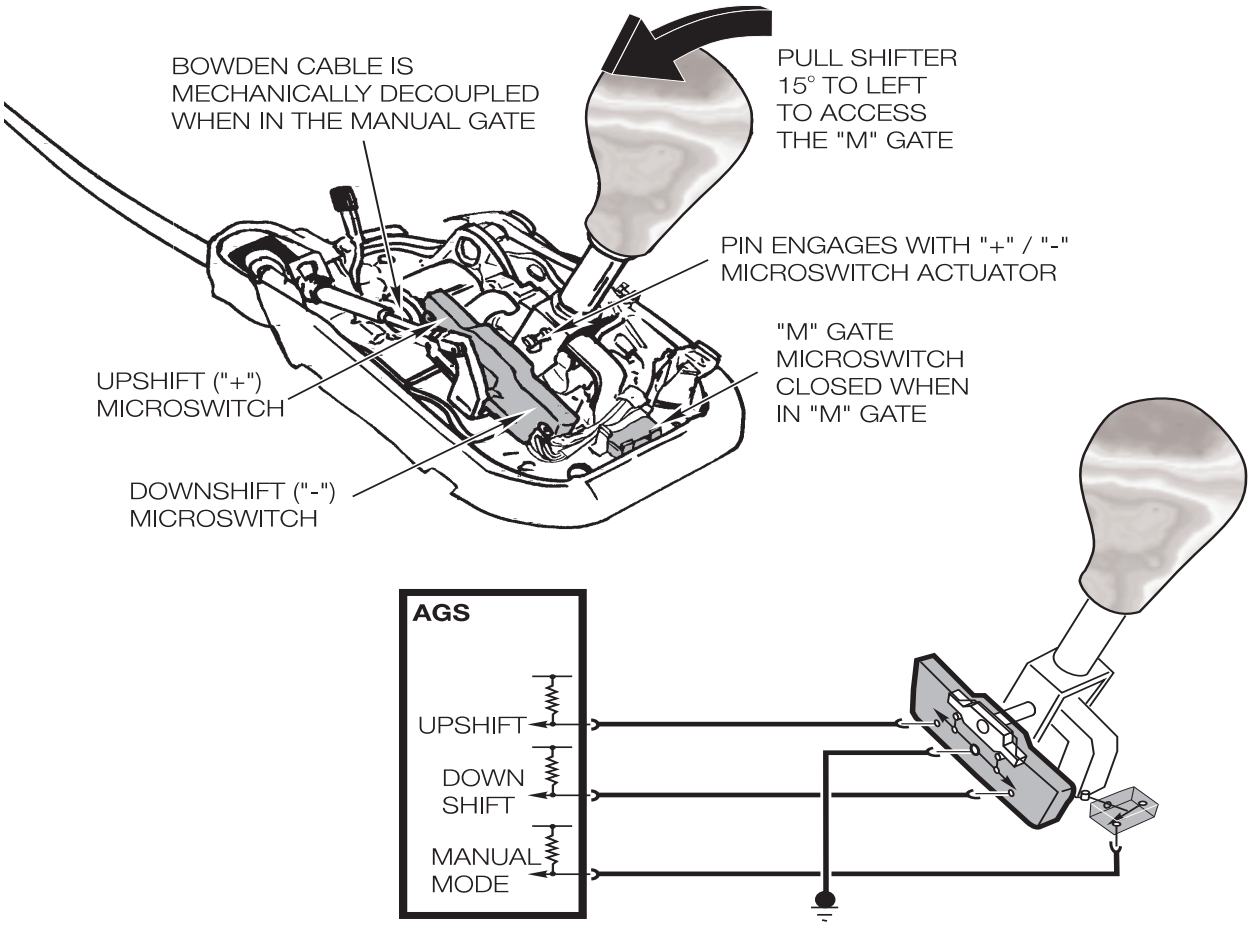
E31 850Ci
Shifter Console

1995 to 1997 Model Year.

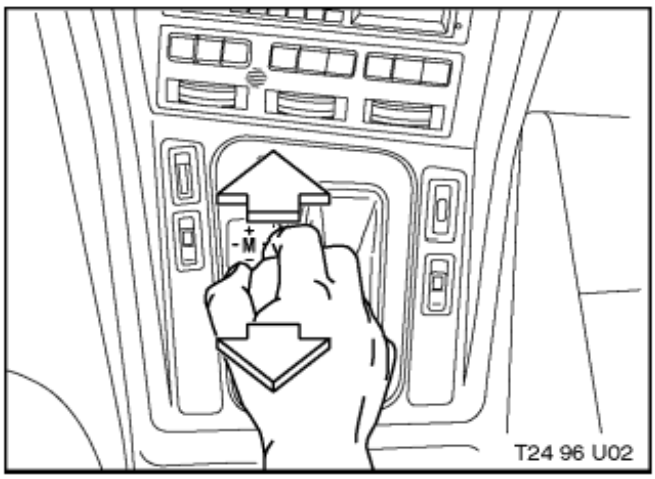


Steptronic Shifter Circuit

In order to achieve manual shifts with Steptronic, the selector lever is moved 15 degrees to the left. A pin on the selector lever engages the “up/down” microswitches which are a ground input to the TCM. The selector lever also triggers the “M” gate microswitch which is also a ground input to the TCM.



The example on the right shows a typical shift console for an E31. Note the shift pattern, upshifts are forward and downshifts are rearward. This shift pattern was used on vehicles up to the end of 2001 production. On vehicles from 2002 production, the shift pattern is reversed.



Steptronic System Comparison

Detail	E31 850Ci 1995 to 1997	All model except E31 850Ci up to 2001 Model year with Steptronic.	All Models from 2002 model year with Steptronic
Shift Console Layout	"M" Gate	M/S Gate	M/S Gate
Selection of Manual Mode	Shift to "M" gate	Shift to "M/S" gate and move lever momentarily to "+" or to "-".	Shift to "M/S" gate and move lever momentarily to "+" or to "-".
Gear Range in Manual Mode.	2nd to 5th gear (1st gear only accepted for 2 minutes after cold start. If the throttle is pressed 100% a 2-1 shift will occur	1st to 5th gears	1st to 5th gears
Un-allowable gear requests.	4th and 5th gear after vehicle standstill. Downshifts that can cause engine over-rev. 1st gear after engine warm up.	4th and 5th gear after vehicle standstill. Downshifts that can cause engine over-rev.	4th and 5th gear after vehicle standstill. Downshifts that can cause engine over-rev.
Upshifts/Downshifts	Upshifts - Forward Downshifts - Rear	Upshifts - Forward Downshifts - Rear	Upshifts - Rear Downshifts - Forward

Shift Pattern up to 2001

Shift Pattern from 2002

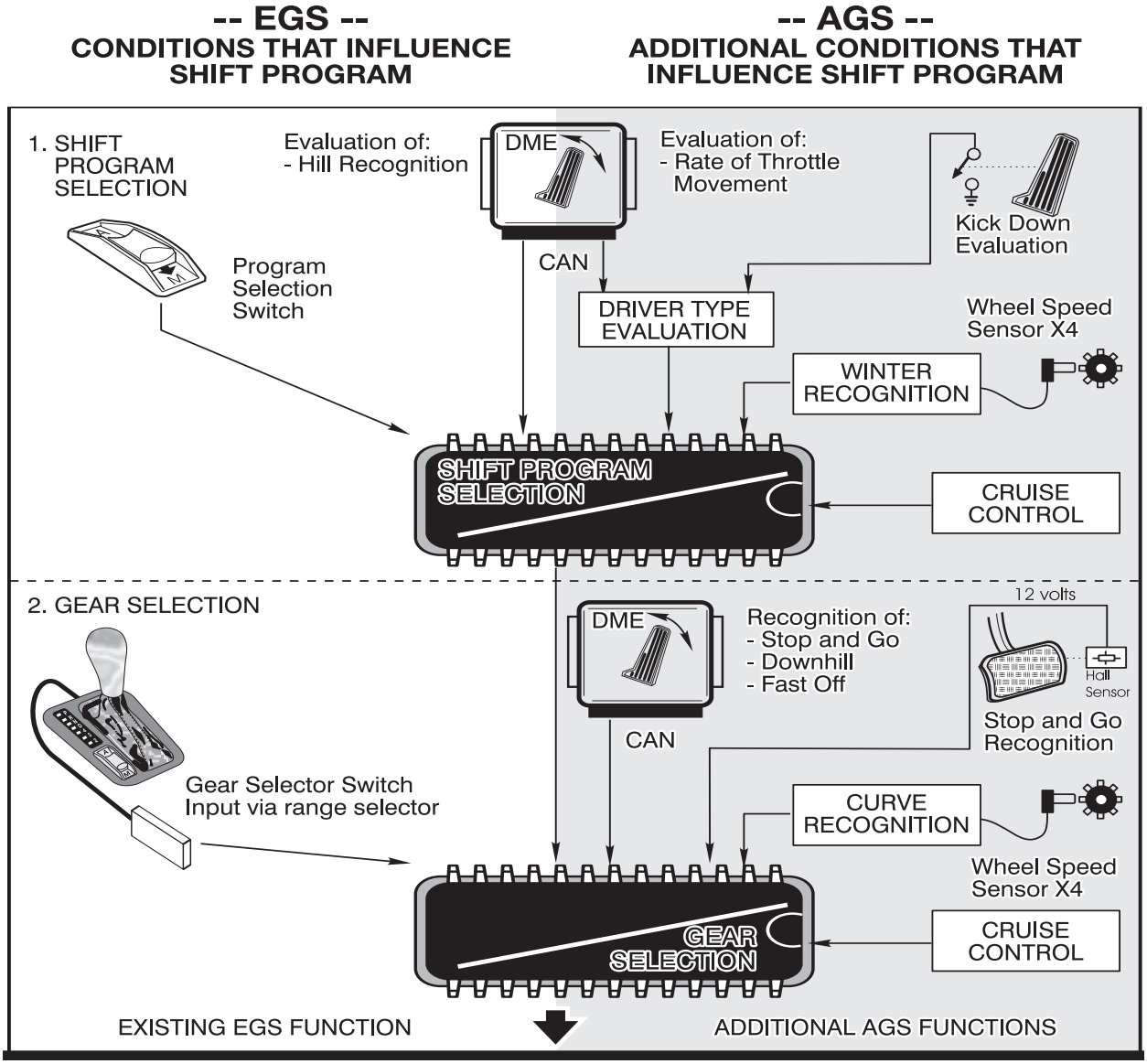
Table of Contents

Electronic Transmission Control

Adaptive Features (AGS)

AGS features were introduced in 1994 with the A5S560Z transmission. AGS control consists of adaptive features that will modify transmission operation according to various factors. AGS operation can be influenced by two major functional groups:

- Driver influenced features (influenced by throttle and kickdown input)
- Environmental influences (such as road conditions - icy, traffic etc.)



The driving program selection is not adapted on a long term basis - nor is it stored in the control module memory when the ignition is switched off. It continually changes as the driver of the vehicle changes driving habits.

Driver influenced features of AGS

The adaptive drive program is based primarily on throttle input. The throttle information comes from the ECM (DME) via the CAN bus. The TCM continuously monitors the throttle input for:

- The current throttle position
- The rate of change in pedal movement
- The number of acceleration requests
- The number of kickdown requests

Drive away Evaluation

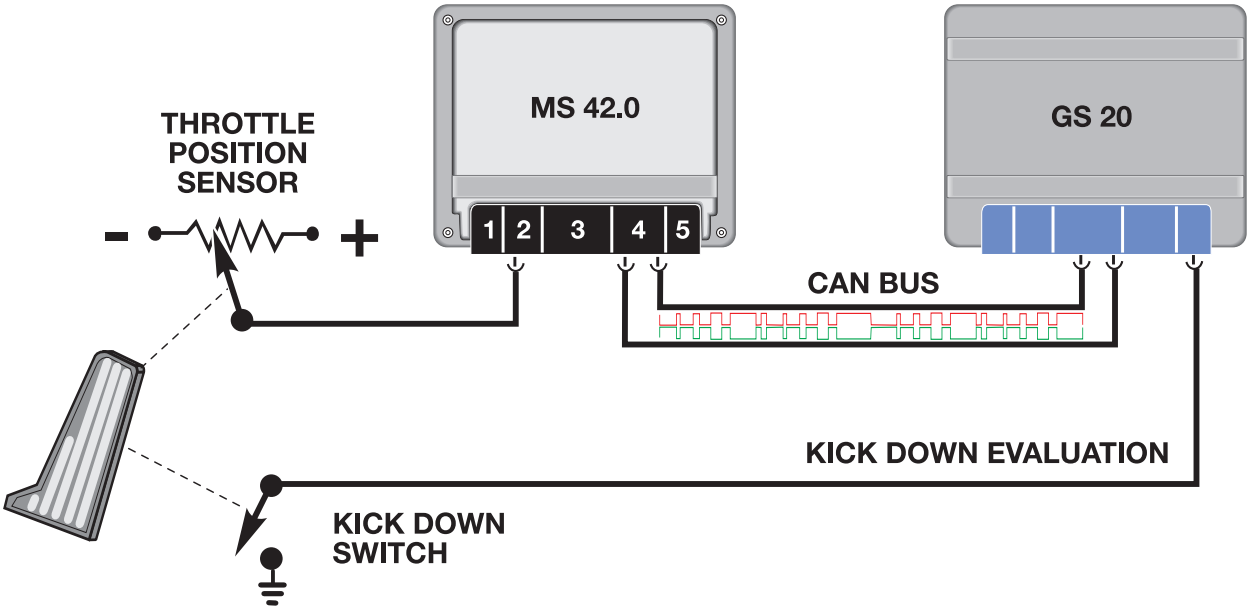
The AGS system selects the appropriate shift program based on the amount of acceleration that occurs during takeoff. When driving away under full throttle the transmission will shift from XE to E.

Kick Fast Feature

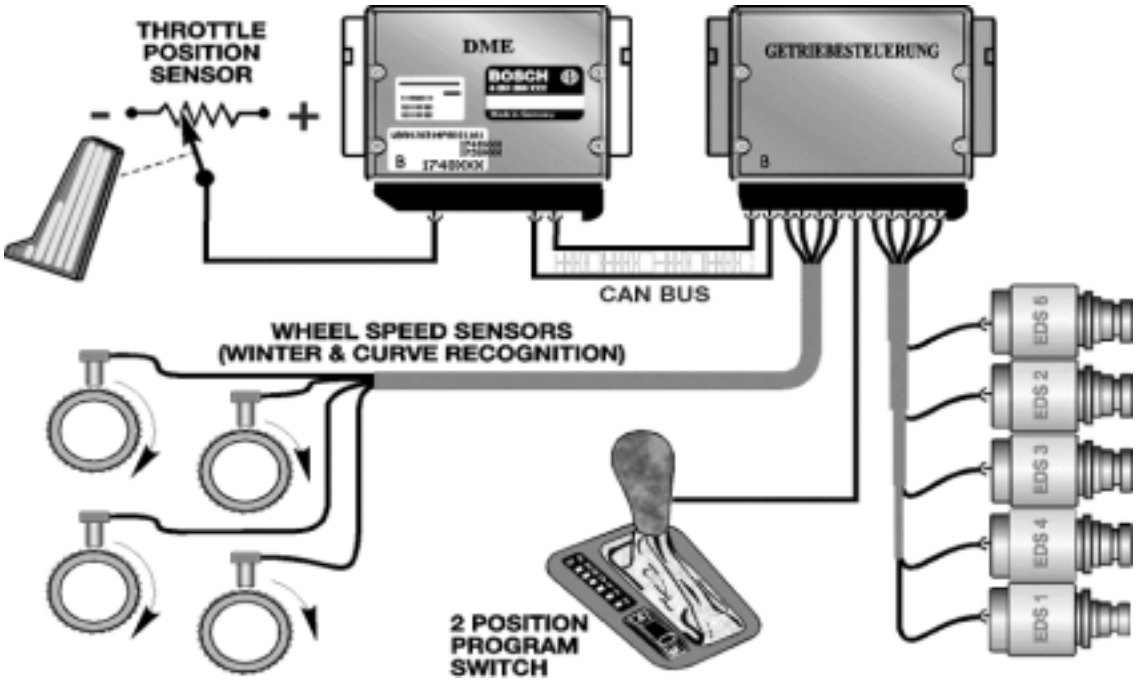
Based on these inputs, the AGS will select one three different driving programs as follows:

- Extreme Economy - Shift points are a low speeds for maximum comfort and economy
- Economy - The shift points are raised for more performance with economy as priority
- Sport - The shift points are higher to take advantage of full engine performance.

Under full throttle acceleration at high speed, single gear downshifts are possible. A two gear downshift is possible if the accelerator pedal is moved quickly to kick-down. The Extreme Sport program was eliminated as part of the kick-fast feature.



Environmentally influenced AGS features



STOP and GO

The feature is activated by defined sequence of shifts which are as follows:

- Upshift from first to second - followed by a downshift from second to first - followed by another upshift from first to second. This is then followed by the vehicle coming to a complete stop.

After this sequence occurs, the transmission will stay in second gear. The AGS control has recognized stop and go driving and this function will prevent excessive shifting during heavy conditions. The second gear start will be cancelled when:

- The vehicle speed exceeds 40 MPH
- The throttle pedal is pressed more than 90%
- The range selector is moved to Park, Neutral, Reverse or Sport (4,3 or 2)
- The vehicle is in Sport Mode

Winter Drive Program

This feature is activated when the TCM detects slippage at the rear wheels by comparing front and rear wheel speed signals. When slippage is detected by the TCM, the transmission will start in second gear and the shift points will be lowered. This will reduce torque to the rear wheels allowing improved driveability and traction on slippery roads.

Hill Recognition Program

There are two hill recognition programs, one for Uphill and one for Downhill. The TCM will activate this feature when it receives a high engine load signal at slower road speeds. The TCM will perceive this information as being consistent with climbing a hill. The shift points will be raised to prevent constant up and down shifting. This is referred to as the pendulum shift effect. When driving downhill, road speed will increase with minimal throttle input. The TCM will detect a downhill situation and hold the current gear to prevent an upshift when going downhill.

Curve Recognition

This feature will inhibit upshifts when the vehicle is in a curve. This is to improve stability when the vehicle is cornering at high speeds. The TCM will initiate this feature when it detects a difference between left and right (front) wheel speed signals. The difference in these signals will indicate that the vehicle is in a curve. Be aware that improper tire sizes, brands and inflation pressures can influence this feature. Always address these issues first when diagnosing delayed upshift complaints.

Cruise Control Drive program

A special cruise control shift map is selected by the TCM when cruise control is active. The TCM will prevent unwanted locking and unlocking of the torque converter clutch. Also, upshifting and downshifting will be minimized. Depending upon application, the cruise control interfaces with TCM via a single wire data link or as on vehicles with electronic throttle control, the TCM will interface with the ECM (DME).

Manually Selected “Extreme Sport” Program

This feature is activated by moving the shift lever to position 4, 3 or 2. This activates the “Extreme Sport Program” where the shift points are raised for maximum rpm and performance. On Steptronic equipped vehicles, the sport program is obtained by moving the shifter to the manual gate to initiate the “Sport Program”.

Modifications to AGS features

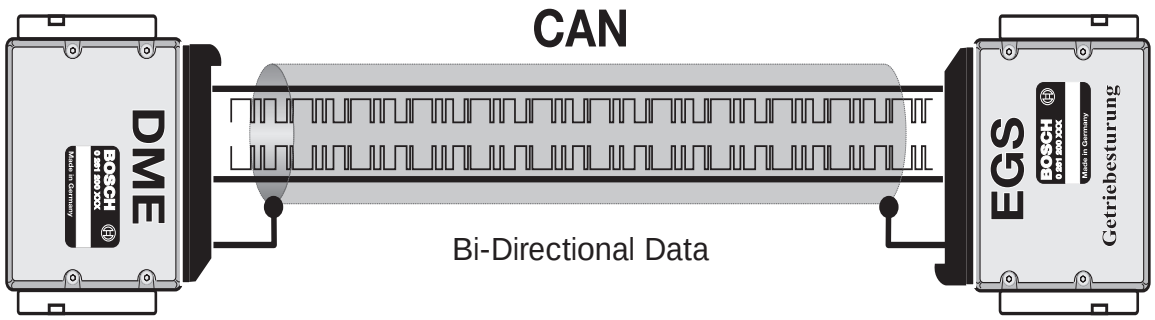
Since the introduction of AGS features in 1994, there have been some software changes to address customer concerns. Some AGS features have been perceived by the customer as malfunctions. To correct this, some of the AGS features were modified with updated software. The AGS features previously discussed in this text reflect the updated modifications. Always refer to the latest Service Information Bulletins for more information on AGS features.

CAN Bus Communication

The CAN bus is a serial communications bus in which all connected control units can send as well as receive information. Data over the CAN bus operates at a rate of up to 1Mb/s (megabits per second).

The CAN protocol was developed by Intel and Bosch in 1988 for use in the automotive industry to provide a standardized, reliable and cost-effective communications bus to combat the increasing size of wiring harnesses.

The CAN bus was originally introduced on BMW automobiles in the 1993 E32 740i/IL as a data link between the TCM (EGS) and the ECM (DME).



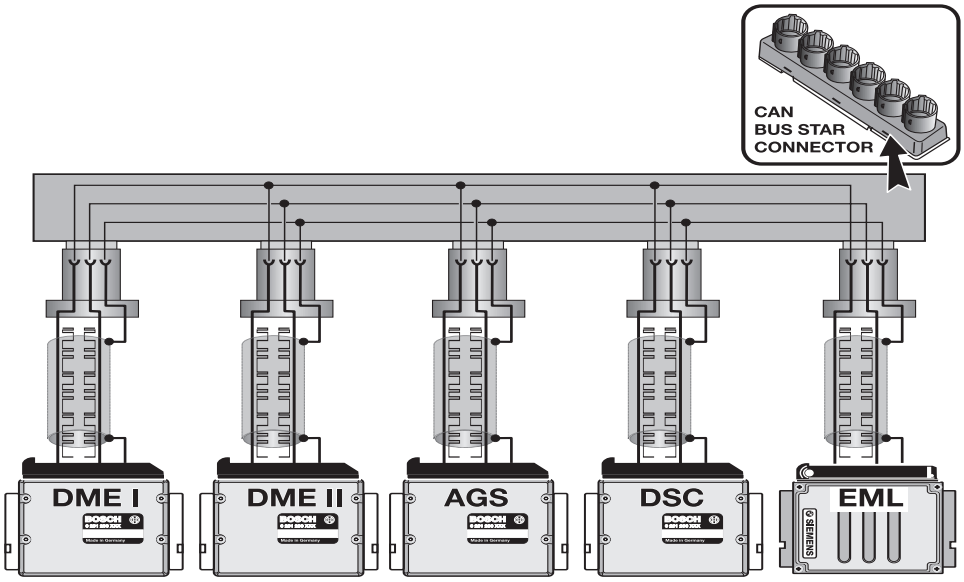
On earlier EGS systems, various signals were transmitted on individual signal wires. This reduced reliability and increased the amount of wiring needed. The CAN bus allows faster signal transmission and increased versatility. For example, the signals listed in the chart below were previously transmitted on individual wires, now these signals are all on the CAN bus. This chart represents only some of the signals on the CAN bus, there are many more signals transmitted between the TCM and ECM.

Sender	Information Item	Receiver	Signal Use
ECM	Engine Temperature	TCM	Shift Point Calculation
ECM	Engine Load (tL)	TCM	Shift Point Calculation
ECM	Engine RPM (TD)	TCM	TCC Slippage
ECM	Throttle Position (DKV)	TCM	Shift Point Calculation
ECM	A/C Compressor ON	TCM	Fine tune shift points to compensate for increased engine load.
TCM	Transmission Range	ECM	Engine Idle Speed Control
TCM	Torque Reduction Signal (ME)	ECM	Timing Retard during shifts.
TCM	TCC Lockup Status	ECM	Engine Timing Map adjustment.

CAN Bus Topology

The CAN bus consists of two twisted copper wires. Each wire contains an opposing signal with the exact same information (CAN-High, CAN-Low). The opposing signals transmitted through the twisted wire serve to suppress any electrical interference. Early CAN bus wiring included a grounded shield around the two wires, later vehicles discarded the shield in favor of the unshielded twisted pair wiring.

Due to the linear structure of the network, the CAN bus is available for other modules in the event of a disconnected or failed control unit. This is referred to as a “Tree” structure with each control unit occupying a branch.



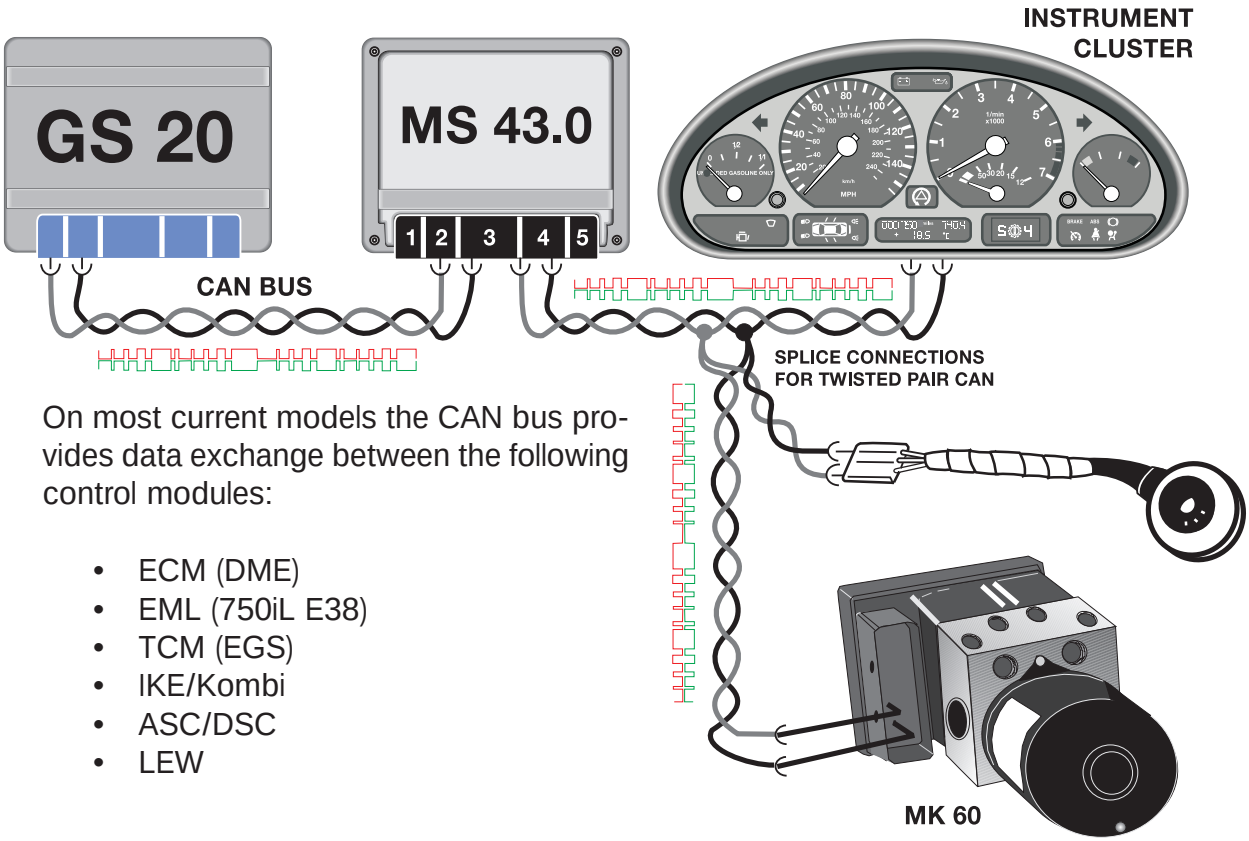
As previously mentioned, the CAN bus initially was used as a high speed communication link between the DME and AGS control units.

With the introduction of the E38 750iL (95 M.Y.), the CAN bus was expanded to include the EML and DSC control modules. The 750iL made exclusive use of the “star coupler” to link the individual CAN bus ends to a common connector.

The 1998 model year introduced new users of the CAN bus. The instrument cluster and the steering angle sensor were linked to expand the signal sharing capabilities of the vehicle.

The 1999 750iL was the last vehicle to use the shielded cable, after which the entire CAN bus went to twisted pair wiring.

Note: Always refer to the proper ETM to determine the exact wiring configuration for a specific model.



On most current models the CAN bus provides data exchange between the following control modules:

- ECM (DME)
- EML (750iL E38)
- TCM (EGS)
- IKE/Kombi
- ASC/DSC
- LEW

On models that use twisted pair, the wire color of the CAN bus is uniform throughout the vehicle with: CAN-Low GE/BR and CAN-High GE/SW or GE/RT. Shielded wiring is easily identified by the black sheath surrounding the CAN bus.

Troubleshooting the CAN Bus

The failure of communication on the CAN bus can be caused by several sources:

- Failure of the CAN bus cables.
- Failure of one of the control units attached to the CAN.
- Failure of the voltage supply or ground to individual modules.
- Interference in the CAN bus cables.

Failure of the CAN bus cables

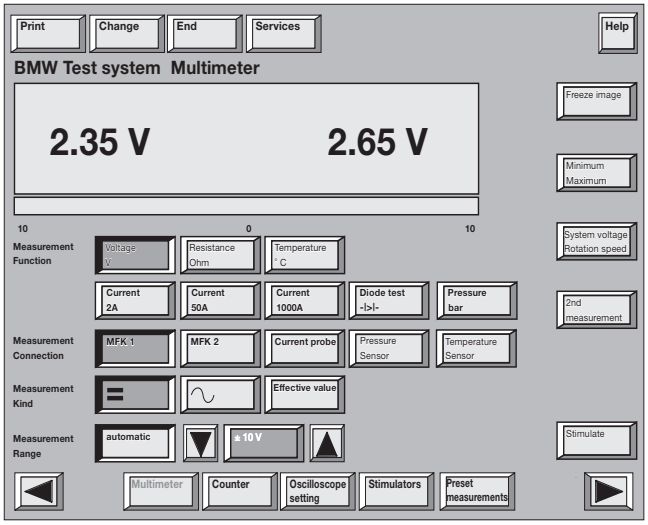
The following faults can occur to the CAN bus wiring:

- CAN-H/L interrupted
- CAN-H/L shorted to battery voltage
- CAN-H/L shorted to ground
- CAN-H shorted to CAN-L
- Defective plug connections (damaged, corroded, or improperly crimped)

In each instance, the connected control units will store a fault due to the lack of information received over the CAN bus.

The voltage of the CAN bus is divided between the two data lines: CAN-High and CAN-Low for an average of 2.5V per line. The voltage measurement is taken from each data line to ground. Each module on the CAN contributes to this voltage.

The fact that 2.5V are present does not mean that the CAN bus is fault free, it just means that the voltage level is sufficient to support communication.



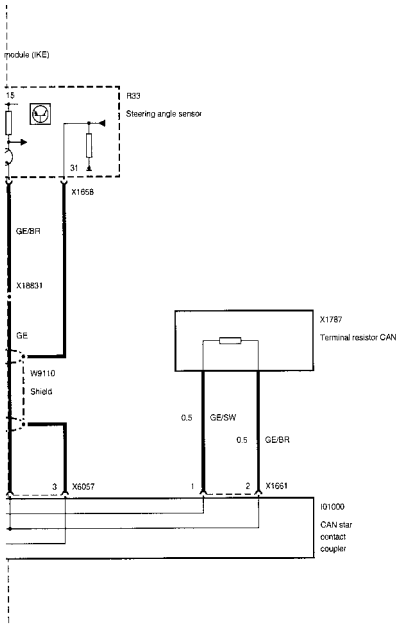
Terminal Resistors: are used in the CAN bus circuit to establish the correct impedance to ensure fault free communication. A 120 Ohm resistor is installed in **two** control units of the CAN between CAN-H and CAN-L. Because the CAN is a parallel circuit, the effective resistance of the complete circuit is 60 Ohms. On some vehicles there is a jumper wire that connects the two parallel branches together, others have an internal connection at the instrument cluster.

The resistance is measured by connecting the appropriate adapter to any of the modules on the CAN and measuring the resistance between CAN-L and CAN-H. The resistance should be 60 Ohms. The CAN bus is very stable and can continue to communicate if the resistance on the CAN bus is not completely correct; however, sporadic communication faults will occur.

The terminal resistors are located in the ASC/DSC control unit and either the instrument cluster or in the DME.

Early 750iL vehicles that used the star connector have a separate external resistor which connect CAN-H and CAN-L together.

Modules which do not have the terminal resistor can be checked by disconnecting the module and checking the resistance directly between the pins for CAN-H and CAN-L. The value at these control units should be between 10kOhms and 50kOhms.



Diagnosis and Troubleshooting

Due to the cost and complexity of today's electronic transmissions, BMW recommends that the technical hotline be contacted before any repairs are performed. It is important that the technician perform some basic diagnostic procedures before contacting technical assistance. The following procedures should be followed:

- Always Verify customer complaint, make sure the complaint is not related to normal operation. (i.e. Warm Up Phase, AGS operation etc.)
- Survey Fault Memory - Perform **complete** quick test. There may be other systems that interface with EGS that could cause faults. (i.e DME, ASC/DSC, IKE/Kombi etc.)
- Print out all fault code with fault conditions. Also print out copy of Identification page and diagnostic report.
- CHECK TO SEE IF THERE ARE ANY SERVICE BULLETINS THAT APPLY TO YOUR SPECIFIC COMPLAINT. THIS INCLUDES THE SERVICE ROUNDTABLE.
- Ensure that battery voltage is sufficient. Battery voltage must be greater than 12.5 with ignition switched off. Check battery connections for tightness and condition.
- Check ground connections. (chassis to engine, grounds to bulkhead and shock tower.)
- Check over vehicle to look for transmission leaks, physical damage, loose connections etc.
- If necessary, check fluid level and condition using DISplus or GT-1.
- Check to see if any aftermarket or performance components have been installed that could effect transmission operation. (DME or EGS software as well as any engine modifications).
- Check repair history to see if there were any recent repairs that could effect the proper operation of the transmission (i.e. Engine replacement with damaged dowel pin etc.).
- Check DCS for any open campaigns or recalls pertaining to drivetrain.
- Check and record chassis number, production date and transmission serial # before contacting technical assistance.

Establishing a Diagnostic Plan

Once all of the pre-diagnostic criteria has been satisfied, a logical diagnostic plan should be followed. A logical, well organized diagnostic plan will help avoid improper diagnosis, unnecessary parts replacement and lost diagnostic time. A technician's goal should be to satisfy the customer by "Fixing it the first time, on time, every time". The productivity of the technician can also be improved by following a logical, common-sense approach to problem solving. The following steps are recommended to form a diagnostic plan:

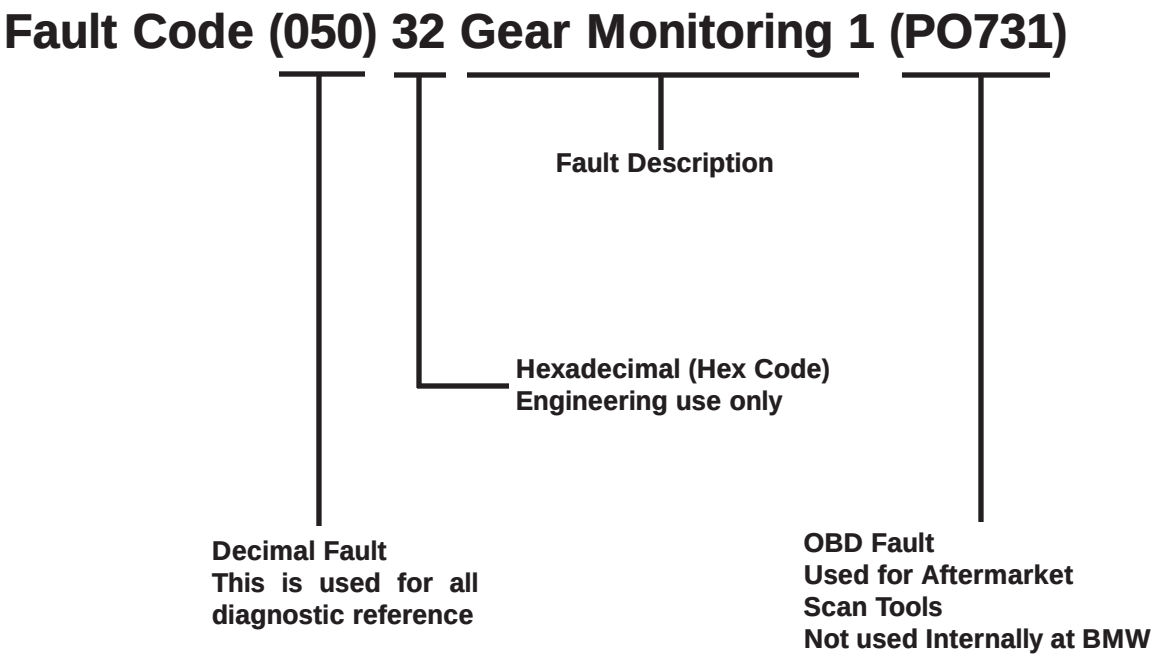
- **Verify the Customer Complaint -** This step is the most important , but also the most overlooked. The focus should always be on the exact customer concern. Make sure that the customer complaint is not a misunderstanding of proper vehicle operation. This step can avoid unnecessary diagnosis and lost time. If the customer concern is not exactly identified, any subsequent repairs can not be verified as being effective. This is the most common cause of "comeback" repairs. Communication between the customer to advisor and the advisor to technician must be clear. Vague or misunderstood customer complaints are often improperly diagnosed. Also make sure that the conditions under which the concern has occurred are duplicated. For example: If the customer is customer is complaining about a shifting concern after a cold start, then the vehicle should be road tested under those conditions.
- **Analyze the Problem -** Once the complaint has been verified, then all available resources should be used to find the "root cause" of the complaint. Start out by checking Service Information Bulletins, DCS messages, and Service Roundtable information. Use the DISplus or GT-1 to access the diagnostic program and per form Diagnostic Test Modules where applicable. Electrical Troubleshooting Manuals (ETM's) should also be used when needed.
- **Isolate the Problem -** Now, the problem can be narrowed down into the final steps of diagnosis. Using proper tools and procedures, the technician can "Isolate" by using the process of elimination and common sense. Having a working knowledge of BMW systems is helpful in this area. When applicable, use all available BMW special tools and equipment. Perform all necessary electrical checks such as Voltage Drop, resistance measurements etc.
- **Repair the Problem -** Once the concern has been correctly identified, perform all necessary repairs as per BMW guidelines. Make sure all repairs are properly documented to comply with warranty policies and procedures.
- **Verify the Repair -** Make sure the customer concern has been rectified. Road test the vehicle under the same conditions whenever possible. Failure to complete this step properly is almost a guaranteed comeback. Repeat repair attempts are costly to the BMW Center and the BMW Service Technician.

REMEMBER - Fix it the first time, On Time, Every time.

Fault Codes

When diagnosing transmission fault codes, always print out the fault code(s) and the fault conditions. When referring to the fault code itself, be aware that there are actually 3 formats for the fault code. The fault code breakdown is as follows:

Fault Code Example:



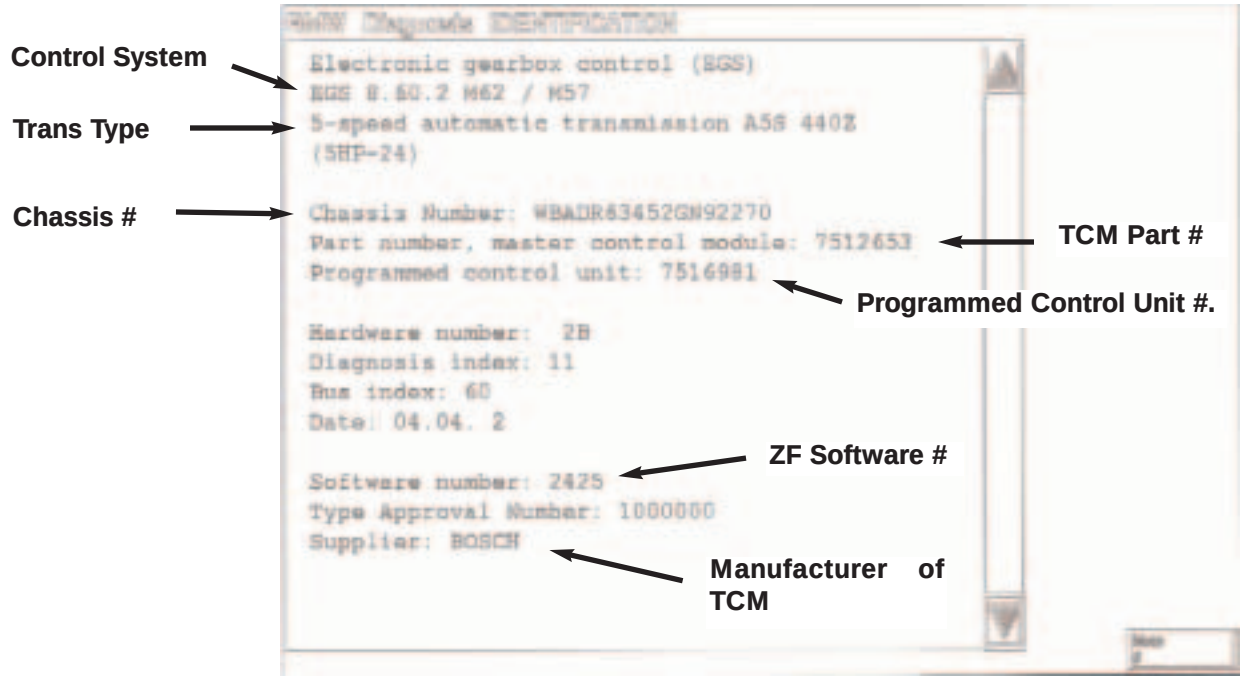
When referring to the “Fault Code” during diagnosis always use the fault that is in Decimal Format. The Decimal fault is referred to in all reference material such as Service Information Bulletins, Test Modules and DCS messages etc. In the example above, FC 050 would be the correct choice.

Fault Conditions

When a fault code is set, it is stored with a set of environmental conditions. The environmental conditions are used to aid in pinpointing the root cause of the fault. Some of the information found in the fault conditions contain information on transmission temperature, engine speed and road speed etc. This information is also helpful when trying to duplicate the customer complaint. For example, if a customer complains about a shifting complaint when cold, check the fault conditions to verify this complaint. Remember to always print out the fault codes with the fault conditions. This information is helpful to the technician as well as technical assistance.

Identification Page

The ID page is helpful to determine the Transmission and control system used as well as the chassis number and current software version. Always print out a copy of the ID page when performing any diagnosis or programming procedures.



Diagnosis Program

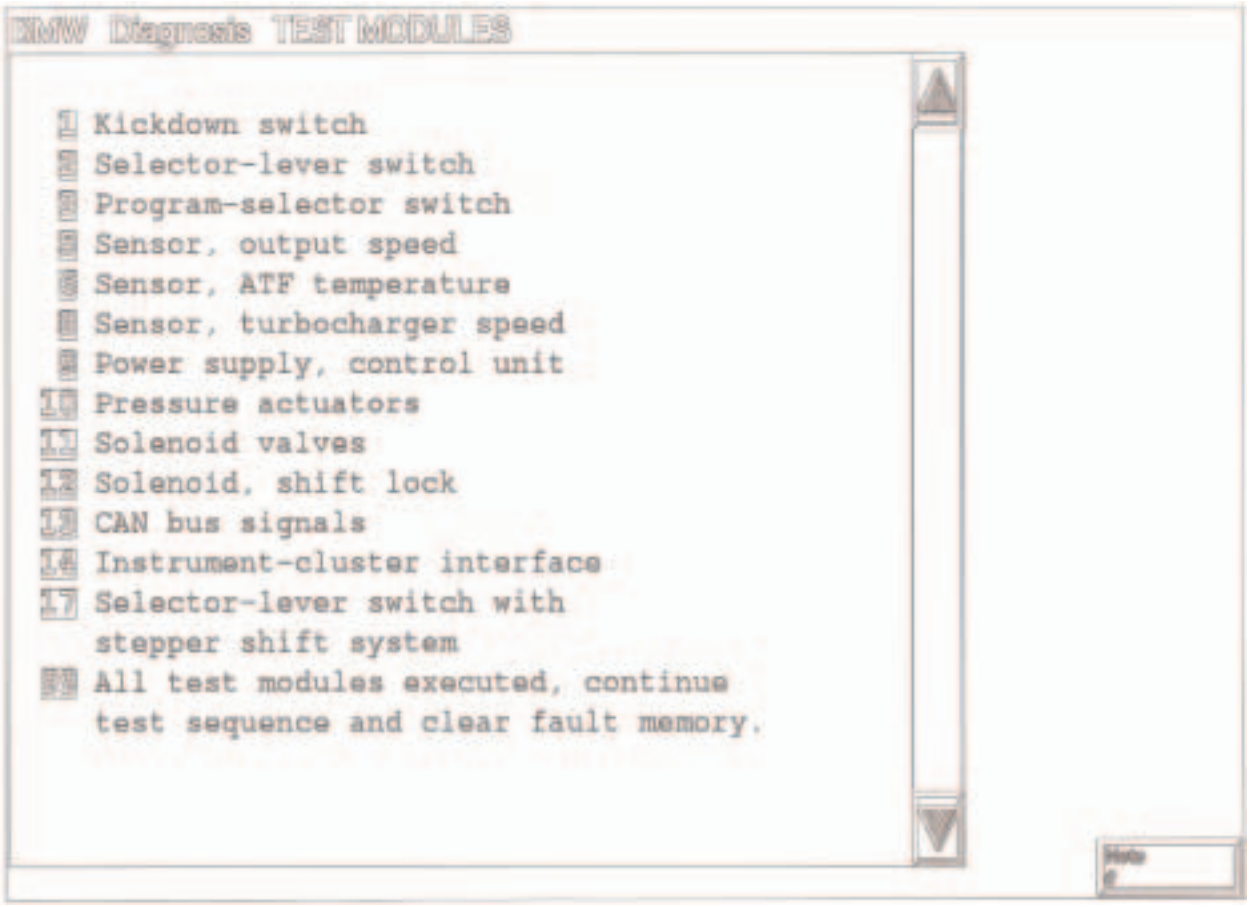
There are two diagnostic formats (programs) used on current model BMW vehicles. The earlier diagnostic program was used on the E38 and E39. The latter diagnostic program was introduced as the “E46 Diagnostic Concept”. This is used on the E46, E65 and the E52 (Z8). The E53 X5 uses a mixture of both diagnostic programs depending upon engine/transmission options. Below is an example of the earlier diagnostic program.

The diagnostic program contains the following features:

- **Fault Symptoms -** This is a symptom driven program that will lead the technician into guided diagnostics. It contains several possible fault scenarios that are common to electronic transmissions. This path is helpful when the technician is not sure where to start in his diagnostic plan.
- **Function Test -** There are no function tests for electronic transmissions.
- **Service Functions -** This is where you will find the ATF level check function. Also Test Codes can be obtained and printed out for warranty purposes. The Adaptation values can be cleared as well as printed out.
- **Expert Mode -** Expert Mode should be used when the technician has a thorough working knowledge of the system. You will find several items in expert mode: Read/Clear fault memory, Diagnosis (Status) requests, Component Activation and Test Modules.

Test Modules

Test modules are found in the diagnosis program of the DISplus and GT-1. These allow the technician to take advantage of a guided diagnostic plan. The program will direct the technician through the various steps using a “trouble tree” format. When using test modules it is important to follow the instructions exactly. Due to the complex nature of some faults, the test modules are not always conclusive. The test module is only as effective as the information provided by the technician. The technician also needs to rely on his experience and some common sense. The test modules should be used to assist the technician, not as a replacement for good diagnostic skills.



Test modules come in two formats. The one shown above is used on E38/E39 vehicles and the E53 with 4.4 and 4.6 engines. The E46, E65 and E53 (with 3.0 M54) uses the new “E46 Diagnostic Concept” which was introduced with the E46 in the 1999 model year. Regardless of the format used, the technician is still guided through a step by step procedure.

Diagnostic Tips

The following consists of some helpful hints to assist the BMW diagnostic technician. It is designed to assist the technician to form a logical path of diagnosis. These suggestions should be used in conjunction with other approved diagnostic routines. This does not exclude the technician from the responsibility to contact technical assistance. All major repairs and transmission replacement must be pre-approved by the BMW Technical Hotline. Transmission concerns can be broken down into several categories:

- **Shift Quality Complaints -** Shift Quality complaints consist of harsh up or down shifts, improper shift points and erratic shifting. These complaints could be related to electronic/software issues or hydraulic/mechanical problems. Perform quick test and check SIB's before proceeding. As with most concerns, check the transmission fluid level and condition as well.
  Do not clear adaptation values unless instructed to do so by BMW Technical Hotline.
- **Delayed/No Upshifts -** Before proceeding on delayed upshift complaints, make sure you are aware of the conditions that this occurs. This could be normal opera tion, such as the "Warm-up Phase" program. Always check front tires for proper inflation pressures, correct size and type. Also check for uneven tire wear. Variations in front tire size from left to right can activate the AGS "Curve Recognition" feature. The TCM will interpret the difference in wheel speed signals as being a turn and suppress (or delay) upshifts.
- **Slipping -** This type of issue is usually associated with a fault code. Be sure to check the transmission fluid level and condition.
- **Noise, Vibration -** Noises and vibrations should be checked over by a good visual inspection. Look for loose transmission or engine mounts. Check the driveshaft, center bearing and flexible coupling (or constant velocity joints). Also check the lateral alignment of the driveshaft. There are several SIB's pertaining to noise and vibration.
- **No Forward or Reverse Gear -** Start by checking transmission fluid level and note the fluid condition. Inspect for leaks and external transmission damage.
- **Leaks -** When investigation transmission leaks, be sure to verify that the suspected leak is actually transmission fluid. Engine oil, hydraulic and brake fluid can be mis-taken for a transmission leak. Check the transmission cooler lines, transmission cooler and transmission pan gasket. Try to locate the source of the leak. Do not make any major repairs until the technical hotline is contacted.
- **Fault Codes -** Perform COMPLETE short test (Quick test) on all vehicle systems. It is important to survey all systems in the event that a related system is causing the transmission fault. Always print out the ID Page, Fault codes and fault conditions.

Information Resources

When diagnosing transmission related concerns it is important to use all information resources available. The following information sources should be utilized at all times:

- Service Information Bulletins
- Technical Data
- ETM Electrical Troubleshooting Manual
- DCS (Dealer Communication System)
- Repair Instructions
- Tightening Torques
- Technical Training Manuals
- Special Tool Information

Technical Information System (TIS)

Most of the above information can be accessed by using the BMW TIS CD or by logging on the the BMW TIS website through **www.bmwcenternet.com.** The BMW TIS website contains a wealth of helpful information for the technician. The information is updated on a regular basis.

Service Roundtable

In addition to the above sources of information, the technician should be up to date on the latest edition of the BMW Service Roundtable. The roundtable will cover the most recent topics and offer some hints that will assist the technician. The Service Roundtable is broadcast live on a monthly basis via the BMW Visionwerke Network. In addition to live broadcasts, the roundtable is rebroadcast on a regular schedule during the month.

TCM Coding and Programming

As with other control modules used on BMW systems, the TCM must be programmed and/or coded for the vehicle. Over the years, these methods have varied from system to system. Refer to Service Information Bulletins for the latest coding and programming information.

Coding

Coding will assign the control unit to a particular application. Information such as differential ratio, tire size, vehicle series, engine, engine control system, w/wo AC etc.are some of the possible variants that have to be considered. Transmission control units are coded using various methods.

- **Grounding pins in wiring harness connector -** On early models equipped with the 4HP22/24 EH transmissions, the TCM was coded to the vehicle by means of grounding pins in the wiring harness connector for the TCM. By selectively grounding specific pins in the harness, the TCM was assigned to that vehicle. For Example: The TCM could be installed in a 535, 635, or a 735. This only applies to the Early E-7 Versions. (E23, E24, E28)
- **TCM ordered for Specific Application** - On some later models, the TCM was ordered for a specific vehicle application, coding was not necessary.
- **Coding performed during programming -** On systems that use a flash programmable TCM, the coding process is done during flash programming.

Programming

Programming refers to the instructions that the TCM is to follow. The TCM is programmed to apply certain shift maps according to operating conditions such as vehicle speed, engine speed, engine temperature, engine load and throttle position. This information can be entered into the TCM via an updated EPROM or through flash programming.

Flash programmable control units use a EEPROM which is Electronically Eraseable. The EEPROM is also soldered into the TCM and cannot be removed or replaced. Flash programmable TCM's can be programmed up to 14 times (with a new TCM).

Note: Always clear adaptations after programming.

Note: Do not program a TCM to correct a complaint unless there is a specific SIB that covers the issue. Only program when installing a new TCM or when instructed to do so by BMW Technical Assistance. Always have the ID page available when calling for technical assistance.

Control System	Transmission	Coding	Programming	TCM Type
GS 1.26 GS 1.27 GS 1.29	4HP22 EH (Early E-7)	Grounding pins in Harness. (Early E-7 Only)	Replaceable EPROM	35 Pin
	4HP22/24 EH (Late E-7 and E-9)	TCM ordered for specific application. Coding not needed.	Replaceable EPROM	35 Pin
GS 7.3 GS 7.32 GS 7.11 GS 8.32	A5S310Z (5HP18)	TCM ordered for specific application. Coding not needed.	Replaceable EPROM	88 Pin
GS 8.60 GS 8.60.4	A5S325Z (5HP19)	Coding done when Programmed	Flash Programming (EEPROM)	134 Pin SKE
GS 8.55 GS 8.60.2	A5S440Z (5HP24)	Coding done when programmed	Flash Programming (EEPROM)	88 Pin up to 98 (E38 M62) 134 Pin SKE from 98 to present.
GS 9.2 GS 9.22 GS 9.22.1	A5S560Z (5HP30)	TCM ordered for specific application. Coding not needed.	Replaceable EPROM	88 Pin
GS 8.60.3	A5S560Z (5HP30) (E38 M73TU)	Coding done when programmed.	Flash Programming (EEPROM)	134 Pin
GS 4.14 GS 4.16	A4S310R (THMR-1)	TCM ordered for specific application. Coding not needed.	Replaceable EPROM	55 Pin
GS 8.34	A4S270R (THMR-1)	TCM ordered for specific application. Coding not needed.	Replaceable EPROM	88 Pin
GS 20	A5S360R A5S390R	Coding done when programmed	Flash Programming (EEPROM)	134 Pin SKE

Transmission Fluid Information

Transmission Fluid (Oil)

The automatic transmission provides filtered, pressure regulated hydraulic fluid for all of the transmissions functional requirements. All BMW automatic transmissions are designed to operate with specific fluids. Use of non-approved oil will cause malfunctions and irreparable transmission damage which is not covered by BMW warranty.

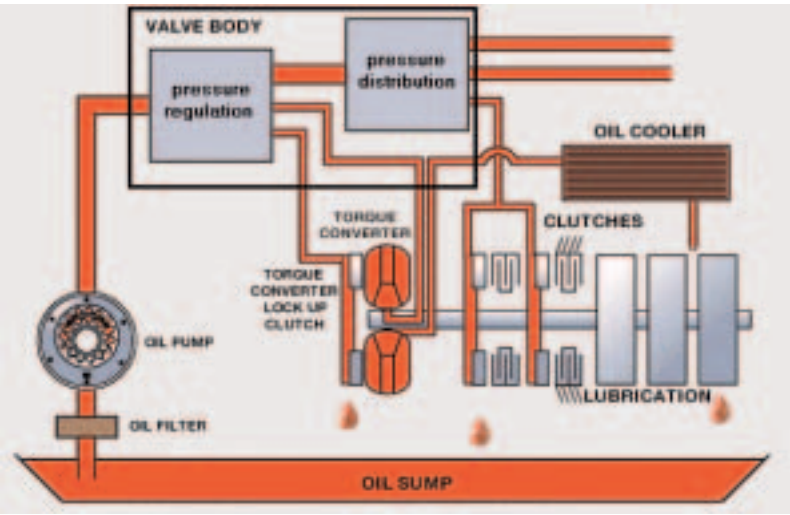
The transmission fluid provides the following functions:

- Lubricates mechanical components (planetary gears, bearings etc.).
- Removes heat and transfers heat to transmission cooling system. (Heat Exchanger).
- Removes debris and contaminants to sump and filter when circulated.
- Provides a transfer of kinetic energy in the torque converter.
- Allows hydraulic operation of mechanical components (clutches, brakes) via control of the valve body.

Also, transmission fluid has various properties to prevent oxidation and breakdown from heat and friction. Each type of transmission fluid has properties specific for each transmission application.

Fluid level is crucial in the proper operation of an automatic transmission. Improper fluid levels will cause improper operation and eventually irreparable transmission damage. Improper fluid level can cause:

- A low fluid level can cause an interruption in oil flow during fast acceleration or hard braking which can cause gear shift malfunctions and noises.
- An excessively high fluid level can cause the rotating mechanical components to paddle in the oil. This produces foam which introduces air into the hydraulic system.
- A low fluid level can also cause transmission overheating causing premature transmission failure.



Transmission Fluid Checking Procedures

Transmission fluid checking is accomplished using the DISplus or GT-1. The DISplus or GT-1 is used to monitor transmission fluid temperature to insure the transmission is not over or under-filled. As with most other current ZF transmissions there is no dipstick, the fluid level is checked and filled at the fill plug. The location of the fill plug varies between transmissions.

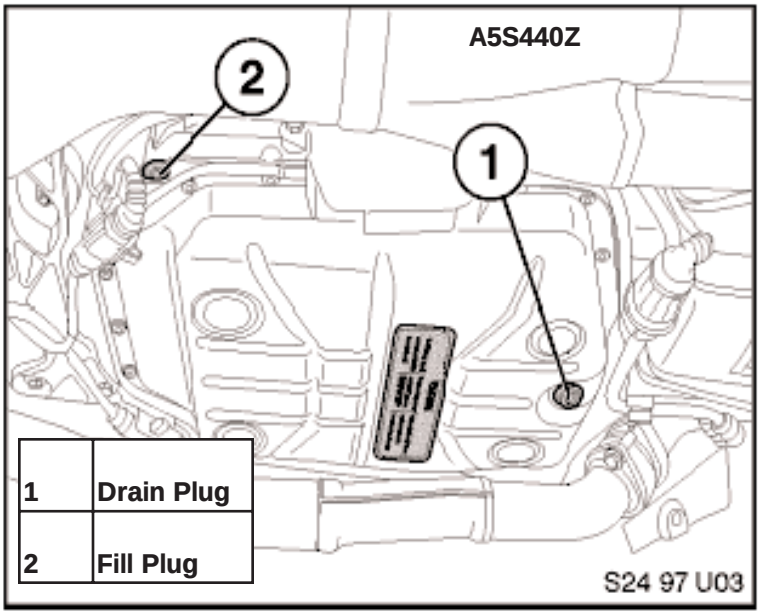
Transmission fluid should be checked between 30 and 50 degrees Celsius (unless otherwise specified). Use the DISplus and/or GT-1 to determine transmission temperature. The transmission temperature information can be found in the diagnosis section under Service Functions.

Proper procedures for checking and filling transmission fluid can be found in BMW Service Information Bulletin B 24 01 98.

When checking transmission fluid, observe the following items:

- Transmission in Park
- Parking brake applied
- Engine Running
- Vehicle level
- No engine load
- Trans Temp 30-50C
- Observe correct drain plug torque
- Use correct fluid

When replacing parts on transmissions that use lifetime fluid, drain fluid into a clean container and reuse.



1	Drain Plug
2	Fill Plug

Transmission Fluid Application

There are numerous types of transmission fluid used in BMW transmissions. With the exception of the early transmissions (4HP22/24, A4S310/270R and the A5S310Z in the E34) all current BMW transmissions use “Lifetime Fill” transmission fluid. There is no maintenance required for these transmissions. It is important to use the correct fluid. Incorrect use of the transmission fluid can cause non-warrantable transmission damage.

When performing repairs on transmissions with lifetime fluid, it is important to drain the transmission fluid in to a clean container for re-use. New fluid should only be used for transmission replacement and for topping off after repairs.

Also, transmission fluid level is vital to the proper operation of the transmission. Refer to BMW Service Bulletin B 24 01 98 for proper fluid level checking procedures.

When servicing or repairing BMW automatic transmissions, refer to TIS for fluid capacities. For fluid types refer to the “Operating Fluids Manual”.

Transmission	Fluid Type	BMW Part #	Container	SIB Ref.
4HP22 **4HP24**	Dexron III Mercon	Available Commercially (Castrol or Texaco)	N/A	
A5S310Z 530i/iT (E34)	Dexron III	Available Commercially (Castrol or Texaco)	N/A	
M3 (E36)	ESSO LT 71141	83 22 9 407 807	20 liter contalner	B 24 03 95
A5S325Z	ESSO LT 71141	83 22 9 407 807	20 liter contalner	
A5S440Z	ESSO LT 71141	83 22 9 407 807	20 liter container	
A5S560Z 740 (E32), 540 (E34) 840Ci (E31- 6/93-12/94) 740i/iL-750iL (E38)	Shell LA2634	83 22 9 407 765	5 liter container	B 24 11 92
540i (3/96-12/96) 850Ci (10/94-6/97)	ESSO LT 71141	83 22 9 407 807	20 liter container	B 24 02 94
A4S310R **A4S270R** **(THM-R1)**	Dexron III Mercon	Available Commercially (Castrol or Texaco)	N/A	
A5S360R **A5S390R**	Texaco ETL 7045E Texaco ETL 8072B	83 22 0 026 922 83 22 0 024 359	25 liter container 25 liter container	
GA6HP26Z **GA6HP32Z**	Shell M-1375.4	83 22 0 142 516	20 liter container	

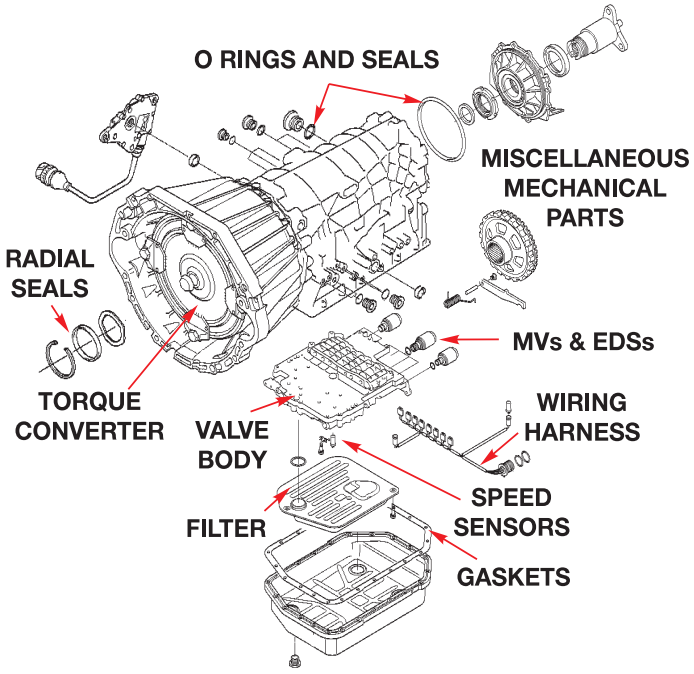
Transmission Service

Overview of Allowable Repairs

Currently, service of transmissions covered under warranty is limited to level I. Level I service includes electrical, minor mechanical and hydraulic repairs as well as repair manual provided service adjustments.

Part availability is limited to include the repair of the following:

- **Oil Leaks** - Radial Seals and gaskets.
- **Mechanical/Hydraulic Faults** - Torque Converter, Valve Body, parking pawl, oil pan, output shaft bearing.
- **Electrical Faults** - Solenoid Valves, pressure regulator valves, wiring harness.
- **Signal Sensing** - Turbine and Output Speed Sensors, CAN bus, Temp Sensor.



BMW Technical Hotline

Before performing any majors repairs or transmission replacement, always contact the BMW Technical Hotline at 1-800-472-7222. When prompted to do so, select option 1 for the Drivetrain Group. Refer to BMW SIB B 00 04 02 for more information regarding the BMW Technical Hotline. Be prepared will all necessary information such as transmission serial number, ID page, fault codes etc. Failure to contact the technical hotline could result in the non payment of warranty claims.

BMW Value Line Program

The Value-Line replacement transmission program provides the availability of factory certified rebuilt units at a very competitive cost. Refer to Part Bulletins in Group 24 for more information.

BMW Special Tools (Transmission)

The following pages contain information about BMW special tools, this is not an all inclusive list. This is a list of tools that would be helpful in the diagnosis and service of BMW transmissions. Always refer to the latest service information regarding special tools.

Transmission Removal and Installation

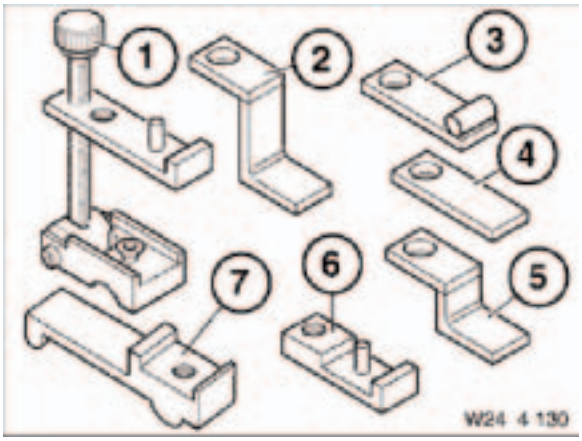
Tool # 24 1 110

This tool is used to remove the torque converter to flexplate bolts. It is a 17 mm socket with 3/8" drive. There is a magnet to help retain the bolt during installation and removal.

W24 1 110

Tool # 24 4 130

During transmission installation and removal the oil pump must be protected from damage. This tool helps keep the torque converter in place, to prevent oil pump damage due to misalignment.



Tool # 24 2 300

Used to align torque converter with flexplate during installation. Use on all BMW automatic transmissions.

Transmission Adjustments

Tool # 24 2 320

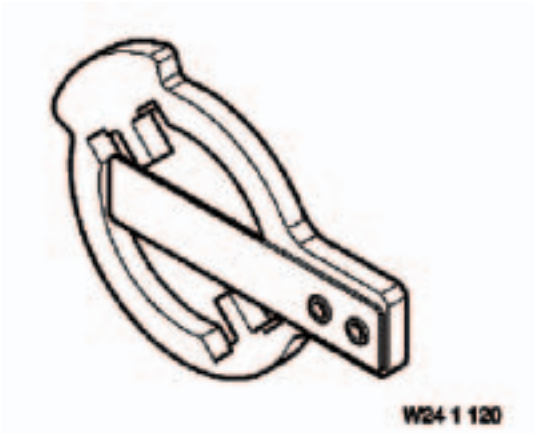
3/16” socket head cap screw (hex) with 1/4 “ drive. Used to adjust brake band on the THMR-1.

Tool # 24 2 330

1/2 open end wrench used to turn lock-nut on the brake band servo when adjusting the brake band. Used only on the THMR-1 transmissions.

Tool # 24 1 120

Used as guide to lock the range selector switch in “P” when installing. It is used on the A4S270R transmission. Used only for applications which have the selector switch mounted on the transmission case.



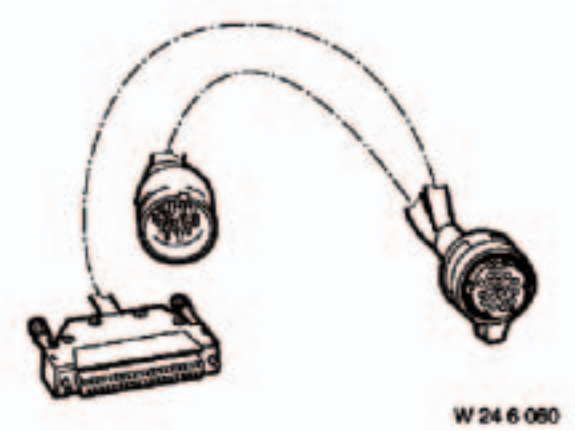
Transmission Diagnostic Tools

Tool # 24 6 000

8-pin test cable used to test the transmission at the “Cannon Plug” located on transmission case. This cable is used for the 4HP22/24 EH.
Used in conjunction with 61 1 459.

Tool # 24 6 060

16 pin test cable used to test the transmission at the “Cannon Plug” located on the transmission case. This cable is used for the A5S310Z and A5S560Z.
Used in conjunction with 61 1 459.



Tool # 24 6 020

14 pin test cable used to test the transmission at the “Cannon Plug” located on the transmission case. This cable is used on the A5S310Z.
Used in conjunction with 61 1 459.

Tool # 24 6 010

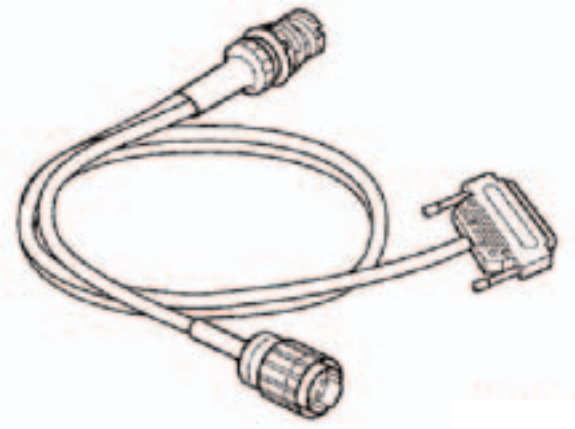
8-pin test cable used to test the transmission at the “Cannon Plug” located on transmission case. This cable is used for the A4S270/310R.
Used in conjunction with 61 1 459.

Tool # 24 6 080

16-pin test cable used to test the transmission at the “Cannon Plug” located on transmission case. This cable is used for the 6HP26Z.
Used in conjunction with 61 1 459.

Tool # 24 6 070

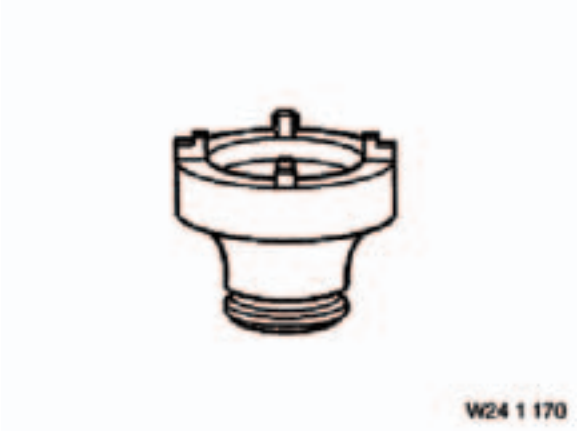
20-pin test cable used to test the transmission at the “Cannon Plug” located on transmission case. This cable is used for the A5S360/390R.
Used in conjunction with 61 1 459.



Service and Repair Tools

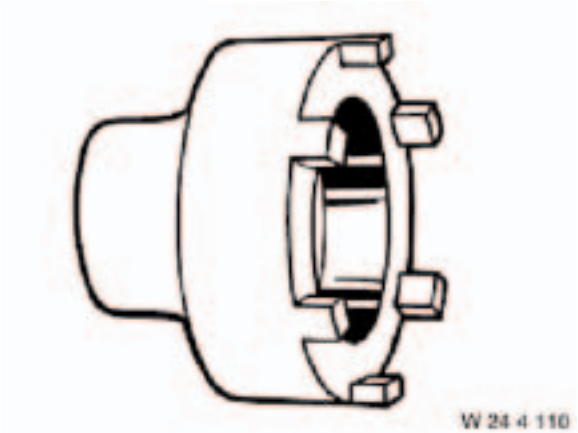
Tool # 24 1 170

For loosening and tightening slotted nut on output drive flange. Used on 5HP18 (A5S310Z). Use in conjunction with tool #24 1 220.



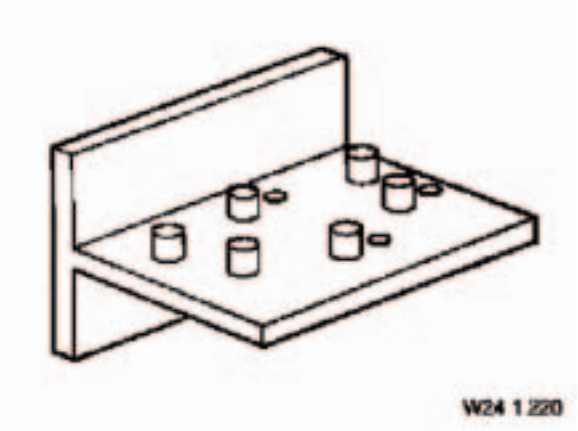
Tool # 24 4 110

For loosening and tightening slotted nut on output drive flange. Used on 5HP24 and 5HP30. Use in conjunction with tool #24 1 220.



Tool # 24 1 220

Take up support for drive flange. Used when tightening of loosening slotted nut on output drive flange. Used with tool numbers 24 4 170 and 24 4 110.



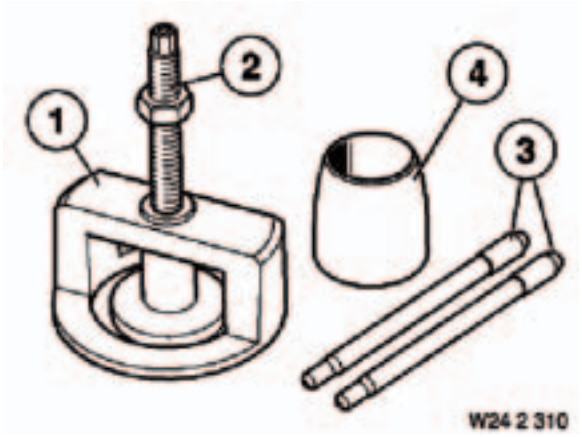
Tool # 24 2 380

34 mm Socket used to tighten and loosen nut on output drive flange. Used with special tool 23 0 020. For GA6HP26Z transmission.

Tool # 24 2 310

Set of tools used to re-seal intermediate plate. Used on A4S310R and A4S270R. Tool Set Consists of:

1. 24 2 311 Pressure Plate
2. 24 2 312 Spindle with Pressure Plate
3. 24 2 313 Guide Pins (2)
4. 24 2 314 Slip Bushing



Tool # 24 1 200

Used to prevent damage to rotary shift shaft seal when fitting new seal on shift shaft. Used on A5S310Z (5HP18).

Review Questions

1. The identification tag on the A5S440Z is located on _____

2. The 5HP19 transmission uses a _____ turbine speed sensor.

3. The transmission fluid temperature sensor is part of the _____ on the GA6HP26Z transmission.

4. On the GM5 transmission, the transmission range selector switch is located

   _____

5. EDS 1 is used for _____ on the 5HP24 transmission.

6. The “Warm up Phase Program” will be terminated if :

   _____

   _____

7. List the fluid types for the following transmissions:

   A5S440Z _____ A5S560Z (late) _____

   A5S360R _____ A5S325Z _____

   GA6HP26Z _____ A5S310Z _____

8. Line pressure will be at _____ when there is no power to the pressure regulating solenoid.

9. What is the difference in Steptronic operation between a 2001 model year vehicle and a 2002 model year vehicle?

   _____

   _____

10. The “Curve Recognition” feature compares the _____

    to inhibit _____ in a turn.

11. List 5 inputs to the TCM from the ECM over the CAN bus.

–

12. What SIB refers to “Transmission Fluid Checking Procedures”? _____

13. The Transmission will always default to the _____ Program when started.

14. List the transmissions which use a gradually applied TCC:

15. List 6 items that will occur during failsafe operation:

Table of Contents

AUTOMATIC TRANSMISSIONS

Subject **Page**

A5S 360R GM 5

Model: E46 All Versions

Production Dates: 323i/Ci/Cic : 6/98 to 3/00, 323it: 1/00 to 3/01, 328i/Ci/Cic: 6/98 to 6/00, 330Xi: from 6/00, 325Xi: from 9/00

Objectives

After completing this module you should be able to:

- List the electronic solenoids used in the valve body of the transmission.
- Explain the purpose of the accumulator chambers.
- Describe the installed location and operation of the range selector switch.
- Identify the communication between the AGS and other modules in the vehicle.
- Describe the features of the AGS driving programs.
- Recognize the symptoms of a vehicle in the transmission emergency program.
- Know how to check and fill the transmission fluid.
- Understand the scope of repairs possible on the A5S 360R transmission.

INTRODUCTION

The E46 introduces a new 5 speed automatic transmission manufactured by General Motors Powertrain division of Strasbourg, France. The transmission is designated:

- A5S 360R - BMW Designation
- 5 L40-E: GM Designation

The transmission will be available as an option in both the 323i and 328i models from start of production. The A5S 360R will also be available in the 1999 528i (9/98 production).

SYSTEM OVERVIEW

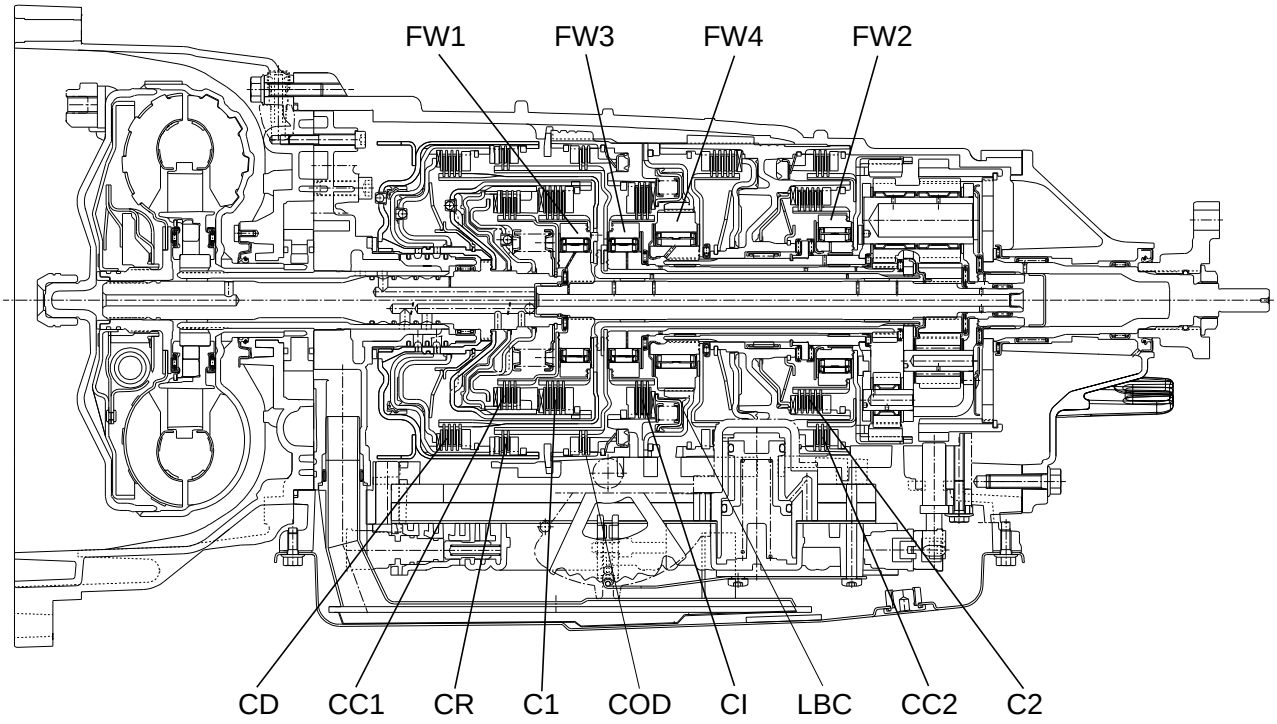
The A5S 360R transmission offers the following features and benefits:

- The A5S 360R's has a maximum torque rating of 360Nm.
- Designed and manufactured to provide maintenance free lifetime operation,
- Transmission fluid is designated as "sealed for life".
- Gradual torque converter lock up providing a controlled degree of clutch slippage and smooth transition to full lock.
- Torque converter variable lock up control can occur in 3rd, 4th and 5th gears.
- New GS 20 control system designed and manufactured via a joint effort with BMW, Siemens and GM.
- AGS shift program logic controlled,
- Transmission diagnostics improved due to the new E46 diagnostic concept,
- Drivetrain management system communication via CAN
- Emergency Program (Safety Mode) activates if certain faults are present

OVERVIEW OF COMPONENTS

The A5S 360R is an assembly of the following:

- Four case housing design (Torque converter bell housing, pump cover plate, main and extension cases)
- Single piece sump pan
- Replaceable oil filter unit
- Four element torque converter assembly with variably controlled lock up clutch.
- Vane type oil pump.
- Four multi-plate drive clutches with single sided friction plates
- Five multi-plate brake clutches with single sided friction plates,
- Four Free Wheel One Way Clutches (sprag type)

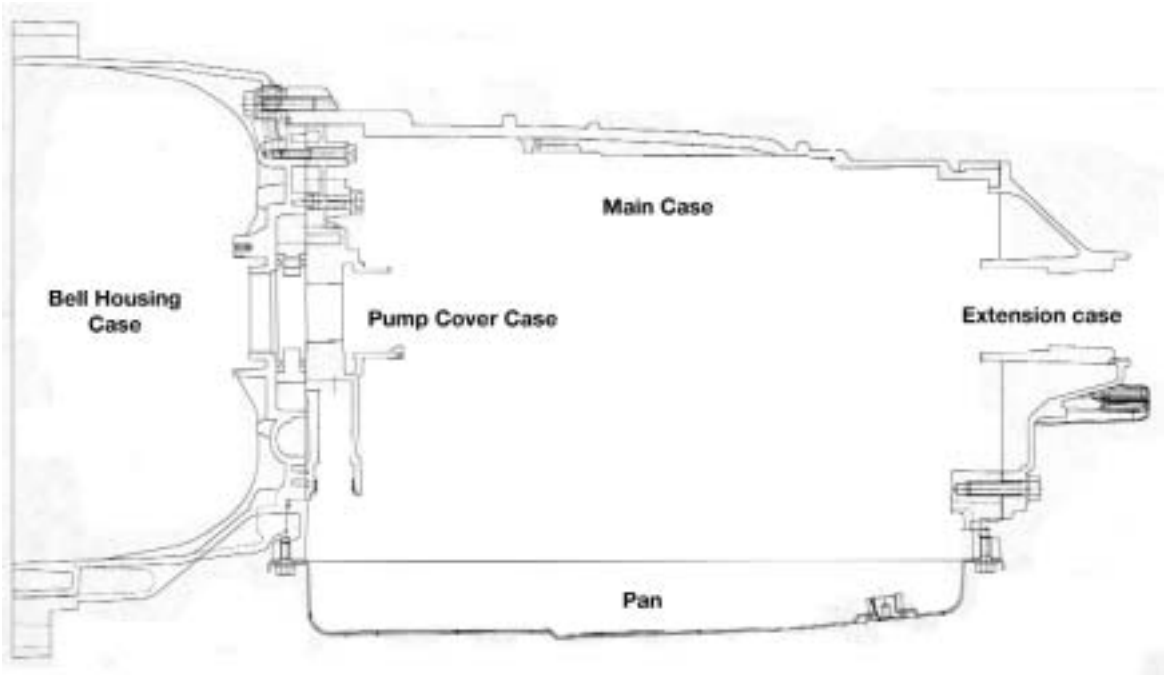


- One Planetary Gearset Assembly
- One Valve Body with solenoids for pressure regulation, shift control, torque converter regulated lock up and reverse lock out (combined function).

COMPONENTS

Transmission Cases and Pan:

Made of aluminum alloy, the cases are light weight. The single piece oil pan is made of single wall sheet metal. It includes a drain plug on the bottom surface at the rear .

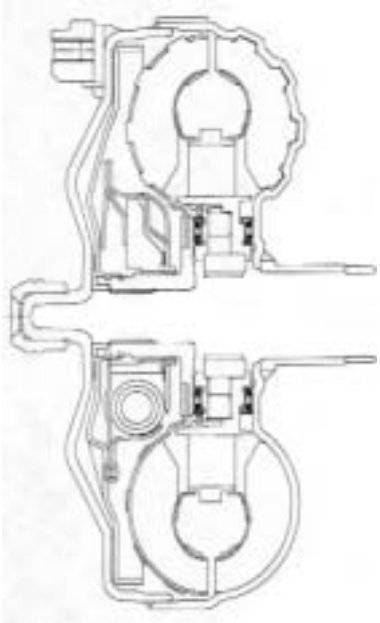


The oil pan is mounted to the main case by 20 bolts. Oil pan sealing integrity is ensured by a controlled compression gasket. Cross tightening is required to ensure an even seal. Final torque of pan bolts is 10-12 Nm.

Torque Converter:

The 4 element torque converter consists of the Turbine, Rotor, Stator with one way clutch and Lock up clutch. Similar in function to previous torque converters, this unit's lock up clutch is:

- Fully disengaged
- Variable engagement providing precise slippage,
- Fully engaged (locked)

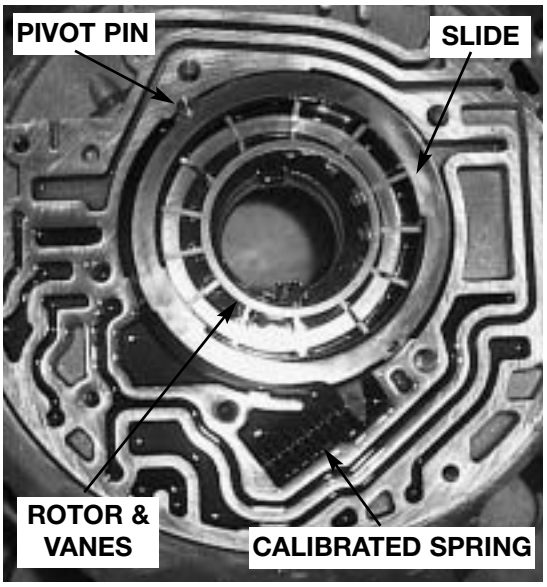


The various clutch application hydraulic pressures are regulated by the control module activated torque converter lock up solenoid.

The torque converter is manufactured specifically for the model it is installed in and is part number specific.

Vane Pump:

The A5S 360R uses a vane pump to provide the transmission main line oil supply for operation and cooling requirements. The pump rotor is mechanically driven by the torque converter oil pump drive tangs at 1:1 engine speed rotation providing pump operation.



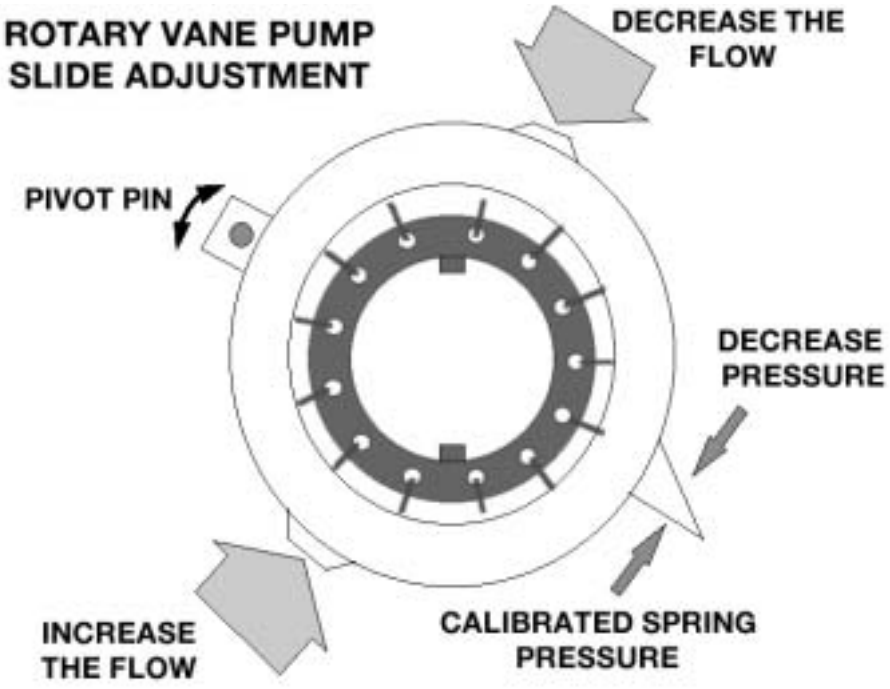
The rotor with 13 vanes is located in a recess on the rear surface of the bell housing covered by the pump cover plate. The rotor and vanes are placed inside a slide mechanism. As the rotor spins, the vanes "sweep" the oil from the pump intake to the output along the mating surface of the vane ends and the interior surface of the slide.

The slide is mounted on a pivot pin. As it pivots, it changes the eccentricity of the rotor to slide mating surface changing the pump output volume.

The slide's position is influenced by a calibrated spring and hydraulic input pressure from the main pressure regulator solenoid in the valve body.

The benefit of changing the slide position is to optimize pump output volume to meet the needs of the operating conditions.

- Max volume during engine startup. This condition provides a fast priming action of the pump for immediate lubrication and hydraulic pressure for operation.
- Regulated output volume for varied driving conditions. Maximum volume is not required at all times.



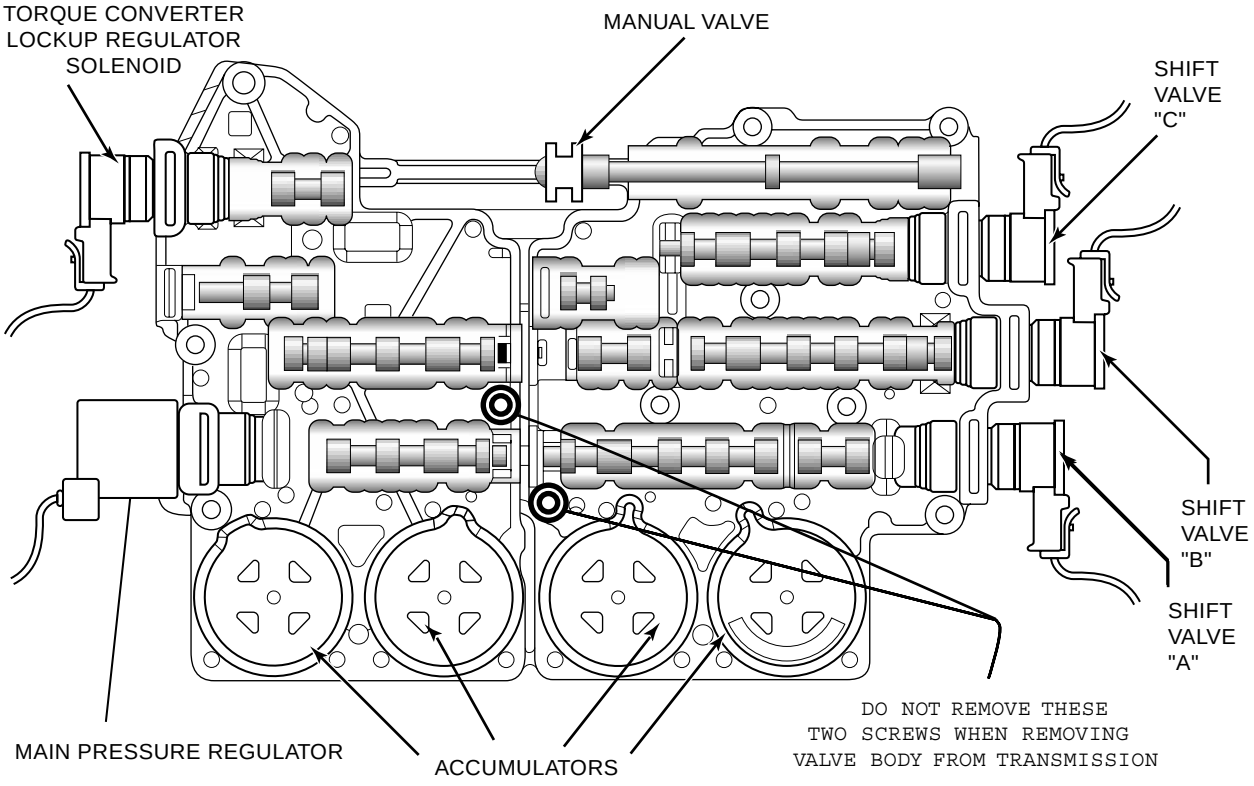
The GS 20 regulates the pump output volume as well as main line pressure regulation

Electro/Hydraulic Valve Body:

Located in the oil sump, the valve body is the electro/hydraulic control center for regulating and distributing pressurized transmission fluid for activating the various clutches, torque converter variable lock up, and regulation of main line oil pressures.

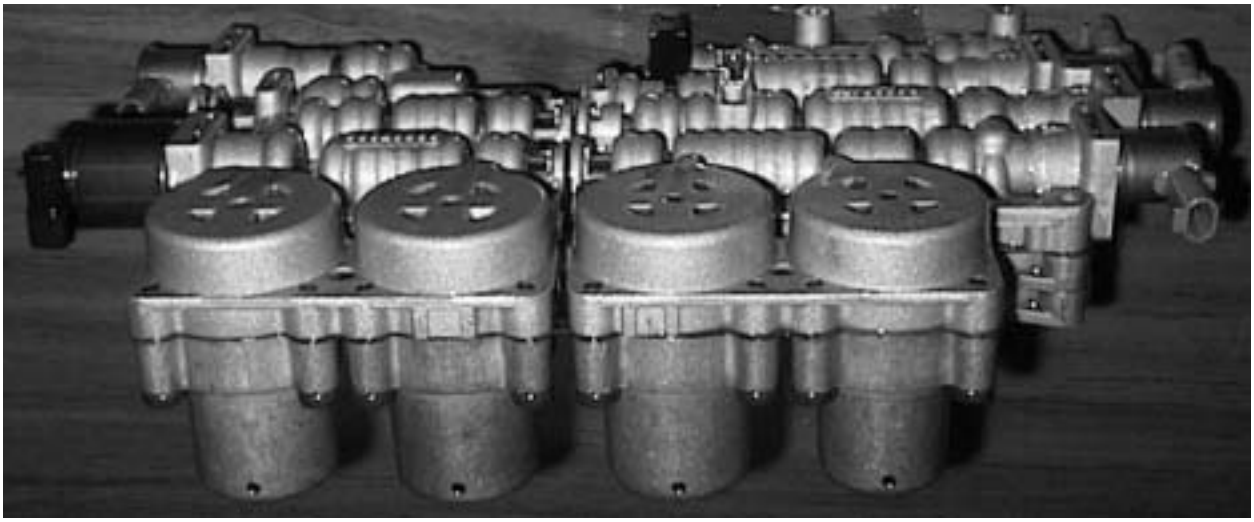
Sub components of the valve body assembly include:

- Manual valve
- One main pressure regulator solenoid (Pressure Regulator Force Motor Solenoid - "GM term")
- One torque converter regulator solenoid (also serves the Reverse Lock out function)
- Three MV shift solenoids (When activated in a coded sequence provide shifts for 1-2,2-3,3-4,4-5)
- The spool valves and springs for controlling apply pressures, activating shifts, regulating torque converter lock up, etc.
- Four accumulator chambers for "cushioning" the transmission fluid apply pressure during upshifts 1-2, 2-3, 3-4, 4-5.

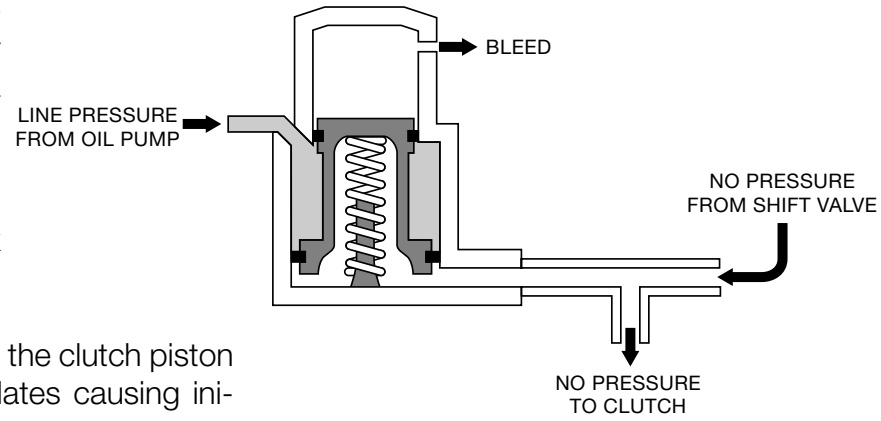


Accumulator Chambers:

The accumulator chambers are similar in function to "fluid dampers". The accumulators are used to improve shift quality by absorbing apply pressures on the multiplate clutches providing a cushioned clutch engagement.



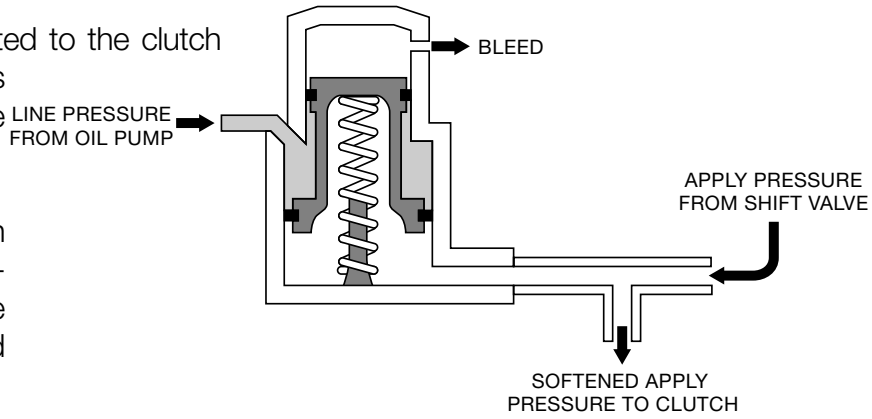
Clutch apply fluid pressure directed to an accumulator piston and helped by a spring force opposes an accumulator fluid line pressure creating an action similar to a shock absorber.



The apply pressure pushes the clutch piston against the steel/friction plates causing initial engagement.

Once the clearance between the clutch plates is taken up by the piston travel and the plates begin complete engagement the fluid pressure builds very rapidly.

The accumulator is connected to the clutch apply circuit which at this point starts to absorb the rapidly building pressure.



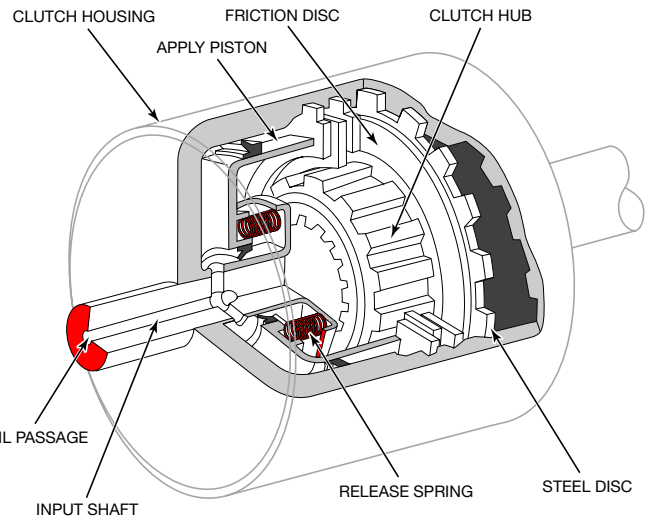
The accumulator piston moves upward accommodating the high pressure fluid causing a delayed complete engagement.

Multi plate Drive and Brake Clutches:

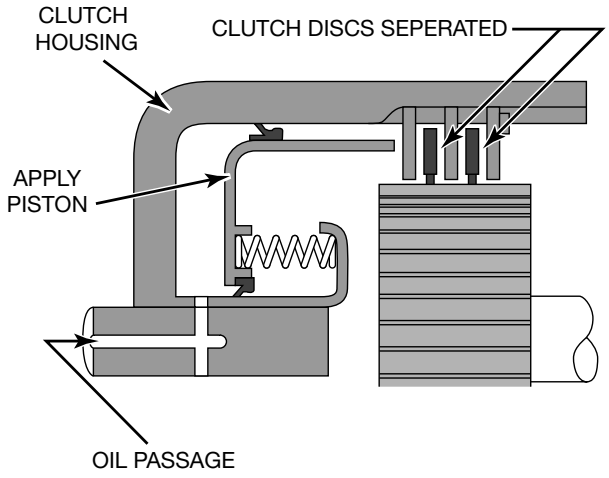
Located in the main case are four drive and five brake clutches. When cushioned hydraulic control pressure is applied, the clutches engage smoothly with a slight delay.

The valve body activates the various drive and brake clutches in a coded sequence to transmit engine drive torque to the planetary gear set providing the various output shaft ratios.

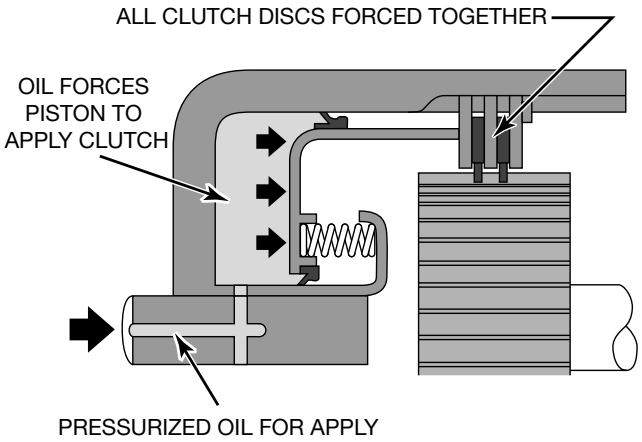
The clutches are multiplate units with both steel and friction plates. The friction plates are single sided.



CLUTCH RELEASED



CLUTCH APPLIED



Free Wheel Clutches (Sprag Type):

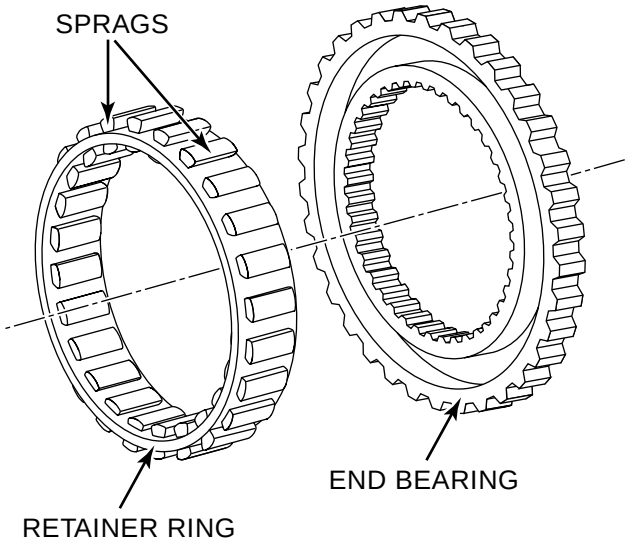
Free wheel clutches spin freely in one direction and lock in the opposite direction.

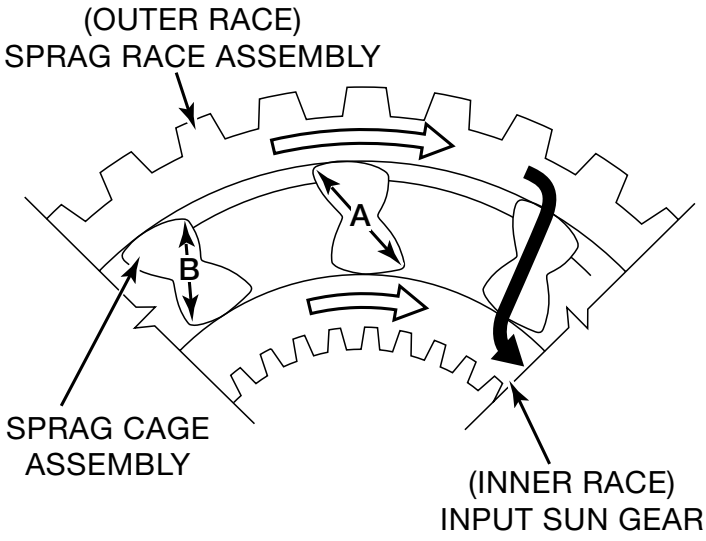
They consist of an inner race, an outer race and the sprag assembly.

The sprag assembly contains individual, asymmetrically shaped wedges (sprags).

- When the inner race is driven, the sprags allow free wheel rotation. There is no effect on the outer race.

- When the outer race is driven, the sprags wedge between the inner and outer races causing them to lock. The inner race is then driven by the outer race.





Free wheel clutches are used to:

- hold components stationary,

- drive components when driven

- free wheel, allowing power to spin the inner or outer race without an output reaction.

The A5S 360R utilizes four Free Wheel clutches to perform various shifting and component holding functions during the delayed, cushioned multi plate clutch engagement preventing an interruption in the power flow during upshifts.

The clutches are identified as FW1, FW2, FW3 and FW4.

Planetary Gearset (Ravigneaux)

Based on the Ravigneaux design, the A5S 360R planetary gearset is made up of two sections; front & rear. It functions as a single integral assembly with a common planetary carrier and a set of common long planetary gears. It consists of the following components:

- Two separate ring gears,
- Two separate input sun gears (one front, one rear)
- One set of three long planetary gears common to both sections (front-rear).
- One set of three short planetary gears (rear)
- One set of three short planetary gears (front)
- One common planetary carrier.

The gearset has three possible torque inputs:

1. Planetary carrier
2. Front input sun gear
3. Rear input sun gear

Three possible reaction components:

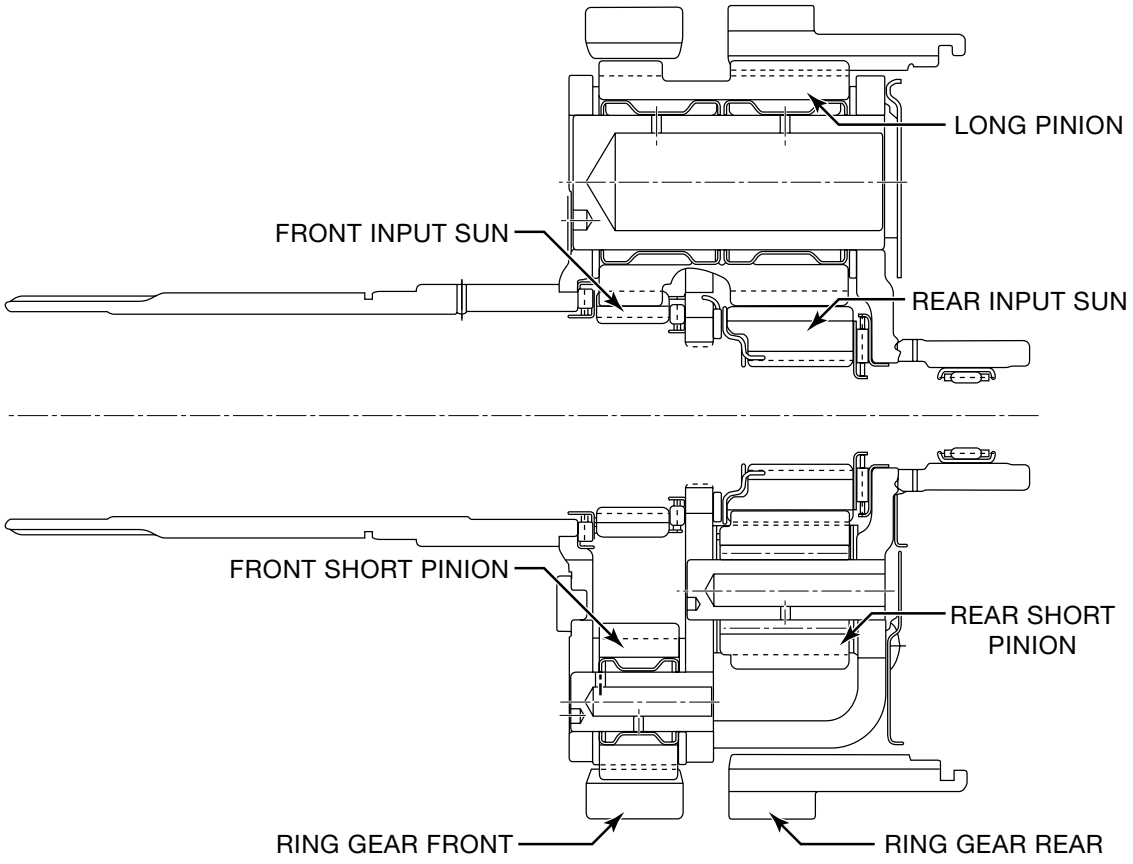
1. Planetary carrier
2. Front ring gear
3. Front input sun gear

and one torque output:

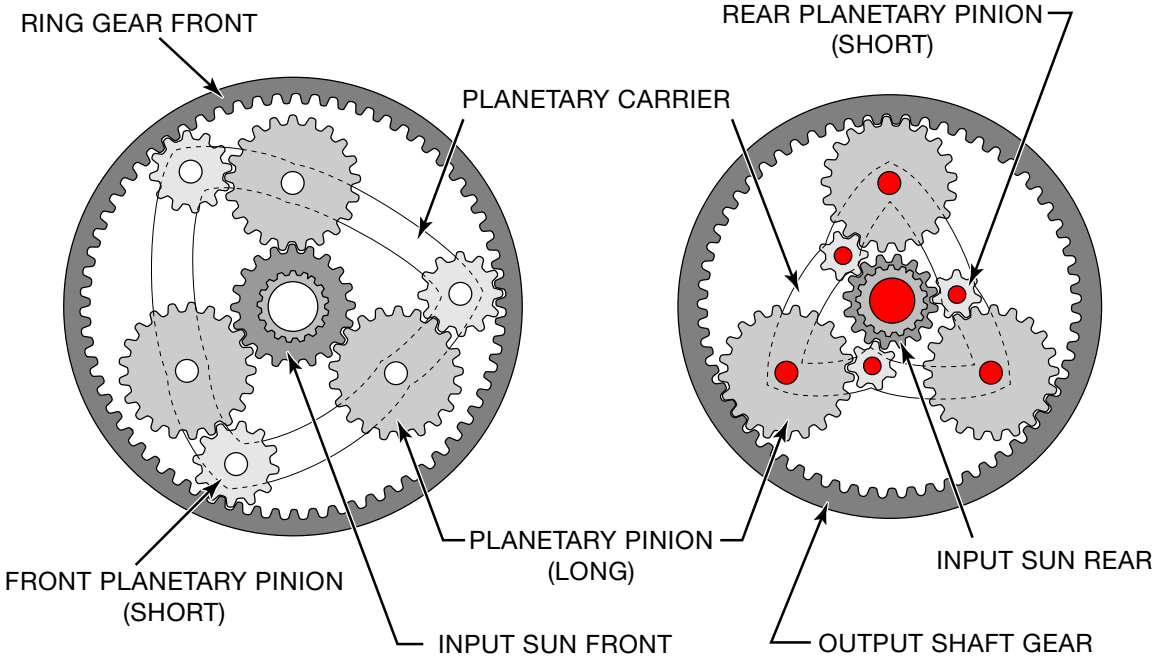
1. Rear ring gear.

Planetary Gearset “Input - Reaction - Output” Chart

Gear	Input	Reaction	Output	Ratio
First	**Rear Input Sun Gear**	**Planetary Carrier**	**Rear Ring Gear**	**3.45:1**
Second	**Rear Input Sun Gear**	**Front Ring Gear**	**Rear Ring Gear**	**2.21:1**
Third	**Rear Input Sun Gear**	**Front Input Sun Gear**	**Rear Ring Gear**	**1.59:1**
Fourth	**Rear Input Sun Gear & Planetary Carrier**	**None**	**Rear Ring Gear**	**1.00:1**
Fifth	**Planetary Carrier**	**Front Input Sun**	**Rear Ring Gear**	**0,76:1**



FRONT VIEW **REAR VIEW**



Transmission Fluid Heat Exchanger:

A transmission fluid heat exchanger is located on the bottom edge of the radiator.

Transmission fluid inlet and outlet hose fittings are located on the driver's side of the transmission.

The heat exchanger provides two functions:

- After initial start up, the transmission fluid is warmed up by the engine coolant as it passes through the heat exchanger. The heat exchanger is controlled by an integral thermostat which regulates the transmission fluid flow into the radiator exchanger. In this state the heat exchanger acts as a transmission oil heater.

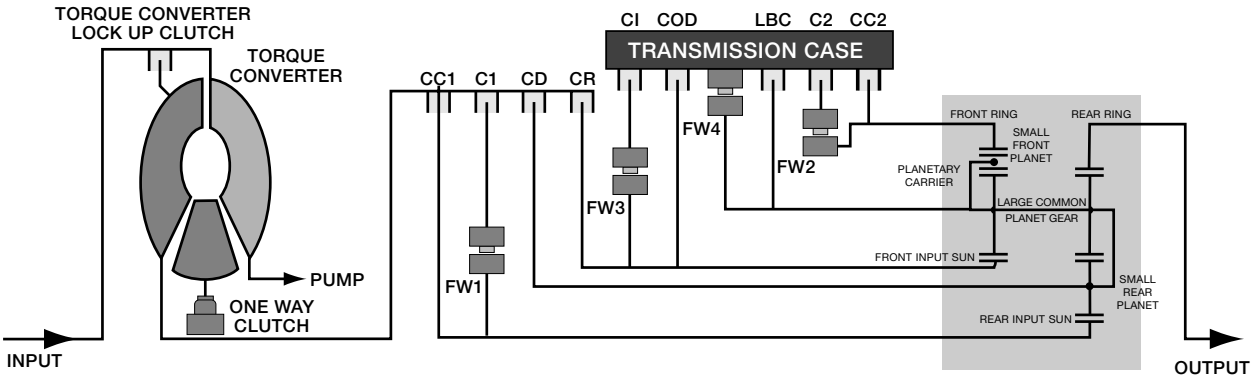
- During operation at higher temperatures, the hot transmission fluid loses heat to the engine coolant when it passes through the heat exchanger and into the core of the radiator.

A5S 360R POWER FLOW

The GS 20 module controls the hydraulic valve body through electrical activation of the various solenoids. Electrical activation is based on a programmed operation map and transmission operating conditions (vehicle speed, engine load, throttle position, range selection, AGS program logic, etc).

Engine torque is transferred by the various drive clutches when activated. The various torque paths enter the planetary gearset as input. Simultaneously, the planetary gearset is provided with reactionary input (held components) from the various brake clutches and Free Wheel clutches.

The output result is five forward drive gears with progressive ratios and a single reverse gear.



Range	Gear	Ratio	Clutches									Free Wheels				Solenoids			
			C1	C2	CI	CD	COD	CC1	LBC	CC2	CR	1	2	3	4	A	B	C	TCC
D/4/3/2	1	3.45:1	X					X	X			X			X	OFF	ON	ON	NO
	2	2.21:1	X	X				X		X		X	X			ON	ON	ON	NO
D/4/3	3	1.59:1	X	X	X		X	X				X		X		ON	OFF	ON	Y/N
D/4	4	1.00:1	X	X	X	X		X				X				OFF	OFF	ON	Y/N
D	5	0.76:1	X	X	X	X	X									OFF	OFF	OFF	Y/N
P/N	/	/														OFF	ON	OFF	

TRANSMISSION CONTROL SYSTEM (GS 20)

The A5S 360R automatic transmission is controlled by the GS 20 control module. The acronym (GS) comes from the German word **"*Getriebesteurung*"**, meaning Gearbox Control.

The design, program development and manufacturing of the GS 20 control system is the result of the combined efforts of BMW, Siemens and GM.

The GS 20 control module is located in the E box in the engine compartment. It utilizes the 134 pin, "SKE" (standard shell construction), modular connector, enclosure.

BMW PRODUCTION LINE LABEL

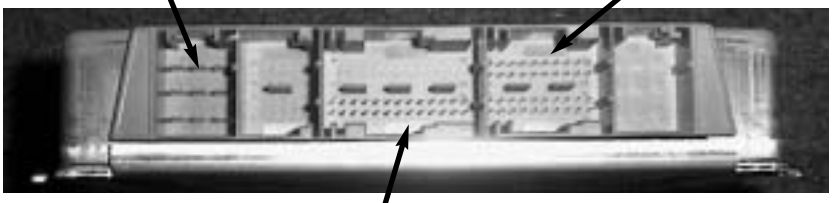
IDENTIFICATION LABEL:

- **BMW Part Number**
- **Version Identification**
- **Software Level**
- **Production Date**
- **Serial Number**
- **Siemens Part Number**
- **GM Part Number**

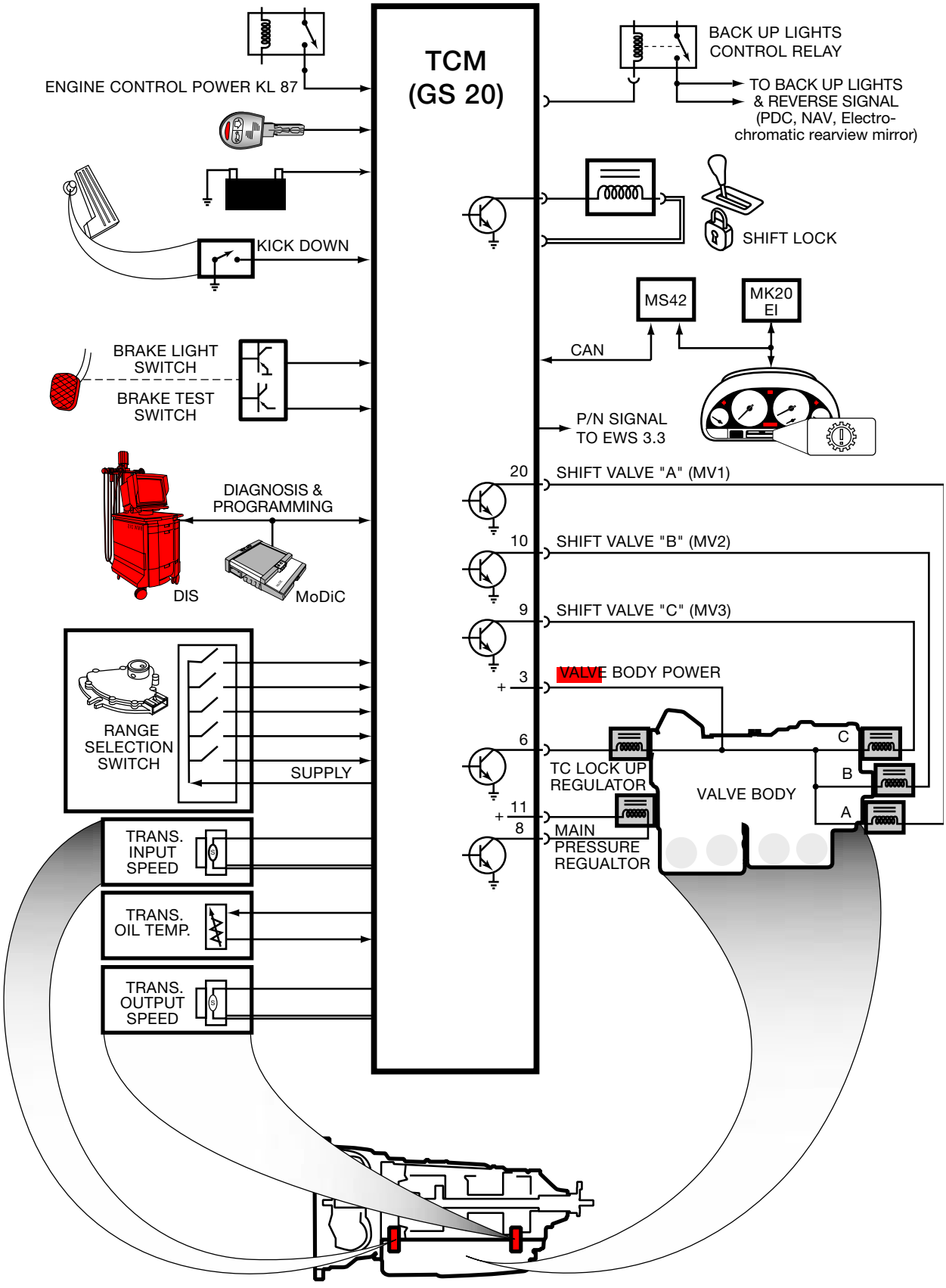
Its blue connector color designates it a Transmission Control Module. The GS 20 utilizes 3 of the 5 modular connectors.

Connector 1: (X70001) 9 pins = Power and ground connections.

Connector 4: X70004, 40 pins = Input and output control signal connections to transmission components in the transmission and CAN to MS 42.0.



Connector 3: (X70003) uses 26 of the 52 pins = Input and output control signal connections to components in interior compartment (shift lock, EWS interface, brake light switch).


TCM
(GS 20)
ENGINE CONTROL POWER KL 87
KICK DOWN
BRAKE LIGHT
SWITCH
BRAKE TEST
SWITCH
DIAGNOSIS &
PROGRAMMING
DIS
MoDiC
RANGE
SELECTION
SWITCH
SUPPLY
TRANS.
INPUT
SPEED
TRANS.
OIL TEMP.
TRANS.
OUTPUT
SPEED
BACK UP LIGHTS
CONTROL RELAY
TO BACK UP LIGHTS
& REVERSE SIGNAL
(PDC, NAV, Electro-
chromatic rearview mirror)
SHIFT LOCK
MS42
MK20
EI
CAN
P/N SIGNAL
TO EWS 3.3
20
SHIFT VALVE "A" (MV1)
10
SHIFT VALVE "B" (MV2)
9
SHIFT VALVE "C" (MV3)
3
+
VALVE BODY POWER
6
TC LOCK UP
REGULATOR
11
+
8
MAIN
PRESSURE
REGULATOR
VALVE BODY
C
B
A

GS 20 INPUT SIGNALS

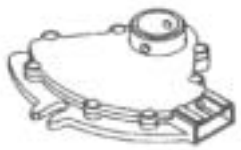
Power Supply and Grounds:

The GS 20 receives:

- KL 30 (constant battery power),
- KL 15 (terminal 15 of the ignition switch)
- KL 87 (operating power from the Engine Control Main Relay)
- KL 31 (ground connection for the control module electronics and peripheral component operation)

The GS 20 monitors the power/ground inputs for shorts (B+ and B-), open circuits and battery voltage levels (high and low).

Range Selector Switch:



The switch is mounted inside the transmission main case on the driver's side. This location provides precise monitoring of the Manual valve position and is sheltered from the harsh environment under the vehicle external of the main case. Adjustment is not required.

The range selector switch has 6 wires. The GS 20 provides the switch with 12 volts on one wire (pin 2 of connector X70004).

Depending on the range selector position, the switch provides coded high signals over five wires to the GS 20. The addition of the fifth wire (pin 1) is new compared with previous four wire range selectors providing a redundant P/N signal circuit.

X70004	Pin 1	Pin 14	Pin 15	Pin 16	Pin 17
Park	X	X			X
Reverse		X	X		
Neutral	X		X		X
Drive			X	X	
4		X	X	X	X
3		X		X	
2				X	X

X = High Signal

Electronic Brake and Brake Test Switch:

The GS 20 monitors the brake pedal position to activate sport mode, down hill recognition and for the shift lock operation. The control module receives both the brake and brake test hall effect sensor signals. When pressed;

· the brake light switch pulls a standing voltage in the GS 20 low,
· the brake test switch provides a high signal to a circuit monitor in the GS 20.

Kick Down Switch:

When the throttle pedal is pressed fully to the floor, the kick down switch closes providing a ground signal to the GS 20.

The GS 20 recognizes the ground as a request to provide an immediate down shift and to switch to the AGS sport mode shifting program.

Transmission Fluid Temperature Sensor:

Located in the transmission oil sump, the NTC oil temperature sensor's ohmic value decreases as the temperature increases. The GS 20 monitors the fluid temperature by sensing the voltage drop across the sensor causing a standing monitor voltage to "bleed" to ground. Rise and fall of the standing voltage value is a direct correlation of the fluid temperature.

Detection of high fluid temperature modifies the torque converter regulation control and modifies the shift program to aid in reducing transmission fluid temperature.

If the signal becomes impaired, the GS 20 applies a substitute temperature value based on Engine Temperature via CAN and stores a specific fault code.

Transmission Input and Output Speed Sensors:

The transmission speed sensors (turbine and output shaft) are analog inductive sensors that produce an AC sine wave similar to an ABS/ASC wheel speed sensor. The AC signal frequency is proportional to the rotation speed of the monitored components .

- The turbine speed sensor scans a pulse wheel attached to the forward clutch housing.
- The output shaft speed sensor scans a pulse wheel attached to the rear ring gear.

The GS 20 monitors these signals along with the engine speed signal (CAN) to calculate transmission slip ratio for plausibility and for the adaptive pressure control function.

The sensors are monitored for plausible signals, opens and shorts. Specific fault codes are stored for defects with these sensors.

GS 20 OUTPUT CONTROL SIGNALS

Valve Body Solenoid and Pressure Regulator Control

The GS 20 activates the 3 shift solenoids by individual switched ground output control signals.

The Main Oil Pressure and Torque Converter Lock up regulators are controlled by a Pulse Width Modulated (PWM) control to ground.

PWM control modulates the hydraulic control pressures based on the current AGS shift program and maintains adaptive pressure control.

Shift Lock Solenoid Control:

The shift lock feature prevents the unintentional movement of the shifter from Park or Neutral.

When KL 15 is switched on, the shift lock is engaged, when the brake pedal is pressed, the GS 20 releases the ground control circuit of the shift lock solenoid unlocking the shift gate. Additionally, above 2500 RPM, the selector lever remains locked in Park even if the brake pedal is applied.

P/N Signal:

As an output function, the GS 20 provides the EWS 3.3 with a switched high/low signal for P/N status.

- P or N = high
- all other ranges = low.

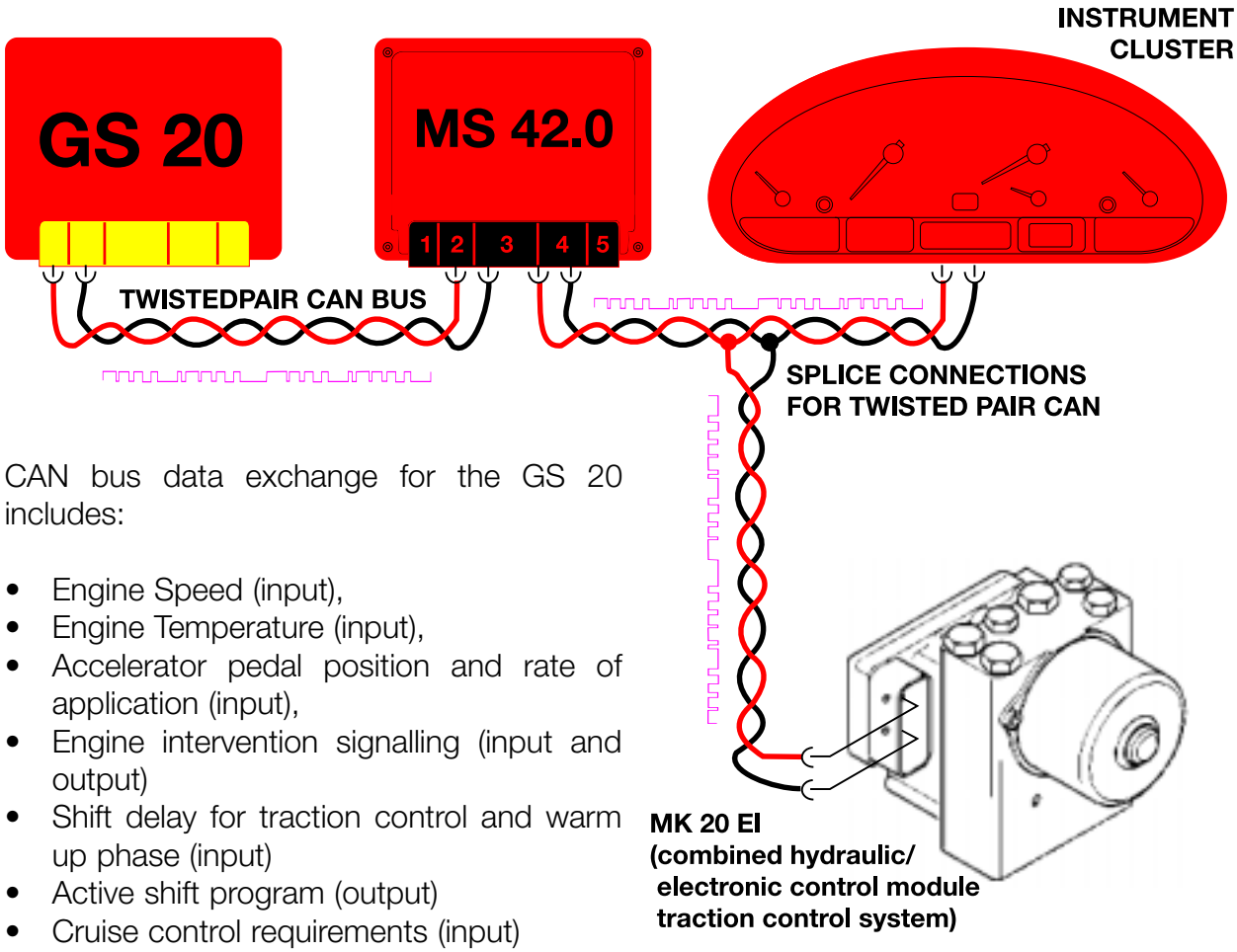
The EWS 3.3 provides the P/N safety feature preventing the starter motor from operating unless the shifter is in P/N (high signal).

Back Up Light Relay Control:

As an output function, the GS 20 provides a switched ground to activate the control circuit of the back up light relay when the range selector is in R. The Back Up Light Relay provides power directly to the back up lights. The lighting circuit is also used as a high signal indicating Reverse status for PDC, NAV and the electro chromatic rearview mirror systems.

CAN BUS COMMUNICATION:

The E46 utilizes the now familiar “twisted pair” CAN bus wiring configuration for drivetrain and instrument cluster communication interface. The MS 42.0 to GS 20 link is a dedicated CAN circuit. The MS 42.0 is the gateway for data exchange between the GS 20 and Mark 20 EI (traction control) and the Instrument cluster.



CAN bus data exchange for the GS 20 includes:

- Engine Speed (input),
- Engine Temperature (input),
- Accelerator pedal position and rate of application (input),
- Engine intervention signalling (input and output)
- Shift delay for traction control and warm up phase (input)
- Active shift program (output)
- Cruise control requirements (input)
- Turn recognition (input)
- Current Range and program selection (output)
- Torque Converter lock up signalling (output)
- Transmission fault indication lamp (output)
- etc..

GS 20 Program Features Overview

AGS (ADAPTIVE TRANSMISSION CONTROL)

The GS 20 adaptive transmission control feature automatically selects suitable shifting programs based on driving style, selected range, monitored signal activity and road/environmental conditions. Advantages to the AGS shift control include:

- Shift points adapted to the driving style
- Improved safety - no unwanted up shifting while in a tight curve,
- Automatic determination and selection of the winter program for better driveaway traction and reduced shift activity.
- Improved comfort - Starting in second gear in stop and go traffic.

The AGS can be divided into two functional groups:

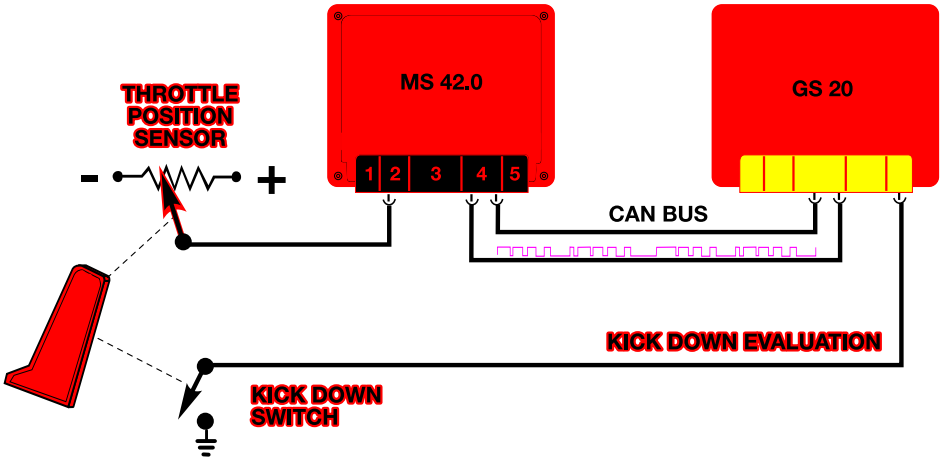
1. Driver influenced features
2. Features that react automatically to the driving style and environmental conditions.

DRIVER INFLUENCED FEATURES OF AGS

The adaptive drive program is based primarily on throttle input from the MS 42.0 control module via the CAN bus. The calculated rate of pedal position change influences the selection of the shift points.

Moderate movement causes moderate downshifts while a quick application of the throttle initiates a downshift.

The GS 20 also monitors braking and kickdown request.



Economical driving: Shifter in D. Drive with slow application of throttle. This provides low and comfortable shift points providing high fuel efficiency.

Quick accelerator pedal activity automatically leads the GS 20 into the intermediate power mode. Based on this input data, the AGS automatically selects a sporty shift strategy.

Sport: Shifter in "D", shift points are higher to take advantage of the full engine performance. The sport program is also immediately activated by a kick down request or excessive braking.

The AGS driving programs are not adapted on a long term basis - nor is it stored in the GS 20 control module memory when the ignition key is switched off.

The GS 20 continuously monitors the driving style and adapts to meet the current driver requirements.

AGS FEATURES THAT REACT TO OPERATING CONDITIONS

Stop and Go Driving: This feature is activated by a defined sequence of shifts which are as follows:

- Upshift from first to second - followed by a downshift from second to first - followed by another upshift from first to second. This is then followed by the vehicle coming to a complete stop.

After this sequence, the transmission will stay in second gear. The GS 20 AGS program has recognized stop and go driving and this function prevents excessive shifting during heavy traffic conditions. The second gear start is cancelled when:

- The throttle pedal movement exceeds limits (quick step on the pedal)
- The range selector is moved to P, N or R.

Curve Recognition: This feature is activated when the GS 20 detects a variation of front wheel speeds via the CAN bus. The Mark 20 EI control module broadcasts the wheel speed sensor signals and their speed variations for any control module programmed to monitor this condition. When curves are recognized, the GS 20 inhibits up shifting until the front wheel speed signals equalize indicating the vehicle is driving straight ahead. This feature enhances the vehicle handling characteristics when cornering at higher speeds.

Winter Drive Program: Wheel slip is calculated by the GS 20 based on wheel rotation data provided by the traction control system via CAN bus. The GS 20 modifies shift characteristics to match winter mode for better traction. When active, the transmission will start in second gear and the shift points are lowered. The purpose of this program is to improve the drivability of the vehicle with slippery road conditions.

Cruise Control Program: When cruise control is activated, the MS 42.0 control module communicates this status via the CAN bus. The GS 20 activates a program suitable for active cruise control operation preventing pendulum locking/unlocking of the torque converter and minimizes up/down shifting. Additionally, the MS 42.0 can request a downshift if the vehicle speed exceeds the set speed limit when coasting downhill.

Hill Recognition Program: The GS 20 activates this feature when it detects a high engine load condition at lower road speeds. When the vehicle is traveling up hill the shift points are raised to prevent repetitive up/down shifting.

NON AGS FUNCTIONS

The following features are part of the GS 20 automatic control system - ***but not AGS specific control features.***

Manually Selected Extra Sport Program: Longer delay shift pattern with higher engine RPM. This program is similar to the AGS detected sport program but requires the driver to move the range selector from D to 4th gear or lower.

This program automatically returns to AGS shift program selection when the shifter is returned to the D position.

Engine Warm Up Cycle: Based on the detected engine coolant temperature (CAN), the shift points are raised during cold engine operation. This is implemented to speed up the warm up cycle of the catalytic converter.

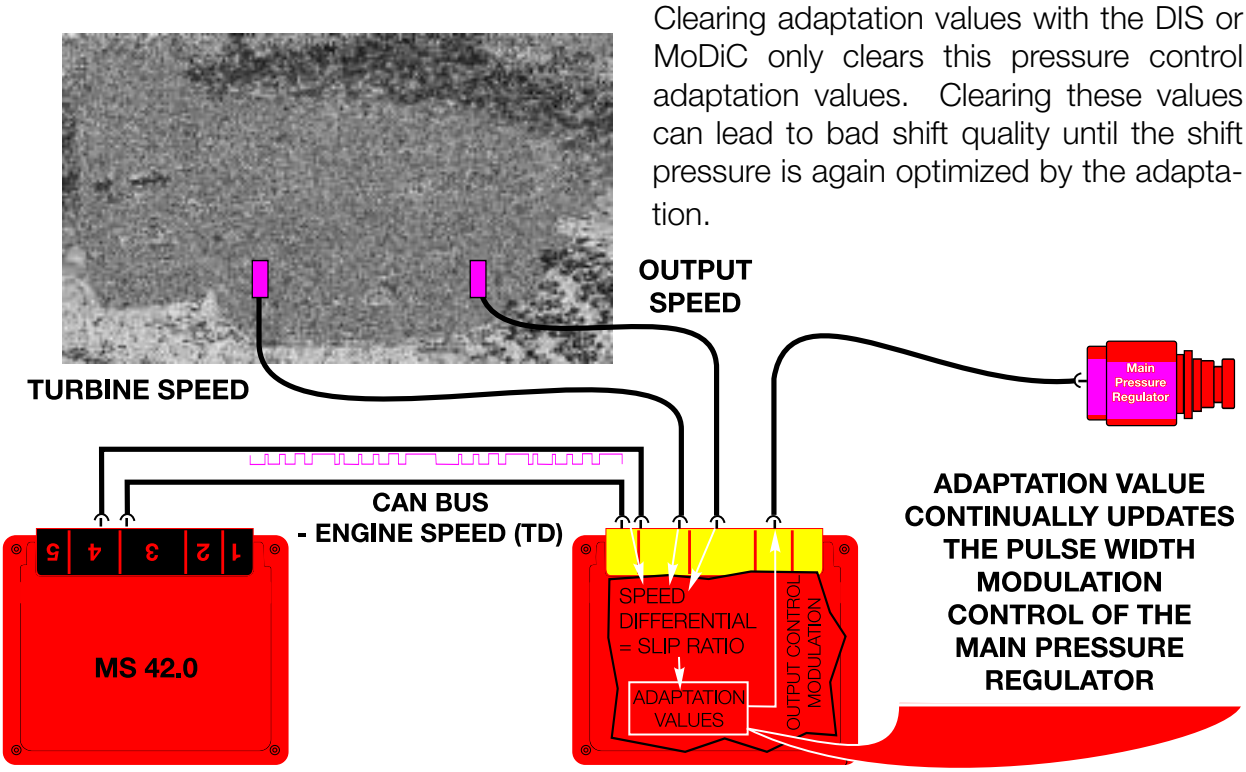
Downshift protection: If the driver moves the range selector to a lower gear at higher vehicle speeds, the GS 20 delays the down shift until the road speed drops below a programmed value. This feature protects the powertrain from unnecessary loads ensuring long life operation.

ADAPTIVE HYDRAULIC PRESSURE CONTROL:

The GS 20 monitors engine speed via the CAN bus along with the transmission input and output speed signals simultaneously to determine the slip ratio and slip time during a shift. Slip ratio and slip time are influenced by production related differences between transmissions and by aging.

The comparison of target & real slip allow the GS 20 to perform the adaptive pressure control function by modifying the PWM control of the main pressure regulator solenoid increasing the clutch apply pressures to compensate for internal slip. The adaptive pressure control function optimizes the shift quality and increases the life span of the clutch plates.

The adaptive pressure control feature is not an AGS function.



Clearing adaptation values with the DIS or MoDiC only clears this pressure control adaptation values. Clearing these values can lead to bad shift quality until the shift pressure is again optimized by the adaptation.

EMERGENCY PROGRAM (SAFETY MODE)

If a malfunction causes the GS 20 to activate the Emergency Program, the transmission fault indicator and the Check Engine Light in the instrument cluster both illuminate (CAN signal activation) and electronic control terminates.

The transmission shifts manually in the following sequence:

- For range selector lever positions D, 4, 3 or 2, Fifth gear is immediately activated (no electrical control). P, R and N positions operate normally.
- Torque converter lock up clutch is not functional
- ***Reverse lock out is also not functional.***

If the vehicle is stopped and restarted with this condition, the vehicle drives normally until the condition that initially caused the Emergency Program activation is once again detected.

If the initial problem was a power down of the GS 20 control module, the transmission will shift manually in the following sequence:

- For range selector lever position D, 4, 3 or 2, Fourth gear is immediately selected. P, R and N positions operate normally.
- Torque converter lock up clutch is not functional
- ***Reverse lock out is also not functional.***

SERVICE INFORMATION

TRANSMISSION FLUID:

- Initial production transmissions are factory filled with DEXRON III.
- Later production transmissions will be factory filled with **Texaco ETL-7045** lifetime oil.

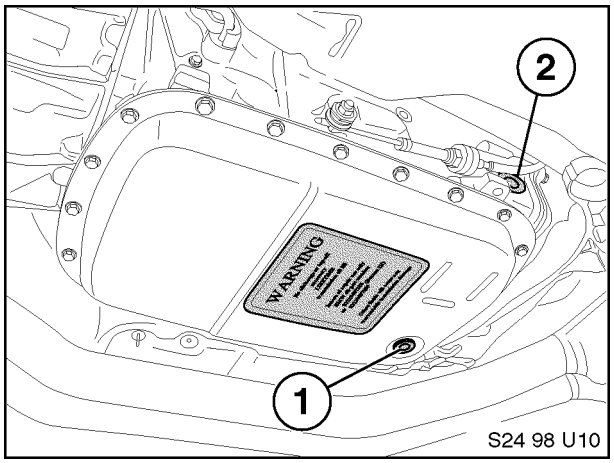
When the transition occurs, the fluid type will be noted by a label change on the transmission pan indicating the actual fluid type in the transmission.

Transmissions filled with Texaco 7045 Dexron III can be "topped off" with the Texaco ETL-7045 oil if required after performing the oil level checking procedure with the DIS/MoDiC.

Fill Capacity: Approximately 7 liters (not including torque converter)
Approximately 8 liters (including torque converter)

CHECKING TRANSMISSION FLUID LEVEL:

The Drain and Fill plugs are located as shown:



Checking the transmission fluid level requires the fluid temperature be between 30°C and 50°C.

- Connect the DIS or MoDiC to the 20 pin diagnostic connector of the vehicle.
- From the diagnosis start screen identify the vehicle and press the continue arrow.
- From the vehicle identification screen press the continue arrow.
- From the Fault Symptom Selection Menu press the "Function Selection" button on the bottom left of the screen.
- From the "Operations" column, select "Service Functions", then "Drive", then "Electronic transmission control"
- Then select "Oil Level Check" from the Components list on the right side of the screen and press the "Test Schedule" button.
- From the Test Schedule listing, select "Oil Level Check" and press the continue button.
- Select 1. Oil Level Check by pressing the #1 button. Follow the instructions on screen to carry out the oil level check procedure.

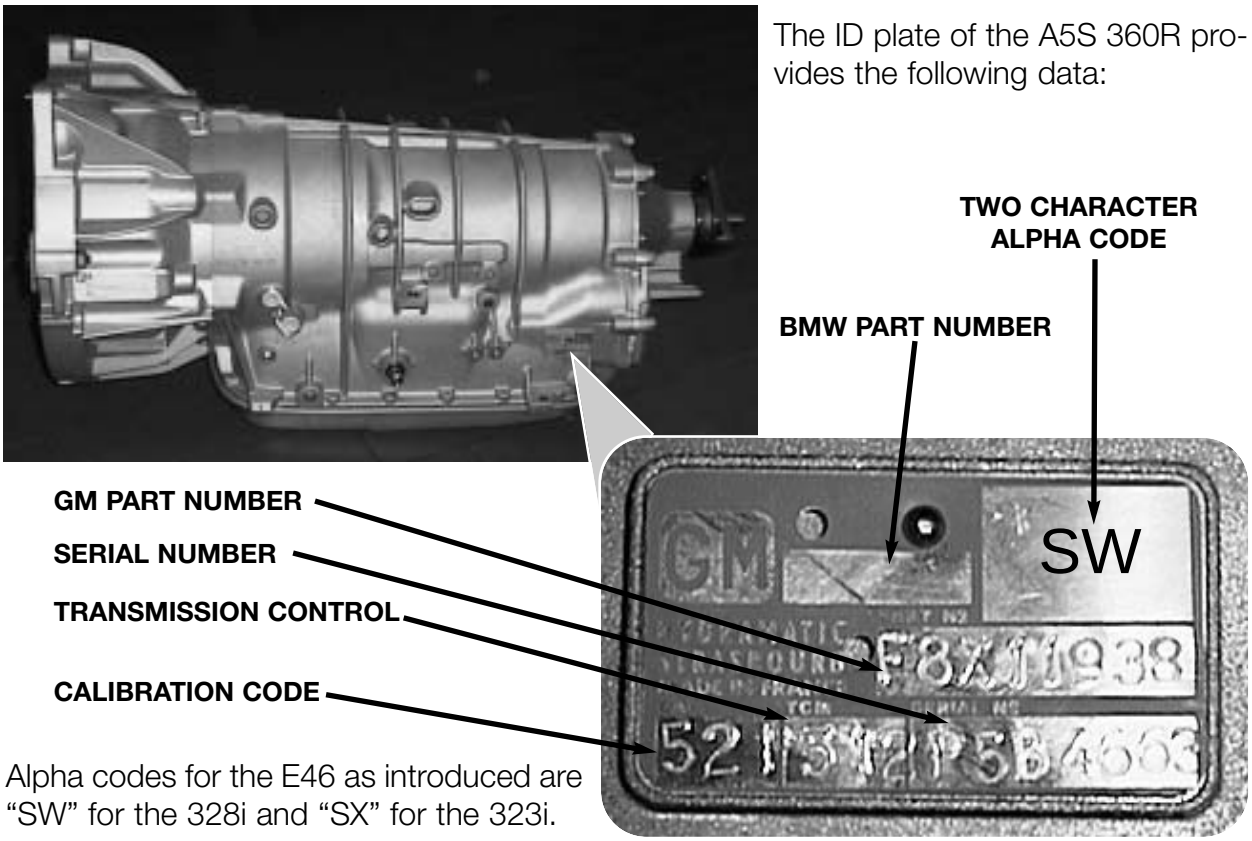
SERVICE AND REPLACEMENT PARTS

For a severely malfunctioning A5S 360R transmission, the service procedure is to exchange it with a replacement core once an authorization has been obtained. However, there are replacement parts available for Limited Service Repairs.

Transmission Identification:

As with all BMW transmissions, an identification plate is attached to the transmission housing. The plate provides a two character alpha code signifying identification.

Refer to the alpha code when ordering a replacement transmission. This code must be checked against the parts system verifying the code is correct for the specific vehicle and for possible code/part number supersession.



The ID plate of the A5S 360R provides the following data:

Alpha codes for the E46 as introduced are "SW" for the 328i and "SX" for the 323i.

Limited Service Repairs:

Minor electrical and mechanical repairs can be performed on the A5S 360R. The following are included in the repair scope of the A5S 360R:

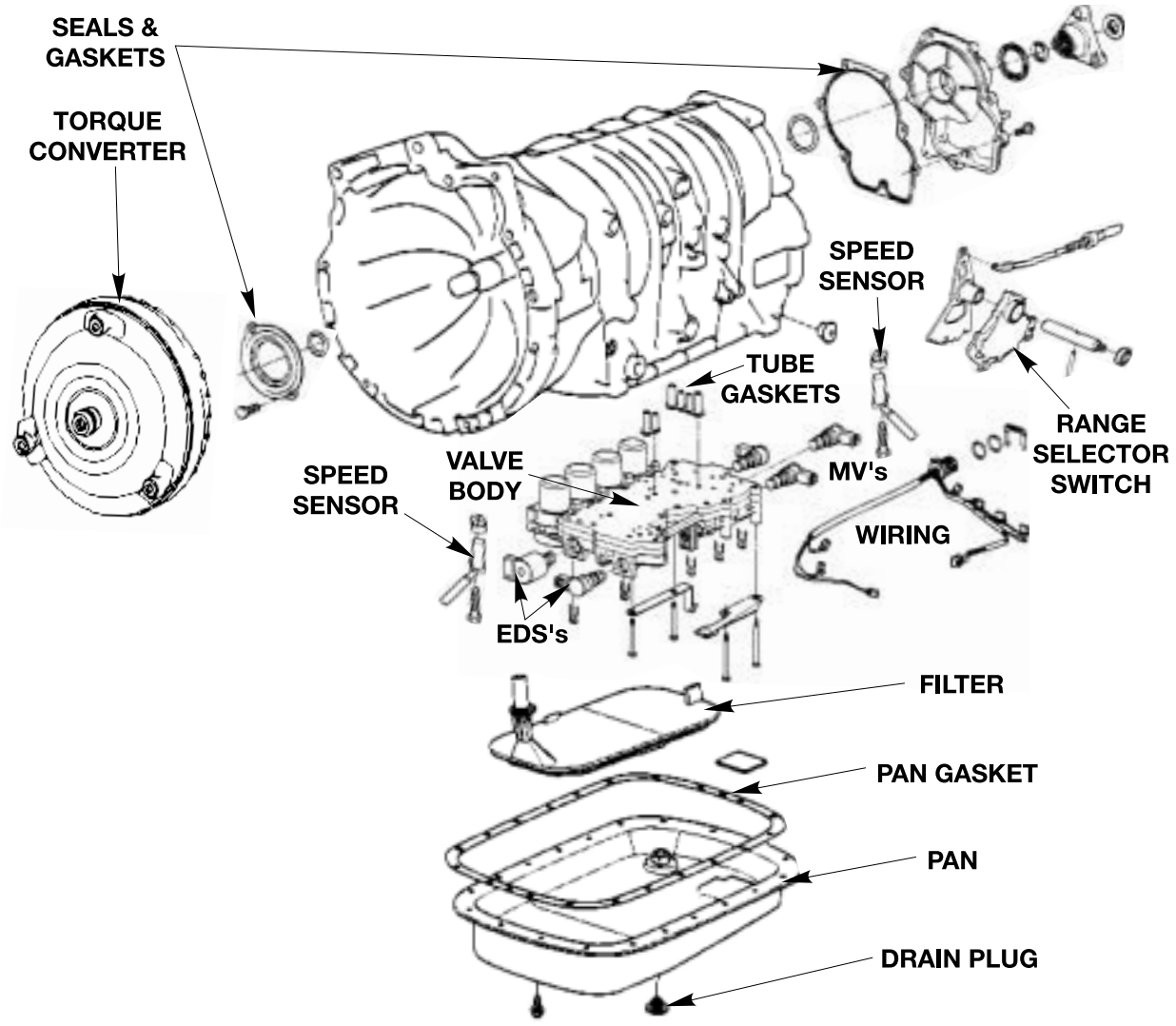
Service Parts: Oil Filter unit, Pan Gasket, Oil Filler and Drain plugs with seals.

Oil Leaks: Radial Seals and Gaskets

Mechanical Faults: Torque converter core replacement, Parking Pawl mechanism,

Hydraulic control faults - Valve Body Replacement

Electrical Faults - Shift Solenoids. Torque converter pressure regulator and Main Line oil pressure regulator, Wiring harness (fluid temperature sensor), Range Selector Switch, Turbine and output speed sensors.



DIAGNOSIS AND PROGRAMMING

The E46 diagnostic concept provides an minimization of Fault Symptom selections based on areas of selection. Follow the test schedule provided by the DIS / MoDiC. The test schedule is based on the selected fault symptom and stored fault codes.

FAULT CODES: The GS 20 monitors the A5S 360R and interfacing systems. When faults are detected, the GS 20 stores the following fault codes

Fault Codes			Description
BMW Code	**DTC**	**Hex code**	
61	None	3D	Transmission Fluid Over Temperature
96	P1750	60	System Voltage Low
96	P1751	60	System Voltage High
80	P1749	50	TCM Memory RAM/ROM/Programming fault
81	P1748	51	TCM NVM not Copied to RAM at Startup
60	P0705	3C	Position Switch Assembly (Range Switch signal not plausible or faulted)
34	None	22	Fluid temperature Sensor Circuit Voltage Low/High
33	P0715	21	Transmission Input Speed Sensor Circuit
32	P0720	20	Transmission Output Speed Sensor circuit
150	P0727	96	CAN - Engine Speed Signal
50	P0731	32	Incorrect 1st Gear Ratio
52	P0732	34	Incorrect 2nd Gear Ratio
53	P0733	35	Incorrect 3rd Gear Ratio
54	P0734	36	Incorrect 4th Gear Ratio
55	P0735	37	Incorrect 5th Gear Ratio
48	P0740	30	Torque Converter Clutch System - Mechanical
0	None	1	Main Pressure Control solenoid circuit
129	P1747	81	CAN Time out DME / TCM
131	None	83	CAN Time out Instrument Cluster
130	None	82	CAN Time out ASC
144	P1747	90	CAN BUS ERROR Protocol
145	None	91	CAN Torque Reduction Signal
146	None	92	CAN Engine Torque Signal
19	None	13	Shift Lock Control Solenoid/Circuit
147	P1765	93	CAN Throttle Position Signal
148	None	94	CAN Engine Coolant Temperature Signal
149	None	95	CAN Wheel Speed
151	None	97	CAN Brake Switch
113	None	71	Kickdown switch circuit malfunction
83	P1746	53	Shift Lock Power Control Solenoid Circuit High
84	P1746	54	TCC/Shift Solenoid Power Control Circuit High
16	P0753	10	Shift Solenoid ‘A’ Control Circuit Low/High Voltage
17	P0758	11	Shift Solenoid ‘B’ Control Circuit Low/High Voltage
4	P0743	4	Torque Converter Clutch PWM Solenoid Control Circuit
18	P0763	12	Shift Solenoid ‘C’ Control Circuit Low/High Voltage

GS 20 PROGRAMMING:

The control module must be programmed to update resident program data in an existing or after replacing a defective GS 20 control module. As with previous systems, the fault memory must be cleared and the system fully functional.

Connect a battery charger to the vehicle prior to programming to ensure adequate voltage supply during the programming procedure. When programming is completed, clear the system adaptation values using the DIS or MoDiC.

Always make sure the programming software is the latest version.

BASIC TROUBLESHOOTING

- Always personally verify the customer complaint.
- Always verify that the complaint is truly a system malfunction.
- Perform a Quick Test to determine if the vehicle systems have logged fault codes.
- Call up the faulted system or appropriate test schedule to verify the correct control module is installed in the car.
- Follow the Diagnostic Information System (DIS) on screen instructions and perform all tests as specified.
- Use the DIS and fault symptom diagnostic procedures as trained.
- Follow the appropriate test module procedures for systems that malfunction but fail to set faults in memory.
- To get a thorough understanding of automatic transmission issues, a GM or ZF Technical Specialist must be contacted whenever a vehicle is brought into the workshop with an automatic transmission related concern. Always have the printouts of fault codes stored in the DME and EGS and the transmission serial number available when calling.
- If there is no Service Information Bullitin published which addresses the specific complaint, do not make any repairs to a 5 speed automatic transmission prior to contacting a GM or ZF Technical Specialist. Contacts may be made by calling the BMW Technical Hotline: **1-800 472-7222**

A5S 325Z 5HP 19 ZF TRANSMISSION

Model: E46 All Versions

Production Dates: 323i/Ci/Cic : 3/00 to 8/00, 323it: from4/01, 330i/Ci/Cic: from 6/00, 325i/Ci/Cic: from 9/00

Objectives

After completing this module you should be able to:

- Recognize the differences between the torque converters used in the 323i/325i and the 330i.
- Understand the purpose of overlap shifts.
- Describe the method used to program the control unit.
- Know how to check and fill the transmission fluid.

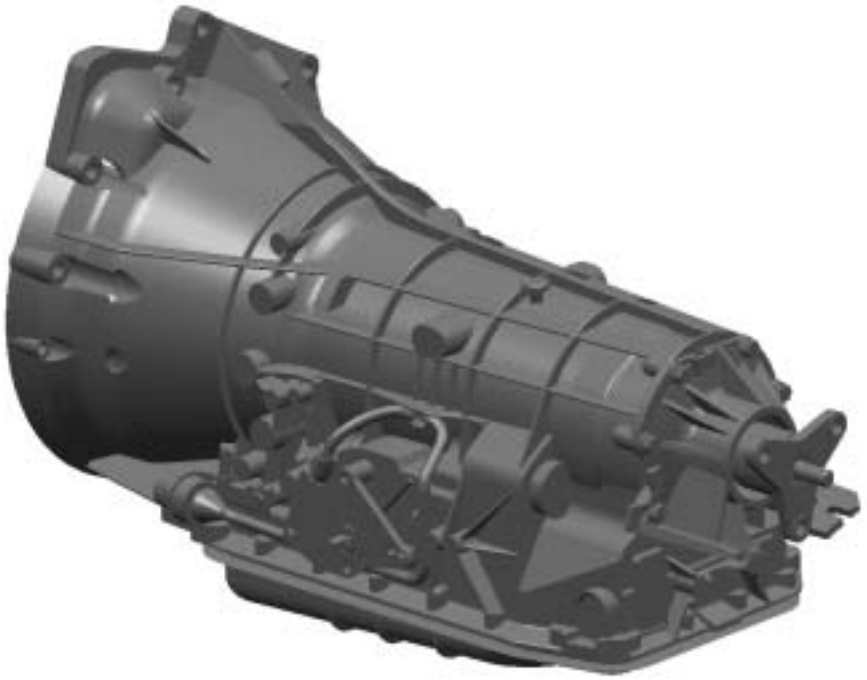
1. A5S325Z Automatic Transmission

1.1 Automatic Transmission A5S325Z

The A5S325Z automatic transmission was jointly designed by BMW and ZF for BMW six-cylinder models with a power output of up to 150 kW/204 bhp. It has electronic-hydraulic control and operation, as is usual for BMW. In addition, it is fitted with an adaptive transmission control system of the kind used, for instance, in the A5S440Z.

The new automatic transmission offers:

- Better shifts
- Enhanced dynamics
- Improved fuel economy
- Quieter operation



KT-2352

Fig. 1: A5S325Z Automatic Transmission

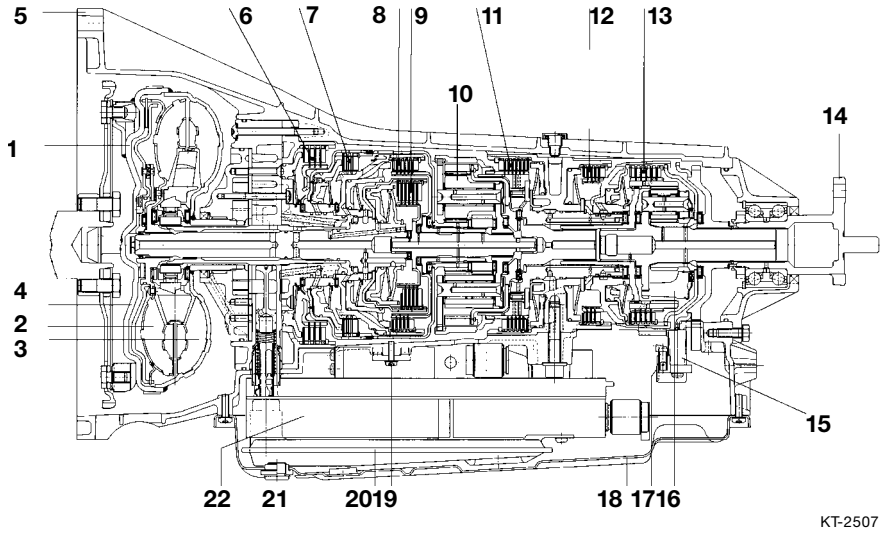


Fig. 2: A5S325Z Transmission

1	Torque converter housing	12	Clutch G
2	Turbine	13	Clutch F
3	Impeller	14	Output flange
4	Torque converter clutch	15	Output speed sensor
5	Transmission case	16	Single planetary gear set
6	Clutch C	17	Oil filler plug in side of oil pan
7	Clutch B	18	Oil pan
8	Clutch E	19	Turbine speed sensor
9	Clutch A	20	Oil filter
10	Planetary gear set	21	Drain plug
11	Clutch D	22	Shift unit

Technical Data:

Transmission type	automatic passenger-car transmission with five gears as standard.					
Torque capacity	max. torque				300 Nm at	3500 rpm
	max. output				150 kW/204 bhp at	6000 rpm
Torque converter	2.8 lt.		W254 with double CTC			
	2.5 lt.		W254 with single CTC			
	2.0 lt.		W254 with single CTC			
Transmission ratios	first gear	3.67	second gear	2.00	third gear	1.41
	fourth gear	1.00	fifth gear	0.74	reverse	4.10
Selector positions	P-R-N-D and Steptronic					
Control	electronic-hydraulic with adaptive control					
Weight	transmission	61.7 kg				
	torque converter	10.4 kg				
	oil	6.9 kg				
	total approx.	79.0 kg				
On tow	200 km at 70 km/h					

1.2 Converter clutch

As in all automatic transmissions, power is transmitted via the torque converter with converter clutch and via the drive and brake clutches to the planetary gear and on to the output flange.

The basic functions of the torque converter and the torque converter clutch are described in the training manual "BMW Automatic Transmission: Design and Function".

The features in which the torque converter and torque converter clutch differ from the A5S310Z are as follows.

- The weight of the torque converter has been reduced and the converter clutch has no torsion dampers, so the mass moment of inertia has been optimised.
- No torsion damper in the torque converter clutch, further optimising the mass moment of inertia.
- This transmission permits oil flow to continue when the torque converter clutch closed. This reduces the oil temperature in the torque converter.
  The torque converter clutch linings have small ducts to permit this flow of oil.
- The torque converter clutch is closed in third, fourth and fifth gears. As in the A5S440Z, clutch closure is slip-controlled.
  Control is in the speed range from approximately 25 km/h to approximately 120 km/h, depending on the load situation. The torque converter clutch is always closed at speeds in excess of 120 km/h.
- The torque converter clutch for the 2.8 litre has two linings (as in the A5S440Z). The version for 2.5 litre and 2.0 litre models has only one lining. This lining is on the torque converter housing, not (as in the A5S310Z) on the clutch.

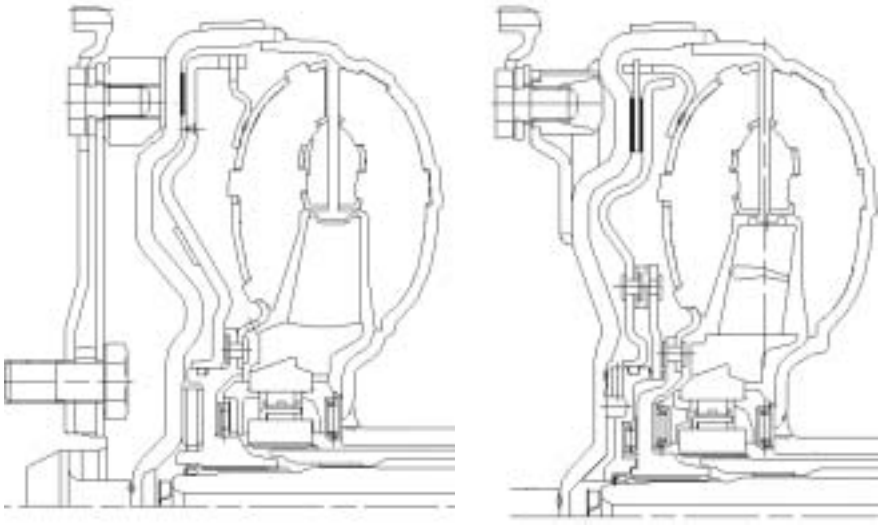


Fig. 3: Torque converter clutch 2.5 litre (left) and 2.8 litre (right)

1.3 Oil pump

The basic clutch functions are described in the training manual "BMW Automatic Transmission: Design and Function".

The delivery rate of the oil pump has been increased from 16 cm per revolution to 24 cm per revolution. This higher delivery rate means that a controlled converter clutch can be used.

The pump draws in oil via a filter and discharges the pressurized oil via a flow control valve which returns excess oil not needed at high engine speeds to the pump intake side. The flow control valve directs the pressurized oil via the main pressure valve in the hydraulic shift unit. This valve regulates the oil pressure and returns excess oil to the intake duct, releasing energy to increase pressure on the intake side in the same way as the flow control valve. This increase in pressure prevents cavitation and reduces noise.

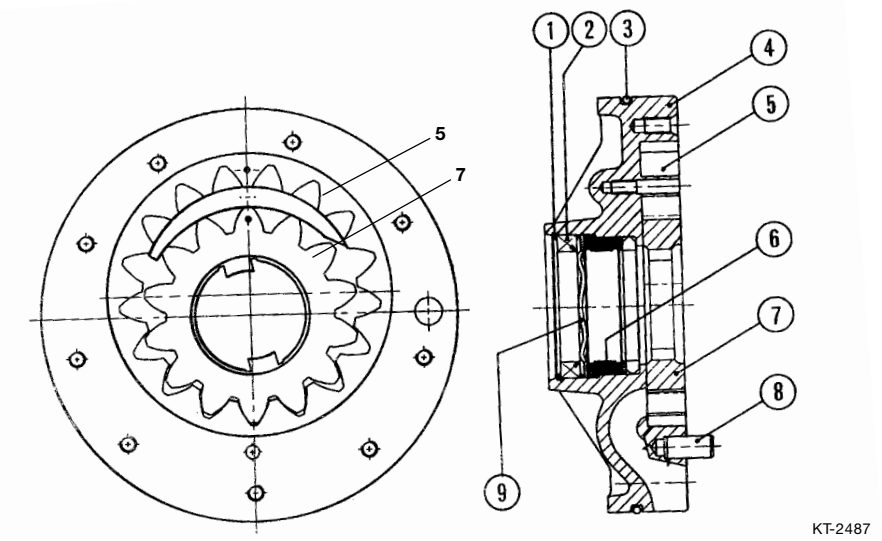


Fig. 4: Oil pump

1 Retaining ring
2 Shaft seal
3 Round seal
4 Pump housing
5 Pump ring gear
6 Needle bearing
7 Impeller
8 Centring pin
9 Corrugated washer

1.4 Clutches

The basic clutch functions are described in the training manual "BMW Automatic Transmission: Design and Function".

The ring-type multi-disc clutches A-B-E and F are drive clutches which transmit engine power to the planetary gear set. Clutches C-D and G are brake clutches which brace the torque against the transmission case.

Shifts from first to second gear are assisted by a freewheel. In these shifts, therefore, there is no clutch overlap.

Shifts from second to third, from third to fourth and from fourth to fifth are overlap shifts. This means that one clutch must continue to transmit drive at reduced main pressure until the other clutch engages.

The transmission dispenses with brake bands, which has led to improved shift quality.

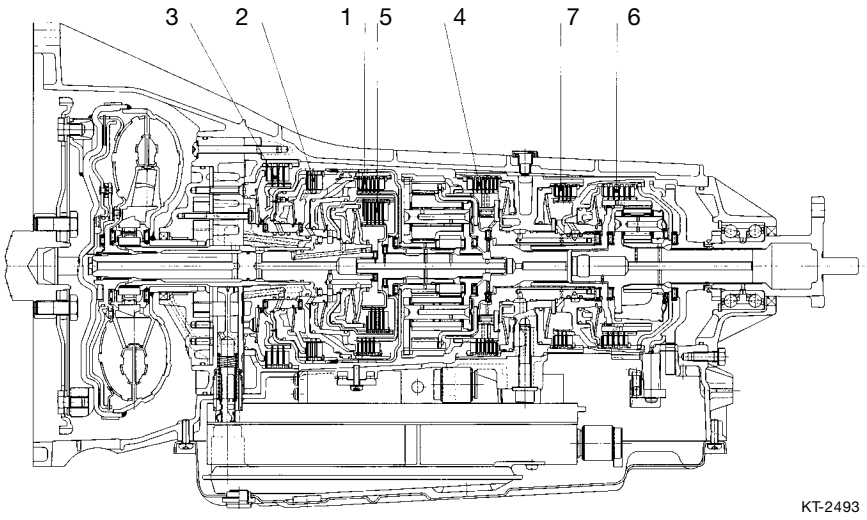


Fig. 5: A5S325Z clutches

1 Clutch A
2 Clutch B
3 Clutch C
4 Clutch D with freewheel
5 Clutch E
6 Clutch F
7 Clutch G

Tolerance limits for the dished-spring forces were reduced for all clutches, so fill-pressure tolerance is down. The gap is now set by the snap ring so fill volume tolerances are narrower. The increase in wear reserves boosts operational dependability and transmission durability.

1.5 Transmission diagram

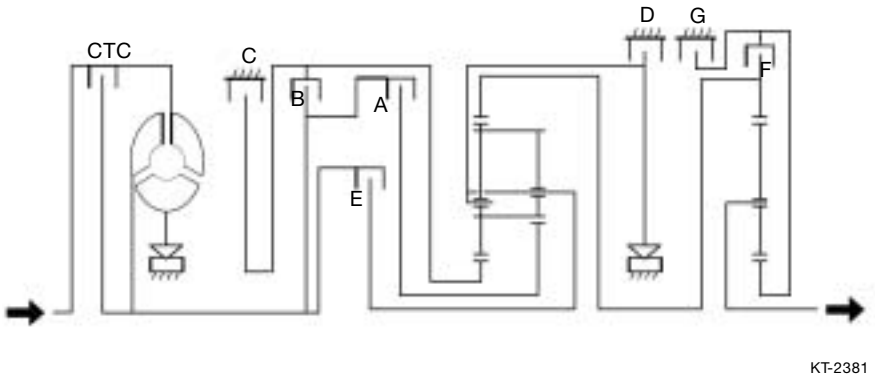


Fig. 6: A5S325Z transmission diagram

Closed shift elements:

Gear	Clutch			Brake				Freewheel	
	A	B	C	D	E	F	G	1	
1	●			❍			●	●	
2	●		●				●		
3	●		●			●			
4	●				●	●			
5			●		●	●			
R		●		●					
❍ = depending on operating status									

1.6 Planetary gear set

The basic functions of the planetary gear set are described in the training manual "BMW Automatic Transmission: Design and Function".

As in the A5S310Z, the A5S325Z transmission uses a Ravigneau planetary gear set.

The bearings of the planetary gears have been improved in this transmission (e.g. double bearings for short planet gears and cage bearings for long planet gears). These design modifications reduce gear noise and improve driving characteristics.

Tail planetary gear set

The tail planetary gear set consists of a sun gear with its four planet gears, a planet spider and a ring gear.

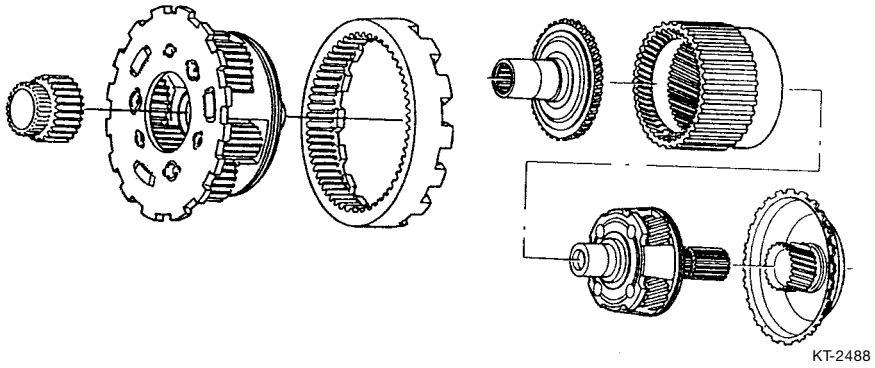


Fig. 7: Planetary gear set with tail planetary gear set

The planetary gear set consists of the following components:

- Ring gear
- Small sun gear
- Large sun gear
- Planetary gears

The tail planetary gear set consists of the following components.

- Ring gear
- Planetary gears
- Spider
- Sun gear

1.7 Oil pan

As in the A5S440Z, the A5S325Z has a flat gasket for the oil pan. This modification maximizes the sealing properties. In order to enhance accessibility for maintenance personnel, the oil filler plug is in the side of the oil pan.

1.8 Transmission weight

At approximately 79.0 kg, the A5S325Z is about 5 % lighter than the A5S310Z. This increases fuel economy.

1.9 Position of selector lever and Steptronic function

The position of the selector lever and the Steptronic function are the same as in the A5S310Z.

1.10 Modifications to electronic-hydraulic control system

The basic functions of the electronic-hydraulic control system are described in the training manual "BMW Automatic Transmission: Design and Function".

Hydraulic shift unit

The A5S325Z has three solenoid valves and four electrical pressure control valves to control the shift unit. Two of the pressure control valves are for gear shifts. One controls the modulation pressure and one operates the torque converter clutch. Controlled converter clutch operation would not be possible without a pressure control valve.

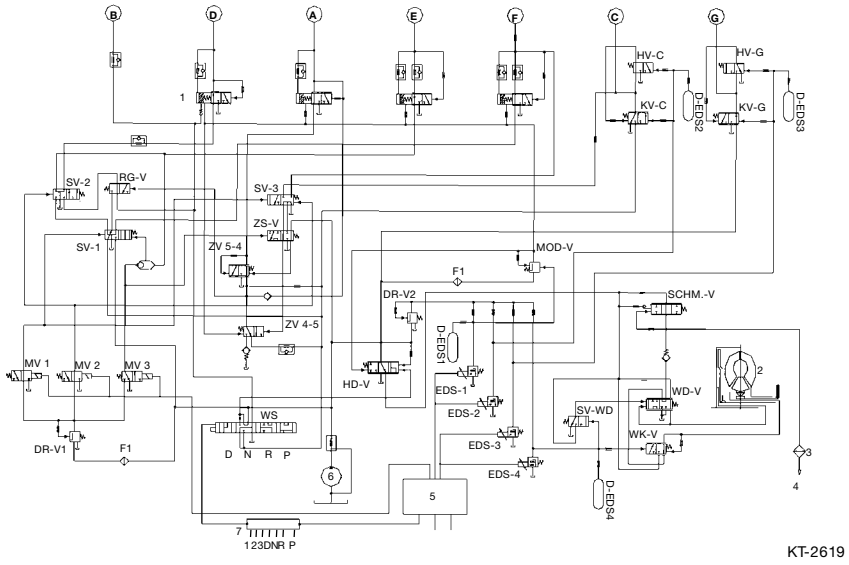


Fig. 8: Hydraulic system

Key

1 Clutch valve with damper
2 Torque converter
3 Oil cooler
4 Lubrication
5 Electronic control unit
6 Pump
7 Position switch

Key to abbreviations

MV	Solenoid valve
EDS	Pressure switch
WS	Selector lever
D-EDS	Damper for pressure actuator
HV	Retaining valve
KV	Clutch valve
SV	Shift valve
ZS	Thrust/coasting valve
ZV	Thrust valve
MOD-V	Modulation valve
SCHM.-V	Lube-oil valve
RG-V	Valve for reverse lockout
DR-V	Pressure relief valve
HD-V	Main valve
WD-V	Torque converter pressure valve
WK-V	Torque converter clutch valve
	Breather
	Restrictor
	Baffle
	Branch

1.11 Solenoid valve and clutch logic

	A5S325Z																
	SOLENOID VALVE LOGIC								CLUTCH LOGIC								
POS/ GEAR	MV			EDS					Clutch				Brake			Free-wheel	
	1	2	3	1	2	3	4		A	B	E	F	C	D	G	1 g	
R = Reverse	★	-	-	★	-	★	-		-	★	-	-	-	★	★	-	
N = Neutral	★	★	-	★	-	★	-		-	-	-	-	-	-	★	-	
D, 1st gear	★	★	-	★	-	★	-		★	-	-	-	-	-	★	★	
D, 2nd gear	★	★	-	★	★	★	-		★	-	-	-	★	-	★	-	
D, 3rd gear	-	★	-	★	★	-	(★)		★	-	-	★	★	-	-	-	
D, 4th gear	-	-	-	★	-	-	(★)		★	-	★	★	-	-	-	-	
D, 5th gear	★	-	★-★	★	★	-	(★)		-	-	★	★	★	-	-	-	
2, 1st gear	★	-	-	★	-	★	-		★	-	-	-	-	★	★	(★)	
D, 5-4 drive	★	-	★	★	★	-	(★)		✪	-	★	★	✪	-	-	-	
TC	-	-	-	-	-	-	★		-	-	-	-	-	-	-	-	

1.12 Electronic control unit

A new control unit is used for A5S325Z transmissions. This control unit has also been fitted to A5S440Z transmissions since model year '98. The new control unit has a modular plug-in system with five chambers. Not all the plug modules are used in the automatic transmission control unit. The ground connections in module 1 are longer. This ensures that these pins are the first to make contact when the plug is pushed onto the control unit.

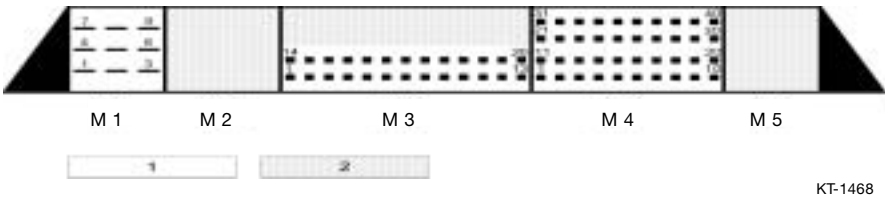


Fig. 9: Plug

Key			
M 1	Module 1	M 4	Module 4, automatic transmission
M 2	Module 2	M 5	Module 5
M 3	Module 3, body		
1	Pins used	2	Pins not used

These new high-end standard control units have shorter access times on account of a new, more powerful 32-bit processor with 256 k memory and a program run time of approx. 10 ms. The old control units had an 8-bit processor with 64 k memory and a run time of approx. 24 ms.

The new control units exclude the possibility of skip downshifts, for example from fifth to third. Downshifts can only be sequential through the gears.

The control units optimise shift quality. The transmission reacts faster to load changes when, for example, the driver allows the car to coast and then immediately presses the accelerator pedal to the floor. Under these conditions, the A5S310Z transmission shifted up a gear and then shifted back down. The A5S325Z transmission cancels the upshift, so the transmission remains in the original gear. Shift transition control, too, has been improved, and clutch draining and filling are better matched. These measures have considerably enhanced levels of shift comfort.

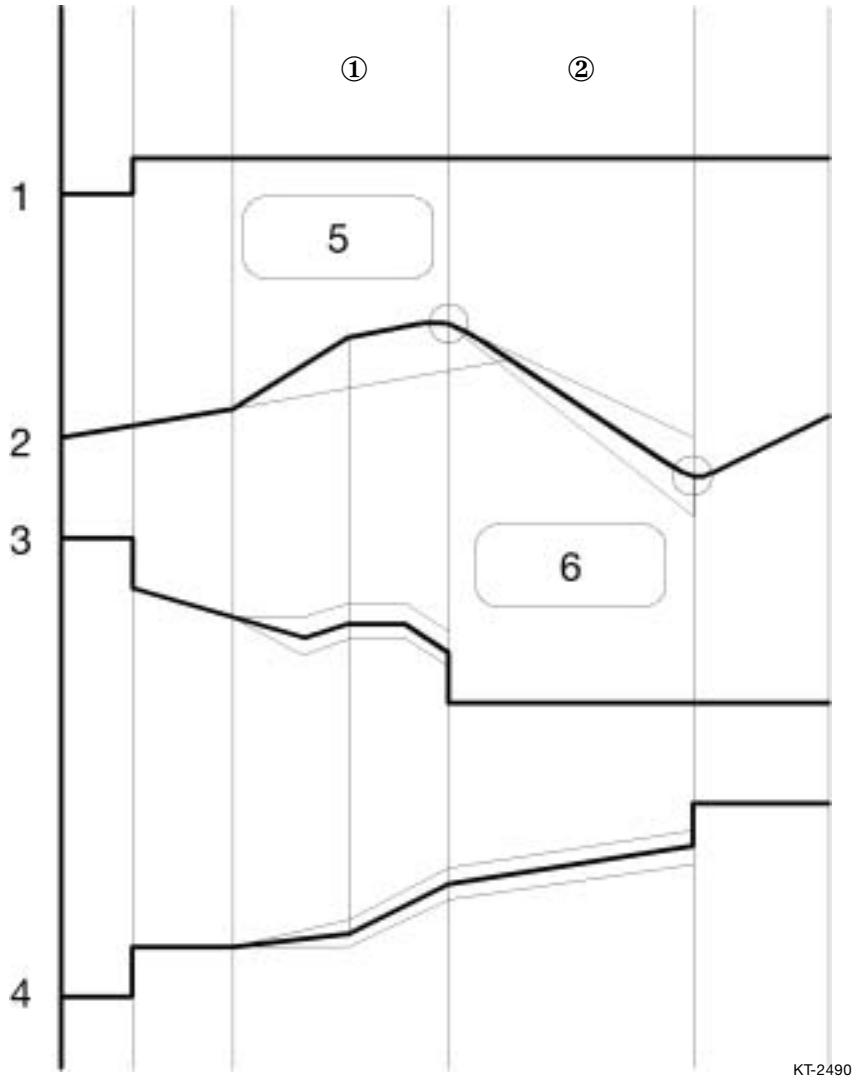


Fig. 10: Shift transition

Key

1 Gear signal

2 Turbine speed

3 Clutch opening under pressure

4 Clutch closing under pressure

5 Slip speed

6 Synchronization point

① Controlled load transfer (CLT)

② Controlled load shift (CLS)

1.13 Registering turbine speed

A Hall sensor (1) registers turbine speed (spider speed) in the A5S325Z transmission. The magnetic pole wheel (3) at cylinder A (4) rotates at turbine speed and generates a pulse frequency. This pulse frequency is registered by the Hall sensor through the non-magnetic bowl (2).

This innovation enables speed to be measured much more accurately than was the case with the A5S310Z transmission.
Synchronisation, in turn, can be calculated to a much finer degree of precision. Shift quality benefits accordingly.

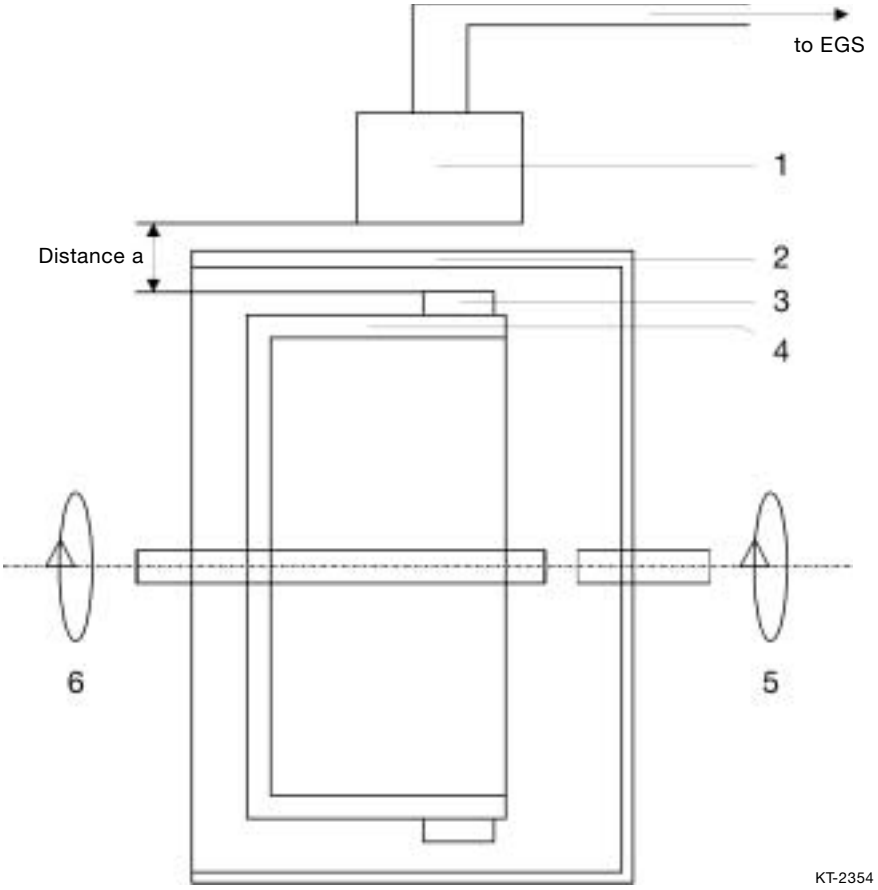


Fig. 11: Registering turbine speed

Key

1 Hall sensor
2 Non-magnetic bowl
3 Magnetic ring with 18 pole pairs uniformly spaced around the circumference
4 Cylinder A, rotating at turbine speed
5 Turbine speed
6 Bowl speed

1.14 Programming

Flashcode programming is the same as that used for the GS 8.55 control unit for the A5S440Z automatic transmission. The programming procedure is largely an adaptation of digital engine management programming with features tailored to electronic transmission control. As in digital engine management, flashcode control units can be programmed 14 times.

Note: The adaptation values always have to be deleted once the electronic transmission control unit has been programmed. The control unit has to re-adapt after the adaptation values have been deleted. The control unit adapts automatically when the car is on the road.
It is, however, advisable to perform a test run covering upshifts and downshifts through all the gears.
The CAN bus is interrupted during programming, with the result that a CAN error is stored in the control units connected (ABS/ASC, DME etc.). Programming should always be followed by diagnosis to clear the fault memories of all the control units connected to the CAN bus.

1.15 Modifications to adaptive transmission control

How adaptive transmission control for A5S325Z transmissions differs from the implementation for A5S310Z transmissions.

The basic function of adaptive transmission control is described in the training manual "Adaptive transmission control unit".

Adaptive transmission control is the same as that implemented for the A5S440Z transmission. This transmission, therefore, has two adaptation modes for the A and S programs.

A program

Basic shift characteristic XE and shift characteristic E are selected in the A program.

It is not possible to switch to the S or XS shift characteristics.

S program

Basic shift characteristic S and performance-oriented shift characteristic XS are selected in the S program.

It is not possible to switch to the XE or E shift characteristics.

1.16 System overview with Steptronic for E46

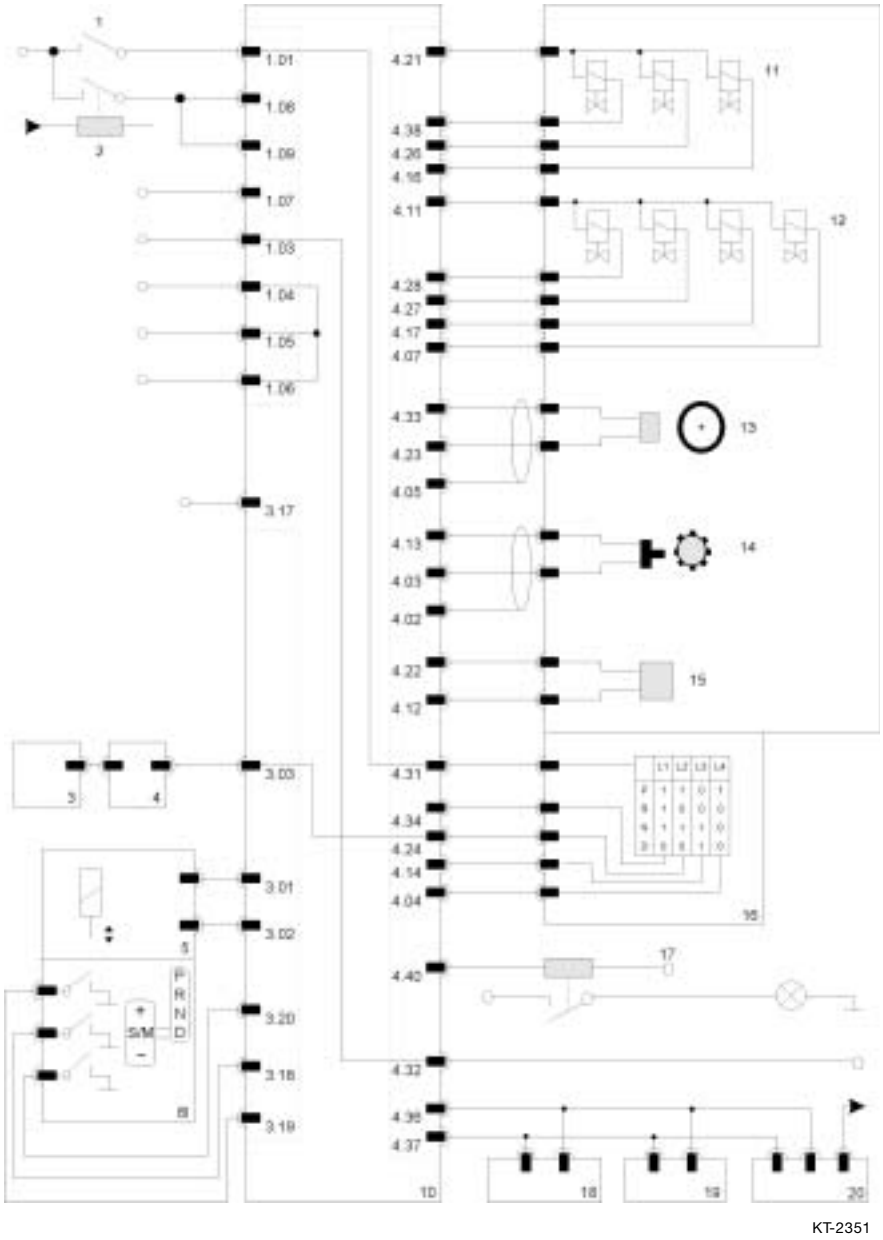


Fig. 12: System overview with Steptronic for E46

Key

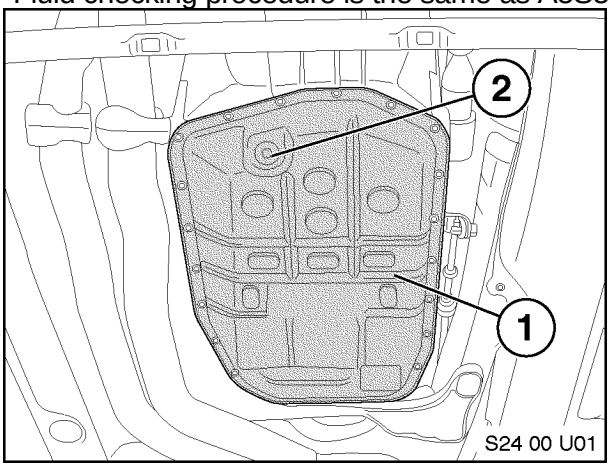
1	Ignition	11	Solenoid valves
2	DME master relay	12	Pressure regulator
3	Starter motor	13	Hall sensor
4	Electronic immobiliser	14	Inductive sensor
5	Shift lock	15	Temperature sensor
6	Selector lever and Steptronic	16	Selector lever switch
7	Auto down	17	Reversing light in E46
8	Manual gate	18	Instrument cluster
9	Auto up	19	ASC
10	Transmission control unit	20	DME

Service Information

5HP19 for M52B25 Specifications

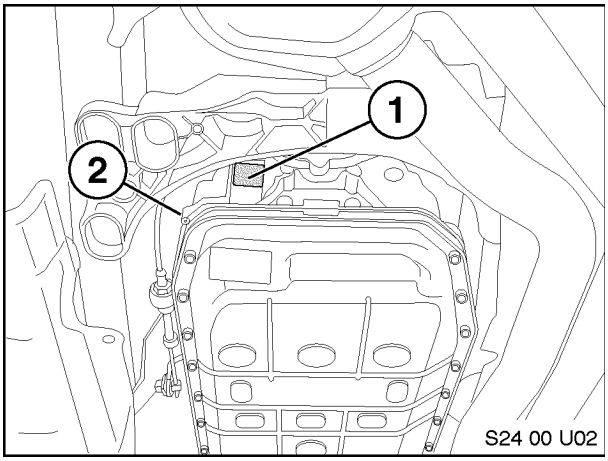
Transmission Type	5 speed automatic, AGS 8.60.4 adaptive transmission control
Transmission Torque Capacity	Torque(max) at 3500 RPM = 300NM
Torque Converter	254 mm dia. with slip controlled lock-up clutch
Transmission Weight	78.9 kg (with oil)
Transmission Ratio	1st gear 3.67 2nd gear 2.00 3rd gear 1.41 4th gear 1.00 5th gear 0.74 Reverse 4.10
Transmission Oil	Lifetime Fill – Esso ATF LT 71141 **BMW P/N 83 22 9 407 807**
Filler plug torque	35NM
Drain plug torque	30NM

Fluid checking procedure is the same as A5S560Z, A5S440Z or A5S310Z. Refer to SIB 24 07 98.



The 5HP19 can be identified by the “ribbed” pan(1).

Drain plug location (2).



The 5HP19 identification tag (1) is located on the left rear of the transmission.

The filler plug (2) is located on the left-rear side (driver-side) of the transmission.

Transmission Application Chart

Trans. Model	Vehicle	Engine	Model Year
4HP 24 E9	750iL (E32) 850i, Ci	M70	1988-94 1990-94
A4S 310R	525i (E34)	M50, M50 TU	1990-92 1993-95
	325i,is,ic	M50 M50 TU	1992 1993-95
	318i,is,ic (ti 95)	M42	1992-95
A4S 270R	328i,(is,ic, -97) Z3 2.3/2.8 323is,ic	M52 M52/TU M52	1996-98 1997-2000 1998-99
	318i,(is,ic, -97),ti, Z3 1.9	M44	1996-99
	528i (E39)	M52/TU	1997-99
A5S 360R **390R**	323i/328i (E46) 325it (E46) 325xi/it/330xi (E46) Z3 2.5/3.0 528i (E39) 525i/530i (E39) X5 3.0i (E53)	M52TU M54 M54 M54 M52TU M54 M54	1999-2000 9/00-3/01 2001- 2001- 9/99-9/00 9/00-3/00 2001-
A5S 310Z	530i, it, (E34)	M60	1994-95
	M3	S50 US	1995
	M3	S52	1996-99
A5S 325Z	323i (E46) 325i/330i (E46) 525i/530i (E39)	M52TU M54 M54	3/00-9/00 6/00- 3/01-
A5S 440Z	840Ci (E31), 540i (E39), 740i/iL (E38) X5 4.4i	M62 M62/TU M62/TU M62TU	9/96-End prod. 1997- 1/97-2001 2000-
A5S 560Z	740i/iL (E32) 540i (E34)	M60	1993-94 1994-1995
	840Ci 740i/iL (E38)	M60	1994-1995 1995-1996
	750iL (E38)	M73/TU	1995-2001
	840Ci (E31)	M62	1996-8/96
	850Ci (E31)	M73	1995-End prod.

Review Questions

1. How does the vane pump of the A5S 360R transmission regulate fluid volume?

2. What type of signal is used to control the pressure regulator solenoid? What happens to the fluid pressure if the control signal is switched off?

3. Describe how the transmission fluid heat exchanger operates.

4. How can the AGS/TCM module be distinguished from the DME/ECM?

5. Why does the AGS module monitor the brake pedal switch?

6. If no repairs are performed to the transmission, why is clearing the adaptation values not recommended?

7. What steps must be performed before determining a transmission needs to be replaced?

8. What is the difference between the torque converter lockup clutch between the two engine displacements?

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Subject **Page**

GA6HP26Z AUTOMATIC TRANSMISSION

Model: E65 - 745i / E66 - 745Li

Engine: N62B44

Production Date: 11/2001 - E65, 01/2002 - E66

Objectives of The Module

After Completing this module, you will be able to:

- List the GA6HP26Z designation.
- Describe Stand By Control.
- Name the clutches used in the GA6HP26Z.
- Identify what is unique about 5th and 6th gear.
- Explain the Parking Lock function.
- Demonstrate how to use the Emergency Release.
- List the Mechatronic components.
- Name the two paths of communication for the Selector Lever.
- Explain the L mode.

GA6HP26Z Automatic Transmission

Purpose of The System

BMW has developed a new automatic six speed gearbox together with ZF (Zahnradfabrik Friedrichshafen), designated the GA6HP26Z for the E65. It represents a further development of transmission technology and features innovations used for the first time in BMW automatic gearboxes. This gearbox makes an important contribution to the "revolutionary" features of the E65 in the luxury class segment.

G = Gearbox
A = Automatic
6 = Number of gears (speeds)
HP = Hydraulic planetary gear
26 = size
Z = Gearbox manufacturer ZF
(Zahnradfabrik Friedrichshafen)

42-05-00

GA6HP26Z Auto Transmission

The GA6HP26Z is designed in two versions for the different E65 engines. There is a more powerful version available for the V-12 that differs with the following components:

- Power output and torque characteristics
- Torque converter
- Clutches with different numbers of steel discs and lined plates
- Lepelletier planetary gear train with a different number of planet gears

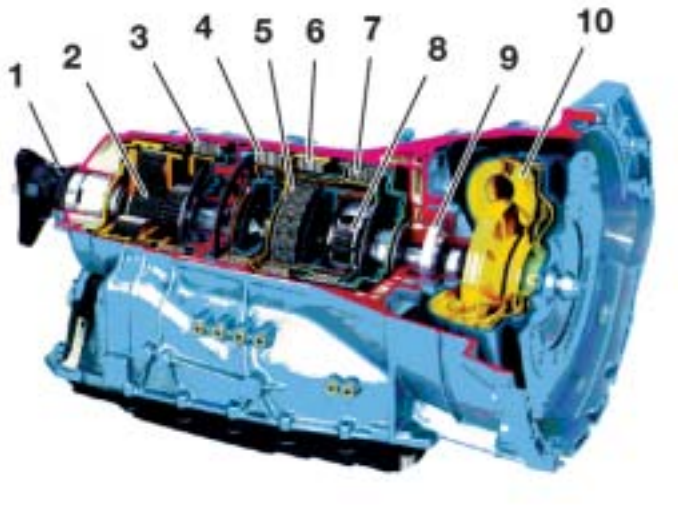
The gearbox used in the 745i is designed for a torque of 440 Nm. The more powerful version (760i) is designed for a power output of 320 kW/435 bhp and a torque of 600 Nm. The fundamental design and function of both gearbox versions are the same.

Mechanical Design of the Gearbox

The mechanical power transmission of the gearbox has been optimized with regard to gearshift comfort, quality and reduced fuel consumption. The engine torque is transferred to the gearbox by a torque converter with a controlled lockup clutch. The six forward gears and the reverse gear are produced by a Lepelletier planetary gear train. The gears are shifted by multi-disc clutches.

1. Output shaft
2. Double gear train
3. Clutch D
4. Clutch C
5. Clutch E
6. Clutch B
7. Clutch A
8. Single gear train
9. Oil pump

10 Torque converter with lockup clutch



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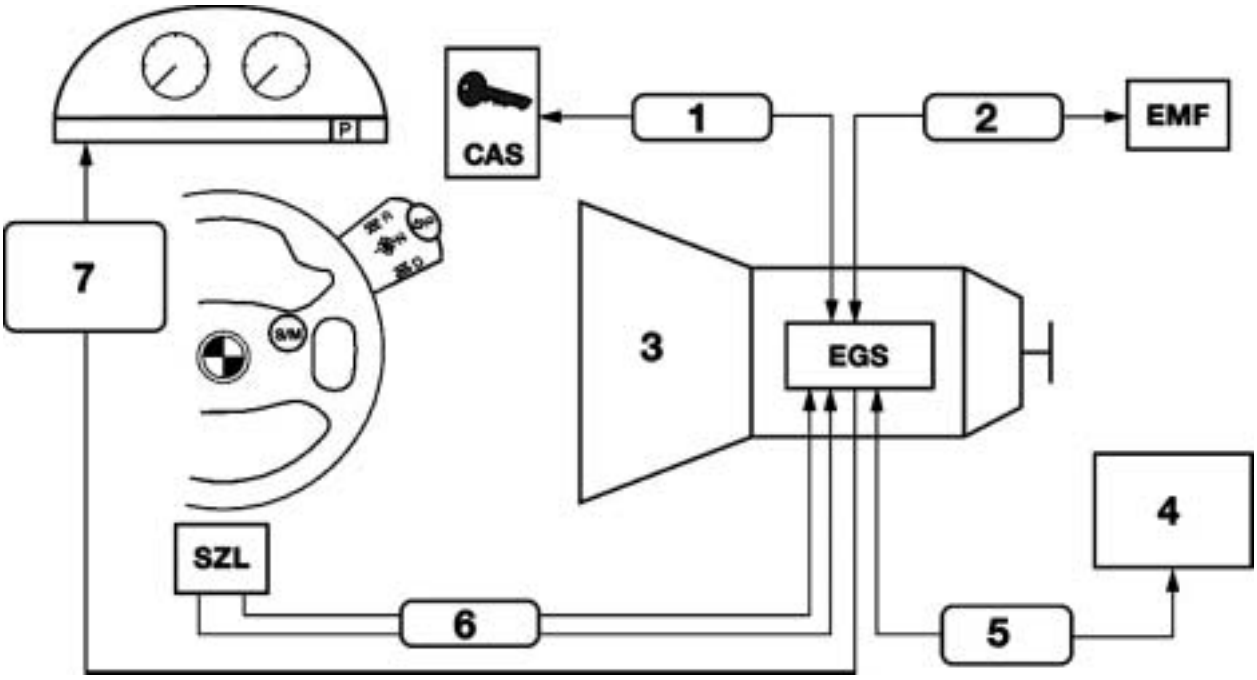
The new automatic gearbox has the following advantages:

- Designed as a 6-speed gearbox with an overdrive ratio in 5th and 6th gear, fuel consumption is reduced by up to 5 percent.
- The 6-speed gearbox allows for more gear spread, improving vehicle acceleration.
- The new 6-speed gearbox is approximately 30 kg lighter and 50 mm shorter as compared to the previously used gearbox (A5S560Z).
- 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 for the electronic transmission.

Transmission Control

The gearbox is controlled by the Mechatronic Module that is a combination of the valve body and electronic control module. The following system overview shows the main components of the electronic control system.



42-05-02

Transmission Control

1. Key signal, starter interlock
2. Redundancy (park lock, n)
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,(L,-)
7. Shift pattern (shift gate)
   Position indicator P, R, N, D, L1...L6
   Shift lock indicator
   Error message

CAS - Car access system
EMF - Electromechanical parking brake
EGS - Electronic transmission control (in mechatronic module)
SZL - Steering column switch center

The driver's request is transmitted in the form of an electrical signal from the selector lever on the steering column or from several control buttons in the multifunction steering wheel. The signals are transferred over the CAN bus to the transmission control module. 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) eliminates the conventional gearshift lever in the center console and all of the associated components. There are additional safety enhancements, for example the automatic parking lock is active when the ignition key is removed. In the event of faults or complete failure of electrical connections or system components, numerous measures are provided:

- An additional serial data link (hard wire) between the selector lever and Mechatronic
- The display of error messages in the instrument cluster and/or in the CC display
- The mechanical emergency park release

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 745i	Max torque at 4200 rpm **440** Nm Max power output at 6600 rpm 230 KW / 313 bhp
Transmission Data 760i	Max. torque at 4200 rpm 600 Nm Max. power output at 5800 rpm 320 kW / 435 bhp
Converter	Slip-controlled torque converter lockup clutch in the gears 1 to 6 Max. permissible continous speed 7000 rpm
Transmission Ratios	1st gear 4.171 / 2nd gear 2.34/ 3rd gear 1.521 / 4th gear 1.143 / 5th gear 0.867 / 6th gear 0.697 / reverse gear 3.403
Control	Electrohydrualic with adaptive electronic control
Weight	84 to 90 kg with oil depending on version

42-05-03

Mechanical System Components

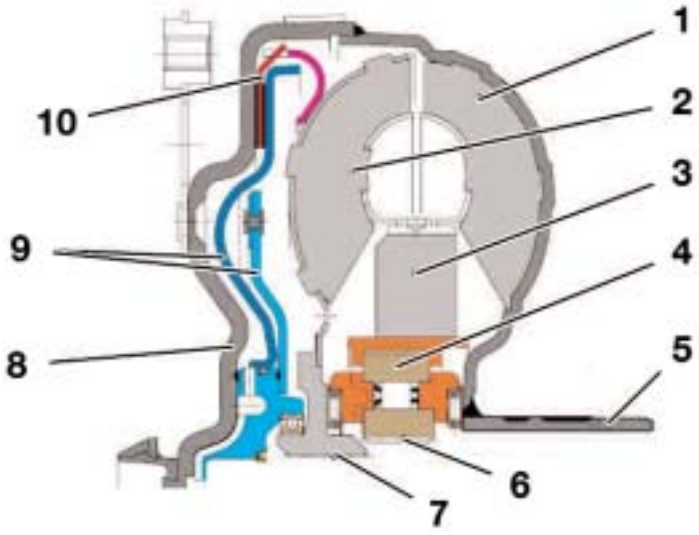
The new features/changes of the individual components as compared to previous BMW automatic transmissions will be covered. The component and functional description follows the power flow progression in the gearbox, from the torque converter to the output shaft.

Torque Converter and Lockup Clutch: The torque converter is the link for transmitting power from the engine to the gearbox. It converts high speed/low torque into low speed/high torque with a slight slip from the fluid coupling. The integral converter lockup clutch eliminates slip during the transfer of rotational speed.

The torque converter clutch is locked when the control module diverts oil pressure in the converter. The oil flow is reversed to depressurize the area in front of the clutch and apply pressure to the back side of the clutch pushing it against the converter housing. The clutch plate locks the turbine wheel directly to the converter housing allowing it to rotate as a unit without slip.

The lockup clutch is a two-friction surface clutch. It is slip-controlled in all forward gears (1 through 6). The operating points when the lockup clutch is engaged are increased which reduces fuel consumption.

1. Pump
2. Turbine
3. Stator
4. Overrunning Clutch
5. Torque Converter Hub
6. Stator Shaft
7. Turbine Shaft
8. Torque Converter Casing
9. Piston for lockup clutch
10. Lined clutch plate



42-05-04

Torque Converter & Lockup Clutch

The lockup clutch will not engage until the oil temperature is >35 ºC. The control of the lockup clutch depends on various factors such as:

- Load requirement signal
- Vehicle speed
- Engine load status
- Gearbox oil temperature
- Selected gearshift program

Examples:

- Control of the lockup clutch takes place in the XE program (extreme economy) in gears 1 through 6 at a speed of approx. >30 km/h when a load requirement of <50% is present. The lockup clutch is disengaged if the load requirement is >50%.

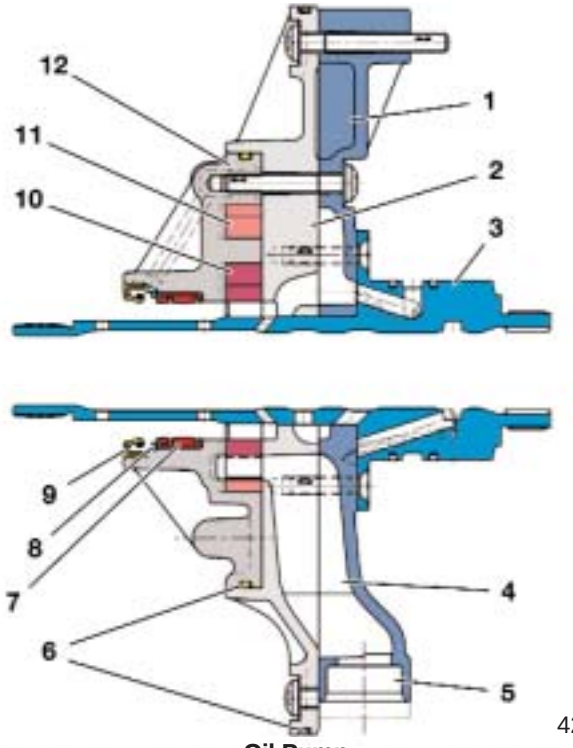
- The converter clutch is engaged from a speed of approx. 80 km/h in all forward gears. It is engaged at a speed of 20 km/h at full load or kick-down.

There are small oil channels in the lining of the lockup clutch. This oil circuit quickly reduces the temperature in the torque converter after the lock-up clutch engages.

The GA6HP26Z has a new feature of reducing the load on the engine when the vehicle is stationary and the brake pedal pressed. The turbine (input) shaft is uncoupled from the drive so that only a minimum load remains, reducing fuel consumption. The uncoupling phase is achieved by a control feature of the "A" clutch which is called ***Stand By Control (SBC).*** The pressure is reduced in the A clutch allowing the turbine shaft and torque converter to turn freely until acceleration is requested.

Oil Pump: The oil pump supplies the required oil pressure and lubricating oil for the automatic gearbox. It is a crescent-type pump and a delivery control valve is not required. The converter is supported by a needle bearing in the pump housing.

1. Intermediate Plate
2. Centering Plate
3. Stator shaft
4. Intake
5. To Oil Strainer (intake pipe)
6. O-ring
7. Bearing
8. Snap ring
9. Rotary shaft seal
10. Impeller
11. Internal Gear
12. Pump Housing



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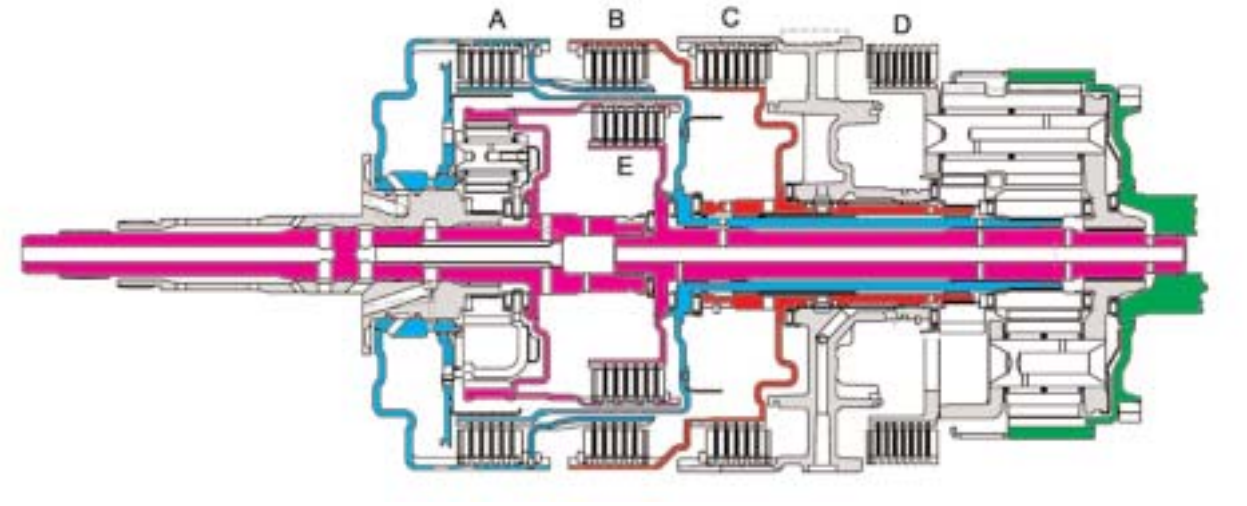
Oil Pump

Multi-disc Clutches: The GA6HP26Z gearbox requires only 5 clutches to engage 6 gears. The clutches are divided into drive clutches and brake clutches. Clutches A, B and E are drive clutches while clutches C and D are brake clutches. The A, B and E drive clutches are “dynamic pressure” balanced.



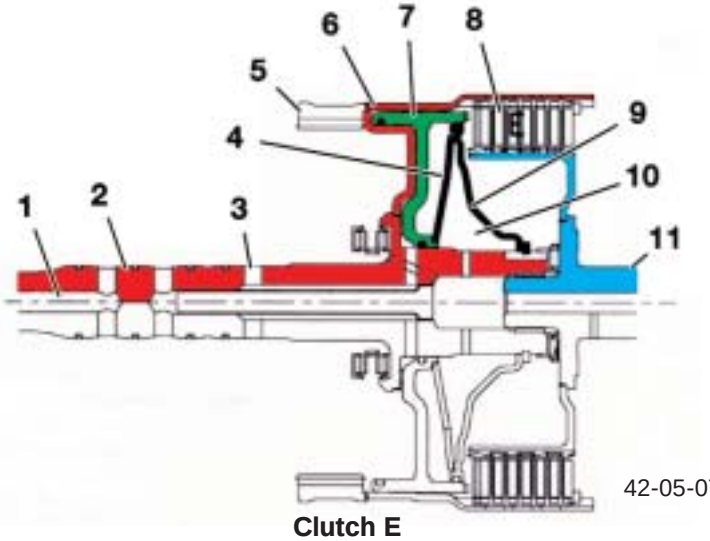
42-05-06

A Drive clutch **B Drive clutch** **C Brake clutch** **D Brake clutch** **E Drive clutch**

Dynamic Pressure Balance (Example: Clutch E)

Oil is applied to the clutch piston on both sides to avoid speed dependent pressure reduction in the clutch. This balance is achieved by the pressure plate (9) and the non-pressurized residual oil in the lubricating oil gallery (1) through which the area between the piston and pressure plate is filled with oil. This ensures the clutch disengages and engages exactly in all speed ranges while also improving gearshift comfort.

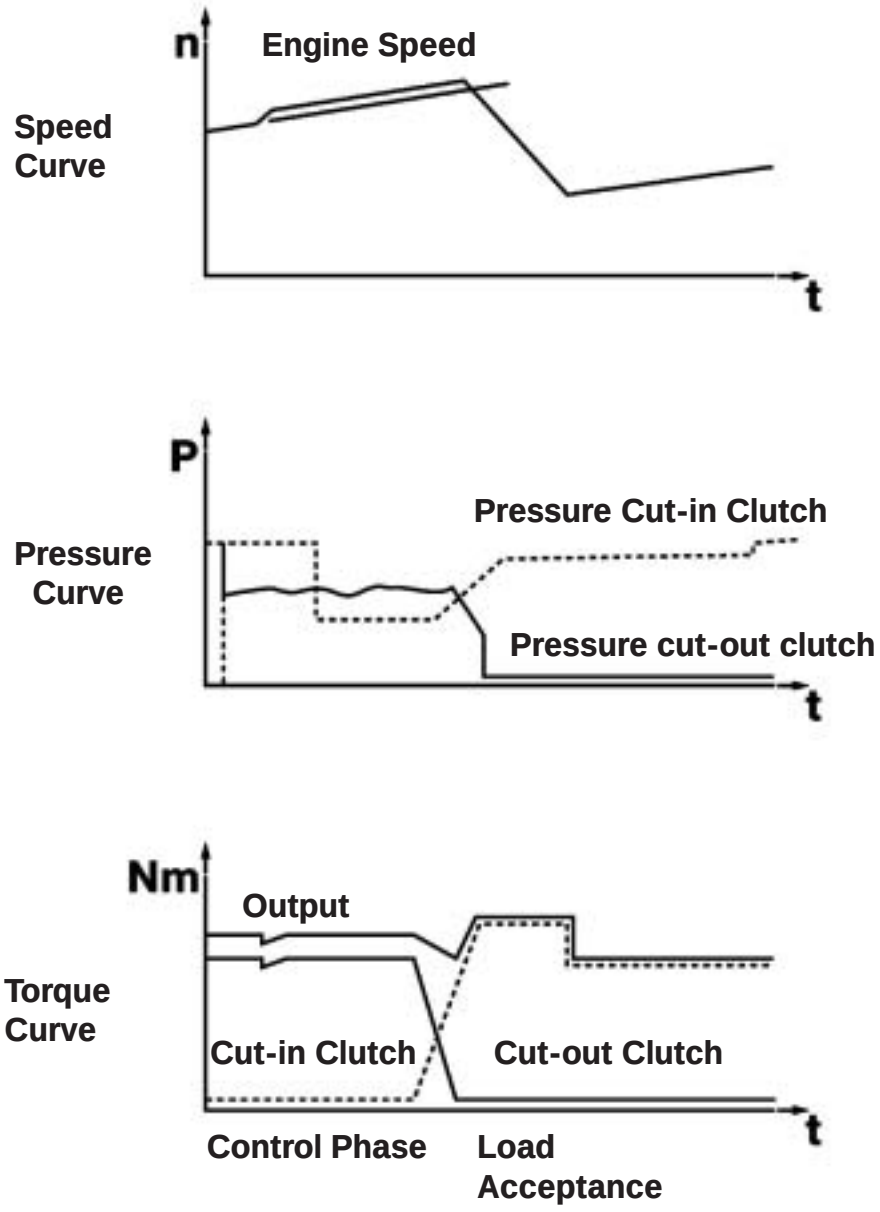
1. Lubrication Oil Gallery
2. Turbine shaft
3. Main pressure for clutch E
4. Disc Spring
5. Internal gear for single gear train
6. Cylinder E (outer disc carrier)
7. Piston E
8. Clutch assembly E
9. Pressure plate
10. Area for pressure compensation
11. Inner disc carrier E



42-05-07

Clutch E

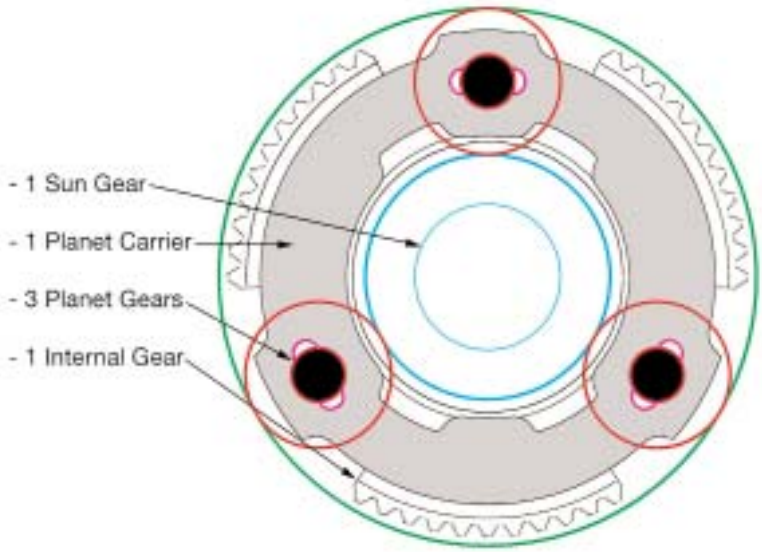
Free wheel gearshifts (using overrunning clutches) are not used in this transmission. In the GA6HP26Z gearbox, all gearshifts from 1st to 6th gear and from 6th to 1st gear are executed as overlap shifts. The overlap gearshift system saves weight and space. The electro-hydraulic gearshift is executed by valves in the valve body that are controlled by pressure regulators. The speed, pressure and torque curves are shown in the following diagrams.



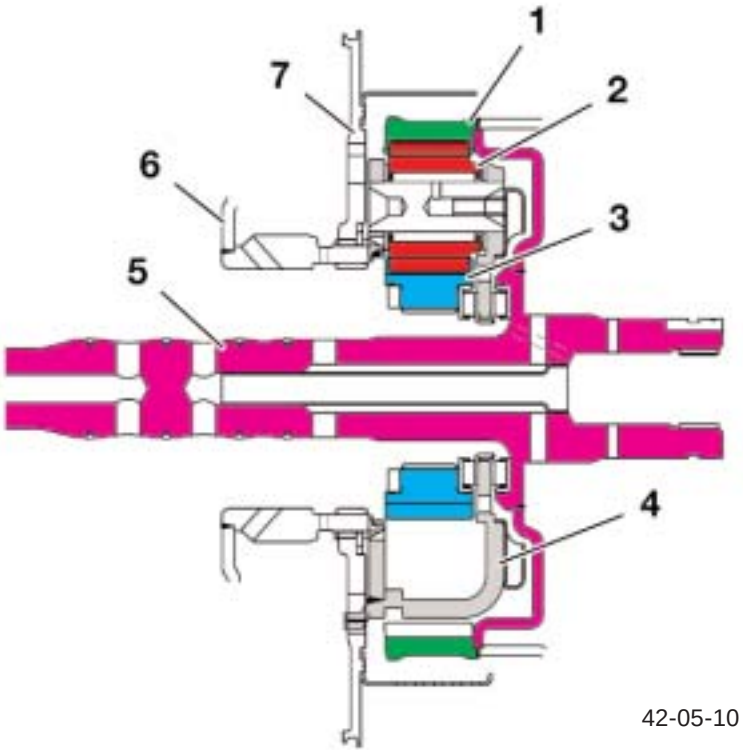
42-05-08

Lepelletier Planetary Gear Train: The Lepelletier planetary gear train provides six forward gears and one reverse gear using a lightweight design. 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 consists of:



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



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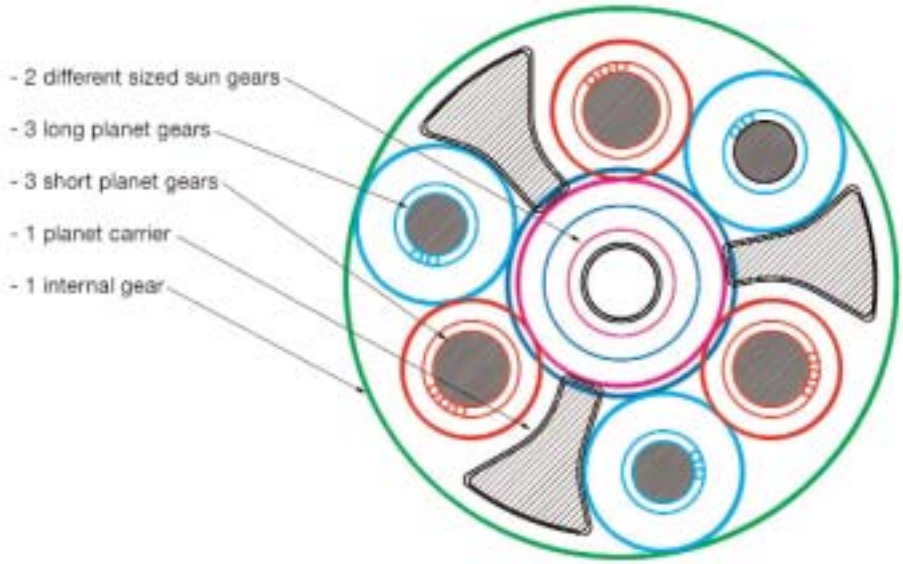
Lepelletier Planetary Gear Train

Double Planetary Gear Train: The series connected double planetary gear train consists of:



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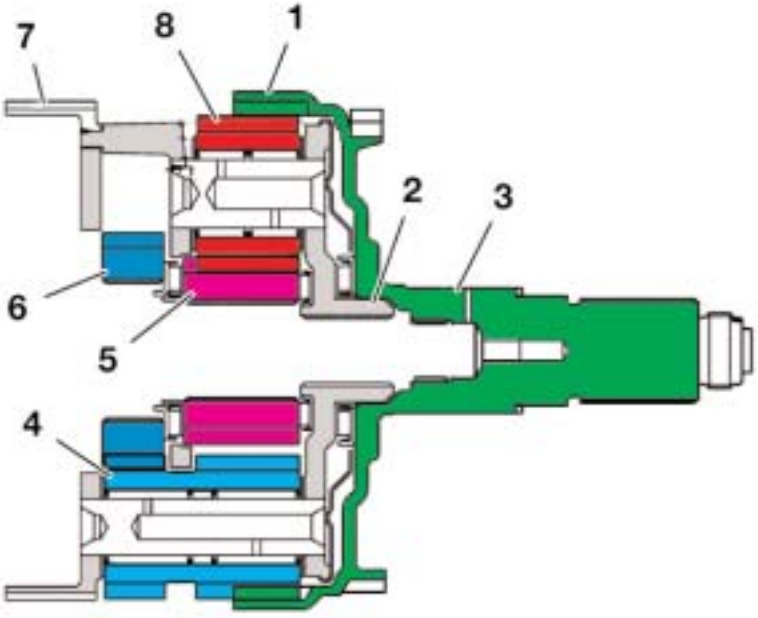


1. Internal gear 2
2. Planet carrier, clutch E
3. Output
4. Double planet gear (long)
5. Sun gear 3, clutch E
6. Sun gear 2, clutch A
7. Planet carrier 1
8. Planet gear (short)

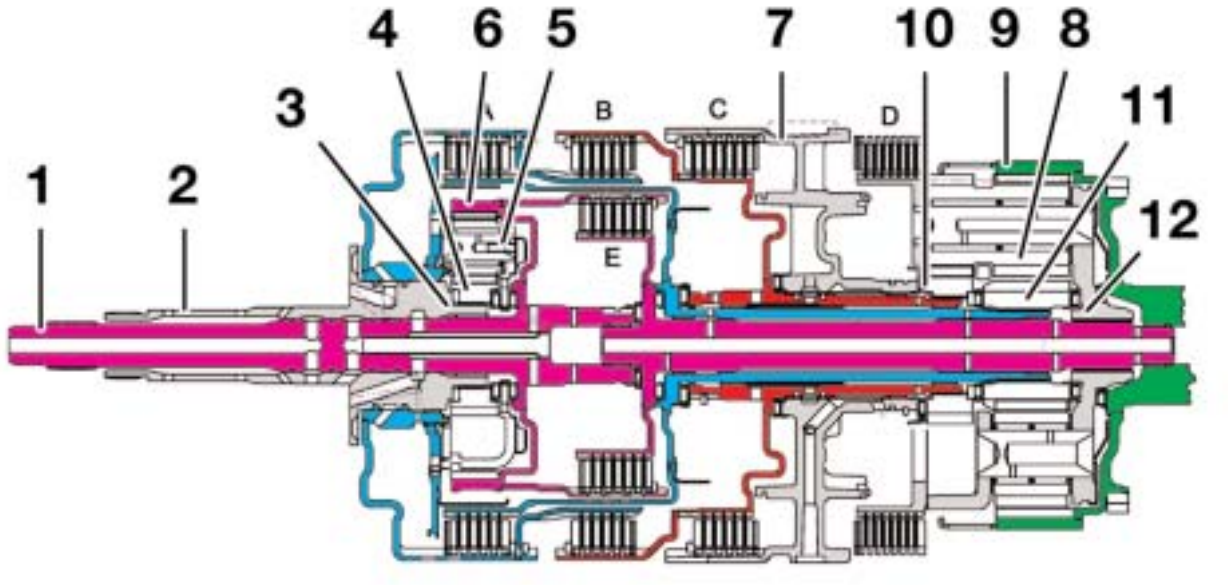
42-05-12

Double Planetary Gear Train

Power Transfer in the Planetary Gear Train

Principle of Operation

Neutral Position: The turbine shaft drives the internal gear for the front single planetary gear train and the outer disc carrier of clutch E. The internal gear drives the planet gears that roll on the fixed sun gear. The planet carrier of the gear train is driven together with the outer disc carrier of clutch A and the inner disc carrier of clutch B. This steps up the drive for clutch A and B.

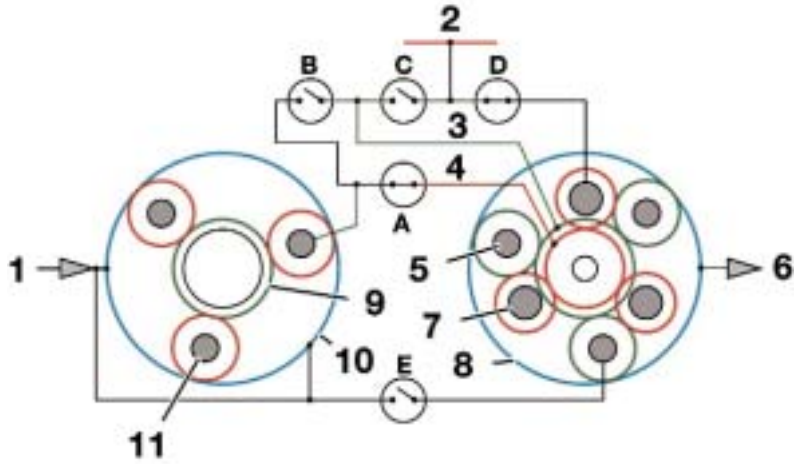


42-05-13

Power Transfer in the Planetary Gear Train

1. Turbine shaft
2. Stator shaft
3. Single gear train
4. Sun gear
5. Planet carrier
6. Internal gear
7. Fixed connection to housing
8. Double gear train
9. Internal gear 2
10. Sun gear 2
11. Sun gear 3
12. Double planet carrier

Power Flow in 1st Gear: Drive clutch A is engaged in 1st gear. The sun gear 3 in the double planetary gear train is driven and is meshed with the short planet gears. Due to clutch D being engaged, the double planet carrier is held by the gearbox housing. As a result, the internal drive gear is driven over the long planet gears (large gear reduction) in the direction of engine rotation.



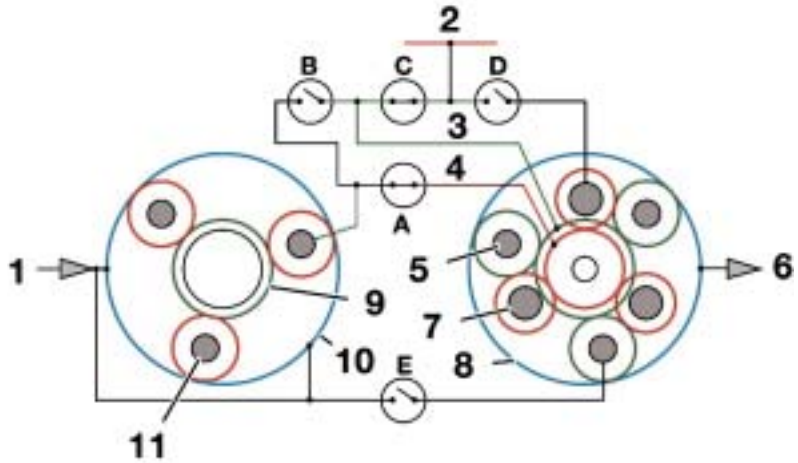
42-05-15

Planetary Gear Train

1. Drive (turbine shaft)
2. Gearbox housing
3. Sun gear 2
4. Sun gear 3
5. Planet gear, long
6. Output
7. Planet gear, short
8. Internal gear 2
9. Sun gear 1 (stator shaft)
10. Internal gear 1
11. Planet carrier

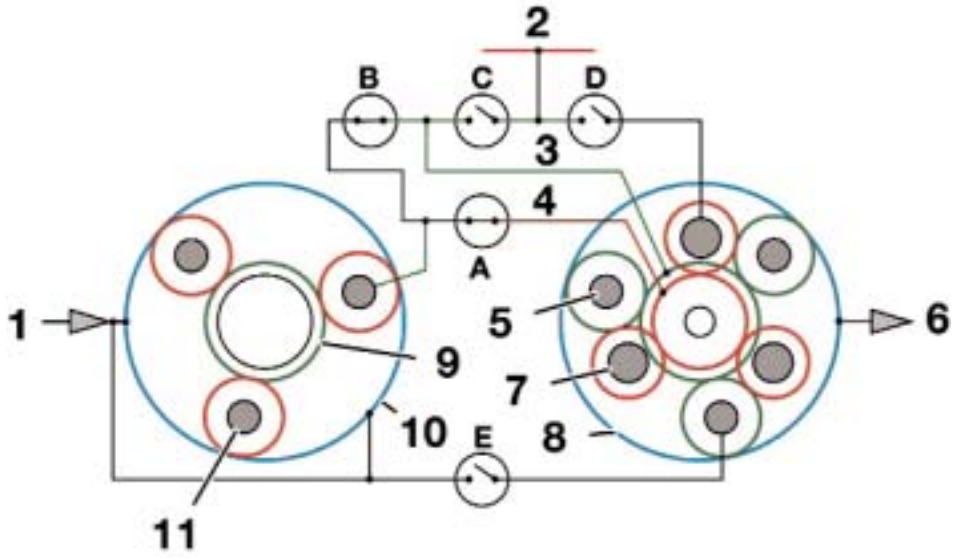
A - Drive clutch
B - Drive clutch
C - Brake clutch
D - Brake clutch
E - Drive clutch

Power Flow in 2nd Gear: Clutch A is also engaged in 2nd gear so that sun gear 3 (4) in the rear gear train is driven. Sun gear 2 (3) in the rear gear train is now blocked by clutch C. The long planet gears and the short planet gears move on rolling contact (reaction) with the fixed sun gear 2 and drive the double planet carrier as well as the internal gear 2 in the direction of engine rotation (gear up - ratio change).



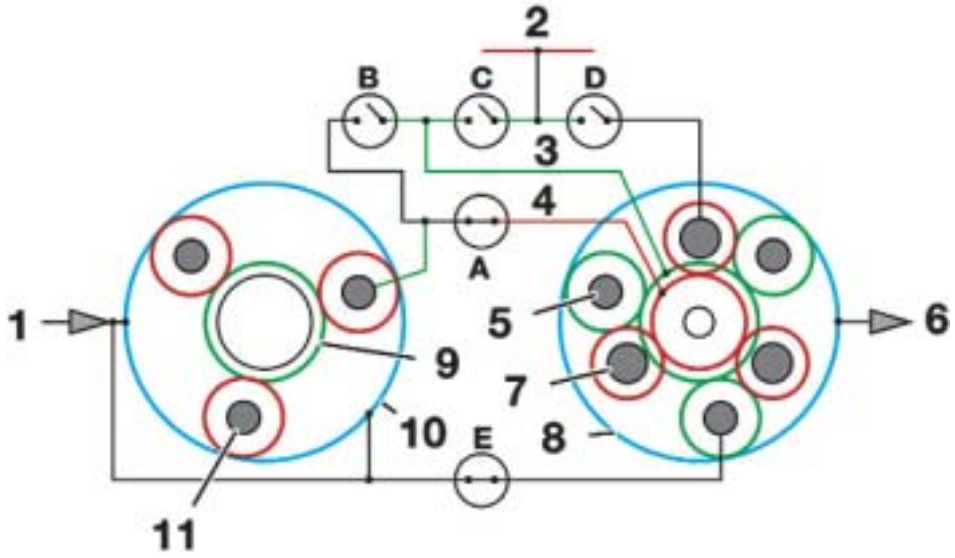
42-05-14

Power Flow in 3rd Gear: As in 1st and 2nd gear, drive clutch A is engaged. Drive clutch B is now also engaged. Both sun gears in the double planetary gear train are driven (reaction). As a result, the gear train moves as an assembly and the gear ratio is achieved only by the front single planetary gear train (gear up - ratio change).



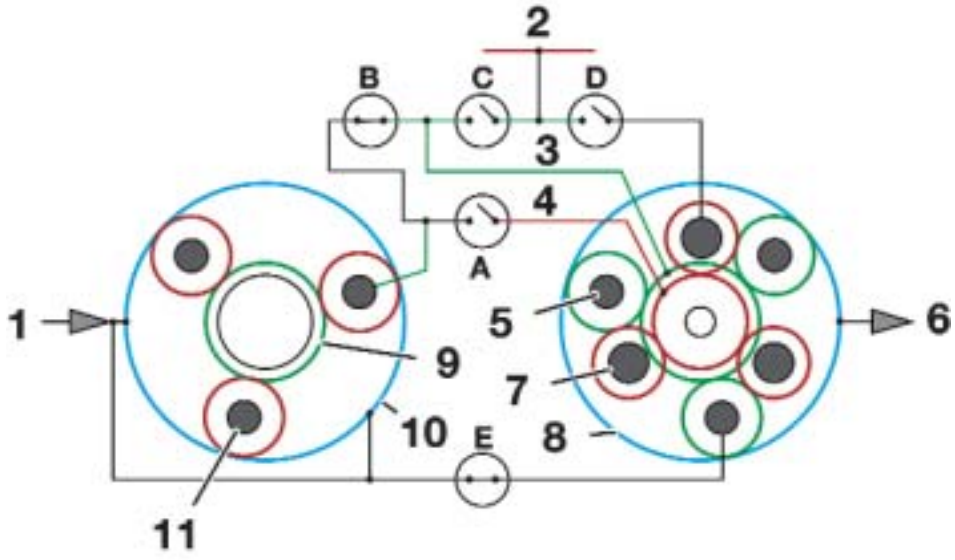
42-05-16

Power Flow in 4th Gear: Drive clutches A and E are engaged in 4th gear. Clutch A drives the sun gear 3 (4). Clutch E drives the planet carrier in the double planetary gear train. Together with the double planet carrier, the long planet gears and the short planet gears drive the internal gear 2 in the direction of engine rotation (gear up - ratio change).



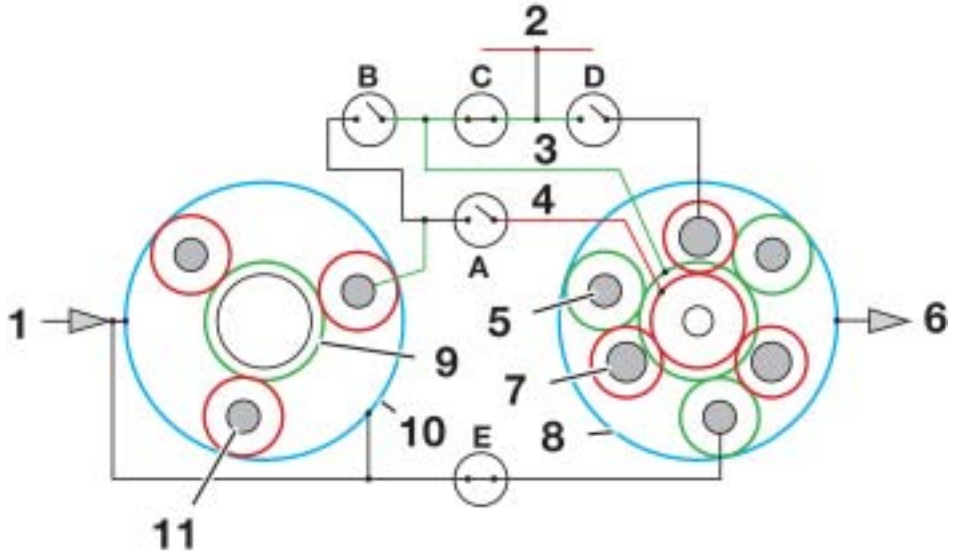
42-05-17

Power Flow in 5th Gear: Drive clutches B and E are engaged in 5th gear. The sun gear 2 (3) in the double planetary gear train is driven by clutch B and the planet carrier of the double planetary gear train by clutch E. Together with the double planet carrier, the long planet gears and the short planet gears drive the internal gear 2 in the direction of engine rotation. ***This results in a gear ratio with a slight overdrive.***



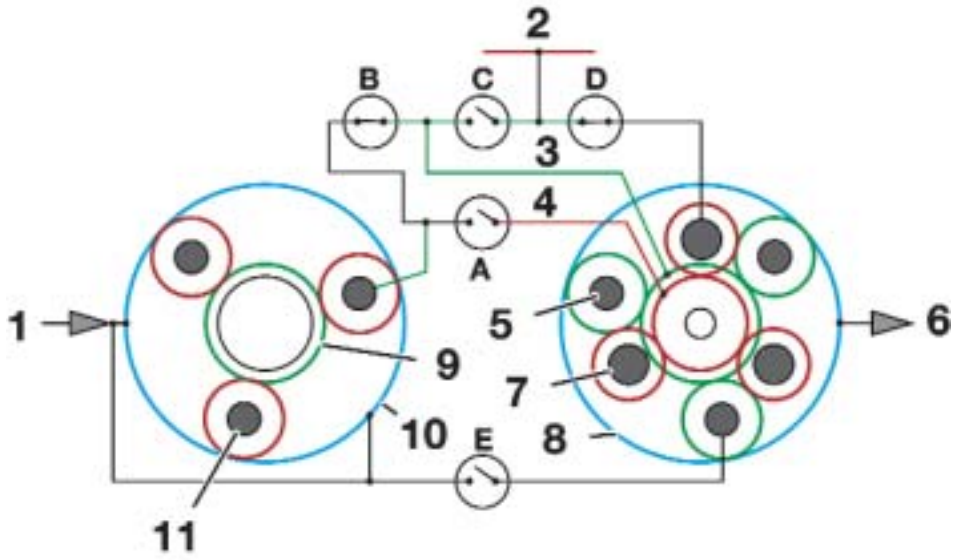
42-05-18

Power Flow in 6th Gear: In 6th gear, the sun gear 2 in the double planetary gear train is blocked by clutch C. The planet carrier is driven by the engaged clutch E. As a result, the long planet gears are forced to move by rolling contact (reaction) on the fixed sun gear 2 (3) and drive the internal gear in the direction of engine rotation. ***This results in a large gear ratio in overdrive.*** The single gear train is not operative in 6th gear.



42-05-19

Power Flow in Reverse Gear: The drive clutch B is closed in reverse gear. As a result, the sun gear 2 (3) in the double planetary gear train is driven while being in mesh with the long planet gears. The double planet carrier is supported by brake clutch D and the gear-box housing. The internal gear 2 (output shaft) can now be driven by the long planet gears in the ***opposite direction*** of engine rotation (large gear reduction).



42-05-20

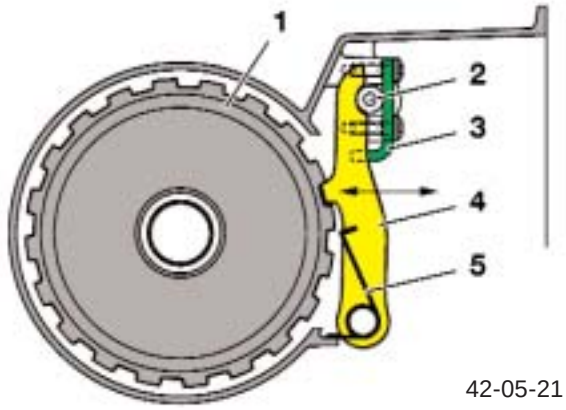
Notes:

Parking Lock

The parking lock secures the vehicle to prevent it from rolling away. When the vehicle is stationary it is electrically applied by a solenoid valve as requested from the selector lever.

The parking lock “locks” the output shaft of the gearbox when the linking rod (2) is extended to pivot the pawl (4) to engage in the gear teeth of the parking lock disc gear wheel (1). The parking lock will hold the vehicle on uphill or downhill gradients of up to 32% and will only engage at speeds below 2 km/h. The Mechatronic Control Module will prevent the parking lock from engaging at speeds above 2 km/h.

1. Parking lock disk (gear wheel)
2. Linking rod
3. Guide plate
4. Parking lock pawl
5. Lock pawl lifting spring



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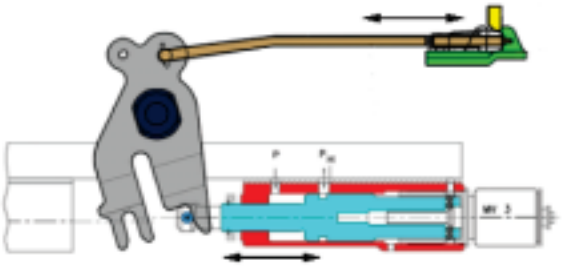
Parking Lock

Principle of Operation

In the electrical parking lock, a combination of mechanical lock engagement (as described above) and electric/hydraulic activation are used. The electrical components include magnetic solenoid valves (MV2 and MV3) mounted on the valve body. MV3 is mounted into the parking lock hydraulic cylinder.

Electrical activation of the parking lock is triggered by a push-button on the selector lever or by removing the ignition key. Activation of the solenoid valves is controlled by the Mechatronic Control Module.



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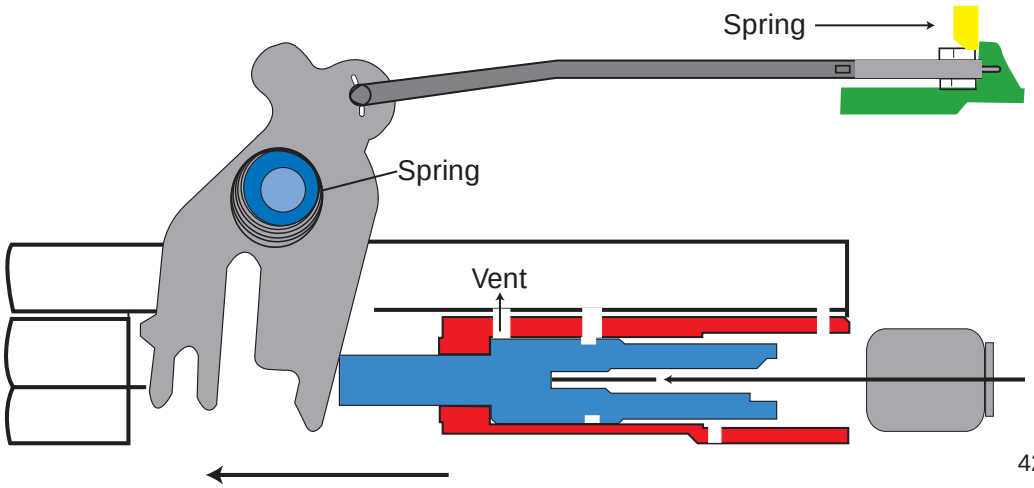
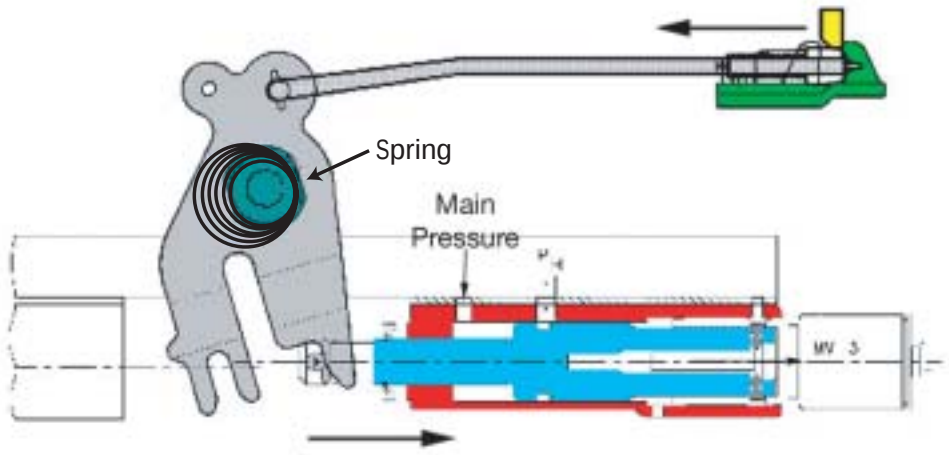
When the parking lock is engaged the solenoid valve (MV3) for the parking lock cylinder is deactivated, cancelling the electro-mechanical lock and the piston released. The solenoid valve (MV2) is also deactivated and the chamber of the parking lock cylinder is vented. The piston is pulled to the parking lock position by a preloaded barrel spring behind the operating lever. The linking rod is extended to pivot the pawl to engage in the parking lock disc.



42-05-01a

When the parking lock is disengaged (below) the MV2 solenoid valve is activated and the main pressure is applied in the chamber of the parking lock cylinder. This pushes the piston, operating lever and linking rod back to release the parking lock. The parking lock pawl is lifted by a spring to disengage from the gear teeth of the parking lock disc gear wheel. The MV3 solenoid valve for the parking lock cylinder is also activated. The piston is additionally held by locking (detent) balls in position “N” when the engine is not running.

The transmission can be shifted from the park position to position “N” only with the engine running (main pressure required). If engine operation is not possible, the parking lock can be released manually by an additional bowden cable.



42-05-24

Examples:

- The parking lock is engaged by pressing the “P” push button on the selector lever when the speed signal is less than 2 km/h.
- The parking lock is automatically engaged when the ignition key is removed and the speed signal is 0.
- Position “N” is automatically engaged when the engine is turned off (ignition switched off) with the key remaining in the lock. The park position will be automatically engaged after approximately 30 minutes. Position “N” can remain engaged for a further 30 minutes if position N is selected again before the 30 minutes have elapsed.
- The parking lock is disengaged only by moving the selector lever in position R, D or N with the engine running and the brake pedal pressed.

Interaction Between Parking Lock and EMF: An electromechanical parking brake (EMF), is fitted in the E65. Based on the operating status of the EMF, it is possible to engage the parking lock when the engine is not running in the event of a fault in the EMF.

Interaction During EMF “AUTO HOLD” Function: The parking brake and parking lock is engaged when the driver leaves the vehicle with the engine running with position D or R engaged, seat is not occupied and the door is opened.

Interaction Between EMF and EGS in the Case of Fault: If the EMF cannot switch from the "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.

Notes:

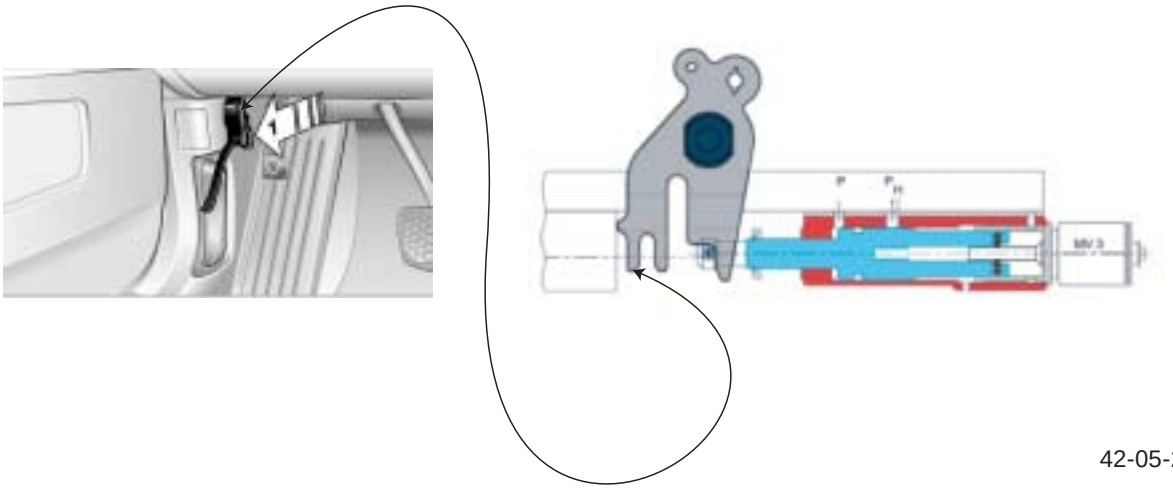
Emergency Release for Parking Lock

A mechanical emergency release is provided if the parking lock can not be automatically released (battery failure, engine, engine electrical system, transmission electrical system, etc.). This allows the vehicle to be towed or pushed as required.

To tow the vehicle, the emergency release must be operated even if the transmission control is fully operable. Depending on the type of fault, the N-hold function cannot be guaranteed during the entire time even if an output speed is recognized (corresponding information in the Owner's Handbook and Towing Instructions for BMW 7 Series).

The emergency release for the parking lock is located in the vehicle interior at the A-pillar in the footwell on the driver's side (1). On US vehicles, the emergency release can only be accessed with the vehicle key releasing the locked cover. ***Before performing this procedure, apply the brake pedal!***

A cable assembly is routed from the operating lever to the gearbox lever on the selector shaft. The emergency release should not be operated during normal vehicle operation. After being released, the "gearbox emergency released" message is displayed in the position indicator section of the instrument cluster.



42-05-25

The emergency release must be reset to re-engage the parking lock after eliminating the fault. The gearbox lever moves during normal operation and must not be influenced by the cable assembly. Press on the red tab on the back side of the lever and guide the lever assembly back into the orignal position.

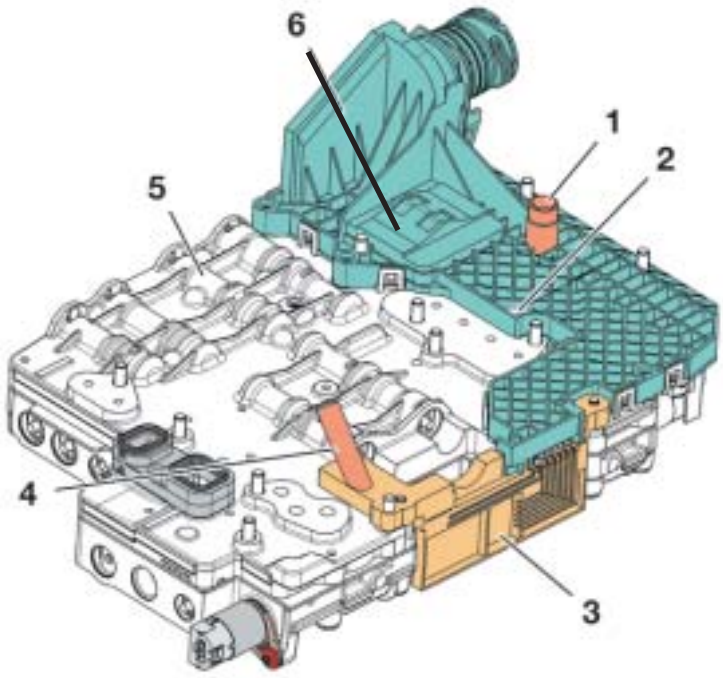
When the emergency release has been operated by mistake or not reset after repairs it is detected by a plausibility check of the actual position by the two park position sensors in the gearbox. In this case, the parking lock cannot be engaged automatically. The driver is informed by an error message in the instrument cluster (Check Control).

Electric-hydraulic Control

System Components

Mechatronic Module: The mechatronic module is a combination of the hydraulic valve body and electronic control module which are installed in the oil sump. This is the first time the mechatronic module is used in a BMW automatic transmission. This offers the advantages of improved shift quality, increased driving comfort and increased reliability due to the reduced number of electrical connections and interfaces.

The hydraulic valve body contains valves, springs, dampers and electric solenoid valves. ***The electronic control module manages the complete electronic control of the transmission and is an integral part of the valve body (replaceable as a complete unit).*** The electronic control module is completely sealed and oil tight.



42-05-26

Electric-Hydraulic Control

1. Output speed sensor
2. Temperature sensor
3. Position switch
4. Turbine (input) speed sensor
5. Hydraulic module (valve body)
6. Electronic Control Module

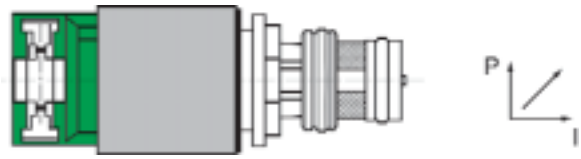
The electronic-hydraulic transmission gearshifts in the GA6HP26Z are controlled by 3 solenoid valves and 6 electronic pressure control valves. These components are not separately replaceable at this time.

Solenoid Valves (MV): Three solenoid valves are mounted on the valve body and are 3/2-way valves, i.e. valves with three hydraulic connections and two electrically switch positions. The solenoid valves are activated by the electronic control module.

Electronic Pressure Control Valves (EDS): The electronic pressure control valves convert electrical current into a proportional hydraulic pressure. They are regulated by the electronic control module to activate the hydraulic valves (in the valve body) to the pistons in the clutch assemblies. Two types of EDS valves are used:

EDS with rising characteristic curve

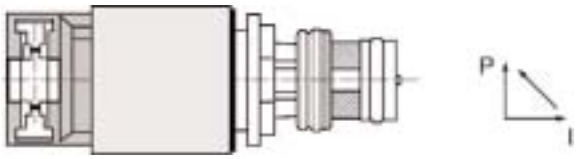
- EDS valves 1, 3 and 6 are identified by a green cap.
- The rising characteristic curve starts at 0 mA = 0 bar, up to 700 mA = 4.6 bar.
- Operating voltage - 12 V
- Resistance at 20 ºC = 5.05 Ohm



42-05-27

EDS with falling characteristic curve

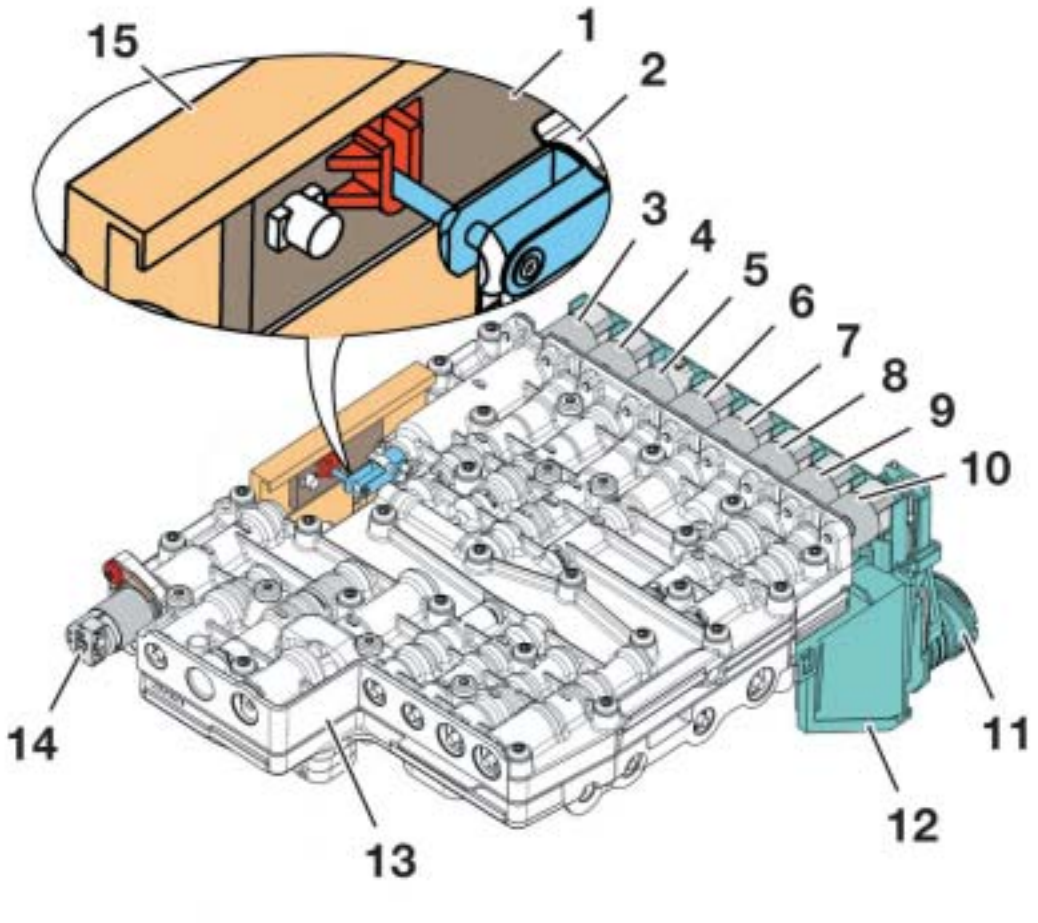
- EDS valves 2, 4 and 5 are identified by a black cap.
- The falling characteristic curve starts at 700 mA = 0 bar, up to 0 mA = 4.6 bar.
- Operating voltage - 12 V
- Resistance at 20 ºC = 5.05 Ohm



42-05-28

Location of Solenoid Valves and Pressure Control Valves

Note: Care must be taken when installing the Mechatronic module to ensure that the piston of the parking lock cylinder (2) is engaged in the position switch (15).



42-05-29

Solenoid Valves and Pressure Control Valves

1. Position Switch Slide
2. Parking lock cylinder piston
3. Solenoid valve 3, parking lock cylinder
4. EDS
5. Solenoid valve 1
6. EDS 4
7. EDS 5
8. EDS 3
9. EDS 2
10. EDS 1
11. Electronic plug connector
12. Electronic module
13. Hydraulic module (valve body)
14. Solenoid valve 2
15. Position switch

Solenoid Valve and Clutch Logic

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

X Activated
-X- Situation-related control
● Engaged

42-06-30

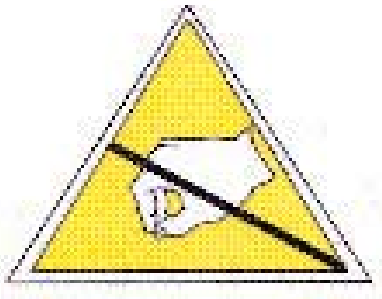
Notes:

Work Shop Hints

Note:

- The transmission requires ***oil replacement every 100,000 miles.***

- Contact the BMW Technical Hotline for additional assistance.



- Consult the Repair Information (in TIS) and the Service Information Bulletins regarding ***static electrical discharge*** before any repair attempts are made to the Mechatronic Module!

- The oil pan can only be removed at temperatures below 40 ºC. The oil pan is made of plastic which will distort at high temperatures.

- External seal replacement, torque converter replacement and replacing the Mechatronic as a unit assembly are the only recommended repairs at this time (aside from replacing the complete transmission). No repair attempts should be made to the valve body components (mechanical or electrical) or the electronic control module.

The drain plug is found in the rear of the oil pan. There are ***final alignment indications*** embossed in the drain plug and the oil pan.

When installing the drain plug, observe the tightening torque. The arrow (embossed in the oil pan) must locate within the range span (embossed in the plug) .

Do not overtighten the drain plug because the plug and oil pan will distort or crack!

42-05-52

The inlet oil filter and debris magnets are integral in the oil pan (replaced as a unit).

When installing the oil pan, observe the tightening torque of the bolts.

Do not overtighten the bolts because the oil pan will distort or crack!

42-05-54

The harness plug insulating sleeve must be removed prior to removing the Mechatronic Module from the transmission housing.

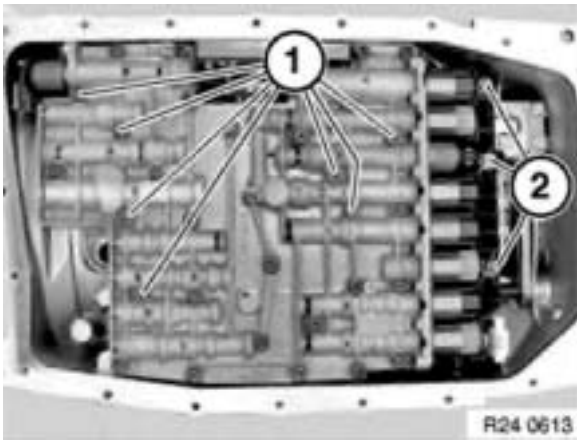
The sleeve is released by sliding the lock lever up as shown to the right. The sleeve is then pulled from the transmission housing.

After the sleeve is installed in the transmission housing, the lock lever must be slid down until it locks.

When unbolting the Mechatronic Module for replacement, ***only the Torx T40 bolts (1) and (2)*** in the diagram are to be loosened to remove the assembly from the transmission housing (as per the Repair Information).

1. = M6 x 58 mm
2. = M6 x 20 mm

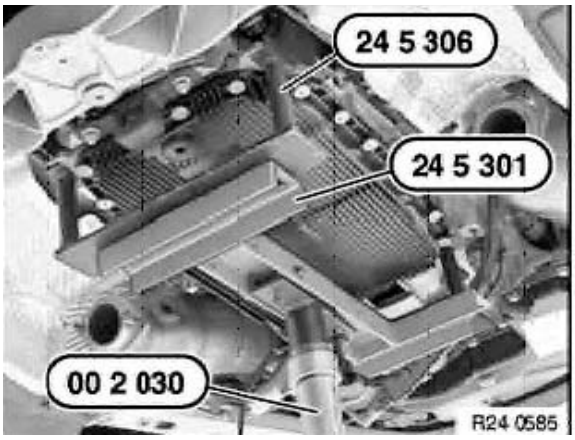
Consult the ***TIS for the correct tightening torque*** on installation. When installing the Mechatronic module, make sure that the piston of the parking lock cylinder and the control lever is engaged in the position switch.



42-05-14

Mechatronic Removal

Use the ***Transmission Support (Special Tool) PN 90 88 6 245 306*** in conjunction with 88 88 6 002 030 for removal/installation of the complete transmission.

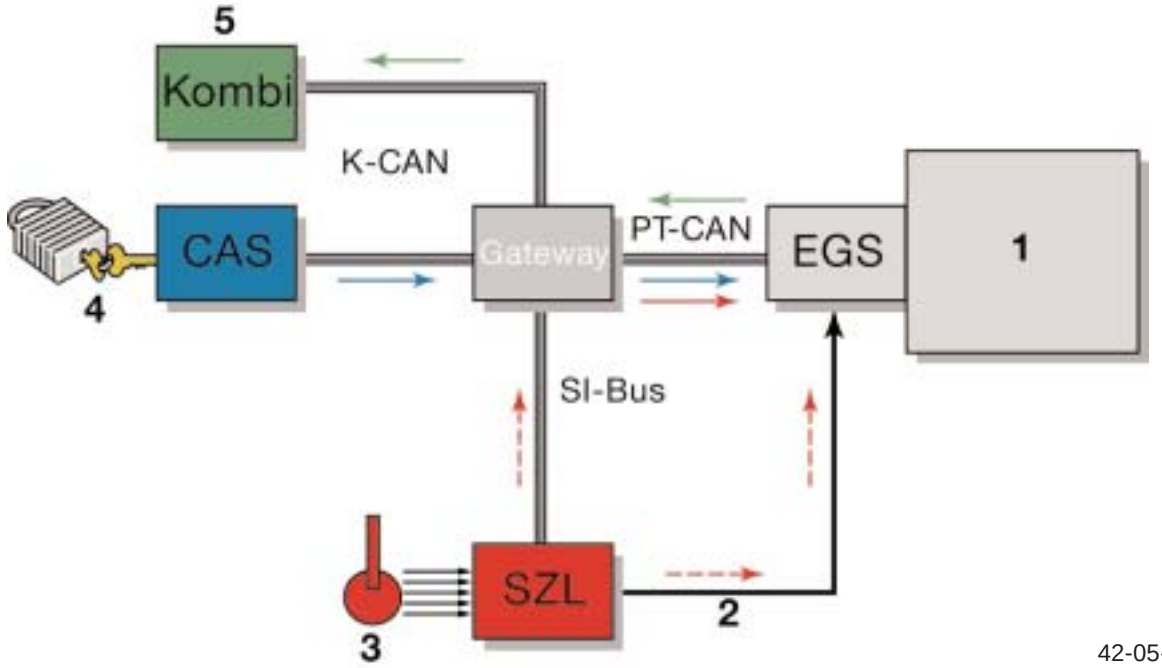


42-05-13

Transmission Removal

Electronic Transmission Control

The electronic transmission control module is an integral part of the Mechatronic Module. The electronic inputs are evaluated in the control module and electronic actuation is output to control the shifts and regulate shift quality. The control module is integrated in the E65 electrical system by the PT-CAN bus (power train) connection and a separate data link (hardwire) for signal transfer between components.



42-05-32

Electronic Transmission Control

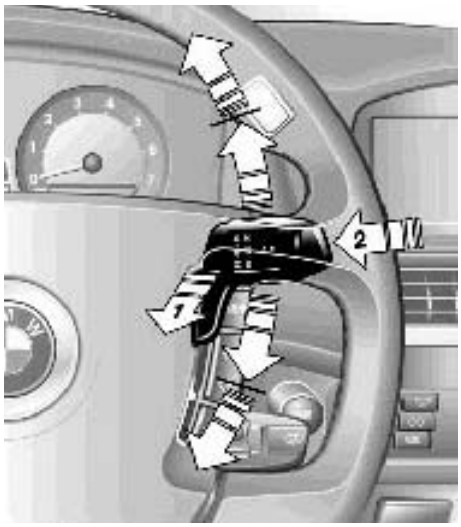
1. Automatic transmission
2. Serial, unidirectional line (hardwire)
3. Selector lever
4. Ignition Key
5. Display, position indicator

CAS module-Car access system
Gateway-Central gateway module (ZGM)
EGS-Electronic transmission control module
SZL-Steering column switch center
PT-CAN (Powertrain)
K-CAN (Body)
SI-Bus-Safety and Information Bus, byteflight optical fiber

In addition to the bus line, the signal transfer between the steering column switch center (SZL) and the transmission control module additionally takes place over a unidirectional serial line (hardwire) for safety reasons. The central gateway module (ZGM) is a link in the data transfer from one bus to another.

The data required for gear shifts are injection timing, engine speed, Valvetronic position, engine temperature and engine intervention. These signals are transmitted between the ECM and transmission control module over the PT-CAN bus.

System Components



42-05-14

Selector Lever: The selector lever is located on upper right of the steering column. Shift position N, D and R are possible. The parking lock P is operated with a push button on the end of the selector lever (2).

All gearshifts are electrically controlled - ***there is no mechanical connection to the gearbox from this lever.*** The positions are indicated in the instrument cluster.

Selector Lever Positions in Automatic Mode

The shift pattern consists of positions R, N, D and the corresponding arrows. The selector lever can be moved from its mid-position by pulling back towards the driver (1). The lever can then be moved in a clockwise or counterclockwise 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 (2).

- **Position R:** With the brake pedal pressed, the selector lever must be pulled back and pressed as far as it will go in the counterclockwise direction (past detent).

- **Position N:** With position R engaged, N can be engaged by pulling the selector lever back and pressing it in the clockwise direction (up to but not beyond detent). When position D is engaged, position N can be engaged by pulling the selector lever back and pressing it in the counterclockise direction (up to but not beyond detent). When position P is engaged, position N can be engaged by pulling the selector lever back and pressing it in either direction.

- **Position D:** With the brake pedal pressed, the selector lever must be pulled back and pressed as far as it will go in the clockwise direction (past detent).

- **Position P:** Position P is engaged by pressing the push button integrated in the selector lever. The parking lock is released by depressing the brake pedal and engaging position R, N or D.

Special Features

- The transmission can be shifted from the park position to position “N” only with the engine running (main pressure required) and the brake pedal depressed.

Automated Functions

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

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

L/D Push Button in MFL: US vehicles are equipped with the L mode (limiting function) which allows the driver to suppress certain shifts (ascending or descending steep grades).

Starting from position D, the limitation mode is selected by pressing the L/D push button. Initially, the current gear is retained and the vehicle will not upshift to a higher gear.

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

Example: Position D is engaged and the gearbox is in 4th gear. After pressing the L/D push button in the MFL, 4th gear is retained and is the upper limit. Gears 1 through 4 will be shifted automatically when the vehicle is driven.

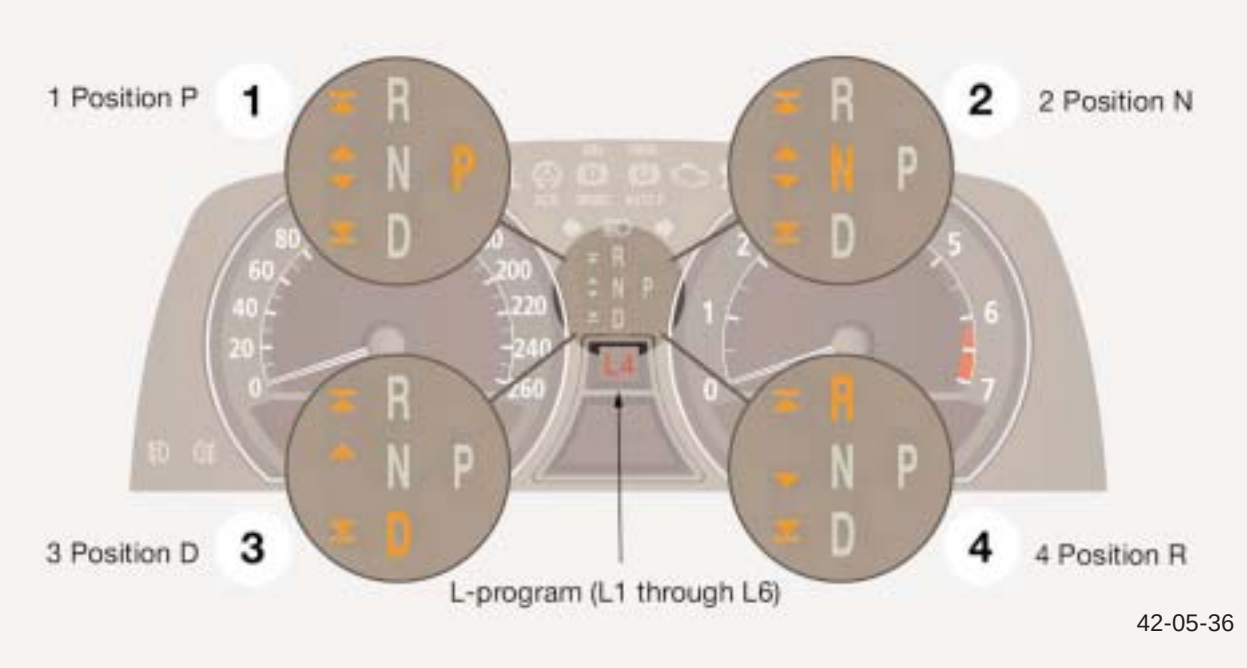
42-05-15

There are two push buttons integrated in the steering wheel facing the driver (ten and two o'clock position as shown above). The limitation stages are manually downshifted by pressing either of these buttons when the L mode is selected. It is not possible to upshift the limitation stages. There is no forced upshift when reaching the maximum engine speed.

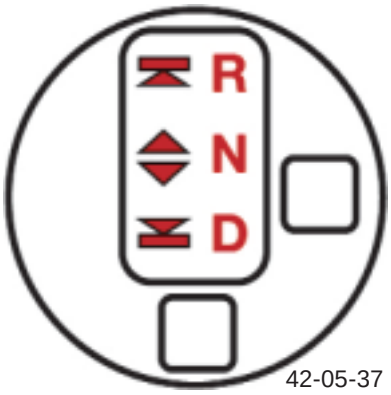
When the L mode is selected, the indicator in the instrument cluster will illuminate to indicate L1 through L6.

Impermissible shift requests, such as a down shift that will cause the engine to exceed the maximum speed are suppressed by the transmission control module and are indicated only temporarily in the instrument cluster.

Position Indication with Shift Pattern: The engaged position is only indicated in the instrument cluster. Depending on what position is selected, the corresponding selection is illuminated in the shift pattern. The arrows indicating the possible movement directions of the selector lever are also illuminated. An additional indication is provided in the L mode.



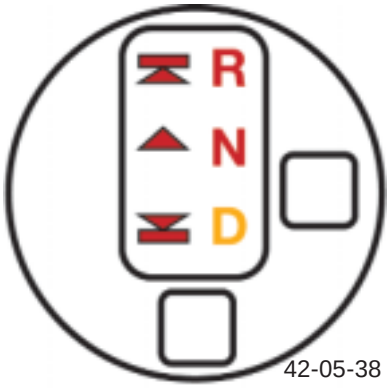
After switching on the ignition and starting the engine, the P or N positions and all of the arrows are indicated. In positions D or R, the single arrow for the shift direction to return to N is indicated (next to the N indicator).



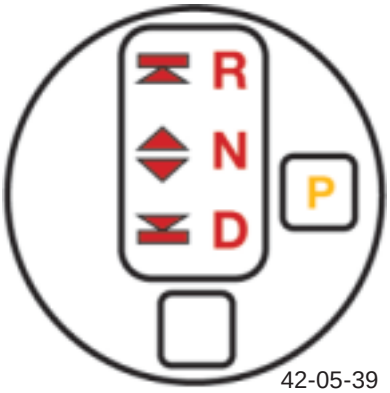
Detailed explanations for Typical Indications:

The ***shift pattern*** consists of the locator illumination for the R, N and D positions with the associated arrows. This is indicated when the ignition is "ON" and the transmission is not in position P.

The ***position indicator*** for R, N or D is highlighted corresponding to the engaged gear position (position D is highlighted here). The positions are indicated when the ignition is "ON" and the transmission is not in position P.

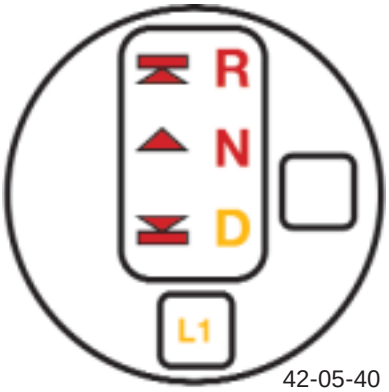


Position P is separate from the actual shift pattern. P is indicated in the instrument cluster only when the park position is engaged and the ignition is “ON”.



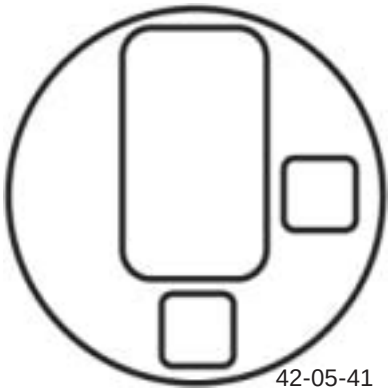
42-05-39

The ***L mode*** is indicated in a separate display and illuminates L1 through L6 when the L mode is selected. Impermissible shift requests, such as a down shift that will cause the engine to exceed the maximum speed are suppressed by the transmission control module and are indicated only temporarily.

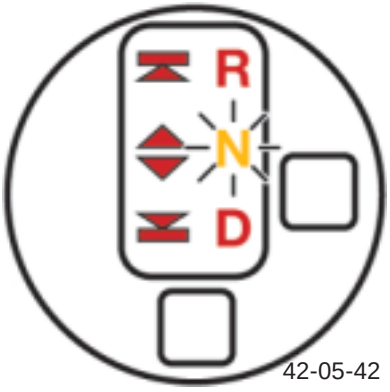


42-05-40

The indicator in the instrument cluster is ***blank*** when the P position is engaged and the bus is in sleep mode. This can also occur when position P is engaged and the bus wakes up, the CAN signals are valid but terminal 15 is OFF.


42-05-41

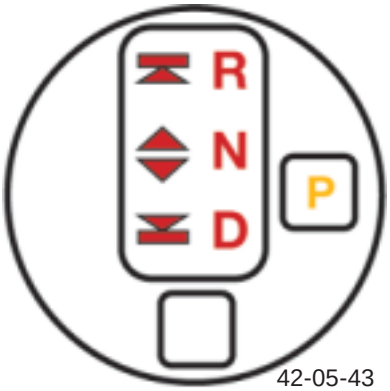
The N position indicator will begin to ***flash*** before the N-hold function elapses (30 min). Flashing takes place at a frequency of 1.5 Hz, controlled by the transmission control module.



42-05-42

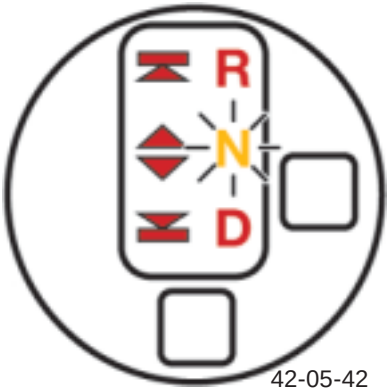
Detailed explanations for Fault Indications:

When the ***CAN signals are invalid*** and the activation line is "high", the shift pattern and P position indicator are illuminated when position P is engaged (Bus is awake).



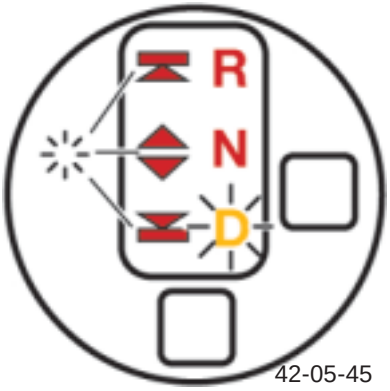
42-05-43

When the ignition is switched “ON” and the transmission control module ***does not detect the P position***, position N will flash in addition to the Check Control message “emergency release may be operated”. This can also occur if the Bus is awake, KL15 is ON and the Bus activation line is "high".



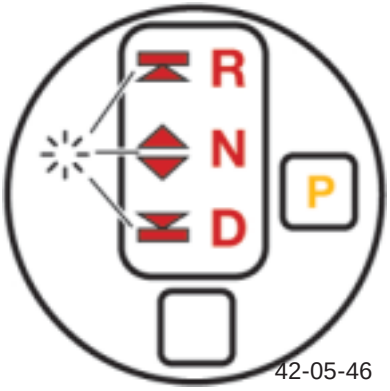
42-05-42

This display is illuminated when the transmission is in the ***mechanical emergency operation*** (with forward movement). The R and N illumination will remain on and all of the arrows along with the D position indicator will flash at a frequency 1.5 Hz.



42-05-45

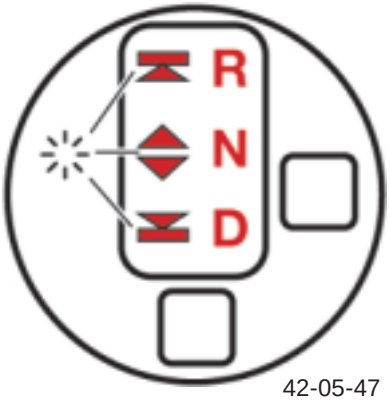
This display is illuminated when the transmission is in the ***mechanical emergency operation*** and in the P position. All of the arrows will flash at a frequency 1.5 Hz. The shift pattern locator illumination for R, N, D will remain on and the P position is indicated.



42-05-46

This display is illuminated when the transmission is in the ***mechanical or electrical emergency operation and the CAN communication is not functional.***

In the event of a transmission failure or a CAN bus error, the instrument cluster assumes control and will illuminate this display. All of the arrows will flash at a frequency 1.5 Hz. The shift pattern locator illumination for R, N and D will remain on and the P position indicator is switched off.



42-05-47

Notes:

Principle of Operation

The data required for gear shifts is transmitted between the ECM and transmission control module (EGS). The transmission control module requires additional information from the vehicle for operation. In addition, other control modules in the E65 require information about the electronic transmission status.

The PT-CAN bus is used for this purpose, below is a list of the the signals and components:

Signals	Transmitter	Receiver
Selector switch	SZL	EGS
Ignition terminal status	CAS	EGS
Central locking system	CAS	EGS
Transmission data (P/N)	EGS	CAS
Engine data	ECM	EGS
Wheel speeds	DSC	EGS
Deceleration request	EMF	EGS
Display, transmission data	EGS	Instrument cluster
Check Control message	EGS	Instrument cluster
Torque requirement	EGS	ECM
Battery voltage	Power module	EGS
Electric loads (30 min. N hold)	EGS	Power module

Note: The turbine (input) and output speeds of the gearbox are determined with Hall sensors that transfer the values directly to the electronic transmission control module. The position switch also transfers information directly over a hardwire.

As in previous transmission control modules, the “flash” programmable coding is for the new control module.

The processor of the transmission control module features a 440 KB internal flash memory. Approximately 370 KB of this is taken up by the basic transmission program. The remaining 70 KB contain the vehicle specific application data.

Interlock

The CAS module signals the "ignition key inserted or not inserted" status to the transmission control module. The parking lock is engaged in the transmission when "ignition key not inserted" is signalled. The parking lock can only be released when the ignition key is inserted, the engine is running, the brake pedal is depressed (Shiftlock) and R, N, or D is selected.

Starter Interlock

The engine will only start in position P or N. The CAS module evaluates two signals from the transmission control module to activate the starter:

- The gearbox P or N position (CAN signal)
- Position P over the hardware line from the P position sensors

The engine can still be started in position P in the event of a CAN signal fault. The engine can not be started if the emergency release is operated (not in P position). In addition to evaluating these two signals when the ignition is switched “OFF”, the transmission always rests in "hydraulic neutral" so the gearbox will not transfer power during an engine start.

Warm-up Program

The warm-up program is selected after every engine start when the engine temperature is below 60 ºC (approx.). The upshifts occur at a higher engine rpm allowing the engine and catalytic converters to reach operating temperature faster. The warm-up program is not in effect when the engine temperature is above 60 ºC or after 120 seconds of operation.

Downshift Inhibit

This function prevents a downshift when the maximum engine speed will be exceeded, preventing engine and transmission damage.

Reverse Interlock

This prevents shifting into reverse gear at a speed above 5 km/h. If the reverse gear is selected at a speed above 5 km/h, the gearbox will shift into neutral and N is indicated 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 again.

Adaptive Transmission Control

As in the previous automatic transmissions, there are different adaptation modes for the A-program (automatic - in selector lever position D) in the 6-speed automatic transmission.

Adaptive transmission control provides the following features:

- Shift points and shift pressures based on driver type
- Maintains shift quality over the lifetime of the transmission through adaptive pressure control
- Torque converter lock up clutch.

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 comfortable gearshift characteristics with very smooth gear changes.

The control module simultaneously monitors engine speed, turbine (input) speed and output speed. This is necessary to determine the slip ratio and slip time during a shift. Slip ratio and slip time are influenced by production differences between transmissions and normal wear.

The control module performs the adaptive pressure control function by modifying the control of the EDS valves increasing the clutch apply pressures to compensate for internal slip. The adaptive pressure control function optimizes the shift quality and increases the life span of the clutch plates.

Pressure adaptation takes place automatically while driving. After performing repairs on the transmission, it is necessary to reset the pressure adaptation with the DISplus. A test drive should then be performed ensuring that the transmission is driven in all gears.

Driver Type Adaptation

In the 6-speed automatic transmission, the driver type adaptation is based on the values of kick-fast, cornering evaluation, brake evaluation and constant driving evaluation. The adaptation function evaluates the longitudinal and transverse dynamics from the standard controls such as accelerator pedal, brake and steering. The current driving status and driver's load choice are calculated from these values.

Based on these values, the adaptation offers a basic gearshift program. To achieve the most fuel economy and comfort, a conservative shift characteristic is selected for driving situations without specific power requirements.

For example, when driving in the highest possible gear and increased power is required, a downshift is not implemented before the engine outputs the full torque. The downshift thresholds are very low so that a maximum of 2 gears can be downshifted over the full pedal travel range. Since this is not the optimum for each situation, the vehicle operation assessment function automatically provides the most suitable basic gearshift strategy.

Kick-Fast

The kick-fast function can change the basic gearshift program depending on the rate of speed that the accelerator pedal is pressed. The accelerator pedal value is compared to a threshold in the control module. As a result, one of two possible functions is selected:

- XE, extreme economy
- E, economy

Moderate movement results in moderate shifts while a quick application of the throttle initiates performance shifts.

Cornering Evaluation

This feature is activated when the control module detects a variation in front and rear wheel speeds (while cornering) from the DSC control module. In addition, the DSC monitors the steering angle sensor, yaw rate and overall vehicle speed to further determine the cornering forces.

When curves are recognized, the control module prohibits up shifting until the wheel speed signals equalize indicating the vehicle is driving straight ahead. Downshifts in conjunction with high power while negotiating a curve can have a negative influence on the stability of the vehicle.

Brake Evaluation

Using the same evaluation method as kick-fast, brake evaluation provides driver type information. Overrun downshifts are triggered at various high speeds depending on the braking requirement.

The vehicle deceleration is determined by the change in the speed proportional signals (wheel speeds or transmission output speed) or the braking pressure in the brake system. The shift speed for the individual downshifts (determined from one of the characteristic curves), depends on the set drive mode, the initial speed at the start of braking and the determined deceleration or brake pressure.

Constant Driving Evaluation

Constant driving evaluation takes place when the driver maintains a constant accelerator pedal position and the vehicle speed does not change. When requested, a downshift takes place immediately in the A-program.

Winter Program

The winter program is activated for the best possible stability and driving safety on slippery roads in winter in addition to control interventions by DSC. Wheel slip is evaluated by the control module based on wheel speed signal data provided by the DSC system over the PT-CAN bus. The control module modifies shift characteristics to match winter mode for better traction.

When active, the transmission will start in second gear and the shift points are lowered. The purpose of this program is to improve the stability of the vehicle with slippery road conditions. Downshift requests that would cause wheel spin are suppressed.

Hill Recognition Function

The control module activates this feature when it detects a high engine load (constant driving resistance) condition at lower road speeds. When the vehicle is traveling up hill the shift points are raised to prevent repetitive up/down shifting.

The parameters that reside in the control module for this feature include vehicle weight, gearbox, differential ratio, rolling resistance and wind resistance.

To adapt for performance reduction of the engine at high altitude, the uphill adaptation is influenced by the altitude compensation function in the ECM.

Cruise Control Shift Strategy

The cruise control function supports speed controlled operation to achieve smooth overall driving characteristics. This function ensures that the acceleration requested of cruise control is achieved while ensuring comfort is not impaired by increased gearshifts.

When cruise control is activated by the ECM, the transmission control module is notified over the PT-CAN bus. The transmission control module activates the program for cruise control operation which minimizes locking/unlocking of the torque converter clutch and up/down shifting. Additionally, the cruise control can request a downshift if the vehicle speed exceeds the set speed limit when coasting downhill.

Notes:

Emergency Programs

The following designs of the GA6HP26Z are used to reduce faults:

- Reduction of system interfaces by using the Mechatronic (assembly)
- Redundant selector lever signals and monitoring (PT-CAN and hardwire)
- Multiple substitute programs

  Substitute program 1: restricted gear selection

  Substitute program 2: corresponds to previous emergency program with only forward, reverse, neutral and park positions possible

  Actuator (MV and EDS) deactivation: hydraulic/mechanical emergency operation

Electrical Emergency Program

The electrical emergency program shifts the transmission into 5th or 3rd gear (speed and previous gear dependent) after a CAN bus failure. After restarting the engine, 3rd gear is engaged when selecting position D. After a CAN bus failure, positions P, R, N and D are selected via a separate serial line (hardwire).

Caution: The Shiftlock function is also deactivated, making it is possible to engage a gear without pressing the brake pedal. This is also indicated by a Check Control message.

When KL15 is switched “OFF”, position P will be engaged immediately at speeds below 2 km/h. This is because the "key inserted/key not inserted" signal is not detected. The N-hold function is not possible with "engine off" (*Caution* in car wash systems).

The instrument cluster can not 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 will flash.

Notes:

Mechanical Emergency Program

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

- No interruption in power transfer while driving forward (no gear changes)
- When the vehicle is stationary and "engine off": the parking lock will be engaged

The transmission electronics may still be in operation during the mechanical emergency program, communication may also still be possible but the power supply to the actuators (MV and EDS) is deactivated. The hydraulic system of the gearbox is designed so that restricted operation is still possible.

It is not possible to reselect a drive position with the selector lever. This means the vehicle can only be driven forward within certain restrictions until the engine is switched off. ***A drive position can not be engaged after turning the ignition off and restarting the engine.***

Vehicle safety is ensured because the parking lock engages when it is depressurized. As soon as the pressure in the parking lock cylinder drops the parking lock system is pretensioned mechanically (operating lever spring). The mechanical parking lock will not engage at speeds > 5 km/h. ***Once engaged, the parking lock can only be released with the mechanical emergency release.***

When the mechanical emergency program occurs:

- While driving forward, 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). This is interrupted by turning off the engine, the parking lock will engage once the hydraulic pressure has dropped.
- While in reverse, the gearbox assumes the neutral position and the parking lock is engaged (< 5 km/h).
- While in hydraulic neutral, the parking lock will engage (< 5km/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 the Check Control messages.

Feedback in the Event of a Failure

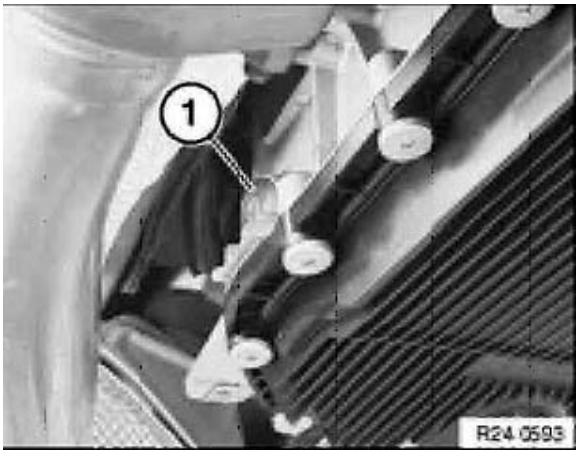
In the event of a total failure of the transmission control or the SZL, the selector lever operation can not be detected or implemented. In addition to the flashing shift pattern and the corresponding error symbols (shown to the right) in the instrument cluster, additional warnings will draw the driver's attention to the situation:

- Acoustic warning signal (gong)

- Acceleration limitation: This function reduces the start-off acceleration when the vehicle begins to move. This function is implemented by the ECM, depending on the restriction of the transmission control by a request or by PT-CAN timeout of the signals.

Workshop Hints

The GA6HP26Z automatic gearbox requires ***oil replacement every 100,000 miles.*** Only the approved oil must be used for replacement or after conducting repairs on the gearbox (consult the Operating Fluids information). Check oil level:



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- The vehicle must be parked flat and level

- Check the oil level through fill plug (1) corresponding to the Repair Instructions (TIS)

- Observe the oil temperature *

* Diagnosis of this gearbox is carried out with the DISplus as part of the service and repair work.

A ***16 Pin Adapter Cable PN 90 88 6 246 080*** is used in conjunction with break out box 88 88 6 611 459 to adapt to transmission harness.

42-05-16

Check Control Messages

The E65 has different warning and information outputs depending on the driving situation and possible faults. The display provides more detailed information with longer and understandable texts in the control display. The message texts and characteristics are stored in the instrument cluster and are initiated by the transmission control module's evaluation of the fault. Only the transmission relevant faults and special messages are shown in the following charts.

Driving Situation Fault/consequences	Check Control Message	Supplemental Information in the control display
Temperature in gearbox high	Transmission Overheated! Drive moderately	Reverts to default shift program, reduce response. Avoid high speeds and engine loads.
Temperature in gearbox very high	Transmission Stop vehicle carefully	Transmission Overheated. Move selector lever to pos. P. Leave engine running. Allow trans. to cool then carefully cont. driving if problems persist, contact BMW Retail Center.
Selector lever CAN fault	Transmission fault! Drive moderately	Limited transmission operation Danger of complete trans. failure! Please contact the nearest BMW Center.
Key signal, invalid CAS, CAN fault, P-Magnet short to positive or open circuit, parking lock engaged incorrectly.	Trans. Range N only with engine on!	The transmission automatically shifts to P when the engine is switched off. Please contact your BMW Center as soon as possible.
Pos. P mechanical emergency operation active (also applies to emergency operation triggered in Pos. R and N)	Gearbox defective Transmission Fault!	The fault may be resolved by restarting engine. Contact the nearest BMW Center if necessary. Use emergency release to disengage park detent prior to towing or pushing vehicle.
Engine speed invalid ECM CAN fault	Transmission Failsafe! Drive moderately	Only P,R,N,D3 and D5 available Ranges may be engaged without depressing brake. Please contact the nearest BMW Retail Center. Have checked by nearest BMW Retail Center.

Driving Situation Fault/consequences	Check Control Message	Supplemental Information in the control display
Gear, monitoring and shift monitoring	Gearbox position R. Transmission range R. Fault!	Reverse gear cannot be engaged. It maybe impossible to select R. Reduce acceleration. Please contact The nearest BMW center.
Short to ground of an MV, EPS mechanical emergency operation and Pos. D Selector level signal fault (CAN and serial line)	Transmission range P,R, N Fault!	Only transmission range D is available. P engages auto. When engine is switched off Please contact the nearest BMW Retail Center.
V>3km/h, P-push-button invalid. p-sensor implausible	Trans. In P only when stationary!	
Signal from P-push-button invalid. P-sensor implausible	Transmission range P Fault!	Transmission range P may be unavailable. Engage parking brake when vehicle is stationary Please contact the nearest BMW Retail Center.
Parking lock does not engage, possible P-sensor fault, emergency release activated	Gearbox in position N! Transimission in position N!	Gearbox position P is engaged Transmission automatically shifts into P when the remote control unit is extracted from the ignition lock or once 30 minutes have elapsed.
Indicate in N-hold phase with door open or seat occupancy = 0 indication in H-hold phase with selector lever operation D,R, and N Detected	Transmission in position N!	Gearbox position P is engaged. Transmission automatically Shifts into P when the remote control unit is extracted from the ignition lock or 30 minutes have elapsed.
EGS CAN interface defective (gearbox fault probably) instrument cluster cannot receive valid display message from EGS. Passive message from Instrument cluster.	Transmission Fault! Drive Moderately	No transmission display. Poss. Reduction of gear selections. Possible to select new gears without depressing the brake. Please contact the nearest BMW Center.

Driving Situation Fault/consequences	Check Control Message	Supplemental Information in the control display
Indicate at terminal 15 on and door open or seat occupancy =0	Gearbox in position N! Transmission in position N!	Gearbox position P is engaged.
Shift lock note	To engage gear, brake	
Brake signal invalid Brake signal implausible	Gear engage without brake poss!	Before engaging gear, Press brake. When leaving the vehicle, switch off the engine. Accident hazzard! Please contact your BMW Retail Center as soon as possilble.
Indication in the event of sloppy operation or P-push-button faulty	Repeat gear selection	
Messege before N-hold phase elapse (30 minutes)	Transmission position P engaging!	To maintain transmission range N, press selecto lever within 10S to position N.
Gear monitoring Shift monitoring	Transmission Failsafe! Drive moderately	Transmission failsafe program activated. Possilbe reduced acceleration. Please contact the nearest BMW Center.
Ignition on and N engine = 0 and gearbox Pos. P and selector lever push to N	Pos. R, N, D Only within engine on.	

Review Questions

1. What does the GA6HP26Z designation stand for?

   G HP A 26 6 Z

2. Describe Stand By Control:

3. Name the clutches used in the GA6HP26Z:

4. What is unique about 5th and 6th gear (as compared to the others)?

5. What happens to the Parking Lock when engine operation is not possible?

6. What does the Emergency Release do?

7. The Mechatronic includes what components?

8. Name the two paths of communication for the Selector Lever: _____ & _____

9. What is the L/D Push Button for?

Table of Contents

E90 Automatic Transmission GA6HP19Z

Subject Page

E90 Automatic Transmission GA6HP19Z

Model: E90

Production: From Start of Production

OBJECTIVES

After completion of this module you will be able to:

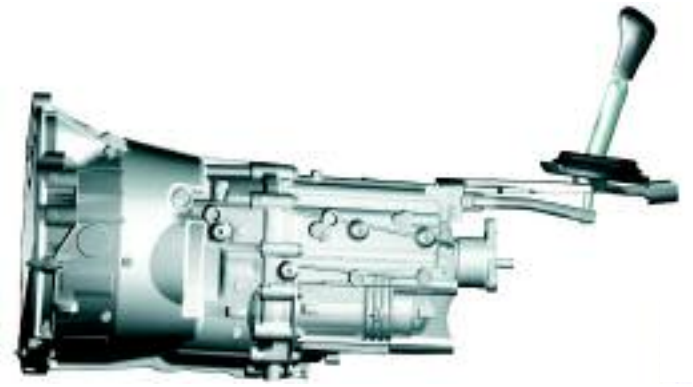
- Establish an overview of E90 transmissions

E90 Transmissions

On the E90 a six speed manual transmission (GS6-37BZ) will be standard and a six speed automatic transmission with STEPTRONIC (GA6HP19Z) will be optional.

Manual Transmission

The Manual Transmission (GS6-37BZ) available on the E90 is the same as that used previously on the E46 and currently on the E60 & E85. The transmission has a lifetime oil fill.



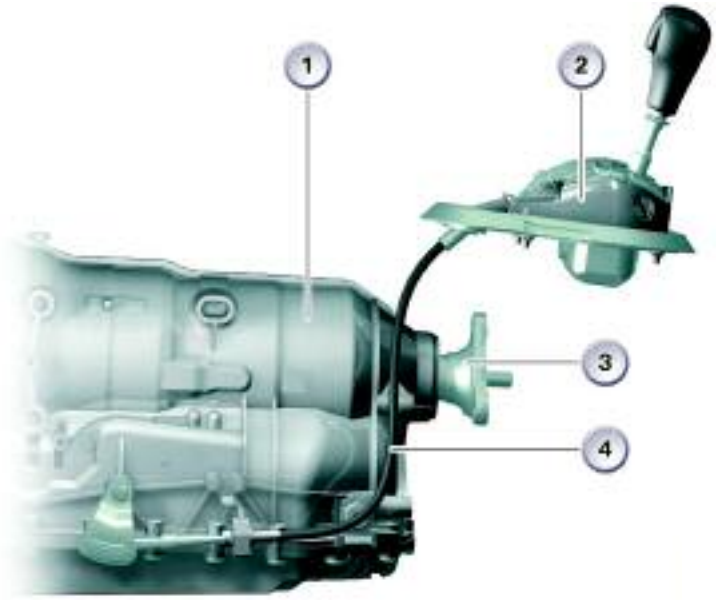
Automatic Transmission

For the first time the 3 series will see a six speed Automatic Transmission (GA6HP19Z) with STEPTRONIC.

The transmission is similar to that used in the E60 with the M54 engine. In order to utilize this transmission on the E90 changes were made to:

- Outer gearshift mechanism with electrical interlock
- New transmission control module
- Adapted hole circle diameter at the output flange

External Gearshift Mechanism



Index	Explanation	Index	Explanation
1	Gearbox Casing	3	Output Flange
2	Selector Lever Unit	4	Cable Assembly

The external gearshift mechanism consists of the selector lever with the following components:

- Cable assembly to gearbox
- Solenoid valve for shiftlock function
- Solenoid valve for interlock function
- Microswitch for detecting locked shift lever
- Emergency release of interlock function
- Switch unit for Steptronic function
- Selector lever position switch indicator

Cable Assembly

The cable assembly is the mechanical connection between the selector lever and the inner gearshift mechanism (mechatronics module). The drive stages are preselected and the parking lock engaged with the aid of the cable assembly.

Shiftlock

The shiftlock function prevents the vehicle from inadvertently being placed in gear with the ignition on, unless the brake pedal is depressed. A solenoid is used to lock the shift lever in position P or N once the ignition is switched off and the lever has been placed into position P or N. The solenoid is activated by a switched ground signal from the Transmission Control Module

Interlock

The interlock function prevents removal of the remote control “key” when the selector lever is not in position P . The selector lever remains locked in position P if the remote control “key” is not inserted in its slot. For this purpose, the selector lever is locked in position P by two electric magnets once the ignition is switched off.

Index	Explanation
1	Emergency Release Pawl for Interlock

Interlock Without Comfort Access:

The selector lever is locked in position P after ignition OFF and the radio remote control “key” can be removed.

The microswitch on the selector lever unit monitors the lock state of the selector lever and sends the signal to the CAS to release the radio remote control once the selector lever is in position P.

Interlock with Comfort Access:

When the vehicle is stationary, the engine or terminal 15 can only be turned off when the selector lever is in position P.

Emergency Release

In case of an emergency (e.g. failure of the power supply system), the selector lever can be released by operating the emergency release. The emergency release is accessible by removing the selector lever cover. The selector lever is released by pressing on the pawl (1).

Transmission Control Module

The newly developed Transmission Control Module (GS 19.11) is used for the automatic transmission GA6HP19Z (in all models). Compared to its predecessor (GS 19.04) it offers the following advantages:

- Flash memory expanded from 512 Kbit to 1 MB
- Designed to withstand higher temperatures
- Electromagnetic compatibility considerably improved
- Reserve for further functions

The Transmission Control Module is located on the mechatronics module in the gearbox with the same housing and pin assignments from the previous version.

Torque Converter

A torque converter (LUK) with a two-layer torque converter lockup clutch is used.

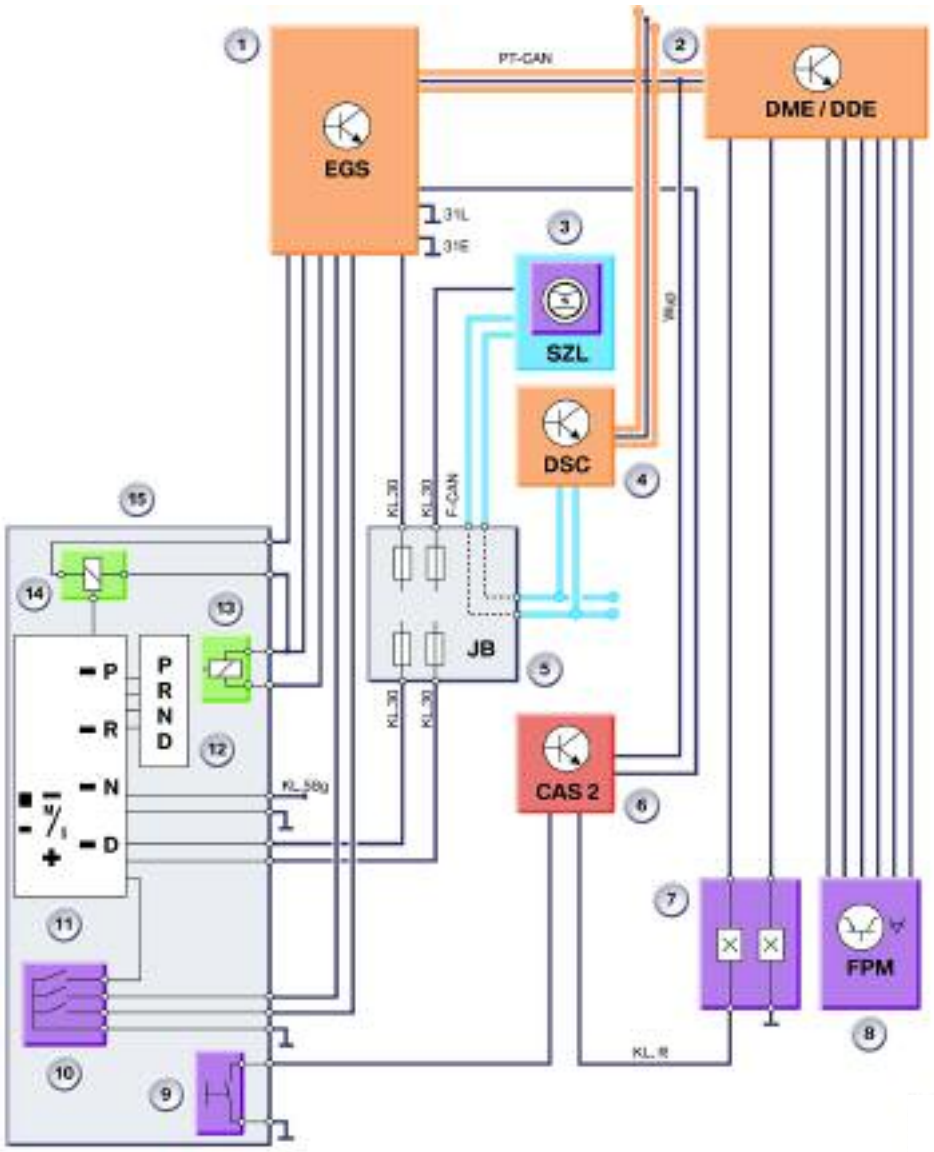
Stationary Disconnection

The gearbox features a stationary disconnection (uncoupling) function for the torque converter. The torque converter is disconnected from the drivetrain instead of running the engine against the torque converter when the vehicle is stationary. By disconnecting the torque converter with the vehicle stationary, the engine is subject to minimum load and fuel consumption is reduced.

Disconnection (uncoupling) of the torque converter is achieved as a function of the following signals:

- Brake operated
- Selector lever position D
- Gear oil temperature > 20°C and < 120°C
- No trailer signal applied

Automatic Transmission Selector Lever - Circuit Diagram



Index	Explanation	Index	Explanation
1	Electronic Transmission Control Module (TCM)	9	Microswitch for Detecting Locked Shift Lever
2	Engine Control Module (DME/ECM)	10	Switch for S-program and Steptronic
3	Steering Column Switch Cluster (SZL)	11	Position indicator on selector lever
4	Dynamic Stability Control (DSC)	12	Sliding Contact for Background Lighting of Position Indicator on Selector Lever
5	Junction Box (JB)	13	Shiftlock Magnet
6	Car Access System (CAS2)	14	Interlock Magnet
7	Brake- Light Switch	15	Selector Lever Unit
8	Accelerator Pedal Module		