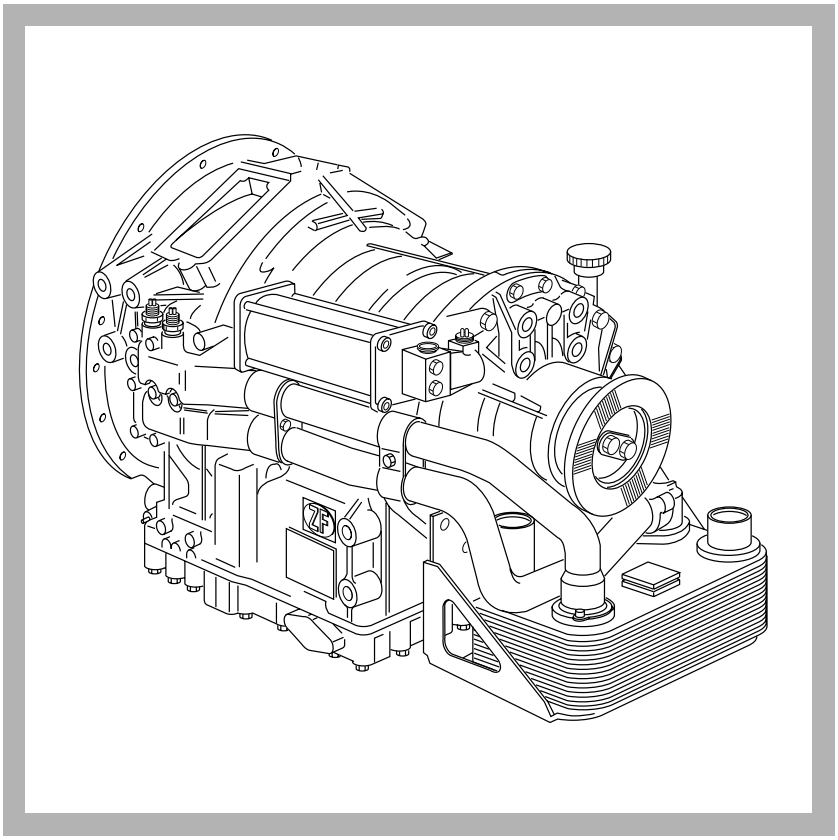
TECHNICAL MANUAL



ZF-ECOMAT 2

HP 502 C HP 592 C HP 602 C
BUSES AND COACHES

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ZF-ECOMAT 2

Automatic transmissions from ranges

HP 502 C HP 592 C HP 602 C

Ecomat2 Technical Manual
for buses and coaches

Subject to alterations in design

Printed in Germany

4149 765 101a

IMPORTANT NOTICE

This Ecomat Technical Manual provides a technical basis for the Ecomat 2 system and has been produced for the benefit of vehicle and coachwork manufacturers as well as ZF employees.

This manual contains answers to questions ranging from specifications to installation inspection and commissioning.

This manual provides the basis for specifications of the transmission and peripheral units.

Optimum procedure leading up to series production delivery:

- Specification of transmission, electronic automatic gear change and peripheral units performed by vehicle manufacturer and ZF using the “Form for parts list preparation”
- Documentation by ZF
- Initial installation
- Initial installation inspection performed by ZF personnel
- Commissioning performed by ZF personnel
- Certificate of Release granted by ZF
- Correction work if required by Certificate of Release

ZF can bear responsibility for any errors in the initial installation only if sign-off has been performed by authorised ZF personnel and if all defects found by ZF have been rectified by the vehicle or bodywork manufacturer. The vehicle or bodywork manufacturer shall bear sole responsibility for any damage caused by defects attributable to the vehicle or coachwork manufacturer which could not be detected by ZF personnel during initial sign-off.

If you require additional information concerning installation and the installation inspection, we have prepared an "Installation Guidelines" manual in addition to the Ecomat technical manual. When installing the transmission, these installation guidelines must be observed.

If you have any questions or suggestions, please contact our department: BPE1 - ECOMAT Application Engineering Department.

Safety instructions

NOTE
Refers to special processes, techniques, data, use of auxiliary equipment, etc.

CAUTION
This is used when incorrect, unprofessional working practices could damage the product.

⚠ **DANGER**
This is used when lack of care could lead to personal injury or death.

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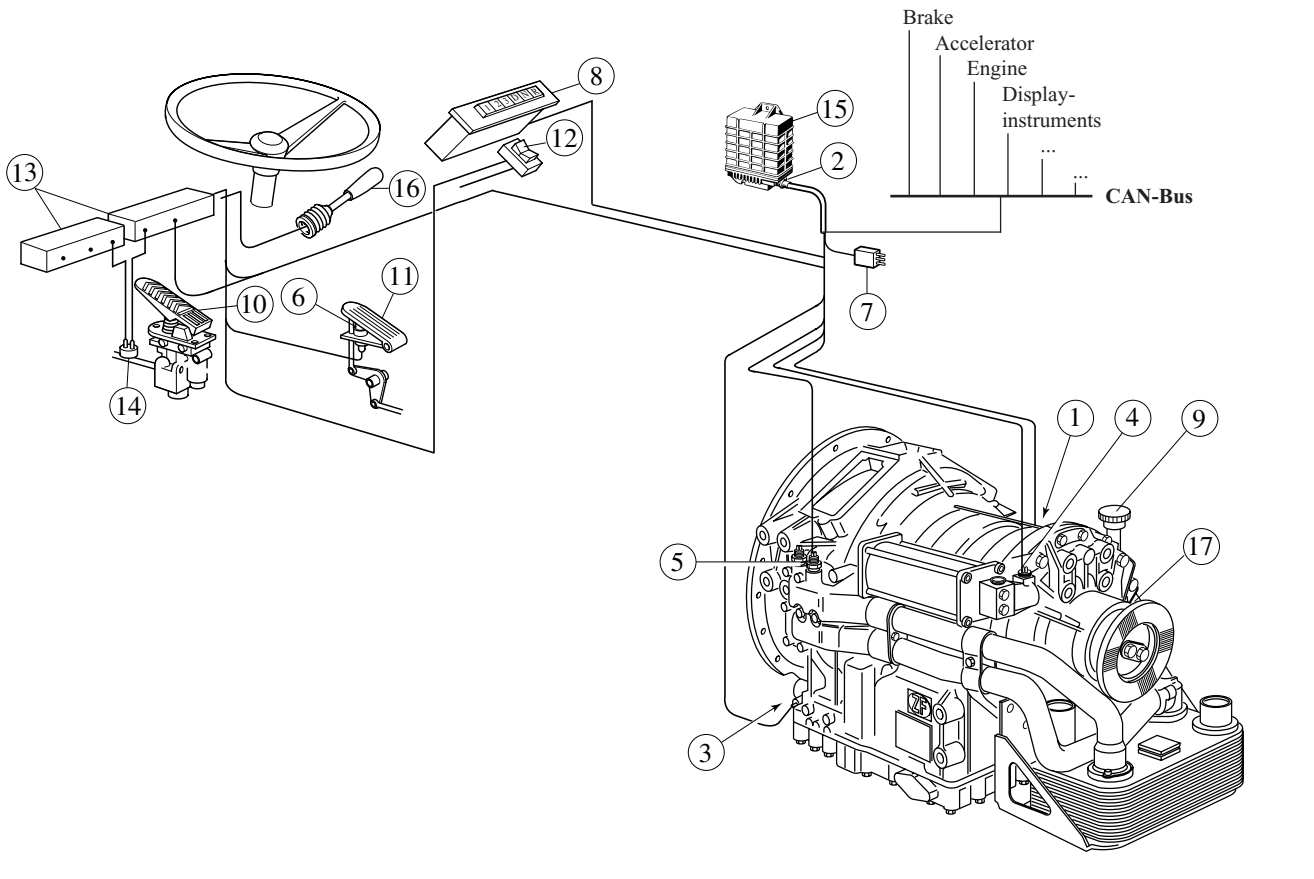
1 Ecomat system solution



Key to drawing

1 Transmission electrical unit connector
2 EST 46 C / EST 47 C connector
3 Retarder connector
4 Accumulator connector
5 Temperature sensor connector
6 Kick down switch
7 ZF diagnosis connection plug
8 Range selector (pushbutton)
9 Dipstick (oil level check, oil status)
10 Footplate brake valve for activating the service brake and continuously variable retarder activation
11 Accelerator
12 Retarder OFF - ON switch
13 Power supply
14 Pushbutton for NBS
15 Electronic automatic control system EST 46 C / EST 47 C
16 Retarder manual lever, electrical
17 Impulse sensor for tachometer

The complete Ecomat system

The Ecomat system diagram illustrates one of the possible Ecomat system set-ups using all necessary components.

All electrical connections required between the Ecomat system and automatic control system and vehicle CAN bus system are located in the interface to the vehicle electrical system (13).

The EST 46C/47C electronic control unit controls the transmission and monitors all functions. The automatic control unit gathers data from the vehicle and transmission (speed range, engine load condition, speeds, etc.) and processes these to produce signals used for controlling the transmission hydraulic system.

The driver may intervene in the Ecomat control system using the following equipment:

· Speed range selector (push-button unit) (8)
· Kickdown switch (6)
· Accelerator pedal (11)
· Brake pedal (10)
· Switch for retarder operation (12/16)

- The desired speed range can be pre-selected using the speed range selector (8).

  The button pressed is illuminated (continuously lit).
- The kickdown switch (6) is used to move the shift points towards higher engine speeds, so the transmission remains in each gear longer when accelerating and shifts out of each gear sooner when decelerating.
- For retarder activation, please consult vehicle manual.
- Oil temperature is monitored using temperature sensors. Data from temperature sensors is transmitted via CAN bus system, EST 46 C/47 C digital output or direct wiring and displayed by means of display, analogue display or warning lamp.

  Retarder torque will be reduced as defined temperature limits are exceeded.

· Engine load data will be transmitted from the engine electronic system EST 46 C/47 C (15) via CAN.

  Pressures for operating the clutch elements are modulated according to the engine load condition using a proportional solenoid valve in the electrical/hydraulic control unit.

2 Description of transmission and technical data

2.1 Brief description of transmission

ZF Ecomat transmissions from ranges HP 502 C, HP 592 C and HP 602 C can be used in multiple applications in commercial and special vehicles. It is possible to select between 4, 5 or 6-speed transmissions to cover all requirements - from fitting in a city bus to use in a long-distance coach. To ensure the broadest possible range of applications, Ecomat transmissions can be fitted with many auxiliaries. They have been designed to comply fully with today's requirement of traffic safety and optimum economy.

ZF Ecomat transmissions from ranges HP 502 C, HP 592 C and HP 602 C offer the following advantages:

- Smooth starting with no mechanical wear, even on extremely rough terrain.
  No clutch wear.
- The automatic shift program and smooth shift characteristics do a great deal to protect the engine and driveline.
- The integral hydrodynamic retarder contributes to road safety and vehicle performance. Substantial cost savings are also achieved by extending the service life of wheel brake linings.
- Increased fuel economy due to close ratio stepping, carefully chosen shift points and restriction of converter operation to the initial driving phase.
- Greater ease of operation for the driver, enhancing driver performance and contributing to road safety.
- Reduction of vehicle operation and maintenance costs, especially under demanding road and traffic conditions or in cases where drivers are changed frequently.

Basic transmissions from ranges HP 502 C, HP 592 C and HP 602 C consist of a hydrodynamic torque converter with a lock-up clutch and rear-mounted multi-speed planetary gear train.

Torque converter

The hydrodynamic torque converter, which uses the TRILOK operating principle, is equipped with a stator mounted on a freewheel and a lock-up clutch. The converter operates only when the vehicle is starting and is then automatically locked up. A lock-up clutch installed in the torque converter establishes a direct mechanical connection between the engine and planetary transmission after the setting-off phase. The power losses incurred by converter transmissions are therefore eliminated.

Retarder

The hydrodynamic retarder, is integrated in the gearbox and no housing extension is necessary. The retarder is located between the torque converter and planetary gear train. This means the full braking effect is available without interruption, even in lower gears.

The retarder braking torque can be continuously varied using a lever-operated or pedal brake valve. If required, the braking torque can be divided into one or several stages, all limited to a value specified by the customer.

Planetary gear train

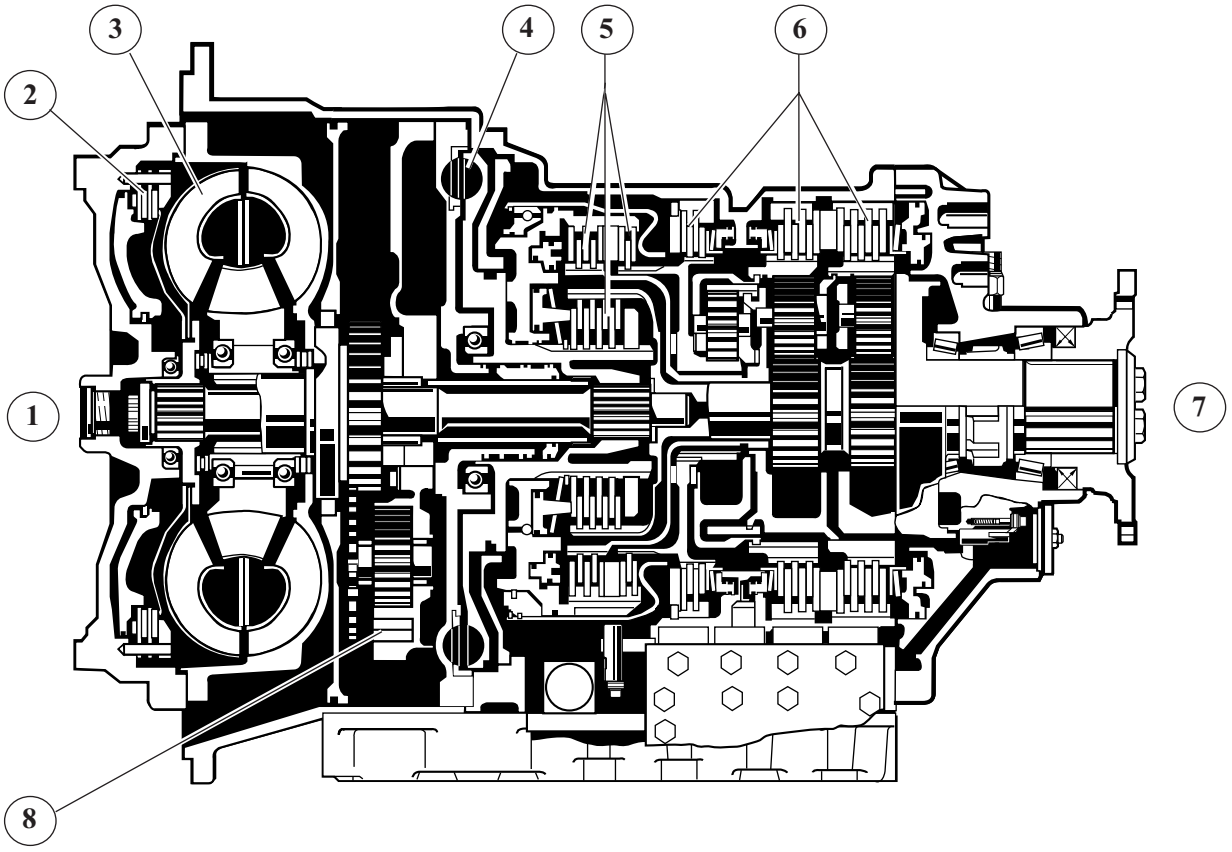
The planetary gear train, arranged behind the torque converter, is designed as a 4, 5 or 6-speed unit. The planetary gear train is a combination of individual planetary gear sets (i.e. not a range system)

The gears in the planetary transmission are selected automatically and without any interruption to traction. The electronic automatic control system EST 46 C/47 C provides signals for the gear selections. The EST 46 C/47 C shifts the appropriate disc clutches and/or brakes via the electro-hydraulic transmission control unit in accordance with various parameters from the vehicle and transmission.

Gear shift control

The electro-hydraulic control system used in these transmissions has given excellent results in practice. It receives shift signals from the EST 18. This modern electronic control unit has a diagnostics capacity and is designed to suit the number of ratios, type of transmission, engine and vehicle.

ZF automatic transmission 5 and 6 HP 502 C, 592 C, 602 C



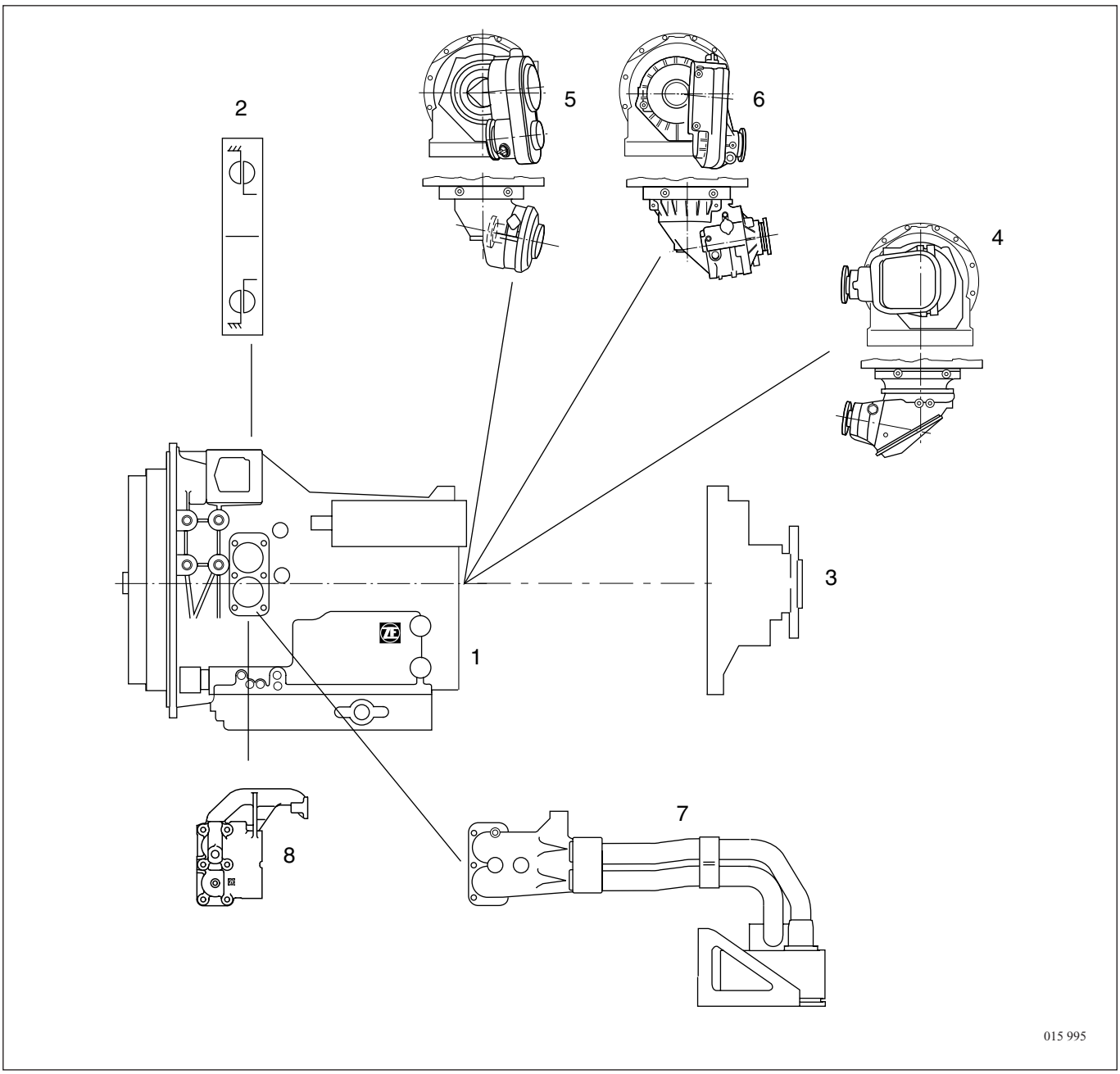
Key to drawing:

1 Input
2 Torque converter lock-up clutch
3 Torque converter
4 Retarder
5 Clutches (A, B, C)
6 Brakes (D, E, F)
7 Output
8 Oil pump

2.2 Transmission structure and auxiliaries

Using the basic transmission, add-on components can be used to make the following variants.

- **Coaxial transmission with fitted oil cooler**
  The basic transmission is fitted with coaxial output and oil cooler at the output end. The heat exchanger module contains the oil cooler connection and cooler connection lines.
- **Coaxial transmission with separate cooler**
  Here, the basic transmission is fitted with a cooler connection piece. A ZF cooler is available for separate attachment or a cooler produced by an external manufacturer can be used following approval from ZF.
- **Transmission with flange-mounted 80° angle drives**
  A 80º angle drive can be attached to the basic transmission without axial offset or a 80º angle drive can be attached to the left or right with axial offset. Cooler attachments (see Chap. 8) or a cooler connection piece are available for this as for the coaxial transmission version with separate cooler.
- **Non-ZF oil cooler**
  If customers provide their own oil cooler:
  – ZF fits the oil cooler connection for non-ZF oil coolers to the basic transmission.
  – The oil cooler must comply with specifications in Section 8, Cooling system.
  – The associated pipework must be provided by the customer and must comply with Section 8, Cooling system.
- **Retarder**
  All transmission versions are supplied with a retarder as standard. The retarder is fitted in the basic transmission between the converter and planetary gear section. The retarder does not increase transmission length and adds only 11 kg to the transmission weight.



Key to drawing:

1 Basic transmission
2 Retarder
3 Coaxial output
4 80° angle drive
5 Angle drive left with offset
6 Angle drive right with offset
7 Oil cooler, fitted at output end
8 Oil cooler connection for non-ZF oil cooler

2.3 Transmission ratios and powerflow diagram

Transmission ratios:

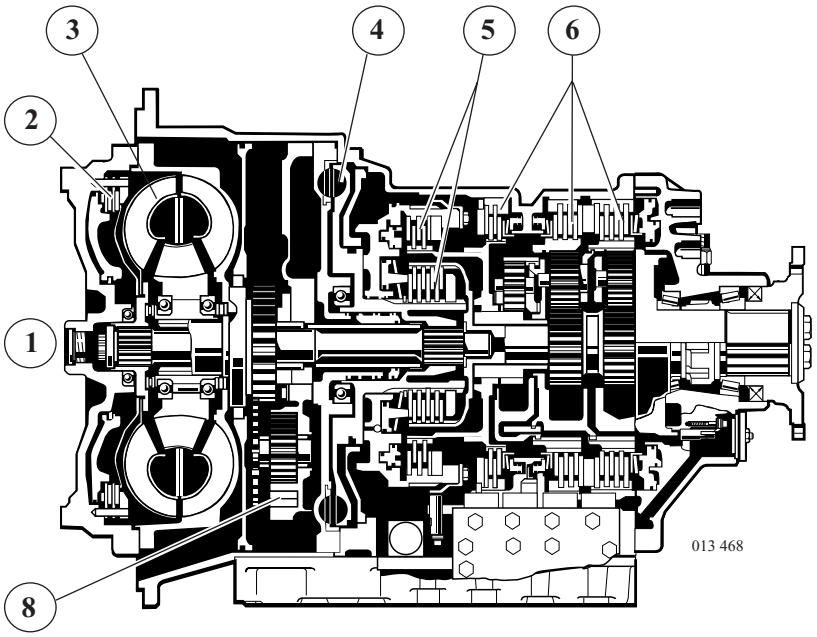
This table gives the mechanical transmission ratios in individual gears (without torque converter).

No. of gears	Ratios							
	1st	2nd	3rd	4th	5th	6th	R	Total
4	2.81	1.84	1.36	1.00	–	–	3.97	2.81
	3.43	2.01	1.42	1.00	–	–	4.84	3.43
5	2.81	1.84	1.36	1.00	0.80	–	3.97	3.52
	3.43	2.01	1.42	1.00	0.83	–	4.84	4.14
6	3.43	2.01	1.42	1.00	0.83	0.59	4.84	5.82

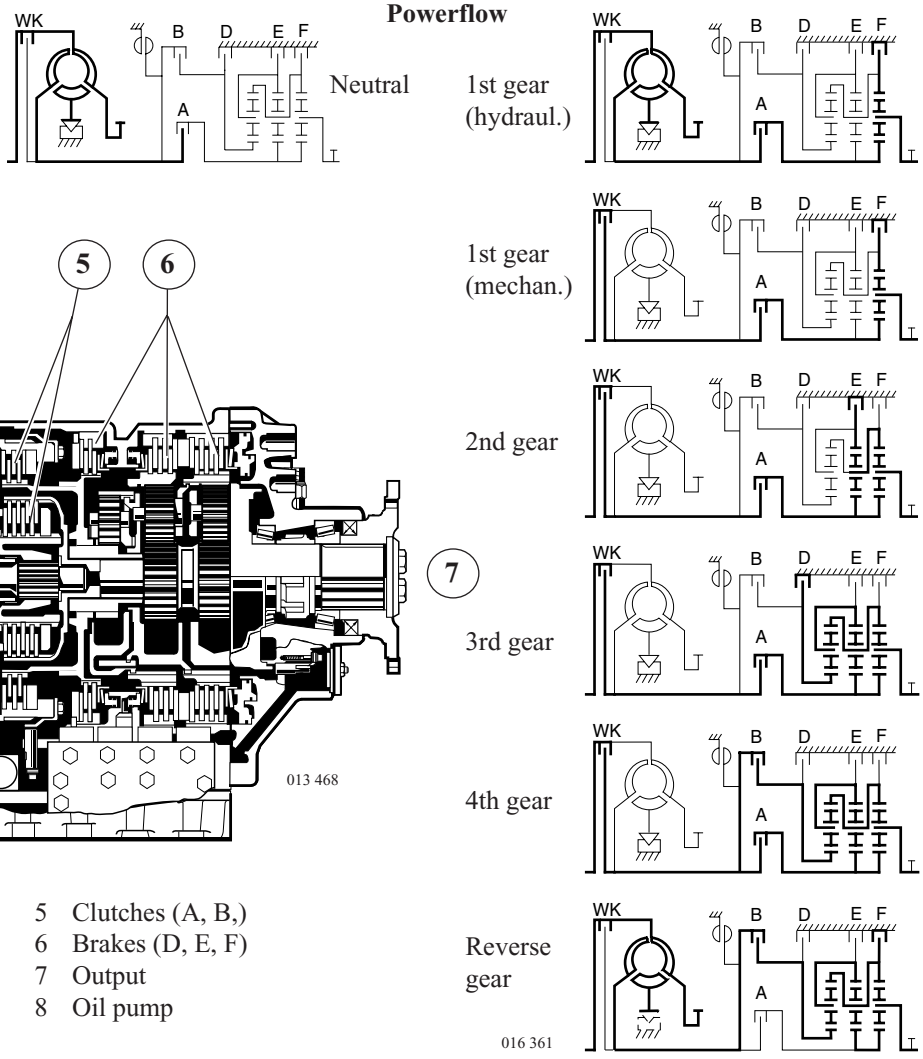
Powerflow diagram:

The powerflow diagram illustrates which clutches and combinations of clutches are closed when individual gears are engaged, depending on transmission ratio.

4-speed version
i = 3,43 – 1,0 / i = 2,81 – 1,0



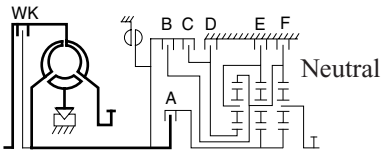
Powerflow



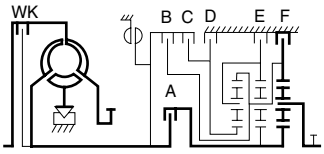
1 Input
2 Torque converter lock-up-clutch
3 Torque converter
4 Retarder
5 Clutches (A, B,)
6 Brakes (D, E, F)
7 Output
8 Oil pump

5-speed version: i = 3.43 – 0.83 / i = 2.81 – 0.8
6-speed version: i = 3.43 – 0.59

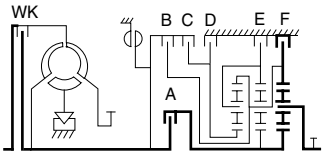
Powerflow



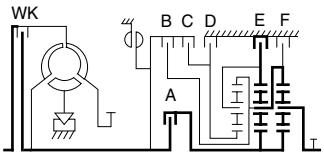
Neutral



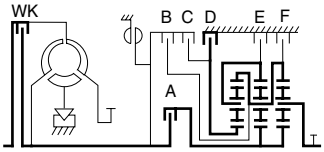
1st gear (hydraul.)



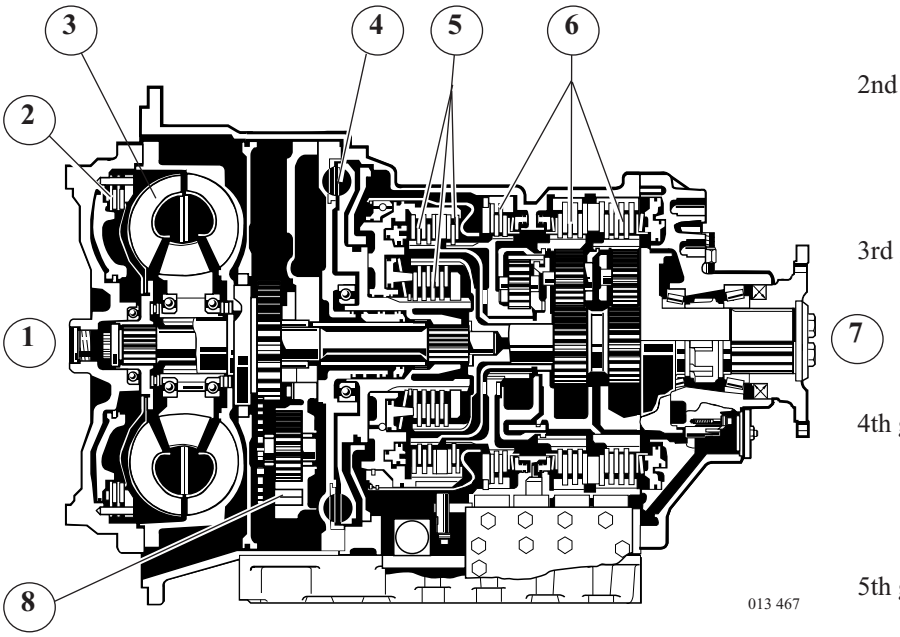
1st gear (mechan.)

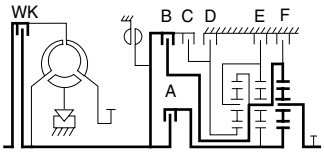


2nd gear

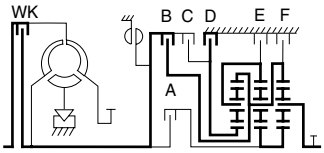


3rd gear

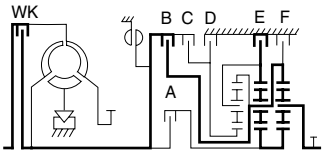




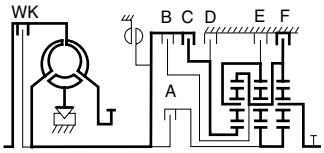
4th gear



5th gear



6th gear



Reverse gear

1 Input
2 Torque converter lock-up clutch
3 Torque converter
4 Retarder
5 Clutches (A, B, C)
6 Brakes (D, E, F)
7 Output
8 Oil pump

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2.4 Maximum engine torques and vehicle weights

Transmis-sion	No. of gears	Ratio	Max. permissible input speed [rpm]	Artic. bus	Coach	City bus
HP 502 C	4	3.43 – 1.0	2800			
	4	2.81 – 1.0	2800			
	5	3.43 – 0.83	2800			
	5	2.81 – 0.8	2800			
	6*	3.43 – 0.59	2800 for i = 0.59 n_{max} = 2000			
	Max. permissible Engine torque ISO 1585			1050 Nm	1100 Nm	1100 Nm
	Max. weight			28 t	26 t	18 t
HP 592 C	4	3.43 – 1.0	2800			
	4	2.81 – 1.0	2800			
	5	3.43 – 0.83	2800			
	5	2.81 – 0.8	2800			
	6*	3.43 – 0.59	2800 for i = 0.59 n_{max} = 2000			
	Max. permissible Engine torque ISO 1585			1250 Nm	1250 Nm	1250 Nm
	Max. weight			28 t	26 t	24 t
HP 602 C	4	3.43 – 1.0	2650			
	4	2.81 – 1.0	2650			
	5	3.43 – 0.83	2650			
	5	2.81 – 0.8	2650			
	6*	3.43 – 0.59	2650 for i = 0.59 n_{max} = 2000			
	Max. permissible Engine torque ISO 1585			1400** Nm	1600 Nm	1400 Nm
	Max. weight			28 t	26 t	24 t

* Only in conjunction with engine version (EEC1/2)

** For use with city buses with a GVW of over 18 t and only ratio i=2.81

2.5 Torsional vibration in driveline – inertia torques – vibration substitution model

WARNING!
Generally speaking, torsional vibration is due to more than one component. The natural frequencies are determined by the distribution of inertia torques and the torsional rigidity of the entire driveline.

The vehicle manufacturer must ensure that the entire driveline does apply any excessive vibration loadings on the transmission.

Limit values for angle acceleration amplitude at the output flange: $\varepsilon_{max} = \pm 2000$ rad/sec^2

For the purpose of mathematical investigations into vibration, the transmission is divided into three distinct rotating masses connected by (zero mass) torsion springs:

- Mass 1: Torque converter without engine flywheel and connection parts
- Mass 2: Clutch carrier
  A, B for i = 3.43 – 1.00 / 2.81 – 1.00
  A, B, C for i = 3.43 – 0.83 (0.59) / 2.81 – 0.80
- Masse 3: Planetary gear section including output flange
- Rigid body 1: Turbine shaft
- Rigid body 2: Input shaft or quill shaft.

Half the moment of inertia of the shafts is assigned to the relevant adjoining masses.

The following tables give the corresponding data (moments of inertia and torsional rigidity) for individual transmission variants.