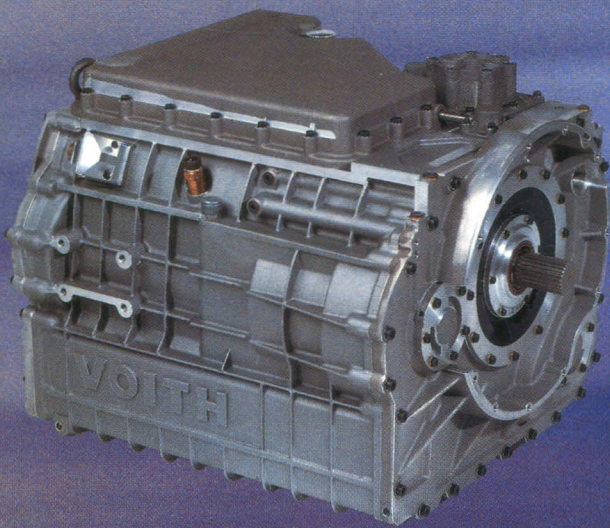


VOITH



SHL-Z
**The stepless automatic
transmission for
tomorrow's city buses.**

**economical
ecological
comfortable
safe**



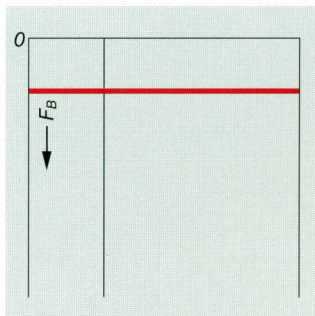
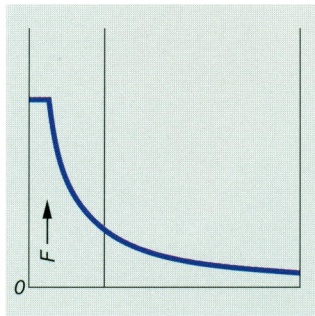
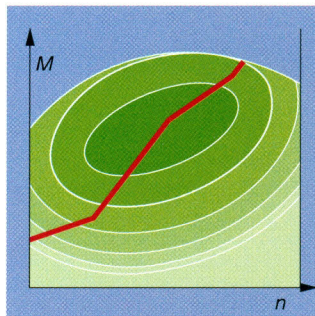
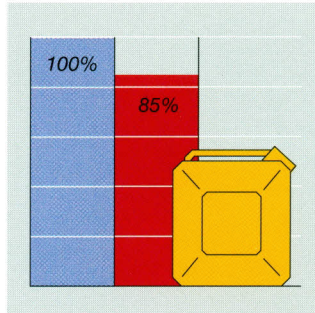
Optimisation with new technology – Voith Automatic type SHL-Z

A stepless hydrostatic power-splitting transmission for tomorrow's city buses

This new transmission has been developed for use in city buses and meets the requirements for an ecological and economical drive system designed to provide comfort and safety. The major advantages of the technology used include:

- Stepless power transmission over the whole operating range.
- Driving and braking combined in a single system.
- High efficiency due to hydrostatic and mechanical power splitting.
- Economical running due to an optimised electronic micro-controller control system.

This new automatic transmission developed by Voith is the result of extensive fundamental work forming part of a research project.



It's economical

- The good overall efficiency of the driveline results in up to 10-15% less fuel consumption.
- The microcontroller converts the driver's wishes into economical running.
- The hydrostatic retarder function substantially increases service brake life.
- The whole driveline is protected by the smooth stepless mode of operation.

It's ecological

- Engine emissions are significantly reduced. The control strategy of the transmission control system proportions the engine's power absorption so that the vehicle always runs in the most favourable performance range.

It's comfortable

- The stepless mode of operation results in continuous smooth acceleration and deceleration.
- The storage capacity for data from the electronic control system can be used for diagnostic purposes.

It's safe

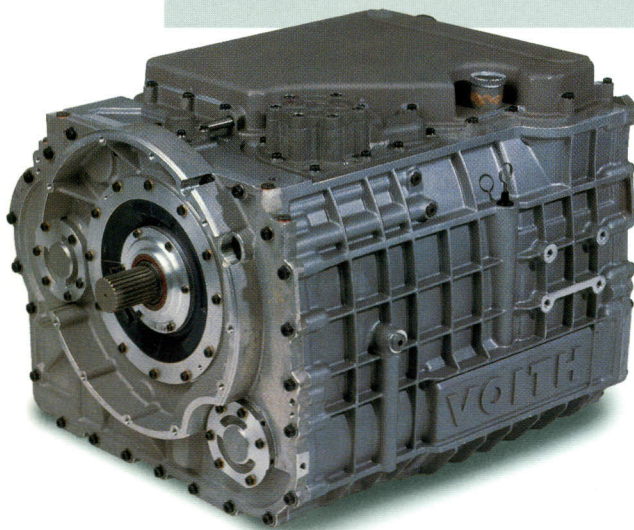
- The retarder acts right up to standstill, whatever the driving speed.
- The stepless mode of operation results in jerk-free acceleration and deceleration, improving safety for standing passengers.

Performance data

The new stepless automatic transmission is used in city buses and can easily be adapted without restrictions to current internal combustion engines, with the possibility of optimising exhaust emissions or fuel consumption.

The new transmission can also be fitted to suburban buses, airport apron buses and more broadly to all municipal and special vehicles.

Type	SHL-Z
Input power	110-210 kW
Input torque	600-1,000 Nm
Input shaft speed	Max. 2,400 min ⁻¹
Starting conversion	5.4 at $dp_{max} = 400$ bar
Total conversion	14
Driving ranges	3
Reversing	73% of forward tractive force
Braking torque on transmission main drive at $dp = 400$ bar	1,300 Nm
Dry weight of transmission	Approx. 350 kg



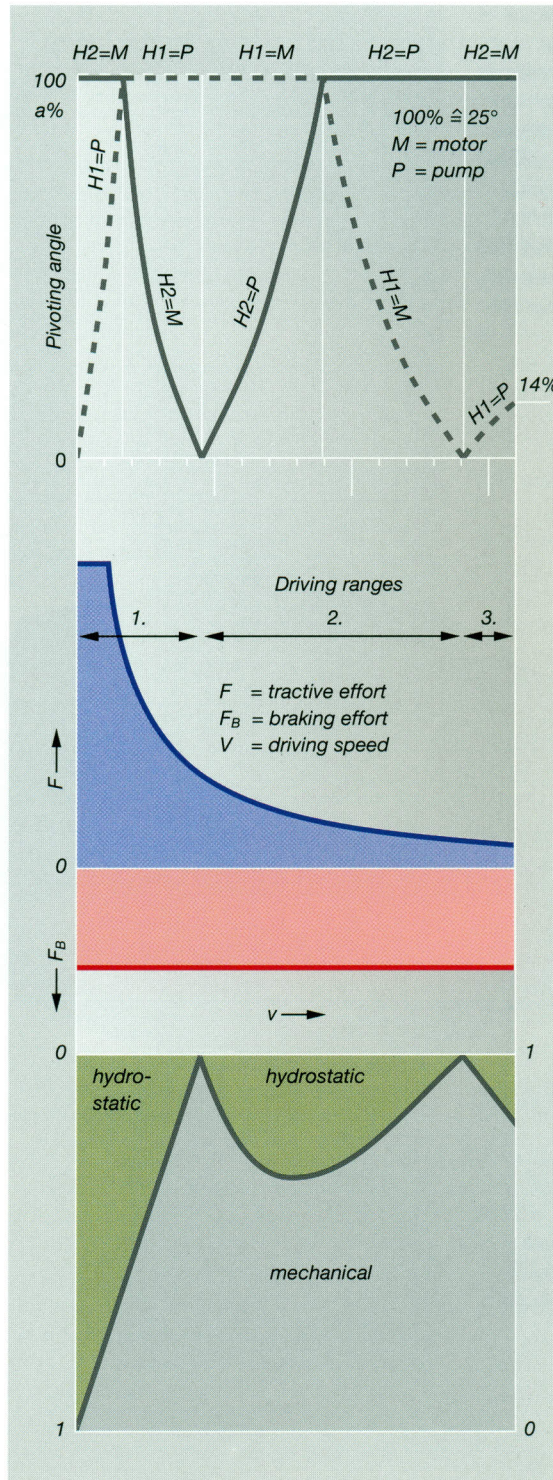
Design and mode of operation

The new automatic transmission operates steplessly and hydrostatically with power splitting. The transmission ratio is altered steplessly by means of the continuously variable absorption and delivery volume of two hydrostatically mutually coupled hydro units (hydrostatic power split). The hydro units are also connected mechanically via a four-shaft planetary differential (mechanical power split).

The new automatic transmission has three steplessly linked driving ranges.

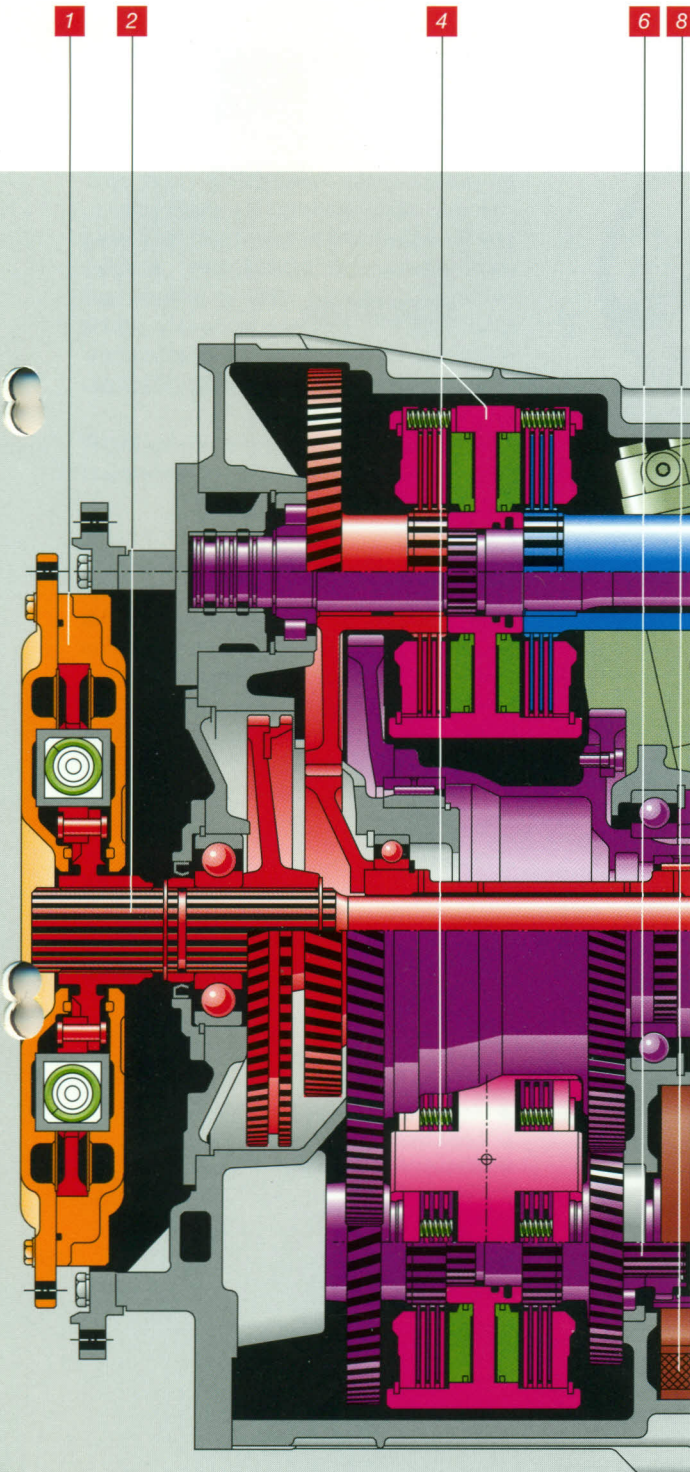
In the braking range, both hydro units operate as pumps and therefore act as retarders. The retarder function can be brought in at any driving speed. The braking power can be controlled steplessly whatever the speed and acts until the vehicle comes to a halt.

In the first driving range, the hydrostatic proportion is 100% at the starting point and falls ultimately to 0%, in the second range it varies between 0 and 25% and in the third between 0 and 13%. The starting conversion is 5.4 (at a differential pressure of 400 bar) and the total conversion is 14, which represents the starting conversion multiplied by the conversion at maximum speed.

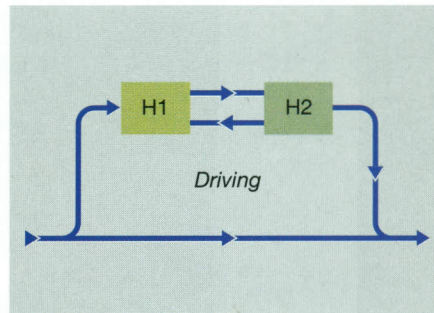


- 1 Vibration damper
- 2 Input shaft
- 3 Output shaft
- 4 Disc clutch
- 5 Planetary differential
- 6 H1 shaft
- 7 H2 intermediate shaft
- 8 Damping element

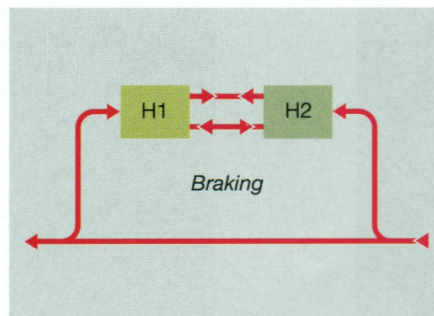
Main technical features of the new transmission



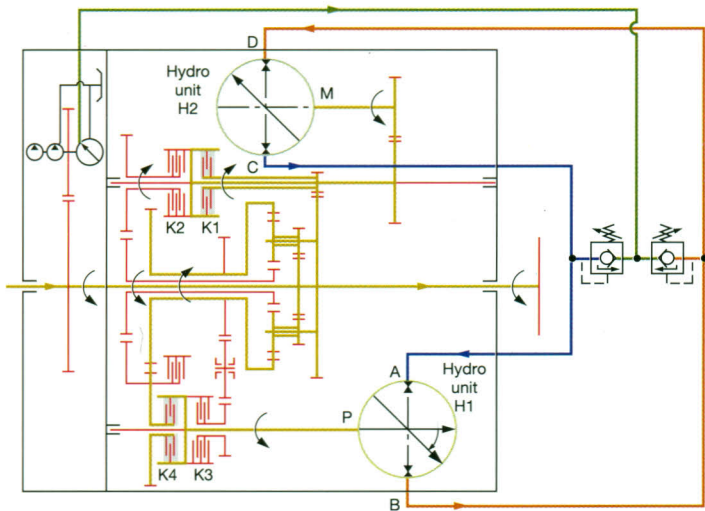
- Driving and braking in one hydrostatic circuit.
- Rapid but smooth acceleration over the whole driving range.
- High starting tractive force.
- High efficiency over the whole driving range.
- Almost wear-free operation.
- Braking force independent of driving speed.
- Kinetic braking energy converted into heat and dissipated to the vehicle's cooling system.



Power split by hydro unit H1 (pump) and hydro unit H2 (motor) in first driving range.



Retarder function with hydro units H1 and H2 acting as pump.



First driving range

Hydro unit H2 (motor) is fully rotated (25°), hydro unit H1 (pump) rotates from 0 to 25°. The resulting reaction torque acts directly on the output shaft. Before the rotation of the hydro unit there is no power absorption. At the same time, the hydrostatic power from H1 is directed to H2 operating as a motor and is fed to the output shaft via the gear train.

Second driving range

H2 rotates to operate as a pump and drive H1. The output shaft is accelerated and the hydrostatically transmitted power increases (up to approx. 27%). If H2 is fully rotated, H1 reverts to 0°. H2 remains almost still. Power transmission is now almost entirely mechanical.

Third driving range

H1 is now only partly rotated, as this range is only usable economically up to a speed ratio of 1.8. The rotation angle of H1 is then approx. 7°.

Reversing range

In this range, clutch K3 is engaged. As in the first driving range, H2 is fully rotated. Altering the direction of rotation on H1 changes the flow direction of H2 accordingly. The output shaft is driven in the opposite direction.

Braking range (hydrostatic retarder)

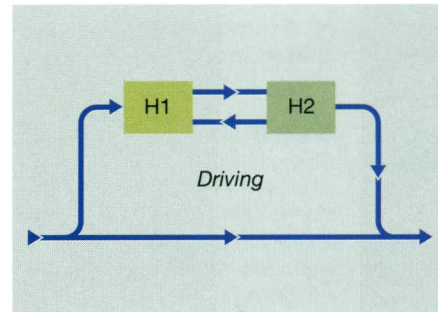
At up to about 23% of maximum driving speed, both hydro units operate as pumps in braking operation. H1 rotates to 25° and H2 keeps the engine speed constant at 70% of its maximum. Below that speed, H1 is set at 0° and H2 is fully rotated. In both cases the braking torque is controlled by the pressure limiting valves according to a signal proportional to the brake pedal position. The pattern of braking torque is linear whatever the driving speed.

Change of driving range

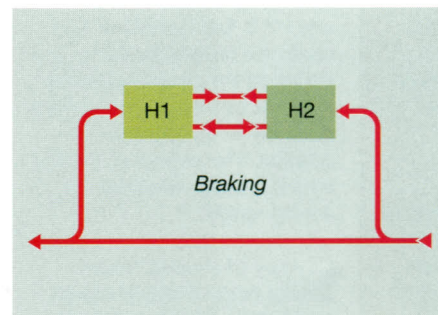
Driving range changes always take place with H2 and H1 in their zero position, resulting in smooth range change without interruption of tractive force.

Main technical features of the new transmission

- Driving and braking in one hydrostatic circuit.
- Rapid but smooth acceleration over the whole driving range.
- High starting tractive force.
- High efficiency over the whole driving range.
- Almost wear-free operation.
- Braking force independent of driving speed.
- Kinetic braking energy converted into heat and dissipated to the vehicle's cooling system.



Power split by hydro unit H1 (pump) and hydro unit H2 (motor) in first driving range.



Retarder function with hydro units H1 and H2 acting as pump.

Main features of the control system

Electronics looking after economics

The driver uses the key switch to select driving range or neutral position or reverse, the driving pedal to accelerate and the brake pedal to decelerate. The retarder function can also be brought in by means of a separate brake selector switch (optional).

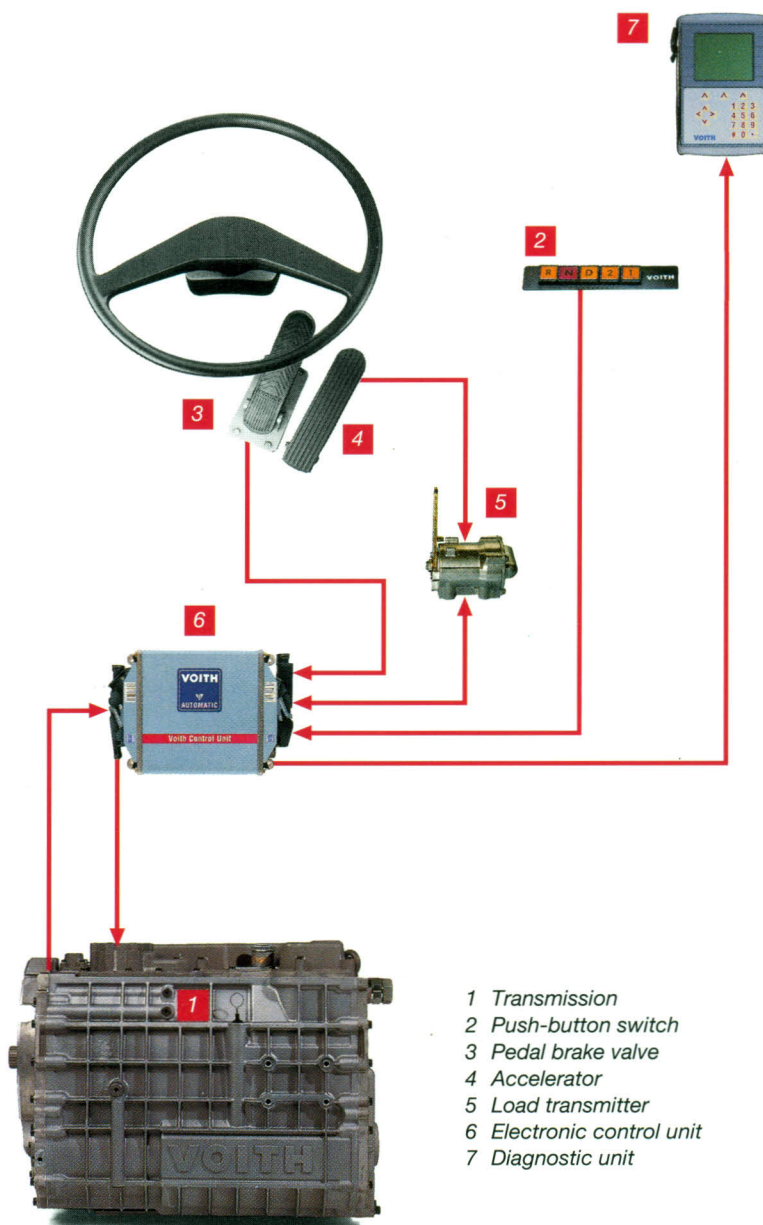
The control strategy of the transmission control system proportions the engine's power absorption so that the vehicle always runs in the most favourable performance range.

Microprocessor control (microcontroller)

- Digital processing of all electrical signals (exhaust gas, brake pickups, sensors).
- High reliability and extremely short actuation times.
- Storage capacity permitting exact diagnosis of transmission state.
- Adaptation to a very wide variety of requirements by easy data replacement (very wide variety of operating strategies by simply changing data sets).
- Fuel saving by optimum engine control strategy.

Hydraulic control system

- Proportional solenoid valves convert digital signals to hydraulic pressures.
- Smooth and stepless driving due to control by hydro units.
- Wear reduced by minimum stressing.



- 1 Transmission
- 2 Push-button switch
- 3 Pedal brake valve
- 4 Accelerator
- 5 Load transmitter
- 6 Electronic control unit
- 7 Diagnostic unit

System diagnosis

- Independent diagnosis as well as linking into vehicle diagnosis systems.
- Long term planning of maintenance and overhaul.

Scope of supply and installation

The new automatic transmission is usually flanged directly onto the engine and mounted in the frame of the vehicle. Installation separately from the engine is also possible. Troublesome vibration between engine and transmission is absorbed by a torsion vibration damper.

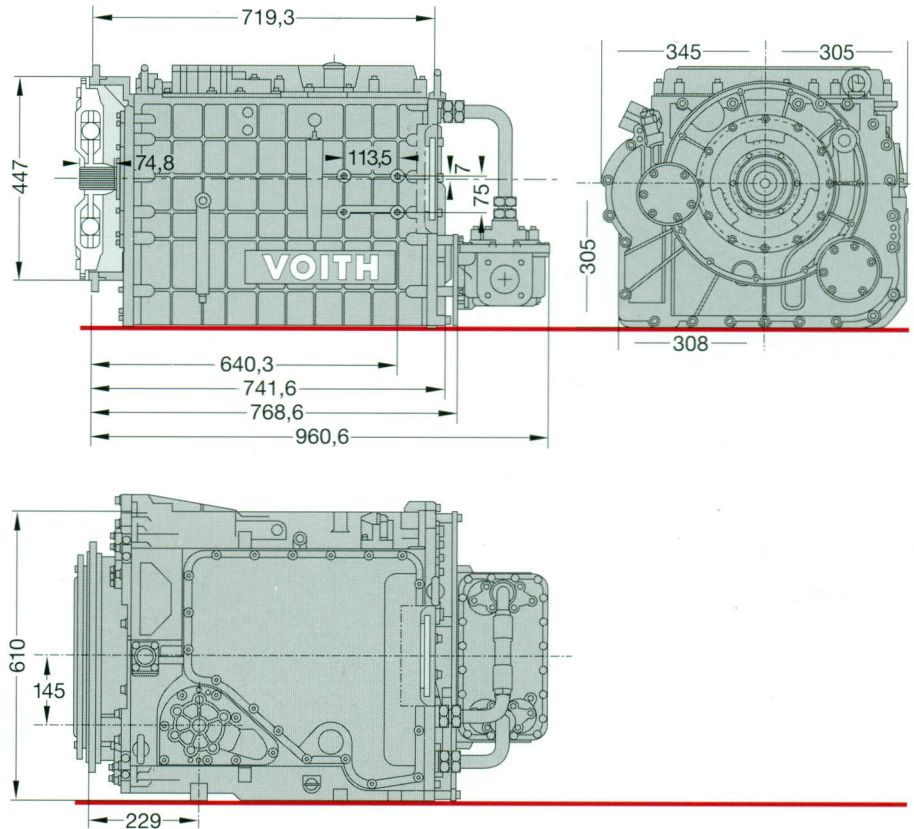
Right-angle drives will be available for transverse rear mounting.

Standard scope of supply

- Basic transmission
- Heat exchanger
- Torsion vibration damper
- Electronic control system
- Push-button switch
- Control unit (exhaust gas)
- Cable set

Extras

- Braking stage manual switch
- Connecting flanges



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