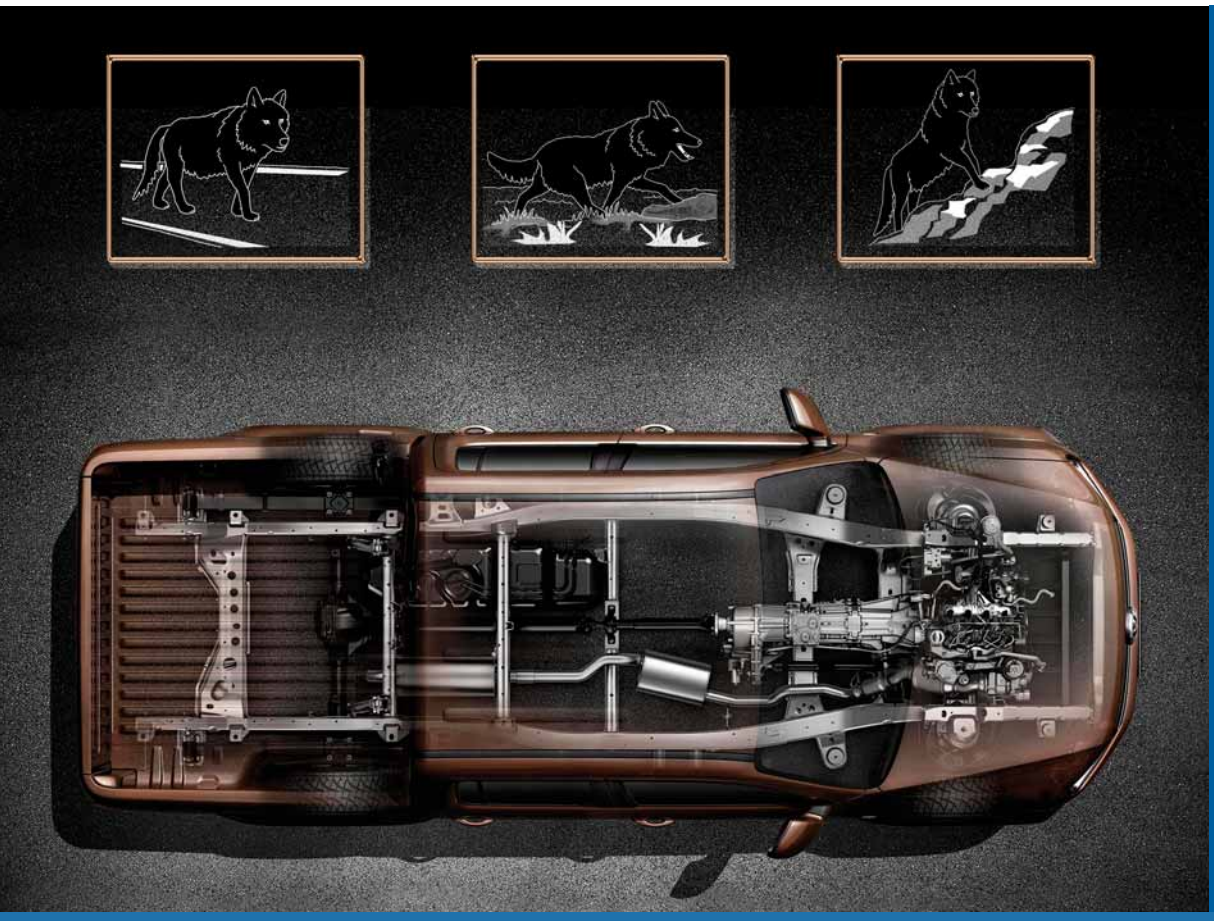
Service Training

Commercial Vehicles

Self-study programme 464

The Amarok - Powertrain and drive concept

Design and function



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With the Amarok, Volkswagen Commercial Vehicles is deliberately and self-assuredly taking part in the global trend towards multifunctional vehicles.

As such, the company is making consistent use of its extensive experience in manufacturing vehicles with both rear and front-wheel drive. The newly developed drive concept offers outstanding driving properties.
Comfortable handling and operation similar to a passenger car are features of the Amarok. Magnificent assistance is given for everyday use through a range of support systems in order to provide road safety and handling benefits when offroad.

In all cases and in all variants, the Amarok can be used both onroad and for heavy-duty offroad use. Depending on use, the four-wheel drive version of the Amarok is available either with permanently or non-permanently engaged four-wheel drive. The Amarok is also available in a standard version with rear-wheel drive. The entire driveline of the Amarok is a new development and has been specifically adapted for use as a commercial vehicle.

Please also refer to self-study programme no. 463
"The Amarok".

Important note

**The self-study programme presents the design and function of new developments!
The content will not be updated.**

Current testing, setting and repair instructions can be found in the provided service literature.

At a glance

Four-wheel drive development at Volkswagen Commercial Vehicles

Volkswagen Commercial Vehicles began to manufacture four-wheel drive vehicles in-house in 1983 in the form of the LT1 4x4.

This was an early response to the desire for as wide a range of vehicle applications as possible – from driving on smooth roads through to use on very difficult ground.

The four-wheel drive is better able to overcome traction problems when used in sports applications and, in particular, as a commercial vehicle.

LT1 4x4
from 1983

T3 syncro
from 1985

T4 syncro
from 1993

Volkswagen Commercial Vehicles markets vehicles all over the world, therefore the company is used to taking account of special conditions, such as in remote areas and difficult open ground – four-wheel drive represents an ideal solution for this.

Amarok 4MOTION
from 2010

Caddy 4MOTION
from 2009

T5 4MOTION
from 2004

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The drive concept of the Amarok

The drive concept of the Amarok offers 3 different drive variants.
The Amarok's powertrain is efficiently supported by intelligent vehicle dynamics programmes.

S464_058

Vehicle dynamics programmes

The Amarok is equipped with the following vehicle dynamics programmes:

- ABS (as standard)
- TCS (as standard)
  MSR (as standard)
  EDL (as standard)
- ESP
- Offroad drive programme (as standard)
- Hill-descent assist
- Hill-hold assist

Rear final drive

In the Amarok with rear-wheel drive, the power is transmitted via a propshaft to the rear axle only. Even with only rear-wheel drive, the Amarok can be used on both consolidated and non-consolidated roads as well as offroad.

S464_006

Permanent four-wheel drive with limited-slip interaxle differential 0BU

In the Amarok with permanently engaged four-wheel drive, the powerflow to both driven axles is distributed by means of a transfer box with permanent engagement using a limited-slip interaxle differential. This offers improved traction compared to rear-wheel drive, above all when offroad.

S464_074

Non-permanently engaged four-wheel drive with part-time transfer box 0C7

In the Amarok with non-permanently engaged four-wheel drive, the powerflow to the driven axle is distributed using a transfer box with electrically engaged front final drive. It is also possible to engage a reduction stage (offroad ratio) in this transfer box. In this version, the Amarok is even better suited for use on difficult ground.

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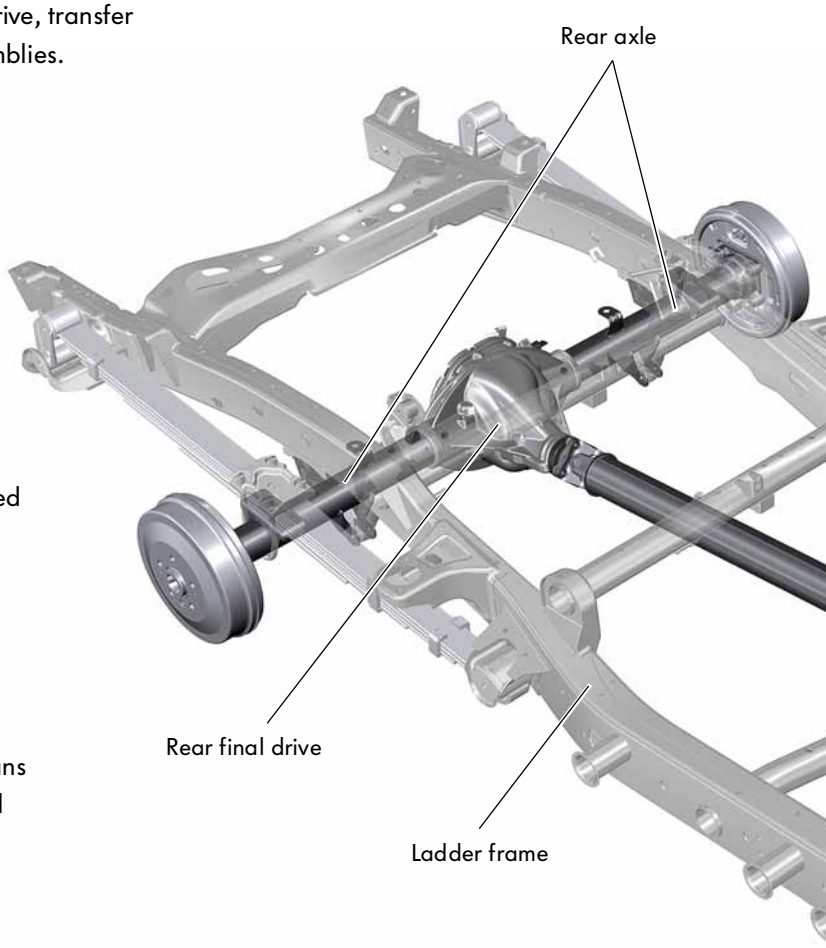
The driveline

The Amarok has a modular driveline in which the individual components such as manual gearbox, front final drive, transfer box and rear final drive are independent subassemblies.



Gearbox

At present, the 6-speed manual gearbox 0C6 is used for transmitting power from the engine

Transfer box

Power is distributed to the final drives either by means of the transfer box 0C7 (non-permanently engaged four-wheel drive) or 0BU (permanently engaged four-wheel drive).

Propshafts

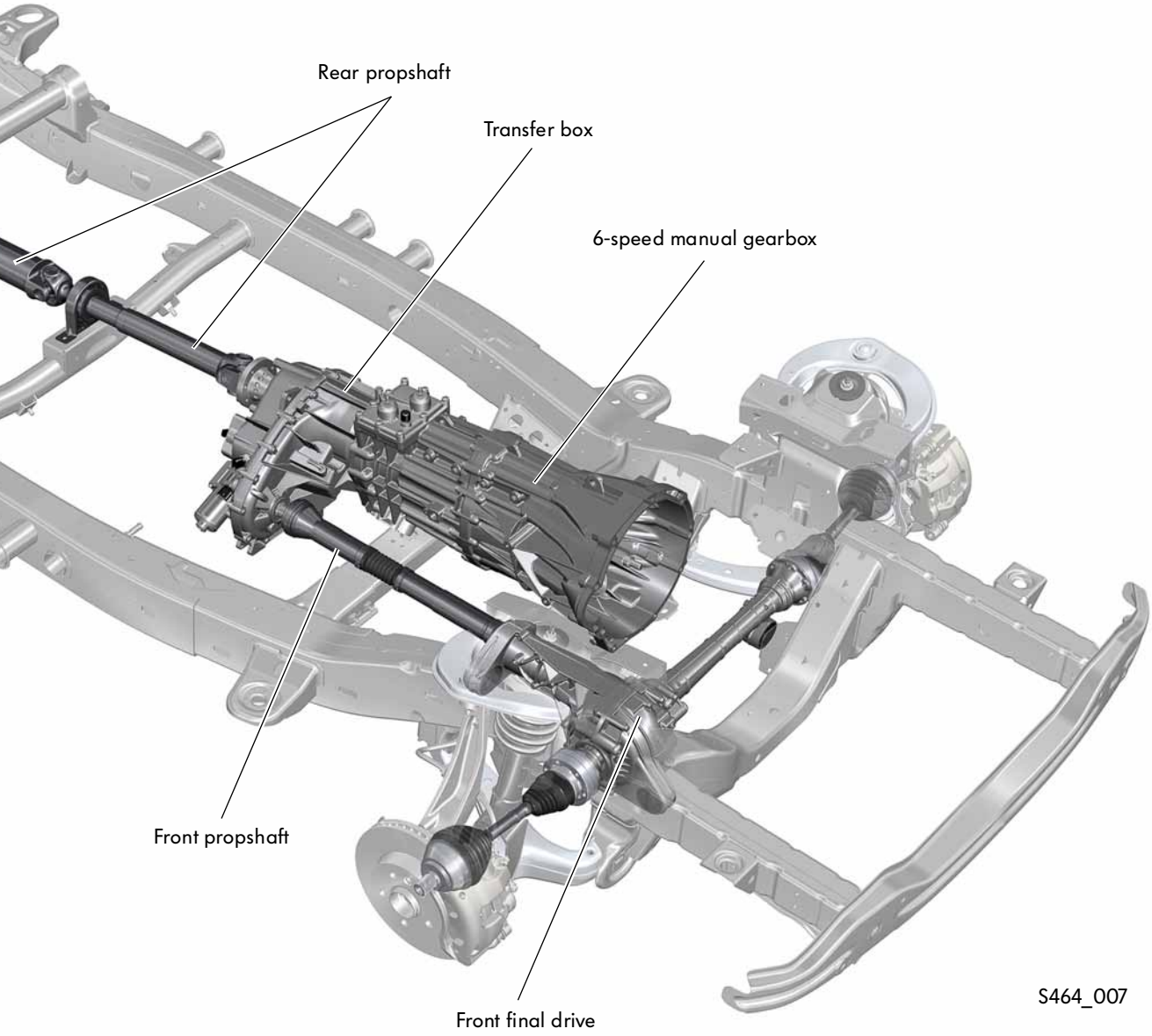
Three different two-part propshafts are used for driving the rear axle.
The front part of the propshaft has a length that is adapted to the particular drive version.

A one-piece propshaft is fitted for driving the front axle. This is identical in both versions of the four-wheel drive.

Rear final drive, front final drive

The rear final drive 0CC arranged in a symmetrical installation position is used for driving the rear axle. The rear axle differential can be locked up.

The front final drive 0C1 is used for driving the front axle, and is available in two different designs. The front final drive is asymmetrically arranged.



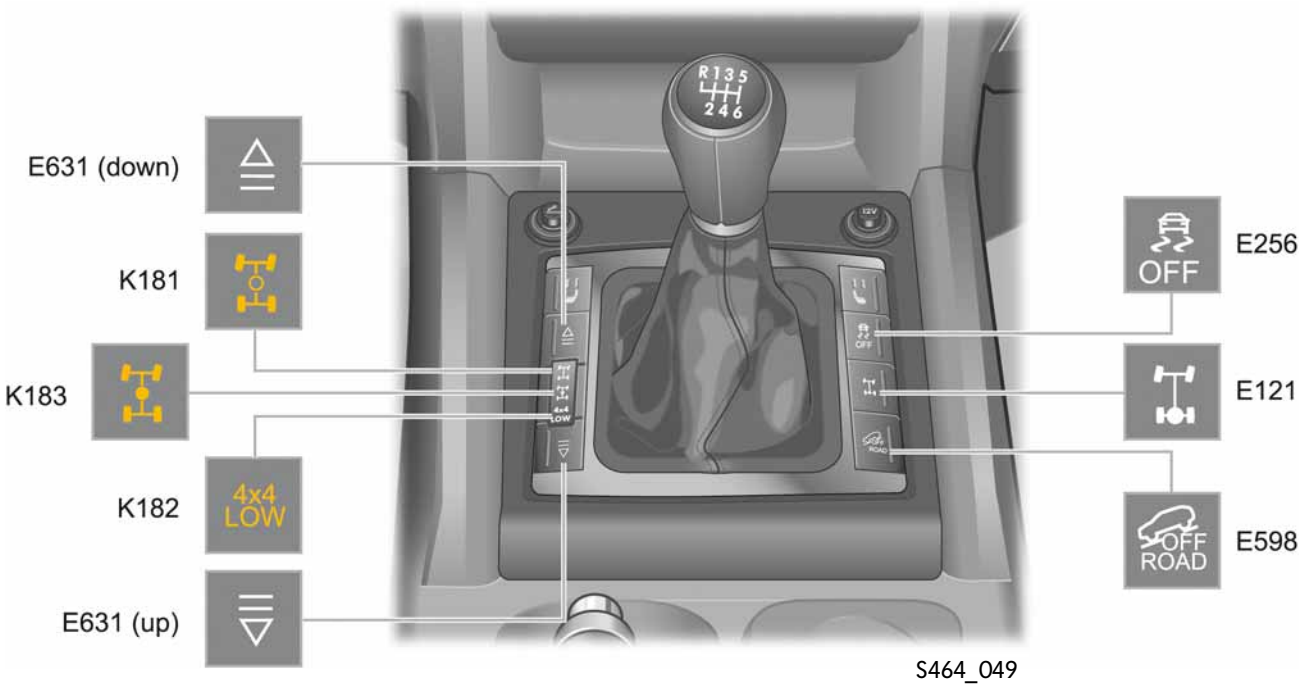
The illustration shows the drivetrain with non-permanently engaged four-wheel drive.

The operation

Four-wheel drive, the reduction ratio (offroad ratio), the differential lock and the offroad drive programme are engaged and disengaged using a button panel in the centre console. The status is displayed by warning lamps K181, K182 and K183.

The four-wheel drive components are each electrically connected to the gearbox.
This means no additional selector levers are required for operating the four-wheel drive ranges.

Centre console button assignments



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Key

E631 (down) = Running gear programme switch (switching on)
K181 Normal operation warning lamp in transfer box operating unit (4x2)
K183 Longitudinal lock-up warning lamp in transfer box operating unit (4x4 HIGH)
K182 Reduction gearing warning lamp in transfer box operating unit (4x4 LOW)
E631 (up) = Running gear programme switch (switching off)
E256 TCS and ESP button (TCS deactivation)
E121 Rear differential lock switch
E598 Driving programme button (offroad driving programme)

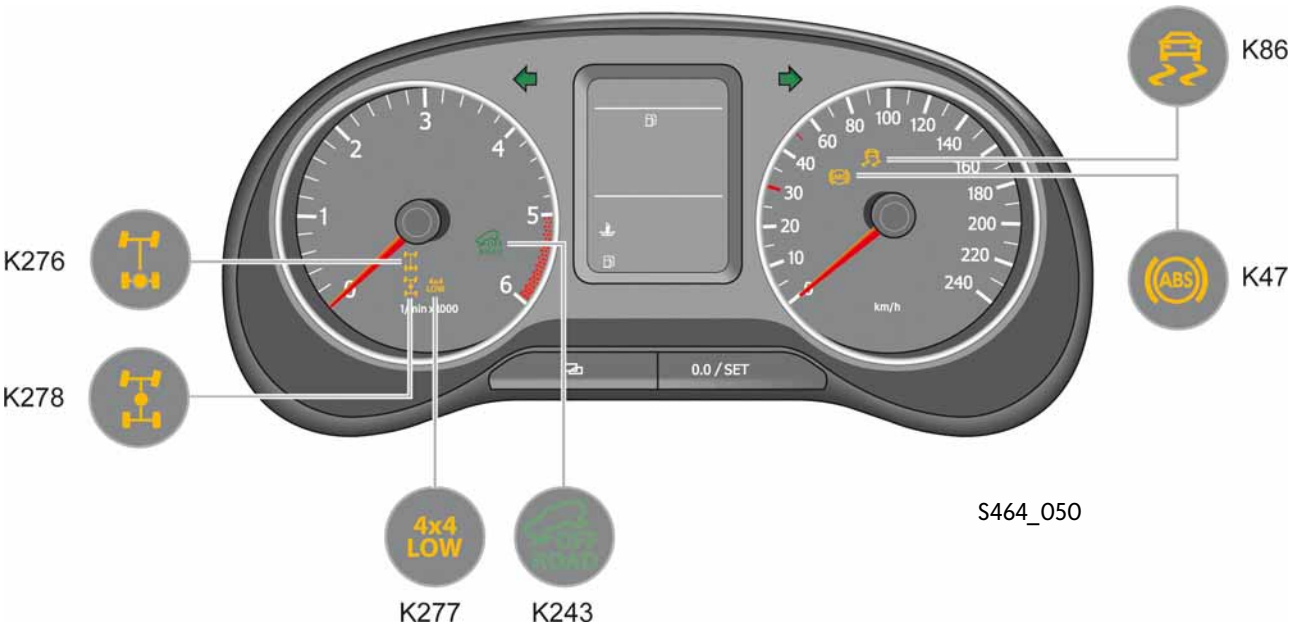
E256, E121 and E598 do not have function lighting

In right-hand drive vehicles, button panel E631 is fitted on the other side of the selector lever.

Displays on the dash panel insert

Each of the four-wheel drive statuses that are activated during operation is backlit in the button panel and also shown in the dash panel insert as a status display.

The status of 4x2 rear-axle mode is only displayed in the centre console.



Key

K278 Longitudinal lock-up warning lamp (4x4 HIGH)
K277 Warning lamp for gearbox low range
K276 Warning lamp for rear transverse lock
K47 ABS warning lamp (ABS fault or ABS deactivated)
K86 Traction control system warning lamp (fault, control or deactivated)
K243 Driving programme warning light (offroad driving programme)

Operation

Four-wheel drive 4x4 HIGH

Display in the dash panel insert

S464_077

... four-wheel drive is engaged (interaxle lock engaged)

Switch-on conditions

- Terminal 15 "ON"
- E631 (up) pressed > 0.5 s
- Can be engaged at any vehicle speed
- No undervoltage
- No relevant error memory entry

Switch-off conditions

- Terminal 15 "ON"
- E631 (down) pressed > 0.5 s
- Can be switched off at any vehicle speed
- No undervoltage
- No relevant error memory entry

Offroad range 4x4 LOW

Display in the dash panel insert

S464_079

... four-wheel drive is engaged and LOW reduction ratio engaged

Switch-on conditions

- Engine speed < 1500 rpm
- E631 (up) pressed > 0.5 s
- Vehicle speed v < 1 km/h
- 4x4 HIGH engaged
- No undervoltage
- No relevant error memory entry

Switch-off conditions

- Engine speed < 1500 rpm
- E631 (down) pressed > 0.5 s
- Vehicle speed v < 1 km/h
- No undervoltage
- No relevant error memory entry

Differential lock

Display in the dash panel insert

... differential lock engaged

S464_081

Switch-on conditions

- Engine running
- E121 pressed > 0.5 s
- Can be engaged at any vehicle speed
- No undervoltage
- No relevant error memory entry
- With non-permanently engaged four-wheel drive: Four-wheel drive range 4x4 LOW engaged

Switch-off conditions

- Button pressed > 0.5 s (E121)
- Can be switched off at any vehicle speed
- 30 s follow-on operation after tl. 15 "OFF". If the engine stalls whilst driving with the differential lock engaged, the lock remains engaged for a period of 30 seconds after tl. 15 "OFF". This means restarting and moving off are possible with the lock engaged. As a result, driving comfort is increased when driving offroad.

The following applies to all variants 4x4 HIGH, 4x4 LOW and for the differential lock with regard to operation

The driver's request for engaging the required four-wheel drive range is stored for 10 s. If the required activation conditions are met within this period then the four-wheel drive ranges 4x4 HIGH, 4x4 LOW and the differential lock are engaged. Operating comfort is therefore improved.

ABS/ESP system statuses

ABS/ESP control is retained during four-wheel drive operation (4x4 HIGH and 4x4 LOW) in all equipment variants of the Amarok. In vehicles with non-permanently engaged four-wheel drive, ABS/ESP control is deactivated when the differential lock is engaged. The mechanical link-up between the two axles (4x4 HIGH/4x4 LOW) and the additional link-up between the two rear wheels means that individual ABS/ESP control for individual wheels is no longer possible. Deactivation is displayed by warning lamps K86 and K47 in the dash panel insert. In vehicles with permanently engaged four-wheel drive, the ABS/ESP function is also retained when the differential lock is engaged.

The offroad drive programme

The offroad drive programme is used as standard in all vehicle variants of the Amarok.
It is intended to assist the driver in special driving situations when offroad. The possible extended functions of the ABS/ESP control unit are used in this case.

- Offroad ABS (adaptations in the ABS control behaviour)
- Offroad ESP (adaptations in the ABS and ESP control behaviour)
- Hill-descent assist

Activation of the offroad programme and indication

The offroad programme is activated • Manually – by pressing the driving programme button E598 (in the centre console, on the right of the selector lever) or • Automatically – when 4x4 LOW drive range is activated	 **E598** S464_073
Display showing activation of the offroad drive programme Activation of the offroad drive programme is indicated by the driving programme warning light K243 in the dash panel insert.	 S464_072

Configurations

- Vehicles with ABS (MK25 E) have offroad ABS
- Vehicles with ESP (MK25 XT) have offroad ABS/ESP and hill descent control

Activation conditions for the offroad programme

- Terminal 15 "ON"
- E598 pressed > 0.5 s

Special case in vehicles with non-permanently engaged four-wheel drive

When 4x4 LOW drive range is engaged, the offroad programme is activated automatically.

The offroad drive programme remains active following activation until the next change of ignition status, without interruption.
For example, if the engine is stalled when driving offroad, the offroad drive programme also remains activated after restarting, with a follow-on operation of 30 s after a change of status on tl. 15.
This increases driving comfort.

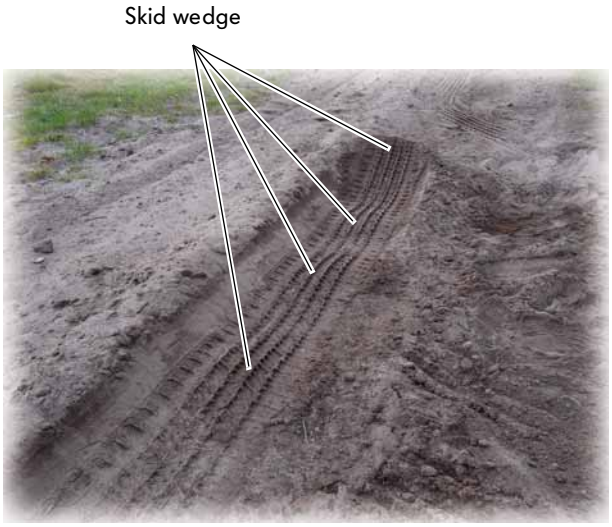
Features of the offroad drive programme

Offroad ABS

Vehicles with offroad ABS can brake better on unconsolidated ground such as sand and gravel.

In ABS control, the pressure buildup and pressure holding phases are extended. The depressurisation is shorter and takes place later. This means wheel slip can occur in each control phase, thereby building up a skid wedge of loose material in front of the wheels.

The skid wedge brakes the vehicle additionally and shortens the braking distance depending on the composition of the ground.



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Special information about using offroad ABS can be found in the owner's manual.

Offroad ESP

Vehicles with ESP have adapted ESP control behaviour as well as offroad ABS in order to improve traction:

- ESP intervenes somewhat later at speeds below 50 km/h when the vehicle is understeering.
- ESP intervenes somewhat later at speeds below 70 km/h when the vehicle is oversteering.
- ASR intervenes somewhat later at speeds below 70 km/h.

Hill-descent assist

The hill-descent assist makes descending steep hills more straightforward and more controllable. It limits the speed by active brake intervention at all 4 wheel brakes using the ESP hydraulics. It keeps the speed constant after the vehicle has started its descent. The driver can increase or reduce the speed at any time using the accelerator and brakes. The hill-descent assist adjusts speed within its control range between 2 and max. 30 km/h. The system functions when driving forwards and in reverse.

Switch-on conditions for hill-descent assist

- E598 pressed > 0.5 s
- Special feature with non-permanently engaged four-wheel drive: automatic activation in 4x4 LOW
- Engine running
- Slope forwards > 10 %, reverse > 8 %
- Vehicle speed v < 30 km/h (> 30 km/h change to standby mode)
- Driver brakes less than the downslope force
- Accelerator pedal is not pressed

For more information about the basic function of the hill-descent assist, refer to self-study programme 374 "Slip control and assistance systems".

The 6-speed manual gearbox

A modern, fully synchronised 2-shaft gearbox of conventional design is used for transmitting power. It has a robust structure and is designed for the specific requirements of commercial vehicles. The developer and manufacturer of the 0C6 gearbox is ZF-Getriebe GmbH

- The 6-speed manual gearbox has a uniform housing for all drive variants.
- The same gear ratios are used for all engines.
- The newly-developed 6-speed manual gearbox is exclusively used in the Amarok at present.

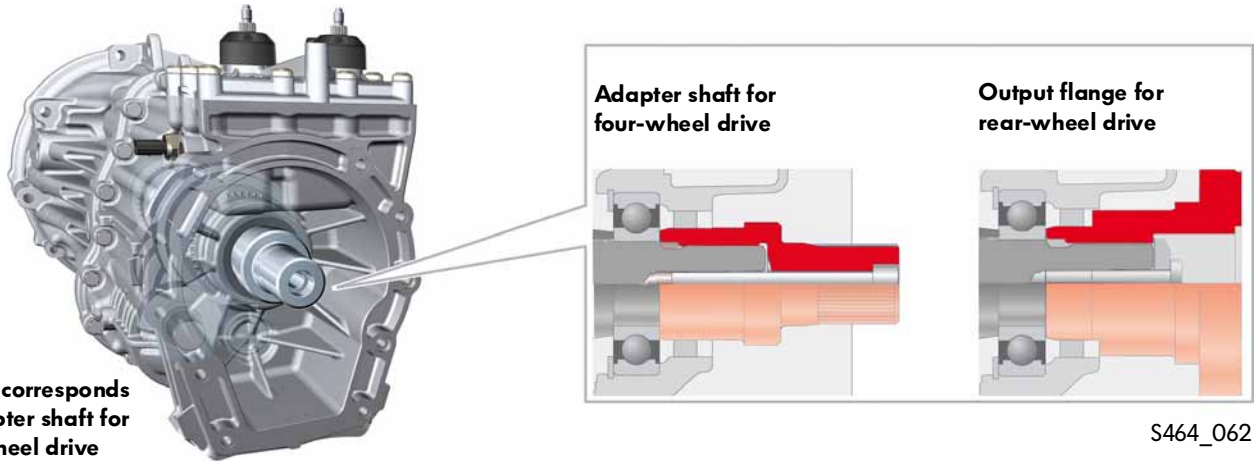
S464_052

Gearbox – output adapter

There are two different gearbox variants for the two drive variants of rear-wheel drive and four-wheel drive. These only differ in the area of the connection to the propshaft in vehicles with rear-wheel drive or the transfer box in four-wheel drive vehicles.

Four-wheel drive – The torque is transferred from the manual gearbox to the transfer box via an adapter shaft. The adapter shaft is connected to the gearbox output shaft by means of splines with a light press-fit seat, and is additionally bolted.

Rear-wheel drive – The torque is transmitted onto the propshaft to the rear axle by means of an output flange. The output flange is mounted on the splines of the output shaft by means of a light press-fit seat, and is additionally secured by a bolted connection.



Picture corresponds to adapter shaft for four-wheel drive

S464_062

Technical data

Gearbox designation	0C6
Gearbox type	6-speed manual gearbox
Gearbox code	e.g. MQU (4x2) NFG, NCR MQV, MJE (4x4) NFF, NCQ, MJE
max. transmissible torque	400 Nm
Shafts	Input shaft and coaxial output shaft, layshaft, R-gear reverse shaft
Installation location	Longitudinal installation
Use with the engines ...	90/120 kW TDI engines 118 kW TSI engine
Shaft clearance	85 mm
Structural length	690 mm
Weight	61 kg
Gear oil specification	Synthetic gear oil (SAE 75W-80)
Fill quantity of lifetime fill	First fill: 1.5 l, change volume: 1.4 l
Change interval	Lifetime fill
Clutch mechanism	Hydraulic

Ratios

	Gear ratio
1st gear	4.82
2nd gear	2.54
3rd gear	1.49
4th gear	1.0
5th gear	0.76
6th gear	0.64
Reverse gear	4.37
Spread	7.53

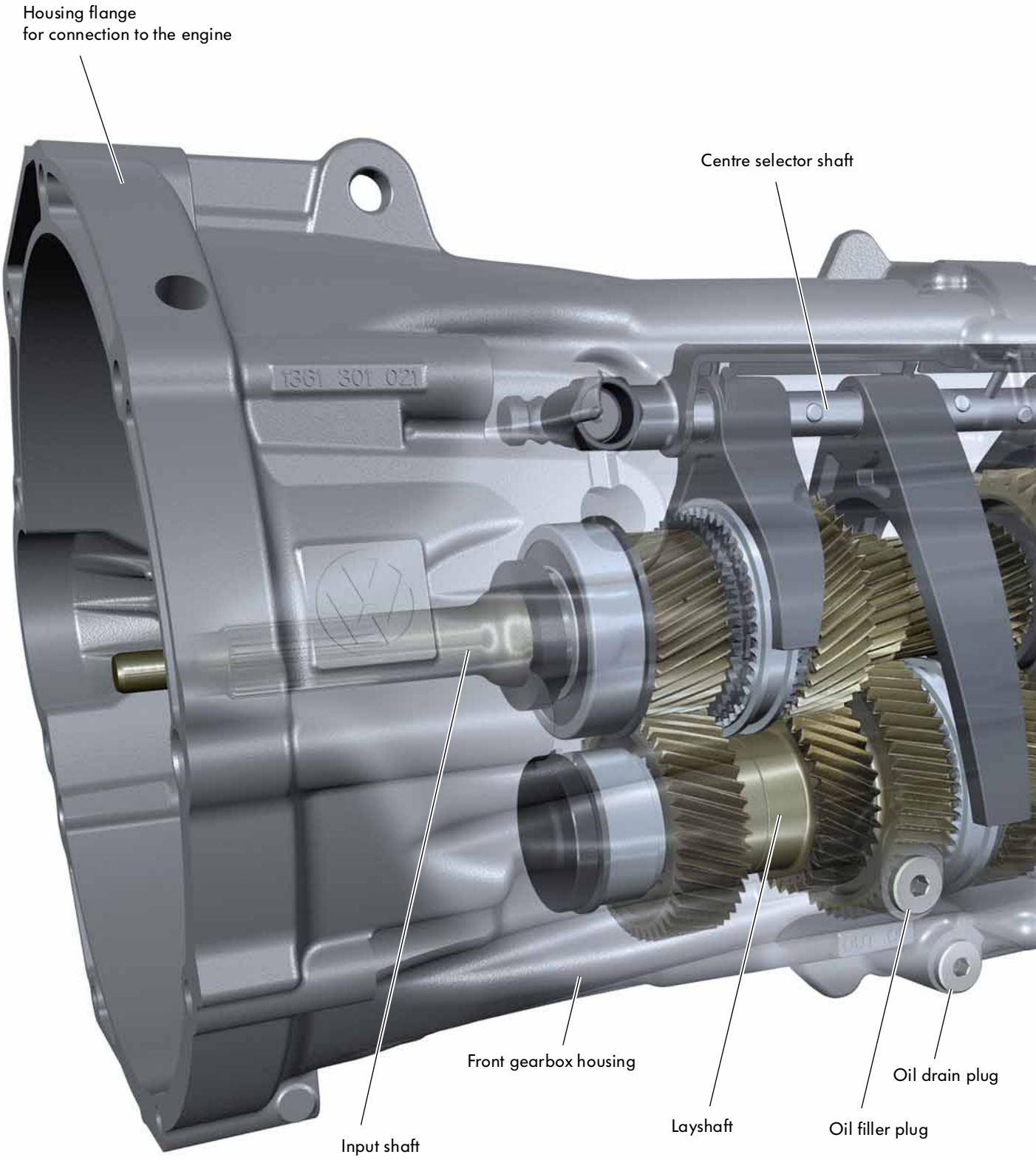
The gear ratios in all gearbox variants are the same. 5th and 6th gears are configured as overdrive.
The vehicle's maximum speed is reached in 5th gear and also in 6th gear. 6th gear is an override used for saving fuel, since the engine rpm is significantly lower.
This reduces CO_2 emissions and reduces wear in the engine.

Example: 120 kW TDI engine (calculated values)
- Vmax 5th gear = 179.5 km/h at 4135 rpm
- Vmax 6th gear = 178.9 km/h at 3457 rpm

1st gear has a relatively high mechanical advantage, specifically for a commercial vehicle. This is used for moving off without overloading the clutch when the vehicles are heavily loaded and/or towing a trailer.

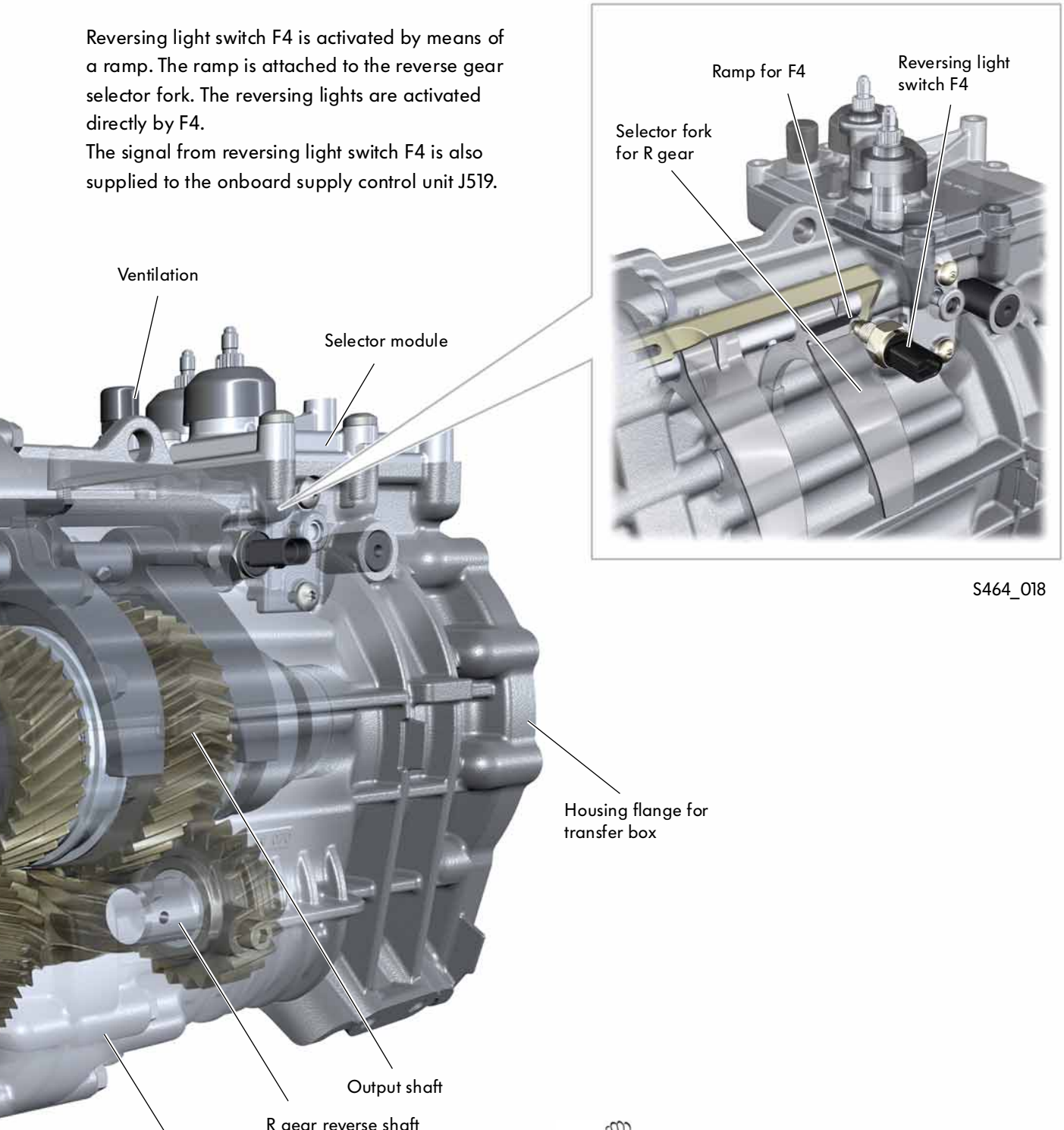
The gearbox structure and function

The two-part gearbox housing is made from aluminium diecastings.



Reversing light switch F4

Reversing light switch F4 is activated by means of a ramp. The ramp is attached to the reverse gear selector fork. The reversing lights are activated directly by F4.
The signal from reversing light switch F4 is also supplied to the onboard supply control unit J519.



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The oil level with a correct oil fill is below the bottom edge of the thread for the oil filler plug.

Follow the information in ELSA regarding the oil fill and checking.

6-speed manual gearbox 0C6

The gearbox sectional view

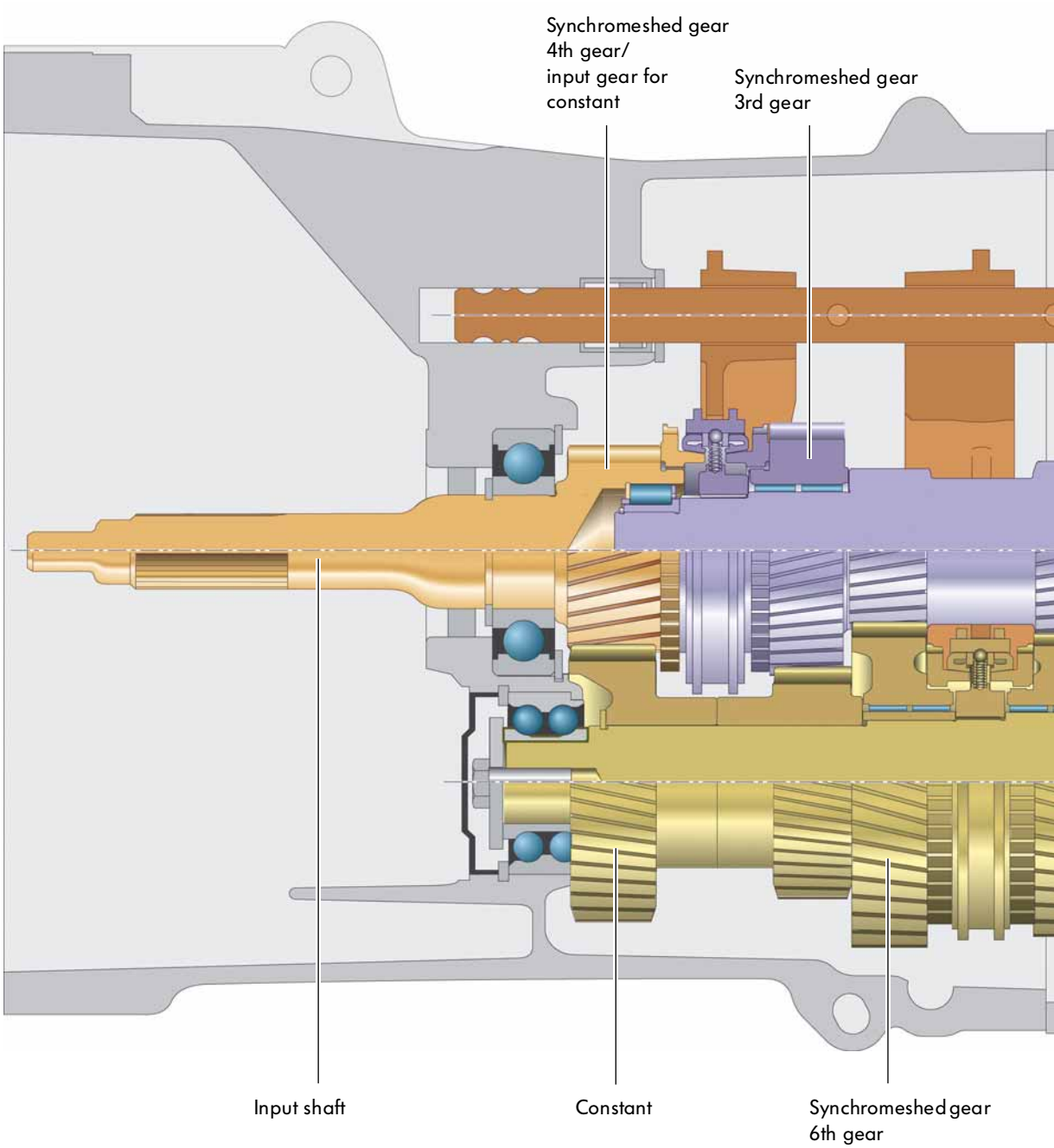
The manual gearbox in the Amarok is a two-stage fully synchronised locking collar speed-changing gearbox.

It has an input shaft, an output shaft, a layshaft and the R-gear reverse shaft.

All synchromeshed gears are all on needle bearings and are distributed over the output shaft and layshaft.

The input shaft and the output shaft are mounted in ball bearings.

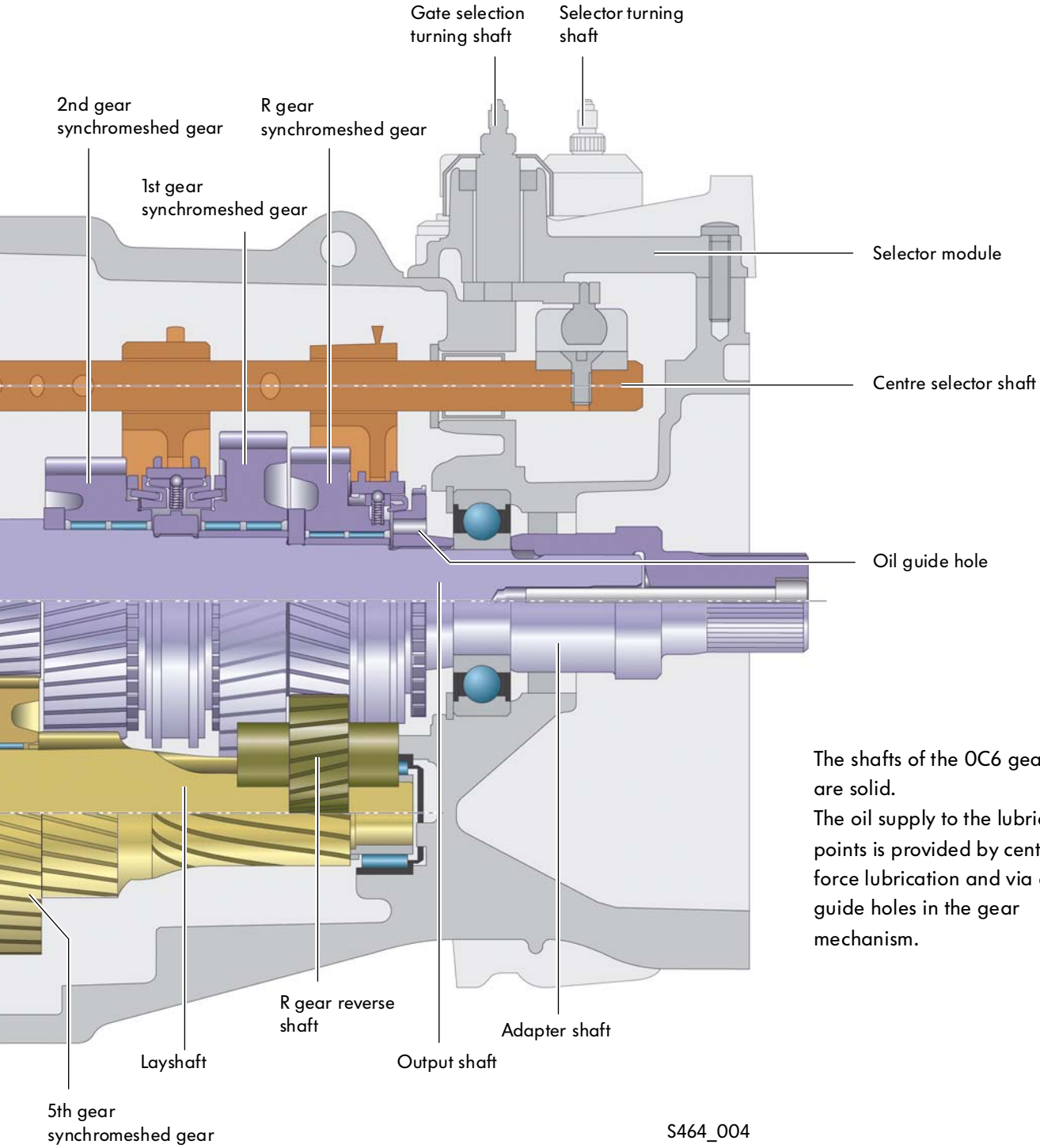
The layshaft is mounted in ball bearings and cylindrical roller bearings.



The gears are shifted using a gear selector and a gate selector turning shaft which are mounted in a rotating arrangement in the selector module.

All selector forks are activated by the centre selector shaft.

The oil drain plug is not magnetic. A magnet is installed in the front gearbox housing in order to collect metallic fragments from the synchronisers or metallic particles in case of mechanical gearbox damage.



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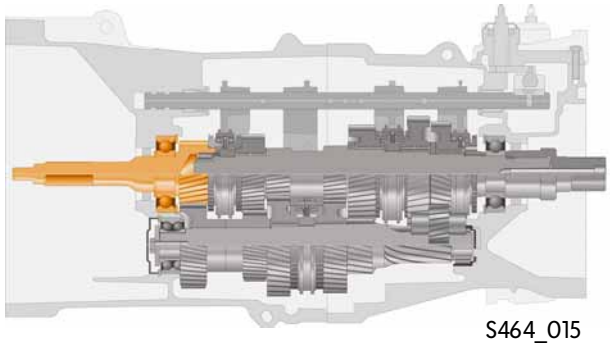
The shafts of the 0C6 gearbox are solid.
The oil supply to the lubrication points is provided by centrifugal-force lubrication and via oil guide holes in the gear mechanism.

Input shaft

The input shaft is mounted in the front gearbox housing in a deep-groove ball bearing as a fixed bearing.

The cylindrical roller bearing is used as a moving bearing between the input shaft and the output shaft. It is located in the hole in the input shaft.

The input shaft gear of the constant stage is a component of the input shaft.



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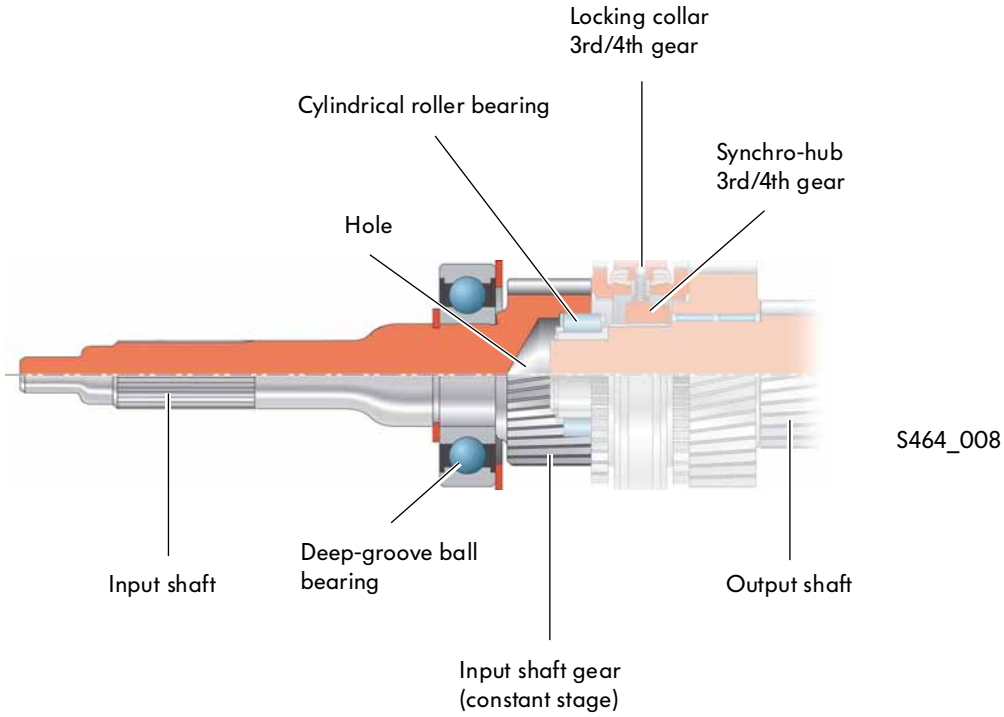

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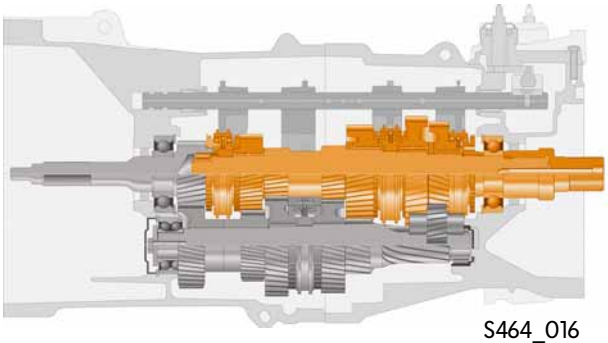
Output shaft

The output shaft has a deep-groove ball bearing as its fixed bearing, which is mounted in the rear gearbox housing. The cylindrical roller bearing is used as a moving bearing between the input shaft and the output shaft.

The fixed gears of the 5th and 6th gear are components of the output shaft. The synchromeshed gears of 1st, 2nd, 3rd and reverse gears are mounted on needle bearings, allowing them to rotate freely. These synchromeshed gears are also referred to as idler gears – they rotate constantly with the corresponding fixed gears.

The synchro-hubs of 1st/2nd and 3rd/4th gears are firmly connected to the output shaft by means of splines. It is a special feature that the synchromeshed gear and synchro-hub of the reverse gear form one structural unit. The clutch splines of reverse gear are connected to the output shaft in a non-rotating arrangement via splines.



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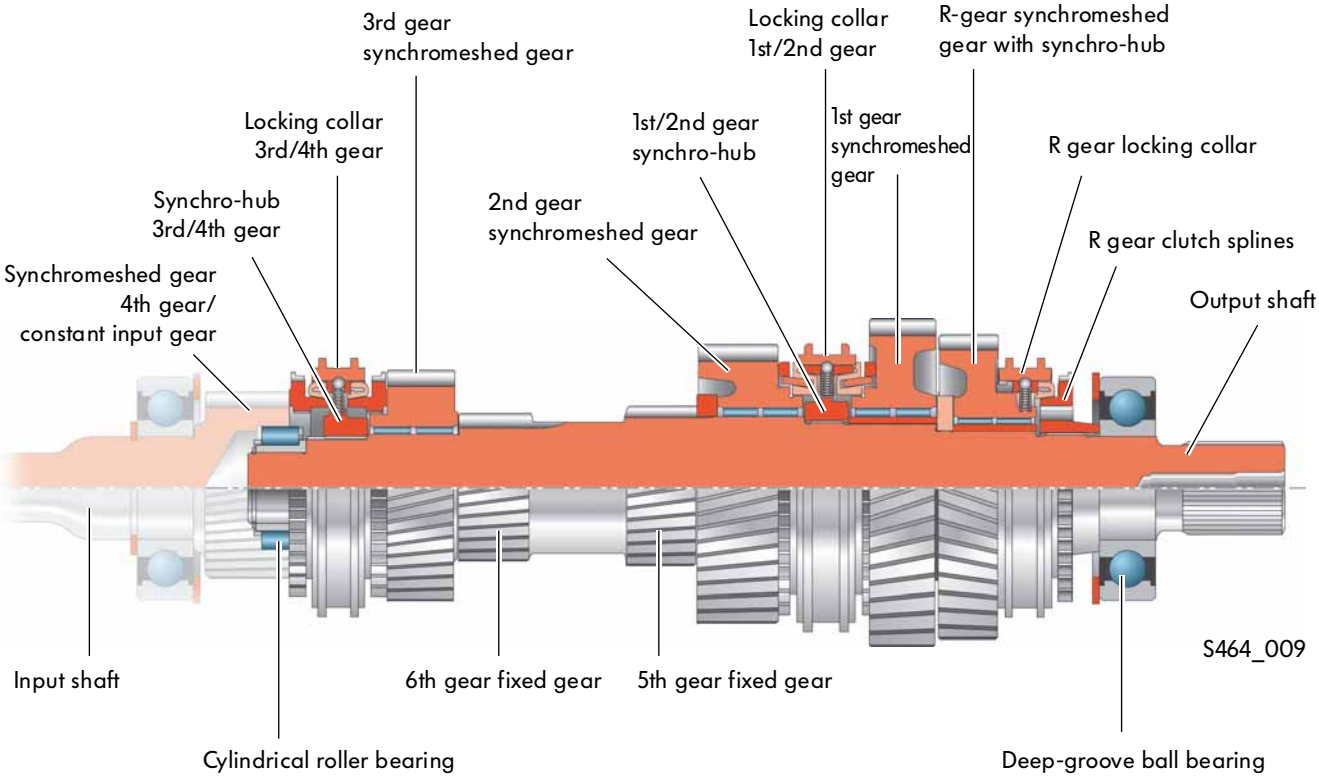
It is only when a gear is engaged that the synchromeshed gears are firmly connected to the output shaft by means of the locking collar and corresponding synchro-hub, thereby allowing them to transmit torque.



6-speed manual gearbox 0C6

Layshaft

A fixed and a moving bearing are also used for mounting the layshaft. The double deep-groove ball bearing is fitted as a fixed bearing in the front gearbox housing, and the cylindrical roller bearing as a moving bearing in the rear gearbox housing.

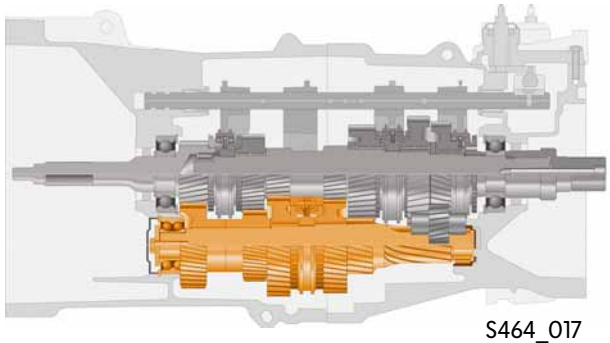
The fixed gears of 1st and 2nd gear are milled out of the layshaft, making them components of the layshaft.

The fixed gear of 1st gear is also used as a drive gear for the reverse shaft.

The synchromeshed gears for 5th and 6th gears are idler gears – they are mounted on needle bearings.

The fixed gear for 3rd gear and the constant are firmly connected to the layshaft by means of a press fit.

The synchro-hubs of 5th/6th gear are also firmly connected to the layshaft by splines.



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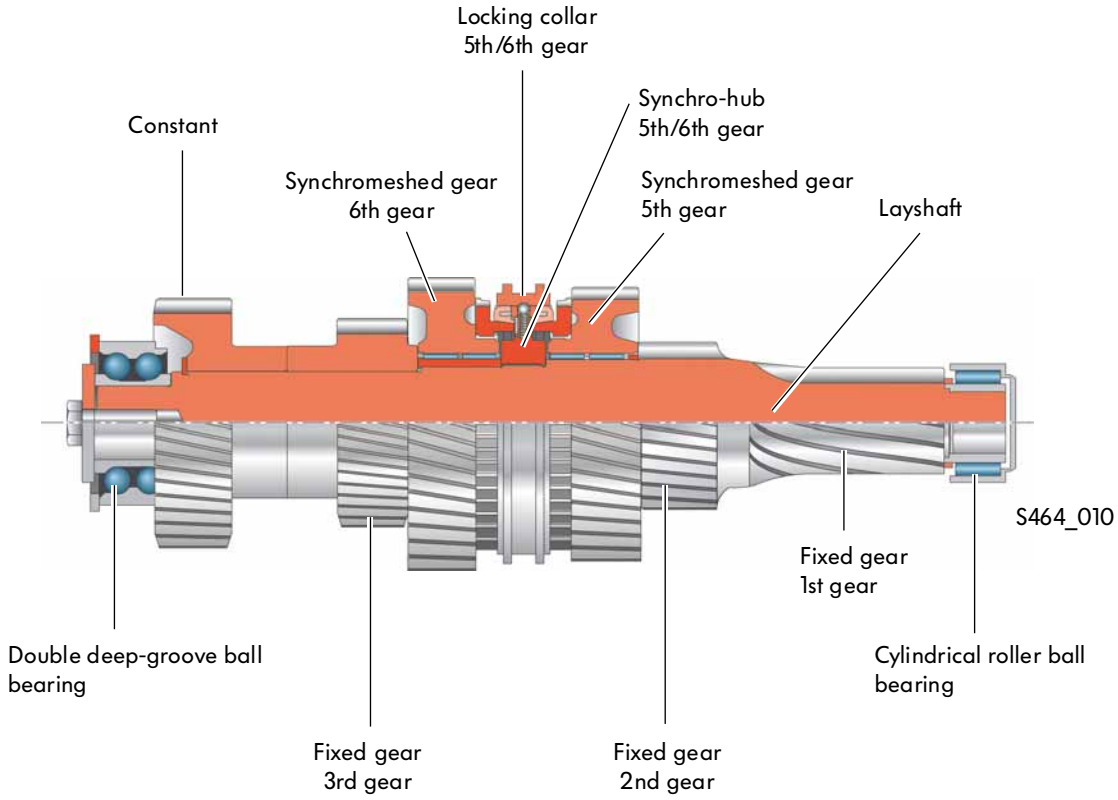


Synchronisation

Due to the design conditions and different dimensions of the gears which need to be synchronised with one another, different synchronisation variants are used in the manual gearbox.
Both bonded and brazed sintered powder linings are used.

Single synchronisation with bonded sintered powder lining

This synchronisation is used in the 3rd/4th gear – 5th/6th gear and R gear.

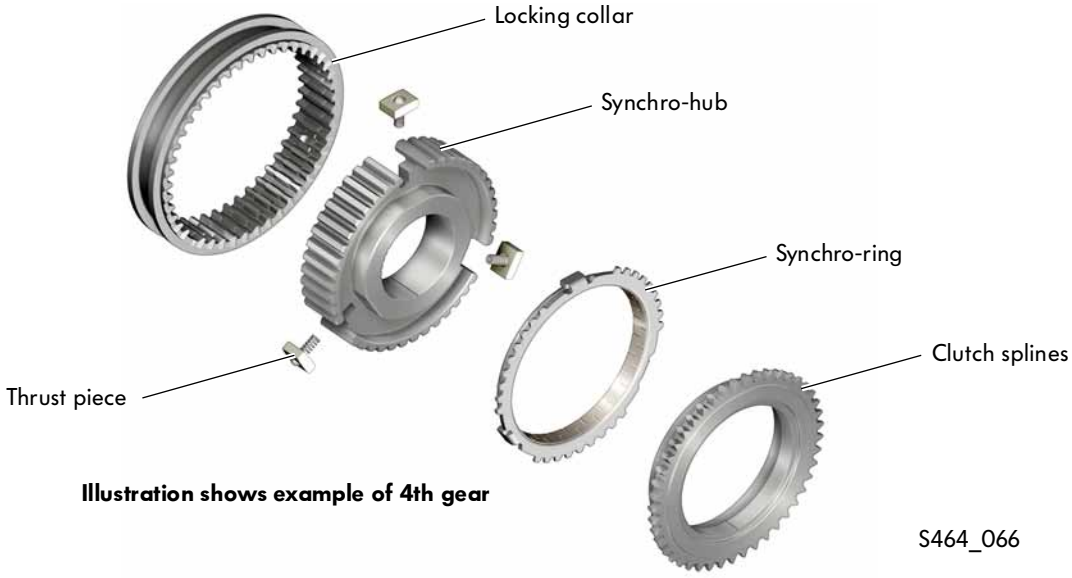


Illustration shows example of 4th gear

S464_066

1st/2nd gear – double synchronisation with brazed sintered powder linings

This synchronisation is used with 1st/2nd gear.

Illustration shows example of 1st gear

S464_065

The powerflow

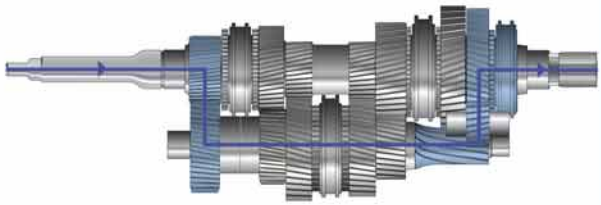
The engine torque is transmitted into the gearbox via the input shaft. The powerflow is transmitted to the layshaft by means of the constant stage gear pair which is constantly in mesh.

Except for 4th gear, the powerflow in all other gears runs from the layshaft through the corresponding gear pairing of the engaged gear onto the output shaft.

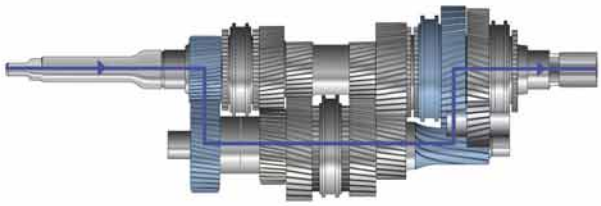
The 4th gear is directly engaged. In this case, the powerflow runs directly from the input to the output shaft.

When reverse gear is engaged, the powerflow runs from the layshaft to the output shaft by means of the additional R-gear shaft, thereby reversing the direction of rotation of the output shaft.

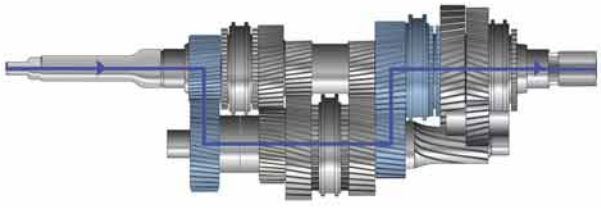
Reverse gear (R gear)

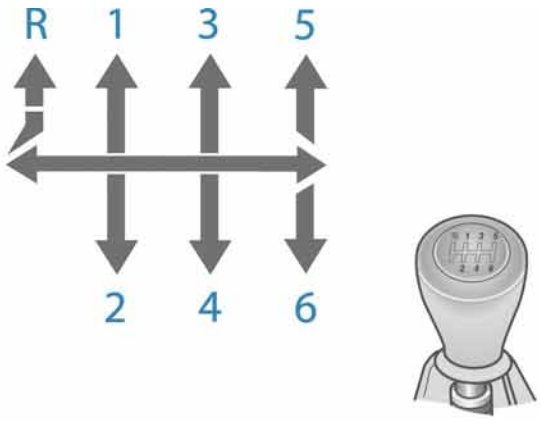


1st gear

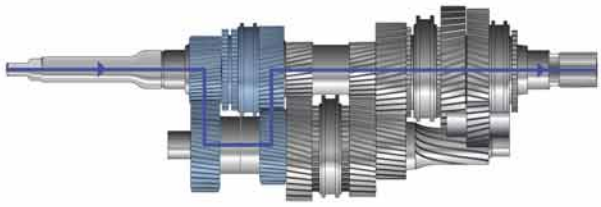


2nd gear

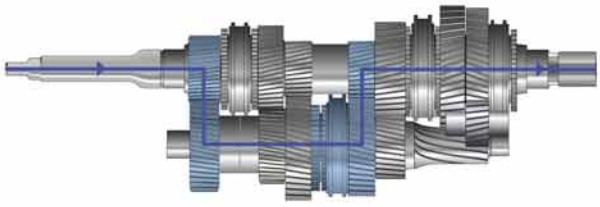




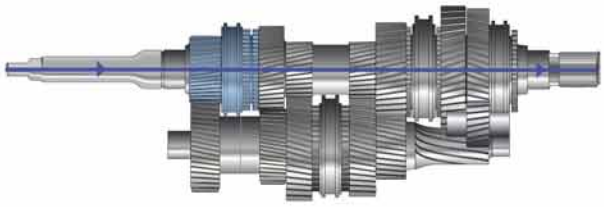
3rd gear



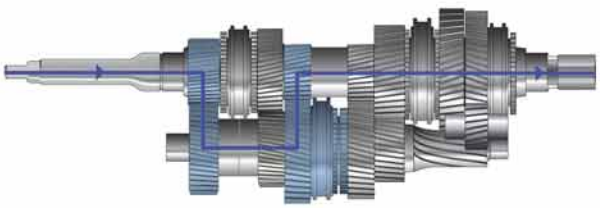
5th gear



4th gear



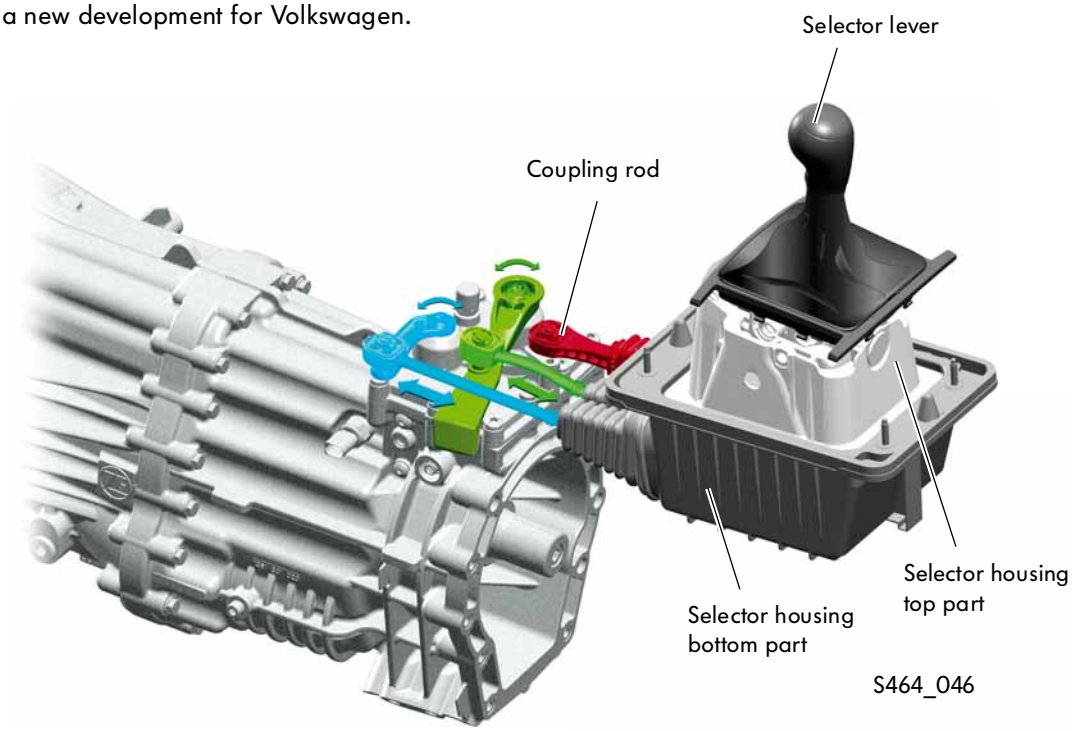
6th gear



S464_019

The external selector mechanism

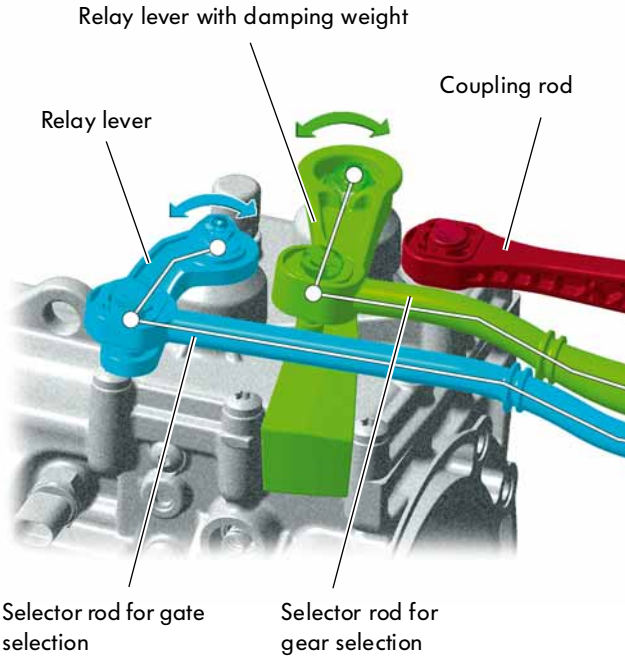
The design of the selector mechanism with coupling rod represents a new development for Volkswagen.



The gearshift positions are transmitted to the selector unit of the gearbox by means of two separate selector rods ...

... through the

- selector rod for gear selection and the
- selector rod for gate selection



Decoupling of selector lever

The coupling rod is used for decoupling the selector lever from the gearbox. It presents vibrations from being transmitted to the selector lever. This design measures increases operating comfort when driving.

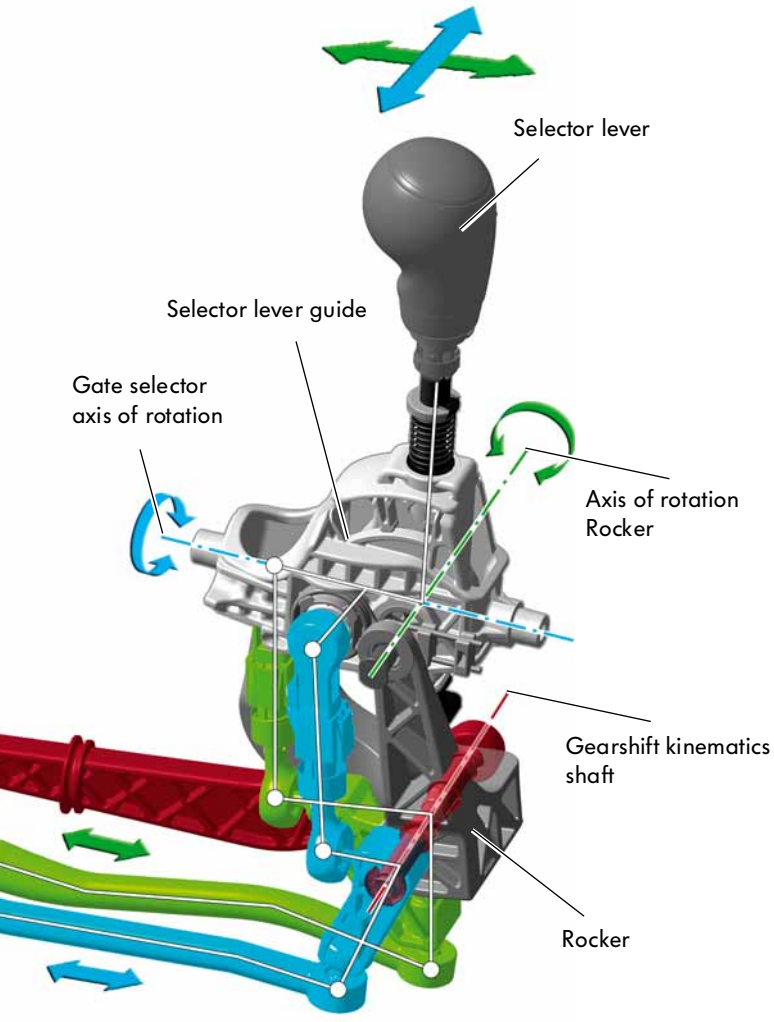
Structure and function

The coupling rod is rigidly connected to the gearbox at the front end by means of a holding pin. At the rear end, it is connected to the gearshift kinematics in the selector housing by means of a rocker. The rocker is mounted on both sides in the selector housing upper part.

The coupling rod keeps the shaft of the gearshift kinematics at a constant distance from the gearbox at all times. During the gearshift procedure, all movements of the gearshift kinematics take place via this shaft.

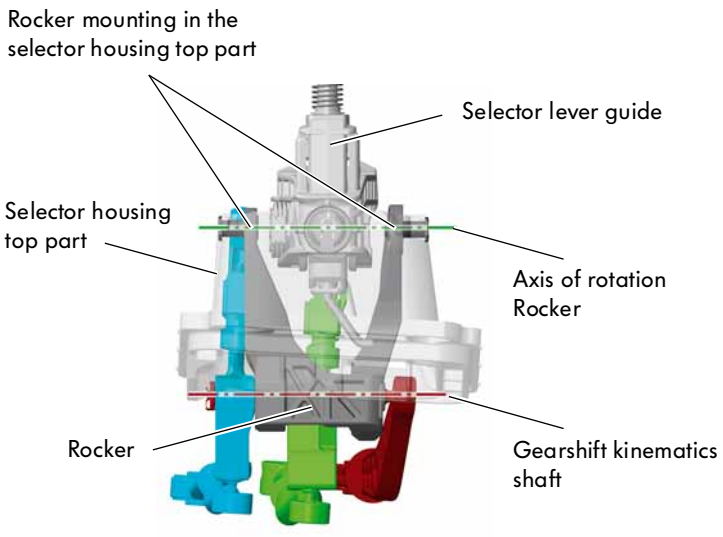
Vibrations and load change-dependent relative movements of the drivetrain are compensated for by relative movement of the gearshift kinematics shaft – due to the connection via the coupling rod.

The selector mechanism always remains free from vibration and feedback of engine/gearbox movements



S464_087

Rear view – in driving direction



S464_103

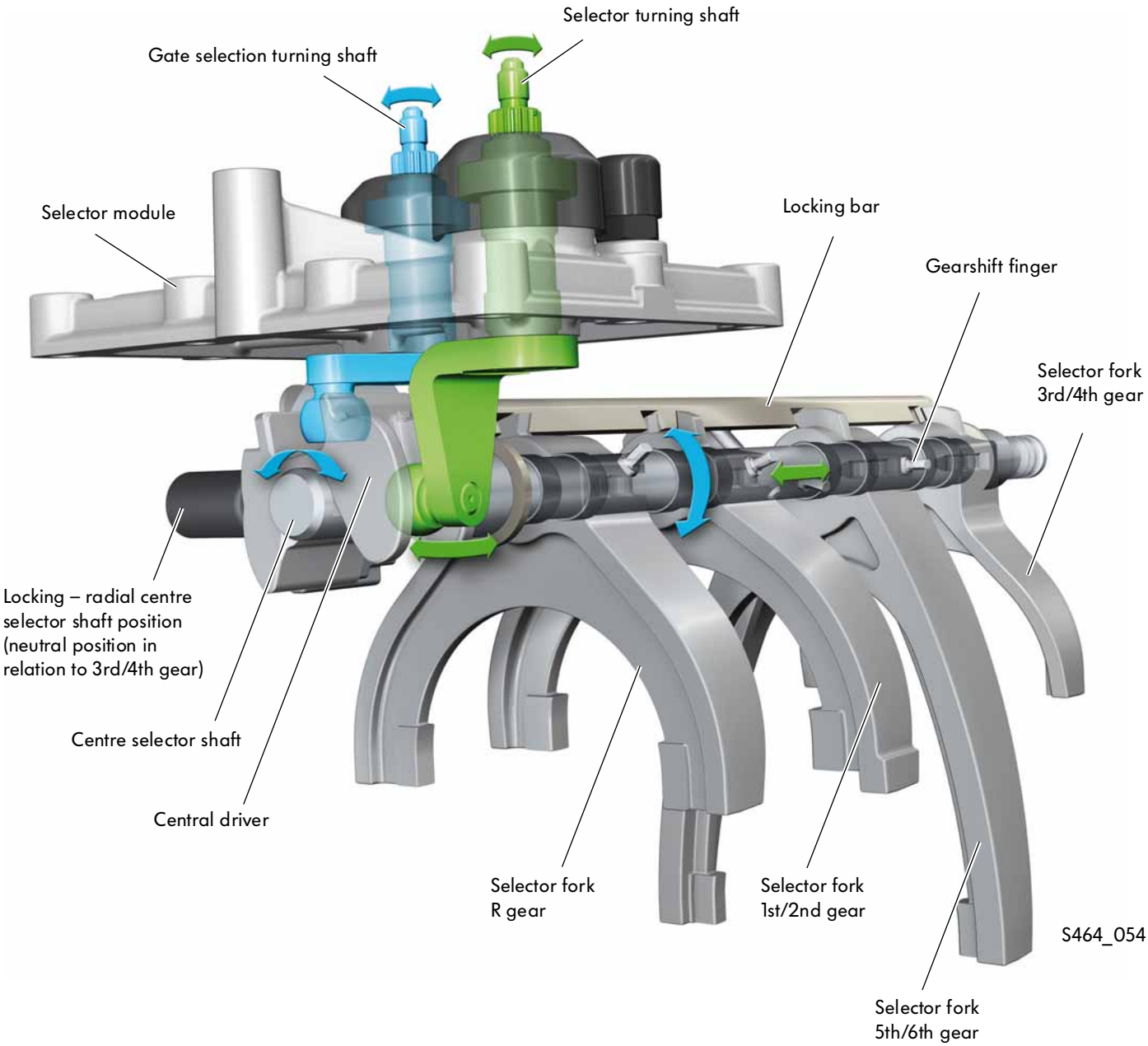
The internal selector mechanism

Structure and function

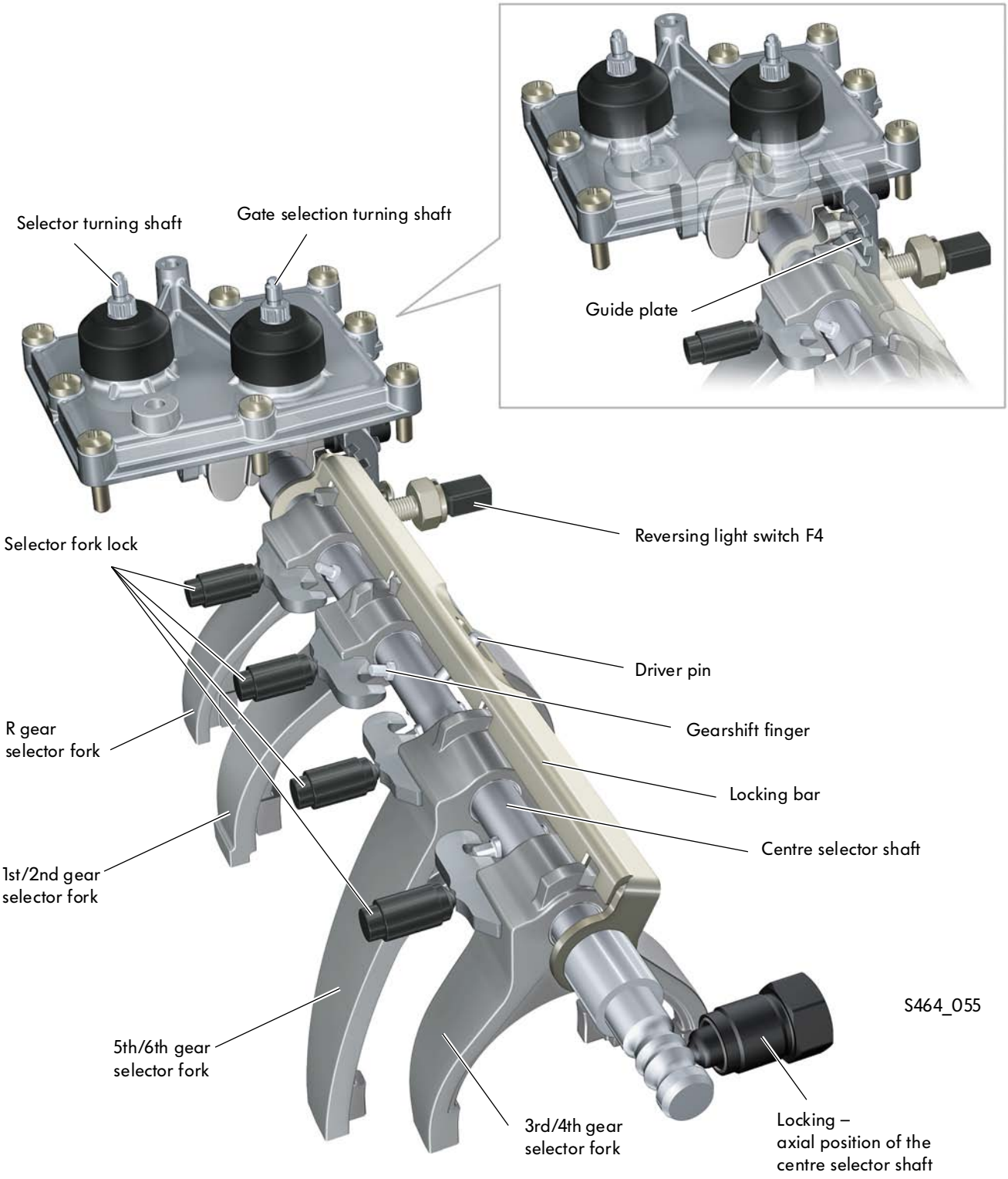
The gear selector and gate selector turning shafts are mounted in the gearshift module in a rotating arrangement. Both turning shafts engage in the centre selector shaft via the central driver by means of a lever mechanism.

The centre selector shaft is mounted in Teflon plain bearings and is connected to all selector forks whilst still being able to rotate. The selector turning shaft pushes the centre selector shaft axially in both directions, thereby engaging both the gears in one gate. A selector fork is allocated to each selector finger.

The gate selection turning shaft rotates the centre selector shaft radially in both directions, thereby selecting the gate. The centre selector shaft as well as the selector turning shaft and gate selection turning shaft are mounted in Teflon-coated plain bearings.



The locking bar is mounted on the centre selector shaft in a rotating arrangement – it cannot be moved axially. The locking bar is moved as well when the gate is selected, by means of the driver pin that is firmly connected to the centre selector shaft. The locking bar has mechanical coding and there is also coding on the selector forks in order to ensure sequential engagement of the individual gears. A guide plate on the central driver provides additional mechanical coding for the gearshift procedure.



Transfer box

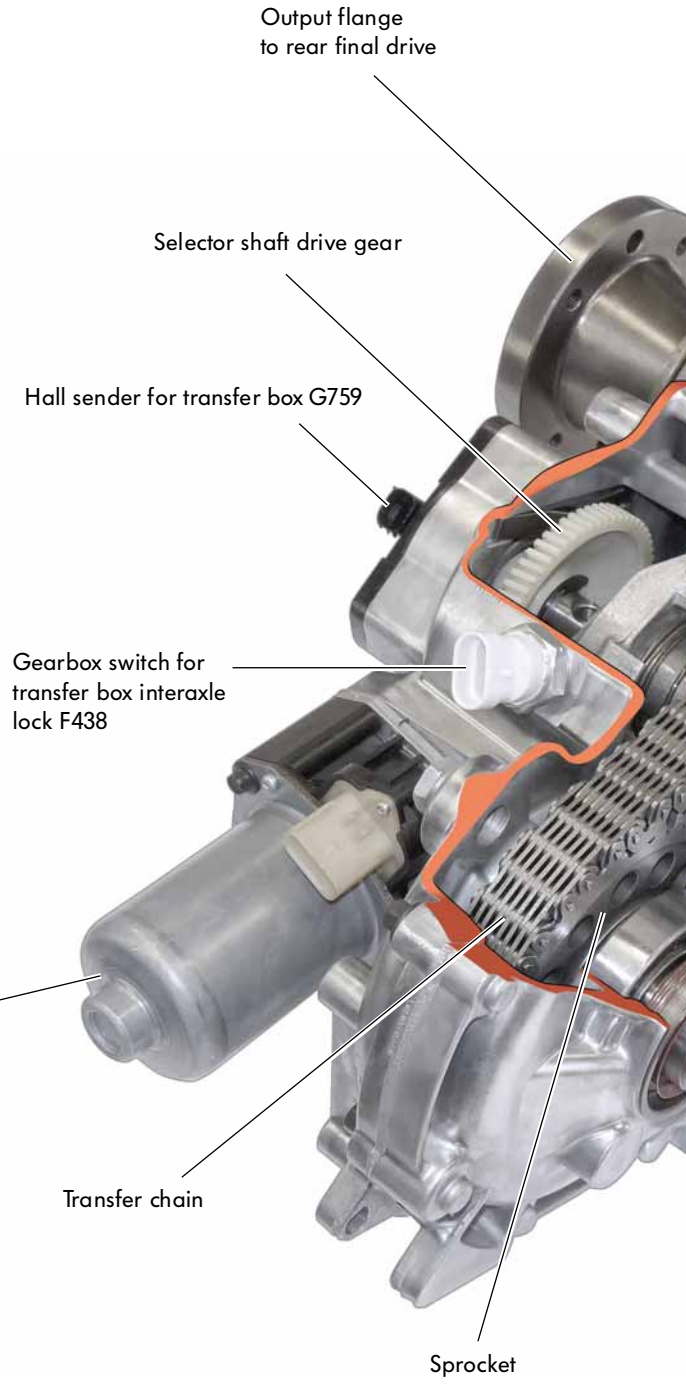
The non-permanently engaged four-wheel drive with transfer box 0C7

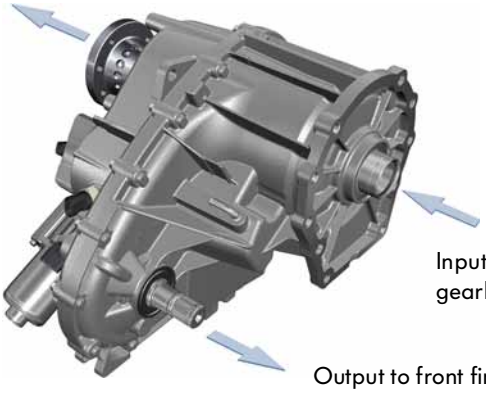
The transfer box that is flange-mounted on the manual gearbox distributes the input torque to the front and rear axles. It makes it possible to engage the front final drive (4x4 HIGH) and the additional reduction stage (offroad range, 4x4 LOW).
The gear engagement procedures are performed by a control motor that engages the gear ratios by means of two separate locking collars.

Non-permanently engaged four-wheel drive

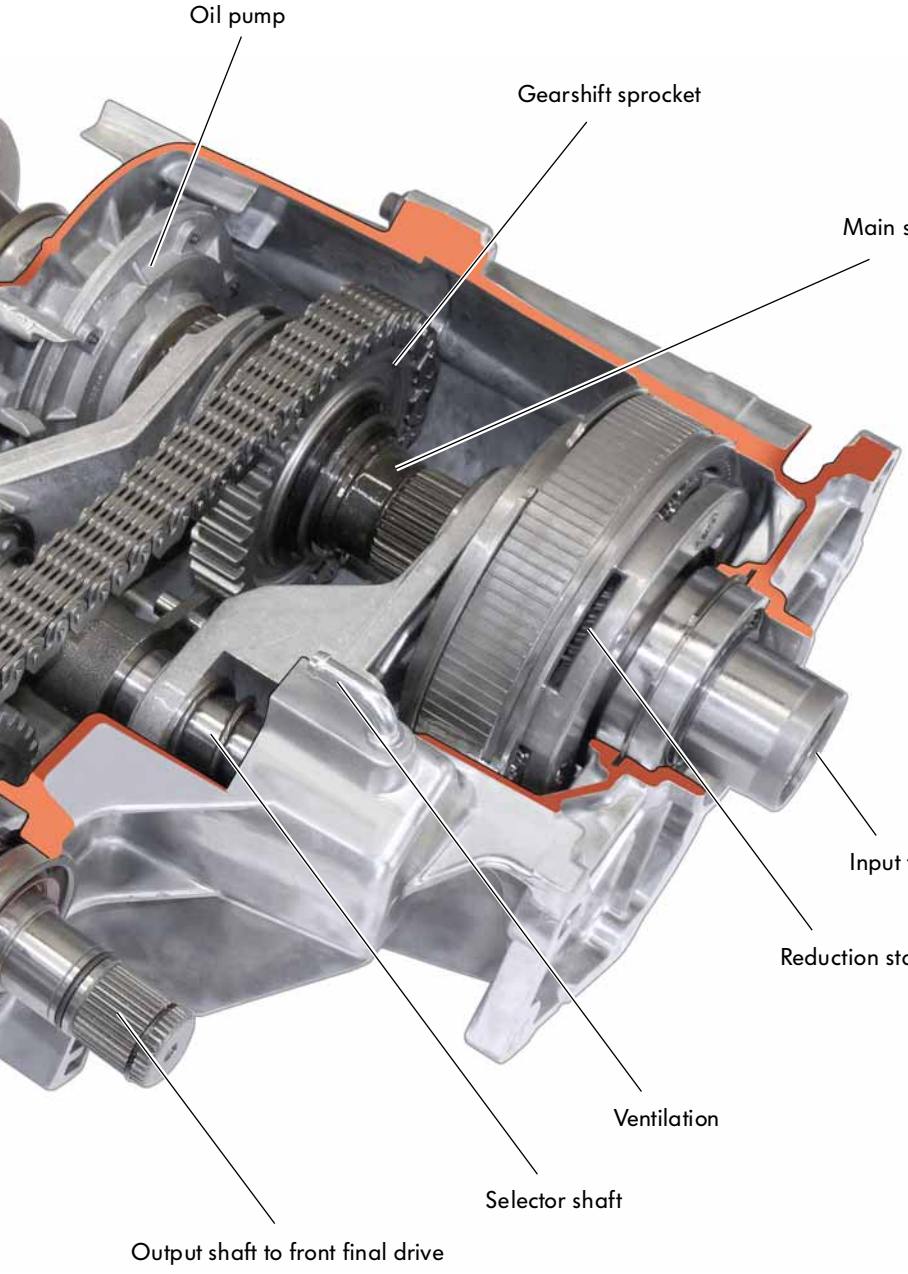
Mechanical structure

- Newly developed transfer box
- Robust structure
- Specifically designed for offroad use
- Offroad range (reduction stage) for all gear stages
- Integration of the system into vehicle dynamics programme
- Input torque distribution:
  Even force distribution by rigid connection between front and rear axles
- Weight = 34 kg
- Oil fill volume 1.25 l
- The developer and manufacturer of the transfer box 0C7 is Magna powertrain





S464_039

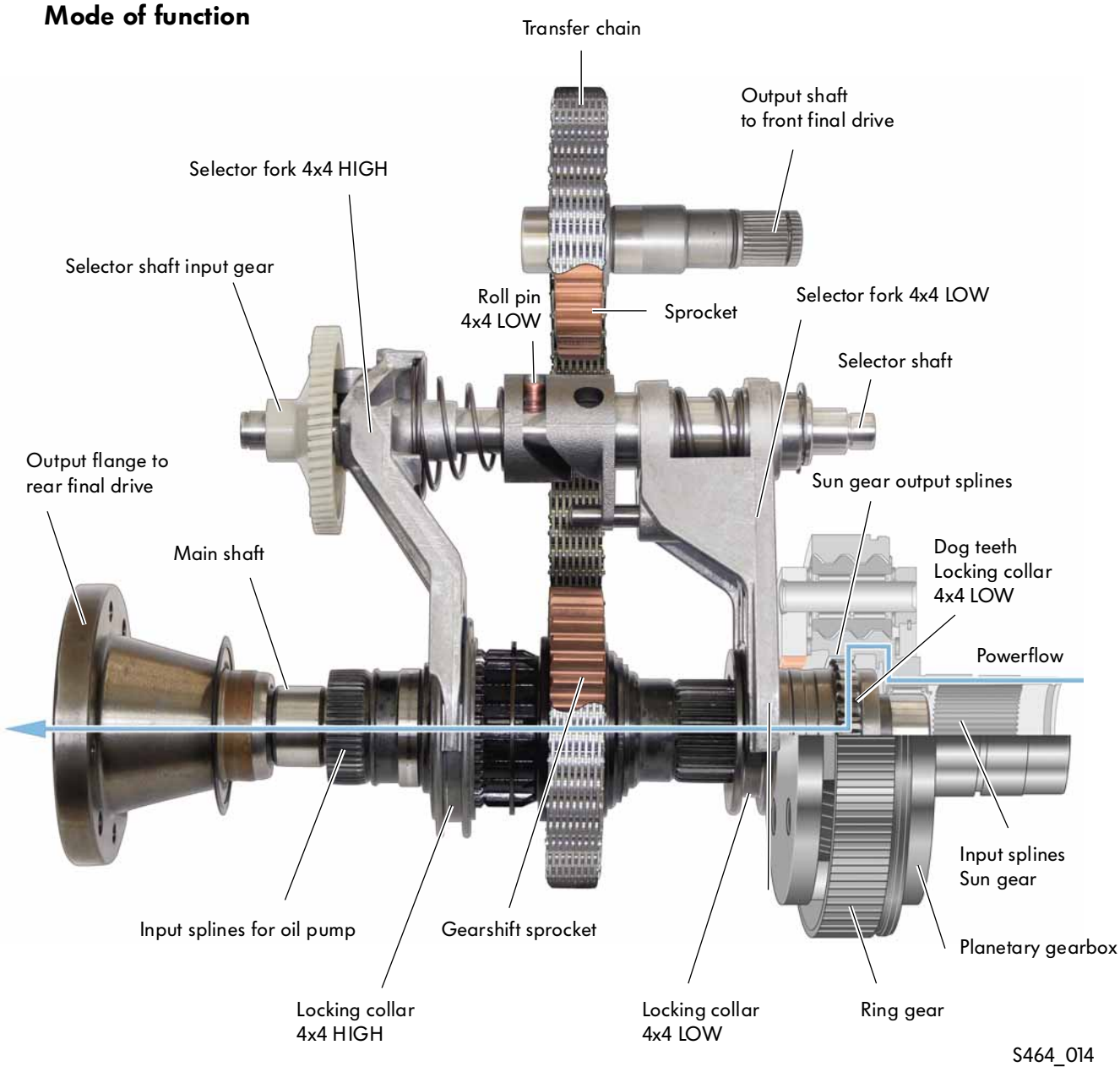


S464_012

Transfer box

Rear final drive 4x2

Mode of function



The main shaft is a shaft that has been drilled through hollow. The main shaft is used for accommodating the gearshift sprocket, both locking collars for 4x4 HIGH and 4x4 LOW and the propshaft flange.
In addition, the drive splines for the oil pump are on the main shaft.

The gearshift sprocket is mounted on the main shaft and can rotate freely.

The 4x4 LOW locking collar is firmly connected to the main shaft by means of its internal splines, and forms a unit with the dog teeth.

Normally, the vehicle is in 4x2 mode – in which case only the rear axle is driven.
Both selector forks for 4x4 HIGH and 4x4 LOW are in their rest position.
The input torque is transmitted from the main gearbox directly via the sun gear of the planetary gearbox onto the main shaft of the transfer box.

Powerflow

Sun gear input splines –> sun gear output splines –> 4x4 LOW locking collar dog teeth –> main shaft –> output flange to rear final drive.

The torque distribution is 100 % to the rear axle.

Planetary gearbox

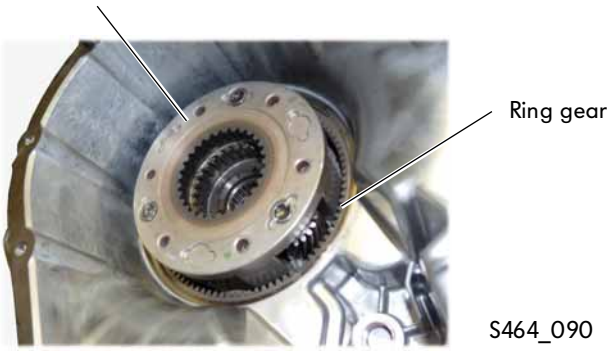
The transmitted torque is always input into transfer box 0C7 via a planetary gearbox on the input end.

It has two functions:

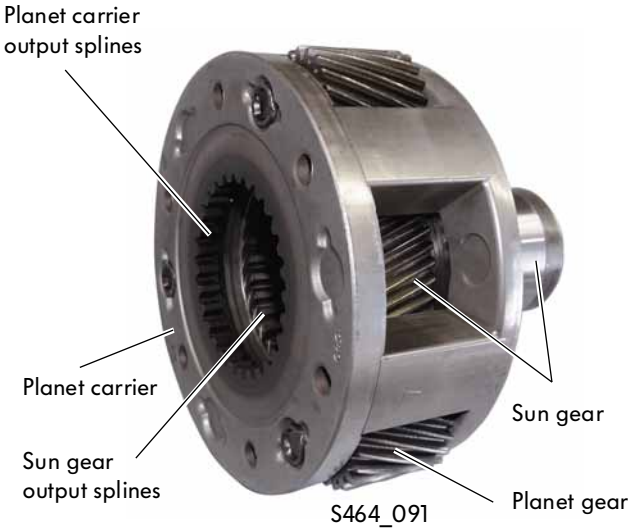
- Force input into the transfer box
- Implementation of offroad range

The planetary gearbox consists of a single planetary gear set. The ring gear of the planetary gearbox is firmly pressed into the gearbox housing. The planet carrier with 3 planet gears runs in this ring gear.
The sun gear is inserted into the planet carrier to drive the planet gears. The planet gears simultaneously engage in the driving sun gear and the ring gear and the planet carrier.

(The planet carrier is only half inserted into the ring gear in order to clarify the view)

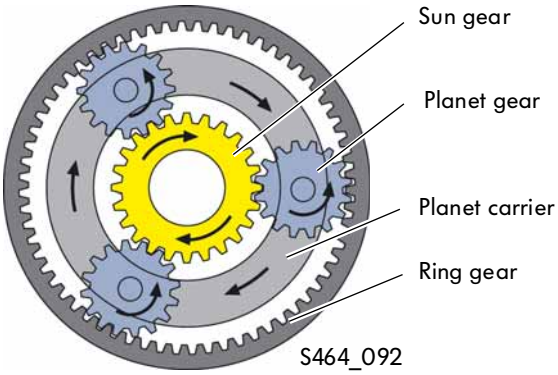


S464_090



S464_091

Single planetary gear set (schematic view)



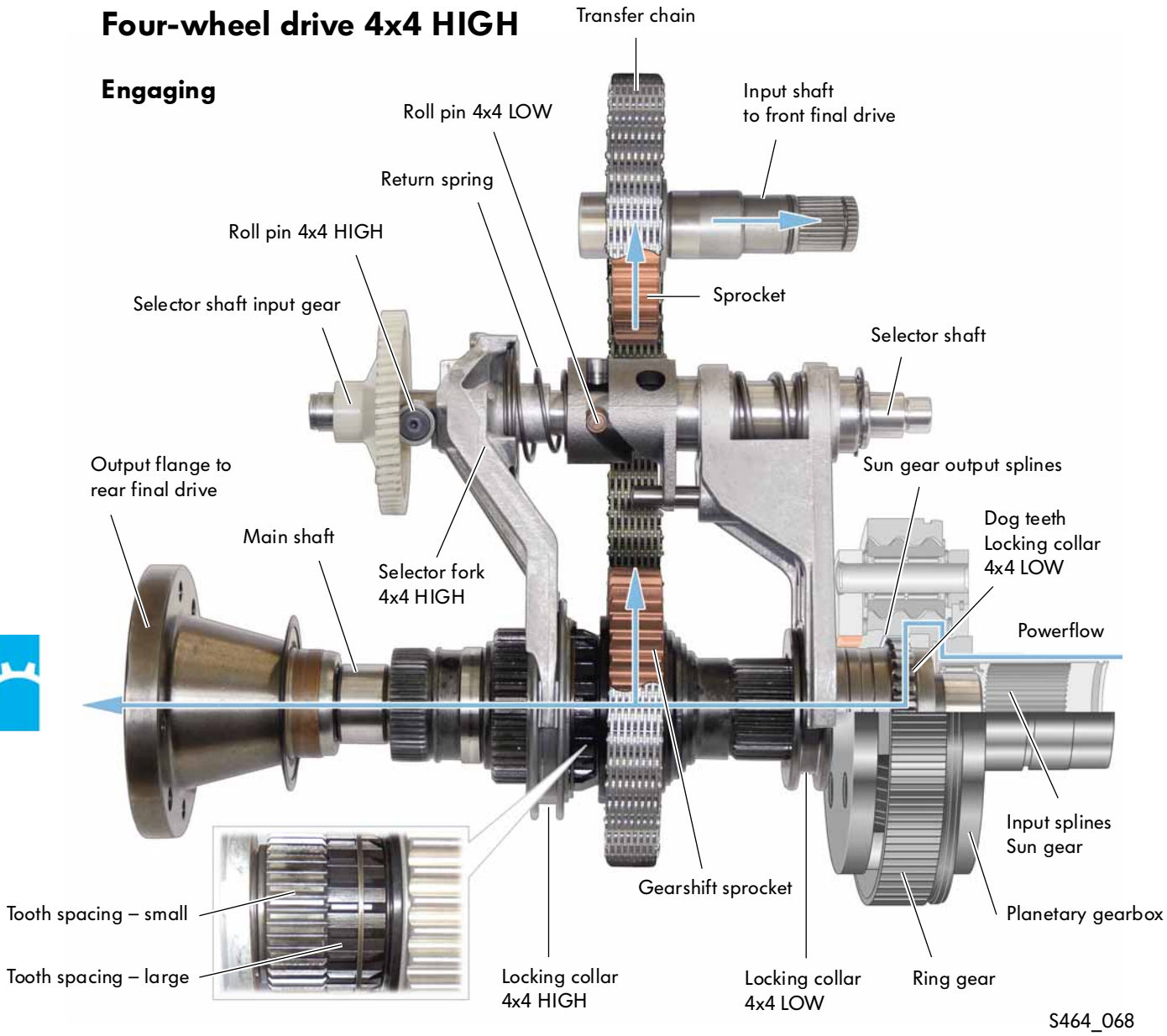
S464_092

The ratio means that the planet carrier rotates with a lower speed than the driving sun gear – this is the reduction. The output splines of the planet carrier (4x4 LOW) and the output splines of the sun gear (4x2, 4x4 HIGH) transmit the input torque on to the 4x4 LOW locking collar and the main shaft.

Transfer box

Four-wheel drive 4x4 HIGH

Engaging



In order to engage 4x4 mode, the transfer box control motor V455 is energised by the transfer box control unit J646 with a pulse-width modulated signal. The motor rotates the selector shaft via the input gear through 90° clockwise. When this happens, the 4x4 HIGH roll pin firmly connected to the selector shaft pushes the 4x4 HIGH selector fork towards the gearshift sprocket by means of a control ramp.
4x4 mode is activated by the 4x4 HIGH locking collar being moved along the straight-splined dog teeth of the gearshift sprocket. The gearshift sprocket is now in a fixed rotating connection with the main shaft.

Powerflow

Sun gear input splines –> sun gear output splines –> 4x4 LOW locking collar dog teeth –> main shaft –> output flange to rear final drive/gearshift sprocket –> transfer chain –> sprocket –> Output shaft to front final drive.

4x4 mode represents a 100% interaxle lock between the front axle and rear axle.
As a result, the input torque is evenly distributed between the front and rear axles.

The gearshift procedure is not synchronised.

4x4 mode can be engaged at any driving speed. During driving, there can in some cases be very small rotation speed differences between the front and rear axles (due to slip, the road surface, different tyre wear, etc.).

To facilitate engaging 4x4 mode whilst driving, the tooth pitch on the dog teeth of the gearshift sprocket is twice as large as that of the main shaft. When 4x4 mode is engaged, this system means there is an idle travel in the powerflow to the front final drive amounting to a few degrees of angle. This idle travel is not a fault, nor does it lead to any restrictions in driving comfort or impairments in the durability of the transfer box.

Disengaging

The shift back to 4x2 mode is performed by the control motor for the interaxle lock turning the selector shaft through about 90° anticlockwise. The selector fork is pushed back into the 4x2 position solely by the effect of the return spring in this case.

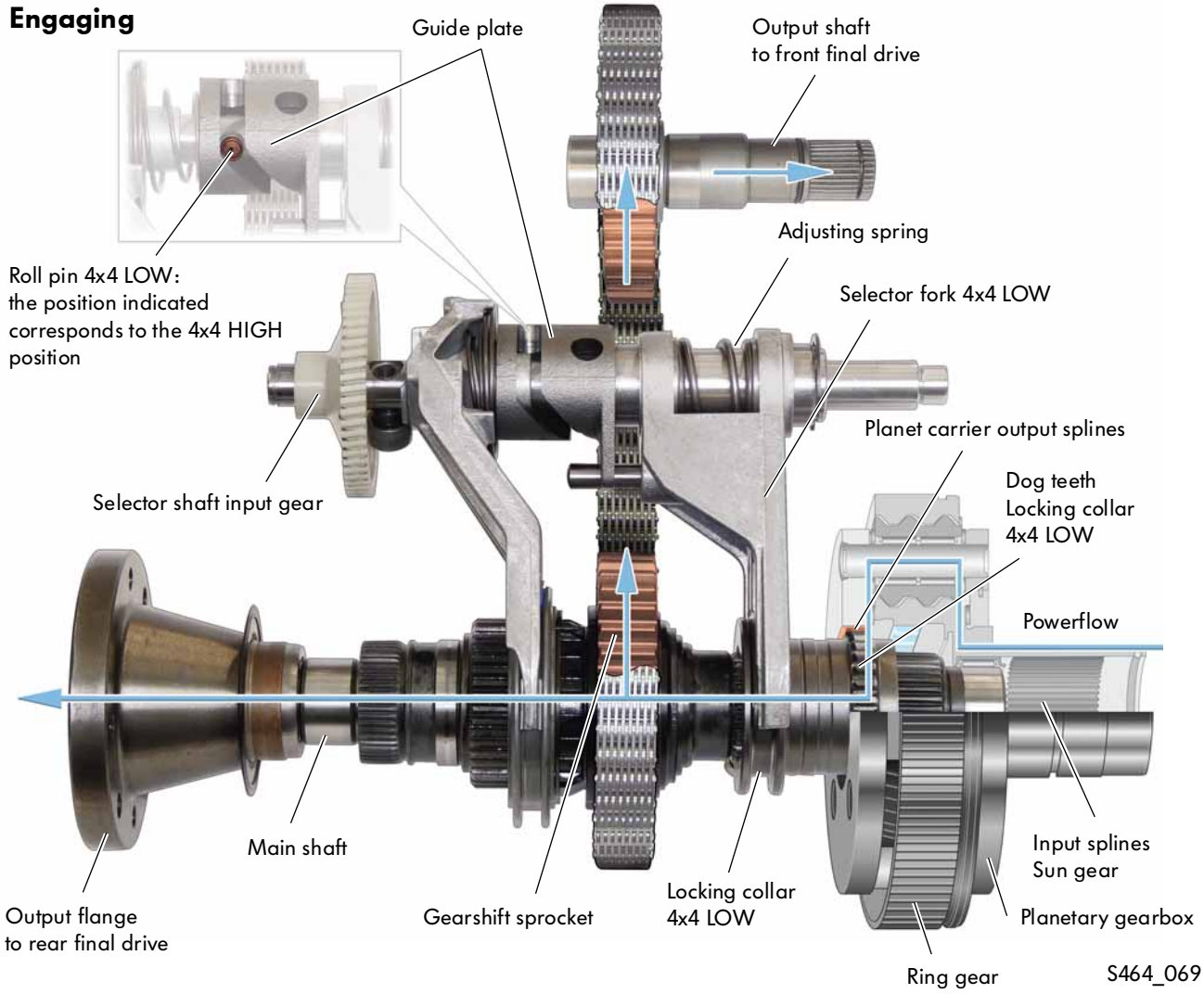
Due to the driving situation, torque wind-up can occur in the driveline in 4x4 mode under certain circumstances. This tension cannot be dissipated when driving on ground that does not permit wheel slip. The tension leads to increased static friction between the locking collar and the dog teeth of the gearshift sprocket.

Static friction means that the locking collar remains in its position when 4x4 mode is deactivated. As soon as the tension has been dissipated by a load change or change of steering direction during driving, the selector fork is moved back to the 4x2 position subsequently by the return spring.

Transfer box

Offroad range 4x4 LOW

Engaging



To engage 4x4 LOW offroad range, the transfer box control motor V455 is energised by the transfer box control unit J646 with a pulse-width modulated signal. The motor turns the selector shaft starting from 4x4 HIGH position via the input gear through about 120 – 130° clockwise. When this happens, the 4x4 LOW roll pin that is firmly connected to the selector shaft pushes the 4x4 LOW selector fork into 4x4 LOW position via the guide plate. (The roll pin can no longer be seen in this engagement position – it is now covered, on the rear of the guide plate.)

The system design means that the reduction can only be engaged after 4x4 HIGH has been engaged.

The gearshift procedure is not synchronised, and is only possible when the vehicle is stationary.

Powerflow

Sun gear input splines –> planetary gearbox –> planet carrier output splines –> 4x4 LOW locking collar dog teeth –> main shaft –> output flange to rear final drive/gearshift sprocket –> transfer chain –> sprocket –> output shaft to front final drive.
The ratio of the reduction stage (offroad range) is i = 2.72 in all vehicles.

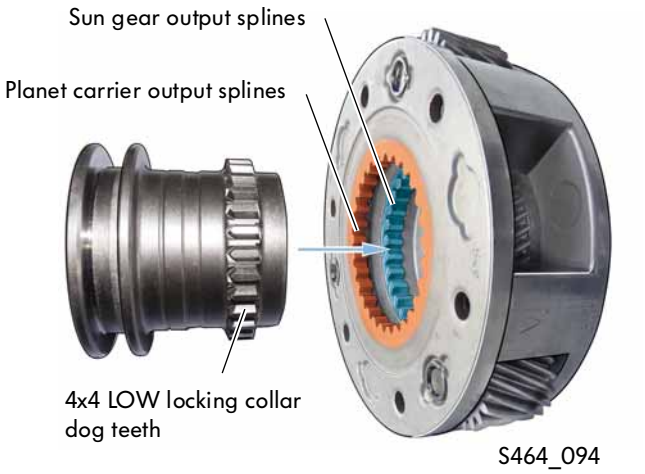
Disengaging

To switch back to 4x4 HIGH, the control motor for the interaxle lock rotates the selector shaft anticlockwise back to the 4x4 HIGH position. The selector fork is moved back along the gate guide into its initial position in this case. The powerflow is now direct from the sun gear to the main shaft without a reduction.

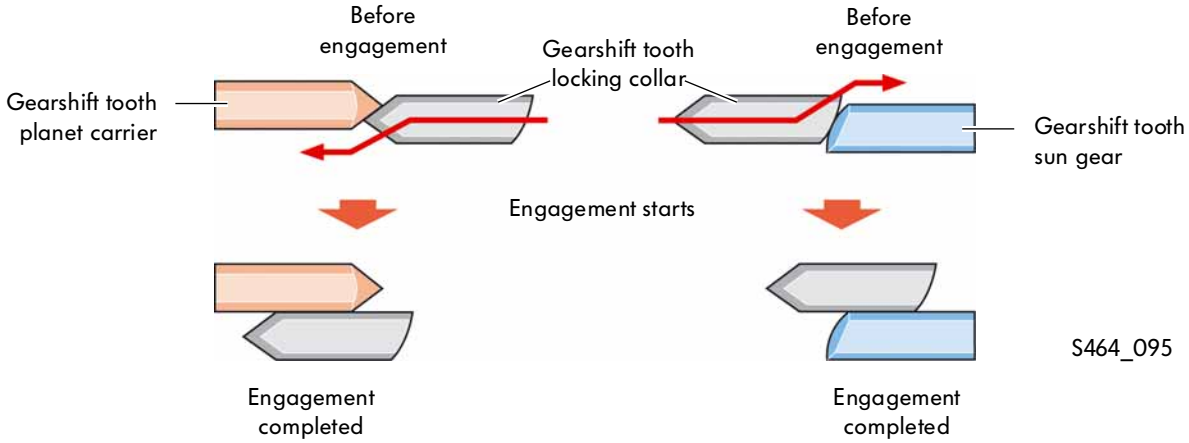
Adjusting spring

The adjusting spring acts in both directions of movement of the 4x4 LOW selector fork. It operates the 4x4 LOW selector fork. In the normal gearshift procedure, the spring is located in its position without tension. The inclined profiles of the dog teeth on the 4x4 LOW locking collar and the planetary gear set means that the engagement generally takes place without resistance.
In case of "tooth-on-tooth" positions, the adjusting spring is preloaded by the rotation of the selector shaft. As soon as the angle position of the sun gear changes by a minimum amount, the engagement procedure can take place with the pre-imposed spring force of the adjusting spring. If the aforementioned situation occurs ("tooth-on-tooth" positions) then the design of the system means there may be grating noises. For this reason, it is advantageous for the gearbox to be shifted to neutral when engaging and disengaging 4x4 LOW, so as to minimise the probability of gearshift grating.

The dog teeth on the locking collar and in the planetary gearbox have symmetrically angled tooth flanks for shifting from HIGH to LOW and asymmetrically angled tooth flanks for shifting from LOW to HIGH. The angled tooth flanks that operate in both movement directions of the dog teeth support the gearshift procedure when engaging and disengaging 4x4 LOW. The dog teeth from LOW to HIGH are optimised for forwards driving because of the asymmetrical tooth flank position.



Engagement of locking collar spines in planet carrier splines **Engagement of locking collar spines in sun gear splines**

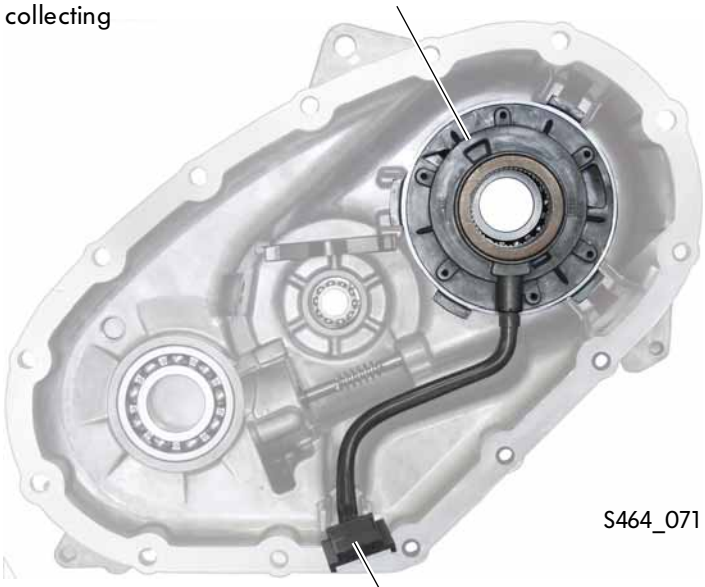


Oil supply

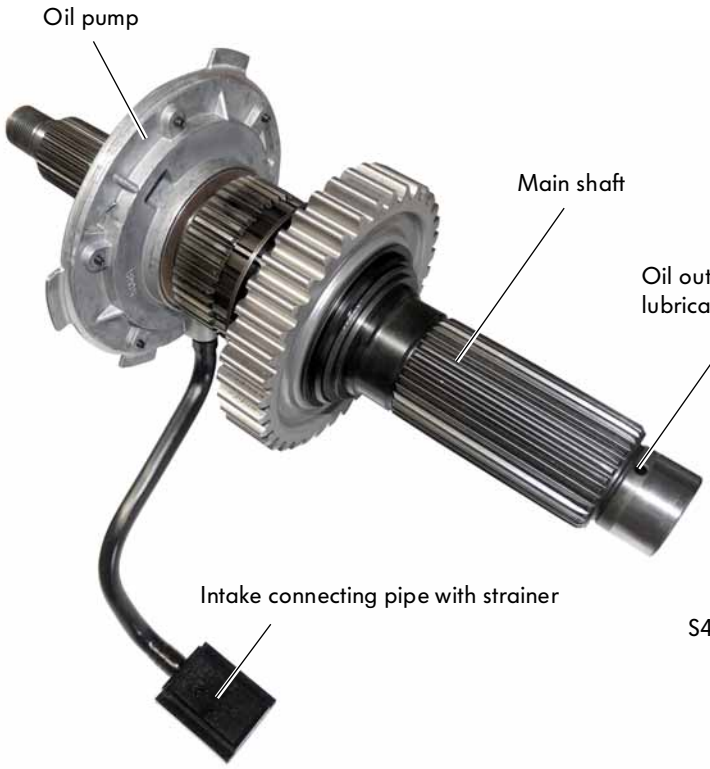
Lubricating oil is supplied by means of force-feed circulating lubrication. The oil pump driven by the main shaft splines supplies the lubricating points by means of oil ducts in the drilled-out main shaft.

The oil pump is configured as a rotor pump.

The oil is drawn in through a suction pipe with oil strainer from the lowest point in the housing. Under the strainer, there is a magnet for collecting ferromagnetic abrasion.



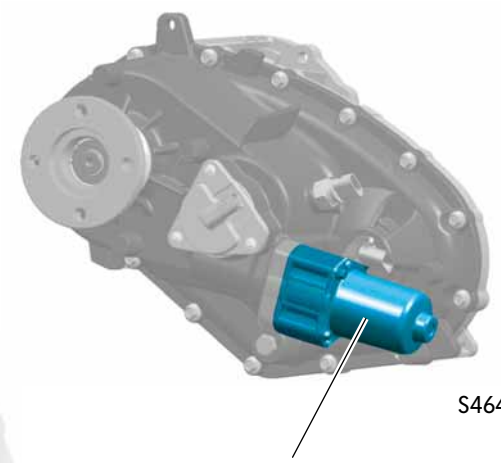
S464_071



S464_096

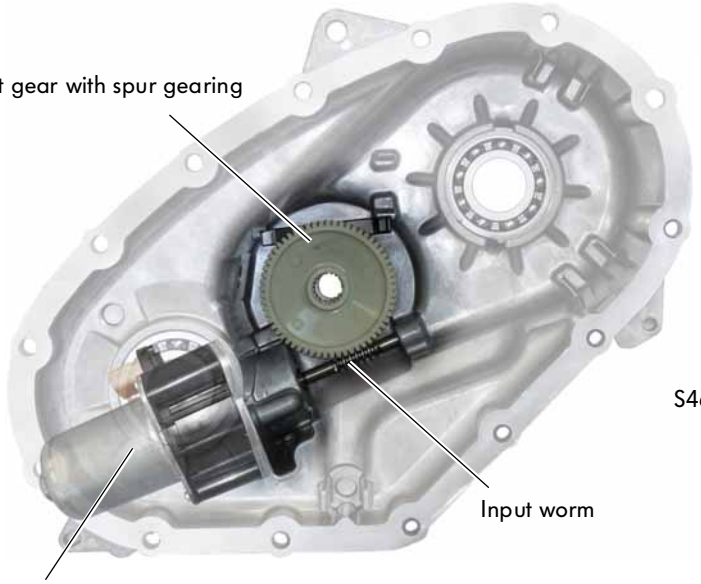
Selector shaft drive

The transfer box control motor V455 bolted onto the gearbox housing is connected to the input worm. The input worm rotates the input gear of the selector shaft via spur gearing.



S464_086

Transfer box control motor V455



Input gear with spur gearing

Input worm

Transfer box control motor V455

S464_070

Transfer box control motor V455

Output to input worm

S464_097

Transfer box control motor V455

Task

The control motor rotates the selector shaft mechanically in order to engage the required drive mode, 4x2, 4x4 or 4x4 LOW.

Mode of function

The control motor operates as a permanent magnet electric motor, in which case the motor is controlled via a PWM signal from the transfer box control unit J646.

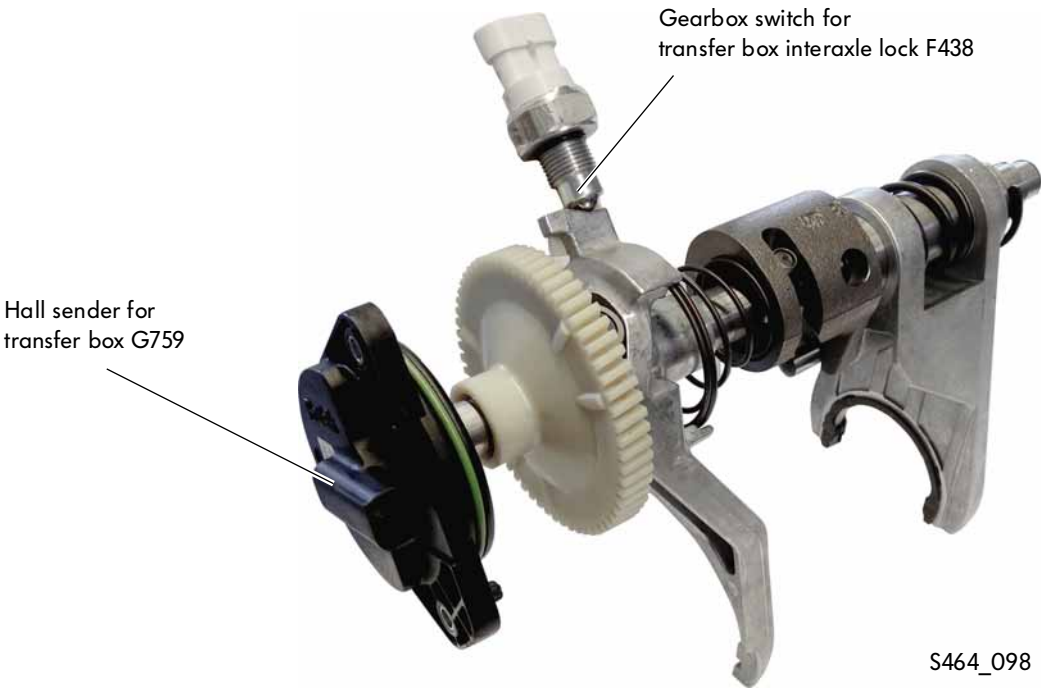
Effects in case of failure

- Fault entry in error memory
- Flashing warning lamp in dash panel insert
- No gearshift procedure possible any longer
- The transfer box remains in the position that was last engaged.

Transfer box

Control of the transfer box

Two sensors are required for registering the system statuses and for controlling the gearshift procedures in the transfer box. They supply the transfer box control unit J646 with all the information required.



S464_098

Hall sender for transfer box G759

Task

- Position detection of the selector shaft.
- Control of the gearshift procedures in the transfer box.

The Hall sender outputs a voltage level according to the position of the selector shaft.

- 4x2 = 4.0 V
- 4x4 HIGH = 2.0 V
- 4x4 LOW = 1.0 V

S464_085

Effects in case of failure

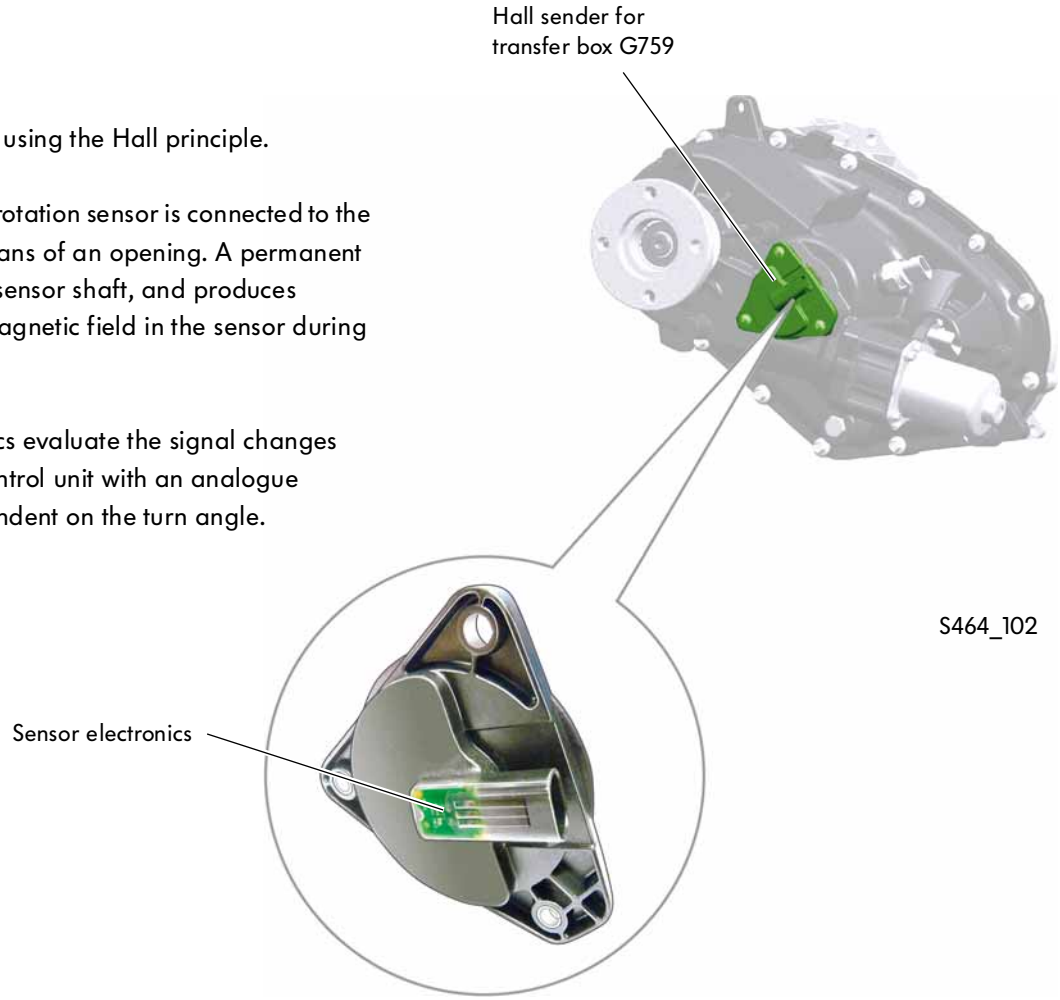
- Fault entry in error memory
- Flashing warning lamp in dash panel insert
- No gearshift procedure possible any longer
- The transfer box remains in the position that was last engaged.

Mode of function

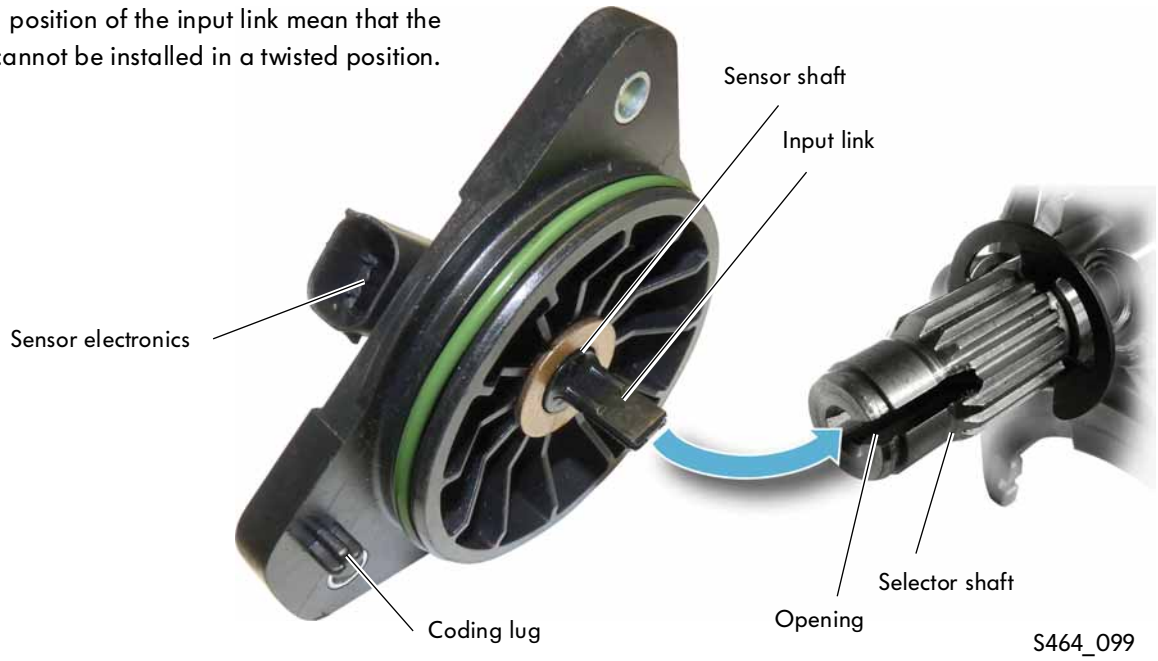
The sensor operates using the Hall principle.

The input link of the rotation sensor is connected to the selector shaft by means of an opening. A permanent magnet acts on the sensor shaft, and produces fluctuations in the magnetic field in the sensor during rotation.

The sensor electronics evaluate the signal changes and provides the control unit with an analogue voltage that is dependent on the turn angle.



The Hall sender for transfer box G759 is bolted on in the rear housing of the transfer box. 3 asymmetrically arranged securing bolts, a coding lug and the asymmetrical position of the input link mean that the Hall sender cannot be installed in a twisted position.



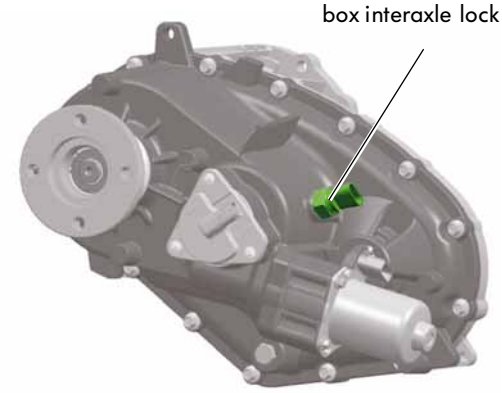
Transfer box

Gearbox switch for transfer box interaxle lock F438

Mode of function

The gearbox switch F438 operates as a simple mechanical button. It is controlled by a ramp on the 4x4 HIGH selector fork.

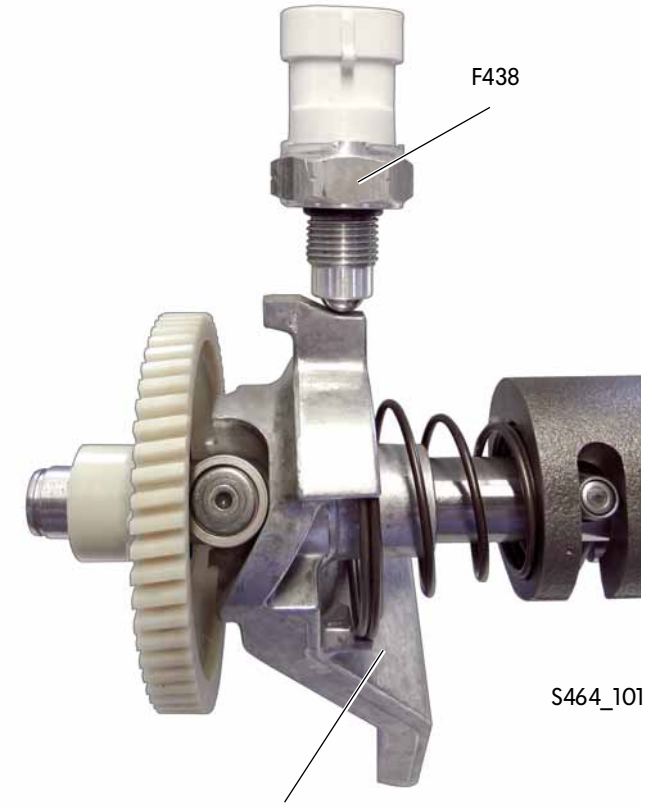
The switch is open in 4x2 mode.



S464_084

Task

- Sensing the actual position of the 4x4 selector fork, i.e. whether four-wheel drive really is disengaged and the selector fork is in the 4x2 position.
- In addition, the control logic of the longitudinal lock-up warning lamp K278 is controlled by means of the gearbox switch for transfer box interaxle lock F438. Warning lamp K278 is no longer activated when the transfer box has completed the gearshift procedure into 4x2 more.

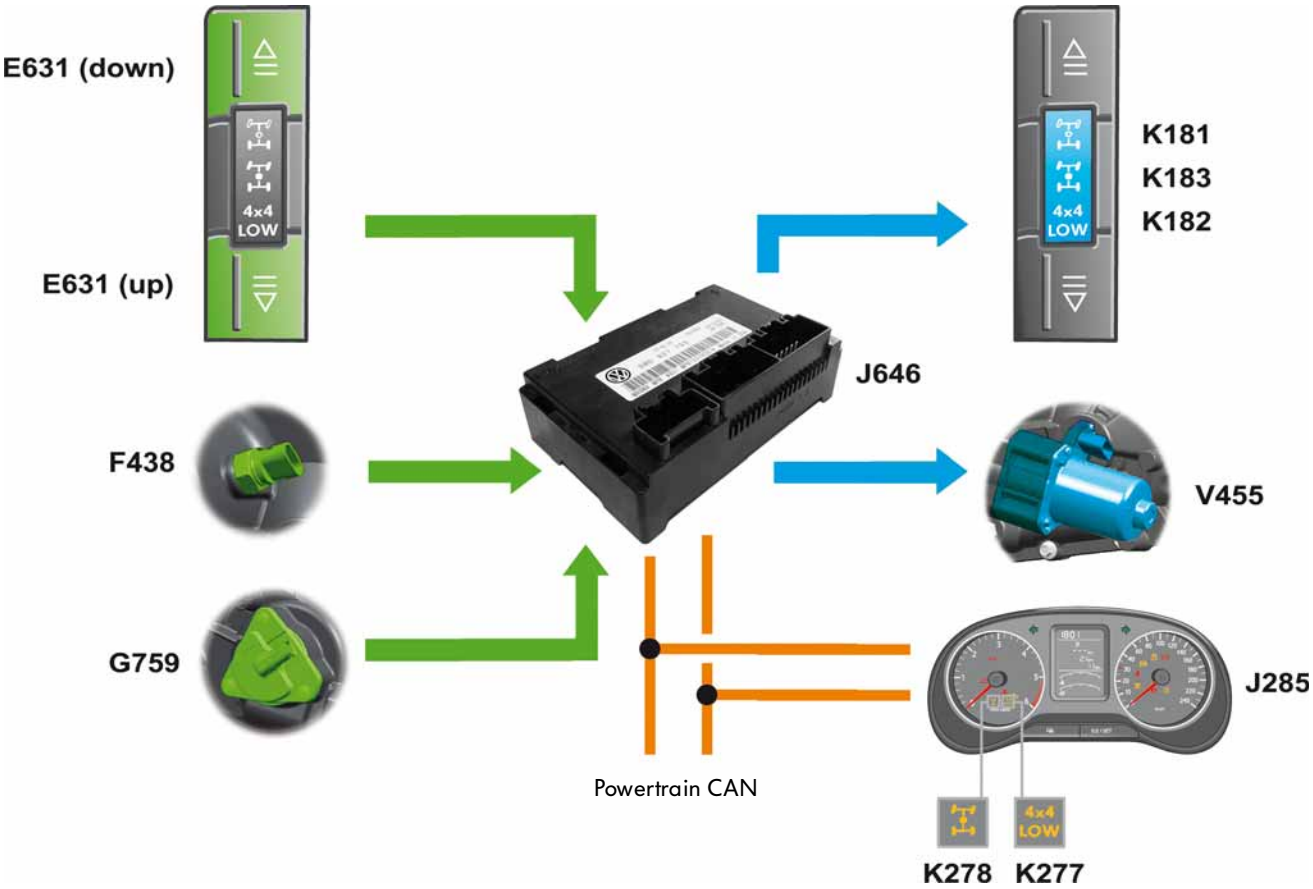


S464_101

Effects in case of failure

- Fault entry in error memory
- Flashing warning lamp in dash panel insert
- No functional restrictions for four-wheel drive.

System overview



S464_035

E631 (down) = Running gear programme switch
E631 (up) = Running gear programme switch
F438 Gearbox switch for transfer box interaxle lock
G759 Hall sender for transfer box
J285 Control unit in dash panel insert
J646 Control unit for transfer box (installed centrally under dash panel)

K181 Normal operation warning lamp in transfer box operating unit
K182 Reduction gearing warning lamp in transfer box operating unit
K183 Longitudinal lock-up warning lamp in transfer box operating unit
K277 Warning lamp for gearbox low range
K278 Longitudinal lock-up warning lamp
V455 Servomotor for transfer box

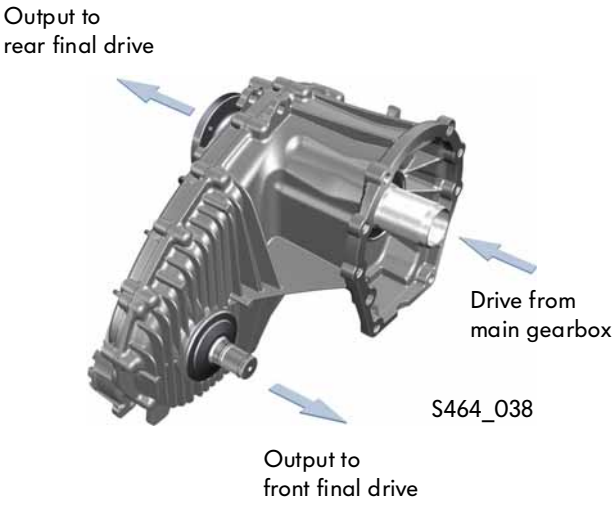
Transfer box

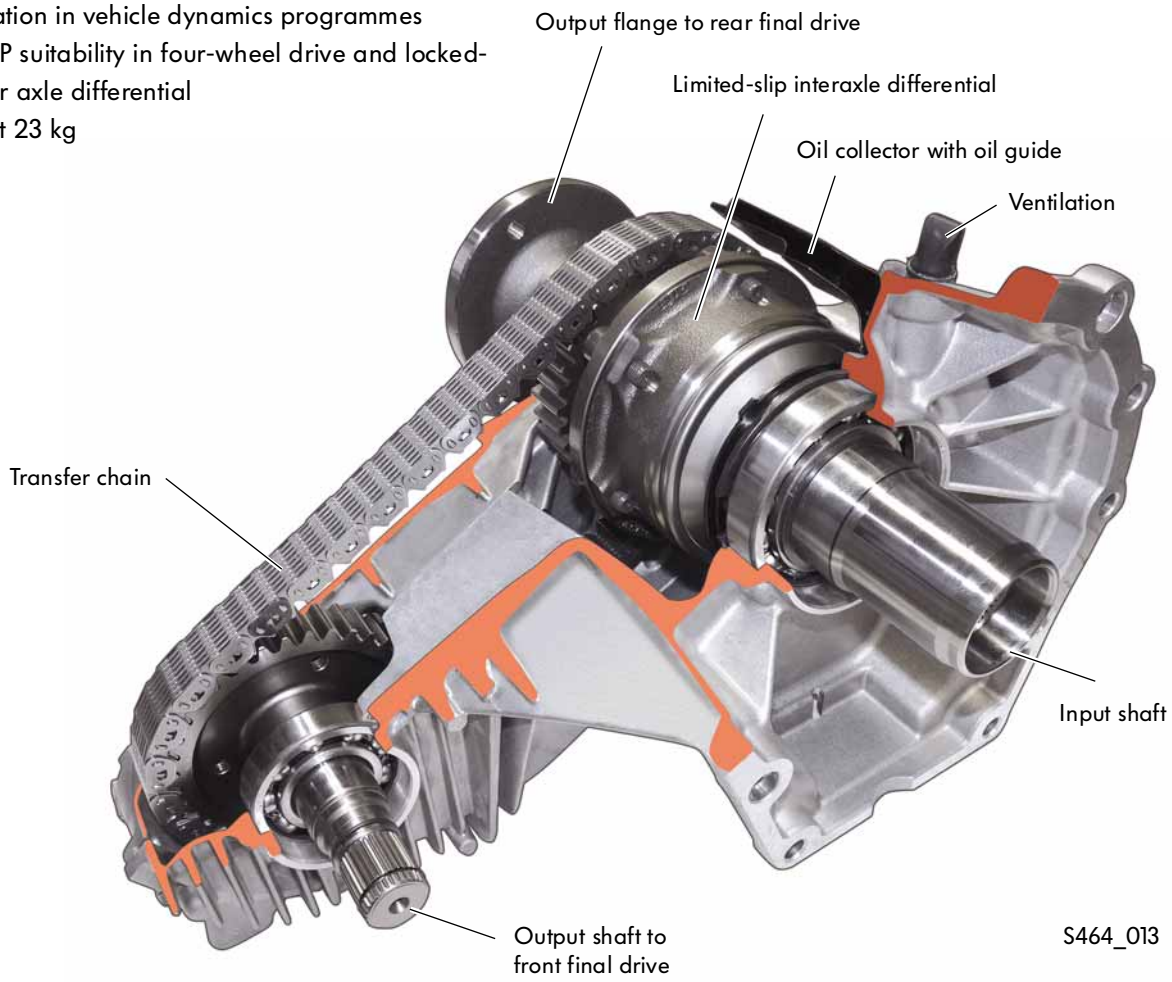
The transfer box with limited-slip interaxle differential 0BU

The design of the transfer box with limited-slip interaxle differential is based on the transfer box of the Audi Q7 and the Touareg 2011. It has been adapted for use in the Amarok.

Technical features

- Modern "four-wheel drive" technology in the Amarok
- Sturdy system operating purely mechanically
- Suitable for onroad and offroad use
- Permanent four-wheel drive
- Differential compensation between the front and rear axles
- Limited-slip interaxle differential with basic distribution of the input torque (when driving without slip on the front and rear axles): front axle = 40 %, rear axle = 60 %
  Variable torque distribution: front axle = 20 – 60 %, rear axle = 40 – 80 %
- Integration in vehicle dynamics programmes
- Full ESP suitability in four-wheel drive and locked-up rear axle differential
- Weight 23 kg



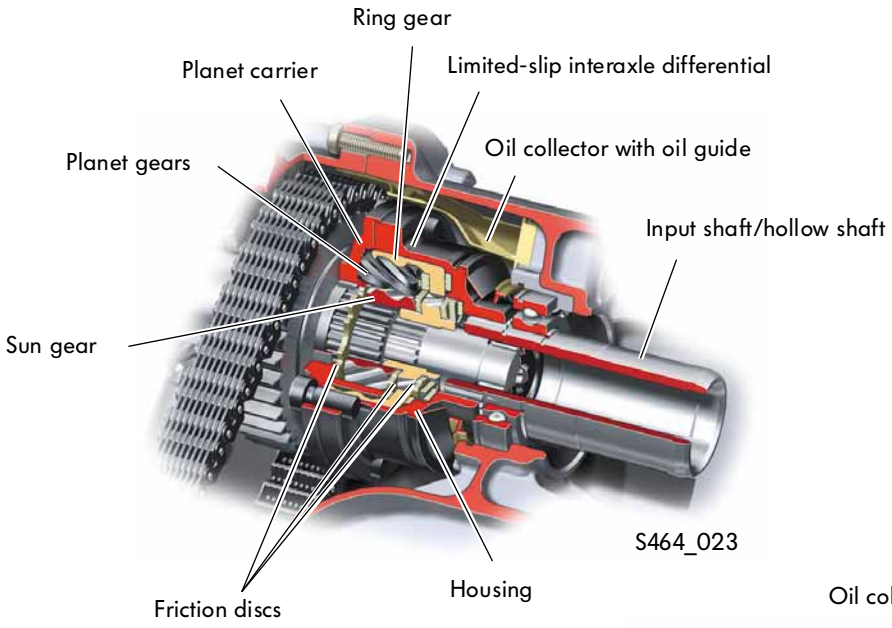


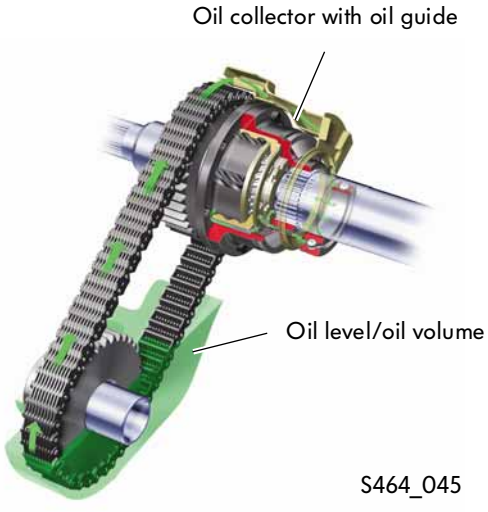
Limited-slip interaxle differential type C

The limited-slip interaxle differential, firstly, compensates for rotation speed differentials between the front and rear axles and, secondly, dynamically adjusts the input torque distribution between the front and rear axles depending on the wheel slip.

The basis structure of the limited-slip interaxle differential corresponds to a single planetary gear set with planet carrier, planet gears, ring gear and sun gear.

In addition, friction discs made from nickel steel are fitted in the interaxle differential. These friction discs and the ATF oil significantly influence the friction torque and therefore the slip value of the differential. The friction torque comes about through the self-locking effect of the helical gearing and by the contact pressure of the sun gear and ring gear on the friction discs.





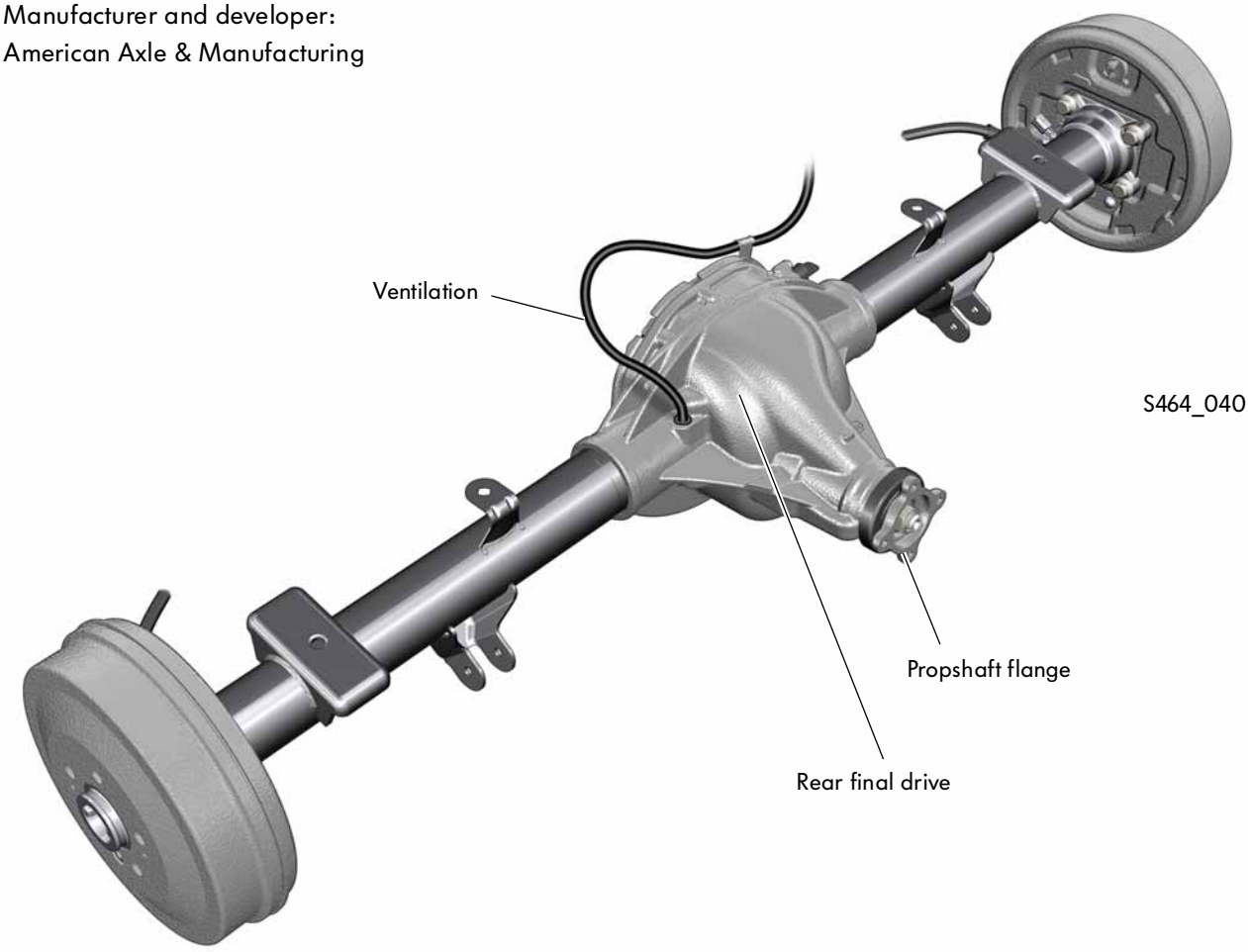
For more information about the design and function of the limited-slip interaxle differential, refer to self-study programme 363 "Audi Q7 powertrain/transfer box 0AQ" and self-study programme 469 "The Touareg 2011 – running gear and four-wheel drive concept".

The rear final drive 0CC

The rear final drive in the Amarok drives via a newly developed rigid axle with leaf suspension and drum brakes.

This axle represents a basic design feature for all variants of the Amarok.

Manufacturer and developer:
American Axle & Manufacturing



Advantages of the rigid axle:

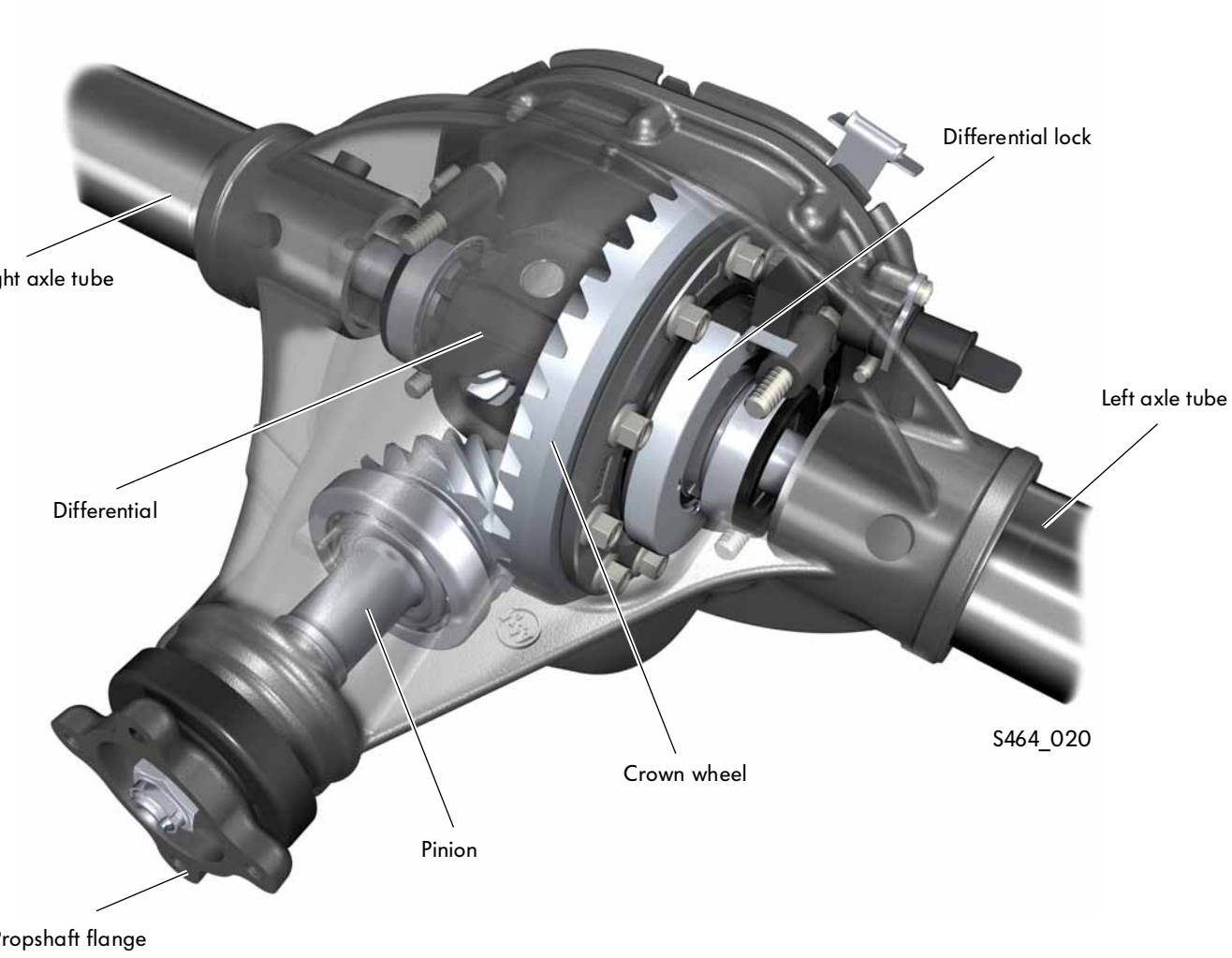
- Wheel guidance with constant toe and camber over the entire suspension travel
- No reduction in ground clearance in compression travel
- Large load volume
- Robust design

Rear final drive

The rear final drive is currently produced with 2 different ratios

i = 4.1 for 120kW TDI engine and

i = 4.3 for 90kW TDI engine and 118kW FSI engine



Optionally, the rear final drive is available with an electrically engaged differential lock for all vehicle variants

Rear final drive 0CC

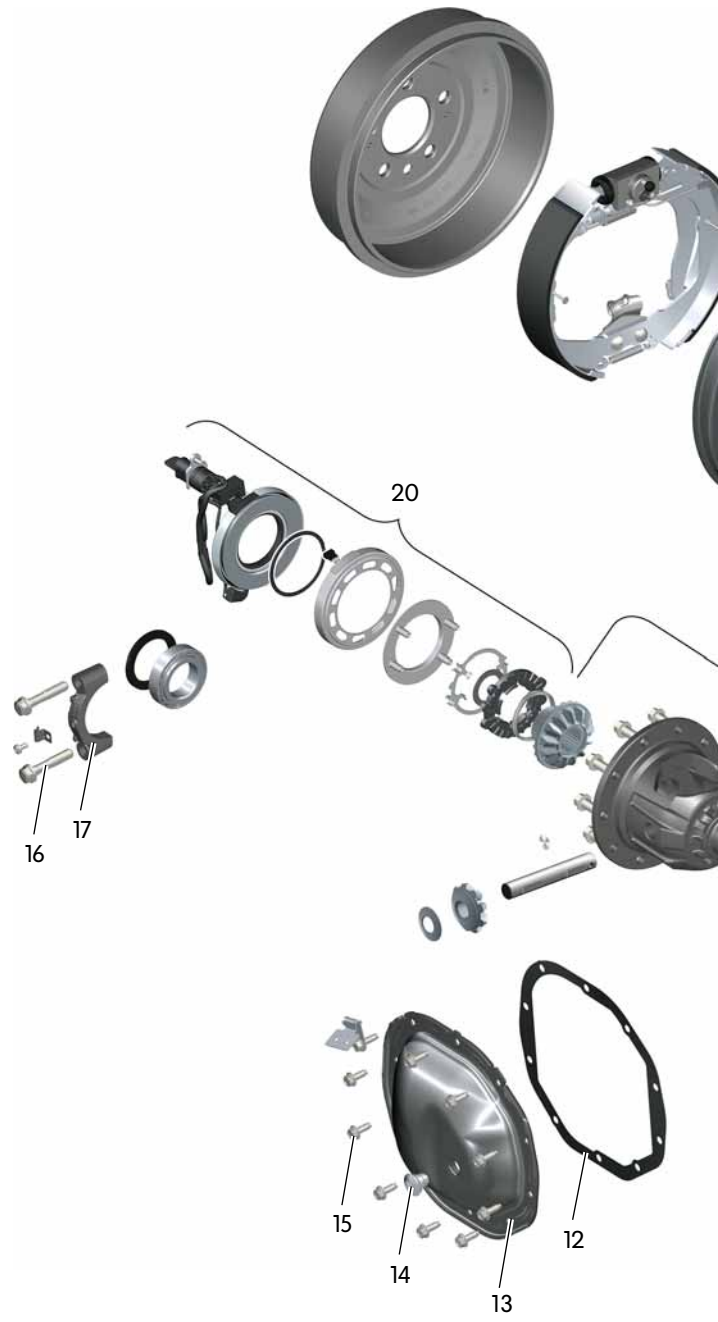
Component overview

The final drive housing is positioned in the centre of the axle and is made from grey cast iron. The axle tubes are made of a steel tube and are welded onto the final drive housing. The stub shafts are solid shafts.

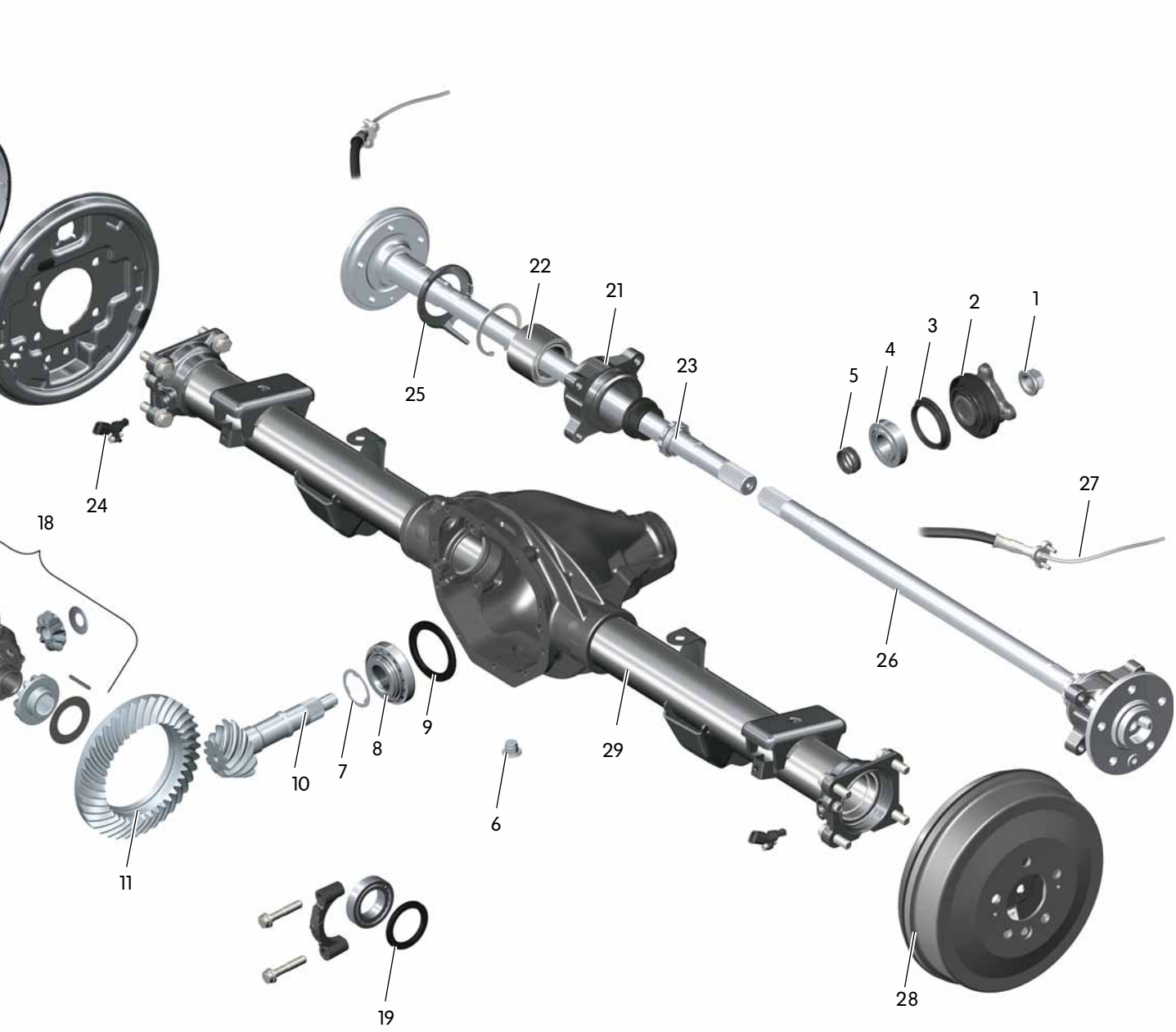
The position of the pinion in relation to the crown wheel is set using a shim behind the inner bearing of the pinion. The bearing preload for the pinion is set using a ram sleeve.

The oil filler plug is located in the housing cover. Only vehicles with a differential lock have an oil drain plug fitted.

Venting is provided by a hose into the ladder frame.



1	Pinion collar nut
2	Propshaft flange
3	Shaft oil seal
4	External tapered roller bearing
5	Ram sleeve
6	Oil drain plug
7	Thrust washer
8	Inner tapered roller bearing
9	Shim
10	Pinion
11	Crown wheel
12	Housing cover seal
13	Housing cover
14	Oil filler plug
15	Bolt
16	Bolt
17	Bearing support
18	Differential with housing
19	Shim
20	Differential lock
21	Wheel hub
22	Wheel bearing

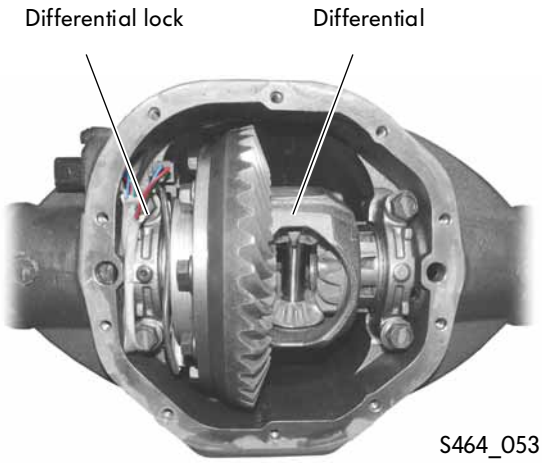


S464_021

23 Wheel bearing collar nut
24 Wheel speed sensor
25 Oil drain
26 Stub shaft
27 Handbrake cable
28 Drum brake
29 Axle tube

Differential lock

The differential lock is activated by means of the rear differential lock switch E121 in the centre console. The status display is located in the dash panel insert. ESP and ABS are deactivated (depending on equipment and variants) when the differential lock is activated.



Function

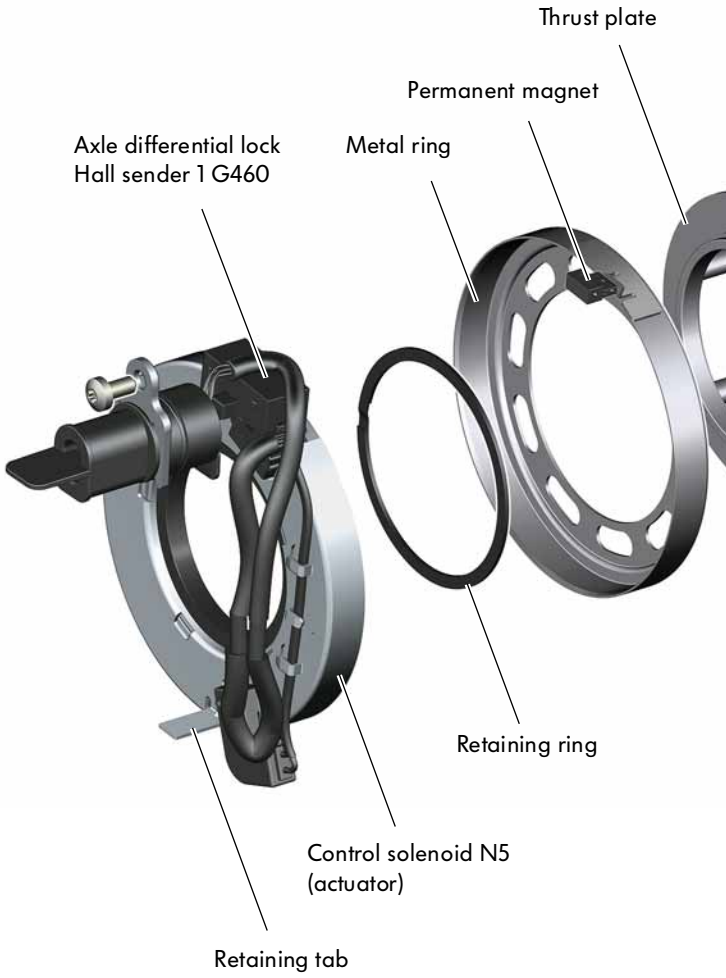
The differential lock is controlled by a differential lock control unit J187 incorporated in the powertrain CAN, which is fitted on the centre console close to the handbrake lever.

- G460 = Axle differential lock Hall sender 1 (sensor for detecting position of differential lock)
- N5 = Control solenoid (actuator)

The actuator is connected to the axle housing in a rotationally fixed arrangement via the retaining tabs. The pressure plate and shift dog are connected to the differential housing in a rotationally fixed arrangement.

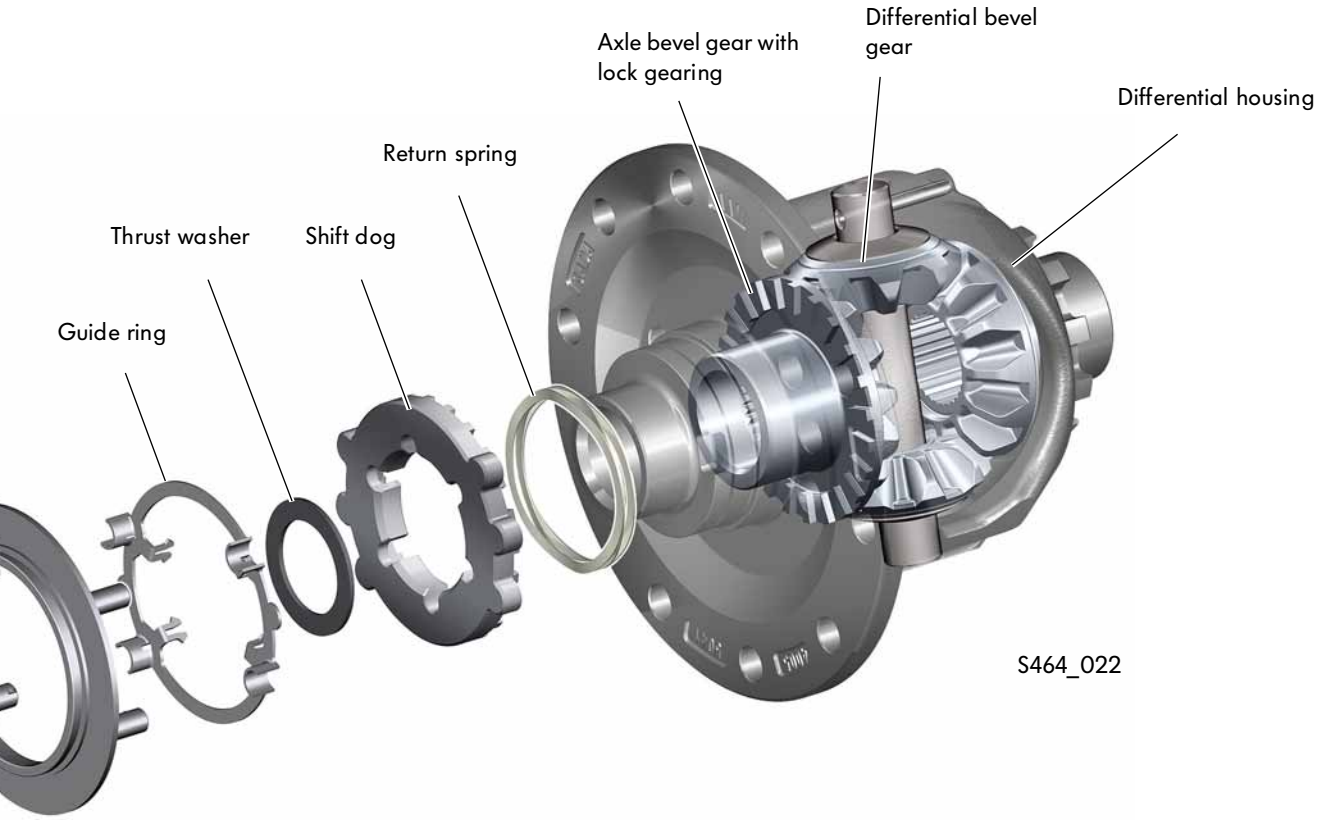
When the differential lock is activated, the magnetic coil of the differential lock control unit J187 integrated in the actuator is energised. The control solenoid moves out and presses against the shift dog via a metal ring and the thrust plate. The shift dog engages in the lock gearing of the axle bevel gear and blocks it.
The axle bevel gear is now connected to the differential housing in a rotationally fixed arrangement. This means the differential is locked. The magnetic coil is energised with pulse width modulation in order to avoid impermissible heating of the control solenoid. The control unit processes the signals from the axle differential lock Hall sender 1 G460 for activation purposes.

Component overview



The axle differential lock Hall sender 1 G460 is fitted on control solenoid N5 (actuator).

This position sensor operates according to the Hall principle – it detects the actual position of the control solenoid or pressure plate. This means the differential lock control unit J187 is informed of the actual position of the differential lock (opened, actuated, "tooth-on-tooth" position). The control solenoid must remain energised for the entire duration of the activation.



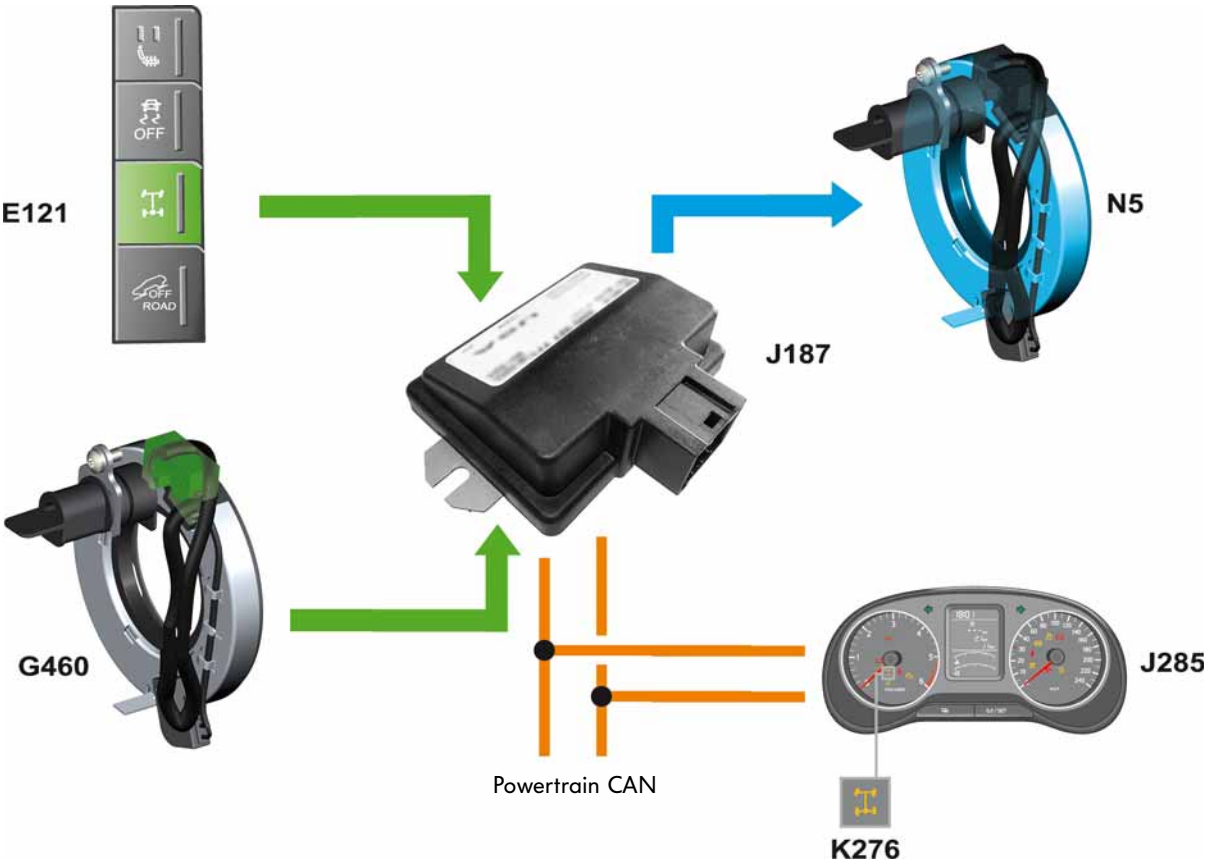
When the lock has been deactivated, the shift dog is returned to its rest position by means of a return spring.

Following repair work, the differential lock control unit J187 must be adapted to the axle differential lock Hall sender 1 G460 using the VAS diagnostic tester.

The final drive must be removed in order for some repair work to be performed on the differential lock. Measuring and setting work is required for this.

For more information about repair work, see ELSA.

System overview – differential lock



S464_067

E121 Rear differential lock switch
G460 Axle differential lock Hall sender 1
J187 Differential lock control unit
J285 Control unit in dash panel insert
K276 Warning lamp for rear transverse lock
N5 Control solenoid

The front final drive 0C1

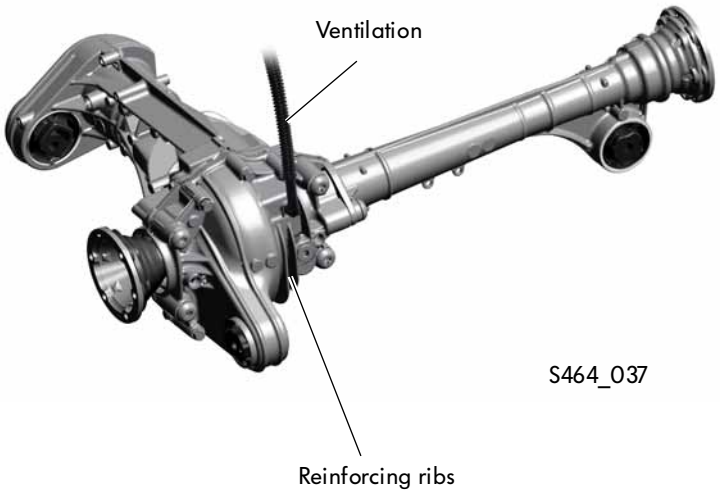
The design of the front final drive is based on the technology of the VW Touareg and the Audi Q7.

Two different versions of it are installed in the Amarok, depending on the drive type.

Both variants are based on the same design principle.

The manufacturer and developer is
ZF Getriebe GmbH.

Configuration for vehicles with permanent four-wheel drive

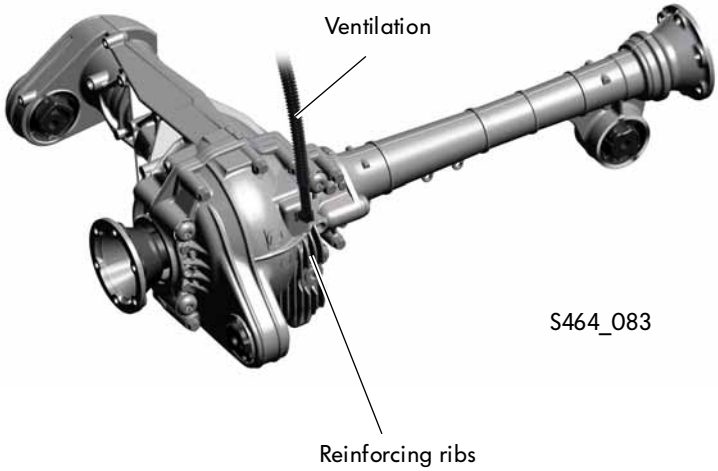


In vehicles with non-permanently engaged four-wheel drive (part time transfer box), relatively high stresses can build up in the drivetrain when driving in four-wheel drive without wheel slip.

Therefore, these vehicles have a reinforced housing with adapted bearings and a larger crown wheel is used.

Ventilation takes place via a hose in the engine compartment in the area of the right inner wing.

Configuration for vehicles with part-time transfer box



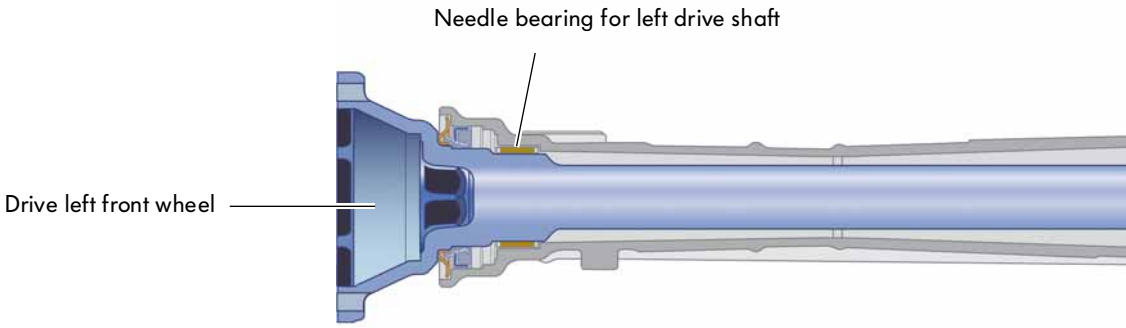
Front final drive 0C1

Structure of the front final drive 0C1

The front final drive 0C1 consists of a bevel gear/crown wheel gearset with hypoid gearing.
The differential effect is achieved using axle bevel gears.

The position of the pinion in relation to the crown wheel is set using a shim in front of the inner bearing of the pinion. The bearing preload is set using a ram sleeve.
The backlash between the bevel gear and crown wheel is adjusted using two shims on the differential housing.

To compensate for the asymmetrical installation position of the front axle box, the left drive flange shaft has been extended accordingly. This means the support torques resulting from the input torques are symmetrically carried by the front axle. Negative effects on the steering properties are thus eliminated.

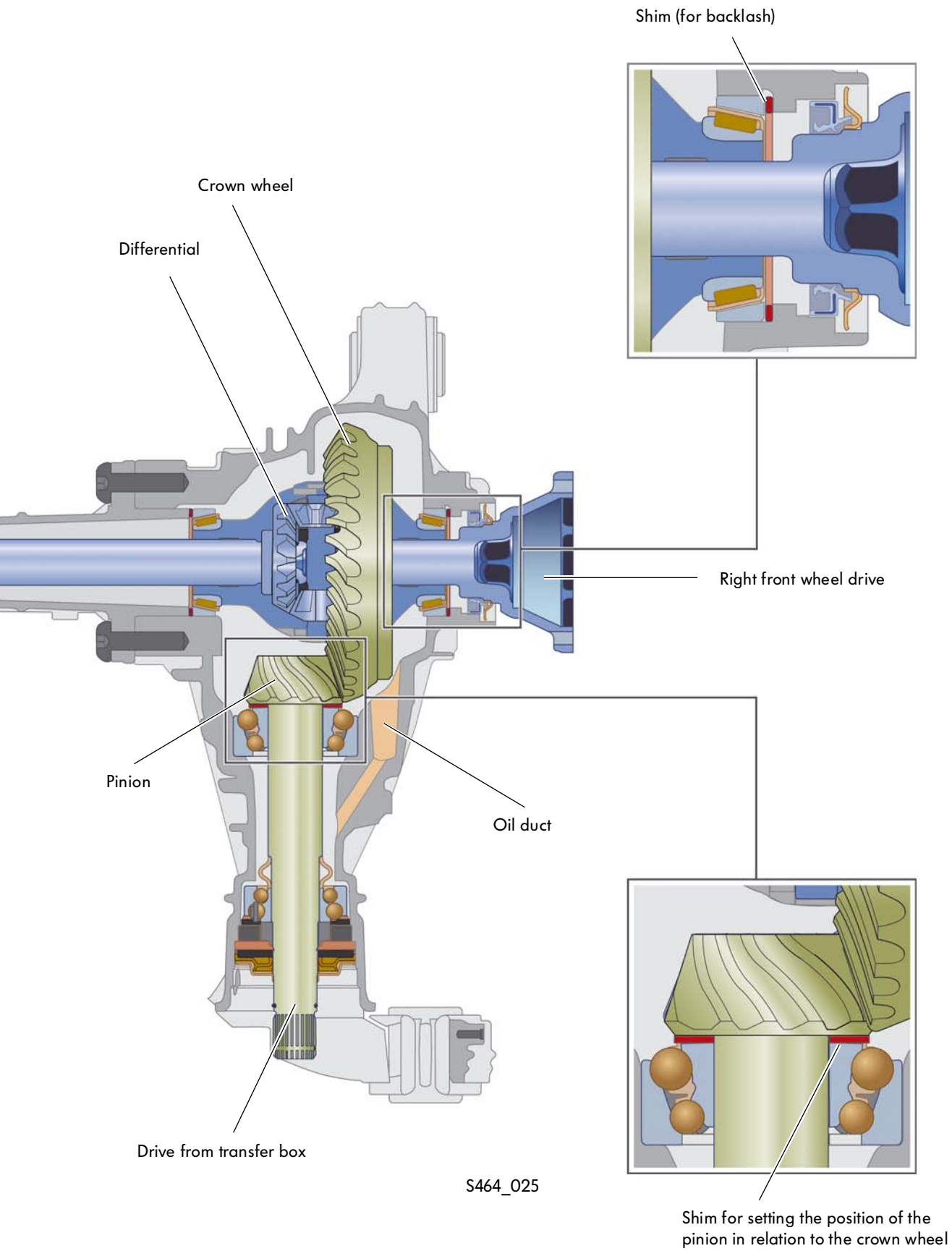


Ratios

The front final drive is offered with two different ratios and two different crown wheel diameters.

Ratio i = 4.1 for 120 kW engine;
Ratio i = 4.3 for 90 kW and 118 kW engines;

Crown wheel diameter: 175 mm in all vehicles with permanently engaged four-wheel drive
Crown wheel diameter: 195 mm in all vehicles with non-permanently engaged four-wheel drive (part-time transfer box)


Shim (for backlash)
Crown wheel
Differential
Right front wheel drive
Pinion
Oil duct
Drive from transfer box
S464_025
Shim for setting the position of the pinion in relation to the crown wheel

Test your knowledge

Which answer is correct?

One or more of the model answers could be correct.

1. Under what conditions can the 4x4 LOW offroad range be engaged?
The following engagement conditions must be met:

☐ a) Engine speed < 1500 rpm, can be engaged at any driving speed, 4x4 HIGH four-wheel drive engaged

☐ b) Engine speed < 1500 rpm, driving speed < 1 km/h, 4x4 HIGH four-wheel drive engaged

☐ c) Engine speed < 1500 rpm, 4x4 HIGH four-wheel drive engaged, differential lock engaged

2. What features apply to the offroad drive programme?

☐ a) The control behaviour of the ABS is adapted. The pressure buildup and pressure holding phases are extended. The depressurisation is shorter and takes place later.

☐ b) The control behaviour of the ABS is adapted. The pressure buildup and pressure holding phases are shortened. The depressurisation is longer and takes place earlier.

☐ c) The control behaviour of the ABS is unchanged. The ASR and EDL control is adapted.

3. What is the task of the adapter shaft in the manual gearbox 0C6?

☐ a) The rear axle in vehicles without four-wheel drive function is driven via the adapter shaft.

☐ b) The drive torque is transferred from the engine to the manual gearbox via the adapter shaft.

☐ c) The drive torque is transferred from the manual gearbox to the transfer box via the adapter shaft.

4. What is the special feature of R gear in the manual gearbox 0C6?

☐ a) There is no reverse shaft in the manual gearbox 0C6. 2nd gear is used for the reversal of the direction of rotation.

☐ b) The synchromeshed gear and synchro-hub of the R gear form one structural unit.

☐ c) The R gear is not synchronised.

5. Which statement regarding the selector mechanism of the manual gearbox 0C6 is correct?

☐ a) The coupling rod always keeps the axis of rotation of the gearshift kinematics at the same distance from the gearbox.

☐ b) The coupling rod engages reverse gear.

☐ c) The coupling rod prevents several gears from being engaged at the same time.

6. What is the gearshift procedure in the non-permanently engaged four-wheel drive 0C1?

☐ a) The return spring holds the 4x4 LOW selector fork firmly in its rest position.

☐ b) In the gearshift procedure from 4x4 HIGH to 4x2 mode, the 4x4 HIGH selector fork is exclusively moved by the force of the return spring.

☐ c) In the gearshift procedure from 4x4 LOW to 4x2 HIGH, the 4x4 LOW selector fork is exclusively moved by the force of the return spring.

7. The Hall sender for transfer box G759 ...

☐ a) ... senses the position of the selector shaft and controls the gearshift procedures in the transfer box.

☐ b) ... registers the output speed of the transfer box and prevents four-wheel drive from being engaged if there are speed differences between the front and rear axles.

☐ c) ... only registers the position of the selector shaft in 4x2 mode.

8. How does the differential lock function in the rear final drive 0CC?

☐ a) The control solenoid N5 operates the multi-disc clutch for blocking the differential.

☐ b) The control solenoid N5 keeps the axle bevel gear fixed in position inductively due to its magnetic field.

☐ c) The control solenoid N5 operates the shift dog via the thrust plate in order to block the axle bevel gear

Answers
1. b); 2. a); 3. c); 4. b); 5. a); 6. b); 7. a); 8. c

000.2812.37.20 Technical status 07.2010

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