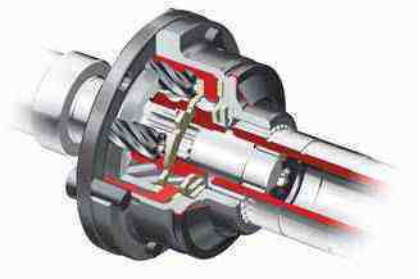
Service Training



The Audi Q7 Power Transmission

Self-Study Program 993603

Audi of America, Inc.
Service Training
Printed in U.S.A.
Printed 02/2006
Course Number 993603

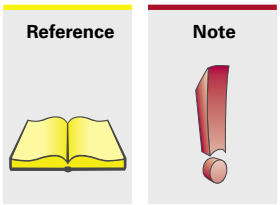
Always check Technical Bulletins and the latest electronic repair information for information that may supersede any information included in this booklet.

Table of Contents

The self-study program provides introductory information regarding the design and function of new models, automotive components or technologies.

The self-study program is not a Repair Manual!
All values given are intended as a guideline only and refer to the software version valid at the time of publication of the SSP.

For maintenance and repair work, always refer to the current technical literature.



Audi Q7 - Power transmission by the inventor of the quattro®

In addition to outstanding dynamics, the Audi Q7 powertrain concept ensures an impressive performance at high speeds, both on highway and off-road.

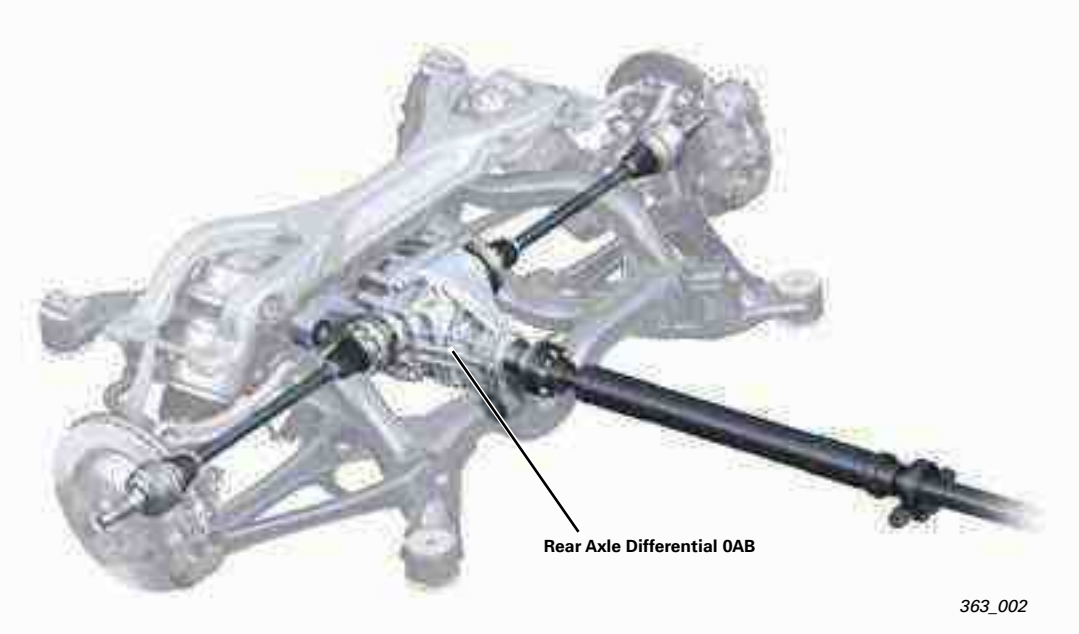
The permanent quattro® four-wheel drive with asymmetric-dynamic torque split ensures maximum traction and cornering stability. These features are essential to good driving dynamics and active driving safety.

The newly designed 0AQ Transfer Case is a key feature of the power transmission system.

The purpose of this SSP is to explain the design and function of this new system.

363_001

Powertrain concept



As an SUV with excellent on- and off-road driving dynamics, the Audi Q7 comes standard with the quattro four-wheel drive.

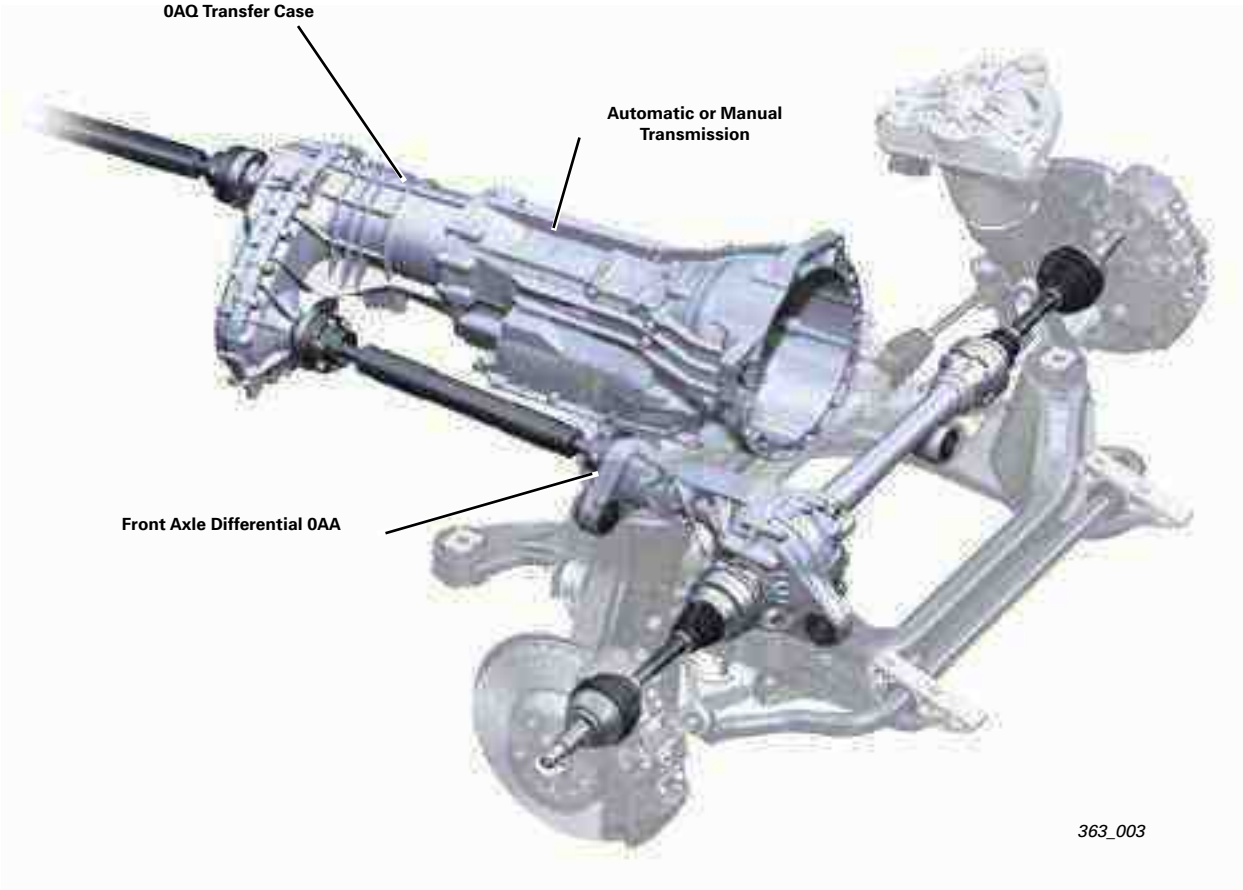
As a result, the transmission gear and the transfer case are close to the center of the vehicle, promoting a well-balanced axle load distribution beneficial to the driving dynamics.

The transmission, front axle differential and transfer case are a modular design. The advantage of this modular design is an increased ground clearance for off-road driving.

The self-locking center differential, already in use in the Audi RS4 and S4, features asymmetric-dynamic torque distribution.

Up to 85% of drive torque can be transferred mechanically, without EDL engagement, to the rear axle and up to 65% can be transferred to the front axle.

When a wheel is spinning - off road or on icy surfaces - the EDL system is activated and helps ensure traction in almost any driving situation.



Sub-assemblies overview

When equipped with the 4.2L V8 FSI engine, the Audi Q7 will use the 09D 6-Speed Automatic Transmission.

363_004

09D 6-Speed Automatic Transmission

When equipped with the 3.6L V6 FSI engine, the Audi Q7 will use the 0AT 6-Speed Automatic Transmission.

363_005

0AT 6-Speed Automatic Transmission

(expected availability: 4th quarter 2006)

Front Axle Differential 0AA

The left drive shaft is extended to compensate for the front axle differential asymmetric mounting.

The additional torque resulting from the drive torque is, therefore, transmitted symmetrically to the front axle. This eliminates any negative effect on steering.

0AA Front Axle Differential

363_007

0AB Rear Axle Differential

363_008

0AQ Transfer Case

363_009

The 0AQ Transfer Case has been redesigned for use in the Audi Q7.

The 0AQ Transfer Case was developed in collaboration with Borg-Warner. It is manufactured by Borg-Warner.

The 0AT 6-Speed Automatic Transmission

The 0AT 6-Speed Automatic Transmission is an electro-hydraulically controlled 6-speed planetary transmission (multi-step automatic transmission) with hydrodynamic torque converter and slip-controlled converter lockup clutch.

The valve body and the electronic control module have been combined into a single unit, called the Mechatronics, located inside the oil sump.

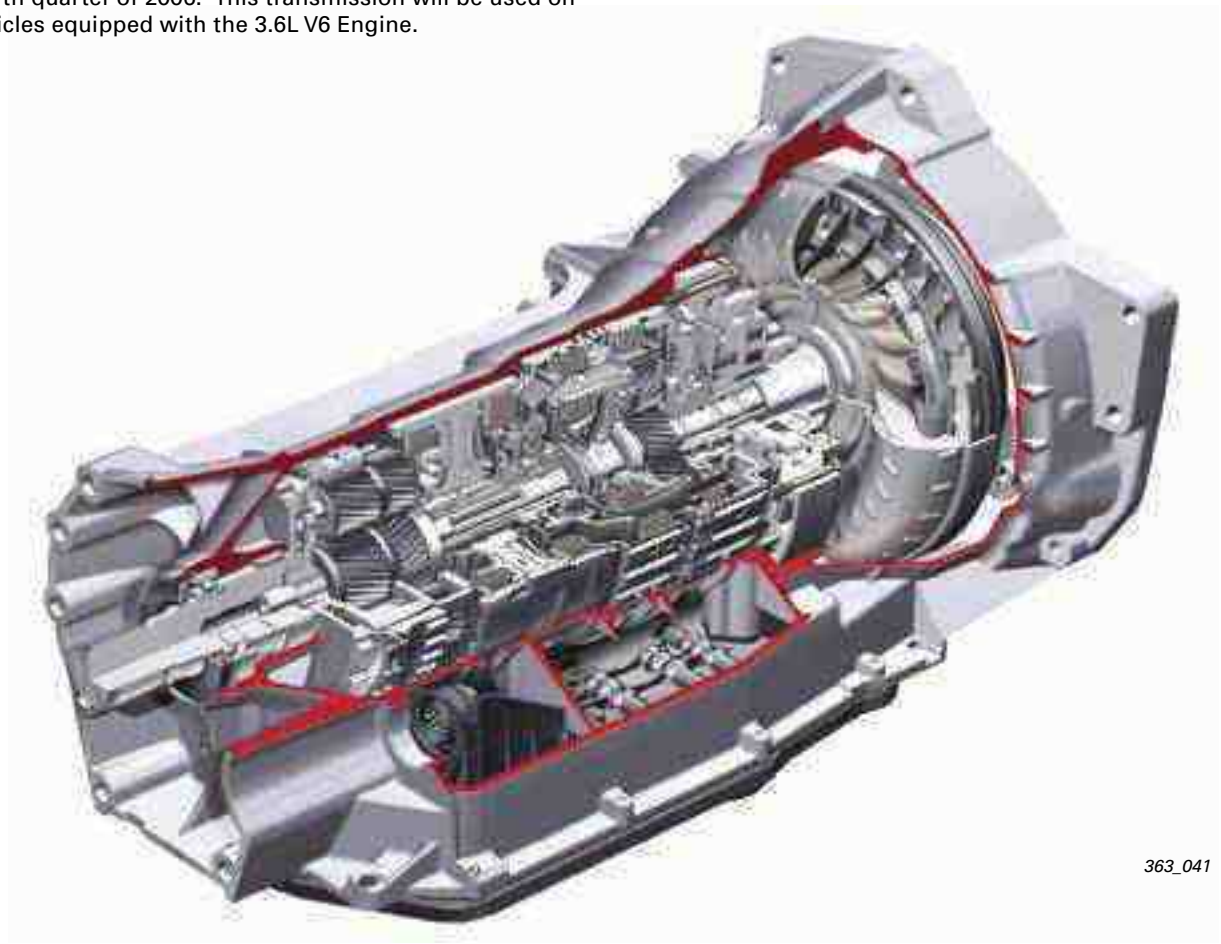
This transmission will be introduced during the third or fourth quarter of 2006. This transmission will be used on vehicles equipped with the 3.6L V6 Engine.

The 0AT transmission:

— is a new development for the Audi Q7, optimized for weight and fuel economy, for engines with up to 295 lbs-ft (400 Nm) of torque

— belongs to the same family as the 6-Speed Automatic Transmissions 09E and 09L

The 0AT transmission was developed and is currently manfactured by ZF-Getriebe GmbH.



363_041

Other features:

— Special deep seated ATF intake point and larger ATF capacity to ensure proper oil intake during off-road use.

— Extended transmission breather pipe to prevent the entry of water in the transmission even under adverse conditions.

— Large-sized torque converter and torque converter lock-up clutch.

— Integration of the transmission into the immobilizer system.

Reference

For more information on the 09E and 09L automatic transmissions, please refer to Self-Study Program 992403, The 2005 Audi A6 Engines and Transmissions, page 63.

The 09D 6-speed Automatic Transmission

The 09D 6-speed Automatic Transmission is a conventional electro-hydraulically controlled 6-speed planetary transmission (multi-step automatic transmission) with hydrodynamic torque converter and slip-controlled converter lockup clutch.

The hydraulic control unit (valve body) is located in the oil sump, while the electronic control module is located externally inside the vehicle (under the right-hand front seat).

The 09D transmission:

— is used for engines with up to 552 lbs-ft (750 Nm) of torque

— belongs to the same family as the 6-speed automatic transmission 09G (see SSP 291)

The 09D transmission was developed and is currently manufactured by Aisin AW Co LTD.

363_004

Other features:

— Special deep seated ATF intake point and larger ATF capacity to ensure proper oil intake during off-road use.

— Extended transmission breather pipe to prevent the entry of water in the transmission even under adverse conditions.

— Large-sized torque converter and torque converter lock-up clutch.

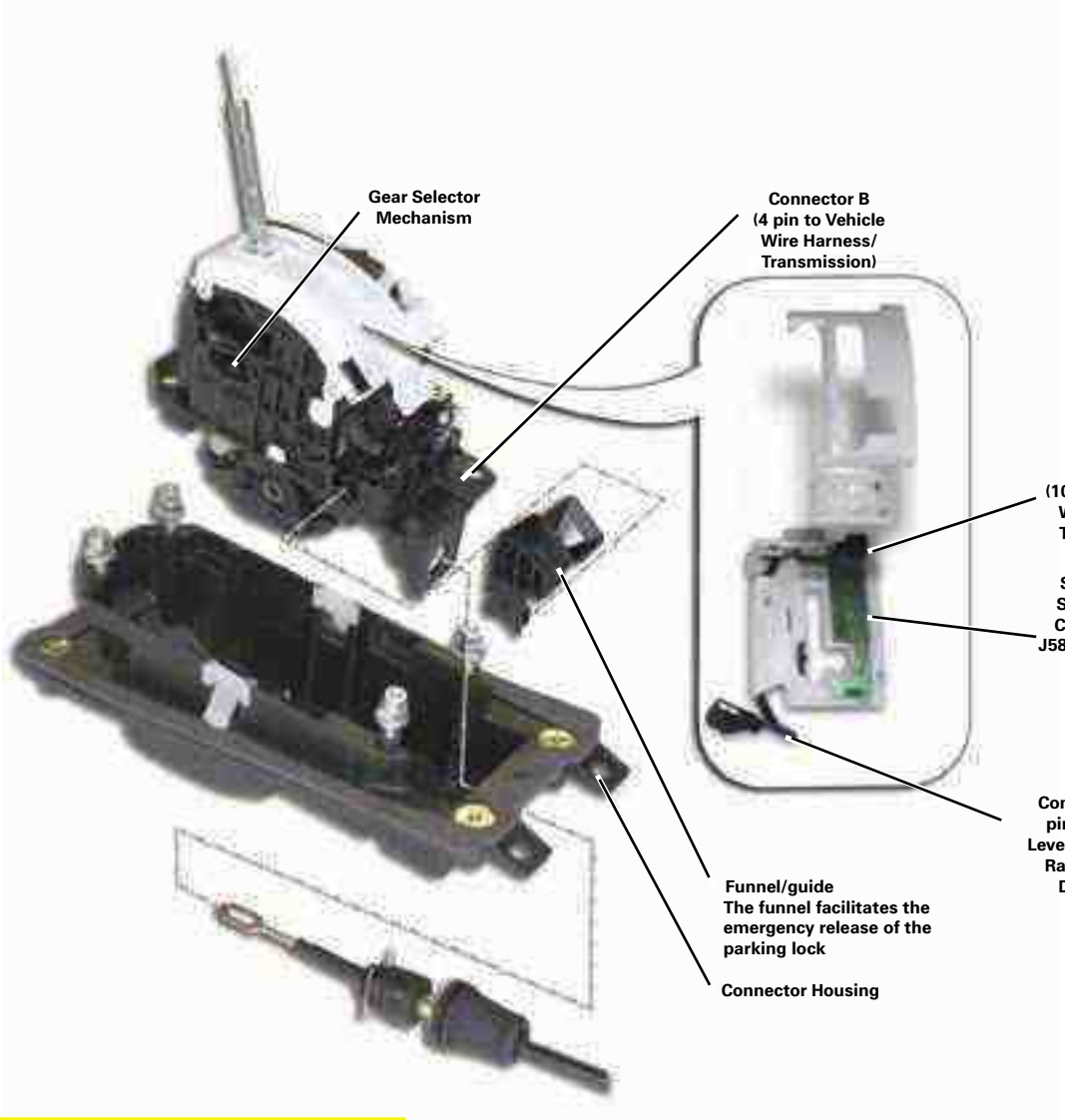
Automatic transmission gear selection

In the Audi Q7, the design and function of the gear selector are largely identical to those used in the 2005 Audi A6. The differences of the gear selector mechanism are listed below.

The gear selector mechanism can be removed from inside the vehicle for repairs (e.g. to replace the microswitch F305).

When the gear selector mechanism is replaced, the housing (installed from the outside) remains installed in the vehicle. Only the gear selector mechanism need be replaced.

Selector Lever Transmission Range (TR) Position Display Y26



Reference

For more information on the gear selector mechanism, please refer to Self-Study Program 992403, The 2005 Audi A6 Engines and Transmissions.

P/R/N/D/S signal

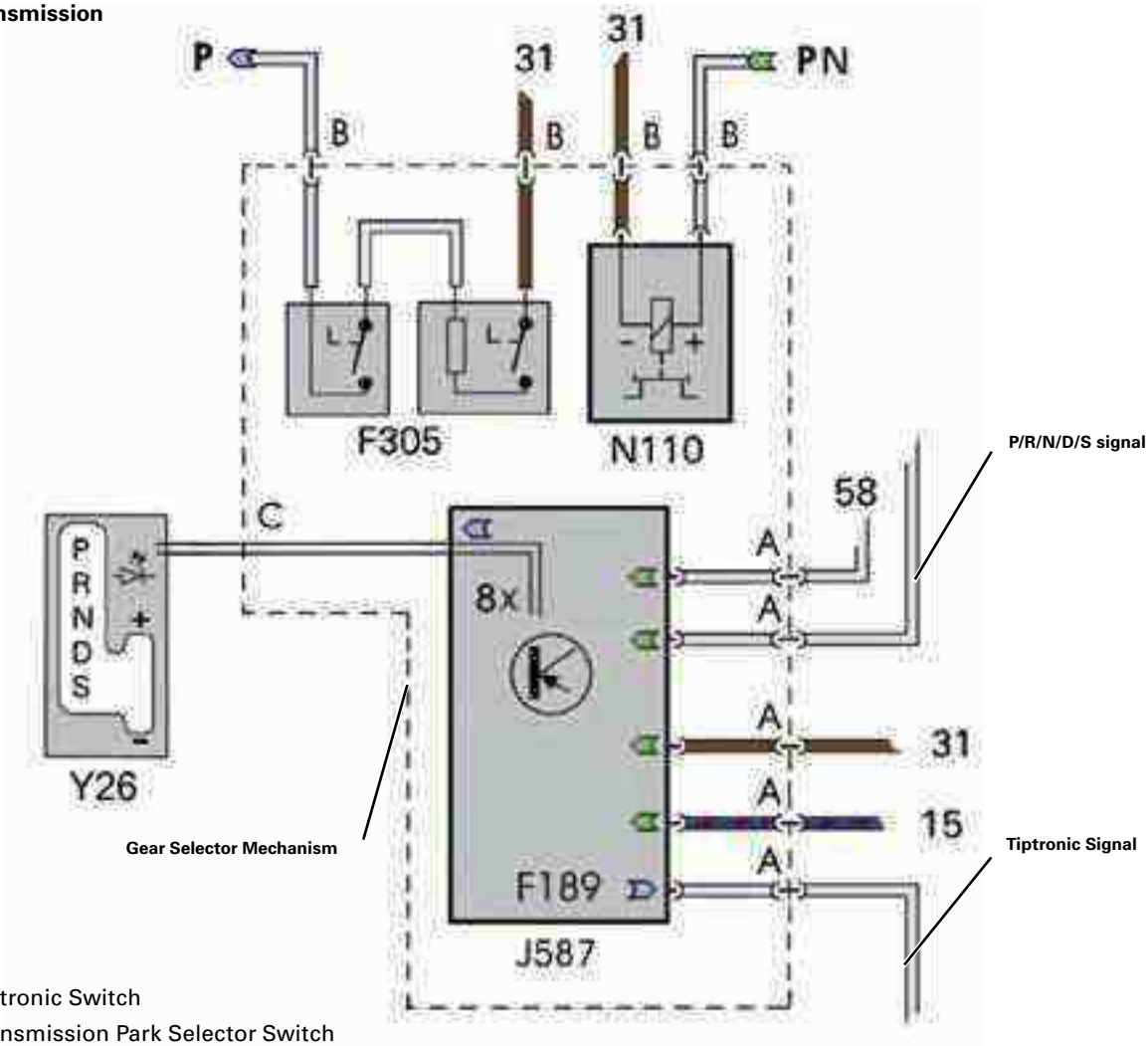
The Selector Lever Sensor System Control Module J587 is in charge of the signal acquisition for the Tiptronic (Tiptronic Switch F189) and activation of the Selector Lever Transmission Range (TR) Position Display Y26. The Hall sensors used previously to determine the selector lever position for activating the display unit Y26 are no longer needed. The information on the selector lever position (P/R/N/D/S signal) is now transferred directly to the Selector Lever Sensor System Control Module by the Transmission Control Module in the form of a frequency-modulated square-wave signal (FMR signal). Then, the Selector Lever Sensor System Control Module activates the corresponding LEDs on the display unit Y26.

A specific signal frequency is assigned to each selector lever position (see DSO images). The Selector Lever Sensor System Control Module evaluates the signal and activates the corresponding LED on the display unit Y26 (ground activation).

The advantages of this new feature are the following:

- Synchronous indication of selector lever position in the instrument panel insert and on the selector lever.
- Cost savings through streamlining of the Selector Lever Sensor System Control Module J587 (elimination of additional Hall sensors).

Function diagram of the gear selector mechanism with the 09D transmission



363_044

F189 Tiptronic Switch
F305 Transmission Park Selector Switch
F189 Tiptronic Switch
J587 Selector Lever Sensor System Control Module
N110 Shift Lock Solenoid
Y26 Selector Lever Transmission Range (TR) Position Display

DSO images of the P/R/N/D/S signals

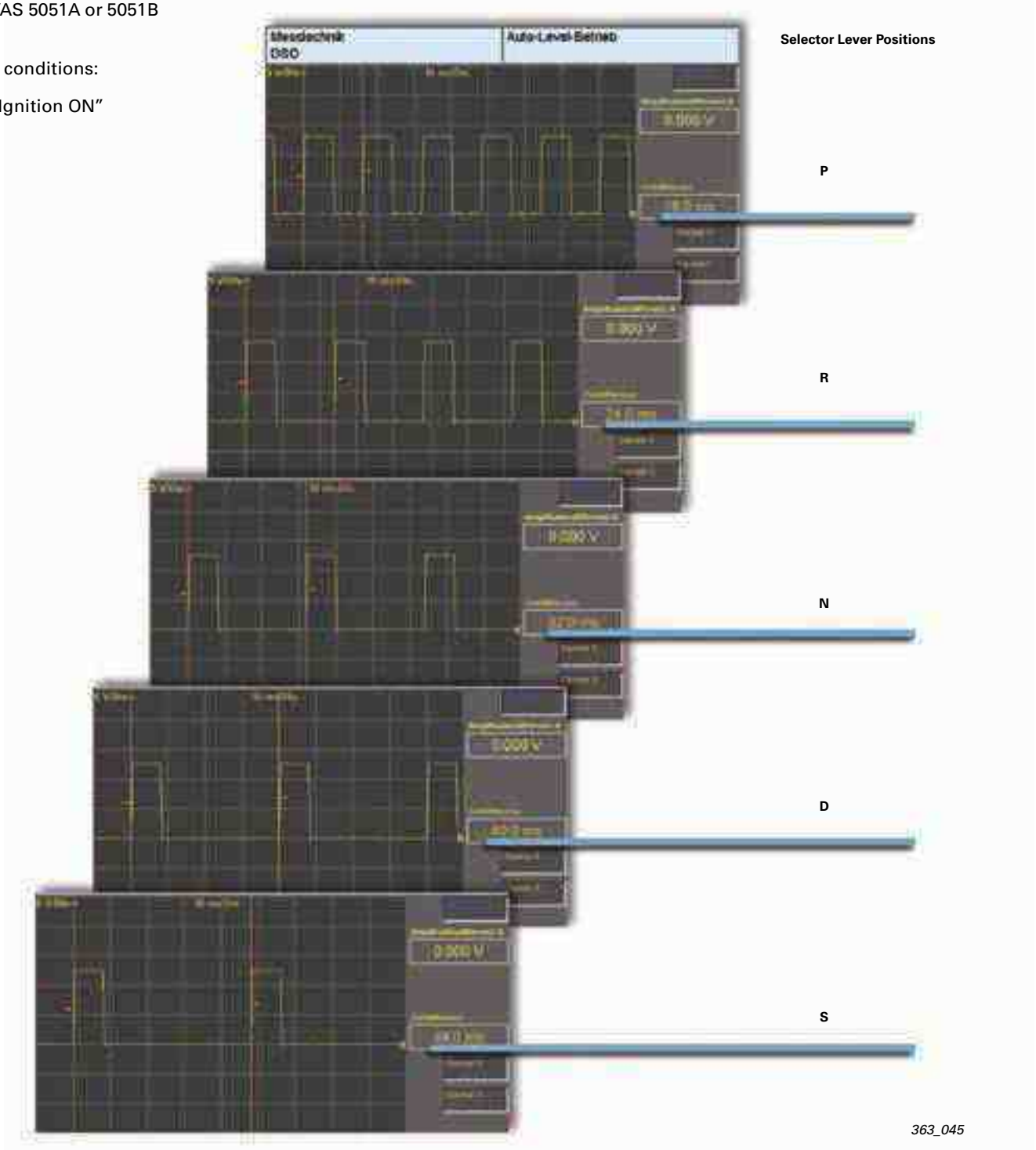
Here are some Digital Storage Oscilloscope images of the frequency modulated square-wave signal (FMR signal) from the selector lever.

The following test equipment must be used:

- VAG 1598/54
- VAG 1598/42
- VAS 5051A or 5051B

Test conditions:

— "Ignition ON"



Tiptronic signal

The information on the selector lever in the Tiptronic gate, selector lever in Tip+ position or selector lever in Tip- position is transmitted to the Transmission Control Module as a frequency-modulated square-wave signal (FMR signal) over a discrete line (see the DSO images).

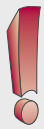
Advantages of this new feature:

— Higher operational reliability - only one line required to the control module (instead of three), resulting in fewer potential sources of fault.
— Better self-diagnosis.

The signals from and to the gear selector mechanism can be tested with the VAG 1598/54 test adapter in combination with the VAG 1598/42 test box.

The signals to and from the 09D transmission can be tested with the VAG 1598/48 test adapter in combination with the VAG 1598/42 test box.

The signals to and from the 0AT transmission can be tested with the VAG 1598/40 test adapter in combination with the VAG 1598/14 test box.



Note

Except for the different signal waveform, the basic function of the selector mechanism is similar to that of the selector mechanism in the 2005 Audi A3.

DSO images of the Tiptronic signal

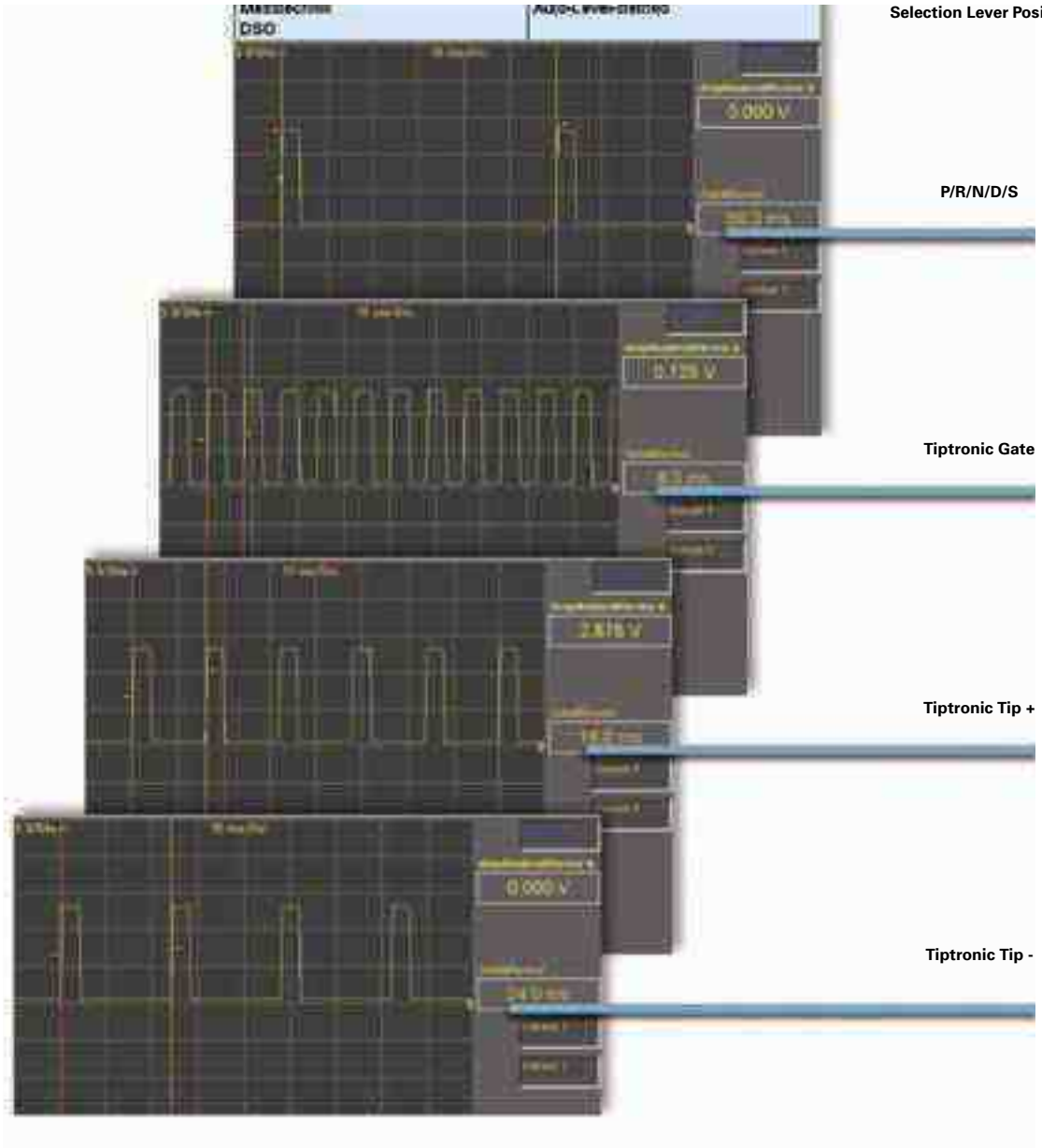
Here are some Digital Storage Oscilloscope images of the frequency modulated square-wave signal (FMR signal) of the Tiptronic function.

The following test equipment must be used:

- VAG 1598/54
- VAG 1598/42
- VAS 5051A or 5051B

Test conditions:

— "Ignition ON"

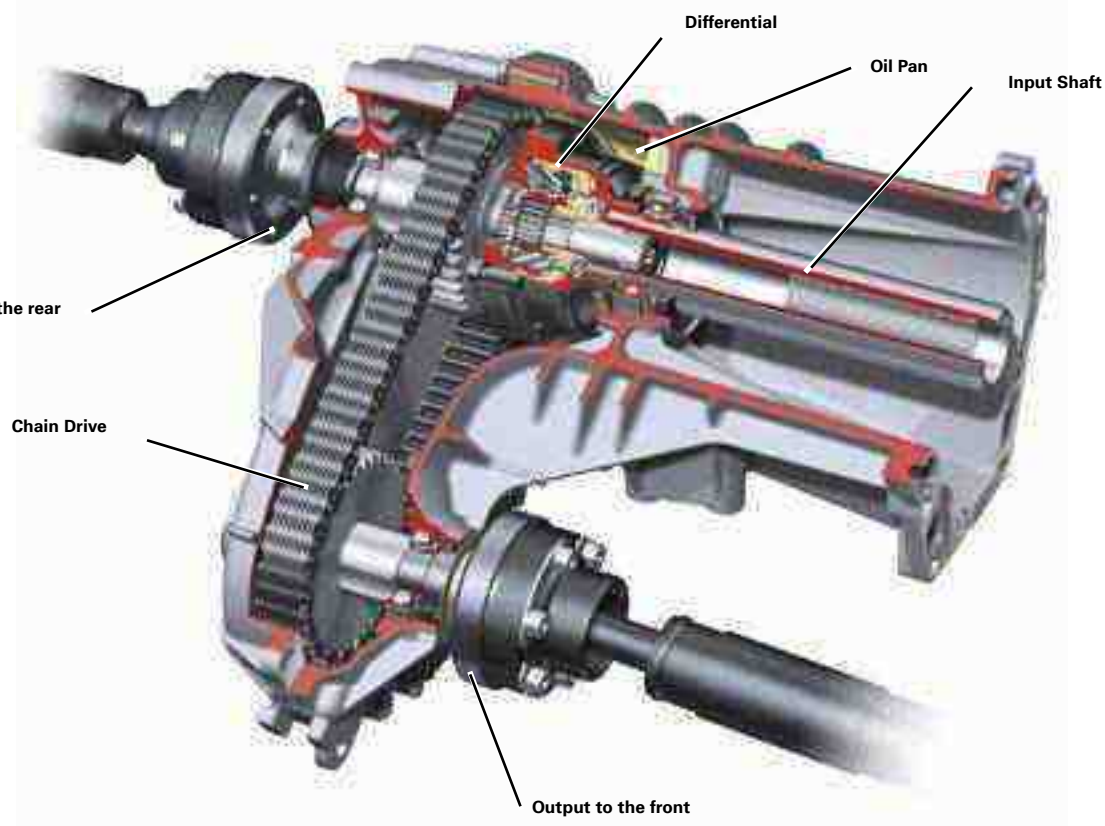


363_046

0AQ Transfer Case

The 0AQ Transfer Case stands out with the following features:

- Latest differential generation, with asymmetric dynamic torque distribution
- Unlimited compatibility with all the dynamic control systems of the ESP
- Fully mechanical system with high reliability
- Designed for engines with a torque up to 552 lbs-ft (750 Nm)
- With a weight of only about 68 lbs (31 kg), it has an exceptionally low power-to-weight ratio
- Maintenance-free transmission with lifetime lubrication



363_012

Design and Function

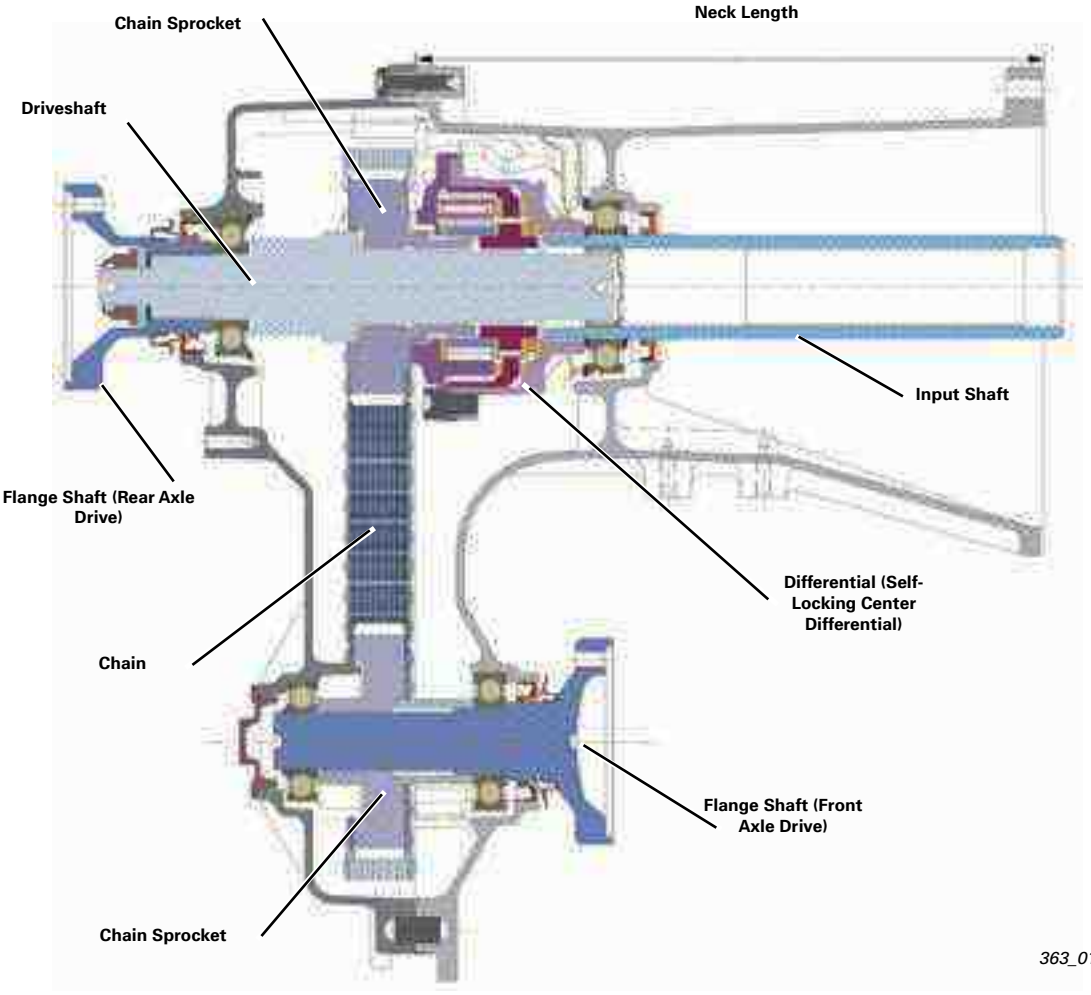
The transfer case is mounted directly to the respective automatic or manual transmission. Three different "neck lengths" compensate for the different transmission lengths.

The input shaft, designed as a hollow shaft, transfers the engine torque to the differential. The differential equalizes the speed differences between the axles and distributes the drive torque.

The drive power is transferred by the differential to the rear axle through the output shaft, which is coaxial to the input shaft. The front axle torque is transferred to the upper chain sprocket. The sprocket rotates freely on the upper output shaft and drives the lower chain sprocket with a chain.

The lower chain sprocket is rigidly mounted on the flange shaft and transfers the power to the front axle differential.

Cross-section of the transfer case



Self-Locking Center Differential

Introduction

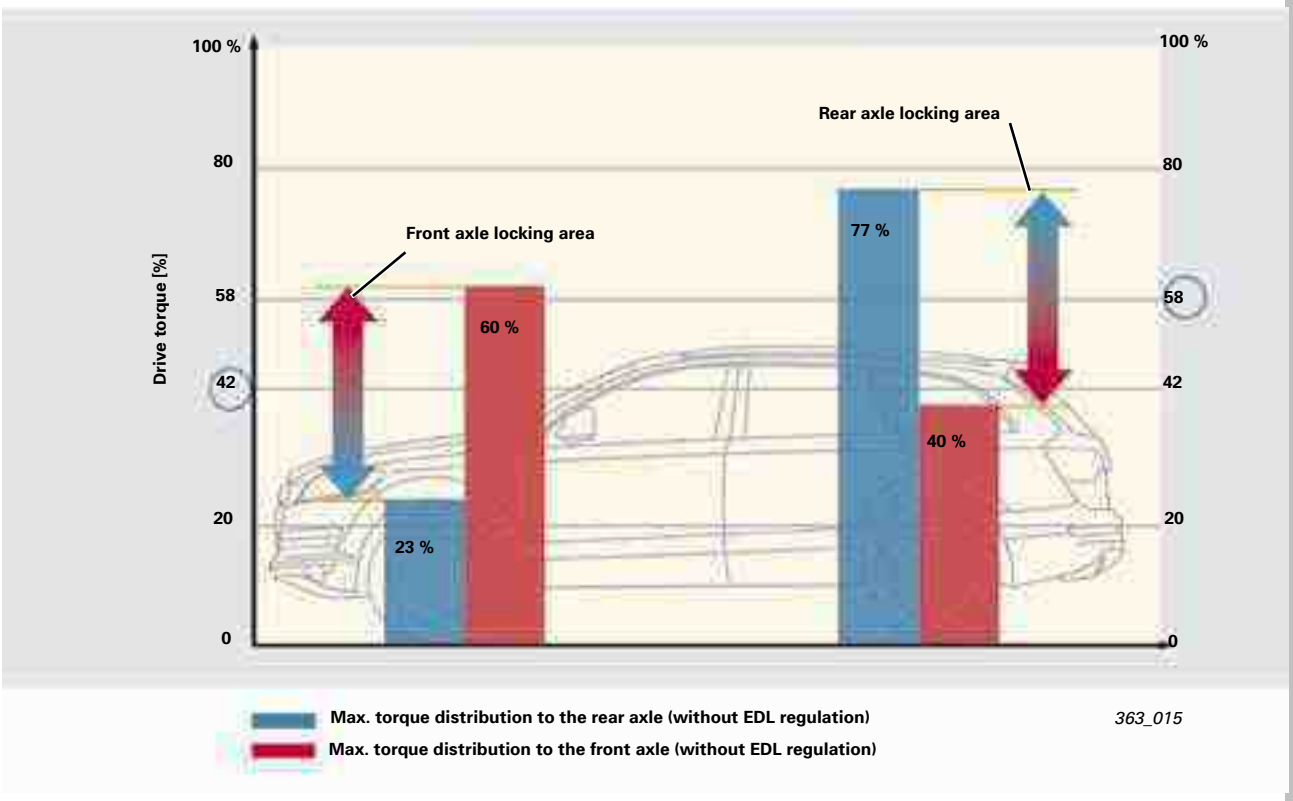
The newly developed 3rd generation Center Differential is introduced in the Audi Q7.

Like its predecessors, this Center Differential is designed as a planetary gear, self-locking unit. The asymmetric-dynamic torque distribution is a new feature.

An asymmetric basic torque distribution of 42% on the front axle and 58% on the rear axle is ideal to achieve a well-balanced vehicle handling.

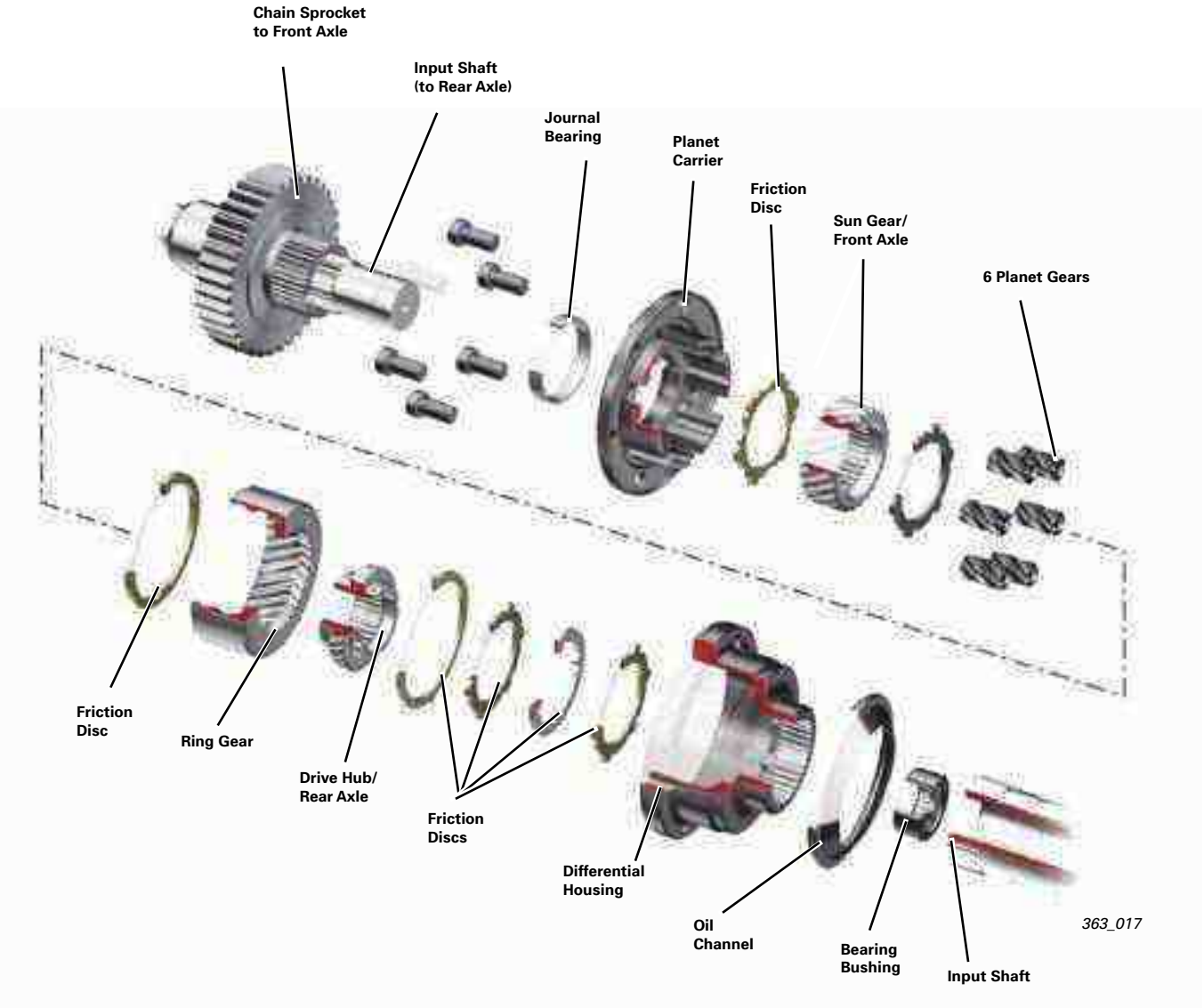
A friction torque proportional to the drive torque is generated in the differential. This friction torque produces a locking torque. The locking torque and basic torque distribution define the torque distribution to the axles.

363_014



363_015

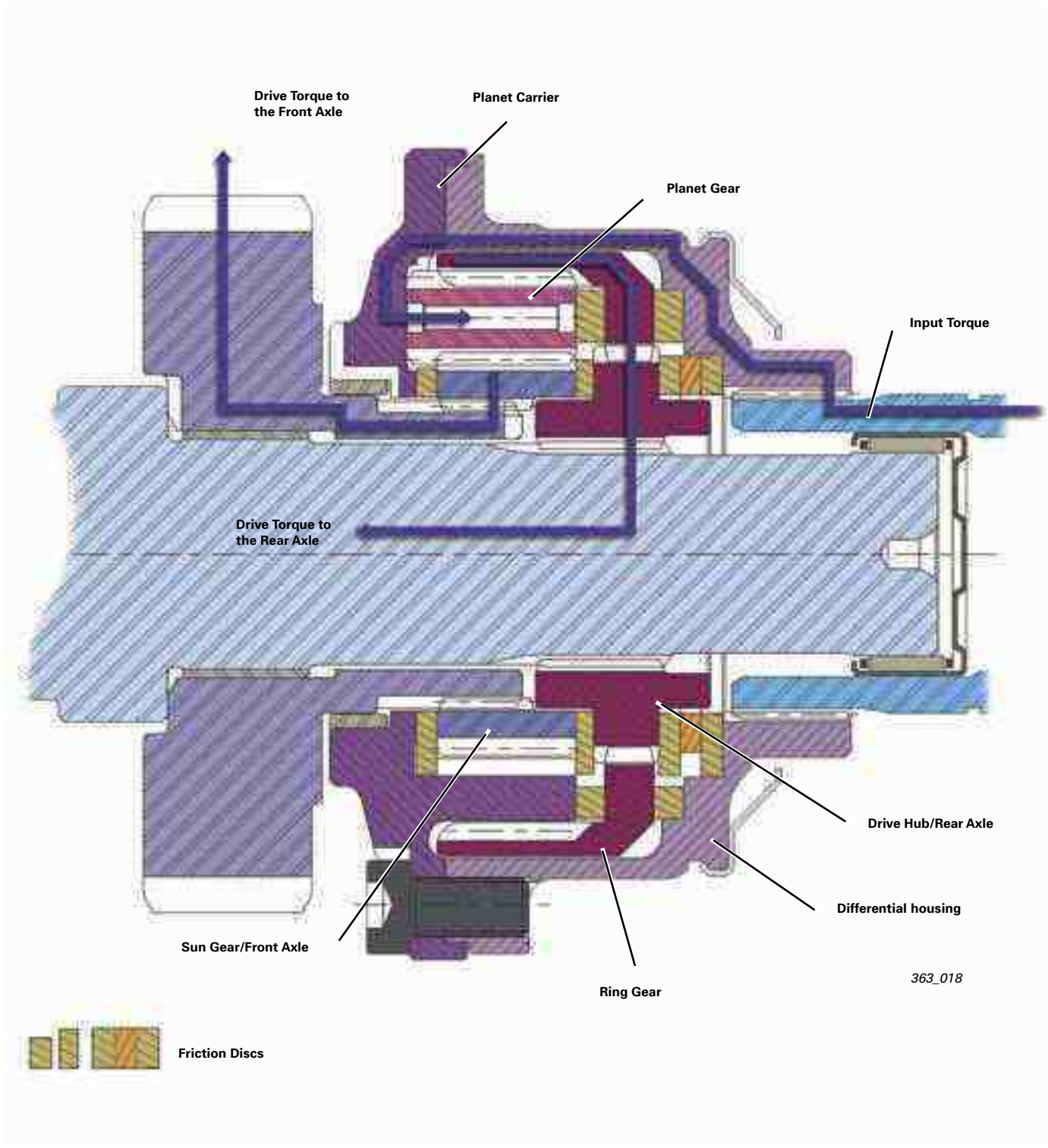
Components overview



Design and Function

The basic design of the Self-Locking Center Differential is identical to that of a simple planetary gear with sun gear, planet gears, planet carrier and ring gear. The planet gears are mounted on the planet carrier. The drive torque is transferred via the planet carrier.

The planet gears form a positive coupling between the sun gear and the ring gear. The ring gear is connected to the rear axle drive shaft. The sun gear is connected to the front axle drive shaft.

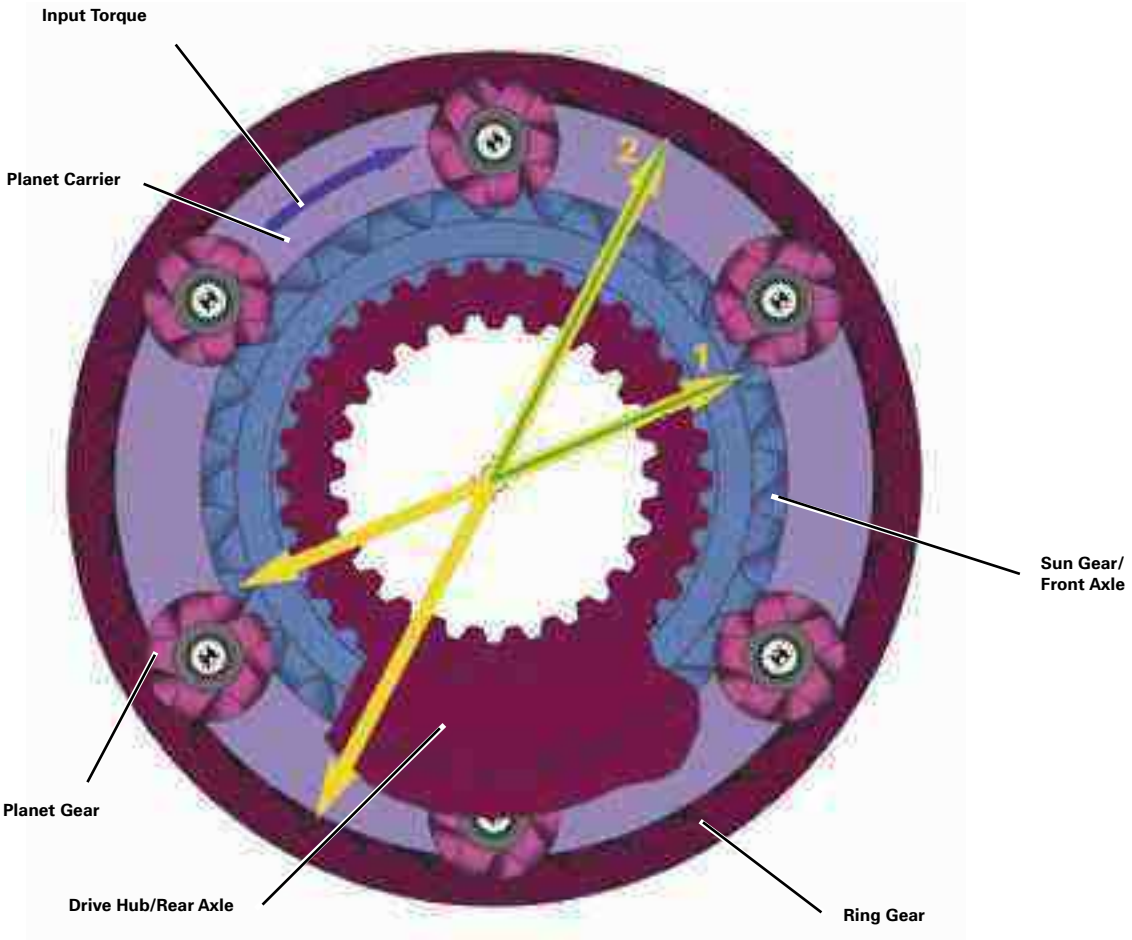


Asymmetric Basic Distribution

The asymmetric basic torque distribution of 42:58 (front axle/rear axle) results from the different pitch circle diameters of the sun gear (front axle drive) and the ring gear (rear axle drive).

1 = small pitch circle diameter = **short lever arm** = low torque (front axle).

2 = large pitch circle diameter = **long lever arm** = high torque (rear axle)



363_019

Pitch circle diameter

Lever arm

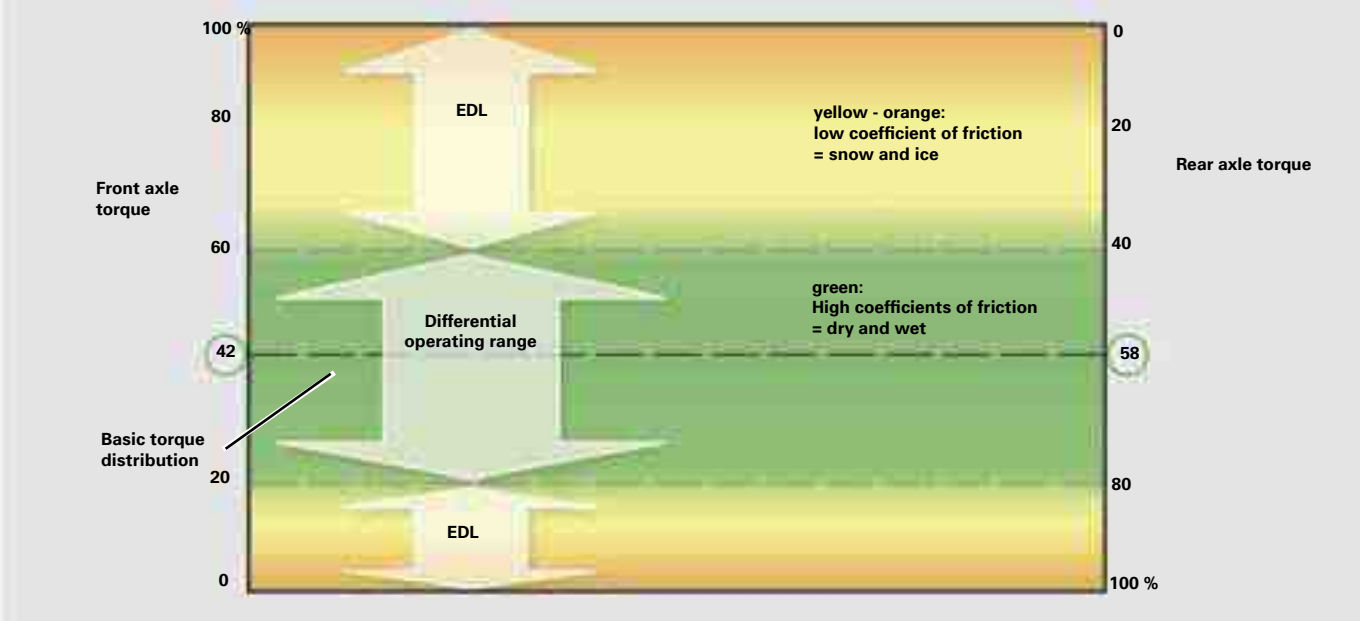
Asymmetric-Dynamic Torque Distribution

In addition to the asymmetric basic torque distribution of 42:58, a friction torque proportional to the drive torque is generated in the differential, resulting in a corresponding locking torque.

The locking torque and basic torque distribution are the key factors for the maximum torque distribution to the axles.

Basically, the center differential responds to changes in torque at the axles. If an axle loses traction, the drive torque is redirected to the other axle within the locking torque distribution limits.

When the working limits of the center differential are exceeded, the EDL control is activated and ensures traction.



Asymmetric-Dynamic Torque Distribution in the Self-Locking Center Differential (under engine

363_016

A Self-Locking Center Differential features four operating states: Maximum distribution to the front axle and maximum distribution to the rear axle while driving under engine torque and while coasting.

These four operating states are characterized by four locking ratios, which can be configured differently.

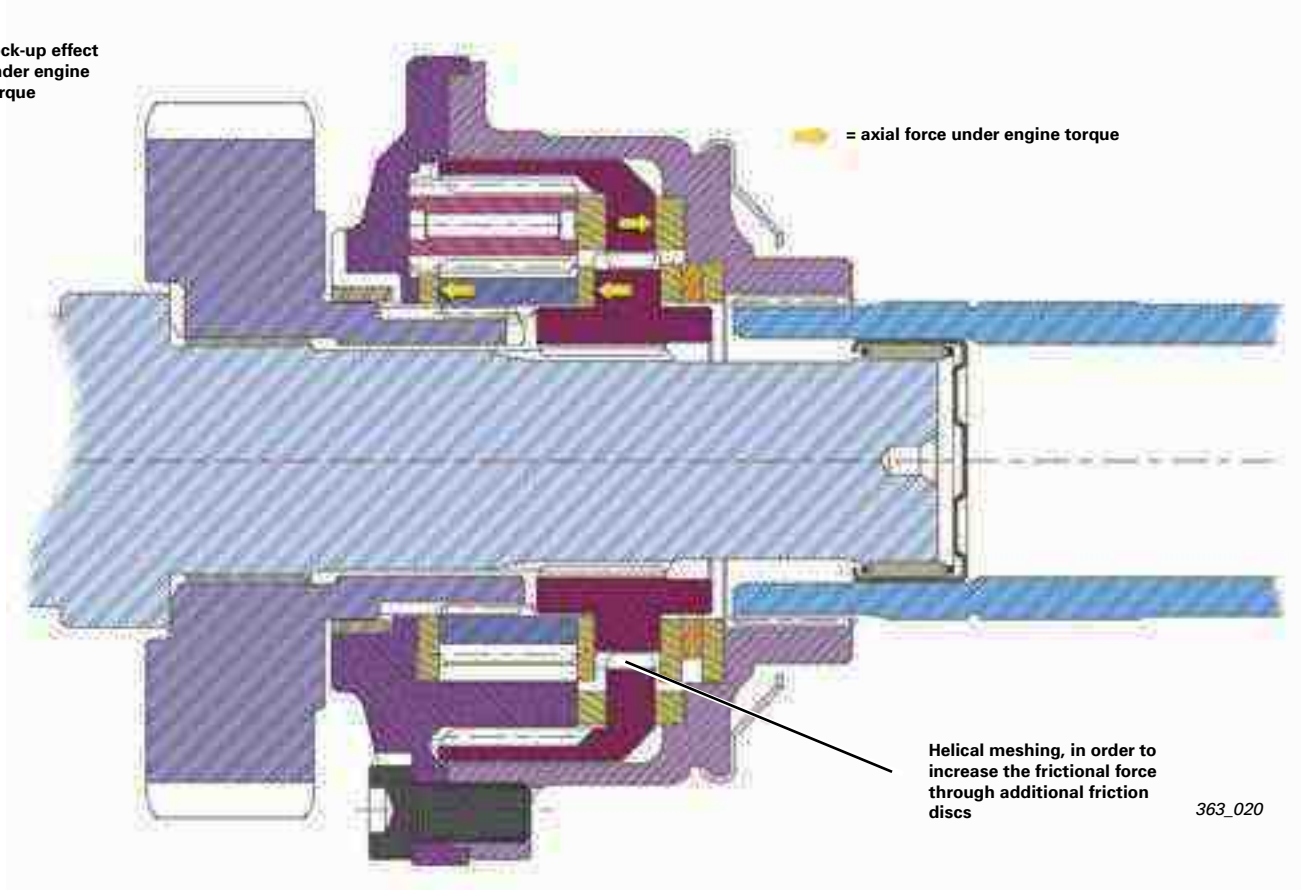
Asymmetric-Dynamic Torque Distribution

The gears of the differential feature a defined helical-cut gear shape.
As a result, the drive torque produces an axial force on the gears, which in turn acts upon various friction discs and generates friction.
The friction provides the desired lock-up effect.

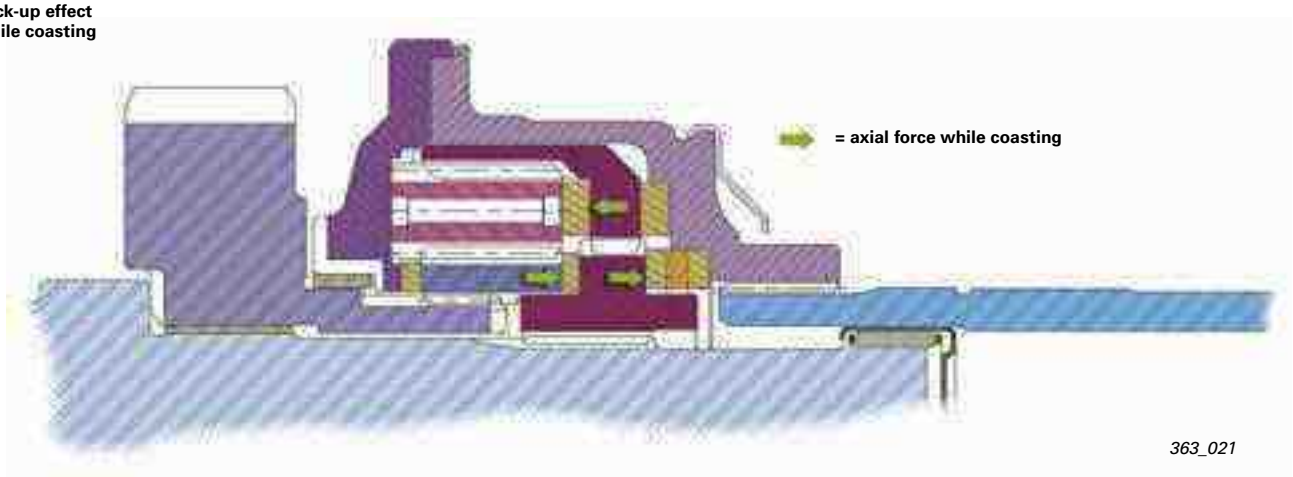
The magnitude of the lock-up effect is defined by the locking ratio. The locking ratio indicates the transfer factor* of the drive torque to the axle which can transfer the greater drive torque.

* number or quantity that is multiplied by another (multiplicand).

Lock-up effect under engine torque



Lock-up effect while coasting

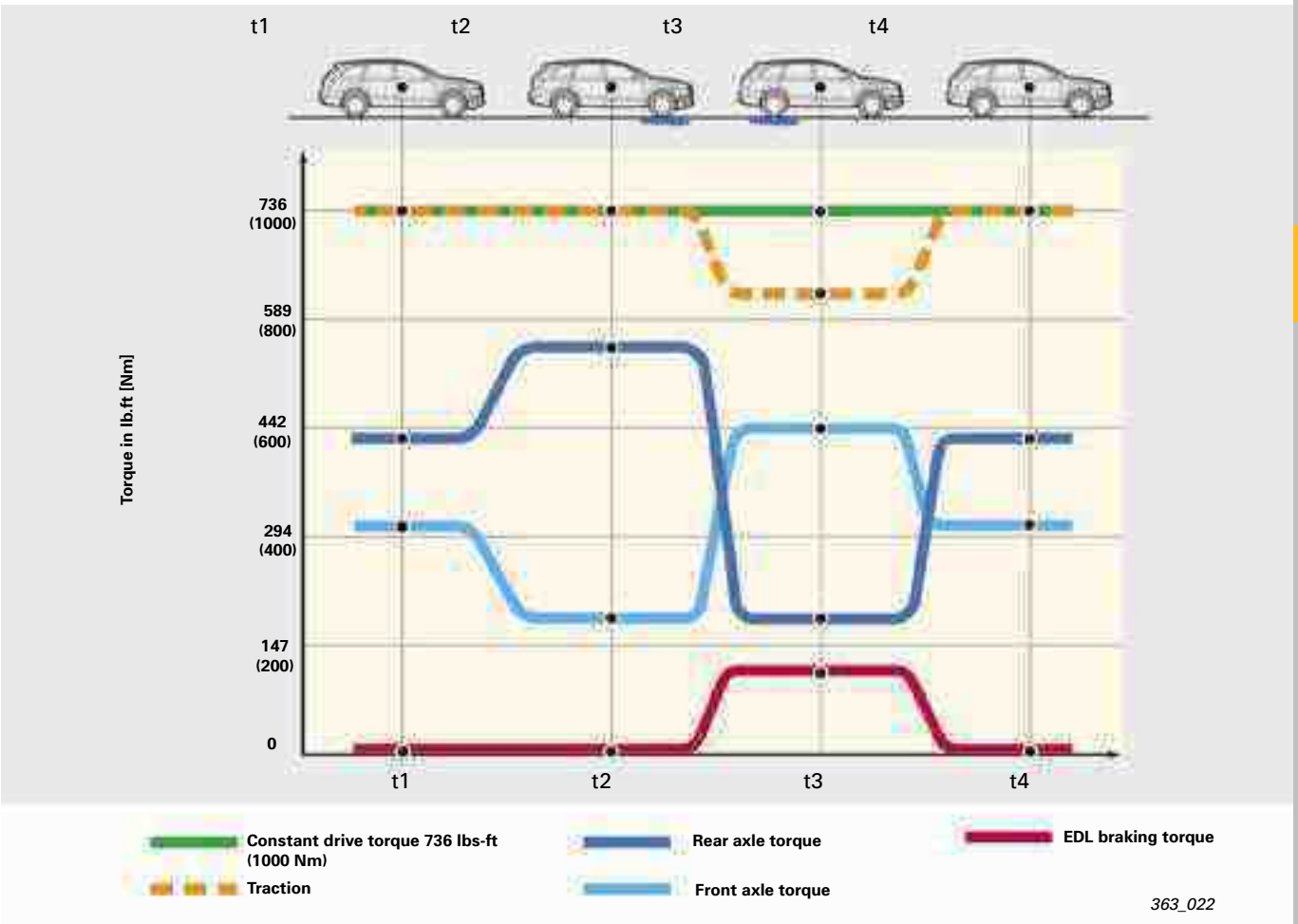


Example of Dynamic Torque Distribution

The following example illustrates how the Audi Q7 responds to changing road conditions.
For comparison purpose, the torque distribution of a vehicle with an open center differential (without lock-up effect) is shown on the next page.

In both cases, the basic torque distribution is 42% to the front axle and 58% to the rear axle.

Audi Q7 Self-Locking Center Differential: traction limit* on icy surface at 184 lbs-ft (250 Nm)



In this example, the Audi Q7 drives over a small patch of ice (driving conditions t2 and t3) under constant drive power. The traction limit* is assumed to be 184 lbs-ft (250 Nm) per axle. The total drive torque (t1 and t4) is 738 lbs-ft (1000 Nm).

When the vehicle is driven over the patch of ice (t2), the front axle loses traction, thus reducing the drive torque to the traction limit* of 184 lbs-ft (250 Nm). Due to the lock-up effect of the differential, the drive torque to the rear axle increases immediately to 750 Nm. Since the torque distribution is within the torque distribution range of the differential, no speed difference occurs between the axles.

100% of the drive power is converted into forward traction; the EDL control does not need to be activated. At time t3, the front axle has already gone over the patch of ice. Now the rear axle encounters reduced friction and can only transfer 184 lbs-ft (250 Nm) of torque. To ensure optimal traction at the front axle, the EDL now takes control of the front axle assistance. 85% of the drive power is converted into forward traction.

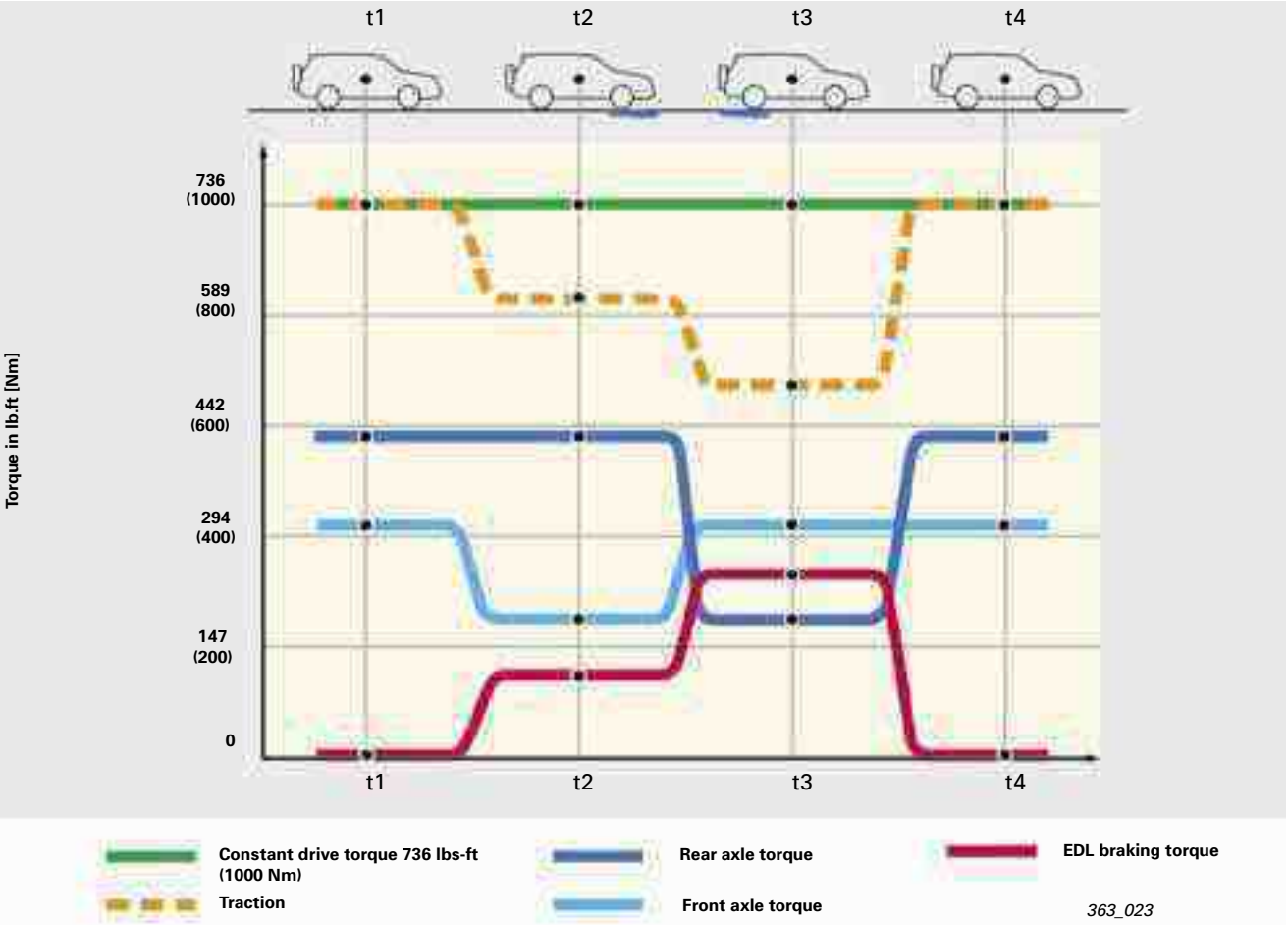
* maximum amount of torque transferable to an axle over the patch of ice

Example of Static Torque Distribution

Just as in the previous example, a vehicle with open center differential is driven over a patch of ice under the same conditions (total drive torque of 738 lbs-ft (1000 Nm), traction limit* of 184 lbs-ft (250 Nm)/ axle on icy surface).

The torque distribution is identical: 42% to the front axle and 58% to the rear axle.

Vehicle with open center differential, torque split 42/58 traction limit* on icy surface at 184 lbs-ft (250 Nm)



The front axle initially loses traction (t2). In order to maintain the torque to the axle with the higher friction coefficient (rear axle), the EDL control must be activated. 17% of the engine power on the front axle is eliminated by the braking action, reducing the forward traction by the same percentage.

When the rear axle comes over the patch of ice at time t3, the EDL control needs to apply additional action to prevent the wheels from spinning. The loss of forward traction is now 33%.

* maximum amount of torque transferable to an axle over the patch of ice

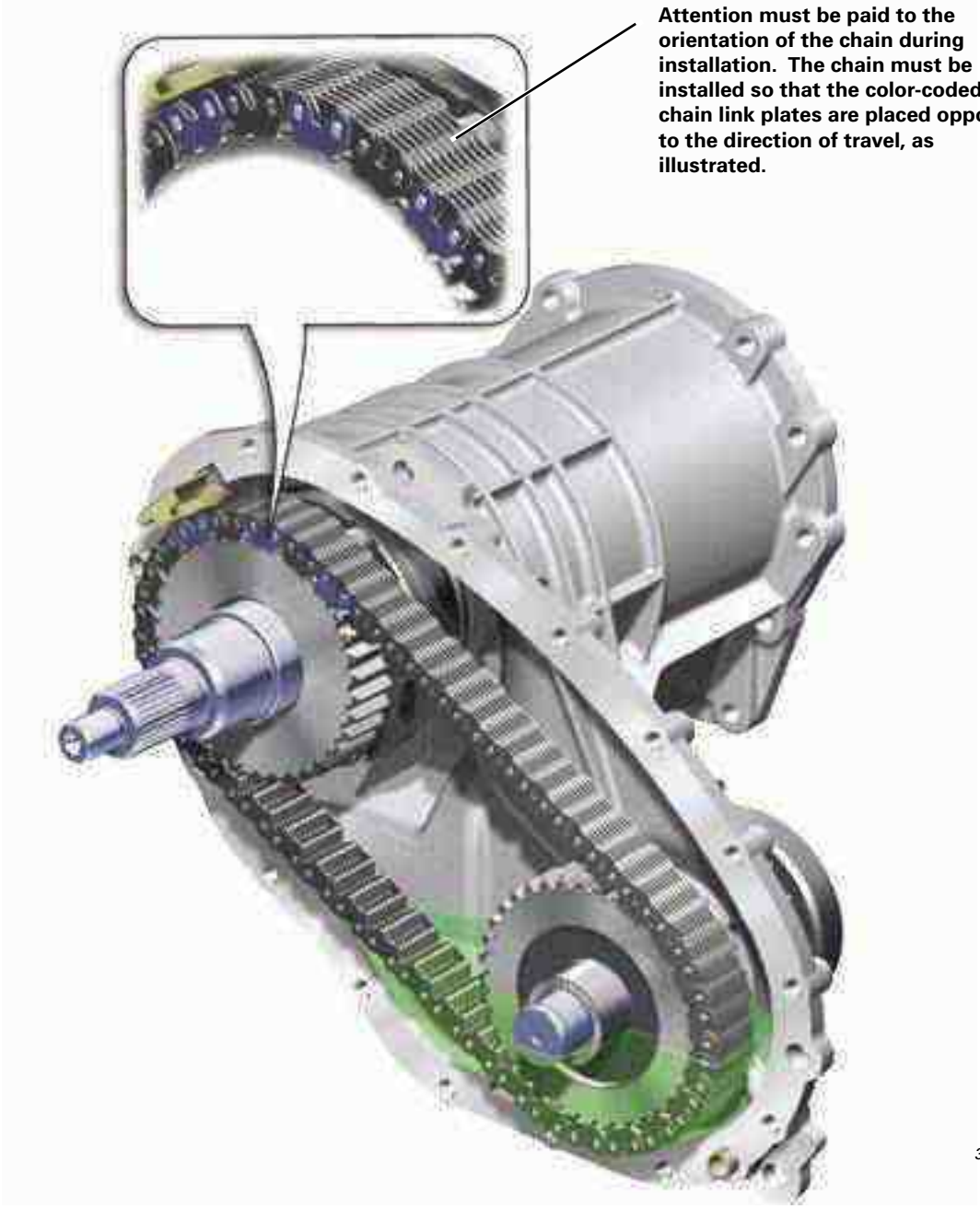
The Chain Drive

The Chain Drive transfers the drive torque to the front axle. A specially developed “toothed chain” and associated sprockets are used.

The Chain Drive in the 0AQ Transfer Case has the following features:

- High torque transfer
- Constant speed
- Quiet running
- Maintenance free
- High efficiency

The special shape of the chain link ensures that the chain runs quietly even at high speed.
The setup of the chain links, with two different tooth surfaces and the relatively high, uneven number of teeth on the sprockets, considerably improves the noise level.

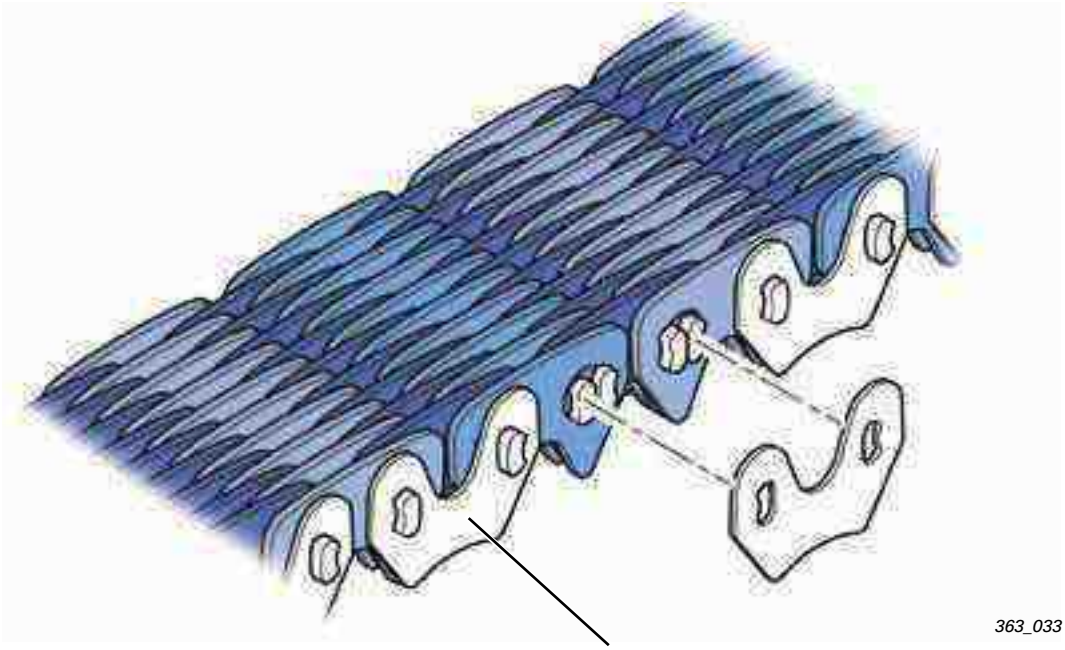


Attention must be paid to the orientation of the chain during installation. The chain must be installed so that the color-coded chain link plates are placed opposite to the direction of travel, as illustrated.

363_035

Design and Function of the Toothed Chain

The Toothed Chain consists of juxtaposed chain links that are continuously joined by two cradle pins at a time. The lateral chain link plates (guiding link plates) provide the necessary guidance to the chain.

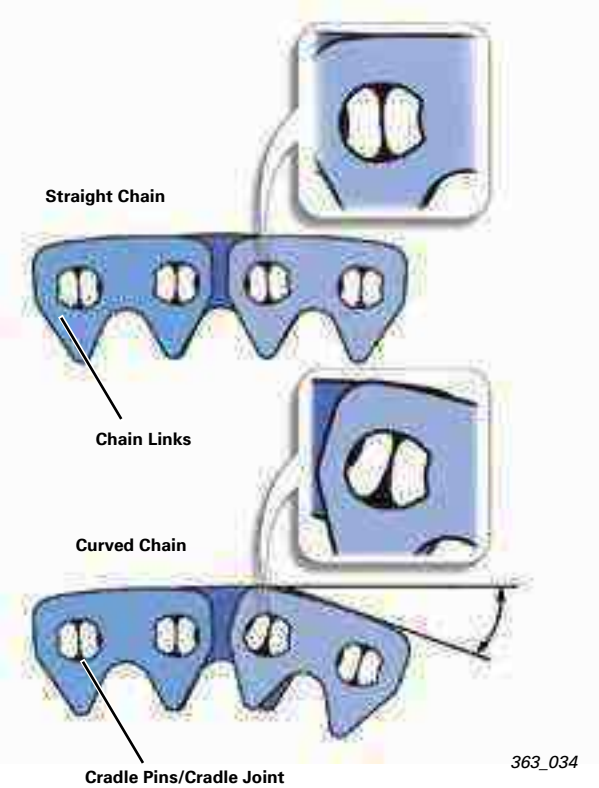


Operation:

Each cradle pin is attached to a row of links in such a way that it cannot rotate. Two cradle pins form a cradle joint.

As the chain curves around the sprocket, the chain links roll off the cradle pins. Consequently, the chain curves around the sprocket almost without any friction.

In this way, despite high torque and continuous operation, wear is reduced to a minimum and efficiency is increased.



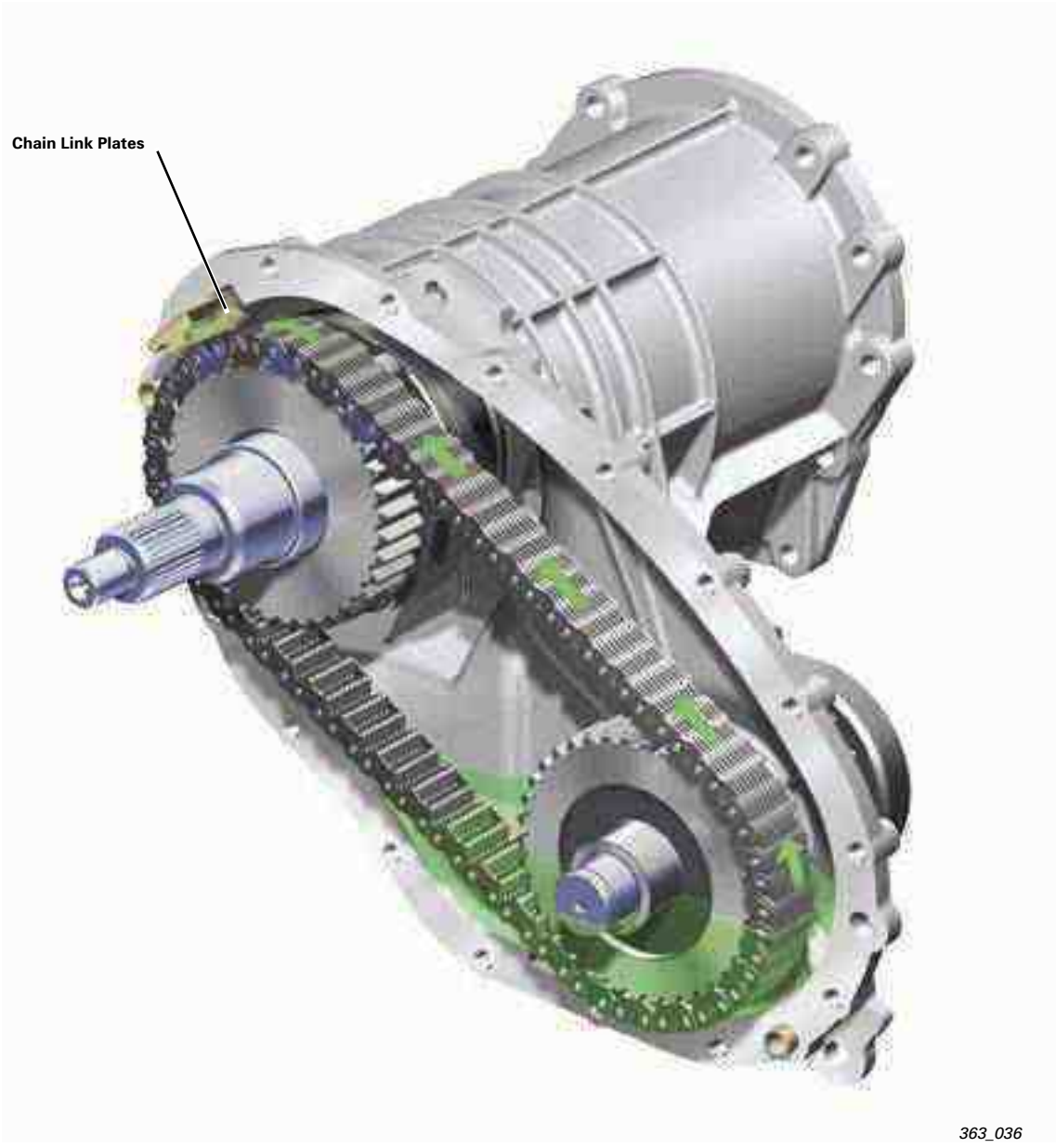
Lubrication

The design of the 0AQ Transfer Case enables the use of automatic transmission fluid (ATF) for lubrication purposes.

ATF is known for its low and constant viscosity over a large temperature range.

The transfer case is lubricated with ATF for the lifetime of the vehicle.

The transfer case installation location and a low oil level require special means for the lubrication of the differential and of the overhead lubrication points.



363_036

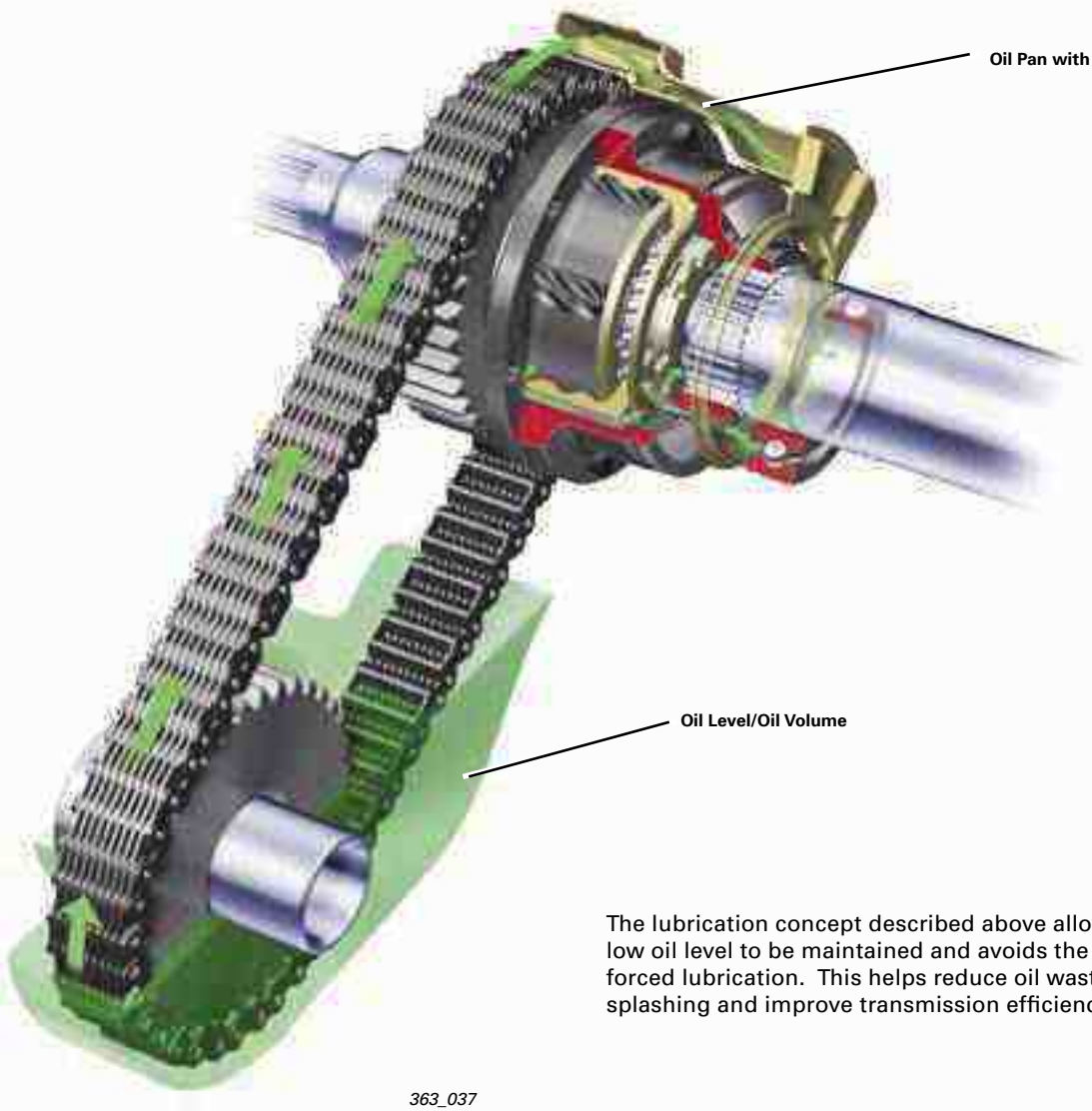
Operation:

The upper shafts and the differential are lubricated using an oil pan and directional oil channels.

During operation, the chain brings the oil upwards where it is removed by the oil pan. A sophisticated oil channel delivers the oil into the differential and toward the input shaft bearing. This ensures sufficient lubrication, even when driving at walking speed. The system also operates when the vehicle is backing up.

An “oil ring” forms in the differential due to the centrifugal force. When the vehicle is stationary, this oil ring collapses and lubricates the inner lubrication points.

The differential housing is designed in such a way that a certain amount of oil remains when the vehicle is at a standstill. This ensures that the system is always lubricated properly when driving away.



363_037

The lubrication concept described above allows a low oil level to be maintained and avoids the need of forced lubrication. This helps reduce oil waste through splashing and improve transmission efficiency.

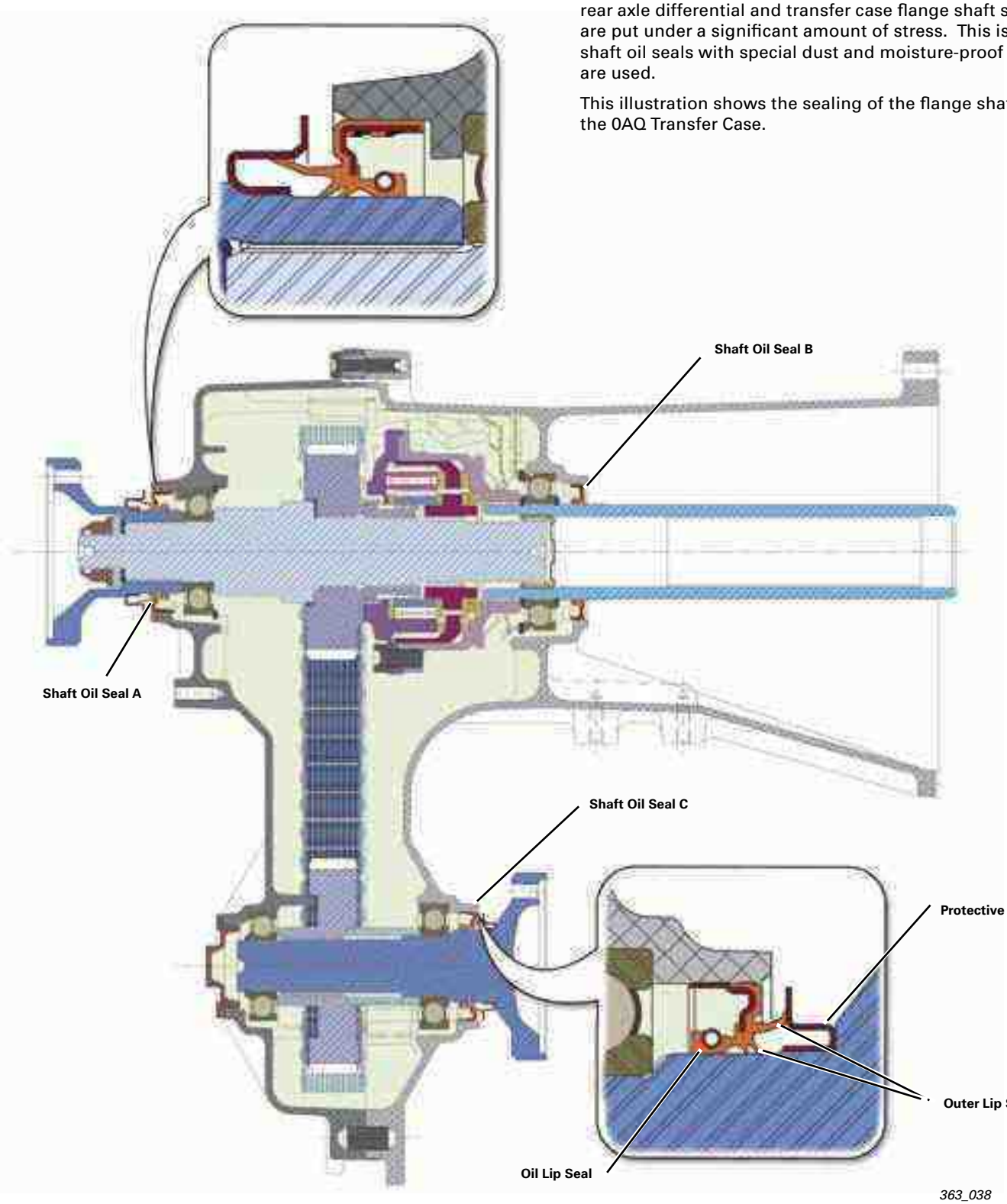
Note

When repairing the transfer case, caution should be used to avoid any contamination of the oil pan and oil channel. They must be cleaned as required.

Oil Supply/Sealing

In adverse off-road conditions, the front axle differential, rear axle differential and transfer case flange shaft seals are put under a significant amount of stress. This is why shaft oil seals with special dust and moisture-proof seals are used.

This illustration shows the sealing of the flange shafts in the 0AQ Transfer Case.



A press-fitted protective ring on the flange shaft acts as a "defelector ring" and helps keep dirt and water away from the lip seals during vehicle operation.

The outer lip seals help to prevent dust and moisture coming into contact with the oil lip seal and its contact surface.

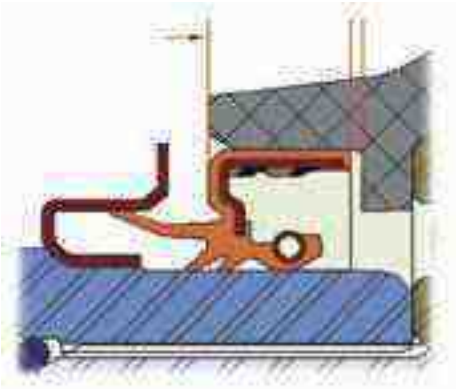
Service/Special Tools

To avoid having to replace shafts, or flanges with sealing surfaces, replacement oil seals must be press-fit more deeply than when they were assembled during initial production.

As a result, the lip seal of the shaft oil seal runs on a new contact surface. This reduces the stress on the sensitive lip seal, which, in turn, extends the seal life and improves sealing performance.

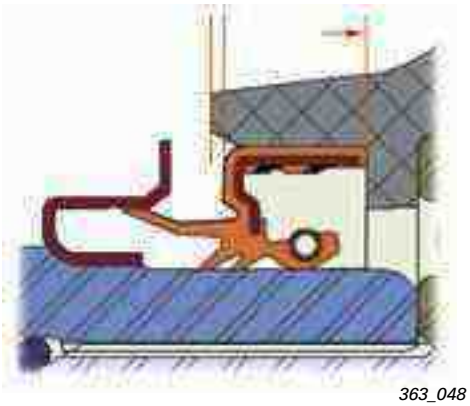
Oil Seal A

Assembly line: Press-fitted flush



363_047

Service: Press-fitted to the limit.



363_048

Pressing Tool T 40115

Oil Seal B

Assembly line: Preset length

363_049

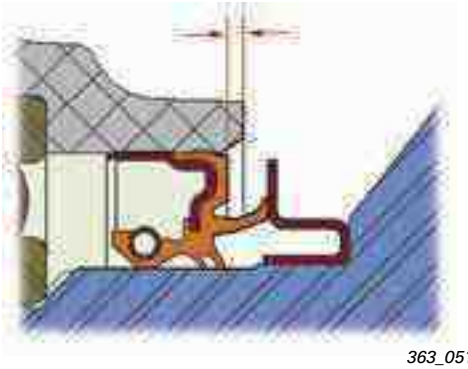
Service: Deeper preset length

363_050

Pressing Tool T 40113

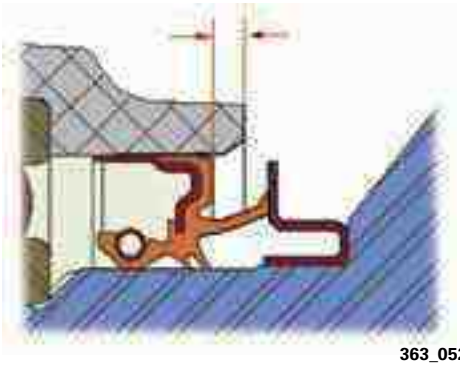
Oil Seal C

Assembly line: Preset length



363_051

Service: Deeper preset length



363_052

Pressing Tool T 40114

Operating Instructions

— The Self-Locking Center Differential is completely different from a 100% mechanical differential lock. If an axle or a wheel is spinning, no drive is provided until the EDL (Electronic Differential Lock) activates.

— The EDL control activates at a preset speed difference between the wheels. Throttle must be applied until the EDL control builds up additional torque through brake application. This additional torque will then be available to the opposite wheel. The Self-Locking Center Differential assists the EDL control by increasing the locking ratio of the other axle while the braking torque is applied. To prevent overheating of the brake due to strong and extended brake activation by the EDL, the EDL will be deactivated at a maximum brake disc temperature computed by the ESP Control Module.

— A constantly high speed compensation between the front and rear axles, combined with a high engine load, will damage the Self-Locking Center Differential.

— If one of the two drive shafts is removed, no drive will be available.

363_040

Reference

For more information on the EDL control, please refer to the “Off-road mode” section.

363_039

Electronic Differential Lock EDL

One of the main purposes for the tuning of an electronic differential lock with brake activaton (EDL) is the build-up of a locking torque with a minimum of wheel slip.

For the initial design of the EDL, the wheel speed control parameters were the main focus. In order to protect the engine from stalling due to the brake application, relatively high wheel differential speeds were necessary.

EDL control was activated at a preset wheel differential speed, depending on the vehicle road speed.

Since the introduction of the ESP, activation of the EDL control is based on a torque balance.

The brake force to be applied is determined by the evaluation of the available engine torque and of the amount of torque transferable to the individual wheels.

This principle applies:
If a high engine torque is available, the EDL can be activated at lower wheel differential speeds than at a low engine torque.

The EDL can be activated up to a speed of 62 mph (100 km/h).

Off-road mode

The ESP Off-road mode can be activated, as required, by pressing the ESP button.

The purpose of the ESP Off-road mode is to improve ESP, ASR, ABS and EDL performance on loose ground (off-road) and to provide the driver with optimum deceleration and traction.

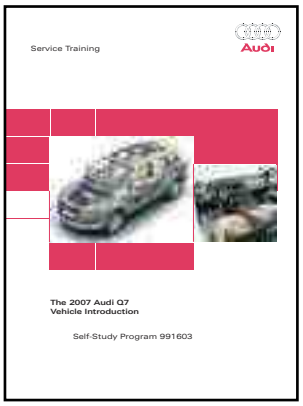
Special auxiliary functions such as deactivation of the car-trailer combination stabilization system, a special “ABS for backing up”, and the “downhill assist” function assist the driver in rough terrain or on loose surfaces.

In Off-road mode, the EDL activation threshold is reduced in order to optimize traction. Consequently, the EDL is activated at a lower wheel speed differential.

The following Self Study Programs are applicable to the Audi Q7:

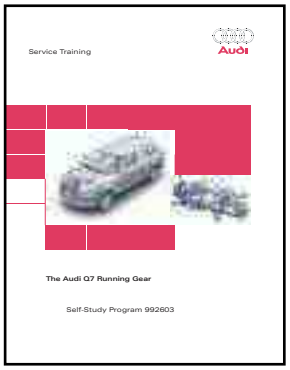
– SSP 991603 The Audi Q7 Vehicle Introduction
– SSP 992603 The Audi Q7 Running Gear
– SSP 993603 The Audi Q7 Power Transmission
– SSP 994603 The Audi Q7 Electrical System
– SSP 996603 Driver Assistance Systems

SSP 991603 The Audi Q7 Vehicle Introduction



– Body
– Passenger protection
– Engine
– Running Gear
– Electrical
– Air conditioning
– Infotainment

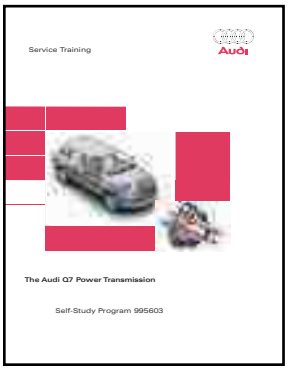
Order number: A04.5S00.14.00



SSP 992603 The Audi Q7 Running Gear

– Front axle
– Rear axle
– ESP braking system
– Steering systems

Order number: A05.5S00.15.00

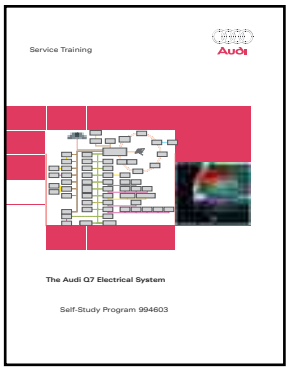


SSP 993603 The Audi Q7 Power Transmission

– Automatic transmission
– Manual transmission
– Torsen differential
– Rear wheel drive

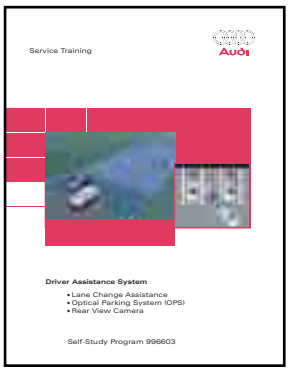
Order number: A05.5S00.16.00

SSP 994603 The Audi Q7 Electrical System



– Networking
– Bus topologies
– Comfort electrical system
– Infotainment

Order number: A04.5S00.09.00



SSP 996603 Driver Assistance Systems

– Lane change assistance (SWA)
– Optical Parking System (OPS)
– Rear View Camera

Order number: A05.5S00.21.00

Notes

Knowledge Assessment

An on-line Knowledge Assessment (exam) is available for this SSP.

The Knowledge Assessment may or may not be required for Certification.

You can find this Knowledge Assessment at:

www.accessaudi.com

From the accessaudi.com homepage:

- Click on the “ACADEMY” Tab
- Click on the “Academy Site” Link
- Click on the ”CRC Certification” Link

For assistance, please call:

Audi Academy

Learning Management Center Headquarters

1-877-AUDI-LMC (283-4562)

(8:00 a.m. to 8:00 p.m. EST)

Vorsprung durch Technik www.audiusa.com

993603

Audi of America, Inc.
3800 Hamlin Road
Auburn Hills, Michigan 48326