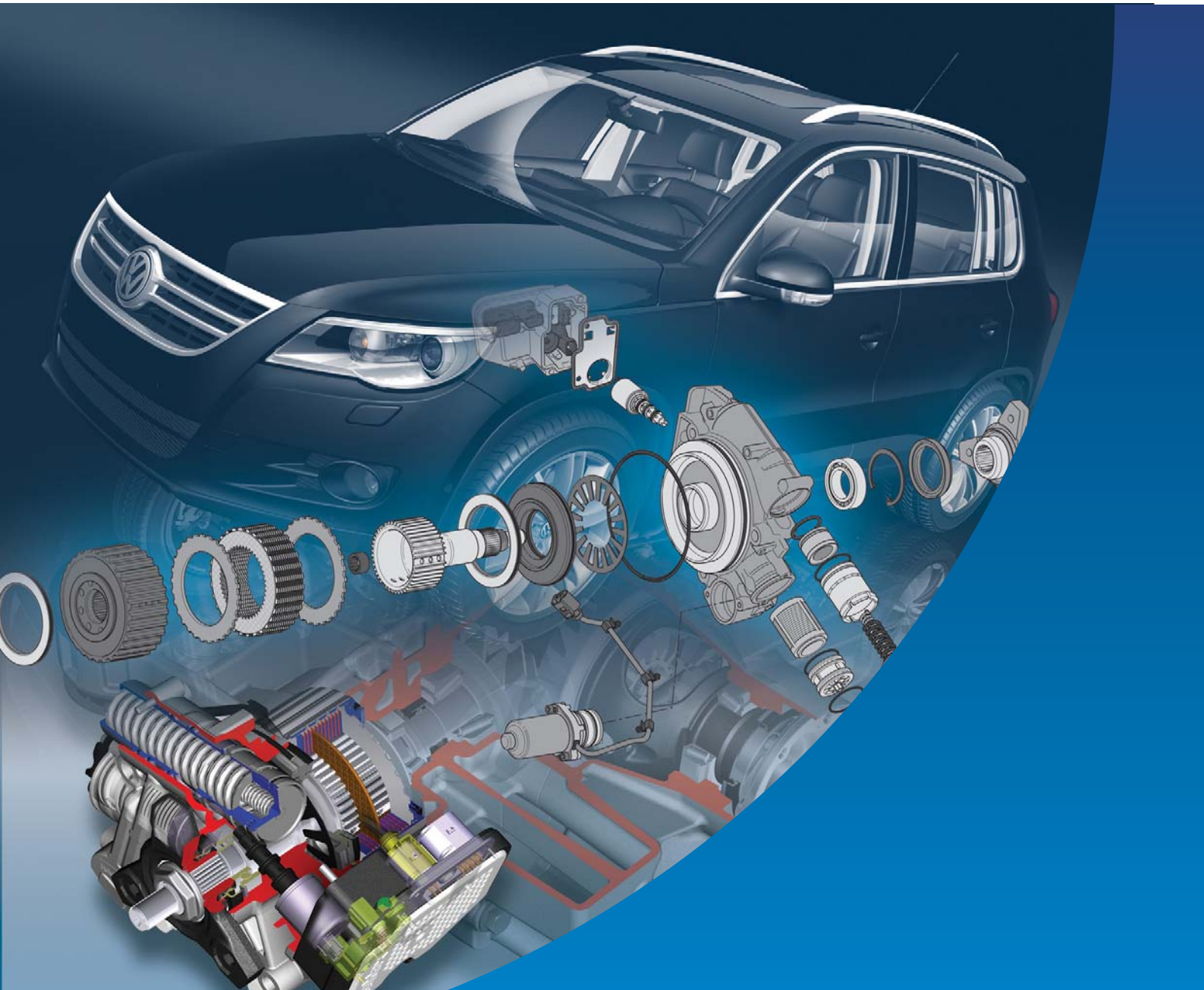
Service Training

Self-study Programme 414

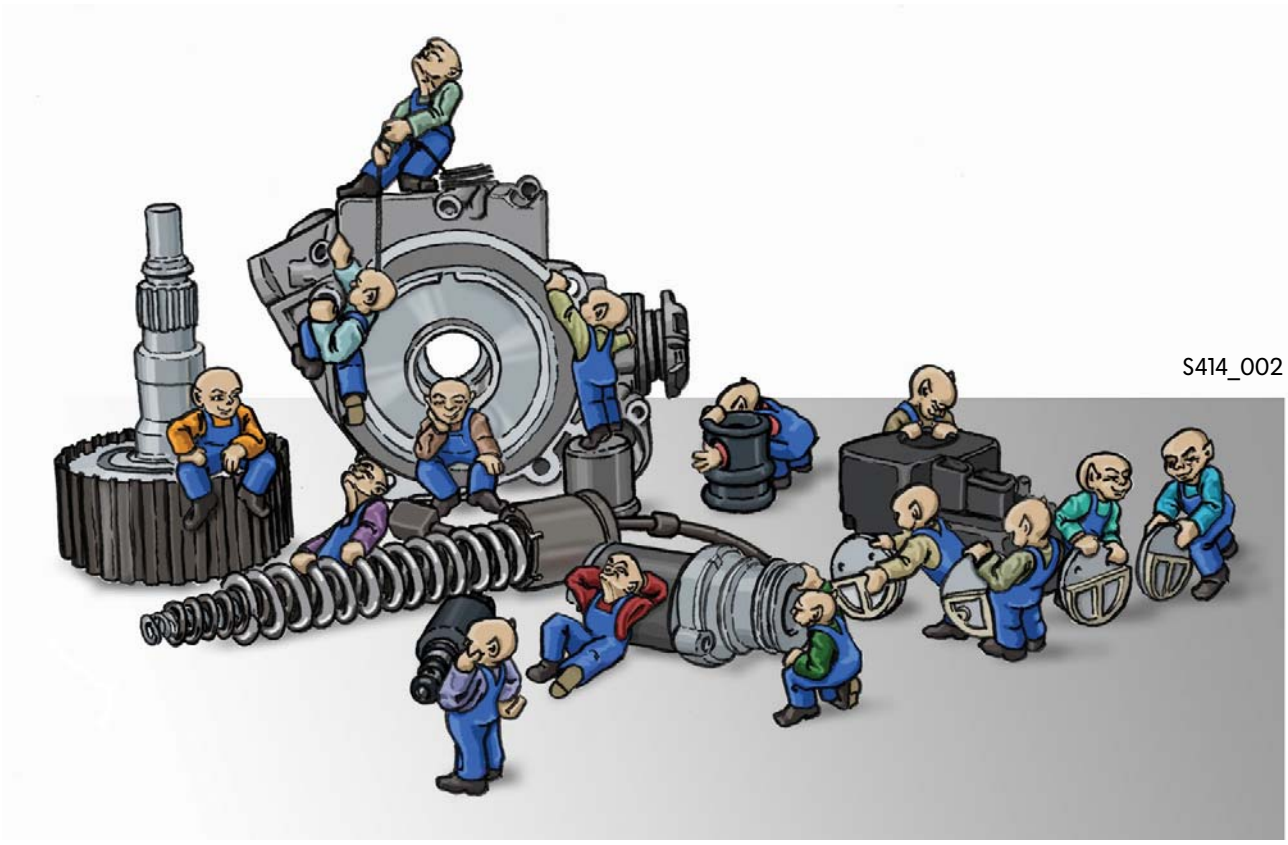
4MOTION with Four-wheel Drive Coupling Generation IV

Design and Function



Volkswagen has been using Haldex couplings for its 4MOTION four-wheel drive system since 1998. The new generation of four-wheel drive coupling is being used for the first time in the Tiguan.

The new four-wheel drive coupling exclusively uses electronic control so that any amount of torque can be built up at any time regardless of slip. The distribution of the drive power to the axles is variable and depends on the driving situation. The new four-wheel coupling in the 4MOTION system can thus react ideally and extremely fast to all driving situations.



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You will find information on the previous generations of the Haldex couplings in self-study programmes:

- SSP206 – Four-Wheel Drive with Haldex Coupling
- SSP333 – 4MOTION with Haldex Coupling, year of models 2004

NEW

Important Note

The self-study programme shows the design and function of new developments. The contents will not be updated.

For current testing, adjustment and repair instructions, refer to the relevant service literature.

Contents

In Brief

Recap

In 1998, the 4MOTION drive system replaced the Synchro four-wheel drive system at Volkswagen. Whilst the Synchro system used a Visco coupling, 4MOTION used a four-wheel drive coupling from Haldex for the first time.

The four-wheel drive can be controlled electronically using this electrohydraulic clutch plate. In addition to slip, the control unit can take driving dynamic states like cornering, speed, deceleration and acceleration into account.

First generation Haldex coupling

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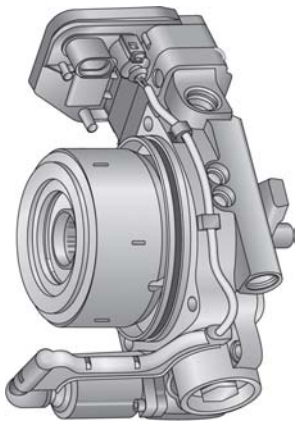
Haldex coupling from model year 2004, generation II



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The third-generation Haldex coupling was not used by Volkswagen.

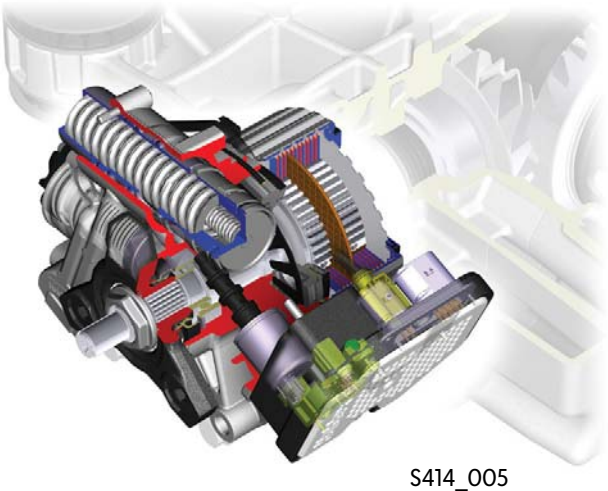
How the Haldex coupling works

On the first two generations of the Haldex couplings, a speed difference between the front and rear axles was used to create a pumping effect that builds up working oil pressure using a lifting plate, actuating rollers and two parallel lifting pistons. This pressure pushes the clutch plate set together via a working piston. The level of the pressure applied determines how much drive torque is transferred.

Suction and pressure valves, an electronically controlled valve and a control unit regulate the pressure on the clutch plates.

Fourth-generation four-wheel drive coupling

In principle, power is transmitted via the clutch plate set on the fourth generation of the four-wheel drive coupling in the same way as the previous Haldex models. One new feature is the pressure being built up with an electric pump. The four-wheel drive control unit J492 determines the torque to be transferred by controlling the coupling opening control valve N373. Speed differences between the front and rear axle are no longer required to activate the four-wheel drive coupling.



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Technical features

- Electrohydraulically controlled clutch plate
- Integrated in the rear axle drive
- Simplified hydraulic system
- Optimised, demand-regulated pump control

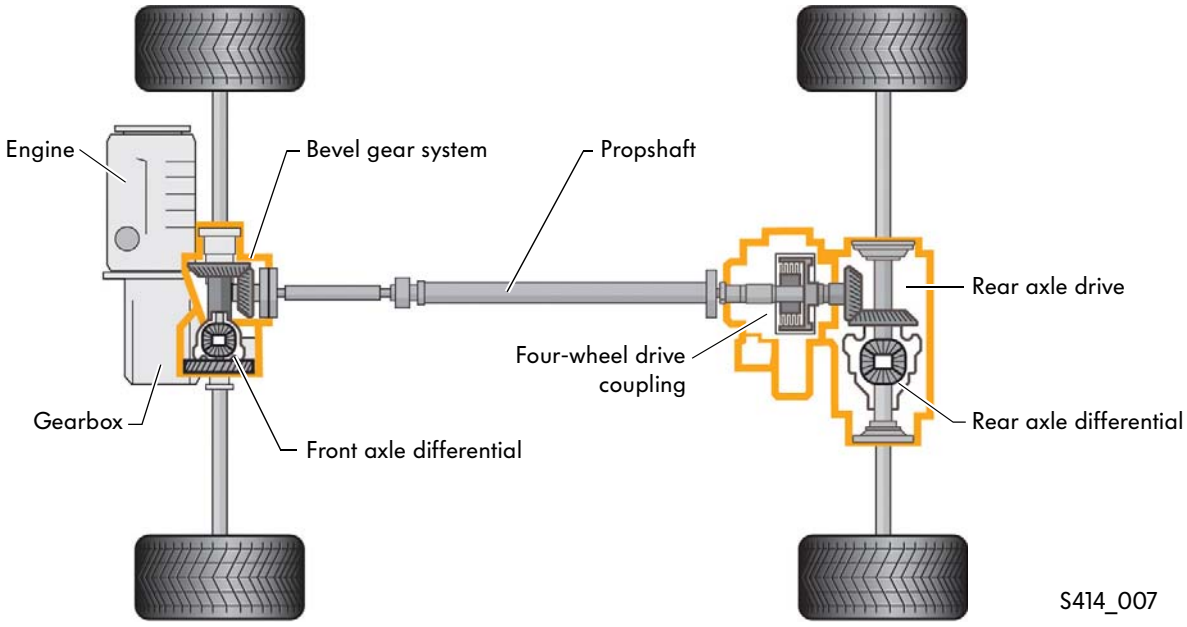
Advantages

- Coupling control not dependent on driving situation
- Fast moment build-up by means of pre-control
- Permanent rear-axle drive capacity
- Fully compatible with traction control systems (e.g. ESP, ABS)

4MOTION Power Train

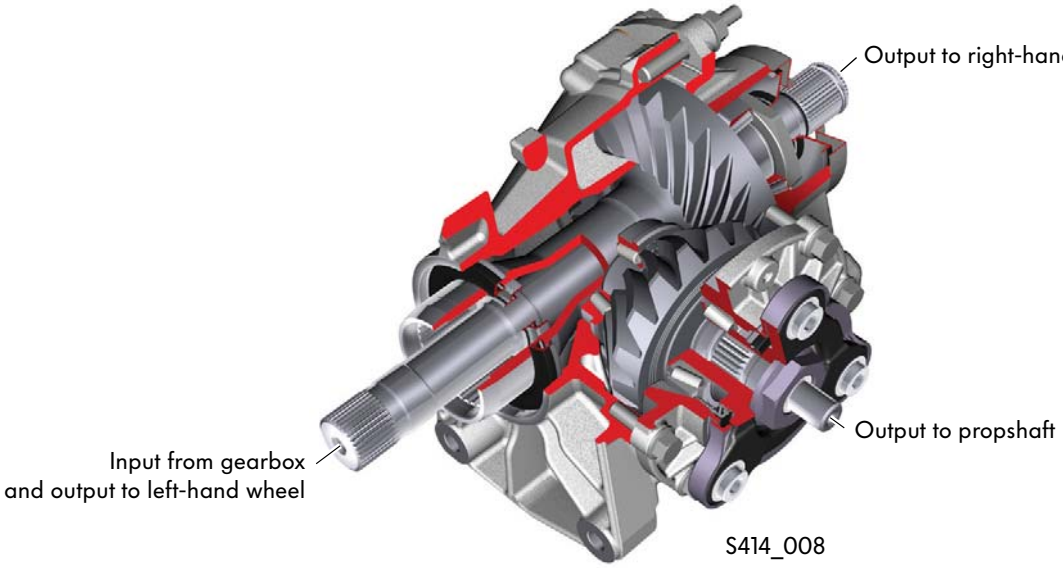
Overview of design

The front wheels are normally driven via the front axle differential. At the same time, the torque is transferred from this differential to the propshaft via a flanged bevel gear system. This is connected to the four-wheel drive coupling. Depending on how wide the four-wheel drive coupling is open, a level of torque determined by the driving situation is transferred to the rear axle drive.



Bevel gear system

The bevel gear system raises the speed by a ratio of 1.6. This allows a shaft with a smaller diameter to be used because it has to transfer less torque. The engine speed is then reduced again by the same ratio in the rear axle drive.



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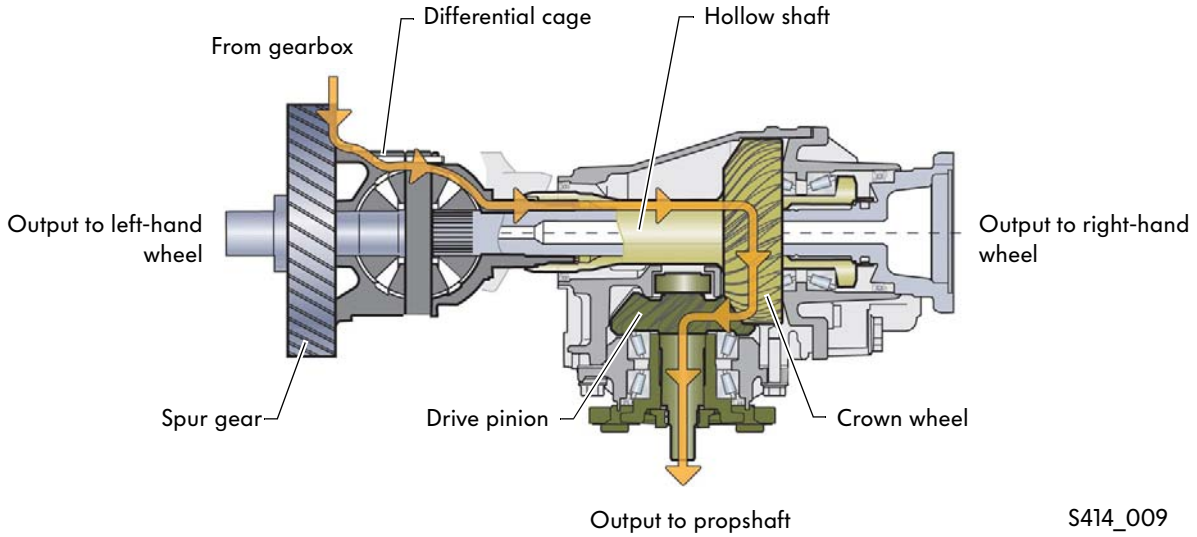
Power transmission

The power is transferred from the spur gear via the differential cage, the hollow shaft with crown wheel and the drive pinion to the propshaft.



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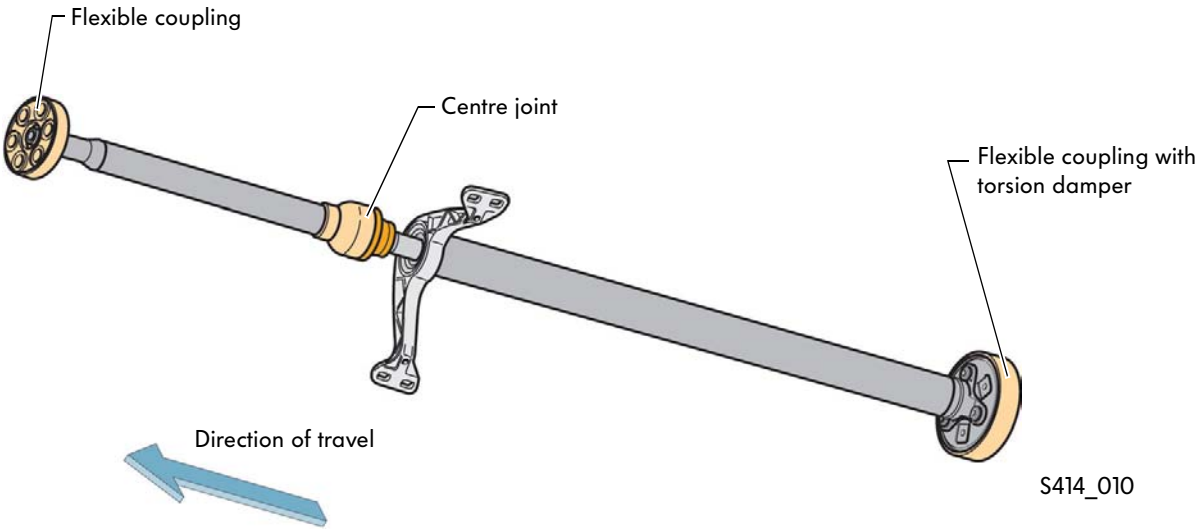
Propshaft

The propshaft is made up of two parts. It is joined by a centre joint. Flexible couplings are fitted to connect the transfer case and the four-wheel drive coupling. A torsion damper is fitted on the outside of the rear flexible coupling (not separable). This reduces the transfer of engine vibrations to the body via the rear-axle gearbox.

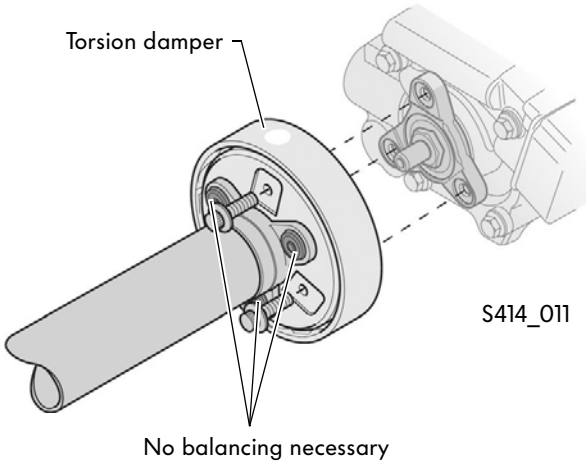


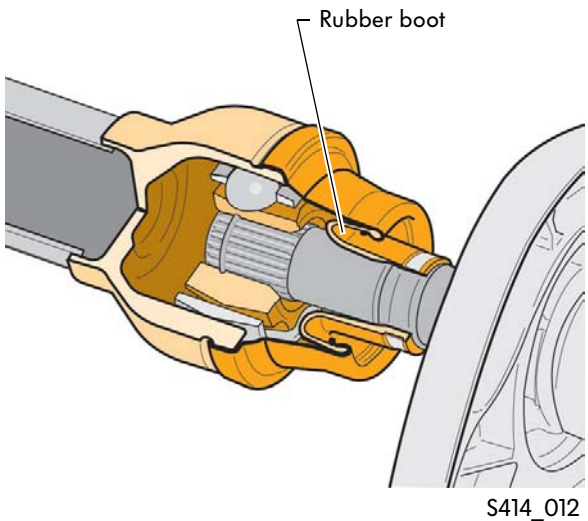
Rear flexible coupling

The rear-axle differential and the propshaft are balanced. For this reason, there is no need to balance the drive train in the vehicle.

Centre joint

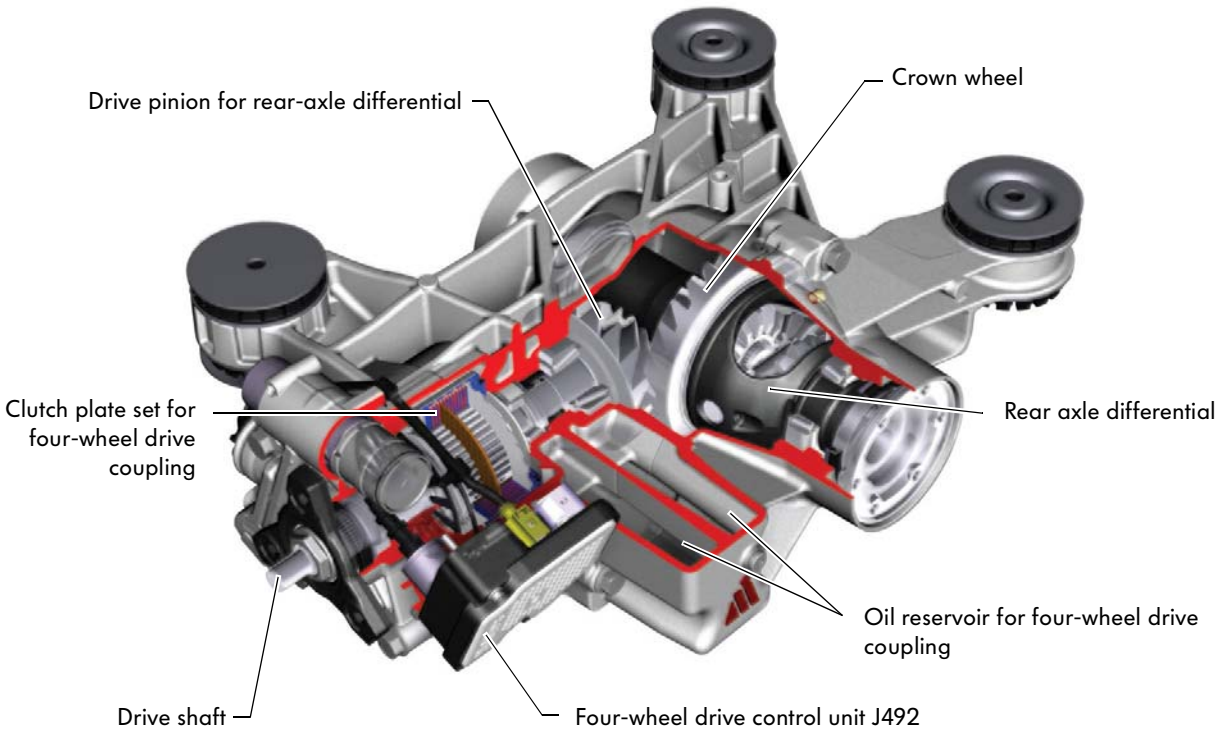
The centre joint is press-fitted and therefore cannot be removed. Volkswagen have managed to make the assembly more compact and lighter. The rubber boot is also better protected.





Rear axle drive

The four-wheel drive coupling is integrated into the rear-axle drive.



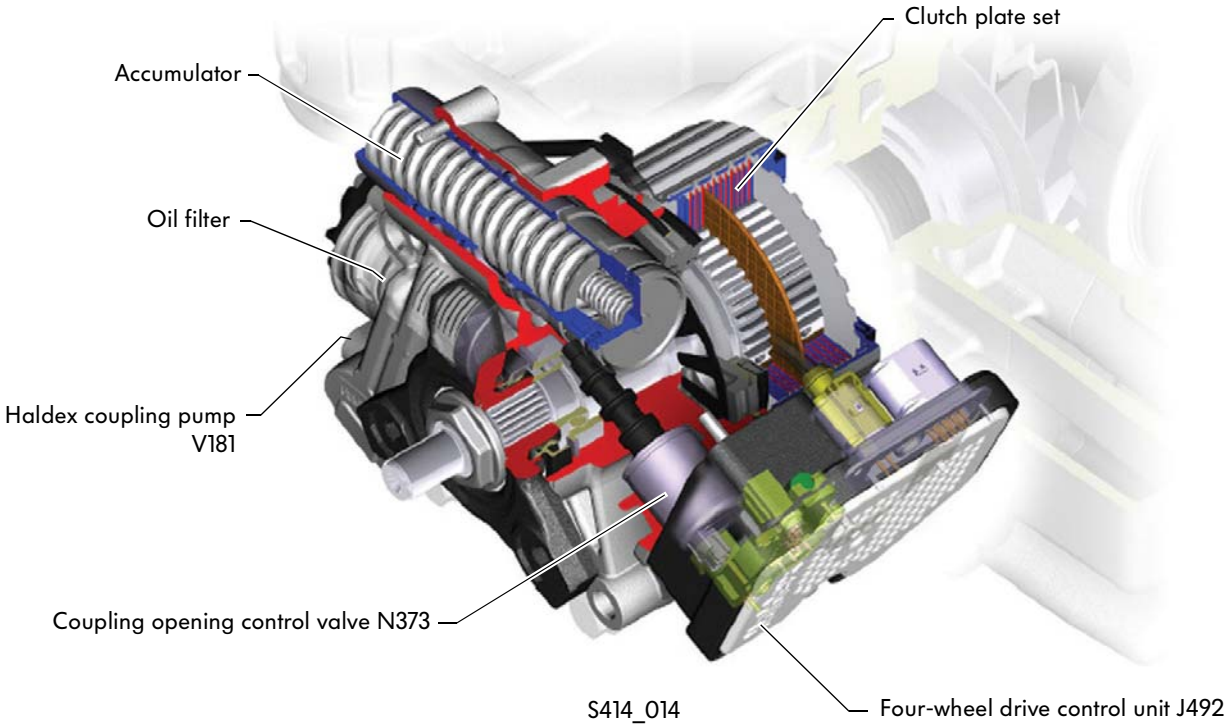
Four-wheel drive coupling

Task

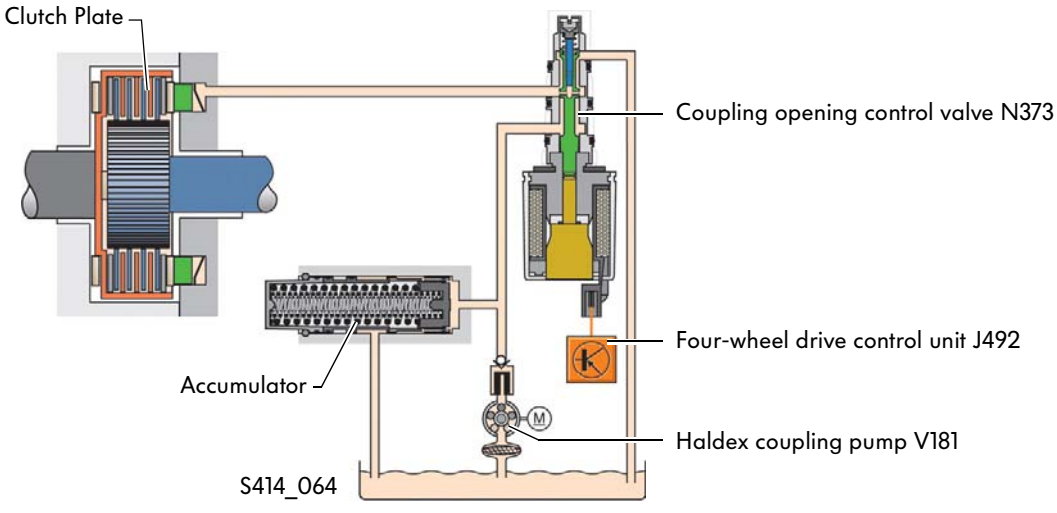
The drive torque transferred to the rear axle is controlled via the four-wheel drive coupling between the front and rear axle drive. It transfers the necessary drive torque to the rear axle depending on how wide the coupling is opened.

Design

The four-wheel drive coupling consists of the following components:



Components in oil system:



Overview

The individual component groups are shown to clarify the function:

Mechanical assembly

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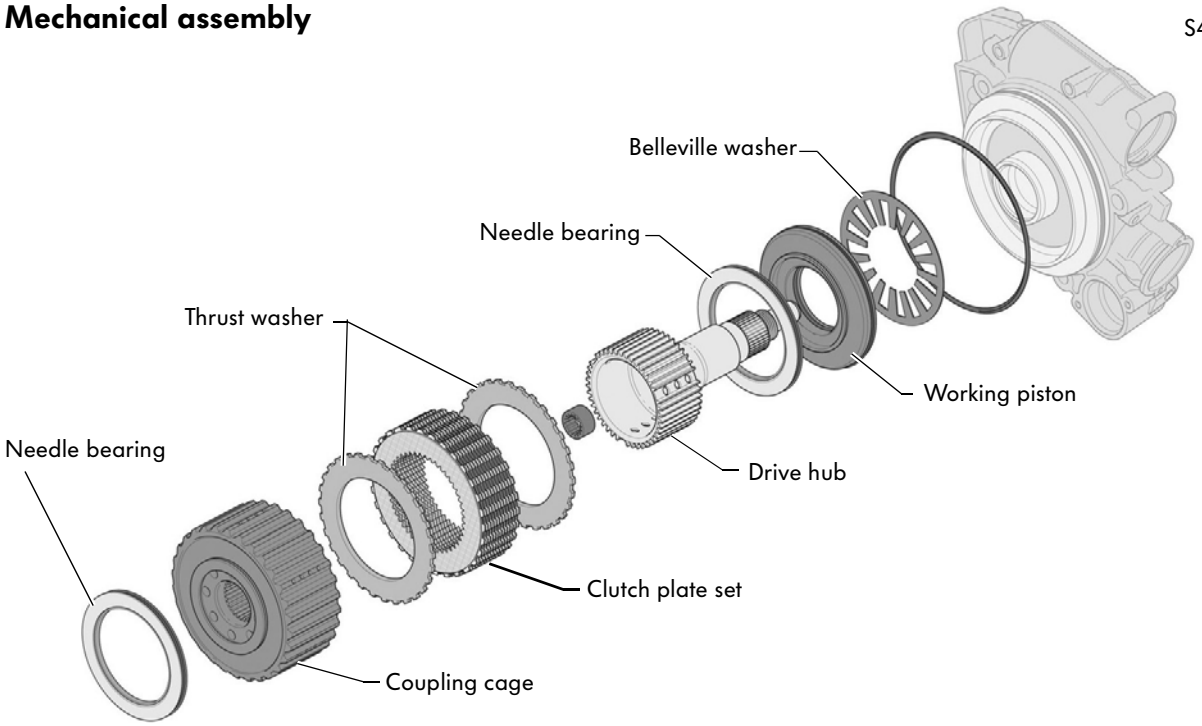

Electrohydraulic assembly and four-wheel drive control unit J492

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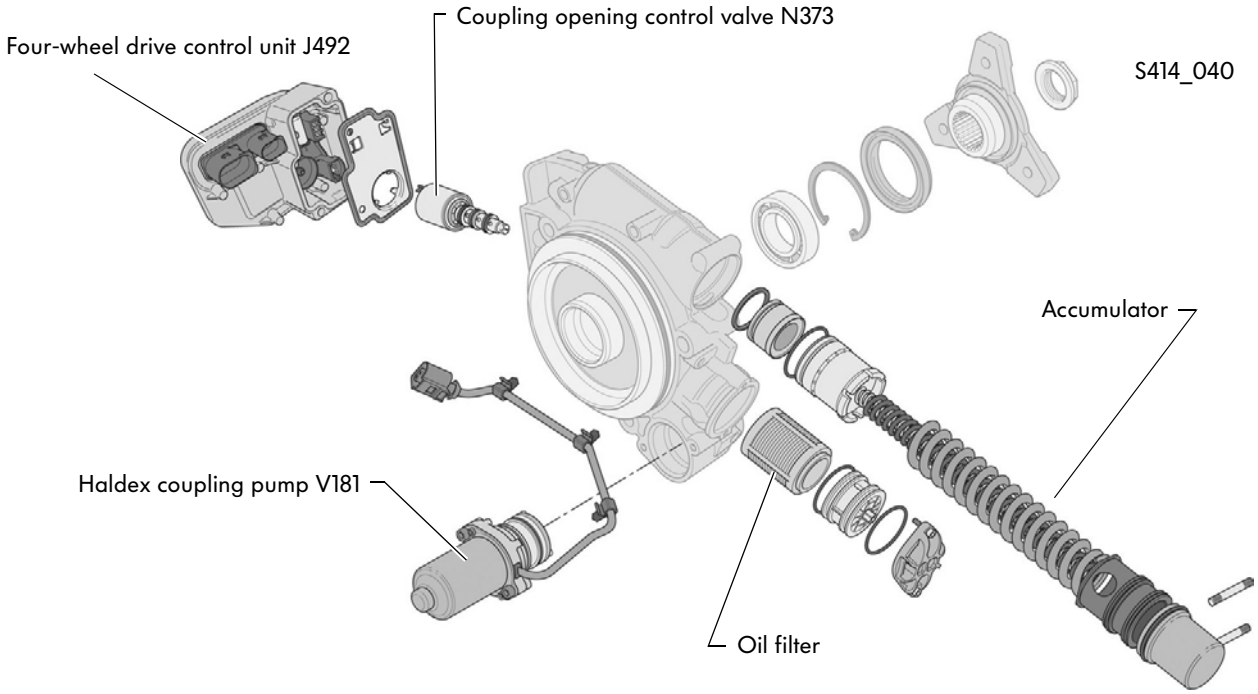


Four-wheel Drive Coupling in Detail

Mechanical assembly

The following subassemblies make up the mechanical assembly:
the clutch plate, the working piston and the belleville washer.

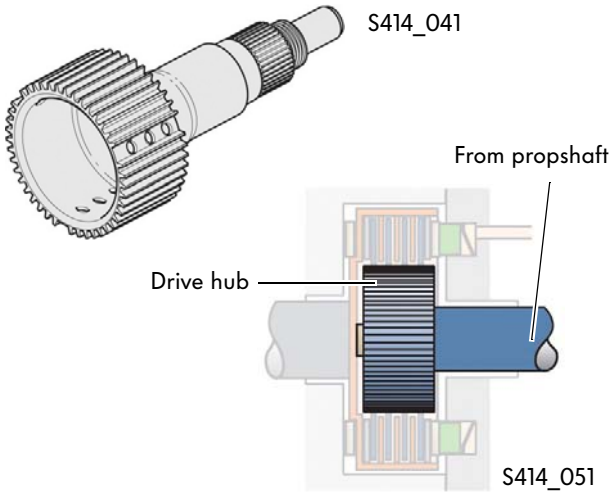
This whole assembly forms the frictional connection between the front and rear axle. If pressure is applied to the working piston, the clutch plate set is pressed together. In this way, a different torque (up to 2400 Nm) can be transferred depending on the clamping load.

Clutch plate

The clutch plate consists of the drive hub, the clutch plate set and coupling cage.

Drive hub

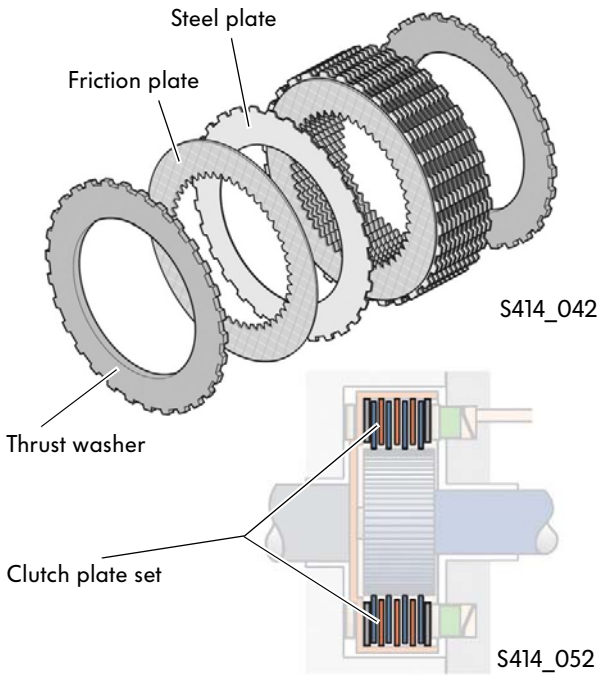
The drive hub is driven by the propshaft via the flange.

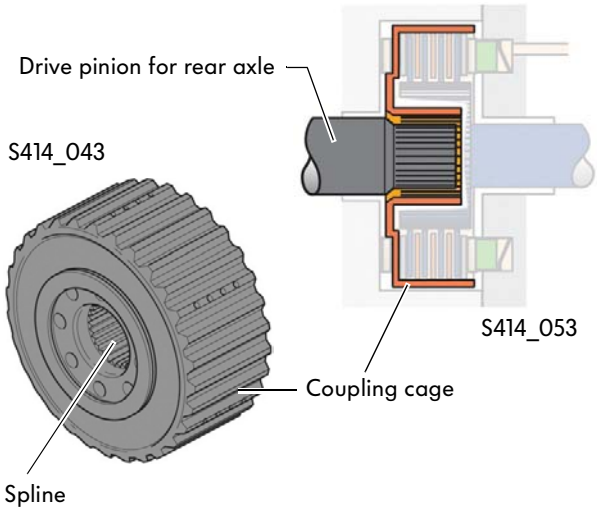


Clutch plate set

The clutch plate set consists of friction plates and steel plates and one thrust washer at the front and one at the rear.

The friction plates have inside teeth and are fitted on the drive hub. The steel plates are connected to the coupling cage by their outer teeth. The number of blades depends on the type of vehicle.

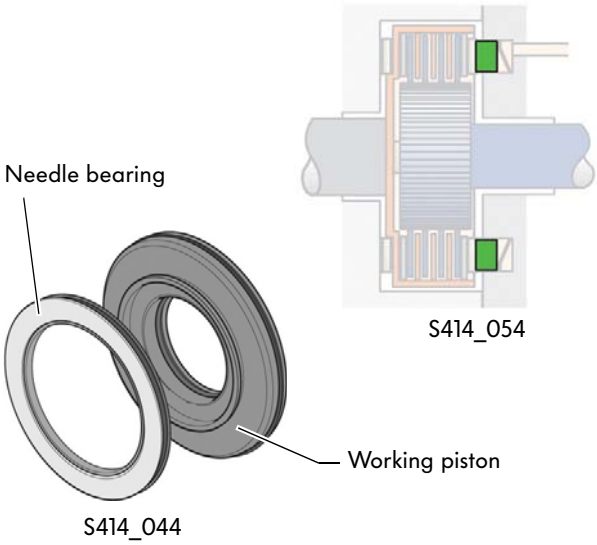




Coupling cage

The coupling cage is connected to the drive pinion for the rear axle via splines and transfers the drive torque to the rear axle.

Working piston



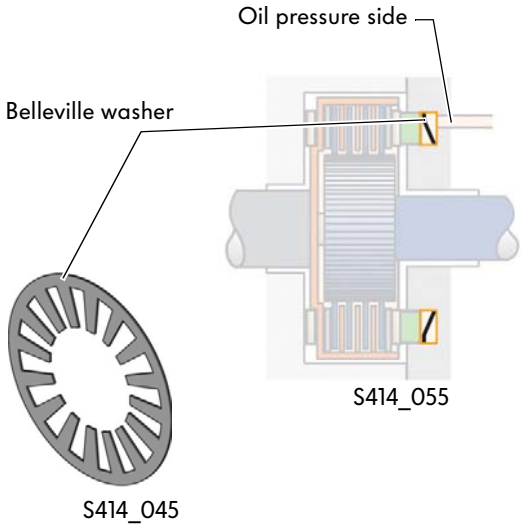
Design

The working piston is an annular piston.

Task

When the coupling is operated, the pressure of the working piston is passed onto the clutch pate set via a needle bearing. The working piston does not rotate. The clutch plate set rotates at the drive speed, however.

Belleville washer



The belleville washer is on the oil pressure side of the working piston.

Task

It pre-tensions the mechanism thus pushing the working piston. This removes the play from the clutch plate set and the needle bearings.

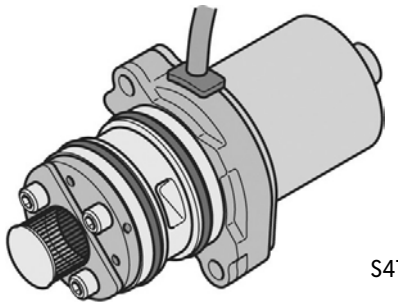
Four-wheel Drive Coupling in Detail

Electrohydraulic assembly

The electrohydraulic assembly consists of the Haldex coupling pump V181, the oil filter, the accumulator and the coupling opening control valve N373.

Haldex coupling pump V181

The Haldex coupling pump V181 is a reciprocating pump and is mounted at the lower section of the four-wheel drive coupling. It produces the oil pressure. The accumulator in the oil system is filled regularly. It is operated on demand by the four-wheel drive control unit J492.



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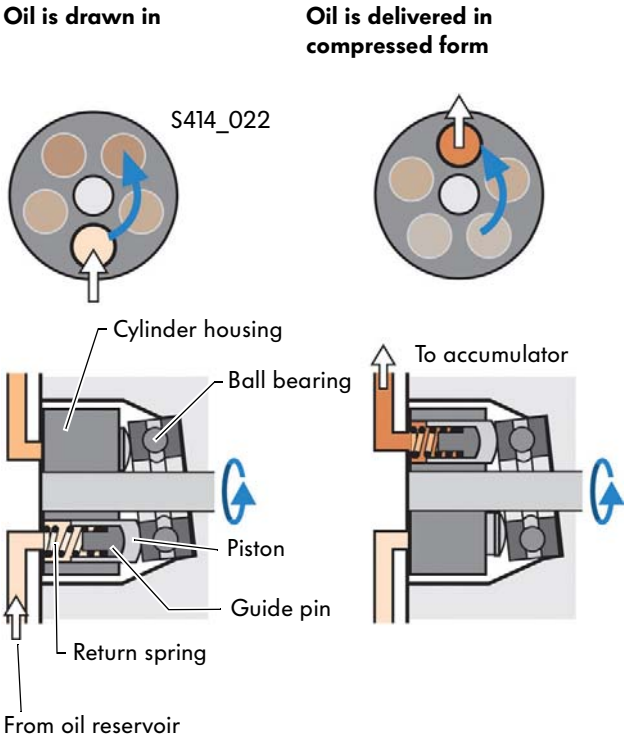
Function

Each bore in the cylinder housing has a piston with a guide pin and a return spring. Due to an angled ball bearing, the piston and guide pin make lifting movements when the cylinder housing rotates so that oil is drawn in at the bottom and after a 180° turn arrives at the top compressed.



Effect upon failure

If the Haldex coupling pump V181 fails, it is no longer possible to build up pressure. Torque is no longer transferred to the rear axle.

Oil filter

The oil filter is a maintenance-free fleece filter. A check valve has been integrated into the oil filter housing and prevents the oil pressure acting on the Haldex coupling pump V181 being released.

Accumulator

The accumulator is very compact, consists of three parallel acting springs and is mounted on the top of the coupling. It adjusts the oil pressure with spring force and maintains it at a level of 30 bar.

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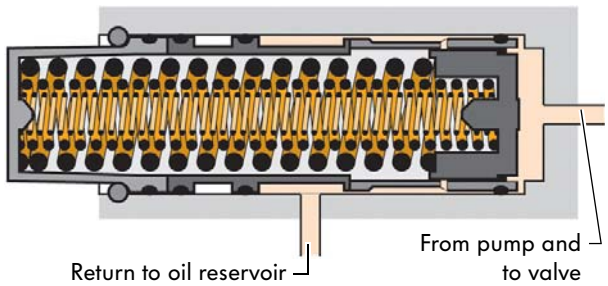
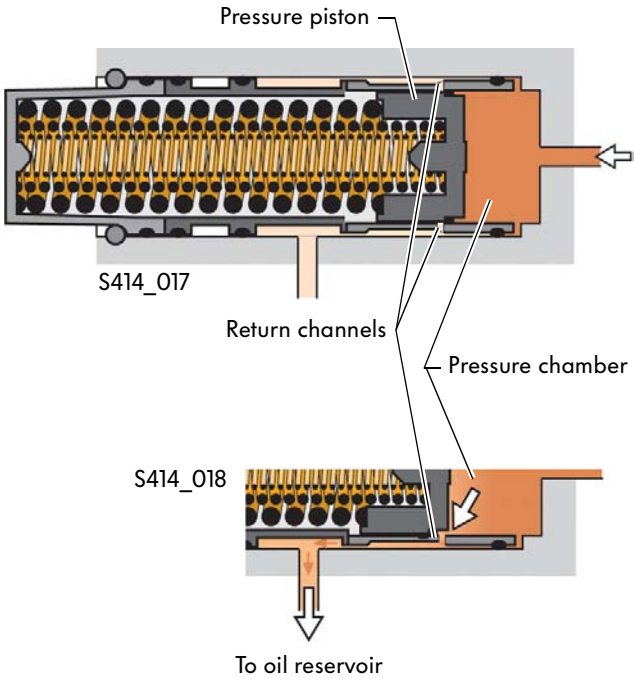


System pressure-free:

The accumulator springs are not tensioned.



System with working pressure:

The pressure chamber is filled by the pump.
This pushes back the pressure piston and the springs are tensioned.

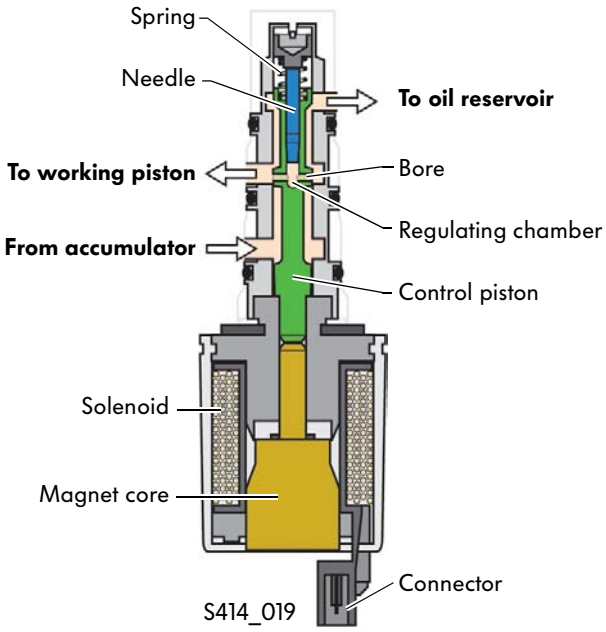
If the pressure is above 30 bar and thus too high, the return channels are opened and the pressure is released back to the oil reservoir.

Four-wheel Drive Coupling in Detail

Coupling opening control valve N373

Task

The coupling opening control valve N373 controls the working pressure that is passed onto the working piston. This rises proportionally to the current.
A precisely defined pressure is generated when a different current is applied to the valve.

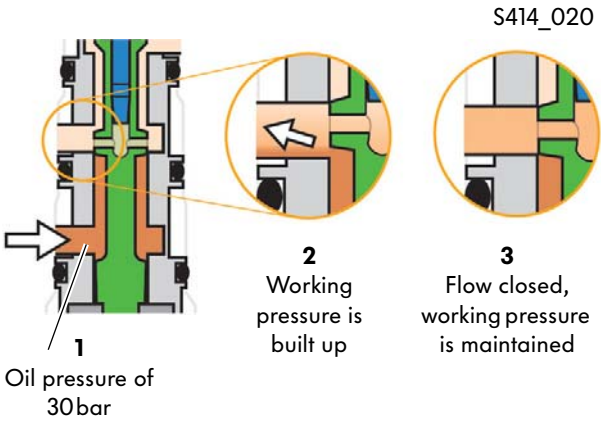


Function

An oil pressure of 30bar is built up by the Haldex coupling pump V181 and the accumulator. (**1**)

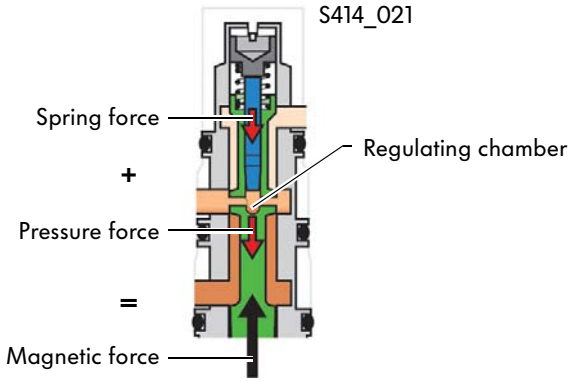
When the solenoid is energised, a magnetic force is produced depending on the size of the current applied. It moves the control piston upwards, opens the flow-through and the working pressure is built up. (**2**)

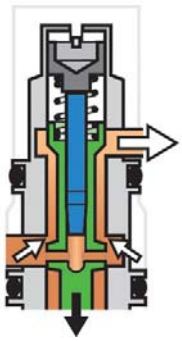
Once the required working pressure has been reached, the equilibrium of forces is formed as described below so that the flow-through is closed and the working pressure is maintained. (**3**)



The working pressure is applied to the working piston and in the regulating chamber of the control piston. The pressure in the regulating chamber acts in the same direction as the return force of the spring and supports this as a counterforce to the magnetic power. An equilibrium of forces is created.

When fully energised, the lower inlet stays open and the total oil pressure is used as a working pressure.





S414_023

If the coupling is to be opened, the solenoid is no longer energised, the control piston returns to the starting position and the pressure is released back to the oil reservoir.

Effect upon failure

If the coupling opening control valve N373 fails, four-wheel drive is no longer possible.

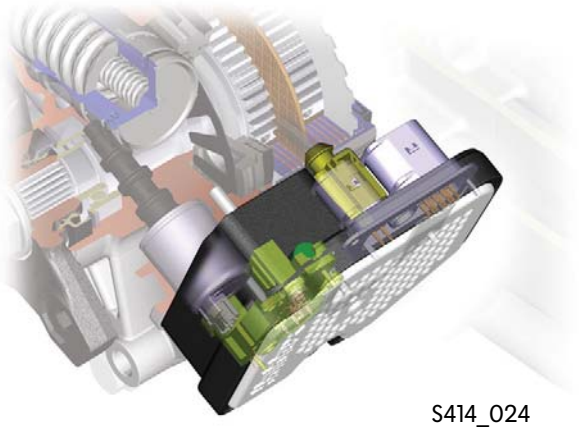
Four-wheel drive control unit J492

Task

The control unit controls the pump running times and the coupling opening control valve N373. The pressure level is exclusively determined by the position of the valve. There is a temperature sensor of the control unit circuit board whose measured values indicate the oil temperature.

The four-wheel drive control unit J492 is incorporated in the drive CAN data bus. This allows it to control the system precisely with just one sensor. The control unit uses the data on the driving situation to determine the current pressure requirement so that the opening size and the transmission of the four-wheel drive coupling is tuned ideally to the situation.

If there is ESP or ABS intervention, the ABS control unit J104 uses the four-wheel drive control unit J492 to determine how far the four-wheel drive coupling is opened.



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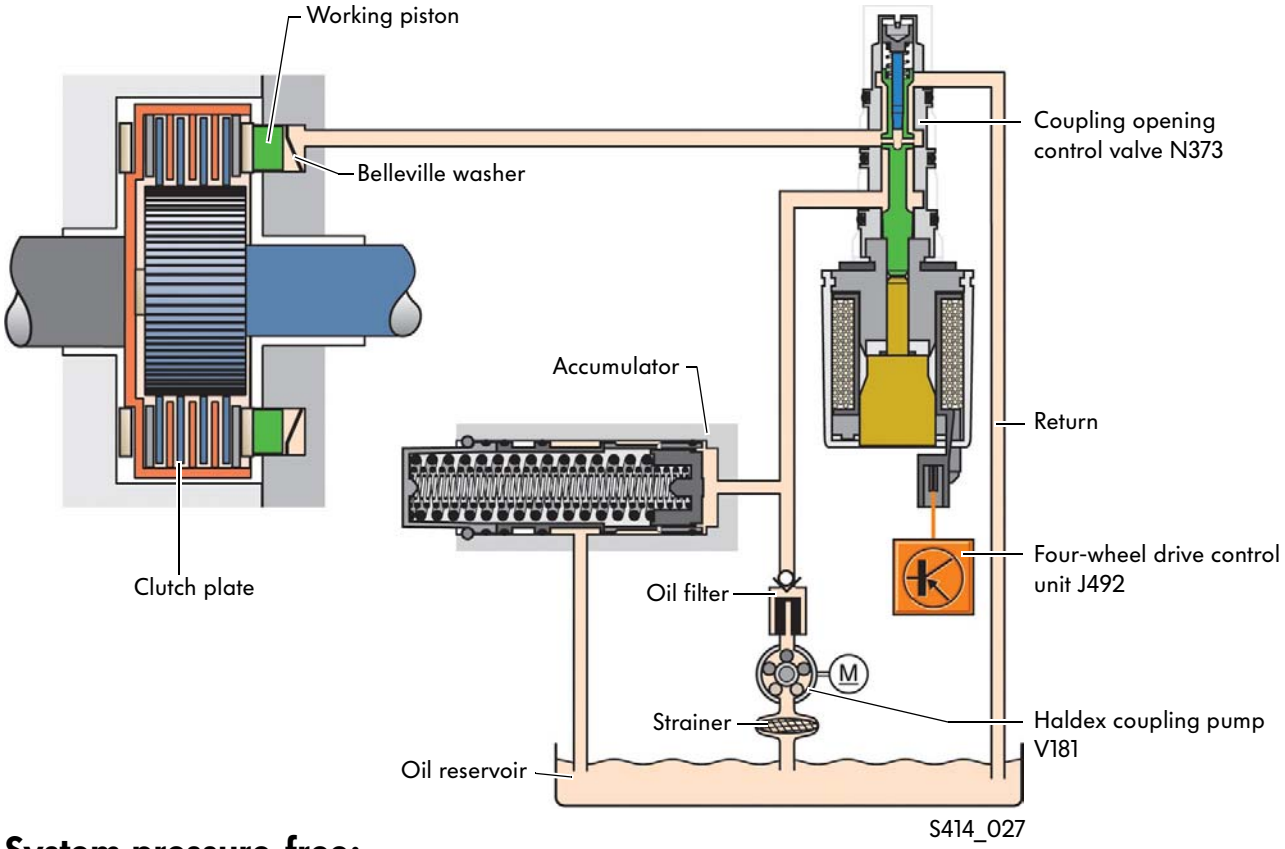
Effect upon failure

The working pressure is not built up because the coupling opening control valve N373 can no longer be controlled. The coupling is opened and the rear axle is therefore no longer driven.

Regulation

Oil system

The electrohydraulic components build up the oil pressure and thus control the clamping pressure on the clutch plate.



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System pressure-free:

The diagram shows the system in pressure-free state. Once the engine has been turned off and only the ignition is turned on, the four-wheel drive control unit J492 is activated, but pressure is not built up. The coupling opening control valve N373 is open when not energised.

A pressure-free system is required in the following situations:

Examples

Towing

S414_030

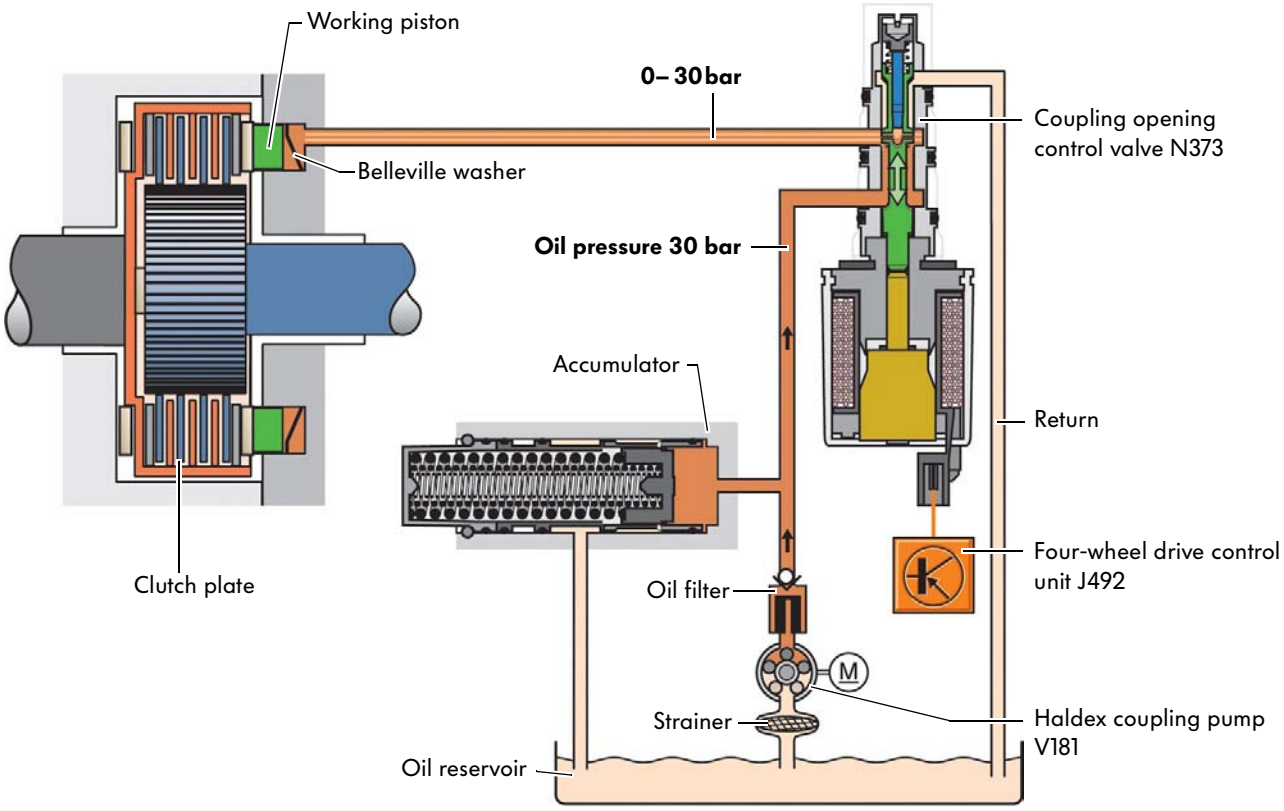
Roller dynamometer

S414_031

As a small basic moment is applied by the belleville washer, a speed of 50 km/h and a distance of 50 km may not be exceeded when the vehicle is towed with a raised axle.

Pressure build-up when engine is started

When the engine is started, the Haldex coupling pump V181 is activated. The pump is activated once an engine speed of 400 rpm is reached. It transports oil via the filter to the accumulator until a pressure of 30 bar is reached in the oil system. The coupling opening control valve N373 is closed by the four-wheel drive control unit J492 so that the working pressure is passed onto the working piston and the clutch plate set is pressed together.



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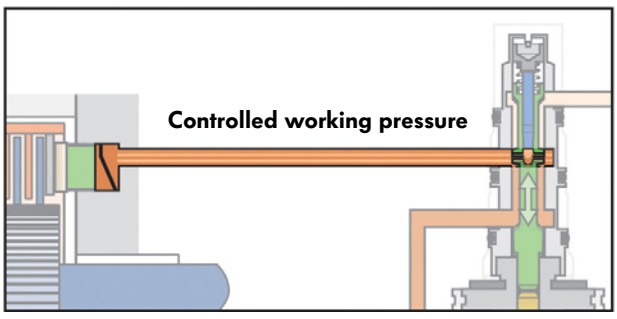
Pulling away

When you pull away and accelerate, the full rear axle drive torque is immediately available.



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System while driving

In all driving situations, the pressure between the pump and valve is held at a constant pressure of 30 bar by the accumulator. The working pressure is exclusively controlled via the coupling opening control valve N373 and can set the pressure applied to the working piston as required.

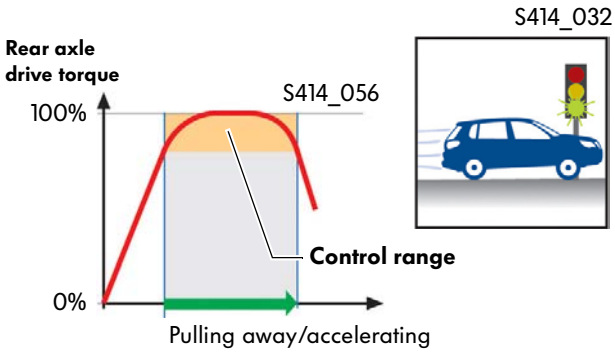
This working pressure can be 0% e.g. when braking and 100% e.g. when accelerating.

Regulation

Driving situations

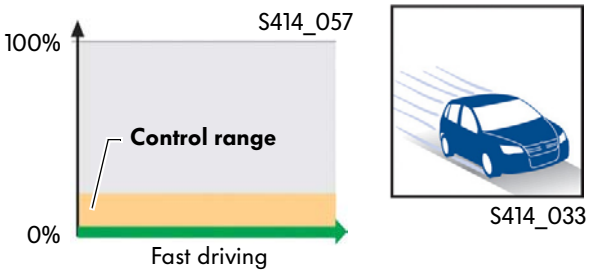
Pulling away or accelerating

A high drive torque is required at the rear axle. The valve closes completely and the clamping pressure can reach maximum.



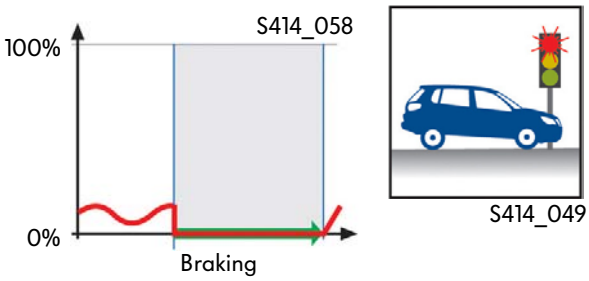
Fast driving

Only a low torque is required at the rear axle. The clamping pressure is controlled as required (control range).



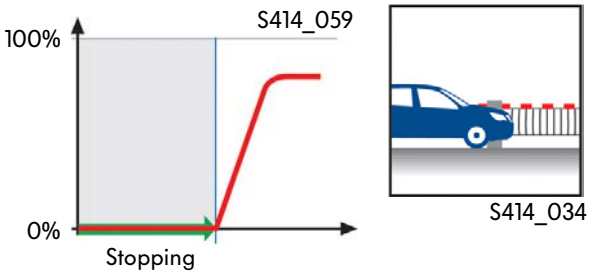
Braking

When braking, no torque should be transferred to the rear axle. Therefore the valve is opened and the pressure on the working piston is released. The coupling opens.



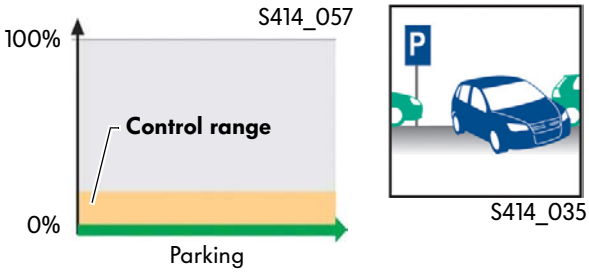
Stopping

The coupling is open while the vehicle is braked. Once the vehicle is stationary, the pre-control uses the accelerator pedal position signal. When pulling away, the pressure is built up again and the full torque is available again.



Parking

Only a low torque is transferred during parking. The drive train is not under load. The coupling is controlled as required (control range).

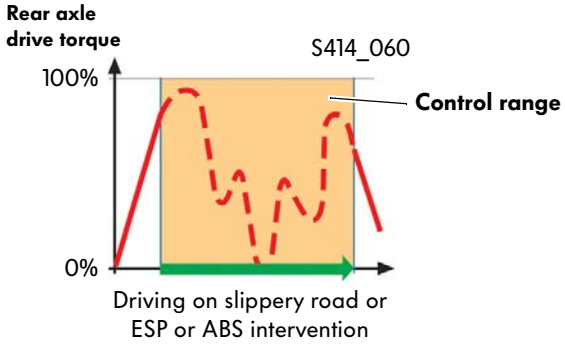


Critical driving situations

S414_036

Driving on slippery roads

The working pressure is controlled according to requirements. Signals also come from the ABS control unit J104 that recognises slip through the speed sensors and calculates the required traction.

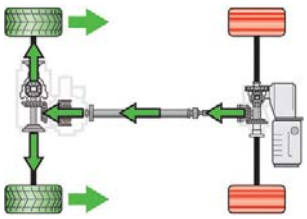


Driving on slippery road or ESP or ABS intervention

ESP or ABS intervention

If a traction control system is activated, the opening of the coupling is controlled indirectly by the ABS control unit J104. For example, the coupling can be fully opened for ABS intervention and can be closed for ESP intervention.

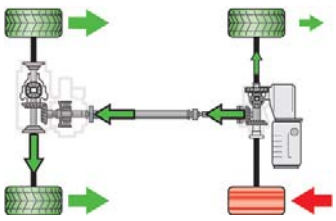
S414_038



S414_065

Pulling away with slip (on ice or snow)

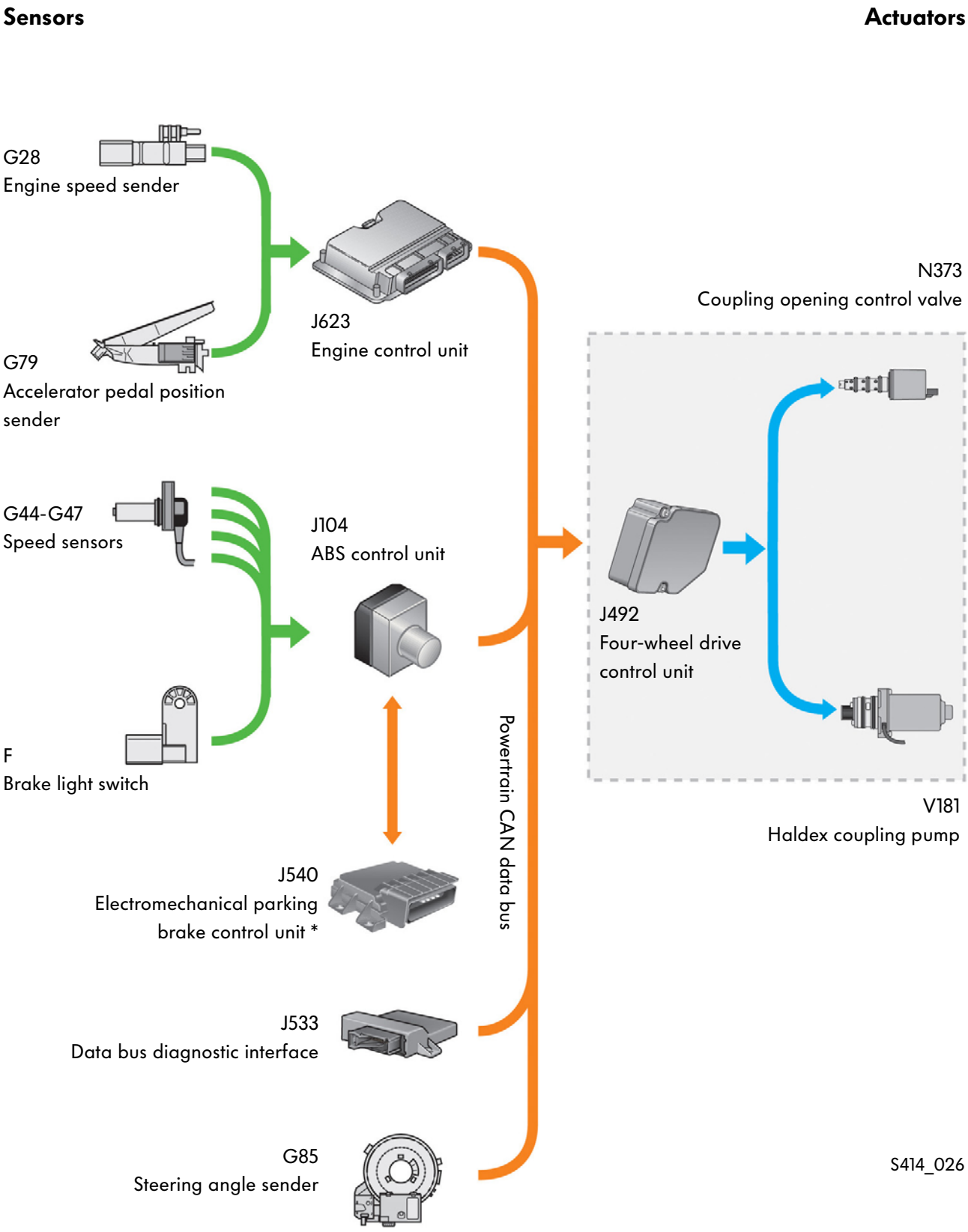
The four-wheel drive coupling is closed if both wheels on the front axle spin. The rear axle takes over drive.



S414_062

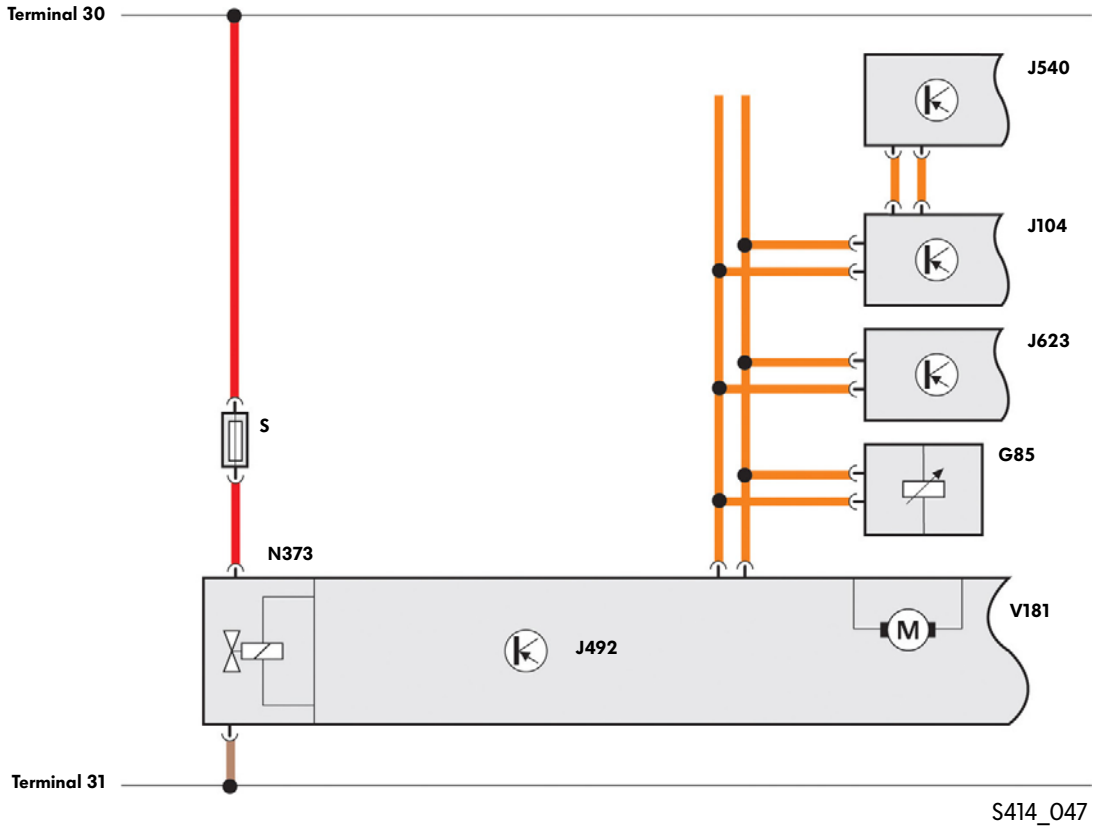
If just one wheel on the front axle spins, the electronic differential lock (EDL) will intervene by braking the spinning wheel and thus increasing the driving power of the other wheel. At the same time, the four-wheel drive coupling is closed and a large part of the driving power is transferred to the rear axle.

System overview



* A sensor cluster is integrated in the electromechanical parking brake control unit. It contains the lateral acceleration sender, the longitudinal acceleration sender and the yaw rate sender.

Functional Diagram



G85 Steering angle sender

J104 ABS control unit
J492 Four-wheel drive control unit
J540 Control unit for electromechanical parking brake
J623 Engine control unit

N373 Coupling opening control valve

S Fuse

V181 Haldex coupling pump

Colour coding

Positive
Earth
CAN data bus line

Diagnosis

Diagnosis functions

The following diagnosis functions are possible with the VAS diagnosis testers:

- Identification of control units
- Query fault memory
- Delete fault memory
- Read data blocks
- Control element test
- Basic setting
- Customisation
- Code

The individual diagnosis functions are available via the guided fault finding system or the guided functions.

VAS 5051B

S414_066

VAS 5052

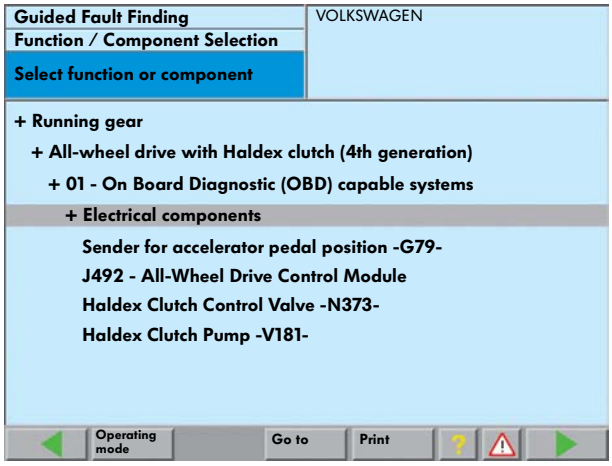
S414_067

VAS 5053

S414_068

Testing individual components

Individual component tests can be called up via the function and component selection in the guided fault finding system.



S414_069

Four-wheel drive control unit J492

The four-wheel drive control unit J492 uses address word 22 for self-diagnosis.

- The four-wheel drive coupling can be replaced separately. There is no need for complicated adjustment work after replacement as the drive pinion belongs to the rear-axle differential and is not replaced.
- The high-performance oil was specially developed for the requirements of the fourth generation four-wheel drive coupling.

Test Yourself

1. What is the difference between the fourth generation of the four-wheel drive coupling and the previous models?

☐ a) The new four-wheel drive coupling is controlled electrohydraulically. Speed differences between the front and rear axle are no longer required to activate the four-wheel drive coupling.

☐ b) The new four-wheel drive coupling uses electronically controlled valves to control the working pressure acting on the clutch plate.

☐ c) Unlike the previous models, the fourth generation of the four-wheel drive coupling can also take driving-dynamic states like cornering, speed, acceleration and deceleration into account.

2. What is the task of the accumulator in the oil system of the four-wheel drive coupling?

☐ a) The accumulator regulates the pressure applied by the working piston to the clutch plate.

☐ b) A pilot pressure of 3 bar is built up by the accumulator.

☐ c) The accumulator is filled by the Haldex coupling pump V181 and ensures a constant oil pressure of 30 bar in front of the coupling opening control valve N373.

3. How does the coupling opening control valve N373 work?

☐ a) When the solenoid for the coupling opening control valve N373 is energised, the control piston starts moving and the working pressure for the working piston is built up. As soon as the required pressure is reached, the flow is closed and the working pressure is maintained.

☐ b) If the coupling opening control valve N373 is energised, the line to the working piston is opened completely and the working pressure of 30 bar is built up on the working piston.

☐ c) If the solenoid for the coupling opening control valve N373 is not energised, the control piston is in rest position and the line to the oil reservoir is open so that the working pressure is released.

☐ d) The working pressure acting on the working piston rises proportionally to the current that is applied to the solenoid for the coupling opening control valve N373.

4. How is drive torque transferred by the four-wheel drive coupling when the vehicle has to stop at a red light?

☐ a) If the vehicle has to stop at a red light, the coupling is immediately opened fully.

☐ b) If the driver brakes before the traffic lights, the clutch plate is opened fully. When the vehicle pulls away, the pre-control uses the signal for the accelerator pedal position to build up the working pressure again via the coupling opening control valve N373.

☐ c) If the vehicle is standing at traffic lights, the drive torque at the rear axle is regulated as required depending on the engine speed.

Answers:

1. a)
2. c)
3. a), c), d)
4. b)

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Volkswagen AG
Service Training VSQ-1
Brieffach 1995
38436 Wolfsburg

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