



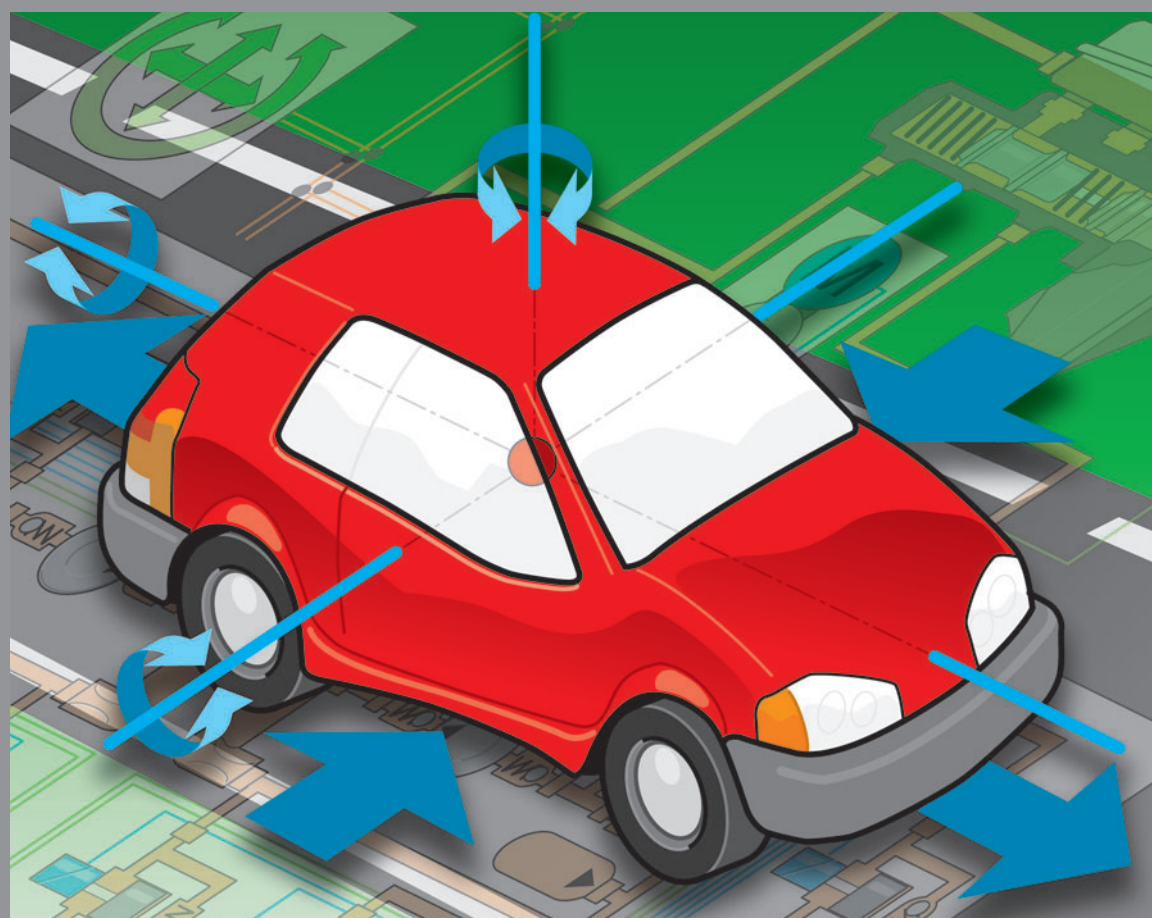
Self-study Programme 374

# Traction Control and Assist Systems

Design and function

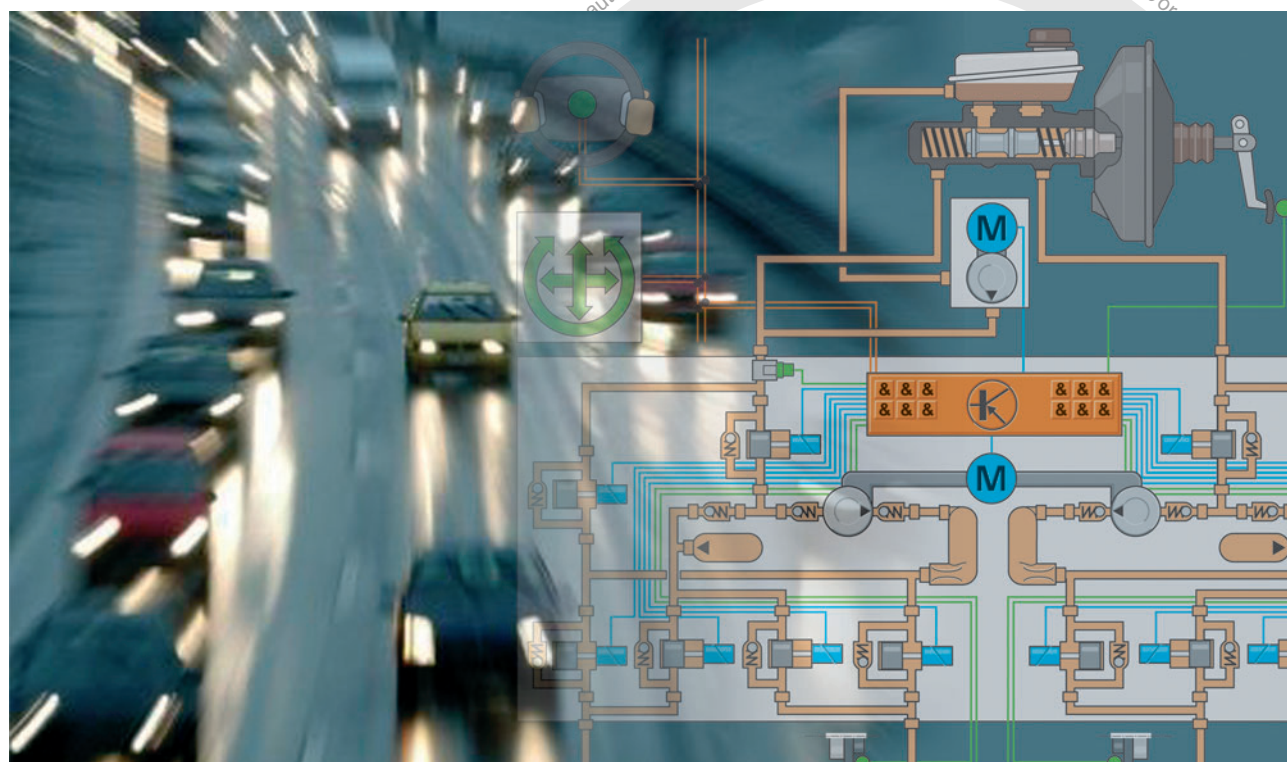


Commercial  
Vehicles



Increasing speed and road traffic density are increasing the need for vehicle dynamics which offer the highest possible level of safety under all operating conditions. This is being achieved via a rising number of traction control and assist systems, some of which have been derived from the anti-lock brake system (ABS) and which support the driver.

This fundamental information booklet provides an overview of these systems. In addition, their fundamental functional principles and which components work together in the relevant systems are explained.



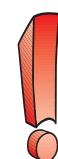
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This self-study programme imparts the basics of the design and function of new vehicle models, new vehicle components or new technologies.  
**The self-study programme is not a workshop manual!.**  
**The contents will not be updated.**

Specified values serve only to facilitate understanding and refer to the software status valid at the time at which the SSP was created.  
For testing, servicing and repair work, please use the current technical literature under all circumstances.



**Further  
information**



**Note**

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# Introduction

## About this booklet

As announced on page 2, this fundamental information booklet deals with the basic structure of the various traction control and assist systems, which influence the vehicle dynamics via the brake system or engine intervention.

The various systems usually make use of the same types of sensor. The chapters dealing with the traction control and assist systems are therefore preceded by a brief chapter concerning the manner in which certain new sensors function.



Information on further sensors, which work in the systems, can be found in self-study programme 204 "ESP Electronic Stability Programme" and in Skoda SSP No. 28 and No. 42.

The chapter entitled "Traction control systems" explains the structure and the way in which the individual brake systems function. The anti-lock brake system ABS is regarded as the origin of all traction control systems and the electronic stabilisation programme ESP as the higher-level system in this case.

The chapter on auxiliary ESP functions provides an overview of the ESP function software extensions which are currently available.

The assist systems have the task of relieving the driver under certain conditions or during driving manoeuvres such as e.g. starting off on a hill. They do not actually belong exclusively to the topic of the running gear and brakes. The assist systems portrayed in this booklet are listed because they are integrated as functions into the ABS/ESP control unit or make extensive use of ESP system functions, such as e.g. its sensor system.

## Overview of the abbreviations which are used



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Designation		VW designation
Active Roll-over Protection	ARP	ROP – Roll-Over Prevention
Adaptive Cruise Control	ACC	ACC – Adaptive Cruise Control
Stopping distance reduction 1	AWV1	AWV1
Stopping distance reduction 2	AWV2	AWV2
Anti-lock Brake System	ABS	ABS
Traction Control System	TCS	TCS
Auto-Hold	AHA	Auto-Hold
Driver Steering Recommendation	DSR	Countersteering support
Dynamic auto release	DAR	DAR
Electronic Parking Brake	EPB	Electromechanical Parking Brake
Electronic Brake pressure Distribution	EBD	EBD
Electronic Differential Lock	EDL	EDL
Electronic Stabilisation Programme	ESP	ESP
Extended anti-lock brake system	ABSplus	ABSplus
Cornering Brake Control	CBC	CBC - Cornering Brake Control
Fading Brake Support	FBS	Overboost
Front Scan Assist	FSA	Front Assist
Yawing moment build-up deceleration	GMA	YMC – Yaw Moment Control
Hill Descent Control	HDC	Hill descent assist system
Hill Hold Control	HHC	HHC – Hill start assist system
Hill Start Assist	HSA	HSA - Hill Start Assist (hill start assist system in the Touareg and T5)
Full Rear Axle Deceleration	FRAD	FRAD
Hydraulic brake servo	HBS	HBS
Hydraulic Brake Assist system	HBA	HBA
Engine intervention anti-lock brake system (extended anti-lock brake system)	E-ABS	E-ABS
Engine Braking effect Control	EBC	EBC
Rain Brake Support	RBS	BSW – Brake disk dry braking
Ready Alert Brake	RAB	Prefill
Roll-Over Programme	ROP	ROP – Roll-Over Prevention
Trailer Stabilisation Assist system	TSA	Vehicle/trailer stabilisation

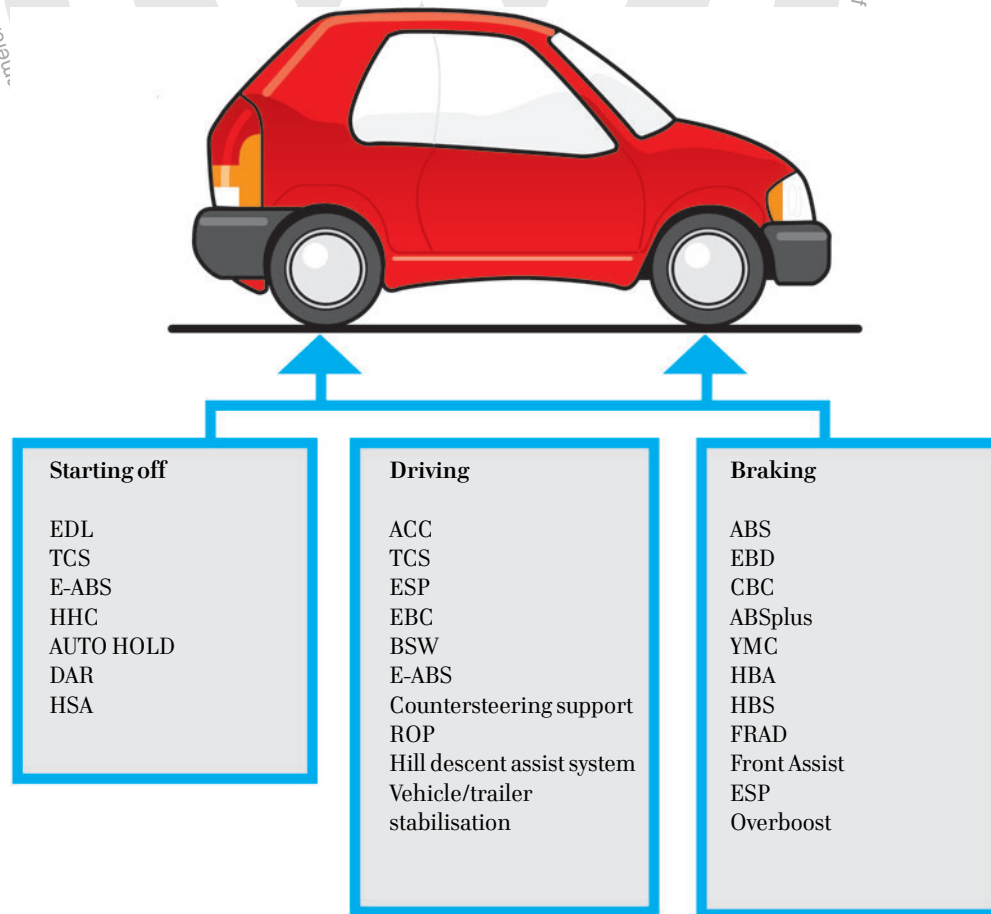


# Introduction

## Classification of the systems

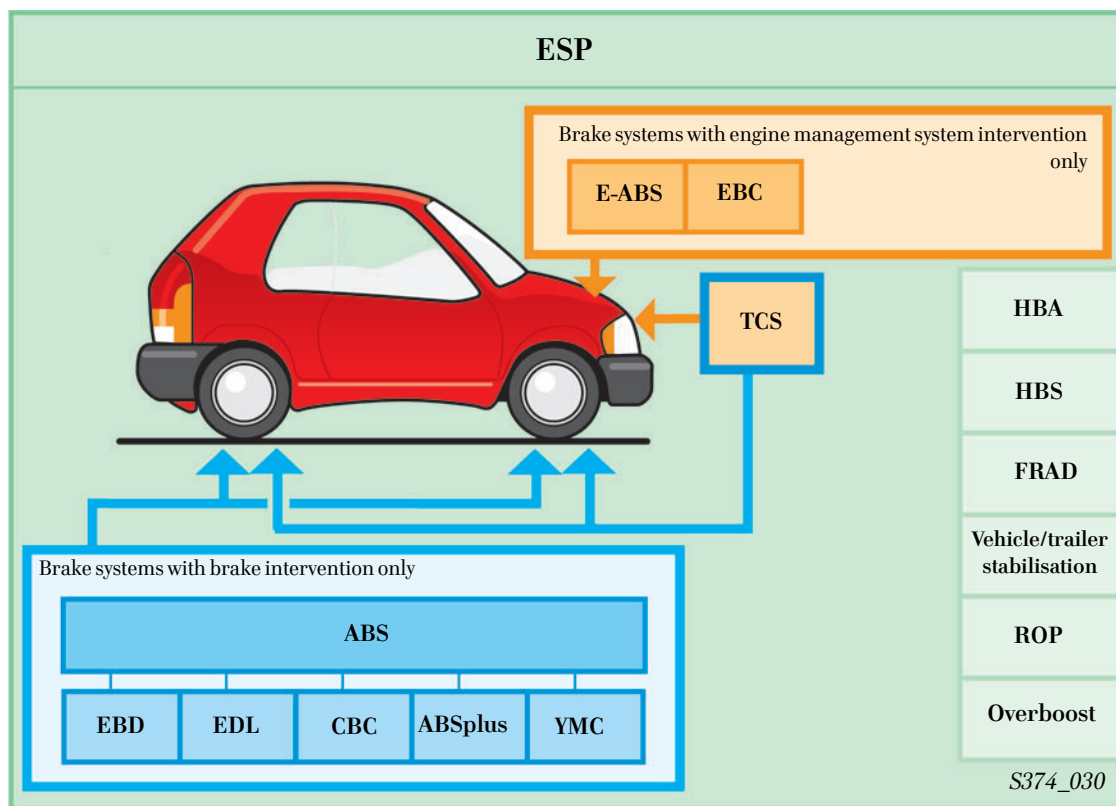
Due to the multitude of control systems, it is difficult to classify the traction control and assist systems logically and clearly. Amongst other aspects, the systems are hierarchically linked to each other, some are at more developed stages and others are based on the others' hardware or software or are additions to existing functions.

One option for classifying them is to assign the traction control and assist systems to the vehicle operating statuses of "starting off", "driving" and "braking". The following illustration shows which system may intervene in which vehicle operating status.



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A further and more detailed option for classifying them is to sub-divide the traction control systems into two groups. Firstly, those systems with brake intervention solely via the hydraulic brake system and secondly, those which additionally influence vehicle dynamics via the engine management system or gearbox management system.



The anti-lock brake system ABS is the source of all traction control systems, and is a brake system with brake intervention only. The software extensions and extensions via additional ABS system components include EBD, EDL, CBC, ABSplus and YMC.

TCS is an extension of the ABS system. In addition to active brake intervention, this also enables intervention in the engine management system. The brake systems with engine management system intervention only include E-ABS and EBC.

All traction control systems are subordinate to the ESP system, when ESP is fitted in the vehicle. If the ESP function is shut down, certain of the traction control systems function autonomously.

The electronic stabilisation programme ESP intervenes independently in the vehicle dynamics when the control electronics ascertain a deviation between the driver's command and the vehicle's actual behaviour. This means that the electronic stabilisation programme ESP decides the vehicle dynamic conditions, and when, which traction control systems are activated or deactivated. ESP is the master function, so to speak.

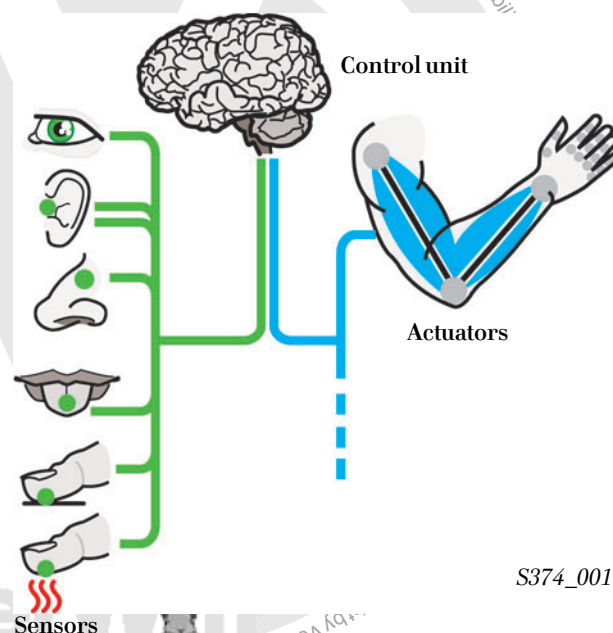
In this booklet, the ESP extensions are called auxiliary ESP functions, and necessitate the vehicle's being equipped with ESP.

# Sensors

## General information

To enable a person to respond to their environment, in order e.g. to avoid an approaching danger, they must be able to perceive (sense) their surroundings.

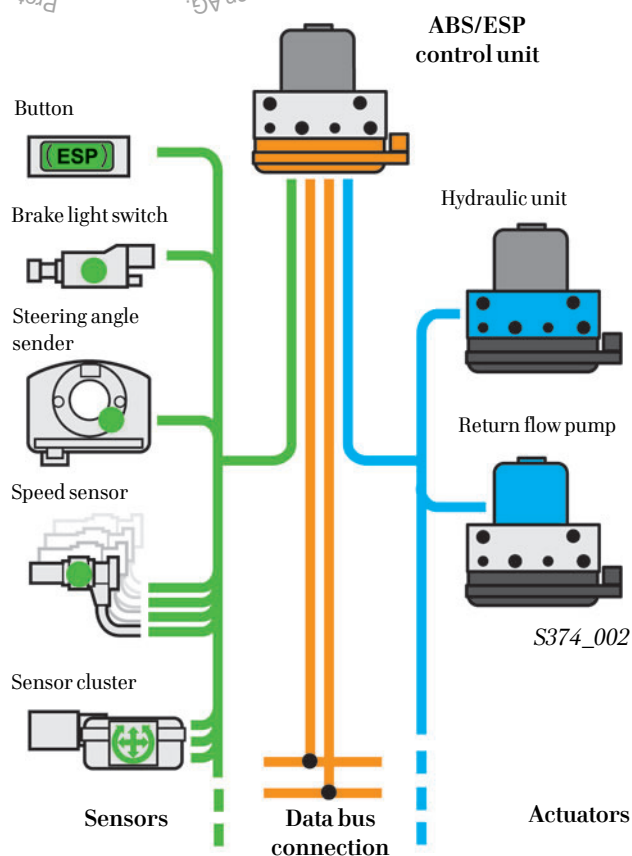
To do this, we make use of our senses, which are given to us by nature. We have optical sensors (eyes), acoustic sensors and our sense of balance (ears), sensors which react to chemical substances (nose & sense of taste) and sensors which react to contact (sense of touch) or temperature. Our ears are actually a sensor cluster, i.e. an amalgamation of several sensors, as we can register both sound and acceleration with them.



S374\_001

A comparable situation applies to motor vehicles and their traction control and assist systems. To enable these systems to work, in order to defuse critical vehicle dynamics situations or prevent them from occurring, they must be equipped with sensors which enable them to register the driving situation. In particular, these include the speed sensors, acceleration and torque sensors. However, pressure sensors, yaw rate sensors or Hall sensors are used in the various systems, e.g. to register a pedal position.

This booklet restricts itself to revealing the difference between active and passive speed sensors. It will also introduce the new sensor cluster. In addition to longitudinal and lateral acceleration senders, this now also contains a yaw rate sensor.



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For more detailed information on the traction control system sensors, please refer to self-study programme 204 "ESP Electronic Stability Programme" and Skoda SSP No. 28 and No. 42.

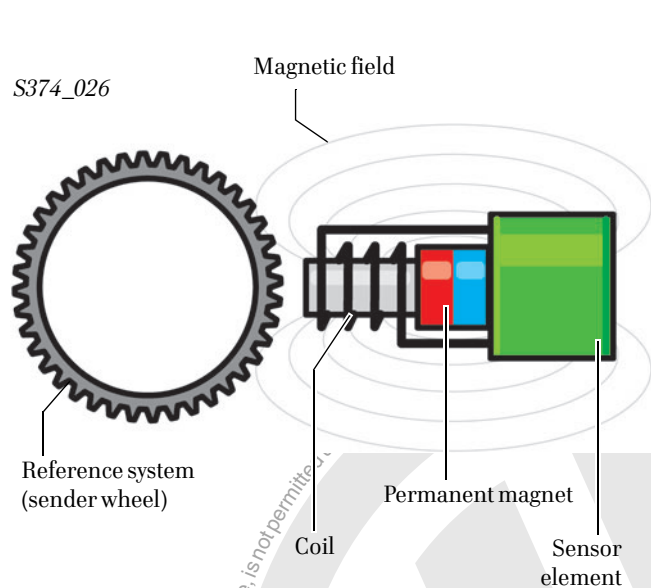


## Passive and active speed sensors

Both types of sensor serve to inform the system of the vehicle speed and, much more importantly, the individual wheel speeds. The systems use differences in the wheel speeds to determine e.g. whether the tyres are located on a road surface with different levels of grip and there is therefore a risk of a critical vehicle dynamics situation occurring under braking.

### Passive speed sensors

This involves the older generation of speed sensors. They have no separate current supply, leading to the name passive sensor. They usually operate according to the induction principle.



#### Design

A sensor element and a reference system are basically required for speed measurement. The sensor element essentially consists of a coil, which is wrapped around an iron core, and a permanent magnet. The reference system is formed by a toothed ring (incremental or pulsed ring).

In addition to the acceleration sensors in the ESP system, the speed sensors supply essential information.

# Sensors

## How it works

If a piece of iron is passed through the magnetic field of a permanent magnet, the strength and shape of the magnetic field change. This change in the magnetic field can be detected with the aid of a coil, as the change in the coil's magnetic field leads to the induction of a voltage, which can be measured. The way in which this type of sensor operates is therefore called the induction principle. Each tooth on the impulse rotor which passes into the sensor's magnetic field therefore leads to an induction voltage. The sequence of voltage peaks within a time interval (frequency) can be used to calculate the wheel speed.

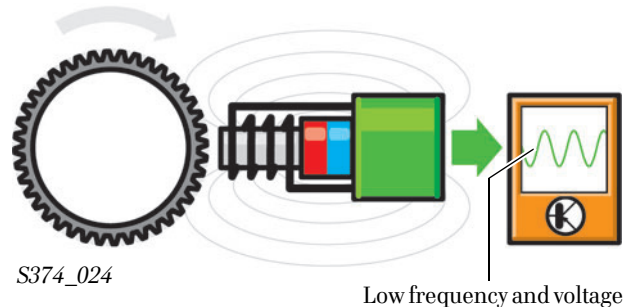
## Advantages/disadvantages

The advantage of passive induction speed sensors is the simple design of the components.

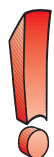
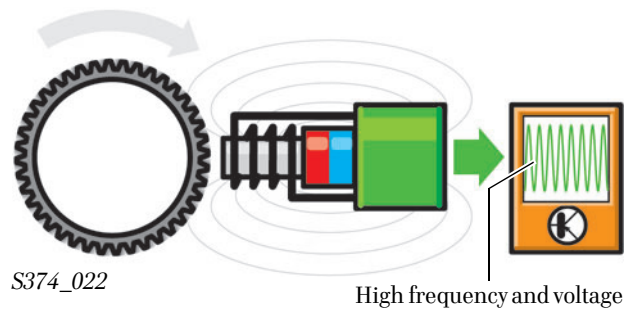
The disadvantage is their reliance on a precise gap dimension between the sender rotor and sensor. In addition, the passive induction speed sensors are heavier and require more installation space.

As not only the frequency, but also the signal voltage, is dependent on the speed of the sender rotor, passive sensors only supply signals with a lower signal voltage at low speeds, in contrast to active sensors.

Sensor signal  
at low speed



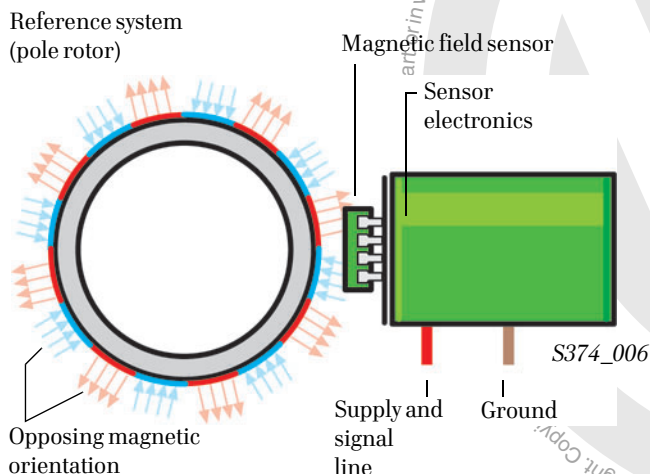
Sensor signal  
at high speed



The signal is unable to reveal whether the sensor is faulty.

## Active speed sensors

In contrast to the passive sensors, the active sensors have a separate voltage supply. This is approx. 12 V. The functional principle of active speed sensors is based on the Hall principle or the magnetoresistive effect.



### Design

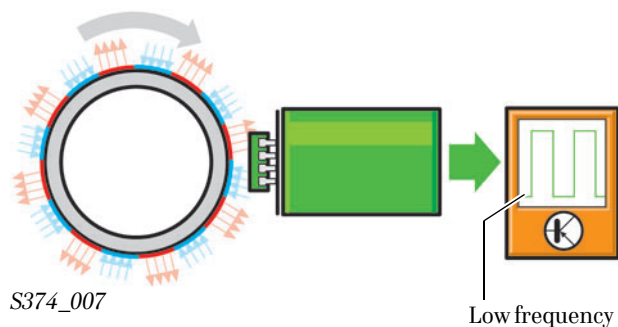
Active sensors comprise of a sensor element and a reference system.

The sensor element is formed by a magnetic field sensor with sensor electronics. The reference system is a plastic ring with opposingly magnetised surface areas (pole rotor).

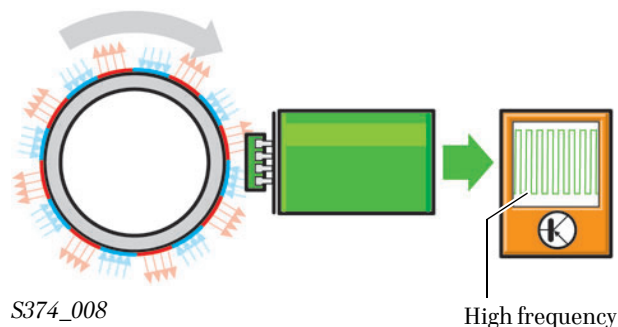
### How it works

If a magnetic field sensor is passed through an alternating magnetic field, its Hall voltage changes; in the case of the magnetoresistive principle, the resistance changes. The faster the opposingly poled magnetic fields of the reference ring pass by the magnetic field sensor, the more frequently the Hall voltage changes. This type of sensor therefore also uses the frequency of voltage changes to calculate the wheel speed.

### Sensor signal at low speed



### Sensor signal at high speed



### Advantage/disadvantage

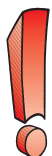
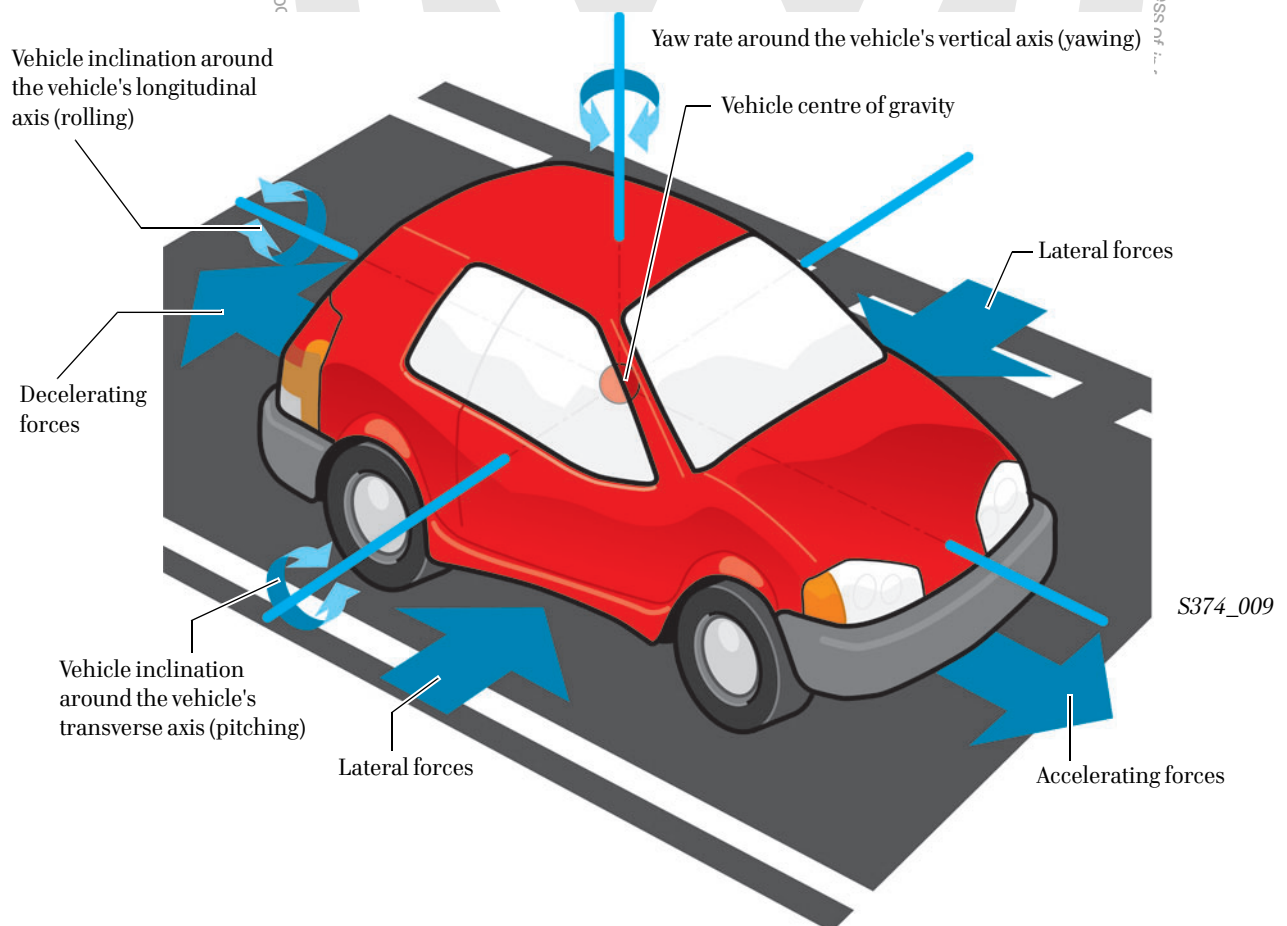
Active speed sensors supply a constantly accurate measurement result throughout the entire measurement range, because the signal strength is not dependent on the speed, but is specified via defined currents. The disadvantage is the difficulty of checking with an ohmmeter.

# Sensors

## Acceleration sensors and the yaw rate sensor

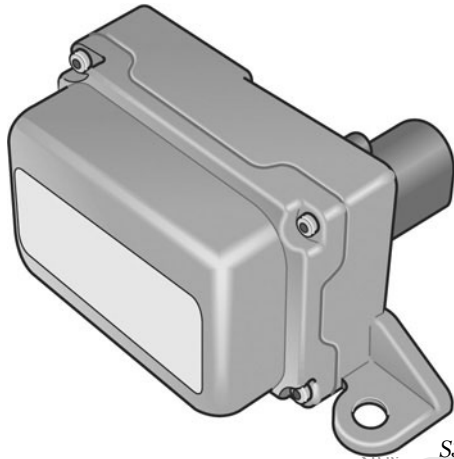
These act as the second, very important, group of sensors for traction control systems. Via these, the different functions find out the direction in which the vehicle is being accelerated or decelerated and whether the yaw rate occurs around the vehicle's vertical axis.

These data enable the control systems to work out the direction in which the vehicle is actually moving, or which forces are acting on the vehicle and may be influencing the direction of movement. As these sensors react very sensitively, they can be used to detect critical situations as they arise and to introduce countermeasures.

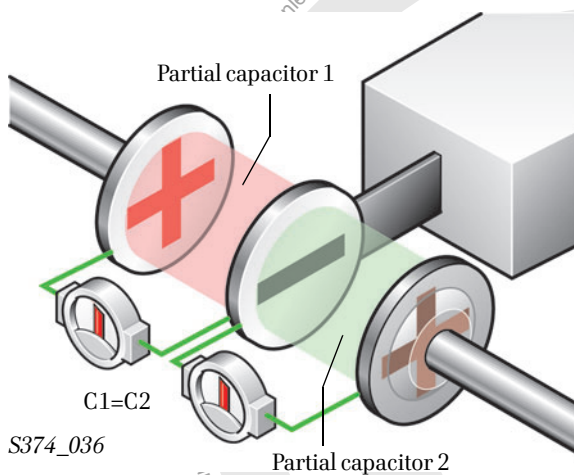


Certain sensors are not required for ABS and E-ABS.

## ESP sensor unit G419



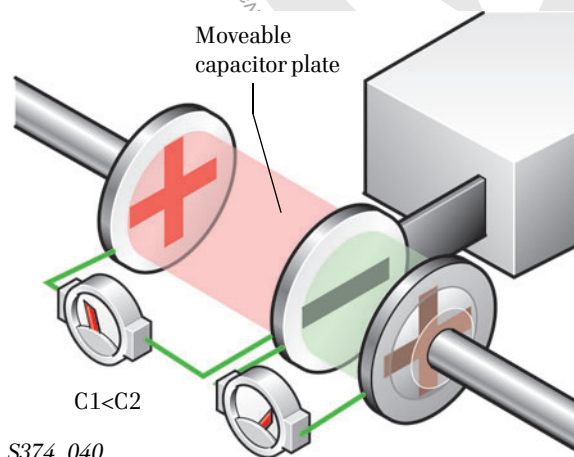
This sensor unit is a combination of the lateral acceleration sender G200, the longitudinal acceleration sender G251 and the yaw rate sender G202. Both acceleration sensors operate according to the capacitive principle and differ only as regards the sensors' spatial orientation to the relevant acceleration direction.



In vastly simplified terms, capacitive principle means that the sensor consists of two partial capacitors with a common capacitor plate, which can be moved via a force. Due to different inertias, the common capacitor plate moves relative to the two other capacitor plates when acceleration or gravity acts on the sensor.

This shift in the common sensor plate changes the capacities, i.e. the electrical storage capability of the partial capacitors, in such a way that the extent of the acceleration can be concluded via the ratio of capacity  $C1$  to  $C2$ .

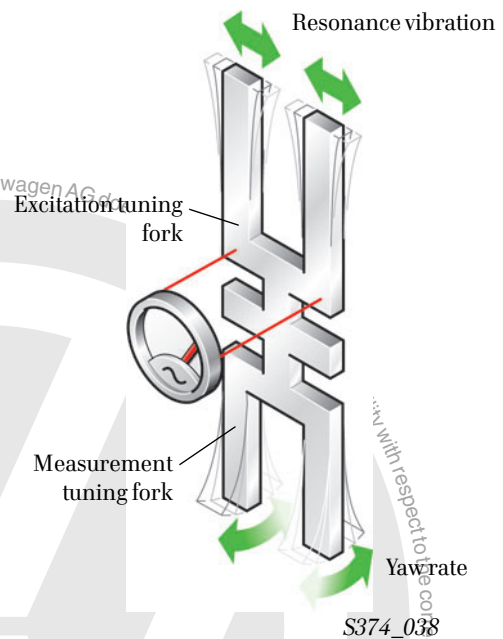
This type of sensor is implemented via a micromechanical system consisting of silicon, in which comb-like structures engage in each other and form the "capacitors".





# Sensors

The yaw rate sender operates according to the resonance principle and records the rotational speed around the vehicle's vertical axis (yaw rate). In this principle, part of a double tuning fork-shaped silicon crystal is caused to vibrate with the aid of a supply voltage. Due to the effect of the Coriolis force, the resonance behaviour of the other part of the double tuning fork changes. This can be measured electrically and used as a measure for the yaw rate.



For the precise functional principle of the individual sensor elements, please refer to self-study programme 204 "ESP Electronic Stability Programme" and Skoda SSP No. 28.



The function of the yaw rate sender is explained here using the example of the tuning fork principle. Other functional principles also exist for such sensors, i.e. Coriolis acceleration and the micromechanical principle.

# Traction control systems

The control intervention carried out by the various traction control systems prevents the wheels from locking in various critical driving situations. The objective is to stabilise the vehicle's behaviour at all times and to maintain steerability. As explained in the introduction, the traction control systems are broken down into those systems which influence vehicle dynamics exclusively via the hydraulic brake system and those which additionally act via the engine management system and, if necessary, the gearbox management system in vehicles with automatic gearboxes.

The first group includes:

- The anti-lock brake system **ABS**,
- Electronic brake pressure distribution **EBD**,
- Corner brake control **CBC**,
- The electronic differential lock **EDL**,
- The extended anti-lock brake system **ABSplus** and
- Yaw moment control **YMC** (yawing moment build-up deceleration **GMA**).

The second group includes:

- The traction control system **TCS**,
- Engine braking effect control **EBC** and
- The engine intervention anti-lock brake system **E-ABS** (extended anti-lock brake system).

The anti-lock brake system **ABS** is the source of all traction control systems. Many of the listed systems represent an extension of the original **ABS** function's software.

None of the listed brake systems require the vehicle to be equipped with **ESP**, but are functional by themselves when the vehicle is fitted with an **ABS** brake system. The **EDL** function requires an extended hydraulic unit.

The electronic stabilisation programme **ESP** independently intervenes, via the brake system, in the vehicle dynamics when the control electronics ascertain a deviation between the driver's command and the vehicle's actual behaviour. **ESP** can be regarded as a higher-level system.

# Traction control systems

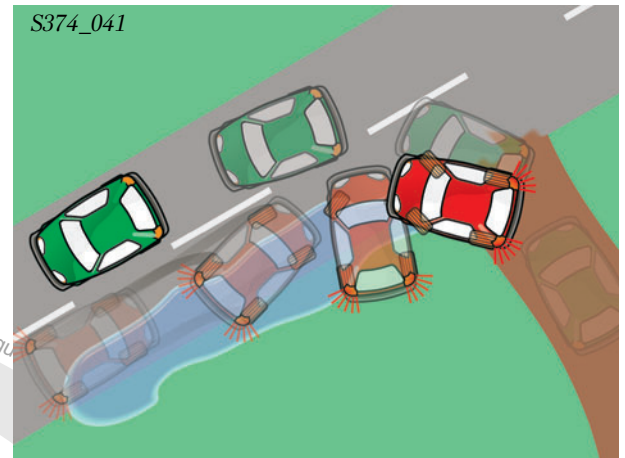
## Anti-lock brake system

If we regard ESP as the higher-level system, the anti-lock brake system ABS is the source of all traction control systems. The first electronic ABS control systems were used in 1969.

During full braking, one or more wheels always tend to lock up earlier than the others because the friction between the wheels and the road surface changes constantly as a result of many influences. A locked-up wheel is also referred to as 100% slip. In this case, the locked-up wheels slip across the road surface like an eraser on paper. When frictional adhesion is lost, the establishment of lateral guidance forces, which keep the vehicle on course, is impossible. The vehicle breaks away as a result of the centrifugal force and can no longer be steered.

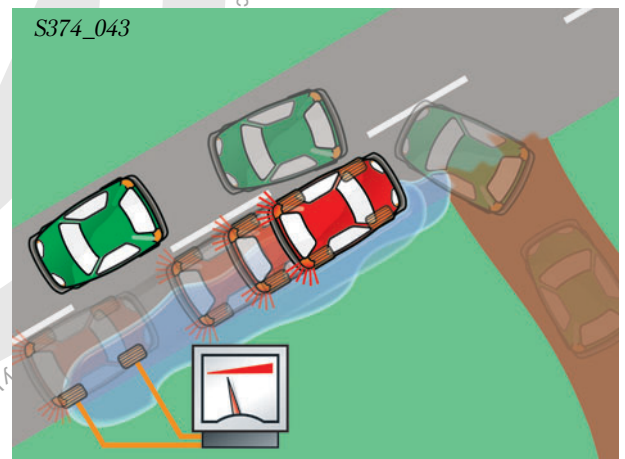
Combating this hazardous driving situation only became possible when the first ABS systems which were adequate for series production were introduced. ABS increases the vehicle's stability by preventing the wheels from locking up on braking. It reduces the brake pressure at the corresponding wheels to such an extent that the maximum frictional adhesion can be transmitted. As a result, forces can again be transmitted onto the road surface, and it remains possible to steer the vehicle.

Vehicles without ABS



In the event of full braking on the wet road surface, the wheels lock up. The vehicle begins to skid.

Vehicles with ABS

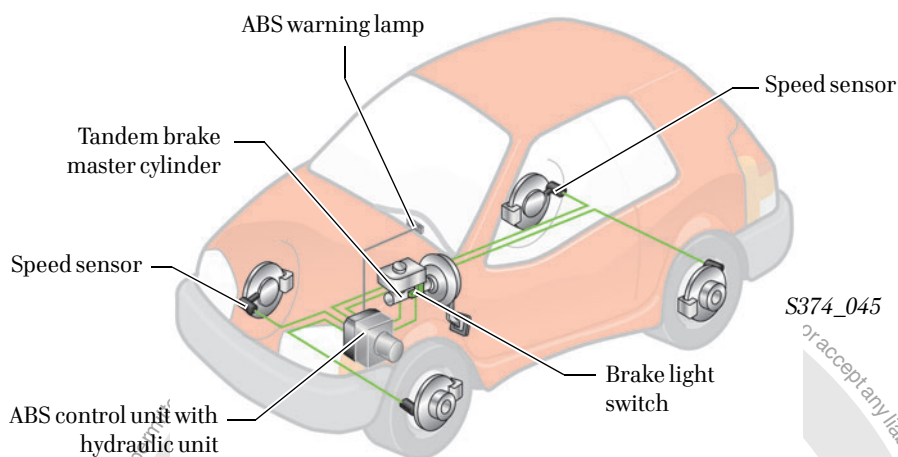


Reducing the brake pressure at the wheels on the wet road surface prevents the wheels from locking up. It remains possible to steer the vehicle.

## Design

The ABS system consists of:

- The hydraulic unit with
  - Electric return flow pump,
  - Two damping chambers and
  - Two pressure accumulators plus
  - Four ABS inlet and outlet valves each,
  - Several non-return valves, which ensure that the brake fluid flows in the necessary direction.
- The ABS control unit,
- The four speed sensors,
- The brake light switch to detect brake actuation,
- The ABS warning lamp and
- Two separate brake circuits, which are supplied with brake fluid and brake pressure via a brake servo.



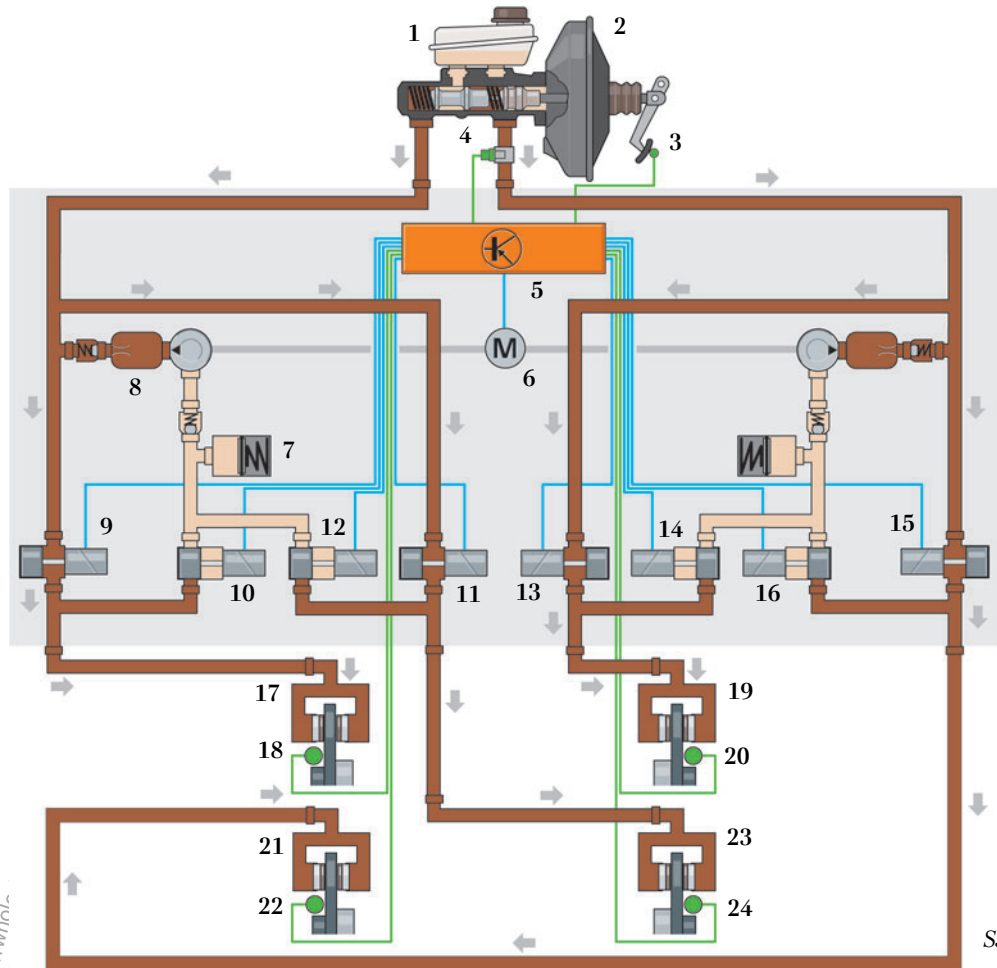
Splitting the brake system into two separate brake circuits increases the vehicle's safety. If one circuit fails, the vehicle can still be brought to a stop via the second brake circuit.

The system can be subdivided into the front axle and rear axle brake circuit or diagonally (left front wheel/right rear wheel and right front wheel/left rear wheel). Diagonal sub-division is usually implemented.

Within a brake circuit, one ABS inlet valve and one ABS outlet valve is assigned to each wheel brake cylinder. As a result of this, each wheel brake can be actuated individually. The low-pressure accumulator in each brake circuit supports fast pressure reduction from the wheel brake cylinder. Transporting the hydraulic fluid back from the low-pressure accumulator to the reservoir is carried out by the return flow pump. This is designed in such a way that both brake circuits have a separate return flow stage, both of which are driven by a common electric motor.

# Traction control systems

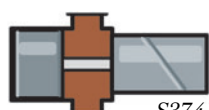
ABS hydraulic circuit diagram



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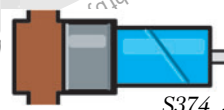
## Legend

- |                                  |                                       |
|----------------------------------|---------------------------------------|
| 1 - Reservoir                    | 13 - Front right ABS inlet valve      |
| 2 - Brake servo                  | 14 - Front right ABS outlet valve     |
| 3 - Brake pedal sensor system    | 15 - Rear left ABS inlet valve        |
| 4 - Brake pressure sender        | 16 - Rear left ABS outlet valve       |
| 5 - ABS/ESP control unit         | 17 - Front left wheel brake cylinder  |
| 6 - Return flow pump             | 18 - Front left speed sensor          |
| 7 - Pressure accumulator         | 19 - Front right wheel brake cylinder |
| 8 - Damping chamber              | 20 - Front right speed sensor         |
| 9 - Front left ABS inlet valve   | 21 - Rear left wheel brake cylinder   |
| 10 - Front left ABS outlet valve | 22 - Rear left speed sensor           |
| 11 - Rear right ABS inlet valve  | 23 - Rear right wheel brake cylinder  |
| 12 - Rear right ABS outlet valve | 24 - Rear right speed sensor          |



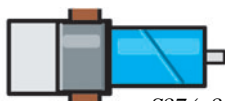
Inlet valve IV(9): Open

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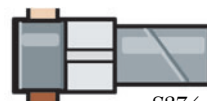
Outlet valve OV(10): Open

S374\_316



Inlet valve IV(9): Closed

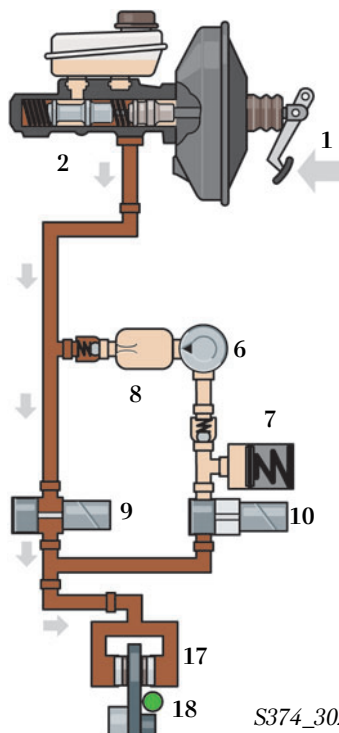
S374\_312



Outlet valve OV(10): Closed

S374\_314





#### Brake actuation by the driver

- 1 - Foot brake depressed
- 2 - Tandem brake master cylinder
- 6 - Return flow pump
- 7 - Pressure accumulator
- 8 - Damping chamber
- 9 - ABS inlet valve
- 10 - ABS outlet valve
- 17 - Wheel brake cylinder
- 18 - Speed sensor

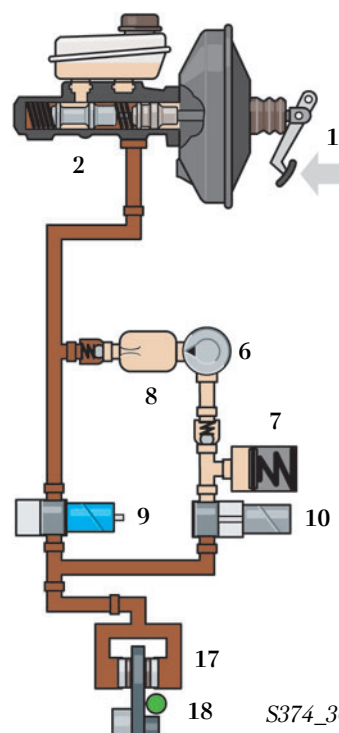
S374\_302

#### How it works

In contrast to ESP, ABS requires the driver to actuate the brake. The system does not act independently.

On braking, ABS compares the speeds of the four wheels. If there is a danger of individual wheels locking up, ABS prevents a further increase in brake pressure. The driver perceives ABS control intervention as slight brake pedal pulsation. This arises due to the changes in brake pressure during ABS intervention.

The vehicle's steerability is maintained, because ABS prevents individual wheels from locking up. The ABS function cannot be manually deactivated.



#### ABS regulation "maintain pressure"

- 1 - Foot brake depressed
- 2 - Tandem brake master cylinder
- 6 - Return flow pump
- 7 - Pressure accumulator
- 8 - Damping chamber
- 9 - ABS inlet valve
- 10 - ABS outlet valve
- 17 - Wheel brake cylinder
- 18 - Speed sensor

S374\_304

#### Pressure maintenance

If the ABS control unit ascertains that a wheel is in danger of locking up, the control system closes the affected wheel's ABS inlet valve whilst the ABS outlet valve is closed at the same time. As a result of this, the pressure in the wheel brake cylinder is maintained and cannot be increased further by the driver's depressing the brake.

IV(9): Closed  
OV(10): Closed

# Traction control systems

## Pressure reduction

If the tendency to lock up remains, the control system opens the ABS outlet valve with the ABS inlet valve closed.

The wheel cylinder's pressure can now be released into the pressure accumulator.

As a result, the wheel is able to accelerate again.

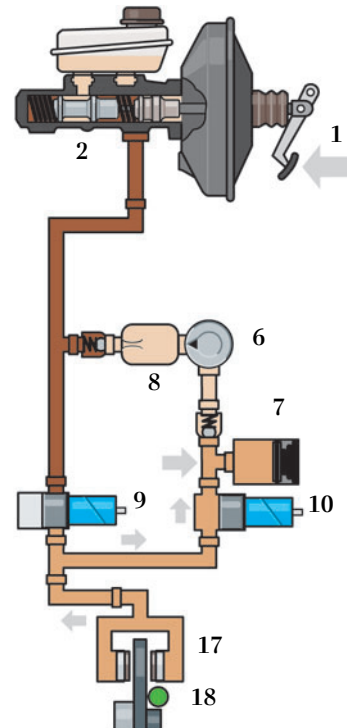
If the capacity of the pressure accumulator is not sufficient to eradicate the wheels' tendency to lock up, the ABS control system switches the return flow pump on to pump the brake fluid back into the reservoir counter to the brake pressure applied by the driver. This causes the pulsation in the brake pedal.

IV(9): Closed  
OV(10): Open

### ABS regulation

#### "reduce pressure"

- 1 - Foot brake depressed
- 2 - Tandem brake master cylinder
- 6 - Return flow pump
- 7 - Pressure accumulator
- 8 - Damping chamber
- 9 - ABS inlet valve
- 10- ABS outlet valve
- 17- Wheel brake cylinder
- 18- Speed sensor



S374\_306

## Pressure build-up

If the wheel speed again exceeds a defined value, the control system closes the ABS outlet valve and opens the ABS inlet valve. The return flow pump continues to run as required.

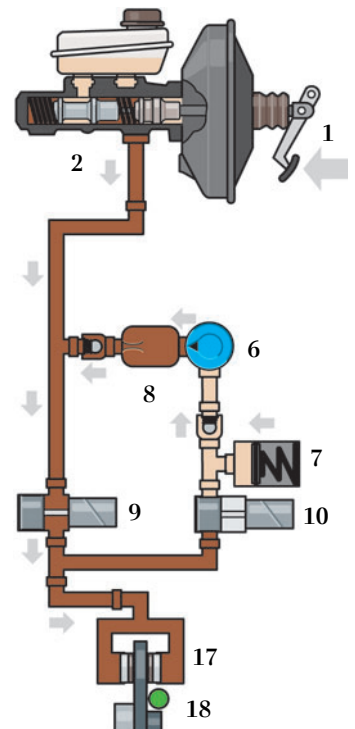
If the lock up limit is reached again, the "maintain pressure", "reduce pressure" and "build up pressure" cycle is repeated until the braking process is completed or comparison of the wheel speeds shows that there is no further danger of the wheels' locking up.

IV(9): Open  
OV(10): Closed

### ABS regulation

#### "build up pressure"

- 1 - Foot brake depressed
- 2 - Tandem brake master cylinder
- 6 - Return flow pump
- 7 - Pressure accumulator
- 8 - Damping chamber
- 9 - ABS inlet valve
- 10- ABS outlet valve
- 17- Wheel brake cylinder
- 18- Speed sensor



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## Brake systems with brake intervention only

In the case of the following traction control systems, a critical driving situation is combated by means of brake intervention via the hydraulic brake system. These traction control systems include:

- Yaw moment control **YMC**,
- Electronic brake pressure distribution **EBD**,
- Cornering brake control **CBC**,
- The electronic differential lock **EDL** and
- The extended anti-lock brake system **ABSplus**.

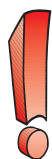
### Yaw moment control

In the past, yaw moment control YMC was also called yawing moment build-up deceleration GMA.

It frequently occurs that a passenger car's four wheels roll on road surfaces with varying grip. For example, it may be the case that road surface defects have been filled with chippings or that parts of the road surface have been worn smooth to varying degrees, as in ruts. During braking manoeuvres, it may therefore be the case that, due to the road surface's different grip levels, yawing moments occur around the vehicle's vertical axis. These attempt to send the vehicle off course.

An ABS control system software extension enables this yawing moment to be combated by temporally limiting the difference in brake pressure build-up between the left and right wheels to different degrees. This is therefore referred to as yaw moment control.

A brake pressure difference is built up slowly to give the driver more time to react.

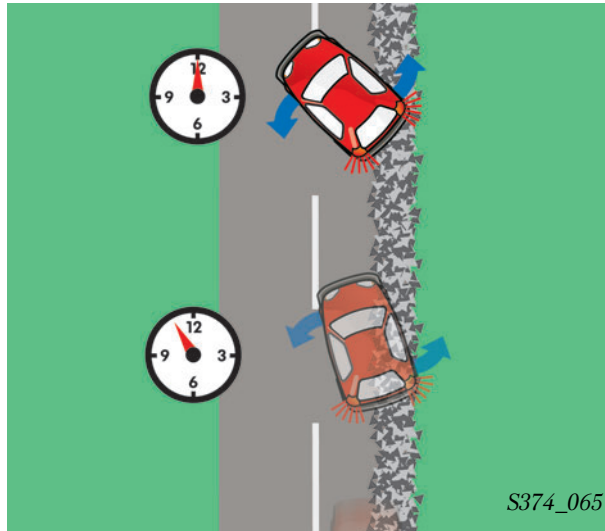


Due to yaw moment control YMC, the stopping distance is extended, by necessity, in favour of improved vehicle stability.



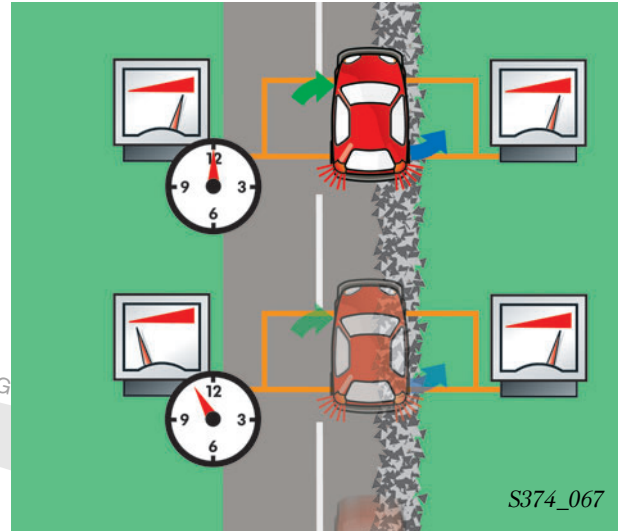
# Traction control systems

Vehicle without YMC



The side of the vehicle on the surface with better grip is braked more extensively than the side of the vehicle on the smooth surface. The yawing moment which occurs in this case causes a yaw rate, which the driver cannot compensate quickly enough via the steering.

Vehicle with YMC



The brake pressure at the wheels on the surface with better grip does not increase so quickly. The dangerous yaw rate is overcome.

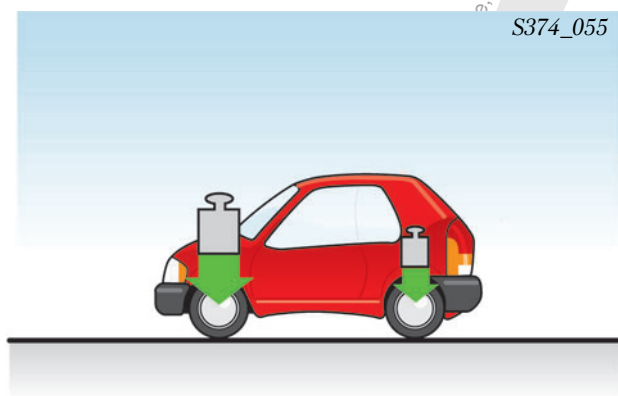
## How it works

If the ABS control system within the YMC function ascertains during a braking manoeuvre that the wheel speeds of the wheels on the left-hand side deviate from those on the right-hand side, the system concludes that disturbing yawing moment may develop.

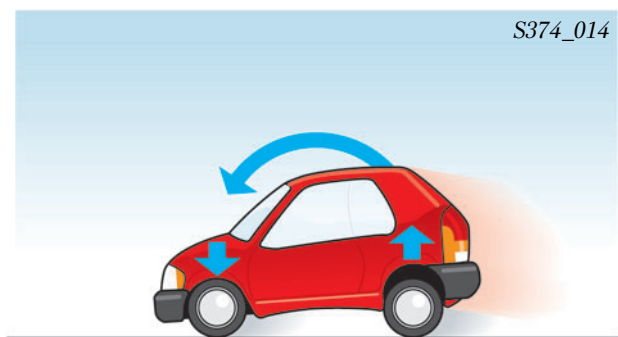
Braking the wheels with the higher speed is therefore delayed slightly until the wheel speeds on the right- and left-hand sides match each other again. To achieve this, the relevant ABS inlet valves are opened slightly later by the control system, with the result that pressure build-up at the wheel brake cylinder takes place more slowly.

## Electronic Brake pressure Distribution

If the vehicle's rear axle locks-up, the vehicle is unstable and can break away in an uncontrolled manner. The electronic brake pressure distribution (EBD) function exists to avoid this critical driving condition.



Weight distribution in the vehicle reveals higher axle load at the front axle.



Due to the pitching motion on braking, the axle load at the front axle is increased and the rear axle is relieved.

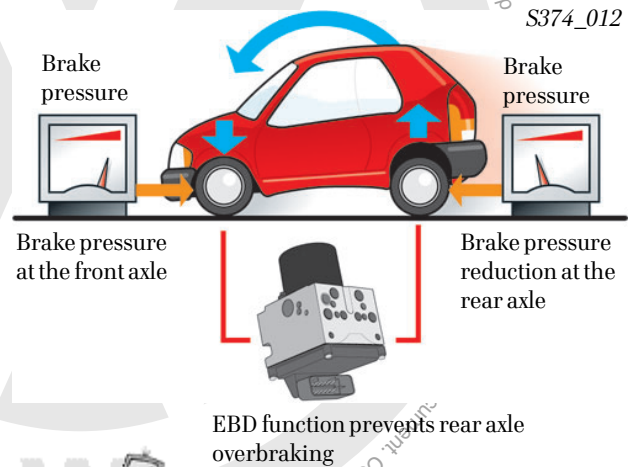
Due to weight distribution in the vehicle, rear axle wheel load is significantly lower than that on the front axle. To achieve controllable vehicle dynamics, brake pressure distribution has been defined such that the front axle brakes should lock up before the rear axle brakes (Directive ECE13; ECE=Economic Commission for Europe), in order to maintain residual vehicle stability in the longitudinal direction.

When braking hard, the vehicle weight is shifted onto the front wheels. The vehicle pitches around its transverse axis. Due to this movement, the rear axle is relieved. As a result, the rear wheels are able to lock up, as the brake power can no longer be applied onto the road due to the reduced ground contact. The brake force distribution directive would therefore be violated.



# Traction control systems

Based on the speed sensors, the control system detects the rear axle overbraking which occurs in the case of pitching. Via solenoid valves in the ABS unit, the EBD system regulates the brake pressure for the rear wheels and thereby ensures maximum brake power at the front and rear axles. This prevents the rear end from breaking away due to rear wheel overbraking.

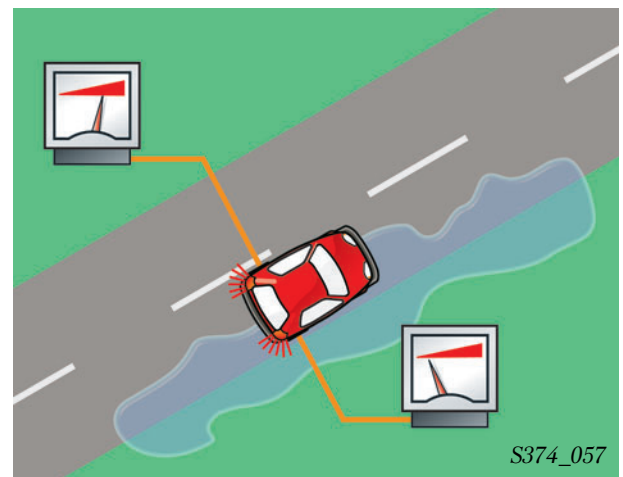


This rear axle overbraking effect was originally overcome via mechanical brake pressure distributors. On introduction of the ABS system, the brake pressure distribution function was also implemented via the vehicle's hydraulic brake system.

Pitching motions on braking and lateral inclination on cornering contribute towards an extensive variation in wheel load depending on the driving situation. Consequently, the brake pressures have to be distributed in different ways. In contrast to mechanical brake pressure distribution, the EBD system is able to regulate the brake pressure individually for each rear wheel. Consideration can therefore also be given to different road surface conditions.

EBD detects the deceleration of one or both rear wheels and reduces the brake pressure at the corresponding wheel.

The EBD system's range of action ends as soon as a wheel reveals an increased tendency to lock up. ABS intervenes in this case.



Different brake pressure distribution between the two rear wheels due to different road surface conditions

## Design

The EBD function does not require any additional components; it uses the components available in the ABS system. Electronic brake pressure distribution is an extension of the ABS system's software.

## How it works

The wheel speeds on the front and rear axle are compared. If the difference exceeds a maximum value, overbraking is detected on the rear axle and the EBD system intervenes.

The EBD system then closes the ABS inlet valves for the left and/or right rear wheel, thereby preventing further pressure build-up and maintaining the pressure in the wheel brake cylinder.

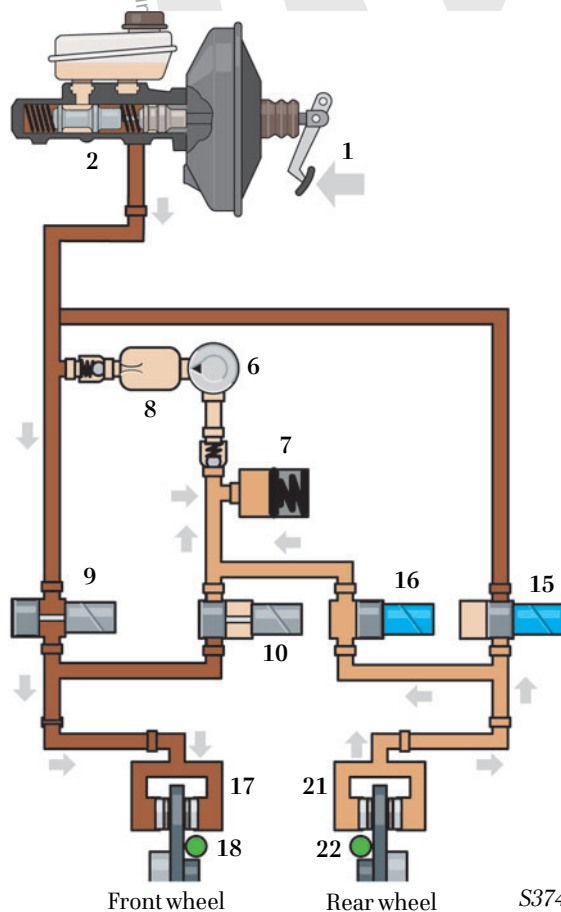
Whilst the front wheel inlet valves are open to build up brake pressure, the rear wheel outlet valves are already closed.

In the event of further rear axle overbraking, the relevant ABS outlet valves are additionally opened to reduce brake pressure.

In the event of underbraking, the pressure level is increased to enable the transmission of as much brake pressure as possible.

This enables optimal exploitation of the potential frictional connection.

Expressed simply, EBD is therefore ABS regulation which only acts on the rear wheels with its three phases: "Maintain pressure", "reduce pressure" and "build up pressure".



### Legend

- 1 - Foot brake depressed
- 2 - Tandem brake master cylinder
- 6 - Return flow pump
- 7 - Pressure accumulator
- 8 - Damping chamber
- 9 - ABS inlet valve
- 10 - ABS outlet valve
- 15 - Rear left ABS inlet valve
- 16 - Rear left ABS outlet valve
- 17 - Front left wheel brake cylinder
- 18 - Front left speed sensor
- 21 - Rear left wheel brake cylinder
- 22 - Rear left speed sensor

# Traction control systems

## Cornering Brake Control

In the past Cornering Brake Control CBC was also referred to as Extended Stabilised Braking System ESBS. Depending on the situation, dangerous cornering behaviour on braking can be expressed as oversteering or understeering on cornering. In extreme cases, this may lead to the vehicle's skidding. This behaviour is based on the fact that yaw rates, which lead to the described vehicle behaviour, can occur during braking manoeuvres on cornering.

CBC overcomes these yaw rates.

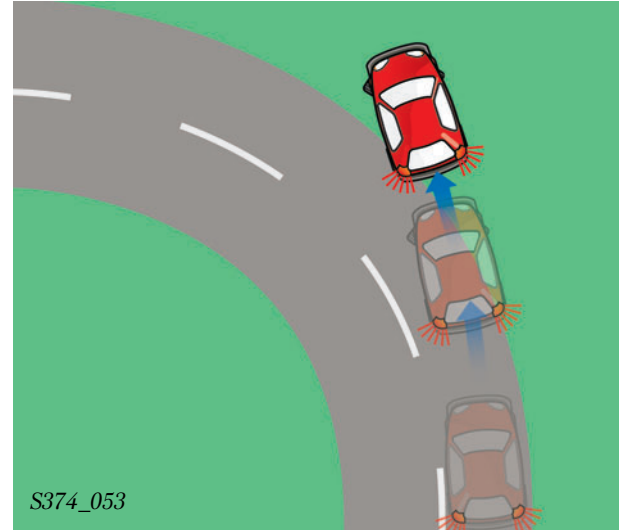
To achieve this, the wheel brakes are specifically actuated by the CBC control system during the braking manoeuvre, in order to build up an opposing, corrective yaw rate.

CBC improves the vehicle's stability when braking on cornering.

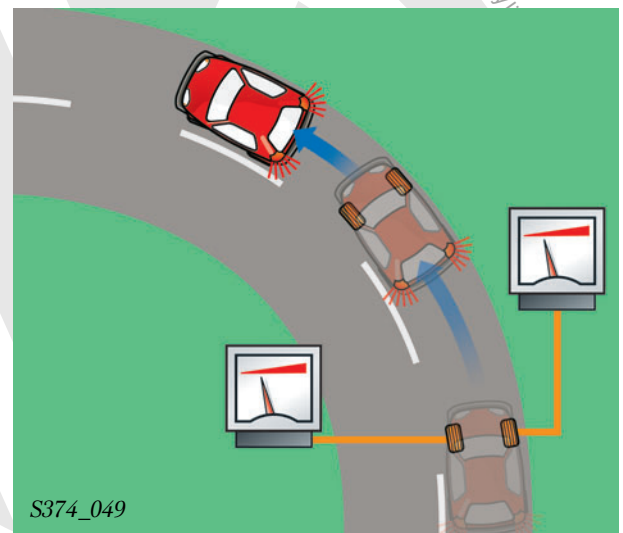
### Design

The CBC does not require any additional components; it uses the components which are available in the ABS system. The CBC system is also a pure extension of the ABS control system's software. Its special feature is that the system is able, without yaw rate or lateral acceleration sensors, to recognise hazardous situations, particularly during braking manoeuvres on cornering, solely on the basis of the wheel speeds.

### Understeering

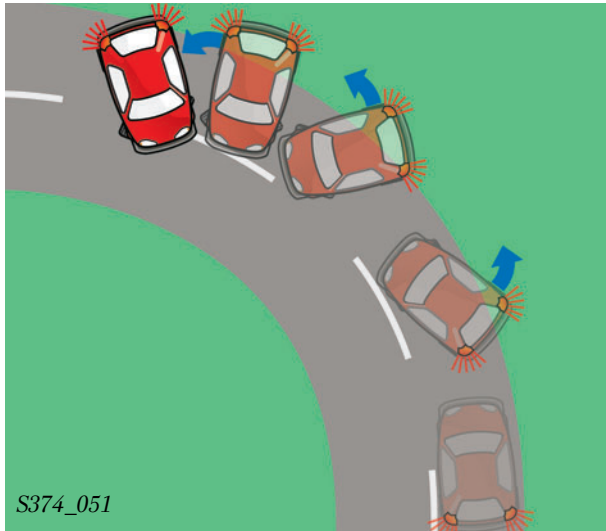


If a vehicle without CBC is braked extensively on cornering, the wheel location forces on the front wheels are reduced. The vehicle pushes over the front axle towards the outer edge of the curve.



In vehicles with CBC, the brake pressure on the front axle is reduced in the event of understeering. As a result, the wheel location forces are increased and the vehicle remains on course.

## Oversteering



If a vehicle without CBC, which enters a curve at an excessive speed, is steered and braked too severely, the rear end breaks away to the outer edge of the curve.

## How it works

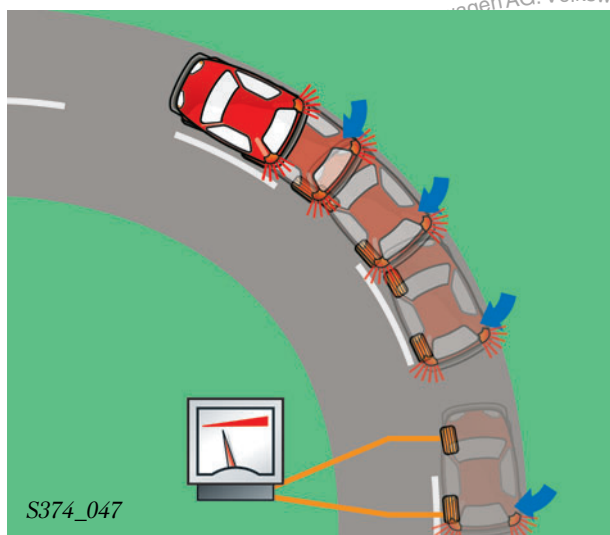
CBC comes into effect when the wheels display slip below the ABS control range.

The CBC system recognises this situation based on the speeds of the individual wheels. Via further analysis, the ABS control unit is able to recognise oversteering or understeering and regulate the brake pressure accordingly.

As in the case of ABS regulation, brake pressure regulation takes place in three phases: "Maintain pressure", "reduce pressure" and "build up pressure".

The vehicle's behaviour is stabilised and steerability is maintained.

If the ABS regulation limit is reached in the event of slip, the ABS takes precedence over CBC. This means that CBC is deactivated and ABS prevents the wheels from locking up.



In vehicles with CBC, the brake pressure at the inner wheels is reduced in the event of oversteering. This increases the wheel location forces at the inner wheels and the vehicle's rear end remains stable.

# Traction control systems

## Electronic Differential Lock

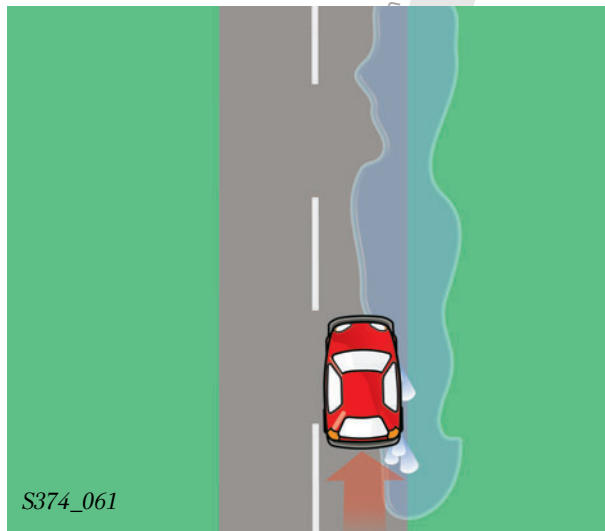
The Electronic Differential Lock EDL was originally designed as a starting aid.

EDL intervenes in the vehicle dynamics if one of the drive wheels spins on accelerating. The spinning wheel is braked. Thanks to the brake's specific intervention, the drive torque which can be transmitted at the spinning wheel is increased.

The differential is able to transmit more drive torque to the gripping wheel on the drive axle. The vehicle accelerates faster and remains steerable.

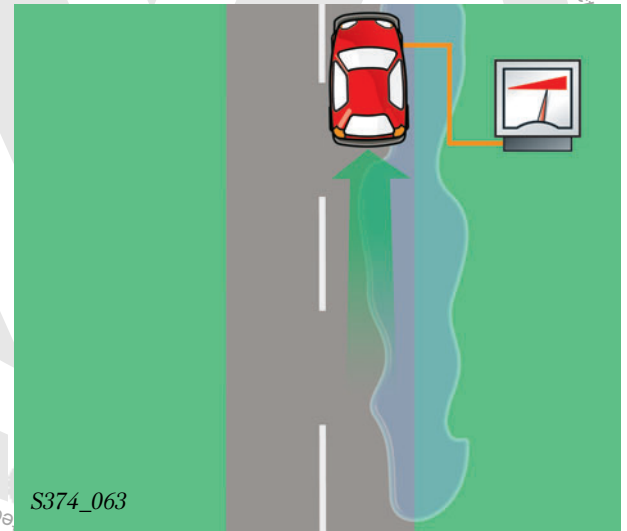
As the effect corresponds approximately to that of the mechanical differential lock, the system was called the electronic differential lock.

Vehicle without EDL



The vehicle can only be accelerated with the drive power transmitted to the spinning wheel, because the differential is able to pass on only the smaller of an axle's two drive torques. The vehicle is only able to accelerate very slowly.

Vehicle with EDL

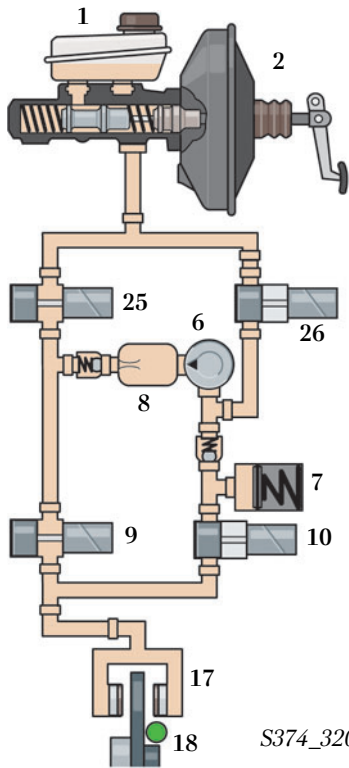


The wheel on the wet road surface is braked and the slip is limited. As a result, the drive power is increased via the differential and transmitted to the wheel which is not spinning. The vehicle with EDL reaches a higher speed in the same time.

EDL intervention can take place up to a speed of 80 km/h (Touareg up to 120 km/h) and also during cornering. On actuation of the brake pedal or at a maximum brake disk temperature, which is calculated by the ABS control unit, the EDL is deactivated immediately.



## Design



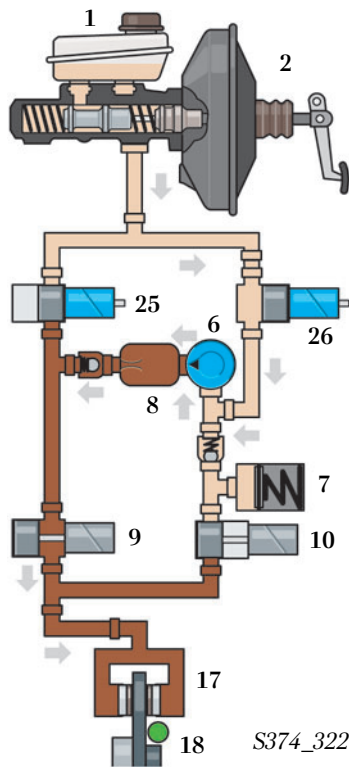
### Resting position

- 1 - Reservoir
- 2 - Brake servo
- 6 - Return flow pump
- 7 - Pressure accumulator
- 8 - Damping chamber
- 9 - ABS inlet valve
- 10 - ABS outlet valve
- 17 - Wheel brake cylinder
- 18 - Speed sensor
- 25 - Switch valve
- 26 - High-pressure valve

Essentially, an ABS brake system with EDL differs from a pure ABS brake system in that the ABS system with EDL is able to independently build up brake pressure. EDL uses the ABS system's speed sensors without any technical extensions. The software in the ABS control unit is extended by the EDL function. This is achieved by means of additional valves and a self-priming return flow pump in the hydraulic unit.

If the control unit detects a situation in which the EDL has to intervene, the brake pressure in the spinning wheel's brake circuit can be built up without having to actuate the brake pedal.

## How it works



### EDL regulation "build up pressure"

- 1 - Reservoir
- 2 - Brake servo
- 6 - Return flow pump
- 7 - Pressure accumulator
- 8 - Damping chamber
- 9 - ABS inlet valve
- 10 - ABS outlet valve
- 17 - Wheel brake cylinder
- 18 - Speed sensor
- 25 - Switch valve
- 26 - High-pressure valve

Based on the wheel speeds, the EDL ascertains that one of the drive axle's wheels has higher slip, i.e. it is rotating faster than the other drive wheel. EDL therefore has to brake the spinning wheel so that drive power can also be transmitted again there. Regulation takes place, like that of the ABS system, in three phases: "build up pressure", "maintain pressure" and "reduce pressure".

### Pressure build-up

To build up pressure, the switch valve is closed and the high-pressure valve is opened. The return flow pump begins working and takes in brake fluid from the brake master cylinder. As a result, brake pressure builds up in the spinning wheel's brake cylinder and the wheel is braked.

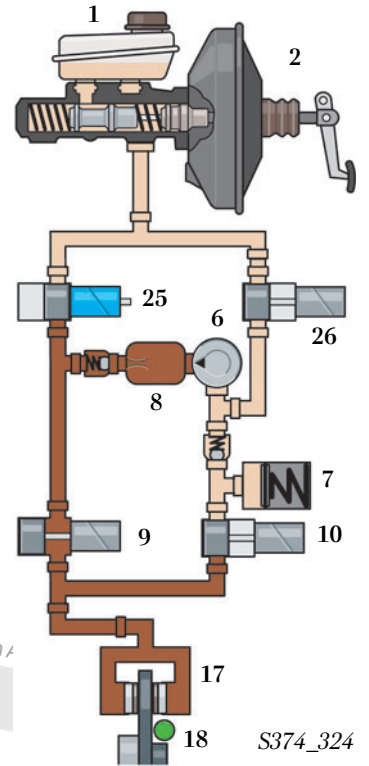
# Traction control systems

## Pressure maintenance

To maintain the brake pressure in the wheel's brake circuit, only the return flow pump is deactivated. The switch valve remains closed. A constant brake pressure is maintained at the wheel brake.

### EDL regulation "maintain pressure"

- 1 - Reservoir
- 2 - Brake servo
- 6 - Return flow pump
- 7 - Pressure accumulator
- 8 - Damping chamber
- 9 - ABS inlet valve
- 10- ABS outlet valve
- 17- Wheel brake cylinder
- 18- Speed sensor
- 25- Switch valve
- 26- High-pressure valve



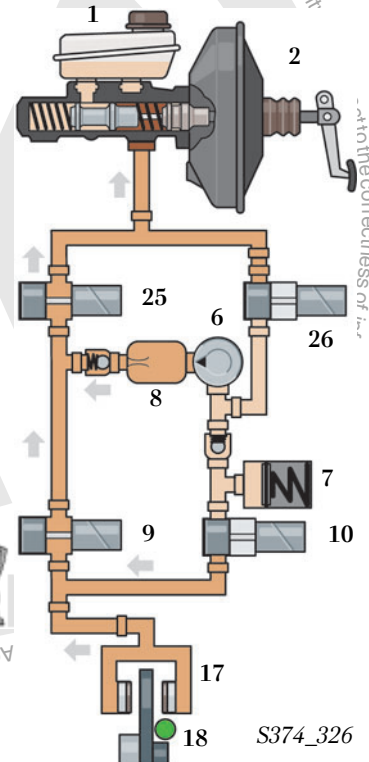
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## Pressure reduction

To reduce pressure, the inlet valve and the switch valve are currentless, i.e. opened.

### EDL regulation "reduce pressure"

- 1 - Reservoir
- 2 - Brake servo
- 6 - Return flow pump
- 7 - Pressure accumulator
- 8 - Damping chamber
- 9 - ABS inlet valve
- 10- ABS outlet valve
- 17- Wheel brake cylinder
- 18- Speed sensor
- 25- Switch valve
- 26- High-pressure valve



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## Extended anti-lock brake system

The extended anti-lock brake system ABSplus is a software extension in the ABS/ESP control unit. Thanks to ABSplus, the stopping distance can be reduced by up to 20 percent on loose surfaces, such as gravel or sand, for example. ABSplus makes use of the ESP sensors. The existing surface is recognised on the basis of the ABS sensors and the ABS control unit.

The stopping distance is reduced by temporarily locking up the wheels in a controlled manner. As a result of this, a so-called brake chock is built up in front of the wheels by pushing the loose surface together; this supports the braking effect and therefore reduces the stopping distance. However, the vehicle remains fully steerable, as the brakes open up again and allow the wheel to run freely.

Vehicle without ABSplus

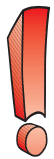


The driver of a vehicle without ABSplus actuates the brake pedal and the vehicle is braked on a loose surface.

Vehicle with ABSplus



In a vehicle with ABSplus, the wheels only lock up briefly on a loose surface, and therefore build up a chock consisting of the corresponding surface material in front of the tyres. This shortens the stopping distance.



The extended anti-lock brake system ABSplus is currently fitted in the Touareg as standard.

## Brake systems with brake and/or engine intervention

In the case of the following traction control systems, a critical driving situation is overcome either via the engine management system and/or by means of brake intervention via the hydraulic brake system.

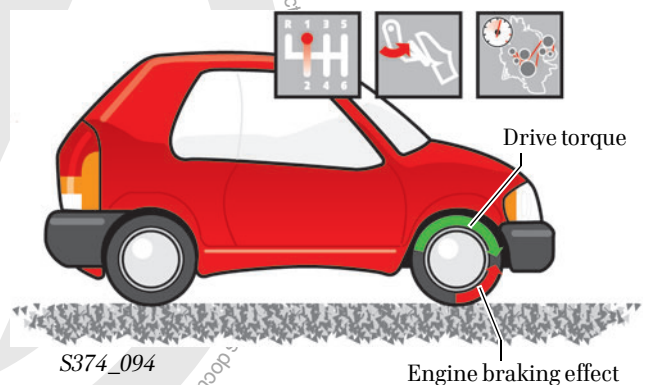
- Engine braking effect control **EBC**,
- Engine intervention anti-lock brake system **E-ABS** and
- Traction control system **TCS**.

# Traction control systems

## Engine Braking effect Control

Engine Braking effect Control EBC recognises that slip is occurring at the drive wheels due to the engine's braking effect and requests corresponding drive torque from the engine, thereby facilitating the wheels' re-starting. Wheel slip phases are shortened and the vehicle's steerability is restored.

During vehicle operation, the driver removes his foot from the accelerator and shifts to a lower gear. In the event of unfavourable road surface conditions, the brake pressure which results on the wheel can cause slip, which may lead to the wheels' locking up. EBC intervenes and reduces the engine's braking effect by increasing the engine torque. The EBC system therefore ensures the vehicle's stability and steerability.



If the driver rapidly releases the accelerator during vehicle operation, the engine is throttled abruptly and the driving power is reduced. Frictional forces, which lead to an engine braking effect, occur within the engine in this case. This effect is also known as the engine brake. This engine braking effect, which acts in the same manner as brake pressure, counters the drive torque. Due to simultaneous downshifting to a lower gear, the engine braking effect is increased.

Under unfavourable conditions in the case of vehicles with very high-powered engines, the engine braking effect may lead to the wheels' locking up or to such extensive slip that lateral guidance forces are lost and it becomes impossible to steer the vehicle.

Engine braking effect control intervenes when the following conditions are met:

- The accelerator is not actuated.
- The drive wheels are slipping or locked up/locked up.
- The gear has to be engaged.
- The clutch is not actuated.

Engine braking effect control makes use of the engine management system to carry out its function.

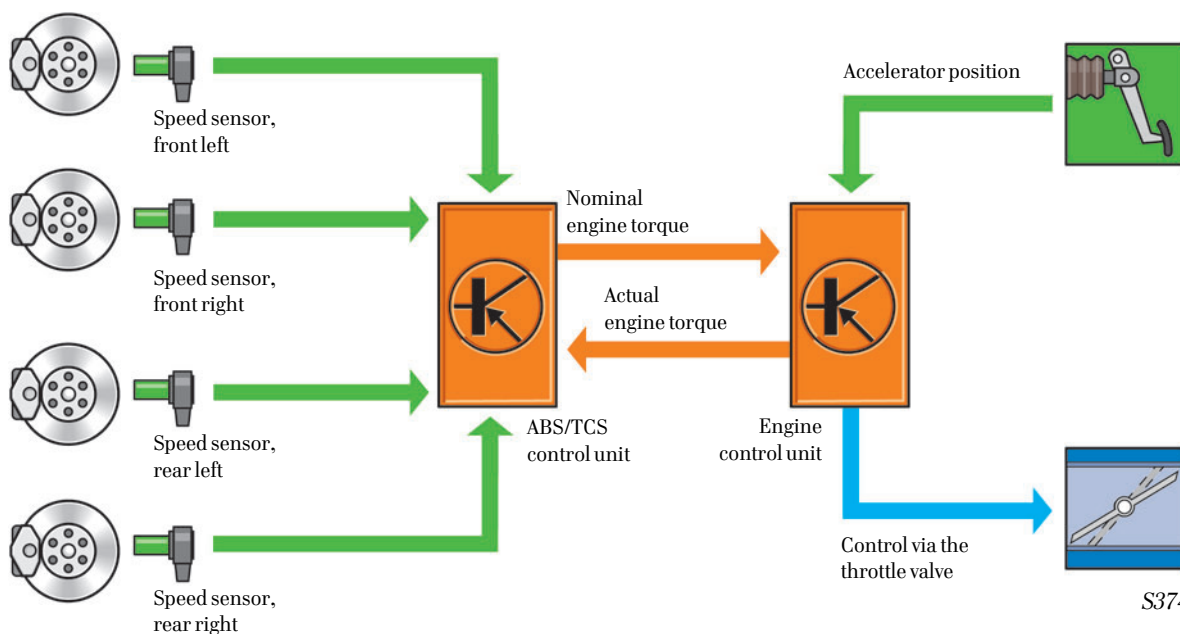
## How it works

The prerequisites of engine braking effect control EBC are ABS components with an engine interface. The ABS software is extended by the EBC software.

Based on the speed sensors and the necessary information from the engine management system (e.g. engine speed, throttle valve position, accelerator position), the ABS control system with EBC function is able to ascertain whether slip occurs at the driven wheels on reducing the engine torque by releasing the accelerator. If this is the case, the ABS/TCS control unit forwards this information to the engine control unit, which uses this to calculate the necessary nominal engine speed.

To increase the engine speed in the case of EBC, the throttle valve is briefly opened until the drive wheel slip has returned to an optimal level. During this process, the system remains in a control range which makes optimal use of the engine braking effect, but which also simultaneously guarantees sufficient lateral guidance forces.

EBC operates throughout the engine's entire speed range. Engine braking effect control EBC is ended by actuating the accelerator.



# Traction control systems

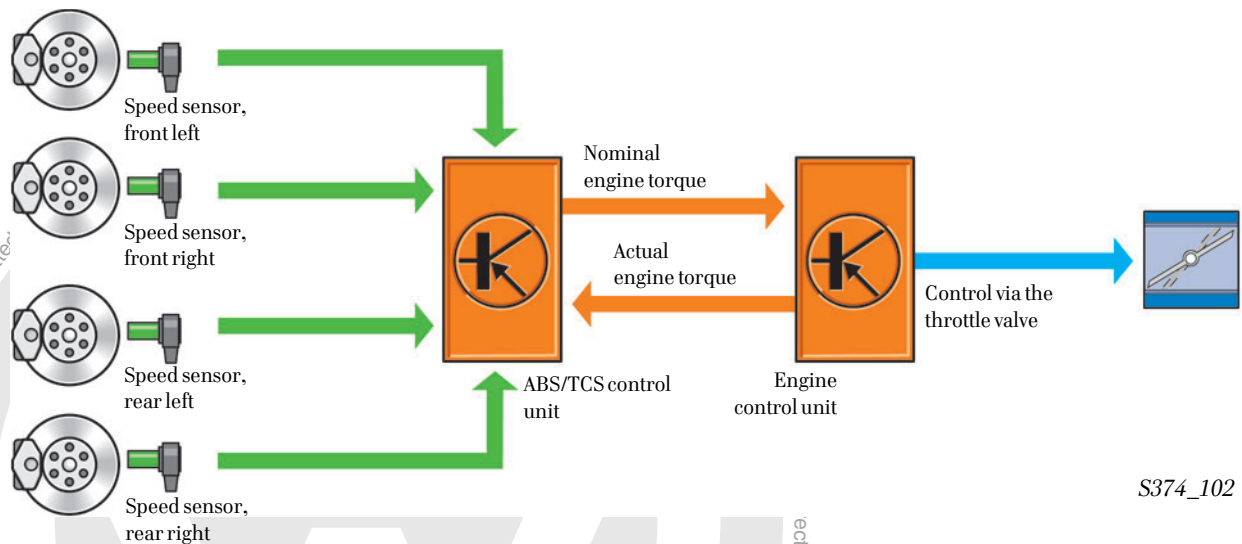
## Engine intervention anti-lock brake system

The engine intervention anti-lock brake system E-ABS is an extension of the ABS system's functional scope. It is intended to support the driver on starting off and to prevent the wheels from spinning.

With E-ABS, the ABS control system has the option of intervening into the engine management system. It is not able to actively build up pressure.

### How it works

If, on the basis of the wheel speeds and the engine management system information, which are transmitted via the CAN data bus, the ABS control system ascertains that the drive wheels are in danger of spinning, E-ABS instructs the engine management system to close the throttle valve further and thereby reduce the drive torque.



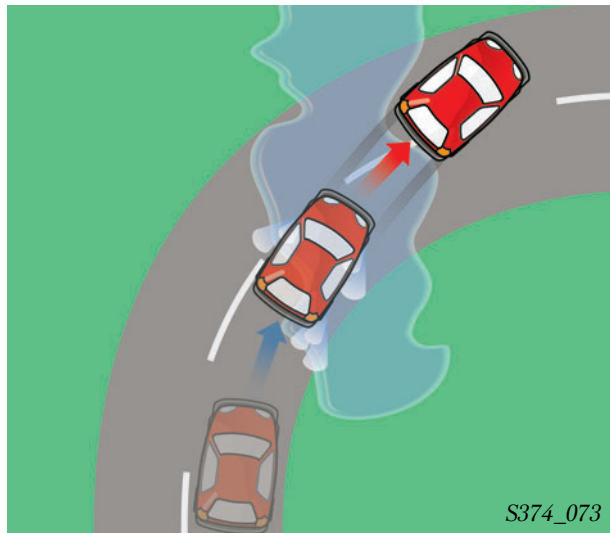
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E-ABS is unable to intervene hydraulically in the drive wheel brake cylinders. The system does not have the option or equipment to independently build up brake pressure via a pressurisation system without the involvement of the driver.



## Traction Control System

### Vehicle without TCS



The vehicle accelerates on a slippery road surface. The wheels spin and the vehicle is not accelerated or is only accelerated very slowly. On cornering, only insufficient lateral guidance forces can be transmitted and the vehicle cannot be steered.

### Vehicle with TCS



TCS reduces the driving power and therefore prevents excessive slip at the drive wheels. The lateral guidance forces are able to act and the vehicle's driving behaviour remains stable.

The Traction Control System (TCS) supports the driver on starting off or accelerating on a slippery road surface by reducing drive slip. If the drive wheels are in danger of spinning, TCS is able to reduce the drive power

- by specifically braking spinning wheels and
- by reducing the drive torque via intervention in the engine or gearbox management system.

Unlike ABS, TCS does not therefore act within braking processes during the deceleration of a vehicle, but within vehicle acceleration. To enable intervention during vehicle acceleration, the system requires a link to the engine management system, enabling it to influence the drive torque, and the option of independently building up pressure in the brake system. This is necessary to be able to brake spinning wheels without the driver's building up the brake pressure via the brake pedal.

TCS acts throughout the entire speed range. As of a vehicle speed of approx. 80 km/h, the driving power is reduced exclusively via intervention in the engine or gearbox management system.

TCS control intervention is indicated using the ESP and TCS warning lamp.

The TCS and ESP button can be used to deactivate intervention in the engine management system.

# Traction control systems

## Design

TSC is based on the ABS system in both hardware and software terms. The TCS software is integrated into a higher-performance ABS control unit with an extended programme memory. The speed sensor signals are used as in the case of ABS.

To enable the required functions to be carried out, the TCS system must be extended at two essential points in comparison with the ABS system.

- Changes in the hydraulic unit
- Interface to the engine management system

### 1. Changes in the hydraulic unit

The EDL function is already integrated into TCS. Therefore, the valve configuration of the ABS hydraulic unit, consisting of two ABS inlet and outlet valves per brake circuit, is also extended by further valves here:

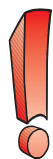
- One switch valve
- One high-pressure valve

A self-priming return flow pump is also required in the hydraulic unit, in order to independently build up brake pressure.

### 2. Interface to the engine management system

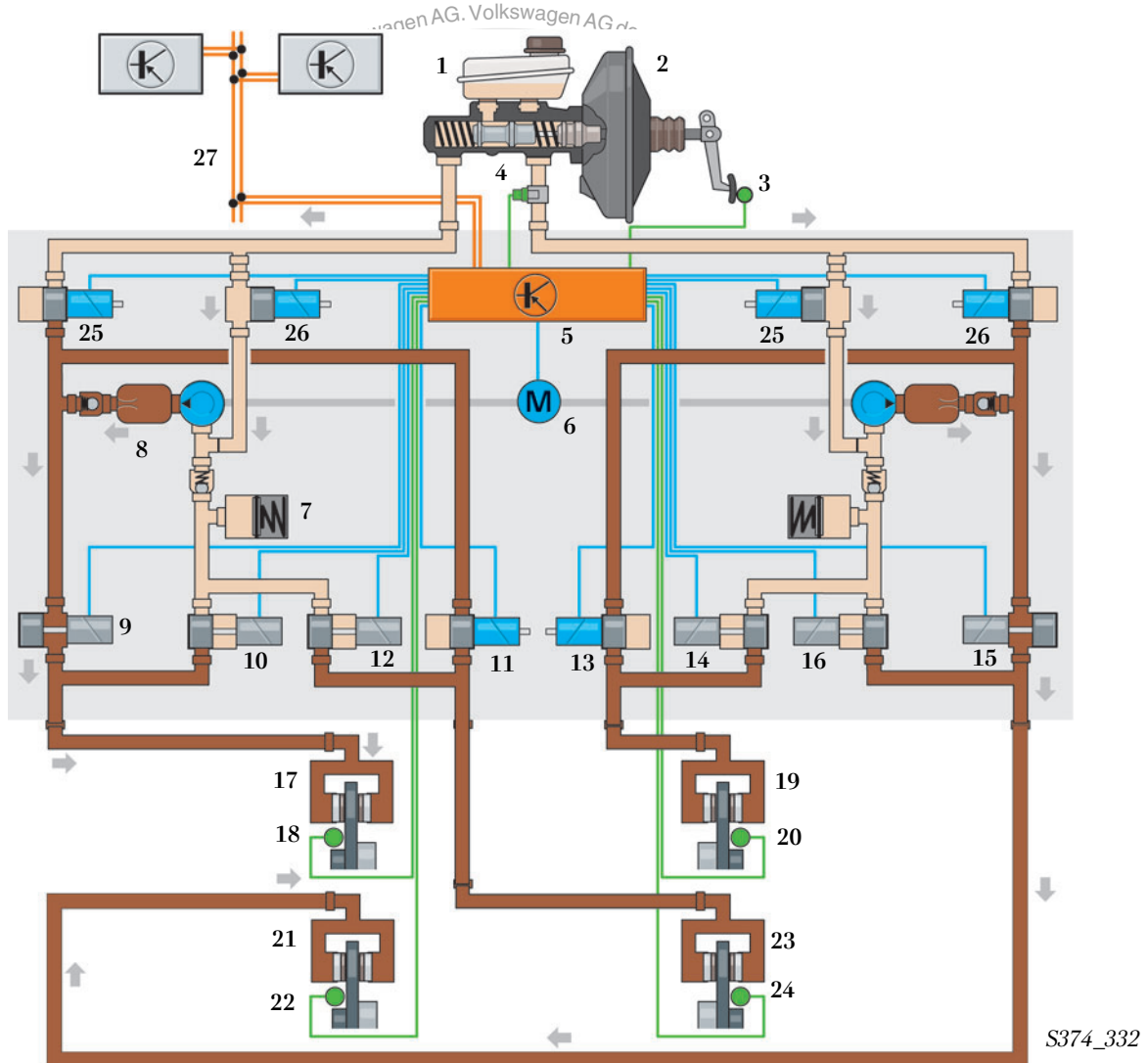
In contrast to ABS and also EDL, TCS acts not only on the brakes and therefore the deceleration of a wheel, but also on the engine output, i.e. the drive torque at the wheels. To achieve this, the accelerator must be mechanically decoupled from the throttle valve position. Regulation of the engine output must therefore be possible independently of the position of the accelerator.

In the first ABS systems with TCS, the approaches to throttling the engine torque differed significantly. For example, systems with a second throttle valve or the option of ignition masking were implemented. On introduction of the CAN data bus systems and the electronic throttle function, it became possible to use this comfortable interface to influence the engine's torque and speed without additional components.



In principle, TCS is an EDL with engine intervention.

TCS hydraulic circuit diagram



#### Legend

- |                                   |                                       |
|-----------------------------------|---------------------------------------|
| 1 - Reservoir                     | 15 - Rear left ABS inlet valve        |
| 2 - Brake servo                   | 16 - Rear left ABS outlet valve       |
| 3 - Brake pedal sensors           | 17 - Front left wheel brake cylinder  |
| 4 - Brake pressure sender         | 18 - Front left speed sensor          |
| 5 - ABS/ESP control unit          | 19 - Front right wheel brake cylinder |
| 6 - Return flow pump              | 20 - Front right speed sensor         |
| 7 - Pressure accumulator          | 21 - Rear left wheel brake cylinder   |
| 8 - Damping chamber               | 22 - Rear left speed sensor           |
| 9 - Front left ABS inlet valve    | 23 - Rear right wheel brake cylinder  |
| 10 - Front left ABS outlet valve  | 24 - Rear right speed sensor          |
| 11 - Rear right ABS inlet valve   | 25 - Switch valve                     |
| 12 - Rear right ABS outlet valve  | 26 - High-pressure valve              |
| 13 - Front right ABS inlet valve  | 27 - CAN data bus                     |
| 14 - Front right ABS outlet valve |                                       |

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# Traction control systems

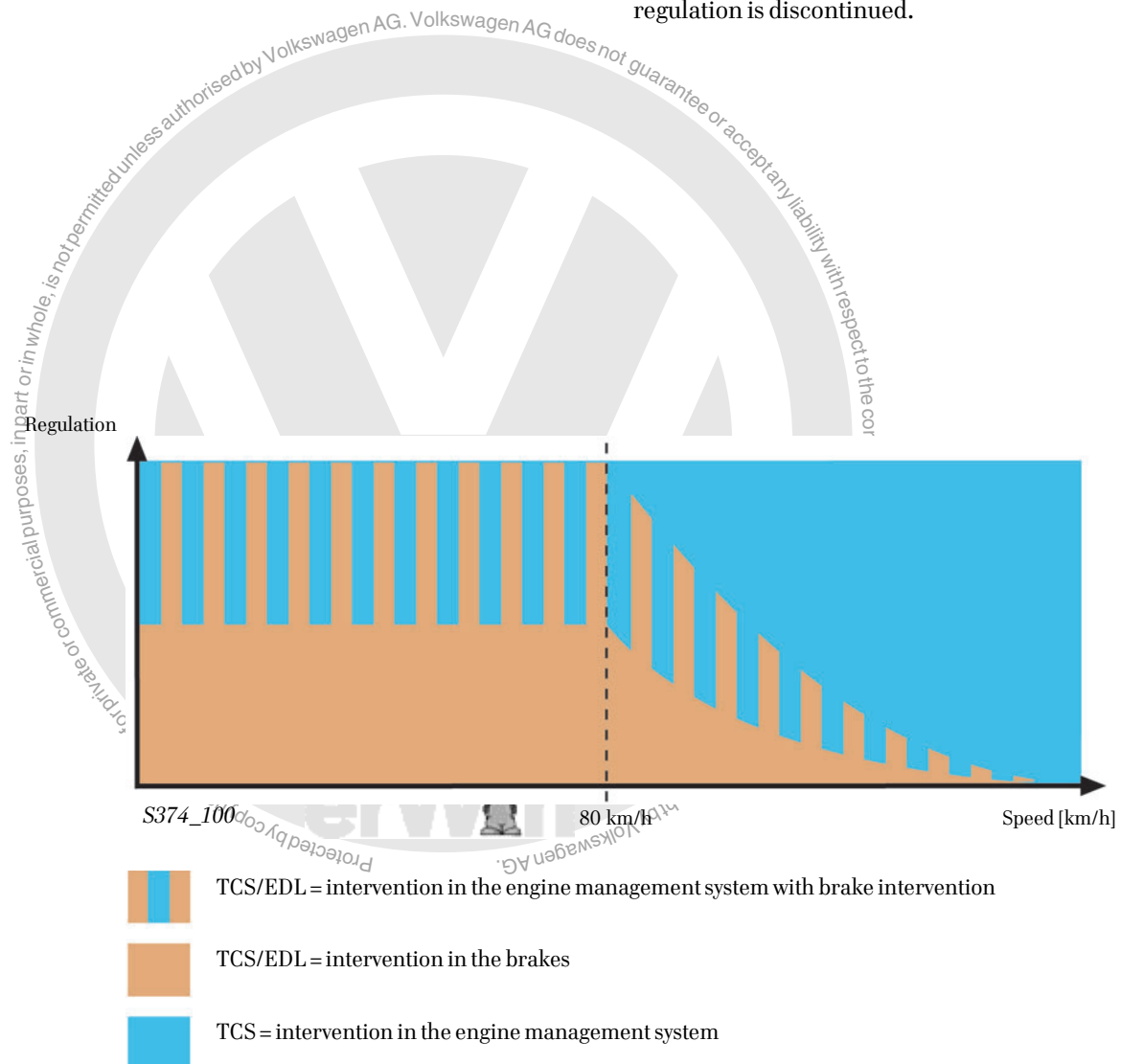
## How it works

In a vehicle with TCS, the wheel rotational speeds are used to calculate the four wheel speeds. By means of an extended evaluation, the TCS software analyses the following driving situations:

- The driven wheels' acceleration is calculated.
- The vehicle speed is calculated from the non-driven wheels' speed.
- Curve detection arises from the comparison of the non-driven wheels' speeds.
- Drive slip is calculated from the difference in the speeds of the driven and non-driven wheels per side of the vehicle.

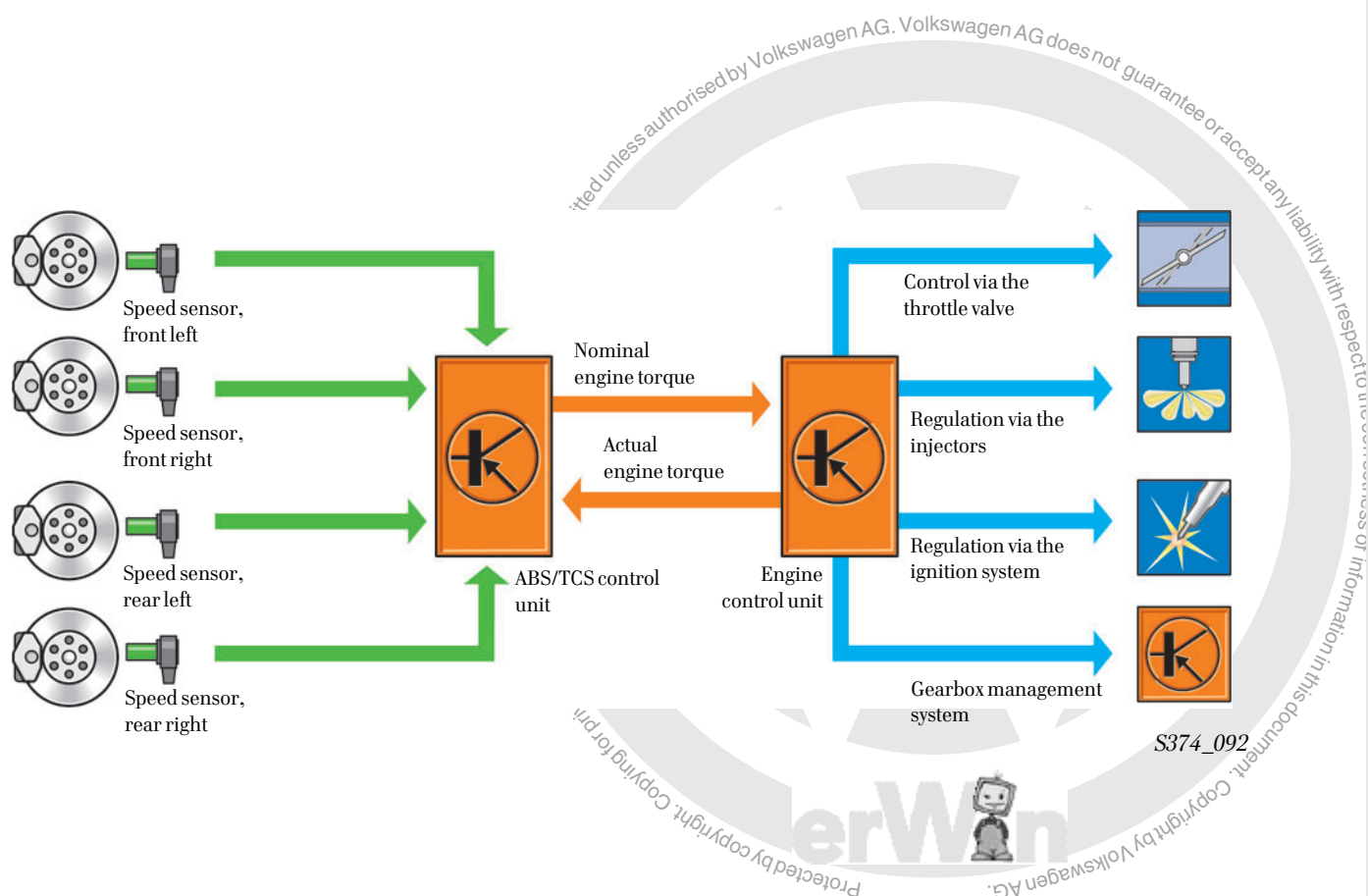
With this information, TCS is able to recognise when the drive wheels are in danger of spinning. A signal regarding the actual engine torque is additionally read by the engine control unit. TCS uses this to calculate the measures to be introduced.

In the low speed range, TCS regulation usually takes place via brake intervention. Regulation takes place, like that of EDL regulation, in three phases: "build up pressure", "maintain pressure" and "reduce pressure". In the case of TCS, brake intervention can be combined with intervention via the engine management system. TCS regulates throughout the entire speed range. As of a speed of 80 km/h, EDL regulation is discontinued.



For intervention via the engine control unit, TCS uses the drive slip which has been determined and the actual engine torque to calculate a necessary nominal engine torque. This is transmitted to the engine control unit. Depending on the available engine management system, the engine control unit has the following options:

- The engine torque is reduced by adjusting the throttle valve.
- In the event of control intervention via the injection system, the engine output is reduced by masking injection pulses.
- In the event of control intervention via the ignition system, either ignition pulses can be masked or the ignition timing can be adjusted in the "retarded" direction.
- In vehicles with automatic gearboxes, TCS additionally transmits a signal to the gearbox control unit, via which a gear change can be suppressed.



# Traction control systems

## Electronic Stabilisation Programme

Nowadays, ESP means "electronic stabilisation programme". When the system was introduced, ESP stood for "electronic stability programme". With the aid of its sensors, the electronic stabilisation programme ESP recognises at an early stage that a critical driving situation is emerging. By specifically braking individual wheels and the possibility of intervention in the engine and gearbox management system, ESP then independently acts to counter this situation in such a way that vehicle stability and steerability are maintained.

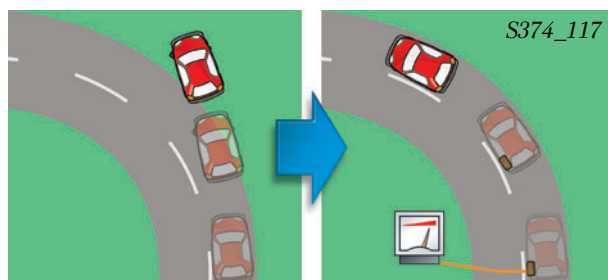
At present, ESP is the most advanced wheel traction control system. It is not an individual system; the wheel traction control systems ABS, EBD, CBC, EDL, YMC, TCS and EBC are already integrated. Each of these sub-systems can operate both autonomously and in combination. ESP is superordinate to the other systems.

The electronic stabilisation programme ESP decides when, and under which vehicle dynamics conditions, which traction control systems are implemented and controls their operation in combination.

ESP is permanently in readiness. The recognition of a critical vehicle dynamics situation is based on comparison of the driver's command and the actual vehicle behaviour. If these deviate from each other, ESP control intervention begins. Depending on the situation, ESP reduces the engine torque and suppresses gear changes in the case of automatic gearboxes. ESP then stabilises the vehicle's behaviour by specifically braking individual, or several, wheels. On understeering, engine management intervention first takes place, in contrast to which brake intervention takes place first in the event of oversteering. Control intervention lasts until all unstable vehicle statuses have been corrected, i.e. the nominal value has been achieved again.

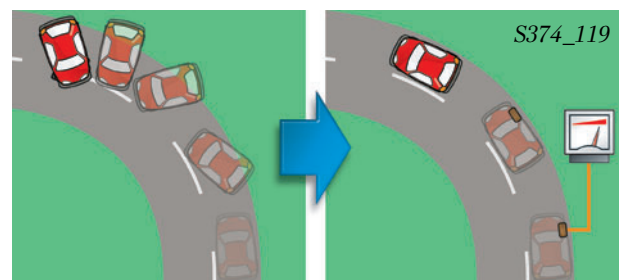
By braking individual wheels, ESP generates a yaw rate around the vehicle's vertical axis. This yaw rate acts counter to the vehicle's direction of movement and stabilises travel in the desired direction. Hazardous understeering or oversteering is therefore effectively prevented.

Understeering



On understeering, ESP prevents departure from the curve by specifically braking the inner rear wheel.

Oversteering

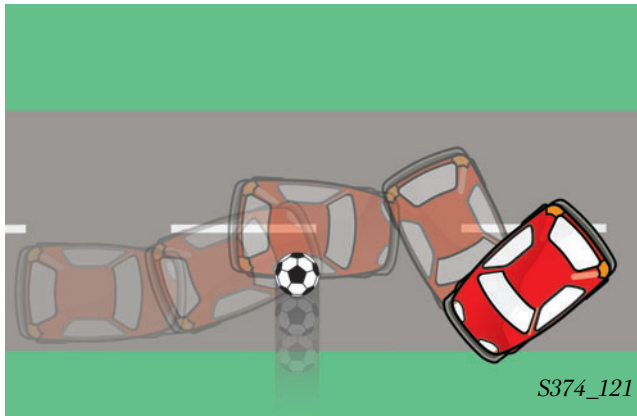


On oversteering, the outer front wheel is braked.



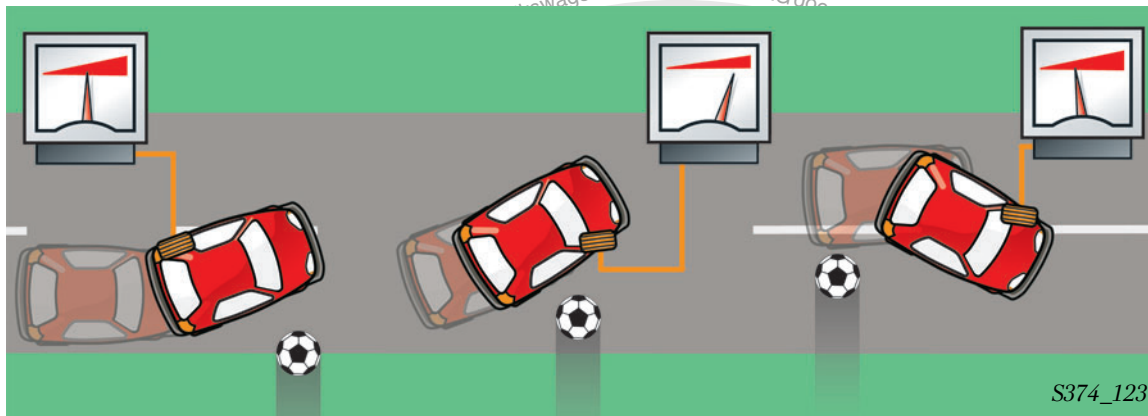
Let us take a closer look at the vehicle's behaviour during evasive action.

#### Vehicle without ESP



The vehicle without ESP has to evade an obstacle which suddenly emerges. The driver first steers very quickly to the left and immediately afterwards back to the right. The vehicle begins to sway due to the preceding steering movements, and the rear end breaks away. The rotation around the vertical axis can no longer be controlled by the driver. The vehicle begins to skid.

#### Vehicle with ESP



The vehicle with ESP attempts to evade the obstacle. ESP recognises that the vehicle is in danger of understeering to the left. The steering movement is initially supported by braking the left rear wheel. At the same time, intervention in the engine management system takes place via the CAN data bus in order to reduce the drive power and additionally brake the vehicle via the engine braking effect.

Whilst the vehicle curves to the left, the driver steers to the right. To support this countersteering, the front right wheel is braked. As the driver wishes to return to his original course, he must now steer to the left again. The preceding lane change may lead to the vehicle's swinging around the vertical axis. The left front wheel is braked to prevent the rear end from breaking away.

# Traction control systems

## Design

The ESP system consists of:

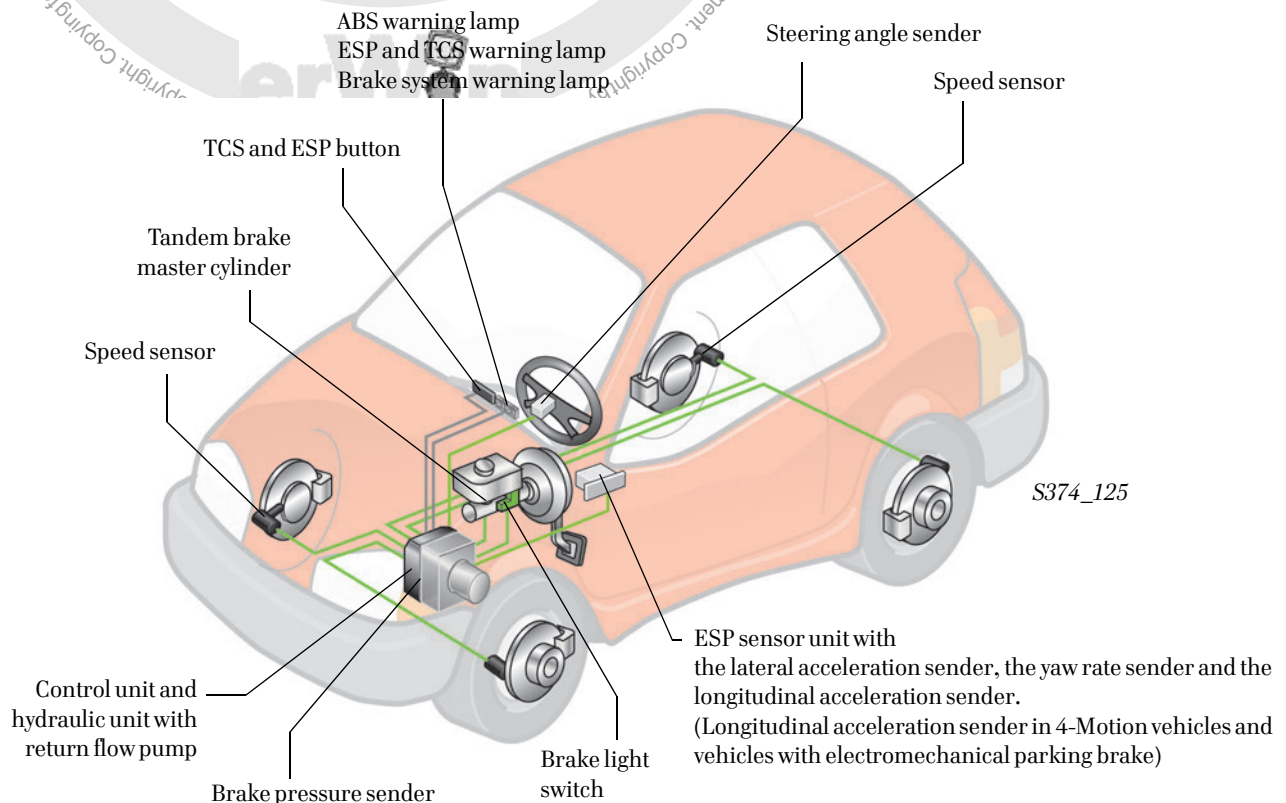
- The ABS/ESP control unit
- The hydraulic unit with electronic return flow pump,
- The four speed sensors,
- The brake pressure sender,
- The TCS and ESP button,
- The brake light switch,
- The brake system warning lamp,
- The ABS warning lamp,
- The ESP and TCS warning lamp,
- The ESP sensor unit and
- The steering angle sender

and in certain vehicles

- An active brake servo or
- A pre-charging pump.

To a large extent, the ESP system makes use of the ABS and TCS components. A control unit with corresponding software and a hydraulic unit with return flow pump are available to regulate the brake pressures. The hydraulic unit must be designed for 4-wheel TCS.

Warning lamps in the dash panel insert are used to inform the driver of control interventions which are taking place and the status of the ESP system. A button in the dash panel can be used to deactivate the ESP/TCS function. In certain vehicles, e.g. the Tiguan, only the TCS function is deactivated. Other brake systems, such as e.g. ABS, remain active even when the ESP function is deactivated.



The system's sensors are sub-divided into the senders for registering the driver's command and those for sensing the vehicle behaviour.

The driver's command is registered by:

- The steering angle sender,
- Information from the engine control unit,
- The brake light switch,
- The brake pedal switch and
- The brake pressure sender.

The steering angle represents the driver's direction command and actuation of the brake pedals represents the command to brake or stop. The brake pressure sender additionally provides information on the intensity of the desired braking.

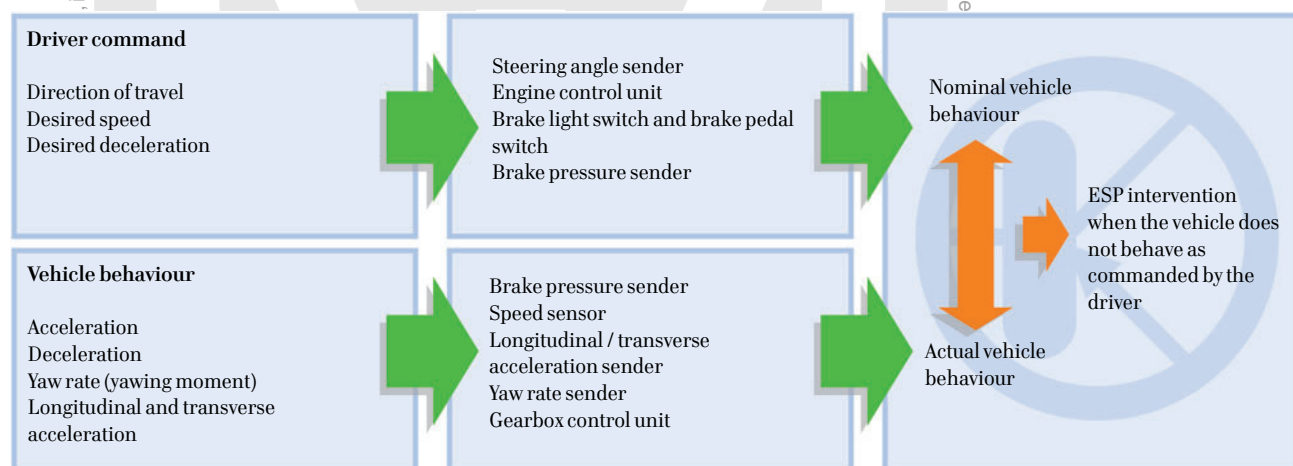
The actual vehicle behaviour is registered by:

- The speed sensors on all four wheels,
- A sender for registering longitudinal and lateral acceleration,
- A sender for sensing the yaw rate and
- A sender for registering the current brake pressure.

The speed sensor signals are used to determine the four wheels' drive and brake slip.

The signals from the transverse acceleration sender, the longitudinal acceleration sender and the yaw rate sender provide information on the vehicle's longitudinal and transverse dynamics. The brake pressure sender registers the actual pressure in the brake system.

In vehicles with automatic gearboxes, a link to the gearbox management system is added in order, firstly, to register the current gear selection and secondly to enable the gearbox to be shifted independently in the event of ESP control intervention.



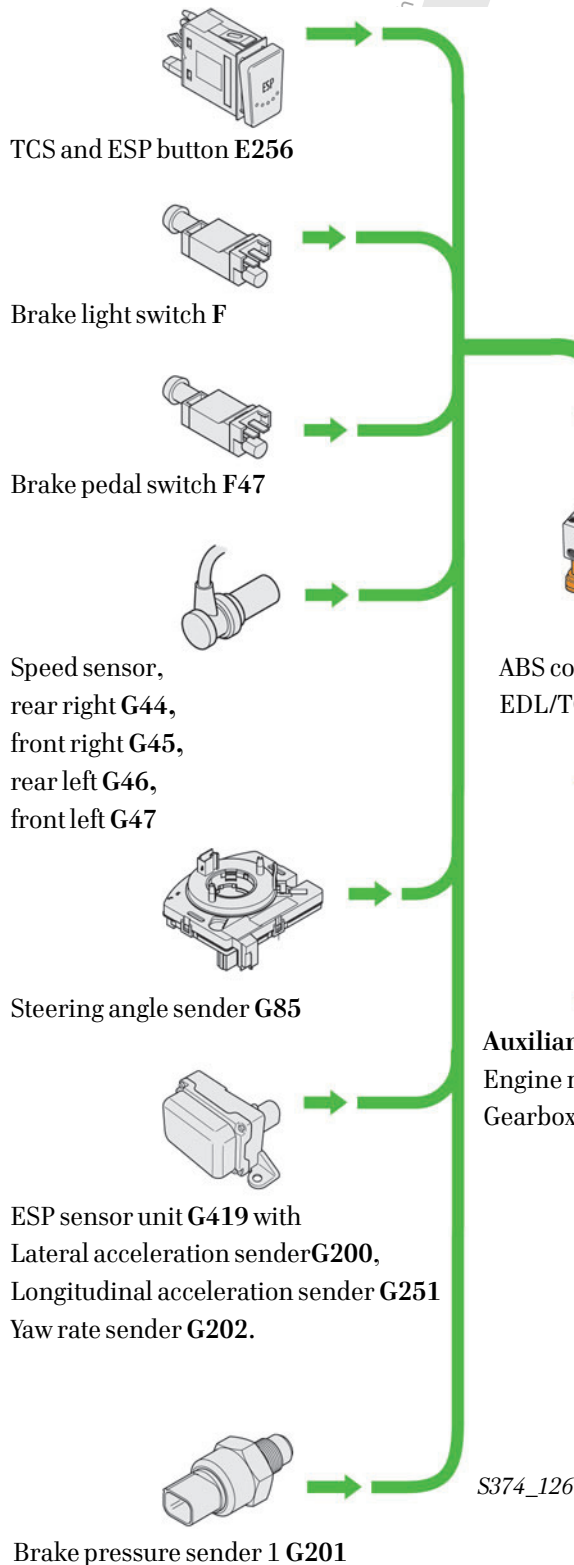
S374\_130

The ABS/ESP control unit uses the data from the driver's command to calculate the nominal vehicle behaviour and the actual vehicle behaviour from the vehicle's actual movements. By comparing the two values, the ESP software detects a critical driving situation, and the necessary control interventions are introduced.

# Traction control systems

## Overview of the system

### Sensors



Diagnosis connector

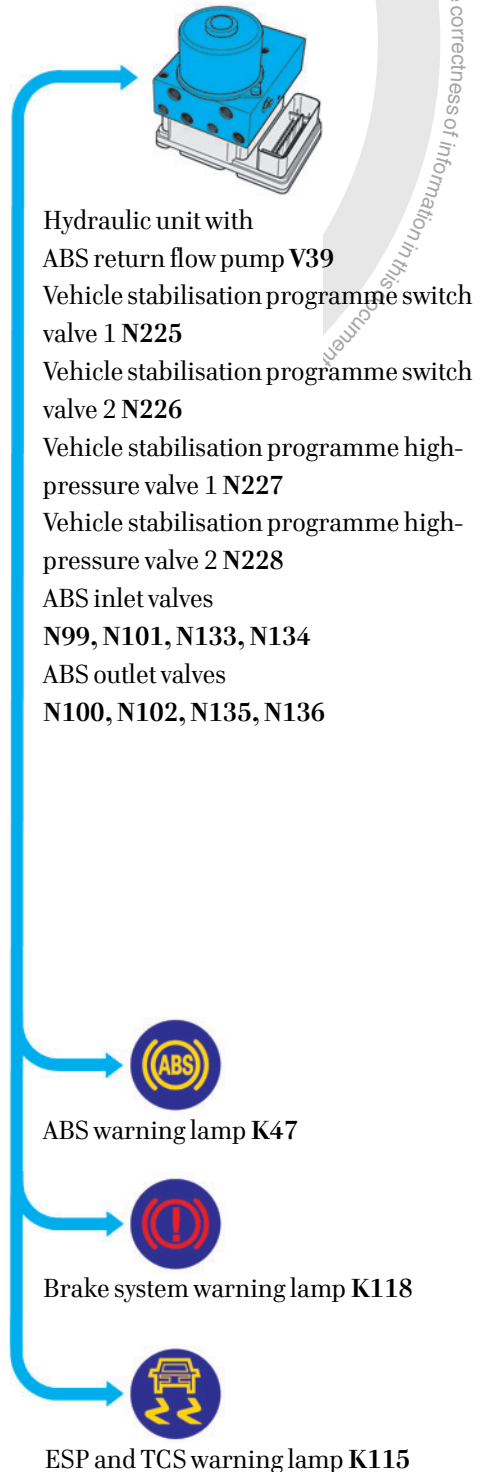
ABS control unit with EDL/TCS/ESP J104

CAN

Auxiliary signals

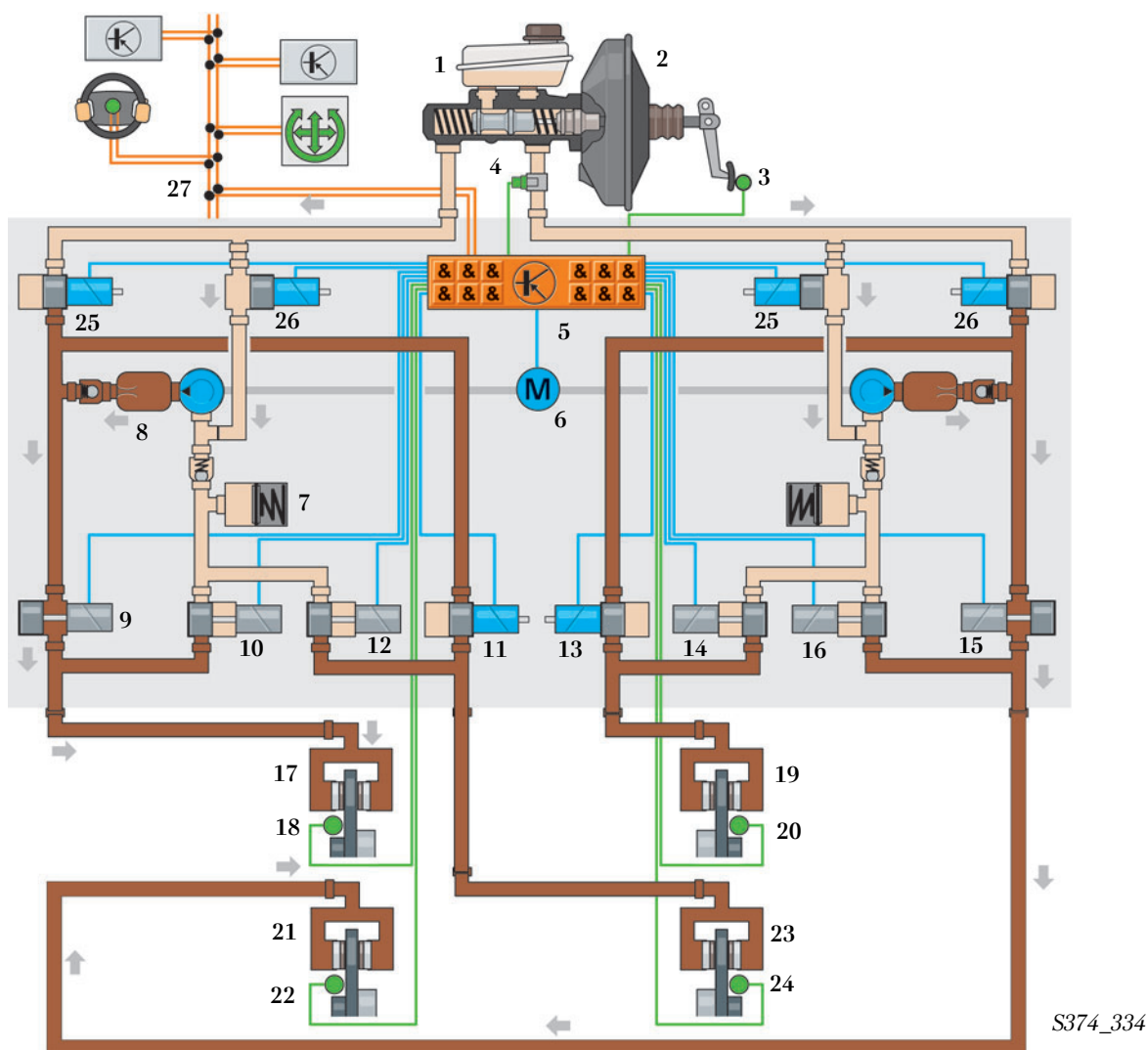
Engine management system  
Gearbox management system

### Actuators



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## ESP hydraulic circuit diagram



### Legend

- |                                   |                                       |
|-----------------------------------|---------------------------------------|
| 1 - Reservoir                     | 15 - Rear left ABS inlet valve        |
| 2 - Brake servo                   | 16 - Rear left ABS outlet valve       |
| 3 - Brake pedal sensors           | 17 - Front left wheel brake cylinder  |
| 4 - Brake pressure sender         | 18 - Front left speed sensor          |
| 5 - ABS/ESP control unit          | 19 - Front right wheel brake cylinder |
| 6 - Return flow pump              | 20 - Front right speed sensor         |
| 7 - Pressure accumulator          | 21 - Rear left wheel brake cylinder   |
| 8 - Damping chamber               | 22 - Rear left speed sensor           |
| 9 - Front left ABS inlet valve    | 23 - Rear right wheel brake cylinder  |
| 10 - Front left ABS outlet valve  | 24 - Rear right speed sensor          |
| 11 - Rear right ABS inlet valve   | 25 - Switch valve                     |
| 12 - Rear right ABS outlet valve  | 26 - High-pressure valve              |
| 13 - Front right ABS inlet valve  | 27 - CAN data bus                     |
| 14 - Front right ABS outlet valve |                                       |

# Traction control systems

## How it works

ESP has various options for stabilising the vehicle:

- Via specific brake intervention
- Via intervention in the engine management system and additionally
- Via intervention in the gearbox management system (in vehicles with automatic gearboxes) and into the four-wheel drive control system

By evaluating the input signals and comparing the vehicle's actual/nominal behaviour, the ABS/ESP control unit recognises an unstable driving situation. In certain situations, it is necessary for ESP to intervene in the engine management system. If, for example, a driver wishes to accelerate in an unstable driving situation, this is prevented via ESP's intervention in the engine management system.

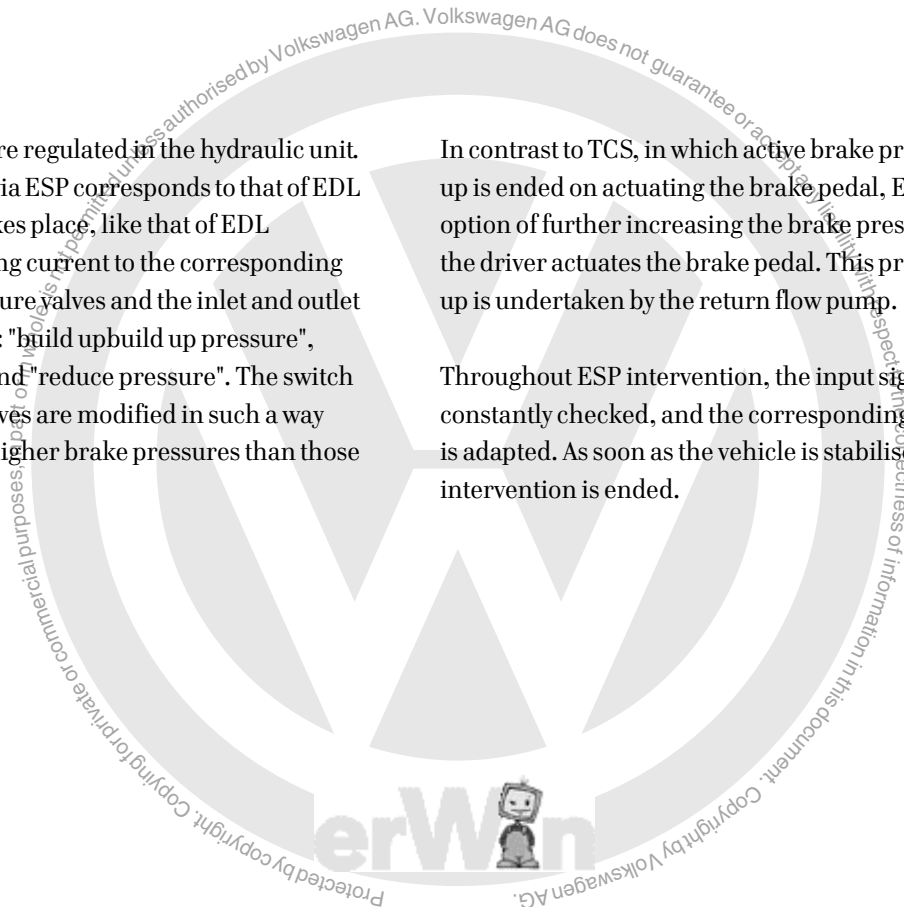
The ESP actuation commands take precedence over the position of the accelerator. The vehicle is not accelerated. Precisely as in the case of TCS and depending on the available engine management system, the engine control unit has the following options for reducing torque:

- By adjusting the throttle valve
- By masking injection pulses
- By masking ignition pulses or by adjusting the ignition timing
- By suppressing gear change processes (in vehicles with automatic gearboxes)

Brake interventions are regulated in the hydraulic unit. Hydraulic regulation via ESP corresponds to that of EDL or TCS. Regulation takes place, like that of EDL regulation, by supplying current to the corresponding switch and high-pressure valves and the inlet and outlet valves in three phases: "build up pressure", "maintain pressure" and "reduce pressure". The switch and high-pressure valves are modified in such a way that they also enable higher brake pressures than those of TCS.

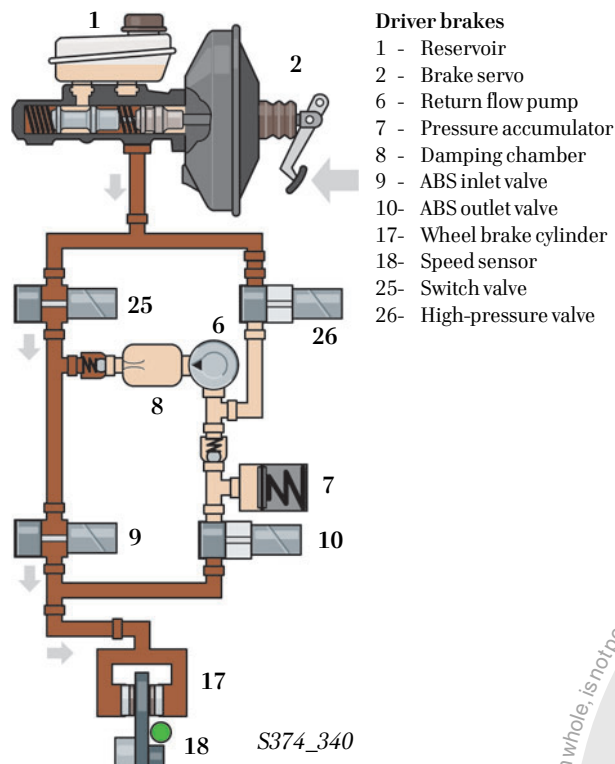
In contrast to TCS, in which active brake pressure build-up is ended on actuating the brake pedal, ESP has the option of further increasing the brake pressure, even if the driver actuates the brake pedal. This pressure build-up is undertaken by the return flow pump.

Throughout ESP intervention, the input signals are constantly checked, and the corresponding regulation is adapted. As soon as the vehicle is stabilised, ESP intervention is ended.



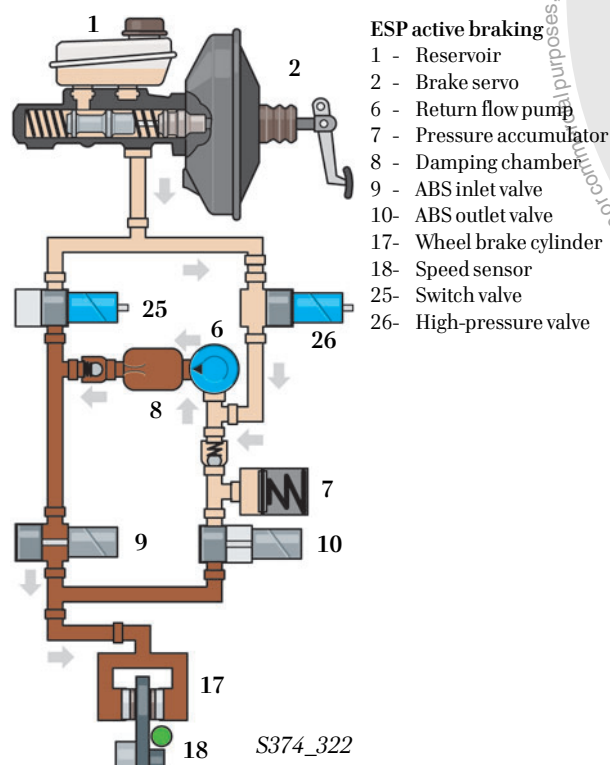


The differences which occur when the driver brakes or when ESP brakes are shown on the basis of a wheel brake.



Pressure build-up in the hydraulic unit when the driver brakes.

The brake pedal is actuated. The switch valve is opened and the high-pressure valve closed. Via the opened inlet valve, pressure can be built up at the wheel brake. The outlet valve is closed.



Pressure build-up in the hydraulic unit in the case of "active braking". This means that ESP specifically brakes the wheel. Brake pressure is built up without the driver's actuating the brake pedal. The switch valve is closed and the high-pressure valve is opened. The return flow pump begins working and intakes brake fluid from the brake master cylinder. As a result, brake pressure builds-up in the wheel brake cylinder of the wheel which is to be braked.

# Auxiliary ESP functions

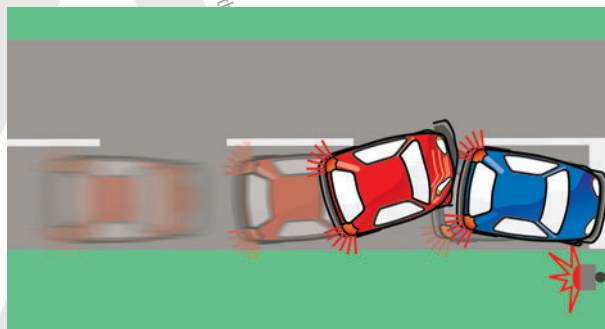
The systems described in the following require an ESP system.

## Hydraulic Brake Assist system

Braking behaviour studies have revealed that many drivers brake too gently and do not therefore make use of the deceleration which is possible in technical and vehicle dynamics terms. The stopping distance increases as a result. The hydraulic brake assist system HBA is intended to support the driver in this. If the pressure on the brake pedal is not sufficient, it recognises the danger situation and independently increases the brake pressure.

A driver is surprised by the fact that the vehicle in front of him suddenly brakes. After his initial shock, he recognises the situation and actuates the brake. Inexperienced drivers often brake with a good response time but with insufficient pedal pressure. The maximum possible brake pressure is not therefore built up in the system, thereby increasing the stopping distance unnecessarily. The vehicle does not then come to a stop in good time.

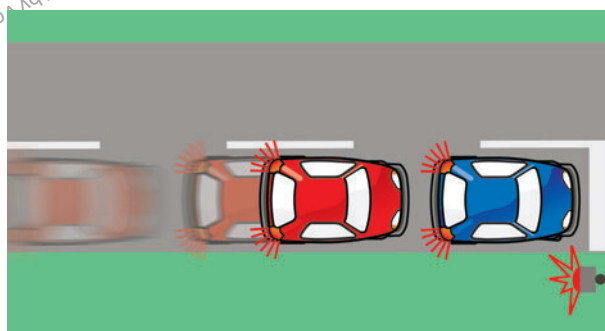
Braking manoeuvre without brake assist system



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In the same situation in a vehicle with the brake assist system, the insufficient pedal pressure applied by the inexperienced driver is compensated. From the speed and pressure with which the brake pedal is actuated, HBA recognises that an emergency situation has arisen. Thanks to the brake assist system, the brake pressure is increased until ABS regulation kicks in to prevent the wheels from locking up. The maximum achievable braking effect can therefore be exploited and the stopping distance can be significantly reduced.

Braking manoeuvre with brake assist system



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## Design

The hydraulic brake assist system HBA is an extension of the ESP system's function. No additional components are required. The ABS/ESP control unit is extended by additional software for the brake assist system function.

The brake pressure sender in the hydraulic unit, the speed sensors and the brake light switch supply the brake assist system with signals, so that it recognises an emergency situation.

## How it works

HBA is triggered in emergency braking situations. The following trigger conditions indicate an emergency braking situation.

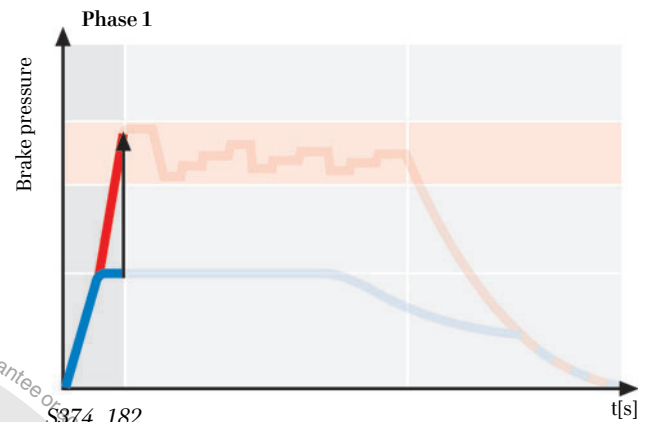
1. The driver brakes. The brake light switch sends the signal that the brake has been actuated.
2. The vehicle drives at minimum speed. The speed sensors supply signals indicating how fast the vehicle is driving.
3. The speed with which the brake pedal is actuated exceeds the brake assist system's activation threshold. The brake pressure sender sends the signal indicating the speed and force with which the driver has actuated the brake pedal.

If the trigger conditions are met and the current brake pressure remains below the nominal value stored in the control unit, the system adjusts the pressure independently. The ABS/ESP control unit activates the brake assist system function and transmits signals to the hydraulic unit. Hydraulic regulation takes place in three phases.

# Auxiliary ESP functions

## Phase 1: Start of brake assist system intervention

The brake assist system increases the brake pressure. Due to this active pressure build-up, the ABS regulation limit is very quickly reached, thereby triggering ABS regulation.

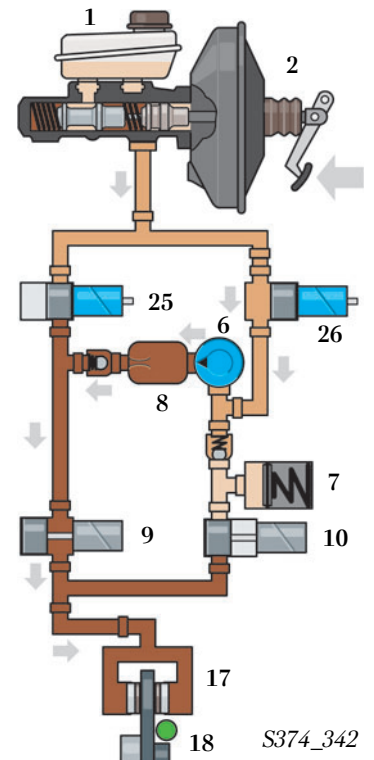


— Brake pressure at the wheel brake cylinder  
— Driver's pedal pressure

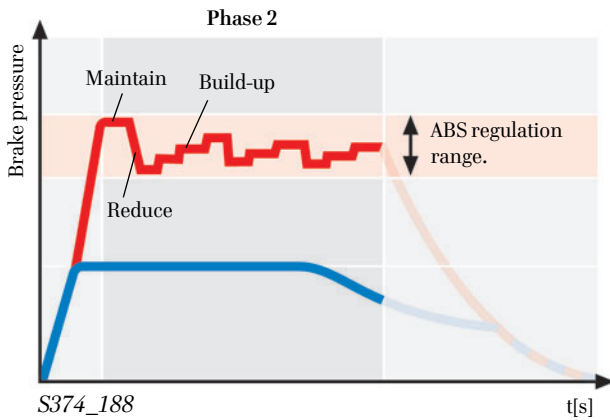
In the hydraulic unit, the switch valve is closed and the high-pressure valve is opened. The return flow pump is actuated and begins pumping. As a result of this, the pressure at the wheel brake is increased to the maximum, over and above the brake pressure triggered by the driver. If the wheels are in danger of locking up, ABS intervenes.

### Active pressure build-up

- 1 - Reservoir
- 2 - Brake servo
- 6 - Return flow pump
- 7 - Pressure accumulator
- 8 - Damping chamber
- 9 - ABS inlet valve
- 10 - ABS outlet valve
- 17 - Wheel brake cylinder
- 18 - Speed sensor
- 25 - Switch valve
- 26 - High-pressure valve

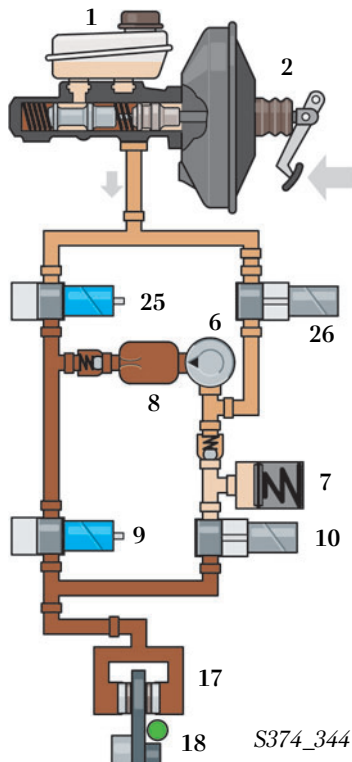


## Phase 2: ABS intervention



- Brake pressure at the wheel brake cylinder
- Driver's pedal pressure

ABS intervention keeps the brake pressure below the lock up threshold. Regulation takes place in three phases: "Maintain pressure", "reduce pressure" and "build up pressure".



- Pressure maintenance**
- 1 - Reservoir
  - 2 - Brake servo
  - 6 - Return flow pump
  - 7 - Pressure accumulator
  - 8 - Damping chamber
  - 9 - ABS inlet valve
  - 10 - ABS outlet valve
  - 17 - Wheel brake cylinder
  - 18 - Speed sensor
  - 25 - Switch valve
  - 26 - High-pressure valve

To maintain the brake pressure in the wheel's brake circuit, the inlet valve and the high-pressure valve are closed. A constant brake pressure is maintained at the wheel brake. The return flow pump is deactivated.

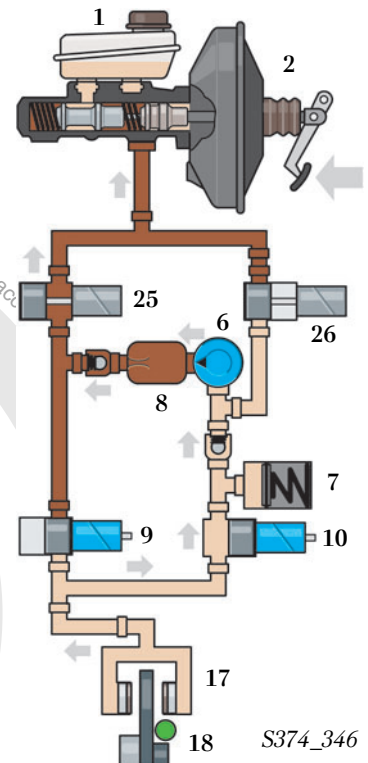
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# Auxiliary ESP functions

To reduce the pressure, the outlet and switch valve are opened. The brake fluid is pumped back into the brake master cylinder by the return flow pump counter to the driver's pedal pressure.

## Pressure reduction

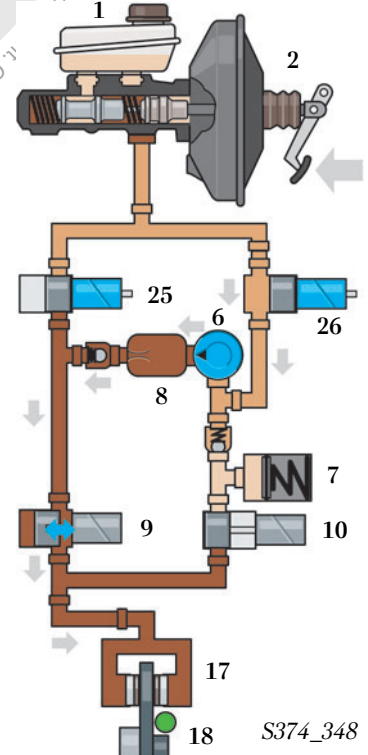
- 1 - Reservoir
- 2 - Brake servo
- 6 - Return flow pump
- 7 - Pressure accumulator
- 8 - Damping chamber
- 9 - ABS inlet valve
- 10 - ABS outlet valve
- 17 - Wheel brake cylinder
- 18 - Speed sensor
- 25 - Switch valve
- 26 - High-pressure valve



In order to then build up the pressure again gradually, the switch and the outlet valve are closed again and the high-pressure valve is opened. The return flow pump is actuated and begins pumping. The inlet valve opens and closes at brief intervals, and the brake pressure can therefore be increased gradually.

## Pressure build-up

- 1 - Reservoir
- 2 - Brake servo
- 6 - Return flow pump
- 7 - Pressure accumulator
- 8 - Damping chamber
- 9 - ABS inlet valve
- 10 - ABS outlet valve
- 17 - Wheel brake cylinder
- 18 - Speed sensor
- 25 - Switch valve
- 26 - High-pressure valve

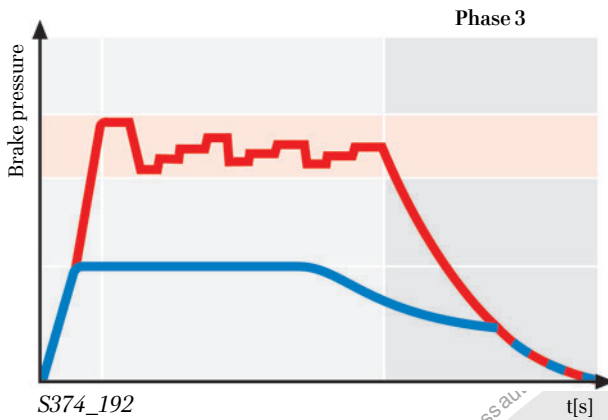


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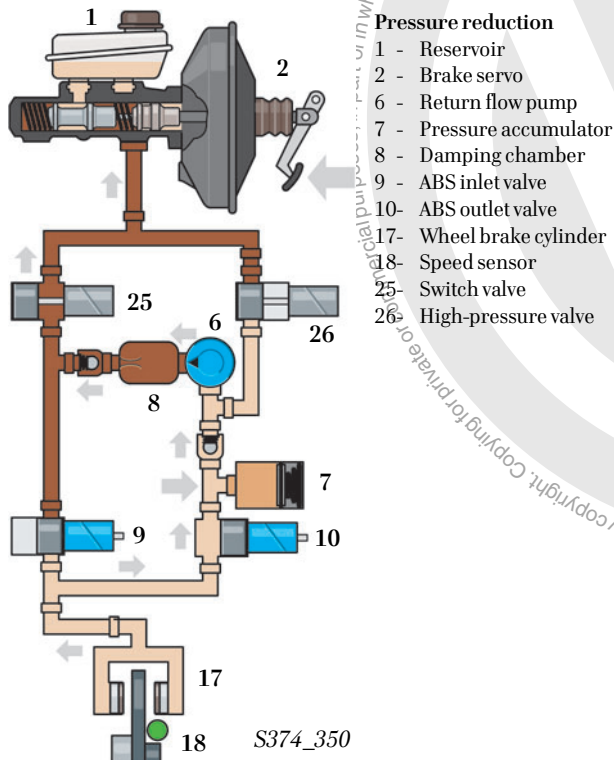


### Phase 3: End of brake support



- Brake pressure at the wheel brake cylinder
- Driver's pedal pressure

If the driver reduces the pedal pressure or negative deviation from the minimum speed occurs, the trigger conditions for the HBA are no longer given. The ABS/ESP control unit recognises that the emergency situation has been averted and begins to end brake assistance. The brake pressure increased by HBA is gradually reduced until it is again adapted to the driver's pedal pressure.



By closing the inlet valve and opening the outlet valve, the brake fluid flows off into the accumulator. It is pumped back in the direction of the reservoir by the return flow pump.

# Auxiliary ESP functions

## Hydraulic brake servo

Under certain engine operating conditions (particularly during the cold-starting phase), the vacuum supply for the brake servo is not sufficient. The hydraulic brake servo has been designed for precisely this case. If insufficient vacuum is available to the brake system, sufficient brake pressure support cannot be provided in the brake servo. This means that the optimal braking effect is not achieved.

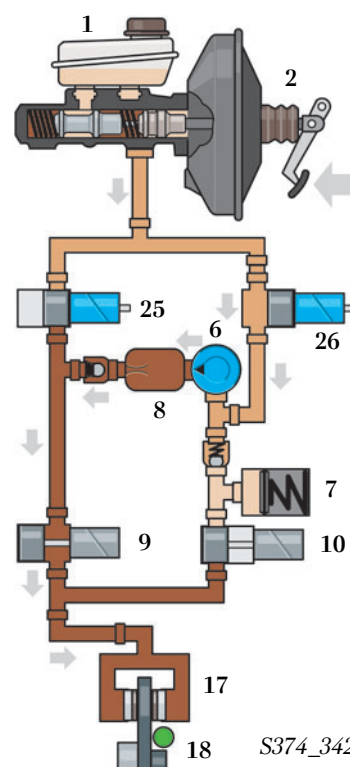
The hydraulic brake servo HBS ensures that the lack of brake boosting caused by insufficient vacuum is compensated by apportioned active pressure build-up via the ESP system's return flow pump. HBS is based on the ESP system's technical equipment and requires no additional components. It is an extension of the ESP regulation system's software.

### How it works

Based on the information arriving from the brake light switch and brake pressure sender, the system recognises that a braking manoeuvre is taking place. It compares the measured brake pressure value with that which ought actually to prevail in the system if the driver has actuated the brake pedal at a specific strength and speed. A vacuum sensor in the brake servo ascertains an inadequate vacuum supply from the engine to the brake servo. The brake pressure in the hydraulic system is then independently increased to the required value. In the hydraulic unit, the switch valve is closed and the high-pressure valve is opened. The return flow pump is actuated and begins pumping. As a result of this, the brake pressure at the wheel brake is increased to the value which corresponds to the driver's brake pedal position. The driver notices no difference versus the conventional brake servo in terms of the force required at the brake pedal.

#### Active pressure build-up

- 1 - Reservoir
- 2 - Brake servo
- 6 - Return flow pump
- 7 - Pressure accumulator
- 8 - Damping chamber
- 9 - ABS inlet valve
- 10 - ABS outlet valve
- 17 - Wheel brake cylinder
- 18 - Speed sensor
- 25 - Switch valve
- 26 - High-pressure valve



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## Overboost

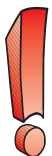
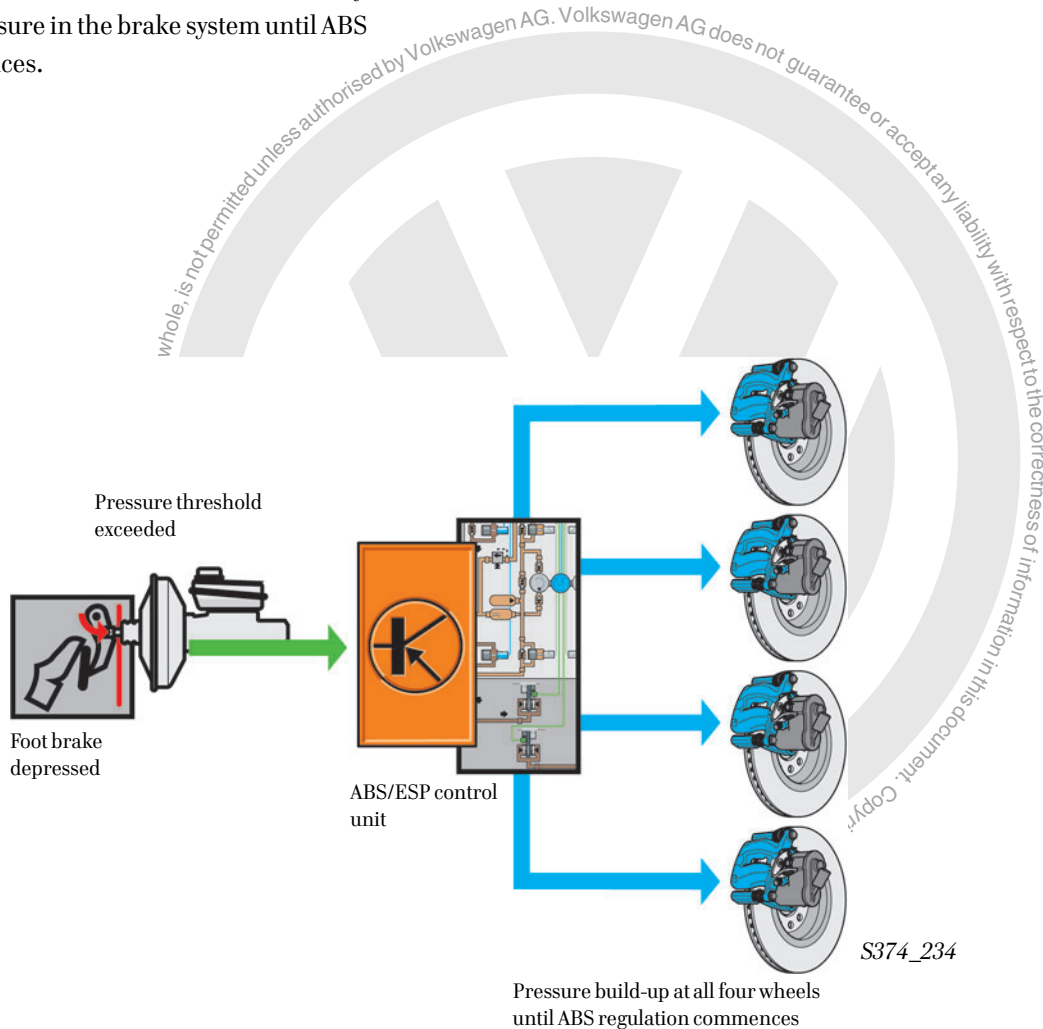
In the specialist literature, overboost is also referred to as Fading Brake Support FBS or fading compensation.

In a critical situation, the driver depresses the brake pedal until a defined pressure threshold in the brake system is exceeded. As the road surface conditions are very good, i.e. good frictional adhesion predominates, no ABS regulation commences at the wheels. As the driver's desire for maximum deceleration still exists, however, overboost intervenes.

The ESP sensors detect this situation and additionally build up brake pressure in the brake system until ABS regulation commences.

Due to ESP regulation, the pressure at all four wheels is increased, via actuation of the return flow pump in the hydraulic unit, until ABS regulation commences at all four wheels. The maximum system pressure is limited due to component protection (e.g. bending the brake calipers open).

Overboost is also a pure extension of the ESP system's software.



The difference between overboost and the hydraulic brake assist system is the fact that the driver is not inexperienced in the case of overboost. In a critical situation, the driver brakes with a good reaction time and maximum pedal pressure.

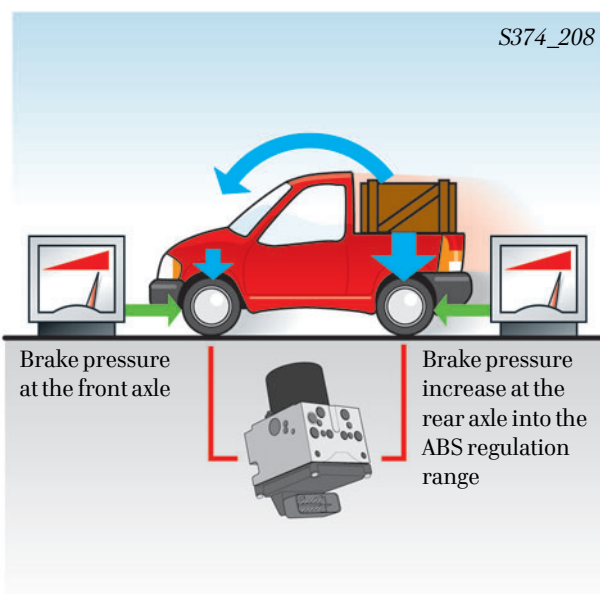
# Auxiliary ESP functions

## Full Rear Axle Deceleration

In simple terms, full rear axle deceleration FRAD is a reversal of electronic brake pressure distribution EBD. Whilst EBD's objective is to prevent overbraking at the rear axle, FRAD ensures that the brake pressure at the rear axle is increased to such an extent that ABS regulation begins to operate on the rear axle.

However, this only applies if ABS regulation is already taking place at the front axle. The objective in this case is also to achieve an optimal braking effect, but also to guarantee vehicle stability by keeping brake slip at the front axle higher than at the rear axle. The regulation limits are particularly designed for laden vehicles.

During a braking manoeuvre by a heavily laden vehicle, the higher mass and therefore higher inertia also necessitate higher brake pressures. The objective is to also achieve optimal use of the maximum brake pressure which can be transmitted for laden vehicles. This optimal braking effect is achieved with ABS control intervention. If the driver depresses the brake, ABS regulation initially commences at the front axle, whilst the rear axle is not yet subject to ABS intervention. Due to the system, this only occurs when it is ascertained that the wheels are in danger of locking up. Due to the high load and therefore axle load, however, the lock up effect is delayed because frictional adhesion at the rear wheels increases and more brake pressure can therefore be transmitted than at the front wheels. Therefore, the maximum braking effect is not initially achieved at the rear wheels. At this point, full rear axle deceleration commences and independently increases the brake pressure at the rear axles to such an extent that ABS regulation also commences there.



The FRAD function enables a maximum rear axle braking effect.

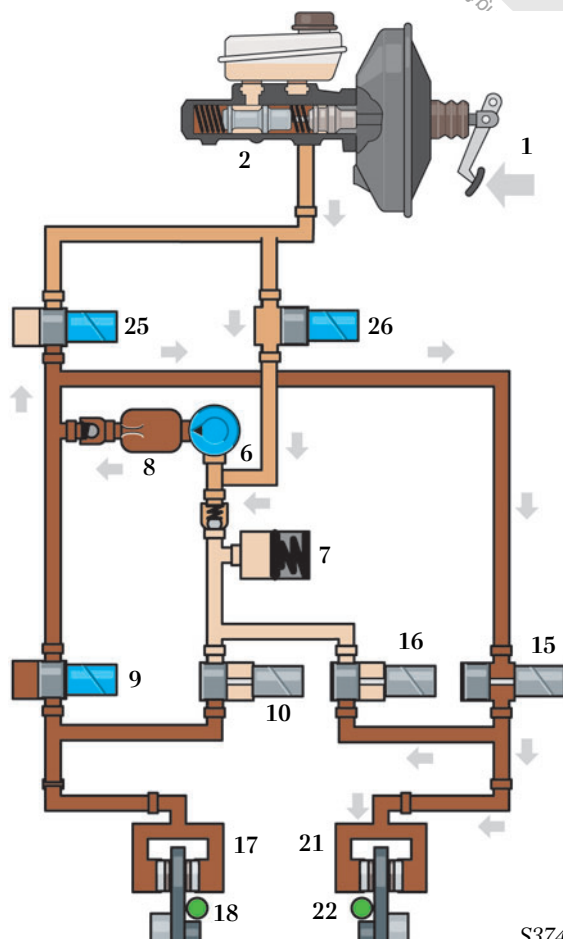
## Design

Full rear axle deceleration FRAD is a pure extension of the ESP regulation software and requires no additional components.

## How it works

Based on the input signals, the ESP/ABS control unit ascertains that ABS intervention is taking place at the front axle and that the driver has actuated the brake pedal with sufficient speed and strength. Now, the brake pressure at the rear wheels is also independently increased to such an extent that ABS regulation also commences there.

The pressure is increased by the return flow pump, and the rear axle's two inlet valves are opened until their speed sensors indicate that the rear wheels are also in danger of locking up. Normal ABS regulation now commences with the phases: "maintain pressure", "reduce pressure", "build up pressure" in order to guarantee the maximum braking effect whilst maintaining controllable vehicle dynamics.



### Legend

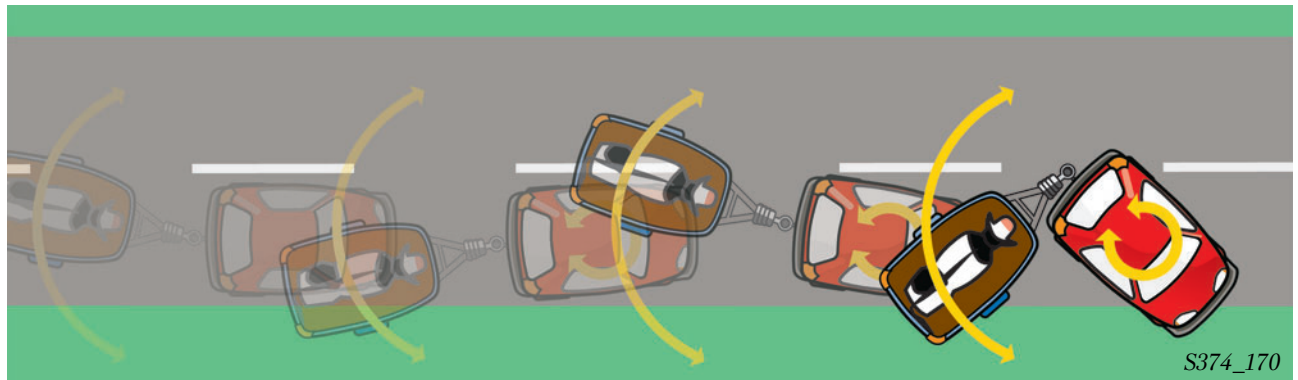
- 1 - Foot brake depressed
- 2 - Tandem brake master cylinder
- 6 - Return flow pump
- 7 - Pressure accumulator
- 8 - Damping chamber
- 9 - ABS inlet valve
- 10 - ABS outlet valve
- 15 - Rear left ABS inlet valve
- 16 - Rear left ABS outlet valve
- 17 - Front left wheel brake cylinder
- 18 - Front left speed sensor
- 21 - Rear left wheel brake cylinder
- 22 - Rear left speed sensor
- 25 - Switch valve
- 26 - High-pressure valve

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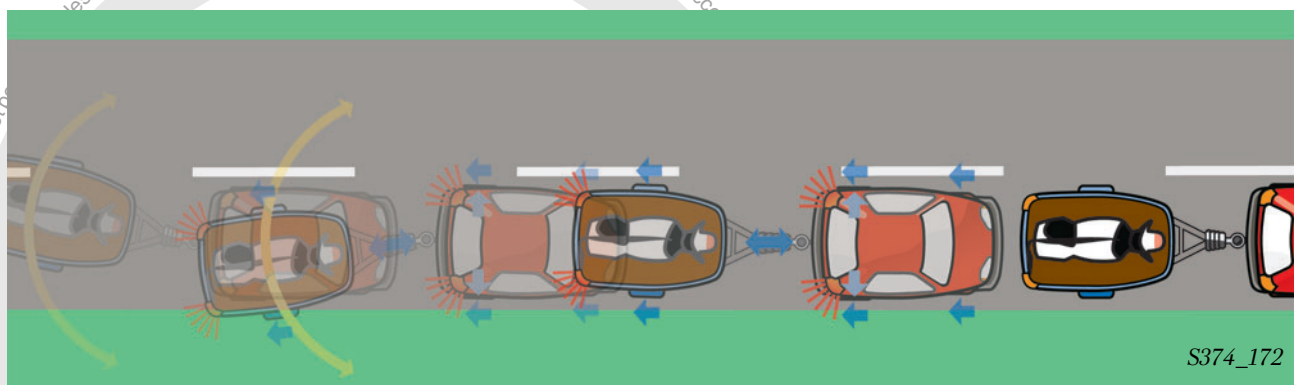
# Auxiliary ESP functions

## Vehicle/trailer stabilisation system

A vehicle with trailer enters into a critical vehicle dynamics situation more easily. Snaking vehicle/trailer combinations are barely controllable even for experienced drivers.



A vehicle/trailer combination's trailer can begin to swing, particularly on routes with gradients, due to side wind, ruts, rapid steering movements during spontaneous evasive manoeuvres or at excessive speed. The trailer's pendulum movements are passed on to the towing vehicle. Depending on the intensity of the pendulum movement and the mass of the trailer, yaw rates and lateral accelerations occur at the towing vehicle; in turn, these affect the trailer. This interaction between the towing vehicle and trailer may increase to such an extent that the entire vehicle/trailer combination begins to skid.



The vehicle/trailer stabilisation system is an extension of the ESP regulation system's software, which overcomes this danger. The vehicle/trailer combination is initially stabilised via brake intervention on alternating sides of the towing vehicle. If this is not sufficient, all four of the towing vehicle's and the trailer's wheels are braked via the trailer's inertia brake for stabilisation purposes.



The vehicle/trailer stabilisation system does not require any additional sensors, as it is a pure extension of the ESP function's software. It makes use of the ESP regulation system's components.

The following prerequisites must be met for the vehicle/trailer stabilisation system to intervene:

- ESP must be activated and its software enabled.
- The vehicle/trailer combination must have reached a minimum speed.
- In certain vehicle models, the ABS/ESP control unit detects the trailer via the occupation of the trailer socket. The ESP function receives the information regarding whether a trailer is coupled to the towing vehicle from the trailer detector control unit via the CAN data bus.

If these prerequisites are met, the corresponding control curve for the vehicle/trailer stabilisation system is active in the ABS/ESP control unit.

### How it works

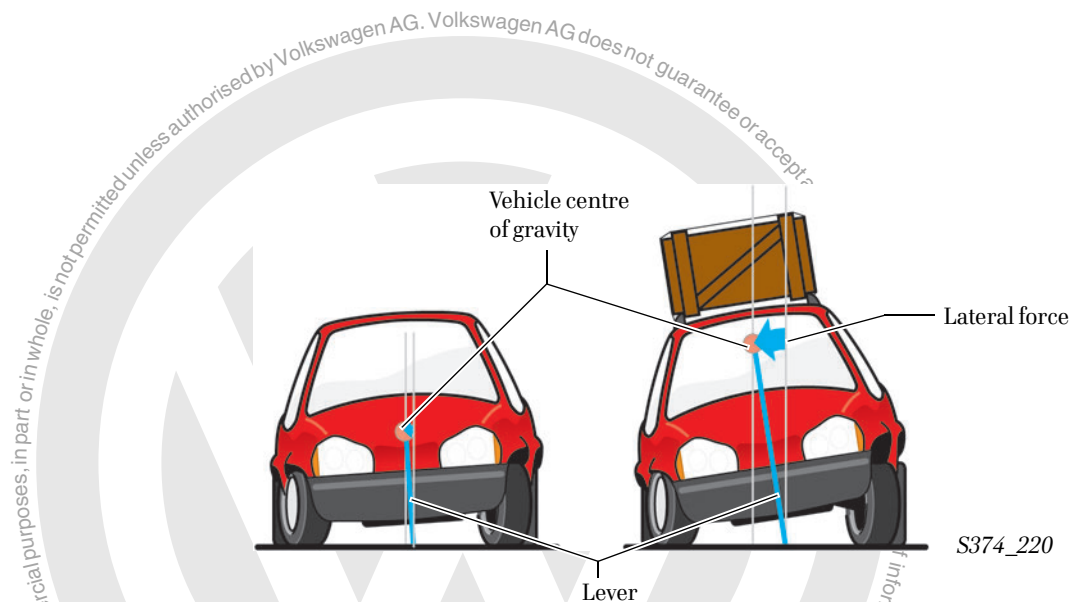
The trailer's pendulum movement leads to the occurrence of yaw rates and transverse accelerations at the towing vehicle. These are registered by the ESP sensors and forwarded to the ABS/ESP control unit. The incoming values (wheel speed, yaw rate, transverse acceleration, steering angle, brake actuation) are compared with the nominal curve stored in the control unit. If defined limit values are exceeded, the vehicle/trailer stabilisation system intervenes.

To improve vibration damping and to compensate the yaw rates (yawing moments) which occur, the front axle is braked on alternating sides. In this way, ESP ensures that the pendulum movement is unable to increase and that the vehicle or trailer axles are unable to lock up. If this is not sufficient, all four wheels are braked by building up brake pressure until the trailer no longer swings. During brake intervention, the brake lights light up to warn traffic following on from behind. The driver is informed of intervention by the ESP warning lamp's lighting up.

# Auxiliary ESP functions

## Roll-Over Prevention

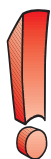
Roll-Over Prevention ROP is also called Roll-Over Programme. It is intended to respond at an early stage to forces and torques which may lead to the vehicle's rolling or tipping over. The ROP system is also a pure extension of the ESP control system's software.



On rapid cornering, torque occurs around the vehicle's longitudinal axis (tilting movement) due to the body's mass inertia and the tyres' frictional adhesion. This can be easily observed by anyone e.g. following a vehicle with a van body through a curve. Depending on the speed, mass and height of the van, the vehicle body inclines in the outer direction of the curve. As the tyres have sufficient frictional adhesion, this results in a lever, whose pivot point is the location in which the tyres and road come into contact.

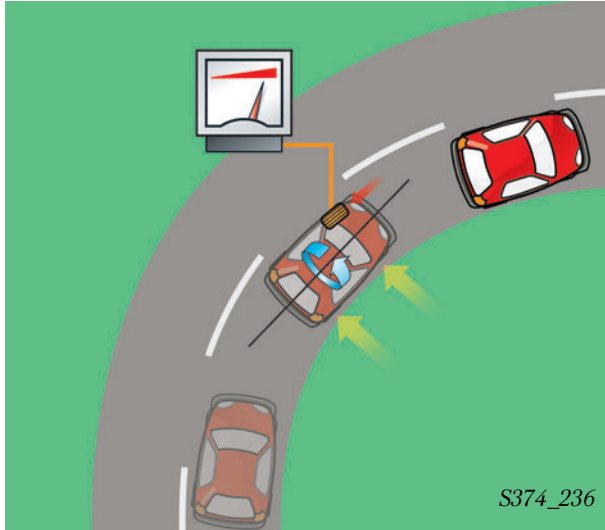
The length of the lever is determined by the position of the vehicle's centre of gravity. The higher the centre of gravity, the longer the lever. If the centre of gravity is particularly high, a small lateral force acting on this lever may be sufficient to lead to the vehicle's tipping over.

This should be prevented in its initial stages by the roll-over prevention system. To achieve this, the system uses the ESP regulation system's sensors.



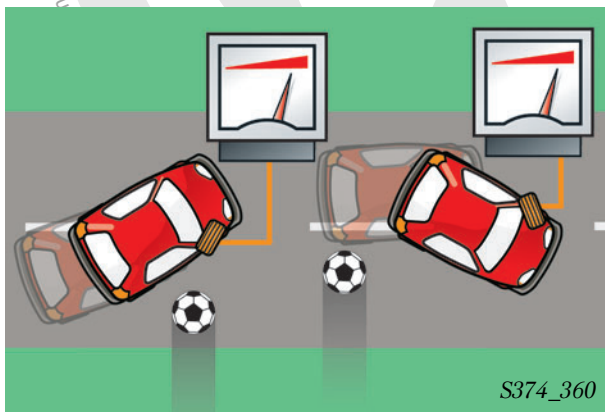
ROP is designed specifically for vehicles with a high centre of gravity, e.g. off-road vehicles or vans.

### Steady-state cornering



To stabilise the vehicle, the outer front wheel is specifically braked via ROP intervention.

### Dynamic swerving manoeuvre



The risk of tipping-over during dynamic swerving manoeuvres on road surfaces with good frictional adhesion is high for almost all vehicles. This manoeuvre is recognised and, although the vehicle is not yet skidding, very high pressure is built up very rapidly at the relevant, outer front wheel.

### How it works

In the example with the van, transverse or lateral forces, which lead to torque around the vehicle's longitudinal axis, occur on rapid cornering. The transverse forces lead to a risk of the vehicle's tipping over. This behaviour is registered by the ESP sensor unit and the information is forwarded to the ESP regulation system. The roll-over prevention system ROP contains stored maps, which enable the ESP regulation system, by comparing the incoming information with these maps, to decide whether the vehicle is in danger of tipping over. As the risk of tipping rises as the load increases, the ROP regulation thresholds are influenced depending on the calculated mass of the vehicle in the case of certain vehicles.

If such a risk is detected, roll-over prevention control intervention takes place. The vehicle is stabilised by reducing its transverse acceleration. The ESP regulation system specifically brakes the outer front wheel. By actuating the return flow pump and, if available, the active brake servo, the necessary brake pressure can rapidly be built up at the wheel. The drive torque is additionally reduced. This leads to the occurrence of a yaw rate which combats the outwards-oriented transverse forces. This prevents the movement from increasing and leading to the vehicle's tipping-over.

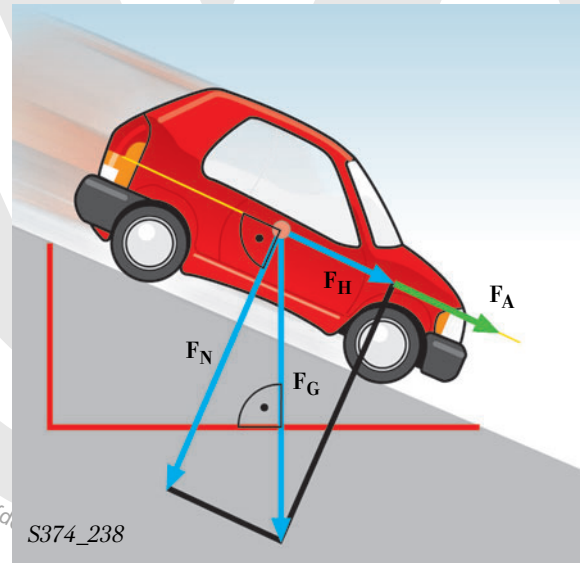
Under certain circumstances, the driver may perceive this regulation, although he has not yet noticed any critical driving situation. During roll-over prevention regulation, the ESP warning lamp flashes.

# Assist systems

Assist functions or systems have the task of supporting the driver in specific manoeuvres or driving situations. Ride comfort and vehicle safety are increased in this way. The systems do not usually intervene only in the event of critical situations, but are permanently active and can be deactivated if necessary.

## Hill descent assist system

The hill descent assist system, also called Hill Descent Control HDC, supports the driver on hilly roads. On descending a hill, the gradient which, in accordance with the force parallelogram, results from the weight pressure, also acts on a mass on an inclined plane. If the mass has a separate drive power, which acts downslope, the gradient is added to this drive power. The acceleration of this mass, which results from the sum of both forces, therefore increases constantly. The result is that the longer a vehicle drives downslope, the faster it becomes in this situation.

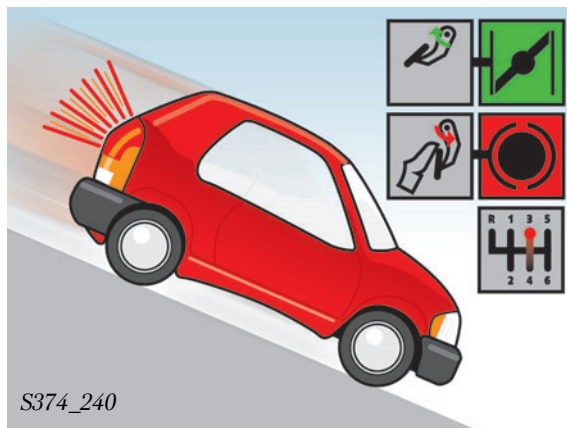


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### Legend

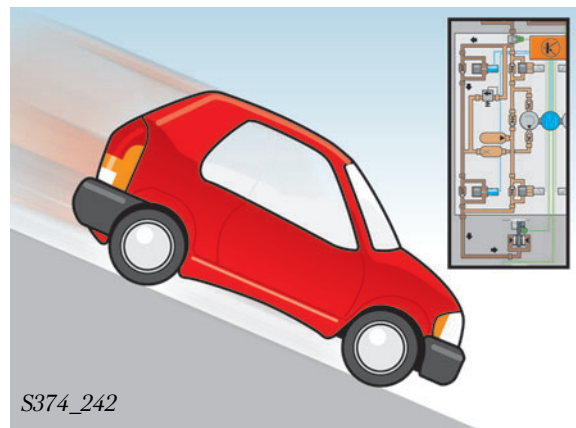
$F_A$  - drive power  
 $F_G$  - weight pressure

$F_H$  - gradient  
 $F_N$  - normal force



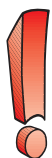
S374\_240

A driver in a vehicle without hill descent assist system must therefore brake manually, shift to a lower gear and release the accelerator in order to maintain a constant vehicle speed.



S374\_242

A vehicle with hill descent assist system relieves the driver of this manual intervention and ensures that the desired speed is also maintained whilst descending the hill.



The above described function will be implemented in the Tiguan for the first time.

## How it works

The hill descent assist system intervenes when the following conditions are met:

- Speed less than 20 km/h
- Gradient greater than 20 %
- Engine running
- Accelerator and brake pedal not actuated

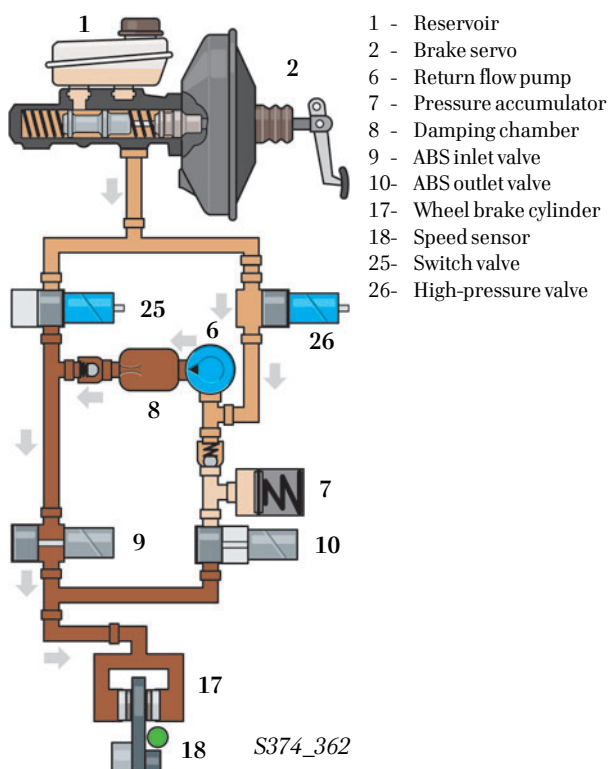
If the trigger conditions are met and the hill descent assist system ascertains, based on the signals from the accelerator, the engine speed and the speed sensors, that the vehicle speed is increasing, the assist system assumes that the vehicle is driving downhill and that brake intervention is necessary. The system operates at a speed which is slightly higher than walking speed.

The vehicle speed, which is to be maintained via brake intervention by the hill descent assist system at all four wheels, depends on the speed at which the gradient is approached and the engaged gear.

The hill descent assist system then starts the return flow pump. The high-pressure valves and the ABS inlet valves are opened, whilst the ABS outlet valves and the switch valves are closed. Brake pressure is now built up in the wheel brake cylinders and the vehicle is braked.

When the vehicle has been braked to the vehicle speed which is to be maintained, the hill descent assist system ends brake intervention and reduces the brake pressure again. If the vehicle speed then increases again without the accelerator's having been actuated, the hill descent assist system starts up again, as it assumes that hill descent is continuing.

In this way, the vehicle is kept within a safe speed range, which is easier to control by the driver.



# Assist systems

## Hill start assist system

If a vehicle stops on a hill, the vehicle's weight pressure does not act on a horizontal surface, but on an inclined plane. In accordance with the force parallelogram, the weight pressure results in a gradient, which allows the vehicle to roll downhill when the brake is released. If the vehicle starts off again uphill, the gradient first has to be overcome. If the driver accelerates too little or releases the brake pedal or the hand brake too early, the drive power is not sufficient to overcome the grade resistance. The vehicle rolls backwards on starting off. The hill start assist system, also referred to as Hill Hold Control HHC, is available to relieve the driver in this situation.

### How it works

The hill start assist system facilitates starting off on a hill without the need to use the hand brake for assistance. To do this, the function delays brake pressure build-up at the wheel brake cylinders on starting off.

The hill start assist system is based on the ESP system. The ESP sensor unit G419 is supplemented by a longitudinal acceleration sensor, which informs the system of the vehicle's position. The hill start assist system is activated under the following conditions:

- The vehicle is stationary. (Information from speed sensors)
- The gradient is greater than approx. 5%. (Information from ESP sensor unit G419)
- The driver door is closed. (Information from convenience control unit, model-dependent)
- The engine is running. (Information from engine control unit)
- Actuation of the foot-operated parking brake (Touareg)

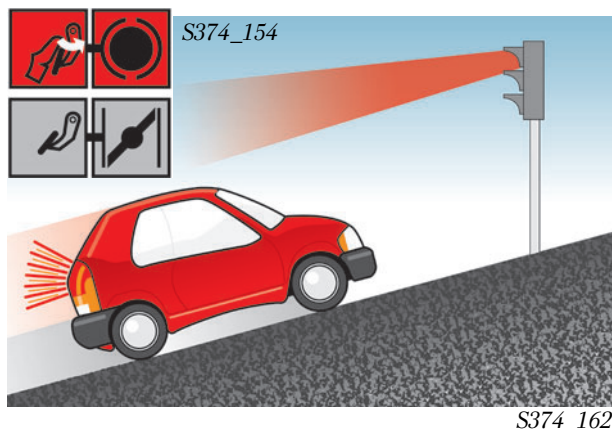
The hill start assist system always operates in the direction of starting uphill. Reverse uphill starting is also supported by the HCC function via detection of the fact that reverse gear has been engaged.

This prevents the vehicle from rolling backwards before sufficient drive power is available for starting off on the hill.

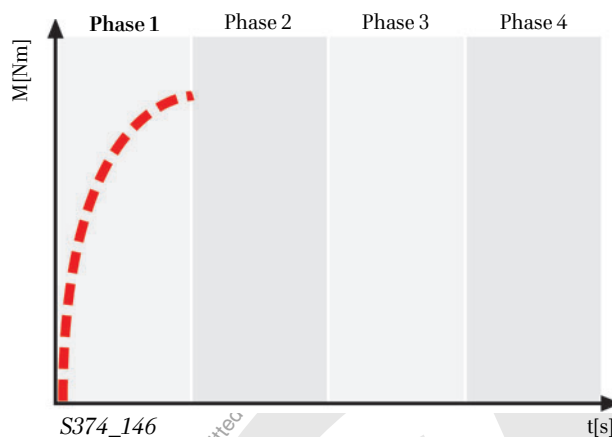
The hill start assist system's function can be described in four phases.



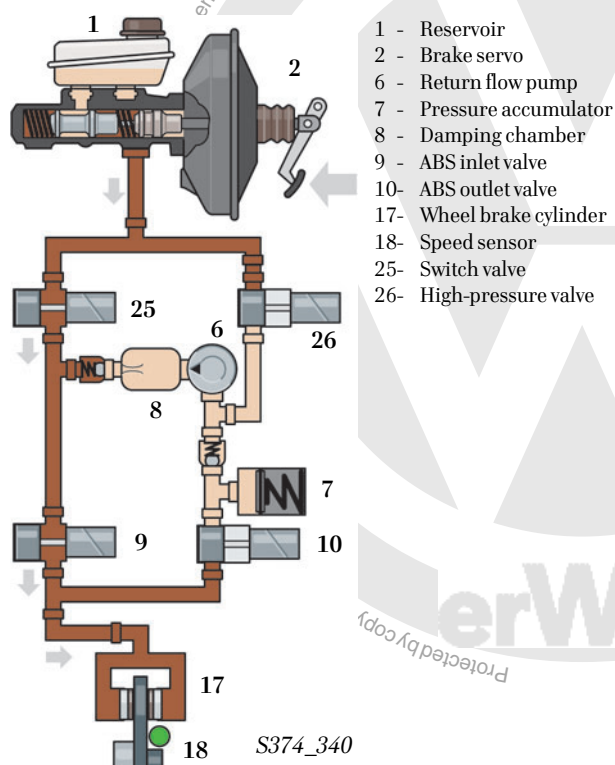
## Phase 1 - build up pressure



The driver stops and holds the vehicle by actuating the brake.



The braking torque is sufficient to hold the vehicle on the slope.

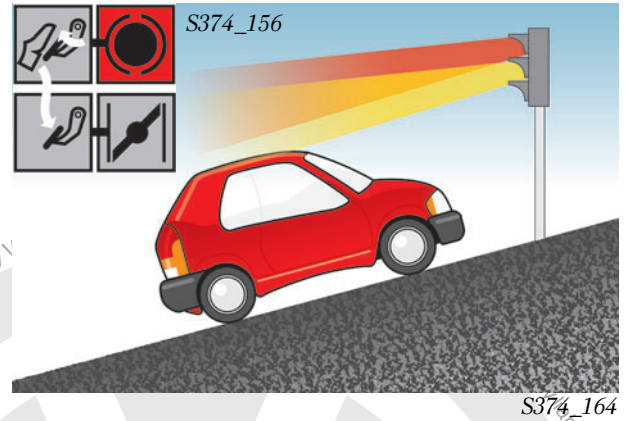


The brake pedal is actuated. The switch valve is opened and the high-pressure valve closed. Via the opened inlet valve, pressure can be built up at the wheel brake. The outlet valve is closed.

# Assist systems

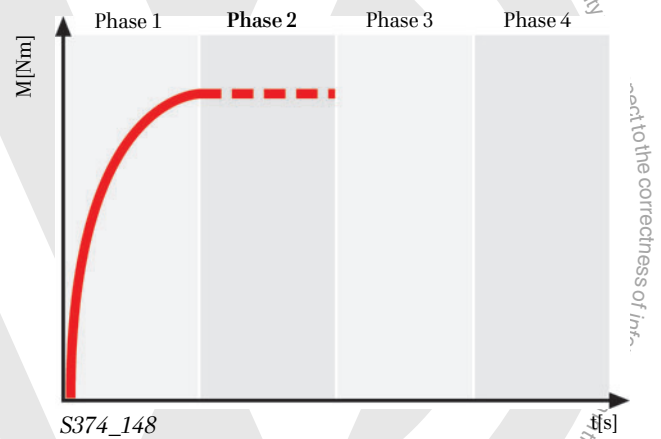
## Phase 2 – maintain pressure

The vehicle is stationary. The driver removes his foot from the brake in order to actuate the accelerator.

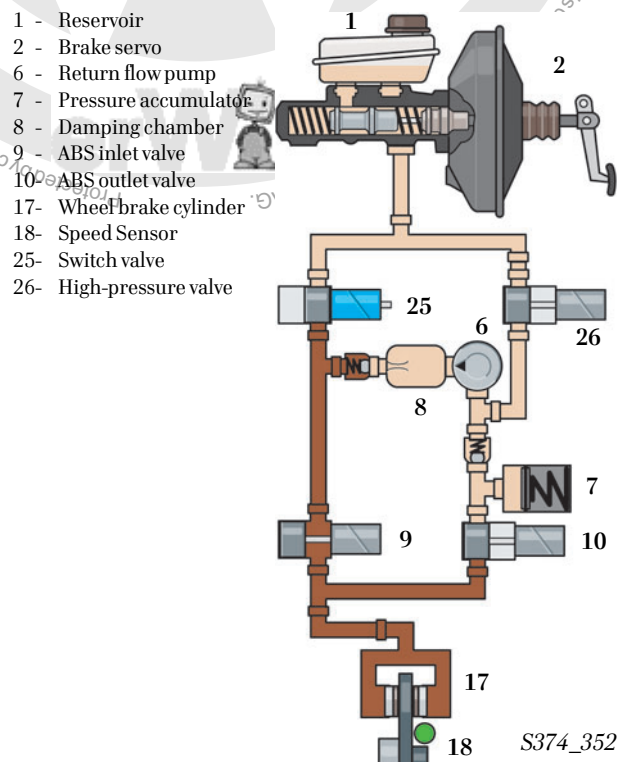


The hill start assist system keeps the brake pressure at the wheel brake cylinders constant for approx. 2 seconds to prevent it from rolling backwards.

Braking torque — red line  
Drive torque — green line

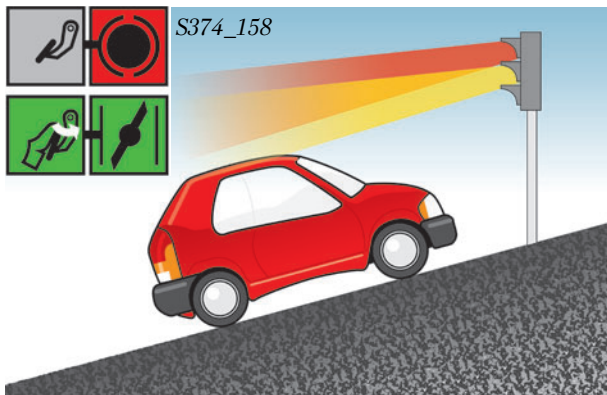


The brake pedal is no longer actuated. The switch valve is closed. The pressure is maintained at the wheel brake. This prevents premature pressure reduction.

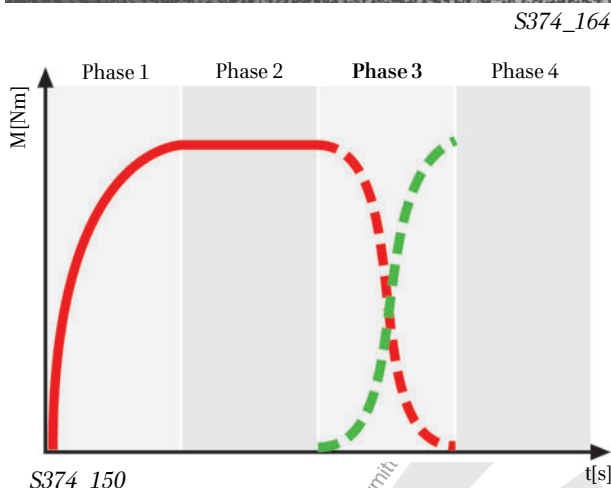


S374\_352

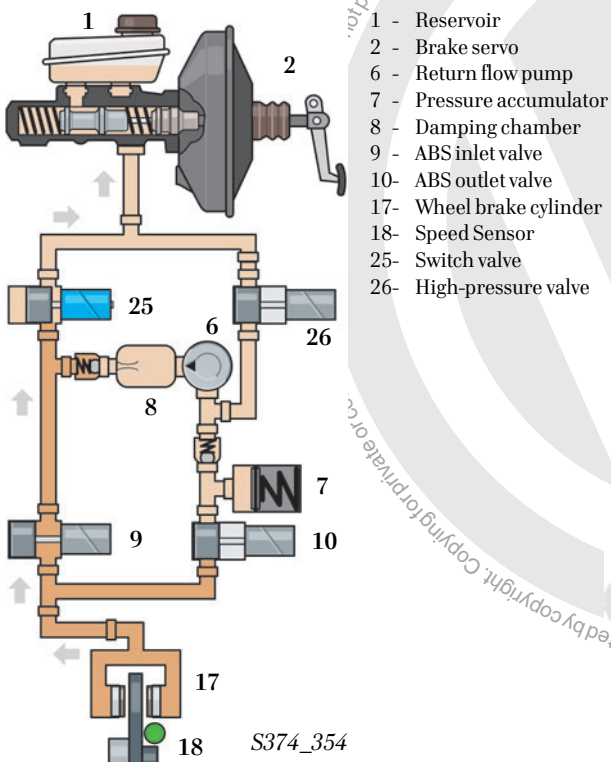
### Phase 3 – relieve pressure



The vehicle is still stationary. The driver actuates the accelerator pedal.



Whilst the driver is increasing the drive torque, the hill start assist system HHC reduces the brake pressure just enough so that the vehicle does not roll backwards and is not restrained when subsequently starting off.

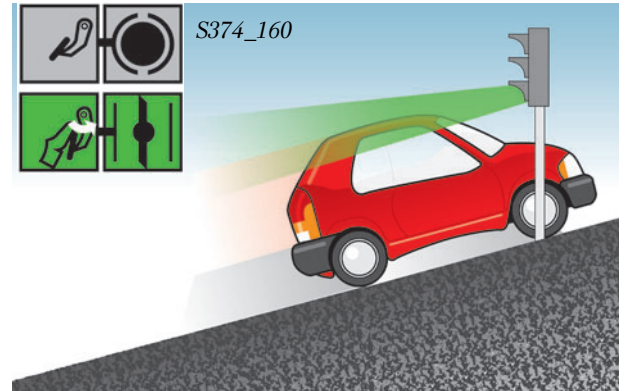


The switch valve is opened gradually. Due to the open inlet valve, pressure can be reduced at the wheel brake.

# Assist systems

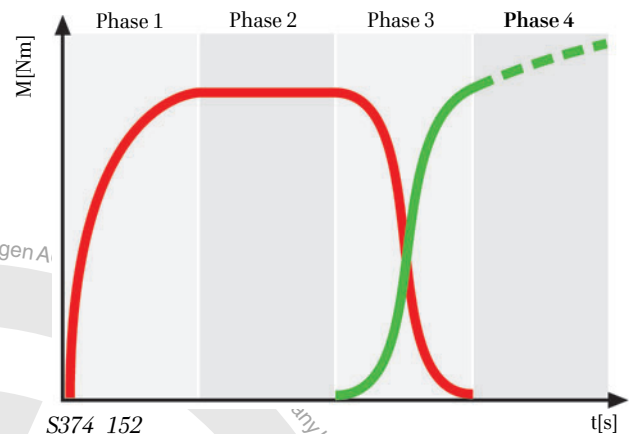
## Phase 4 – reduce pressure

The vehicle starts off.



S374\_166

The drive torque is sufficiently high to accelerate the vehicle forwards. The brake pressure has been reduced to zero by the hill start assist system. The vehicle starts off.

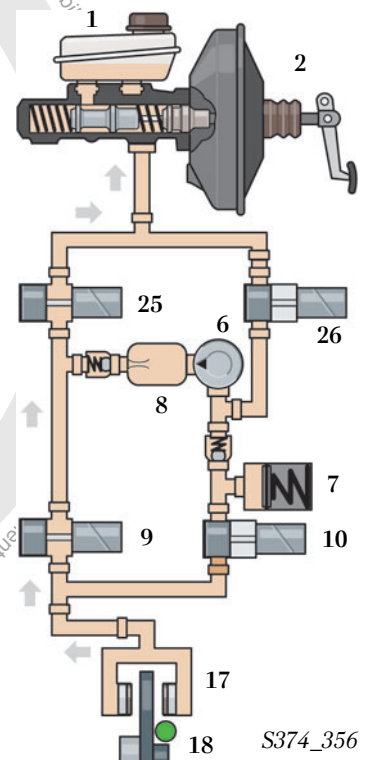


S374\_152

The switch valve is fully open.

There is no brake pressure at the wheel brake.

- 1 - Reservoir
- 2 - Brake servo
- 6 - Return flow pump
- 7 - Pressure accumulator
- 8 - Damping chamber
- 9 - ABS inlet valve
- 10 - ABS outlet valve
- 17 - Wheel brake cylinder
- 18 - Speed Sensor
- 25 - Switch valve
- 26 - High-pressure valve



S374\_356

## AUTO HOLD

AUTO HOLD supports drivers whose vehicles are fitted with an electromechanical parking brake instead of a mechanical hand brake. AUTO HOLD guarantees automatic and controlled holding of the vehicle when stationary, regardless of how the vehicle has come to a stop, and supports the driver on starting off (forwards or reverse travel). AUTO HOLD combines the following assist functions:



S374\_210

### Stop-and-go assist

When the vehicle is braked to a stop, the stop-and-go assist system automatically actuates the brakes. This offers additional driving comfort in stop-and-go traffic, as the driver no longer has to actuate the brake pedal to hold the stationary vehicle.



S374\_214

### Hill start assist

Automation of the holding and starting off process supports starting off on gradients. On starting off, the brake is released at the right point in time by the hill start assist system. Undesired rolling backwards is avoided.



S374\_212

### Automatic parking

If the vehicle is stopped with the AUTO HOLD function activated and the driver door or the driver's seat belt buckle is then opened or the ignition is switched off, the parking brake is automatically activated.

AUTO HOLD is also a pure extension of the ESP regulation system's software, and requires the vehicle to be equipped with ESP and an electromechanical parking brake.

# Assist systems

The following prerequisites must be met for the AUTO HOLD function to be activated:

- The driver door must be closed.
- The driver's seat belt buckle must be fastened.
- The engine must be started.
- AUTO HOLD must be activated by pressing the AUTO HOLD button. Activation is indicated by the warning lamp in the button lighting up.

If one of the prerequisites changes, AUTO HOLD shuts off. Each time the ignition is started again, it must be re-activated with the AUTO HOLD button.

## How it works

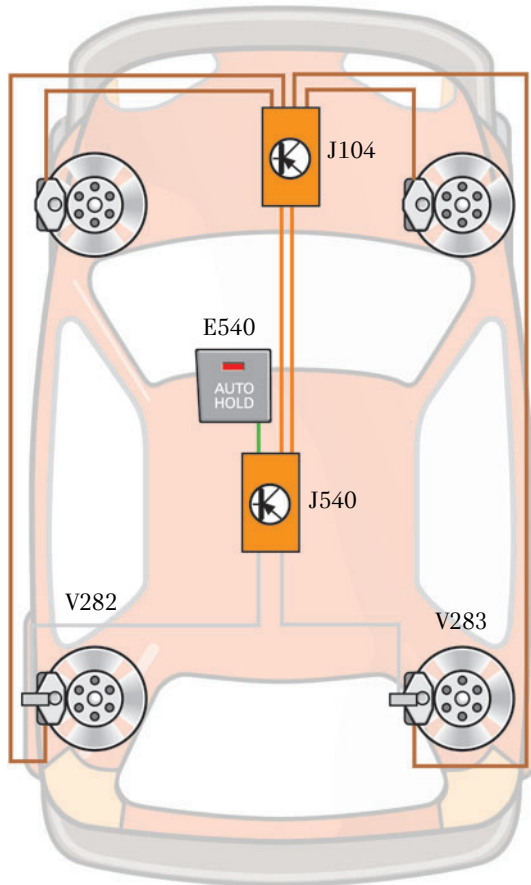
AUTO HOLD is switched on. Based on the wheel speed signals and the signal from the brake light switch, AUTO HOLD recognises that the vehicle is stationary and that the driver is actuating the brake pedal. This brake pressure is then "frozen" by blocking the valves in the hydraulic unit, and the driver no longer has to actuate the brake pedal. When the AUTO HOLD function is activated, the vehicle must therefore always be initially held via the four hydraulic wheel brakes when stationary.

If the driver does not actuate the brake pedal and the vehicle begins rolling again after standstill has been detected, the ESP system is activated. Hydraulic operation is carried out. This means that the brake pressure at the wheel brake cylinders is actively built up until the vehicle is stationary again. The pressure required for this is calculated and set by the ABS/ESP control unit depending on the gradient. To achieve this, the function actuates the return flow pump and opens the high-pressure valves and the ABS inlet valves; the ABS outlet valves and switch valves are or remain closed.

If the driver actuates the brake pedal in order to start off again, the ABS outlet valves are opened and the return flow pump reduces the brake pressure, via the open switch valves, in the direction of the reservoir. The vehicle's inclination uphill or downhill is taken into consideration in this case in order to prevent it from rolling backwards.

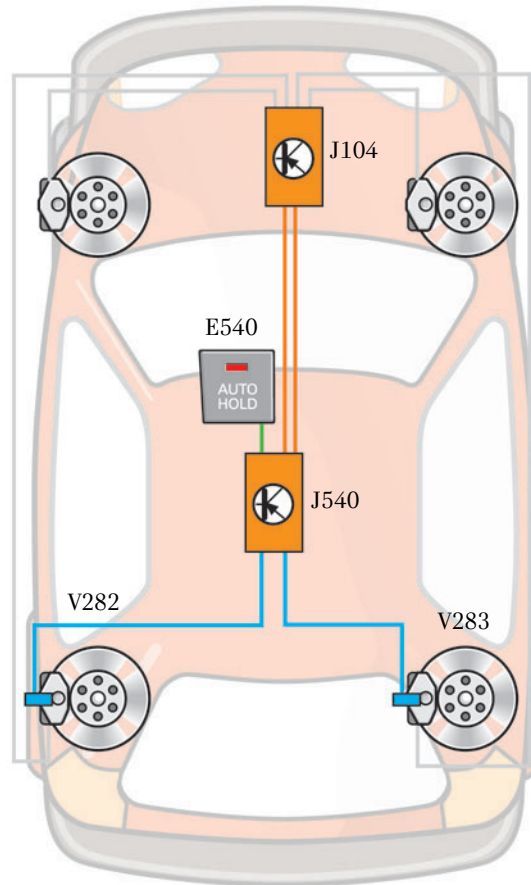


### Vehicle holding via the ESP hydraulic system



S374\_216

### Vehicle holding via the electromechanical parking brake



#### Legend

- E540 AUTO HOLD button
- J104 ABS control unit
- J540 Control unit for electromechanical parking brake
- V282 Left parking brake motor
- V283 Right parking brake motor

After holding the vehicle for three minutes, a switch from the ESP hydraulic system to the electromechanical parking brake takes place. The calculated holding torque is transferred from the ABS control unit to the electromechanical parking brake control unit. The two parking brake motors on the rear wheel brakes are actuated by the electromechanical parking brake control unit.

The brake is held electromechanically. The hydraulic brake pressure is automatically withdrawn. To do this, the ABS outlet valves are opened again and the return flow pump reduces the brake pressure, via the open switch valves, in the direction of the reservoir. The hydraulic unit's valves are therefore protected against overheating.

# Assist systems

## Dynamic starting assist system

The dynamic starting assist system DAR is also a special function for vehicles with an electromechanical parking brake. DAR facilitates starting off when the electromechanical parking brake is applied and when starting off on gradients.

The system prerequisites are an ESP system and the electromechanical parking brake. The function itself is stored as a software extension in the electromechanical parking brake control unit.

If the electromechanical parking brake is activated and the driver would like to start off, the electromechanical parking brake does not have to be deactivated via the electromechanical parking brake button. The dynamic starting assist system automatically releases the electromechanical parking brake when the following conditions are met:

- The driver door must be closed.
- The driver's seat belt buckle must be fastened.
- The engine must be started.
- The desire to start off must exist.

### Starting off with the parking brake actuated

When stopping at a traffic light e.g., the vehicle does not have to be held with the foot brake if the parking brake is actuated. As soon as the accelerator is actuated, the parking brake is automatically released and the vehicle is set in motion.



S374\_210

### Starting off on gradients

On inclines, e.g. the driver is relieved of having to gradually release the parking brake, simultaneously operate the clutch and accelerator and pull out into moving traffic. Undesired rolling backwards is prevented, as the parking brake is only released when the vehicle's drive torque is greater than the hill output torque calculated by the control unit.



S374\_214

## How it works

The vehicle is stationary. The electromechanical parking brake is activated. The driver would like to start off, engages 1st gear and actuates the accelerator.

The dynamic starting assist system checks all input signals which are important for the release time point of the electromechanical parking brake:

- The inclination angle (determined by the longitudinal acceleration sender),
- The engine torque,
- The accelerator pedal position,
- The clutch pedal position (in vehicles with manual gearbox, the clutch position sender signal is evaluated. In vehicles with automatic gearbox, the current gear selection is read instead of the clutch pedal position),
- The desired driving direction (in the automatic gearbox, this is determined via the selected driving direction and via the reversing light switch in the case of the manual gearbox)

These input signals are used by the electromechanical parking brake control unit to calculate the hill output torque and the optimal point in time for releasing the electromechanical parking brake without the vehicle's unintentionally rolling backwards on gradients.

If the vehicle's drive torque is greater than the hill output torque calculated by the electromechanical parking brake control unit, the two parking brake motors on the rear wheel brakes are actuated by the control unit.

The parking brake on the rear wheels is electromechanically released. The vehicle starts off without rolling backwards.

The dynamic starting assist system does not access the hydraulic brake system, but only makes use of the sensor information made available via the ESP system, to carry out its task.



# Assist systems

## Brake disk dry braking

In the past, brake disk dry braking BSW was also referred to as brake disk wiper or Rain Brake Support RBS.

In wet weather, a thin film of water may form on the brake disks. Due to this film of water, the braking effect is delayed, because the brake pads initially slip on the film of water until the water evaporates due to the brakes heating up or has been wiped "dry" on the brake pad. Only then can the full braking effect be achieved.

When braking in critical situations, each fraction of a second is valuable. The brake disk dry braking assist system has therefore been developed to reduce this braking effect delay when driving in wet weather. Brake disk dry braking BSW ensures that the front wheel brake disks are dry and clean. This is achieved by briefly and gently applying the brake pads onto the brake disks. The full braking effect is therefore available faster and the stopping distance can be reduced.

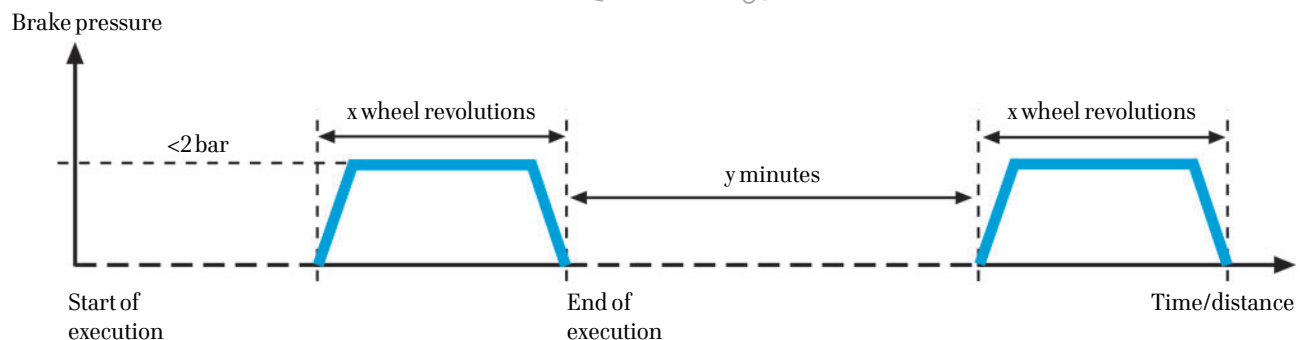
The prerequisite for equipping the vehicle with brake disk dry braking is the presence of ESP in the vehicle. The activation conditions for brake disk dry braking are:

- A vehicle speed of at least 70 km/h and
- Windscreen wiper actuation.

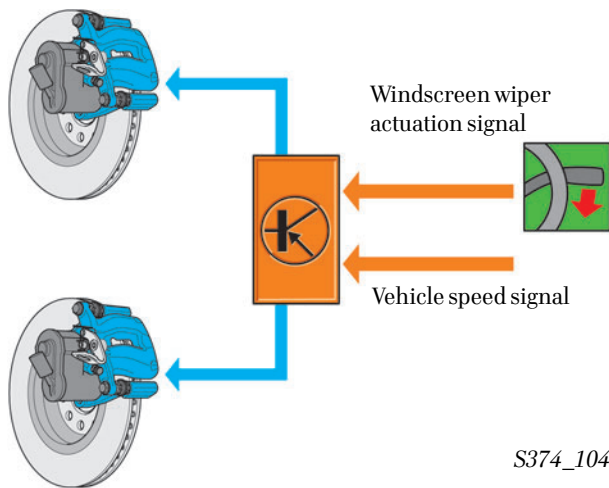
If these activation prerequisites are met, the front wheel brake pads are applied onto the brake disks for a specific period of time at specific intervals throughout continuous or intermittent windscreen wiper operation. The maximum brake pressure in this case is 2 bar.

During one-touch wiping, the braking process only takes place once per actuation.

The slight brake intervention caused by brake disk dry braking is not perceptible to the driver.



S374\_108



Pressure build-up at the front wheels

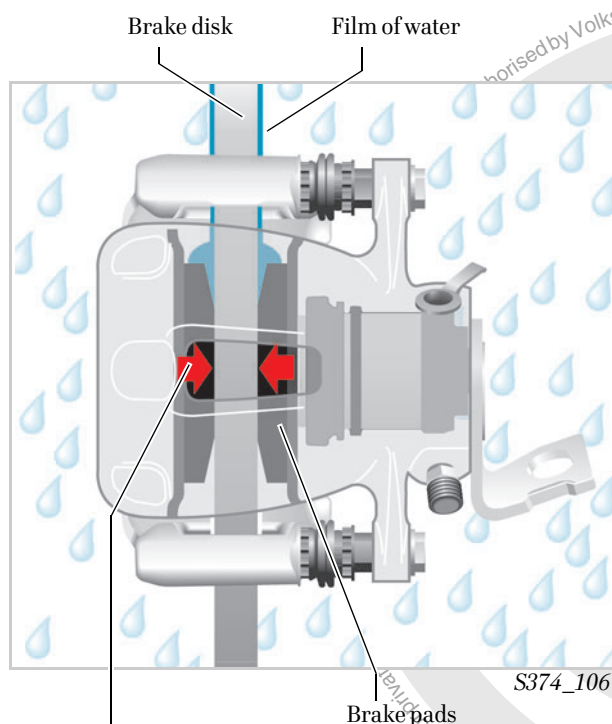
S374\_104

## How it works

Via the CAN data bus, the ABS/ESP control unit receives the information that the speed signal is  $> 70 \text{ km/h}$ . The function additionally requires the signal from the windscreen wiper motor. From this, the brake disk dry braking function concludes that it is raining, and that a delay in braking must be anticipated due to the film of water on the brake disks. The brake disk dry braking function then starts the braking cycle. The valves for filling the front wheel brake cylinders are actuated. The return flow pump begins working and builds-up approx 2 bar for approx. x revolutions.

During this process, the brake pressure is monitored continuously. If the brake pressure in the system exceeds a threshold value, which is stored in a map, the regulation system immediately reduces the brake pressure again to prevent any perceptible braking effect.

If the brake is manually actuated by the driver, the current cycle is aborted and then starts again from the beginning.



S374\_106

Brief application of the brake pads onto the brake disks

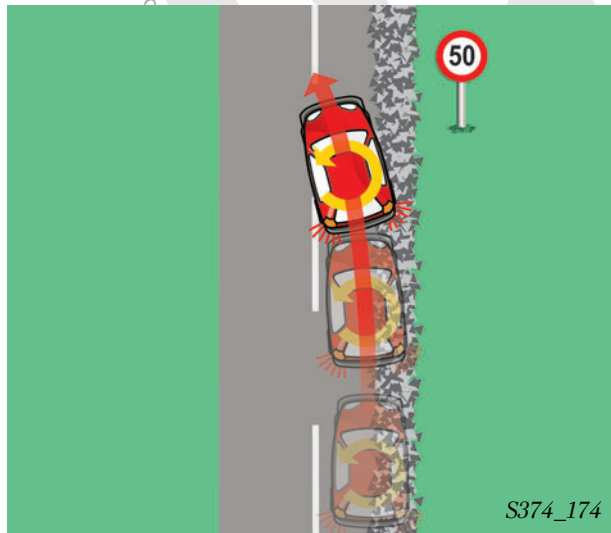
# Assist systems

## Countersteering support

Countersteering support, also referred to as Driver-Steering Recommendation DSR, is a supplementary safety function in the ESP system. This assist system makes it easier for the driver to stabilise the vehicle in critical situations (e.g. when braking on road surfaces with different levels of grip or during transverse dynamic driving manoeuvres).

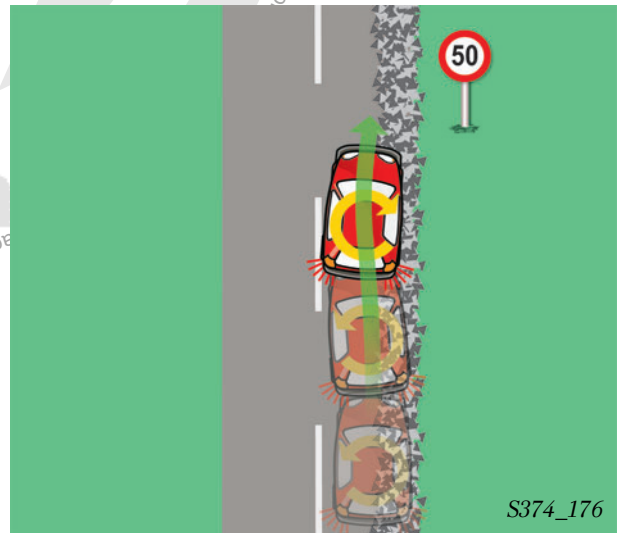
Let us also analyse a driving situation for this function: A vehicle brakes on a road surface, on one side of which winter damage has been filled in with loose gravel. The road surface's different levels of grip lead to transverse forces and yaw rates on braking; these have to be compensated by means of countersteering so that the vehicle remains on course.

Vehicle without countersteering support



In a vehicle without countersteering support, the time and extent of countersteering support are determined solely by the driver. In the case of inexperienced drivers, this may lead to excessive steering movements, which may result in an unstable driving situation.

Vehicle with countersteering support



In a vehicle with countersteering support, correspondingly targeted steering forces are applied via the power steering system to support the driver in countersteering. As a result of this, the stopping distance is reduced, there is less deviation from the course and the vehicle's stability is increased.

The system prerequisites are:

- An ESP system and
- Electromechanical power steering.



The countersteering support system is also effective in oversteering situations.



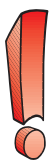
## How it works

In the driving situation example, the pressure difference between the left and right front wheels during ABS regulation is determined. Further data are also registered via a slip detection system. The assist system uses these data to calculate the extent of the steering torque required to support the driver during the evasive steering movement. As a result, ESP intervention is reduced or suppressed.

According to this data, the ABS/ESP control unit instructs the power steering control unit to actuate the electromechanical power steering motor. The supporting steering torque required by the electromechanical power steering is implemented in the correct countersteering direction. The incorrect countersteering direction is not supported and the steering torque is therefore impeded. This support is provided as long as it is requested by the ABS/ESP control unit in order to stabilise the vehicle and the stopping distance can be reduced as a result.

This ESP warning lamp is not actuated; this only occurs if ESP intervenes. Countersteering support takes place prior to ESP regulation.

The countersteering support assist system does not therefore actively intervene in the hydraulic brake system, but merely uses the ESP system's sensors to obtain the necessary information. Active support is then carried out via communication with the electromechanical power steering.



Countersteering support in the ESP system merely provides the driver with support in critical situations. The vehicle is unable to steer itself with this function!



# Assist systems

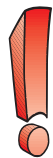
## Adaptive Cruise Control

Studies have shown that maintaining distance stresses and fatigues drivers, particularly on long journeys. Automatic proximity control, also referred to as Adaptive Cruise Control ACC, is a driver assist system for enhancing comfort. It relieves the driver when driving and therefore helps to increase road safety.

The adaptive cruise control system is an extension of the conventional cruise control system (CCS). Like CCS, the adaptive cruise control system regulates the vehicle's speed to a value previously set by the driver.

The adaptive cruise control system additionally ensures that a distance, which can be selected by the driver, from a preceding vehicle is maintained. In this case, the speed of the vehicle is adapted to the speed of any preceding vehicle.

The distance and speed of a preceding vehicle are determined by the control unit for proximity control. Only objects moving in the same direction are used for calculation purposes.



No emergency braking is introduced, e.g. at the end of a traffic jam.

### How it works

#### Constant speed

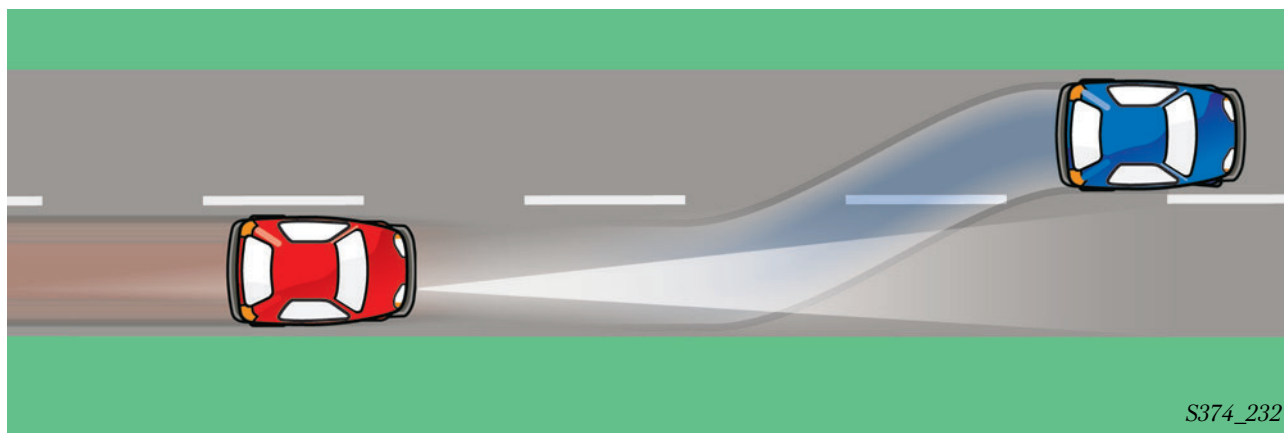


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No vehicle is located in the proximity control sender's field of vision.

The vehicle's set, desired speed is maintained.

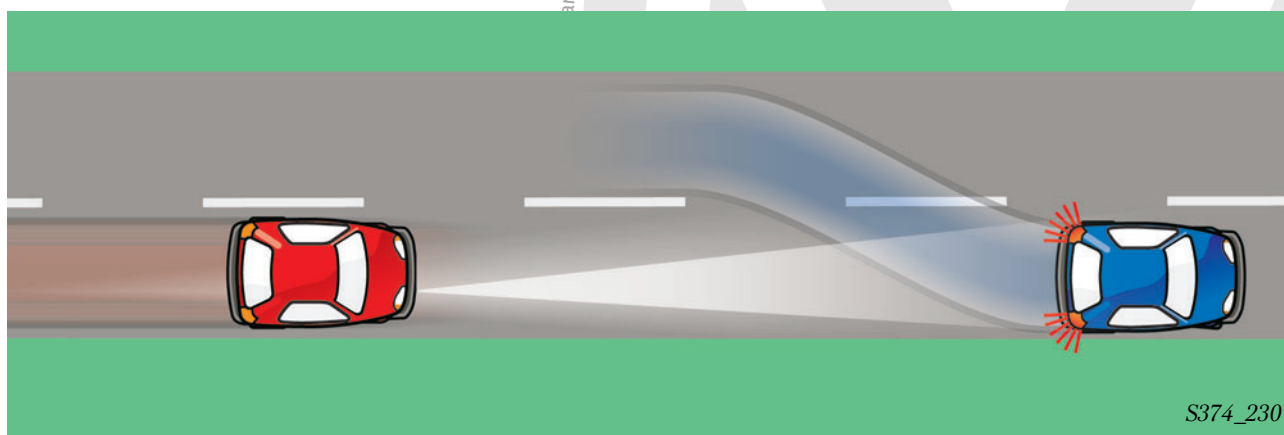
## Acceleration



The distance becomes greater than the desired distance, because the preceding vehicle accelerates or clears the way by changing lanes.

The vehicle with ACC is accelerated to the pre-selected desired speed again.

## Deceleration



If the distance becomes less than the desired distance, because the preceding vehicle brakes or a slower vehicle moves in front by changing lanes, the vehicle is braked to the pre-selected desired distance. This deceleration may take place via intervention in the engine management system. If deceleration via the engine torque is not sufficient, brake intervention takes place.

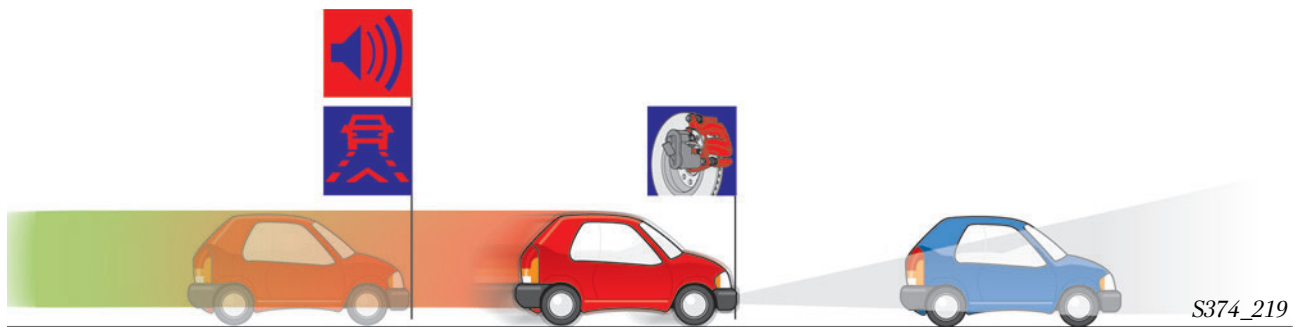
The systems fitted in the Touareg can brake the vehicle to a standstill if the traffic situation necessitates.

Brake intervention is implemented via the hydraulic unit with return flow pump. In the hydraulic unit, the switch valve is closed and the high-pressure valve is opened. The return flow pump is actuated and begins pumping. As a result of this, the pressure at the wheel brake is built up.

# Assist systems

## Front assist system

The front assist system is an assist system with a warning function, and serves to prevent rear-end collisions. Stopping distance reduction AWW1 and stopping distance reduction AWW2 form part of the front assist system. When a preceding vehicle is approached in a hazardous manner, the front assist system has two action time points, the preliminary warning and the main warning.



**Main warning**  
AWV2: Warning jolt  
AWV1: HBA changeover "maximum sensitivity"

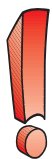
**Preliminary warning**  
AWV2: Optical/acoustic warning  
AWV1: Prefill  
AWV1: HBA changeover "increased sensitivity"

### Preliminary warning

In the event of the preliminary warning, a warning symbol first appears in the dash panel insert (optionally, an acoustic signal is sounded). At the same time, the brake system is pre-filled (Prefill) and the hydraulic brake assist system (HBA) is switched to "increased sensitivity".

### Main warning

If the driver does not react, a brief warning jolt is output. At the same time, the brake assist system is switched to "maximum sensitivity".



Stopping distance reduction does not take place at a vehicle speed of less than 30 km/h.

## Stopping distance reduction AWC1

Switching from the accelerator to the brake pedal takes a little time, as does pressure build-up in the hydraulic brake system. In emergencies, however, fractions of a second are vital. Stopping distance reduction AWC1 prepares the vehicle for imminent emergency braking by the driver. This is carried out by:

- Pre-filling the brakes (Prefill)
- Switching the hydraulic brake assist system (HBA)

### Prefill

The four wheel brakes are pre-filled to achieve faster brake response in the event of emergency braking by the driver. This process is also referred to as Prefill, and means that the air gap between the brake disk and the brake shoe is reduced. The pads are therefore gently applied onto the brake disk without the driver's noticing. If the control unit for proximity control reports a very rapid reduction in the safety distance from the preceding vehicle, Prefill causes slight pressure build-up in the system.

This brake pressure acts for a maximum of 5 seconds and is approx. 2 bar. If the brake pedal is then actually actuated, the system responds to the first brake pulse without delay and with full pressure. If not, the brake pressure is reduced again.

### HBA changeover

To build up braking power faster if there is a risk of a collision, the hydraulic brake assist system's sensitivity is switched in 2 stages. The hydraulic brake assist system observes the brake pedal and intensifies vehicle deceleration if an emergency braking command is detected. On approaching a preceding vehicle in a hazardous manner, the trigger threshold is lowered in order to reduce the stopping distance.

Switching to "increased sensitivity" is carried out at the same point in time as the optical/acoustic warning. Switching to "maximum sensitivity" is carried out at the same point in time as the brake jolt (warning jolt).

The sensitivity is switched for a maximum of 5 seconds.

## Stopping distance reduction AWW2

Stopping distance reduction 2 actively warns the driver of an impending rear-end collision. The distance from and speed of a preceding vehicle are monitored by the control unit for proximity control. If the preceding vehicle is approached too closely, the system informs the driver in two stages, if the driver fails to respond to the behaviour of the preceding vehicle within a specific time:

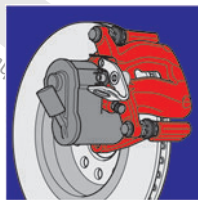
- Optical/acoustic warning
- Short brake jolt



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1. The first warning takes place via the simultaneous activation of an optical and acoustic signal. A warning symbol appears in the dash panel insert as the optical signal. The acoustic signal is a warning buzzer (optional).
2. If the driver does not defuse the situation, the second warning is output. Brake pressure is temporarily built up. The ABS/ESP control unit receives a braking request from the control unit for cruise control via the CAN data bus and actuates either the active brake servo or the return flow pump in the hydraulic unit. Braking is temporarily carried out. Due to the brake jolt, the driver's attention is drawn to the risk of a collision. However, the jolt does not reduce the vehicle speed.



## Vehicle models and their traction control systems

Vehicle model	Year	SSP No.	Brake equipment	Special features
Passat Variant syncro	1984	65	ABS	Control unit and hydraulic unit are separate components, Bosch 2S
Golf	1986	81	ABS	Teves, control unit and hydraulic unit are separate components, Mark 2
Volkswagen Transporter	1987	86	ABS	Bosch, control unit and hydraulic unit are separate components, Bosch 2S
Golf	1989	117	ABS with EDL	Mark 2 for left-hand drive; Mark 4 for right-hand drive
Golf model 92	1991	140	ABS with EDL	Control unit and hydraulic unit are separate components, Mark 4
LT	1993	158	ABS	Control unit and hydraulic unit are separate components, Bosch 2S or 2E
VW Sharan		169	ABS with EBD, EDL	04GI from ITT Teves
Polo model 1995	1995	166/171	ABS with EBD, EDL	Teves 20GI with electronic differential lock, hydraulic unit and control unit form one unit.
Caddy	1995	179	ABS with EBD, EDL	Mark 20GI as optional equipment
Volkswagen CADDY pick-up	1996	184	ABS	Mark 20GI as optional equipment
LT '97	1996	188	ABS with EBD and EDL	5th generation from Bosch Control unit and hydraulic unit are bolted together.
Passat	1997	191/192	ABS	Bosch 5.3 Control unit and hydraulic unit are bolted together.
Golf 98	1997	200	ABS with EBD, EDL, EBC	Mark 20 IE
Lupo	1997	201	ABS with EBD, ESBS (CBC)	ITT Mark 20 IE
New Beetle	1998	211	ABS/ESP	ITT Automotive
Lupo 3L	1999	218	ABS with EBD, ESBS (CBC), EBC	Teves Mark 30
Passat 2001	2000	251	ABS with ESP	Bosch 5.3

# Annex

Vehicle model	Year	SSP No.	Brake equipment	Special features
New Beetle RSi	2001	258	ABS with ESP	ITT Mark 20 IE
Passat W8		261	ABS with ESP, hydraulic BA	Bosch 5.7, hydraulic unit and control unit form one unit, pressure sensor in hydraulic unit, with two-stage return flow pump
Polo 2002	2001	263	ABS ESP	ABS MK60 Conti-Teves as standard ESP Bosch 5.7 optional
Phaeton	2002	277	ABS with ESP	5.7 from Bosch
Touareg	2002	302	ABS/ESP with BA, EDL, TCS, EBC, HSA	MK25 from Conti-Teves MK25 E1 as of 2007
Touran	2003	306	ABS/EDL/ESP, hydraulic BA	MK60 from Conti-Teves Pressure sensor in hydraulic unit
Transporter 2004	2003	310	ABS, EDL, TCS, EBD ESP optional	MK25 from Conti-Teves
Golf 2004	2003	321	ABS ESP	MK70 from Conti-Teves MK60 from Conti-Teves
Caddy	2004	328	ABS with EBD, TCS, EBC ESP with BA	MK70 from Conti-Teves MK60 from Conti-Teves
Golf Plus	2005	338	ESP	MK60 from Conti-Teves
Passat 2006	2005	339	ABS/ESP with HBS, BA, TSA, RBS, EPB, DAR, AUTO HOLD optional	EBC 440 from TRW (Thompson-Ramo-Wooldridge)
Fox 2006	2005	349	ABS ESP optional	8.0 from Bosch
Jetta 2006	2005	354	ESP	MK60 from Conti-Teves
EOS 2006	2006	355	ESP with BA	MK60 from Conti-Teves
Passat Estate 2006		356	ABS/ESP with EPB, DAR AUTO HOLD and TSA optional	EBC 440 from TRW (Thompson-Ramo-Wooldridge)
Crafter 2006	2006	369	ESP, ABS, TCS, EBD, BA, HHC	8.1 from Bosch

# Test yourself

## Which answer is correct?

One or several of the given answers may be correct.

### 1. How can TCS optimise the acceleration process in critical situations?

- ☐ a) By throttling the engine's output
- ☐ b) By changing down to a lower gear
- ☐ c) By suppressing the gear change
- ☐ d) By braking the drive wheel which is rotating faster

### 2. What is characteristic of understeering?

- ☐ a) Yawing moment arises due to different transverse forces at the front and rear axle.
- ☐ b) The vehicle pushes over the front axle out of the curve.
- ☐ c) The vehicle breaks away and begins to skid.
- ☐ d) The front wheels' frictional adhesion is not sufficient to build up the required lateral guidance force.

### 3. Which statements on EBC are correct?

- ☐ a) EBC requests increased engine torque to reduce the engine braking effect.
- ☐ b) EBC reduces the idle speed in order to operate the vehicle with reduced power in critical driving situations.
- ☐ c) EBC reduces the engine's braking effect, in order to avoid the wheels' locking up in critical driving situations.
- ☐ d) EBC increases the engine's braking effect, in order to provide increased brake pressure in critical driving situations.

### 4. Which wheel has to be braked by the ESP system when the vehicle threatens to oversteer?

- ☐ a) The outer front wheel
- ☐ b) The inner front wheel

# Test yourself

5. Which of the following statements about ABS are correct?

- ☐ a) The stopping distance is always shortened during ABS braking.
- ☐ b) Wheel lock up is prevented during ABS braking.
- ☐ c) Vehicle steerability is maintained during ABS braking.
- ☐ d) All wheels lock up during ABS braking.

6. What is the effect of the electromechanical parking brake's dynamic starting assist system?

- ☐ a) It undertakes the starting process after the parking brake has been released.
- ☐ b) It relieves the driver when starting off on inclines.
- ☐ c) It releases the electromechanical parking brake at the optimal point in time on starting off.
- ☐ d) On starting off, it checks whether the driver door is closed and the seat belt buckle fastened, in order to warn the driver if necessary.

7. How does brake disk dry braking function?

- ☐ a) The brake pads are briefly applied onto the brake disks.
- ☐ b) Due to aerodynamic measures on the brake caliper, an air flow cleans the brake disks.

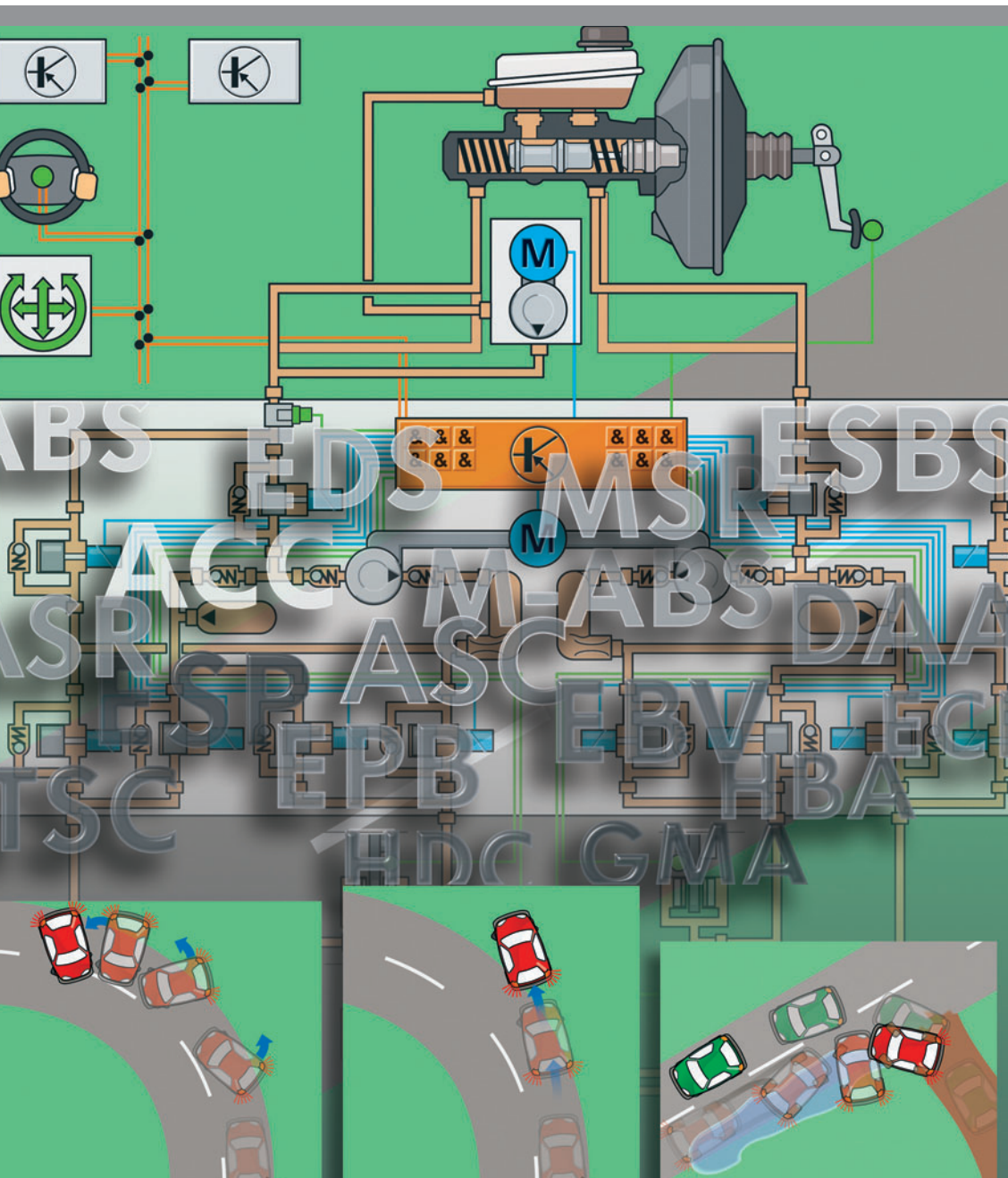
8. When is the brake assist system activated?

- ☐ a) In the case of full braking which is carried out with excessive pedal pressure.
- ☐ b) Whenever the driver brakes.
- ☐ c) On braking in which the pedal is actuated at high speed but insufficient force.

## Answers

1. a), c), d)
2. b), d)
3. a), c)
4. a)
5. b), c)
6. b), c)
7. a)
8. c)





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