Electronic Stabilization Program

Introduction

The electronic stabilization program (ESP) is one of the vehicle's active safety features.

It is also known as a "driving dynamic control system."

Expressed in simple terms, ESP is an anti-skid system. It recognizes when the vehicle is in danger of skidding and compensates when the vehicle breaks traction.

Advantages of ESP:

- ESP is not an independent system. In fact it is based on other traction control systems. That is why it also includes the performance features of these systems.
- It relieves the burden on the driver.
- The vehicle remains manageable.
- It reduces the accident risk if the driver overreacts.

Glossary

ABS

Antilock **B**raking **S**ystem

This system prevents the wheels from locking while braking. Despite the system's powerful braking effect, track stability and steerability are retained.

ASR

Anti **S**lip **R**egulation

This system prevents the driven wheels from spinning, such as on ice or gravel, by intervening with the engine management system to reduce engine torque.

EBD

Electronic **B**rake Pressure **D**istribution

This system prevents overbraking of the rear wheels before ABS takes effect or if ABS is unavailable, due to specific fault states.

EDL

Electronic **D**ifferential **L**ock

This system makes it possible to drive away on road surfaces where each wheel has a different degree of traction by braking the wheel which is spinning.

ESP

Electronic **S**tabilization **P**rogram

This system prevents the vehicle from skidding by selectively intervening in the brake and engine management systems. The following abbreviations are also used for this type of anti-skid system:

- **ASMS** (**A**utomatic **S**tability **M**anagement **S**ystem),
- **DSC** (**D**ynamic **S**tabilization **C**ontrol),
- **DDC** (**D**riving **D**ynamic **C**ontrol),
- **VSA** (**V**ehicle **S**tabilization **A**ssist) and
- **VSC** (**V**ehicle **S**tabilization **C**ontrol).

EBC

Engine **B**raking **C**ontrol

This system prevents the driven wheels from locking due to the engine braking effect when the accelerator pedal is released suddenly or when the vehicle is braked with a gear engaged.

Control Process

Before ESP can respond to a critical driving situation, it must answer two questions:

A — In what direction is the driver steering?

B — In what direction is the vehicle moving?

The system obtains the answer to the first question from the steering angle sensor (1) and the speed sensors at the wheels (2).

The answer to the second question is supplied by measuring the yaw rate (3) and lateral acceleration (4).

If the information received provides different answers to questions A and B, ESP assumes that a critical situation can occur and that intervention is necessary.

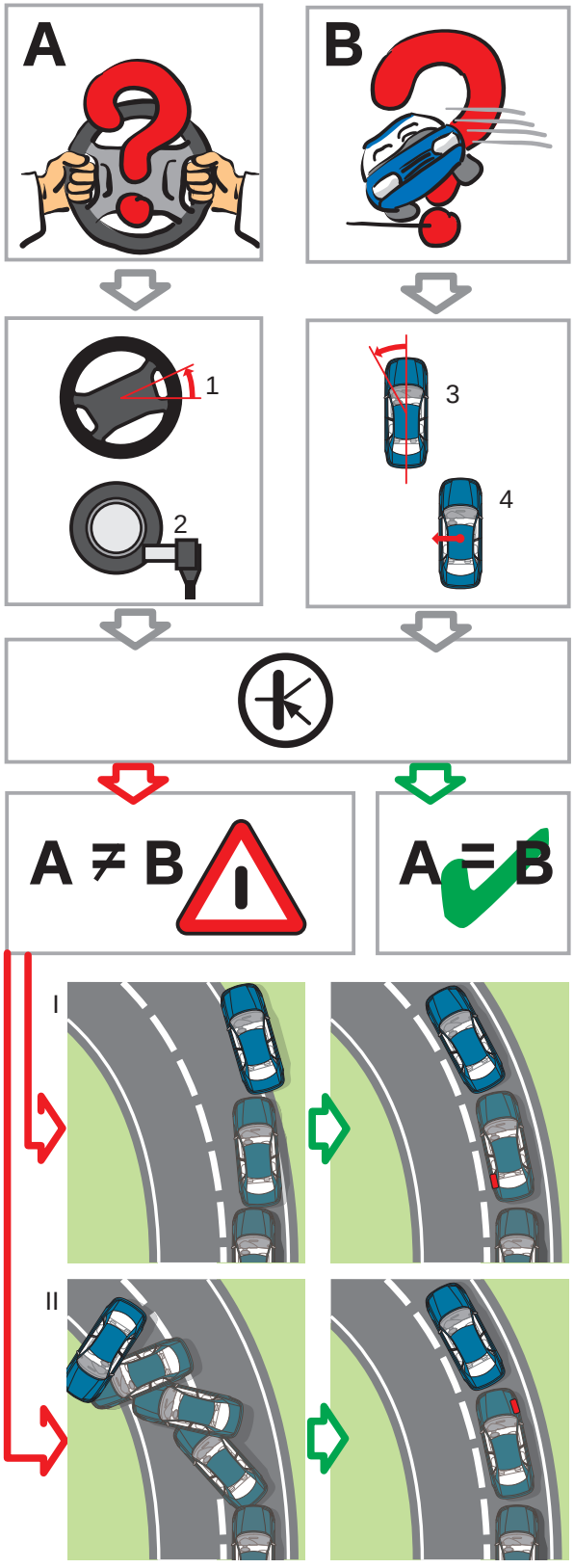
A critical situation can result in two different types of behavior of the vehicle:

I. The vehicle threatens to understeer.

By selectively activating the rear brake on the inside of the corner and intervening in the engine and transmission management systems, ESP prevents the vehicle from overshooting the corner.

II. The vehicle threatens to oversteer.

By selectively activating the front brake on the outside of the corner and intervening in the engine and transmission management systems, ESP prevents the vehicle from skidding.



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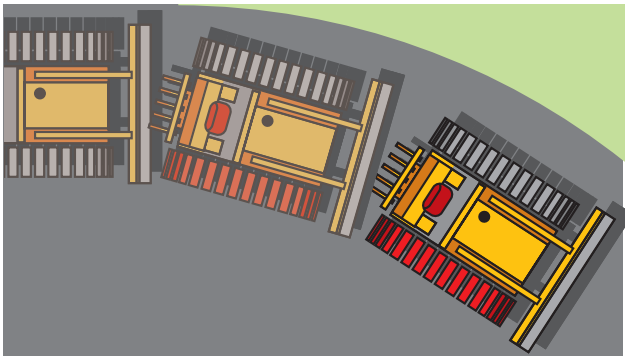
Electronic Stabilization Program



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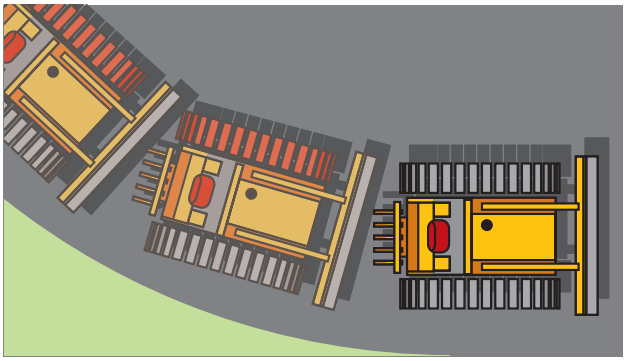

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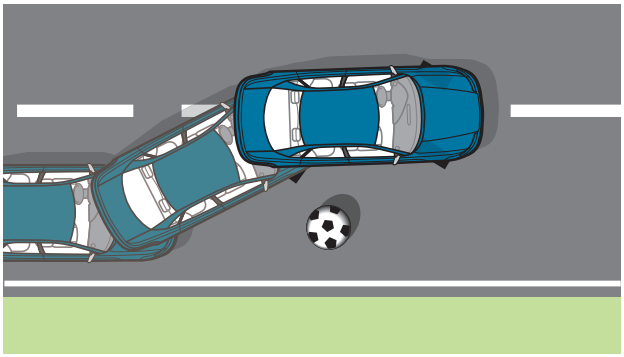

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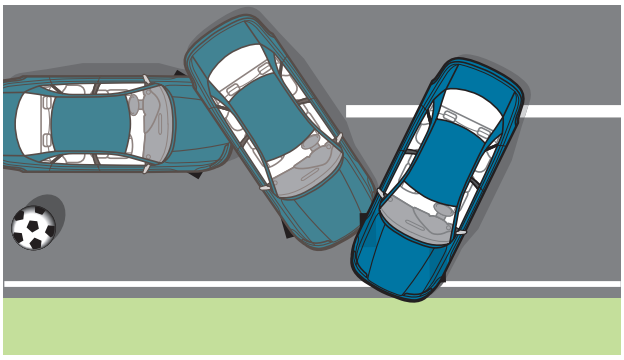

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As you can see, ESP can counteract both oversteer and understeer.

To achieve this, it is necessary to initiate a change of direction without direct intervention in the steering system.

The basic principle applied is the same as that used for tracked vehicles. When a bulldozer wants to negotiate a left-hand bend, the track on the inside of the corner is braked and the outer track is accelerated.

To make a right-hand turn and return to the original direction of travel, the track which was previously on the inside of the corner and now on the outside of the corner is accelerated and the other track is braked.

ESP intervenes along much the same lines. Here is an example of how a sudden maneuver is handled by a vehicle **without ESP.**

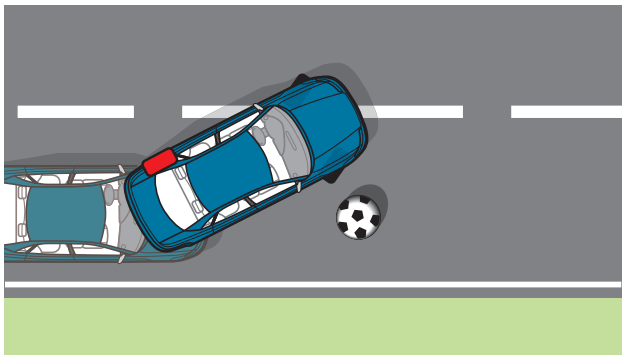
The vehicle must avoid an obstacle which suddenly appears. At first, the driver steers very quickly to the left and to then immediately to the right.

The vehicle swerves due to the driver's steering wheel movements and the rear end breaks away. The driver is no longer able to control the resulting rotation of the vehicle around its vertical axis.

Now let us observe how a vehicle **with ESP** handles the same situation.

The vehicle attempts to avoid the obstacle. From the data provided by the sensors, ESP recognizes that the vehicle is losing stability.

The system calculates its counteraction measures: ESP brakes the left-hand rear wheel. This promotes the turning motion of the vehicle. The lateral forces acting on the front wheels are equalized.



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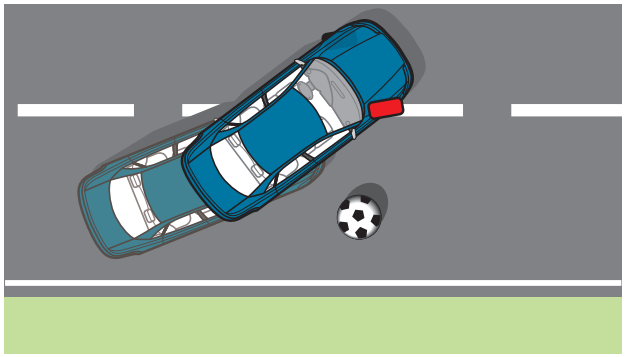
As the vehicle swerves to the left, the driver steers to the right. To help the driver steer into the oversteer, the front right wheel is braked. The rear wheels roll freely in order to ensure an optimal buildup of lateral forces acting on the rear axle.



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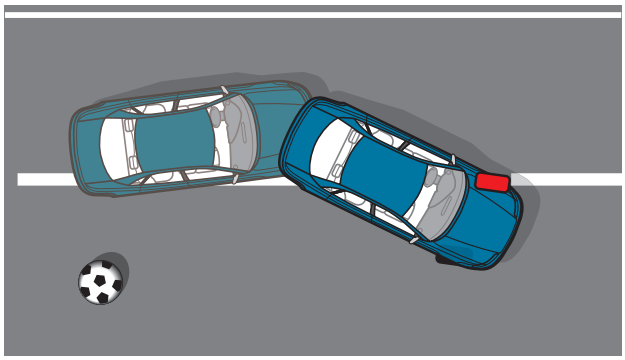
The preceding lane change can cause the vehicle to rotate about its vertical axis. To prevent the rear end from breaking away, the front left wheel is braked. In highly critical situations, the wheel may be braked very heavily in order to limit the buildup of lateral forces on the front axle.



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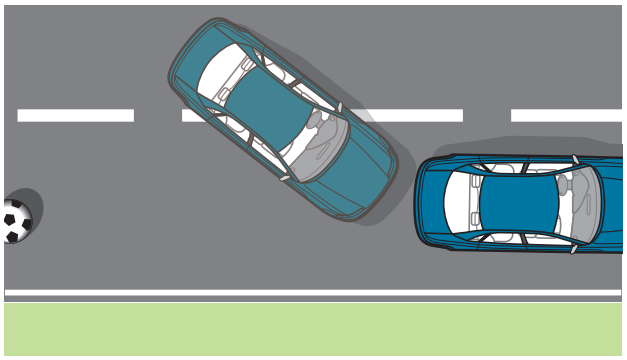
Once all unstable operating states have been corrected, ESP ends its corrective intervention.



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Electronic Stabilization Program

The System and Its Components

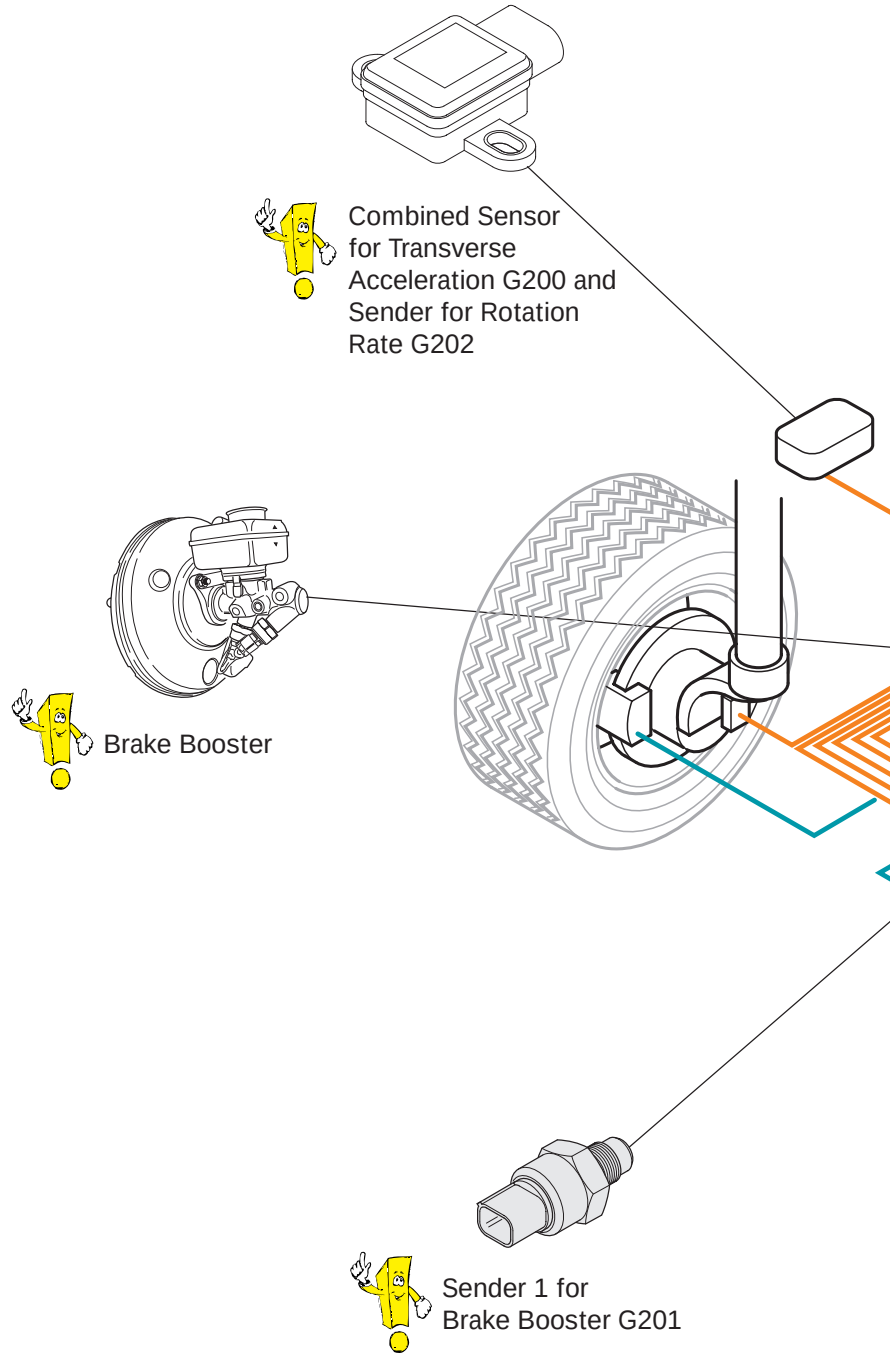
As mentioned already, the electronic stabilization program is based on the proven traction control system.

However, it has one key additional feature:

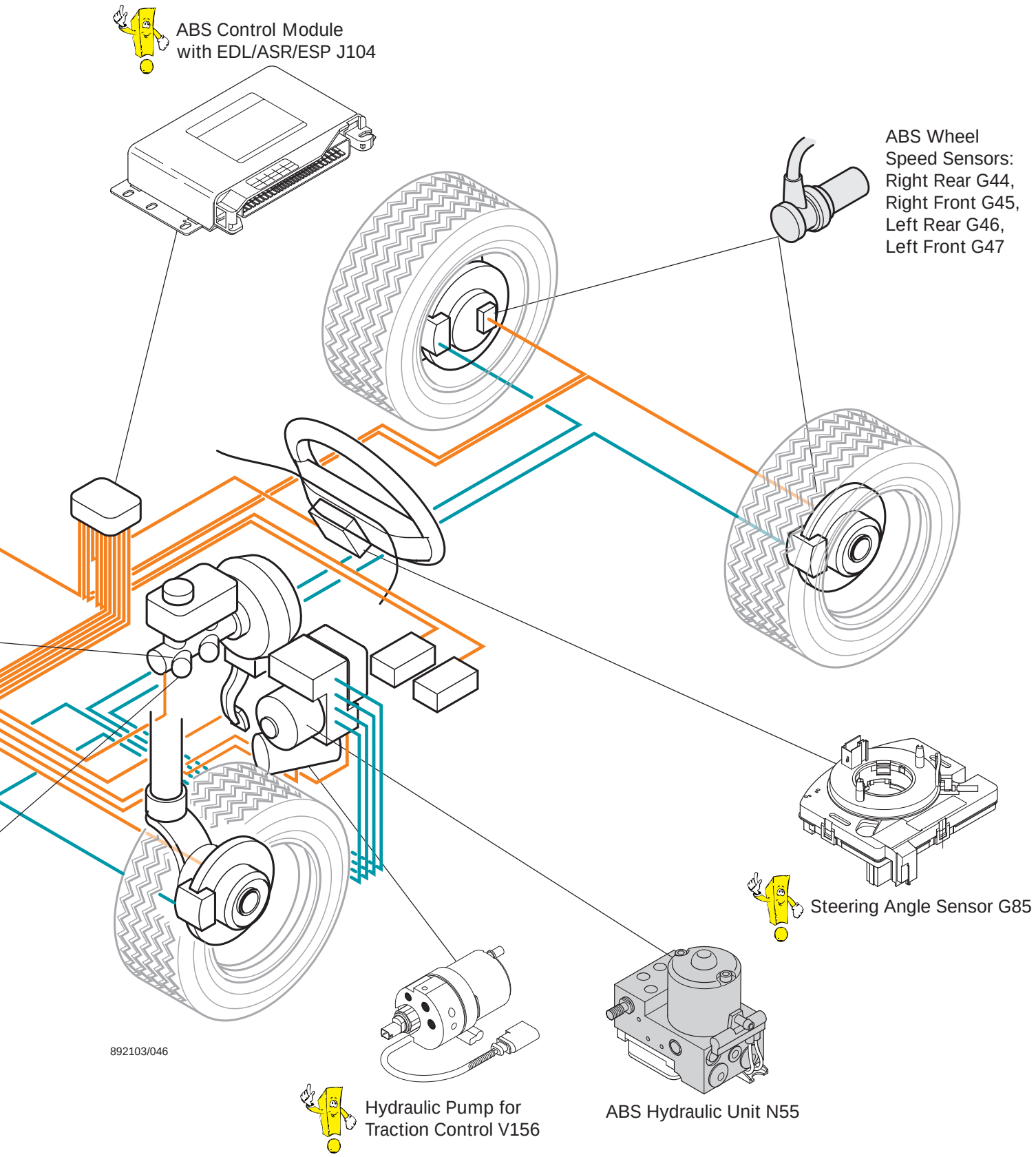
- The system can recognize and compensate for unstable vehicle operating states such as skidding at an early stage.

To achieve this, several additional components are required.

Before we explain ESP in greater detail, here is an overview of these components.



Electronic Stabilization Program



Electronic Stabilization Program

System Overview

Sensors

Button for ASR/ESP E256

Brake Light Switch F

Brake Pedal Switch F47

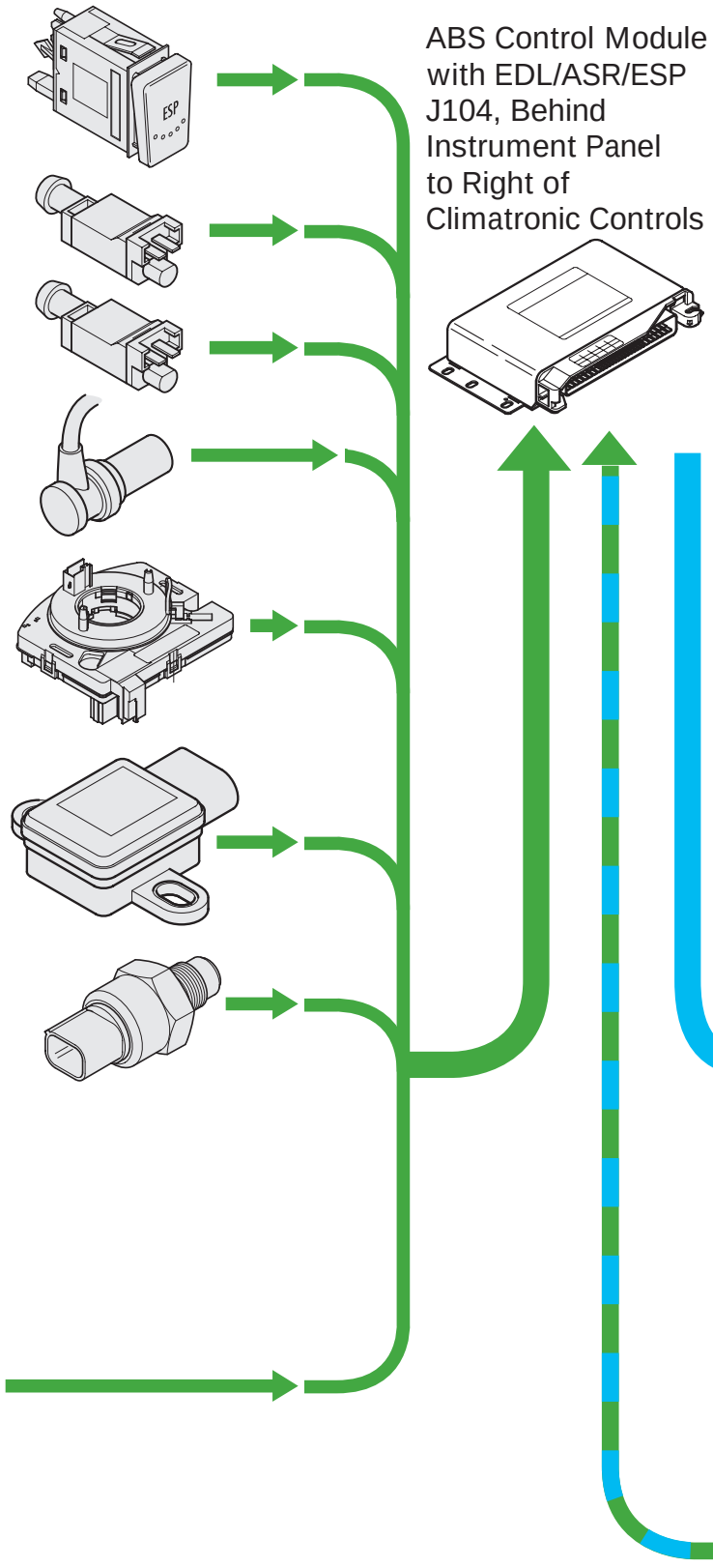
ABS Wheel Speed Sensors:
Right Rear G44,
Right Front G45,
Left Rear G46,
Left Front G47

Steering Angle Sensor G85

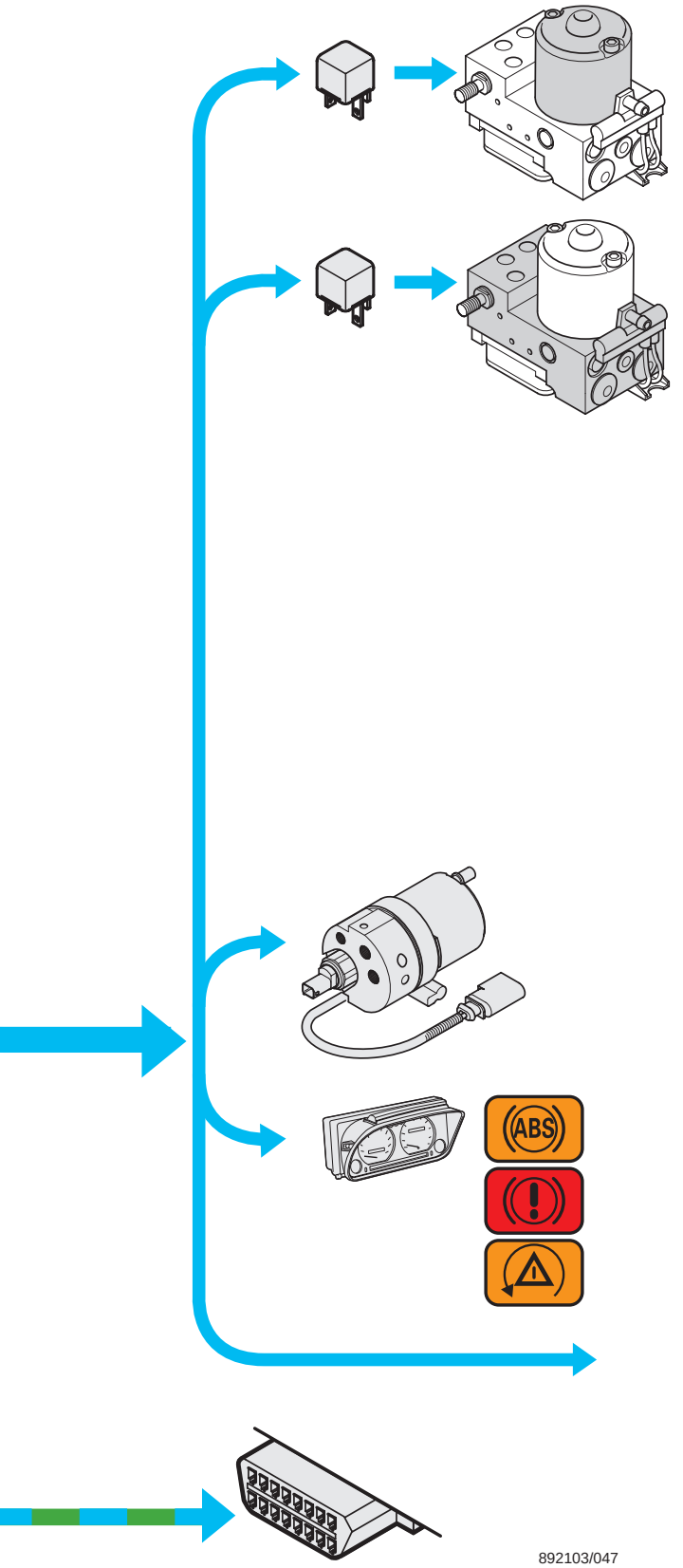
Combined Sensor for Transverse Acceleration G200 and Sender for Rotation Rate G202

Sender 1 for Brake Booster G201

Auxiliary Signals:
Engine Management System
Transmission Management System



Electronic Stabilization Program



Actuators

ABS Return Flow Pump Relay J105,
Near Right HVAC Air Duct

ABS Return Flow Pump V39

ABS Solenoid Valve Relay J106,
Near Right HVAC Air Duct

ABS Inlet Valves: Right Front N99,
Left Front N101, Right Rear N133,
Left Rear N134

ABS Outlet Valves: Right Front N100,
Left Front N102, Right Rear N135,
Left Rear N136

Pilot Valve -1- Traction Control N225
Pilot Valve -2- Traction Control N226

High Pressure Switch Valve -1- Traction Control N227
High Pressure Switch Valve -2- Traction Control N228

Hydraulic Pump Traction Control V156

Control Module with Indicator Unit in Instrument Panel Insert J285

ABS Warning Light K47

Warning Light for Brake System K118

ASR/ESP Warning Light K155

Auxiliary Signals:
Engine Management System
Transmission Management System

Data Link Connector (DLC)
Wire Connector TV14

Electronic Stabilization Program

Design and Function

Control Cycle

The ABS wheel speed sensors provide a continuous stream of data on speeds for each wheel.

The steering angle sensor is the only sensor which supplies data directly via the CAN data bus to the control module. The control module calculates the desired steering direction and the required handling performance of the vehicle from both sets of information.

The sensor for transverse acceleration signals to the control module when the vehicle breaks away to the side, and the sender for rotation rate signals when the vehicle begins to skid. The control module calculates the actual state of the vehicle from these two sets of information.

If the nominal value and actual value do not match, ESP performs corrective intervention calculations.

ESP decides:

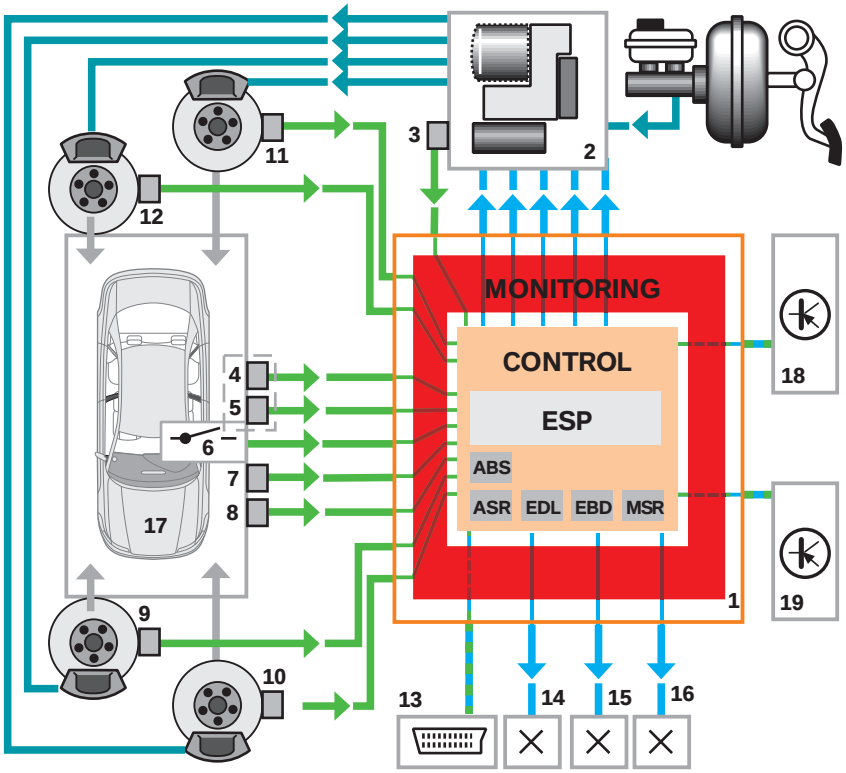
- what wheel to brake or accelerate and to what extent,
- whether engine torque is reduced and
- whether the transmission control module is activated on vehicles with automatic transmission.

The system then checks to see if intervention was successful from the data it receives from the sensors.

If intervention was successful, ESP ends it and continues to monitor the vehicle's handling characteristics.

If unsuccessful, the intervention cycle is repeated.

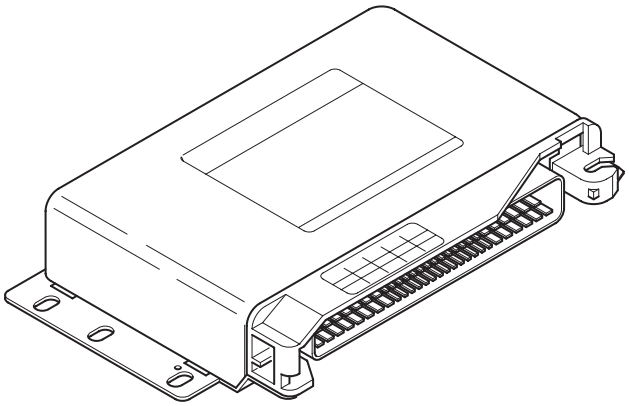
When corrective intervention is taking place, this is indicated to the driver by the flashing ASR/ESP warning light.



1 ABS Control Module with EDL/ASR/ESP J104
2 ABS Hydraulic Unit N55 with Hydraulic Pump for Traction Control V156
3 Sender 1 for Brake Booster G201
4 Sensor for Tranverse Acceleration G200 (Combined with G202)
5 Sender for Rotation Rate G202 (Combined with G200)
6 Button for ASR/ESP E256
7 Steering Angle Sensor G85
8 Brake Light Switch F
9-12 ABS Wheel Speed Sensors G44, G45, G46, G47
13 Data Link Connector (DLC) Wire Connector TV14
14 Warning Light for Brake System K118
15 ABS Warning Light K47
16 ASR/ESP Warning Light K155
17 Vehicle and Driver Behavior
18 Intervention in Engine Management
19 Intervention in Transmission Control Module (TCM) J217 (Vehicles with Automatic Transmission Only) 892103/048

ABS Control Module with EDL/ASR/ESP J104

In the Bosch ESP system, the control module and the hydraulic unit are separated. The control module is located behind the right side of the instrument panel near the HVAC housing.



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Design and function

The ABS control module comprises a high-performance microcomputer.

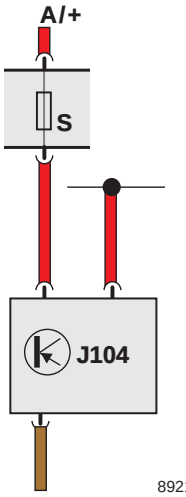
Since a high level of fail-safety is required, the system has two processors as well as its own voltage monitoring device and a diagnostics interface.

The two processors use identical software for information processing and for monitoring each other.

Dual-processor systems of this type have what is known as active redundancy.

Electric circuit

The ABS Control Module with EDL/ASR/ESP J104 obtains its power supply via the positive connection in the dash panel wiring harness.



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Effects of failure

In the unlikely event of control module failure, the driver will only have use of the standard brake system without ABS, EDL, ASR and ESP.

Self-diagnosis

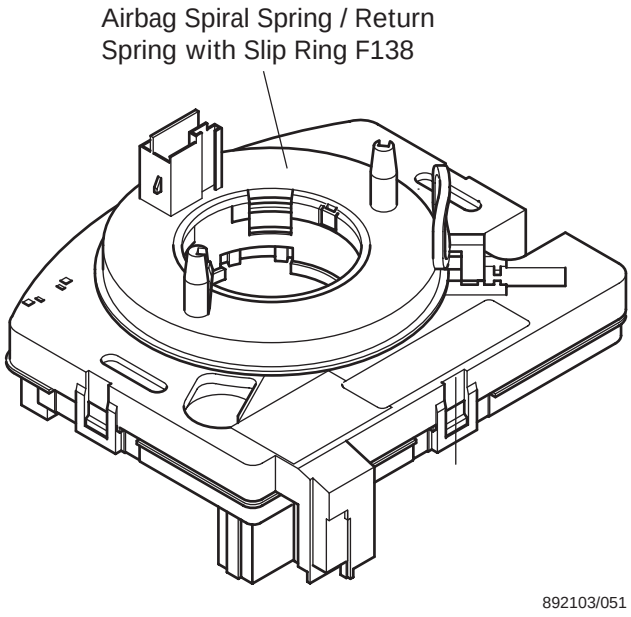
The following faults are detected:

- Control module defective
- Power supply failure

Electronic Stabilization Program

Steering Angle Sensor G85

is mounted on the steering column between the steering column switch and the steering wheel. The Airbag Spiral Spring / Return Spring with Slip Ring F138 is integrated in the Steering Angle Sensor G85 and located on its base.



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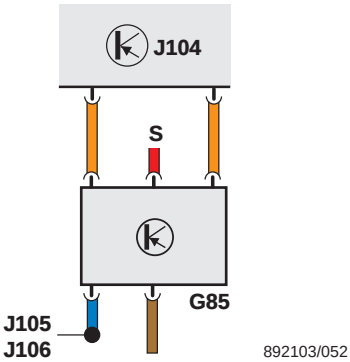

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Task

The sensor transfers the steering wheel lock angle to the ABS Control Module with EDL/ASR/ESP J104. A measured angle of ±720° corresponds to four full turns of the steering wheel.

Electric circuit

Steering Angle Sensor G85 is the only sensor of the ESP system which transfers information directly via the CAN data bus to the control module. After switching on the ignition, the sensor initializes itself as soon as the steering wheel has been rotated through an angle of 4.5°. This is equivalent to a turning movement of approximately 0.6 inch (15 mm).

Effects of failure

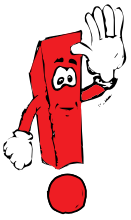
Without the information supplied by the Steering Angle Sensor G85, ESP would be unable to determine the desired direction of travel. The ESP function fails.

Self-diagnosis

After replacing the control module or the sensor, the zero position must be recalibrated.

Faults can include:

- Steering angle sensor – no communication
- Wrong setting
- Mechanical fault
- Defective
- Implausible signal



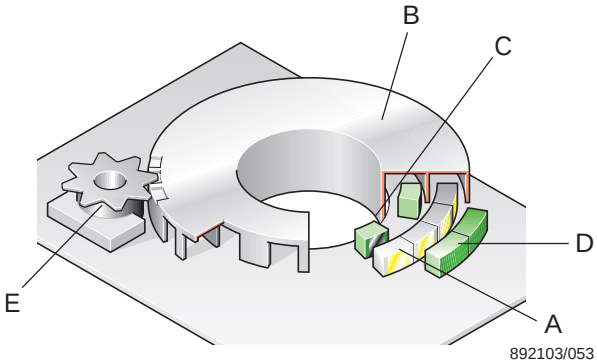
Faults can occur if the track has become maladjusted. Make sure that the sensor is connected securely to the steering wheel.

Design

The angle is measured using the principle of the light barrier.

The basic components are:
- a light source (A)
- an encoding disc (B)
- optical sensors (C and D)
- a counter (E) for full revolutions

The encoding disc comprises two rings: the absolute ring and the incremental ring. Both rings are scanned by two sensors each.



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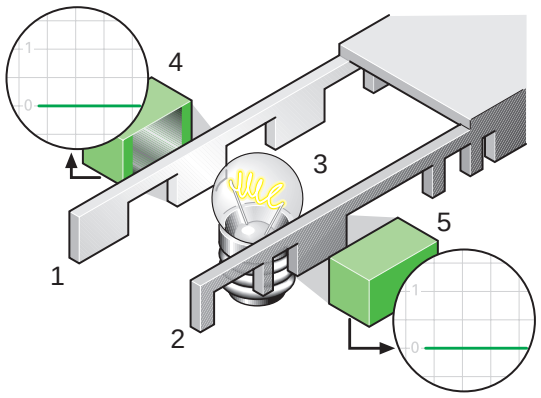
Function

We can simplify the setup by arranging an incremental hole template (1) and an absolute hole template (2) side by side. The light source (3) is positioned in between the hole templates. The optical sensors (4 and 5) are located on the outside.



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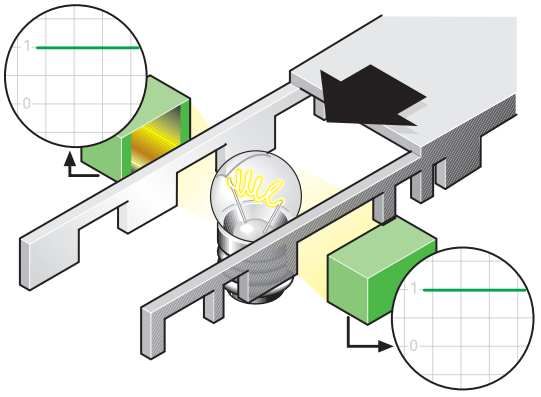
Light shining on a sensor through a gap generates a signal voltage. If the light source is covered, the voltage drops down again.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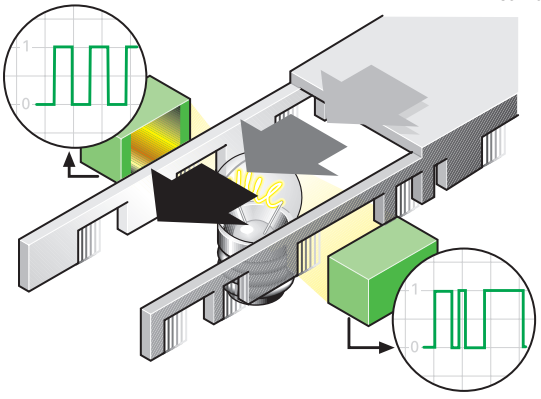
Moving the hole templates produces two different voltage sequences. The incremental sensor supplies a uniform signal, since the gaps follow each other at regular intervals. The absolute sensor generates an irregular signal, since light passes through the gaps in the template at irregular intervals. By comparing both signals, the system can calculate how far the hole template has moved. The absolute voltage sequence determines the starting point of the movement.

Designed to send a usable signal to the control module for one steering wheel rotation in one direction at a time, the steering angle sensor uses the same principle.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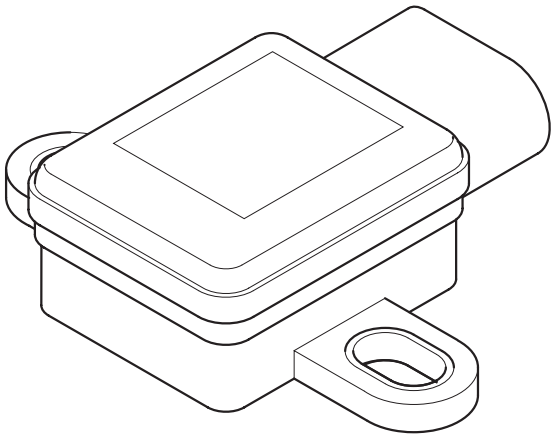
Electronic Stabilization Program



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This sensor is highly sensitive to damage.

Combined Sensor for Transverse Acceleration G200 and Sender for Rotation Rate G202

is mounted at the base of the passenger side ‘A’ pillar. This component contains sensors to measure both lateral acceleration and steering yaw rate. Both sensors are mounted on a printed circuit board and operate according to micro-mechanical principles.

The Sensor for Transverse Acceleration G200 determines whether and to what extent lateral forces are causing the vehicle to lose directional stability.

The Sender for Rotation Rate G202 must determine if the vehicle is rotating about its vertical axis. This process is known as measuring the yaw rate.

Effects of failure

Without these signals, the actual vehicle operating state cannot be calculated in the control module. The ESP function fails.

Self-diagnosis

The diagnosis establishes whether an open circuit has occurred, or a short circuit to positive or ground exists.

The system is also able to determine whether the sensor is defective or not.

Design of Sensor for Transverse Acceleration G200

The sensor is a tiny component on the printed circuit board of the combined sensor.

Expressed in simple terms, the Sensor for Transverse Acceleration G200 is a capacitor plate with a moving mass which is suspended so that it can move back and forth. Two additional permanently mounted capacitor plates enclose the movable plate to form two series-connected capacitors (K1 and K2). The quantity of electricity which the two capacitors can absorb can now be measured by means of electrodes. This quantity of electricity is known as capacitance C.

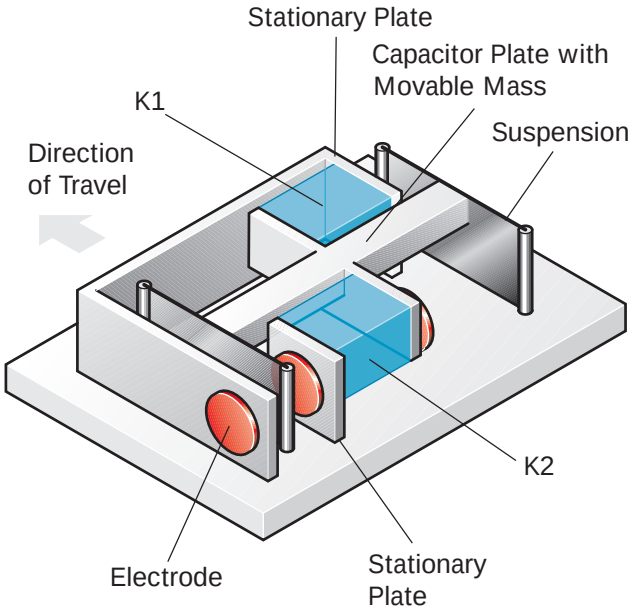
Function

As long as no acceleration acts on this system, the measured quantities of electricity (C1 and C2) of the two capacitors are of equal magnitude.

If lateral acceleration acts on the system, the inertia of the movable mass at the center plate causes the part opposite the fixed plate to move against the direction of acceleration. This causes the spacing between the plates to change and this also changes the measured quantities of electricity of each of the capacitors.

The spacing of the plates at capacitor K1 increases and the associated capacitance C1 decreases.

The spacing of the plates at capacitor K2 decreases and capacitance C2 therefore increases.



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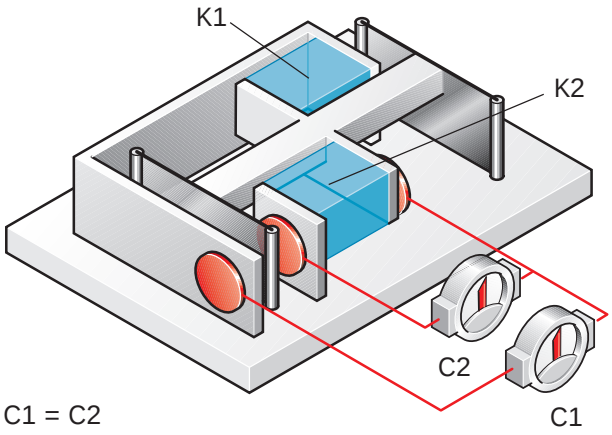

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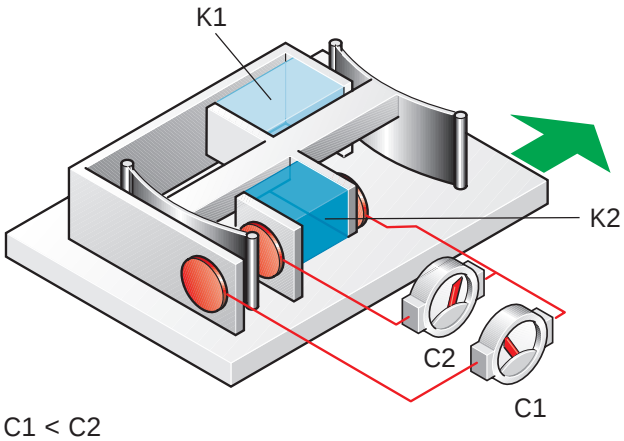

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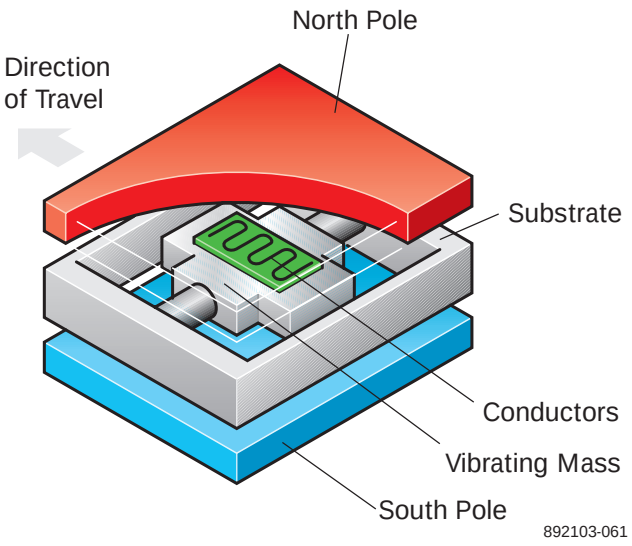
Electronic Stabilization Program



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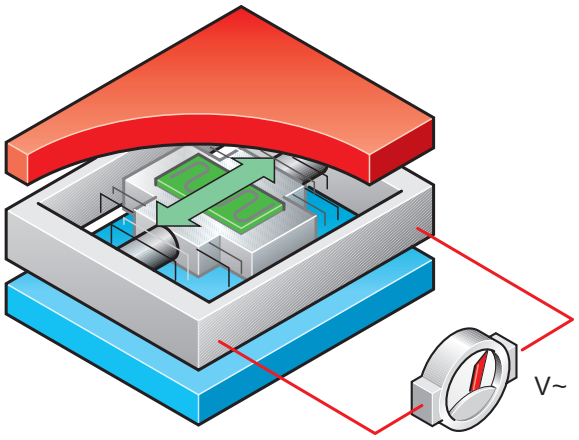

Linear Vibration Corresponding to AC Voltage Applied

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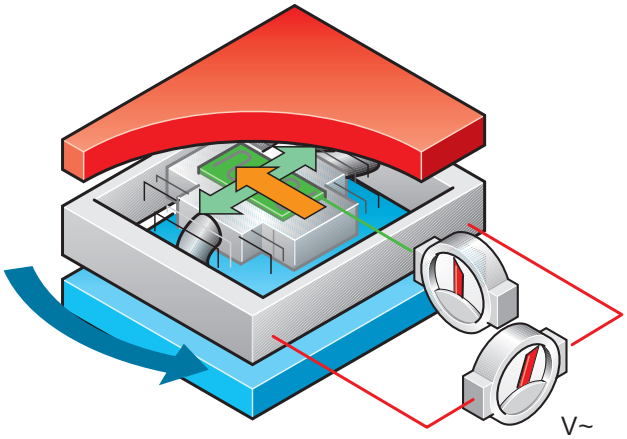

Yaw Rate

Coriolis Acceleration

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Design of Sender for Rotation Rate G202

The Sender for Rotation Rate G202 is mounted on the same board, but is otherwise separate from the Sensor for Transverse Acceleration G200.

This design can also be explained in simple terms.

Imagine a vibrating mass suspended in a support between the north and south poles of a constant magnetic field. Printed circuits comprising the actual sensor are attached to this vibrating mass.

In the actual sender, this configuration is duplicated for reliability.

Function

If you apply an AC voltage (V~), the part containing the conductors begins to oscillate in the magnetic field.

If angular acceleration acts on this structure, the oscillating mass ceases to oscillate back and forth. Since this occurs in a magnetic field, the electrical behavior of the conductors changes.

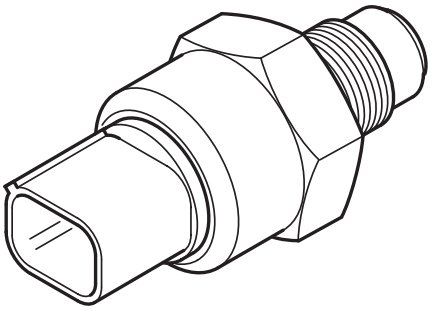
When measured, this change shows the magnitude and direction of the vehicle's rotation around its vertical axis. The evaluation electronics calculate the yaw rate from this data.

Sender 1 for Brake Booster G201

is threaded into the Hydraulic Pump for Traction Control V156.

Task

The Sender 1 for Brake Booster G201 signals the momentary pressure in the brake circuit to the control module. From this, the control module calculates the wheel braking forces and the longitudinal forces acting on the vehicle. If ESP intervention is necessary, the control module allows for this value when calculating the lateral forces.



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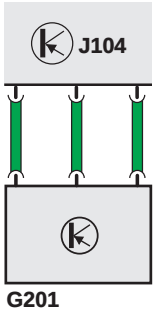
Electric circuit

The Sender 1 for Brake Booster G201 is connected to the ABS Control Module with EDL/ASR/ESP J104 by three wires.



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Effects of failure

Without values for current brake pressure, the system is no longer able to calculate the lateral forces correctly. The ESP function fails.

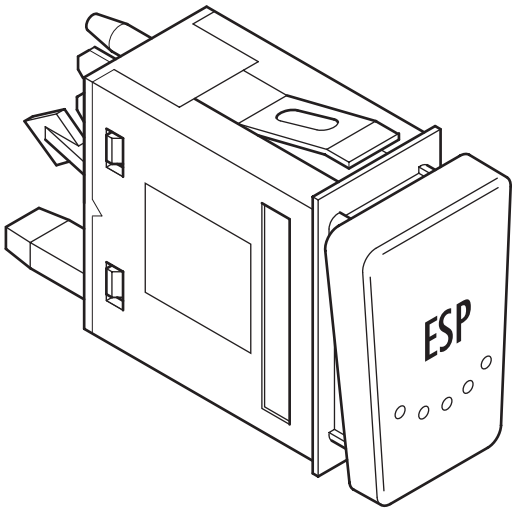
Self-diagnosis

The diagnosis establishes whether an open circuit exists or whether a short circuit to positive or ground has occurred. The system is also able to recognize whether the sensor is defective.

Do not remove the sender from the hydraulic pump.

It must be replaced together with the pump.

Electronic Stabilization Program



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Button for ASR/ESP E256

This button is located on the instrument panel, just above the radio.

It allows the driver to deactivate the ESP function. When the driver depresses the brake pedal or presses the button again, it reactivates the ESP function. If the driver forgets to reactivate ESP, the system reactivates itself when the engine is restarted.

It makes sense to deactivate the ESP function in the following situations:

- when trying to free the vehicle from deep snow or loose surfaces by rocking the vehicle back and forth,
- when driving with snow chains installed, and
- to run the vehicle on a dynamometer.

The system cannot be deactivated while ESP intervention is in progress or above a certain speed.

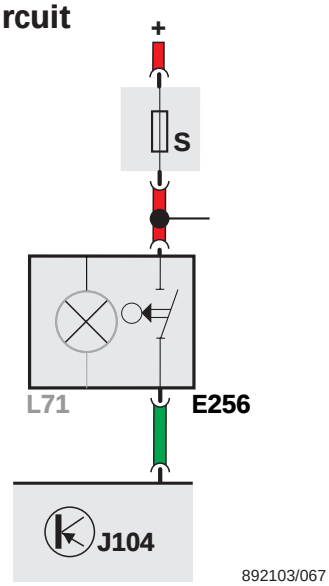
Effects of failure

If the button is defective, the ESP function cannot be deactivated. A malfunction is indicated on the Instrument Panel Control Module with Indicator Unit in Insert J285 by the ASR/ESP Warning Light K155.

Self-diagnosis

The self-diagnosis cannot detect a defective button.

Electric circuit



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The Hydraulic Pump for Traction Control V156

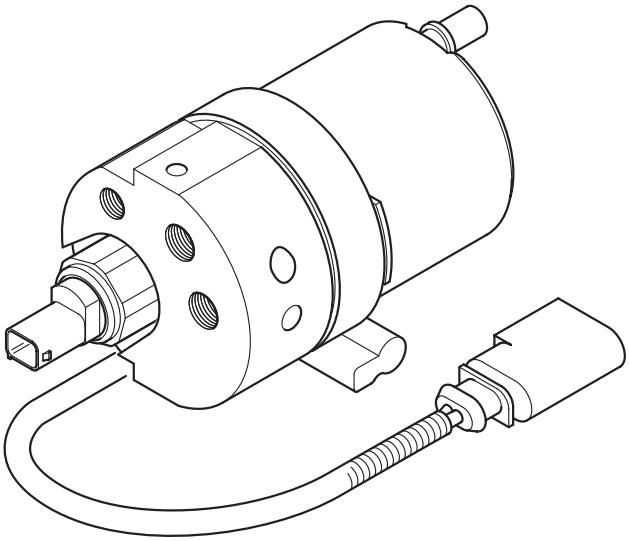
is mounted below the ABS Hydraulic Unit N55 in the engine compartment on a common support.

Task

In an ABS system, a small quantity of brake fluid must be pumped through the brake master cylinder against a high pressure. This task is performed by the return flow pump. However, the return flow pump cannot provide a large quantity of brake fluid at low or zero pedal pressure because the brake fluid has a viscosity that is too high at low temperature.

The ESP system therefore requires an additional hydraulic pump in order to build up the necessary pre-pressure on the suction side of the return flow pump.

The pressure for pre-charging is limited by an orifice in the master cylinder. The hydraulic pump itself is not regulated.



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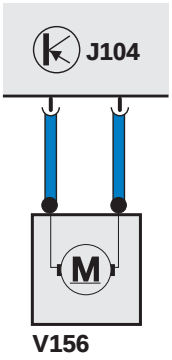
Electric circuit

Both wires of the hydraulic pump are connected to ABS Control Module with EDL/ASR/ESP J104.



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Effects of failure

The ESP function can no longer be executed. ABS, EDL and ASR functions are not impaired.

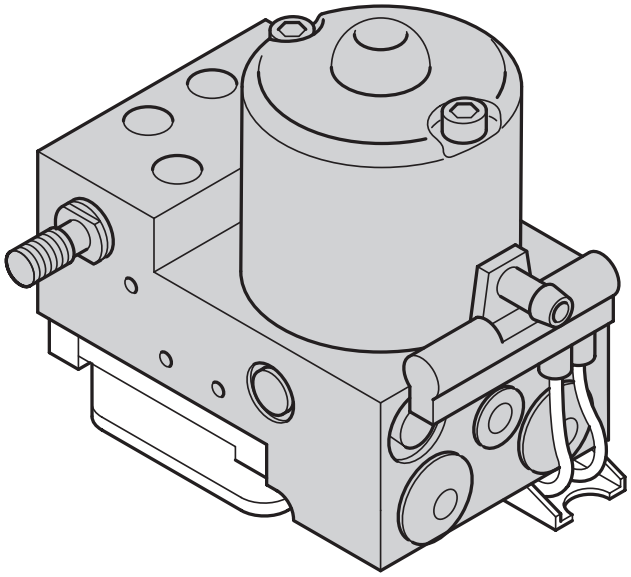
Self-diagnosis

The self-diagnosis indicates open circuit as well as short circuit to positive and ground.

Do not repair the hydraulic pump. It must be replaced as a unit.

As a replacement part, the pump is already filled with brake fluid. Do not remove the plug prematurely. Do not use an empty hydraulic pump.

Electronic Stabilization Program



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The ABS Hydraulic Unit N55

is mounted on a support in the engine compartment. The exact location may vary depending on vehicle type.

Task

The hydraulic unit has two diagonally split brake circuits.

Compared with older ABS units, the hydraulic unit has been modified by the addition of a changeover valve and an intake valve for each brake circuit. The return flow pump is now self priming.

The changeover valves are as follows:

Pilot Valve -1- Traction Control N225
Pilot Valve -2- Traction Control N226

The intake valves are as follows:

High Pressure Switch Valve -1- Traction Control N227
High Pressure Switch Valve -2- Traction Control N228

The individual wheel brake cylinders are activated by the valves in the hydraulic unit. Three states are possible by activating the hydraulic unit inlet and outlet valves for a wheel brake cylinder:

- Raise pressure
- Hold pressure
- Reduce pressure

Effects of failure

If proper functioning of the valves cannot be assured, the complete system is deactivated.

Self-diagnosis

Changeover and intake valves are each checked for open circuit and short circuit to positive and ground.

Warning Lights and Buttons in the Diagnosis

If a fault occurs while ESP corrective intervention is in progress, the system tries its best to complete corrective intervention. At the end of the corrective process, the subsystem is deactivated and the warning light is activated.

Faults and activation of warning lights are always saved to the fault memory.

The ESP function can be deactivated by pressing the Button for ASR/ESP F47.

Warning Lights

Warning Light for Brake System K118

ABS Warning Light K47

ASR/ESP Warning Light K155

	K118	K47	K155
Ignition "on"			
System OK			
ASR/ESP intervention			
Button for ASR/ESP E256 “off” ABS remains active, ESP is deactivated when coasting and accelerating, but remains active during ABS intervention.			
ASR/ESP failure Fault at Sender for Rotation Rate G202, Sensor for Transverse Acceleration G200, Steering Angle Sensor G85, or Sender 1 for Brake Booster G201; in event of ABS failure, emergency ESP function remains active. EBD remains active.			
ABS failure All systems switch off.			

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