Self-study programme 264

The Brake Assist System

Design and function
Accident statistics show that in 1999 alone, 493,527 accidents in Germany were caused by driver error. Many accidents caused by ignoring right-of-way, driving on the wrong side of the road, inappropriate speed, insufficient distance from other vehicles and so on might have been prevented had the vehicles been able to brake faster.

What does this mean?
Studies have shown that many drivers do not apply the brakes sufficiently in emergency situations due to lack of experience. That means that the greatest possible braking effect is not attained because the drivers did not press the brake pedal hard enough.

Therefore, the brake assist system was developed to support the driver in critical braking situations.
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Early in automobile development, the brakes played a rather subordinate role because the friction in the drive train was so great that a vehicle was slowed sufficiently even without the brakes being used.

Increasing power and speed as well as constantly increasing traffic density led to the consideration in the 20s of how an appropriate brake system could provide a counterbalance to greater power and driving performance.

But only after advances in electronics and micro-electronics could systems be developed which could react fast enough in emergency situations.

The ancestor of the electronic brake systems is the ABS, which, since its introduction in 1978, has been continuously further developed and extended by additional functions. These functions intervene actively in the driving process to increase driving stability.

Currently, the trend in development is to driver support systems such as the brake assist system. The brake assist system supports the driver when braking in emergency situations to achieve the shortest possible brake path while maintaining steering ability.
What does the brake assist system do?

To answer this question, let’s first take a look at a braking manoeuvre without a brake assist system.

A driver is surprised by the car in front of him braking suddenly. After a momentary shock, he recognises the situation and applies the brakes. Perhaps because he has not had to brake in critical situations very often and therefore has no feel for how hard he must brake, he does not press the pedal with all his might. Consequently, the greatest possible brake pressure will not be developed in the system and valuable braking distance is lost. The vehicle may not come to a stop in time.

In comparison, let’s look at a car in the same situation but with a brake assist system. As before, the brakes are not applied with sufficient force. Based on the speed and force with which the brake pedal is pressed, the brake assist system detects an emergency. The brake assist system increases the brake pressure until the ABS regulation intervenes to prevent the wheels from locking. This way the greatest possible braking effect can be achieved and the brake path can be shortened significantly.
Depending on the manufacturer of the wheelspin regulation system, the developmental goal of a brake assist system was attained in different ways. Currently, we can distinguish between two different types:

- the hydraulic brake assist systems and
- the mechanical brake assist systems.

In hydraulic brake assist systems, like that from Bosch, the return flow pump of the ABS/ESP hydraulic system provides pressure, thus the expression „hydraulic brake assist system“. In this context, we speak of active pressure development.

The advantage in design is that no additional components needed to be integrated.

At VOLKSWAGEN, the hydraulic brake assist system is currently being used in the 2002 Polo, the 2001 Passat and the D-class vehicle.
In the mechanical brake assist systems from Continental-Teves, brake pressure is developed and an emergency situation is detected by mechanical components in the brake servo.

The mechanical brake assist system is being used in the current models of the Golf and Bora.

Both systems make use of existing system components to implement the function of the brake assist system. Therefore brake assist systems are currently available only in conjunction with ESP.

In this self-study programme, the differences in design and function between the hydraulic and mechanical brake assist systems will be described.
The hydraulic brake assist system

Design...

The central component in the Bosch brake assist system is the hydraulic unit with the integrated ABS control unit and the return flow pump. The brake pressure sender in the hydraulic unit, the speed sensors and the brake light switch supply signals to the brake assist system so that it can identify an emergency. Pressure is raised in the brake slave cylinders by the actuation of certain valves in the hydraulic unit and the return flow pump for TCS/ESP.

... Comparison...

The vehicle without a brake assist system attains the ABS regulation range later than the vehicle with a brake assist system and consequently has a longer brake path.
... and Function

The function of the brake assist systems can be divided into two phases:

- Phase 1 - Start of brake assist system intervention
- Phase 2 - Conclusion of brake assist system intervention

If the trigger conditions have been fulfilled, the brake assistance increases the brake pressure. The ABS regulation range is quickly attained through this active pressure increase.

The brake assist system increases brake pressure until ABS regulation intervenes.

The electronic stability program switch valve N225 in the hydraulic unit is opened and the electronic stability program high-pressure valve N227 is closed. Consequently, the pressure created by the actuation of the return flow pump is directed immediately to the brake slave cylinders.
The function of the brake assist system is to increase the brake pressure as quickly as possible to the maximum value. The ABS function, which is supposed to prevent the wheels from locking, limits the pressure increase when the locking threshold is reached. That means that once the ABS intervention has begun, the brake assist system can no further increase the brake pressure.

When the ABS intervenes, the ESP (brake pressure) switch valve N225 is closed again and the ESP high-pressure valve N227 is opened. The discharge from the return flow pump keeps the brake pressure below the locking threshold.
If the driver reduces the pressure on the brake pedal, the trigger conditions are no longer fulfilled. The brake assist system concludes that the emergency situation has been resolved and moves to phase 2. Now the pressure in the brake slave cylinders is adapted to the driver's pressure on the brake pedal. The transition from phase 1 to phase 2 occurs not with a jump but smoothly, with the brake assist system reducing its contribution to the pressure relative to the reduction of pressure on the brake pedal. When its contribution finally reaches zero, normal braking function is restored.

The brake assist system also ends its intervention when the vehicle speed drops below a predefined value. In both cases, brake pressure is reduced by the actuation of the corresponding valves. Brake fluid can flow to the accumulator and is pumped back into the brake fluid reservoir by the return flow pump.

Phase 2

The brake pressure is reduced.

a = Accumulator
b = ESP (brake pressure) switch valve N225
c = ESP high-pressure valve N227
d = Return flow pump
The hydraulic brake assist system

The trigger conditions

An emergency braking situation is identified by the following trigger conditions, triggering intervention by the brake assist system. These conditions must be fulfilled:
1. The signal from brake light switch indicating that the brakes have been applied.
2. The signals from the speed sensors indicating how fast the vehicle is travelling.
3. The signal from the brake pressure sender indicating how fast and with what force the driver has applied the brakes.

The speed and force with which the brakes are applied are determined using the pressure development gradient in the brake master cylinder. That means that the control unit determines the change in current brake pressure via the pressure sensor in the hydraulic unit over a certain period of time. That is the pressure development gradient.
The intervention threshold for the brake assist system is a predefined value depending on the vehicle speed. If the brake pedal pressure exceeds this defined value in a period of time, the brake assist system initiates intervention. When the change in pressure drops below this threshold, the brake assist system ends its intervention.

In other words, if the pedal pressure reaches a certain value within a short period $t_1$, the intervention conditions are fulfilled and the brake assist system intervenes. If the same pedal pressure is attained only after a longer time $t_2$, the curve is flat and the brake assist system does not intervene. Thus, no intervention occurs if:

- the brake pedal is pressed to slowly or not at all,
- the change in pressure remains below the threshold,
- the vehicle speed is too low or
- the driver has applied the brakes with sufficient force.

An experienced driver develops sufficient pressure using the brake pedal and the brake servo. ABS prevents the wheels from locking.
The hydraulic brake assist system

Electrical components

Brake light switch F

The brake light switch is installed in the pedal cluster and detects the operation of the brake pedal.

- How it works
  The brake light switch is a classic mechanical two-position push button.

- How the signal is used
  The switch provides one of two signals: brake pedal pressed or brake pedal not pressed.

The signal from the brake light switch is used for the various brake systems, the engine management system and the switching on of the brake lights.

- Switch failure
  The brake assist system is not functional without the brake light switch signal.

- Self-diagnosis
  A switch defect will be detected by self-diagnosis and saved in the fault memory. If the switch is renewed, it must be adjusted according to the workshop manual.
Brake pressure sender G201

If the brake system has ESP, the brake pressure sender is screwed directly into the hydraulic unit and senses the current pressure in the brake system.

● How it works
The heart of the sender is a piezo-electric element. It reacts to changes in pressure with a change in the charge distribution within the element, producing a measurable change in voltage.
Changes in the sender’s voltage are detected and evaluated by the control unit.

● How the signal is used
As described above, the signal over a period of time is used to calculate a pressure gradient which defines the intervention conditions for the brake assist system.

● Sender failure
Neither the brake assist system nor the ESP is functional without the signal from the brake pressure sender.

● Self-diagnosis
A sender defect will be detected by self-diagnosis and saved in the fault memory.
The hydraulic brake assist system

**Speed sensors G44 - G47**

The speed sensors are inductive sensors which, using a rotor on each wheel hub as sender wheel, determine the current rotational speed of the wheels.

- **How it works**
  The sensor consists of a soft iron core with a permanent magnet and a coil. The magnetic field which the permanent magnet creates over the iron core is influenced by the sender wheel. Changes in the magnetic field induce measurable voltage in the sensor coil. The faster the sender wheel passes the coil, the higher the frequency of the voltage change.

- **How the signal is used**
  The ABS control unit calculates the rotational speed of each wheel based on the frequency. The rotational speed of the wheels is used by a variety of different vehicle systems.

- **Sensor failure**
  Without the speed sensor signal, the brake assist system cannot calculate the speed-dependent threshold. The brake assist system is switched off.

- **Self-diagnosis**
  A defect in a speed sensor is detected by self-diagnosis and saved in the fault memory.