EBS

IN TOWING VEHICLES AND BUSES

SYSTEM DESCRIPTION

WABCO

EBS in towing vehicles and buses

System Description

3rd edition

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WABCO
Vehicle Control Systems

We reserve the right to make changes
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1 Safety information

Read the vehicle manufacturer's technical documentation and make sure you strictly follow the relevant specifications and instructions.

This document describes structure, functions and components of the WABCO Electronic Braking System in trucks, semitrailer tractors and buses.

Read this publication thoroughly. Adhere to all instructions, information and safety information to prevent injury to persons and damage to property.

WABCO will only guarantee the security, reliability and performance of their products and systems if all information in this publication is adhered to.

- Only trained and qualified technicians are to perform any work on the vehicle. Special training courses are required for start-up and EBS parameter settings.
- Make sure you strictly follow the specifications and instructions of the vehicle manufacturer.
- Only use products that have been approved by WABCO or the vehicle manufacturer.
- Adhere to all company safety regulations as well as regional and national regulations.
- Wear suitable protective clothing when necessary.
- Your workplace must be dry as well as sufficiently illuminated and ventilated.

Risk of injury!

The diagnostic software is used to actuate the vehicle components. This may cause the vehicle to move. Therefore you need to make sure the movement causes no danger before you start the diagnostics.

Pedal actuations can lead to severe injuries if persons are in the vicinity of the vehicle.

– Switch the gearbox to "neutral" and apply the park brake.

– Use chocks to secure the vehicle against rolling.

– Fasten a visible note to the steering wheel indicating the work is being performed on the vehicle and that the pedals must not be operated.

– Make sure that the complete compressed air system is vented before any devices are dismantled.

– Do not wear a tie, loose clothing, open hair, arm bands, etc. when working on the vehicle, especially with the engine running. Keep your hands and hair away from the moving parts.

Fire hazard!

– Only use lamps that are earthed.

– Keep flammable material (cloths, paper, etc.) away from the exhaust system.

– Do not smoke in the workplace.

– Check electrical lines for proper insulation and fastening.

1.1 Avoiding electrostatic charge and uncontrolled discharging (ESD)

Observe the following during construction and assembly of the vehicle:

– Prevent potential differences between components (e.g. axles) and the vehicle frame (chassis).

  Make sure that the resistance between metal parts of the components and the vehicle frame is lower than 10 Ohm (< 10 Ohm).

  Connect moving or insulated vehicle parts such as axles electrically conductive with the frame.

– Prevent potential differences between the towing vehicle and the trailer.

  Make sure that an electrically conductive connection is made via the coupling (king pin, fifth wheel, claws with pins) between metal parts on the towing vehicle and the hitched trailer, even without a cable being connected.

– Use electrically conductive bolted connections when fastening the ECUs to the vehicle frame.

– Use only cable conforming to WABCO specifications or original WABCO cable.

– Run the cable in metallic casing if at all possible (e.g. inside the U-beam) or behind metal and grounded protective plating to minimise the influence of electro-magnetic fields.

– Avoid the use of plastic materials if they can cause electrostatic charging.

During repair and welding work on the vehicle observe the following:

– Disconnect the battery - if installed in the vehicle.

– Disconnect cable connections to devices and components and protect the connectors and connections from contamination and humidity.

– Always connect the grounding electrode directly with the metal next to the welding position when welding to prevent magnetic fields and a current flow via the cable or components.

  Make sure that the current is well conducted by removing paint or rust.

– Prevent heat influences on devices and cabling when welding.

2 Introduction

The quality of the braking system contributes substantially to the road safety of commercial vehicles. In 1996, WABCO was the first supplier to launch series production of an Electronic Braking System (EBS) on a larger scale. As a global leader in this sector, WABCO supplies EBS for light to heavy commercial vehicles with trailers or semitrailers as well as for buses.

The benefits of EBS

Braking comfort and improved safety through EBS

The driver enters his deceleration command by operating the brake. EBS then transmits this command to all braking system components electronically. Response and build-up times at the brake cylinders are reduced significantly due to electronic actuation. The ECU also facilitates a sensitive dosing of the braking system during this process. The result: comfortable braking "feel", independently of the load status, and a much shorter braking distance.

The functions integrated in EBS ensure that both the vehicle's driving stability and steerability are maintained during the braking process. The Differential Slip Control (DSR) system automatically distributes the braking forces between the front and rear axle according to the respective load status. When operated with a trailer, DSR also ensures that the tractor-trailer combination is optimally balanced. Towing vehicle and trailer respectively brake their own portion of weight in the tractor-trailer combination. The coupling force of the tractor-trailer combination is thus kept low when braking. The integrated anti slip regulation applies traction control.

Lining wear optimisation and ease of maintenance through EBS

EBS from WABCO provides the option to continuously monitor and balance lining wear. This means that service and lining replacement times can be coordinated. All linings on the vehicle are then replaced simultaneously. The integration of non-wearing brakes, such as retarder and engine brake, also help to protect brake linings for longer operating times.

Extensive integrated diagnostic and monitoring functions carry out constant self-inspections of EBS. Corresponding warning facilities alert the driver immediately if operational readiness is impaired. A diagnostic device or the on-board diagnostic display in the vehicle can be used to determine the causes quickly and easily. Maintenance and workshop periods can also be significantly reduced by means of the extensive test functions of the diagnostic system.

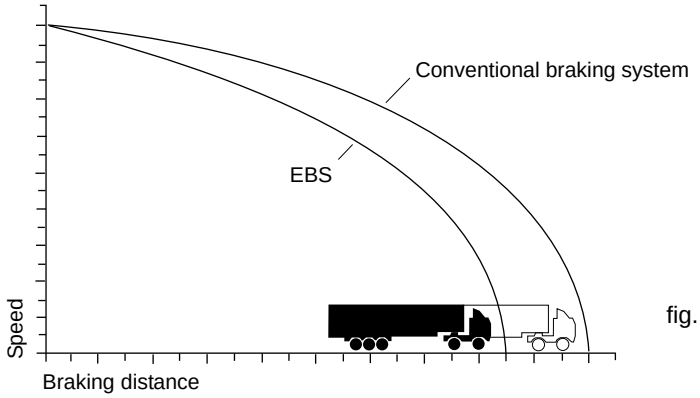


fig. Significantly reduced braking distance with EBS

3 Functional description

3.1 EBS basic function

WABCO EBS operates with electronic signals. The EBS electronic control unit controls the system through these signals and can communicate with the individual components at any times. The valves on the brake cylinders generate the required braking pressure according to the control signals.

Speed sensors installed on the wheels of the vehicle for the integrated ABS function constantly provide up-to-date wheel speed information to the EBS. Different integrated brake management functions detect any deviations from normal driving conditions and intervene in the driving process in the event of hazards. Apart from improving safety, specific functions also optimise driving comfort and lining wear.

If the electronic control system malfunctions, all valves simultaneously coordinate operation as in a conventional pneumatic system. Backup pressures are here conducted to the brake cylinders where the pneumatic system, however, is effectively applied only with a certain delay. Since the pneumatic system does not operate with a load-sensing valve, however, the pneumatic backup may cause overbraking of the rear axle. What is known as a backup valve therefore blocks the effect of the pneumatic circuit on the rear axle brake cylinders while EBS functions normally.

3.2 Brake management

Deceleration control / Braking force control

The deceleration control system is used to adjust the braking pressure level to the braking command from the driver. EBS ensures that with identical pedal operations the vehicle is always braked with the same effect, regardless of the load status. If the brake linings are wet for example, EBS will increases the braking pressure until the desired deceleration is achieved. For this reason there is no need for a separate axle load sensing system for braking force control.

However, this adaptation is only carried out within certain limits. when the coefficient of friction becomes too poor, deceleration control ceases to make any adjustments. This will bring the change in braking performance to the driver's attention.

In addition, deceleration control improves the braking hysteresis. During each brake release event the program selects the release steps in manner that immediately changes the braking force.

Braking force distribution

The distribution of braking forces to front and rear axle depends, among other factors, on the comparison of actual and desired vehicle deceleration values computed by the "deceleration control" program function. The braking deceleration is captured via the wheel speed changes detected by speed sensors. An evaluation of the sensors provides exact information on the slip on each axle and thus their braking performance. If the slip differs, one axle contributes more towards deceleration than the other. Consequently, this axle is also subject to greater wear. 'EBS applies differential slip control to regulate the pressures on front and rear axle for optimum distribution of braking forces.

Brake lining wear control

EBS can obtain more accurate information on the wear condition of the brakes from analogue lining wear sensors. The brake lining wear control intervenes in the distribution of braking forces during uncritical braking events if a difference in the linings on the front and rear axles was detected. The pressure of the wheel brake with the greater wear is reduced slightly, and the pressure on the wheel brake with less

worn linings is increased as required, but by no more than 0.5 bar. In this way wear is balanced without the driver noticing.

! If brake lining wear sensors are installed instead of wear indicators, wear can only be regulated by the EBS ECU.

Endurance brake integration

The endurance brake integration function controls the correct application of the available brakes. It makes sure that the non-wearing brakes, such as retarder and engine brake, contribute the maximum possible portion of braking work for the vehicle as a whole. The wheel brakes thus stay cool, reducing wear of brake linings and drums or brake discs.

Brake assist system

The brake assist system supports the driver during full braking by detecting intense braking and supplying the full braking pressure into the brake cylinders - regardless of the brake pedal being fully depressed or not. Only when the driver releases the brake pedal does the brake assist system terminate the braking process.

Anti Roll Brake (ARB)

The anti roll brake allows the driver to start uphill comfortably by preventing the vehicle from rolling backwards. The driver can activate the function by briefly tapping the brake pedal, which is connected directly to the EBS ECU. The EBS then adjusts the braking pressure as required.

This function can be switched on and off using the ARB switch.

! With the halt brake function, EBS systems for buses are equipped with an enhanced anti roll brake (see chapter 4.2 “EBS in buses”, page 18).

Drag torque control

Drag torque occurs in the drive line due to gear shifting or gas exchange. The resulting braking torques can cause the driving wheels to lock, making the vehicle unstable. The drag torque control function prevents this situation. When a defined slip state is exceeded, the engine torque is increased relative to the speeds of the driving wheels, reducing the braking torques that occur. Drag torque control terminates as soon as stable driving wheel values are received again.

Integrated ABS function

ABS is integrated in EBS. Inductive sensors measure the rotational speed of individual wheels so that any tendency to lock is detected early. The EBS ECU can then reduce, stop or increase the braking pressure for the brake cylinders on the front axle accordingly via the ABS solenoid valves. The axle modulator, whose electronic control unit includes the relevant control algorithms, performs the same task for the rear axle.

One problem that may occur with vehicles that are equipped with ABS is the yaw moment that occurs when braking on roads with extreme differences in the coefficient of friction between the left and right hand side. The brake force utilisation is then different on either side, which makes the vehicle impossible or extremely difficult to control on such roads. This is why, while the rear axle wheels are controlled individually (IR), the braking pressures of the front axle wheel brakes are controlled dependent on one another (MIR). Pressure differences are only possible to a certain degree with this type of control; so the tyres on the slippery side of the road surface do not lock and the vehicle remains steerable.

if the driving wheels show a tendency to lock during endurance brake application on a slippery road surface and there is a risk of an instable vehicle state, the system deactivates the endurance brake via the vehicle data bus to ensure continued driving stability.

> ! In vehicles with 3 and 4 axles and a 4S/4M system the wheels that are not sensed are also integrated in the control process side by side.

Integrated anti slip regulation (ASR)

If the driving torque on the wheels is greater than the static friction on the wheels, the slip becomes too great and there is a risk of the wheels spinning. The ASR function detects this and adjusts the driving torque via the engine control electronics. Such an intervention in engine control only makes sense if both wheels of one axle show a tendency to spin. If only one driving wheel spins, ASR can selectively brake this wheel using the axle modulator. A function lamp indicates that ASR control has been activated.

Trailer control

Control of the trailer is implemented electronically by means of the towing vehicle to trailer interface (ISO 11992) as well as pneumatically via the electropneumatic trailer control valve. The coupling force is not sensed to save costs. Initially the deceleration of the towing vehicle lies at the centre of the EC Brake Band. If the trailer deceleration has the same value at this time, no coupling forces are generated. If the trailer deceleration deviates from this position at the centre of the band, the towing vehicle ECU detects this through the "deceleration control" program function and adjusts the trailer control pressure accordingly.

If the response threshold of the trailer brakes should be greater, this is compensated by a corresponding pressure inshot.

The inshot of pressure into the trailer's control line (yellow) occurs at the start of braking with approx. 2 bar. The inshot is brief so that the linings make contact quickly, then EBS adjusts the braking pressure in accordance with the deceleration command. Most of the problems known today are solved with this approach.

WABCO has collaborated in shaping the standardisation of the electronic towing vehicle to trailer interface (ISO 11992).

3.3 Supporting functions

Determining the nominal brake signal

The brake pedal distance measured by the sensors in the brake signal transmitter is transmitted to the EBS ECU which then calculates the corresponding desired deceleration.

Pressure control on the axles and trailer control

The pressure is adjusted to the calculated nominal pressures in the three pressure control circuits for front axle, rear axle and trailer control. The solenoid currents in the solenoid valves are controlled to improve the pressure control characteristics.

> ! This does not apply if axle modulators of the 2nd or 3rd generation are fitted, because pulsed solenoid valves are used here.

Rotational speed sensing and tyre compensation

Wheel speed sensing corresponds to the sensing function known from ABS. An automatic tyre compensation function compensates differences in nominal tyre sizes and thus the rolling circumferences between the axles. If unacceptable wheel tyre combinations are used, this is detected as a fault.

> ! New parameters need to be set for the braking system when wheels with different tyre sizes are used or there is a change regarding the permissible axle load of the vehicle. Your vehicle manufacturer must be consulted in this case.

3.4 Electronic Stability Control ESC

Since 2000, WABCO offers ESC (Electronic Stability Control) as an extension to EBS (Electronic Braking System). While EBS is responsible for the brake management, ESC increases stability during normal driving. Particularly during lane change, avoidance and cornering manoeuvres there is a risk of commercial vehicles tilting, rolling or swerving due to their high centre of gravity and great weight.

Using the aid of various sensors, the ESC detects such critical situations and corrects the engine and braking power accordingly if necessary. This assists the driver and improves road safety.

! Additional components are required for ESC (see chapter 5.13 “ESC components”, page 27).

3.4.1 ESC control functions

Within physical limits, ESC operates automatically and comprises two independent functions:

Control of tracking stability (yaw control)

This function is activated when the vehicle loses stability in critical situations (e.g. during a sudden lane change). The yaw movement is measured by a yaw rate sensor that is integrated in the ESC module. In such situations ESC uses EBS to regulate the braking forces on each wheel, throttles the engine output, thereby reducing the risk of swerving when cornering and during avoidance manoeuvres.

ESC prevents potential "jack-knifing" of a semitrailer train by simultaneous, dosed braking of the semitrailer even if it is equipped with a conventional braking system.

Driving stability control (RSC – Roll Stability Control)

RSC controls the engine output and applies the service brake to reduce the risk of overturning in corners. For this purpose, RSC identifies the critical lateral acceleration by means of the lateral acceleration sensor integrated in the ESC module.

When the lateral acceleration exceeds a specific level, RSC reduces the engine torque, activates the engine brake and brakes the towing vehicle axles as well as the trailer as required.

RSC also applies the brakes on the towing vehicle front axle by means of a 3/2 solenoid valve fitted there.

3.4.2 Specifics with ESC

Trailer operation with semitrailer tractors

In principle, ESC can also be used in combination with trailers. When the ESC control function intervenes, a coordinated braking of the trailer is carried out through the EBS brake management of the towing vehicle. In this regard it is of no significance whether or not the trailer is equipped with Trailer EBS.

For trailer operation with Trailer EBS and activated RSS function, the trailer is always controlled via RSS. Only when ESC initiates a higher pressure level than RSS is this higher pressure passed on to the trailer.

! No ESC is yet available for a towing vehicle in combination with a drawbar trailer.

Deactivation of ESC by the driver

ESC must be deactivated for off-road driving, operation with snow chains and during test drives through banked curves. The system therefore provides the option to deactivate ESC via the ASR switch.

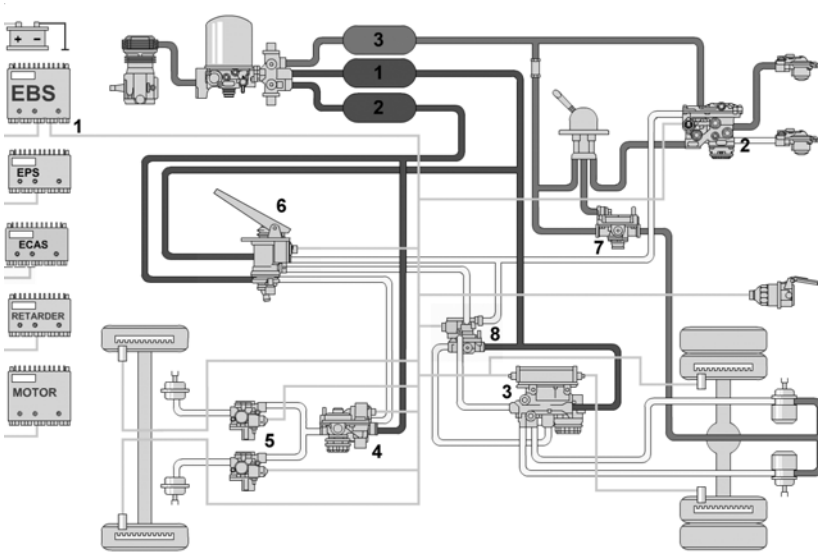
! This option can be completely deactivated by setting certain EoL parameters, depending on the vehicle manufacturer. If you wish to be able to deactivate ESC, please contact the vehicle manufacturer directly.

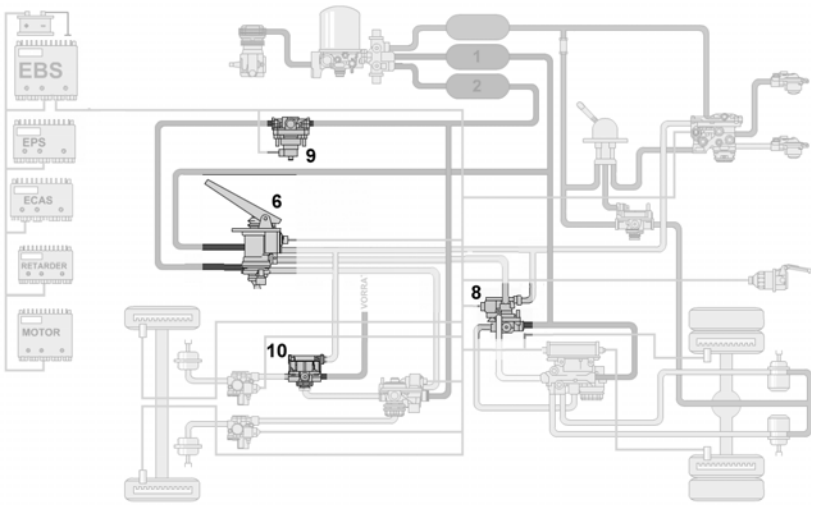
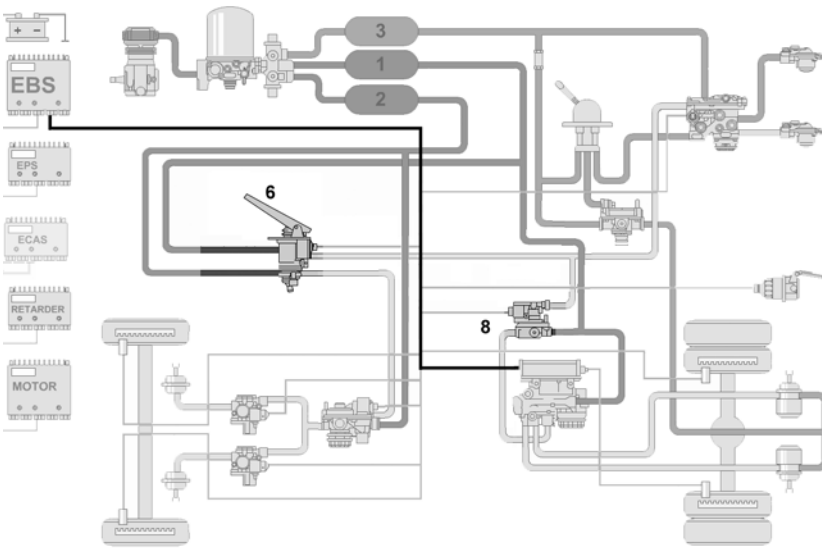
4 System variants

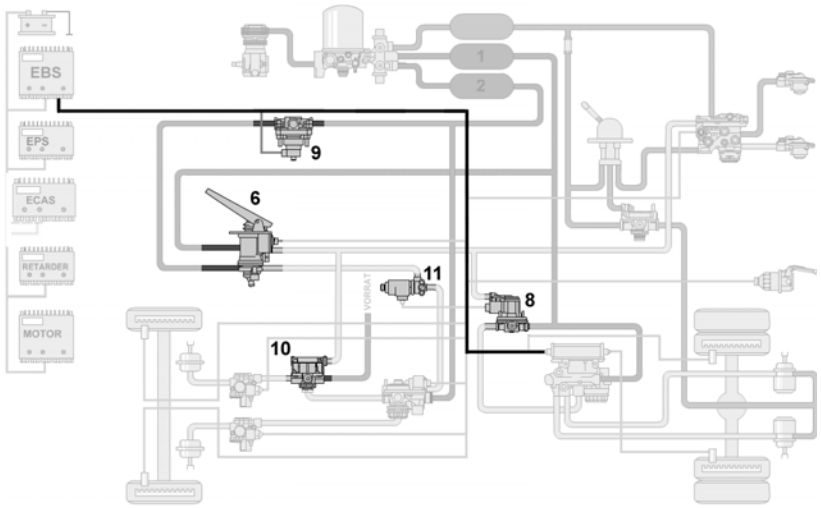
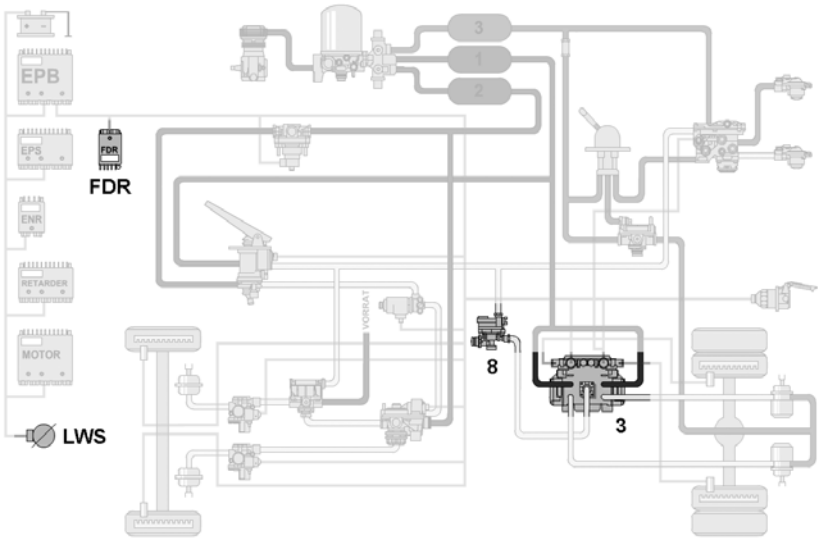
WABCO have continuously developed and improved their EBS since 1996. The following chart shows the system variants produced since then and their differences. The following differences in scope of the system apply within the different system variants, depending on manufacturer and vehicle type:

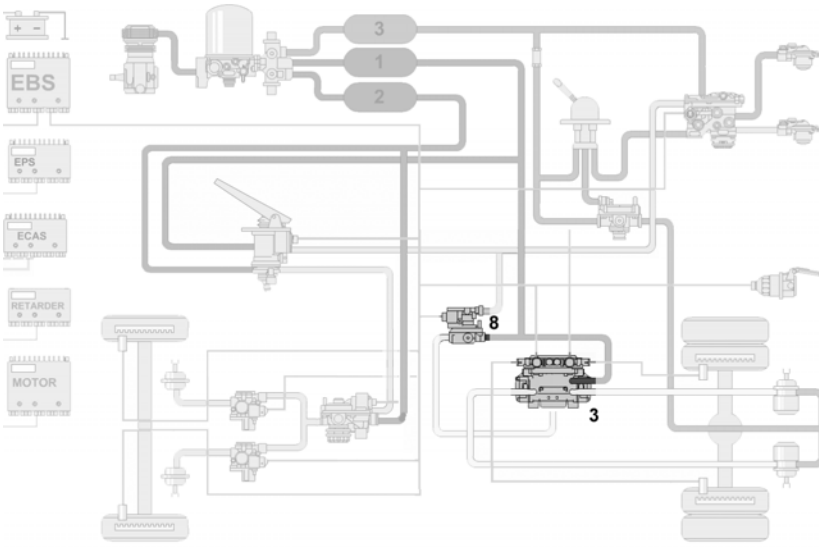
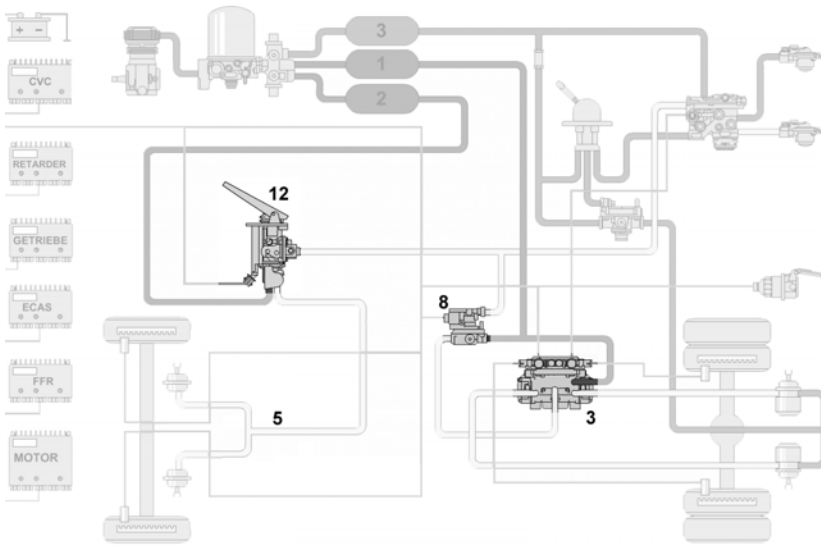
- from 4S/3M- to 6S/6M-System
- Implementation of backup
- Trailer control strategy
- Electronic interfaces
- ABS control

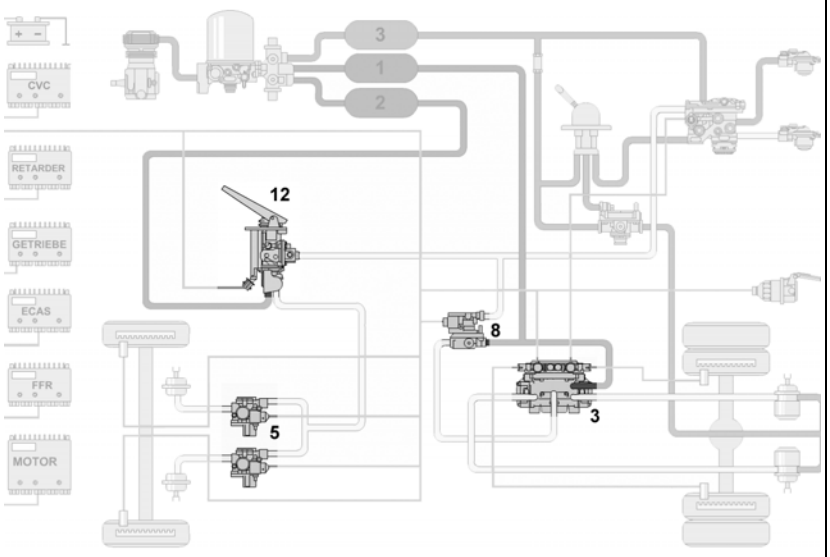
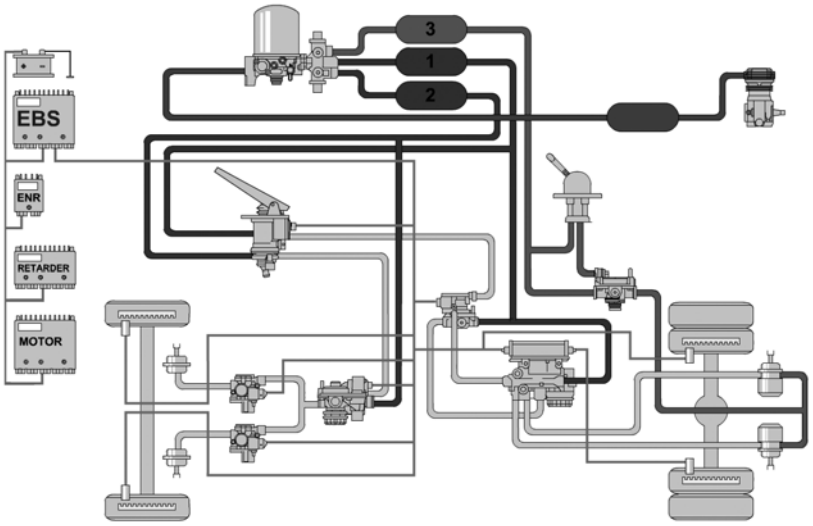
4.1 Development of EBS variants

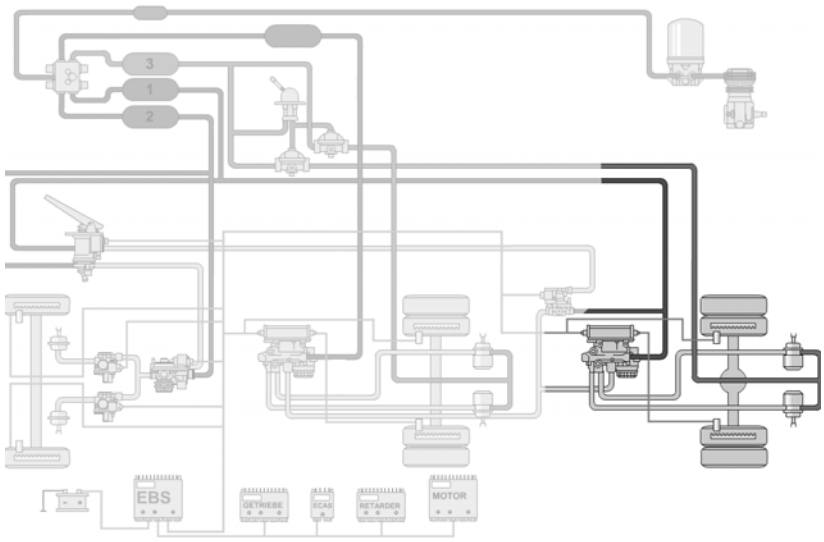
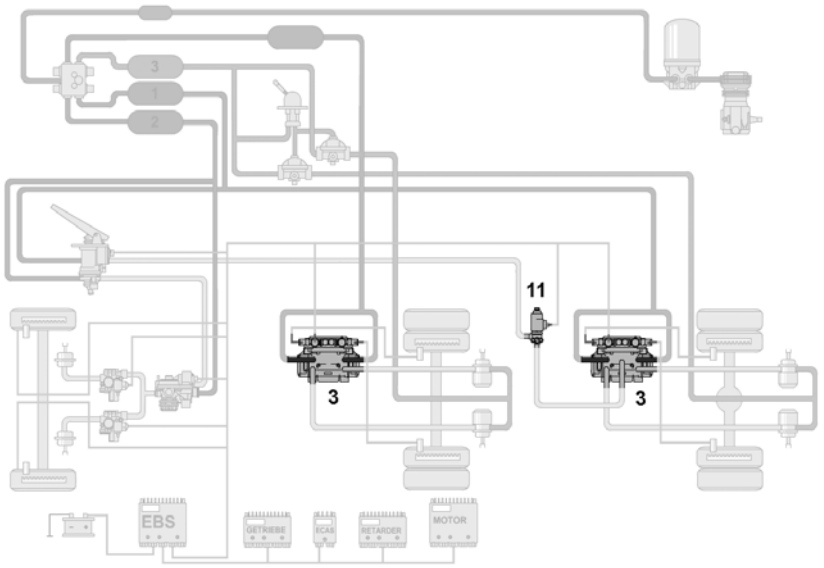
System variant	Diagram
[A] EBS 1A (for Mercedes: EPB) Truck, 1996 – 2000 WABCO started EBS series production with this system variant in cooperation with Mercedes in 1996. The brake signal transmitter (6) has five pneumatic connections and the backup valve (8) also has five connections. The number of lines was reduced in later versions because, among other changes, the brake signal transmitter and the backup valve were no longer connected by means of a separate compressed air line. In contrast to the systems for other manufacturers, the vehicle data bus is an IES bus in compliance with Mercedes standards.	 fig. [A] EBS 1A / EPB, Truck (1) EBS central module, (2) Trailer control valve, (3) axle modulator, (4) prop. relay valve, (5) ABS solenoid valve, (6) brake signal transmitter, (7) relay valve, (8) backup valve rear axle

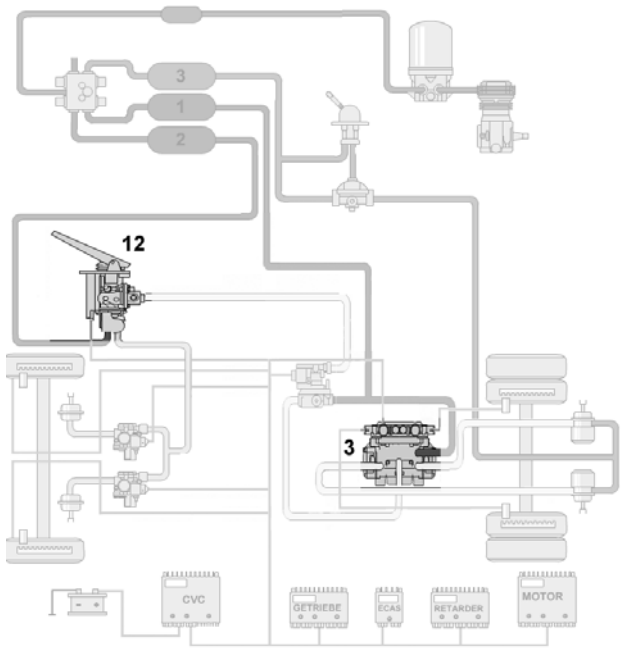
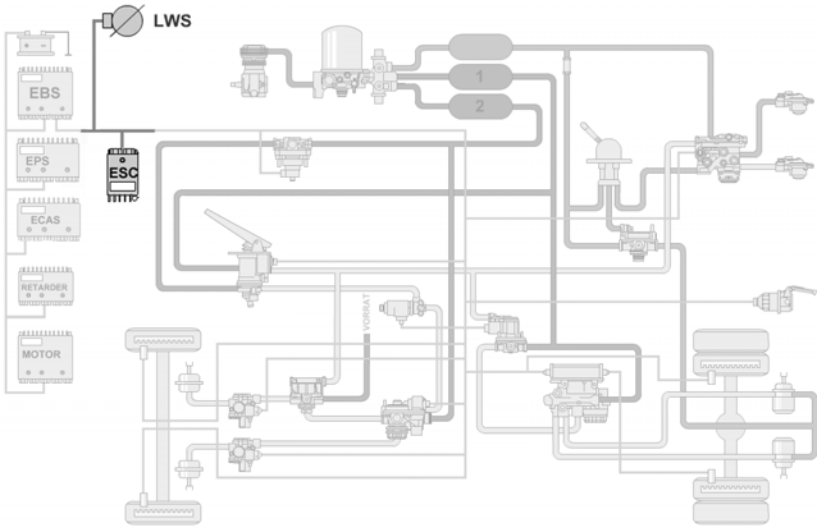
System variant	Diagram
[B] EBS 1A (for Mercedes: EPB) Semitrailer tractor, 1996 – 2000 Two special valves were installed for the relatively light semitrailer tractor from Mercedes. The pressure limiting valve (9) prevents the front axle overbraking when driving without a trailer, and the secondary brake valve (10) ensures the minimum braking performance in the event of a front axle braking circuit failure. In contrast to the systems for other manufacturers, the vehicle data bus is an IES bus in compliance with Mercedes standards. The design of the rest of the system is identical to the version for trucks (see [A]).	 fig. [B] EBS 1A / 1B, semitrailer tractor
[C] EBS 1B (for Mercedes: EPB) Semitrailer tractor, 2001 – 2004 In combination with the option of ESC (see [O]), an advanced EBS was also installed at Mercedes as of 2001. The brake bus works in this system at 500 kBit/s. In this version specifically for Mercedes, the vehicle data bus also operates in accordance with IES standards.	
[D] Euro EBS / EBS 1B (for DAF, Iveco) Truck, 2000 – 2004 The diagram shows the first major advancement in EBS. In the Euro EBS, the brake signal transmitter (6) now only has two pneumatic control lines and the backup valve (8) only one pneumatic control port. There is no backup valve (8) fitted on the rear axle in the version for semitrailer tractors. In contrast to the previous versions for Mercedes, the vehicle data bus is manufactured according to the SAE standard. The brake bus works in this system at 500 kBit/s. The electronic stability control (ESC) (see [O]) has not been installed here.	 fig. [D] Euro EBS, Truck

System variant	Diagram
[E] EBS 1B for Mercedes Actros MP II Truck and semitrailer tractor, from 2004 The brake signal transmitter also has only two pneumatic control lines in this system designed especially for the Actros MPII. An installed pressure limiting valve (9) prevents the front axle from being overbraked when driving empty. The secondary braking valve (10) ensures minimum braking performance when the braking circuit for the front axle malfunctions. A new feature is the relay stop valve (11) on the front axle. The truck and semitrailer tractor have a backup valve (8) on the rear axle, with only one pneumatic connection (unlike earlier versions). The vehicle data bus operates in compliance with IES standards. The brake bus operates at 500 kBit/s, and ESC (see [O]) may already be installed in semitrailer tractors.	 fig. [E] EBS 1B, Actros MP II
[F] EBS 1C, Actros MP II Evolution Truck and semitrailer tractor, from 2006 Mini brake signal transmitter with 4 pneumatic connections, axle modulator (3) with integrated backup valve and dual brake bus on the rear axle, 2:1 pressure reducing valve (8) upstream of the axle modulator on the rear axle, backup shut-off valve on the front axle, vehicle data bus as per Mercedes standard (IES bus), 2nd brake bus at 500 kBit/s, special valves for Mercedes semitrailer tractor, steering wheel angle sensor (SAS) on the IES bus	 fig. [F] EBS 1C, Actros MP II Evolution

System variant	Diagram
[G] EBS Evolution / EBS 1C (e.g. DAF) Truck, since 2004 WABCO has been offering the EBS Evolution since 2004. This version has a lighter, more compact axle modulator (3). In this version the brake bus also operates at 500 kBit/s and the vehicle data bus operates according to the SAE standard. There is no backup valve (8) fitted on the rear axle in the version for semitrailer tractors. Electronic Stability Control (ESC) (see [O]) can be fitted.	 fig. [G] EBS Evolution, Truck
[H] EBS Compact / EBS 2A (e.g. MAN) Truck 4S/3M System version, since 2005 EBS Compact has also been on the market since 2004. The system combines the brake signal transmitter, the proportional relay valve and the central module into the central brake unit (12). When the brake pedal is actuated, the CBU creates an electronic signal value as well as a pneumatic backup pressure. For the braking pressure on the front axle, the CBU switches off the backup pressure and controls the required braking pressure electronically when the electronic regulation is functioning properly. The lighter and more compact axle modulator (3) version was installed as with EBS Evolution [G]. There is no backup valve (8) fitted on the rear axle in the version for semitrailer tractors. EBS Compact in the 4S/3M model is a system version for light trucks and articulated trucks. Instead of the ABS solenoid valve, the CBU (12) assumes control of the front wheels with active ABS, in which case both wheels are controlled equally – Modified Axle Regulation (MAR). This is the reason why no ABS solenoid valves are fitted in this position (5). The vehicle data bus operates according to the SAE standard.	 fig. [H] EBS Compact, Truck, 4S/3M

System variant	Diagram
[I] EBS Compact / EBS 2A (e.g. Iveco, MAN) Truck 4S/4M system version, since 2004 The system is similar to the 4S/3M model (see [H]). There are two ABS magnet control valves fitted in position (5). In the event of an ABS control process, the front axle wheels are controlled independently of one another via the ABS solenoid valve (MIR). There is no backup valve fitted on the rear axle (8) in the version for articulated trucks. The vehicle data bus operates according to the SAE standard. Optionally, Electronic Stability Control (ESC) (see [M]) may also be fitted in combination with EBS Compact in 4S/4M models.	 fig. [I] EBS Compact, Truck, 4S/4M
[K] EBS 1B / Euro EBS for buses 2000 – 2007 (e.g. Neoplan, Solaris) The figure shows EBS for buses in the 4S/4M version. The construction is the same as for the towing vehicle EBS with no trailer control valve. Additionally, ESC (see [O]) may already be fitted in this version. Customer specific work on the data bus can be carried out either according to the SAE or the IES standards.	 fig. [K] EBS 1B, buses 4S/4M

System variant	Diagram
[L] EBS 1B / Euro EBS for buses 2000 – 2007 (e.g. Neoplan, Solaris) The structure of this EBS variant is similar to that of variant [K], only in this case two axle modulators are installed in the 6S/6M version for three-axle or articulated buses.	 fig. [L] EBS 1B, three-axle or articulated buses
[M] EBS Evolution / EBS 1C for buses from 2007 (e.g. Solaris, VDL Bus) The structure of this EBS variant is similar to the [L] model. Instead of the first generation axle modulator, however, the new axle modulator 2 (3) is fitted. A 3/2 directional control valve (11) may also be fitted in the bus instead of a backup valve. The data bus operates as the customer requires, according to the SAE standard. The brake bus operates at 500 kBits/s. Electronic Stability Control (ESC) (see [O]) can be installed. For Evo Bus a variant with IES bus and axle modulator 3 with dual brake bus (EPB for bus) is available.	 [M] EBS 1C, three-axle or articulated buses, 6-channel, 2nd generation

System variant	Diagram
[N] EBS Compact for buses from 2004, (e.g. NEOMAN) EBS compact has been fitted in buses since 2004. The system combines the brake signal transmitter, the proportional relay valve and the central module into the central brake unit (12). When the brake pedal is actuated, the CBU creates an electronic signal value as well as a pneumatic backup pressure. For the braking pressure on the front axle, the CBU switches off the backup pressure and controls the required braking pressure electronically when the electronic regulation is functioning properly. The lighter and more compact axle modulator (3) version was installed as with EBS Evolution [M]. A 3/2 directional control valve can also be fitted in the bus instead of a redundancy valve. Customer specific work on the data bus can be carried out either according to the SAE or the IES standards. As the brake bus already operates at 500 kBits/s, an ESC (see [O]) may also be fitted.	 fig. [N] EBS Compact, buses
[O] ESC as an additional option Electronic stability control ESC can be fitted with some systems as an option. For this purpose, the steering wheel angle sensor (SAS) and the ESC ECU are connected to the electronic system (see chapter 3.4 “Electronic Stability Control ESC”, page 9). Retrofitting the ESC is not possible at present.	 fig. [O] Electronic Stability Control ESC

4.2 EBS in buses

Following its application in commercial vehicles, the WABCO EBS will now be applied in buses. The system construction is principally the same. The laden-unladen ratio on the rear axle is lower in buses than is the case with trucks or semitrailer tractors. This is why the backup pressure on the rear axle in buses is controlled at a ratio of 1:1 and not reduced to a ratio of 2:1 as it is in trucks or in semitrailer tractors.

In systems where second generation axle modulators are used, a 3/2 control valve can also be fitted instead of a backup valve because a relay function is already integrated into these axle modulators.

EBS in three axle or articulated buses is executed through two axle modulators. Circuit diagrams can be obtained from the appendix to this brochure or in our INFORM product database on the internet (www.wabco-auto.com, Index word: "circuit diagram").

Otherwise the EBS regulation in buses is carried out using the usual EBS brake management functions, whereas the braking behaviour is specifically matched to the circumstances in the bus. Put simply, the roll brake function in the bus has been modified into a halt brake.

Halt brake

As soon as the bus driver operates the halt brake or actuates the door control, the request "actuate the halt brake" is sent to the EBS ECU via the CAN Bus or the halt brake switch. This causes a braking pressure actuation of e.g. 2 bar. Using the proportional relay valve and the axle modulator(s), the brake cylinders are pressurised with the respective braking pressure on the front and rear axle(s). With some vehicles, only the brake cylinders on the drive axle are filled with braking pressure.

If the halt brake command is deactivated via the switch or via the door ECU and the accelerator pedal is then activated, the "halt brake" command is cancelled via the EBS ECU.

4.3 Certificates

Reports and legal guidelines exist for the application of EBS. The following reports and legal texts are available for download as a PDF file from our website at www.wabco-auto.com:

- EBS, Report EB 116.0 /116.0E
  EBS, Test Report EB 116.0 /116.OE
- EBS 2 Report EB 147.1E
  EBS 2, Test Report EB 147.1 E
- Legal guidelines, ECE R13

Reports on the Internet

– Open the WABCO website www.wabco-auto.com.

– Click on the "Quick Access" area in the INFORM product catalogue and then on "Index".

– Enter the word "Reports" into the search field.

– Select "EBS, Reports" and click on "Documents".

– Now select your language and open or download the available reports to your PC.

5 Components

This component description details the properties of basic components. You can find further details by entering the product number in the INFORM product database on the Internet (www.wabco-auto.com).

Information on order numbers and interchangeability of the components see chapter 7.3 “Overview of spare parts”, page 35.

5.1 Brake signal transmitter (480 001/002 … 0)

The brake signal transmitter receives the delay request from the driver via the brake pedal, then produces the electrical signals and pneumatic pressures for charging and venting the actuators.

Brake signal transmitter

Brake signal transmitter, e.g. fitted in IVECO

smaller brake signal transmitter

The figure shows the mode of operation for a brake signal transmitter with two control lines (connections 21 and 22). In the EBS versions [A] and [B] there is a third pneumatic line that is separately run from the brake signal transmitter to the backup valve. This so-called load/empty connection (4) is situated between (21) and (22).

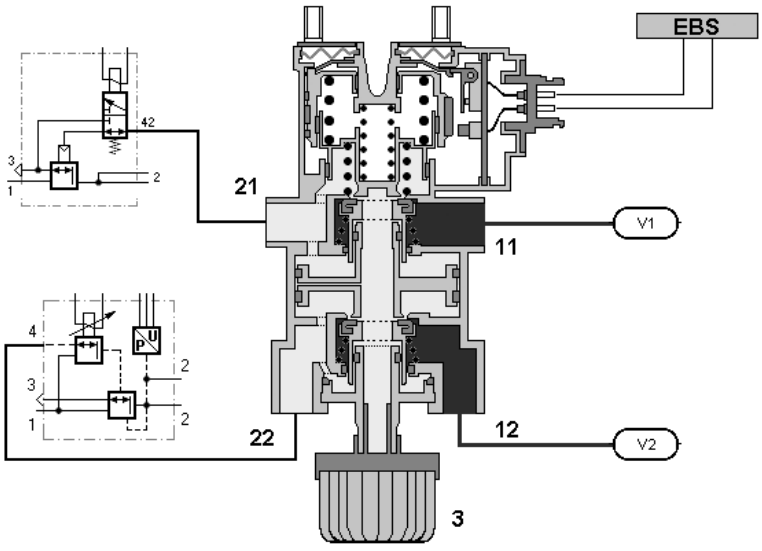


fig. Mode of operation for the brake signal transmitter with no connection 4

The device has a dual-circuit electronic and a dual-circuit pneumatic structure.

When actuating the brake pedal, at first two electrical switching signals are created within a leeway. These are released to two individual switches that are allocated to

the electronic circuit and are used for the operational discharge and monitoring of the braking procedure. The switching operation is carried out mechanically. After driving through the leeway, the pedal travel is recorded by two sensors and is emitted from the switch as a Pulse Width Modulated signal (PWM).

The pneumatic part of the brake signal transmitter consists of a slide-operated two-circuit foot brake valve in a tandem construction. After the switch and first linear transducer signals have been transferred, the pneumatic backup pressures in circuits 1 and 2 are controlled. If one of the circuits malfunctions, the other electronic circuit and the two pneumatic circuits remain functional.

5.2 Central module (446 130 0.. 0)

The central module controls and monitors the electronically controlled braking system. It determines the vehicle's nominal delay from the signals received by the brake signal transmitter. The set delay and wheel speed that are measured through the speed sensors create a collective input signal for the electro-pneumatic control. The central module calculates the nominal pressure value for the front axle, the rear axle and for the trailer control valve from the input signal.

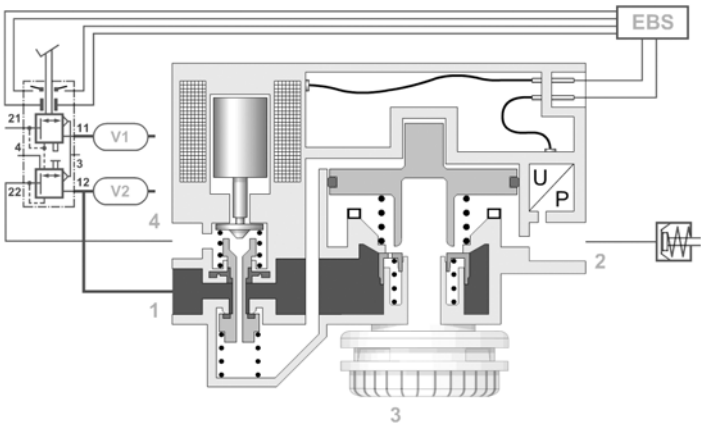
For this purpose it compares the nominal pressure value with the measured actual value. The central module regulates the current difference on the front axle using the proportional relay valve. The trailer control pressure output is achieved in a similar manner. The central module sends the set default value for the axle modulator via the EBS system bus.

Moreover, the wheel speeds are evaluated by the central module so that, in the event of locking, ABS control can be carried out by modulating the braking pressure in the brake cylinders.

Electrical braking systems for trailers are actuated via a data interface as per ISO 11992. The central module communicates with other systems on the towing vehicle such as the motor control or the retarder using a vehicle data bus.

5.3 Proportional relay valve (480 202 00. 0)

The proportional relay valve is used in the electronically controlled braking system to modulate the braking pressure on the front axle.



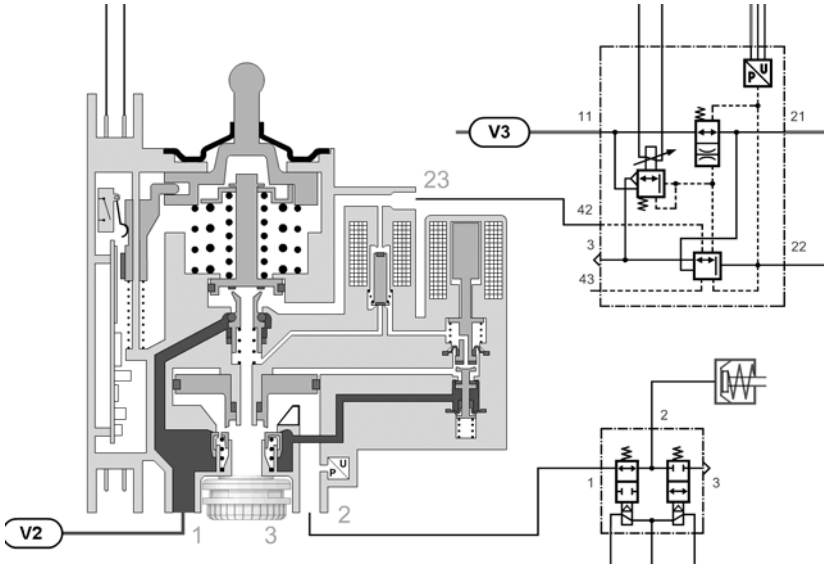
It comprises the proportional solenoid valve, relay valve and pressure sensor. The electrical actuation and monitoring are carried out by the central module.

In the proportional relay valve, the electronically received nominal values are implemented using a proportional solenoid valve in a control pressure for the relay valve. The proportional relay valve output pressure is proportional to this pressure.

The pneumatic drive on the relay valve takes place via the brake signal transmitter pneumatic circuit. This backup pressure is added to the electro-pneumatic pressure in the EBS versions [A] to [E] and the version [I] for buses. The proportional relay valve matches the added pressure to the nominal value before being set. In case of a backup, the complete relay pressure is controlled this way.

5.4 Central Brake Unit CBU (480 020 0.. 0)

The CBU is a combination of brake signal transmitter, central module and proportional relay valve and replaces these three components in the EBS Compact version ([H], [I] and [N]). This is constructed as one pneumatic and one electronic circuit.



The CBU contains superior brake management functions for the front axle and the rear axle control and evaluates the sensor signals.

As the driver actuates the pedal, an electrical signal value and a pneumatic backup pressure are created, controlling the required front axle braking pressure by itself.

The pneumatic backup pressure for the front axle will now be deactivated via a 3/2 way valve integrated in the CBU through the electronic pressure regeneration as with the rear axle backup.

With a 4S/3M system, the integrated proportional relay valve on the CBU takes over the ABS function as per the principle of the Variable Axle Control (VAR).

With the 4S/4M system, control is carried out using two ABS solenoid valves as per the principle of the Modified Individual Control (MIR).

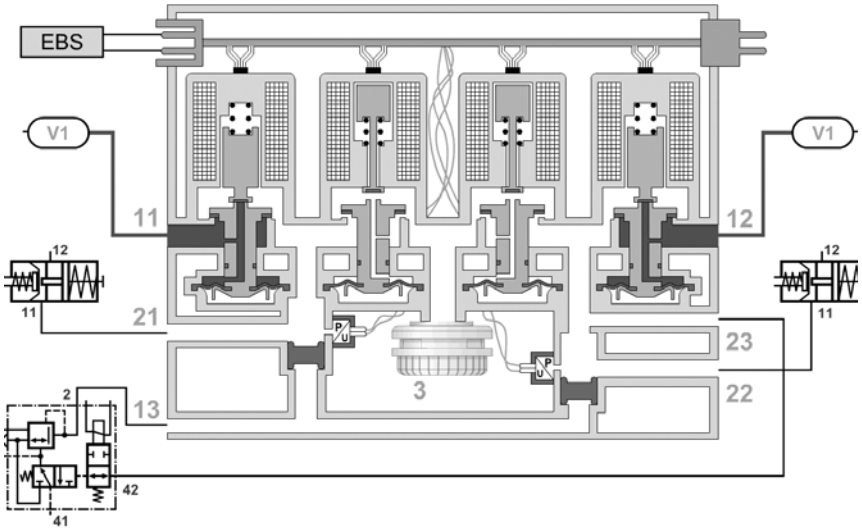
! The CBU can also be supplied in a version with two connectors on the top of the housing component.

5.5 Axle modulators (480 103/104/105 … 0)

WABCO has developed and fitted three axle modulators since EBS was introduced into serial production in 1996.

5.5.1 Axle modulator, 1st generation

The axle modulator controls the brake cylinder pressure on both sides of a single or dual axle. It contains two independent pneumatic pressure control channels (channels A and B), each containing one inlet and one outlet valve, plus one braking pressure sensor, sharing one electronic control unit.



The axle modulator records the wheel speed using speed sensors, evaluates it and sends it to the central module, which subsequently calculates the nominal pressure. ABS control is applied by the axle modulator. In case of wheel lock or wheel spin, the axle modulator modifies the nominal pressure.

Provision is made for connecting two sensors to detect brake lining wear.

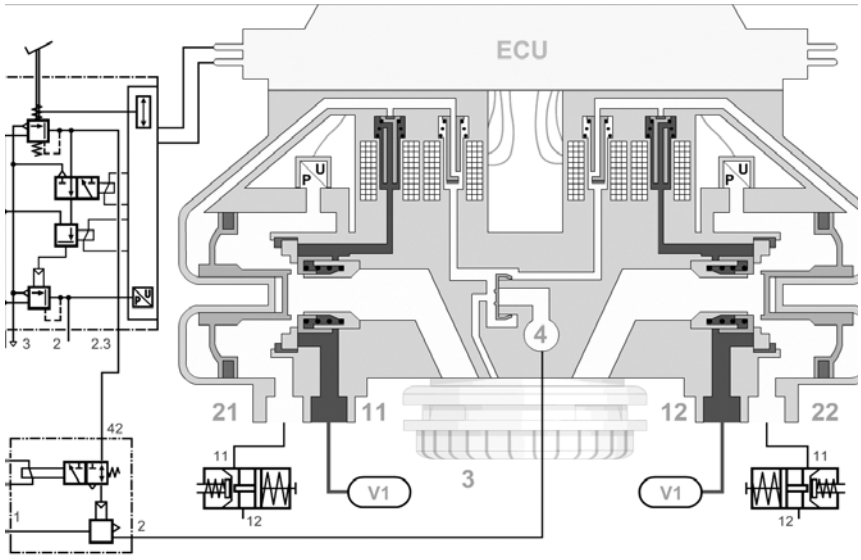
The axle modulator for the drive axle comes with an additional connection for the redundant pressure control circuit for the brake signal transmitter. A two-way check valve on each side drives the higher pressure (electro-pneumatic or redundant) to the brake cylinder. The axle modulator for the additional axle does not have three two-way valves.

6S/6M systems can be constructed with two axle modulators for controlling the individual wheels.

- Communication at 250 kBits/s
- with proportional solenoid valve
- applied in [A, B]
- Versions [C to E] operate at 500kBit/s

5.5.2 Axle modulator, 2nd generation

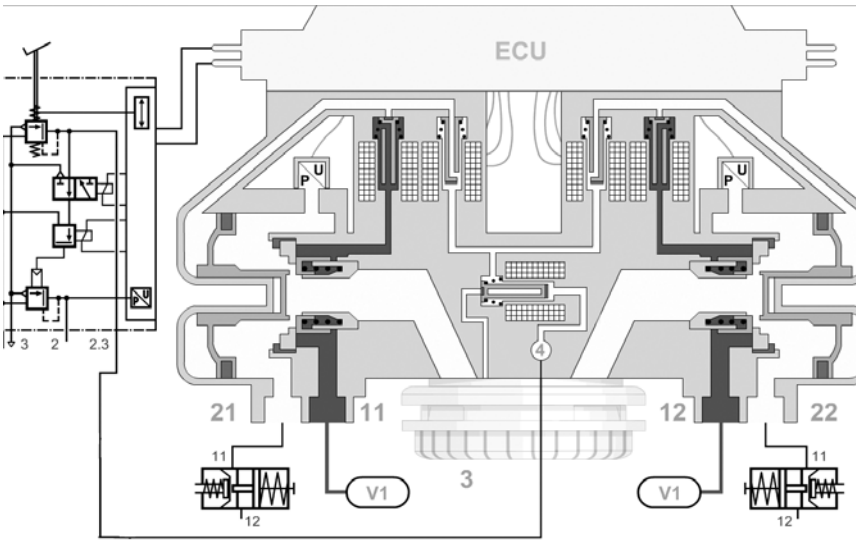
A modern, more compact and more powerful axle modulator was introduced with EBS Evolution [G] system in 2004. With this system the EBS ECU and axle modulator communicate at 500 kBit/s.



This axle modulator fulfils the same functions as the first axle modulator generation. However, this operates with a clocked solenoid valve.

- Communication at 500 kBits/s
- with a clocked solenoid valve (cf. EBS trailer modulator)
- applied since 2004
- Communication at 500 kBits/s

5.5.3 Axle modulator, 3rd generation

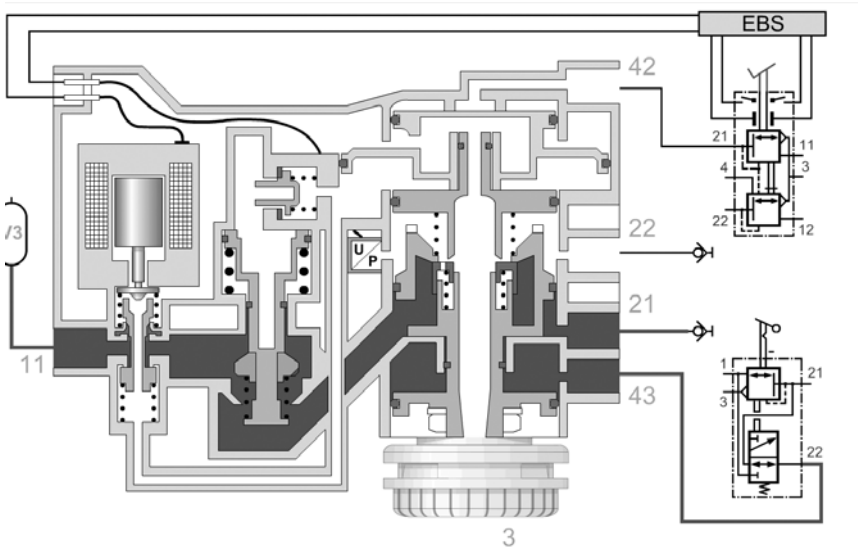


The third generation axle modulator operates like the second generation axle modulator in principle. The plug forms have been slightly modified in some cases and a backup valve has been flanged.

- Communication at 500 kBits/s
- dual EBS brake bus
- with a clocked solenoid valve (cf. EBS trailer modulator)
- used from 02/2006 for Mercedes and EvoBus

5.6 Trailer control valve (480 204 00. 0)

The trailer control valve controls the braking behaviour of the trailer using an electro-pneumatic circuit and a pneumatic circuit. It receives the nominal values from the EBS ECU.



The trailer control valve consists of a proportional solenoid valve, a relay valve, a breakaway emergency valve and a braking pressure sensor. The control current specified by the ECU is transformed via the proportional solenoid valve into a control pressure for the integrated relay valve.

Pneumatic actuation of the relay valve is effected by means of the backup pressure from the brake signal transmitter and the output pressure from the hand brake valve.

! The trailer control valve does not require predominance setting.

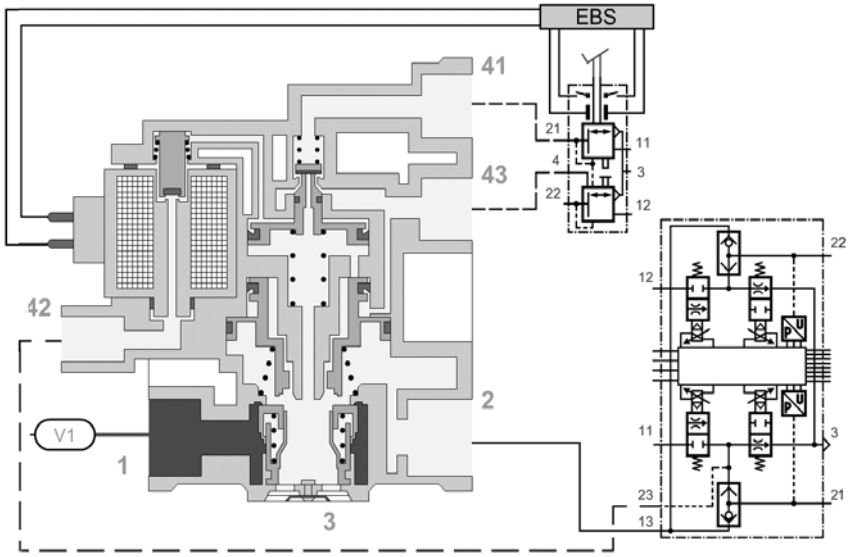
5.7 Backup valve (480 205 … 0)

The backup valve is used to supply air to and remove air quickly from the brake cylinder on the rear axle in case of backup, and comprises several valve units which must fulfil the following functions as a minimum:

- 3/2 directional control valve function to switch off the pneumatic connection with intact electro-pneumatic brake circuits
- Relay valve function, to improve the response times of the backup system
- Pressure retention to start the synchronisation of the pressure control on the front and rear axles if the electro-pneumatic circuit malfunctions.
- Pressure reduction to avoid overbraking of the rear axle as far as possible in the event of a backup (reduction approx. 2:1).

The backup valve installed in the Mercedes Actros also has a 2/2 way valve that is energised in the event of ABS. This prevents involuntary drive through of the rear axle backup pressure during ABS control.

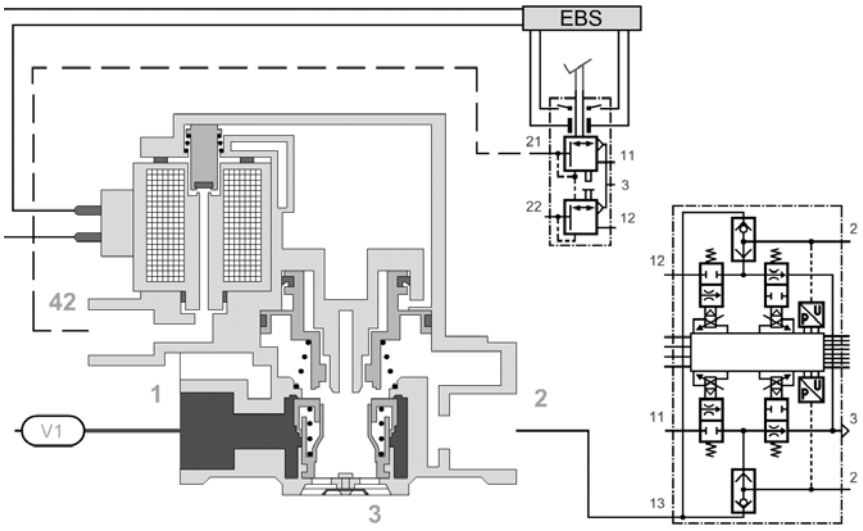
fig. Backup valve with five connections (Mercedes)



Backup valves are installed on the rear axle so that the pneumatic backup pressure can be mechanically deactivated. The figure above shows the valve variant with 5 connections as used to be installed at Mercedes.

With later system designs, the course of the pneumatic lines were slightly modified so that only three compressed air connections were needed on the backup valve.

fig. Backup valve with three connections



5.8 3/2 directional control valves (472 17. … 0)

fig. 3/2 directional control

With EBS functions that already operate with the second generation axle modulator and so with the integrated relay function, the backup can be controlled at a ratio of 1:1. This is the reason why the pneumatic rear axle backup in this version can also be controlled via a 3/2 directional control valve. This technique is presently used in buses.

5.9 Pressure reducing valve (473 303 000 0)

The pressure reducing valve is a mechanically operating pressure ratio valve and is used in the 1C [F] EBS system. It reduces the backup operating pressure controlled by the central module and conducted to the axle modulator. The pressure is reduced according to a predefined ratio of around 2:1.

In combination with the flanged-on solenoid valve on the axle modulator, the pressure reducing valve replaces the backup valve on the rear axle.

The reduction ratio takes into account that, during a backup event, vehicles with a low load portion on the rear axle, as is the case with two-axle semitrailer tractors for example, can be easily graduated up to the locking limit during braking and do not get into critical driving situations (even though not protected by ABS). Vehicles with a particularly high portion of load on the rear axle still have sufficient braking force reserves.

5.10 ABS solenoid valve

The ABS solenoid valves are fitted on the front axle. The valves are open during normal driving conditions and control the activated pressure to the brake cylinder from the proportional solenoid valve. When the ABS is activated, the inlet valves close and do not let any new pressure into the brake cylinder. If the tyres still lock, pressure is released through an additional outlet in the valve.

Different numbers of ABS solenoid valves are installed, depending on the system variant. For example, there are four speed sensors and two ABS solenoid valves fitted in a 4S/4M system. Two ABS solenoid valves are additionally integrated in the axle modulator to control the rear axle. There are also systems where the pressure of both front axles are controlled via a CBU (e.g. 4S/3M).

5.11 Rotational speed sensor (441 032 … 0)

The rotational speed sensor permanently calculates the actual wheel speed via a pole wheel and transfers the data to the EBS, which then calculates the actual speed by means of the reference values. If there are any deviations to the normal condition, the system intervenes in the regulation of the brake and motor controls.

5.12 Brake lining wear indicator/sensor (BVA)

The brake lining wear indicator consists of an electrical contact that lies within the brake lining. As soon as the lining is worn, the wire contact is broken and the electrical circuit is interrupted. The ECU signals to the driver that the brake linings must be replaced.

Some manufactures install an alternative brake lining wear sensor that shows the driver the thickness of the brake lining. Brake lining wear sensors can be retrofitted by WABCO. You can find more information on this from your local WABCO partner.

! Analogue wear sensors are necessary for the "Wear Control" EBS function. The wear differences between the front and rear axle during operation are recorded through these sensors.

5.13 ESC components

ESC is easily integrated when installing EBS, but retrofitting is not possible. You will find a schematic diagram of ESC in Kapitel 4 „System variants“ under [O].

A prerequisite for the installation of ESC is a CAN data bus system with at least 500 kBit/s and an EBS ECU that can enable ESC. In addition to the EBS components, an ESC control module and a steering wheel angle sensor must be installed.

The overall sensing technology in the ESC system comprises:

- ABS sensors - already required for EBS - that measure the wheel speed
- steering wheel angle sensor[1)] that measures the steering wheel's angle of rotation
- the EBS ECU, which evaluates the signals from the steering wheel angle sensors and also assumes control of various ESC functions for fault detection and diagnosis
- the ESC control module into which the lateral acceleration and yaw rate sensors are integrated. At this point the sensor signals are immediately evaluated and are compared with nominal values.

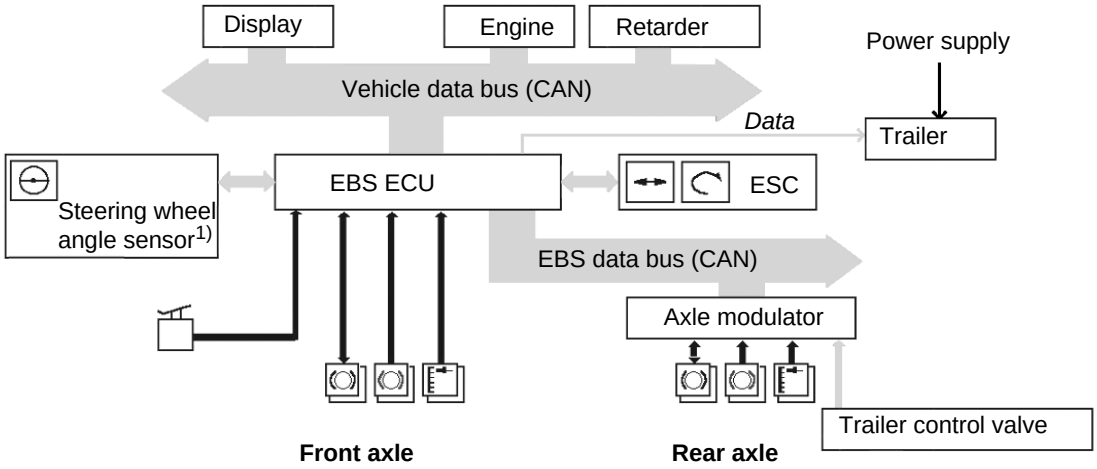


fig. Connecting the ESC onto the Electronic Braking System from version 1C

[1)] In some more recent braking systems, the steering wheel angle sensor is connected directly to the vehicle data bus and not the EBS data bus.

5.13.1 ESC control module (446 065 … 0)

The ESC control module processes the data from the yaw rate, lateral acceleration and steering wheel angle sensors and communicates with the EBS control unit via the EBS data bus. The yaw rate and lateral acceleration sensors are integrated into the ESC control module.

Besides the measurement data from the sensors, the ESC module also receives other data, such as the wheel speeds, for evaluating the current status of the vehicle from the EBS ECU.

In the event of regulation, the ESC module sends the regulation information to the EBS ECU. The necessary interventions are then initiated in the engine, gearing or retarder control.

! If there are simultaneous requests for limiting engine output from the EBS, which is the case with activated anti-slip regulation for example, the request with the lowest torque has priority.

The ESC module is always mounted near to the vehicle's centre of gravity to enable correct measurement by the yaw rate and lateral acceleration sensors.

5.13.2 Steering wheel angle sensor (441 120 … 0)

The steering wheel angle sensor is installed between the steering wheel and the steering column.

It captures the current angle of rotation at the steering wheel. The course desired by the driver is computed from the angle of rotation at the steering wheel, the vehicle speed derived from the wheel speeds and the speed differences at the wheels (left and right).

6 Fault detection and diagnosis

6.1 Functions for fault detection

Various functions for fault detection are integrated into the EBS. These are intended to minimise the effect of system malfunctions and inform the driver of functional limitations. Some of these functions correspond to the usual ABS monitoring functions and some are EBS specific.

Nominal value sensing

The brake signal transmitter provides two sensor and two switch signals. The (pulse-width modulated) sensor signals are checked to see whether they conform with the authorised values, and for mutual deviations. The digital switching signals are checked for correct switching states.

braking pressure sensoring for the front and rear axle and trailer control valve

The analogue pressure sensor's signals in the pressure control circuits are checked to see whether they correspond to the authorised values.

! The cabling for the two rear axle sensors cannot be accessed from outside, since it is an internal axle modulator cabling.

Wear monitoring on the front and rear axle.

The analogue signals of the wear sensors are checked to see whether they correspond to the admissible values.

Monitoring the EBS specific solenoid valves

The continuous solenoids in the proportional relay valve and the trailer control valve, where the pressure is proportional to the magnetic flow, are monitored for their correct control condition. The rear axle backup valve's solenoid switch is monitored to see that control takes place correctly.

The rear axle's inlet and discharge solenoid valves are located inside the axle modulator. The solenoid cables are not accessible from outside.

Monitoring the braking pressure control

The electronically controlled braking pressure and pneumatically redundant pressures are monitored with following functions:

- A test is carried out to see if a minimum braking pressure with a defined magnetic flow is present on the front axle or the trailer control valve.
- In normal braking processes the measured braking pressure on the left and right sides of the rear axle must almost be equal. If the braking pressure deviation exceeds the admissible value, a fault is reported.
- In certain situations when the vehicle is stationary or the parking brake is in stop position, electronic control of the braking pressure on the front and rear axle is prevented. If the driver now actuates the brake pedal, the brakes on front and rear axle are controlled via pneumatic backup. If the front axle braking pressure exceeds a certain value, the rear axle must have a specified minimum pressure. If this is not the case, a fault is reported.
- Normally, pneumatic 3/2 relay pressure control in the rear axle is prevented by the backup valve. If controlling is no longer possible because of a fault, the rear axle braking pressure cannot be reliably reduced in the ABS controls. The reason for this is that the ABS compatible rear axle redundancy pressure can enter the rear axle brake cylinder. The EBS reports a fault in this situation.

Monitoring the data transmission

EBS monitors the data transmission between

- the EBS control units such as the central module, CBU, axle modulator (system bus)
- the EBS and other system control units (vehicle bus)
- the towing vehicle and an electronically braked trailer

If communication is not possible or is interrupted, a fault is reported.

Possible function shut-downs

Following a fault detection, certain functional fields in the EBS are generally deactivated. Functions not impaired by the failure are maintained. The term "emergency mode" is used for an EBS drive with limited functions.

Operating without ABS function:
Depending on the type of fault, the ABS function is deactivated on an individual wheel, an axle or on the complete vehicle.

Operating without ASR function:
The anti slip regulation can be switched off completely or partially. Complete deactivation means that both the braking system and the engine control unit are deactivated. Partial deactivation means that only the braking system is deactivated.

Pressure control / auxiliary pressure control:
Normally, braking pressure control requires braking pressure sensor signals. If this signal is no longer available, electrical braking pressure can be produced using auxiliary means. In this case, we talk in terms of pressure control operation or auxiliary pressure control. However, the accuracy of this pressure production is limited, compared to error-free pressure control.

Backup operation:
If electrical pressure control becomes impossible, the corresponding axle is braked using the pneumatic backup pressure.

6.2 Fault display

Detected faults are transmitted by the EBS central module to the instrument panel display via the vehicle data bus, and displayed there.

Alternatively, in vehicles without such a display, faults can also be reported via a red and yellow warning light. A separate ASR light then indicates to the driver the ongoing ASR control activities.

Red warning lamp	Yellow warning lamp
System switched off	Minor fault: e.g. failure of a sensor (emergency mode)

6.3 ESC fault detection

Faults in the ESC do not have any effect on the braking system. If a fault occurs, the ESC function is deactivated separately and the EBS functions remain active. However, to ensure preferably optimum availability of the ESC, deactivation is carried out in a hierarchical manner depending on the error gravity. Thus for example roll stability control stays active despite a fault in the yaw rate sensor.

! The driver is informed of faults in the ESC by a warning lamp.

The ESC system diagnosis and the ESC parameters are integrated into the diagnosis of the EBS system and are therefore processed by the EBS ECU.

6.4 Diagnosis

> ! The diagnostic software is used to actuate the vehicle components. This may cause the vehicle to move. Therefore you need to make sure the movement causes no danger before you start the diagnostics.

The diagnosis is carried out using a PC or laptop that is connected to the vehicle electronics via a diagnostic interface. The WABCO diagnostic software must be installed on the laptop. This software is available in different languages for different EBS system designs.

The diagnostic software and current measuring data can be obtained using the diagnostic program. The error is described when malfunctions occur.

The diagnosis with the diagnostic software can be performed by any user. If parameters are to be changed however, authorisation is required (PIN). You can obtain this PIN through relevant training at the WABCO University. More information on WABCO University training courses can be found on the Internet at www.wabco-university.com.

6.4.1 Hardware

PC / Laptop
WABCO offers you a workshop-suitable, impact- and contamination-resistant laptop. This "Toughbook" with preinstalled diagnostic software can be obtained from WABCO.

However, the diagnostic software will run on all standard PCs with a Microsoft Windows 2000 operating system or higher.

There are no other special hardware requirements. The PC should however have a free USB connector or a free serial connector (COM interface, 9-pin) to connect the diagnostic interface.

Diagnostic Interface Set
To set up the diagnosis, the WABCO Diagnostic Interface Set (order number 446 301 030 0 - USB connection) is required. The set contains the diagnostic interface and a USB connecting cable to the PC or laptop.

The old diagnostic interfaces with serial connection (446 301 021 0) and USB connection (446 301 022 0) can still be used.

6.4.2 Diagnostic connection

A special diagnostic cable is required to create a connection between the computer, the diagnostic interface and the vehicle. This cable differs according to the vehicle manufacturer and type and is supplied by WABCO. You can find more details

concerning this from your local WABCO partner or in our brochure "Diagnosis - Hardware/Software" (815 ..0 037 3).

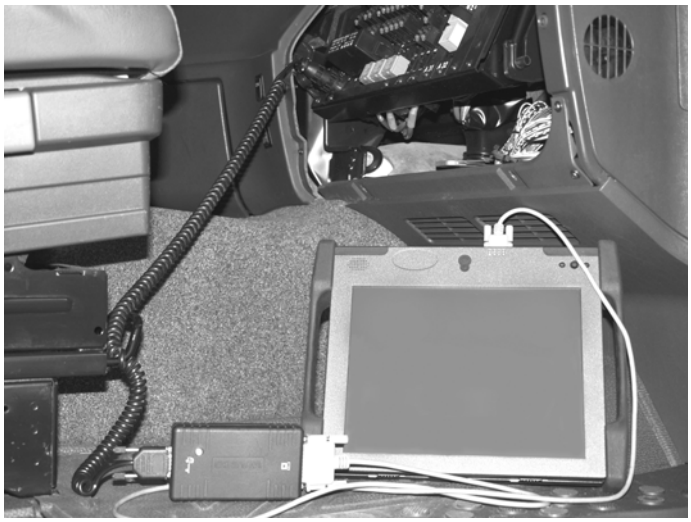


fig. Diagnostic connection via diagnostic interface to the PC

The diagnostic socket is usually situated in the driver's cabin. Contact your vehicle manufacturer to find out where the connector can be found in your vehicle.

6.4.3 Diagnostic software

There are three ways to obtain the diagnostic software:

- Offline as a USB stick version
- Online as a single download
- As a part of a WABCO system diagnostic subscription

For diagnosing multiple WABCO systems, WABCO offers you four different diagnostic software subscriptions via the Internet. These contain numerous diagnostic programs at one very low price.

Go to www.wabco-auto.com/sd on the Internet. There, you will find further information and can order the diagnostic software in your language and to load onto your PC.

Operating the diagnostic software

After you have connected the vehicle, diagnostic interface and notebook to one another, start the diagnostic software matching your vehicle and EBS version.

! First, open the diagnostic memory under *Messages*> *Diagnostic memory* or click on the respective button for the diagnostic memory and save the input in a safe place. This allows you to distinguish later faults from present faults, e.g. that have been recorded during the start-up procedure and have been lost.

The software displays the vehicle configuration, ECU data and current error messages. The diagnostic software can be operated using the menu as well as the different buttons.

Normally the control electronics recognises the actual fault by itself. In case you would like to initiate a complete diagnosis, click on the *Start Diagnosis* button or select the respective menu item in the *Diagnosis* > *Start* menu. The software will now check the individual components and log current faults it finds. The software collates all the faults that occur in the diagnostic memory (*Messages* > *Diagnostic memory*) . Current faults are coloured red in the overview and those that are not current are

coloured blue. To obtain more information on a specific fault, select it and click the *Info* button.

To refresh the diagnostic memory, e.g. during repairs, click on the *Refresh* button or activate the *Cyclical update* control box.

If you have further questions concerning the operation, use the *Help* menu.

7 Workshop instructions

CAUTION!
Risk of injury

– Observe all safety instructions (see chapter 1 “Safety information”, page 3).

– These instructions must be observed to avoid personal injury or material damage.

7.1 Replacing components

EBS is maintenance free. It monitors itself and its components. If a fault occurs, the driver is notified that the vehicle must be taken to the workshop or that the vehicle must be stopped.

Information on the error detection function integrated into the EBS and possible deactivation of functions see chapter 6.1 “Functions for fault detection”, page 29. The defective EBS system can be checked using the WABCO diagnostic software in a workshop (see chapter 6.4 “Diagnosis”, page 31).

Replacing components

! Generally, repairing EBS components is not permitted. Only replacement of a complete component is possible.

- Read the corresponding component description in Kapitel 5 „Components“, Seite 19 before replacing and obtain information on suitable replacement devices. You will find relevant information in Kapitel 7.3 „Overview of spare parts“, Seite 35.
- New parameters need to be set for the braking system when wheels with different tyre sizes are used or there is a change regarding the permissible axle load of the vehicle. Your vehicle manufacturer must be consulted in this case.
- EBS tests and monitors itself. Resistances or tensions must only be measured on the wiring harness when the system signals a fault and when the diagnostic software signals this.

! **Only with axle modulator, 3rd generation**

When a pneumatic circuit malfunction occurs on the rear axle, the front axle circuit will slowly empty via the axle modulator while the engine is idling and the brakes are actuated, leads to a venting noise. The brakes can also be actuated using a pedal spanner.

An overflow flap conducting the compressed air to the rear axle braking pressure is integrated into the axle modulator piston. This is the reason for the venting noise. The axle modulator does not have to be replaced.

Disposal of old parts

When disposing of defective components, observe the current local, regional and national laws and legal regulations.

WABCO strives to protect the environment. As with other old devices, it can be returned to WABCO. Contact your local WABCO partner for more details concerning disposal.

7.2 Test on the roller test stand

Completion of the compulsory braking action of the vehicle is usually proved on the roller test stand in the workshop. For this purpose, it is necessary to brake each axle

with the maximum possible force. At the same time the EBS brake management function must remain unaffected, e.g. load dependent braking force control. Therefore this chapter describes how you can activate the roller test stand function with an EBS vehicle to be able to carry out the following compulsory measurements.

Vehicles from Mercedes

To activate the roller test stand function on a stationary vehicle, switch on the ignition and wait 5 seconds. If all wheel speeds are less than 3 km/h or if one axle does not rotate when the other rotates at less than 12km/h, which is the case on the roller test stand, you have activated the roller test stand function.

If you must drive the vehicle onto the test stand and want to subsequently activate the roller test stand function, make sure that the vehicle speed has been running at less than 12 km/h for at least 20 seconds. The EBS then recognises that the vehicle has stopped and activates the roller test stand function.

To deactivate the roller test stand function, accelerate the wheels on both axles to 3 km/h or accelerate the wheels of one axle to more than 12 km/h.

Vehicles from other manufacturers

To be able to enter the roller test stand testing mode, proceed as follows:

Switch off the ignition. Then switch on the braking system by actuating the brake pedal. The roller test stand function is now activated and you can turn on the engine to fill the braking system. The test bench function stays active.

! If the on-board supply voltage is too low, the EBS device might reset when starting the engine. In this case, the roller test stand function is deactivated.

To deactivate the roller test stand function, accelerate the wheels on both axles to 3 km/h or accelerate the wheels of one axle to more than 12 km/h.

7.3 Overview of spare parts

! Electronics such as the central module, the CBU and the axle modulator must be specifically parameterised to the vehicle configuration.

In the following charts, you can find information concerning the individual components and their respective spare parts.

A device that is entered as spare part can be replaced without making changes. However, changes are necessary when replacing with an alternative device. In this case contact your local WABCO sale partner.

7.3.1 3/2 directional control valve

WABCO no.	Application	Comment	Installation	Replacement / Alternative
434 205 051 0	Mercedes			
472 176 316 0	Mercedes, Neoplan / Neoman, Standard Bus	Pressure P2:P42 = 1:1		
472 176 916 0	Mercedes	MP II (front axle)		

WABCO no.	Application	Comment	Installation	Replacement/ Alternative

7.3.2 Axle modulator

480 103 001 0	Mercedes	6×2, 6×2/4, 6×2 and 8×4 with disc brake on the rear axle. With drum brakes on the rear axle the corresponding axle modulator package 97 (= 480 103 005 0) must be fitted!	1996–1997	480 103 012 0
480 103 002 0	Mercedes	all 4x2 with disc brakes on the rear axle With drum brakes on the rear axle the corresponding axle modulator package 97 (= 480 103 004 0) must be fitted!	1996–1997	480 103 011 0
480 103 004 0	Mercedes	all 4×2 with disc brake and drum brake	1997–1998	480 103 011 0
480 103 005 0	Mercedes	6×2, 6×2/4, 6×4, 8×4 with disc and drum brake	1997–1998	480 103 012 0
480 103 006 0	Mercedes	4×2	1998–1999	480 103 011 0
480 103 007 0	Mercedes	6×2, 6×2/4, 6×4 and 8×4	1998–1999	480 103 012 0
480 103 008 0	Mercedes	Bus, additional axle, with backup valve	1998–	
480 103 009 0	Mercedes	Bus, additional axle, no backup valve	1998–	
480 103 011 0	Mercedes	4×2	1999–	
480 103 012 0	Mercedes	6×2, 6×2/4, 6×4 and 8×4	1999–2003	
480 103 013 0	Mercedes	all 4×2 with ESC, no longer downwards compatible!	2000–2003	
480 103 014 0	Mercedes	6×2, 6×4, 8×4		
480 103 015 0	Mercedes	4×2	2001–	
480 103 016 0	Mercedes	all vehicles except 4×2		
480 103 017 0	Mercedes	fording ability version	2005–	
480 103 022 0	IVECO		1998–2004	
480 103 024 0	IVECO	Semitrailer tractor	2000–	
480 103 025 0	IVECO	Truck	2000–	
480 103 041 0	DAF	FA (4×2), 4×2 with backup valve, screw plugs on p21.2 and p22.2	04/2001–10/2003	480 103 042 0
480 103 042 0	DAF	FTG (6×2), FAG (6×2), 6×2 with backup valve	04/2001–10/2003	
480 103 043 0	DAF	FT (4×2), 4×2 without backup valve	04/2001–10/2003	
480 103 061 0	Mercedes, Neoplan / Neoman, Solaris Bus	Bus, drive axle / additional axle, with backup valve	2000–	
480 103 063 0	Mercedes, Neoplan / Neoman, Solaris Bus, Standard Bus	Bus, drive axle / additional axle, with backup valve	2000–	
480 103 066 0	Mercedes	Bus, drive axle, with backup valve	1999–2002	
480 104 001 0	DAF	Trucks 4x2 with backup valve	10/2003–	480 104 002 0
480 104 002 0	DAF	Semitrailer tractor 6x2 with backup valve	10/2003–	

WABCO no.	Application	Comment	Installation	Replacement / Alternative
480 104 003 0	DAF	Semitrailer tractor FT 4×2 without backup valve	10/2003–	
480 104 005 0	IVECO	Semitrailer tractor	2004–	
480 104 006 0	IVECO	Truck	2004	
480 104 007 0	Standard Bus	Bus, additional axle		
480 104 009 0	Standard Bus	Bus, drive axle		
480 104 101 0	MAN, Neoplan / Neoman	Truck / Bus with trailer control valve, drive axle, with backup valve	2003–2006	480 104 104 0
480 104 103 0	MAN, Neoplan / Neoman	Truck / Bus without trailer control valve, additional axle in 6S/6M vehicle or drive axle in 4S/4M vehicle, with backup valve	2003–2006	480 104 105 0
480 104 104 0	MAN, Neoplan / Neoman	Truck / Bus with trailer control valve, drive axle, with backup valve	2005–	
480 104 105 0	MAN, Neoplan / Neoman	Truck / Bus without trailer control valve, additional axle in 6S/6M vehicle or drive axle in 4S/4M vehicle, with backup valve	2005–	
480 105 001 0	Mercedes	all 4×2 vehicles with trailer control valve, with backup valve	2006–	
480 105 002 0	Mercedes	all vehicles except 4×2 vehicles with trailer control valve, with backup valve	2006–	

7.3.3 Trailer control valve

480 204 000 0	Mercedes	old 7 pin standardised bayonet, 4x2		480 204 001 0
480 204 001 0	DAF, IVECO, Mercedes	4×2, 6×2/4, revised 7 pin standardised bayonet; DAF FT/FA 4×2, FTG/FAG 6×2	04/2001–10/2003	480 204 002 0
480 204 002 0	Mercedes, Standard Bus	7 pole DIN bayonet, plugged from below		

7.3.4 Brake signal transmitter

480 001 000 0	Mercedes	without silencer, without Voss fittings, with port 4	1996–2000	480 001 010 0
480 001 004 0	Mercedes	for suspended pedal	–2004	480 001 005 0
480 001 005 0	Mercedes	for suspended pedal	2004–	
480 001 010 0	Mercedes	with integrated silencer, with Voss couplings, port 4	2000–	
480 001 011 0	Mercedes	with integrated silencer, with Voss coupling, without port 4, not compatible with 480 001 010 0	2003–	
480 001 300 0	IVECO	for suspended pedal	1999–2004	
480 001 500 0	DAF	FT/FA 4×2, FTG/FAG 6×2	04/2001–	
480 002 000 0	Mercedes, Neoplan / Neoman	for standing pedal	1997–2003	
480 002 002 0	Mercedes	for standing pedal	1998–2003	480 002 004 0
480 002 003 0	Solaris Bus	for standing pedal	2002–	
480 002 004 0	Mercedes	for standing pedal	2004–	

WABCO no.	Application	Comment	Installation	Replacement/ Alternative
480 002 021 0	VDL Bus, Van Hool, BMC	Standard Bus, with plate 25°		
480 002 022 0	VDL Bus, Van Hool, BMC	Standard Bus, with plate 46°		

7.3.5 CBU Central Brake Unit

480 020 001 0	MAN, Neoplan / Neoman	4×2, 6×2/4; 4S/4M, 6S/6M. If the vehicle is fitted with a halt brake or RSF, the AS Tronic must also be updated		480 020 004 0
480 020 002 0	MAN	4S/3M		
480 020 004 0	MAN, Neoplan / Neoman	4S/4M, 6S/6M	10/2004	
480 020 010 0	IVECO			

7.3.6 Pressure limiting valve

475 009 008 0	MAN	10/0.7 ±0.1 bar		
475 010 300 0	MAN	8.5 - 0.4 bar		
475 010 301 0	MAN	10 ± 0.3 bar		
475 010 302 0	DAF	4.8 bar, only with LF55 for 6×2 vehicles		
475 010 317 0	Mercedes			
475 010 318 0	Mercedes			
475 010 325 0	Mercedes	for MP II		
475 010 330 0	Mercedes			
475 010 331 0	Mercedes			
475 010 332 0	Mercedes			
475 010 400 0	DAF	FA 4×2, FAR/FTG/FAG/FTS/FAS 6×2, FTT/FAT/FAD 8×4		
475 015 029 0	MAN	12.5/7.4 +0.2 bar		
475 019 000 0	DAF	FTG/FAG 6×2	2001–	
475 020 001 0	Mercedes	specially for semitrailer tractors, 4.9 bar		475 020 006 0
475 020 002 0	Mercedes	specially for semitrailer tractors, 5.2 bar		475 020 006 0
475 020 003 0	Mercedes	specially for semitrailer tractors, 5.5 bar		475 020 006 0
475 020 004 0	Mercedes	specially for semitrailer tractors, 4.6 bar		475 020 006 0
475 020 005 0	Mercedes	specially for semitrailer tractors, 4.1 bar		475 020 006 0
475 020 006 0	Mercedes	4.1 bar, with silencer		

7.3.7 ESC module

446 065 000 0	Mercedes	MP II	2001–2003	446 065 003 0
446 065 001 0	Mercedes	Bus	2001–2003	446 065 004 0

WABCO no.	Application	Comment	Installation	Replacement / Alternative
446 065 003 0	Mercedes	Semitrailer tractor	2003–2005	446 065 021 0
446 065 004 0	Mercedes	Bus	2003–2005	446 065 022 0
446 065 005 0	DAF, IVECO	Semitrailer tractor, DAF FX95/CF75/CF85	2003–2005	446 065 020 0
446 065 006 0	IVECO, Neoplan / Neoman	IVECO fire engine, Neoplan / Neoman Bus	2003–2005	446 065 025 0
446 065 022 0	Mercedes	Bus	2006–	
446 065 023 0	Mercedes	Articulated trucks with EBS 1C		
446 065 024 0	Mercedes	Bus		
446 065 025 0	Standard Bus		2006–2007	446 065 026 0
446 065 026 0	Standard Bus		2007–	

7.3.8 Steering wheel angle sensor

441 120 003 0	Standard Bus			

7.3.9 Proportional relay valve

480 202 001 0	Mercedes	for all vehicles except for 8x4, old 7 pole standardised bayonet		480 202 004 0
480 202 002 0	Mercedes	8×4		480 202 005 0
480 202 004 0	DAF, IVECO, Mercedes, Standard Bus	identical with EBS 1A and 1C, for all vehicles except 8×4	04/2001	
480 202 005 0	DAF, Mercedes	DAF FT/FA 4×2, FTG/FAG 6×2		

7.3.10 Backup valve

472 173 206 0	Standard Bus			
480 205 001 0	Mercedes	for all vehicles		480 205 104 0
480 205 002 0	Mercedes			
480 205 010 0	Mercedes	4×2, 6×2, articulated bus		
480 205 103 0	DAF	Identical with EBS 1a and 1c		
480 205 104 0	MAN, Mercedes	MP II		

7.3.11 Pressure ratio valve

473 303 000 0	Mercedes	Pressure reduction 2:1, only used in combination with axle modulator with flanged-on solenoid valve.		

7.3.12 Special relay valve

973 011 300 0	Mercedes			

WABCO no.	Application	Comment	Installation	Replacement/ Alternative

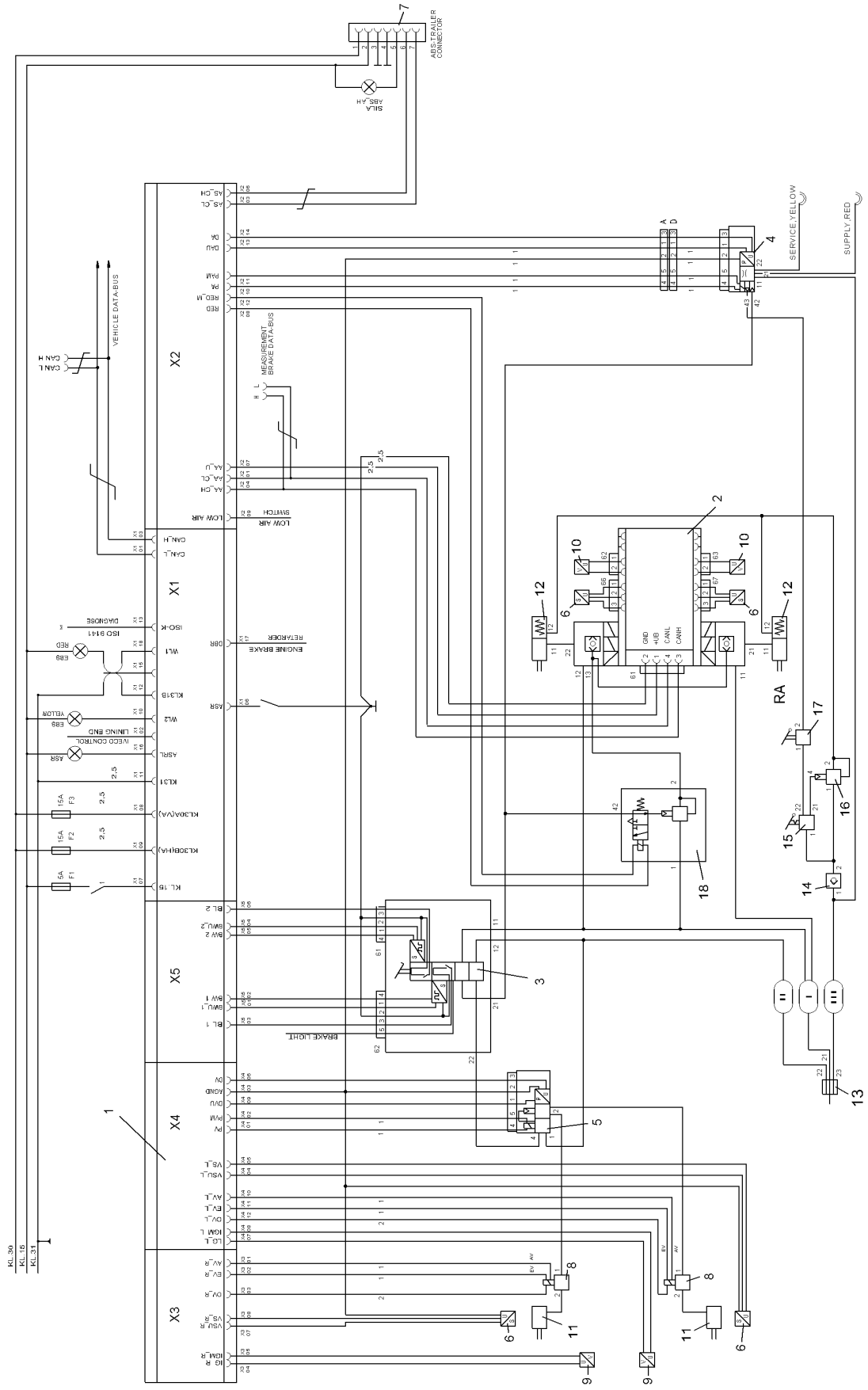
7.3.13 Central module

446 130 000 0	Mercedes	all vehicles with disc brakes on the front axle		446 130 014 0
446 130 004 0	Mercedes	4×2, 6×2, 6×2/4, 6×4 and 8×4 with EPS/EAS except semitrailer tractors with 4×2 and standard frame height		446 130 014 0
446 130 005 0	Mercedes	all 4x2 semitrailer tractors with standard frame height and EPS/EAS		446 130 015 0
446 130 008 0	Mercedes	4×2, 6×2, 6×2/4, 6×4 and 8×4, except 4×2 semitrailer tractors with standard frame height and hydraulic gear shift		446 130 014 0
446 130 009 0	Mercedes	4x2 semitrailer tractors with standard frame height and hydraulic gear shift		446 130 015 0
446 130 010 0	Mercedes	4×2, 6×2, 6×2/4, 6×4 and 8×4, except 4×2 semitrailer tractors with EPS/EAS and hydraulic gear shift		446 130 014 0
446 130 011 0	Mercedes	all 4x2 semitrailer tractors with standard frame height with EPS/EAS and hydraulic gear shift		446 130 015 0
446 130 014 0	Mercedes	4×2, 6×2, 6×2/4, 6×4 and 8×4 /except 4×2 semitrailer tractor) with EPS/EAS and hydraulic gear shift	1998–	
446 130 015 0	Mercedes	all 4x2 semitrailer tractors with standard frame height with EPS/EAS and hydraulic gear shift	1998–	
446 130 018 0	Mercedes	4×2, 6×2,6×2/4, 6×4 and 8×4, except 4×2 semitrailer tractors with EPS/EAS, hydraulic gear shift and ESC		
446 130 019 0	Mercedes	all 4x2 semitrailer tractors with standard frame height, EPS/EAS, hydraulic gear shift and ESC		
446 130 020 0	Mercedes	City bus 6S/6M	1999–	446 130 024 0
446 130 021 0	Mercedes	City bus 4S/4M		446 130 025 0
446 130 022 0	Mercedes	Coach 4S/4M	1999–	
446 130 023 0	Mercedes	Coach 6S/6M	1999–	
446 130 024 0	Mercedes	City bus 4S/4M	2000–	446 130 028 0
446 130 025 0	Mercedes	City bus 6S/6M	2000–	446 130 029 0
446 130 026 0	Mercedes	Coach 4S/4M	2002–	446 130 030 0
446 130 027 0	Mercedes	Coach 6S/6M	2002–	446 130 031 0
446 130 028 0	Mercedes	Bus 4S/4M	2000–	
446 130 029 0	Mercedes	Bus 6S/6M	2000–	
446 130 050 0	Mercedes	MP II		446 130 053 0
446 130 051 0	Mercedes	MP II		446 130 053 0
446 130 054 0	Mercedes	all vehicles with EBS 1c		
446 130 055 0	Mercedes	all Mercedes buses	2007–	
446 135 017 0	DAF	FT/FA 4×2, FTG/FAG 6×2, EOL parameters from DAF	1999–	

WABCO no.	Application	Comment	Installation	Replacement / Alternative
446 135 018 0	IVECO	4×2, 6×2, 6×2/4, 6×4 and 8×4, except 4×2 semitrailer tractors with EPS/EAS, hydraulic gear shift and ESC		
446 135 038 0	DAF	as of EBS 1C, 4×2 and 6×2 semitrailer tractors	2003–	
446 135 041 0	Standard Bus	4S/4M, 6S/6M	2007–	

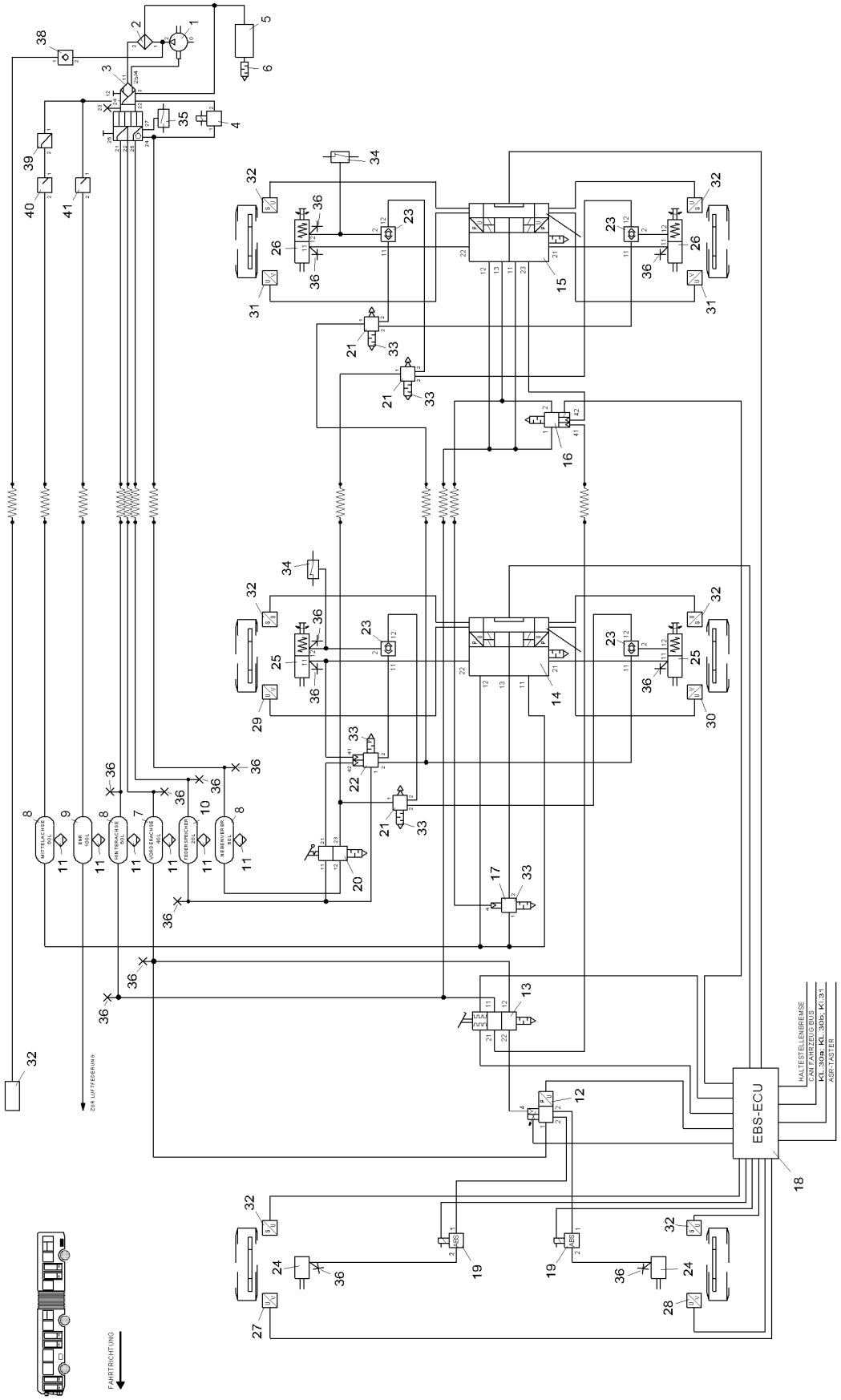
8 Appendix

8.0.1 Circuit diagram [D], EBS 1B, 4S/4M (841 100 478 0)



1 EBS central module
2 Axle modulator
3 Brake signal transmitter
4 Trailer control valve
5 Proportional relay valve
6 Wear sensor
7 ABS trailer plug connection
8 ABS solenoid valve
9 ABS speed sensor
10 ABS speed sensor
11 Brake cylinder
12 Tristop cylinder
13 Four-circuit protection valve
14 Check valve
15 Hand brake valve
16 Relay valve
17 Trailer hand brake valve
18 Backup valve
x1 - x5 Slots

8.0.2 Circuit diagram [K], EBS 1B for buses, 6S/6M (841 200 213 0)



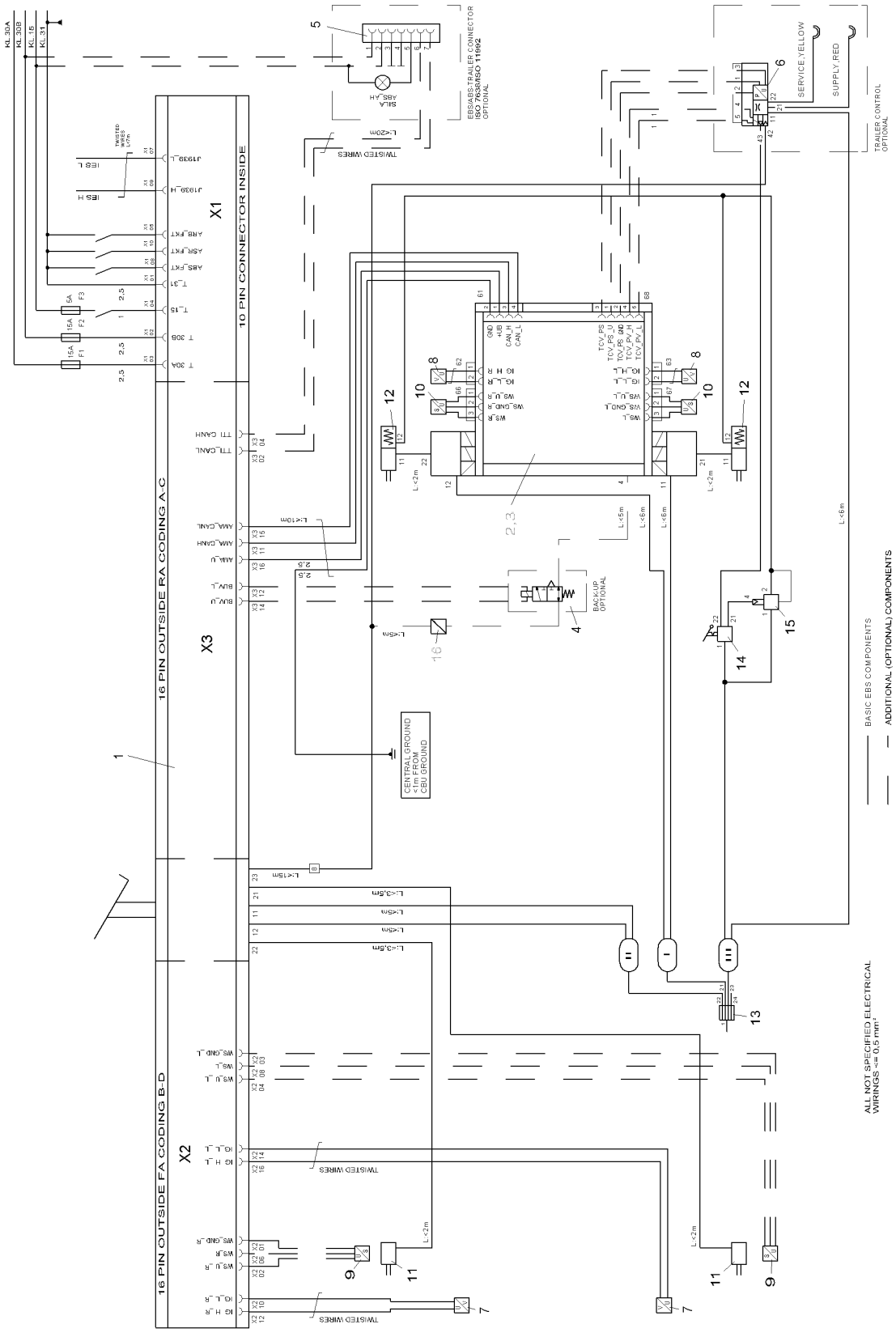
1 2 cylinder compressor
2 Cyclone container
3 APU
4 Solenoid valve
5 Condensation container
6 Silencer
7 - 10 Air reservoir
11 Drainage valve

12 Proportional relay valve
13 Brake signal transmitter
14 + 15 Axle modulator
16 Backup valve
17 Relay valve
18 EBS central module
19 ABS solenoid valve
20 Hand brake valve

21 Quick release valve
22 Relay valve
23 Two-way valve
24 Membrane cylinder
25 + 26 Tristop cylinder
27 - 31 Speed sensor
32 Brake lining wear sensor
33 Silencer

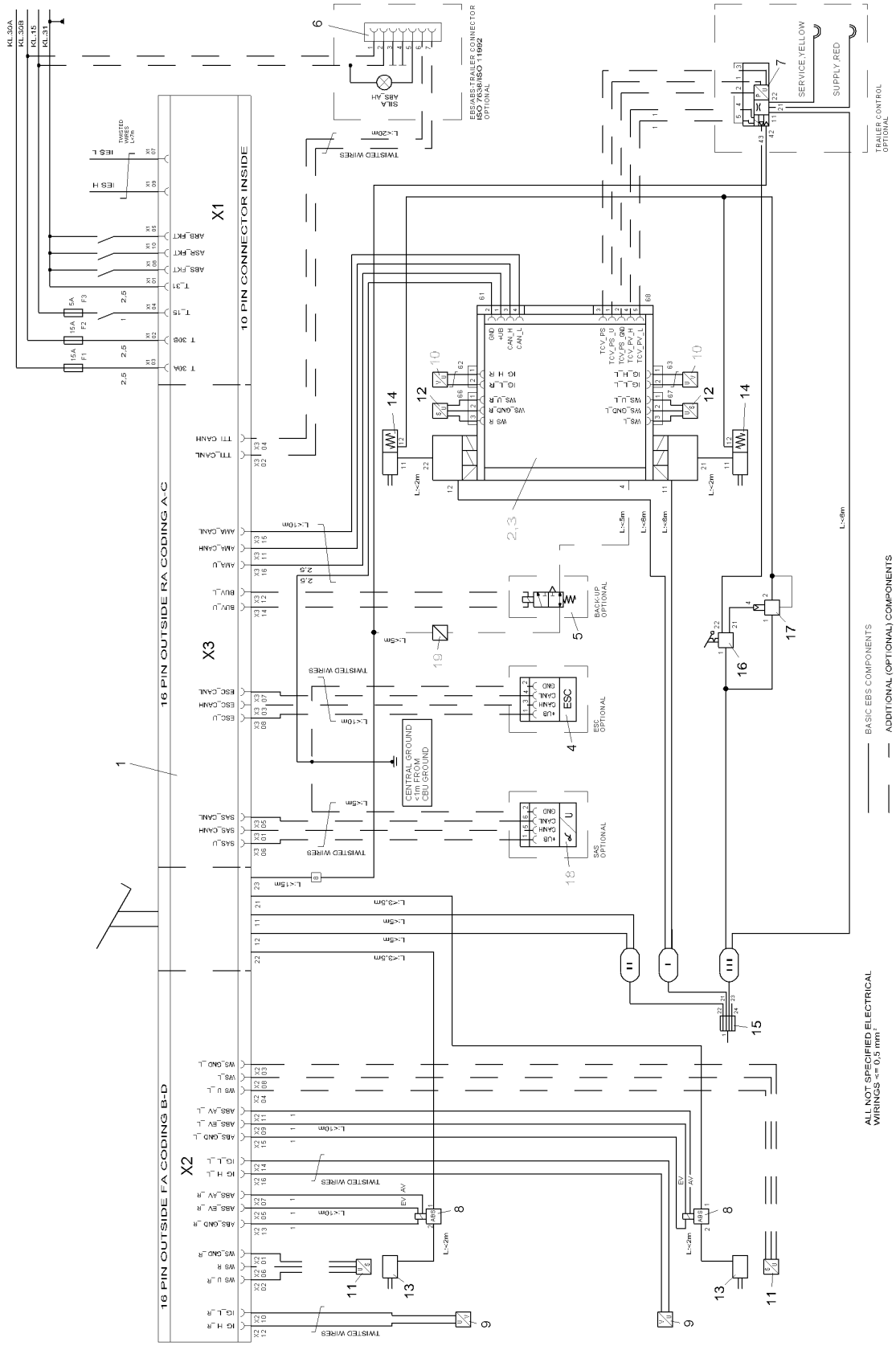
34 Pressure switch "A"
35 Pressure switch "B"
36 Test port
37 -
38 Check valve
39 Pressure limiting valve
40 + 41 Charging valve

8.0.3 Circuit diagram [H], EBS Compact, 4S/3M (841 100 532 0)



1 Central Brake Unit CBU
2 Axle modulator
3 Axle modulator
4 Backup valve
5 EBS / ABS trailer plug connection
6 Trailer control valve
7 ABS speed sensor
8 ABS speed sensor
9 Wear sensor
10 Wear sensor
11 Brake cylinder
12 Tristop cylinder
13 Four-circuit protection valve
14 Hand brake valve
15 Relay valve
16 Adapter valve
x1 - x3 Slots

8.0.4 Circuit diagram [I], EBS Compact, 4S/4M (841 100 531 0)



1 Central Brake Unit CBU
2 Axle modulator
3 Axle modulator
4 ESC module
5 Backup valve
6 EBS / ABS trailer plug connection
7 Trailer control valve
8 ABS solenoid valve
9 Speed sensor
10 Speed sensor
11 Wear sensor
12 Wear sensor
13 Brake cylinder
14 Tristop cylinder
15 Four-circuit protection valve
16 Hand brake valve
17 Relay valve
18 Lateral acceleration sensor
19 Adapter valve
x1 - x3 Slots

8.1 Abbreviations used

4S/3M	System design with four speed sensors and three ABS solenoid valves, of which two are integrated into the axle modulator. In this version for light vehicles, the EBS is only fitted with one ABS solenoid valve on the front axle, so ABS regulation can only be carried out on both wheels using this valve. For this reason, both wheels of this axle must always be regulated simultaneously.
4S/4M	System design with four speed sensors and four ABS solenoid valves, of which two are integrated into the axle modulator. In this version, the EBS can carry out ABS regulation on each individual wheel.
4×2	Vehicles with four wheels, of which two are the driving wheels.
ABS	Anti-Lock Braking System
ARB	Anti Roll Brake, roll brake for starting on slopes
ASR	Anti-Slip Regulation
CAN	Data bus system for communication between vehicle systems
CBU	Central Brake Unit
CVC	Central Vehicle Control, central onboard computer (MAN)
DSR	Differential Slip Control
EAS	Electronic Gearbox Control
EoL	End-of-Line
EPB	Electro-Pneumatic Brake System, at WABCO: EBS
EPS	Electro-Pneumatic Gear Shift, at WABCO: EDS
ESC	Electronic Stability Control
ESC	Dynamic Driving Control, at WABCO: ESC
FFR	Vehicle Guidance Computer
IES	Mercedes standard for data communication
IR	Individual Control, type of control for ABS
KOM	Bus
SAS	Steering (wheel) angle sensor
MIR	Modified Individual Regulation, type of control for ABS
PWM	Pulse width modulated
RSC	Roll Stability Control, with ESC
RSS	Roll Stability Support, dynamic vehicle support with trailers
SAE	Society of Automotive Engineers, creates general standards for the automotive industry
VAR	Variable Axle Control, ABS type of control

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WABCO (NYSE: WBC) is a leading global supplier of technologies and control systems for the safety and efficiency of commercial vehicles. Founded around 150 years ago, WABCO continues to pioneer breakthrough electronic, mechanical and mechatronic technologies for braking, stability and transmission automation systems supplied to the world's leading commercial truck, bus and trailer manufacturers. With sales of $2.9 billion in 2014, WABCO's head office is in Brussels, Belgium.

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