# EBS
# Electronically Controlled Brake System

## System and functional description

2nd Edition

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WABCO


Version 002/12.05
815 010 015 3

## Purpose of the publication

This publication is meant for commercial vehicle workshop personnel with knowledge of automotive electronics.
Faults in the Electronically Controlled Brake System on the vehicle can be diagnosed and repaired using the knowledge of these contents.

Before you begin with the diagnosis or repair, read all safety notices in this publication These safety notices must be adhered to avoid personal injury or material loss.

## Explanation of Symbols

**WARNING**

Possible dangers
Grave personal injuries or death

**CAUTION**

Immediately impending dangers
Personal injury or material loss

! Important note

- List

## General safety instructions

**WARNING**

Read the technical documentation of the vehicle manufacturer and carry out the requirements and instructions as shown.

Special trainings are necessary for putting EBS into operation.

Only qualified workshops with qualified skilled personnel with specific system knowledge must carry out repairs on vehicle safety systems.

Only products that have been exclusively released by WABCO or the vehicle manufacturer must be used.

Make sure that the complete compressed air system is emptied before the device is dismantled.

Before mounting equipment, perform all necessary safety precautions, i.e. securing car against rolling away.

Using the diagnostics software you can 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.

Before work is carried out on the vehicle, an instruction sign must be fixed onto the steering wheel to prevent any accidents.

**CAUTION**

Comply with the company and national accident prevention / health & safety regulations.

Do not clean the foundation brakes using compressed air. The resulting dispersed dust can lead to severe damage to health.

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 diagnosis software signals this.

## Used abbreviations

| | |
|---|---|
| 4S/3M | System version with four speed sensors and three solenoid modulator valves of which two are integrated in the axle modulator. In this version for lighter vehicles, the EBS is only fitted with one solenoid modulator valve on the front axle and therefore an 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 version with four speed sensors and three solenoid modulator valves of which two are integrated in the axle modulator. In this version, the EBS can carry out an ABS regulation on each individual wheel. |
| 4x2 | Vehicles with four wheels of which two are the driving wheels. |
| ABS | Anti-lock brake 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 Board Computer (MAN) |
| DC | Daimler Chrysler |
| 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 |
| FDR | Driving Dynamic Control, at WABCO: ESC |
| FFR | Vehicle Track Computer |
| IES | Daimler Chrysler standard for data communication |
| IR | Individual Control, type of control for ABS |
| KOM | Bus |
| LWS | Steering (wheel) angle sensor |
| MIC | Modified Individual Control, type of control for ABS |
| PWM | Pulse width modulated |
| RSC | Roll Stability Control with ESP |
| RSS | Roll Stability Support, Vehicle dynamics support with trailers |
| SAE | Society of Automotive Engineers, creates the general standards for the automobile industry |
| VAR | Variable Axle Control, ABS type of control |

# 1. Introduction

The quality of the brake system is a significant safety factor in commercial vehicles on the roads. In 1996, WABCO was the first supplier that has introduced an Electronically Controlled Brake System (EBS) serially in larger numbers. As a leading global supplier, as of now WABCO supplies ABS for light commercial vehicles to HGV´s with trailers or semi trailers as well as for buses as a leading global.
An increasing density of traffic and raising demands require a constant improvement of products and quality. This brochure is supposed to present a detailed overview of the different systems, highlight the differences and at the same time serve as an aid with repairs.

**The advantages of EBS**

- **Comfort when braking and an increased safety through EBS**
  The driver sets their delay request through operating the brake. EBS then transfers these requirements electronically to all components of the brake system. Distinctively shorter reaction and threshold times are practiced on the brake cylinder through the electronic controlling. At the same time, the electronics allow a sensitive dosage of the brake system. The result: comfortable braking feeling independent from the loading condition and a much shorter braking distance.

  The functions integrated in the EBS ensure the driving stability and steering capability of the of the vehicle are maintained during the braking process at the same time. An automatic distribution of the braking force between the front and rear axles is carried out depending on the condition of the load using the Differential Slip Control (DSC). At the same time, the DSC provides an optimal calibration of the trailer during operation. The motor vehicle and trailer brake their own respective trailer weight. Thereby the coupling force of the tractor combination is kept low when braking. A traction control is carried out through the integrated anti slip regulation.

- **Pad wear optimisation and maintenance ease through EBS**
  EBS from WABCO offers the possibility to continuously monitor and consort the brake pad wear. Therefore, service and pad replacement points can be coordinated with each other. All pads of the vehicle will then be replaced at the same time. An integration of non-wearing brakes such as retarder and exhaust brake additionally conserve the brake pads and lead to an extended operating life.

  The EBS permanently checks itself through extensive integrated diagnostics and monitoring functions. The driver is immediately informed through respective warning devices if there is a limited operating state. The cause of the problem can be found fast and can easily be determined using the aid of a diagnostics device or the display of the onboard diagnostics in the vehicle display. Additional maintenance and workshop periods are shortened through the extensive testing functions of the diagnostics.

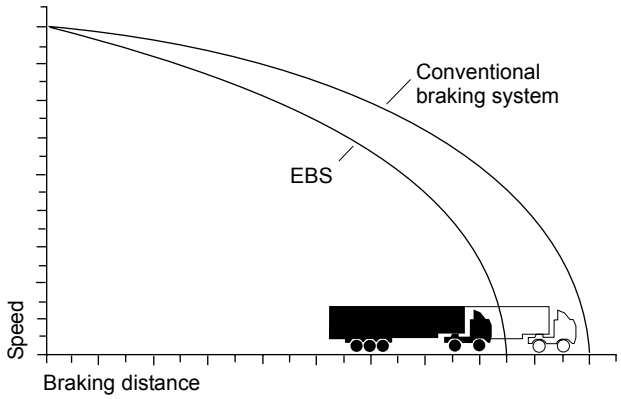



*Fig. 1: A distinct shorter braking distance with EBS*

# 2. System description

## 2.1 Basis function of EBS

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

The EBS permanently receives current information concerning the speed of the wheels through speed sensors that are mounted on the wheels of the vehicle for the integrated ABS function. Different integrated brake management functions recognise deviations from the normal driving conditions and intervene in the driving process at hazards. Next to the benefit of safety, the driving comfort and the wear of the pads are optimised through certain functions.

If the electronic control system malfunctions, all valves work simultaneously similar to the conventional pneumatic system. Therefore the braking pressure is managed redundant to the brake cylinder whereas the pneumatic system acts temporally delayed. As the pneumatic system works independent from a load-dependant load sensing valve, the pneumatic relay can act as an over braking of the rear axle.

Therefore a so called redundancy valve blocks the influence of the pneumatic circuit on the brake cylinder of the rear axle as long as the EBS functions properly.

## 2.2 Brake management functions

**Delay control / Load sensing valve control**
The delay control serves as an adaption of the brake pressure level of the braking requirements of the driver. Using the same pedal operation, the EBS ensures that the vehicle brakes evenly independent from the load condition. As an example, if the brake pads are wet, the EBS increases the braking pressure until the required braking action has been reached. Therefore, a separate axle load sensing for the brake load control valve is not necessary.

However, this adaption is only carried out in certain limits. When the wear coefficient wears down too much, the delay control ends all adoptions. So the driver is alerted to the changed braking performance.

Besides, the delay control assures an improved braking hysteresis. The programme selects the release steps every time the brake is loosened so that an immediate braking force modification can be set.

**Braking force distribution**
The distribution of braking forces on front and rear axle depends, amongst others, on the comparison made in the program range ”Delay control” between the actual and nominal value of vehicle delay. The delayed braking is recorded via speed sensors through the change of speed of the wheels. The evaluation of the sensors displays an exact image of the slip on every axle and therefore also over their brake power. If the slip is different, one axle has an increased braking compared to the other. As a result, this axle has an increased wear. Using the differential slip control, EBS regulates the pressure on front and rear axle so that the braking force is optimally distributed.

**Brake pad wear control**
EBS can obtain closer information concerning the wear condition of the brakes through the analogue pad wear sensors. The brake pad wear control intervenes when braking uncritically and detecting a difference in the pads between front and rear axle. The pressure of the wheel brake with the greater wear is released by a small amount and the pressure of the wheel brake with the lower wear is increased by an adequate measure of up to 0.5 bar. Therefore the wear is regulated without the driver noticing.

! For the case that wear indicators are installed instead of brake pad wear controllers, wear control is only possible through the EBS electronic.

**Permanent brake integration**
The correct application of the available brakes is taken over by the permanent brake integration. This assures that the non-wearing brakes such as the retarder and the exhaust brake take over a maximum of braking work for the whole vehicle. Thereby the wheel brakes stay cold and the wear on the brake pads and drums and brake discs respectively is reduced.

**Brake assistant**
The brake assistant supports the driver during the full application of the brake through recognising a strong braking and irrelevant if the brake pedal has been pushed to the floor, the complete braking pressure is led to the brake cylinder. The brake assistant finishes the braking process not until the driver releases the brake pedal.

**Anti Rolling Control (ARB)**
The anti rolling control allows the driver to comfortably start uphill through prevention of the backwards rolling of the vehicle. The driver can activate the function through tapping lightly onto the brake pedal that is connected directly to the EBS electronics. The EBS then controls the required amount of braking pressure.
This function can be switched on and off using the ARB switch.

! The EBS systems for buses include an extended anti rolling control with a bus stop brake function. More information can be obtained in the chapter "EBS in buses".

**Drag torque control**
Drag torque occurs in the drive line due to actuation or change of gas. The resulting braking torque can lead to the driving wheel locking and therefore to vehicle instability. The drag torque control prevents this situation. When a slip state is exceeded, the engine torque increases and the brake torque is reduced, depending on the driving wheel velocity. The function of the drag torque control system ends when the driving wheel values become stable again.

**Integrated ABS function**
ABS is integrated in EBS. Inductive sensors measure the speed of the individual wheels to allow an early recognition of blocking wheels. The EBS electronics can respectively reduce, stop or increase the braking pressure for the brake cylinders over the front axle using the ABS magnetic control valve. The axle modulator fulfils the same task for the rear axle where the control algorithms are integrated in the electronics.

One problem that may occur with vehicles that are equipped with ABS is the yaw moment that is caused when braking on roads with extreme differences in the

coefficient of friction between the left and right hand side. The vehicle cannot be handled or is difficult to handle on such roads through the distribution of the different braking forces. Whereas the rear axle wheels are individually controlled (IR), the braking pressure of the front axle wheels are therefore controlled interdependent (MIR). Pressure indifferences are only possible to a certain point with this type of controlling; thus the tyres on the smooth side of the road do not block and the vehicle can be steered.
When the sustained action brake tends to block the drive wheels and therefore an instable controlling of the vehicle is imminent when being operated on a smooth surfaced road, the system switches off the sustained action brake through the vehicle-data-bus disconnection and therefore ensures a stable driving stability.

! With 3 and 4 axle vehicles with 4S/4M system a side wise control of the non-sensored wheels is carried out.

**Integrated anti slip regulation (ASR)**
If the drive torque on the wheels is greater then the static friction on the wheels then a slippage is created and the wheels may spin. The ASR function recognises this and transfers the driving torque to the electronics of the engine management system. Such an intervention in the engine management system is only suggestive when both wheels of one axle tend to spin. If only one drive wheel spins, the ASR can selectively brake this using the axle modulator. An activated anti slip regulation is displayed on the function lamp.

**Trailer control**
The trailer control is carried out electronically as well as through the motor vehicle trailer interface (ISO 11992) as well as pneumatically through the electro-pneumatic trailer control valve. A string strength sensor is renounced for reasons of cost. At first the braking ratio in the towing vehicle lies in the middle of the EC braking band. At a simultaneous band middle situation of the trailer no string strength will arise. If the trailer differs from the band middle situation, this is recognised by the towing vehicle electronic due to the programme part "Delay regulation" and correspondingly controls the trailer pressure .
A possible discrimination threshold of the trailer brakes which can be made is compensated by a corresponding inshot.

The inshot of pressure in the control line (yellow) of the trailer starts at the beginning of the braking with approx. 2 bar. This is kept as short as possible so that the brake pads meet the system quickly, afterward, the EBS corrects the braking pressure according to the delay requirement.

Most of the problems known today are solved with this approach.
WABCO has collaborated in the design of the standardisation of the electrical vehicle trailer interface in charge (ISO 11992).

## 2.3 Backup functions

**Determining the brake nominal value**
The brake pedal distance measured by the sensors in the brake sensor transmitter is transferred to the EBS electronics which then calculates the respective nominal delay.

**Pressure control on the axles and trailer control**
The calculated nominal pressures are compensated in the three pressure control loops front axle, rear axle and trailer control. In order to improve the pressure control properties, the solenoid current in the solenoid valves are controlled.

! Does not apply when the axle modulators of the 2nd or 3rd generation are fitted as switched mode magnetic valves have been used.

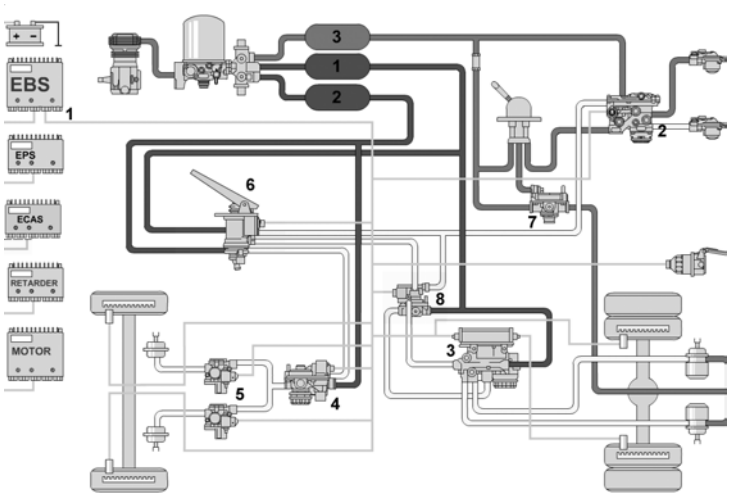
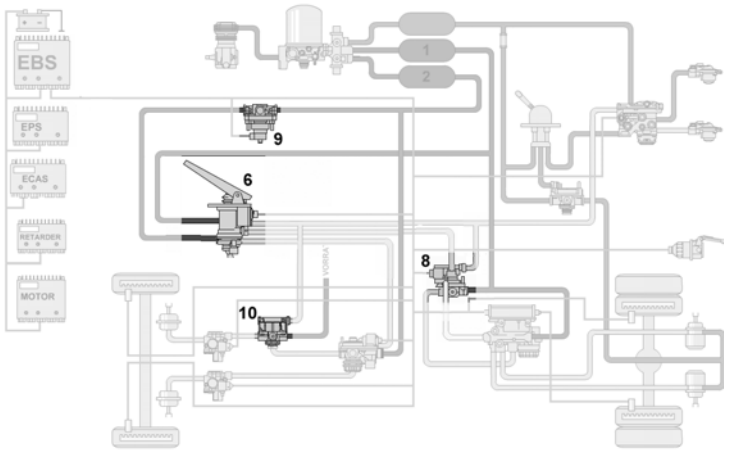
**Wheel speed sensing and wheel adjustment**
Wheel speed sensing corresponds to the sensing function known to ABS. Automatic wheel adjustment makes up for the nominal wheel sizes and thus the rolling circumferences between the axles. If unacceptable wheel combinations are used, this is recognised as an error.

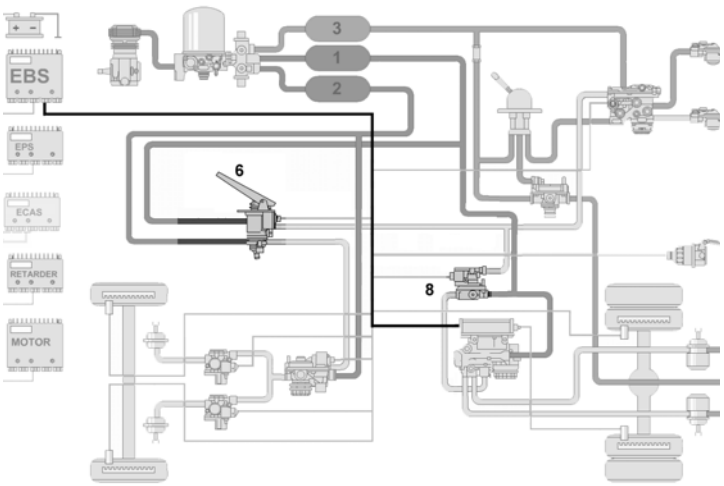
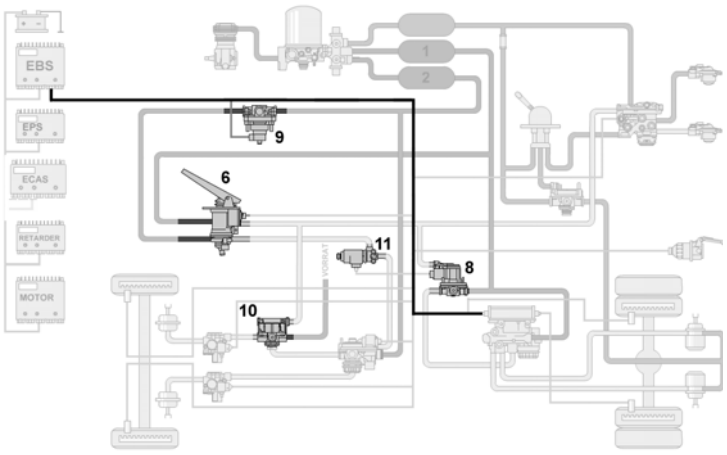
! A re-parameterisation of the braking system is necessary when using wheels with other tyre sizes or the modification of the allowable axle load of the vehicle. Your vehicle manufacturer must be consulted in this case.

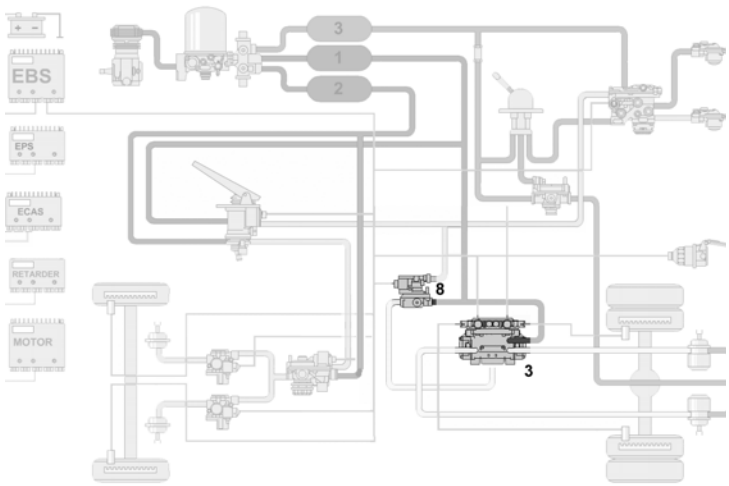
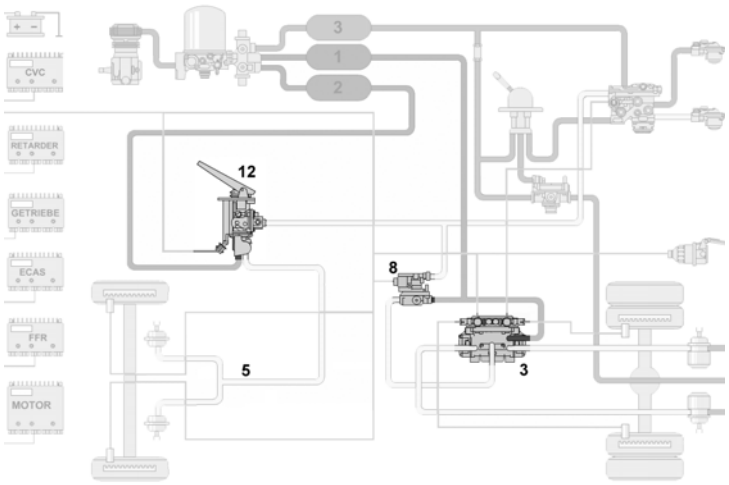
## 2.4 Overview of the system variants

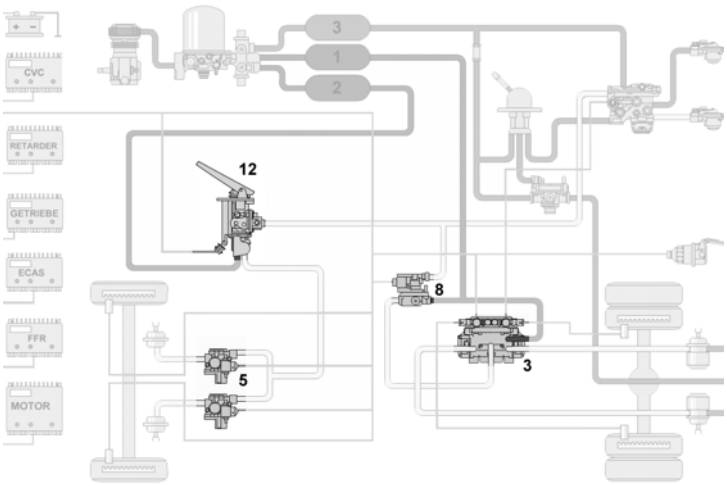
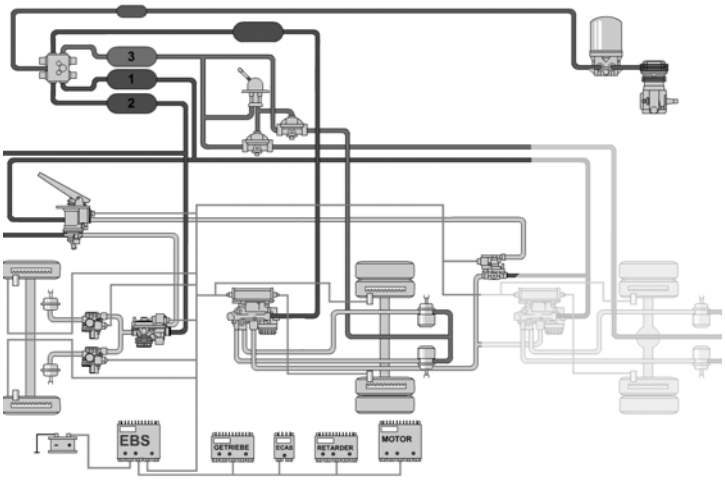
WABCO has continuously developed and improved their EBS since 1996. The following chart shows the system versions that have been created and their differences. Following differences in the scope of system within the different system versions are displayed according to the manufacturer and vehicle:

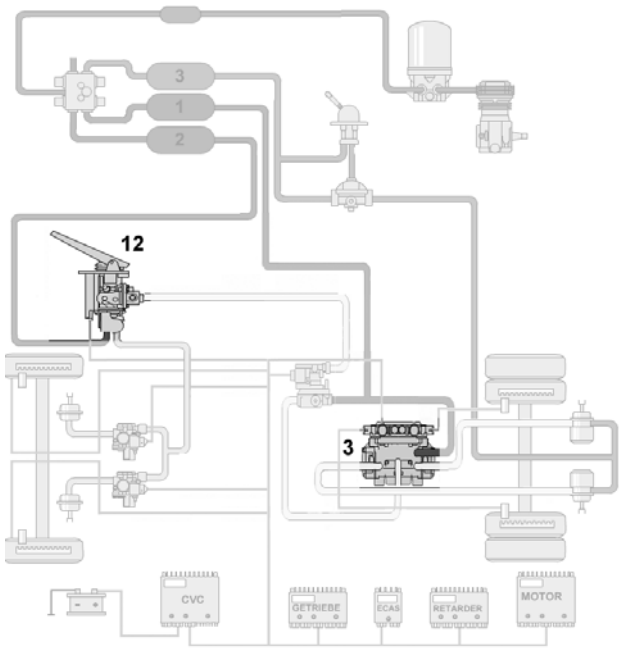
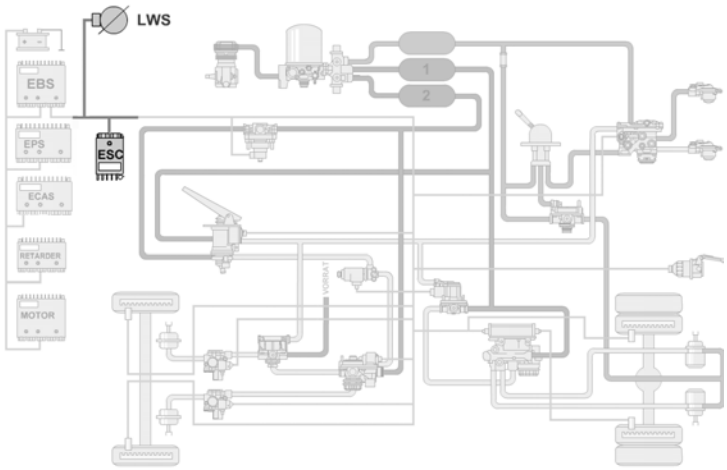
- from 4S/3M- to 6S/6M-System
- Implementing the redundancy
- Trailer guideline strategy
- electronic interfaces
- ABS guidelines

| System version | Diagram |
|---|---|
| **[A] EBS 1A** (with Daimler Chrysler: EPB)<br>Truck, 1996 - 2000<br><br>WABCO started the EBS serial production with this system together with Daimler Chrysler in 1996.<br><br>The brake value sensor (6) has five pneumatic connections and the redundancy valve (8) also has five connections. The number of lines had been reduced in later versions because, amongst others, the brake value sensor and the redundancy valve were not connected to a separate compressed air line any more.<br><br>In contrast to the systems of other manufacturers, the vehicle data bus is a IES bus in the Daimler Chrysler standards. |  <br>*Fig. 2: [A] EBS 1A / EPB, Truck*<br><br>**Legend**:<br>(1) EBS Central module, (2) Trailer control valve, (3) Axle modulator, (4) Prop. relais valve, (5) ABS Magnet control valve, (6) Brake value sensor, (7) Relay valve, (8) Redundancy valve rear axle |
| **[B] EBS 1A** (with Daimler Chrysler: EPB)<br>Articulated trucks, 1996 -2000<br><br>Two special valves were installed for the proportionally light articulated truck from Daimler Chrysler. The pressure limiting valve (9) prevents the front axle from being over braked when driving empty and the secondary braking valve (10) ensures a minimum braking performance when the braking circuit of the front axle malfunctions.<br><br>In contrast to the systems of other manufacturers, the vehicle data bus is a IES bus in the Daimler Chrysler standards.<br><br>The other system constructions are equivalent to the version for trucks (see [A]). |  <br>*Fig. 3: [B] EBS 1A / 1B, Articulated trucks* |
| **[C] EBS 1B** (with Daimler Chrysler: EPB)<br>Articulated trucks, 2001 -2004<br><br>As of 2001, in connection with Daimler Chrysler, a further developed EBS had been installed with the option of the electronic stability control ESC (see [M]). The brake bus with 500 kBit/s works in this system.<br>The vehicle data bus also works according to the IES standards in this Daimler specific version. | |

| System version | Diagram |
|---|---|
| **[D] Euro EBS** / EBS 1B (with DAF, Iveco)<br>Truck, 2000 -2004<br><br>Fig. 4 shows the first larger further development of the EBS. In the Euro EBS, the brake value sensor (&) only has two pneumatic control lines and the redundancy valve only has one pneumatic control connection. In contrast to the previous versions for Daimler Chrysler, the vehicle data bus is manufactured according to the SAE standard. The brake bus with 500 kBit/s works in this system.<br><br>The electronic stability control ESC (see [M]) has not been installed here. |  <br>*Fig. 4: [D] Euro EBS, Truck* |
| **[E] EBS 1B** for Daimler Chrysler Actros MP II<br>Truck and articulated trucks, from 2004<br><br>The brake value sensor has also only two pneumatic control lines in this system version especially for the Actros MPII. An installed pressure limiting valve (9) prevents the front axle from being over braked when driving empty. The secondary braking valve (10) ensures a minimum braking performance when the braking circuit of the front axle malfunctions.<br>A new feature is the relay stop valve (11) on the front axle.<br>Both truck and articulated truck have a redundancy valve on the rear axle (8) that only has one pneumatic connection in comparison to earlier versions. The vehicle data bus operates according to the IES standard.<br><br>The brake bus operates with 500 kBits/s and with the articulated trucks, the Electronic Stability Control (ESC) (see [M]) can already be installed. |  <br>*Fig. 5: [E] EBS 1B, Actros MP II* |

| System version | Diagram |
|---|---|
| **[F] EBS Evolution** / EBS 1C (i.e. DAF)<br>Truck, since 2004<br><br>WABCO has offered the EBS Evolution since 2004, this version possesses a light and compact axle modulator (3). In this version the brake bus also has 500 kBit/s and the vehicle data bus operates according to the SAE standard.<br><br>There is no redundancy valve fitted on the rear axle (8) with the version for articulated trucks. The Electronic Stability Control ESC (see [M]) can be fitted. |  <br>*Fig. 6: [F] EBS Evolution, Truck* |
| **[G] EBS Compact** / EBS 2A (i.e. MAN)<br>Truck 4S/3M System version, since 2005<br><br>EBS Compact is also on the open market since 2004. In the central brake unit (12) the system combines the brake value sensor, the proportional relay valve and the central module. When operating the brake pedal, the CBU creates an electronic signal value as well as a pneumatical redundancy pressure. For the brake pressure of the front axle the CBU switches off the redundancy pressure and controls the required brake pressure electronically when the electronic regulation functions properly.<br>The lighter and compacter version similar to the EBS Evolution [F] has been fitted as the axle modulator (3).<br><br>There is no redundancy valve fitted on the rear axle (8) with the version for articulated trucks.<br><br>EBS Compact in the 4S/3M model is a system version for light trucks and articulated trucks. Instead of the ABS magnetic valve, the CBU (12) takes over the controlling of the front wheels when the ABS is activated, whereas both wheels are regulated the same. This is the reason why no magnet control valve is fitted on the position (5).<br><br>The vehicle data bus operates according to the SAE standard. |  <br>*Fig. 7: [G] EBS Compact, Truck, 4S/3M* |

| System version | Diagram |
|---|---|
| **[H] EBS Compact** / EBS 2A (i.e. Iveco)<br>Truck 4S/4M system version, since 2004<br><br>The system is similar to the 4S/3M model (see [G]). On position (5) there are two ABS magnet control valves fitted. In cases where the ABS is used, the front axle wheels are controlled independently from each other through the magnet control valve.<br>The vehicle data bus operates according to the SAE standard.<br><br>There is no redundancy valve fitted on the rear axle (8) with the version for articulated trucks.<br>The Electronic Stability Control ESC (see [M]) can be fitted with the EBS Compact in 4S/4M models optionally. |  <br>*Fig. 8: [H] EBS Compact, Truck, 4S/4M* |
| **[I] EBS 1B / Euro EBS for buses**<br>2000 - 2007 (e.g. EvoBus, Neoplan, Solaris)<br><br>Fig. 9 shows the EBS for buses in the 4S/4M or 6S/6M models. The construction is equal to the motor vehicle EBS without trailer control valve.<br>Furthermore, the ESC (see [M]) can 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.<br><br>Two axle modulators are fitted with the EBS version 6S/6M for three axle or articulated bus. |  <br>*Fig. 9: [I] EBS 1B, Bus* |
| **[K] EBS Evolution / EBS 1c for buses**<br>from 2007 (e.g. EvoBus, Neoplan, Solaris)<br><br>The construction of this new EBS model is equal to the [I] model. Instead of the axle modulator of the first generation, the new axle modulator 2 is fitted.<br>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. The brake bus operates with 500 kBits/s. The Electronic Stability Control ESC (see [M]) can also be fitted.<br><br>Specific information and circuit diagrams can be obtained in our product database INFORM on www.wabco-auto.com. | |

| System version | Diagram |
|---|---|
| **[L] EBS Compact for buses**<br>from 2004, (e.g. NEOMAN)<br><br>EBS compact has been fitted in buses since 2004. In the central brake unit (12) the system combines the brake value sensor, the proportional relay valve and the central module. When operating the brake pedal, the CBU creates an electronic signal value as well as a pneumatical redundancy pressure. For the brake pressure of the front axle the CBU switches off the redundancy pressure and controls the required brake pressure electronically when the electronic regulation functions properly.<br>The lighter and compacter version similar to the EBS Evolution [K] has been fitted as a the axle modulator (3). Customer specific work on the data bus can be carried out either according to the SAE or the IES standards.<br><br>A 3/2 directional control valve can also be fitted in the bus instead of a redundancy valve. As the brake bus already operates with 500 kBits/s, an ESC (see [M]) can also be fitted. |  <br>*Fig. 10: [L] EBS Compact, buses* |
| **[M] ESC** as additional option<br><br>The electric stability control ESC can be fitted with some systems optionally. For this purpose, the steering wheel angle sensor (LWS) and the ESC electronics are connected to the electrical system.<br>Specific information concerning ESC can be obtained under chapter 3 "ESC Electronic Stability Control".<br><br>A retrofitting of ESC is not possible at present. |  <br>*Fig. 11: [M] Electronic Stability Control ESC* |

## 2.5 EBS in buses

After the application in commercial vehicles the WABCO EBS will now be applied in buses. The system construction is principally the same. The load-empty relationship with buses is lower than with trucks or articulated trucks. This is the reason why the redundancy pressure in buses is controlled with a ratio of 1:1 and not reduced to a ratio of 2:1 like in trucks or in articulated trucks.
In those systems where second generation axle modulators are used a 3/2 control valve can also be fitted instead of a redundancy valve because a relay function is already integrated into these axle modulators.

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

Besides the regulation of the EBS for buses is carried out using the usual brake management functions of EBS whereas the braking behaviour is especially matched to the situation of the bus. Simply the anti rolling function in the bus has been modified to a bus stop brake.

**Bus stop brake**
As soon as the bus driver operates the bus stop brake or activates the door control, the demand "operate the bus stop brake" is sent over the CAN Bus or the switch of the bus stop brake to the EBS electronics. This initiates a brake pressure control of e.g. 2 bar.

Using the proportional relay valve and the axle modulator(s) the brake cylinders are pressurised with the respective brake pressure on the front and rear axle(s). With some vehicles, only the brake cylinders of the drive axle are filled with braking pressure.

If the bus stop brake command is deactivated via the switch or via the door electronic unit, and then the driving pedal activated, the ”bus stop brake” command is cancelled via the EBS electronic.

## 2.6 Reports

Reports and legal guidelines exist for the application of EBS. These texts are not part of this brochure but you may request them from WABCO or open them in product database INFORM on the Internet (www.wabco-auto.com, index word: "report"). Following reports are stored there:

- 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

# 3. Electronic Stability Control ESC

Since 2000, WABCO offers the Electronic Stability Control ESC as an addition to the Electronically Controlled Brake System EBS. Whereas EBS generally controls the brake management, the ESC increases the stability during normal driving operation. Especially when changing lanes, dodging and curve driving, there is a hazard that commercial vehicles may tip over, roll or slide through their higher point of gravity and their large masses.
Using the aid of different sensors, the ESC recognises such critical situations and when necessary, corrects the engine and brake performance. Thus the driver is supported and the road safety is increased.

When installing EBS, ESC can easily be integrated. A retrofitting is not possible.

A precondition for the installation of ESC is a CAN databus system with at least 500 kBits/s and an EBS electronic that allows ESC. In addition to the EBS components, an ESC control module and a steering wheel angle sensor must be installed.

The overall sensors of the ESC system are composed of:

- ABS sensors that measure the wheel speed and that are also used for EBS
- a steering wheel angle sensor that measures the driver activities
- the EBS electronic that evaluates the signals of the steering wheel angle sensors as well as it takes over the different ESC functions for fault recognition and diagnostics.
- the ESC control module where the lateral acceleration and yaw rate sensors are integrated. At this point the sensor signals are immediately evaluated and are compared with set values.

! You can find an ESC-overview diagram in "Overview of system variants" under [M].

## 3.1 The components of ESC

Apart from the ESC control module, a steering wheel angle sensor is necessary for the ESC functions. This is fitted to the steering column and transfers information of the steering movement of the driver to the EBS electronics.

*Fig. 12: ESC Control module*

The EBS electronic passes this information onto the connected ECS control module. In addition to the measurement data of the steering wheel angle sensor, the ESC module receives all other data from the EBS electronic that are necessary to evaluate the actual driving condition such as wheel speed. Yaw rates and lateral acceleration sensor are integrated in the ECS module.

In regulation cases, the ESC module sends the regulation information to the EBS electronic. Hereupon the necessary interventions are initiated in the engine, gearing or the retarder control.

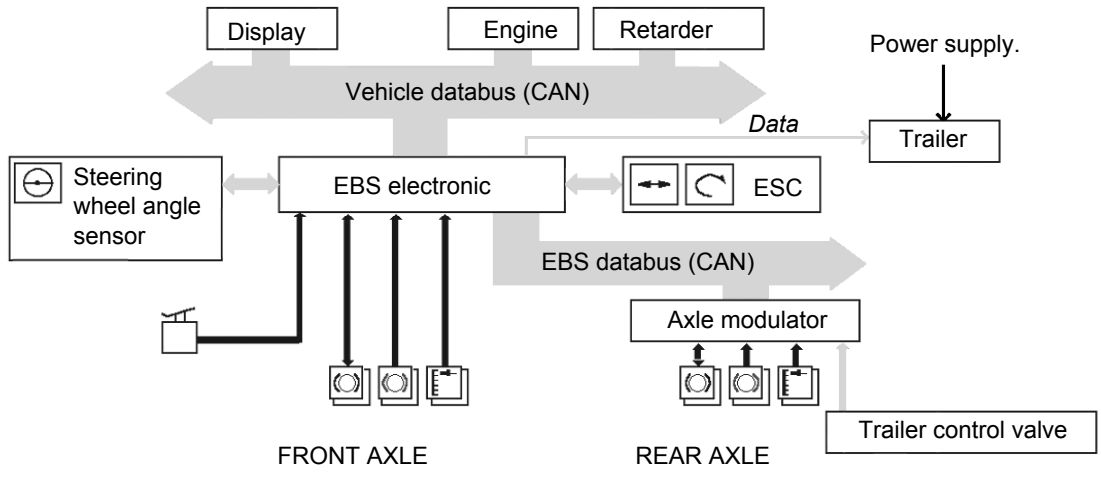



*Fig. 13: Connections of the ESC onto the Electronically Controlled Brake System from version 1C*

! In case simultaneous requirements for the limiting of the engine capacity exist from the EBS, such as activated anti slip regulation the requirements of the lowest moment have priority.

! The ESC module is always mounted near to the point of gravity of the vehicle to allow a correct measurement of the yaw rate and lateral acceleration sensor.

## 3.2 ESC control functions

Following control functions are integrated in ESC:

**Yaw control**
Yaw is the rotary motion of a vehicle across its own vertical axis. The yaw rate sensor measures these movements permanently. The ESC module compares the measurement data with a physical range of values where a stable vehicle condition is guaranteed. In the vehicle leaves this range then the vehicle may break-out or start to slide.
Therefore the ESC module informs the EBS electronic when this limit range is approached. This reduces the vehicle speed and if necessary makes a corrective change of direction over direct single wheel braking.

**Roll Stability Control (RSC)**
When driving through curves, the lateral acceleration is proportional to the force that acts on the side of the vehicle and with an unfavourable loading (high point of gravity) or when driving to fast, the vehicle might tip over. These lateral accelerations are measured in the ESC module and are compared with a tip critical estimated threshold value of the loading condition. If the threshold is exceeded, first of all a driving torque limiter is activated to adjust the driving speed over the engine control. If the increase of lateral acceleration can not be limited by this alone, the ESC module activates the main brake. The required actual delay is calculated in this case and the value is transferred to the EBS brake management that initiates the brake.

## 3.3 Special operating conditions

You will find information concerning the function of the ESC under special operating conditions in this chapter.

**Trailer operation with trucks**
The use of ESC is basically possible in trailer operation also. When the ESC control function intervenes, a coordinated braking of the trailer is carried out through the EBS brake management of the motor vehicle. At the same time it is irrelevant if the trailer is fitted with EBS.

The trailer is generally controlled over the RSS during trailer operation with trailer EBS and activated RSS function. Only if ESC initiates a higher pressure setting as the RSS, this is passed to the trailer.

! When operating a drawbar trailer, there is no ESC for the motor vehicle available at present.

**Deactivation of the ESC by the driver**
The ESC must be deactivated when operating off-road, with test drives in steep curves and when operating with snow chains. This is the reason why there is a possibility to deactivate the ESC over the ASR switch on the system side.

! This deactivation may be able to be carried out over the EoL parameter depending on the manufacturer. In such cases, refer to vehicle manufacturer to deactivate the ESC.

## 3.4 Error correction and diagnostics with ESC

Errors in the ESC do not have any effect on the brake system. If an error occurs, the ESC function is deactivated separately and the EBS functions remain active. However, to assure a preferably optimal availability of the ESC the deactivation is carried out hierarchised depending on the error gravity. Thus for example the roll stability control stays active despite the error in the yaw rate sensor.

! The driver is informed of errors in the ESC through a warning lamp.

The diagnostics of the ESC system and the ESC parameter are integrated in the diagnostics of the EBS system and are therefore processed over the EBS electronics.

# 4. Components

This component description details the properties of basic components. You find further details such as dimensions via product number in product database INFORM on the Internet (www.wabco-auto.com).

**! Information about order numbers and replaceability of the components can be obtained in the chapter "Overview of the spare parts".**

## 4.1 Brake signal transmitter

The brake signal transmitter receives the delay request of the driver through the brake pedal and thereupon produces the electrical signals and pneumatic pressures for the aeration and ventilation of the actuators.

**Brake signal transmitter**

*Fig. 14: Brake signal*

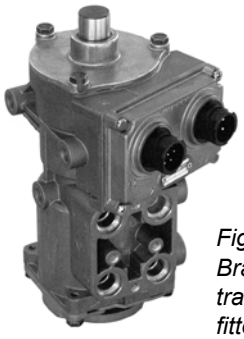


*Fig. 15: Brake signal transmitter, e.g. fitted in IVECO*

*Fig. 16 small brake signal transmitter*

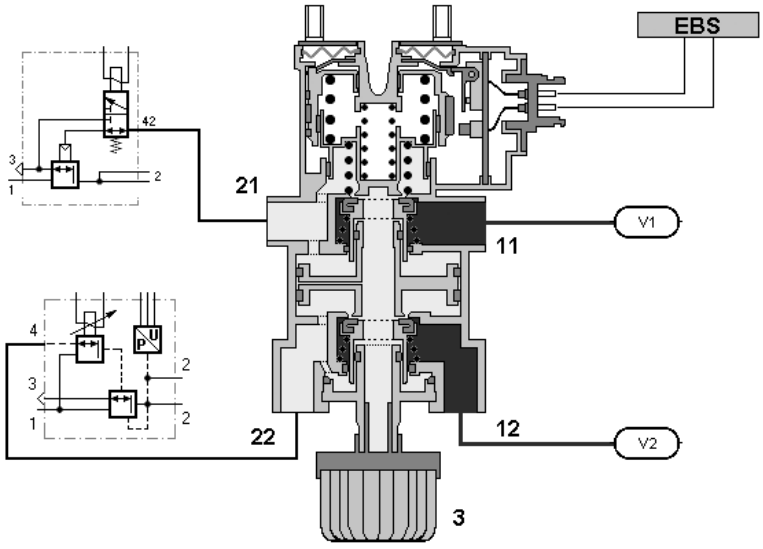



*Fig. 17: Mode of operation of the brake signal transmitter without connection 4*

The figure shows the mode of operation of the 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 lead from the brake signal transmitter to the redundancy valve. This so-called load/empty connection (4) is situated between (21) and (22).

The device has a dual-circuit electric and a dual-circuit pneumatic structure.
When operating the brake pedal, at first two electrical switching signals are created within a leeway that are released to two individual switches that are allocated to the electronic circuit and serve the operational discharge and the 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 also released from the switch as a Pulse Wide 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 redundancy pressures in circuits 1 and 2 are controlled. If one of the circuits malfunctions then the other electronic circuit and the two pneumatic circuits stay functional.

### 4.2 Central module

The central module controls and monitors the electronically controlled brake 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 set pressure value for the front axle, the rear axle and for the trailer control valve from the input signal.

*Fig. 18: Central module*

For this purpose it compares the set pressure value with the measured actual value. The central module regulates the present difference on the front axle with the aid of the proportional relay valve. Output of the trailer control pressure is achieved in a similar manner. The set default value for the axle modulator sends the central module over the EBS system bus.

Moreover, the wheel speed is evaluated so that in case of locking, an ABS control can be carried out by modulating the braking pressure in the brake cylinders.

Electrical braking systems for trailers are activated via a data interface according to ISO 11992. The central module communicates with other systems of the motor vehicle such as the motor control or the retarder using a vehicle databus.

## 4.3 Proportional relay valve

The proportional relay valve is used in the Electronically Controlled Brake 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 set values are implemented using a proportional magnetic valve in a control pressure for the relay valve.

The proportional relay valves output pressure is proportional to this pressure.

The pneumatic drive on the relay valve takes place via the brake signal transmitters pneumatic circuit. This redundancy pressure adds itself to the electro-pneumatic with the EBS versions [A] to [E] and the version [I] for buses. The proportional relais valve equals the added pressure of the set value before being set. In case of a redundancy, the complete relay pressure is controlled this way.

**Proportional relay valve**

*Fig. 19:*
*Proportional relay valve*

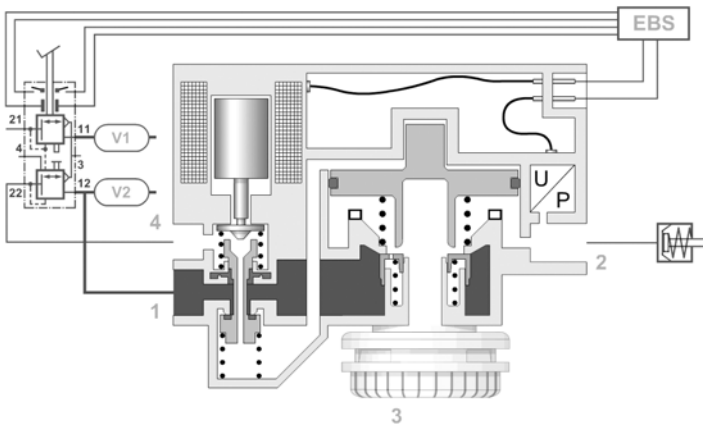



*Fig. 20: Mode of function of the proportional relay valve*

### 4.4 Central Braking Unit CBU

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

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

Respective to the drivers pedal operating, an electrical signal value is created as well as a pneumatic redundancy pressure and it controls the necessary front axle brake pressure by itself.

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

With a 4S/3M system, the integrated proportional relay valve of the CBU takes over the ABS function according to the principle of the Variable Axle Control (VAR).
With the 4S/4M system, the control is carried out using two magnetic control valves according to the principle of the Modified Individual Control (MIR).

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**Central Braking Unit CBU**

*Fig. 21: CBU*

! The CBU can also be supplied in a version with two plugs on the top of the enclosure.

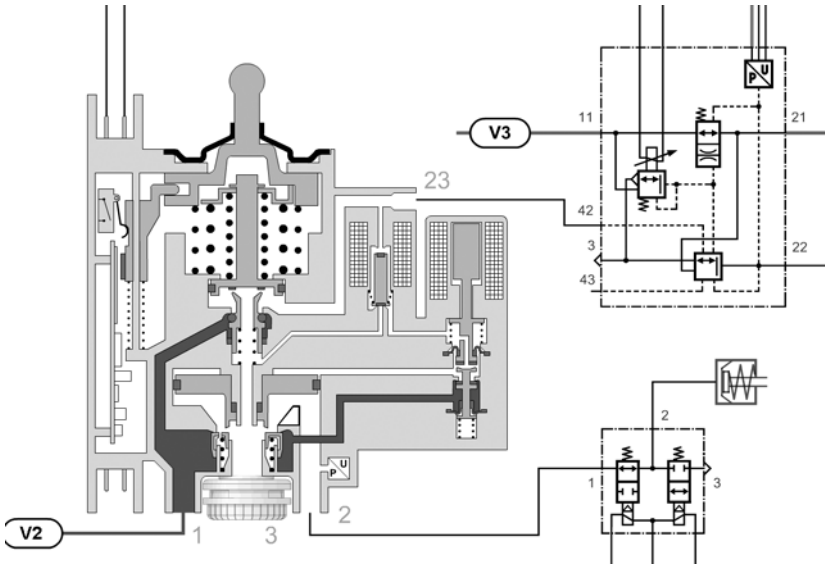



*Fig. 22: Mode of function of the CBU*

## 4.5 Axle modulators

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

**Axle modulator, 1st generation**
The axle modulator controls the brake cylinder pressure on both sides of one or two axles. It contains two independent pneumatic pressure control channels (channels A and B), each containing one inlet and one outlet valve, plus one brake 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 that subsequently calculates the set pressure. ABS control is applied by the axle modulator. In case of wheel lock or wheel spin, the axle modulator modifies the set pressure.
Provision is made for the connection of two sensors to detect brake pad wear.

The axle modulator comes with an additional connection for the redundant pressure control circuit of the brake signal transmitter. A two-way check valve on each side drives the higher pressure (electro-pneumatic or redundant) to the brake cylinder.

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

**Axle modulator, 1st generation**

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

*Fig. 23: Axle modulator, 1st generation*

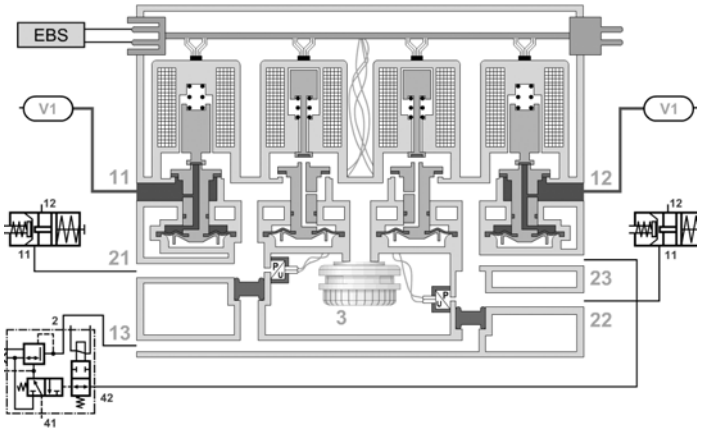



*Fig. 24: Mode of function of the axle modulator, 1st generation*

**Axle modulator, 2nd generation**
A modern, more compact and more powerful axle modulator has been introduced with the system EBS Evolution [F] in 2004. With this system the EBS electronic and axle modulator communicate with 500 kBit/s.

The new axle modulator fulfils the same functions as the first axle modulator generation. But this operates with a clocked magnetic valve.

**Axle modulator, 3rd generation**
The axle modulator of the third generation principly operates like the axle modulator of the second generation. The plug forms have been slightly modified in some cases and a redundancy valve has been flanged.

**Axle modulator, 2nd generation**

- Communication with 500 kBits/s
- with a clocked magnetic valve (like EBS trailer modulator)
- applied since 2004

*Fig. 25: Axle modulator, 2nd generation*

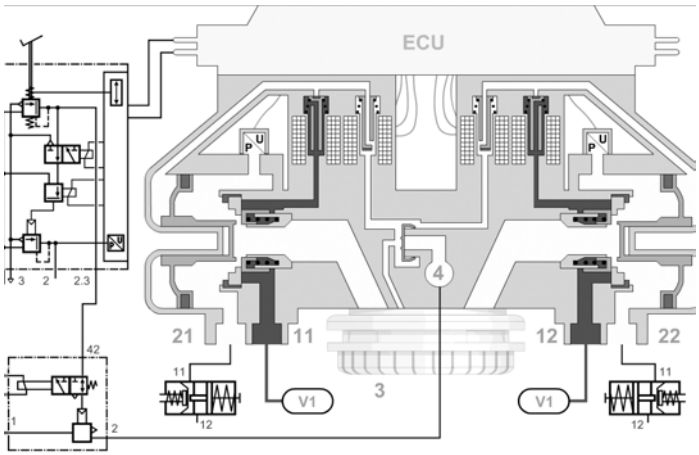



*Fig. 26: Mode of function of the axle modulator, 2nd generation*

**Axle modulator, 3rd generation**

- Communication with 500 kBits/s
- with a clocked magnetic valve (like EBS trailer modulator)
- applied since 02/2006

*Fig. 27: Axle modulator, 3rd generation*

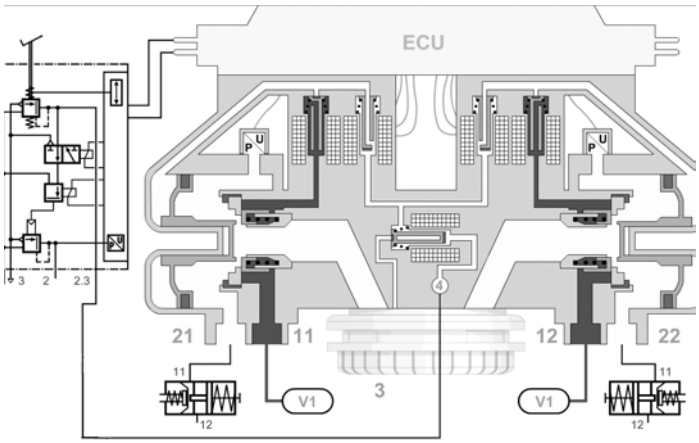



*Fig. 28: Mode of function of the axle modulator, 3rd generation*

## 4.6 Trailer control valve

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

The trailer control valve consists of a proportional magnetic valve, a relay valve, a breakaway emergency valve and a brake pressure sensor. The control current impressed by the electronic unit is transformed via the proportional magnetic valve into a control pressure for the relay valve.

The 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 a lead phase setting.

**Trailer control valve**

*Fig. 29: Trailer control valve*

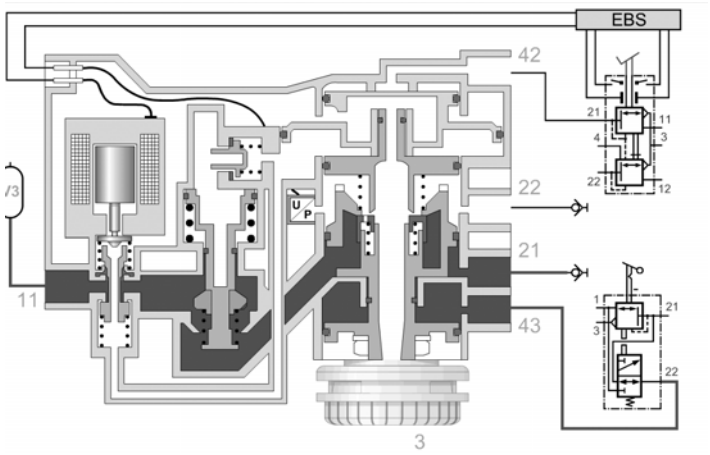



*Fig. 30: Mode of operation of the trailer control valve*

## 4.7 Redundancy valve (optional)

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

- 3/2 directional control valve function to switch off the pneumatic connection with intact electro-pneumatic brake circuits
- Relay valve function, to improve the time behaviour of redundancy,
- Pressure retention to start the synchronisation of the pressure control of the front and rear axles when the electro-pneumatic circuit malfunctions.
- Pressure reduction to avoid over braking of the rear axle to the largest possible extent in the case of a backup (reduction approx. 2:1).

The redundancy valve which is installed in the Actros consists in addition to that of a 2/2 directional control valve which is energised in any case of ABS. This prevents a involuntary drive through of the rear axle redundancy pressure during ABS control.

**Redundancy valve**

*Fig. 31: Redundancy valve with five connections*

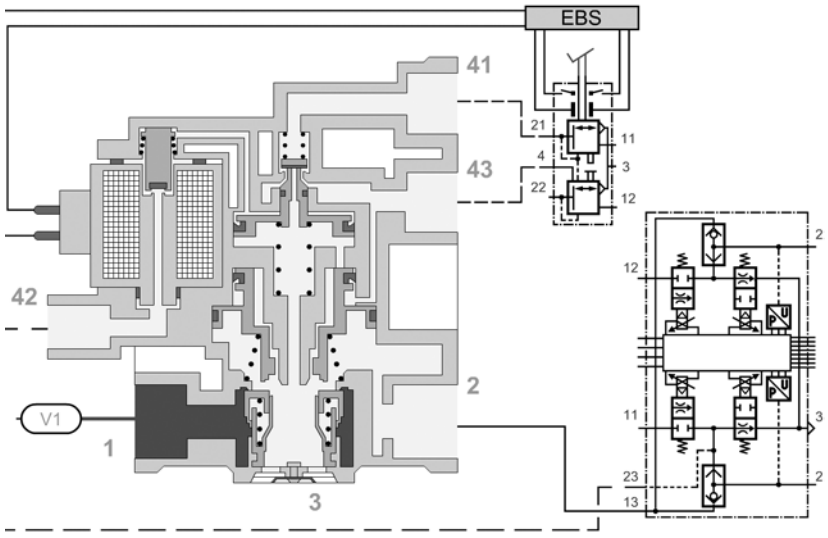



*Fig. 32: Mode of function*

Redundancy valves are fitted on the rear axle to switch away the pneumatic redundancy pressure mechanically. Fig. 31 and fig. 32. show the valve versions that have been fitted by Daimler Chrysler in the past. With later system versions, the course of the pneumatic lines have been slightly modified so that only three compressed air connections were necessary on the redundancy valve (fig. 33 and fig. 34).

**Redundancy valve**

*Fig. 33: Redundancy valve with three connections*

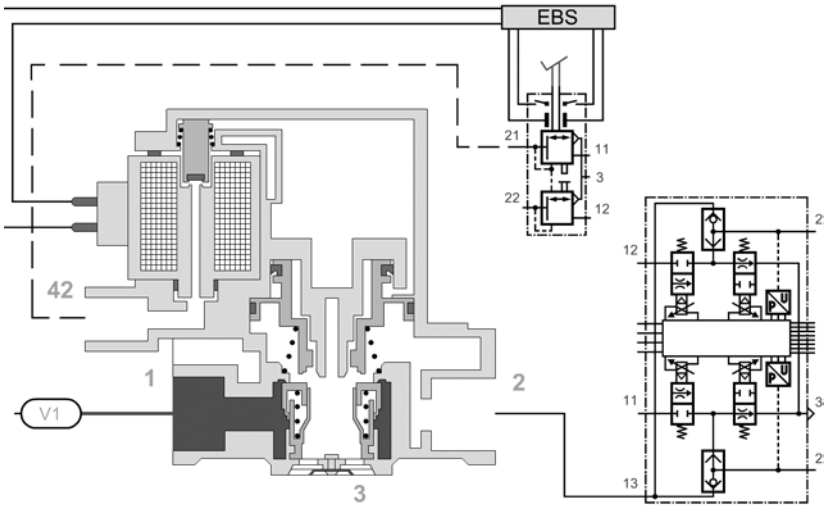



*Fig. 34: Mode of function of the redundancy valve*

*Fig. 35: 3/2 Directional Control Valve*

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

## 4.8 Further components

Further components of the Electronically Controlled Brake System are:

**ABS-Solenoid Modulator Valve**

*Fig. 36: ABS-Solenoid Modulator Valve*

The ABS Solenoid Modulator 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 modulator valve. When the ABS is activated, the input valves close and do not let any new pressure into the brake cylinder. If tyres still block then pressure is released through an additional outlet in the valve.

Depending on the system version, there is a different number of solenoid modulator valve installed. For example, there are four speed sensors and two solenoid modulator valve fitted in a 4S/4M system. Two solenoid modulator 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 over a CBU (e.g. 4S/3M).

**Speed sensor**

*Fig. 37: Speed sensor*

The speed sensor calculates the actual wheel speed permanently over a pole wheel and transfers the data to the EBS electronic 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.

**Brake pad wear indicator/sensor (BVA)**

*Fig. 38: Brake pad wear indicator*

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

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

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

# 5. Error recognition function

There are different error recognition functions in the EBS. These are supposed to decrease the effect of system malfunctions and inform the driver about functional limits. Some of these functions accord to the usual ABS monitoring functions and some are EBS specific.

**Set value sensor**
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 correctness of the switch signals are then tested.

**Brake 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 sensing 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 of the EBS specific magnetic valve**
The continuous magnets of 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 redundancy 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 of the brake pressure control**
The electronically controlled brake pressure as well as the pneumatic redundant pressures are monitored with following functions:

- A test is made if a minimum brake 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, an error is reported.
- In certain situations when the vehicle stands still, parking brake in stop position, an electronically control of brake pressure on front- and rear brake is prevented. If the driver now activates the brake pedal, the brakes on front- and rear axle are controlled via pneumatical redundancy. 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, an error is reported.
- Normally, pneumatic 3/2 relais pressure control in the rear axle is prevented by the redundancy valve. If the controlling is no longer possible because of a fault, the rear axle braking pressure cannot be reliably reduced with the ABS control. The reason for this is that the ABS capable rear axle redundancy pressure can enter the rear axle brake cylinder. The EBS reports an error in this situation.

**Monitoring of data transmission**
EBS monitors data transmission between

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

If the communication is not possible or is interrupted, an error is reported.

**Possible function shut-downs**
At the end of an error detection, certain functional fields of the EBS are generally deactivated. Functions not impaired by the failure are maintained. For the EBS-drive with limited functions, the term "emergency mode" is used.

- Operation without ABS function
  Depending on the type of error, the ABS function is deactivated on an individual wheel, an axle or on the complete vehicle.
- Operation without ASR function
  The anti slip regulation can be switched off completely or partially. Complete deactivation means that both the brake system and the engine control unit are deactivated. Partial deactivation means that only the brake system is deactivated.

- Pressure control / auxiliary pressure control
  Normally, braking pressure control requires the braking pressure sensor signal. If this signal is no longer available, electrical brake 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 hitch-free pressure control.
- Redundancy operation:
  If electrical pressure control becomes impossible, the corresponding axle is braked with the help of the pneumatic redundancy pressure.

# 6. Diagnostics

**WARNING** Using the diagnostics software you can 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 diagnostics are carried out using a PC or notebook that is connected to the vehicle electronics. WABCO diagnostics software must be installed on the notebook. The software is available in different languages for different EBS system versions. You may learn the current status from the Internet (www.wabco-auto.com) over menu "Download". All available language versions of the WABCO diagnostic program are shown on the diagnostics software subscription pages.

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

! Change of the control device settings will not be possible while being in diagnostic mode. For this purpose, a PIN must be entered which can only be received after participating a special EBS training.

## 6.1 Diagnostic connection

A special diagnostics cable is required to create a connection between the computer, the interface and the vehicle. This cable differs in 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 "Diagnostics and Testing Equipment".

*Fig. 39: Diagnostics connection through the interface on the diagnostics PC.*

The connector for the diagnostics is usually situated in the drivers cabin. Contact your vehicle manufacturer to find out where connector can be found in your vehicle.

## 6.2 Operating the diagnostics software

After you have connected the notebook to the vehicle, start the respective vehicle and EBS versions of the diagnostics software.

! At first, open the diagnostics memory under *Message* > *Diagnostics memory* or click on the respective push button of the diagnostics memory and save the entries in a safe place. This allows you to differ later errors from present errors, e.g. that have been protocoled during the initiation and have been lost.

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

Normally the control electronic recognises the actual error by itself. In case you would like to initiate a complete diagnosis, click on the push button *Start Diagnosis* or select the respective menu point in the menu *Diagnostics* > *Start*. Now the software checks the individual components and protocols current errors that occur. The software collects all errors that occur in the diagnostics memory (*Message* > *Diagnostics memory*) . Current errors are coloured red in the overview and those that are not current are coloured blue. To receive more information concerning a certain error, mark it and click on the button *Info.*

To refresh the diagnosics memory, e.g. during repairs, click on the button *Refresh* or activate the control box *Refresh cyclical*.

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

# 7. Workshop instructions

**WARNING**

Read the technical documentation of the vehicle manufacturer and carry out the requirements and instructions as shown.

Special trainings are necessary for putting EBS into operation.

Only qualified workshops with qualified skilled personnel with specific system knowledge must carry out repairs on vehicle safety systems.

Only products that have been exclusively released by WABCO or the vehicle manufacturer must be used.

Make sure that the complete compressed air system is emptied before the device is dismantled.

Before mounting equipment, perform all necessary safety precautions, for example securing car against rolling away.

Before work is carried out on the vehicle, an instruction sign must be fixed onto the steering wheel to prevent any accidents.

**CAUTION**

Comply with the company and national accident prevention / health & safety regulations.

Do not clean the foundation brakes using compressed air. The resulting dispersed dust can lead to severe damage to health.

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 diagnosis software signals this.

## 7.1 General instructions

EBS is maintenance free This monitors itself and its components. If an error occurs then the driver is notified that the vehicle must betaken to the workshop or that the vehicle must be stopped.
Information concerning the integrated error recognition functions and the possible function deactivations of the EBS can be found in the chapter "Error Recognition Functions"

The defective EBS system can be checked using the aid of the WABCO diagnostics software in a professional workshop. Further information can be found in chapter "Diagnostics"

**Reparation of components**

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

Before replacing the component, read the respective chapter in the component overview under "Components" and inform yourself as to which replacement device fits. Further information can be found in chapter "Overview of the spare parts"

! A re-parameterisation of the braking system is necessary when using wheels with other tyre sizes or the modification of the allowable axle load of the vehicle. Your vehicle manufacturer must be consulted in this case.

! **Only with axle modulator, 3rd generation**
When a pneumatic circuit malfunction on the rear axle occurs, the front axle circuit will will slowly empty over the axle modulator when the motor is standing and the brakes are operated that leads to deaeration noise. The brake operation can also be carried out using a pedal spanner.
An overflow blind is integrated in the piston of the axle modulator that carries the compressed air to the rear axle brake pressure. This is the reason for the deaeration noise. The axle modulator does not have to be replaced.

## 7.2 Roller dynamometer test

The fulfilment of the compulsory braking action of the vehicle is usually proved on the roller dynamometer 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 stay without effect, e.g. load dependant braking force control. Therefore this chapter describes how you can activate the function of the roller dynamometer with an EBS vehicle to be able to carry out the following compulsory measurements.

**Proceeding with Daimler Chrysler vehicles:**
To be able to activate the roller dynamometer on the standing 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 with less than 12 km/h, which is the case on the roller dynamometer, then you have activated the roller dynamometer.

If you must drive the vehicle onto the test bench and want to subsequently activate the roller dynamometer, make sure that the vehicle speed has been running for at least 20 second with less than 12 km/h. Then the EBS recognises the that the vehicle has stopped at this point and activates the roller dynamometer.

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

**Procedure with vehicles of other manufacturers**
To be able to enter the testing mode of the roller dynamometer, procede as follows:

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

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

To deactivate the roller dynamometer, 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 Disposal

When disposing the defect components, observe the current local, regional and national laws and legal regulations. WABCO makes efforts to protect the environment. Used devices can be returned to WABCO using the usual process as with other used devices. Contact your local WABCO sales partner for more details concerning disposal.

## 7.4 Overview of the 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 having to be changed. Changes are necessary when replacing an alternative device. In this case contact your local WABCO sale partner.

| 3/2 Directional Control Valve | | | | |
|---|---|---|---|---|
| **WABCO no.** | **Comment** | **Installation** | **Replacement** | **Alternative** |
| **Daimler Chrysler** | | | | |
| 472 176 916 0 | MP II | | | |
| 434 205 051 0 | | | | |
| 472 176 316 0 | | | | |
| **Neoplan / Neoman** | | | | |
| 472 176 316 0 | | | | |

| Axle modulators | | | | |
|---|---|---|---|---|
| **WABCO no.** | **Comment** | **Installation** | **Replacement** | **Alternative** |
| **DAF** | | | | |
| 480 103 041 0 | FA (4x2), 4x2 with redundancy valve<br>! Locking screws on p21.2 and p22.2 | 01.04.01 - 01.10.03 | | 480 103 042 0 |
| 480 103 042 0 | FTG (6x2), FAG (6x2), 6x2 with redundancy valve | 01.04.01 - 01.10.03 | | |
| 480 103 043 0 | FT (4x2), 4x2 without redundancy valve | 01.04.01 - 01.10.03 | | |
| 480 104 001 0 | Trucks 4x2 with redundancy valve | from 01.10.03 | | 480 104 002 0 |

| Axle modulators | | | | |
|---|---|---|---|---|
| **WABCO no.** | **Comment** | **Installation** | **Replacement** | **Alternative** |
| 480 104 002 0 | Articulated truck 6x2 with redundancy valve | from 01.10.03 | | |
| 480 104 003 0 | Articulated truck FT (4x2) without redundancy valve | from 01.10.03 | | |
| **Daimler Chrysler** | | | | |
| 480 103 001 0 | For 6x2, 6x2/4, 6x2 and 8x4 with disc brakes on the rear axle<br>! 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 | For all 4x2 with disc brakes on the rear axle<br>! 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 | For all 4x2 with disc brakes and drum brakes | 1997 - 1998 | 480 103 011 0 | |
| 480 103 005 0 | For 6x2, 6x2/4, 6x4, 8x4 with disc brakes and drum brakes | 1997 - 1998 | 480 103 012 0 | |
| 480 103 006 0 | for 4x2 | 1998 - 1999 | 480 103 011 0 | |
| 480 103 007 0 | For 6x2, 6x2/4-, 6x4 and 8x4 | 1998 - 1999 | 480 103 012 0 | |
| 480 103 008 0 | Bus, additional axle, with redundancy valve | from 1998 | | |
| 480 103 009 0 | Bus, additional axle, without redundancy valve | from 1998 | | |
| 480 103 011 0 | for 4x2 | from 1999 | | |
| 480 103 012 0 | For 6x2, 6x2/4-, 6x4 and 8x4 | 1999 - 2003 | | |
| 480 103 013 0 | For all 4x2 with ESC<br>! No more downwards compatibility! | 2000 - 2003 | | |
| 480 103 014 0 | 6x2, 6x4, 8x4 | | | |
| 480 103 015 0 | for 4x2 | from 2001 | | |
| 480 103 016 0 | For all vehicles except 4x2 | | | |
| 480 103 017 0 | Fording ability version | from 2005 | | |
| 480 103 061 0 | Bus, additional axle, with redundancy valve | from 2000 | | |
| 480 103 063 0 | Bus, drive axle, with redundancy valve | from 2000 | | |
| 480 103 066 0 | Bus, drive axle, with redundancy valve | 1999 - 2002 | | |
| 480 105 001 0 | For all 4x2 vehicles with trailer control valve<br>with redundancy valve | from 2006 | | |

| Axle modulators | | | | |
|---|---|---|---|---|
| **WABCO no.** | **Comment** | **Installation** | **Replacement** | **Alternative** |
| 480 105 002 0 | For all *except* 4x2 vehicles with trailer control valve with redundancy valve | from 2006 | | |
| **IVECO** | | | | |
| 480 103 022 0 | | 1998 - 2004 | | |
| 480 103 024 0 | Articulated trucks | from 2000 | | |
| 480 103 025 0 | Truck | from 2000 | | |
| 480 104 005 0 | Articulated trucks | from 2004 | | |
| 480 104 006 0 | Truck | from 2004 | | |
| **MAN** | | | | |
| 480 104 101 0 | Vehicle with trailer control valve, drive axle, with redundancy valve | 2003 - 2006 | 480 104 104 0 | |
| 480 104 103 0 | Vehicle without trailer control valve, for additional axle in 6S/6M vehicle or drive axle in 4S/4M vehicle, with redundancy valve | 2003 - 2006 | 480 104 105 0 | |
| 480 104 104 0 | Vehicle with trailer control valve, drive axle, with redundancy valve | from 2005 | | |
| 480 104 105 0 | Vehicle without trailer control valve, additional axle in 6S/6M vehicle or drive axle in 4S/4M vehicle, with redundancy valve | from 2005 | | |
| **Neoplan / Neoman** | | | | |
| 480 103 061 0 | Bus, drive axle, with redundancy valve | from 2001 | | |
| 480 103 063 0 | Bus, additional axle, with redundancy valve | from 2001 | | |
| 480 104 101 0 | Bus with trailer control valve, drive axle, with redundancy valve | 2003 - 2006 | 480 104 104 0 | |
| 480 104 103 0 | Bus without trailer control valve, additional axle in 6S/6M vehicle or drive axle in 4S/4M vehicle, with redundancy valve | 2003 - 2006 | 480 104 105 0 | |
| 480 104 104 0 | Bus with trailer control valve, drive axle, with redundancy valve | from 2005 | | |
| 480 104 105 0 | Bus without trailer control valve, additional axle in 6S/6M vehicle or drive axle in 4S/4M vehicle, with redundancy valve | from 2005 | | |

| Axle modulators | | | | |
|---|---|---|---|---|
| **WABCO no.** | **Comment** | **Installation** | **Replacement** | **Alternative** |
| **Solaris Bus** | | | | |
| 480 103 061 0 | Bus, drive axle, with redundancy valve | from 2001 | | |
| 480 103 063 0 | Bus, additional axle, with redundancy valve | from 2001 | | |

| Trailer control valve | | | | |
|---|---|---|---|---|
| **WABCO no.** | **Comment** | **Installation** | **Replacement** | **Alternative** |
| **DAF** | | | | |
| 480 204 001 0 | FT (4x2), FA (4x2), FTG (6x2), FAG (6x2) | 01.04.01 - 01.10.03 | | 480 204 002 0 |
| **Daimler Chrysler** | | | | |
| 480 204 000 0 | Old 7 pole normed bayonet, 4x2 | | 480 204 001 0 | |
| 480 204 001 0 | Revised 7 pole normed bayonet, 4x2 | | | 480 204 002 0 |
| 480 204 002 0 | 7 pole DIN bayonet, plugged from below | | | |
| **IVECO** | | | | |
| 480 204 001 0 | 4x2, 6x2/4 | | | 480 204 002 0 |

| Brake signal transmitter | | | | |
|---|---|---|---|---|
| **WABCO no.** | **Comment** | **Installation** | **Replacement** | **Alternative** |
| **DAF** | | | | |
| 480 001 500 0 | FT (4x2), FA (4x2), FTG (6x2), FAG (6x2) | from 04/2001 | | |
| **Daimler Chrysler** | | | | |
| 480 001 000 0 | Without silencer, without Voss fittings, with port 4 | 1996 - 2000 | | 480 001 010 0 |
| 480 001 004 0 | For suspended pedal | up to 2004 | 480 001 005 0 | |
| 480 001 005 0 | For suspended pedal | from 2004 | | |
| 480 001 010 0 | With integrated silencer, with Voss fittings, with port 4 | from 2000 | | |
| 480 001 011 0 | With integrated silencer, with Voss fittings, without port 4, not compatible with 480 001 010 0 | from 01.01.03 | | |
| 480 002 000 0 | For standing pedal | 1997 - 2003 | | |
| 480 002 002 0 | For standing pedal | 1998 - 2003 | 480 002 004 0 | |
| 480 002 004 0 | For standing pedal | from 2004 | | |
| **IVECO** | | | | |
| 480 001 300 0 | For suspended pedal | 1999 - 2004 | | |

| Brake signal transmitter | | | | |
|---|---|---|---|---|
| **WABCO no.** | **Comment** | **Installation** | **Replacement** | **Alternative** |
| **Neoplan / Neoman** | | | | |
| 480 002 000 0 | For standing pedal | from 2001 | | |
| **Solaris Bus** | | | | |
| 480 002 003 0 | For standing pedal | from 2002 | | |

| CBU Central Braking Unit | | | | |
|---|---|---|---|---|
| **WABCO no.** | **Comment** | **Installation** | **Replacement** | **Alternative** |
| **IVECO** | | | | |
| 480 020 010 0 | | | | |
| **Neoplan / Neoman** | | | | |
| 480 020 001 0 | 4x2, 6x2/4<br>4S/4M, 6S/6M<br>! In case the vehicle is fitted with a bus stop brake or RSF, the AS Tronic must also be updated | | 480 020 004 0 | |
| 480 020 004 0 | 4S/4M, 6S/6M | from 01.10.04 | | |
| **MAN** | | | | |
| 480 020 001 0 | 4x2, 6x2/4<br>4S/4M, 6S/6M<br>! In case the vehicle is fitted with a bus stop brake or RSF, the AS Tronic must also be updated | | 480 020 004 0 | |
| 480 020 002 0 | 4S/3M | | | |
| 480 020 004 0 | 4S/4M, 6S/6M | from 01.10.04 | | |

| Pressure Limiting Valves | | | | |
|---|---|---|---|---|
| **WABCO no.** | **Comment** | **Installation** | **Replacement** | **Alternative** |
| **DAF** | | | | |
| 475 010 302 0 | 4.8 bar, only with LF55 for 6x2 vehicles | | | |
| 475 010 400 0 | FA (4x2), FAR (6x2), FTG (6x2), FAG (6x2), FTS (6x2), FAS (6x2), FTT (6x4), FAT (6x4), FAD (8x4) | | | |
| 475 019 000 0 | FTG (6x2), FAG (6x2) | from 2001 | | |
| **Daimler Chrysler** | | | | |
| 475 010 317 0 | | | | |
| 475 010 318 0 | | | | |
| 475 010 325 0 | For MP II vehicles | | | |
| 475 010 330 0 | | | | |

| Pressure Limiting Valves | | | | |
|---|---|---|---|---|
| **WABCO no.** | **Comment** | **Installation** | **Replacement** | **Alternative** |
| 475 010 331 0 | | | | |
| 475 010 332 0 | | | | |
| 475 020 001 0 | Especially for articulated trucks, 4.9 bar | | | 475 020 006 0 |
| 475 020 002 0 | Especially for articulated trucks, 5.2 bar | | | 475 020 006 0 |
| 475 020 003 0 | Especially for articulated trucks, 5.5 bar | | | 475 020 006 0 |
| 475 020 004 0 | Especially for articulated trucks, 4.6 bar | | | 475 020 006 0 |
| 475 020 005 0 | Especially for articulated trucks, 4.1 bar | | | 475 020 006 0 |
| 475 020 006 0 | 4.1 bar, with silencer | | | |
| **MAN** | | | | |
| 475 009 008 0 | 10/0.7 +/- 0.1 bar | | | |
| 475 010 300 0 | 8.5 -0.4 bar | | | |
| 475 010 301 0 | 10 + -0.3 bar | | | |
| 475 015 029 0 | 12.5/7.4 + 0.2 bar | | | |

| ESC Module | | | | |
|---|---|---|---|---|
| **WABCO no.** | **Comment** | **Installation** | **Replacement** | **Alternative** |
| **Daimler Chrysler** | | | | |
| 446 065 000 0 | MPII | 2001-2003 | 446 065 003 0 | |
| 446 065 001 0 | Bus | 2001-2003 | 446 065 004 0 | |
| 446 065 003 0 | Articulated trucks | 2003-2005 | 446 065 021 0 | |
| 446 065 004 0 | Bus | 2003-2005 | 446 065 022 0 | |
| 446 065 022 0 | Bus | from 2006 | | |
| 446 065 023 0 | Articulated trucks with EBS 1C | | | |
| 446 065 024 0 | Bus | | | |
| **IVECO** | | | | |
| 446 065 005 0 | Articulated trucks | 2003-2005 | 446 065 020 0 | |
| 446 065 006 0 | Fire-fighting vehicle | 2003-2005 | 446 065 020 0 | |
| **DAF** | | | | |
| 446 065 005 0 | FX95, CF75, CF85 | 2003-2005 | 446 065 020 0 | |
| **Neoplan / Neoman** | | | | |
| 446 065 006 0 | Bus, replacement device 446 065 025 0 available from the middle of 2006 | 2003-2005 | 446 065 025 0 | |

| Proportional relay valve | | | | |
|---|---|---|---|---|
| **WABCO no.** | **Comment** | **Installation** | **Replacement** | **Alternative** |
| **DAF** | | | | |
| 480 202 004 0 | Identical with EBS 1a and 1c | 04/2001 | | |
| 480 202 005 0 | FT 4x2, FA 4x2, FTG (6x2), FAG (6x2) | | | |
| **Daimler Chrysler** | | | | |
| 480 202 001 0 | For all vehicles except for 8x4, old 7 pole Normed bayonet | | | 480 202 004 0 |
| 480 202 002 0 | For 8x4 | | | 480 202 005 0 |
| 480 202 004 0 | For all vehicles except 8x4 | | | |
| 480 202 005 0 | | | | |
| **IVECO** | | | | |
| 480 202 004 0 | For all vehicles except 8x4 | | | |

| Redundancy valves | | | | |
|---|---|---|---|---|
| **WABCO no.** | **Comment** | **Installation** | **Replacement** | **Alternative** |
| **DAF** | | | | |
| 480 205 103 0 | Identical with EBS 1a and 1c | | | |
| **Daimler Chrysler** | | | | |
| 472 176 916 0 | MP II vehicle (front axle) | | | |
| 480 205 001 0 | For all vehicles | | | 480 205 104 0 |
| 480 205 002 0 | | | | |
| 480 205 010 0 | 4x2, 6x2, articulated bus | | | |
| 480 205 104 0 | MP II vehicles | | | |
| **MAN** | | | | |
| 480 205 104 0 | | | | |

| Special relay valve | | | | |
|---|---|---|---|---|
| **WABCO no.** | **Comment** | **Installation** | **Replacement** | **Alternative** |
| **Daimler Chrysler** | | | | |
| 973 011 300 0 | | | | |

| Central module | | | | |
|---|---|---|---|---|
| **WABCO no.** | **Comment** | **Installation** | **Replacement** | **Alternative** |
| **DAF** | | | | |
| 446 135 017 0 | FT 4x2, FA 4x2, FTG 6x2, FAG 6x2<br>EOL parameter setting by DAF | from 1999 | | |
| 446 135 038 0 | from EBS 1c<br>4x2 and 6x2 articulated truck | from 2003 | | |
| **Daimler Chrysler** | | | | |
| 446 130 000 0 | For all vehicles with disc brakes on the front axle | | 446 130 014 0 | |
| 446 130 004 0 | For 4x2, 6x2, 6x2/4, 6x4 and 8x4 with EPS /EAS except for articulated trucks with 4x2 and normal frame height | | 446 130 014 0 | |
| 446 130 005 0 | For all 4x2 articulated trucks with normal frame height and EPS/EAS | | 446 130 015 0 | |
| 446 130 008 0 | For 4x2, 6x2, 6x2/4, 6x4 and 8x4 except for 4x2 articulated trucks with normal frame height and hydraulic gear shift | | 446 130 014 0 | |
| 446 130 009 0 | For 4x2 articulated trucks with normal frame height and hydraulic gear shift | | 446 130 015 0 | |
| 446 130 010 0 | For 4x2, 6x2, 6x2/4, 6x4 and 8x4 except for 4x2 articulated trucks with EPS/EAS and hydraulic gear shift | | 446 130 014 0 | |
| 446 130 011 0 | For all 4x2 articulated trucks with normal frame height and EPS/EAS and hydraulic gear shift | | 446 130 015 0 | |
| 446 130 014 0 | For 4x2, 6x2, 6x2/4, 6x4 and 8x4 (except for 4x2 articulated trucks) with EPS/EAS and hydraulic gear shift | from 1998 | | |
| 446 130 015 0 | For all 4x2 articulated trucks with normal frame height and EPS/EAS and hydraulic gear shift | from 1998 | | |
| 446 130 018 0 | For 4x2, 6x2, 6x2/4, 6x4 and 8x4 except for 4x2 articulated trucks with EPS/EAS and hydraulic gear shift and ESC | | | |
| 446 130 019 0 | For all 4x2 articulated trucks with normal frame height, EPS/EAS, hydraulic gear shift and ESC | | | |
| 446 130 020 0 | Bus 6S/6M | from 1999 | 446 130 024 0 | |
| 446 130 021 0 | Bus 4S/4M | | 446 130 025 0 | |
| 446 130 022 0 | Bus 4S/4M | from 1999 | | |
| 446 130 023 0 | Bus 6S/6M | from 1999 | | |

| Central module | | | | |
|---|---|---|---|---|
| **WABCO no.** | **Comment** | **Installation** | **Replacement** | **Alternative** |
| 446 130 024 0 | Bus 4S/4M | from 2000 | 446 130 028 0 | |
| 446 130 025 0 | Bus 6S/6M | from 2000 | 446 130 029 0 | |
| 446 130 026 0 | Bus 4S/4M | from 2002 | 446 130 030 0 | |
| 446 130 027 0 | Bus 6S/6M | from 2002 | 446 130 031 0 | |
| 446 130 028 0 | Bus 4S/4M | from 2000 | | |
| 446 130 029 0 | Bus 6S/6M | from 2000 | | |
| 446 130 050 0 | For all MPII vehicles | | 446 130 053 0 | |
| 446 130 051 0 | For all MPII vehicles | | 446 130 053 0 | |
| 446 130 054 0 | For all vehicles with EBS 1c | | | |
| **IVECO** | | | | |
| 446 135 018 0 | For 4x2, 6x2, 6x2/4, 6x4 and 8x4 except for 4x2 articulated trucks with EPS/EAS, hydraulic gear shift and ESC | | | |

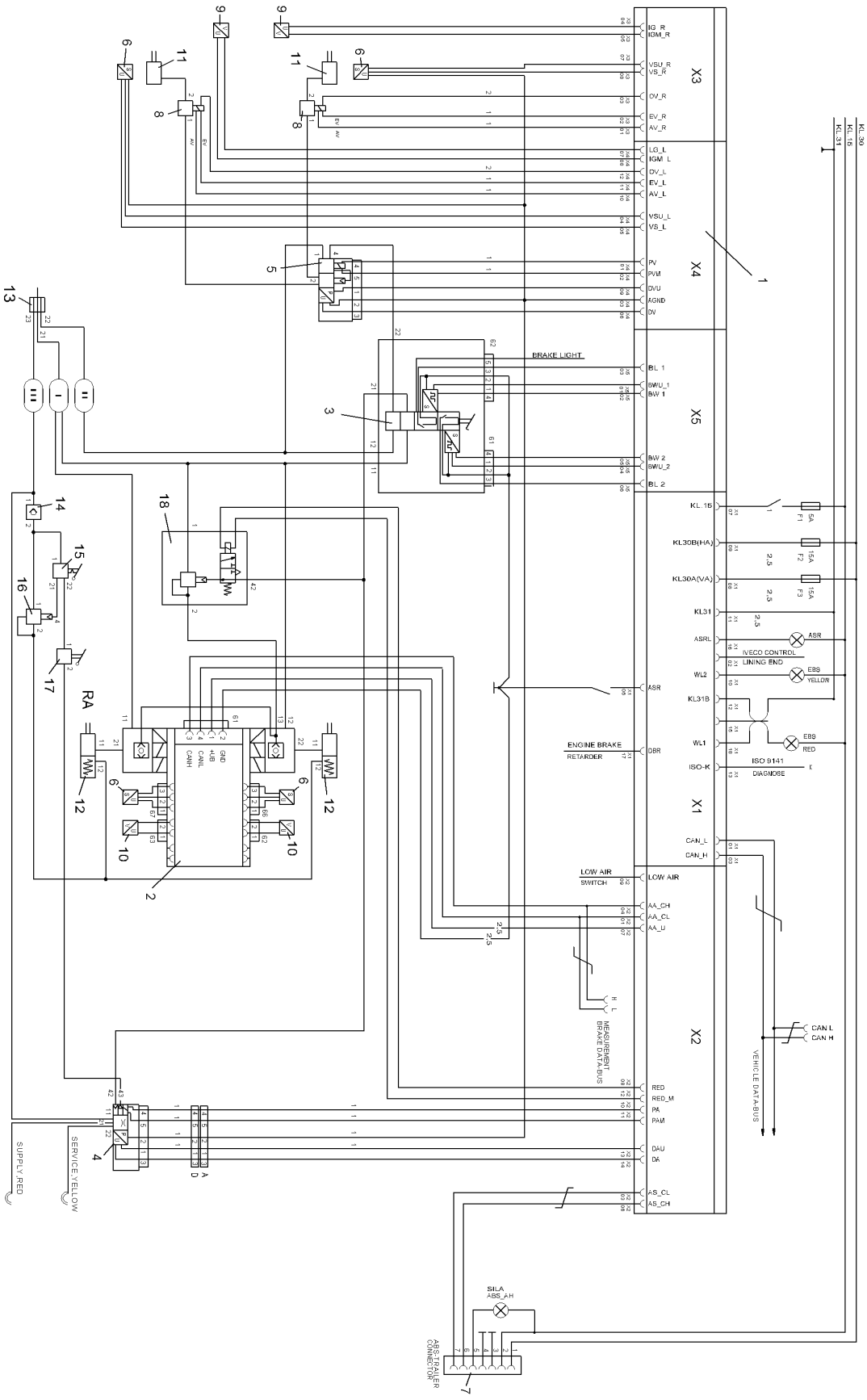
# Wiring diagram for [D], EBS 1B, 4S/4M (841 100 478 0)

**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 control valve
**9** ABS speed sensor
**10** ABS speed sensor

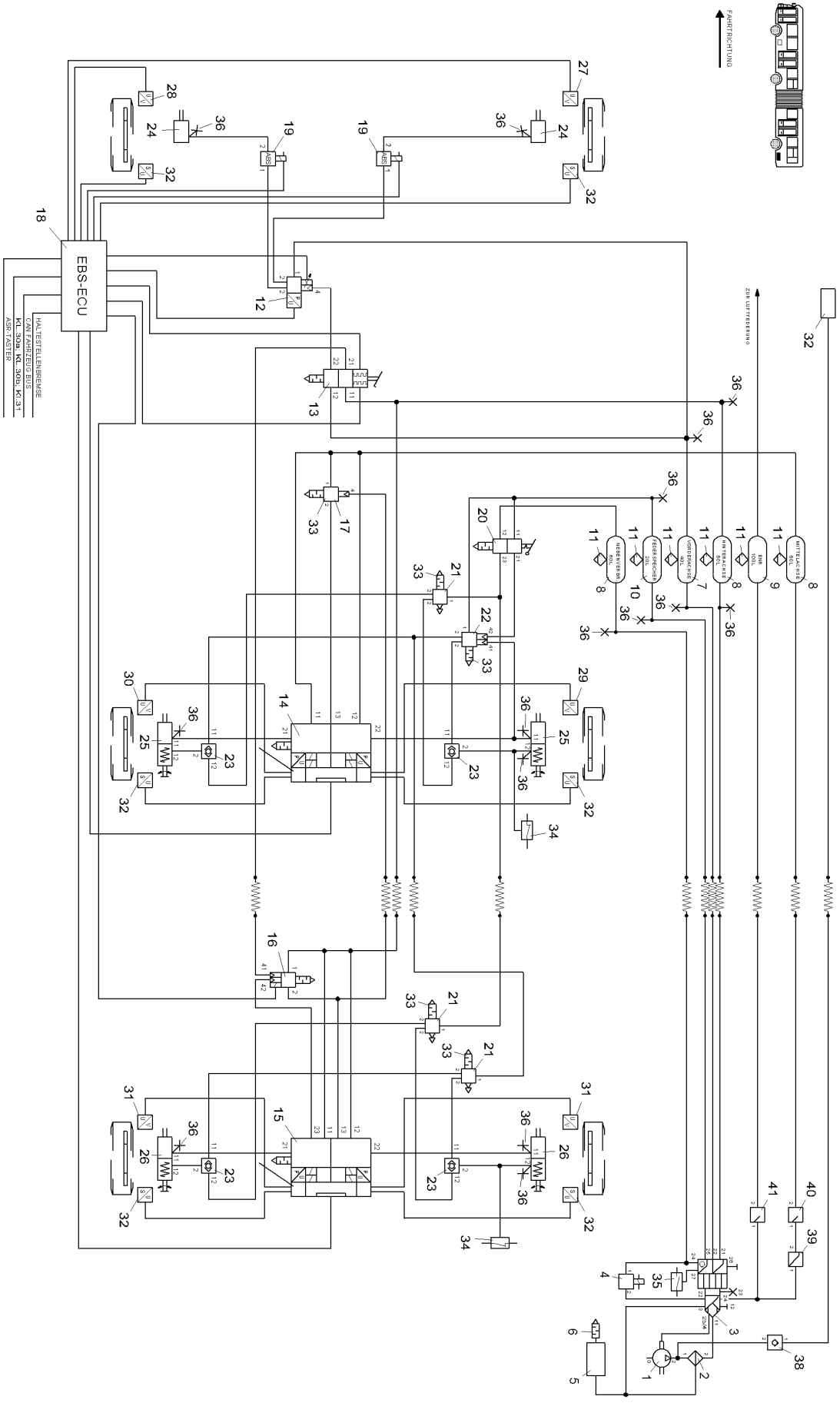
**11** Brake cylinder
**12** Tristop cylinder
**13** Four-circuit protection valve
**14** Check valve
**15** Hand brake valve

**16** Relay valve
**17** Trailer hand brake valve
**18** Redundancy valve
**x1 - x5** Slots



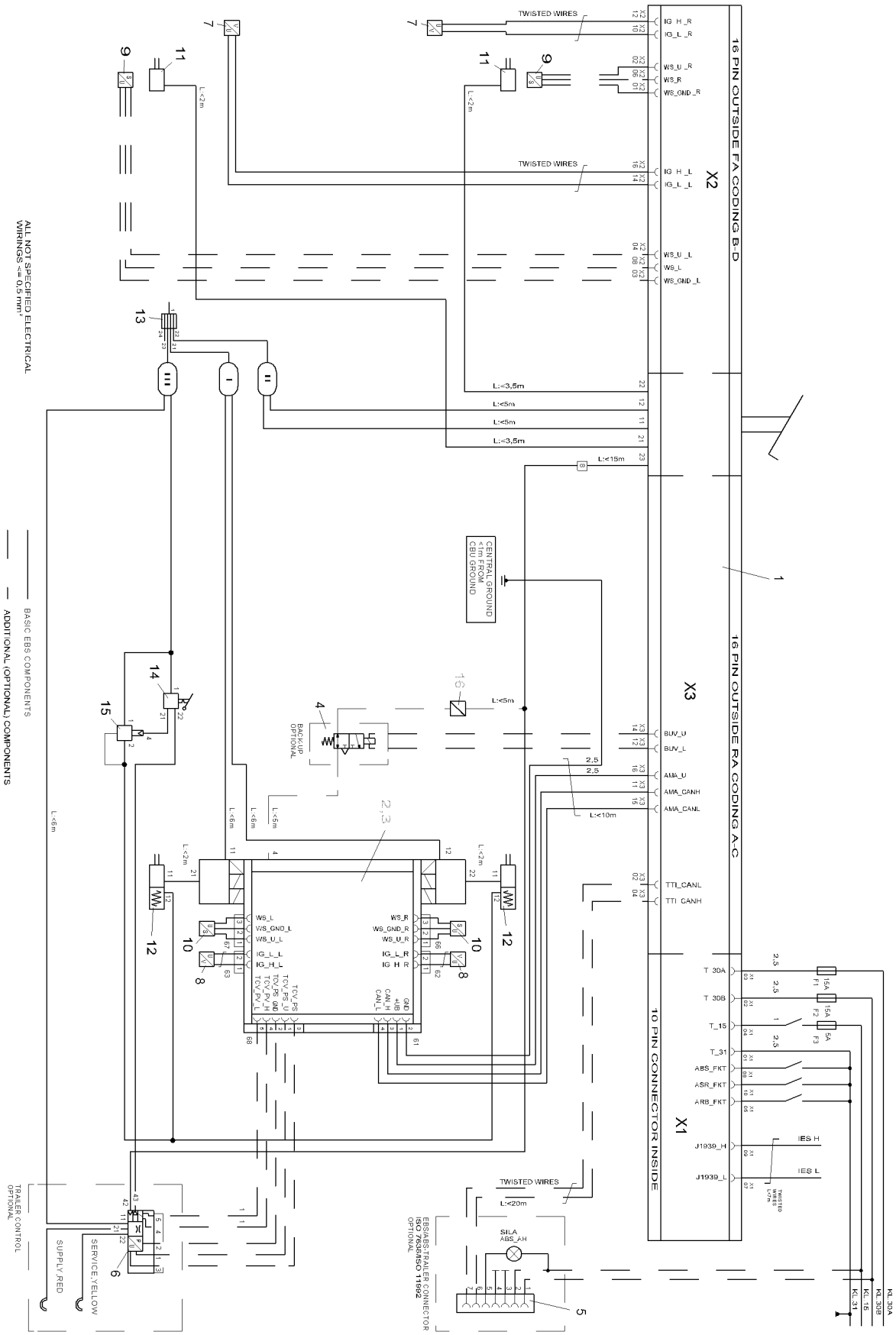



WABCO




**1** 2 Cylinder compressor
**2** Cyclone container
**3** APU
**4** Magnetic 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** Redundancy valve
**17** Relay valve
**18** EBS central module
**19** ABS solenoid control 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 pad 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** Overflow valve

**1** Central Braking Unit CBU
**2** Axle modulator
**3** Axle modulator
**4** Redundancy valve
**5** EBS / ABS trailer plug connection

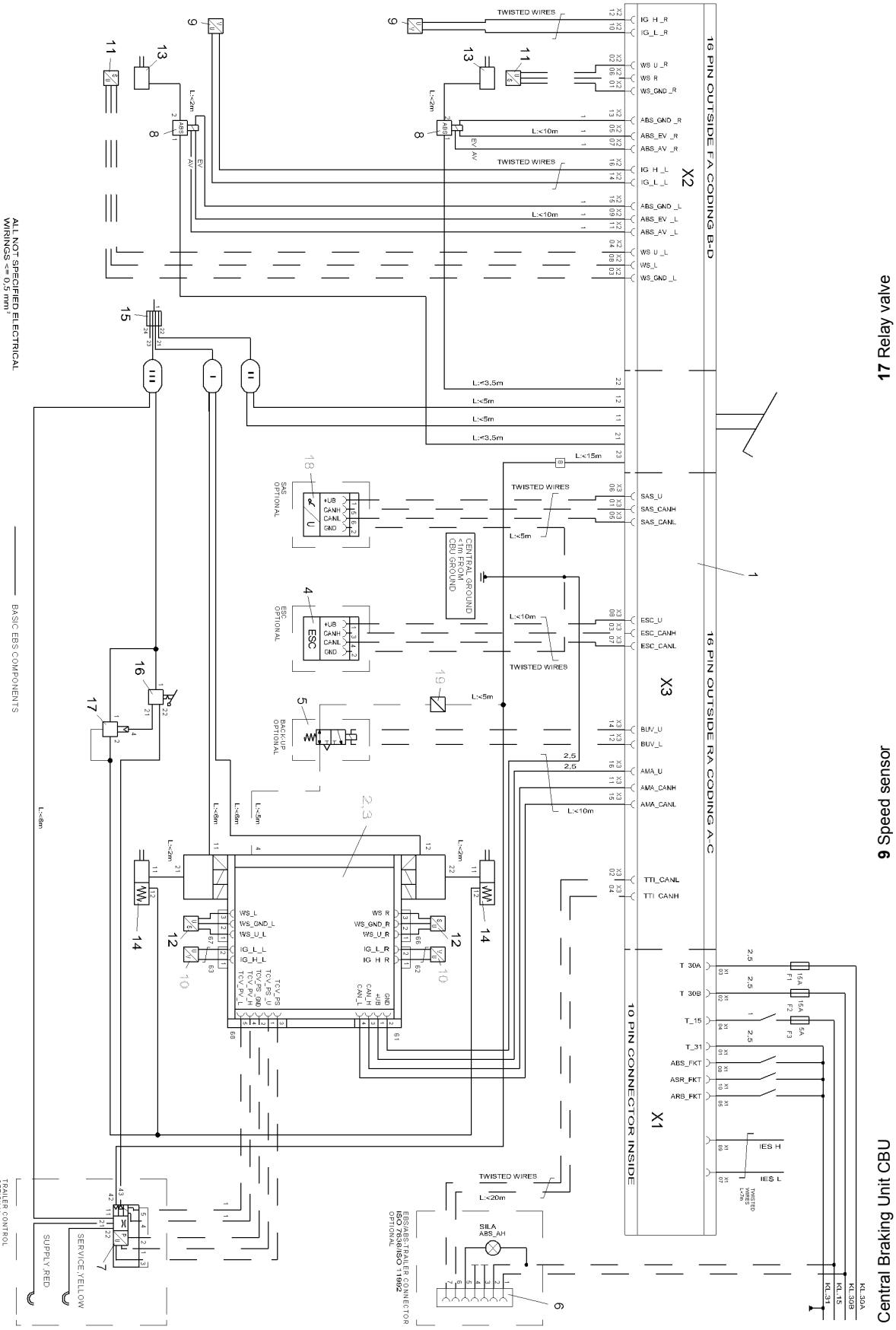



**6** Trailer control valve
**7** ABS speed sensor
**8** ABS speed sensor
**9** Wear sensor
**10** Wear sensor

**11** Brake cylinder
**12** Tristop cylinder
**13** Four-circuit protection valve
**14** Hand brake valve

**15** Relay valve
**16** Adapter valve

**x1 - x3** Slots




**1** Central Braking Unit CBU
**2** Axle modulator
**3** Axle modulator
**4** ESC-Module
**5** Redundancy valve
**6** EBS / ABS trailer plug connection
**7** Trailer control valve
**8** ABS solenoid control 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