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advice on fault-finding reasons for faults and how they can be repaired
tools all tools required for installation and service
diagnostic equipment fault-finding by dedicated diagnostic equipment
literature a list of all available WABCO literature concerning ABS
The VARIO-C concept

In the early eighties WABCO launched their first ABS system. The development of the system continued in leaps and bounds, not just for motor vehicles but also for trailers.

One of the first priorities was to replace the number of systems available by the "VARIO-B" concept which, as a modular system, comprised only three variants of the protective housing for 2, 4 and 6 channel systems respectively. The ECU was the same as that used in motor-vehicle systems.

As more research and development was completed it soon became apparent that a system as used in motor vehicles was unnecessarily costly for trailers.

The modular harness concept has been carried over from VARIO-B, the wiring itself remains identical to that used in the VARIO-B system i.e. the cables for sensor, valve and supply.

The terminology used in describing the VARIO-B system i.e. 2, 4 or 6 channel referred to a channel as one sensor coupled with one control valve; the VARIO-C concept however does not require an equal number of valves and sensors. For example on a tri-axle trailer all wheels can be sensed (6S) but only three valves (3M) are needed to provide the necessary control; this system is then referred to as a 6S/3M system.

One of the main design targets of the VARIO-C system was to produce one ECU which could be used with all possible system configurations; the 6S/3M system referred to above represents the "maximum" system, a range of simpler systems are available down to the simplest system of two sensors controlling one modulator valve (2S/1M).

If the vehicle has one or two lift-axles, their operation can be detected automatically by the ECU, whilst the VARIO-B system would have required the fitment of individual 2-channel systems to achieve this.

The electrical current requirement has also been reduced by virtue of the fact that only one of the coils within the solenoid valve is energised at any one time. The maximum number of valves to be controlled has been reduced from 4 to 3 compared with in VARIO-B 4-channel systems, for example.

A significant advance has been made in the area of system reaction to faults occurring in service: a sensor failure in the old VARIO-B 4-k system would have resulted in an entire diagonal (two sensors and two modulator valves) being shut down i.e. returned to normal, non-ABS braking. However with the increased processing power of modern electronics, faults can be assessed much more accurately as to their effect on the total vehicle safety, thus the VARIO-C ECU may decide to shut down one sensor, one valve/sensor control group or the entire system dependant on the severity of the fault.

The components

The design concept of VARIO-C follows the modular philosophy of VARIO-B but with far greater flexibility. The ECU and the ABS valves are available in both 12 and 24 Volt versions.

The following part numbers make up the VARIO-C manifest:

<table>
<thead>
<tr>
<th>Component</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronic control unit (ECU)</td>
<td>446 105 0 . 0</td>
</tr>
<tr>
<td>ECU (various)</td>
<td>446 105 010 4</td>
</tr>
<tr>
<td>ECU housing</td>
<td>446 105 53 0</td>
</tr>
<tr>
<td>Fittings packs</td>
<td>472 195 02 0</td>
</tr>
<tr>
<td>ABS relay valves</td>
<td>472 195 00 0</td>
</tr>
<tr>
<td>ABS solenoid valves</td>
<td>894 601 0 0 2</td>
</tr>
<tr>
<td>Valve cable</td>
<td>894 590 0 0 2</td>
</tr>
<tr>
<td>Sensor cable</td>
<td>441 032 633 0</td>
</tr>
<tr>
<td>Sensor</td>
<td>441 032 634 0</td>
</tr>
<tr>
<td>Power-supply cable</td>
<td>446 010 0 0 2</td>
</tr>
<tr>
<td>Dummy socket</td>
<td>446 008 60 0 2</td>
</tr>
<tr>
<td>Relay valve (pneumatic)</td>
<td>973 011 000 0</td>
</tr>
</tbody>
</table>

---

— for use when response times need to be improved because of large brake-chambers.
The VARIO-C concept

Planning the system

<table>
<thead>
<tr>
<th>The ECU</th>
<th>24 V</th>
<th>12 V</th>
<th>24 V (see page 13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>446 105 001 0</td>
<td>003 0</td>
<td>051 0</td>
</tr>
<tr>
<td>C2</td>
<td>031 0</td>
<td>041 0</td>
<td></td>
</tr>
<tr>
<td>C plus</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

these ECUs may be used for all system variants from 6S/3M to 2S/1M

<table>
<thead>
<tr>
<th>The reduced-capacity system</th>
<th>24 V</th>
<th>12 V (2S/2M only)</th>
<th>24 V see page 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>446 105 009 0</td>
<td>011 0</td>
<td>052 0</td>
</tr>
<tr>
<td>C2</td>
<td>032 0</td>
<td>042 0</td>
<td></td>
</tr>
<tr>
<td>C plus</td>
<td></td>
<td>043 0</td>
<td></td>
</tr>
</tbody>
</table>

C1 "reduced" ECUs may only be used with 4S/2M or 2S/2M systems, i.e. systems using two modulators.

C2 "reduced" ECUs may in addition be used for 2S/1M systems.

For larger fleets the fact that one ECU can work with all system configurations is a major advantage. The C1 ECU is able to recognise the system to which it is connected each time it is switched on, therefore an individual ECU can be swapped between vehicles having different systems. The C2 version has a similar capability using a "system-recognition" mode.

"Wading" version ECU 446 105 023 0

This ECU variant is available for those vehicles requiring a wading facility e.g. military or off-road vehicles. Because the ECU may find itself partially or fully immersed as the vehicle fords streams or other water obstacles, certain changes have been made to protect the ECU from water ingress. The two glands on the underside of the ECU housing which normally allow condensation or other moisture to escape are sealed in the wading variant, special care should also be taken when securing the threaded seals for the various cable inlets to the ECU.

(see "Vehicle Installation Requirements" page 29)

Wheel Sensing

It is generally true that only those wheels which are sensed can be relied upon not to lock at any time. Satisfactory control can, however, be achieved by grouping a sensed wheel with a non-sensed wheel of similar dynamic behaviour; this has the added advantage of reducing system complexity and hence cost.

If further compromise between cost and control is required then a 2S/2M system may be installed on a tri-axle semi-trailer where one wheel on each side of the vehicle is sensed and the data from this wheel is then used to control the remaining two non-sensed wheels on that side of the vehicle *1.

Retro-Fitting

If a vehicle is to be retro-fitted it is always better to over-estimate the number of axles to be sensed; if the initial estimate proves too low it is far more difficult (and costly) to re-work the additional axle than it would be to simply connect sensors already installed.

GGVS Vehicles (ADR / Dangerous Goods)

The components of the VARIO-C system meet or exceed the requirements of the German GGVS and ADR rules on wiring of vehicles used for the transportation of dangerous goods.

ADR (engl.): European Agreement Concerning the International Carriage of Dangerous Goods by Road

ADR (french): Accord européen relatif au transport international des marchandises Dangereuses par Route.

ADR (german): ~ GGVS

ADR [38] (australian): Australian Design Rules please do not confuse with the European meaning of ADR

*1 see layout diagram on page 74
The VARIO-C concept

Air Lines
Long vehicles with large brake chambers can present problems with regard to response times; in such cases care must be taken to avoid using T-pieces or other restrictions in the air lines.

For recommended reservoir sizes, see WABCO publication "TÜV Test Report" (WABCO No. 815 000 123 3)

ABS relay valve
If a C1 ECU is used then only the ABS relay valve may be used and NOT the ABS solenoid valve as used in motor vehicle systems. The reason for this is that during the pressure-increase phase of the ABS control the ABS solenoid valve has both solenoids energised whereas the ABS relay valve uses only one.

Detailed system layouts can be found in the VARIO-C working file and the official TÜV test report on VARIO-C, both of these publications are available from WABCO on request (see page 62).

Installation of the ABS relay valve
The ABS relay valve must always be mounted on the vehicle frame, under no circumstances should it be axle-mounted.

To achieve the optimum ABS regulation the pressure in the brake chamber should react quickly to changes in the control chamber of the ABS relay valve. Each ABS relay valve should control no more than 2 litres of air volume (equivalent to two Type 30 brake chambers). The length of brake hoses connecting the ABS relay valves to the brake chambers should be kept to a minimum (max. 2.5m). If two brake chambers are to be controlled by one ABS relay valve, the brake hoses connecting each chamber to the valve should be of the same length (Figs. 1 and 2). Nominal diameters of the hoses should be between 9 and 11mm. The supply line to the ABS relay valve (port 1) should have a nominal diameter greater than 9mm.
Components of the VARIO-C System

![Diagram](image)

Control and supply lines to the valves should be "symmetrically" installed.

During full braking with small brake chambers it is possible for a wheel to lock momentarily simply because the reaction time of the electronic control unit is much quicker than that of the mechanical components. This problem can be cured by installing a suitable orifice in the control line downstream of port 4.

For individual vehicle requirements it is possible to operate the ABS relay valve without using its relay function (''add-on'' circuit).

In two and three axle drawbar trailers this "add-on" circuit should always be installed on the front axle. The brake line or control line from the trailer-control valve, should be connected directly to port 1 and a bypass installed between ports 1 and 4 so long as no additional brake equipment is already connected. If, however, the vehicle has such additional equipment (load sensing valve, adapter valve, etc.), they should be fitted in the bypass (between ports 1 and 4).

This bypass should be made with as short an air line as possible.

This is only possible if response times without the relay function are short enough, e.g. on front axles of drawbar trailers sheer steep pressure gradients are achieved due to short lines.

When retro-fitting VARIO-C, and the normal braking system includes a relay valve (e.g. on the rear axles), this relay valve is no longer needed when ABS relay valves are fitted, i.e. the control and supply lines can be connected to the ABS relay valves direct.

When installing a 4S/2M system on a tri-axle semi-trailer the two axles most likely to lock first must be determined taking laden and unladen behaviour into account. The brake chambers of these two axles should then be connected to the operating port 2 of the ABS relay valve on their respective side of the vehicle. If a "live" test drive (on private ground!) is not possible, the system configuration should be carefully checked to ensure symmetry i.e. air-lines of similar length and diameter from valves to their respective brake chambers.

If the above recommendations are followed it should be possible to carry out a correct installation of the ABS relay valves and therefore provide ABS function as required.

Components of the VARIO-C System

![Diagram](image)
Components of the VARIO-C System

The Electronic Control Unit (ECU)

This is brain of the system, constantly interpreting data from the vehicle and making control decisions to ensure its safety. The ECU should always be handled with care.

Now take the time to look at the ECU. Place it in front of yourself as shown below.

Each ECU is supplied with a wiring diagram (see page 10) and four screws to secure the ECU to its housing. The housing itself is a simple aluminium casting. It is a robust part but should not be dropped.

1 Locating pins for mounting ECU onto housing. They also prevent the contacts touching any surface when placed face down.

2 Holes for fixing screws for cover (hexagon socket M 6 x 50).

3 Drain grommet (not visible here, must face downwards after assembly).

4 Name plate (not visible here).

5 Side lugs enable the ECU to be sealed against interference.

6 Rivets to secure the cover plate.

7 Polyurethame foam seal.

8 Blinkcode light.
Components of the VARIO-C System

The seal looks like this:

![Seal Image]

It is injected into a channel in the casting, and no attempt should be made to alter or remove it! Such an attempt would result in damage to its sealing properties and leave the ECU exposed to water ingress. The seal is not available as a spare part.

If the seal has been damaged the WABCO warranty is no longer valid. The same applies to any damage to the fixing rivets of the black plastic cover plate.

The black plastic cover plate protects the electronic components of the ECU and the wiring to the coloured base connectors. If one of the coloured connectors proves difficult to remove from its base connector then on no account should brute force be used to try and free it as this may result in irreparable damage. Instead a wide-blade screwdriver should be used to gently lever the connector off its base. Care should always be taken when connecting and disconnecting the coloured connectors; under no circumstances should excessive force be used.

On either side of the WABCO name plate you can see a rubber part with a semi-circular opening. This belongs to the rubber drain-grommet with a "labyrinth" seal, allowing the ECU to breathe. These are the only outlets in an otherwise waterproof assembly. It follows that the assembly should always be mounted such that these grommets face downwards to prevent external water such as rainfall or spray from entering the ECU. You should, however, take care not to spill any fluids (beer, coke etc.) over the ECU before it is fitted because although you may not be able to see the printed circuit it is not waterproof at this time.

The outer face of the ECU has arrows and the word "TOP" marked on it in accordance with this requirement (see Fig.) above.

The base connectors of the ECU are colour-coded to facilitate installation and prevent cross-wiring. The pins are also configured on the base connectors to match with their corresponding vehicle harness connectors. These harness connectors are included in the VARIO-C fitting pack (see page 18) and are correspondingly colour-coded. On the black ECU cover plate abbreviations appear under each base connector denoting which colour harness connector is to be connected:

- BK black
- RD red
- YE yellow
- BU blue

The contact arrangements of the red, yellow and blue base connectors are identical, only the black base connector is different.

The white part of the black base connector is the power connector through which the ECU receives its supply voltage. The warning lamp in the truck cab is also controlled via this connector.

The black part of the connector is used for fault diagnosis.

A simple way to remember the contact arrangement of the base connectors is that all power connections (ECU, valves) lie in one row.

The ECU after assembly

![ECU Image]
Components of the VARIO-C System

Supply plug white (follow the lines of the letter "G")

Contact assignment for all VARIO-C ECU:
1. positive for valves
2. positive for ECU
3. negative for warning light
4. negative for ECU and valves
5. connector for warning lamps
6. L-line for flash code / diagnosis
7. free for C1; C2 (C2 plus) see page 11
8. free for C1; C2 (C2 plus) see page 13
9. K-line / diagnosis
10. negative, internal connection with 4

Connection of solenoid cables:
- to inlet valve (brown)
- Ground / negative (yellow/green)
- to outlet valve (blue)

The housing 446 105 010 4
is an aluminium casting, surface-treated and with threaded ports for the vehicle wiring. The ports are of three different thread-sizes;

- PG 16 — for the power supply cable in corrugated tube
- PG 11 — for the solenoid cables
- PG 9 — for the sensor cables

Those ports not used are sealed using threaded blanks supplied in the fittings packs. The latest version of the housing has pre-defined cast ports which can be opened using a mandril as needed.

Advantage: the time required and risk of error when sealing the non-used ports are minimized. The housing should always be mounted such that one of its longer edges is horizontal (see section on ECU, page 8). On the inner face of the housing are threaded bosses in the casting to provide secure mounting for relays if required. These relays are used where the ECU has a mixed power supply e.g. ISO 7638 and brake-light supply see page 31.

Connection of solenoid cables:
- not used

E.g. baseplate "YE" — yellow

- Holes for fixing screws: housing to vehicle frame
- Holes for fixing screws: ECU to housing
- Threaded boss: for mounting of distribution connector block for combined ISO 7638 / stop light supply (ISO 1185)
- Threaded boss: for mounting of relay
- Threaded port, PG 16
- Threaded port, PG 11
- Threaded port, PG 9
- Securing lugs (matching lugs on the ECU) see page 7
Components of the VARIO-C System

The Wiring Diagram 24 volts 841 801 180 0 12 volts 841 801 220 0

If you are not familiar with reading electrical circuit diagrams, a short description:
When viewing the wiring diagram the direction of vehicle travel is from left to right, to prevent unnecessary cross-wiring. At the extreme right of the diagram can be found the ISO 7638 connection.

Sensor Connections
The sensors are always connected diagonally, i.e. top left and bottom right (viewed across the free portion of the cover plate with the LED). It is, however, immaterial whether you plug the brown or the black lead of the sensor extension to the left or the right of the corner. The connections of a sensor must never be opposite each other.

On the red (RD) plate, the sensors for right and left are interchangeable without this resulting in a fault. It is, however, advisable to get used to using the ports marked with a "1" for the right side of the vehicle; this simplifies any fault location.

The blue and yellow base connector should never have sensor 2 connected if sensor 1 is not used.

ABS Valve Connections

N. B. The inlet and outlet connections must be made in the following way:

<table>
<thead>
<tr>
<th>EV</th>
<th>OUTLET valve is always connected with the BLUE wire of the solenoid cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>AV</td>
<td>INLET valve is always connected with the BROWN wire of the solenoid cable</td>
</tr>
</tbody>
</table>

The contacts for the ABS valves can be found on the upper half of the blue, yellow and red base connectors. Each base connector can accept one three-pin valve connector (correspondingly colour-coded), the contacts on the base connector are arranged in a group of three, two of which have already been discussed above, the other is the earth (ground) connection to which the green/yellow wire of the valve cable is connected.

There are NO configurations in which the colored plates have a sensor connected but no valve.

The left-hand side of the diagram shows the wiring arrangement for stop-lamp power supply, wire of 2.5mm section should be used for this application. More about this can be found on page 31.

Beneath this on the diagram you can see the wiring arrangement for mixed-power supply. The relay shown fulfills two requirements;

a) it switches the ECU automatically to ISO power whenever this supply is available,
b) the coil current through the relay is also the ABS current through the Info-module in the towing vehicle.

The connection of the "External Warning Lamp" (in Europe for example it is green) is a legal requirement in Europe and other countries, it is connected to contact 30 of the relay and contact 1 or 2 of the power base connector on the ECU (white).

There are specific wiring diagrams available for individual system arrangements.

<table>
<thead>
<tr>
<th>System</th>
<th>24 Volt</th>
<th>12 Volt</th>
</tr>
</thead>
<tbody>
<tr>
<td>4S/3M</td>
<td>841 801 181 0</td>
<td>841 801 221 0</td>
</tr>
<tr>
<td>4S/2M</td>
<td>841 801 182 0</td>
<td>841 801 222 0</td>
</tr>
<tr>
<td>2S/2M</td>
<td>841 801 183 0</td>
<td>841 801 223 0</td>
</tr>
<tr>
<td>2S/1M</td>
<td>841 801 184 0</td>
<td>841 801 224 0</td>
</tr>
</tbody>
</table>

These are abbreviated versions of the "full" version shown opposite and are available through the WABCO dealer network.

Differences between VARIO-C1 and -C2 / -C plus
The only difference lies in the diagnostic part of the supply plate.

In all VARIO-C2 versions ( ... 031 0 to ... 052 0), the speed signal is emitted via pin 8 which is not used in VARIO-C1 versions (see page 50, "v-signal").

With the exception of the ... 051 0 version (see page 13), pin 7 is a second warning lamp output with a special feature. If there is more than one VARIO-C2 ECU behind a towing vehicle (special vehicles, 2- or 3 trailer operation), the warning lamp of the towing vehicle will always come on in the event of a fault since one of the ECUs has switched pin 5 to earth / negative.

The warning light output, i.e. pin 7, is only switched to negative by the ECU affected by a fault.

A 2 watt lamp connected to pin 7 (e.g. mounted directly on the housing) indicates, as you walk past the trailer combination, which ECU has caused the warning lamp in the motor vehicle to light up.
The VARIO-C2 ECUs

### Components of the VARIO-C System

**The VARIO-C2 ECUs**

<table>
<thead>
<tr>
<th>24 volts</th>
<th>12 volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>446 105 031 0</td>
<td>446 105 041 0</td>
</tr>
<tr>
<td>032 0</td>
<td>042 0</td>
</tr>
<tr>
<td>only 2S/2M</td>
<td>043 0</td>
</tr>
</tbody>
</table>

The VARIO-C2 is the latest development of the VARIO-C ECU and is fully interchangeable with earlier variants. The main differences between C1 and C2 are:

- improved control performance as a result of field experience
- MAR control available on the blue and the yellow base connectors (but not both together!)
- "system-recognition" facility
- speed-signal output.

With the earlier versions of the ECU it would have been neccessary to use the full 6S/3M version even for vehicles fitted with a 2S/1M system where only the red base-connector would be used. Now a "reduced" ECU variant is available to cater for systems lower than 4S/2M.

**System Recognition**

The VARIO-C1 ECU recognises the system to which it is connected each time it is switched on, e.g. 6S/3M and whether the correct number of valves and sensors are present (For example, an interrupted sensor connection is a sensor "not available" to the ECU). As soon as the ECU is switched off, this "knowledge" is lost.

The VARIO-C2 (plus) ECU has the knowledge as to which system it is or will be connected to (even before it has been unpacked!). All VARIO-C2 ECUs are supplied with the following settings:

- 3-valve systems are stored as 4S/3M system
- 1-valve systems are stored as 2S/1M system

with one exception:

The ECU ... 042 0 is stored as 2S/2M (12 volts system).

If the installed system differs from that stored in the ECU it is a relatively simple procedure to adjust the ECU accordingly.

The "system-recognition" procedure is simple to perform and can be repeated as often as required. The procedure also used for deleting faults stored in the error memory of the ECU must be repeated with the error memory empty. **The supply voltage must not be turned off at any time during this process!**

If, for example, a new ECU – with an assumed stored system code of 4S/3M – is fitted in a faulty 6S/3M system (sensor Z2 (E) defective), VARIO-C2 will first return the error code. After the fault has been repaired or deleted from the memory, it will display 1-1-1; 1-- meaning 6S/3M system connected and -1-1 meaning the system connected does not match with that stored in the ECU memory. This eliminates the difficulties in interpreting displays as often was the case with C1 – please also refer to step by step test instructions "Flash Code".

**This illustrates the individual steps in a chart:**

![System Recognition Chart](chart.png)

Another new feature of the VARIO-C2 ECU is the speed signal available on pin 8 (the pin on the black base connector on which the black diagnostic connector is normally "parked"). The signal is of the pulse-width modulated type (PWM) and can be used to control such things as steer-axle disablement via a special relay.

**Voltage supply**

For VARIO-C1 / C2

- 24 Volt system
  - > 23 Volt permanent
  - < 18 Volt

- 12 Volt system
  - > 10.8 volt permanent
  - < 8.5 Volt

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 19 Volt</td>
<td>warning lamp OFF</td>
</tr>
<tr>
<td>&lt; 18 Volt</td>
<td>undervoltage</td>
</tr>
<tr>
<td>&gt; 8.5 Volt</td>
<td>warning lamp OFF</td>
</tr>
<tr>
<td>&lt; 8.5 Volt</td>
<td>undervoltage</td>
</tr>
</tbody>
</table>
Components of the VARIO-C System

VARIO-C "plus" ECUs
6S/3M to 2S/1M (24volts) 446 105 051 0
4S/2M to 2S/1M (24volts) 446 105 052 0

these variants can be recognised by their green base connector. These ECUs have the suffix "plus" to indicate they can be used with either the ABS relay valve or the ABS modulator valve as used on motor vehicles or in VARIO-B. A mixture of both types is also possible but not across one axle.

Only the ... 051 0 ECU is fitted with a retarder switch function (pin 7). However this ECU only has one warning lamp output. If the retarder switch function is to be used the system-recognition procedure should be followed. There are two ways in which the retarder switching function can be used:

— the signal from pin 7 is connected directly to the switch-out relay of the retarder,

— the switching relay for the retarder is installed in the ECU housing using fittings pack 446 105 535 2 (see page 30).

The second option requires one additional relay but has the advantage that the ABS and retarder are not directly connected electrically i.e. an electrical fault in the retarder system will have no influence on the ABS electrics.

A fault in the retarder Switch control will not affect the ABS system. It makes no difference whether an electrical or hydraulic retarder is fitted, the control circuit is the same.

The retarder axle must have sensors. Use only H (C, D) sensor, not those of the L and Z axle.
Minimum configuration is a 4S/2M system.

The reason for this is that the wheels of the retarder axle have a greater mass inertia than the other wheels and are more sluggish after venting. With very low friction values, this can cause locking. A second pair of sensors is needed to maintain the reference speed and prevent the wheels on retarder axle from slowing.

Note: if a "green" base connector ECU (VARIO-C plus) was fitted to a vehicle then it may only be replaced by an ... 051 or ... 052 0 ECU.

But: if the vehicle was originally fitted with a 24 Volt standard ECU (VARIO-C 1 or 2) it may be replaced by a "green" C plus ECU.

Unlike VARIO-C1 or C2, VARIO-C plus ECUs use both valve solenoids simultaneously regardless of whether ABS relay valves or ABS modulator valves are installed. What this means in terms of current draw is listed below:

Comparison of current consumption between 446 105 032 0 and ... 052 0 ECUs when each is connected to a 4S/2M system (each individual solenoid has a current draw of 1.6 amps).

... 032 0 2 x 1.6 A = 3.2 A
2 ABS relay valves

... 052 0 4 x 1.6 A = 6.4 A
2 ABS modulator valves

The Proust Function of ECUs ... 031 0 to ... 052 0
This function concerns the behaviour of the trailer ABS warning lamp in the driver's cab and means:

Compared with the present warning lamp behaviour (ON when ignition on, OFF at speeds > 6 - 7 km/h) the warning lamp will go off if the Proust function is active (set via Diagnostic Controller) 3 to 4 seconds after ignition ON -- although the vehicle is still stationary.

Provided
a) no current fault prevails
b) no previous sensor fault is present in the memory.

It remains OFF if the 7 km/h threshold is definitely recognized when the vehicle starts to move, i.e. at least two sensors of one axle have to supply the corresponding signal.
In the stationary vehicle the lamp will stay ON if

— a sensor fault is stored in the memory
— a current fault prevails.

When the vehicle starts to move:
If a sensor fault is stored in the memory but no current fault prevails, the warning lamp will go OFF at 6 - 7 km/h and will behave like the normal version.

N.B. The warning lamp will also stay OFF if the ECU does not receive sufficiently strong signals from any of the sensor fitted.

Note:

It is strongly forbidden to use a VARIO-C1 or C2 ECU on a vehicle fitted with ABS modulator valves (motor-vehicle type)
Components of the VARIO-C System

The ABS Relay Valve 472 195 02 . 0

This valve comprises two sub-assemblies: a relay valve and a solenoid control unit.

Fig. 1

1. — Supply port
2. — 2 Delivery ports (to brake chamber(s))
3. — Vent
4. — Control port
K — Piston
RV — Check valve
M1 — Solenoid 1
M2 — Solenoid 2
A — Piston chamber, upper
B — Piston chamber, lower
RK — Piston
F — Spring

Valve Operation

Example 1:
Supply pressure at port 1, no control pressure at port 4.

The spring (F) forces piston (RK) against the valve seal thus sealing off supply port 1 against piston chamber (B).

Example 2:
Supply pressure at port 1 and control pressure at port 4 (e.g. 1 bar)

The control pressure at port 4 flows past the two solenoids (M1 & M2) into the piston chamber (A) and forces piston (K) downwards. This in turn moves piston (RK) downwards opening a small gap between the piston crown and the valve seal, allowing air to flow from port 1 to port 2 and into the brake chamber(s). The area of the piston is the same above and below, that means as soon as the pressure at port 2 equals that at port 4, the piston returns to its ‘rest’ position and seals the boundary between port 1 and piston chamber lower. If the control pressure is reduced, piston (K) is forced upwards and the excess pressure is vented through the opening (3).

If an ABS cycle is in operation and the ECU selects the ‘pressure hold’ phase and the driver release in the same moment the pressure in the control line, the check valve is activated and the pressure in piston chamber upper is vented into the control line.

Fig. 2  Pressure increase

Both solenoids non-energized
Control pressure present at port 4
Gap exists between piston (RK) and seal
Air flows from ports 1 to 2
Available variants.

<table>
<thead>
<tr>
<th>WABCO No.</th>
<th>Control port</th>
<th>Supply/Delivery</th>
<th>Voltage</th>
<th>Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>472 195 020 0</td>
<td>M16 x 1.5</td>
<td>M22 x 1.5</td>
<td>24</td>
<td>Standard</td>
</tr>
<tr>
<td>472 195 021 0</td>
<td>3/8 - 18 NPTF</td>
<td>1/2 - 14 NPTF</td>
<td>12</td>
<td>USA / Australia</td>
</tr>
<tr>
<td>472 195 022 0</td>
<td>M16 x 1.5 Parker</td>
<td>M22 x 1.5 Parker</td>
<td>24</td>
<td>(France)</td>
</tr>
<tr>
<td>472 195 024 0</td>
<td>M16 x 1.5</td>
<td>M22 x 1.5</td>
<td>12</td>
<td>12 V Europe</td>
</tr>
</tbody>
</table>

Fig. 3  Pressure hold

Solenoid M1 energized, its core is raised, therefore, despite the presence of control pressure at port 4, the flow of air from the control line to the upper chamber (A) is interrupted.
Pressure between upper and lower chambers equalizes. Piston (RK) is forced upwards by the spring sealing the chamber.
Air can not flow from ports 1 to 2 nor from 2 to atmosphere.

Fig. 4  Pressure release

Solenoid M2 energized
Control pressure in prevented from entering upper chamber. The raised seal at the foot of solenoid M2 vents the pressure in the upper chamber (A) through the central opening in the piston. Piston (K) moves upwards, piston (RK) is forced against the valve seal and air from the lower chamber, delivery port and the brake chamber(s) is vented to atmosphere.
For reduced-noise applications, two noise dampers are available – see parts list on page 17.

Installation advice

If the aluminium valve housing is to be mounted on a part of the steel frame which has not been surface-treated, the holes drilled to mount the valve should be deburred and coated with a suitable finish to prevent contact corrosion.

The exhaust port (3) must point downwards.
Leave a space of approx. 50 mm for pressure to escape.
Components of the VARIO-C System

The ABS solenoid valve 472 195...0

N.B. Only to be used if connected to ECU 446 105 051 0 or 052 0

Operated by control signals from the ECU this valve enables the pressure in the brake chambers to be rapidly increased and decreased or maintained. The valve operates on 24 volts with a maximum operating pressure of 10 bar. The air-lines between valve and brake chamber should be no longer than 1.5 metres.

Fig. 1 Pressure increase.

Pressure at port 1 immediately raises the inlet diaphragm (a) allowing air to flow through to chamber B and on to the brake chamber(s). Additionally air flows through the channel (d) and over the outlet diaphragm (c); air also flows down channel (b) over the non-energized outlet solenoid and under the outlet diaphragm (c). So long as no wheel-lock tendency is detected, the valve remains in this passive condition, i.e. each increase in pressure at port 1 results in a corresponding pressure at port 2 and at the brake chamber(s).

Fig. 2 Pressure decrease

If the ECU decides that corrective action must be taken to prevent wheel lock, the following operation is carried out to reduce the pressure in the brake chamber(s).

The inlet solenoid I is energized, sealing valve (h) and opening valve (j). The air in chamber A can now flow into chamber D and via the connecting channel (shown in dotted lines) into chamber E. The build-up of pressure in chamber E closes the inlet diaphragm (a).

At the same time solenoid II is energized, closing valve (g) and opening valve (f). Pressure in chamber C now increases, opening the outlet diaphragm (c) and air is vented to atmosphere through port 3.

The pressure at port 2 (and in the brake chamber(s)) is also vented through port 3 via channel (e). This continues until the wheel returns to stable braking and solenoid II is de-energized.
Components of the VARIO-C System

Available variants

<table>
<thead>
<tr>
<th>WABCO No.</th>
<th>Inlet port</th>
<th>Outlet port</th>
<th>Voltage</th>
<th>Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>472 195 003 0</td>
<td>M22 x 1.5</td>
<td>M22 x 1.5</td>
<td>12</td>
<td>USA</td>
</tr>
<tr>
<td>472 195 004 0</td>
<td>M22 x 1.5</td>
<td>1/2 - 14 NPTF</td>
<td>24</td>
<td>Standard</td>
</tr>
<tr>
<td>472 195 005 0</td>
<td>1/2 - 14 NPTF</td>
<td>1/2 - 14 NPTF</td>
<td>12</td>
<td>USA/Australia/Canada</td>
</tr>
<tr>
<td>472 195 006 0</td>
<td>1/2 - 14 NPTF</td>
<td>1/2 - 14 NPTF</td>
<td>24</td>
<td>USA/Australia/Canada</td>
</tr>
<tr>
<td>472 195 007 0</td>
<td>M22 x 1.5 Parker</td>
<td>M22 x 1.5 Parker</td>
<td>24</td>
<td>France</td>
</tr>
<tr>
<td>472 195 010 0</td>
<td>M22 x 1.5</td>
<td>M22 x 1.5</td>
<td>24</td>
<td>wading</td>
</tr>
</tbody>
</table>

Silencer 432 407 . . . 0

Due to the prescribed values for the noise level of compressed air braking systems, it is necessary to use silencers in order to fulfill legal requirements. Because of low pressure peaks, only absorption type silencers are used to keep noise emission to a minimum. These are available for two different volumes and cut-off pressures.

Standard values:

- 59 mm diameter = 78 dB (A)
- 75 mm diameter = 72 dB (A)

The silencer is connected with a snap-on fastener or a thread M22 x 1.5.
Components of the VARIO-C System

Fittings packs 446 105 530 2
to 534 2

These contain all the necessary fittings to complete the ELECTRICAL installation of the VARIO-C system:

1. the coloured connectors for the vehicle harness (for connection with their corresponding colour-coded base connectors on the ECU)
2. fixing screws and nuts for securing the ECU housing to the frame of the vehicle
3. threaded blanks with O-rings to seal those ports on the ECU housing which are not used (B)
4. Fittings consisting of:
   - threaded fastener (DS)
   - cable grip (K)
   - sealing ring (D)

This drawing shows the order of fitting the compression gland.

The compression gland comprises three parts each of which sleeves over the incoming cable: a rubber sealing ring which seats in the threaded entry port of the ECU housing, a flexible plastic toothed cable grip and a plastic threaded fastener. Once the electrical connection between ECU and harness connector has been made, the compression gland should be secured such that it provides strain relief for the cable. The rubber sealing ring is pushed along the length of the cable until it seats in the threaded port of the ECU housing through which the cable passes. The flat end of the toothed cable grip is then pushed over the sealing ring and the threaded fastener passes over the toothed grip/ring assembly. As the threaded fastener is tightened the teeth of the cable-grip close around the insulation sheath of the cable, the grip itself is compressed against the sealing ring these two actions combine to provide a watertight seal around the cable. Those ports on the ECU housing not used are sealed using threaded blanks supplied with the fittings packs.

Note: Not all ECU housing require sealing blanks

Fa. Lapp: Part No. 6179 1260

The tool shown is very useful for fitting or removing the compression gland. When using this tool, please read page 28 on tightening torque.

Connectors and crimp-contacts

"Coloured connectors" refer to the connector housing (coloured) and the individual crimp-contacts contained in it. The coloured connectors match their correspondingly coloured base connectors on the ECU. There is ONE exception to this rule; a 2S/1M RED harness connector may be attached to either the blue or yellow base connector of the VARIO-C2 ECU.

This is the only time the coding pin may be cut off since there is no danger of making a wrong connection. In order to make absolutely sure that the match is right, the connector housing have coding pins so that even in poor or blinding light conditions mismatching is not possible (see page 9). Although normal crimp contacts with notch may hold, they cannot be combined with connector housings because they cannot be locked. For this reason we do not recommend these simple crimp contacts.

The diagram below shows how the contacts are inserted into the housing and how they may be freed.

The contact has a spring-loaded mechanism which keeps it in place within the connector housing. However the contact can be freed using a small screwdriver (blade-width 1-3 mm). The blade of the tool should be inserted within the side-edges of the contact and then rotated this will depress the locking mechanism of the contact. If at the same time the contact wire is lightly pulled, the contact will be freed from its housing. If an attempt is made to free the contact by brute force, damage will inevitably result to contact and/or wiring.
Components of the VARIO-C System

Additional reasons for this contact type include:

1. Housings having more than 4 contacts of standard form require too large a connecting/removal force which could cause damage.
2. The contacts used by WABCO meet the requirements of GGVS-Carriage of dangerous goods.
3. WABCO contacts are surface-treated: tin-plated

A list of the special tools required for these contacts appears on page 60.

Individual coloured connector housings are not available as replacement parts.

Should new contacts be required, for repair or re-wiring, the following replacement parts are available:

For sensor cables > 0.5 - 1 mm 894 070 704 4
For solenoid cables > 1 - 2.5 mm 894 070 705 4
For supply cables 4 mm 894 070 706 4
6 mm 894 070 707 4

Mixed power supply pack 446 105 535 2
This pack contains all the necessary fittings to configure the ECU for mixed power supply, i.e. ISO 7638 and stop-lamp supply.

Contents:
There is a 5-lead connection from the prewired terminal to the white supply plug which in simply plugged onto the ECU (please note that this is done last -- for reason please refer to step by step instructions flash code). On the other side there are one red and one brown wire ending in a relay socket.

Also included are:
2 screws for fastening the terminal
1 screw for fastening the relay
1 fitting PG 11 for supply (brake light)
1 fitting PG 9 for the cable to the green warning lamp on the front of the trailer (legal requirement)
The required relay must be ordered separately.

Special Fittings Packs
For the C plus ECUs the following fittings packs are available:
( for 446 105 051 0 ) 446 105 538 2
( for 446 105 052 0 ) 446 105 539 2

These packs contain a green harness connector; otherwise they are identical to the standard fittings packs ... 530 2 and ... 534 2. This connector housing is specially coded to provide
— a reminder that a C plus ECU was installed before
— a reminder that no "normal" VARIO-C1 / C2 ECU must be used.

Both packs show the WABCO part number and a green label instead of a blue one.

For information on installation, please refer to the section on "Installation in the Vehicle" on page 30.

Polyurethane cable coil (100 m) 811 519 200 6
2 x 2.5 mm²
"Green Lamp" 446 105 537 2
complete, ready for fitting, including 10 m of cable and bracket
Spare part bulb: OSRAM 5626
(not a part of WABCO delivery)
Components of the VARIO-C System

Sensors

Two variants of sensor are available for the VARIO-C system, the only difference being cable length. Both sensors are fitted with a moulded socket which connects with the plug moulded to the WABCO extension cables. Plug and socket when connected conform to sealing standard IP 68.

The socket *2 is moulded onto the sensor cable and cannot be removed. If the sensor is to be stored or transported e.g. as part of an axle assembly, there is a plastic cap available which prevents dirt and water from entering the open socket.

When replacing a sensor, the bushing 899 760 510 4 should also be replaced.

Electrical Values of the WABCO Sensors

Compared with sensor 441 032 001 0 (Z-type) the output voltage has been doubled (at the same speed and the same air gap) – now 110 millivolts instead of 55 millivolts at 1.8 km/h.

The table below shows one example for each type of sensor. All voltage refer to a speed of 1.8 km/h and an air gap of 0.7 mm.

The letters are printed onto the sensor head.

When taking resistance readings, please note:
If you are using a harness test unit or Diagnostic Controller and the sensor temperature is more than 40°C (hot brakes) this can lead to indication overvalue. A multimeter would show correspondingly higher readings in this case.

<table>
<thead>
<tr>
<th>Sensor Type</th>
<th>resistance in Ω</th>
<th>output voltage</th>
<th>example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z</td>
<td>1280 ± 80</td>
<td>~ 20 millivolts</td>
<td>55 millivolts</td>
</tr>
<tr>
<td>K</td>
<td>1750 ± 100</td>
<td>~ 40 millivolts</td>
<td>110 millivolts</td>
</tr>
<tr>
<td>S</td>
<td>1150 ± 100/50</td>
<td>~ 40 millivolts</td>
<td>110 millivolts</td>
</tr>
</tbody>
</table>

Rule of thumb:
Per 10°C change in temperature = 4% change in resistance.

A detailed functional description of sensor and toothed-wheel begins on page 40.

Bush and sensor must be fitted using grease.

Approved types of grease:
- Staborags NBU (1 kg) 830 502 063 4
- “” (8 g) 068 4

If the sensor has been pushed back in its mounting, due to excessive play in the wheel-bearing for example, it should be pushed fully home again to ensure good signal uptake. This should NOT be carried out with a sharp instrument as damage to the sensor head could result.

To securely connect sensor and extension cable we recommend the use of Mount support 441 902 352 4

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*2 detail drawing can be found on page 74 and 75
Components of the VARIO-C System

Power Supply Cable (ISO 7638)
The ISO power cables have two forms of end connector: for semi-trailers the end connector (headboard mounted) is a socket containing the pin contacts (male) while for drawbar trailers the end connector is a plug containing pin connectors (female). The cables are available in 12 and 24 volts versions, and to prevent cross-connection the 12 and 24 volts sockets and plugs have different keyways:

(looking at plug or socket with cover at the top)
24 volts plugs and sockets have their keyways in the 6 o’clock position,
12 volts sockets have a raised keyway in the 4 o’clock position,
12 volts plugs have a recessed keyway in the 8 o’clock position.

The type of supply cable determines the following variants:

- a) drawbar-trailers 24 volts
- b) semi-trailers 24 volts
- c) drawbar-trailers 12 volts
- d) semi-trailers 12 volts

Like all 24 volts components, items c and d are mainly destined for export.

The table below shows the variants available. For crimp contacts which may be required, please refer to page 61.

Drawbar-trailer *3

<table>
<thead>
<tr>
<th>length</th>
<th>voltage</th>
<th>WABCO No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 m</td>
<td>24</td>
<td>446 010 056 2</td>
</tr>
<tr>
<td>10 m</td>
<td>24</td>
<td>011 2</td>
</tr>
<tr>
<td>12 m</td>
<td>24</td>
<td>037 2</td>
</tr>
<tr>
<td>8 m</td>
<td>12</td>
<td>036 2</td>
</tr>
<tr>
<td>12 m</td>
<td>12</td>
<td>035 2</td>
</tr>
</tbody>
</table>

Semi-trailer

<table>
<thead>
<tr>
<th>length</th>
<th>voltage</th>
<th>WABCO No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 m</td>
<td>24</td>
<td>446 010 057 2</td>
</tr>
<tr>
<td>12 m</td>
<td>24</td>
<td>012 2</td>
</tr>
<tr>
<td>14 m</td>
<td>24</td>
<td>044 2</td>
</tr>
<tr>
<td>6 m</td>
<td>12</td>
<td>029 2</td>
</tr>
<tr>
<td>8 m</td>
<td>12</td>
<td>032 2</td>
</tr>
<tr>
<td>14 m</td>
<td>12</td>
<td>031 2</td>
</tr>
<tr>
<td>18 m</td>
<td>12</td>
<td>034 2</td>
</tr>
</tbody>
</table>

Dummy socket

A “dummy” socket is available for fitting to vehicles to prevent dirt and moisture entering the unused plug.

<table>
<thead>
<tr>
<th>dummy socket</th>
<th>voltage</th>
<th>WABCO No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 volts</td>
<td>446 008 600 2</td>
<td></td>
</tr>
<tr>
<td>12 volts</td>
<td>446 008 605 2</td>
<td></td>
</tr>
</tbody>
</table>

Special Supply Cables

For special installation requirements a 50m coil of supply cable can be supplied under WABCO number 446 010 390 2

This cable, consisting of 5 leads, in corrugated tubing and available from branch offices and authorized dealers who will also supply it per metre.

The plugs and sockets can be ordered separately under the following numbers:

<table>
<thead>
<tr>
<th>plug or socket</th>
<th>voltage</th>
<th>WABCO No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 volts plug</td>
<td>446 008 360 2</td>
<td></td>
</tr>
<tr>
<td>12 volts plug</td>
<td>446 008 365 2</td>
<td></td>
</tr>
<tr>
<td>24 volts socket</td>
<td>446 008 361 2</td>
<td></td>
</tr>
<tr>
<td>12 volts socket</td>
<td>446 008 366 2</td>
<td></td>
</tr>
</tbody>
</table>

Drilling templates see last page

CAUTION! if the socket is ordered separately it is not supplied complete with fittings; these must also be ordered under separate numbers:

- threaded cap (cable-to-socket) 893 071 440 4
- rubber sealing ring (under threaded cap) 897 050 140 4

Should the contacts themselves need replacing a selection pack of spare contacts is available containing two 6 mm² contacts and three 1.5 mm² contacts. This pack can be ordered under the WABCO number: 446 010 091 2

Individual contacts may also be ordered as individual parts:

- Pin contact 1.5 mm² 446 008 310 4
- Pin contact 6 mm² 446 008 311 4
- Socket contact 1.5 mm² 446 008 315 4
- Socket contact 6 mm² 446 008 316 4

Components of the VARIO-C System

*3 Drawings see page 64 and 65
Components of the VARIO-C System

These contacts must be "crimped" to their respective wires using the following tools:

<table>
<thead>
<tr>
<th>Tool</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pliers</td>
<td>446 008 900 2</td>
</tr>
<tr>
<td>Standard tool</td>
<td>446 008 912 2</td>
</tr>
<tr>
<td>Grip</td>
<td>446 008 912 4</td>
</tr>
<tr>
<td>Mounting</td>
<td>446 008 913 4</td>
</tr>
<tr>
<td>Removal</td>
<td>446 008 914 4</td>
</tr>
</tbody>
</table>

Extension cables for sensors and modulator valves

To reduce the risk of installation error and poor electrical contact the extension cables for sensors and valves are supplied "pre-crimped". The connectors are crimped to their respective wires by an automatic process ensuring consistent quality and to reduce cost and wastage. The finished cables are available in a range of different lengths.

Once the location for the ECU has been chosen it is then possible to decide the number and lengths of extension cables required to connect the sensors and valves to the ECU.

The ABS relay valve/modulator is normally sited on the vehicle frame such that the air-line connecting it to its brake chamber(s) is about one metre or less in length (up to 2.5 m max). The valve extension cable would normally be shorter than the corresponding sensor extension cable for the same wheel.

If a place can be found for the ECU/housing along the central line of the trailer, then the various extension cables for valves and sensors are the same left and right of the vehicle.

For semi-trailer applications, it is possible to site the ECU such that it is equidistant from all sensed wheels. In this case one length of cable can be ordered for all sensors and one for all valves.

For drawbar trailers this would not normally be possible as the ECU would be sited nearer to either the front or rear axle(s).

Normally cable lengths are used in pairs. When retrofitting prepared but as yet unsensed axles it may be possible use

the sensor 441 032 634 0
or 579 0

with a cable length of 1 m to use the next shorter extension cable.

Cable lengths available for:

Sensor extension: *4

<table>
<thead>
<tr>
<th>Length</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5 m</td>
<td>894 590 017 2</td>
</tr>
<tr>
<td>3 m</td>
<td>010 2</td>
</tr>
<tr>
<td>5 m</td>
<td>011 2</td>
</tr>
<tr>
<td>8 m</td>
<td>012 2</td>
</tr>
<tr>
<td>10 m</td>
<td>015 2</td>
</tr>
<tr>
<td>12 m</td>
<td>014 2</td>
</tr>
<tr>
<td>15 m</td>
<td>016 2</td>
</tr>
</tbody>
</table>

For special purposes:

Cable per metre without plug 894 604 149 6

Solenoid cables with 3 pole plug 24 x 1:

<table>
<thead>
<tr>
<th>Length</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 m</td>
<td>894 601 026 2</td>
</tr>
<tr>
<td>3 m</td>
<td>010 2</td>
</tr>
<tr>
<td>4 m</td>
<td>011 2</td>
</tr>
<tr>
<td>6 m</td>
<td>012 2</td>
</tr>
<tr>
<td>9 m</td>
<td>014 2</td>
</tr>
<tr>
<td>12 m</td>
<td>019 2</td>
</tr>
<tr>
<td>15 m</td>
<td>024 2</td>
</tr>
</tbody>
</table>

For special purposes:

Cables per metre without plug 811 519 144 6

---

*4 Drawings see page 72 and 73
Special Applications

Distribution Box 446 010 092 2

There are special vehicle applications where more than one ECU may be installed in the vehicle e.g.:

— vehicles having more than four axles
— vehicle combinations having more than one trailer behind the towing vehicle.

In both cases the power from the towing vehicle must be distributed.

Example 1: Vehicle with two ECUs

Example 2: Vehicle with one ECU but with an additional power distribution for a second trailer.

Example 3: Vehicle having two ECUs and additional power distribution to a second trailer.

The advantages of using the distribution box shown in the diagrams above are as follows:

— faults are easier to locate (simply open the distribution box, not the ECU) to disconnect the warning lamp line;
— when using the normal WABCO test equipment, each system can be tested individually without touching the ECU;
— the step by step test instructions can be used without any restrictions by disconnecting one system;
— the individual ECUs can be fused separately (lines 1 and 2).

Design: *5

Aluminium casting, aluminium cover with seal, painted, when assembled conforms to ISO IP 54 standard.
3 PG fittings for corrugated tube NW 13 attached. A fourth bore hole is closed with dummy plug, the fourth fitting in supplied inside the box and can easily be used as needed.

Further contents:

5 insulated 4 way distributors (H shaped).

Please note:

When connecting these distributors, do not use the crimp contacts as used inside the ECU.

Reason: The lack of space between the insulation and the core results in constant pressure on the locking mechanism, releasing it. Only crimp contacts with notch may be used!

If the systems are to be individually fused we recommend to use a so-called "inline fuse" available from accessory shops.

Amp values:

<table>
<thead>
<tr>
<th>Line</th>
<th>Amps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line 1</td>
<td>8 amp</td>
</tr>
<tr>
<td>Line 2</td>
<td>2 amp</td>
</tr>
</tbody>
</table>

*5 Drawing see page 76
Cable Connector 446 105 750 2

For special vehicle applications where the pre-fabricated extension cables must be extended further there is a cable connector available from WABCO. This connector may also be used where repair to an extension cable is necessary. The connector carries a label confirming its compliance with GGVS (the German wiring standard for the carriage of dangerous goods).

The connector can be used to join the following cable combinations:
- corrugated tube – corrugated tube
- sheathed cable – corrugated tube
- sheathed cable – sheathed cable
- corrugated tube: NW 10
- sheathed cable: 6 - 8.7 mm diam.

Warning Lamp Principle

Warning lamp circuits are often difficult to understand, particularly to those not familiar with electrical matters.

We would like to briefly go into some questions which people repeatedly ask: "Why do I now have to measure positive polarity?" "Why is there no short?" "And why do I now have to measure negative polarity?"

In all of our examples, clamp 15 carries supply voltage (ignition ON).

K1 / K2: contacts of switch S.

In all measurements at K1, a negligible current present through the measuring equipment.

Lamp ON because positive voltage on the left, negative voltage or earth on the right. An electrical connection is established.

Lamp is OFF. There is also a positive voltage on the left. This voltage can be measured at K1 of switch S. The electrical circuit is broken.

Lamp is ON because earth reaches the lamp via the switch.

All switches open: the lamp is OFF. A positive voltage can be measured at each of the K1 contacts. The electrical circuit is broken.

As soon as any one of the switches is closed, the lamp will come on, irrespective of which switch it is. The electrical circuit is closed. However, you can only determine which of the switches is closed by severing the connections between a K1 and the lamp.

If you now transfer the last diagram to the circuit diagram on the following page you have the warning lamp circuit. Contact K1 is nothing but pin 5 of the ECU or the Info Module.
Two ABS Systems in One Trailer
(Dolly axles, e.g. sales containers)

Trailers with a individual frame or divided axles can, and in some cases have to, have two separate ABS systems.

The version shown here uses a portion of the Info Module normally fitted in the motor vehicle so that special supply cables are not required.

Operation:
The supply current for pin 2 on ECU 2 passes through the Info Module. For this reason, the function is identical to that in the motor vehicle (see also page 53).

Connection AK (trailer recognition) is directly connected to earth (in the motor vehicle, the test current would go to the trailer stop lights via this contact). Consequently this circuit means that there is always a trailer present for the Info Module.

If there is no ABS current available for ECU 2, the Info Module will internally switch output IL to earth (in the motor vehicle the info lamp would come on). In this case, however, the output is used to connect the trailer ABS warning lamp in the motor vehicle to earth. It will light up.

This happens irrespective of the warning lamp output condition of either ECU. As soon as ECU 2 has been properly connected, IL will no longer supply earth. The warning lamp will still be on if one of the ECUs, or both, connect the warning lamp to earth. When the vehicle begins to move and \( v > 7 \text{ km/h} \), this earth is also switched off and the lamps goes off.

Testing of the system:
Info Module -- without opening the distribution box:
ECU 2 unplugged. Establish bridge with a lamp between the contacts (pins 2 and 3 of the ISO 7638 connector) instead of ECU 2 (lamp = 24 volts, 10 - 25 wath). Disconnect supply plug of ECU 1, provide supply similar to motor vehicle operation. This can, of course, also be achieved by means of a sufficiently dimensioned power-pack with a simulated warning lamp at the ISO connector.

Result:  motor vehicle lamp OFF; remove bridge with lamp -- motor vehicle warning light ON

ECU 1: Bridge with lamp must be connected. Test system with Diagnostic Controller, flash code or multimeter or locate faults.

Warning lamp behaviour:
Rotate wheels on axle 1, one after the other. Warning lamp must go off. It is not necessary to rotate both wheels at the same time.

ECU 2:
Supply directly at the ISO connector leading to the distribution box in normal operation. The same applies here: when the wheels are rotated, the warning lamp must go off.

---

Special Applications
Special Applications

If you are sure that the second axle is never used on its own behind the towing vehicle, you can use the configuration shown below. It is necessary to point out this restriction since the presently unused contacts for lines 6 and 7 in the ISO 7638 cable have different allocations for future applications.

In this configuration the driver is alerted if he has failed to connect the system of the 2nd axle, i.e. the warning lamp stays on.

Operation
The system of axle 1 is connected with the towing vehicle in keeping with the standard. Relay R1 will continue to connect warning lamp output 5 of ECU 1 to earth (line 3) until a proper connection of system 2 provides the earth for relay 1.

This will cause the relay to change over and switch the warning lamp of system 2 in parallel to system 1.

If a fault is reported by either of the ECUs, this is indicated to the driver in the same way as with a normal trailer.

Testing of the system:
Two separate tests are necessary. If you want the warning lamp of system 1 to go off, you have to connect a bridge between lines 6 and 4 in order to be able to switch off the motor vehicle’s warning lamp via ECU 1. For testing purposes, system 2 can be powered via the second ISO 7638 connectors.
Installation in the Vehicle

The installation of the system in the vehicle begins with identifying a suitable place to site the ECU.

The choice of site for the ECU should be made with consideration to material requirement and ease of installation.

As a general rule the ECU is best placed in or around the centre of the bogie (for semi-trailers) in this way the lengths of the valve and sensor extension cables are kept to a minimum.

The fact that the cable fittings have to be on the side on the housing is also dealt with in the sections on ECU and Housing.

The ECU should be sited such that:

— it does not lie in the direct line of spray or stones thrown up by the tyres

— it is easily accessible for diagnostic purposes.

For the mounting of the ECU housing, 8 mm holes should be drilled in the vehicle frame at the chosen spot, this should provide adequate location tolerance for the M6 bolts supplied for securing the housing.

The holes should be deburred to prevent injury and corrosion, and where the holes are drilled in steel they should be suitably treated to prevent corrosion e.g. painted. Steel screws, even when zinc-coated, can be subject to chemical corrosion when in contact with aluminium, to prevent or retard this process the screws or their location should be wax-treated by hand, or by spraying.

ABS relay valves must be mounted on the vehicle frame, mounting on a non-suspended axle is NOT allowed. (see page 15). Pipe routing should be in accordance with the requirements listed on pages 4 and 5.

Where three brake chambers are supplied from one valve (two ports), the required T-piece should be placed in the line to the nearest (or smallest) brake chamber. Air-lines should be no longer than 2.5 metres.

Sensor cables
Sensor extension cables are of special construction and should not be connected to, or replaced by, other two-core cables in order to extend their reach.

Sensor cables should not be routed alongside other cables which carry intermittent high current, e.g. signal currents for hydraulic systems in special vehicles.

Such signals could affect the sensor signal resulting in a fault being detected by the ECU (sensor bounce).

It is not possible to list all the installation variants and requirements here. Therefore the information in this section is of a general nature. It is safer, in any event, to position the sensor cables at a distance of 50-100 mm from solenoid and other cables.

Solenoid cables
Routing of the solenoid cables does not present any problems. Surplus cable, sensor or valve, must never be coiled together. For this reason pre-crimped sensor and solenoid cables are available in a variety of lengths so the most suitable variant can be chosen for each application.

Experience has shown that before pre-crimped cables were available, 90% of faults in the ABS system were caused by faulty crimping (which is still done with a pipe wrench today in many cases!).

It is always cheaper to hold different lengths of cable in stock than to shorten a cable that is too long. The time requirement (and therefore the cost) to cut corners is much more than to hold 5 or 6 lengths of cable in stock.

In many cases shortening the cable leads to damage of the insulation sheath and even individual strands in the core, which can cause the cable to break.
Installation in the Vehicle

Any slack remaining in the cable once the connections have been made can be gathered up in the way shown, i.e no coils and no bending at the turns (marked "x"). The cables should be supported at suitable intervals along their length with tie-wraps, where slack has been gathered in the way shown above, a place should be found to stow the excess it should then be secured in place with at least two tie-wraps.

For all sheathed cables:
The bending radius of a cable must always be 9 to 10 times greater than the cable's diameter.

The cables should be fastened simultaneously, using cable clamps, and starting from both the housing and the valves. They are then looped as shown in a positive where they do not show and fastened with two cable clamps.

Entry of cable into the ECU housing
Cables must always approach the ECU assembly from below. The reason for this is to prevent external water from "creeping" along the sheath of the cable to the seal and collect there. If one of the pressure screws has not been tightened sufficiently (or does not sit straight-these things happen), it will not come to the worst because the water will not collect in the housing but will run down the lowest point of the cable instead.

Before a solenoid or sensor cable enters the ECU housing, the compression gland (see page 18) must first be sleeved over the cable.

To require the glands to be tightened with a torque-wrench may seem at first a little excessive, however if the correct torque is not set one of the following situations may arise.

If the gland is not tightened sufficiently, neither, is the rubber seal squeezed sufficiently, nor does the toothed grip hold the insulation properly.

Result: the cable is not sealed at point-of-entry to the ECU, and is free to move.

If the gland is over-tightened, damage may result to the cable sheath, the seal or the thread of the gland.

The required torque setting for these compression glands is between 0.8 and 1 Newton metre (Nm).

If, however, such a torque wrench is not available, you can use a Spanner (approx. 20 cm)
1 Nm = 0.1 mkg

Place hammer in spanner (weight of handle not taken into account !). Since the lever arm is 1/5 of a metre, the weight has to be five times as great e.g. a hammer weighing 500 g.
A simpler and more elegant way is to use a spring balance.
Installation in the Vehicle

For wading systems, special care must be taken.

All cables must enter the ECU housing from below as shown opposite or where this is not feasible the cable should be arranged with a "U"-bend in it to act as a water trap.

If the cable is to be shortened, the free length of the individual wires must be no longer than 100mm. Under no circumstances should the sheath or cable protection end before the compression gland.

If the cables are to be crimped for the first time there are three different crimp connectors available:

- for sensor cables 894 070 704 4
- for solenoid cables 894 070 705 4
- for supply-cables (4 mm²) 894 070 706 4
- for supply-cables (6 mm²) 894 070 707 4

For further information on crimping, see section on Tools, page 60.

Arrangement of the cables

The task of wiring the system can be made considerably easier for yourself and others if you apply a degree of consisteney when leading the cables into the housing.

Suggestion:
Drawbar trailer with 4S/3M system.
Cables take the shortest route, from ECU output to sensor or valve.

Supply cable not shown.

Suggestion:
Semi-trailer 4S/2M

Cables are so arranged that they do not cross or twist over one another. In this way the route from ECU to sensor or valve is easy to follow even after years of service and the build-up of paint and dirt.
Mixed Power Supplies for ABS – VARIO-C (ISO 7638 / ISO 1185 with fittings pack 446 105 535 2)

Installation in the Vehicle

Retarder control and retarder switch-off with VARIO-C plus

Explanations to the circuit please see page 49
Installation in the Vehicle

Stop-lamp supply
From a technical standpoint WABCO recommends the use of ISO 7638 power supply; however, the use of the stop-lamp power supply is also permitted.

The decision to use stop-lamp supply should never be made on cost alone since over the life of the vehicle this option could work out more expensive than the ISO supply with its higher initial cost.

The basis for choosing stop-lamp supply should be either legislative requirements or the interchangeability of towing vehicles.

In order to minimize the risk of error when using stop-lamp supply, the following installation recommendations should be adhered to.

Voltage supply of ECU:
Especially for semi-trailers, an elegant and low-cost solution appears to be suitable.

As soon as the ABS is activated, the stop-lamp supply current would increase by 1.6 amps for each solenoid energized, i.e. if only two solenoids are energized (plus the stop-lamps!) the current draw would increase to over 6 amps and the resultant voltage-drop would be 2.4 volts.

In practice, however, the effect is worsened due to the following points:

— The voltage drop in the towing vehicle must also be taken into account (much of the wiring in modern trucks is often only 1.0 mm² section).

— Stop-lamp switches in the towing vehicles are often only rated at 6 amps (voltage drop, service life).

— There is a voltage drop across the truck-to-trailer connection, the size of the drop is dependent on the condition of the plugs and sockets.

A two-core cable is taken from the stop-lamp circuit to the ECU (see diagram) – that is all.

BS = stop-lamp switch
L = lamp (18 Watt)
Resistance of the copper wire (1.5 mm²)
= 13 milliohms per metre at 20°C.

Using the above figures a simple calculation can be made to show the level of voltage-drop which can be expected:
Example: a 30 metre cable with the above resistance value would have a total resistance of 390 milliohms which at a supply current of 3 amps (stop-lamps on) would result in a voltage drop of approximately

30 · 0.013 · 3 (m · Ω · A) = 1.2 volts if only the stop-lamps are on and all connections are in order.

The wiring of the trailer is therefore the only variable and should be so designed as to minimize the effect of voltage drop.
Installation in the Vehicle

Therefore we suggest the following solution.

Here the feed for the ECU is taken from the stop-lamp circuit as close to the trailer socket as possible, the use of 2.5 mm cable for this feed reduces the effect of voltage drop.

Polyurethane cable 811 519 200 6

Although it is technically possible to power the stop-lamps via the ECU and this would negate the need for a junction box. The main disadvantage with such an arrangement is that each time a fault occurs in the stop-lamp circuit the ECU must be opened in order to locate and/or rectify the problem. Each opening and re-sealing of the ECU brings with it the possibility for error.

Retro-fit of ISO 7638 or Stop-lamp power?

Before the decision is made as to which of the above systems is used, a number of points need to be made:

Safety: for driver, vehicle and load.

The ECU when powered performs a system status check 250 times per second! This includes individual component checks. If the ECU is stop-lamp powered these checks will only be made during braking, but if ISO power is used the checks are made continuously during the vehicle's journey.

This means that if a fault such as a broken cable occurs during the journey, the driver will not be made aware of it until the next time the vehicle brakes.

Reliability

As stated earlier in this text the brake-light switch in most vehicles is rated for currents up to 6 amps. The cost of replacing a brake-light switch (time and material) which has been overloaded during ABS usage is comparable to the cost of the ISO cable and connector. If you also account for time laid up, the Info module is worthwhile.

Another possibility is to combine the brake-light switch with a relay, but the re-wiring from the 24N socket with large-section cable and the relay itself is also an on-cost.

One of the most serious disadvantages of the stop-lamp power option is the use of only one earth pin (31) in the 24N connector. Through this pin, the return current from all the lamps on the trailer plus its ABS system must flow. This will result in a voltage-drop, producing a fault in the ECU; the cause of this fault would prove very difficult to locate.

Undervoltage in trailers is a problem of which is difficult to locate. Two hours spent locating and repairing a single fault would cover the additional cost of installing the ISO power supply.

NOTE: If the info-lamp is illuminated with a mixed power supply, this could be due to the fact that the switching relay in the ECU housing is drawing too little current.

To rectify this, the load on contacts 85/86 should be increased by about 30 milliamps.

A full description of the method for retro-fitting the ISO power supply, with and without info-module, can be found on page 53.
The version shown here is not supplied by WABCO in Germany because the 24 S socket is used only for special applications in this country.

It is only shown in this document for cases where such a system requires repair; it is not a suggested configuration for installation.

**Operation:**
ISO 7638:
If all three connectors are in use, ISO 7638 is automatically given preference at all times. Line 2 supplies the current for relays 1 and 2. R1 switches line 1 of ISO 7638 connector to pin 1 of the ECU whilst R2, due to its change-over function, supplies pin 2 of the ECU. R3 is not involved.

24 S
This connector is used in certain countries (e.g. United Kingdom) is intended for special facilities on the trailer. Contact 6 supplies the power for the ABS, contact 2 transmits the warning lamp signal. The Info module cannot be used in this type of circuit!
As soon as the 24 S connection is established, R3 is energized (K 30/87 is closed). R1 and R2 are not energized, so contacts K 30/87a are closed. Therefore, pin 1 is supplied direct, pin 2 via the de-energized R2.
It is recommended to use relays with an internal diode to avoid voltage peaks at the time of disconnection. It is, therefore, of the utmost importance that K 86 is always connected as the positive and K 85 as the negative side.
**Mis-matching of polarity would result in destruction of the respective fuse.**

24 N
If neither ISO 7638 nor 24 S are available, all relays are de-energized and the ECU is only supplied when the brake is actuated. The "green lamp" required in this case can be supplied from the ECU direct or from the relay box.

**Testing of the system:**
For testing, only one of the three connections should be plugged in.

Only ISO 7638:
The current consumption of line 2 is between 60 and 80 milliamps higher than in the mixed supply ISO 7638 with stop-lamp described above. Overall power consumption is approx. 450 milliamps for the ECU and between 120 and 160 milliamps for R 1 and R 2 ( these figures may vary depending on voltage level and temperature).

Only 24 S:
The current consumption must be lower by the amount of one relay coil.

Only 24 N:
Only the current consumption of ECU pin 2 can be measured, no relay is energized.

To assist you in your repair work, please note the prescribed cable colours of the 24 S socket.

<table>
<thead>
<tr>
<th>Contact No.</th>
<th>Circuit</th>
<th>color of wires</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ground</td>
<td>white</td>
</tr>
<tr>
<td>2</td>
<td>Warning lamp (ABS)</td>
<td>black</td>
</tr>
<tr>
<td>3</td>
<td>reverse lamp</td>
<td>yellow</td>
</tr>
<tr>
<td>4</td>
<td>Power supply</td>
<td>red</td>
</tr>
<tr>
<td>5</td>
<td>controlled via supply</td>
<td>green</td>
</tr>
<tr>
<td>6</td>
<td>additional power supply</td>
<td>brown</td>
</tr>
<tr>
<td>7</td>
<td>rear fog lamp</td>
<td>blue</td>
</tr>
</tbody>
</table>
Installation in the Vehicle

ECU Connections:
Following installation the system should be tested with an adapter and harness tester or with the Diagnostic Controller. A "system OK" message from the blinkcode does not fulfil the requirement of a post-installation check since it is no guarantee that the components are arranged in the correct order i.e. valves and sensors are grouped together at their appropriate wheels.

The step-by-step test procedure can be found in WABCO publication no 815 000 094 3.

Points to remember

--- N.B. It is assumed the reader is viewing the ECU as in the photograph on page 7.
--- The "high" power connectors, i.e. those lines carrying relatively large currents for valve and ECU power supply, are arranged in a row (valves, supply plug).
--- The wiring arrangement for each valve connector regardless of colour remains the same, i.e. from left to right, brown, yellow/green, blue (see page 10).
--- The red base connector is either completely occupied or completely empty, i.e. there is no free contact or only free contacts.
--- If one of the coloured base connectors has its sensor(s) contacts occupied it must also have a valve connected to it.

Once the installation check is complete the adapter should be disconnected and the ECU re-connected and secured. During this process the power supply should be switched off. As a general rule the ECU power connector should be the first to be disconnected and the last to be re-connected.

Make sure that the earth pins 3 and 4 of the ECU are the first to make contact with the plug.

Blinkcode Testing
Activate blinkcode; if there are any faults stored in the memory, these should be erased.

--- The ECU is supplied with the error memory empty.
--- Before the ECU is secured to the housing the following visual checks should be made:
--- The drain seals should be facing downwards.
--- None of the cables inside the housing should be under mechanical strain.
--- No lines are pinched.

--- No tools or other debris should be left inside the housing.
--- The injected seal on the periphery of the ECU and its matching recess on the housing should be visually inspected.

The ECU may now be secured to the housing using the screws supplied, not forgetting to spray the recesses for the screws with a suitable agent. If no spray is available, use a small amount of grease on the bore before putting in the screw.

The screw bores in the housing are open at the bottom. This means that moisture could get into the bore. Wax or another suitable agent should be used to protect aluminium and steel parts. Thus steel screws can easily be removed even after several years.

Further points regarding installation.
Sensor cables should be located on the rear of the axles to prevent damage through chippings or stones. Do not, for instance, place cables on the brake levers since this would mean that it would be bent twice, in two places, every time the brakes are actuated.

Bends in sheathed cables should be at least 10 times the cable diameter.

The cables should be long enough to ensure that even when axles are at their lowest (vehicle hanging on a crane) no cables are stretched excessively.

On no account should any of the system cables be secured with steel cable ties. If, however, no other material is available, the cable to be fastened must be covered by a fabric hose to protect it against cuts from steel edges.

ISO connector.
The ISO connector should not be installed parallel to the longitudinal axis of the vehicle but slightly inclined downwards. The reason is straightforward:

If the connector were to be installed upwardly inclined, water would not only enter the connector but would be retained there; it would then only be a matter of time before the resultant corrosion led to a failure in the system.
Installation in the Vehicle

Corrugated tube:
The protective corrugated tubing containing the five cables from the ISO connector should be supported at regular intervals along their length with cable ties. The ties themselves should be made secure without over-tightening them as this could deform the protective tubing. This might result in edges forming which can break with time. Water can get into the ECU. Damage of this kind is not covered by warranty. Do not use a pistol tool for tightening cable ties!

Sensor and Valve cables
As a general rule these cables should also be supported at regular intervals along their lengths. A special problem arises with the sensor cables in that they start at a non-suspended part of the vehicle (the axle) and run to a suspended area (the vehicle frame). To get around this problem the sensor cable should be tied to the air hose coming from the brake chamber and then where appropriate to the vehicle frame. In this way the vertical movement of the suspension (axle) will not apply undue strain to the cables. Again the same applies as described for the corrugated tubing: do not tighten cable ties excessively. Reason: The air hose expands under pressure. An over-tightened cable tie will pinch the cable (always in the same place !) and eventual damage to the cable is inevitable. This does not apply exclusively to air hoses. High-pressure pipes for central lubrication, for example, lead a similar "life of their own". Cables are lightly suspended and not tightened unduly.

General information on cables:
Seals are specifically designed for the sensor, solenoid and supply cables supplied by WABCO. In special applications, additional cable may be needed. Please make sure that only cable of the circular section type and the right diameters are used.

ECU housing
When screwing the ECU to the housing, using the 4 hexagon socket screws supplied, there must be no gap between cover and housing. If you are able to slide a piece of paper between the two, the fit is not close enough.

It is only when the screws are tightened properly (diagonally please !) that you can be sure that no water or dirt can get into the housing. To remind you once again: Insert screws with grease or other suitable agent to prevent corrosion.

Sealing range:

<table>
<thead>
<tr>
<th>Type</th>
<th>Sealing</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG 9</td>
<td>sealing</td>
<td>4.5 to 9 mm</td>
</tr>
<tr>
<td>PG 11</td>
<td>sealing</td>
<td>6.0 to 11 mm</td>
</tr>
</tbody>
</table>

By the way: These cable diameters are set out in the TÜV Technical Report. Any deviations from these requirements can cause problems at inspection time.
Installation in the Vehicle

Electro-magnetic interference:
To avoid problems in the ABS system, please make sure that additional solenoid valves or coils outside the ABS system use only suitable components.

Reason:
A current flowing through a solenoid produces a magnetic field around it. When, however, the current is switched off, the resultant collapse of the magnetic field produces a momentary "spike" voltage of anything up to 500 volts. Even though this spike lasts only milliseconds, it could affect other parts of the system.

Consumers such as lamps, motors etc., are not affected by this impulse, but electronic circuits can be. Although the ECU as such is not damaged, it may produce an error message even if there is no actual fault in the system.

Result:
The warning lamp will come ON without any apparent reason, although all tests show that there is no fault. This may involve a lot of time spent an locating a non-existing fault.

Function of equipment connector 894 101 150 2

When switch S is closed, a current flows in the coil. A magnetic field develops (dotted lines) and the diode closes.

When switch S is opened, the field collapses, producing a voltage spike. The current attempts to continue in the same direction. This is made possible by the diode closing. No voltage spike will appear.

Information for repair work

If cable is to be used with sensors or solenoid valves then polyurathane-insulated cable should be used.

The advantages of this cable are flexibility, temperature range and its resistance to mechanical damage.

It is extremely difficult to ensure correct insulation when using free cable. Proper insulation is a difficult job and, if done by inexperienced personnel, can result in damage to internal insulation. For this reason, cables are offered in different lengths to make the job in the workshop easier. If, however, you have to do your own insulation work, look at this sketch.

Using a knife to cut the sheath will have no effect if little force is applied. If excessive force is used, you are likely to cut the inner insulation layer along with the sheath.

The best tool to use is a pair of side nippers. Bend the cable and gradually cut along the outer edge, bending the cable as you go. By bending the cable you can also reach the insulating material between the lines.

For crimp contacts, use only suitable crimping tool. The majority of faults in the ABS system are caused by poor crimping of contacts and the resulting disconnections or loose contacts.

It is particularly loose connections which can result in costly and time-consuming attempts at locating faults.

Welding on trailers or towing vehicles
Investigation has shown that arc welding presents no danger to the ECU.

This assumes that no metallic part of the system components or the housing be used as the earth connection for the welding gear.
Crimping
To produce a satisfactory crimp connector is not as simple as it might seem at first glance. It is imperative that the contact is crimped to its wire with the dedicated crimp tool. Poor connections will normally result in faults which do not occur until some time afterwards. These are: Loose connections, disconnections or broken wires. The descriptions below are based on experience.

Crimping has itself certain requirements which should be fulfilled if a secure connection is to be made:

A complete crimp contact (Fig. 1) comprises:
— the locking notch
— the wire contact
— the insulation grip

A perfectly crimped contact (Fig. 2) is one where
— the wire ends just short of the locking mechanism.
— the wires are properly compressed.
— the wire insulation ends half way between wire crimps and insulation crimp.
— the insulation crimp’s ends touch without perforating the insulation itself.

Here is a close-up view of a wellmade crimp (Fig. 3):
1. Wires
2. Insulation
3. Gap between wire and insulation crimp
4. Wire crimp
5. Insulation crimp
6. Ingoing arch
7. Outgoing arch

The wire crimp should be so compressed that neither air nor moisture can enter between the copper strands. The ingoing arch (6) must be present to prevent crushing of the strands. The outgoing arch (7) is not mandatory. The insulation crimp is designed to protect the wire crimp against vibration.

— The individual wire strands within the wire crimp should be of honeycomb section when compressed.
— The edges of the wire crimp should butt up against one another when compressed (2). This does not have to be the case along the whole length of the wire crimp but is vital at its ends.
— The minimum removal force requirement must be met (DIN Standard). This force is measured with the insulation crimp open.
— The height and width of the crimp serve as a check as to how well the crimp has been made; this is not, however, a substitute for the removal force test.
Installation in the Vehicle

--- The width of crimp is mandatory.

--- The crimp height is tested in the release procedure and is a recommended dimension only.

--- Insulation surround (1)

   a) At least one third of the circumference of the insulation must be in contact with the inside of the insulation grip.

   b) The edges of the insulation grip must pierce the cable insulation

--- The grip edges must not cut completely through the insulation; the copper strands must remain intact.

--- The bending test must meet the requirements of DIN 41 611, Section 3, page 3 (10 cycles) with wire crimp attached.

--- Point (B) may arch upwards.

--- The distance between the entrance flange and insulation should be sufficiently large that the copper strands are not damaged by entering the flange at too steep an angle. The ingoing arch is designed to prevent individual wires being cut or severed. The ingoing arch is present when crimp height is visibly exceeded at Point (A) depending on the various cross-sections.

--- The end of the insulation (1) is cut flush with the edge of the insulation crimp (2). The end of the insulation must be visible.

--- The end of the insulation butts ends flush the wire crimp. The end of the insulation must be visible.
Common crimping faults

Crimp claws (1) and (2) do not butt against each other at Point (3).
Crimp overcrowded.

Crimp claws (1) and (2) are curled in at the sides, touching the bottom of the crimp (3). Crimp claws appear too long; crimp too large for application.

Crimp open (1).
Insufficient contact with cable insulation.

Crimp material too large (1).
Wire can slip sideways (2).

Crimp material too small.

Caution: This may cause damage to the insulation (1). Vibration will cause the wire to part at the crimp.

— Insulation of wire (1) is caught in the wire crimp.

— Insulation of wire (1) is too short.
The speed of the wheels is monitored electro-magnetically. The ECU can "hear" a sound whose pitch is dependent upon the speed of the wheel. To illustrate this, let us use a comparison:

The ECU is the stereo amplifier (always two sensors per axle), and

— the sensor is the pick-up - but with one difference: It does not touch the toothed wheel;

— the toothed wheel is the record (LP);

— the solenoids can be compared with the loud-speaker cabinets.

The sensor signal consists of two physical values:

— voltage and frequency.

The output voltage must be sufficient to permit the input circuits. (Referring to our comparison: If you connect your dynamic pick-up to the socket for "cristal", you will barely hear anything because the voltage is insufficient).

When the vehicle is stationary, there is no sensor signal (just like you will have no sound from your record player when, although the stylus may be touching the record, the turntable is not moving).

The sensor voltage will increase with the speed of the wheel but it is not used for ABS control. Unfortunately there are a few factors in addition to wheel-speed which affect the output voltage.

For the combination sensor/toothed wheel, the following formula applies: the frequency = cycles per second in Hertz (Hz) depends on:

— the number of teeth/gaps on the toothed wheel;

— tyre circumference;

— driving speed (wheel speed).

The following pages use a slightly simplified form to explain the operation of toothed wheels and sensors. This will also provide some information on possible sources of errors.

One major advantage of this system of monitoring wheel speed is the fact that it is not susceptible to any dirt which may be present at the toothed wheel. If the gaps between the teeth are full of dust and particles from the brake linings, this will not have any effect on the operation. The magnetic properties of the dirt in the gaps is similar to that of air. As long as the change in flow is determined by the teeth and the gaps of the toothed wheel, the output voltage will remain unaffected.

Although some people claim that a fault in the ABS system can be remedied by cleaning the toothed wheel using compressed air, this can safely be put aside as fabrication.

How the signal is produced:

A bar magnet produces a magnetic field which, convergent within the magnet, runs through the air outside. This can easily be made visible by sprinkling iron filings on a piece of paper beneath the magnet.

N = "north pole"
S = "south pole"
MF = magnetic flux

The bar magnet is located in an iron pipe (E). Iron has a magnetic permeability 100,000 times that of air. The flux will always follow the most advantageous route.

From the "north pole", the flux (MF) will flow through the now cupular iron pipe into the air on the right, and most of it will then return to the "south pole" via the iron portion (ES).

A coil is wound around ES. If no change occurs in the flux, nothing will happen in the coil.

An additional, flexible piece of iron $E_2$ is now placed in front of E and ES. The closer $E_2$ gets to E, the smaller the air gap $L_s$. This will increase the flux through ES. As a consequence, a voltage is produced in the coil.
As soon as there is no longer any change in the flux, no voltage is generated. The voltage is dependent on the number of turns in the coil, the strength of the magnetic flux and the rate at which the magnetic flux is altered:

- increased number of turns in coil = increased voltage
- increased magnetic flux = increased voltage
- increased rate of alteration = increased voltage

But:
- increased air gap = reduced flux = reduced voltage.

Hopefully the principle of operation of the sensor/toothed-wheel arrangement (P) can now be more fully understood. The rotating toothed wheel is no more than a constantly changing air gap \( L_s \). This change in the air gap causes a change in the magnetic flux - voltage is generated. GM is an imaginary axis between tooth and gap. This axis involves an intermediate magnetic flux. (H = mounting)

What does the voltage look like?
If, for instance, you connect a headlamp bulb to the positive and negative terminals of a battery (using alligator clips, for instances), it is operated by a direct current. If you now reverse the clips and keep doing this so rapidly that the lamp does not go out, you have an alternating voltage.

The drawing below illustrates a "slow" alternating current:

In this graph, no connection is made between t0 and t1; the lamp is out and a connected voltmeter would read zero.

At t2, the heavy black line at the 12 volt level, contact is made at the battery, the lamp is on and a connected voltmeter would read 12 volts.

After one second, the terminals are reversed (for the purpose of this example, this reversal occurs within one tenth of a second).

During the process of reversal, a connected voltmeter would display zero volts - the line is at 0. When the reversal is complete, it will read 12 volts - the lamp is on once again.

If this "reversal" of voltage is done evenly, you will have a (sinusoidal) alternating voltage with a curve as shown next page.
Sensors and Toothed wheels

Measuring an alternating voltage.

It does not matter whether a lamp is supplied with direct or alternating voltage. However, an alternating voltage will only reach its peak after a certain time; before and after that voltage might even be zero.

Consequently, in order to achieve an effective voltage of a certain value, the peak value of that voltage must be higher.

Three separate voltage values should, therefore, be considered:

- $V_{\text{average}}$ or $v_{\text{rms}}$: 1 volt in our example
- $V_{\text{peak}}$: 1.4 volts in our example
- $V_{\text{peak-to-peak}}$: 2.8 volts in our example

A "normal" multimeter displays the $V_{\text{effective}}$ value ($V_{\text{peak}}$ times 0.7). ABS Tester 446 007 00 0 will show $V_{\text{peak-to-peak}}$ ($V_{\text{effective}}$ times 2.8). The multimeter of the Diagnostic Controller will show $V_{\text{effective}}$.

Another example from everyday-life: 220 $V_{\text{effective}}$ = 311 $V_s$ = 622 $V_{SS}$

The intermediate magnetic flux (see page 41) corresponds to the zero line in the following drawing.

In this example, the toothed wheel is rotating at a speed of 10 k.p.h. past the sensor in the direction shown by the arrow. The sensor moves past the toothed wheel, producing the output voltage shown. The magnetic flux is shown as a dotted line; the sensor is shown in a position between the edges (F1 and F2) of a tooth.

Although this increases the average magnetic flux, it is constant, so there is

- no voltage (1).

Edge (F2) of the tooth is approaching. This means that the magnetic field of the sensor will begin changing at the right-hand side of the sensor as we look at it:

- Voltage is generated (2).

The fact that the voltage shown here becomes positive is coincidental and merely due to the polarity of the measuring connector!

Edge (F2) goes past the centre of the sensor. At this point, the change in the magnetic flux is at its greatest:

- Voltage reaches its maximum (3).

Edge (F2) goes past the sensor to the left, i.e. the air gap (Ls) is increased up to the imaginary zero axis:

- Voltage is reduced (4).

The axis between F2 and F3 passes the sensor. The magnetic flux does not change, there is

- no voltage (5).

The magnetic flux is further decreased (and falls below the value of the imaginary axis), resulting in

- negative voltage (6).

Edge (F3) reaches the centre of the sensor. Again the change in magnetic flux is at its peak - this time from its trough to its peak (see (4)):

- Voltage reaches its (negative) maximum.

The combination of the positive half-wave and the negative half-wave is referred to as one cycle. The
number of cycles per second is known as the voltage frequency and is measured in Hertz.

The faster the teeth/gaps of the toothed wheels pass the sensor, the higher the frequency - and thus the vehicle speed measured.

You will now be able to assess how disastrous it can be if you hit a toothed wheel with a hammer. If only one tooth is damaged, the mechanical dimensions of that tooth to the gap are distorted. This in turn leads to a sudden change in frequency as soon as this tooth passes the sensor - or, in other words - the speed at which the change from negative to positive occurs (or vice versa) is significantly different at this point from the speed before and after.

The ECU will notice this, switch on the warning lamp and switch off the sensor. Error detection and repair is costly.

**Sensor mounting**

This is normally the job of the axle manufacturer but is sometimes done in the workshop.

One of the most important points to remember is that you select a site for the sensor mounting that does not have excessive vibration. Vibration (in either direction) of the sensor and its mounting during the braking process will override the even rotating motion of the toothed wheel.

Result: sensor jump error message.
If, during vehicle service, a sensor needs to be replaced, the bush should also be replaced - see page 20.

Figs. 1 and 2 show an oscilloscope trace of the sensor signal during one complete revolution of a 100-tooth wheel.

**Fig. 1**
This signal is produced by a correctly mounted toothed wheel. The output signal remains very nearly constant throughout the revolution of the toothed wheels. Beginning and end of the revolution are arbitrary with regard to the toothed wheel.
The air gap is approx. 0.7 mm.

**Fig. 2**
This signal is produced by a poorly mounted toothed wheel with pronounced "run-out". When the distance from the toothed wheel to the sensor is small, the voltage will reach its maximum. As wheel and toothed wheel continue to turn, the distance between toothed wheel and sensor will increase and voltage will fall.

If it falls below the operating threshold, the ECU will recognize this is a fault - sensor jump.

<table>
<thead>
<tr>
<th>Vertical axis:</th>
<th>output voltage in volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal axis:</td>
<td>time in milliseconds (ms)</td>
</tr>
<tr>
<td>1000 ms = 1 second</td>
<td></td>
</tr>
</tbody>
</table>

The trace represents one complete revolution of the toothed wheel occurring in one second.

**Speed:**

With a tyre circumference of about 3.4 metres, speed is around 12.24 k.p.h. (3.4 x 3600, i.e. one complete revolution per second times the number of seconds in one hour).

**Frequency:**

1 revolution/second and 100 teeth = 100 Hz (cycles per second).

**Error definition**

**Air gap:**

If one sensor is producing no signal when other sensors on the vehicle are, or if differing signals are produced equivalent to a speed difference of more than 8 k.p.h. (example: one side 100 teeth, toothed wheel on other side 80 teeth).

**Sensor "jump"**

The sensor output jumps from, say, 0 k.p.h. to over 5 k.p.h. (uncontrolled), or an inexplicable change in speed signal occurs. This could be due to the excessive wobble of the toothed wheel as described above.
**Sensors and Toothed wheels**

**Sensor and toothed wheels in actual operation**

The sensor can only produce an output voltage if the wheel is turning. This voltage depends upon:

- the type of sensor used;
- the diameter of the toothed wheel (not quite so significant);
- the air gap between sensor and toothed wheel (quite significant);
- the speed of the wheel.

Sensors (S) and (K) have double the voltage output compared with sensor (Z) (provided all other data are the same).

**Fig. 1**

This shows the connection between toothed wheel diameter and output voltage in relation to the diameter at equal speeds. The voltage is shown in Volt peak-to-peak. The frequency is 50 Hz.

**Fig. 2**

This shows the output voltage of the sensor in relation to the air gap. The highest voltage is obtained when the sensor drags on the toothed wheel; it would, however, be damaged very quickly if dragging persists (firmly corroded).

The line with the voltage values clearly shows that halving the air gap results in more than double the output voltage.

**Fig. 3**

This shows the output voltage of the sensor in relation to air gap and speed.

The trigger threshold is the minimum voltage the ECU needs for recognizing the sensor signals.

The air gap refers to the constant distance between sensor and toothed wheel during one revolution. Although the "wobble" can never be eliminated completely, an ideal value of zero has been assumed here.

**Fig. 3** shows that the air gap lines starting at zero are less steep as the air gap increases, so that the point at which they intersect with the trigger threshold is reached at a higher frequency or speed. You can also put it the other way around:

If you follow the vertical lines from the speed to the intersection of voltage / air gap at the trigger threshold you can see that, as the air gap widens, a higher speed is needed to reach the trigger threshold.

To make sure that all individual tolerances are taken into account, the ECU does not start to work until a speed of 1.8 k.p.h. is reached.
Sensors and Toothed wheels

The ABS warning lamp is not switched off until a speed of between 6 and 7 k.p.h. is reached - provided there is no fault.

ABS-controlled braking would not really be of use after moving off at speeds below that value; from higher speeds, however, ABS-controlled braking is possible until the vehicle is almost stationary.

In the event of the warning lamp not going out until a higher speed is reached, this usually means too wide an air gap at one of the sensors.

Conclusion: If the air gap at both sensors on an axle is too wide, the ECU considers the vehicle to be "stationary".

Result: The warning lamp is on, the vehicle is moving, an examination shows no error stored in the memory.

This can have three possible causes - all of which have actually happened before:
— both air gaps wider than 2 mm;
— wrong material used for toothed wheels (e.g. stainless steel, brass);
— no toothed wheels have been fitted.

Of course the missing sensor signal could be detected immediately by measuring the voltage - but for this the axle has to be raised - and this is not always possible. Such a problem is more likely to occur on 2S/2M vehicles than on 4S/xM since more reference values are available with an increasing number of sensors.

Use of grease
Often we are asked why special types of grease approved by WABCO (see page 20) should be used when mounting both sensors and bush. The reasons are:
— Grease must remain solid even at the high temperatures in the vicinity of the trailer’s brakes;
— resistance against water splash;
— compatibility with other types of bearing grease;
— compatibility with cables and cap at the sensor.

Corrosion of the bush into the mounting must be avoided at all costs to ensure that the sensor can recede if there is a force from the toothed wheel in excess of 200 N. On the other hand it should not loosen as a result of vibration.

After replacing (or initially fitting) the sensor it is pushed fully into its mounting. When fitting the wheel hub with the toothed wheel (in repair-work, hub, drum, rim and tyre are often taken off or re-fitted on the axle as one unit), the toothed wheel will push back the sensor. Since a certain amount of "wobble" is inevitable, the sensor has not taken its final position until one complete revolution has been completed.

A sensor which has corroded into place and subsequent settling of the bearing will quickly lead to sensor failure.

Bearing grease
It is very important that the specifications of the axle manufacturer (type and make) are complied with. Any mixing of different types of grease can have very unpleasant consequences and even causes the destruction of the bearing. Also you should avoid using too much grease because it could reach the area of the brakes when heated.

This could result in the plastic of the sensor cap and its cables to lose some of their elasticity, to swell and to become mechanically sensitive. Subsequent setting of the sensor with a tool which may otherwise be quite suitable can cause its destruction.

Wheel mounting
Depending on the design of the sensor adaption (axle hub sensing, sensor in 10 o'clock position, for instance), slight angling of the wheel as it is pushed onto the axle can result in a wide air gap. Therefore you should make sure that in pushing the wheel into its final position (using both arms), the greater pressure is exerted on the side opposite the sensor.

Recommendation:
When fitting the wheel, use only the wheel nut to push the wheel (hub) across the last few millimetres into its final position.
Advice on Fault-Finding

Here is a brief description of how faults can be isolated without dedicated diagnostic equipment.

All evaluations to date of faults which have occurred show that faults in the ECU itself are very rare. The most common causes of system faults lie in the power supply, the sensors, or - as far as the solenoid valves are concerned - in the pneumatic portion (dirt).

For this reason it is advisable to be led by the laws of probability when trying to locate a fault. If the flash code indicates a fault pointing to the ECU, you can be sure that when connecting another ECU and the fault persists that it is not the ECU which is at fault.

The first thing you have to do is to closely observe the fault and its description. Experience has shown that many errors are not described correctly.

First you look at the configuration of the system. How many sensor lines (thin) and how many solenoid lines (slightly thicker) come out of the ECU?

Knowing this is useful when looking for faults in the supply since the power consumption increases with the number of solenoid coils, and corrosion can have more of an effect.

Power supply: only ISO 7638 or combined with stop light (mixed supply)? Or maybe even stop-light supply only?

Does the fault occur only with one particular type of power supply, or does this make no difference?

Is the vehicle new, or has it been in service for some time, i.e. has the fault occurred in operation?

Unfortunately, faulty installation cannot be ruled out altogether in a new vehicle. Let us look at an example: You have a semi-trailer with a lifting axle. Every time the axle is raised, the warning lamp will stay on. Cause: Sensors H1 and H2 are fitted to the lifting axle. These sensors, however, are not designated for use in lifting axles!

A power supply fault in the ISO 7638 system can be assumed if the red and yellow lamps of the towing vehicle are on. If this happens with a semi-trailer, the most likely place for the fault to be located is the coiled cable. In the case of draw-bar trailers, this problem can occur when an attempt at towing by means of the ABS cable was aborted in time before the whole of the cable breaks or is pulled out of the ECU.

These examples illustrate how useful the Info-module can be for locating faults.

Anyone standing near to the ECU when the power is switched on should be able to hear a definite "click" - this is the internal relay switching. If two clicks are heard, the relay has switched off again. (This can also be felt by hand!)

You can now draw the conclusion that the fault can only lie in the solenoid supply or in the ECU itself. There is no need to investigate the sensors at this point.

All of the examples described here can be clarified without opening the ECU.

In the fault described last (relay switches off again), particular attention should be paid to the earth lines (yellow/green) of the solenoid valves after opening the ECU.

For safety reasons, the ECU will check if (due to wiring errors, frayed cables) a positive voltage has reached the valves and thus the ECU. The ECU will also monitor whether the output stages are in order, i.e. if the respective output will close or open when it is supposed to do so. The test impulse needed for this is so brief that it has no effect inside the valve. If the ECU is operated on a table - for this purpose you would, of course, use a relay valve instead of two lamps, plus a sufficient power supply (see suggestion on page 51), you can hear the test impulse operate (very faintly).

If the problem lies in the earth (ground) connection, this could be caused by an interruption within the valve itself or in the earth wiring. One example of the sort of problem this could lead to is that the test impulse intended for the inlet amplifier may route via the outlet coil to the outlet stage and be interpreted as an interference voltage - see diagram on page 47.

If no additional test equipment is to hand, the solenoid contacts may be BRIEFLY connected directly to the operating voltage. Bear in mind, however, that the duty cycle of a solenoid is 5% in any 5-minute period. This means that the solenoid may be energized continuously for 5% of any 5-minute period, i.e. 5% of 300 seconds = 15 seconds. Under no circumstances may this duty cycle be exceeded since this could result in overheating of the solenoid coils. For a simple test, one to two seconds are sufficient.

In exceptional circumstances, the ECU (C1) may not recognize the system to which it is connected. Do not, therefore, attach any importance to the system code returned.
If the earth line is briefly disconnected, the ECU may not be able to ascertain a clear allocation to a solenoid. This happens very rarely; the only way to locate such a fault is to carefully measure all cables and solenoid coils. For this purpose, bend the cables and shake them gently, if possible, and knock the solenoid coils with, for instance, the handle of a screw-driver.

There is one method for locating faults which works for both VARIO-C1 and -C2 systems. In the case of a -C2 system, you have to change the recognition phase both before and after the repair job.

Example of a 4S/3M system: Fault cannot be erased.
You have at your disposal: the vehicle, a sufficient power supply and a few lengths of wire.
You have no measuring equipment, no step-by-step test instructions and no flasher-code list. All you know is the system code returned.

Very important:
Do not work on the system when there is supply voltage present!
In the case of VARIO-C2 (plus), change the recognition phase.

Connecting the system:
Disconnect ECU from the housing but leave electrical connections on.

ISO 7638 plug or socket:
- pins 1 and 2 to positive;
- pins 3 and 4 to negative;
- pin 5 is not used.

The ABS warning lamp (WL) is connected to the ECU by means of a normal test lamp (between 2 and 10 watts) between chamber 2 (red/white line) and chamber 5 (yellow/blue) of the supply plug.
- The lamp must light up.
- Black test plug in position "flash code output"
- Flashing will start approx. 5 seconds later.
- Count the code, e.g. 2 - 3 - 9.

First you look if the test lamp connected as the warning lamp (WL) and the diode flashing in the ECU behave differently. If they do, you will find that the valve relay of the ECU is open.
If the lamp between supply 2 and supply 5 is on permanently, but the built-in LED is flashing, the most probable location of the fault is inside the ECU. In the example shown here, it is this effect which is we are assuming - and yet it is not the ECU which is at fault.

Now let us show you how to use the ECU in locating the fault.

Disconnect black test plug and allow the flash code in progress to finish.
Disconnected power supply remove the white or green connector (The red connector stays where it is!).
Re-connect the power supply and start the flash code.
Now there are two possibilities:

The fault can be erased, or the fault cannot be erased.

If the fault has been erased, this means that the 2S/1M system you now have, including its sensors and the ABS valve, is in working order. The fault is bound to come from the yellow or the blue connector.

Another point: Since the valve relay opened (can be seen by the lamp between supply 2/5 and internally flashing warning lamp staying on), the fault cannot be in the sensors.

Now for the next step: Using the above-mentioned lengths of wire (preferably with a flat socket on one end and a flat plug on the other) saves taking out the contacts from the blue or yellow protective housing. Thus you avoid mechanical coding when testing.

Repeating the procedure with the solenoid valves and connecting only the "yellow" valve to the red base connector, will provide you with an error code.

Again you have to determine whether it is the solenoid cable or the solenoid of the valve causing the error.
Advice on Fault-Finding

Since the "yellow" and "blue" valves are usually fairly close to one another, all you have to do is swap the connecting cables at the valve. If the error has now been deleted, you have successfully located the fault in the "yellow" valve.

This procedure can be used whenever the system used is larger than 2S/1M.

Use the same procedure for locating sensor faults.

Tracking down the fault:

Mark lines and make very sure that after locating the fault, all original connections are established.

To the ECU, the "sensor" consists of the extension cable and the sensor itself.

Again, remember to shut down the supply voltage before disconnecting a sensor line!

Disconnect red sensor plug, then disconnect one sensor from its plug and connect directly to the red base connector. Replace the second sensor by one from the blue or yellow line.

Switch on system, start the flasher code.

If no fault is indicated by the flasher code, the sensor which has remained in place (of blue or yellow) is the one at fault.

Now all you have to do is find out whether it is the extension cable or the sensor itself which is faulty. If you have a spare sensor available, connect this to the extension cable instead of the (presumed) defective sensor.

No error shown: It is the sensor which is defective.

Error persists: It is the extension cable.

This procedure will not work if the fault is located in the area of the toothed wheel/sensor (wobble, air gap, damaged toothed wheel).

Fault in Power Supply

Faults of this kind do not usually occur until the vehicle has done several years of service, i.e. when corrosion takes its toll on switches, connectors or even lines.

One indication of this happening is if the warning lamp (WL) comes on sometimes when the vehicle is moving; depending on the fault and the type of circuit used, this can also be accompanied by the yellow Info lamp.

Should such a fault in the trailer ABS occur it is advisable to investigate motor vehicle and trailer together.

When the system is energized, you will have voltage drops at corroded connectors. The higher the power, the lower the voltage present in the line behind the corrosion.

For this reason, the line to be investigated needs to be measured when energized. The power for lines 1 and 4 should be at least 10 amps without the voltage changing by more than 1.5 volts during the measuring process (This refers to a line diameter of 6 mm²).

Important: Line 2 (red/white) of ISO 7638 must not carry more than 2 amps if the towing vehicle carries an Info module.

In 24 volt systems you achieve a power of 10 amps at a load of 240 watts (24 volts x 10 amps) - this corresponds to approx. 4 lamps at 55 watts each.

For a power of 2 amps, a load of approx. 45 watts is required.

Procedure

Disconnect ECU from the housing and remove supply plug.

Using a voltmeter, measure the voltage between 1 (red, 6 mm²) and 4 (brown, 6 mm²). Energize between 1 and 4 and again take voltage reading.

If this shows a voltage drop > 1.5 volts, this may be an indication of excessive contact resistance.

The voltage drop is dependent on the total length of cables to and from the battery. If, say, the drop in voltage is 2 volts, you have to ascertain if the loss occurs in lines 1 or 4.

Those not familiar with electrical technology and with the metering process may find the following suggestion of help:

Take a separate 1 or 1.5 mm² line from the negative pole of the battery to the negative pole of the measuring instrument (on the trailer). Then take reading at the brown 6 mm² line (brown) when lamp is energized.

The permissible drop in voltage can be calculated by doing a little mental arithmetic: There is a resistance of approx. 3 milliohm per metre of a line (6 mm² in this case).

Let us assume the overall length (motor vehicle - coiled cable - trailer) to be 25 metres, i.e. 75 milliohms, multiplied by the load (10 amps), this will provide a voltage drop of U = R x I (0.075 ohm x 10 amps) = 0.75 volts. For the contacts at plug/sockets you should assume a further 250 to 300 millivolts, so the voltage drop at 10 amps could be approx. 1 to 1.1 volts on this strand.

Shorter length = smaller voltage drop
Greater length = greater voltage drop
Advice on Fault-Finding

Incidentally: If the line in our example has a diameter of 1.5 mm², the voltage drop would be four times as great (1.5 = 1/4 of 6). If the voltage is measured at the red 6 mm² line (using a separate measuring/earth line), the same voltage drop should be observed (procedure when measuring red line: first without load, then under load, the difference being the voltage drop). Both voltage drops must be similar. Subtract the sum of both voltage drops from the supply voltage. This value gives you the voltage available at the "consumer" - e.g. the ABS relay valve.

The summary below shows the symptoms or faults in a 5-core supply line.
The following applies generally:
All lines start in the motor vehicle!
We are looking at intermittent interruptions between the location where the line starts and the trailer ECU whilst the vehicle is in motion (supply ISO 7638)

Fault in line 1:
Warning lamp ON: Flasher code would show under-voltage since there is no entry in the non-volatile memory.
Warning lamp OFF: when contact is re-established.

Fault in line 2:
Warning lamp ON: No entry in the memory. Reason: The ECU cannot tell whether ignition is switched off or line 2 interrupts.
Warning lamp OFF: when contact is re-established.
If Info module in motor vehicle: Info lamp ON; as long as "interrupt" exists.
If the fault occurs whilst the vehicle is stationary and is provoked by joggling the coiled cable or the plug-in connections, you can hear the valves being switched on when contact is re-established.

Fault in line 3:
Warning lamp ON: Entry in non-volatile memory. ABS is working in spite of this.

Fault in line 4:
Warning lamp ON: Info lamp on. No clicking sound can be heard in the ECU (relay is not activated), no valve test.

Fault in line 5:
Interruption: Warning lamp stays off, ABS is working, no entry in memory.
Short circuit: Warning lamp on permanently, ABS is working, no entry in memory.

Shorts (against chassis) in lines 3 or 4 do not affect operation of the system. However, an electrical connection between negative and chassis is not allowed in vehicles carrying hazardous loads (ADR / GGVS).

Stop-light supply
If intermittent faults occur in systems of this kind (green warning lamp on the trailer is on while braking) you should first check the supply on connector 54 of the 24 N connection. Recommended load: from the stop lights you have 2 x (4 x) 18 watts = 3 amps, for the ECU with valves (3M) approximately 5 amps, i.e. a total of 8 amps.

This current must pass from connector 54 to 31 (brake actuated) without the voltage falling below 22 volts. Next step: same measuring procedure but 24 N coiled cable connected.
Next step: Take reading in opened ABS housing at the disconnected supply plug.
If the trailer is tested whilst attached to a motor vehicle, make sure that ISO 7638 cable is pulled out of the socket.
Reason: If both supplies are connected, the ISO supply automatically takes precedence over the relay.

Retarder control and retarder switch-off
(please also refer to circuit diagram on page 30)
In a 3-axle trailer, the second axle is fitted with a retarder. Only sensors of the type H1/H2 can be used for this, because when it is the retarder alone which provides the braking force - the air braking system is not actuated - it is controlled by the ABS. The maximum transferrable brake force of this axle is maintained. If the air brake is used in addition to the retarder, and one of the wheels of the non-retarder axles causes ABS braking, the retarder is switched off.

The system is fitted using mixed supply pack 446 105 535 2 (relay not included).
In the event of ABS control, pin 7 of the ECU supplies a positive voltage, via the red/white line, to contact 86 of the relay. Contact 85 is connected to pin 10 of the ECU via the brown line and the middle contacts of the terminal, and thus to earth. This causes the relay to close.

The connection between contacts 30 and 87a is thus broken and the control circuit for the retarder is switched off.
When the ABS control process is finished, the relay will open once again and the retarder will continue to operate in the selected mode. The purpose of the relay is to electrically separate ABS and retarder to ensure that any
faults from the retarder control circuit can not affect the ABS system.

Important: If the ECU has a recognition phase for retarder operation, pin 7 must be energized, otherwise a fault will be reported. The same monitoring criteria apply as for the solenoid valves.

Retarder control will also work without a corresponding recognition phase; however, it will then not be monitored by the ECU.

In order to permit this monitoring process at any time, do not remove the plug for starting/deleting the flash code. The flasher code is, therefore, started from the terminal.

The flash code is started by connecting the yellow/blue line from chamber 1 (parking position of the plug) to the middle earth contacts. Breaking this connection will delete the contents of the memory.

Apart from the circuit shown on page 30, a variant without the relay would also be feasible. Any break in the earth in the control line from the motor vehicle to the trailer (for grading of retarder operation, 4 relays are successively activated), would connect the positive voltage of these relays to pin 7 of the ECU - ABS would switch off since there would be external voltage present at the output.

The v-signal (also C3 or B7)
is well-known in the motor vehicle as a speedometer signal. It was, however, not possible to use such a signal in the trailer because it required additional wiring and there was no standardized interchange point between the motor vehicle and the trailer.

With VARIO-C2, this signal is now available from pin 8 of the ECU.

It is used for ECAS (electronically controlled air suspension system) and for activating trigger switches (anti-squat control - lifting axle, steering lock, etc.).

Trigger switches are now available from WABCO. They are special electrical switches for switching a 24 volts voltage in dependence upon the speed.

Example: A 3-axle assembly is to lock the steering axle at speeds in excess of 20 k.p.h. The ABS ECU supplies a speed signal. When this signal corresponds to a speed of 20 k.p.h., the connected trigger switch is actuated and the steering axle is locked. As soon as the speed falls below 20 k.p.h. the steering axle is released.

The ECU obtains the v-signal from valid sensor information. It does not matter if pin 8 is unintentionally connected to earth or positive; the ECU will not be damaged.

Figs. 1 to 3 below show what this signal looks like.

---

**Fig. 1**
- v = 3 k.p.h.
- horizontal: 10 ms/box
- vertical: 2 volts/box

---

**Fig. 2**
- v = 40 k.p.h.
- horizontal: 1 ms/box
- vertical: 2 volts/box

---

**Fig. 3**
- v = 115 k.p.h.
- horizontal: 1 ms/box
- vertical: 2 volts/box

---

Information regarding the scale:
Please note that Fig. 1 is 10 times greater in the (horizontal) time axis than in Figs. 2 and 3. This means: Compared with Figs. 2 and 3, Fig. 1 would have to be shown 10 times as wide. This would make the narrow impulse as wide as shown in Figs. 2 and 3 - but so would the distance between one impulse and the next.
Advice on Fault-Finding

The impulse itself (pulse width "PB") is always constant at approx. 1 millisecond (1/1000 of a second). The pulses only occur more frequently as speed is increased. This "period" (PD) follows a certain formula. It is usually measured from pulse rise to the rise of the pulse which follows. The same reading is obtained when measuring from the middle of the pulse to the middle of the pulse which follows, or from pulse fall to pulse fall.

For this reason, this signal is also known as PWM (pulse-width modulated) signal.

The output voltage
is zero between an impulse spike of 8 volts and approx. 0.8 volt. The fact that it does not actually "switch through" to 0 volts is characteristic for electronic switches.

The output resistance
is very high, ensuring that only a very small current can flow (0.5 milliamps). This means that the connected load must have a similarly high resistance to prevent the output voltage from collapsing.

Measuring:
Voltages of this type are measured using an oscilloscope (formerly oscillograph) - it is unlikely, however, that there is one available in your workshop.

A multimeter cannot be used - neither with an analogous direct reading instrument nor with a digital multimeter. Instead you can use a luminous diode which is available, at low cost, from any electrical shop.

The positive pole of this diode (LED) is connected to pin 8, the negative to pin 10, without a compensating resistance. The diode can be seen to flash with each pulse even if only one sensed wheel can be turned. Due to the small current the LED shows a very weak light; for this reason the area around it should be dark enough for it to be seen.

An example from our experience:
A trailer with a steering lock is taken to the workshop because the steering lock is not working.
If WABCO’s Diagnostic Controller is available, this can be used to provide the ABS ECU with the speed as set on the trigger switch.
The circuit behind the trigger switch appears to be in order. This means that the fault must lie in the trigger switch, the line leading up to the ECU, or in the ECU itself.

In this case you can use the luminous diode at the trigger switch input

| - signal recorded | - defective trigger switch |
| - no signal | - defective cable |
| ECU output | - defective ECU. |

How to investigate the error memory of a WABCO ECU on your desk
A sensor can be simulated by using a resistor of 5 kilohms.
These resistors are available, at low cost, in any electronics shop; required wattage = 1/4 watt.

Pull the connecting wires (length approx. 15 cm) through the side of the drawer of a matchbox and solder them to the resistor. If you want to be particularly conscientious, push a suitable hose (approx. 3 cm) over the wires to stop it bending.

Since the whole thing is to be cast in a transparent synthetic resin, the connections should be sealed. Small quantities of resin are available from do-it-yourself shops.

The ends of the lines must be crimped with ordinary flat plugs - now you have 6 "sensors". The left-overs from the matchbox can be removed once the resin has set.

Advice on Fault-Finding

ordinary flat plugs
valve substitute can easily be built using 2 lamps 24 volts / 5 watts.

If you have three of these lamp circuits, all you now have to do is provide a power supply of 24 volts / 0.8 amps, and you have an "ABS" (6S/3M) on your desk to play with (connect pins 1/2 and 3/4). By scaling it down, you can simulate any permissible system.
warning lamp 24 volts / 2 watts 
(normally in the motor vehicle)

Power supply in the form of two plug-in mains units for 
the circuit described above.

T = key button, opens when pressed (saves having to 
take out the plug). If depressed = ignition off.

Flasher code and recognition phase are fully functional. 
Many faults can be simulated, displayed and erased (for 
training of staff).
For the display you can use both the flasher code and 
the Diagnostic Controller - see section on diagnosis.

Please bear in mind, however: 
The warning lamp cannot be made to go OFF 
because - as due to the resistors used - no speed 
signals are produced.

The Info Module 
is available in 4 variants: 

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Variant Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 volts</td>
<td>446 016 000 0</td>
</tr>
<tr>
<td>12 volts</td>
<td>884 900 523 0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New</th>
<th>Voltage</th>
<th>Variant Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 volts</td>
<td>446 016 002 0</td>
<td></td>
</tr>
<tr>
<td>12 volts</td>
<td>446 016 003 0</td>
<td></td>
</tr>
</tbody>
</table>

socket for Info-module 894 055 981 4

Variants 3 and 4 are designed in the shape of a relay 
cube and require less space than the previous square 
type. In addition they permit you to select whether stop 
light or turn indicator is being sensed and whether the 
(yellow) warning lamp always comes on when no trailer 
is used or only when the brakes are actuated.

Purpose and operation
The Info module - not required by legislation - is very 
useful for the vehicle’s safety and for servicing. It determines whether 

a) a trailer is being used behind the motor vehicle, and 

b) whether this trailer has ABS (in the event of the 
   coiled cable braking, or if the plug has not been 
   pushed into the socket between motor vehicle and 
   towbar trailer, the trailer does not have a (func-
   tioning) ABS since there is no supply.)

First of all the Info module has to determine if a trailer is 
connected. This is done via the 24 N (ISO 1185) 
connection. The Info module supplies a small testing 
current passing through stop lamp or turn indicator 
(depending on the type of sensing selected).

Stop-Light sensing 
Normally the stop lights of the motor vehicle and its trailer 
are switched in parallel to each other. For this reason it 
is not possible to pass the testing current through the 
trailer’s lamps alone.

Relay R separates the lamps of the motor vehicle from 
those on the trailer as long as there is no voltage at the 
motor vehicle’s stop lights - i.e. as long as it is not being 
braked.

For this reason, the testing current can only flow via the 
trailer’s lamps. As the brakes are operated, the testing 
current becomes zero since R is actuated.

The testing current is used to determine if a trailer 
"exists".

The current is also directed through the Info module to 
the trailer’s ECU (line 2). If there is only the testing 
current present, the Info module will switch on the yellow 
lamp. If there is additional current to the trailer’s ECU, 
the lamp is switched off.
Advice on Fault-Finding

Connecting the Info module (446 016 002 0 / ... 003 0)

Please connect the Info module according to its markings.
(Looking at the Info module from below - not on its base!)

Connections:

UES (5) is the supply voltage for Info module and trailer ABS.

IL (8) Info lamp (24 volts/5 watts) has one side connected to connector 15, the other leads to the Info module. Earth is present from there (electronic switch) if the lamp is to come on.

UA (4) Output voltage to the trailer’s ABS. According to DIN 74001 standard, the current flowing to the ECU may be between 0.1 amps and 2.0 amps.

S1 (3) Input 1: actuates an internal electronic lock. This prevents that "IL" lights up when the brakes are actuated since the testing voltage now becomes zero (full operating voltage at the stop lights!).

AK (6) Trailer code, supplies the testing current for the trailer connected.

S2 (1) Input 2: If this input is connected to connector 15, the Info lamp will always be on as long as a trailer without ABS is connected. S2 to stop light: lamp will light up only when brakes are actuated.

Possible faults
Info lamp is on permanently - this fault is often reported after repairs have been carried out, or after retro-fitting.

Cause: Error of the relay separating the stop lamp / turn indicator of the motor vehicle from those of the trailer.

Info lamp glowing - can be the result of excessive ripple of the vehicle’s electrical system. This means that voltage ripple from the alternator is added to the 28-volt direct voltage.

The VARIO-C ECU has at its input a reverse battery protection diode with an upstream capacitor. If the capacitor is fully charged during voltage peaks, no current will flow through the Info module for a split-second after the peak has passed - the lamp begins to glow. Clear indication that this has happened: The glow will change with the engine speed.

Simple remedy: A relay in the VARIO-C housing with its connectors 86 and 85 is connected in parallel to connectors 2 and 4. (Power consumption is increased.)

Retro-fitting of ISO supply

* Note: ISO 7638 is required for light to function correctly
Advice on Fault-Finding

Testing trailer ABS supply at the motor vehicle
When coupling a trailer to a towing vehicle, there can be a number of reasons why you may ask whether a fault is due to the motor vehicle or the trailer. We would like to show you a very simple way for testing the system of the motor vehicle.

The test comprises two steps:

Step No. 1: Is the 24N supply in order?
Step No. 2: Is the ISO 7638 socket supplying all required voltages?

Reason:
- a) Trailer with mixed supply (24N and ISO 7638 for the ABS)
- b) Checking the Info module's function in the motor vehicle

You can proceed straight to Step No. 2 if the trailer’s ABS only has an ISO 7638 supply and the motor vehicle does not have an Info module fitted (i.e. if there is no (yellow) lamp in the vicinity of the red trailer ABS lamp).

Test via 24N (Step No. 1)
Since the Info module can operate with either stop-light or turn indicator sensing, the tester should be designed for both possibilities. As a test plug, use the ordinary 24 N plug which is to be connected internally with three diodes and the mounting for a fine-wire fuse.

The diodes prevent the turn indicators being hooked up when the brakes are actuated (and vice-versa). For the diodes you can use low-cost mains rectifiers 100 volts / 3 amps which are available from any electronics shop.

The fine-wire fuse is designed to protect the diodes in the event of a short-circuit in the lamp (rough handling in the workshop). The lamp is the actual "trailer substitute" for the Info module. The glass bulb should be outside the plug. You can see from the driver’s seat if it lights up.

Looking at the connectors of the motor vehicle’s 24 N socket or the rear (wire connectors) of the coiled cable or trailer plug.

Behaviour of the 18/21 watt lamp:
- braking: lamp comes on together with the stop lights.
- using turn indicator: lamp also flashes, irrespective of whether indicator is set to left or right.

Behaviour of yellow Info lamp:
- lights up after ignition on and stays on, or
- lights up after ignition on and braking (depending on the selected connection of the Info module).

General information on voltage supply
There are three possible ways of separately supplying the trailer with voltage:

1) batteries
2) simple mains supply (without electronic stabilization)
3) electronically stabilized mains supply

Re. 1)
The disadvantage of a voltage supply from a battery is that it tends to be insufficiently charged when you need it most!

Never use a battery charger on its own! Spikes in excess of 35 volts can damage the ECU!

Re. 2)
This type of power supply is not often used these days so we shall not go into it further.

Re. 3)
This type of power supply should always be of sufficient capacity (10 amps). Please remember that at moments of overload, inadequate types will reduce the current (and the voltage) for a split-second. This effect cannot be detected by means of direct reading instruments or a digital multimeter if the overload for the mains unit is caused by the test pulses for the valves, for example.
Advice on Fault-Finding

The ABS socket

Looking into the motor vehicle's socket or "wire side" of the ISO 7638 socket.

Connections:
1. red, via 25-amp fuse directly to battery; 6 mm²
2. white/red, supply of trailer's ECU via connector 15 - if Info module is fitted, it is led through this module; 1.5 mm²
3. brown/blue, ECU earth 1.5 mm²
4. brown, valve earth; 6 mm²
5. yellow/blue, warning lamp for trailer ABS, 1.5 mm²

Testing of ABS socket (Step No. 2)

Fig. 1: Connect lines 1 and 4 via an external 24-volt/45-watt headlamp (L1).
Connect lines 2 and 3 via a 24-volt/21-watt bulb (L2). Switch line 5 to 3 or 4.
After plugging in and ignition OFF:
L1 lights up
Ignition ON: L1 and L2 light up trailer warning lamp on

Fig. 2: An improved circuit
The cold resistance of a 70-watt lamp is very low. As a consequence, a high current flows when the test plug is connected; this can lead to scorching at contacts 1 and 4.

A relay is additionally connected to 2 and 3. The 70-watt lamp cannot light up until the ignition is switched ON. Advantage: The relay contacts take up the current at make - and they are designed accordingly.

After plugging in and ignition OFF:
all lamps OFF
Ignition ON: L1 and L2 and warning lamp in driver's cab are on.

Testing of trailer - electrical supply of ABS
Circuit suggestions

Key button T permits the ECU to be switched off without disconnecting any plugs.
No fuse needed since mains unit is electronically fused.
**Diagnosis**

**VARIO-C Flash code**

Following System-Codes are established for VARIO-C

<table>
<thead>
<tr>
<th>System</th>
<th>Code 1st position</th>
</tr>
</thead>
<tbody>
<tr>
<td>6S / 3M</td>
<td>1 identical with C1</td>
</tr>
<tr>
<td>4S / 3M</td>
<td>2 &quot;</td>
</tr>
<tr>
<td>4S / 2M</td>
<td>3 &quot;</td>
</tr>
<tr>
<td>2S / 2M</td>
<td>4 &quot;</td>
</tr>
<tr>
<td>2S / 1M on red, or yellow, or blue</td>
<td>5 &quot;</td>
</tr>
<tr>
<td>6S / 3M with retarder control</td>
<td>6 additional to C plus</td>
</tr>
<tr>
<td>4S / 3M with retarder control</td>
<td>7 &quot;</td>
</tr>
<tr>
<td>4S / 2M with retarder control</td>
<td>8 &quot;</td>
</tr>
<tr>
<td>2S / 2M with retarder control</td>
<td>9 &quot;</td>
</tr>
</tbody>
</table>

Each VARIO-C ECU is supplied with a vehicle speed output for a PWM (pulse-width modulated) signal (comparable with the speedometer signal C3) - see page 50.

This output is present on the black diagnostic base plate in the form of pin 8.

Please also refer to circuit diagram on page 10.

Example:

Flash code with error message

Flash code without error message (Systemcode)
### Diagnosis

<table>
<thead>
<tr>
<th>System Code</th>
<th>Fault Code 1</th>
<th>Fault Code 2</th>
<th>Fault Code 3</th>
<th>Cause of Fault</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td>System OK</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td>Parameterize system (re-initialise flash code)</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>0</td>
<td></td>
<td>Sensor B (L1): Sensor speed jump</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>0</td>
<td></td>
<td>Sensor B (L1): Air gap</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>0</td>
<td></td>
<td>Sensor B (L1): Interruption of wire, short circuit</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>0</td>
<td></td>
<td>Sensor D (H1): Sensor speed jump</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>0</td>
<td></td>
<td>Sensor D (H1): Air gap</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>0</td>
<td></td>
<td>Sensor D (H1): Interruption of wire, short circuit</td>
</tr>
<tr>
<td>1</td>
<td>9</td>
<td>0</td>
<td></td>
<td>Sensor A (L2): Sensor speed jump</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>0</td>
<td></td>
<td>Sensor A (L2): Air gap</td>
</tr>
<tr>
<td>1</td>
<td>11</td>
<td>0</td>
<td></td>
<td>Sensor A (L2): Interruption of wire, short circuit</td>
</tr>
<tr>
<td>1</td>
<td>12</td>
<td>0</td>
<td></td>
<td>Sensor C (H2): Sensor speed jump</td>
</tr>
<tr>
<td>1</td>
<td>13</td>
<td>0</td>
<td></td>
<td>Sensor C (H2): Air gap</td>
</tr>
<tr>
<td>1</td>
<td>14</td>
<td>0</td>
<td></td>
<td>Sensor C (H2): Interruption of wire, short circuit</td>
</tr>
<tr>
<td>1</td>
<td>15</td>
<td>0</td>
<td></td>
<td>Sensor F (Z1): Sensor speed jump</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>1</td>
<td></td>
<td>Sensor F (Z1): Air gap</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
<td>Sensor F (Z1): Interruption of wire, short circuit</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0</td>
<td></td>
<td>Sensor E (Z2): Sensor speed jump</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>0</td>
<td></td>
<td>Sensor E (Z2): Air gap</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>0</td>
<td></td>
<td>Modulator A (L) IV: Break in wiring</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>0</td>
<td></td>
<td>Modulator A (L) OV: Break in wiring</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>0</td>
<td></td>
<td>Modulator B (H1) IV: Break in wiring</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>0</td>
<td></td>
<td>Modulator B (H1) OV: Break in wiring</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>0</td>
<td></td>
<td>Modulator C (H2) IV: Break in wiring</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>0</td>
<td></td>
<td>Modulator C (H2) OV: Break in wiring</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>0</td>
<td></td>
<td>Modulator A (L) IV: Short to earth / ground</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
<td>0</td>
<td></td>
<td>Modulator A (L) OV: Short to earth / ground</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>0</td>
<td></td>
<td>Modulator B (H1) IV: Short to earth / ground</td>
</tr>
<tr>
<td>2</td>
<td>13</td>
<td>0</td>
<td></td>
<td>Modulator B (H1) OV: Short to earth / ground</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
<td>0</td>
<td></td>
<td>Modulator C (H2) IV: Short to earth / ground</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>0</td>
<td></td>
<td>Modulator C (H2) OV: Short to earth / ground</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>2</td>
<td></td>
<td>Contact 3 (supply plug) earth missing</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td>Undervoltage</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
<td>Break in wiring contact 7: retarder (ECU 446 105 051 0 only)</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td>Short circuit contact 7: retarder (ECU 446 105 051 0 only)</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td>Earth break modulator A (L) [red] *)</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td></td>
<td></td>
<td>or ECU *)</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
<td>Earth break modulator B (H1) [yellow] *)</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td></td>
<td></td>
<td>or ECU *)</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td></td>
<td></td>
<td>Earth break modulator C (H2) [blue] *)</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td></td>
<td></td>
<td>or ECU *)</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td></td>
<td></td>
<td>Overvoltage</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td></td>
<td></td>
<td>Permanent positive at contact 7: retarder (ECU 446 105 051 0 only)</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td></td>
<td></td>
<td>Modulator A (L) IV: Short circuit to positive</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
<td></td>
<td></td>
<td>Modulator A (L) OV: Short circuit to positive</td>
</tr>
<tr>
<td>3</td>
<td>14</td>
<td></td>
<td></td>
<td>Modulator B (H1) IV: Short circuit to positive</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td></td>
<td></td>
<td>Modulator B (H1) OV: Short circuit to positive</td>
</tr>
<tr>
<td>3</td>
<td>16</td>
<td></td>
<td></td>
<td>Modulator C (H2) IV: Short circuit to positive</td>
</tr>
<tr>
<td>3</td>
<td>17</td>
<td></td>
<td></td>
<td>Modulator C (H2) OV: Short circuit to positive</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td></td>
<td></td>
<td>No operative modulator connected</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td>No operative sensor connected</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
<td>Short circuit to positive contact 7: retarder (ECU 446 105 051 0 only)</td>
</tr>
</tbody>
</table>

*) With this fault, the system configuration flashed out is meaningless. Before changing the ECU, check the earth lead (yellow / green) of each valve against outlet (OV) and inlet valves (IV) again.
WABCO provides the opportunity of using the modern technology of data processing for considerably speeding up the final acceptance of new vehicles, or of repairs.

All electronic control units of the "C" generation (motor vehicles, trailers) have non-volatile memories in which any errors which have occurred are stored and which can be retrieved at any time (in theory, even after storage of several years).

Although such errors can easily be directly read out by means of the flasher code without any additional equipment being needed, that procedure is more time consuming than using the Controller.

The housing of approx. 270 (width) x 100 (height) x 250 (depth) contains a computer which, using a suitable programme card, can

- read out the ECUs error memory;
- test the ECUs supply;
- check the allocation of sensors and modulators;
- provide specific information for error location;
- permits physical measurements to be taken due to the built-in multimeter
- cause the ECU to execute certain functions such as activating the modulators, output of a v (C3) signal (PWM), etc.;
- and which makes it possible to print a log of the values established by connecting a printer.

A further benefit of the Controller:

If several errors have been stored, they will all be displayed; if the flash code is used, any errors after the first one will not become visible until that first error has been deleted.

All text readings appear in a 4-line display.

There are three operating keys whose function is shown to the user in the respective step of the programme.

The voltage for the Controller is always taken from the vehicles voltage supply.

Even older VARIO-B systems in trailers can be checked using the Controller (e.g. by temporarily replacing the original "B" electronics with "I-C" testing electronics for motor vehicles).

For further information § following page and § respective printed materials.

Printing of Data from the Diagnostic Controller on Printers with A Parallel Interface

Often it is useful to print the Controllers log, but no printer with a serial connection (Epson FX or compatible) is available.

It is also possible to print the log via a computer with a printer connected, provided you have a serial data cable, the software is Windows or Symphony, and you know how to use the respective programme.

The type of data cable to be used depends on the serial interface of the computer. If this is a portable computer, it will have a 9-pole socket, whilst a normal computer has a 25-pole socket similar to the output socket of the Controller. The cable may be up to 50 metres long but must not be in the vicinity of any strong magnetic fields (welding equipment, electrical motors).
The diagnostic device is replacing all separate test devices for electronic systems having interface to ISO 9141. For additional measurements the Diagnostic Controller has an integrated multimeter. If there is no diagnostic plug according to ISO 9141 available an Inter-Adapter can be used. Which test equipment is used for which system is shown in following list.

### Trailer ABS "VARIO C"
- Diagnostic Controller Set: 446 300 331 0
- Program-Card "VARIO C1/C2": 446 300 537 2
- Inter-Adapter: 446 300 318 0
- Multi-Meter Cable black: 894 604 354 2
- Multi-Meter Cable red: 894 604 355 2

### Trailer ABS "VARIO-B"
- ABS "B 4-Cannel": 884 902 266 0
- Diagnostic Controller Set: 446 300 331 0
- Program-Card "C1/C2": 446 300 516 2
- Test-Electronic ABS "C 4-Kanal": 884 902 266 0
- Inter-Adapter: 446 300 315 0
- or Diagnostic Cable (ISO 9141): 894 604 303 2

- Adapter Plug (35 pins): 446 300 314 0
- Multi-Meter Cable black: 894 604 301 2
- Multi-Meter Cable red: 894 604 302 2
- Jumper Cable: 894 604 300 2
Tools for ABS

For all work done on cables in the installed housing, the following tools are available:

- Service hand tool for Matrix 446 008 901 2
- Matrize for receptacle with notch see page 21 446 008 902 2
- Matrize for ABS socket / plug 446 008 903 2
- Matrize for DIN contacts 6.3 mm without insulation 446 008 904 2
- Matrize for DIN contacts 6.3 mm with insulation 446 008 905 2
- Matrize for spring contacts (35-pins plug, B/C ECU) 1.5 mm$^2$ and 2.5 mm$^2$ 446 008 906 2
- Matrize for DIN contacts 2.8 mm without insulation (7-pins Info-module) 446 008 907 2
- Case with inset without tools 446 008 910 2
- Case with inset and tong as well as . . . 902 2 446 008 911 2

The blue case provides enough space for all the above mentioned parts. Additionally there is some space for various receptacle, socket and pins

In case of frequent crimping of socket / pin in ISO 7638 couplings it is recommendable to use

- Hand tool ( former 884 026 143 4 ) 446 008 900 2
- Inserted ejector pin (for ISO 7638) 446 008 912 2
- Handle 446 008 912 4
- Contact insertion sleeve 446 008 913 4
- Contact extraction sleeve 446 008 914 4
## Tools for ABS

<table>
<thead>
<tr>
<th>Used for</th>
<th>Contact type</th>
<th>Dimension</th>
<th>Part number</th>
<th>Crimp nest no. of the Matrix</th>
<th>Crimp-matrix part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS-power supply socket</td>
<td>pin contact</td>
<td>1.5 mm² / 6.0 mm²</td>
<td>446 008 310 4 / 446 008 311 4</td>
<td>á</td>
<td>446 008 903 2</td>
</tr>
<tr>
<td>Plug</td>
<td>Socket contact</td>
<td>1.5 mm² / 6.0 mm²</td>
<td>446 008 315 4 / 446 008 316 4</td>
<td>á</td>
<td>ó</td>
</tr>
<tr>
<td>35-pins electronic plug</td>
<td>Spring contact</td>
<td>1.0 mm² / 2.5 mm²</td>
<td>894 510 297 4 / 894 510 298 4</td>
<td>á</td>
<td>ì</td>
</tr>
<tr>
<td>ECAS operating element</td>
<td>Spring contact</td>
<td>0.5 mm² / 1.0 mm²</td>
<td>894 511 346 4 / 894 070 666 4</td>
<td>ñ</td>
<td>ñ</td>
</tr>
<tr>
<td>54-pins electronic plug</td>
<td>Spring contact</td>
<td>1.0 mm² / 2.5 mm²</td>
<td>894 070 712 4 / 894 070 713 4</td>
<td>á</td>
<td>ì</td>
</tr>
<tr>
<td>Info modul</td>
<td>Receptacle with notch</td>
<td>A2.8 - 1.5</td>
<td>811 540 008 4</td>
<td>ñ</td>
<td>446 008 907 2</td>
</tr>
<tr>
<td>ABS/ASR &quot;C&quot; truck cabling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABS/ASR &quot;C&quot; truck cabling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABS &quot;Vario C&quot; trailer and ABS trailer supply cable</td>
<td>Receptacle with notch</td>
<td>1.0 mm² / 2.5 mm²</td>
<td>894 070 704 4 / 894 070 705 4</td>
<td>á</td>
<td>ì</td>
</tr>
<tr>
<td>ABS &quot;Vario C&quot; truck cabling</td>
<td>Tabs with notch</td>
<td>0.3 - 0.8 / 0.8 - 2.1 / 2.5 - 4.0 / 4.0 - 6.0</td>
<td>894 101 499 4 / 894 101 493 4 / 894 101 539 4 / 894 101 495 4</td>
<td>ñ</td>
<td>ñ</td>
</tr>
<tr>
<td>ABS trailer</td>
<td>Tap pre-insulated</td>
<td>6.3 - 1.0 / 6.3 - 2.5 / 6.3 - 6.0</td>
<td>red / blue / yellow</td>
<td>446 008 905 2</td>
<td>red / yellow/blue</td>
</tr>
</tbody>
</table>
## Literature ABS "VARIO-C"

<table>
<thead>
<tr>
<th>Title</th>
<th>WABCO No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS VARIO-C</td>
<td>815 000 124 3</td>
</tr>
<tr>
<td>Working Folder</td>
<td></td>
</tr>
<tr>
<td>Step-by-Step Test Instructions with operation of Blinkcode</td>
<td>815 000 094 3</td>
</tr>
<tr>
<td>Checklist</td>
<td></td>
</tr>
<tr>
<td>6S/3M</td>
<td>826 001 169 3</td>
</tr>
<tr>
<td>4S/3M</td>
<td></td>
</tr>
<tr>
<td>4S/2M</td>
<td>826 001 168 3</td>
</tr>
<tr>
<td>2S/2M</td>
<td></td>
</tr>
<tr>
<td>2S/1M</td>
<td>826 001 167 3</td>
</tr>
<tr>
<td>TÜV-Gutachten (in German language)</td>
<td>815 000 092 3</td>
</tr>
<tr>
<td>Anti-Lock-Systems ABS for Trailers &quot;VARIO-C&quot;</td>
<td>815 000 086 3</td>
</tr>
<tr>
<td>Diagnostic Controller</td>
<td>820 001 025 3</td>
</tr>
<tr>
<td>Diagnostic Controller Adapter Survey</td>
<td>820 001 029 3</td>
</tr>
<tr>
<td>Operating instructions for the Program Card 446 300 537 2</td>
<td>815 000 157 3</td>
</tr>
<tr>
<td>Flash code</td>
<td>826 001 009 3</td>
</tr>
<tr>
<td>ABS VARIO-C system</td>
<td></td>
</tr>
</tbody>
</table>
List of part numbers

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List of part numbers

(statements without guarantee)

Because some trailer ABS malfunctions can be caused by faults in the towing vehicle, this list also contains parts for the Motor vehicle ABS system.

The column headings are as follows:

<table>
<thead>
<tr>
<th>WABCO-No.</th>
<th>D</th>
<th>Parts description</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>432 407</td>
<td>000</td>
<td>Silencer 78 dB (A) / M22 x 1.5</td>
<td>MV T</td>
</tr>
<tr>
<td>000 0</td>
<td>001</td>
<td>Silencer 72 dB (A) / &quot;</td>
<td>MV T</td>
</tr>
<tr>
<td>001 0</td>
<td>010</td>
<td>Silencer 78 dB (A) / with snap-on fastener</td>
<td>MV T</td>
</tr>
<tr>
<td>011 0</td>
<td>011</td>
<td>Silencer 72 dB / &quot;</td>
<td>MV T</td>
</tr>
<tr>
<td>441 032</td>
<td>000</td>
<td>Sensor 3000 mm cable, without coupling</td>
<td>T MW</td>
</tr>
<tr>
<td>578 0</td>
<td>001</td>
<td>Sensor (S) 400 mm cable, with coupling</td>
<td>T</td>
</tr>
<tr>
<td>579 0</td>
<td>008</td>
<td>Sensor (S) 1000 mm cable, with coupling</td>
<td>T</td>
</tr>
<tr>
<td>580 0</td>
<td>033</td>
<td>Component outline drawing</td>
<td>.. 578 0 / .. 579 0</td>
</tr>
<tr>
<td>633 0</td>
<td>034</td>
<td>Sensor (K) 400 mm cable, with coupling</td>
<td>T</td>
</tr>
<tr>
<td>634 0</td>
<td>035</td>
<td>Sensor (K) 1000 mm cable, with coupling</td>
<td>T</td>
</tr>
<tr>
<td>921 2</td>
<td>032</td>
<td>Complete sensor set 633 0 including bush and grease</td>
<td>T</td>
</tr>
<tr>
<td>922 2</td>
<td>036</td>
<td>Complete sensor set 634 0 including bush and grease</td>
<td>T</td>
</tr>
<tr>
<td>441 902</td>
<td>352</td>
<td>Mount support (plastic)</td>
<td>T</td>
</tr>
<tr>
<td>446 007</td>
<td>001</td>
<td>ABS Test Unit 24 volts</td>
<td>MV, T, (ABS Wiring)</td>
</tr>
<tr>
<td>005 0</td>
<td>236</td>
<td>ABS Trailer Test Unit</td>
<td>A-ABS power supply</td>
</tr>
<tr>
<td>236 0</td>
<td>313</td>
<td>ABS Testing cable (for .. 005 0)</td>
<td>A-ABS</td>
</tr>
<tr>
<td>313 0</td>
<td>320</td>
<td>ABS Adaptor (for .. 005 0)</td>
<td>A-ABS</td>
</tr>
<tr>
<td>320 0</td>
<td>001</td>
<td>ABS Adaptor for VARIO-C and .. .07 001 0</td>
<td>A-ABS</td>
</tr>
</tbody>
</table>

List of part numbers 78
<table>
<thead>
<tr>
<th>WABCO-No.</th>
<th>D</th>
<th>Parts description</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>446 008</td>
<td>230 0</td>
<td>1 ABS Coiled cable 24 volts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>231 0</td>
<td>1 ABS Coiled cable 24 volts</td>
<td>MV Iveco</td>
</tr>
<tr>
<td></td>
<td>232 0</td>
<td>1 ABS Coiled cable 12 volts</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td>310 4</td>
<td>1 Pin contact 1.5mm² for ISO 7638</td>
<td>ISO 7638</td>
</tr>
<tr>
<td></td>
<td>311 4</td>
<td>1 Pin contact 6mm² for ISO 7638</td>
<td>ISO 7638</td>
</tr>
<tr>
<td></td>
<td>315 4</td>
<td>1 Socket contact 1.5mm² for ISO 7638</td>
<td>ISO 7638</td>
</tr>
<tr>
<td></td>
<td>316 4</td>
<td>1 Socket contact 6mm² for ISO 7638</td>
<td>ISO 7638</td>
</tr>
<tr>
<td></td>
<td>360 2</td>
<td>1 ABS Plug 24 volts, ISO 7638</td>
<td>MV T</td>
</tr>
<tr>
<td></td>
<td>361 2</td>
<td>1 ABS Socket 24 volts, ISO 7638</td>
<td>MV T</td>
</tr>
<tr>
<td></td>
<td>365 2</td>
<td>1 ABS Plug 12 volts, ISO 7638</td>
<td>MV T</td>
</tr>
<tr>
<td></td>
<td>366 2</td>
<td>1 ABS Socket 12 volts, ISO 7638</td>
<td>MV T</td>
</tr>
<tr>
<td></td>
<td>600 2</td>
<td>1 ABS Dummy socket 24 volts, ISO 7638</td>
<td>MV T</td>
</tr>
<tr>
<td></td>
<td>605 2</td>
<td>1 ABS Dummy socket 12 volts, ISO 7638</td>
<td>MV T</td>
</tr>
<tr>
<td></td>
<td>900 2</td>
<td>1 Hand tool for ABS crimps</td>
<td>ISO 7638</td>
</tr>
<tr>
<td></td>
<td>901 2</td>
<td>1 Hand tool with interchangeable crimpers</td>
<td>T MV</td>
</tr>
<tr>
<td></td>
<td>902 2</td>
<td>1 Crimp matrix for 6.3mm receptacle with notch</td>
<td>VARIO-C</td>
</tr>
<tr>
<td></td>
<td>903 2</td>
<td>1 Crimp matrix for ISO 7638 Plug / Socket</td>
<td>ABS MV T</td>
</tr>
<tr>
<td></td>
<td>904 2</td>
<td>1 Crimp matrix for 6.3mm receptacle without insulation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>905 2</td>
<td>1 Crimp matrix for 6.3mm receptacle with insulation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>906 2</td>
<td>1 Crimp matrix for Junior Power contacts</td>
<td>35/54 pol ABS Plug</td>
</tr>
<tr>
<td></td>
<td>910 2</td>
<td>1 Case for tong / matrix without tools</td>
<td>MV C</td>
</tr>
<tr>
<td></td>
<td>911 2</td>
<td>1 like ... 910 2 but with tong + ... 902 2</td>
<td>ISO 7638</td>
</tr>
<tr>
<td></td>
<td>912 2</td>
<td>1 Hand tool for crimps</td>
<td>ISO 7638</td>
</tr>
<tr>
<td></td>
<td>912 4</td>
<td>1 Handle (for) ... 913 4 / ... 914 4</td>
<td>ISO 7638</td>
</tr>
<tr>
<td></td>
<td>913 4</td>
<td>1 Contact insertion sleeve</td>
<td>MV T</td>
</tr>
<tr>
<td></td>
<td>914 4</td>
<td>1 Contact extraction sleeve</td>
<td>MV T</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WABCO-No.</th>
<th>D</th>
<th>Parts description</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>446 009</td>
<td>001 2</td>
<td>1 35 pole plug complete 4 and 6 channel</td>
<td>MV, VARIO-B</td>
</tr>
<tr>
<td></td>
<td>004 2</td>
<td>1 35 pole plug complete 2 channel</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td>008 2</td>
<td>1 54 pole plug complete motor vehicle &quot;C&quot;</td>
<td>MV T, VARIO-B</td>
</tr>
<tr>
<td></td>
<td>140 4</td>
<td>1 Gasket</td>
<td></td>
</tr>
<tr>
<td></td>
<td>311 4</td>
<td>1 Base contact carrier</td>
<td>002 2</td>
</tr>
<tr>
<td></td>
<td>310 4</td>
<td>1 Contact carrier</td>
<td></td>
</tr>
<tr>
<td></td>
<td>450 4</td>
<td>1 Rubber socket</td>
<td>002 2</td>
</tr>
<tr>
<td></td>
<td>451 4</td>
<td>1 Handle cover with coding 4/6 channel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>454 4</td>
<td>1 Handle cover with coding 2 channel</td>
<td></td>
</tr>
</tbody>
</table>

T - Trailer  D = delivery availability  MV = Motor vehicle  1 yes, 0 no
<table>
<thead>
<tr>
<th>WABCO-No.</th>
<th>D</th>
<th>Parts description</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>446 010</td>
<td>0</td>
<td>4-channel complete cabling for drawbar-trailers</td>
<td>T</td>
</tr>
<tr>
<td>001 0</td>
<td>0</td>
<td>4-channel complete cabling for semi-trailer</td>
<td>T</td>
</tr>
<tr>
<td>002 0</td>
<td>0</td>
<td>4-channel complete cabling D GGVS</td>
<td>T</td>
</tr>
<tr>
<td>003 0</td>
<td>0</td>
<td>4-channel complete cabling S GGVS</td>
<td>T</td>
</tr>
<tr>
<td>004 0</td>
<td>0</td>
<td>4-channel complete cabling D with power reduction</td>
<td>T</td>
</tr>
<tr>
<td>005 0</td>
<td>0</td>
<td>4-channel complete cabling S with power reduction</td>
<td>T</td>
</tr>
<tr>
<td>006 0</td>
<td>0</td>
<td>4-channel complete cabling D GGVS with power reduction</td>
<td>T</td>
</tr>
<tr>
<td>007 0</td>
<td>0</td>
<td>4-channel complete cabling S GGVS with power reduction</td>
<td>T</td>
</tr>
<tr>
<td>008 0</td>
<td>0</td>
<td>2-channel complete cabling S GGVS</td>
<td>T</td>
</tr>
<tr>
<td>010 4</td>
<td></td>
<td>Body VARIO-B</td>
<td>VARIO-B</td>
</tr>
<tr>
<td>650 4</td>
<td></td>
<td>Cover without screws for body . . . 010 4</td>
<td>VARIO-B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Screws see 893 . . .</td>
<td></td>
</tr>
<tr>
<td>011 2</td>
<td>1</td>
<td>Power Supply cable with plug, ISO 7638 24 volts (10000mm)</td>
<td>T</td>
</tr>
<tr>
<td>012 2</td>
<td>1</td>
<td>Power Supply cable with plug, ISO 7638 24 volts (12000mm)</td>
<td>T MV T supply</td>
</tr>
<tr>
<td>013 0</td>
<td>0</td>
<td>Distribution box, plastic art, black</td>
<td>T</td>
</tr>
<tr>
<td>014 0</td>
<td>0</td>
<td>Distribution box, aluminium casting</td>
<td>T</td>
</tr>
<tr>
<td>020 0</td>
<td>0</td>
<td>Prime mover-complete cabling</td>
<td>MV</td>
</tr>
<tr>
<td>021 0</td>
<td>1</td>
<td>Distribution box, GGVS</td>
<td>A-ABS and further</td>
</tr>
<tr>
<td>022 2</td>
<td>1</td>
<td>Distribution box, aluminium casting</td>
<td>A-ABS and further</td>
</tr>
<tr>
<td>029 2</td>
<td>1</td>
<td>Power Supply cable with socket, ISO 7638 (6000mm)</td>
<td>T 12 volts</td>
</tr>
<tr>
<td>031 2</td>
<td>1</td>
<td>Power Supply cable with socket, ISO 7638 (14000mm)</td>
<td>T 12 volts</td>
</tr>
<tr>
<td>032 2</td>
<td>1</td>
<td>Power Supply cable with socket, ISO 7638 (8000mm)</td>
<td>T 12 volts</td>
</tr>
<tr>
<td>034 2</td>
<td>1</td>
<td>Power Supply cable with socket, ISO 7638 (18000mm)</td>
<td>T 12 volts</td>
</tr>
<tr>
<td>035 2</td>
<td>1</td>
<td>Power Supply cable with plug, ISO 7638 (12000mm)</td>
<td>T 12 volts</td>
</tr>
<tr>
<td>036 2</td>
<td>1</td>
<td>Power Supply cable with plug, ISO 7638 (8000mm)</td>
<td>T 12 volts</td>
</tr>
<tr>
<td>037 2</td>
<td>1</td>
<td>Power Supply cable with plug, ISO 7638 (12000mm)</td>
<td>T 24 volts</td>
</tr>
<tr>
<td>038 2</td>
<td>1</td>
<td>Power Supply cable with socket, ISO 7638 (18000mm)</td>
<td>T 24 volts</td>
</tr>
<tr>
<td>040 2</td>
<td>1</td>
<td>Lockbend</td>
<td>VARIO-B and MV</td>
</tr>
<tr>
<td>044 2</td>
<td>1</td>
<td>Power Supply cable with socket, ISO 7638 (14000mm)</td>
<td>T 24 volts</td>
</tr>
<tr>
<td>046 2</td>
<td>1</td>
<td>like ... 011 2, but wading</td>
<td>T</td>
</tr>
<tr>
<td>050 4</td>
<td>1</td>
<td>Sealing plate</td>
<td>VARIO-B</td>
</tr>
<tr>
<td>072 0</td>
<td>0</td>
<td>Protective body 2 channel, complete</td>
<td>VARIO-B</td>
</tr>
<tr>
<td>074 0</td>
<td>0</td>
<td>Protective body 4 channel, complete</td>
<td>VARIO-B</td>
</tr>
<tr>
<td>076 0</td>
<td>0</td>
<td>Protective body 6 channel, complete</td>
<td>VARIO-B + MV</td>
</tr>
<tr>
<td>078 0</td>
<td>0</td>
<td>Mounting plate for ... 076 0</td>
<td>VARIO-B + MV</td>
</tr>
<tr>
<td>084 0</td>
<td>1</td>
<td>Protective body 4 channel complete, MV C-ECU</td>
<td>MV or Trailer</td>
</tr>
<tr>
<td>085 0</td>
<td>1</td>
<td>Plate with cabling from .... 084 0 MV C-ECU</td>
<td>MV or Trailer</td>
</tr>
<tr>
<td>085 2</td>
<td>1</td>
<td>like ... 085 0, without plate C-ECU</td>
<td>MV</td>
</tr>
<tr>
<td>086 0</td>
<td>1</td>
<td>Protective body 6 channel complete, MV C-ECU</td>
<td>MV C-ECU</td>
</tr>
</tbody>
</table>

T - Trailer  
D = delivery availability  
MV = Motor vehicle  
1 yes 0 no
### List of part numbers

#### 446 010 ... .

<table>
<thead>
<tr>
<th>WABCO-No.</th>
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<th>Parts description</th>
<th>Application</th>
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<tbody>
<tr>
<td>446 010</td>
<td>087 0</td>
<td>1 Plate with cabling from ... 086 0 MV C-ECU</td>
<td>446 010 004 0 to 007 0</td>
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<tr>
<td></td>
<td>087 2</td>
<td>1 like ... 087 0, without plate MV C ECU</td>
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</tr>
<tr>
<td></td>
<td>090 2</td>
<td>1 Option pressure reduction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>091 2</td>
<td>1 ABS crimp contacts (6) for power supply cable</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td>092 2</td>
<td>1 Distribution box ( 4 x PG 16)</td>
<td>T MV</td>
</tr>
<tr>
<td></td>
<td>390 2</td>
<td>1 Supply cable 50 metre coil</td>
<td>T MV</td>
</tr>
<tr>
<td></td>
<td>530 2</td>
<td>1 Option pressure reduction</td>
<td>VARIO-B</td>
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<tr>
<td></td>
<td>650 4</td>
<td>1 Cover</td>
<td>VARIO-B</td>
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#### 446 (016-105) ... .

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<th>Parts description</th>
<th>Application</th>
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<tbody>
<tr>
<td>446 016</td>
<td>000 0</td>
<td>1 Info module 24 volts</td>
<td>MV for T-ABS</td>
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<tr>
<td></td>
<td>001 0</td>
<td>0 Info module 12 volts</td>
<td>MV for T-ABS</td>
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<tr>
<td></td>
<td>002 0</td>
<td>1 Info module 24 volts</td>
<td>MV for T-ABS</td>
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<tr>
<td></td>
<td>003 0</td>
<td>1 Info module 12 volts</td>
<td>MV for T-ABS</td>
</tr>
<tr>
<td></td>
<td>050 4</td>
<td>1 Sealing plate for Info module</td>
<td>MV for T-ABS</td>
</tr>
<tr>
<td>019</td>
<td>000 0</td>
<td>1 ASR Engine Module 24 volts</td>
<td>MV</td>
</tr>
<tr>
<td>036</td>
<td>000 0</td>
<td>1 Relay 24 volts</td>
<td>MV and T-ABS</td>
</tr>
<tr>
<td>105</td>
<td>001 0</td>
<td>1 VARIO-C1 ECU 24 volts 6S/3M and lower</td>
<td>Trailer ABS</td>
</tr>
<tr>
<td></td>
<td>003 0</td>
<td>1 VARIO-C1 ECU 12 volts 6S/3M and lower</td>
<td>Trailer ABS</td>
</tr>
<tr>
<td></td>
<td>009 0</td>
<td>1 VARIO-C1 ECU 24 volts 4S/2M 2S/2M</td>
<td>Trailer ABS</td>
</tr>
<tr>
<td></td>
<td>010 4</td>
<td>1 Housing</td>
<td>VARIO-C trailer ABS</td>
</tr>
<tr>
<td></td>
<td>011 0</td>
<td>1 VARIO-C1 ECU 12 volts 4S/2M 2S/2M</td>
<td>Trailer ABS</td>
</tr>
<tr>
<td></td>
<td>023 0</td>
<td>1 VARIO-C1 ECU 24 volts 6S/3M</td>
<td>wading</td>
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<tr>
<td></td>
<td>031 0</td>
<td>1 VARIO-C2 ECU 24 volts 6S/3M § 2S/1M</td>
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</tr>
<tr>
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<td>032 0</td>
<td>1 VARIO-C2 ECU 24 volts 4S/2M § 2S/1M</td>
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<tr>
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<td>041 0</td>
<td>1 VARIO-C2 ECU 12 volts 6S/3M § 2S/1M</td>
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<tr>
<td></td>
<td>042 0</td>
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<tr>
<td></td>
<td>051 0</td>
<td>1 C+ ECU 24 volts 6S/3M § 2S/1M</td>
<td>Trailer with MRV, Retarder</td>
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<tr>
<td></td>
<td>052 0</td>
<td>1 C+ ECU 24 volts 4S/2M § 2S/1M</td>
<td>Trailer with MRV</td>
</tr>
<tr>
<td></td>
<td>530 2</td>
<td>1 Fittings pack VARIO-C 6S/3M</td>
<td></td>
</tr>
<tr>
<td></td>
<td>531 2</td>
<td>1 Fittings pack VARIO-C 4S/3M</td>
<td></td>
</tr>
<tr>
<td></td>
<td>532 2</td>
<td>1 Fittings pack VARIO-C 4S/2M</td>
<td></td>
</tr>
<tr>
<td></td>
<td>533 2</td>
<td>1 Fittings pack VARIO-C 2S/2M</td>
<td></td>
</tr>
<tr>
<td></td>
<td>534 2</td>
<td>1 Fittings pack VARIO-C 2S/1M</td>
<td></td>
</tr>
<tr>
<td></td>
<td>535 2</td>
<td>1 mixed supply ISO 7638 + stop light</td>
<td>also for Retarder switch off</td>
</tr>
<tr>
<td></td>
<td>536 2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>537 2</td>
<td>1 &quot;green lamp&quot; complete with 10000 mm cable</td>
<td>T with mixed supply and ECAS</td>
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<tr>
<td></td>
<td>538 2</td>
<td>1 Fittings pack VARIO-C+ 6S/3M with supply plug green</td>
<td></td>
</tr>
<tr>
<td></td>
<td>539 2</td>
<td>1 Fittings pack VARIO-C+ 4S/2M with supply plug green</td>
<td></td>
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<tr>
<td></td>
<td>750 2</td>
<td>1 Cable connetor</td>
<td>MV T</td>
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</table>
## List of part numbers

### 446 300 ... .

<table>
<thead>
<tr>
<th>WABCO-No.</th>
<th>D</th>
<th>Part description</th>
<th>Application</th>
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<tbody>
<tr>
<td>446 300</td>
<td>2</td>
<td>Carrying case for Diagnostic Controller</td>
<td>MV T</td>
</tr>
<tr>
<td>309</td>
<td>0</td>
<td>Adapter plug 54 pins</td>
<td>to measure ABS MV 6channel-C</td>
</tr>
<tr>
<td>310</td>
<td>0</td>
<td>Adapter plug 35 pins</td>
<td>to measure ABS MV 4channel-C</td>
</tr>
<tr>
<td>311</td>
<td>0</td>
<td>Adapter plug 25 pins</td>
<td>to measure ECAS MW, ATC</td>
</tr>
<tr>
<td>314</td>
<td>0</td>
<td>Adapter plug 35 pins</td>
<td>to measure MV ECAS, ABS</td>
</tr>
<tr>
<td>315</td>
<td>0</td>
<td>Inter adapter 35 pins</td>
<td>to measure ABS MV 4channel-C</td>
</tr>
<tr>
<td>316</td>
<td>0</td>
<td>Inter adapter 35 pins</td>
<td>to measure ECAS MW</td>
</tr>
<tr>
<td>317</td>
<td>0</td>
<td>Inter adapter 25 pins</td>
<td>to measure ECAS MW</td>
</tr>
<tr>
<td>318</td>
<td>0</td>
<td>Inter adapter VARIO-C</td>
<td>to measure A-ABS</td>
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<tr>
<td>319</td>
<td>0</td>
<td>Inter adapter 54 pins</td>
<td>to measure ABS MV 6channel-C</td>
</tr>
<tr>
<td>320</td>
<td>0</td>
<td>Diagnostic Controller</td>
<td></td>
</tr>
<tr>
<td>321</td>
<td>0</td>
<td>replaced by ... 331 0</td>
<td></td>
</tr>
<tr>
<td>328</td>
<td>0</td>
<td>Diagnostic Controller Keyboard</td>
<td>to correct Parameter</td>
</tr>
<tr>
<td>331</td>
<td>0</td>
<td>Diagnostic Controller Set</td>
<td>to measure</td>
</tr>
<tr>
<td>501</td>
<td>0</td>
<td>Program-Card VARIO-C in German language</td>
<td>T</td>
</tr>
<tr>
<td>510</td>
<td>0</td>
<td>Program-Card ABS/ASR C in German language</td>
<td>MV C1</td>
</tr>
<tr>
<td>511</td>
<td>0</td>
<td>Program-Card ABS/ASR C in English language</td>
<td>MV C1</td>
</tr>
<tr>
<td>514</td>
<td>0</td>
<td>Program-Card ABS/ASR SAE</td>
<td>MV</td>
</tr>
<tr>
<td>515</td>
<td>0</td>
<td>Program-Card ABS/ASR C in German language</td>
<td>MV C1/C2</td>
</tr>
<tr>
<td>516</td>
<td>0</td>
<td>Program-Card ABS/ASR C in English language</td>
<td>MV C1/C2</td>
</tr>
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<td>520</td>
<td>0</td>
<td>Program-Card ECAS in German language</td>
<td>MV ECAS 4 x 2-A</td>
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<tr>
<td>522</td>
<td>0</td>
<td>Program-Card ECAS in German language</td>
<td>ECAS - Bus</td>
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<tr>
<td>524</td>
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<td>Program-Card ECAS in German language</td>
<td>MV ECAS LKW o D.</td>
</tr>
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<td>526</td>
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<td>Program-Card ECAS in German language</td>
<td>MV ECAS 6 x 2-A</td>
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<tr>
<td>528</td>
<td>0</td>
<td>Program-Card ECAS in German language</td>
<td>MV ECAS Bus-A</td>
</tr>
<tr>
<td>532</td>
<td>0</td>
<td>Program-Card ECAS in German language</td>
<td>MV ECAS LKW m. D.</td>
</tr>
<tr>
<td>534</td>
<td>0</td>
<td>Program-Card ATC in German language</td>
<td>MV ATC (ATR-KK)</td>
</tr>
<tr>
<td>537</td>
<td>0</td>
<td>Program-Card VARIO-C in English language</td>
<td>T</td>
</tr>
</tbody>
</table>

### 472 195 ... .

| 472 195   | 0 | replaced by ... 004 0                   | 24 volts    |
| 003       | 0 | ABS solenoid valve M22 x 1.5            | T MV        |
| 004       | 0 | ABS solenoid valve M22 x 1.5            | 12 volts    |
| 005       | 0 | ABS solenoid valve 1/2-14 NPTF         | 12 volts    |
| 006       | 0 | ABS solenoid valve 1/2-14 NPTF         | 24 volts    |
| 007       | 0 | ABS solenoid valve M22 x 1.5 Parker    | 24 volts    |
| 010       | 0 | ABS solenoid valve M22 x 1.5           | 24 volts    |
| 020       | 0 | ABS relay valve M16 x 1.5 / M22 x 1.5   | 24 volts    |
| 021       | 0 | ABS relay valve 3/8-18NPTF / 1/2-14NPTF | 12 volts    |
| 022       | 0 | ABS relay valve M16x1.5 Parker / M22x1.5 Parker | 24 volts    |
| 024       | 0 | ABS relay valve M16x1.5 / M22x1.5       | 12 volts    |

**Legend:**
- T - Trailer
- D = delivery availability
- MV = Motor vehicle
- 1 yes 0 no

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# List of part numbers

## 811 ... ...

<table>
<thead>
<tr>
<th>WABCO-No.</th>
<th>D</th>
<th>Parts description</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>811 519</td>
<td>144 6</td>
<td>Solenoid cables per metre without plug</td>
<td>MV T</td>
</tr>
<tr>
<td></td>
<td>200 6</td>
<td>Polyurethane line 100 m (2 x 2.5 mm$^2$)</td>
<td>T</td>
</tr>
<tr>
<td>540 007</td>
<td>4</td>
<td>Receptacle 6.3 mm, silver plated</td>
<td>Info Module ... 002 0</td>
</tr>
<tr>
<td></td>
<td>008 4</td>
<td>Receptacle 2.8 mm, tin-plated</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>009 4</td>
<td>Receptacle 2.8 mm, silver plated</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>010 4</td>
<td>Receptacle 6.3 mm, tin-plated</td>
<td>&quot;</td>
</tr>
</tbody>
</table>

## 893 ... ...

| 893 020   | 850 4 | Screws for cover                                  | VARIO-B     |
| 071 440   | 4   | Union nut for ISO 7638 socket                     | MV T        |
| 750 030   | 2   | Screwing PG12/13 for corrugated tube              | VARIO-B     |
|           | 100 0 | Screwing PG9 (sensor cables)                      | VARIO-B     |
|           | 110 0 | Screwing PG11 (solenoid cables)                   | VARIO-B     |

## 894 ... ...

| 894 050   | 130 2 | Relay 24 volts                                    | MV / VARIO-B / C |
|           | 134 2 | Relay 24 volts                                    | MV / VARIO-B / C |
|           | 140 2 | Relay 12 volts                                    | MV / VARIO-B / C |
| 055 981   | 4   | 9 pins socket for Info module                     | ..... 002/003 MV |
| 070 704   | 4   | Receptacle with notch (sensor cables)             | MV T        |
|           | 705 4 | Receptacle with notch (solenoid cables) valve     | MV T        |
|           | 706 4 | Receptacle with notch (supply cables 4 mm$^2$)    | MV T        |
|           | 707 4 | Receptacle with notch (supply cables 6 mm$^2$)    | MV T        |
| 101 150   | 2   | Connector with free running diode                 | MV T        |
| 110 017   | 4   | Snap in relay socket for Info module (2 pieces necessary) | 446 016 000 0 |
|           | 020 2 | 1 Relay socket                                    |             |
| 510 297   | 4   | Spring contact 1.5 mm$^2$                         | 35pins plug |
|           | 298 4 | Spring contact 2.5 mm$^2$                         | 446 009 001 |
| 590 010   | 2   | Sensor-cables 2x0.75 mm$^2$ with receptacle; 3000 mm | T MV        |
|           | 011 2 | Sensor-cables 2x0.75 mm$^2$ with receptacle; 5000 mm | T MV        |
|           | 012 2 | Sensor-cables 2x0.75 mm$^2$ with receptacle; 8000 mm | T MV        |
|           | 013 2 | Component outline drawing                         |             |
|           | 014 2 | Sensor-cables 2x0.75 mm$^2$ with receptacle; 12000 mm | T MV        |
|           | 015 2 | Sensor-cables 2x0.75 mm$^2$ with receptacle; 10000 mm | T MV        |
|           | 016 2 | Sensor-cables 2x0.75 mm$^2$ with receptacle; 15000 mm | T MV        |
|           | 017 2 | Sensor-cables 2x0.75 mm$^2$ with receptacle; 15000 mm | T MV        |
|           | 019 2 | Sensor-cables without receptacle; 13000 mm        | T MV        |

T - Trailer  D = delivery availability  
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1 yes  0 no
### List of part numbers

<table>
<thead>
<tr>
<th>WABCO-No.</th>
<th>D</th>
<th>Parts description</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>894</strong></td>
<td>590</td>
<td>Sensor-cables without receptacle; 8700 mm</td>
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<tr>
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<td>020</td>
<td>Sensor-cables without receptacle; 10000 mm</td>
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<td>021</td>
<td>Sensor-cables without receptacle; 4700 mm</td>
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<td>023</td>
<td>Sensor-cables without receptacle; 2800 mm</td>
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<td>024</td>
<td>Sensor-cables with receptacle; 6500 mm</td>
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<td>100</td>
<td>Sensor-cables 3x1.5 mm² without receptacle; 350 mm</td>
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<td>102</td>
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<td></td>
<td>103</td>
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<td>106</td>
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<td>108</td>
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<td>601</td>
<td>Solenoid cables 3x1.5 mm² with receptacle; 3000 mm</td>
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<td>010</td>
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<tr>
<td></td>
<td>012</td>
<td>replaced by 894 590 101 2</td>
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<tr>
<td></td>
<td>013</td>
<td>Solenoid cables 3x1.5 mm² with receptacle; 9000 mm</td>
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<td>014</td>
<td>Solenoid cables with angle plug, without receptacle; 900 mm</td>
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<td>015</td>
<td>Jumper cable</td>
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<td>016</td>
<td>Multi-Meter cable black</td>
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<td>017</td>
<td>Multi-Meter cable red</td>
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<td>018</td>
<td>Diagnostic cable ISO 9141</td>
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<td>019</td>
<td>Adapter 54/35</td>
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<tr>
<td></td>
<td>024</td>
<td>Sensor-cables 3x1.5 mm² without receptacle; 15000 mm</td>
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<tr>
<td></td>
<td>026</td>
<td>Sensor-cables 3x1.5 mm² without receptacle; 2000 mm</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WABCO-No.</th>
<th>D</th>
<th>Parts description</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>899</strong></td>
<td>470</td>
<td>Venting guide</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td>760</td>
<td>Bush, sensor / sensor mounting</td>
<td>T</td>
</tr>
</tbody>
</table>

Whilst every effort is made to ensure the accuracy of this information, WABCO accepts no responsibility for difficulties arising from its use, however caused.

T - Trailer  
D = delivery availability  
MV = Motor vehicle  
1 yes 0 no
drilling template for ISO 7638 socket