Vario Compact ABS

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System Documentation
Installation
Components

2. Edition

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WABCO

Vehicle Control Systems

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The System

When in the early Eighties ABS was first installed as standard equipment in commercial vehicles, it was WABCO systems which were being fitted. The use in the towing vehicle was soon followed by the use in trailers. After the initial ABS systems for trailers,the VARIO-B generation was developed which, through system versatility, offered new potential. The basic wiring concept of VARIO-B was also used for the VARIO-C generation which was introduced in 1989.

Because of its improved versatility and improved diagnostics, VARIO-C has set a new standard for the market.

Additional requirements by the trailer manufacturers for easy installation and testing whilst maintaining the usual WABCO quality standard were among the reasons for WABCO to develop its latest ABS generation - **V**ario **C**ompact AB**S** - **VCS**.

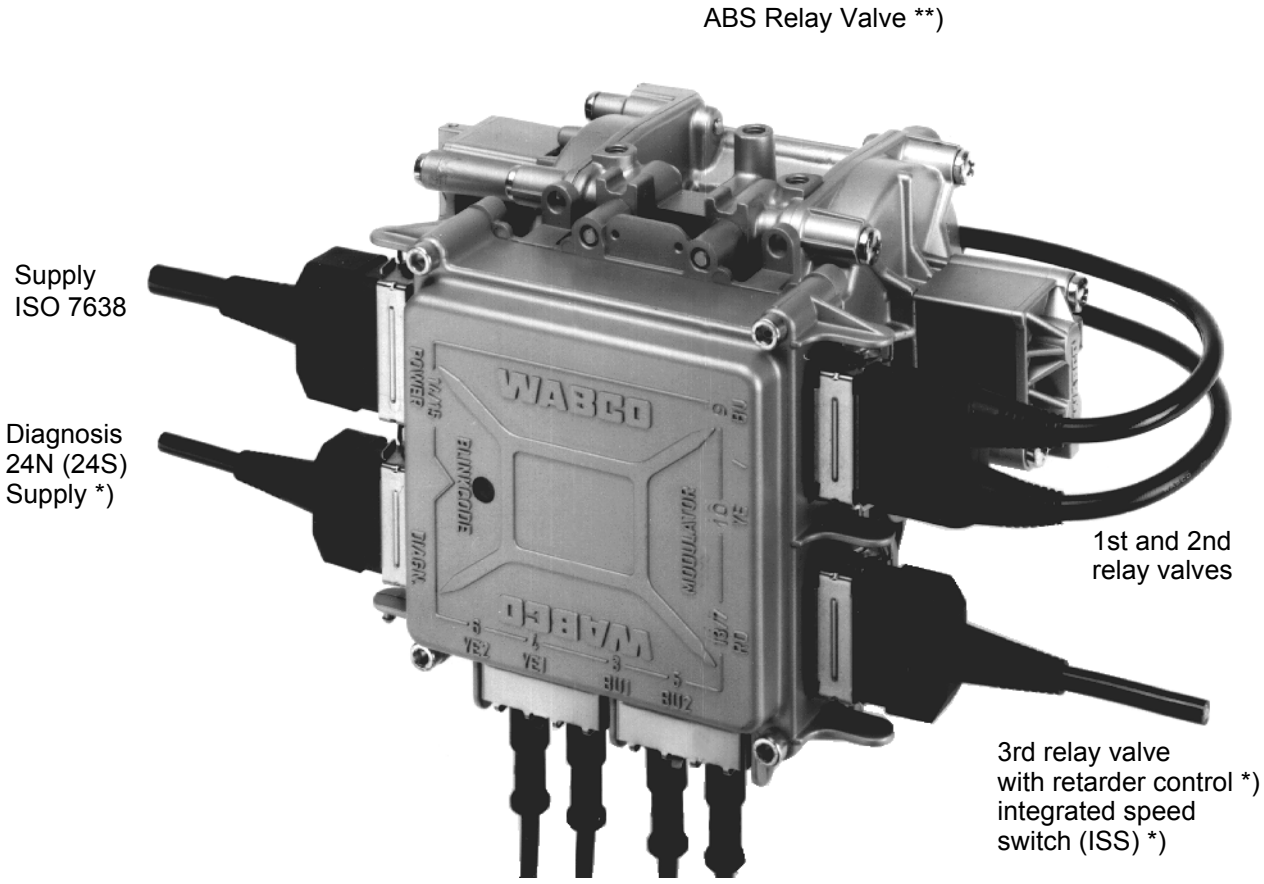
Possibilities and System Features

VCS is a ready-to-install ABS system for trailers meeting all legal requirements of the A category.

The range of systems extends from a 2S/2M system for semitrailers to a 4S/3M system for towbar trailers or, for instance, a semitrailer with a steering axle.

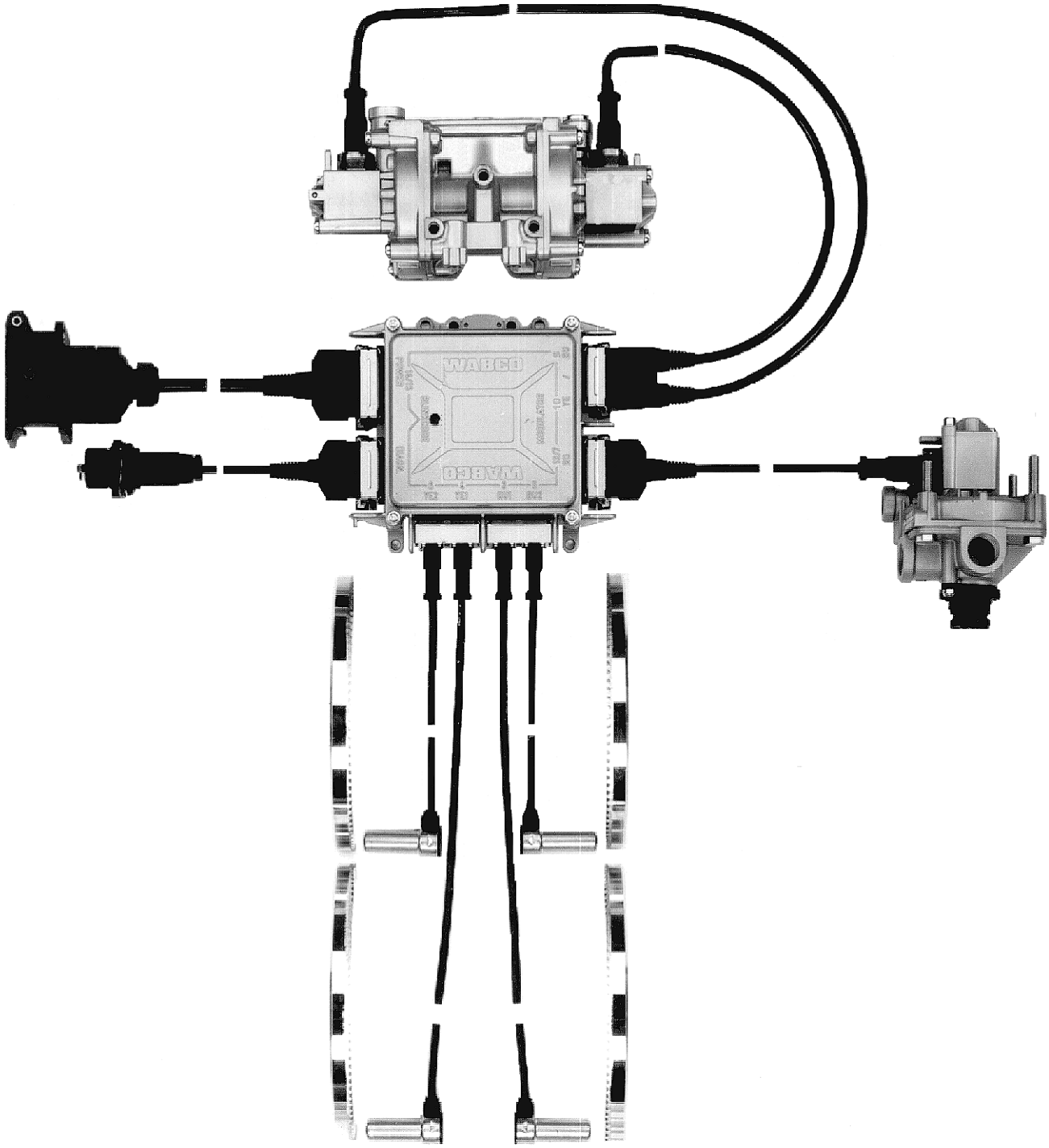
In keeping with the specific needs of the trailer manufacturers, VCS is available either as a compact unit or as a modular system, i. e. ECU and valves are installed separately.

Compact Design:



*) optional
**) optionally flanged to compact unit

Separate ECU:



Please note:

With VCS (whether supplied as a compact unit or as a modular system), the vehicle manufacturer always receives a ready-to-install ECU which is completely sealed at the factory and which, due to its plug-in connection, permits extremely low-cost and highly reliable installation.

This also applies to any diagnostic and repair work. The ECU no longer needs to be opened.

1. Design of the ABS System

The Vario Compact System (VCS) can be used on any trailer with an air braking system. It covers systems from 4S/3M to 2S/1M.

The ABS system is an enhancement of the conventional braking system and essentially consists of:

- two to four inductive wheel sensors and toothed pole wheels to pick up the speeds of the individual wheels
- one, two or three electro-pneumatic modulators with the following functions:
  - building up brake pressure
  - maintaining brake pressure
  - reducing brake pressure

Both ABS relay valves and ABS solenoid valves can be used. The choice depends on the braking system used, and more particularly on time response. It is important that the appropriate ECU is used (please also refer to Chapter 10).

If the control valves are not electrically actuated, the ordinary increase or decrease of brake pressure the driver needs is not affected. The special function of ”maintaining brake pressure“ serves to improve both the control performance of the ABS system, and air consumption.

- one ECU (Electronic Control Unit) with one, two or three control channels, subdivided into the following functional groups:
  - input circuit
  - main circuit
  - safety circuit
  - valve actuation

In the input circuit, the signals generated by the respective inductive sensors are filtered and converted into digital information for determining period lengths.

The main circuit consists of a microcomputer. It contains a complex programme for the computation and logical operation of the control signals and for outputting the actuating variables for the valve control system.

The safety circuit monitors the ABS system, i. e. the sensors, solenoid control valves, ECU and wiring, before the vehicle moves off and whilst it is in motion, irrespective of whether the brakes are being actuated or not. It alerts the driver to any errors or defects by means of an indicator lamp and shuts off the whole or part of the system. Whilst the conventional brake remains operational, it is only the anti-lock system which is deactivated wholly or in part.

The valve actuation contains (output stages) which are actuated by the signals from the main circuit and which switch the current for actuating the control valves.

The electronic control unit of the VARIO Compact ABS is a further development from the established Vario-C ABS, building on its proven principles.

In a **2S/1M configuration**, the ABS consists of two sensors and one modulator. They control one axle.

1.1 Modular System Design

Vario Compact ABS is of a modular design and comprises the system configurations 2S/1M, 2S/2M, 4S/2M and 4S/3M. This permits configurations suitable for almost any type of vehicle. At least one sensor and one modulator form one control channel.

1.2 Possible System Configurations And ABS Control Principles

The wheel on this axle which first shows a tendency to lock dominates the ABS control process which is subject to the **MAR** principle (modified axle control). The 2S/1M system is a minimum configuration which should be used in exceptional cases only on light semitrailers or central axle trailers. If this configuration is used it is vital to consider whether its performance in terms of stopping distance and thus safety is sufficient.

In a **2S/2M configuration**, one sensor and one modulator are each combined one side of the vehicle to form one control channel. All other wheels on that side, if any, are also controlled, although indirectly. The brake forces are controlled according to the principle of so-called 'individual control' **(IR)** in which each side of the vehicle receives the brake force feasible for the prevailing road conditions and the specific brake factor. If wheels which have no sensors are indirectly controlled on a vehicle with several axles, this is called 'indirect individual control' **(INIR)**.

In a **4S/2M configuration**, there are two sensors on each side of the vehicle. The sensor signals from their two wheels are used by the ECU for controlling one modulator. This also means side control. The brake pressure is the same for all wheels on one side of the vehicle. The two wheels on that side which have sensors attached are controlled according to the principle of 'modified side control' **(MSR)**, and the wheel on one side of the vehicle which first shows a tendency to lock determines ABS control. On the other hand, the two modulators are controlled individually. This means that both sides of the vehicle are subject to individual control. If wheels which have no sensors are indirectly controlled on a vehicle with several axles, this is then called 'indirect side control' **(INSR)**.

A **4S/3M configuration** is most frequently used for towbar trailers or semitrailers with one trailing axle. The steering axle has two sensors and one modulator for axle control because the brake pressure is identical for all wheels on this axle. The wheels of the steering axle are controlled by the ABS modulator (A). Control is achieved according to the principle of 'modified axle control' **(MAR, see above)**. Another axle has one sensor and one modulator fitted for side control. These wheels are subject to individual control (IR). Thus the control philosophy behind 4S/3M can be described as a combination of a 2S/1M system with MAR on the steering axle, and a 2S/2M system with IR on another axle.

The configurations of 4S/3M and 4S/2M can also be used for retarder control. The brochure entitled "System Suggestions" contains examples for system configurations.

All configurations permit brake cylinders in addition to those on the wheels with sensors to be connected to the existing modulators.

System Configuration Overview:

	2S/1M	2S/2M	4S/2M	4S/3M
Number of sensors	2	2	4	4
Number of modulators	1	2	2	3
Control principle	MAR	IR	MSR	MAR + IR
Number of directly controlled axles	1	1	2	2
Retarder control	–	–	X	X
Lifting axle operation (lifting axle with sensor)	–	–	X	X
Integrated speed switch (ISS)	X	X	X	X

From these indirectly controlled wheels, however, no information is supplied to the ECU. For this reason, it is possible that those wheels may lock.

1.3 Error Monitoring

During operation, the electronics are monitored by an integrated safety circuit. If this perceives any errors in the ABS, this either causes the defective component to be switched off (selective inactivation), or the whole of the ABS to be inactivated. Conventional braking functions are maintained.

For diagnostic purposes, the type of error and its frequency are permanently stored in an EE-PROM (non-volatile memory).

In the case of selective inactivation, the control channels which are still active permit a residual availability of the ABS which not only maintains braking performance but also secondary stability for the vehicle.

1.4 Description of an ABS Control Cycle

Fig. 1 shows an example for a control cycle with the essential regulating variables, i. e. wheel retardation threshold -b, wheel acceleration threshold +b, and slip thresholds λ_1 and λ_2.

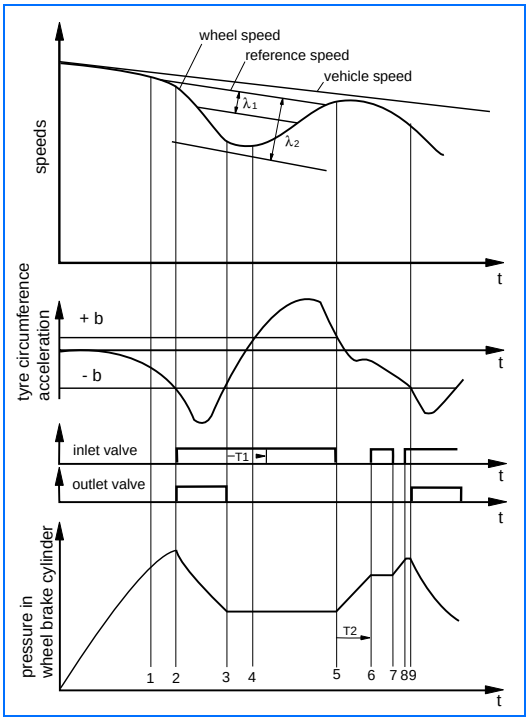


Fig. 1

As the brake pressure increases, so does wheel retardation. At Point 1, the wheel retardation exceeds a value which the vehicle's retardation cannot physically exceed. The reference speed which up until that point was equal to the wheel speed now leaves the wheel speed and decreases according to a predefined vehicle retardation. From the reference speeds established, the maximum value is computed and generally used as the common reference speed of the wheels. The respective wheel slip is then computed from the prevailing wheel speed and the common reference speed.

At Point 2, the retardation threshold -b has been exceeded. The wheel is moving within the unstable range of the μ–λ slip curve. The wheel has now reached its maximum brake force, i. e. any additional increase in braking torque would exclusively increase wheel retardation. For this reason, the brake pressure is reduced rapidly, and the wheel retardation will be reduced after a short delay. This delay is essentially determined by the hysteresis of the wheel brake and by the course of the μ–λ slip curve within the unstable range.

It is only once the wheel brake hysteresis has been passed that any further reduction in pressure will also cause wheel retardation to be reduced.

At Point 3 the retardation signal -b falls as it passes below the threshold, and the brake pressure is held at a constant level for a predetermined time T1.

Usually wheel acceleration will exceed acceleration threshold +b during that holding period (Point 4). As long as this threshold is exceeded, the brake pressure is kept at a constant level. If the +b signal is not generated within time T1 (e. g. on low friction surfaces), the brake pressure is lowered further via slip signal λ_1. The higher slip signal λ_2 is not reached within this control cycle.

When the threshold is no longer reached (Point 5), the +b signal falls. The wheel is now within the stable μ–λ slip curve, and the utilized μ value is slightly below the maximum.

for each subsequent control cycle. After this steep input curve, the brake pressure is increased by pulsing, i. e. by alternating pressure hold and pressure increase.

The logic shown here in principle is not preset but is adapted to the prevailing dynamic behaviour of the wheel on different friction coefficients, i. e. the system is an adaptive one, nor are the thresholds for wheel retardation, acceleration and slip constant; they are determined by a number of parameters, e. g. vehicle speed.

The number of control cycles is determined by the dynamic behaviour of the overall control circuit ABS controller - wheel brake - wheel - road surface, with adhesion playing an essential part. Usually there will be between 3 and 5 cycles per second, but fewer on wet ice.

The ECU has a diagnostic interface according to ISO Standard 9141 and operates in bidirectional mode 8.

1.5 ABS Control of One Retarder

The Vario Compact anti-lock system is capable of including one retarder in its control cycles. Control is achieved by a black/white circuit. The output stage incorporated in the ECU actuates a relay which switches the retarder off and on. In order to switch off the retarder, the output stage supplies + 24 volts. The relay is not integrated in the ECU but should be located either in a separate housing or preferably in the control housing for the retarder. An example for the wiring is shown on Page 22.

If a trailer has both VCS and a retarder fitted, only 4S/3M or 4S/2M systems can be used for the configuration of the ABS. The retarder axle must then always have sensors c and d fitted to it. It is important that a vehicle with a retarder has sensors not only on the retarder axle but also on one additional axle because due to its great mass the retarder axle's dynamic behaviour differs from that of an ordinary axle.

In order to prevent this having any negative impact on ABS control, a vehicle with a retarder axle always has to have sensors fitted to another axle. If the vehicle not only has a retarder but also a lifting axle, this may not have sensors fitted.

If the retarder is actuated on its own and the sensors on one or both wheels of that axle report excessive slip or excessive wheel retardation, the retarder is switched off until the tendency to lock has ceased. It is then automatically switched on again until once again a tendency to lock is detected, or until the driver switches it off.

If, in addition to the sustained-action brake, the driver actuates the service brake and the wheels with sensors show a tendency to lock (as a consequence of overlay of brake forces), the service brake pressures are controlled during the ABS control process, and the retarder is switched off permanently.

2. Compatibility

In terms of sensors and modulators, the Vario Compact ABS is compatible with the Vario-C system. Since a new plug-in system has been introduced, supply cables, solenoid and sensor extension cables have to be replaced.

3. Diagnostic Interface

Interface and system software permit

- type and frequency of stored errors to be read out and to be deleted
- functional testing to be performed
- diagnostic or system parameters to be changed

the mileage counter to be read out and to be calibrated.

been entered correctly, they can subsequently be modified at any time. The mileage shown is updated using

4. Recognition of Lifting Axles

If the vehicle has lifting axles and these have speed sensors fitted, the ECU will recognize automatically whether that axle is raised or not.

The VCS brochure entitled "System Suggestions" (Order No. 815 000 243 3) contains examples for system configurations for vehicles with lifting axles.

The lifting axle may only have sensors e and f fitted. Sensors c and d may not be fitted to the lifting axle.

5. Speed Signal C3

Vario Compact ABS provides a speed signal C3 which can be used to support all systems using this signal (e. g. ECAS). It is a rectangular signal with modulated pulse widths. The exact technical data are shown on the respective VCS control units.

When the vehicle is stationary, a minimum speed of 1.8 k. p. h. is output. This is useful for error recognition on ECAS, for instance.

6. Mileage Counter

VCS has an integrated mileage counter recording the distance covered whilst ABS was in operation. This permits two separate functions:

I. The **total mileage counter** records the total distance covered since the system was first installed. This distance is stored at regular intervals and can be read out at any time using different diagnostic tools (e. g. Compact Tester, Diagnostic Controller).

II. In addition it contains a so-called **trip recorder** which can be reset to zero at any time. This can be used, for instance, to establish the distance covered between maintenance intervals or within a certain period. The trip recorder can be read out or reset by means of the Diagnostic Controller only.

For operating the mileage counter, the ECU must have been given information on the rolling circumference of the tyre and the number of teeth on the pole wheel on the axle that has had sensors c and d fitted. Sensors e and f are used for the mileage counter only on trailers which use a retarder.

The standard setting of the mileage counter is shown in the applicable list of parameters (see Annex A). For these nominal conditions, the resolution is 100 metres.

In order to receive information which is as accurate as possible, these data should be changed if the tyre actually used deviates significantly from the standard setting. The tyre tables from the tyre manufacturers show the respective dynamic rolling circumference. If these data have not

the new data. By using such calibration methods, a very high degree of accuracy can be achieved. It lies in the area of between 1% and 3% and essentially depends upon the tyre manufacturers' production tolerances and tyre wear. For deviations if no calibration is done, please refer to the table in Annex B showing the differences as compared with the standard parameter settings.

The mileage counter can be calibrated using the various diagnostic equipment available from WABCO. This equipment has a selection menu for the common numbers of pole wheels. In addition, the rolling circumference for the tyres has to be entered. These data are then used for computing an adjustment factor.

If special pole wheels are used which are not listed, special calibration is required. For this purpose, a special calibration constant must be entered which is calculated from the rolling circumference of the tyre used and the number of teeth on the pole wheel:

Special calibration constant SK:

$$SK = 59,76 \frac{1}{mm} x \frac{\text{rolling circumference [mm]}}{\text{number of pole wheel teeth [-]}}$$

Example:

Number of teeth on pole wheel:	64
Tyre diameter:	2075 mm (185/75R16C)

$$SK = 59,76 \frac{1}{mm} x \frac{2075 mm}{64} = 1938$$

In this case, a special calibration value of 1938 must be entered.

The mileage counter requires the operating voltage. If the ECU does not have any supply at any stage, the mileage counter does not work. For this reason it is possible to manipulate it. If the system receives its voltage supply via the stoplamp, only the distance covered during the braking process can be recorded. If a mixed voltage supply is used (ISO 7638 and 24N), the information returned by the mileage counter is inconclusive.

7. Integrated Speed Switch (ISS)

Some VCS control units (e.g. 446 108 032 0) have a switch output port which operates on speed (**I**ntegrated **S**peed **S**witch **ISS**). If the vehicle's speed falls below a speed threshold for which the parameter can be set, or exceeds that speed, the switching status of that output will change. This permits activating or inactivating relays or solenoid valves, for instance, depending on the speed of the vehicle.

This function can be used wherever the vehicle's functions are to be controlled depending on its speed, such as:

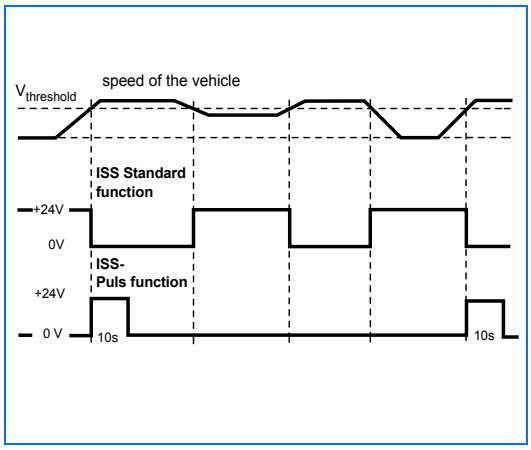
- steering axles to be locked at certain speeds
- lifting axles to be raised or lowered at certain speeds

The parameter for the speed threshold at which the switching status of the output changes can be freely selected between 4 and 120 k. p. h.

Annex A shows the standard parameters preset when the system is supplied.

By setting the parameters, the function of the switch output is determined. Two modes of operation

are possible (Fig. 2): the 'standard function' and the 'pulse function'.



Standard function:
Below the speed threshold for which the parameter has been set, the switch output is activated. In this state, output is +24volts. When the threshold is reached, the output is deactivated. When the speed again drops below the threshold, there will be an initial hysteresis of approx. 2 k.p.h. before the output is activated once again.

Pulse function:
Below the speed threshold for which the parameter has been set, the switch output is deactivated. When the speed threshold is reached, the output is switched on for 10 seconds (pulse). After that time has elapsed, the output is deactivated once again, irrespective of the speed. The pulse will not be generated again until the vehicle has been stationary (v = 0 k.p.h.)

The parameters are set using the Diagnostic Controller, or by using the PC diagnostic function.

In the event of an error, it must be ensured that the components controlled by the switch output are in a safe condition. For instance, if the voltage supply fails, the steering axle should be locked since this would represent a safe condition. The vehicle manufacturer must make sure that the components to be controlled are designed in such a way that this is ensured.

The wiring for the integrated speed switch is shown on Page 23.

8. Voltage Supply

The VCS operates with a nominal voltage of 24 volts. For the primary supply, a 5-pole supply connection according to ISO 7638 is used. WABCO recommends that this type of supply is used.

Some control units provide for an alternative voltage supply via ISO 1185 (stoplight supply 24N, wiring diagram see Page 23) or ISO 3731 (permanent voltage supply 24S).

Either of these may be used.
If 24N/24S/ISO 7638 are to be used simultaneously, an additional external switchover facility via a relay is required. A circuit diagram for this is shown on Page 24. If several types of supply are connected, the control unit will select the one which is available first. If any type of supply fails, switchover to the next one occurs automatically.

9. Indicator lamps and their functions

9.1 Operation of Indicator Lamps

Vario Compact ABS can activate up to three indicator lamps

- indicator lamp in the towing vehicle via ISO 7638
- integrated display lamp in the ECU
- in the case of mixed voltage supply (additional supply via ISO 1185 or ISO 3731): external indicator lamp on the trailer

The integrated display lamp in the ECU is always present. Depending on the parameters set, the indicator lamp in the towing vehicle and the external one on the trailer operate according to the indicator lamp functions described below.

The indicator lamp integrated in the ECU operates as follows:

- When the vehicle is stationary, this integrated indicator lamp goes off after approx. 3 seconds provided the system is free from any static faults.
- Any currently existing fault is permanently flashed out automatically.

The external indicator lamp on the trailer is active only if the system is supplied via ISO 1185 (when brakes are actuated) or ISO 3731. The reactions of this indicator lamp will then be identical to those in the towing vehicle.

When the flash code is activated, all indicator lamps are synchronized and usually activated identically. After the flash code has been completed, they revert to their initial status.

In the event of a fault, the following will occur:

- When the ECU has recognized the fault, the indicator lamp in the towing vehicle is switched on (plus the external indicator lamp on the trailer if it has a voltage supply).
- The internal display lamp automatically starts to flash

9.2 Indicator Lamp Functions

The VCS provides for three different indicator lamp functions (Fig. 3). These three alternatives, which can be changed at any time by setting the parameters accordingly, are described below.

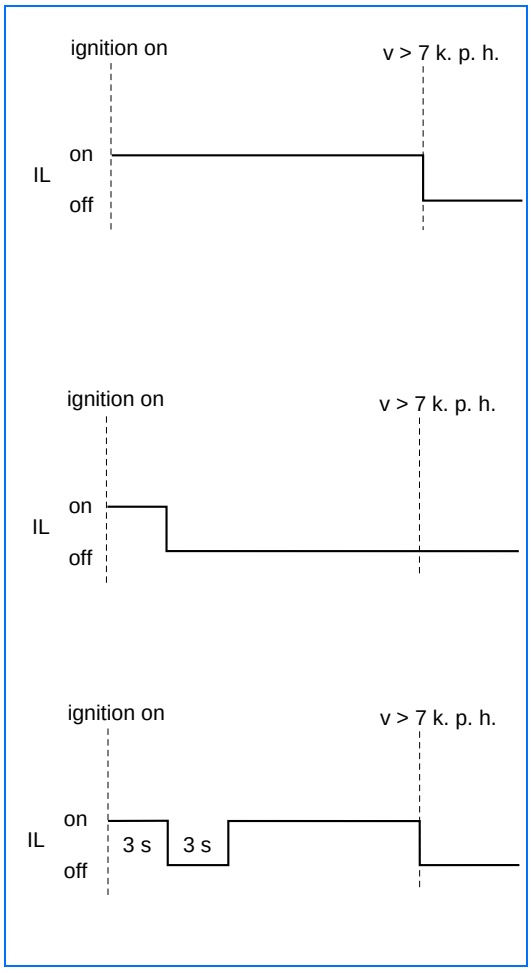


Fig. 3

Alternative 1 is WABCO's standard function for the actuation of the indicator lamps. In the event of a perfectly operating system, the indicator lamp will go off when the vehicle has reached a speed of approx. 7 k. p. h.

Alternative 2:

The second alternative is mainly used for passenger ABS. The indicator lamp goes off even before the vehicle has started to move provided there is no static fault.

Alternative 3:

With the third alternative, provided there is no static fault, the indicator lamp is briefly switched off whilst the vehicle is still stationary. When it has reached a speed of approx. 7 k. p. h. it goes off completely.

Since for trailer ABS the configurations with two sensors only are often used, there is the hazard in the event of a fault (if both sensors show a very wide air gap, e. g. after maintenance work on the braking system) in the case of Alternative 2 that this is not detected. Although ABS is not ready to perform its control functions, the indicator lamp stays off permanently even when the vehicle has moved off. This is a disadvantage which does not apply to Alternatives 1 and 3. For this reason they should be given preference for an ABS for trailers.

The current standard parameters are listed in Annex A.

10. ABS Modulators

Vario Compact ABS is designed for actuating ABS relay valves (e. g. WABCO No. 472 195 031 0 or 472 195 041 0). All control units can operate these modulator types. These ABS relay valves have been developed specifically for the use in trailers. They can be used in place of existing relay valves without ABS function. In addition, they are designed for low power consumption. This is particularly important for vehicles which do not have a permanent voltage supply.

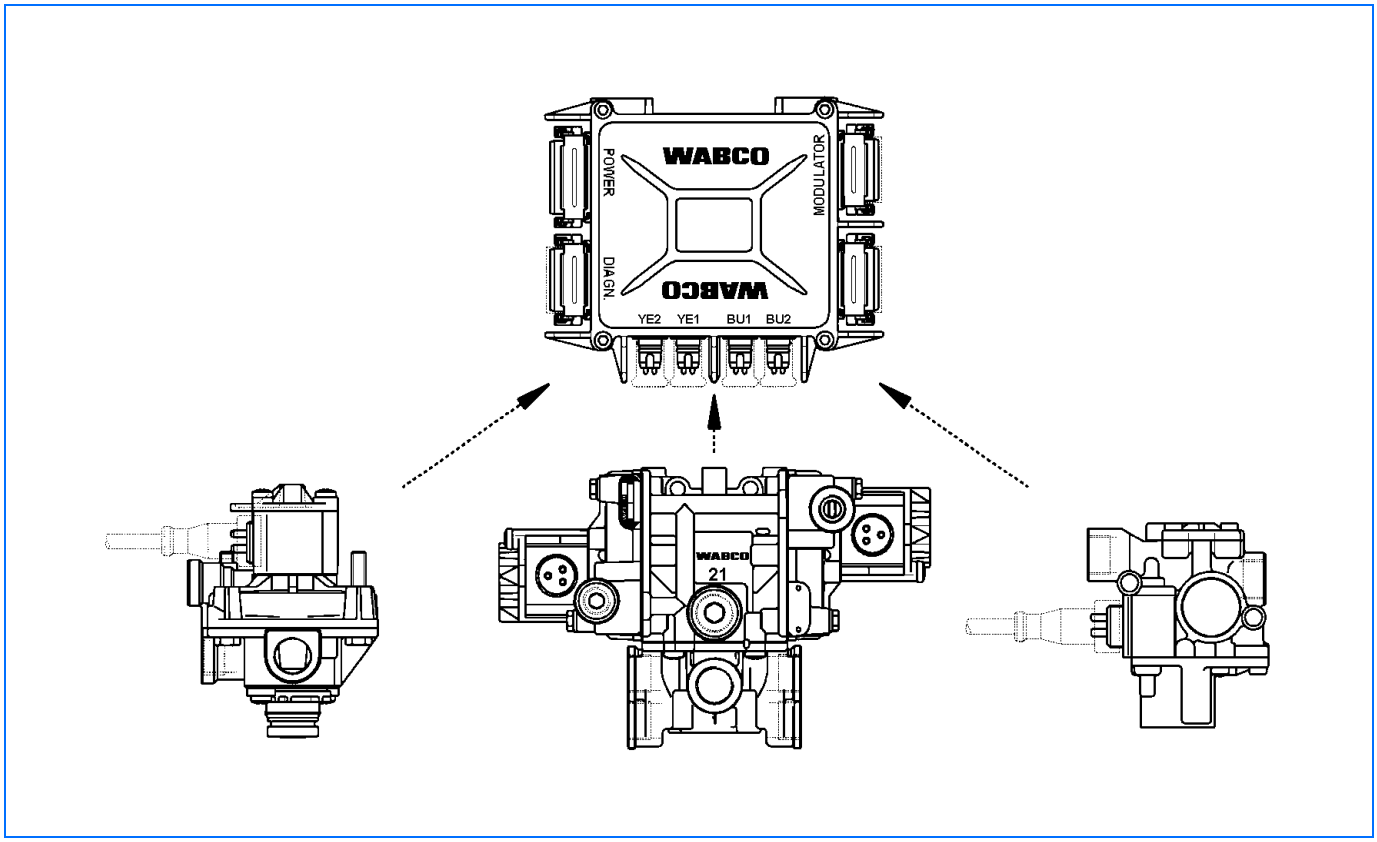


Fig. 4

In some cases it may be advisable to use ABS solenoid control valves (e. g. WABCO No. 472 195 018 0). This mainly applies to smaller towbar and central axle trailers whose time response is so favourable that they require no relay valves. For such cases, control units are available which are capable of actuating both ABS solenoid control valves and ABS relay valves. For this type of operation, power consumption is higher. For this reason it is suitable only if a permanent voltage supply is available. The control units suitable for actuating solenoid control valves are called ”VCS plus“ (e. g. WABCO No. 446 108 031 0 or 446 108 041 0).

Annex C shows the functions of both types of modulators.

11. Allocation of Tyre Circumference and Pole Wheels

For the ABS function it is necessary to allocate the tyre circumference and the number of teeth on the pole wheel because a number of control functions refer to the wheel speed or to absolutely or relatively derived quantities.

For this reason, a pole wheel with a defined number of teeth is permissible for a certain range of tyre sizes only. This allocation is shown in Annex D (Page 44).

In principle, each tyre circumference should be allocated to a number of pole wheel teeth. This allocation represents the centre line in the hatched portion of the diagram. In order to limit the number of different pole wheels used, a range of permissible tyre sizes has been defined for each pole wheel on the basis of certain tolerances. This is shown in the hatched section. Any combination of tyre diameter and pole wheel number must lie within that range.

11.1 Different Tyre Sizes on Different Axles

In some special cases it can be necessary or advisable to use different tyre sizes on different axles of a vehicle. If in such cases the difference in rolling circumferences does not exceed the permissible value of 6.5%, this is acceptable and does not affect the ABS function. If such differences are greater than 6.5%, the parameters for VCS can be set accordingly in order to avoid special pole wheels having to be used (as would be necessary for Vario-C).

The parameters for the different tyre sizes on the respective axles are set using the Diagnostic Controller. Since this function changes essential quantities in the ECU and requires in-depth background knowledge, it can only be accessed using a Personal Identification Number (PIN).

This PIN is allocated upon request and after thorough training by WABCO.

The parameters are set by entering the rolling circumference of the tyres and the number of teeth on the pole wheels. Initially the number of teeth on the pole wheel fitted is entered. This is followed by entering the rolling circumference of the wheel. This can be taken from the tyre manufacturer's list of tyres. The ECU uses these data to compute an adjustment factor for the respective wheel speeds.

For details on this procedure, please refer to the operating instructions for the Diagnostic Controller or for PC Diagnosis.

12. Special Functions

12.1 Service Signal

The service signal is a function which informs the driver when the vehicle has covered a pre-defined distance. This function can be used, for instance, to indicate that the vehicle is due for maintenance or service.

This function is activated by means of diagnostic equipment (Diagnostic Controller or PC diagnosis). When the system is initially supplied, it is switched off. In addition, a distance in kilometers can be freely selected. When the vehicle has covered this distance, the warning lamp is activated the next time the ignition is switched on, and will flash 8 times in succession. This process alerts the driver and is repeated every time the ignition is switched on.

When the vehicle has been serviced, the service signal can be reset using diagnostic equipment (Compact Tester, Diagnostic Controller or PC diagnosis). The service interval will then commence again, and after the preset distance has again been covered, the signal will be generated once more.

For the mileage set at the factory, please refer to Annex A.

12.2 Integrated Notebook

The control unit contains a storage section for storing any type of data; this is known as the integrated notebook. This area can be accessed by means of PC diagnosis.

The user can choose between two structures for the notebook; however, a selection has to be made as they cannot be used simultaneously:

- WABCO diagram
- free notebook section

The WABCO diagram is a pre-defined structure into which the user can enter specific data applicable to the vehicle. This includes information on vehicle identification, data on its chassis, its air suspension and its load-sensing facilities. Although this information can also be taken from the vehicle's documents, these may not be available at all times.

Optionally the free notebook section may be selected in which a total of any 340 alphanumeric characters can be stored.

Both sections can be protected by a password consisting of four alphanumeric characters. Whenever the user has allocated a password, the data cannot be changed without that password being used, although they are available to be read at any time.

When the system is initially supplied, both sections are blank.

12.3 Voltage Output T. 15

Some VCS control units have a voltage output for the on-board voltage used, (ignition, T. 15). This can be used to activate auxiliary functions. This output is located on Pin 5 of the terminal board RD for the 3rd modulator (see wiring diagram on Page 24).

The current load is limited to 1 ampère. All downstream wiring must be protected by using suitable fuses.

For using this output, cables 449 454 000 0 or 449 402 000 0 are available from WABCO (see Table of Standard Cables, Page 32 ff.).

13. Assistance when Errors are Detected

Some error situations may initially appear inexplicable to the user. For this reason, some cases are described below which might be helpful. Any repair work should be done only after the system has been switched off.

Error Situation	Cause	Remedy
System parameters cannot be set, integrated display lamp flashes permanently.	A defect currently exists.	Remove defect, switch system off and then on again.
Error memory cannot be cleared, integrated display lamp flashes permanently.	A defect currently exists.	Remove defect, switch system off and then on again.
Defect ”sensor leap“ immediately after switching on	Sensor wire too close to supply wire / solenoid wire.	Increase distance between supply / solenoid wire <> sensor wire.
Indicator lamp in the towing vehicle and integrated display lamp are on permanently, no defect exists.	Permanent flash code irritation due to faulty wiring (L line is accidentally connected to ground).	Remedy accidental ground of L line.
Error persists after repairs.	Error recovery is only recognized after RESET.	Switch system off and then on again (RESET).
Diagnostic equipment not working with ECU with mixed supply.	Electricity supply of diagnostic equipment only via stoplight	Actuate service brake.
ISS function is not available	No configuration for ISS	Set system configuration to ISS (e. g. 4S/3M+ISS)

14. Abbreviations

μ	friction
λ_1	slip threshold 1
λ_2	slip threshold 2
+b	wheel acceleration threshold
-b	wheel retardation threshold
2S/1M	2 sensors, 1 modulator
2S/2M	2 sensors, 2 modulators
4S/2M	4 sensors, 2 modulators
4S/3M	4 sensors, 3 modulators
ABS	Anti-Blockier-System
C3	speed signal
ECAS	Electronically Controlled Air Suspension
ECU	Electronic Control Unit
IL	Indicator lamp
INAR	Indirect Axle Control
INIR	Indirect Individual Control
INSR	Indirect Side Control
IR	Individual Control
ISO	International Organization for Standardization
ISS	Integrated Speed Switch
MAR	Modified Axle Control
MSR	Modified Side Control
PIN	Personal Identification Number
SK	Special Calibration Constant
VCS	Vario Compact ABS

For Planning a System

The ECU 446 108 030 0 can be used as a universal unit for all variants from 4S/3M to 2S/2M.

The ”scaled-down“ version 446 108 040 0 can be used for 4S/2M or 2S/2M.

This does not have the socket for the 3rd modulator.

Both ECUs can also have their parameters set for 2S/1M.

For Sensors

Basically it is only wheels which have sensors fitted which never lock. For cost reductions, however, it is possible to combine two wheels on one side of a semitrailer, for instance, although the wheels which have not had sensors fitted might lock.

If an even greater compromise between ABS control and costs is to be achieved, the result would be a 2S/2M system for the semitrailer with 3 axles.

Standard Equipment / Retrofitting

Whilst as standard equipment it is definitely worth optimizing the system and the trials required for this purpose, it is always better when retrofitting this system to equip one additional axle with sensors if in doubt. Usually the additional materials required serve to reduce the labour costs ensuing if the result is not satisfactory.

Vehicles Carrying Dangerous Loads

Since late 1990, the German guideline TRS 002 (Technical Guideline Roads) no longer applies.

The provisions have been simplified slightly and are contained in Code of Practice 5202 from ”TÜV“ (German Technical Control Board). ”Electrical Equipment for Vehicles Carrying Dangerous Loads - Comments on Margin No. 11 251 and 220 000 (Annex B.2) GGVS/ADR“.

However, all the components of Vario Compact ABS continue to meet the requirements of the former TRS guideline so that there should be no difficulties when a vehicle with a properly installed system is inspected.

ADR (German): ~ GGVS

ADR:
European **A**greement Concerning the International Carriage of **D**angerous Goods by **R**oad

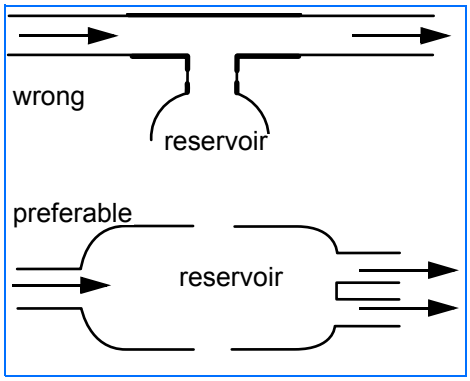
ADR (French):
Accord européen relatif au transport international des marchandises **D**angereuses par **R**oute.

PLEASE NOTE!

GGVS is often confused with explosion protection.
They are not the same!
No ABS components may be located in parts of the vehicle (e. g. pump area) in which only explosion-proof parts may be installed.

Air Lines

energy supply towards the valves



Long vehicles and large brake cylinders can be critical in terms of time response. In such cases it is important to avoid T-pieces with unfavourable flow properties, unnecessary elbows and supply lines of insufficient diameters.

For reservoir sizes, please refer to "Test Report for Trailers" expertise, WABCO No. 815 000 314 3.

Energizing ABS Relay Valve 472 195 03. 0

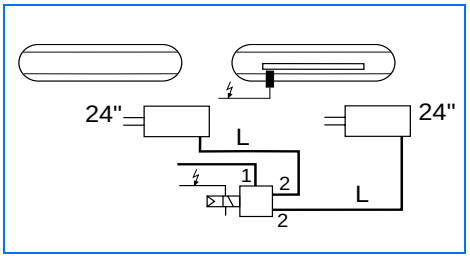


Fig. 5
Length L is identical for identical brake cylinders

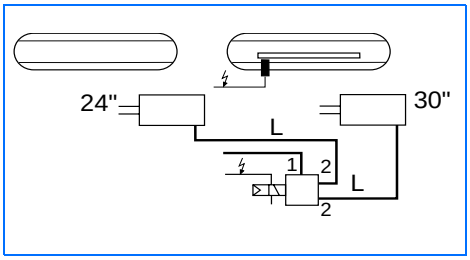


Fig. 6
With cylinders of different sizes: Select greater L leading to the smaller cylinder

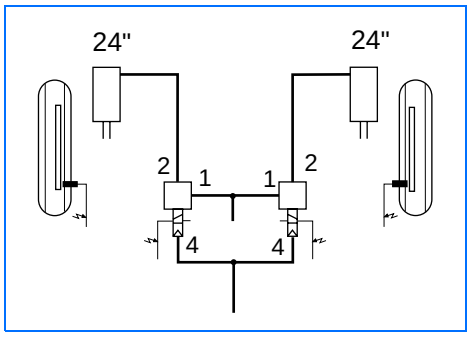


Fig. 7
Pilot and supply lines leading towards the valves should be divided as symmetrically as possible

The ABS relay valve must be mounted on the vehicle frame. Mounting on the axle is not acceptable.

For the **ABS to function properly** with the WABCO control units specified for the purpose, it is always important that the brake pressure in the connected brake cylinders is quick enough to follow that in the control chamber of the ABS relay valve. For this reason, the brake cylinder volume controlled by an ABS relay valve should usually not exceed a total of 2 dm³ (e. g. 2 brake chambers Type 30).

The length of the lines between the ABS relay valve and the brake cylinders should be as short as possible, and never more than 2.5 metres. If two brake cylinders are actuated by one ABS relay valve, both operating ports (2) must have lines of equal length leading to the brake cylinders (Fig. 5). Their nominal width should be between 9 mm and 11 mm. The nominal width of the supply lines leading to the ABS relay valves (Port 1) should be as great as possible (NW ≥ 9 mm).

If two ABS relay valves are supplied from one supply line (Fig. 7), please make sure that the lengths and nominal widths of the lines are identical to achieve **identical flow conditions.** This also applies to the use of T-pieces.

The pilot lines leading up to the ABS relay valves (Port 4) should have a nominal width ≥ 6 mm, and be as similar as possible. If excessive braking occurs with small brake cylinders or a small filling volume (brief locking phases possible when the braking process is commenced), a throttle may be fitted downstream from Port 4 - e. g. the nominal width of the brake pressure pipe / hose can be reduced to NW 6 (e. g. pipe 8 x 1).

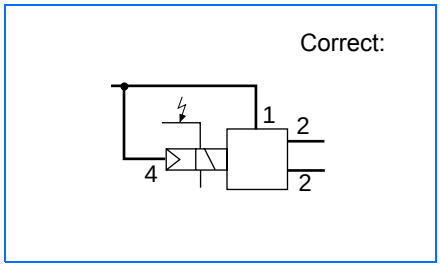


Fig. 8
If the relay function is not required, the pilot connection (4) is taken off the supply line (1) - so-called add-on circuit. Supply pressure arrives a few milliseconds before pilot pressure

In some cases it is possible to operate the ABS relay valve without any relay function (”add-on“ circuit).

Here the control or pilot line from the relay emergency valve runs directly to Port 1 and is connected to Port 4 using a bypass with a line which is as short as possible (e. g. T-piece directly at Port 1) if no other components of the braking system are to be fitted downstream. If an ALB, adapter or similar valve is present, these should be placed in the bypass (between Ports 2 and 4 of the ABS relay valve).

This is possible only in the case of favourable response times, e. g. on the front axles of towbar trailers where steep pressure gradients are achieved through short pipes.

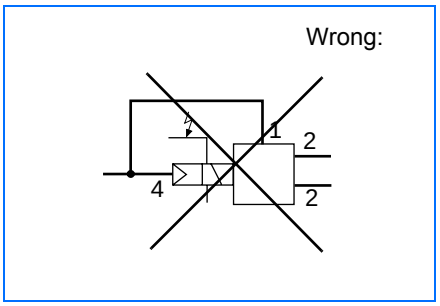


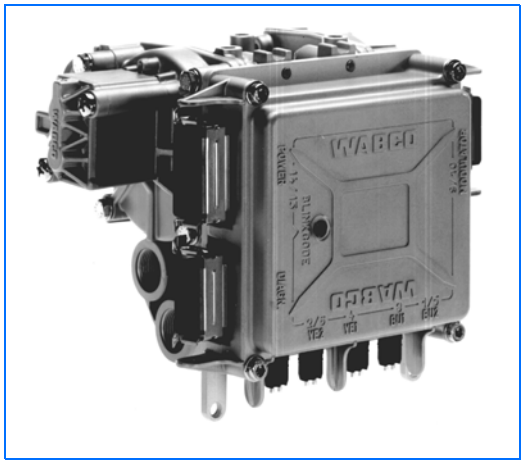
Fig. 9
Due to the straight piping, the pilot pressure is present at 4 before the supply pressure.

Result: valve overreacts.

When retrofitting the system, please bear in mind: If the normal braking system contains a relay valve (e. g. on the rear axles), this can be removed when ABS relay valves are installed, i. e. the supply and pilot lines can be run directly to the ABS relay valves.

When fitting a 4S/2M system on 3-axle semitrailers (three brake cylinders on one side of the semitrailer are controlled by one ABS relay valve), the order in which the axles lock should be ascertained first (laden/unladen) before the ABS relay valves are fitted. The two brake cylinders on the axles which are the first to show a tendency to lock should be connected together to an operating port (2) of the ABS relay valve. If the trial runs necessary for this purpose cannot be done on private terrain, please contact the manufacturer of the axle assembly. Installation should be symmetrical, with identical piping cross-sections and lengths, from the T-piece.

Using the description above it should be possible to properly install the ABS relay valve and thus to ensure proper functioning of the ABS system.

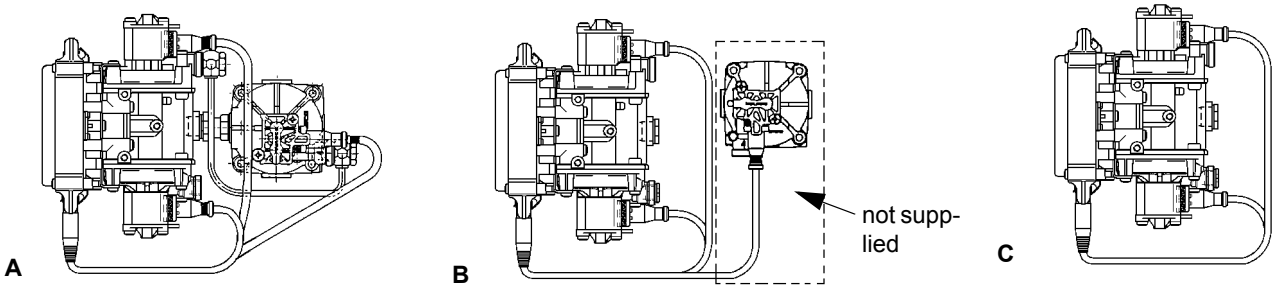


The ECU 446 108 . . . 0

Compared with that for Vario-C, this ECU is considerably smaller and lighter.
Its essential features are:

- external plug-in connections
  It is no longer necessary to open the ECU.
- integrated flashcode - LED
- error code reference on the housing

The information below provides an overview of the system as a whole.

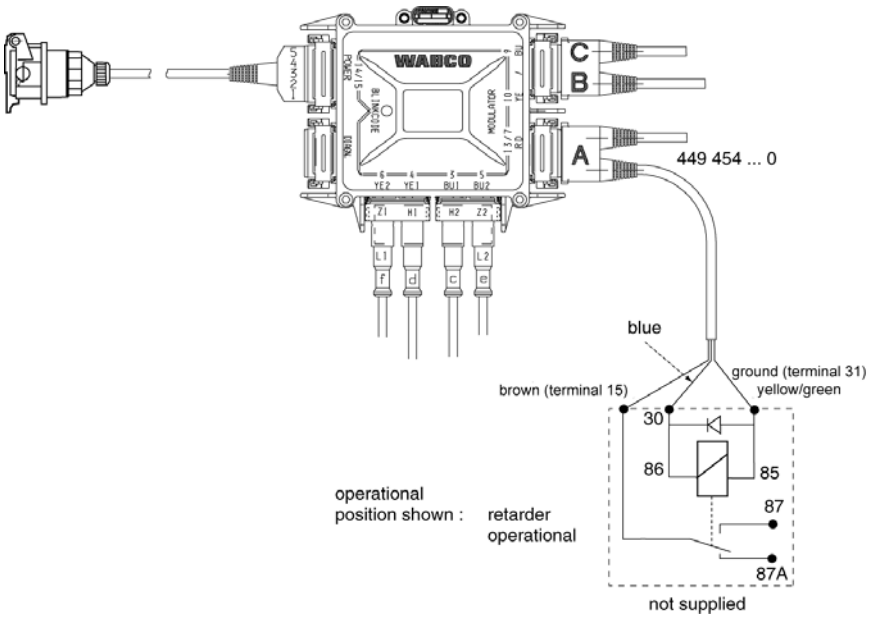


WABCO - Part Number			Possible Systems			Features							Comments
Type A													
Compact-Design Standard	**Compact-Design with coating**	**separate ECU**	**4S/3M**	**4S/2M**	**2S/2M**	**ISO**	**24N**	**RV**	**MRV**	**ISS**	**RET**	**C3**	
400 500 030 0	–	446 108 030 0	X	X	X	X	–	X	–	X	–	X	3 MOD
–	–	446 108 031 0	X	X	X	X	–	X	X	X	–	X	VCS-Plus
400 500 037 0	–	–	X	X	X	X	X	X	–	X	–	X	3 MOD
400 500 038 0	–	–	X	X	X	X	X	X	–	X	–	X	3 MOD
Type B													
400 500 032 0	–	446 108 032 0	+RET	X	X	X	–	X	X	–	X	X	2 MOD, 4S/3M+RET
400 500 034 0	–	–	X	X	X	X	X	X	–	X	–	X	w. stud bolts, 2 MOD
400 500 035 0	400 500 063 0	446 108 035 0	X	X	X	X	X	X	–	X	–	X	2 MOD
400 500 036 0	400 500 064 0	–	X	X	X	X	–	X	–	X	–	X	2 MOD
400 500 050 0	–	446 108 050 0	X	X	X	X	–	X	X	X	–	X	12 V-ECU
Type C													
400 500 040 0	400 500 066 0	446 108 040 0	–	X	X	X	–	X	–	–	–	X	
–	–	446 108 041 0	–	X	X	X	–	X	X	–	–	X	VCS-Plus
400 500 042 0	–	–	–	X	X	X	–	X	–	–	–	X	
400 500 045 0	400 500 067 0	446 108 045 0	–	X	X	X	X	X	–	–	–	X	
400 500 046 0	–	–	–	X	X	X	X	X	–	–	–	X	

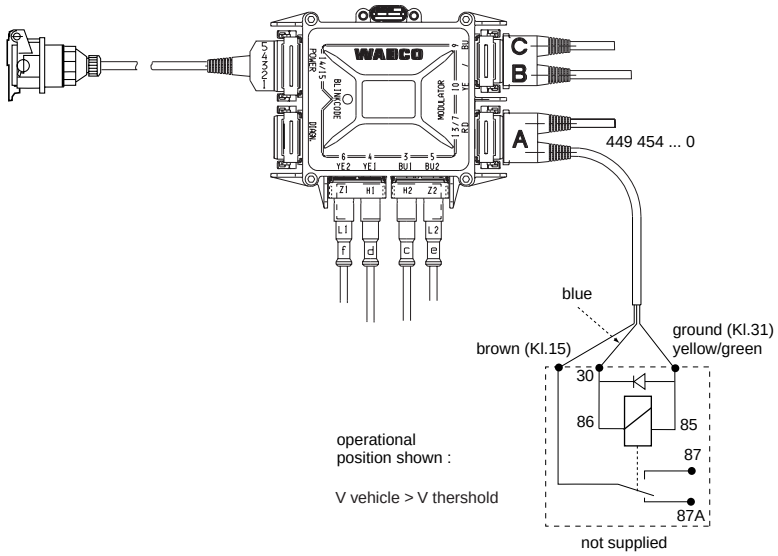
Explanations:

– 4S/3M, 4S/2M, 2S/2M:	system suitable for the respective ECU; grey background means as supplied, 2S/1M always being possible.
– ISO:	Supply according to ISO 7638; with supply exclusively according to ISO, voltage output for Diagnostic Controller on the diagnostic plug.
– 24N:	additional supply with 24N (mixed supply)
– RV:	actuation for ABS relay valve only
– MRV:	actuation for solenoid control valve (ABS relay valve possible)
– Ret:	actuation of a retarder possible
– ISS	**I**ntegrated **S**peed **S**witch
– C3	Output for speed signal at the diagnostic plug
– 2 MOD	3rd modulator and solenoid cable are **not** supplied with the compact unit
– 3 MOD	3rd modulator and solenoid cable are supplied with the compact unit.
– w. stud bolts	with 3 stud bolts M8 for mounting on the ABS relay valve.

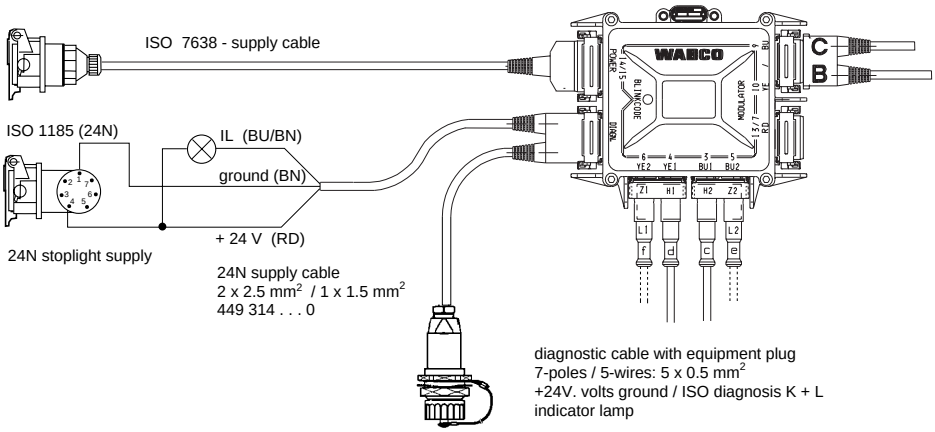
Wiring with retarder control:



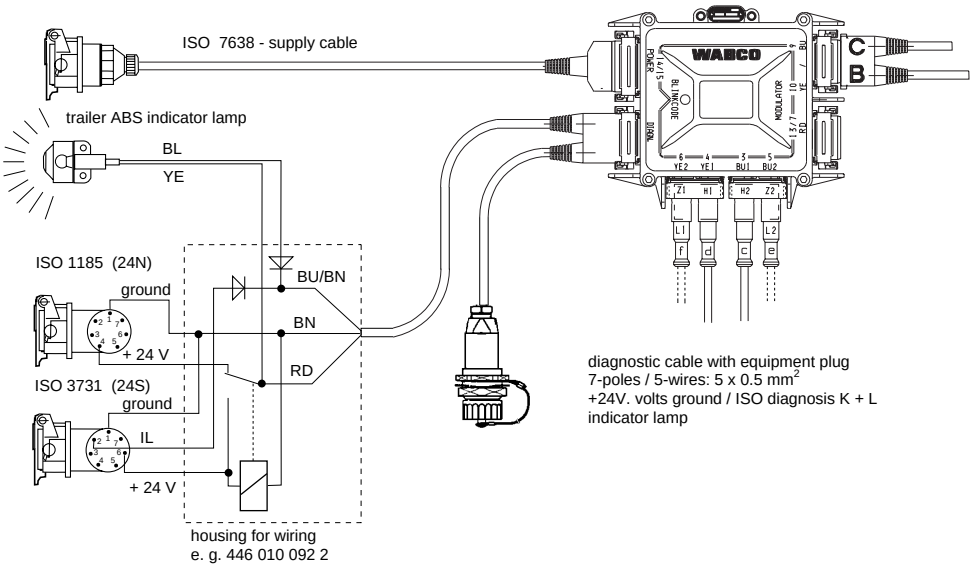
Wiring of integrated speed switch (ISS):

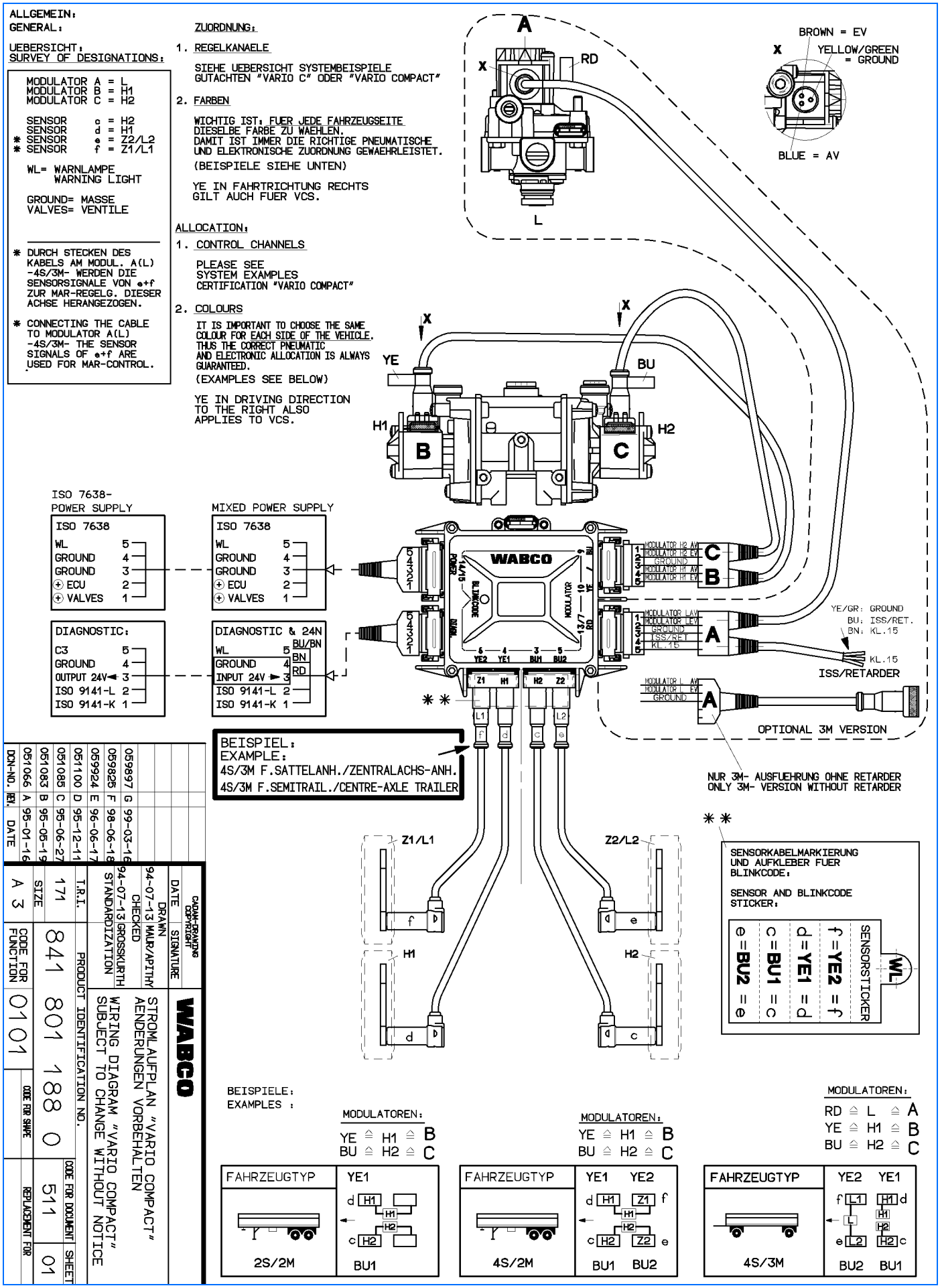


With mixed supply ISO 7638 + 24N (optional):



With mixed supply ISO 7638 + 24N + 24S




ALLGEMEIN:
GENERAL:
UEBERSICHT:
SURVEY OF DESIGNATIONS:
MODULATOR A = L
MODULATOR B = H1
MODULATOR C = H2
SENSOR c = H2
SENSOR d = H1
* SENSOR e = Z2/L2
* SENSOR f = Z1/L1
WL= WARNLAMPE
WARNING LIGHT
GROUND= MASSE
VALVES= VENTILE
* DURCH STECKEN DES KABELS AM MODUL. A(L) -4S/3M- WERDEN DIE SENSORSIGNALE VON e+f ZUR MAR-REGELG. DIESER ACHSE HERANGEZOGEN.
* CONNECTING THE CABLE TO MODULATOR A(L) -4S/3M- THE SENSOR SIGNALS OF e+f ARE USED FOR MAR-CONTROL.
ZUORDNUNG:
1. REGELKANAELE
SIEHE UEBERSICHT SYSTEMBEISPIELE GUTACHTEN "VARIO C" ODER "VARIO COMPACT"
2. FARBEN
WICHTIG IST: FUER JEDE FAHRZEUGSEITE DIESELBE FARBE ZU WAEHLEN. DAMIT IST IMMER DIE RICHTIGE PNEUMATISCHE UND ELEKTRONISCHE ZUORDNUNG GEWAEHRLEISTET.
(BEISPIELE SIEHE UNTEN)
YE IN FAHRTRICHTUNG RECHTS GILT AUCH FUER VCS.
ALLOCATION:
1. CONTROL CHANNELS
PLEASE SEE SYSTEM EXAMPLES CERTIFICATION "VARIO COMPACT"
2. COLOURS
IT IS IMPORTANT TO CHOOSE THE SAME COLOUR FOR EACH SIDE OF THE VEHICLE. THUS THE CORRECT PNEUMATIC AND ELECTRONIC ALLOCATION IS ALWAYS GUARANTEED.
(EXAMPLES SEE BELOW)
YE IN DRIVING DIRECTION TO THE RIGHT ALSO APPLIES TO VCS.
A
RD
L
X
BROWN = EV
YELLOW/GREEN = GROUND
BLUE = AV
YE
BU
H1
H2
B
C
ISO 7638-
POWER SUPPLY
ISO 7638
WL 5
GROUND 4
GROUND 3
ECU 2
VALVES 1
MIXED POWER SUPPLY
ISO 7638
WL 5
GROUND 4
GROUND 3
ECU 2
VALVES 1
DIAGNOSTIC:
C3 5
GROUND 4
OUTPUT 24V 3
ISO 9141-L 2
ISO 9141-K 1
DIAGNOSTIC & 24N
WL 5
GROUND 4
INPUT 24V 3
ISO 9141-L 2
ISO 9141-K 1
BU/BN
BN
RD
WABCO
MODULATOR H2 AV
MODULATOR H2 EV
GROUND
MODULATOR H1 AV
MODULATOR H1 EV
MODULATOR L AV
MODULATOR L EV
GROUND
ISS/RET.
KL.15
YE/GR: GROUND
BU: ISS/RET.
BN: KL.15
KL.15
ISS/RETARDER
OPTIONAL 3M VERSION
NUR 3M- AUSFUEHRUNG OHNE RETARDER
ONLY 3M- VERSION WITHOUT RETARDER
BEISPIEL:
EXAMPLE:
4S/3M F.SATTELANH./ZENTRALACHS-ANH.
4S/3M F.SEMITRAIL./CENTRE-AXLE TRAILER
Z1/L1
Z2/L2
H1
H2
SENSORKABELMARKIERUNG UND AUFKLEBER FUER BLINKCODE:
SENSOR AND BLINKCODE STICKER:
e=BU2 = e
c=BU1 = c
d=YE1 = d
f=YE2 = f
SENSORSTICKER
WL
BEISPIELE:
EXAMPLES :
MODULATOREN:
YE ≙ H1 ≙ B
BU ≙ H2 ≙ C
FAHRZEUGTYP
YE1
2S/2M
BU1
FAHRZEUGTYP
YE1 YE2
4S/2M
BU1 BU2
FAHRZEUGTYP
YE2 YE1
4S/3M
BU2 BU1
MODULATOREN:
RD ≙ L ≙ A
YE ≙ H1 ≙ B
BU ≙ H2 ≙ C
DDN-NO. 051066 051083 051085 051100 059924 059825 059897
REV. A B C D E F G
DATE 95-01-16 95-05-19 95-06-27 95-12-11 96-06-17 98-06-18 99-03-16
94-07-13 DRAWN
94-07-13 MALR/APITHY CHECKED
94-07-13 GROSSKURTH STANDARDIZATION
T.R.I.
PRODUCT IDENTIFICATION NO.
841 801 188 0
CODE FOR FUNCTION 0101
CODE FOR SHAPE
CODE FOR DOCUMENT 511
REPLACEMENT FOR
SHEET 01
SIZE A 3 171
WABCO
STROMLAUFPLAN "VARIO COMPACT" AENDERUNGEN VORBEHALTEN
WIRING DIAGRAM "VARIO COMPACT" SUBJECT TO CHANGE WITHOUT NOTICE
CADAM-DRAWING COPYRIGHT
DATE
SIGNATURE

Wiring Diagram 841 801 188 0

This diagram shows the wiring for the maximum version 4S/3M with a retarder. Systems 4S/2M and 2S/2M can be derived from this.

Supply Connection:
The allocation of the supply connection (POWER marking on the cover) is in keeping with ISO 7638. The plug is larger than any other so that mismatching is not possible. It always has to be connected.

Modulator Connections:
At the modulator connection BU/YE, two modulators are connected via one solenoid cable (Y cable) 449 444 ... 0. Valves B and C are connected to each other. This terminal always has to be assigned.

Modulator connection RD is required only for 4S/3M systems or for retarder operation (please also refer to Page 22). It is present only on ECUs ... 030 0 to ... 035 0. If one of these ECUs is used for a 4S/2M or a 2S/2M system, this terminal must be closed using a cover similar to the one used on the diagnostic connection.

Sensor Connections:
For a 2S/2M system, only terminals YE1 and BU1 are used. If a 4S/2M or 4S/3M system is connected, terminals YE2 and BU2 also have to be used.

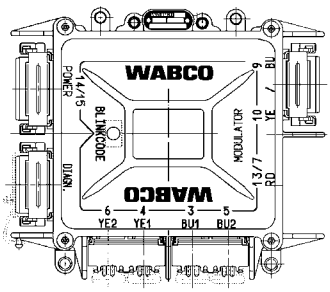
Please note:
Similar to Vario-C, the sensors of the yellow terminals (YE1 and YE2) are connected to the vehicle's right-hand side.

Diagnostic Connection:
Marked ”DIAGN“, this connection is used for connecting diagnostic equipment. For this reason, this is where the K and L lines to the diagnostic connection are located. ECUs for supply according to ISO only, the electricity supply for the diagnostic equipment is provided, and this is where the output of the speed signal (C3) is located.

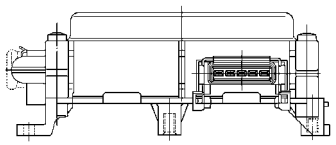
Please note:
If supply is mixed, apply foot to the brake for diagnosis!

Fitting Position:

The standard arrangement on the ECU has sensor terminals pointing vertically downwards.

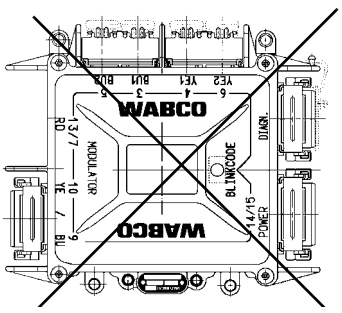


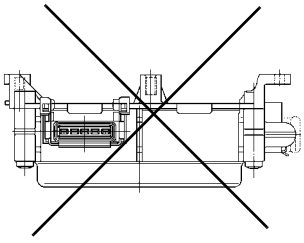
Alternatively it is also possible to have a horizontal arrangement. The integrated flash code lamp must then point upwards.



If fitted as shown, water might collect between the cover and the terminal frame and not drain off.

PLEASE NOTE:
Unacceptable Fitting Position:





The VCS Plug-In System

The wiring has been changed significantly from Vario-C. The ECU has all terminals on its outside. Diagnostics are also externally accessible so that the ECU no longer needs to be opened. Therefore, the following applies:

The ECU may not be opened !

PLEASE NOTE !

The plugs for the electricity supply, modulators and diagnostics are coded to prevent mismatching. Coding sleeves are available for the sensor plugs.

All plug-in connections have special locking straps fitted. To connect a cable, the locking strap is pushed up, the plug pushed in and the strap locked. If a locking strap is found to be stiff after a time, use a screwdriver to **cautiously** lift the strap.

If the vehicle is painted after the ECU has been installed, excessive coats of paint in the area of the plug in connections should be avoided.
A protective cover (Part No. 830 902 402 4) is available for covering this area. This is a disposable item and should be removed after painting.

Coding Sleeves

The sensor extension cables can have coding sleeves fitted to prevent mismatching of sensors.

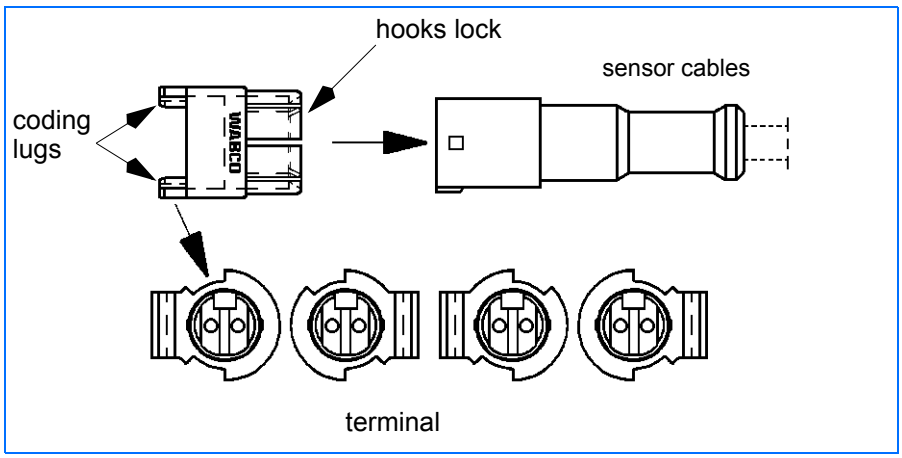


Fig. 10

For this purpose, the coding sleeves are placed on the coupling sockets of the sensor extension cables. Their hooks lock into place but can be removed as necessary. The coding sleeves have coding lugs which fit into corresponding gaps on the connector frame (see Fig. 10). Each sleeve will fit only one location.

The coding sleeves (Part No. **472 195 374 2**) are available as an accessory kit.

ABS Relay Valve
472 195 03 . 0

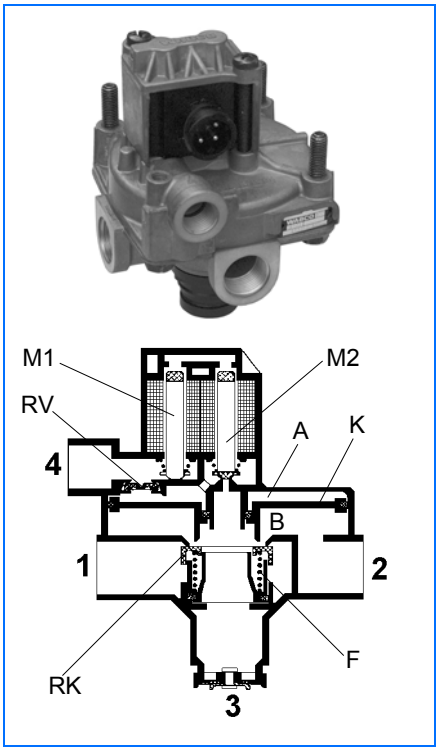


Fig. 11

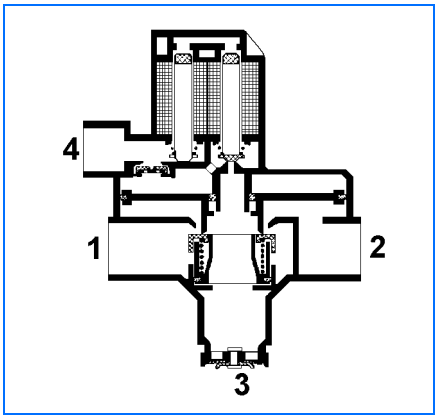


Fig. 12

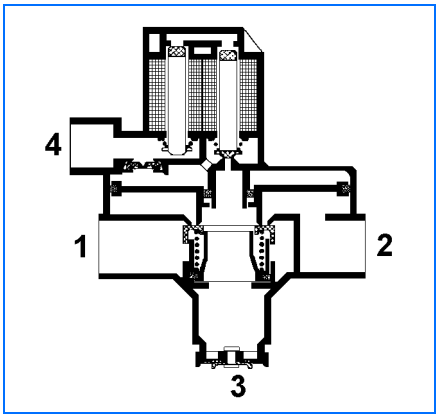


Fig. 13

This consists of two subassemblies: The actual relay valve and the electro-magnetic control valve.

Using the illustration, here is a brief description how it operates.

Fig. 11 ports and designations:

1 - supply port
2 - 2 brake cylinder ports
3 - exhaust
4 - pilot connection
K - piston
RV - check valve
M1 - solenoid 1
M2 - solenoid 2
A - upper piston chamber
B - lower piston chamber
RK - annular piston
F - spring

Functional Description:
Example 1
Supply pressure present but no pilot pressure:
Annular piston (RK) is pushed against its seat by spring (F), closing Inlet 1 against Chamber B (and thus Port 2).

Operation with ABS control:
Fig. 12

Pressure Buildup:
The solenoid is dead and the pilot pressure is present in Chamber A. The gap between the annular piston and the seat is visible. Air flows from 1 to 2.

Fig. 13

Pressure Hold:
Solenoid 1 is excited and the armature has attracted. This has broken the passage of air from 4 to Chamber A (in spite of the rising pilot pressure). The pressures in Chambers A and B are balanced.

The annular piston is in contact with its seats. Air can neither pass from 1 to 2 nor from 2 to 3 (atmosphere).

Example 2
Supply pressure present, pilot pressure e. g. 1 bar:

The pilot pressure at 4 flows via Solenoids M1 and M2 into the upper piston chamber, forcing the piston downwards. A small gap between 1 and Chamber B opens (see Fig. 12). At Port 2, the pressure increases (connected brake cylinder not shown). Since the surfaces on the piston's upper and lower sides are identical, the piston returns to its original position as soon as the pressure at 2 equals that at 4. The annular piston is once again in contact with its seat - the passage between 1 and Chamber B is closed. When the pilot pressure falls, the piston (K) is raised and the pressure is released via 2, Chamber B and Exhaust 3.

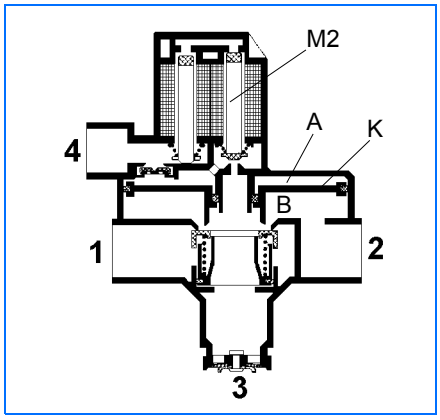


Fig. 14

Fig. 14
Pressure Decrease:
Solenoid 2 excited

1. Pilot pressure closed against Chamber A

2. The raised seal at the foot of M2 releases the pressure in Chamber A through the inside opening of the annular piston to atmosphere.

This raises Piston K, and air now escapes from B through the visible gap at the annular piston, via Port 2 and the connected brake cylinder.

For low-noise installation, a muffler is available. WABCO Part No. see Page 30.

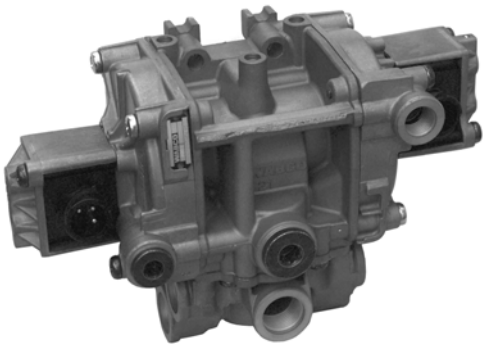
Important for Mounting:
Avoid mounting the aluminium housing on any steel parts unless they have sufficient surface protection.

Debur drilled hole in steel and paint

- Then attach the valve.
This prevents contact corrosion.
Valve outlet pointing downward, leaving a space of approx. 50 mm to permit free blow-out.

Double ABS Relay Valve 472 195 041 0 „Horizontally Opposed Valve"

This valve is the result from combining 2 x 472 195 031 0. Its time response is identical with that of those valves.



Please note:

The supply line must be 18 x 2.
Port 21 is designed to supply a third modulator (supplied with a screw-in plug).
The electrical connections and the lengths of hoses and pipes are also to be treated similar to
472 195 031 0.

ABS Relay Valve:

Part Number	Pilot Connection	Inlet/Outlet	Volts	used as/in	Comments
472 195 031 0	1 x M16x1.5	3 x M 22x1.5	24	Standard	with bayonet to DIN 72585-A1-3.1-Sn/K1
472 195 033 0	1 x 3/8“-18NPTF	2 x 3/4“-14NPTF 4 x 3/8“-18NPTF	12	USA / Austr.	with bayonet to DIN 72585-A1-3.1-Sn/K1 pilot pressure higher by 4 psi
472 195 034 0	1 x M 16x1.5	3 x M 22x1.5	12	12 V Europe	with bayonet to DIN 72585-A1-3.1-Sn/K1
472 195 041 0	1 x M 16x1.5	7 x M 22x1.5	24	Horizontally opposed valve	with bayonet to DIN 72585-A1-3.1-Sn/K1
472 195 044 0	1 x M 16x1.5	7 x M 22x1.5	12		with bayonet to DIN 72585-A1-3.1-Sn/K1

Solenoid Control Valve 472 195 . . . 0

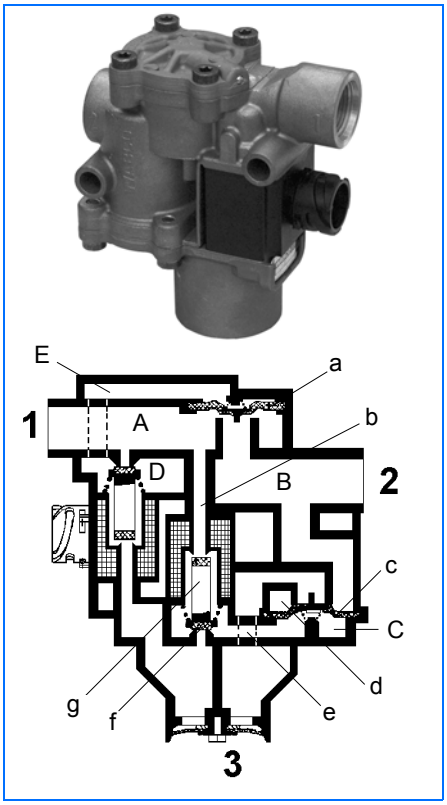


Fig. 15

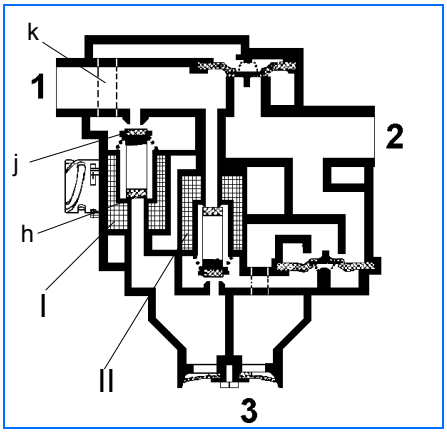


Fig. 16

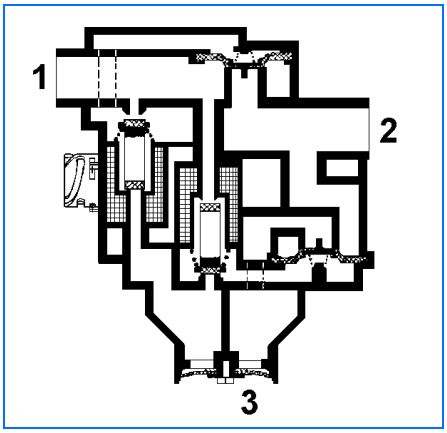


Fig. 17

The purpose of the solenoid control valve on the trailer

– used only with
  ECU 446 108 031 0
  or 446 108 041 0

is to **increase, reduce or hold** the pressure in the brake cylinders during a braking process depending on the control signals, in milliseconds, received from the ECU. It is designed for 24 volts at a maximum operating pressure of 10.0 bar.

The line between the valve and the brake cylinder should be no longer than 1.5 m.

Pressure Increase: (Fig. 15)
The pressure coming in at Port 1 immediately opens the inlet diaphragm (a). The ensuing pressure increase in Chamber B causes the compressed air to flow via Port 2 to the brake cylinder and into annular duct (d) above outlet diaphragm (c). At the same time, compressed air flows through the duct (b) via the opened valve (g) into Chamber C below the outlet diaphragm. Any increase in pressure at Port 1 is passed on via Port 2. The same applies vice versa every time the pressure is reduced.

Pressure Reduction: (Fig. 16)
When the ABS electronics provide the signal for decreasing the pressure, **Solenoid I** is reversed, valve (h) closes and valve (j) opens. The compressed air in Chamber A flows via Chamber D and duct (k) into Chamber E where it closes the inlet diaphragm (e). At the same time, **Solenoid II** reverses, closing valve (g) and opening valve (f). This causes the pressure in Chamber C to be reduced via Exhaust 3. Outlet diaphragm (c) opens.

The brake pressure at Port 2 escapes to atmosphere via duct (e) and Exhaust 3.

Pressure Hold: (Fig. 17)
Through a corresponding impulse as **Solenoid II** reverses, valve (f) is closed and valve (g) opened. This causes the pressure present at Port 1 to return to Chamber C, closing the outlet diaphragm (c).

The solenoid control valve is now in a ”pressure hold“ position.

Solenoid Control Valve:

Part Number	Inlet / Outlet Port	Volts	Comments
472 195 016 0	M 22 x 1.5 Voss	24	with bayonet to DIN 72585-A1-3.1-Sn/K1
472 195 018 0	M 22 x 1.5	24	
472 195 019 0	M 22 x 1.5 Parker	24	
472 195 052 0	1/2“-14 NPTF	12	
472 195 066 0	M 22 x 1.5	12	

Silencer 432 407 . . . 0

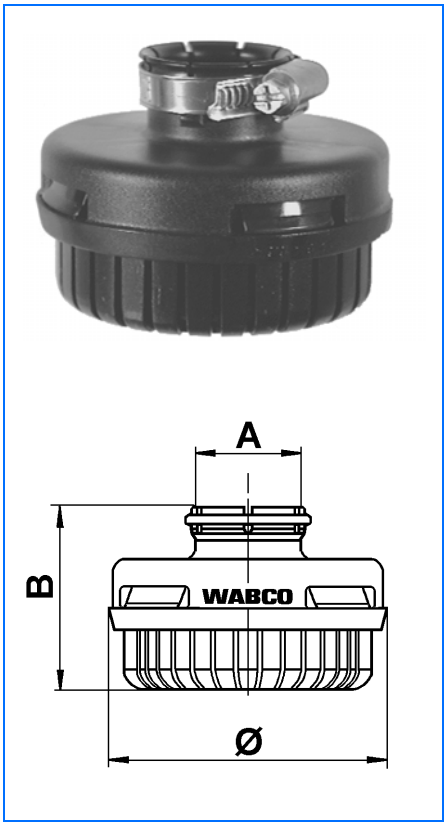


Fig. 18

The definition of limits for the noise from compressed air braking systems requires the use of noise mufflers to make sure that any exhaust or blowout noise does not exceed the legally permissible level.

Silencer for Components of the Braking System

Due to low pressure peaks, only absorption dampers are used for this purpose.

They are connected to the components via a thread M22 x 1.5, or a snap fastener.

Particularly the snap fastener permits easy retrofitting of silencers provided the basic component has a suitable connector provided.

Part Number	Noise Emission at	B [mm]	Diameter Ø [mm]	Port A
432 407 012 0	13 bar < 70 dBA	62	87	snap-on contour and clamp (for air dryer)
432 407 060 0	11 bar < 69 dBA 13 bar < 72 dBA	55.5	69	M 22 x 1.5
432 407 070 0	10 bar < 69 dBA	53	69	snap-on contour

Sensors 441 032 808 0 and 809 0

Vario Compact ABS provides for 2 types of sensors which differ only in cable length and are completely identical otherwise. Both have sprayed-on coupling sockets for a corresponding plug and meet the requirements of IP 68 when connected.

The coupling socket is sprayed onto the cable and is destroyed when removed.

To provide protection against dirt or water ingress during storage or transport of the axle, the coupling is closed with

Plug 898 010 370 4

Cable lengths:
400 mm = 441 032 808 0
1000 mm = 441 032 809 0

When replacing a sensor it is advisable to also replace
Clamping bush 899 760 510 4

Electrical Data for WABCO Sensors:

Compared with Sensor 441 032 001 0 (Z version), the voltage output of K and S sensors has been doubled for the same speeds (instead of 55 mV now 110 mV at 1.8 k. p. h. and identical air gap).

The table below shows an example for each series. All voltages refer to 1.8 k. p. h. and an identical air gap (0.7 mm).
The letters are printed on the sensor cap.

For measuring the resistance, please note: If a cable tester or the Diagnostic Controller are used for measuring the resistance whilst sensor temperatures are higher than 40°C (hot brakes), it is possible that the display range is exceeded.

In this case a multimeter would show the higher values.

Thumb rule:
per 10°C change in temperature = 4% change in resistance.

Sensor Type	Resistance in Ω	Output Voltage Ueff	Uss	e. g.
Z	1280 ± 80	≈ 20 mV	55 mV	441 032 001 0
K	1750 $^{+100}_{-100}$	≈ 40 mV	110 mV	441 032 633 0
S	1150 $^{+100}_{-50}$	≈ 40 mV	110 mV	441 032 578 0
S Plus	1150 $^{+100}_{-50}$	≈ 40 mV	110 mV	441 032 808 0
S Plus	1150 $^{+100}_{-50}$	≈ 40 mV	110 mV	441 032 905 0

Please note:
Grease must be used for fitting both bush and sensor.

This prevents the sensor getting stuck.

When adjusting the sensor (excessive air gap), never use force or inappropriate tools such as pointed or sharp objects which might damage the sensor's cap.

Repair-Kit: 441 032 935 2
4 x bushes, grease and clamp

Authorized types of grease:
Staborags NBU
1 kg drum 830 502 063 4
5 g tube 068 4

Complete sensor kit ... 808 0
clamping bush +
grease 441 032 921 2

Complete sensor kit ... 809 0
clamping bush +
grease 441 032 922 2

Axle BPW
Complete sensor kit ... 905 0
clamping bush +
grease 441 032 963 2

Coupling Retainer 441 902 352 4

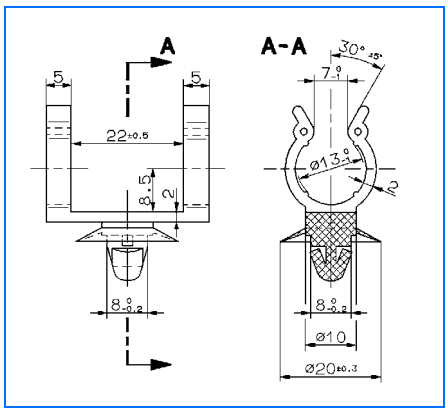
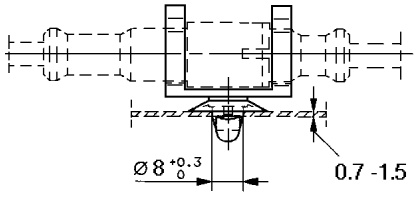


Fig. 19

For securing the sensor to its connection cable, it is advisable to use the coupling retainer shown in Fig. 19.

Example for Installation:



Standard Cables

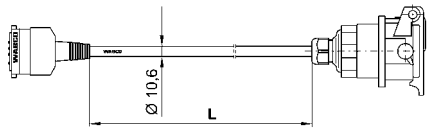
Ready-made cables must be used for VCS. These cables have sprayed-on plugs which considerably enhance product quality and prevent improper installation of electrical connections.

There is a number of standard types of cables available in various lengths; these can be supplied at short notice and at favourable prices.

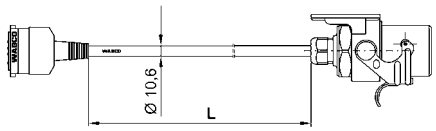
Supply Cables

For the standard application in towbar and semitrailers, thew 5-wire supply cables are available with ”plugs“ and ”sockets“ in accordance with DIN/ISO 7638.

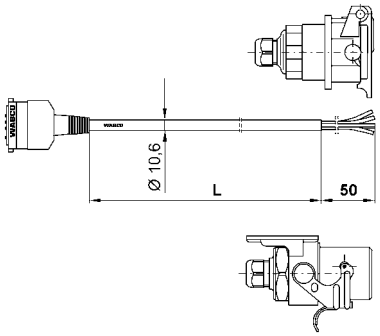
Semitrailer



Towbar trailer



Part Number: 24 V 446 008 380 2
12 V 446 008 385 2



Part Number: 24 V 446 008 390 2
12 V 446 008 395 2

Plugs and sockets are not supplied and need to be ordered separately.

Mixed Supply Cable

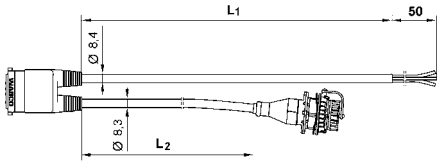


Fig. 20

Part Number	Length [mm]		Part Number	Length [mm]
With Socket for Semitrailer				
449 112 035 0	3500		**449 112 100 0**	10000
449 112 047 0	4700		**449 112 120 0**	12000
449 112 060 0	6000		**449 112 130 0**	13000
449 112 080 0	8000		**449 112 140 0**	14000
449 112 090 0	9000			
With Plug for Towbar Trailer				
449 212 060 0	6000		**449 212 100 0**	10000
449 212 080 0	8000		**449 212 120 0**	12000
449 212 090 0	9000		**449 212 140 0**	14000
Without Coupling Socket				
449 332 003 0	300		**449 332 120 0**	12000
449 332 060 0	6000		**449 332 140 0**	14000
449 332 080 0	8000		**449 332 180 0**	18000
449 332 090 0	9000		**449 332 250 0**	25000
449 332 100 0	10000			
Mixed Supply Cables (L1 / L2)				
449 314 017 0	12000 / 250		**449 314 237 0**	12000 / 5000
449 314 055 0	8000 / 1000		**449 314 257 0**	12000 / 6000
449 314 057 0	12000 / 1000		**449 314 337 0**	12000 / 12000

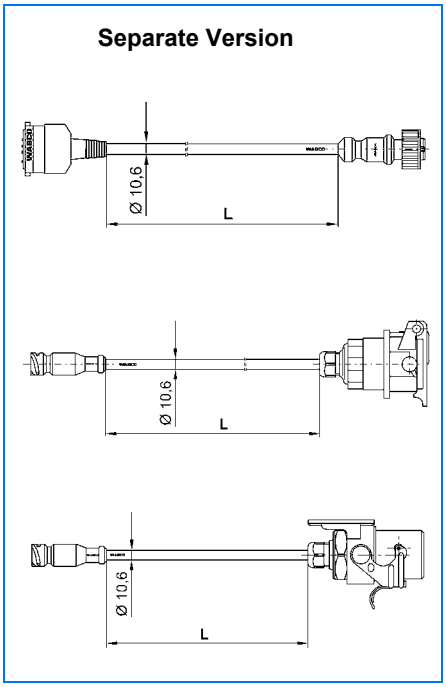


Fig. 21

Part Number	Length [mm]		Part Number	Length [mm]
Supply Line for Separate Version				
449 331 003 0	300		**449 331 100 0**	10000
449 331 025 0	2500		**449 331 120 0**	12000
449 331 060 0	6000		**449 331 160 0**	16000
Cables with ABS Socket				
449 132 035 0	3500		**449 132 120 0**	12000
449 132 080 0	8000		**449 132 140 0**	14000
449 132 090 0	9000		**449 132 150 0**	15000
449 132 100 0	10000			
Cables with ABS Plug				
449 242 080 0	8000		**449 242 100 0**	10000

Sensor extension and solenoid valve cables

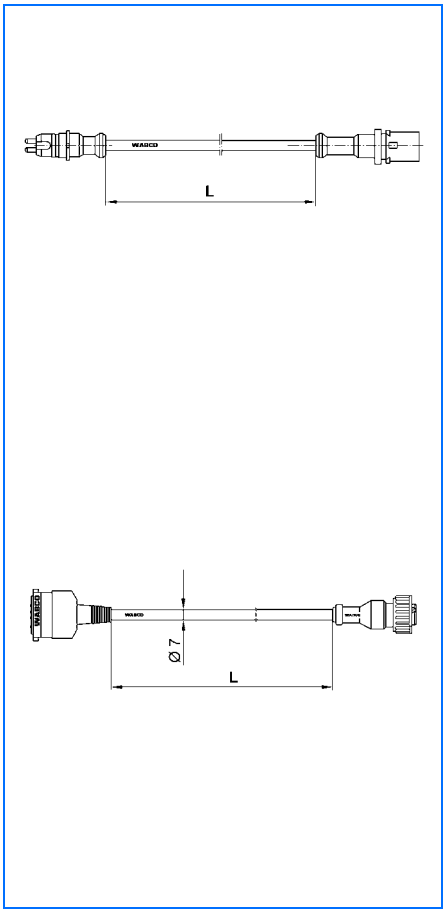
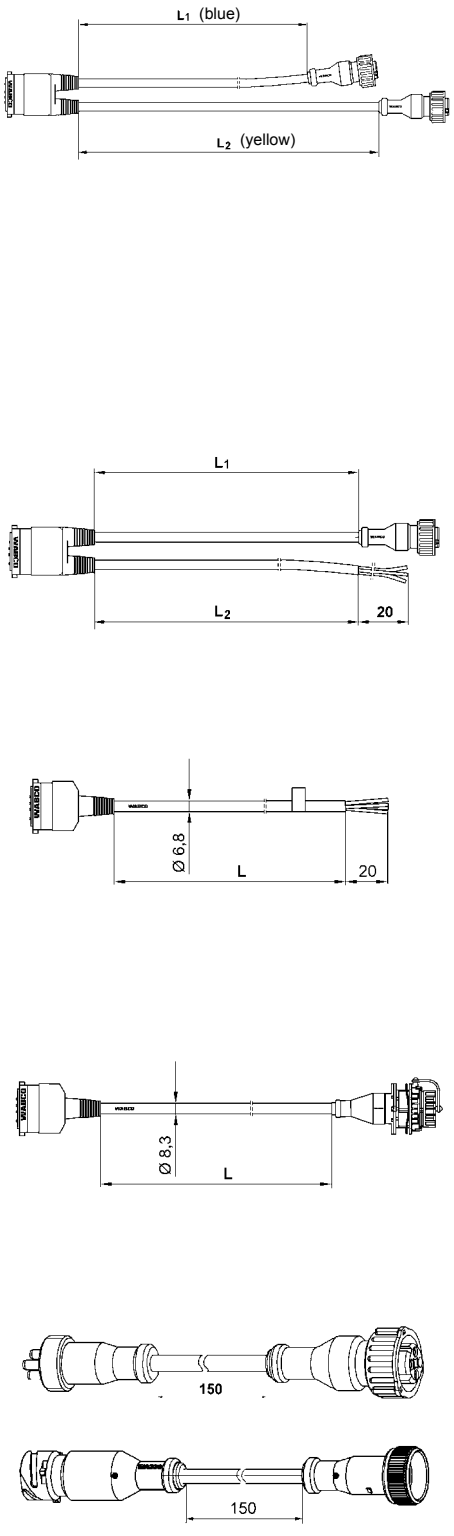


Fig. 22

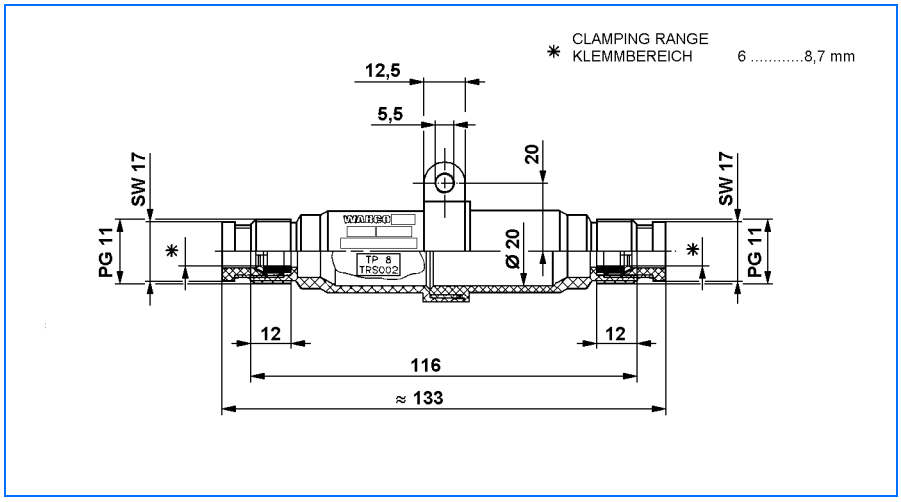
Part Number	Length [mm]		Part Number	Length [mm]
Sensor Cables				
449 712 008 0	760		**449 712 064 0**	6350
449 712 018 0	1780		**449 712 070 0**	7000
449 712 023 0	2300		**449 712 080 0**	8000
449 712 030 0	3000		**449 712 090 0**	9000
449 712 035 0	3500		**449 712 100 0**	10000
449 712 038 0	3810		**449 712 120 0**	12000
449 712 040 0	4000		**449 712 130 0**	13000
449 712 051 0	5080		**449 712 150 0**	15000
449 712 060 0	6000		**449 712 200 0**	20000
Solenoid Valve Cable				
449 411 005 0	480		**449 411 060 0**	6000
449 411 013 0	1300		**449 411 070 0**	7000
449 411 015 0	1500		**449 411 080 0**	8000
449 411 020 0	2000		**449 411 090 0**	9000
449 411 030 0	3000		**449 411 100 0**	10000
449 411 040 0	4000		**449 411 120 0**	12000
449 411 050 0	5000		**449 411 140 0**	14000



Part Number	Length [mm]		Part Number	Length [mm]
Solenoid Cables for Relay Valve (L1 / L2)				
449 444 022 0	400 / 400		**449 444 188 0**	3000 / 4000
449 444 023 0	1000 / 400		**449 444 190 0**	4000 / 4000
449 444 043 0	1000 / 1000		**449 444 197 0**	12000 / 4000
449 444 064 0	1350 / 1350		**449 444 232 0**	5000 / 5000
449 444 103 0	1000 / 2000		**449 444 235 0**	8000 / 5000
449 444 104 0	1350 / 2000		**449 444 251 0**	4500 / 6000
449 444 106 0	2000 / 2000		**449 444 253 0**	6000 / 6000
449 444 108 0	2000 / 3000		**449 444 273 0**	6000 / 7000
449 444 134 0	7000 / 2500		**449 444 274 0**	7000 / 7000
449 444 150 0	4000 / 3000		**449 444 316 0**	10000 / 10000
449 444 169 0	3500 / 3500		**449 444 337 0**	12000 / 12000
449 444 187 0	2500 / 4000		**449 444 358 0**	15000 / 15000
Solenoid Cable 3rd Modulator / Retarder (L1 / L2)				
449 454 155 0	8000 / 3000		**449 454 295 0**	8000 / 8000
449 454 235 0	8000 / 5000			
ISS Cable				
449 402 020 0	2000		**449 402 070 0**	7000
449 402 030 0	3000		**449 402 100 0**	10000
449 402 040 0	4000		**449 402 120 0**	12000
449 402 060 0	6000		**449 402 130 0**	13000
Diagnostic Cable				
449 612 010 0	1000		**449 612 060 0**	6000
449 612 030 0	3000		**449 612 120 0**	12000
449 612 050 0	5000			
Adaptor - solenoid cable				
			cable end type	
894 601 132 2	150		Plug M 24 x 1	Socket bajonet DIN 72585 B1-3.1-Sn/K1
894 601 133 2	150		Socket bajonett DIN 72585 B1-3.1-Sn/K1	Plug M 24 x 1

Fig. 23

Cable Connector
446 105 750 2



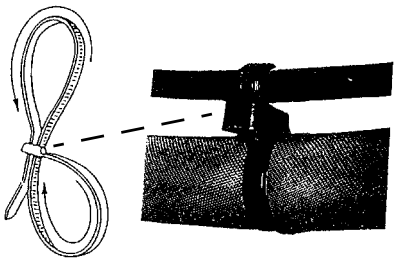
For special cases in which ready-made cables need to be extended, or for repairing a cable which is already in place but has been damaged, this connector can be used. It is approved for use in vehicles carrying dangerous loads, as shown by its imprint.

The connector is suitable for connecting the cables

corrugated pipe – corrugated pipe
sheath – corrugated pipe
sheath – sheath
corrucated pipe – NW10
sheathed cable 6– 8.7 mm ø

Fig. 24

ABS sensor cable binder with double fastener
894 326 012 4



When doing the wiring, “ordinary“ cable binders are often used. This can cause snagging or breaks, especially if corrugated pipe is used. For wiring which not only looks good but offers a good technically sound solution, the cable binder with double fastener should be used.

Flash Code Vario Compact

With the development of Vario Compact ABS (VCS), WABCO has considerably enhanced the well-known Vario-C flash code.

The essential changes are:

– The ECU no longer needs to be opened for diagnostic purposes

– Flash code available for normal and expert modes.

– For the first time it permits actual commissioning using the flash code plug.

Please also refer to the brochure entitled ”Description of Flash Code for Vario Compact ABS”. The address from which that brochure can be ordered is shown on the outside back cover.

Diagnostic Cable 449 612 ... 0

With this diagnostic cable, WABCO has made it possible to perform external diagnosis on the vehicle. For this purpose, the cable is fitted directly on the side of the vehicle, or on its front or rear.

This cable has the sprayed-on VCS plug on its electronics end and a round 7-pole connector.

Other Diagnostic Means

If the diagnostic means listed above appear to make diagnosis excessively time-consuming, WABCO also offers more comfortable and easy-to-use diagnostic equipment:

Compact Tester:
This tester now permits the Vario-C and VCS electronic systems in a trailer to be tested without any documentation and to achieve real commissioning. Any errors are logically assigned to symbols and are clearly defined.

Compact Tester:	446 300 400 0
Diagnostic Cable:	446 300 401 0

Diagnostic Controller:
This allows what is probably the most comprehensive type of diagnosis. The Controller has an integrated multimeter. The findings from testing the ABS can also be printed out in a log.

Diagnostic Controller-Set:	446 300 331 0
Programme Card	
VCS German	446 300 624 0
VCS English	446 300 651 0
Diagnostic Cable for external diagnostic connection	446 300 329 2

Diagnosis with the PC
In parallel to the long-term known diagnostic tools WABCO offers the PC Diagnosis. All functions are available like they are given with the Diagnostic Controller. Upon that a notepad function can be used.

Ordering number for VCS Software disk is 446 301 502 0.
This Software is available via Software Subsription, too.

The software offers comprehensive and convenient diagnosis. The software and the interface will run on **any conventional PC or laptop** with the following qualities:

Hardware Requirements
The following hardware is required:

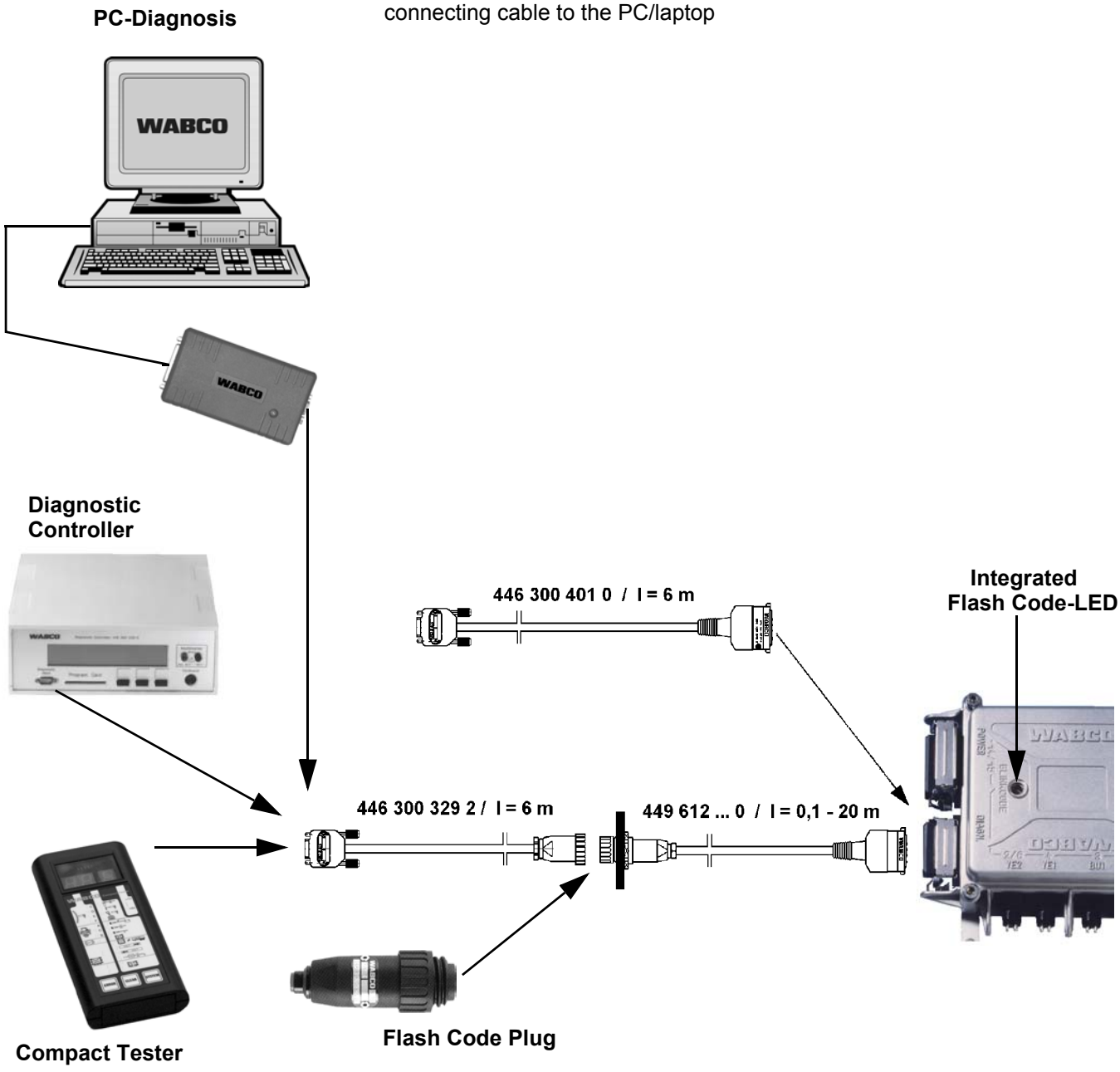
- Notebook / laptop wherever possible
- Pentium PC or higher
- 16 MB main memory, colour display 800x600
- ca 10 MB free disk space
- 3.5" floppy drive
- 1 COM interface (9-pin) for the Diagnostic Interface
- Win95/98/2000, WIN NT

Diagnosis Interface

For establishing diagnosis with the control unit, WABCO Diagnostic Interface Set Part No. 446 301 021 0 is required.

The set contains the interface and a connecting cable to the PC/laptop (for the COM interface, 9-pin connection).

The vehicle connection on the interface is similar to the connection for the Diagnostic Controller, permitting the continued use of connecting cables used in the past.



Annex

List of Standard Parameters

Vario Compact ABS

As of: 16/01/96

Parameters which can be changed by the customer:

Parameter	Possible Settings	Standard Setting
Indicator lamp function	**WABCO** standard passenger car function Grau function	**WABCO**-Standard
Calibration of mileage counter	number of pole wheels 80, 100, 120 teeth rolling circumference of tyre	number of pole wheels z = 100 rolling circumference of tyre u_{dyn} = 3240 mm
ISO-Address		10
ISS Function	Standard or Pulse Function	Standard Function
ISS speed threshold	between 4 and 120 k. p. h.	0 k. p. h.
Service signal	Can be set at random	30.000 km

Parameters which can be changed only when entering the PIN:

Parameter	Possible Settings	Standard Setting
ABS tyre parameters	number of pole wheels 80, 100, 120 teeth rolling circumference of tyre	number of pole wheels z = 100 rolling circumference of tyre u_{dyn} = 3425 mm

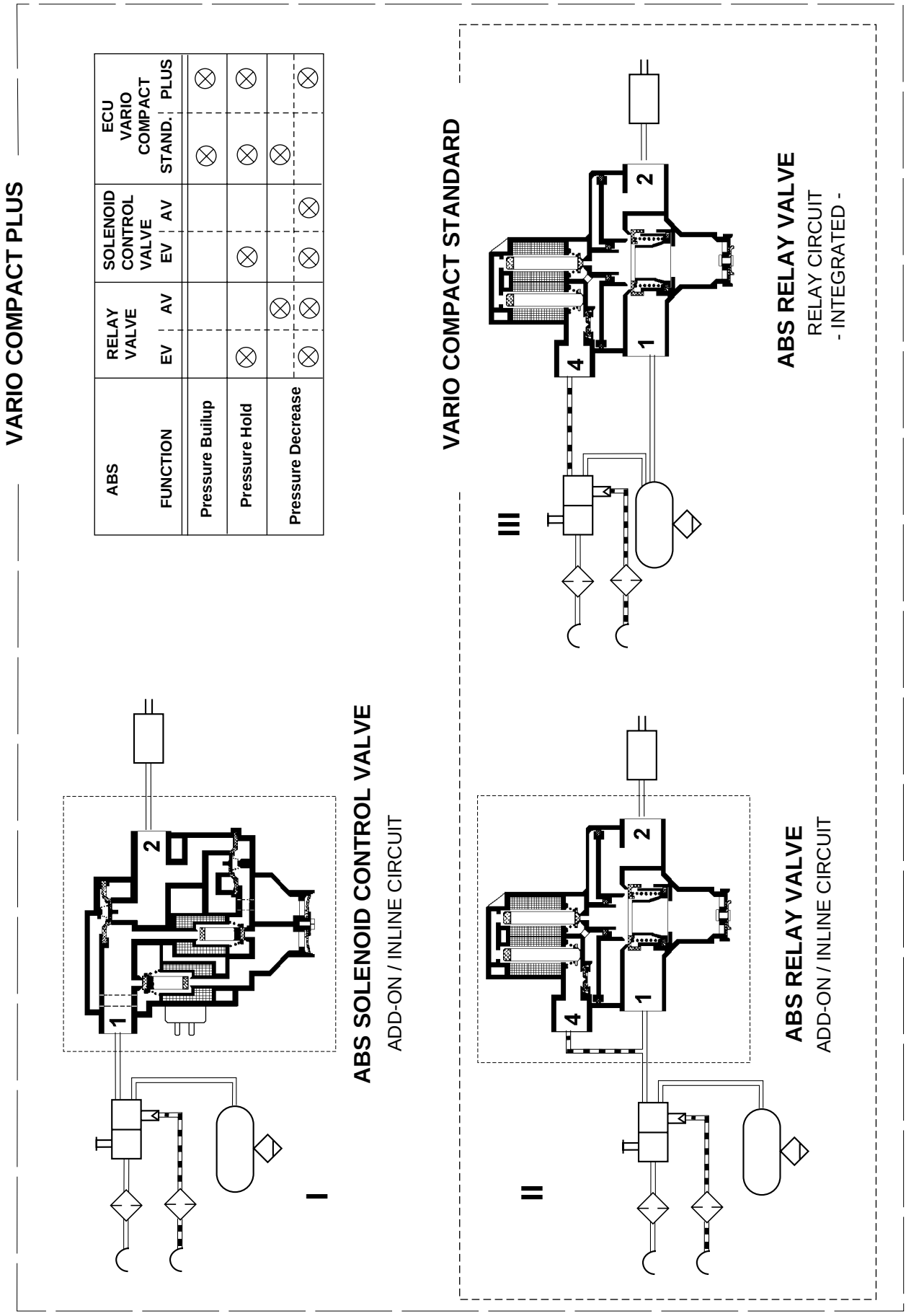
Tyre Data for Mileage Counter

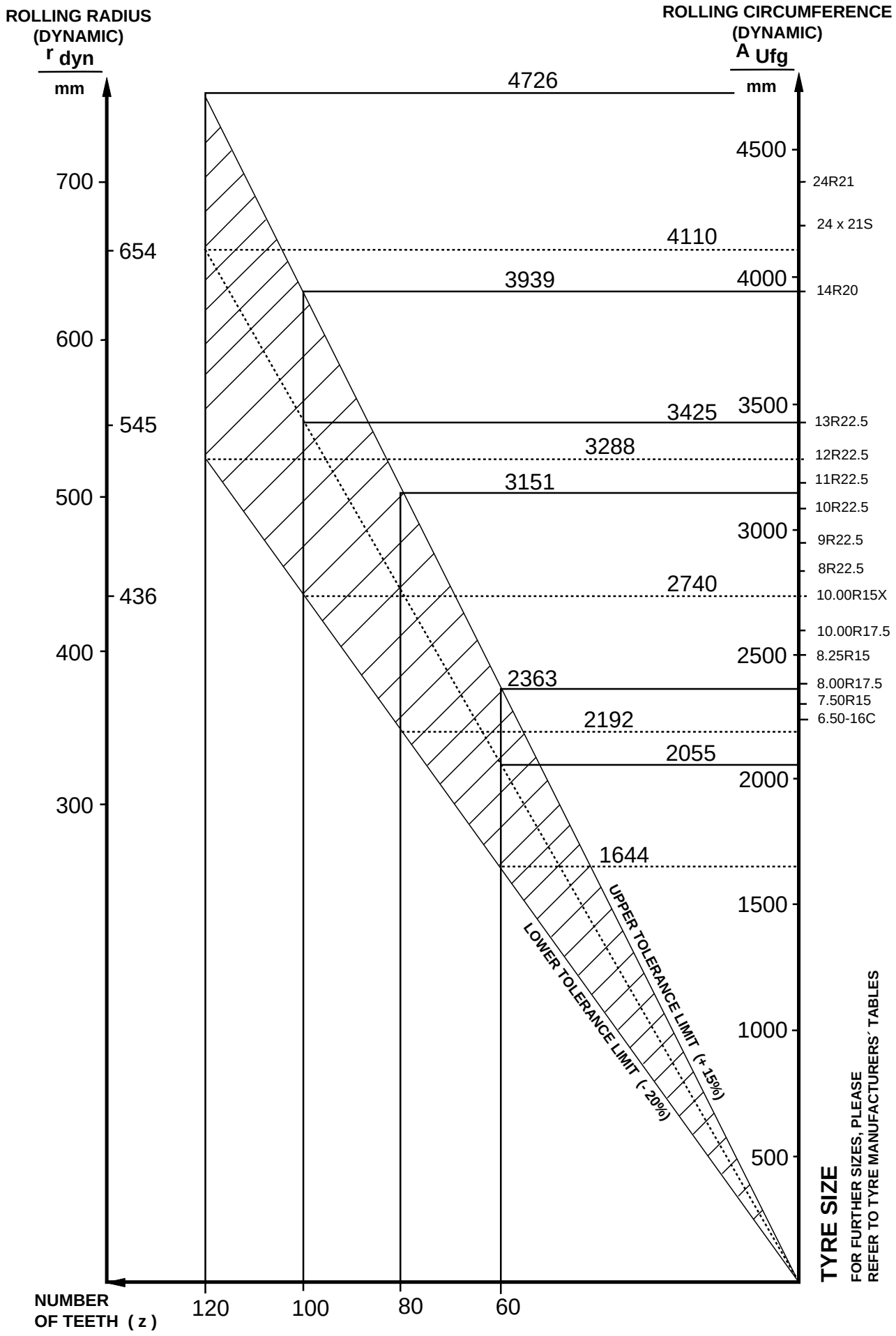
Type of Tyre	r dyn	U dyn (=2*rdyn*3.14)	No. of teeth on pole wheel/mileage counter reading after 1.000 km									
			60 teeth		80 teeth		90 teeth		100 teeth		120 teeth	
	[mm]	[mm]	%	km	%	km	%	km	%	km	%	km
6,70 R 13	318	1998	-3	972								
205 R 14C	324	2036	-1	991								
7,00 R 12	329	2067	1	1006								
6,70 R 14	336	2111	3	1027								
220/75 R 15	340	2136	4	1040								
205/80 R 15	344	2161	5	1052								
205/65 R 17,5	345	2168	5	1055								
205/75 R 15	347	2180	6	1061	-20	796						
6,70 R 15	350	2199	7	1070	-20	803						
7,00 R 15	353	2218	8	1079	-19	809						
6,00 R 16	357	2243	9	1091	-18	819						
6,50 R 16	362	2274	11	1107	-17	830						
7 R 17,5	362	2274	11	1107	-17	830						
205/75 R 17,5	366	2300	12	1119	-16	839						
7,50 R 15	371	2331	13	1134	-15	851						
215/75 R 17,5	372	2337	14	1137	-15	853						
6,50 R 17	375	2356	15	1147	-14	860						
7,00 R 16	380	2388			-13	871						
8 R 17,5	380	2388			-13	871						
225/75 R 17,5	380	2388			-13	871						
8,5 R 17,5	384	2413			-12	881						
245/70 R 17,5	386	2425			-11	885						
235/75 R 17,5	388	2438			-11	890						
7 R 19,5	388	2438			-11	890						
7,50 R 16	389	2444			-11	892						
9 R 17,5	399	2507			-9	915	-19	813				
8,25 R 15	406	2551			-7	931	-17	827				
245/70 R 19,5	407	2557			-7	933	-17	829				
9,5 R 17,5	408	2563			-6	936	-17	831				
8 R 19,5	415	2607			-5	952	-15	846				
10 R 17,5	416	2614			-5	954	-15	848				
8,25 R 16	417	2620			-4	956	-15	850				
6,50 R 20	417	2620			-4	956	-15	850				
265/70 R 19,5	421	2645			-3	965	-14	858				
8,25 R 17	430	2702			-1	986	-12	876				
275/80 R 18	430	2702			-1	986	-12	876				
435/50 R 19,5	449	2821			3	1030	-12	880				
7,00 R 20	433	2721			-1	993	-12	882				
9 R 19,5	434	2727			0	995	-12	884				
285/70 R 19,5	434	2727			0	995	-12	884				
9,00 R 16	442	2777			1	1014	-10	901	-14	855		
445/45 R 19,5	442	2777			1	1014	-10	901	-14	855		
9,5 R 19,5	445	2796			2	1020	-9	907	-14	861		
10,00 R 15	446	2802			2	1023	-9	909	-14	863		
305/70 R 19,5	448	2815			3	1027	-9	913	-13	867		
7,50 R 20	450	2827			3	1032	-8	917	-13	870		
255/70 R 22,5	451	2834			3	1034	-8	919	-13	872		
8 R 22,5	454	2852			4	1041	-7	925	-12	878		
275/80 R 20	455	2859			4	1043	-7	927	-12	880		
10,5 R 20	460	2890			5	1055	-6	937	-11	890		
11/70 R 22,5	465	2922			7	1066	-5	948	-10	900		
275/70 R 22,5	465	2922			7	1066	-5	948	-10	900		
8,25 R 20	466	2928			7	1069	-5	950	-10	901		

Tyre Data for Mileage Counter

Type of Tyre	*r dyn*	*U dyn*	*No. of teeth on pole wheel/mileage counter reading after 1.000 km*									
		*(=2*rdyn*3.14)*	*60 teeth*		*80 teeth*		*90 teeth*		*100 teeth*		*120 teeth*	
	[mm]	*[mm]*	*%*	*km*	*%*	*km*	*%*	*km*	*%*	*km*	*%*	*km*
335/80 R 18	469	2947			8	1075	-4	956	-9	907		
9 R 22,5	470	2953			8	1078	-4	958	-9	909		
425/55 R 19,5	474	2978			9	1087	-3	966	-8	917		
295/70 R 22,5	478	3003			10	1096	-3	974	-8	925		
C 22,5 Pilote X	480	3016			10	1101	-2	978	-7	929		
385/65 R 19,5	484	3041			11	1110	-1	986	-6	936		
305/70 R 22,5	485	3047			11	1112	-1	988	-6	938		
D 20 Pilote X / 12/80 R 20	490	3079			12	1124	0	999	-5	948		
D 22,5 Pilote X	491	3085			13	1126	0	1001	-5	950		
275/80 R 22,5	492	3091			13	1128	0	1003	-5	952		
335/80 R 20	493	3098			13	1130	0	1005	-5	954		
315/70 R 22,5	493	3098			13	1130	0	1005	-5	954		
9,00 R 20	495	3110			14	1135	1	1009	-4	958		
10 R 22,5	495	3110			14	1135	1	1009	-4	958		
12,5 R 20	497	3123			14	1140	1	1013	-4	961		
405/70 R 20	501	3148			15	1149	2	1021	-3	969		
16,5 R 19,5	505	3173					3	1029	-2	977		
375/75 R 20	505	3173					3	1029	-2	977		
295/80 R 22,5	507	3185					3	1033	-2	981		
D 20 Typ X / 10,00 R 20	509	3198					4	1037	-2	985		
E 20 Pilote X / 13/80 R 20	509	3198					4	1037	-2	985		
11 R 22,5	509	3198					4	1037	-2	985		
12/80 R 22,5	509	3198					4	1037	-2	985		
13/75 R 22,5	509	3198					4	1037	-2	985		
E 22,5 Pilote X	509	3198					4	1037	-2	985		
385/65 R 22,5	517	3248	curr. VCS standard tyre				5	1054	0	1000		
445/65 R 19,5	518	3255					6	1056	0	1002		
15 R 22,5	518	3255					6	1056	0	1002		
18 R 19,5	522	3280					6	1064	1	1010		
315/80 R 22,5	522	3280					6	1064	1	1010		
E 20 Typ X / 11,00 R 20	526	3305					7	1072	2	1018		
12 R 22,5	526	3305					7	1072	2	1018		
14,5 R 20	528	3317					8	1076	2	1021		
F 20 Pilote X / 14/80 R 20	528	3317					8	1076	2	1021		
365/80 R 20	530	3330					8	1080	3	1025		
16,5 R 22,5	541	3399					10	1103	5	1047		
425/65 R 22,5	543	3412					11	1107	5	1050		
12,00 R 20	545	3424					11	1111	5	1054		
14,75/80 R 20	545	3424					11	1111	5	1054		
425/75 R 20	545	3424					11	1111	5	1054		
13 R 22,5	545	3425					11	1111	5	1054		
F 20 Typ X	546	3431					11	1113	6	1056		
11,00 R 22	549	3449					12	1119	6	1062		
Pilote X / 13,00 R 20	551	3462					12	1123	7	1066		
445/65 R 22,5	555	3487					13	1131	7	1074	-15	848
18 R 22,5	559	3512					14	1139	8	1081	-15	855
12,00 R 22	567	3562							10	1097	-13	867
13,00 R 20	571	3588							10	1105	-13	873
12,00 R 24	594	3732							15	1149	-9	908
G 20 Typ X	598	3757									-9	914
14,00 R 20	601	3776									-8	919
16,00 R 20	645	4053									-1	896
14,00 R 24	661	4153									1	1010

Comparison of Principles for ABS Solenoid Control Valve and Relay Valve




ROLLING RADIUS
(DYNAMIC)
r dyn
mm
ROLLING CIRCUMFERENCE
(DYNAMIC)
A Ufg
mm
4726
4110
3939
3425
3288
3151
2740
2363
2192
2055
1644
700
654
600
545
500
436
400
300
4500
4000
3500
3000
2500
2000
1500
1000
500
24R21
24 x 21S
14R20
13R22.5
12R22.5
11R22.5
10R22.5
9R22.5
8R22.5
10.00R15X
10.00R17.5
8.25R15
8.00R17.5
7.50R15
6.50-16C
UPPER TOLERANCE LIMIT (+ 15%)
LOWER TOLERANCE LIMIT (- 20%)
TYRE SIZE
FOR FURTHER SIZES, PLEASE
REFER TO TYRE MANUFACTURERS´ TABLES
NUMBER
OF TEETH (z)
120
100
80
60

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