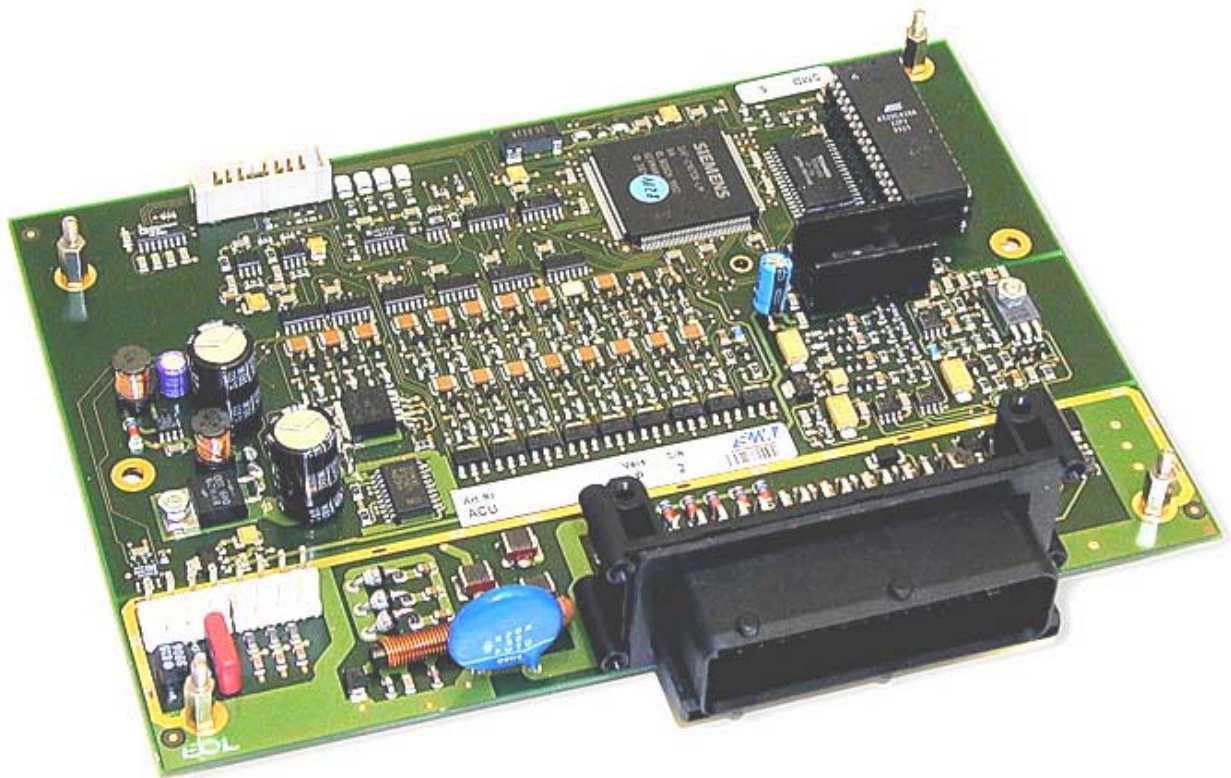


Service Instructions for ACU

Part no. 0492 00173 00-0002(A)

G_00173A.doc

Articulation Control Unit



Electronic Control Unit for Bus Articulation Systems



1. Task of the Controller

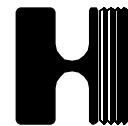
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1. Task of the Controller

1 Task of the Controller

Viewing the entire system – pusher articulation bus – you will find out that such kind of system is unstable. Due to an overlaying of different loading conditions, road geometry and road conditions as well as due to the arrangement of motor and articulation system at all driving situations you will have a torque around the normal axis of the articulation system. This torque causes that the articulated bus will bend in towards one side.

To avoid this behaviour we use a damping system. As the curve of the torque which is meant to avoid the bending is not proportional to the bending angle but has to be readjusted for each new driving situation an electronic controller is necessary. For the determination of the driving situation values such as “forward driving or reversing” are put into gear, speed, travel direction, bending angle and steering angle are recorded.

For a satisfactory solution of this kind of task as well as to meet today’s demands on driving comfort and serviceability and beyond it to recognise driving mistakes or other critical driving situations in time and to take protective measures for the articulation system it is practical to use a programmable controller. Due to the fact that the controller is freely programmable it is possible to easily adjust it to each type of vehicle.

The present document shall enable to carry out the diagnosis of the controller and to solve failures or errors on the articulation system or vehicle, if necessary. For this purpose the use of the ACU-specified diagnosis software is described and a general circuit scheme or error list is provided.

2. Functional Specification

2 Functional Specification

In order to carry out a trouble-shooting on an articulation system and its components it firstly requires to understand the function of the controller during normal operation. The following chapter provides a short insight into the reactions of the system.

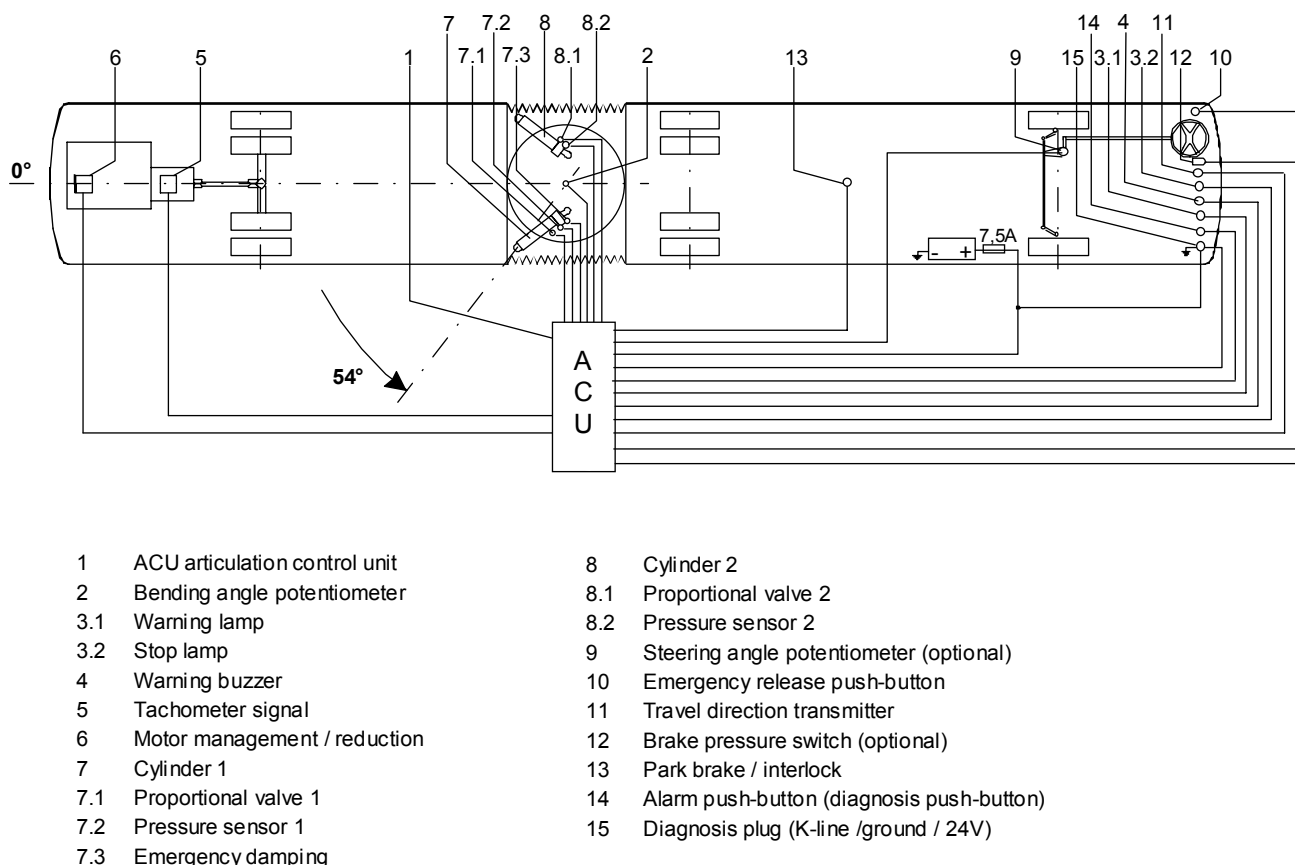
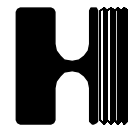


Figure 1 Scheme: Structure of damping system

2.1 Warning Buzzer

The warning buzzer provides acoustic alarm indication of individual angle ranges. It signals to the driver by audio warning which angle range is reached. Furthermore, the warning buzzer is always activated for approx. 3 seconds when an error occurs to call the driver's attention to the warning lights.

Every switching-on of ignition causes an activation about 3 – 5 seconds. This serves for a check-up of the cabling or the function of the buzzer.



2. Functional Specification

2.2 Warning Lamp (yellow)

When a light failure occurs which still permits limited driving operation the controller activates the warning lamp. The warning buzzer is also activated for a short period. A yellow warning lamp signals to the driver to continue the driving operation with increased attention till reaching the next garage. The failure should be remedied before the vehicle can take up again normal operation.

It may be possible with some failures that the warning lamp does not light up immediately again although a failure occurred before switching-off of ignition. Cause of this circumstance is that some failures are not directly identifiable in standstill, therefore they only reoccur during driving operation.

Every switching-on of ignition causes an activation about 3 – 5 seconds. This serves for a check-up of the cabling or the function of the warning lamp.

2.3 Stop Lamp (red)

When a grave failure occurs in the articulation system or at a required input signal the vehicle has to be stopped immediately and should be only moved to the garage with low speed and utmost care. In such a case the controller signals the failure by means of the red stop lamp. It may be possible with some failures that the stop lamp does not light up immediately again after having switched-off and on the ignition. When this lamp lights up, however, a control of system should be carried out on the spot.

Every switching-on of ignition causes an activation about 3 – 5 seconds. This serves for a check-up of the cabling or the function of the stop lamp.

2.4 Throttle Reduction

Similar to the activation of the damping the articulation control unit can induce a throttle reduction which depends on the driving condition. This function is subject to the direction of travel, speed and bending angle of the articulation system. Generally, e.g. the throttle reduction initiates at reversing, and mounts with increasing bending angle.

2.5 Interlock

To protect the articulation system and thus the vehicle from damage when reversing the interlock is activated shortly before reaching the mechanical stop of the articulation system. The activation is dependent on both the speed of vehicle and the current bending angle. The interlock is basically only activated at reversing.

2. Functional Specification

2.6 Emergency Release

As it may happen for a vehicle to come into a situation where the above mentioned functions, such as throttle reduction, damping or interlock make it impossible to drive on although absolutely requested, the controller provides an emergency release button which enables the driver to deactivate the controller for a short period. The emergency release has to be pressed to deactivate the controller. This is signalled by a flashing of the warning lamp.

This function is only available while the speed of vehicle does not exceed 15 km/h.



During emergency releasing the safety functions of the controller are switched off. Please drive with extreme care as otherwise the vehicle could be damaged.

2.7 Damping Built-up

The damping of the articulation system is effected with all versions via an hydraulic system which is controlled by the articulation electronics. Depending on the system one or two hydraulic cylinders are mounted into the articulation system, and are connected to a so-called hydraulic control block which can regulate the pressure within the hydraulic circuit. With new systems this control block is no more connected to the cylinders by tubes as previously but directly mounted to the cylinder.

A proportional valve exists in the respective control block and regulates the pressure within the hydraulic circuit. In addition it is provided with a sensor technology in form of pressure switches or sensors controlling the pressure built-up. With current systems a so-called emergency damping valve additionally applies which ensures the pressure built-up and to safely stop the vehicle in case of breakdown of the electronics or the proportional valve.

All other hydraulic systems which may apply are passive systems, i.e. pressure can only be built-up when the articulation system moves. If the articulation system comes to standstill an examination of the specified pressure is not possible because only with oil flow this comes about.

To adjust the damping correctly depending on driving situation the following input signals are required for the controller:

- speed
- bending angle
- direction of travel
- steering angle (optional)
- brake pressure (optional)

So e.g. a pressure is adjusted at the proportional valve depending on speed of vehicle or motion of the articulation system.

2. Functional Specification

2.8 Angle Ranges

To protect the articulation system during slow driving operation the maximum bending angle is divided in four ranges to increase the damping or the throttle reduction before reaching the mechanical stop, if necessary.

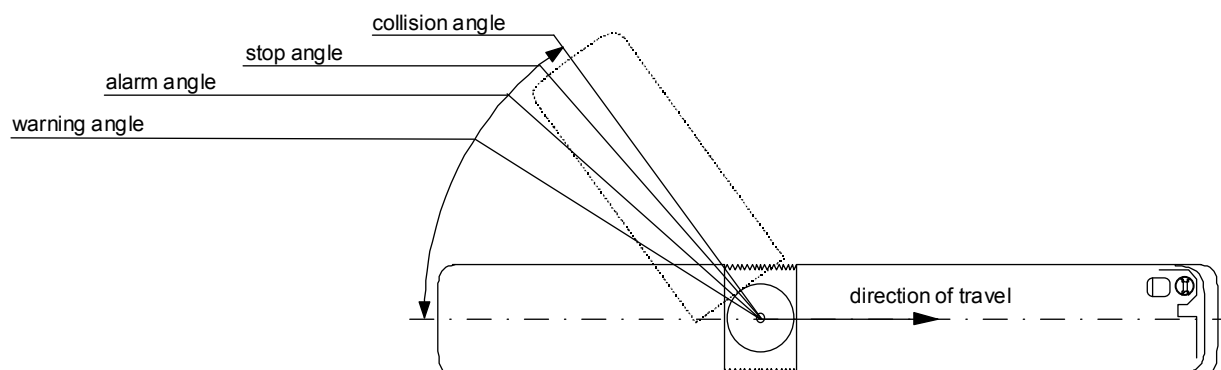


Figure 2: Representation of the angle ranges

Depending on the respective angle range of the articulation system and the direction of travel of the vehicle, various reactions are actuated in the controller. In this way e.g. the pressure in the hydraulics mounts with increasing articulation angle. The pressure is specified separately in forwards and backwards parameters for the respective ranges. A survey is provided by the following chart whereas the angle values and indication in percentage have been chosen freely and may vary in the vehicle of different manufacturers.

angle ranges	damping	throttle/torque deduction	warning buzzer	interlock	capable for emergency release
warning angle forward 45°	20%	20%	out	No	Yes
alarm angle forward 52°	50%	80%	fast	No	Yes
collision angle forward 54°	100%	100%	continuous alarm	No	Yes
warning angle backwards 39°	50%	60%	slow	No	Yes
alarm angle backwards 47°	100%	100%	fast	Yes	Yes
stop angle backwards 51°	100%	100%	fast	Yes	No*
collision angle backwards 54°	100%	100%	continuous alarm	Yes	Yes/No*

Chart 1 Reaction of the controller in the angle ranges

* The activation of the stop angle function is not provided by all vehicle manufacturers. The specific function is to determine that the interlock is no more suspended by means of the emergency release button once the stop angle has been reached at reversing. If the stop angle function is deactivated the interlock can be released till reaching the collision angle.

3. Communication and Diagnosis

3 Communication and Diagnosis

This chapter contains an overview over the structure and function of the communication interface of the articulation control unit.

3.1 Overview of Hardware Requirements

The following components are required for the diagnosis of the control unit:

- Pentium-Laptop with serial interface and 16 MB memory
- Diagnosis interface according to ISO 9141
- Windows 95 or 98
- HÜBNER-Diagnosis Software ACU_COM

3.2 Diagnosis Interface

An interface according to ISO 9141 is required for the diagnosis of the ACU. This interface converts the signals of the serial interface of the laptop into a transfer signal usually used in the automotive industry. The vehicle manufacturer must provide an accessible diagnosis plug that is connected to the ACU via the vehicle connection in order to connect the interface. HÜBNER recommends the following type of AMP for this plug.

Pin 1: U_{BAT}
Pin 2: Ground
Pin 8: K-line



Figure 3: Diagnosis plug AMP 182916-1

3.3 Diagnosis Software

Communication with the control unit is carried out with the aid of the diagnosis software ACU_COM. The software contains all the functions required for the diagnosis. For the installation of the software a user identification is required which is saved in the control unit when the data is altered and always shows the last user who made modifications at the control unit.

HÜBNER allocates the user identifications.

3.3.1 Start of Program

After the start of the program an information window with the current version number of the diagnosis software appears. Furthermore it shows for whom the software was registered and which access is allowed. This window can be closed with the ENTER-key or it disappears by itself after some time.



Figure 4: Program information

Then appears the main window which used as it is normal in Windows. For this a menu structure or buttons are available for the direct selection of important functions.

The menu structure of the main window comprises the following:

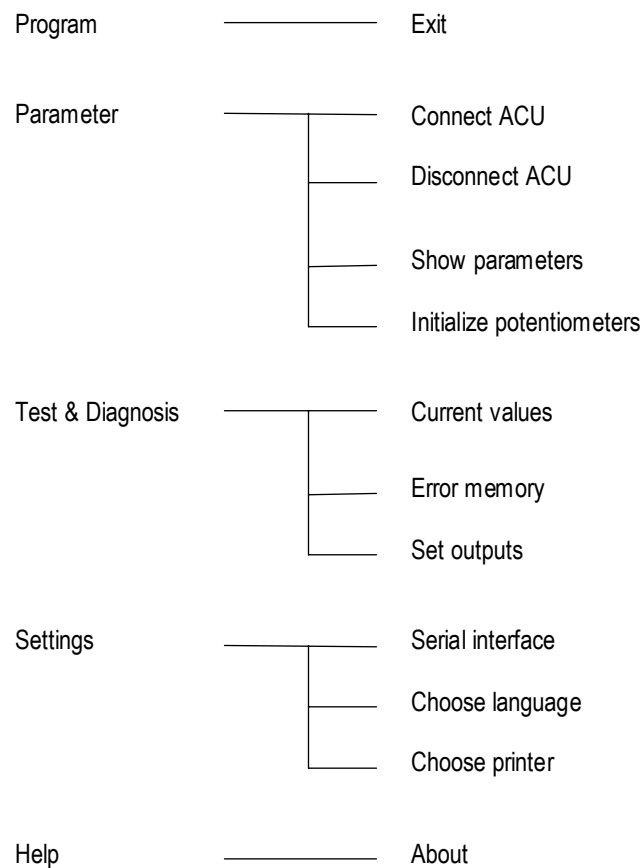


Figure 5: Menu structure

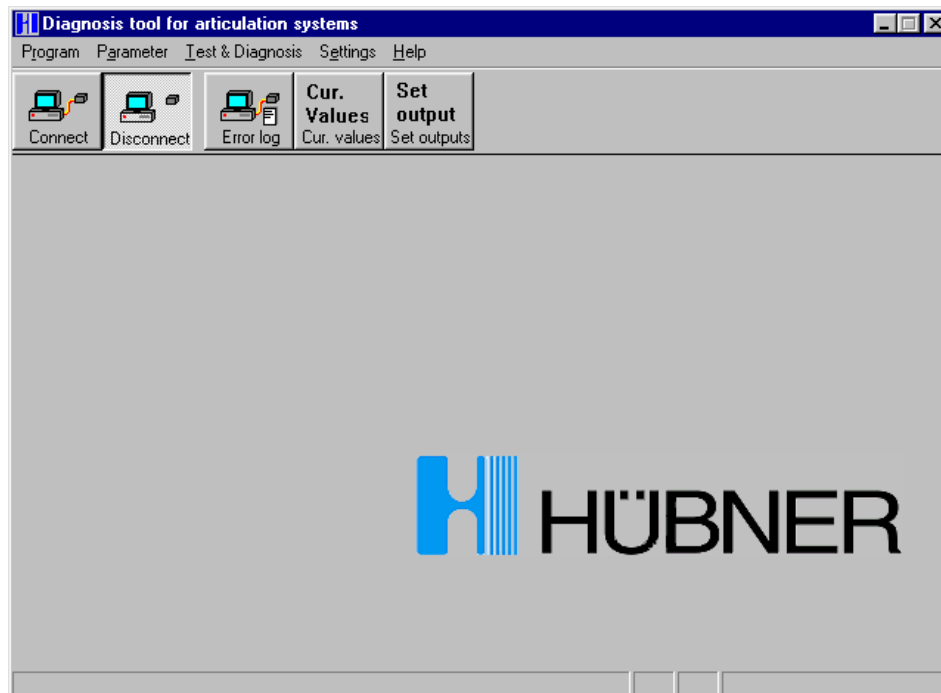


Figure 6: Main window

3.3.2 Basic Settings of the Diagnosis Software

After the first start of program the basic settings of the diagnosis software should be carried out. The settings are usually required only once and are saved when leaving the program.

3.3.2.1 Language Choice

If required, choose an available language by means of the menu point **Choose system language**. English and German are the basic languages included in the delivery of Hübner.

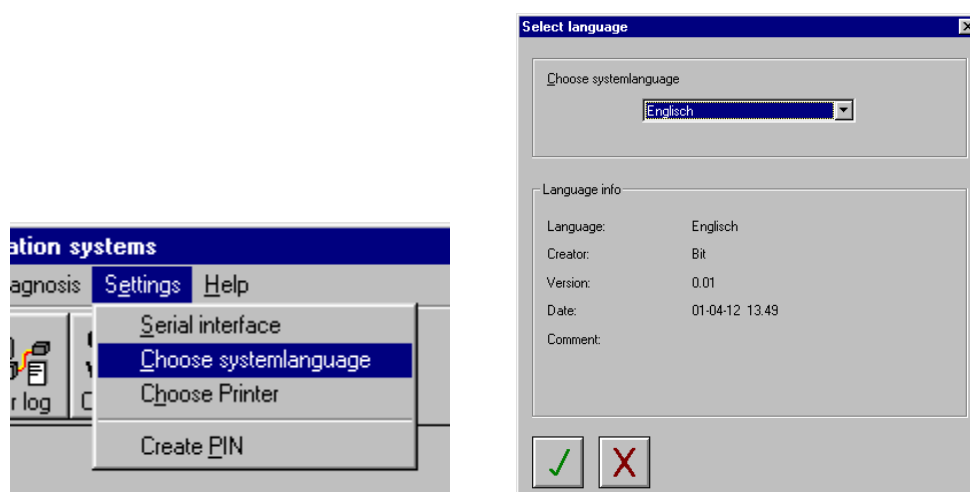


Figure 7: Language choice

Should no language data set be available the basic setting in English will be at disposal for you.

3. Communication and Diagnosis

3.3.2.2 Choice of Serial Interface

Most laptops usually only provide one serial interface which is specified as, so-called COM1 and configured. This interface is already selected as basic setting after the installation of the diagnosis software. Should another interface apply in your laptop you are able to select this ad libitum from COM1 till COM4 by means of the menu point **Serial Interface**.

3.3.2.3 Printer Installation

As the error memory or the current parameters can be printed if required, the menu point **Choose Printer** allows to choose and configure a printer if the required driver was already installed under Windows.

3.3.3 Setting up Connection with ACU

Prior to be able to start the diagnosis the connection to the control unit has to be set up. The menu point **Connect ACU** or the corresponding button in the main window is selected for this. After successful setting up of the connection the following information windows appears:

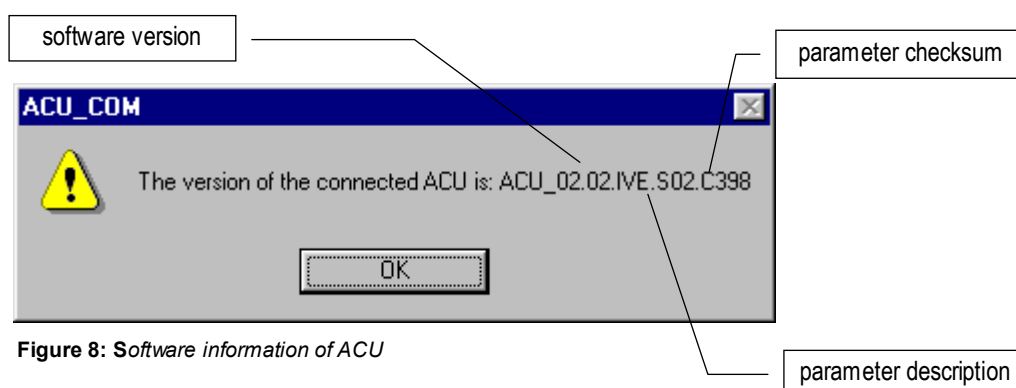


Figure 8: Software information of ACU

You can refer to this window for the above illustrated detail information about the software version. The indications serve for easy identification of the applied control unit should any questions arise.

3. Communication and Diagnosis

3.3.4 Display of Current Values

For the diagnosis of the control unit a function is provided which enables the display of the current values of the ACU during operation. The display window can be selected by means of the menu point **Current values** or the corresponding button in the main window.

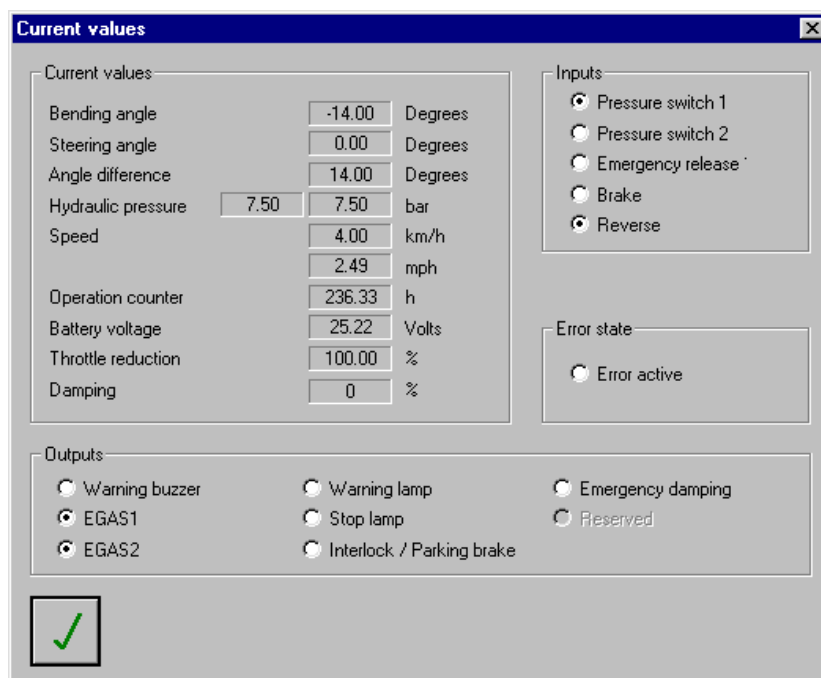


Figure 9: Current values

In the illustrated window the current values are combined in following groups. The display is realised independently whether the signals are read in by digital inputs or by CAN.

- Current values - Display of all analogue values. The values of angle difference, throttle reduction and damping are the intrasystem calculated values of the control unit.
- Inputs - Display of input status for switched signals.
- Outputs - Display of the current activated outputs.
- Error active - Shows a present existing error.

3. Communication and Diagnosis

3.3.5 Error Memory

3.3.5.1 Output via Diagnosis Software

The ACU has an error memory that contains useful information for trouble-shooting should this become necessary. It can be reached via menu point **Error memory** or the corresponding button in the main window.

3.3.5.1.1 Read Error Memory

For reading the error memory you choose the corresponding menu point or button in the main window.

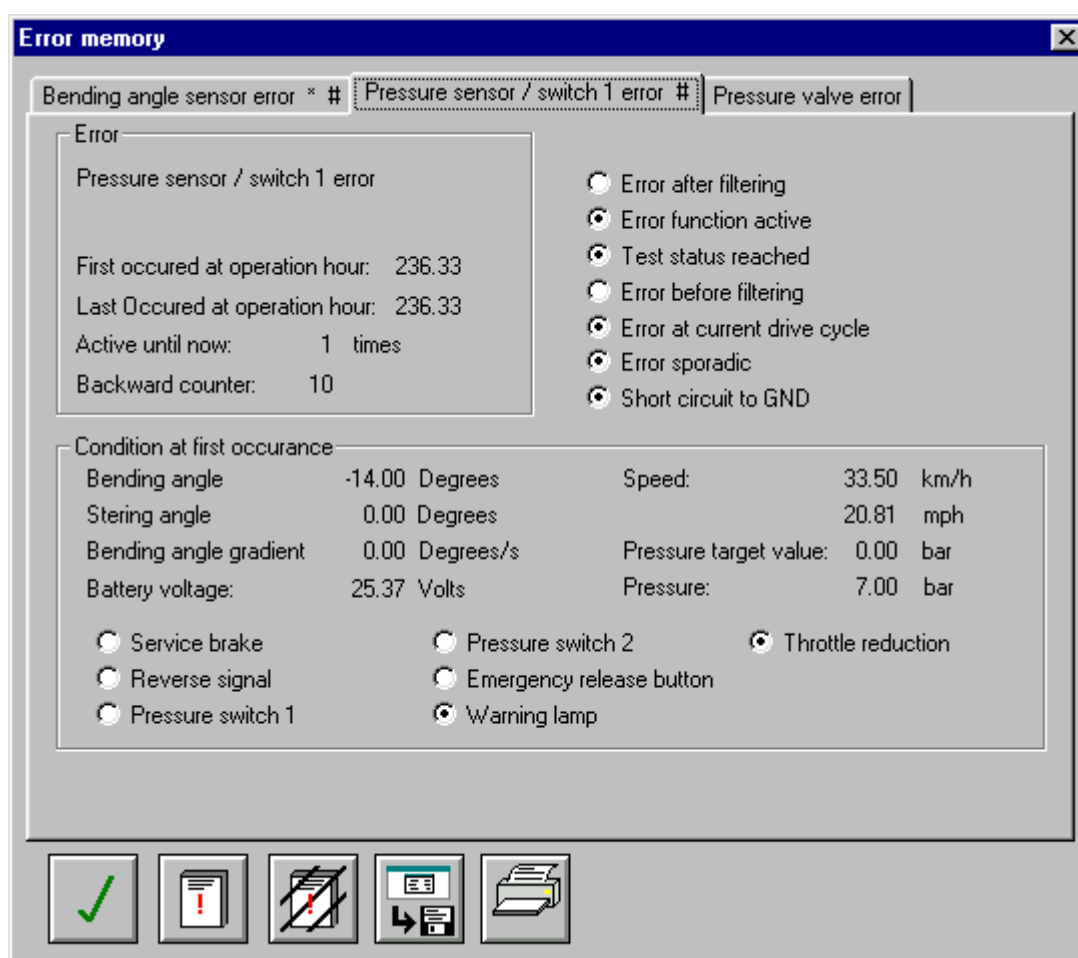


Figure 10: Error memory

When viewing the error memory each error is displayed with an index card. A star sign (*) behind the index card indicates that an error presently exists. A hash sign(#) signals that the control unit activated the safety functions as determined for this fault (e.g. warning lamp activated). Index cards without star or hash sign(#) point to errors which have been occurring at least once in the past but do not have any current influence on the control performance.

The following illustrations explain the individually displayed values:

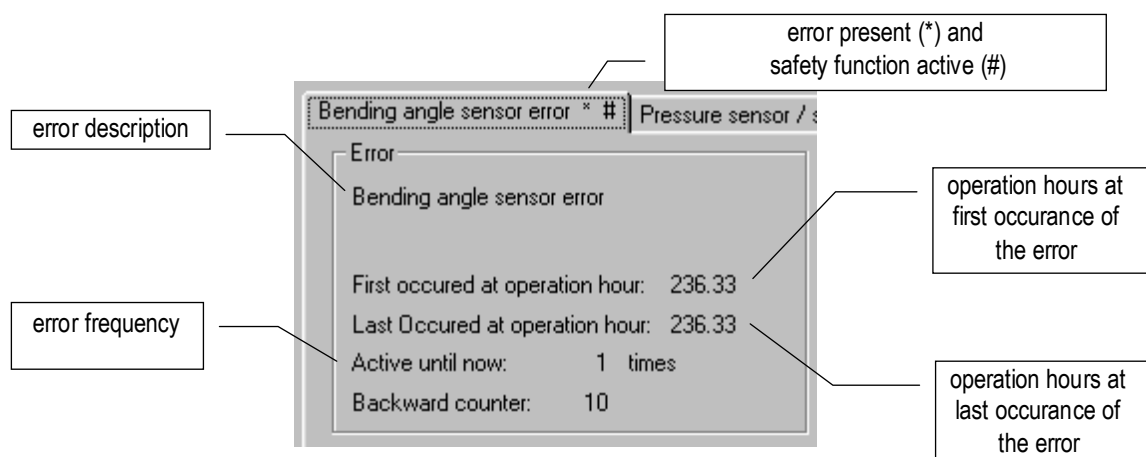


Figure 11: Error description

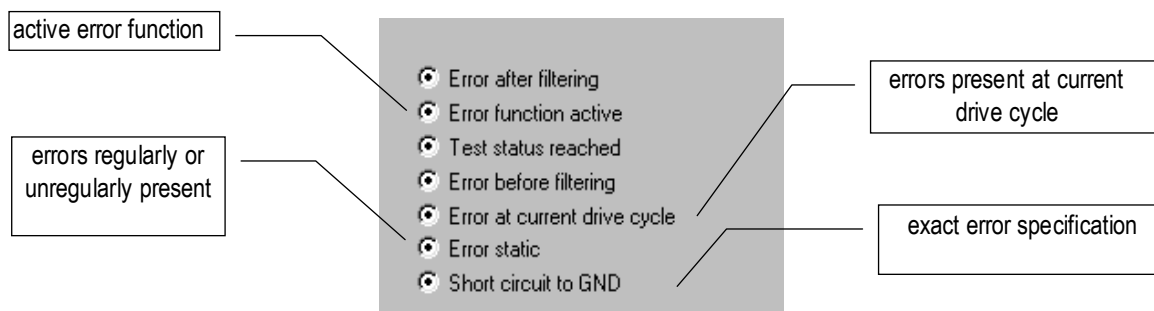


Figure 12: Error status

The lower part of the index card informs about the circumstances of the controller at first occurrence of error. This information serve to isolate the error which only occur in certain driving conditions.

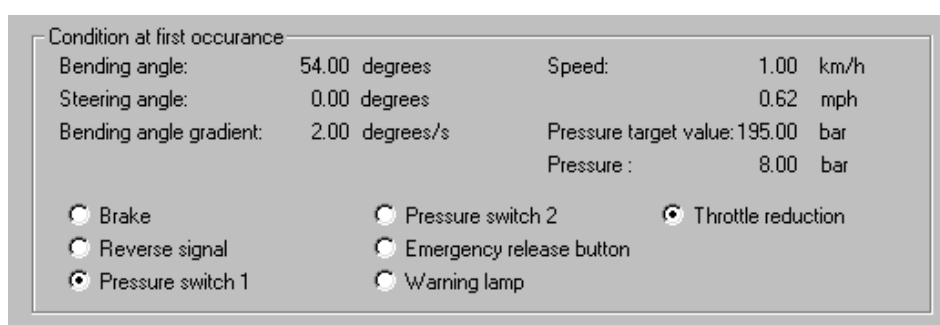


Figure 13: Surrounding conditions for the error

3.3.5.1.2 Error memory Reset

For error memory reset use the  button. Only such errors can be reset which do not presently exist in the controller. In order to check whether all errors have been reset the error memory should be read out after every reset operation by means of the  button.



3. Communication and Diagnosis

3.3.5.2 Flash Code Output

For trouble-shooting without a laptop it is possible to carry out a single diagnosis via the warning lamp. In order to initiate an output the K-line on pin 37 of the controller must be connected to ground (see chapter 6.1) For this a flash code button should be installed near the diagnostic connector which can easily be reached, if required.

3.3.5.2.1 Read Error Memory

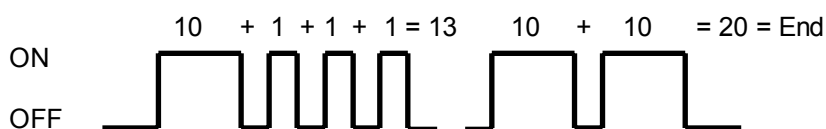
The output of the flash code is initiated via the function lamp by pressing the flash code button for at least 1 second after the electronics was booted up (function lamp off = no current error). Should the warning lamp in the vehicle be already flashing caused by a current error, press the flash code button permanently during the output.

The output of the errors from the error memory occurs according to priority. Errors greater than 9 are additionally displayed with a long impulse.

Short impulse: 1.5 seconds on, then a pause of 1.5 seconds until next impulse

Long impulse: 5 seconds on, then a pause of 1.5 seconds until next impulse

Example: Error 13 is shown as follows as a flash code via a function lamp:



After the error output there is a pause of 5 seconds. By pressing the flash code button during this time the next error is displayed as a flash code.

It is possible to constantly press the alarm button. Then all errors in the error memory are displayed.

3.3.5.2.2 Termination of Error Memory

After output of all errors or if no errors are present in the memory the output is terminated with two long impulses.

3.3.5.2.3 Erasing of Error Memory

To reset the error memory the flash code button must be pressed down for at least 1 second while the voltage supply - normally the ignition - is switched on.

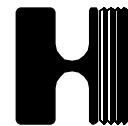
3.3.5.3 Error List

Error No.	Error Name	Error Description	Kind of error
1	Bending angle potentiometer electrical	Indicates a failure of the bending angle potentiometer/sensor or of the lead to the potentiometer/sensor.	Short circuit to ground or disconnection Short circuit to voltage supply
2	Speed signal	Indicates a failure of the speed signal	Short circuit to ground or disconnection Short circuit to voltage supply When following software version occurs: 9.25;9.37;2.00;2.02 Plausibility 1: Angle modification with standing vehicle or loss of speed signal by CAN Plausibility 2: Speed too high > 128 km/h With all other software versions occurring. Plausibility 1: Speed too high > 128 km/h Plausibility 2: Angle modification with standing vehicle or loss of speed signal by CAN
3	Interlock	Indicates a failure at interlock output or lead to interlock	Short circuit to ground or disconnection Short circuit to voltage supply
4	EGAS 1	Indicates a failure at output of engine power reduction 1 or lead to motor control system	Short circuit to ground or disconnection Short circuit to voltage supply
5	EGAS 2	Indicates a failure at output of engine power reduction 1 or of the lead to motor control system	Short circuit to ground or disconnection Short circuit to voltage supply
6	Steering angle potentiometer electronic	Indicates a failure of steering angle potentiometer or of lead to potentiometer	Short circuit to ground or disconnection Short circuit to voltage supply Plausibility 1: If signal is activated by CAN and message is not received
7	Pressure sensor/ pressure switch 1	Indicates a failure in the minimum pressure control. According to applied articulation system a pressure switch (3 bar) or a pressure sensor is installed for this. When using a two-cylinder system the sensor in cylinder 1 is concerned.	Short circuit to ground or disconnection Short circuit to voltage supply Plausibility 1: Measured pressure value is smaller than minimum pressure

Error No.	Error Name	Error Description	Error Mode
8	Articulation angle mechanical	Indicates a failure in the mechanical steering of the bending angle potentiometer / sensor.	Plausibility 1: Travel speed does exist for a longer period without articulation motion
9	Emergency damping valve	Indicates a failure at emergency damping valve output or lead to the emergency damping valve	Short circuit to ground or disconnection Short circuit to voltage supply
10	Brake signal	Indicates a failure at brake pressure signal input or lead to brake signal input	Plausibility 1: Vehicle accelerates with applied brake or if signal is activated by CAN and message is not received. Plausibility 2: Signal is received by CAN but not admissible
11	Proportional valve 1	Indicates a failure at proportional valve output or lead to proportional valve. When using a two-cylinder system the proportional valve in cylinder 1 is concerned.	Short circuit to ground or disconnection Short circuit to voltage supply
12	Reversing signal	Indicates a failure of the travel direction signal	Plausibility 1: Change in travel direction during high speed or if signal is activated by CAN and message is not received. Plausibility 2: Signal is received by CAN but not admissible.
13	Pressure range cylinder 1	Indicates a failure in pressure built-up of the hydraulic system. When using a two-cylinder system the cylinder 1 is concerned. This failure can also point to a malfunction of the lead to pressure switch 2 (50 bar) or to a malfunction of the pressure switch or pressure sensor.	Plausibility 1: Calculated pressure is not reached or exceeded
14	Checksum	Indicates a failure in the program code of the control system.	Plausibility 1: Error in the program memory area Plausibility 2: Error in the data area
15	DKV/DKR	Shows a continuous voltage at DKV input (= throttle valve demand input)	Short circuit to ground or disconnection Short circuit to voltage supply
16	Battery voltage	Indicates a failure in the voltage supply of the control system	Plausibility 1: Voltage under 16 V

Error No.	Error Name	Error Description	Error Mode
17	CAN Bus	Indicates a breakdown of CAN communication	Plausibility 1: CAN message is not sent or received successfully. Plausibility 2: CAN is BUS OFF
18	Emergency release button	Indicates a breakdown on the emergency release button information on CAN bus	Plausibility 1: Signal is activated by CAN but message is not received Plausibility 2: Signal is received by CAN but not admissible
19	Pressure pulse control	Indicates a failure in the pressure built-up of the hydraulic circuit. When using a two-cylinder system the cylinder 1 is concerned.	Plausibility 1: Calculated pressure is not reached
20	Proportional valve cylinder 2	Indicates a failure at proportional valve output2 or lead to proportional valve at cylinder 2.	Short circuit to ground or disconnection Short circuit to voltage supply
21	Pressure sensor 2	Indicates a failure in cylinder 2 at pressure sensor 2 or lead to pressure sensor 2.	Short circuit to ground or disconnection Short circuit to voltage supply
22	Pressure comparison function	Indicates a difference in the pressure behaviour of cylinder 1 to cylinder 2.	Plausibility 1: Difference in both cylinders is too large
23	Pressure range cylinder 2	Indicates a failure in pressure built-up of the hydraulic system in cylinder 2. This failure can also point to a malfunction of the pressure sensor 2.	Plausibility 1: Calculated pressure is not reached.

Remark: The above specified error list includes all present existing error identification routines. Due to the variety of articulation systems and variants in vehicle design all error routines are never simultaneously possible or necessary so that the error control has to be adjusted to every articulation system or vehicle.



3. Communication and Diagnosis

3.3.5.4 Trouble-Shooting

In order to facilitate the error correction in case of occurring failures the following pages shall provide assistance for the error diagnostics. Depending on type of error the following equipment is required:

- laptop with diagnosis software
- diagnosis interface
- multimeter
- hydraulic filling pump with articulation system HNGK 9.2
- manometer with articulation system HNGK 9.2

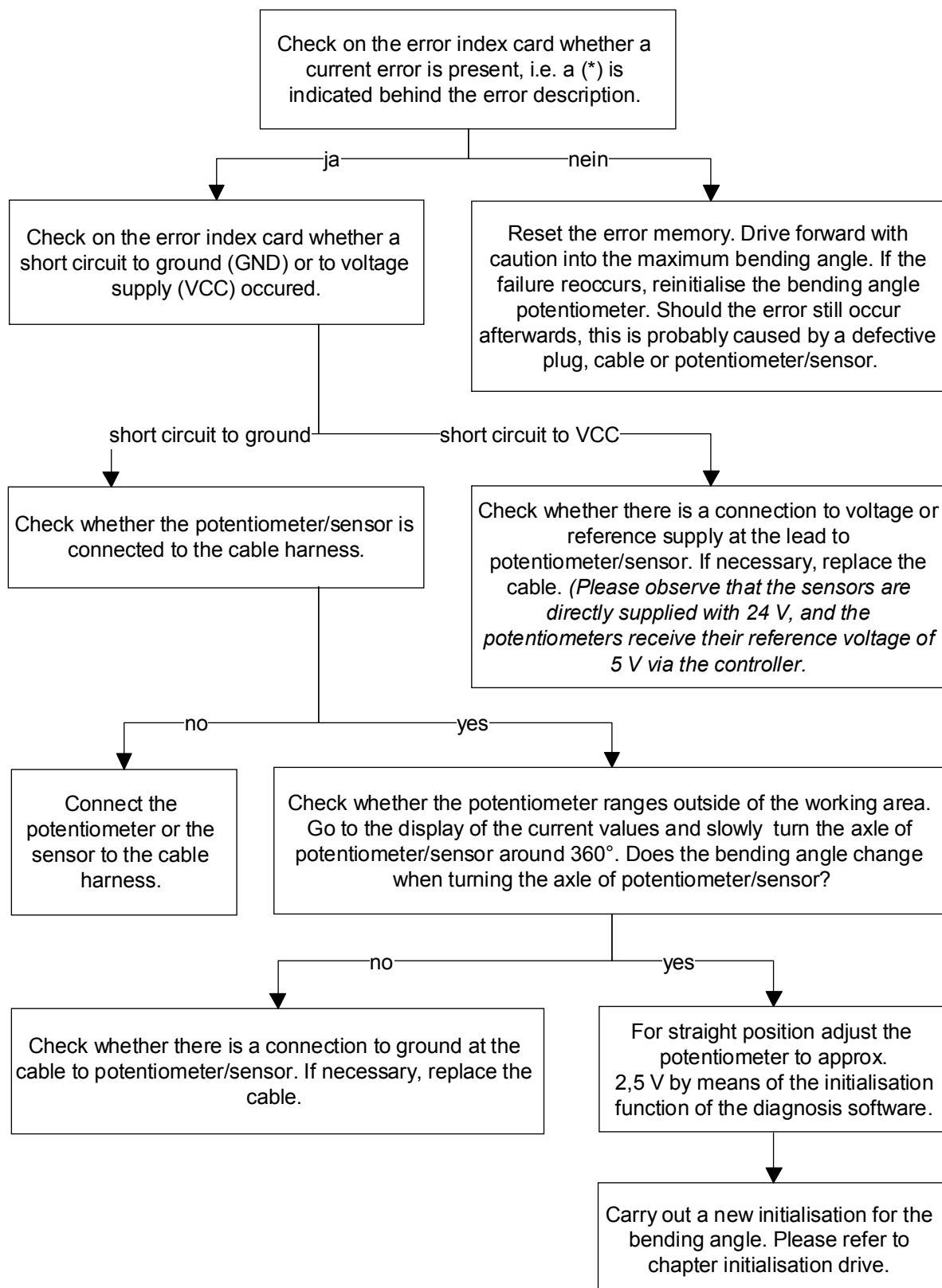
Furthermore it is reasonable to keep on stock a spare potentiometer and spare controller, if necessary. A simple replacement of these components may be very helpful in many cases during trouble-shooting. As some of the affected parts have been directly installed into the articulation system the figures in chapter 7 provide a short summary where the most important components are positioned.

Please observe that the various articulation systems are not equipped identically. Due to this all following failures described cannot not occur simultaneously.

3. Communication and Diagnosis

3.3.5.4.1 Error No. 1: Bending Angle Potentiometer, electric

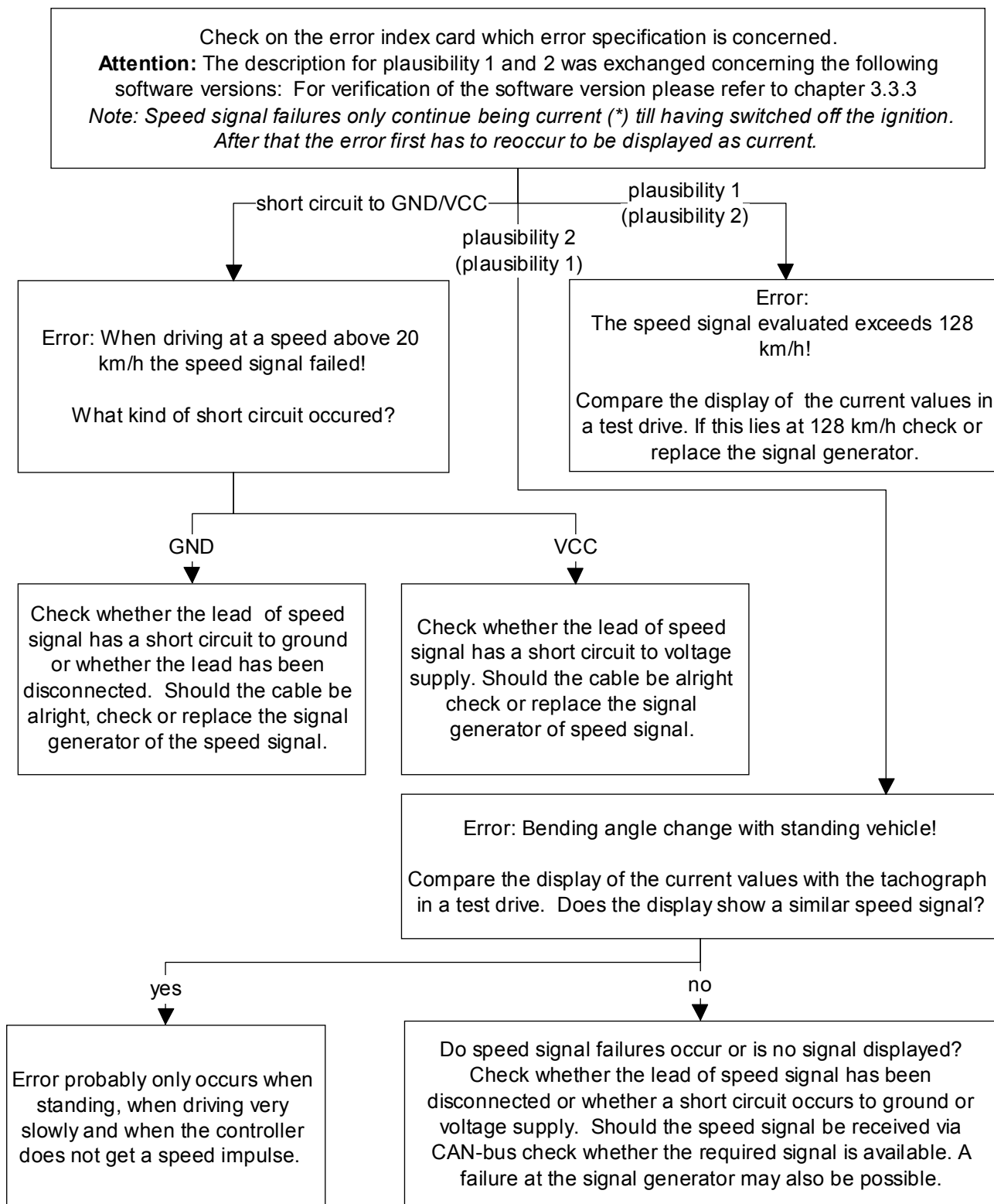
An error in the electrical system of the potentiometer/sensor or its cabling.

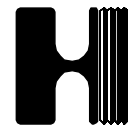


3. Communication and Diagnosis

3.3.5.4.2 Error No. 2: Speed Signal

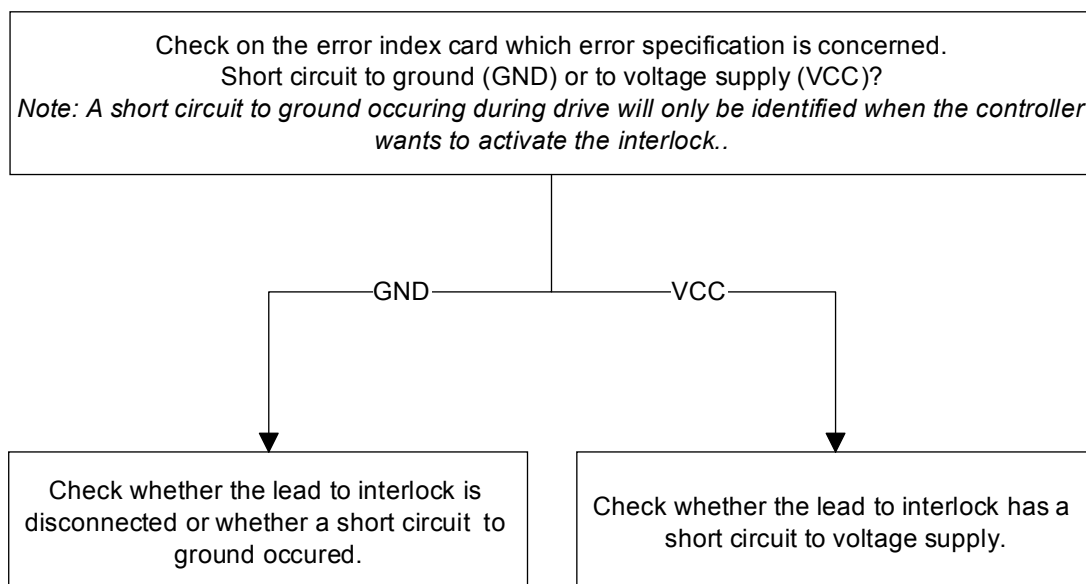
An error of speed signal or its cabling.





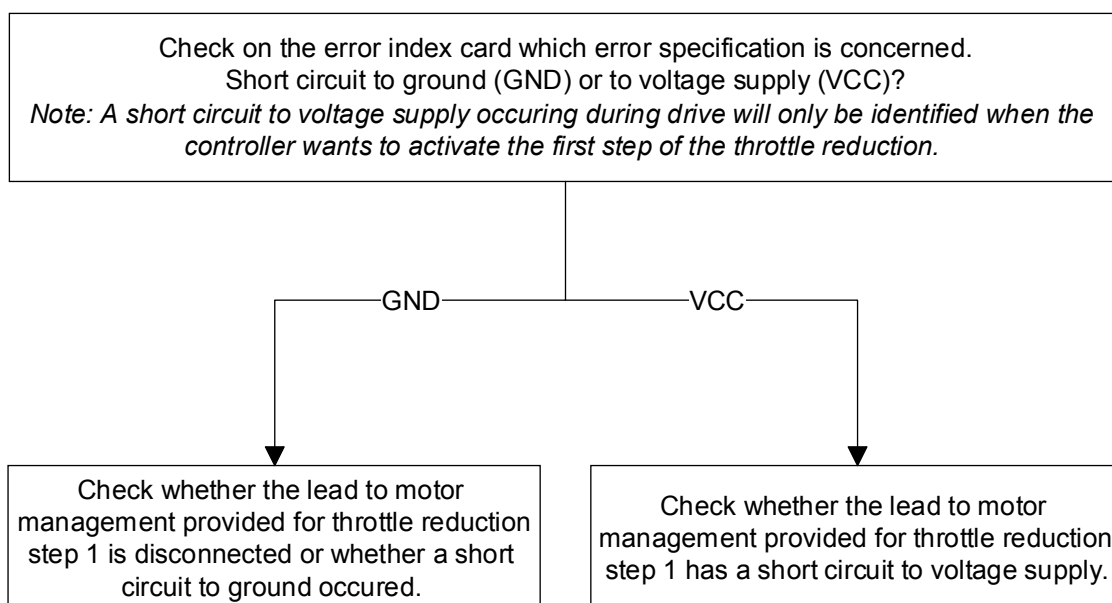
3.3.5.4.3 Error No. 3: Interlock Output

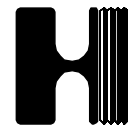
An error of the interlock output or its cabling.



3.3.5.4.4 Error No. 4: EGAS 1

An error of the throttle reduction output 1 or its cabling.

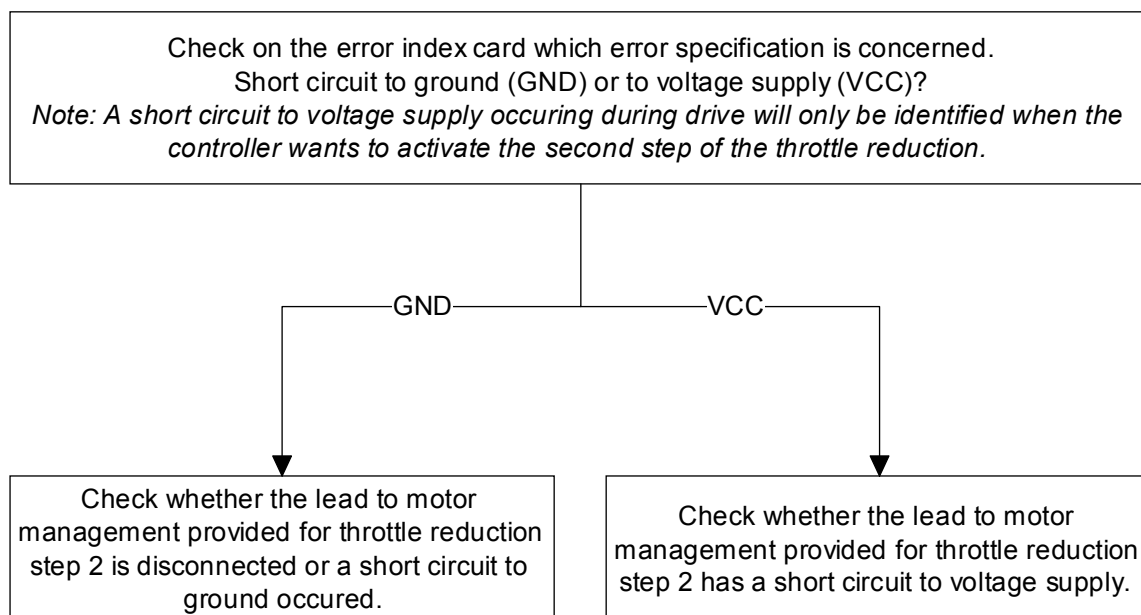


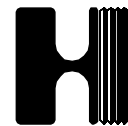


3. Communication and Diagnosis

3.3.5.4.5 Error No. 5: EGAS 2

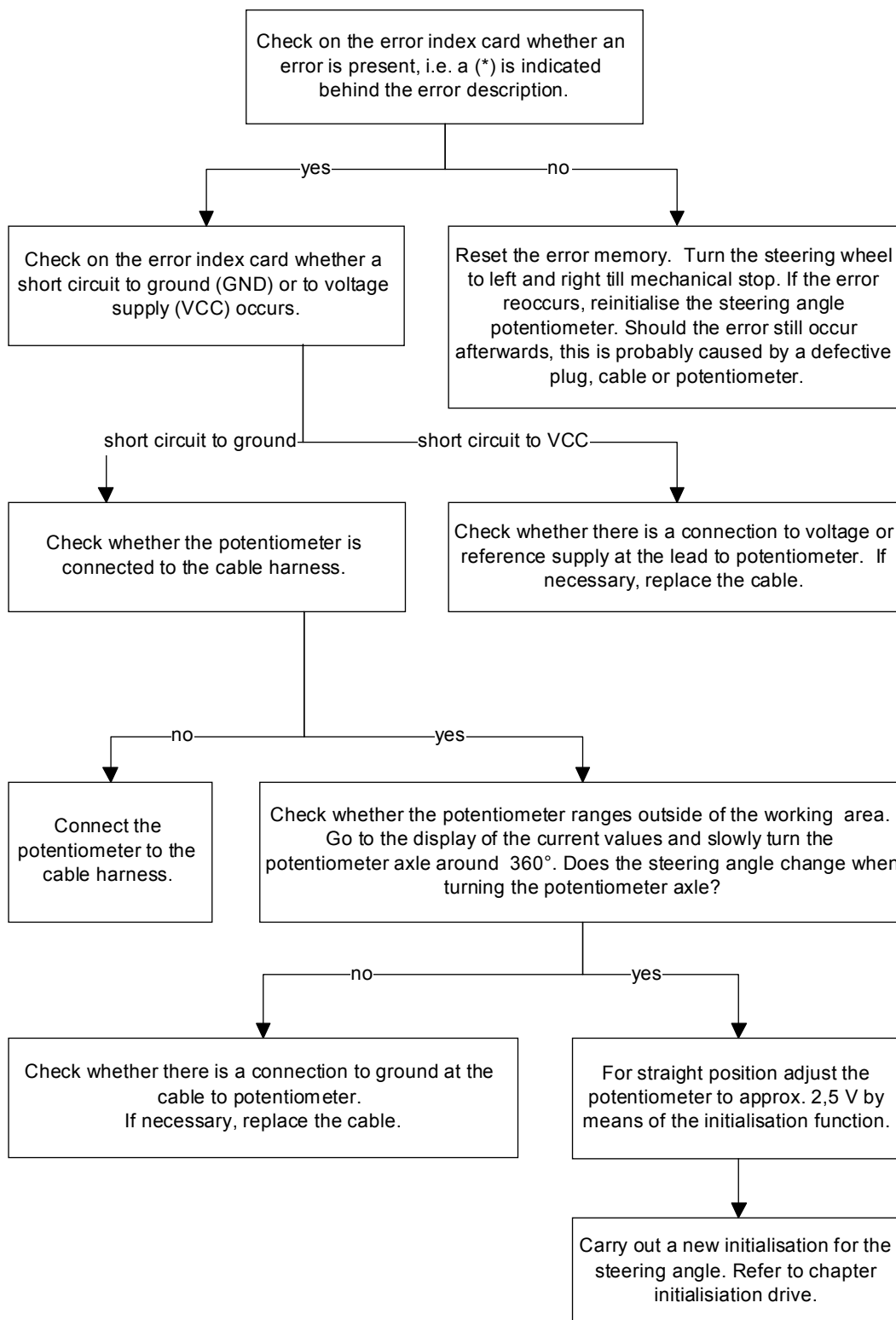
An error of the throttle reduction output 2 or its cabling.

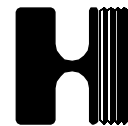




3.3.5.4.6 Error No. 6: Steering Angle Potentiometer, electric

An error in the electrical system of the potentiometer or its cabling.

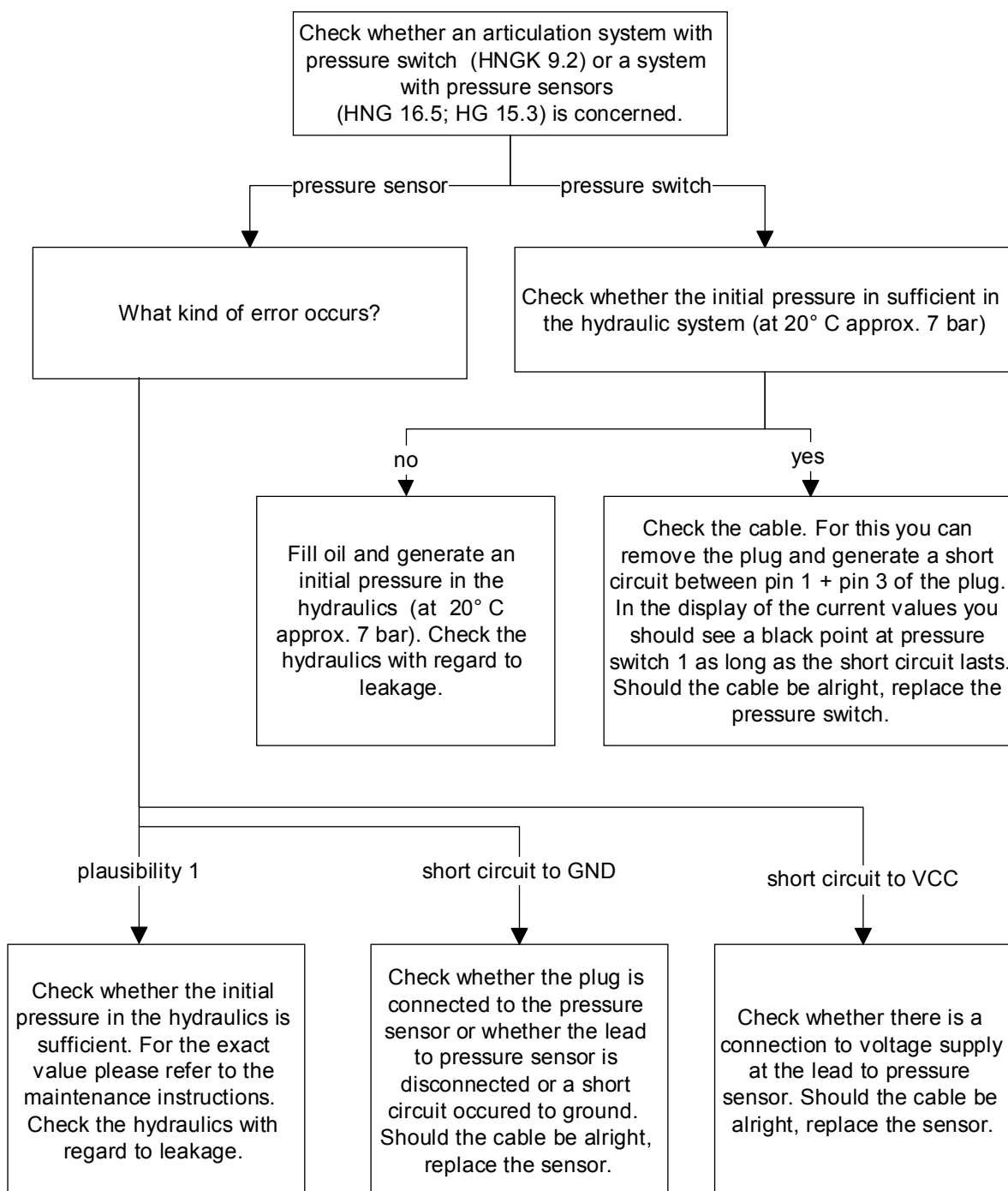


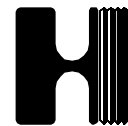


3.3.5.4.7 Error No. 7: Pressure Sensor / Pressure Switch 1

The minimum pressure in the hydraulic system has fallen short or a failure occurred in the electrical system of the pressure sensor or of the pressure switch of 3 bar or of its cabling. When using a two-cylinder hydraulic system the failure refers to the pressure sensor in cylinder 1.

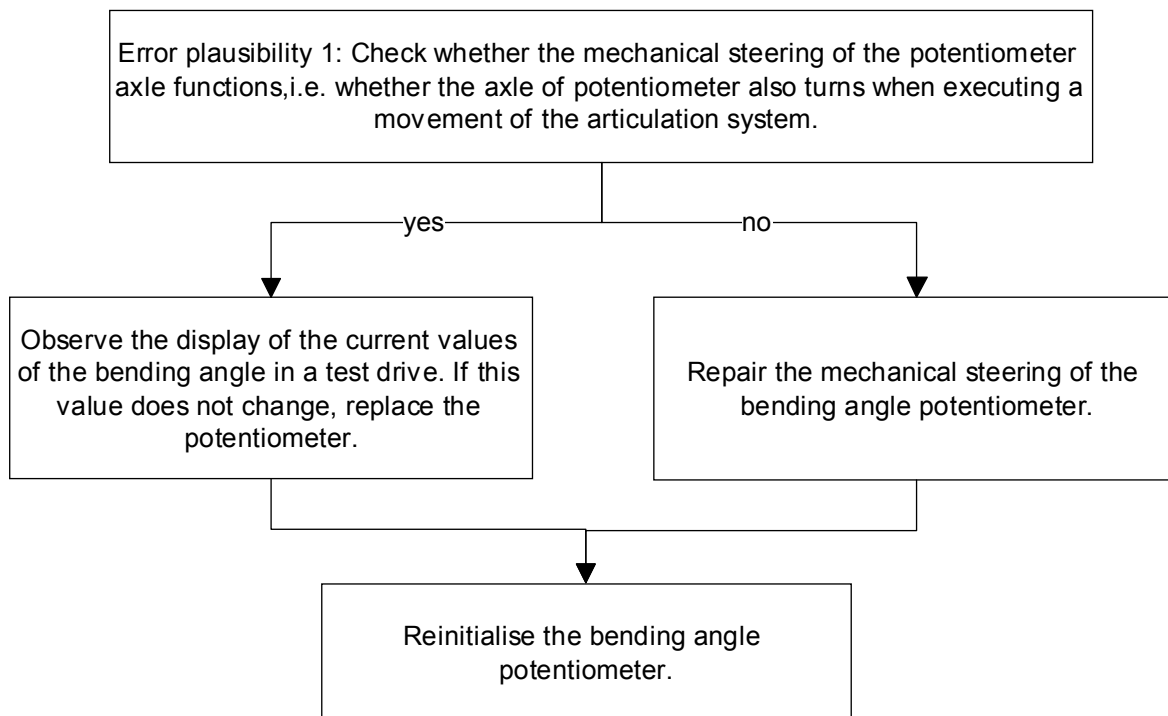
With the articulation system HNG 16.5 the cylinder 1 is located in travel direction left and with the articulation system HG 15.3 .at the right hand side. A pressure switch is installed with the articulation system HNGK 9.2. From the serial number on the type label you can see what type of articulation system applies (e.g. 165).





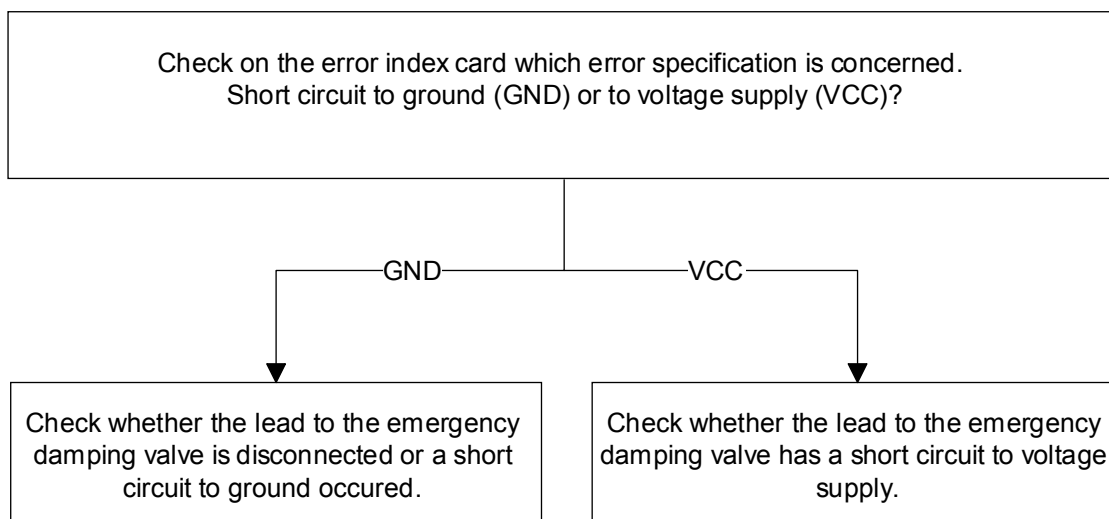
3.3.5.4.8 Error No. 8: Bending Angle Potentiometer, mechanical

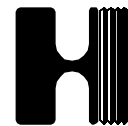
An error in the mechanical steering of the potentiometer.



3.3.5.4.9 Error No. 9: Emergency Damping Valve

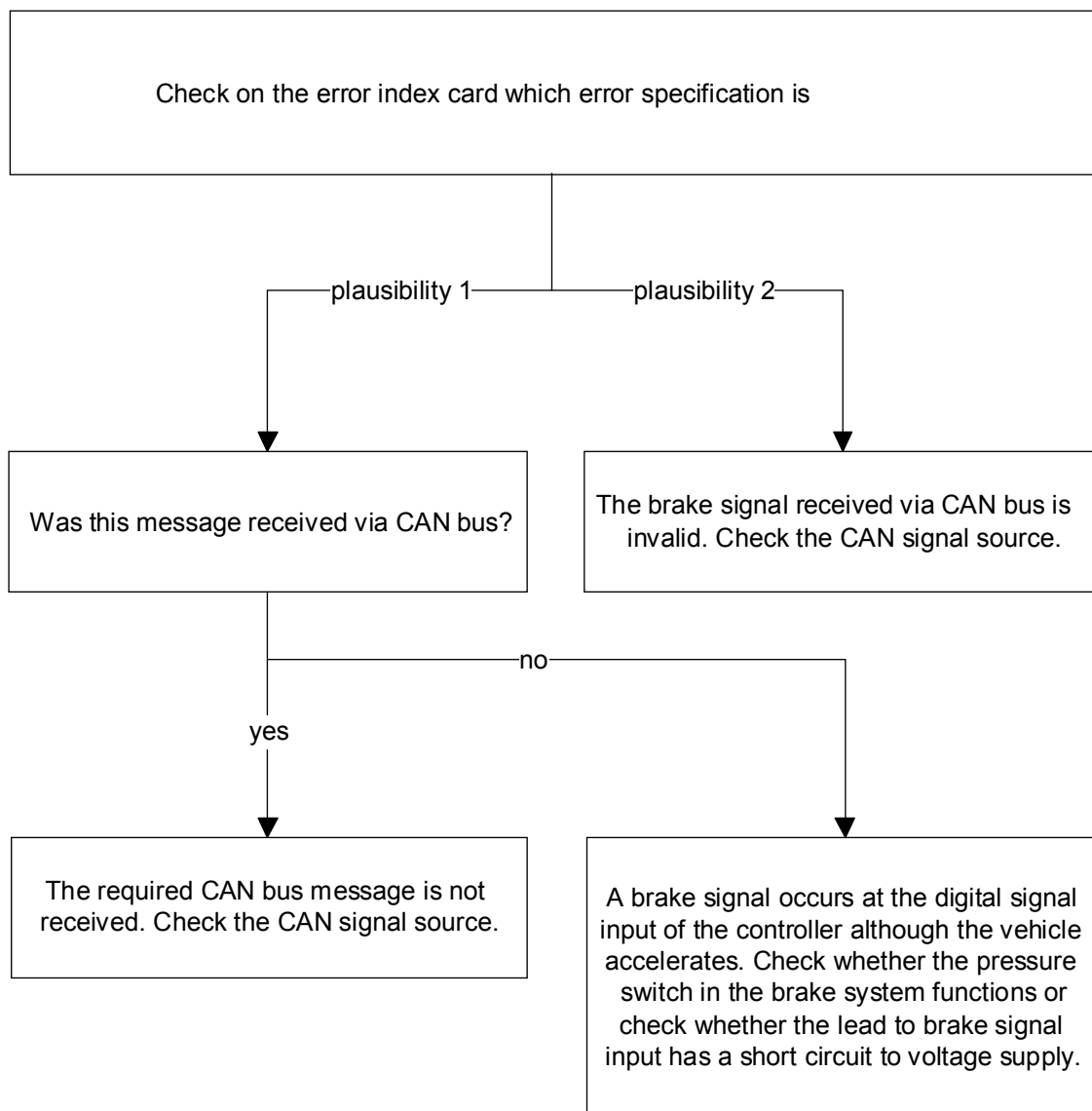
An error of the emergency damping valve output or its cabling.

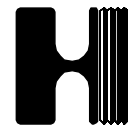




3.3.5.4.10 Error No. 10: Brake Signal Input

An error of the brake signal input or its cabling.

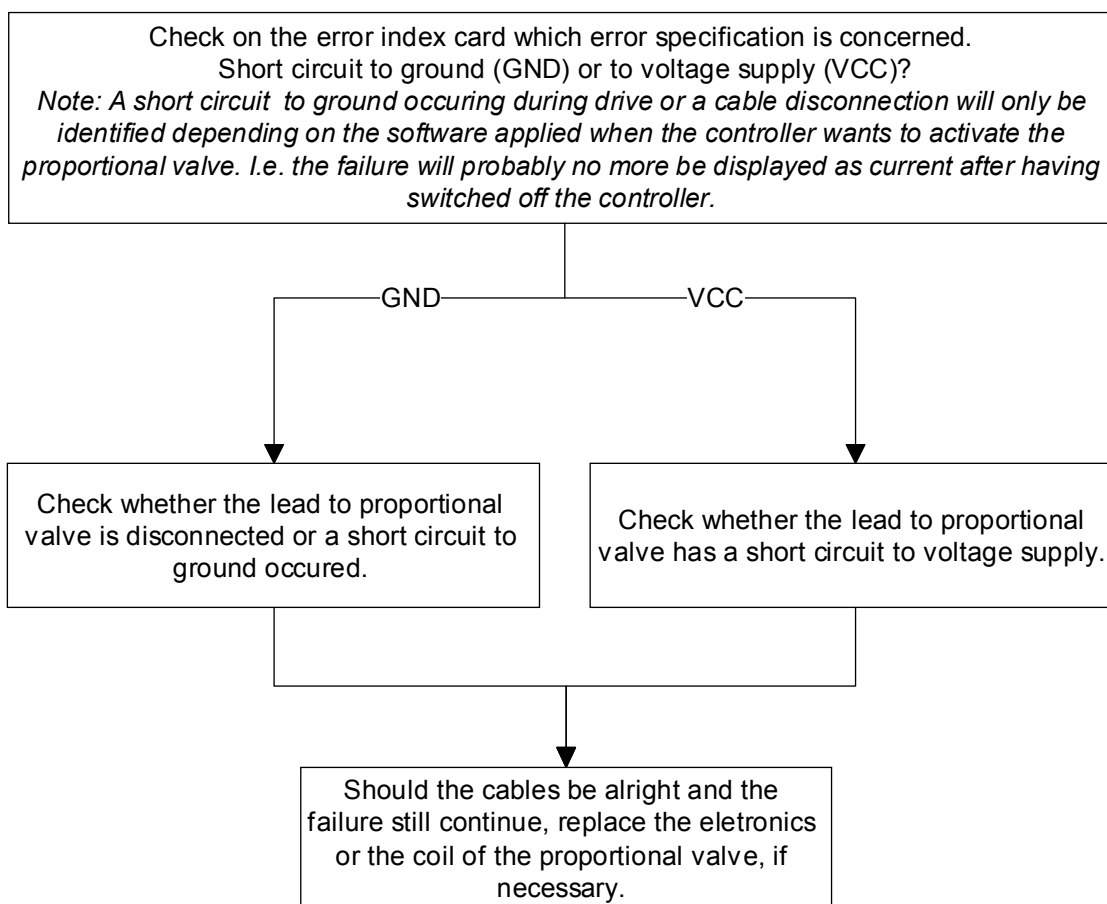


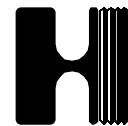


3.3.5.4.11 Error No. 11: Proportional Valve / Cylinder 1

An error of the proportional valve output or its cabling.

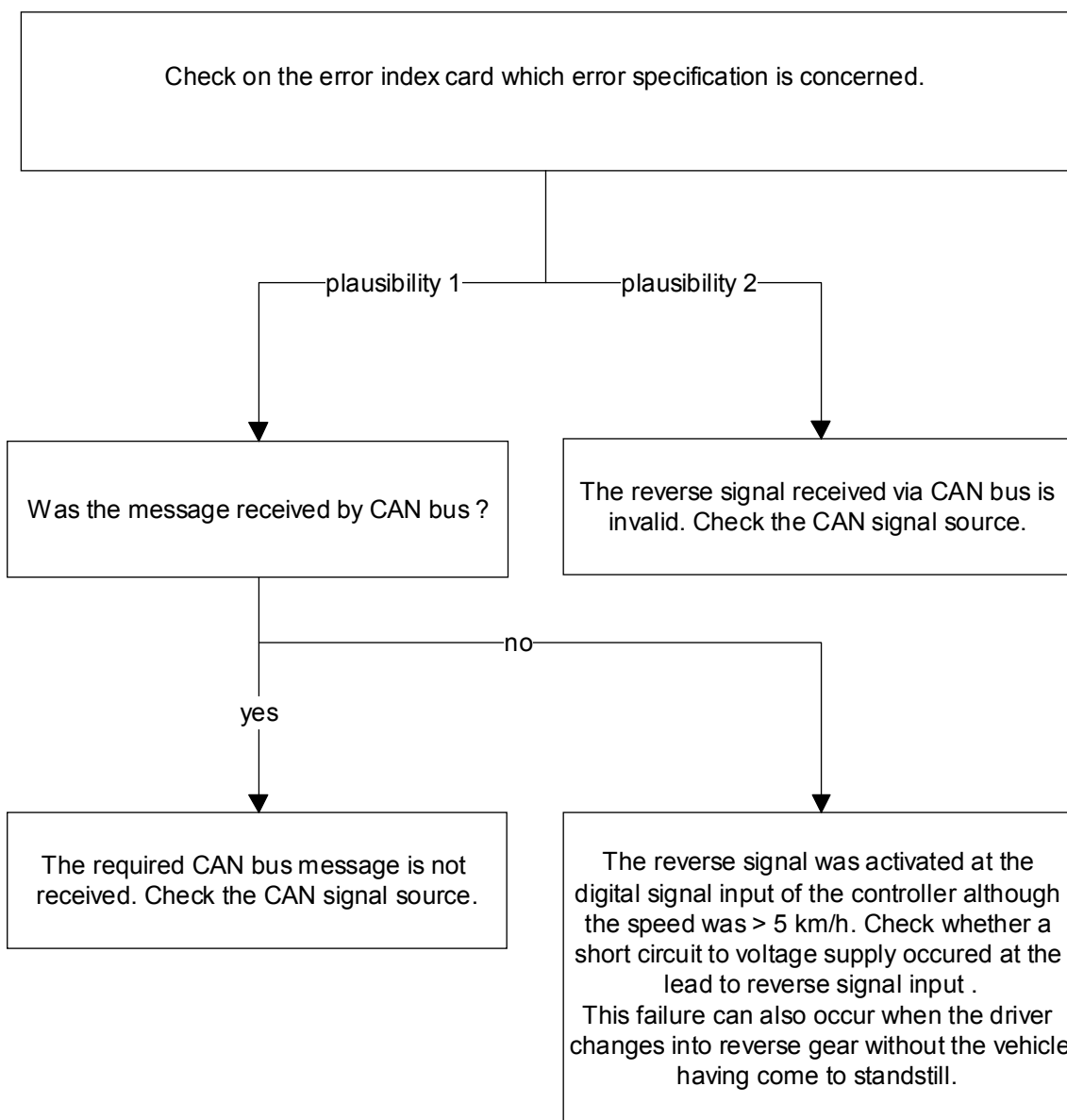
When using a two-cylinder hydraulic system the failure refers to cylinder 1. With the articulation system HNG 16.5 the cylinder 1 is located in travel direction left, and with the articulation system HG 15.3. From the serial number on the type label you can see what type of articulation system applies (e.g. 165).





3.3.5.4.12 Error No. 12: Reverse Signal

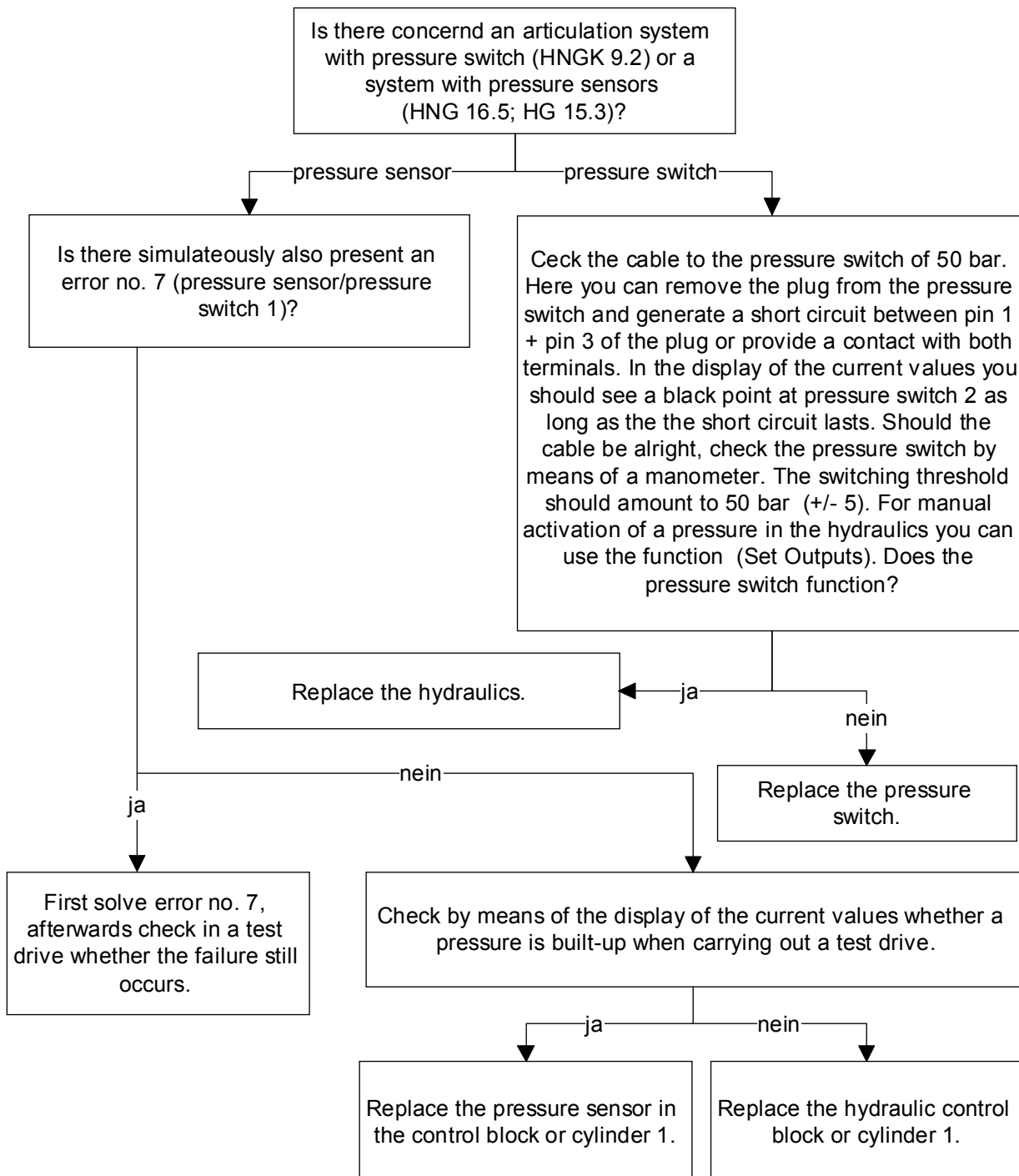
An error of reverse signal or its cabling.



3.3.5.4.13 Error No. 13: Pressure Range 1

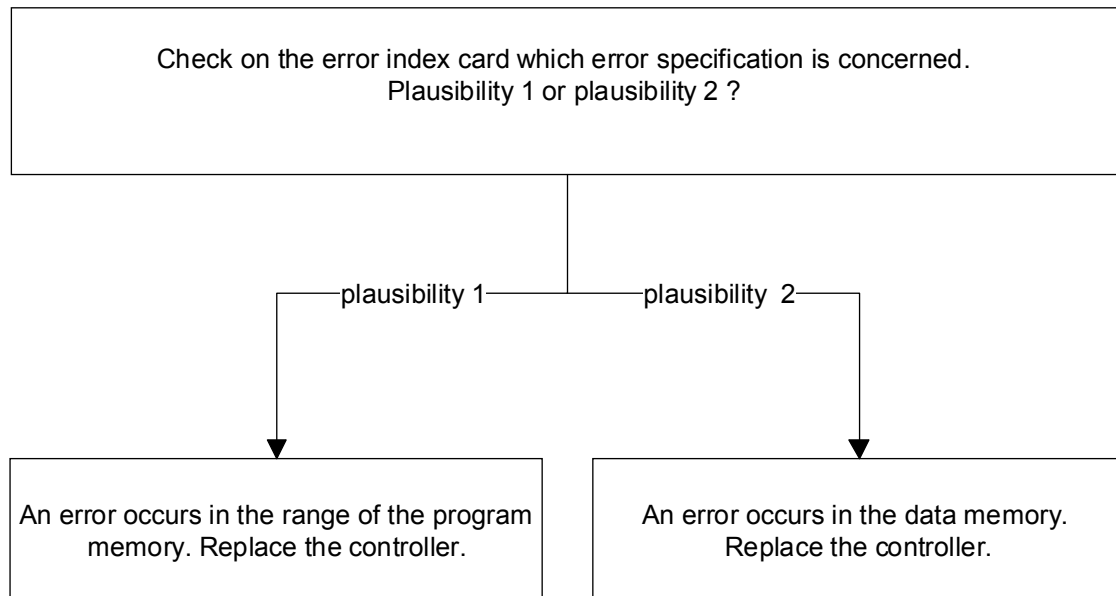
The specified pressure in the hydraulic system has not been reached or an error occurred in the electrical system of the pressure sensor or of the pressure switch of 50 bar or of its cabling. When using a two-cylinder hydraulic system the failure refers to the pressure built-up in cylinder 1.

With the articulation system HNG 16.5 the cylinder 1 is located in travel direction left, while located right with the articulation system HNGK 9.2. A pressure switch is installed with the articulation system HNGK 9.2. From the serial number on the type label you can see what type of articulation system applies. (e.g. 165).



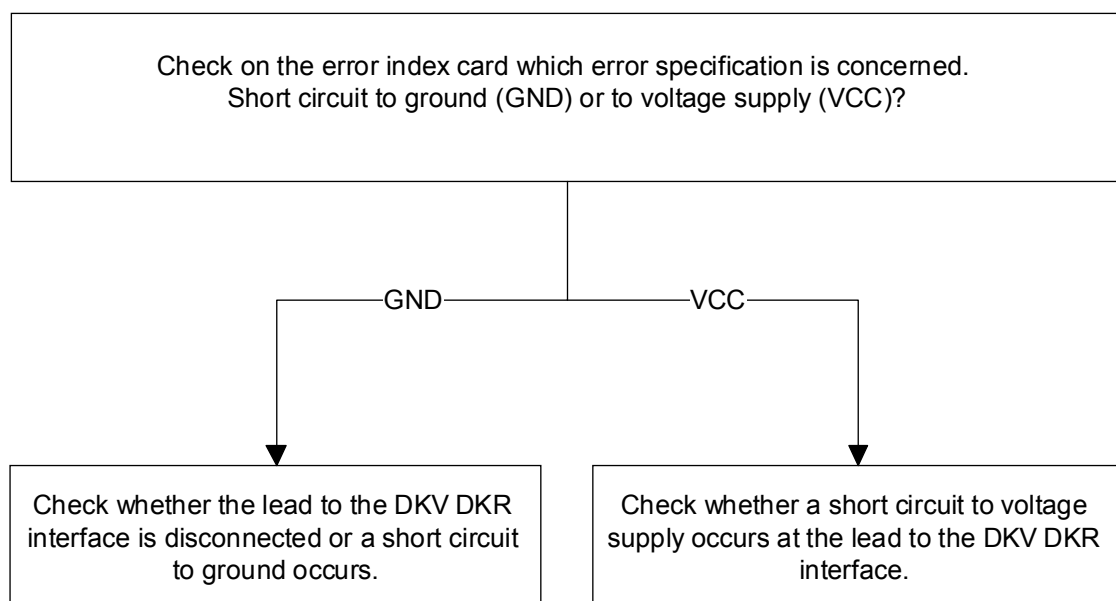
3.3.5.4.14 Error No. 14: Checksum

An error in the memory of the controller.



3.3.5.4.15 Error No. 15: DKV DKR Interface

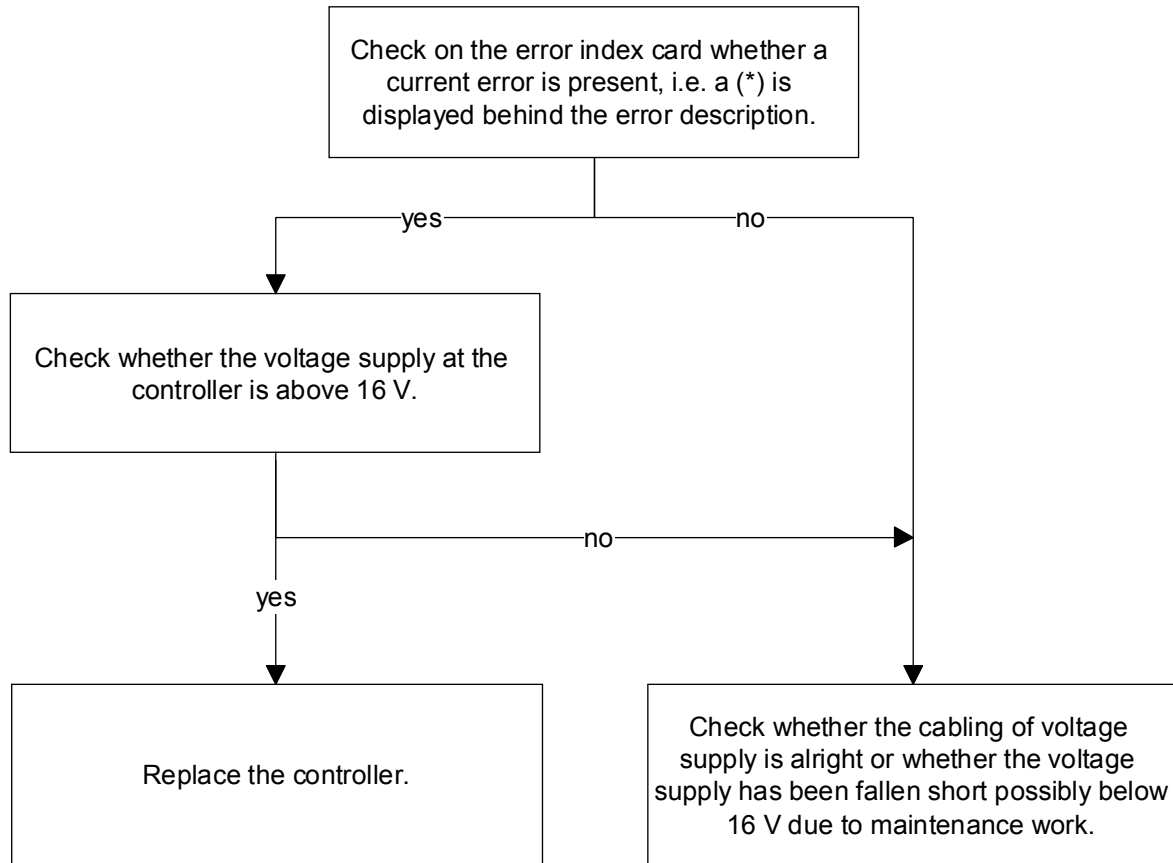
An error of the DKV/DKR interface or its cabling.





3.3.5.4.16 Error No. 16: Battery Voltage

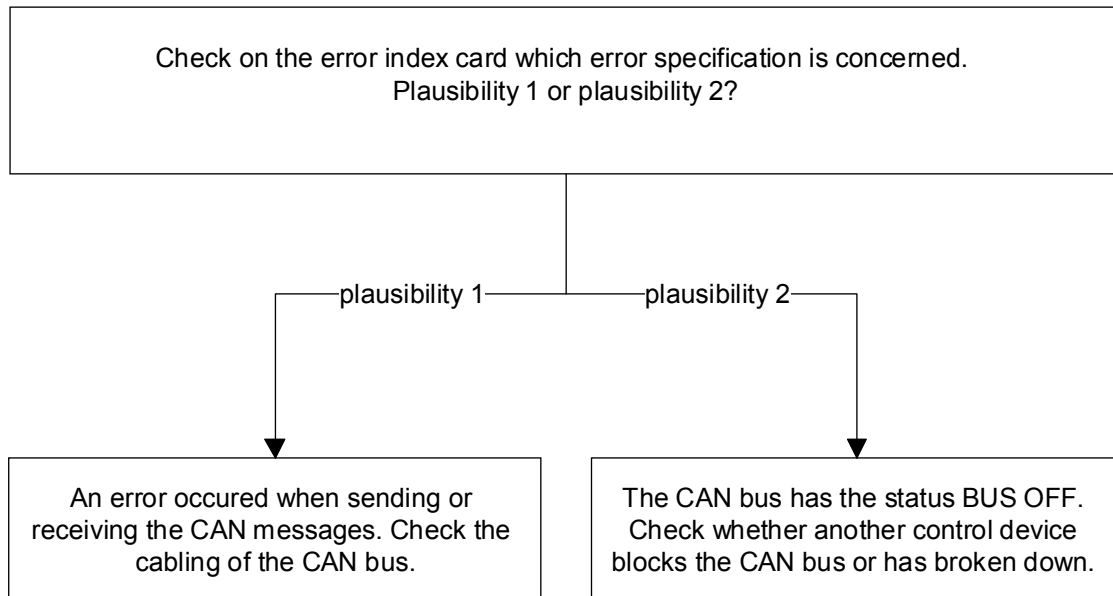
An error in the voltage supply of the controller occurs.





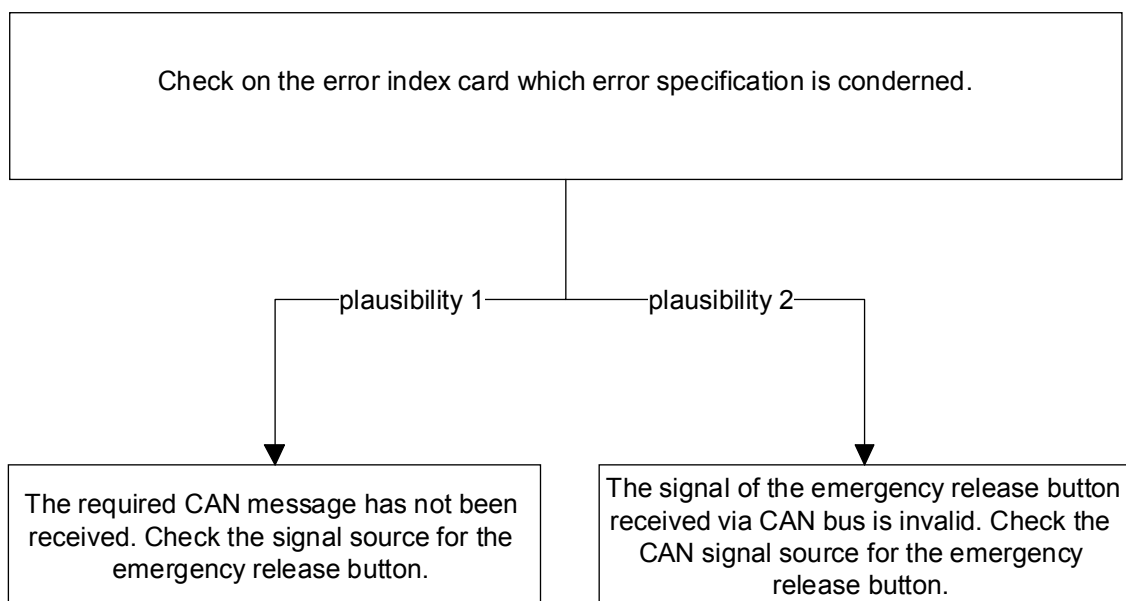
3.3.5.4.17 Error No. 17: CAN Bus

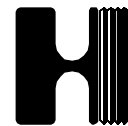
An error on the CAN bus of the controller occurs.



3.3.5.4.18 Error No. 18: Emergency Release Button

An error of the emergency release via the CAN bus or its cabling.

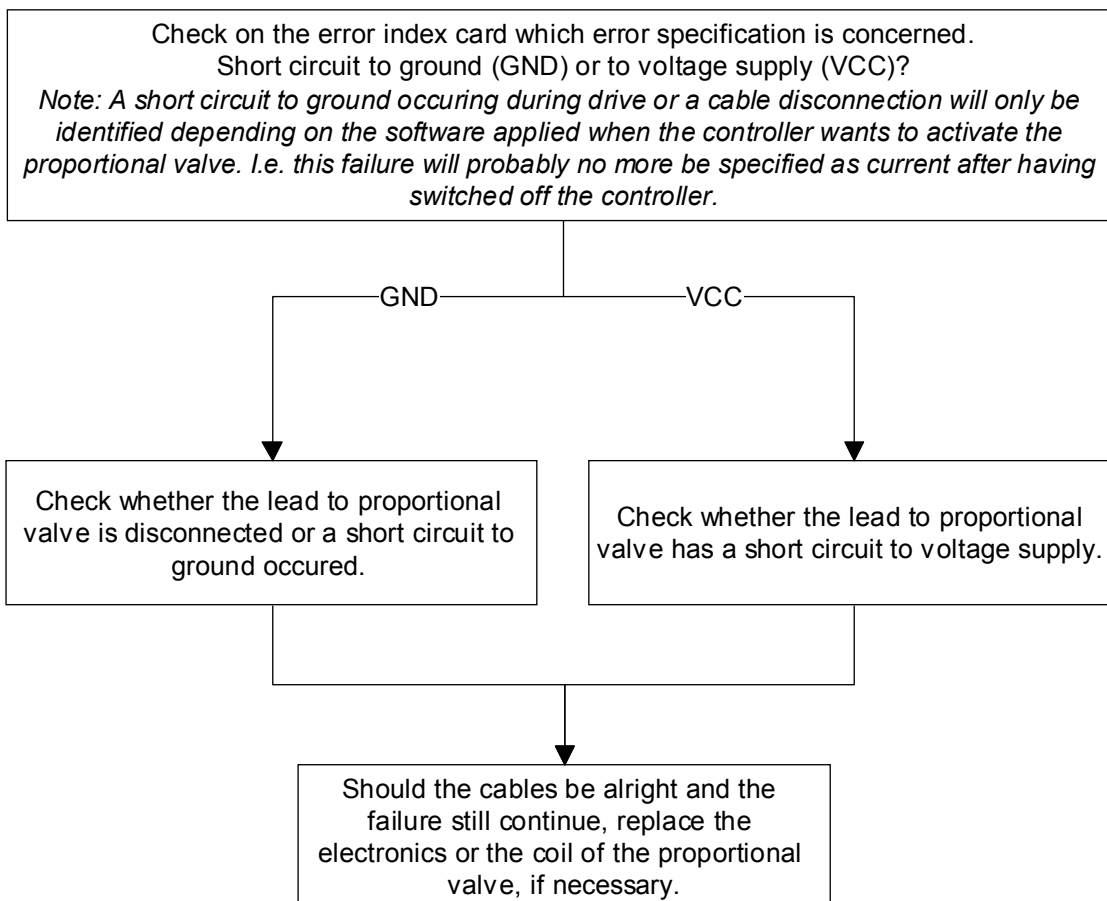




3.3.5.4.19 Error No. 20: Proportional Valve 2

An error of the proportional valve output 2 or its cabling.

With the articulation system HNG 16.5 cylinder 2 is located in travel direction right, and with the articulation system HG 15.3. From the serial number on the type label you can see what type of articulation system applies (e.g. 165).

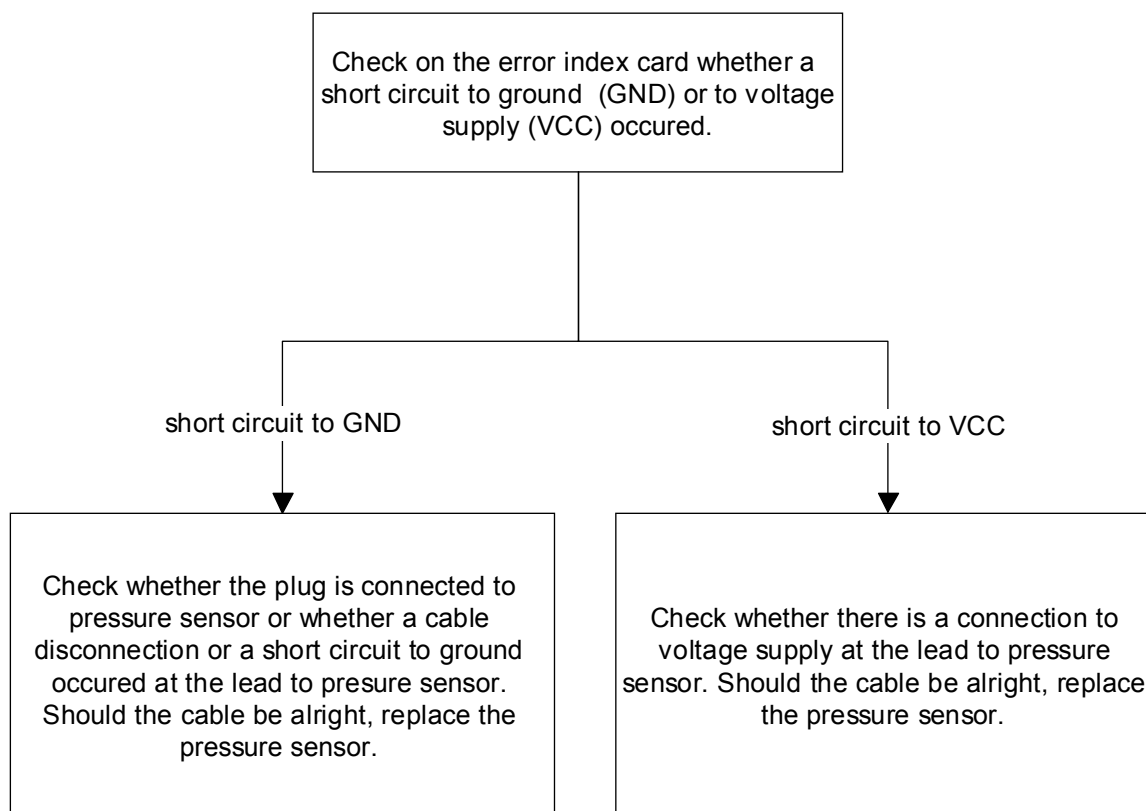




3. Communication and Diagnosis

3.3.5.4.20 Error No. 21: Pressure Sensor 2

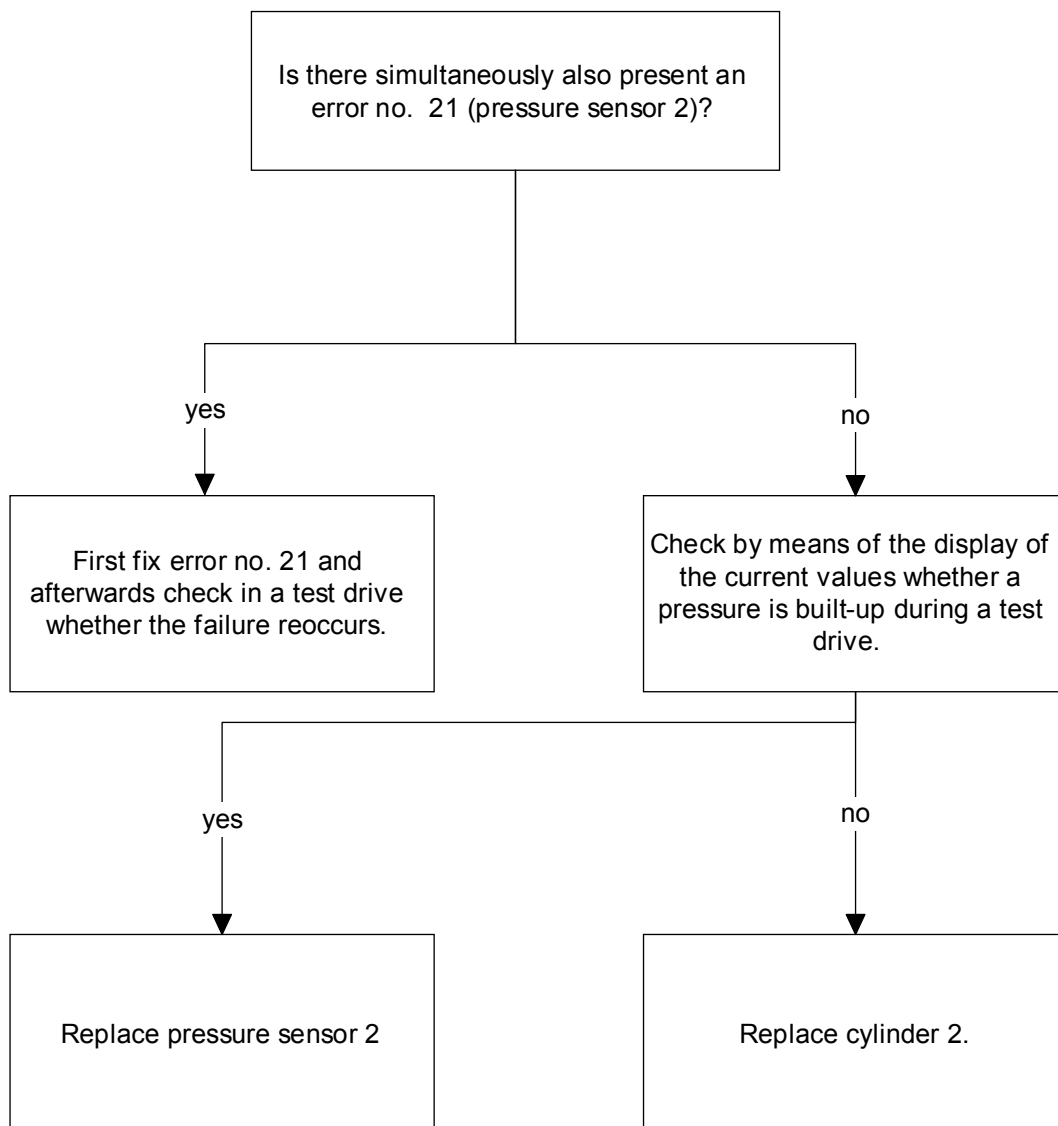
An error in the electrical system of the pressure sensor 2 or its cabling occurs. With the articulation system HNG 16.5 cylinder 2 is located in travel direction right, and with the articulation system HG 15.3. From the serial number on the type label you can see what type of articulation system applies (e.g. 165).





3.3.5.4.21 Error No. 23: Pressure Range 2

The specified pressure in the hydraulic system has not been reached or a failure occurred in the electrical system of the pressure sensor its cabling. When using a two-cylinder hydraulic system the failure refers to the pressure built-up in cylinder 2. With the articulation system HNG 16.5 cylinder 1 is located in travel direction right, and with articulation system HG 15.3. From the serial number on the type label you can see what type of articulation system applies (e.g. 165).



3.3.6 Testing of Outputs

In order to test the function of the outputs and the wiring of the connected controls each output can be activated individually through the ACU. For this use menu point *Set outputs* or the corresponding button in the main window.

After selecting the required output it can be switched on and off cyclically. The repetition time and duration of operation can be changed. The output via CAN is also activated parallel to the digital outputs.

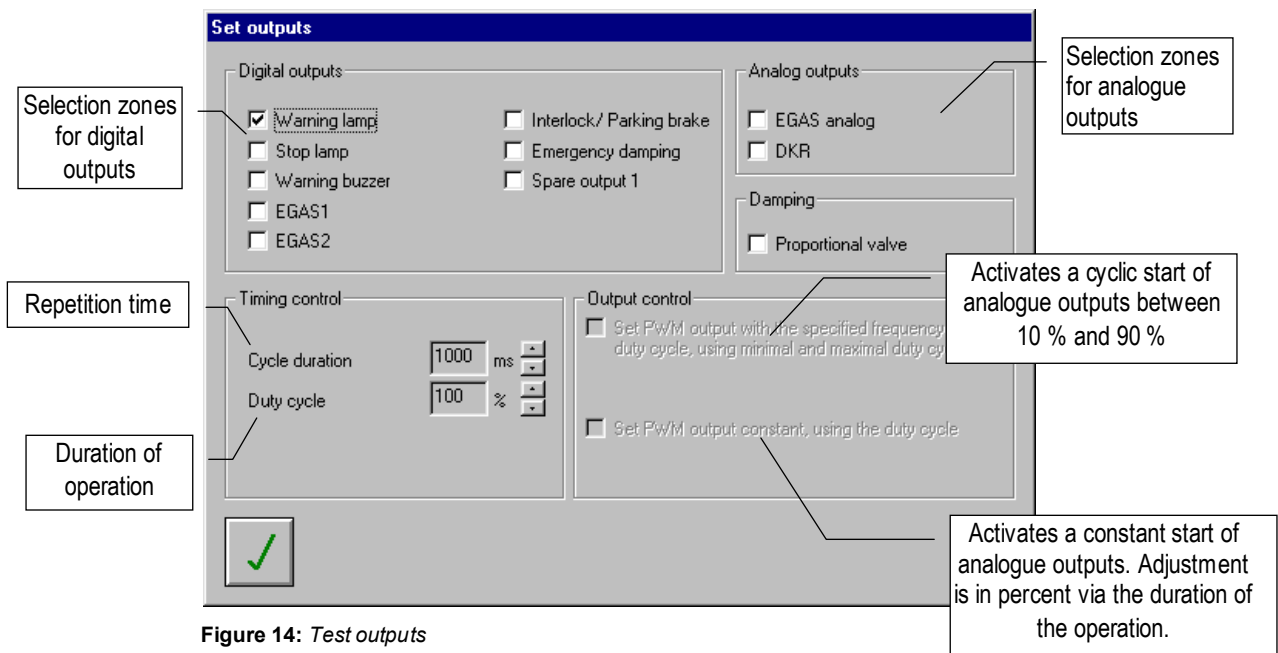


Figure 14: Test outputs

When leaving the window with an activated output the output remains active. This function is used for the simpler error research as the window with the current values can be used to observe the reaction of the output to further inputs. In order to prevent that the driving safety is impaired by the function testing the outputs can only be tested with a speed of < 15 km/h.

The testing mode for the outputs is automatically stopped when leaving the diagnosis program.

3. Communication and Diagnosis

3.4 Initialisation Drive

This chapter describes the sequence of initialisation of the bending angle and steering angle potentiometer (optional).

In order to align the physical angles of the vehicle with the electric values of the potentiometer after a potentiometer or the controller have been exchanged an initialisation is required. For this it is differentiated between the potentiometer for the bending angle and the potentiometer for the steering angle. Both must be initiated independently from each other and the values calculated must be saved in the control unit.

3.4.1 Initialisation of the Bending Angle

For the initialisation of the bending angle first initiate communication with the control and go to menu point **Initialize Potentiometers** in the menu **Parameter**.

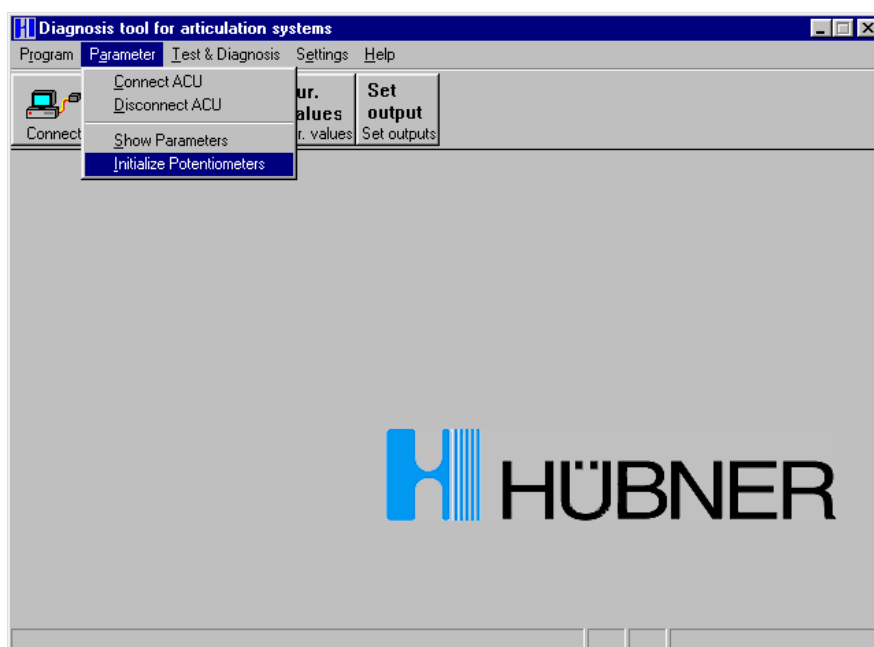


Figure 15: Initialisation of potentiometer

Now the initialisation window occurs and you have the option to select the potentiometer which should be initialised. At the same time the old values of the last initialisation which are already recorded in the control are shown as voltage values.

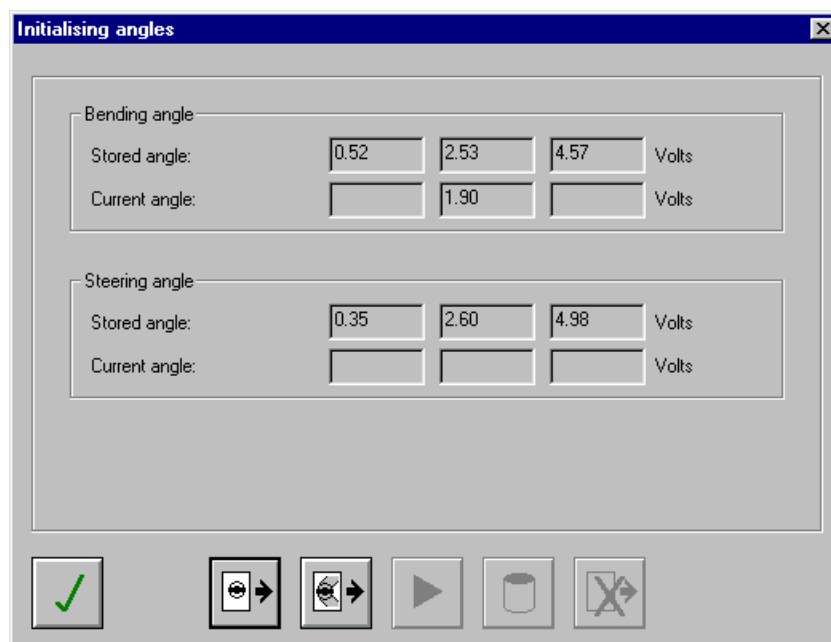


Figure 16: Initialisation window

Start the initialisation process by means of the  button. It follows the request to align the vehicle.

Align the vehicle in a way that it faces straight ahead. This is aided by viewing the vehicle from the outside.

During vehicle alignment you can see in the display window how the current voltage value for the straight position modifies. In the ideal case this value should range between 2,35 V and 2,65 V after vehicle alignment. If the value is out of this range, this means that the potentiometer is not mounted in the correct position so that a mechanical readjustment of the mounting position is required at the potentiometer.

When the vehicle is aligned and the indicated value is in the permissible range, press the start button  and confirm with „YES“ in the interrogation window.

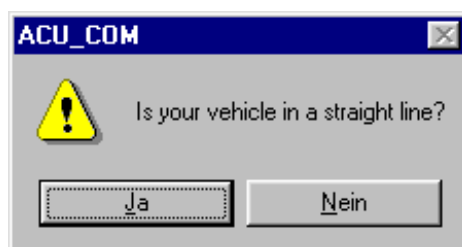
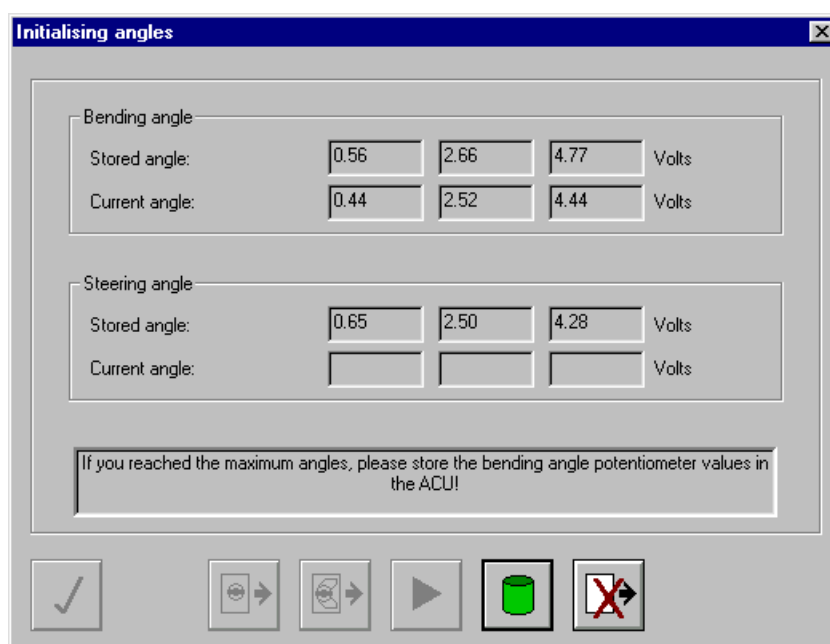


Figure 17: Interrogation of the vehicle position



During the initialisation process the safety functions of the vehicle are switched off. Please drive with extreme care as otherwise the vehicle could be damaged.

After confirmation the current angle is indicated 3 times for you. The program requests you to bend the articulation system at maximum to the right and the left. For this please reverse carefully till reaching the mechanical stop ri/le of the articulation system and observe the missing safety function to the articulation system.



Initialising angles						
Bending angle						
Stored angle:	0.56	2.66	4.77	Volts		
Current angle:	0.44	2.52	4.44	Volts		
Steering angle						
Stored angle:	0.65	2.50	4.28	Volts		
Current angle:				Volts		
If you reached the maximum angles, please store the bending angle potentiometer values in the ACU!						
☐ ☐ ☐ ☐ ☐ ☐						

Figure 18: Calculated values of the bending angle

During the initialisation drive the diagnosis program records the calculated maximum and minimum values and keeps them in the memory. During the drive you can watch the alteration of the voltage values.

After termination of the initialisation drive you are requested to press the  button in order to save the determined values in the control system. If the initialisation process should be aborted without saving press

the  button. When the memory process has been successfully completed the determined values are shown to you as saved values.

Now you can leave the window with the  button or start another initialisation process.

Should the following error message occur during the memory process, this results from the voltage values which have been exceeded or fallen short. Please ensure that the potentiometer has been mechanically mounted with reference to the already above mentioned range of 2,35 V and 2,65 V for the straight position.



Figure 19: Error during the save process of the initialisation values

3.4.2 Initialisation of Steering Angle

The initialisation of the steering angle potentiometer is carried out according to the same scheme. Please initiate the communication with the control system and go to the menu point **Initialize Potentiometers** in the menu **Parameter**. (See figure 24).

Start the initialisation process for the steering angle using the  button. Afterwards you are requested to align the vehicle steering.

Align the vehicle steering in a straight position. This is facilitated by moving the vehicle slightly forward as an adjustment during standstill is mostly inaccurate.

During the vehicle alignment you can observe in the display window how the current voltage value for the straight position modifies. In the ideal case this value should range between 2,35 V and 2,65 V after vehicle steering alignment. If the value is out-of-range, the potentiometer is not mounted in the correct position so that at the potentiometer a mechanical readjustment of the mounting position is required.

When the vehicle steering is aligned and the indicated value is in the permissible range, press the start button  and confirm with "YES" in the interrogation window.

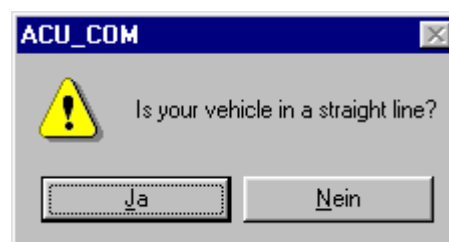
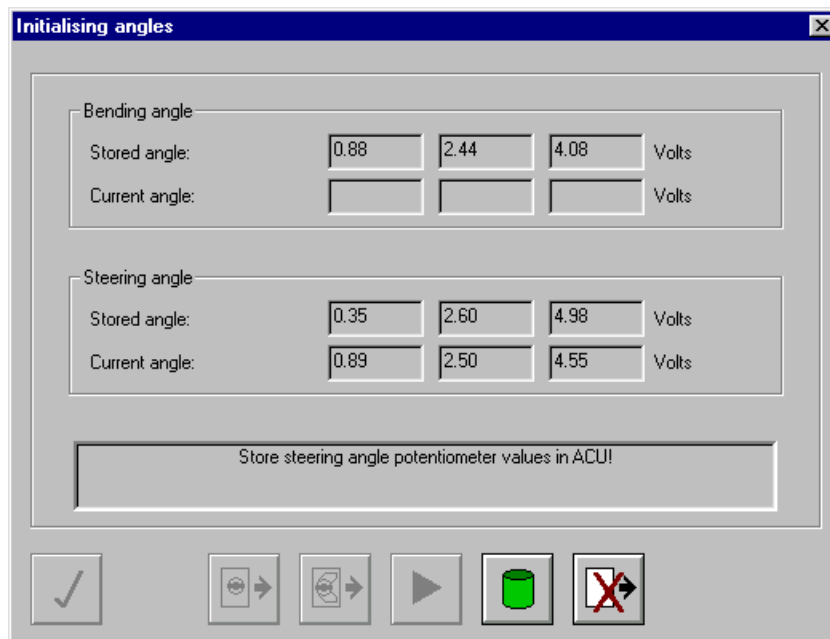


Figure 20: Interrogation of vehicle position



During the initialisation process the safety functions of the articulation system are switched off. Please drive with extreme care as otherwise the vehicle could be damaged.

After confirmation the same value is indicated to you three times. Now the program requests you to turn the vehicle steering to the left and right as far as possible (maximum). As in the standing position the vehicle steering can not be turned to the maximum in the most cases, this is made simplified by driving a circle in forward direction and at the same time turning the vehicle steering to the maximum. Please keep in mind that the safety functions of the articulation system are missing.



The dialog box titled "Initialising angles" contains two sections: "Bending angle" and "Steering angle". Each section has "Stored angle" and "Current angle" labels, followed by three input fields and a "Volts" label. The "Steering angle" section also includes a text box with the instruction "Store steering angle potentiometer values in ACU!". At the bottom, there are five buttons: a checkmark, a left arrow, a right arrow, a green cylinder, and a red X with a right arrow.

Section	Type	Value 1	Value 2	Value 3	Unit
Bending angle	Stored angle	0.88	2.44	4.08	Volts
	Current angle				Volts
Steering angle	Stored angle	0.35	2.60	4.98	Volts
	Current angle	0.89	2.50	4.55	Volts

Store steering angle potentiometer values in ACU!

Figure 21: Calculated values of the steering angle

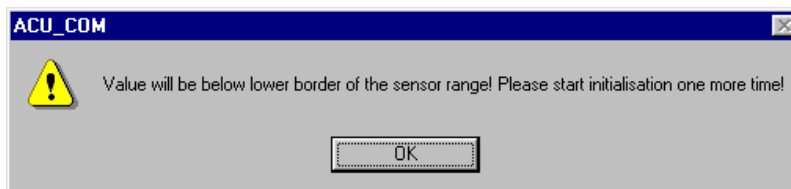
During the initialisation drive the diagnosis program records the calculated maximum and minimum values and keeps them in the memory. During the drive you can watch the alteration of the voltage values. After

completion of the initialisation drive you are requested to press the  button to save the calculated values in the memory of the control unit. In order to aborted a initialisation process without saving please

press the  button. If the memory process has been completed successfully the determined values are

shown to you as saved values. Now you can leave the window with the  button or start another initialisation process.

Should the following error message occur during the memory process, this results from the maximum or minimum permissible voltage values which have been exceeded or fallen short. Please make sure that the potentiometer was mechanically mounted with reference to the already above mentioned range of 2,35 V and 2,65 V for the straight position.



The dialog box titled "ACU_COM" displays a yellow warning triangle icon and the message: "Value will be below lower border of the sensor range! Please start initialisation one more time!". An "OK" button is located at the bottom.

Figure 22: Error during save process of the initialisation values

4. Replacement Instructions

4 Replacement Instructions

4.1 Replacement of the Controller

The control system is supplied in various versions, whereas the electronics is identical for all models. The differences of the casing boxes result from the mounting places, because the mounting has to be made by placing it directly into the articulation system or externally to the vehicle, depending on the type of articulation system installed.

The connection of the control system with the hydraulics or electronics of vehicle is made by means of a cable harness which is prepared for every case of application.

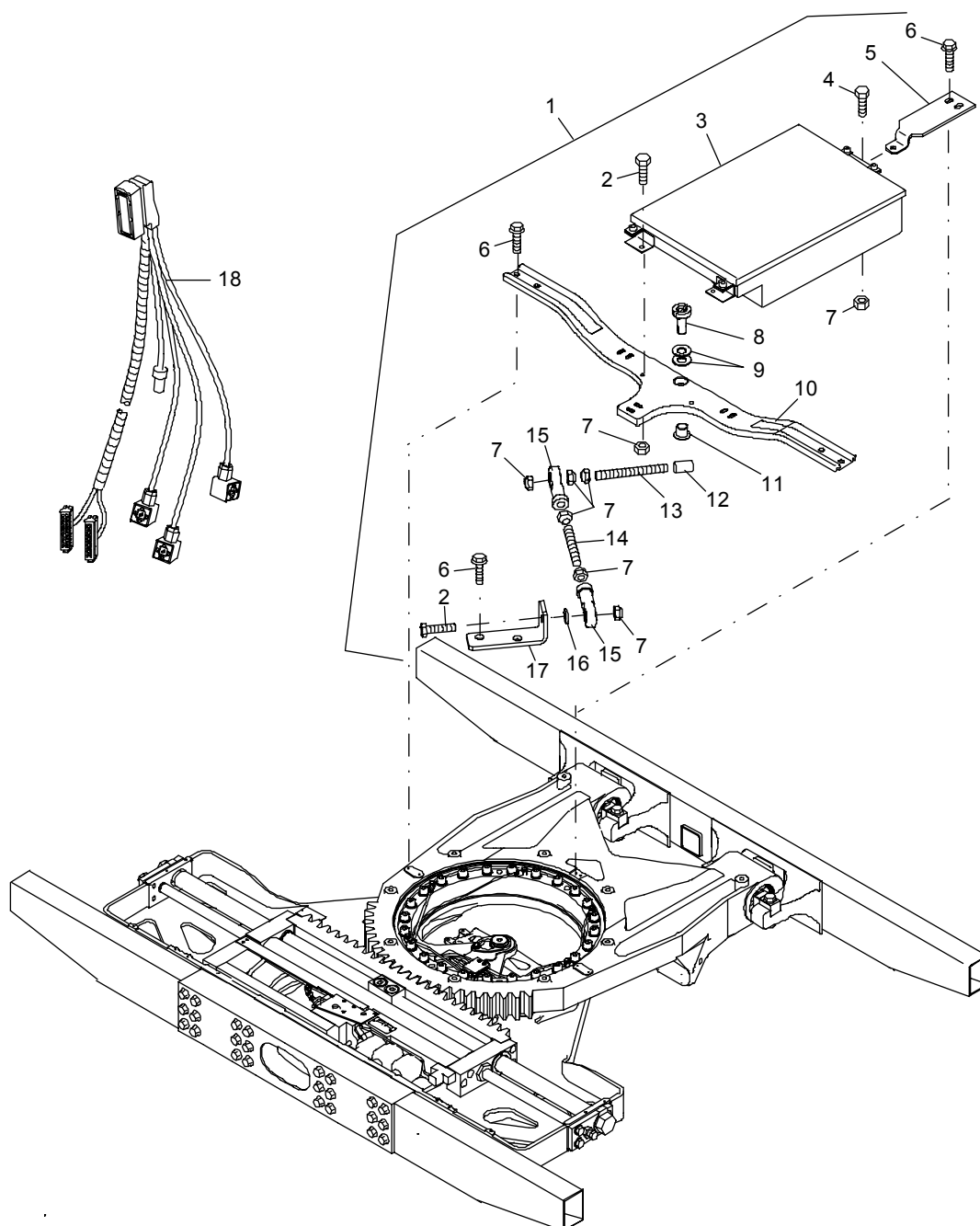


Figure 23: Example: Mounting situation of ACU in articulation system HNGK 9.2

4. Replacement Instructions

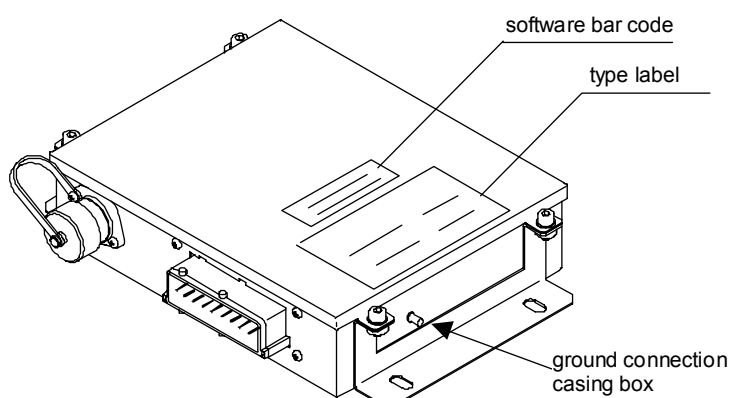


Figure 24: Example: Control system placed outside the articulation system



When replacing the control unit the voltage supply has to be switched off beforehand to prevent failures.

Please ensure that the new control unit provided for installation has the same software version as the control unit removed. You may check this by means of the bar code label on the casing cover. The same 15 digit part number with the appropriate code should be found on the label (e.g. 0422 0XXXX 00 000Y). In addition, you should compare the messages between the new and the previous control unit displayed when starting the diagnosis connection. (Cf. chapter 3.3.3 Setting up Connection with ACU . In the case that the messages vary or different bar code label are available, please contact the vehicle manufacturer.)



After replacement of the control unit provide a new initialisation of the potentiometer.

4.2 Replacement of the Potentiometer

The potentiometer required for the control system exists in various versions. Main difference is that the potentiometer is integrated into the control's casing box which is directly connected to the board when using the articulation system HNGK 9.2. With all other articulation systems the potentiometer is mounted externally and connected to the control system by the cable harness.

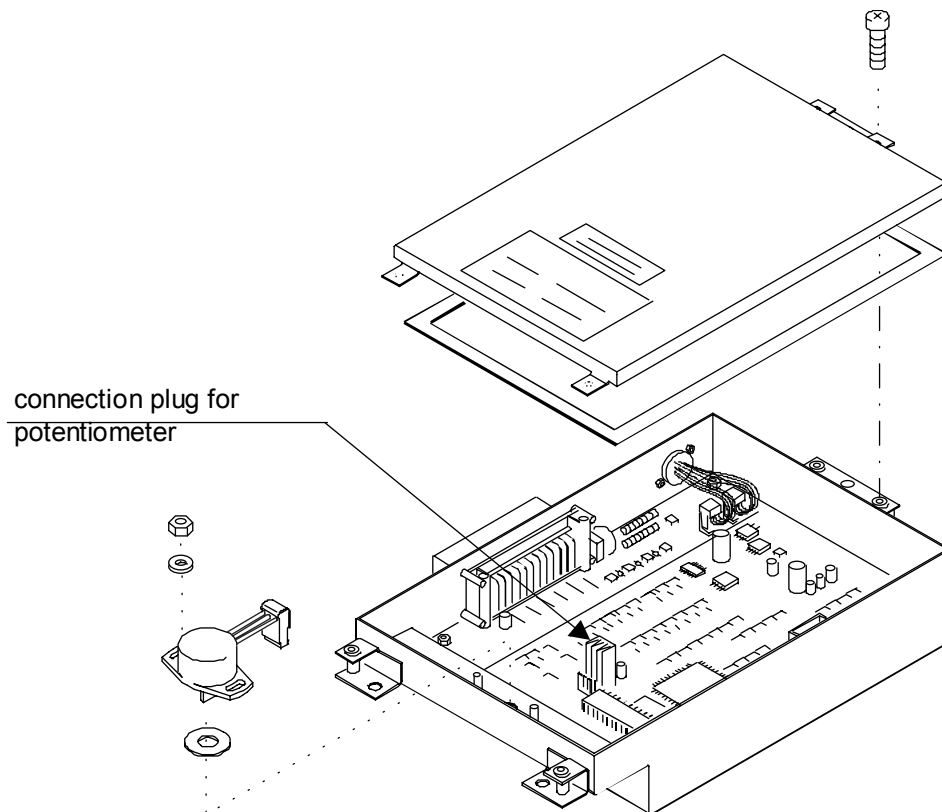


Figure 25: Mounting of potentiometer with the articulation system HNGK 9.2

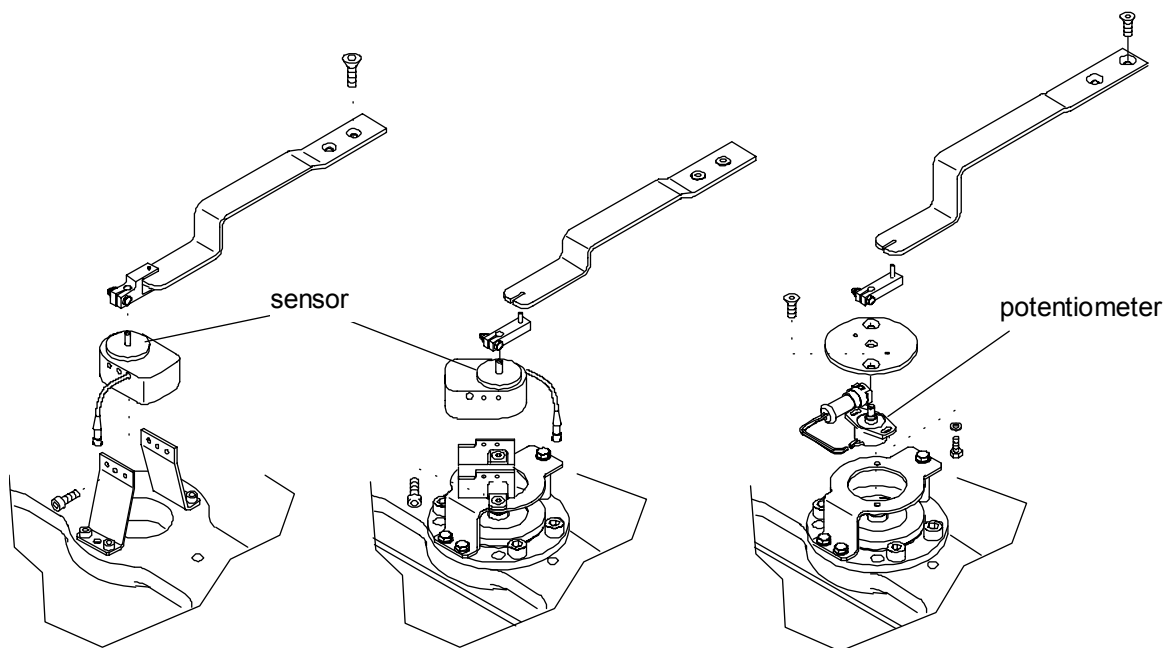


Figure 26: Mounting of the potentiometer with the articulation system HNG 15.3

4. Replacement Instructions

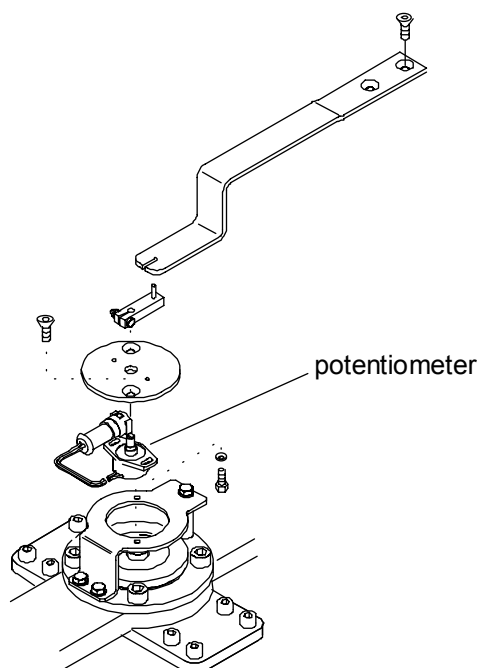


Figure 27: **Mounting of the potentiometer with the articulation system HNG 16.5**

When exchanging the potentiometer make sure that the mounting is carried out with a vehicle alignment in straight position and with a potentiometer in central position. According to the potentiometer design a marking is provided which marks this position.

As most of the potentiometer designs do not have a mechanical stop in order to avoid damages the potentiometer axle can be mounted in wrong position, i.e. turned of 180°. This leads to an error message in the control system concerning the bending angle. A wrongly installed potentiometer is not accepted during the initialisation. To check the installation in correct central position please proceed as described in the chapter 3.4.



After replacement of the potentiometer provide a new initialisation of the potentiometer.

4.3 Cable Harness

A cable harness is used for the connection of the ACU with the potentiometer, the hydraulics and the electronics of vehicle. The different kinds of design and length are adapted to the respective articulation systems or versions of hydraulics. For installation please refer to the Mounting Instructions of your articulation system. Should only a part of the cable harness be replaced, please observe to use only original cables because these have been especially adjusted for the service conditions and the articulation system. The use of an inappropriate cable can cause early wear and tear.

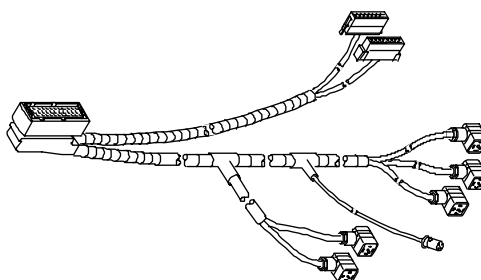


Figure 28: **Example: Cable harness of articulation system**



5. Specification of Signals

5 Specification of Signals

5.1 Digital Inputs

The following charts describe the technical characteristics of the digital inputs.

function	type of signal	signal name on plug	characteristics
pressure switch 1	$D_{IN-}U_{BAT}$	DSCH1	cut-off frequency 10Hz
pressure switch 2	$D_{IN-}U_{BAT}$	DSCH2	cut-off frequency 10 Hz
emergency releasing key	$D_{IN-}U_{BAT}$	NL	cut-off frequency 10 Hz
damping influencing	$D_{IN-}U_{BAT}$	DPF	cut-off frequency 10 Hz
reversing input 1	$D_{IN-} U_{BAT}$	RUE1	cut-off frequency 10 Hz
reversing input 2	$D_{IN-} U_{BAT}$	RUE2	cut-off frequency 227 Hz
reserve	$D_{IN-} U_{BAT}$	RES3	cut-off frequency 10 Hz
throttle reduction	DKV_{ST}	DKV	cut-off frequency 338 Hz
speed 1	$D_{IN-}B7/D3$	FGES1	cut-off frequency 2,9 kHz

$D_{IN-}U_{BAT}$ $\equiv$ switching to supply voltage, digital input with pull-down resistance against GND

$D_{IN-}B7/D3$ $\equiv$ switching to ground, digital input with pull-up resistance against U_{BAT}

DKV_{ST} $\equiv$ switching to ground, digital input with pull-up resistance against U_{BAT}

All digital inputs are equipped with a Schmitt-Trigger stage. A continuous short circuit against supply voltage U_{BAT} or against GND will **not** destroy the input.

Definition of digital inputs:

- $D_{IN-}UBAT$ = switching to positive, digital input with pull-down resistance against GND.

level high, typical	+ 24 V
level high, worst case	12,8 V ... U_{BAT}
level low, typical	0 V
level low, worst case	0 V ... 3,0 V
input resistance (pull-down), typical	5,6 k Ω
cut-off frequency of input filter (-3dB), typical	See chart: Digital Inputs



5. Specification of Signals

- DIN-B7/D3 = switching to ground, digital input with pull-up resistance (200 kOhm) against supply voltage U_{BAT}

level high, typical	+ 24 V
level high, worst case	3,5 V ... U_{BAT}
level low, typical	0 V
level low, worst case	0 V ... 2,0 V
input resistance (pull-down), typical	57 k Ω
cut-off frequency of input filter (-3dB), typical	2,9 kHz

- DKVST-input = switching to ground, digital input with pull-up resistance (22 kOhm) against supply voltage U_{BAT}

level high, typical	+24 V
level high, worst case	12,8 V ... U_{BAT}
level low, typical	0 V
level low, worst case	0 V ... 3,0 V
input resistance, typical	32 k Ω
cut-off frequency of input filter (-3dB), typical	338 Hz

5.2 Digital Outputs

The following charts describe the technical characteristics of the digital outputs.
The following digital outputs are realised on the articulation control unit ACU:

function	type of signal	PIN on plug	characteristics
proportional valve 1	$D_{OUT} U_B$	2/3	U_B -switching/ fix on GND
interlock	$D_{OUT} U_B$ / $D_{OUT} GND$	30/ 31	U_B -switching/ GND switching
warning lamp	$D_{OUT} GND$	4	GND-switching
stop lamp	$D_{OUT} GND$	18	GND-switching
warning buzzer	$D_{OUT} GND$	32	GND-switching
emergency damping	$D_{OUT} U_B$	5	U_B -switching
throttle reduction by DKR	$D_{OUT} GND$	19	GND-switching
throttle reduction 1	$D_{OUT} GND$	33	GND-switching
throttle reduction 2	$D_{OUT} GND$	6	GND-switching
reserve 1	$D_{OUT} GND$	16	GND-switching
reserve 2	$D_{OUT} GND$		GND-switching

$D_{OUT} U_B \equiv$ switching outputs U_B -switching (high-side outputs)

$D_{OUT} GND \equiv$ switching outputs GND-switching (low-side outputs)



5. Specification of Signals

Switching Outputs U_B -switching

The articulation control unit has 3 high-side outputs (switching outputs U_B -switching). The outputs serve for switching of ohmic and inductive loads (for lamps see output performance). The high-side outputs have the following characteristic data:

- Output PV1-P and ANF-P :

output voltage	$U_{BAT} - 1,4 \text{ V}$
nominal current output (min/max.)	0,85A ... 2,75 A*
short circuit current (typical switch-off)	16 A*

* The load and short circuit response is defined by the parameters of the driver (BTS726L1), see the corresponding data sheet.

- Output RUECK:

output voltage	$U_{BAT} - 1,4 \text{ V}$
nominal current output (min/max.)	0,15A ... 1,6 A*
short circuit current (typical switch-off)	2,7 A*

* The load and short circuit response is defined by the parameters of the driver (BTS410F), see the corresponding datasheet.

The high-side drivers have an integrated overvoltage protection diode. Due to EMC-reasons for inductive load it is necessary to connect an additional freewheeling diode as close as possible parallel to the load.

A continuous short circuit against supply voltage U_{BAT} of the articulation control unit or against GND will **not** destroy the output.

It is definitely **not** permitted to use the parallel connection of the outputs also with other systems. If this is explicitly provided the output should be externally uncoupled.

Switching Outputs GND-switching

The articulation control unit has 9 low-side outputs (switching outputs GND-switching). The outputs serve for switching of ohmic and inductive loads (for lamps see output performance). The low-side outputs have the following characteristic data:

- Output ANF-M:

output voltage	GND + 0,4 V
nominal current output (max.)	3,5 A*
short circuit current (typical switch-off)	> 30 A*

* The load and short circuit response is defined by the parameters of the driver (BTS121A), see the corresponding datasheet.

5. Specification of Signals

- Output RES1, RES2, FKTL,DKWL,SUMM, DKR, GBGR1, GBGR2 :

output voltage	GND + 0,4 V
nominal current output (max.)	0,7 A*
short circuit current	1 A – 1,9 A*

* The load and short circuit response is defined by the parameters of the driver(BTP75), see the corresponding datasheet

Due to EMC-reasons it is necessary with an inductive load to connect an additional freewheeling diode as close as possible parallel to the load.

A continuous short circuit against supply voltage U_{BAT} of the articulation control unit or against GND will **not** destroy the output.

It is definitely **not** permitted to use the parallel connection of outputs also with other systems. If this is explicitly provided the output should be externally uncoupled.

5.3 Speed Signal Input

In many cases the ACU receives its speed signal as impulses per stretch of way. The signal can be transmitted as simple uniform or as standardised frequency. In both cases the increasing share of impulses is identical at rising speed. The following images shows the usual appearance of a speed signal. For the definition of input please refer to chapter 5.1

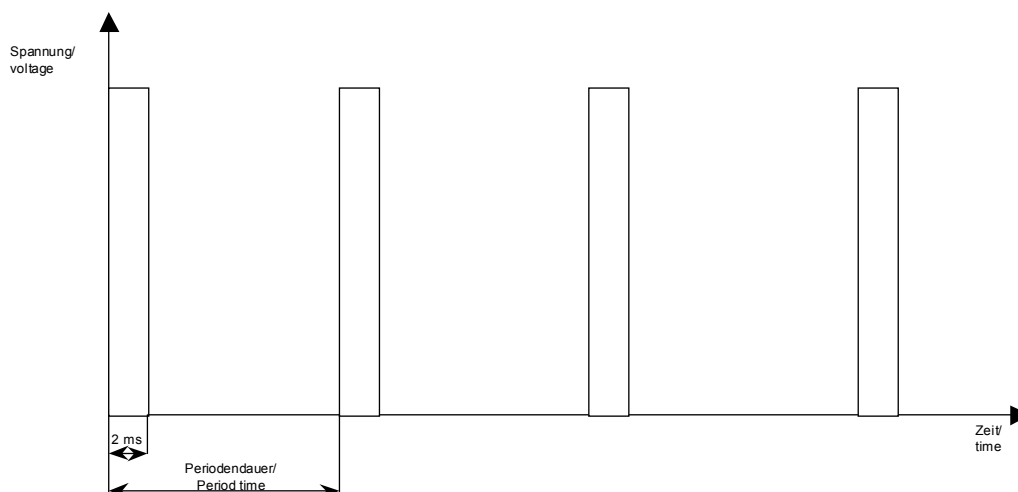


Figure 29: Standardised speed signal

5.4 Bending Angle Potentiometer Input

The bending angle signal represents a voltage which ranges between 0 and 5 V. It is read into the controller via an analogue input. The correlation of the exact angles to a voltage results from the initialisation drive as described in chapter **Error! Error source could not be found.** The following diagram only exemplifies the voltage values. The exact values are dependent on the vehicle.

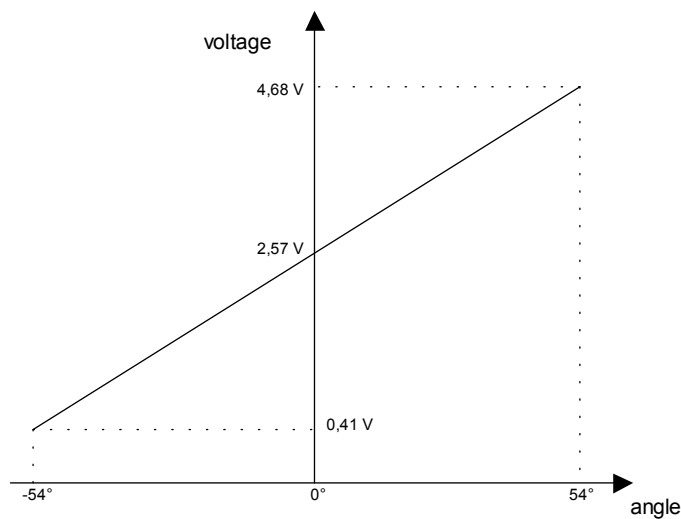


Figure 30: Example for characteristic line of a bending angle

5.5 Pressure Sensor Input

Similar to the bending angle signal the information about pressure is read in via an analogue input of the controller. Here the characteristic line of the pressure sensor has already been stored in the parameters of the controller. The operational range on the pressure sensor ranges between 0,5 and 4,5 V. When falling short or exceeding this range a breakdown of the sensor or its cabling can be diagnosed. The following diagram shows the progress of voltage with a sensor of 400 bar.

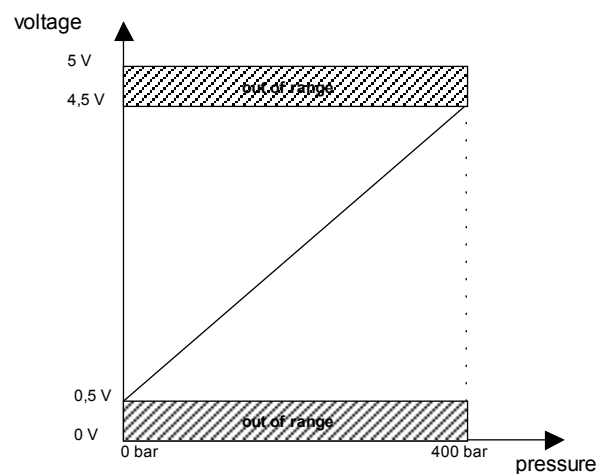


Figure 31: Pressure sensor of 400 bar

5. Specification of Signals

5.6 Proportional Valve Output

To control the current of the proportional valves a PWM signal is emitted with amplitude of the voltage supply. The current is infinitely variable by means of the pulse wide. depending on the software the frequency of output amounts to 200 or up to 500 Hz. Please observe that all valves connected are only designed for 12 V. This means that the regular pulse wide ranges between 0 and 50 %. A permanent drive with voltage supply may damage the valves.

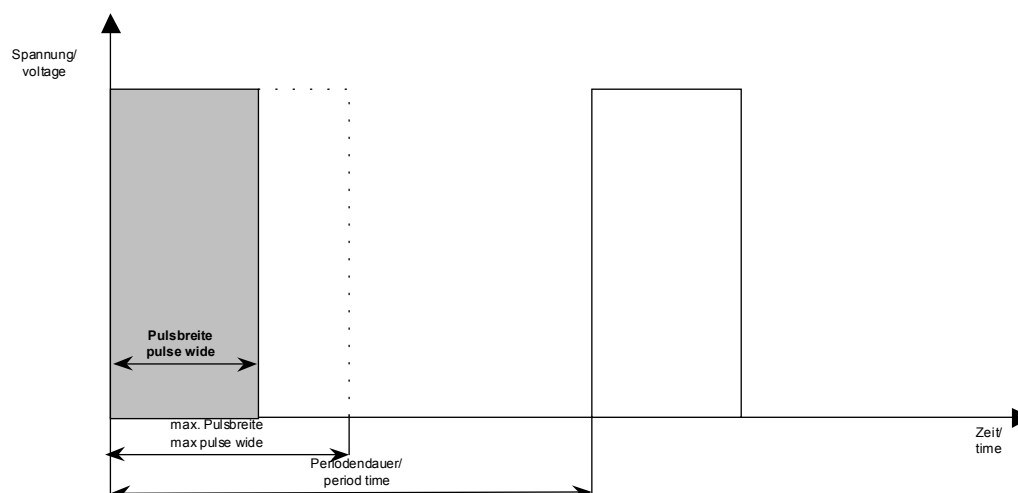


Figure 32: PWM signal to control the proportional valves



5. Specification of Signals

5.7 CAN Message

Block structure for CAN-message of ACU J1939

Length of message: 8 Byte

Transfer frequency: 50 ms

CAN-ID: 0x18FF07E7 (parameter can be achieved via diagnosis software)

Byte 0

Bit	Coding	Description
0..3	0000	System recognition, Initialisation completed
	0001	Not used
	0010	Not used
	0011	Not used
	0100	Not used
	0101	Not used
	0110	Not used
	0111	Not used
	1000	System recognition, Initialisation is running
	1001	Not used
	1010	Not used
	1011	Not used
	1100	Not used
	1101	Not used
	1110	Not used
	1111	Signal is not transferred
4..5	00	Function lamp is not active
	01	Function lamp is active
	10	Not used
	11	Signal is not transferred
6..7	00	Stop lamp is not active
	01	Stop lamp is active
	10	Not used
	11	Signal is not transferred

Byte 1

Bit	Coding	Description
0..7		Not used

Byte 2

Bit	Coding	Description
0..3	0000	Not control
	0001	Warning buzzer 1 – continuous sound
	0010	Warning buzzer 2 – low frequency
	0011	Warning buzzer 3 – high frequency
	0100	Not used
	0101	Not used
	0110	Not used
	0111	Not used
	1000	Not used
	1001	Not used
	1010	Not used
	1011	Not used
	1100	Not used
	1101	Not used
	1110	Not used
	1111	Signal is not transferred
4..5	00	Interlock is not active
	01	Interlock is active
	10	Not used
	11	Signal is not transferred



5. Specification of Signals

Byte 3

Bit	Coding	Description
0..7		Not used

Byte 4

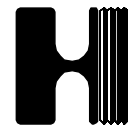
Bit	Coding	Description	Resolution	Value range
0..7	0..250 251.. 254 255	Steering angle Not used Signal is not transferred	0.5 Degree/Bit	-62.5 .. 62.5 Degree

Byte 5

Bit	Coding	Description	Resolution	Value range
0..7	0..250 251.. 254 255	Tilt angle Not used Signal is not transferred	0.5 Degree/Bit	-62.5 .. 62.5 Degree

Byte 6

Bit	Coding	Description	Resolution	Value range
0..7	0..250 251..254 255	Reduction Not used Signal is not transferred	0.4%/Bit	0.. 100%



6. Scheme of Connector Assignment

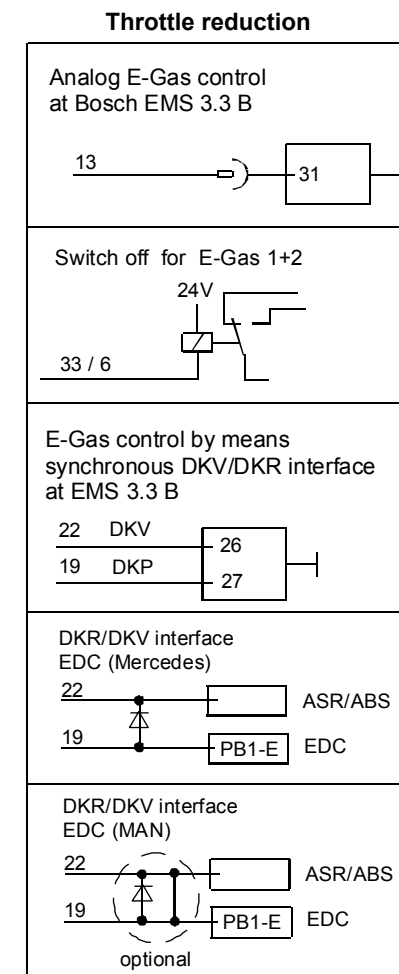
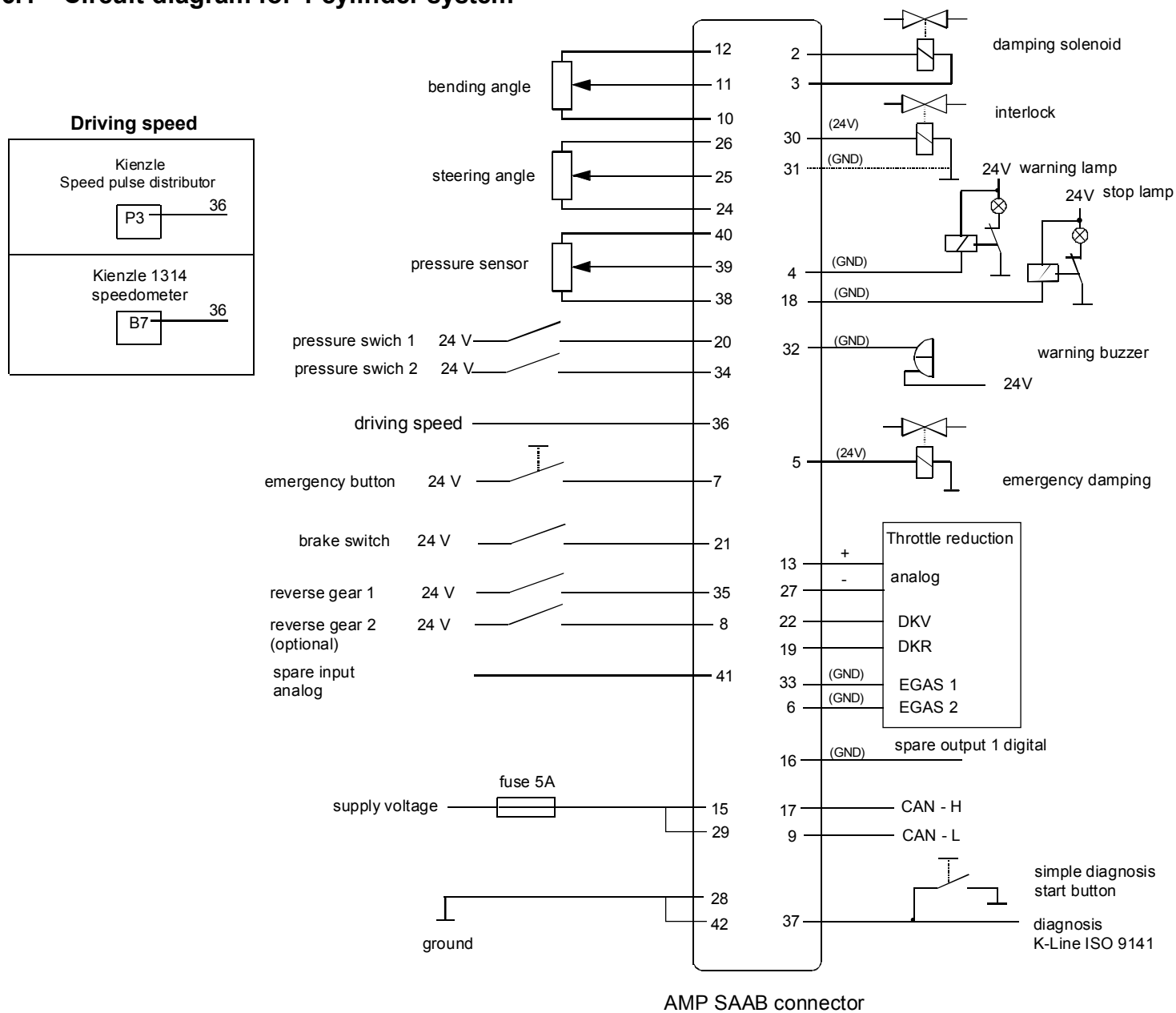
6 Scheme of Connector Assignment

A 42-PIN AMP plug is used for connection of the electronics to the control unit. The hydraulic damping system as well as the connection to the vehicle electronics is realised via this plug.

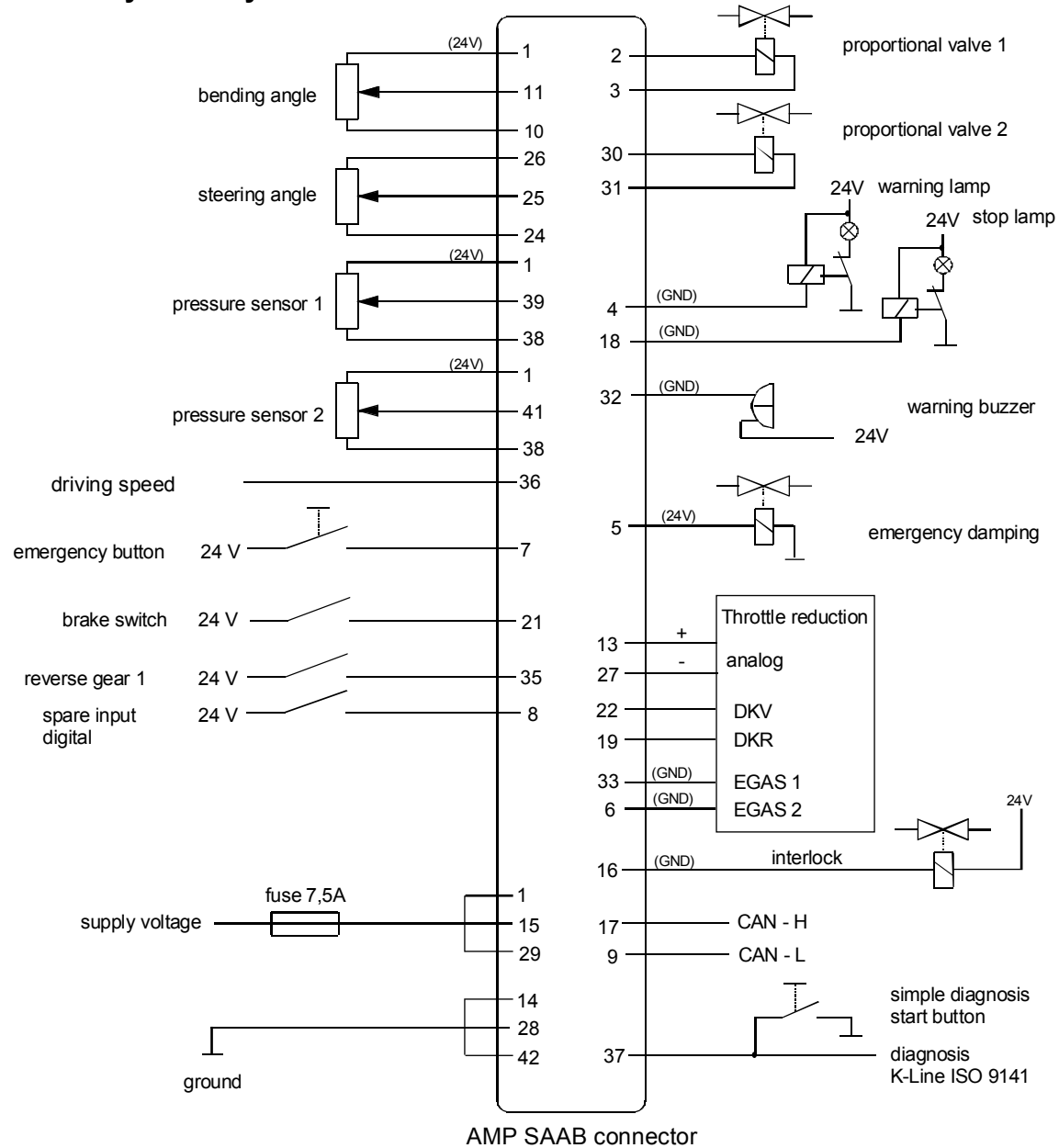
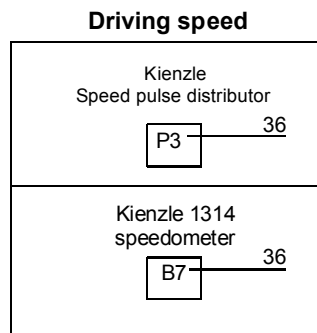
As the control system is used both in hydraulic systems with one proportional valve (e.g. articulation type HNGK6.2, HNGK9.2, HF485) and in systems with two proportional valves (e.g. articulation type HG 15.3; HNG 16.5) the connections of some outputs differ. The following two connector assignments show the various connection types for this.

The connection is realized by a customer-specific cable harness which represents the interface between electronics and vehicle. The versions as shown here should only be seen generally. For detailed design please refer to the corresponding documents of the respectively applied articulation type.

6.1 Circuit diagram for 1 cylinder system

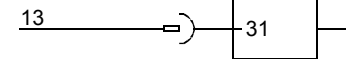


6.2 Circuit diagram for two-cylinder system

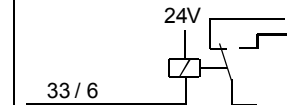


Throttle reduction

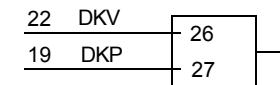
Analog E-Gas control
at Bosch EMS 3.3 B



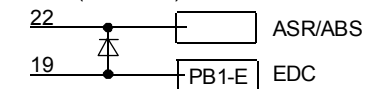
Switch off for E-Gas 1+2



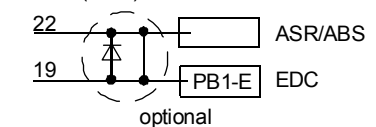
E-Gas control by means
synchronous DKV/DKR interface
at EMS 3.3 B



DKR/DKV interface
EDC (Mercedes)



DKR/DKV interface
EDC (MAN)



7. Representation of the Hydraulic Systems

7 Representation of the Hydraulic Systems

The following representations shall help to identify the various components of the damping system according to the articulation system utilised by you.

7.1 HNGK 9.2

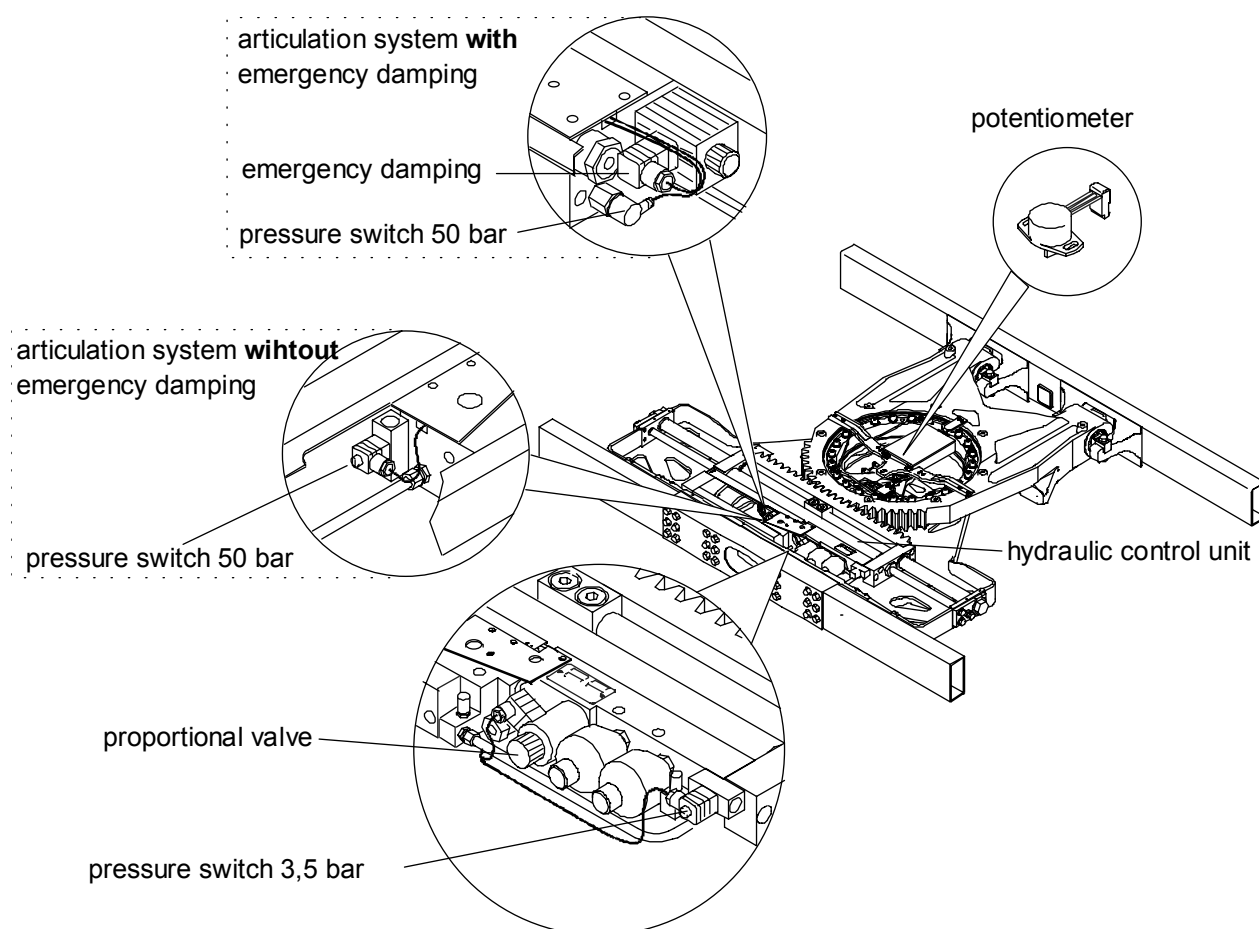


Figure 33: HÜBNER articulation system HNGK 9.2

7. Representation of the Hydraulic Systems

7.2 HNG 15.3

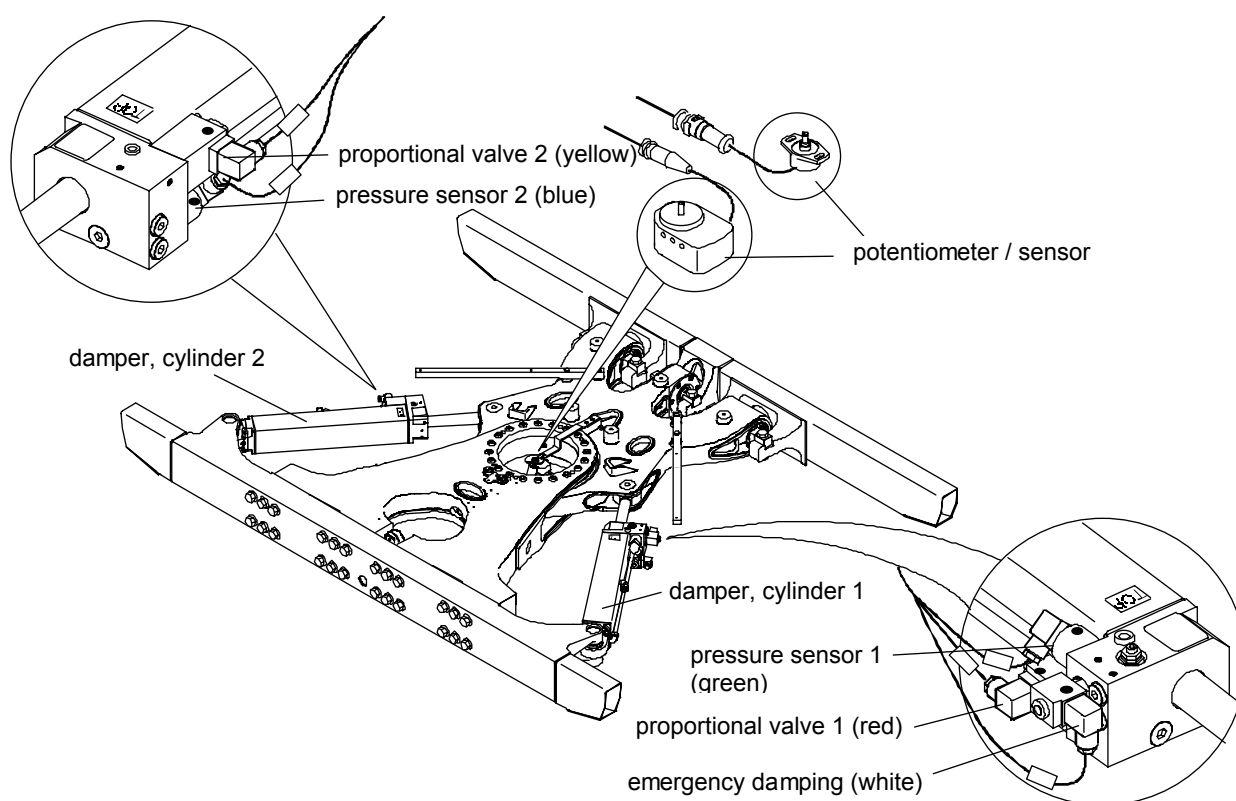


Figure 34: HÜBNER articulation system HNG 15.3

7. Representation of the Hydraulic Systems

7.3 HNG 16.5

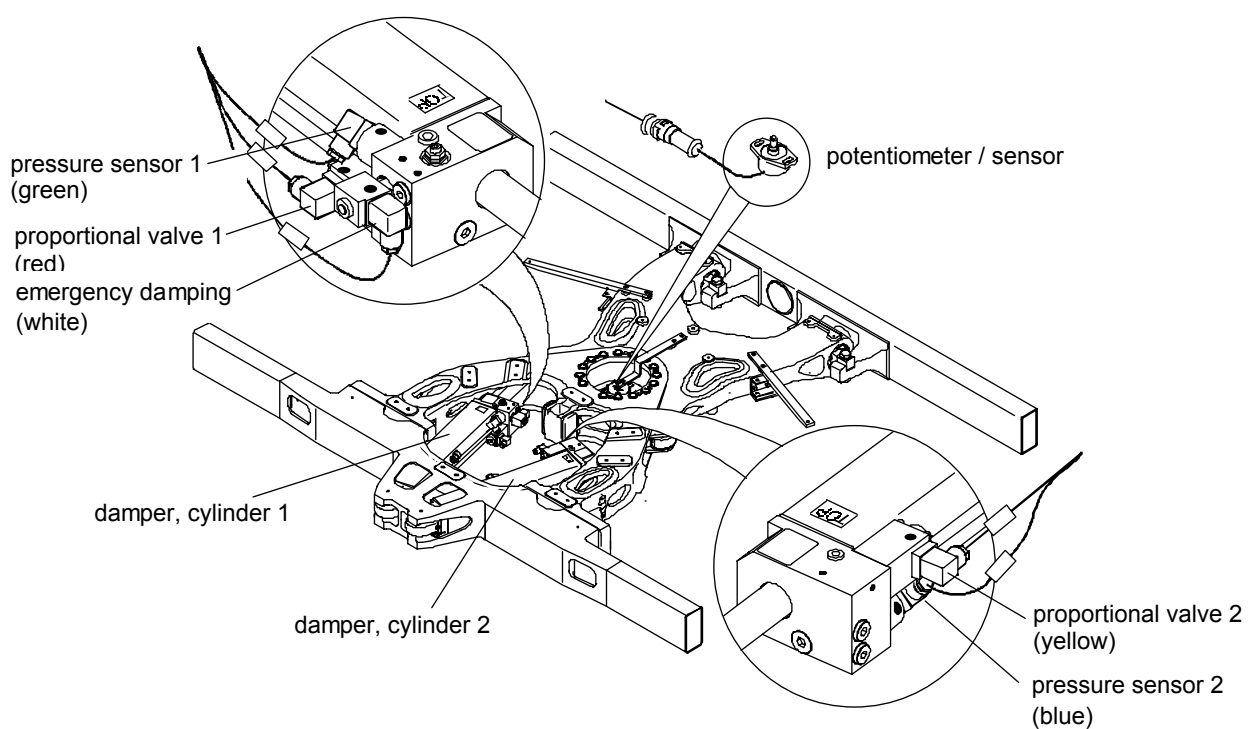


Figure 35: HÜBNER articulation system HNG 16.5

7. Representation of the Hydraulic Systems

7.4 HG 485

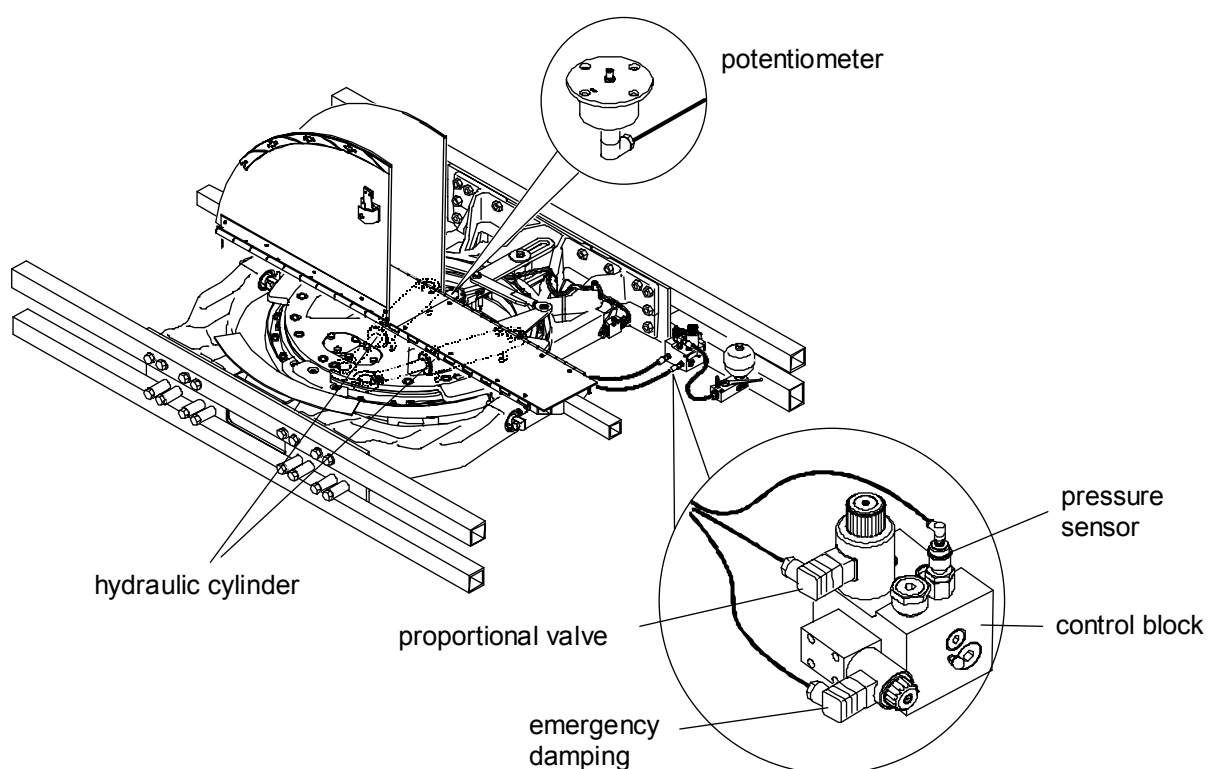
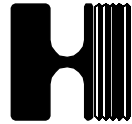


Figure 36: HÜBNER articulation system HF 485



8 Admission

The control system was admitted by the Kraftfahrt-Bundesamt for the operation in vehicles. The following type-approval was issued:



Kraftfahrt-Bundesamt

D-24832 Flensburg

EWG-BG Nr. e1*72/245*95/54*1818*02

T y p g e n e h m i g u n g s b o g e n

EEC type-approval certificate

Benachrichtigung über die Typgenehmigung

für ein Bauteil gemäß der Richtlinie 72/245/EWG, zuletzt geändert durch die Richtlinie 95/54/EG.

Communication concerning the type-approval

of a type of component with regard to Directive 72/245/EEC, as last amended by Directive 95/54/EC

Typgenehmigungsnummer: **e1*72/245*95/54*1818*02**
Type-approval No.

Figure 37: Excerpt from the type-approval