AUTOMATIC TEMPERATURE CONTROL WITH CAN IN MAN CITY BUS

SYSTEM DESCRIPTION

WABCO

Mobilizing Vehicle Intelligence

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The German version is the original document.

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All non-German language editions are translations of the original document.

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You will find the current edition at:
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1 List of abbreviations

Abbreviation	Meaning
AC	Alternating current
CAN	Controller Area Network; serial bus system
DC	Direct current
EBS	Electronic Braking System
ECU	Electronic Control Unit
EDC	Electronic Diesel Control
FFR	(German: Fahrzeugführungsrechner); Vehicle Management Computer
HVAC	Heating, ventilation, climate control
IBIS	Integrated on-board information system
KWP	Key Word Protocol
MTS	(German: Modulare Türsteuerung); modular door control
NTC	Negative Temperature Coefficient Thermistor
PIN	Personal Identification Number
PWM	Pulse Width Modulation
VDV	(German: Verband Deutscher Verkehrsunternehmen); Association of German Transport Companies

2 Symbols used

Important information, notes and/or tips

Reference to information on the internet

Descriptive text

– Action step

1. Action step 1 (in ascending order)
2. Action step 2 (in ascending order)

   ⇨ Consequence of an action

- Listing
  - Listing

3 Introduction

Heating, ventilation and air conditioning control (HVAC) now belong to the standard equipment on city buses and touring coaches.

Different control panels, designs and parameter settings are used to adapt the Automatic Temperature Control to the respective vehicle-specific requirements by the vehicle manufacturer.

3.1 Physical principles

The Automatic Temperature Control regulates the temperature in the interior of an Omnibus. Warm and cold air is mixed to achieve a pleasant climate.

Two major requirements are the heating and ventilation systems on Omnibuses:

- Providing a comfortable climate
- Clearing the windows of frost and humidity

Comfort is also influenced by other alternating factors:

- Individual state of the person, for instance:
  - Activity or idle
  - Clothing
- Heating, ventilation and air conditioning control, for instance:
  - Air temperature
  - Air speed
  - Exchange of air
- Constructive passenger compartment arrangement:
  - Radiation temperature
  - Temperature of the adjacent areas
- Duration of stay
- Density of occupancy

These influencing factors must be adapted to one another during the time that people are in the passenger compartment so that comfort is guaranteed.

The influencing factors that are indicated here are by no means exhausted and show the complexity that the driver is confronted with in Omnibuses to achieve a comfortable climate for everyone.

Electronics according to the specified control characteristics can be used to alleviate the driver of manual air conditioning control.

Studies on comfort and the subjective well-being of persons have shown that a temperature stratification in the passenger compartment ("warm feet-cool head"), should not exceed 40 °C and that this should be independent of the inside-to-outside temperature.

3.2 Air conditioning requirements

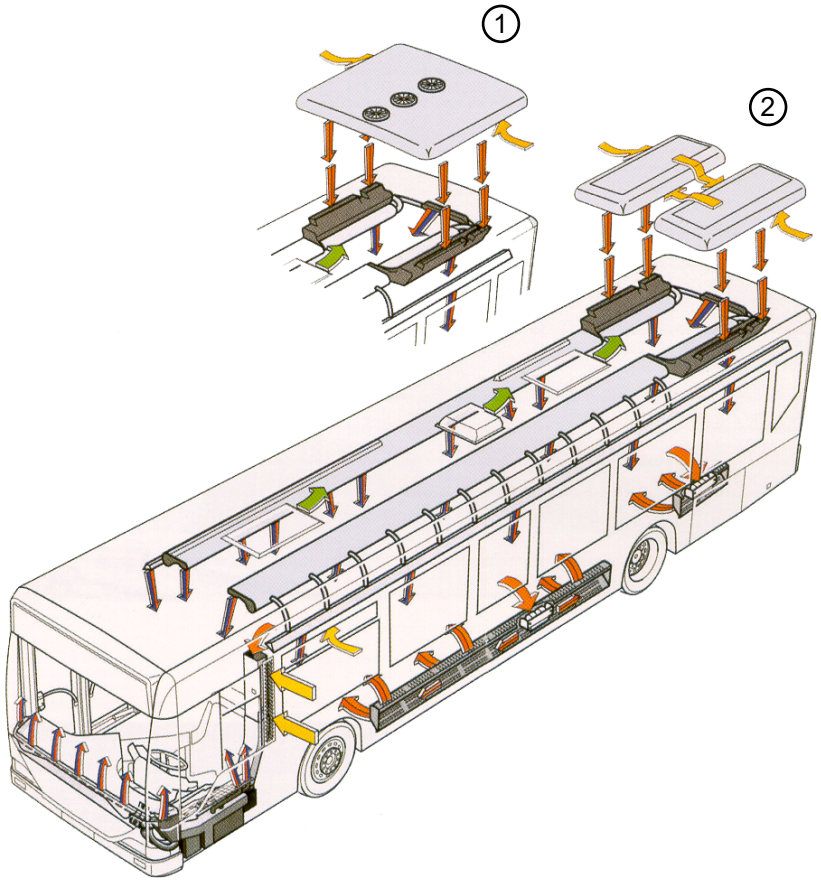
All requirements for an ideally acclimatized city bus are summarized in Regulation 236 of the VDV (Verband Deutscher Verkehrsunternehmen e.V.; Association of German Transport Companies).

- Compartment temperature
  - Passenger compartment between +18 °C and +22 °C
  - Driver's area between +18 °C and +25 °C
  - Approximately +3 °C below the outside temperature in cooling mode
- Flow speeds
  - Avoiding draughts
  - Ensure adequate air circulation
- Humidity
  - Clear windows
  - Unregulated drying in cooling mode
- Air quality
  - Minimum fresh air rate 15 m^3/h
  - Air exchange through forced ventilation
  - Air purity 70 % for particles > 1 µm
- Noise emissions
  - Average value approx. 68 dB (A)

3.3 Features

- Master Satellite System that communicated with the vehicle via a CAN interface: direct read-in of required vehicle data (such as cooling water temperature)
- Connection of the sub-stations via an internal HVAC-CAN Bus
- Control panel with integrated display for vehicles without a central display
- Nominal value setting via control panel
- Temperature control precision of approx. 1 °C
- Connection of additional and independent heating is possible
- Control of blower speeds
- Optimised door closing through signals from the door movements
- Extensive onboard diagnosis in the control panel with display
- Functions that are integrated in the control panels such as smog mode, defrost function and reheat operation

3.4 Example of a conventional bus-HKL system



1 Air conditioning unit
2 Roof heating unit

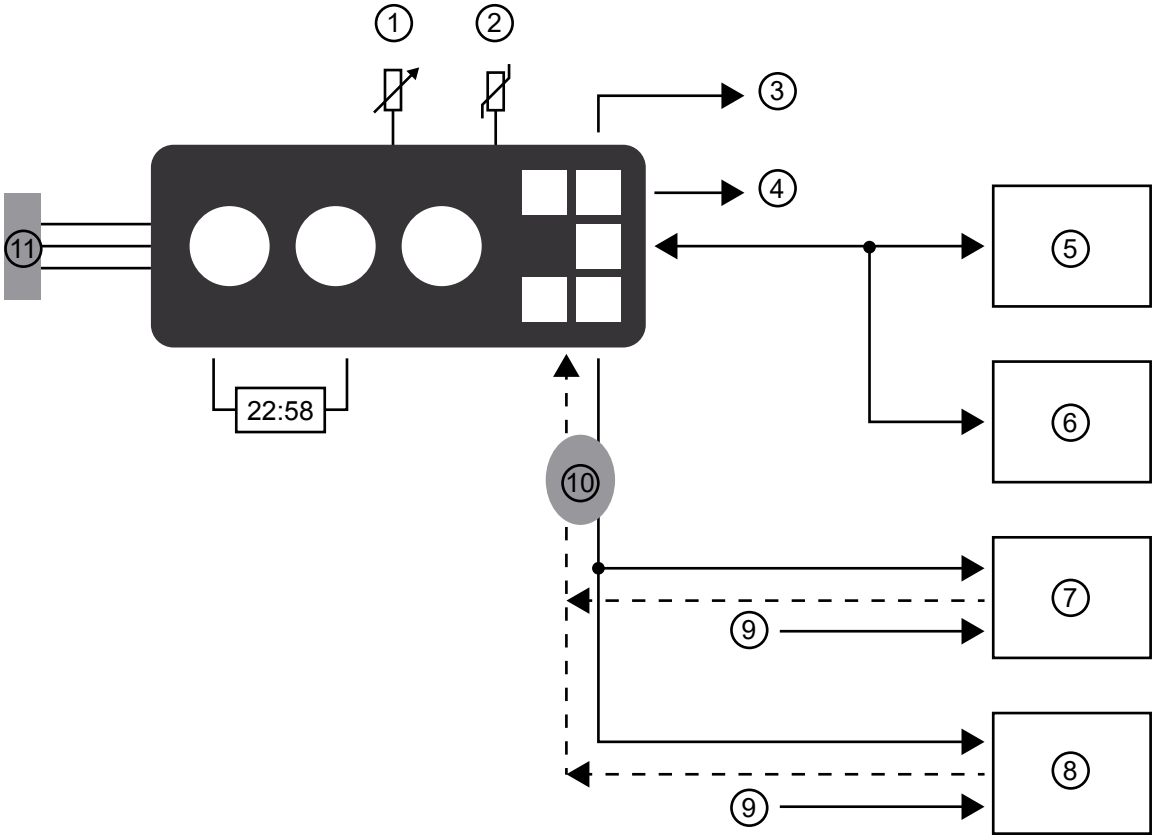
Fresh air
Circulating/heated air

Heated air, fresh air or conditioned air
Circulating air
Discharged air

4 Function

The electronics handle the room temperature control in the passenger compartment, which cannot be influenced by the driver. The air conditioning of the passenger compartment is fully automatic. Only when transferring the buses can the passenger compartment control be switched off via a switch by the driver.

Only these electronics are required in the simplest variation. The electronics of the control panel regulates the entire front box as well as the floor area of the vehicle. If the bus is equipped with a roof mount system or if an articulating bus is used, additional substations are used there. The control panel is connected with the substation via an internal CAN Bus. The substations can be implemented universally. All characteristics and parameters are defined centrally for this system. Data exchange with the substations is done via the internal CAN Bus.

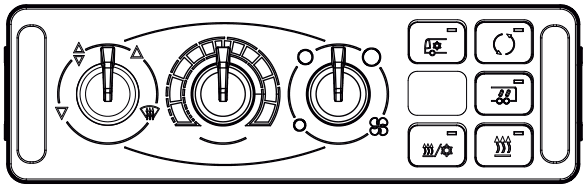


Legend	
1	Nominal value setting (optional)
2	Air outlet temperature: Floor and front box
3	Water pump
4	Additional heating
5	Front box ■ Water valve ■ Ventilation flaps ■ Blower

Legend	
⑥	Floor ■ Water valve ■ Blower
⑦	"Roof attachment" substation ■ Water valve ■ Ventilation flaps ■ Blower ■ Air conditioning unit
⑧	"Rear section" substation ■ Water valve ■ Ventilation flaps ■ Blower ■ Air conditioning unit
⑨	Compartment temperature sensor Discharged air sensor Icing sensor
⑩	Internal CAN bus ⇨ Transfer of the digital inputs and temperatures to the control panel ⇨ Fault messages ⇦ Regulation of actuators as per specifications from the control panel ⇦ Forwarding of nominal values to the substations
⑪	Vehicle CAN bus (also used by MAN for diagnostics) ⇨ Motor signal ⇨ Door signal ⇦ Compartment temperature ⇨ Outside temperature ⇨ Speedometer ⇨ Water temperature ⇦ Additional heating ⇦ Fault message ⇦ Water pump

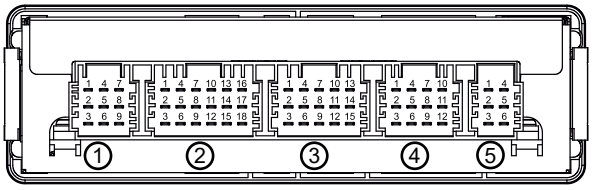
5 Components

5.1 Control panel ECU 446 195 024 0



Technical data

- Supply voltage via terminal 30 (24 V)
- Quiescent current: 0.005 A
- Maximum current consumption: 4 A
- Reverse polarity protection



Pin	Meaning
① **9-pin plug connector**	
1	Terminal 30 "steady positive voltage"
2	Terminal 15 "ignition on – wake up"
3	Terminal 31 "vehicle ground"
4	Terminal 58 "lighting"
5	Input "motor signal (D+61)"
7	CAN interface "vehicle bus high"
8	CAN interface "vehicle bus ground"
9	CAN interface "vehicle bus low"
② **18-pin plug connector**	
1	Water valve "front box DC motor (+)"
2	Water valve "front box DC motor (–)"
3	not assigned
4	not assigned
5	Front windscreen flap (+)
6	Activation substations
7	PWM output "front box fan"
8	Front windscreen flap (–)
9	Additional heating return information
10	Reference voltage "recirculation potentiometer"
11	Water valve "front DC motor potentiometer feedback"
12	Ground "recirculation potentiometer"
13	Input "potentiometer feedback front windscreen flap"
14	Input "potentiometer blower adjustment"
15	Input "air monitoring sensor

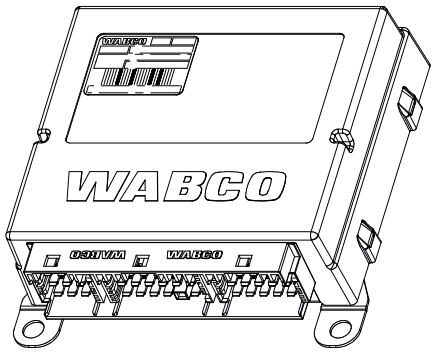
Pin	Meaning
16	Outside air temperature sensor
17	Temperature sensor "driver's area"
18	Ground "temperature sensors"
③ **15-pin plug connector**	
1	Fresh air/recirculation flap (+)
2	Passenger compartment blower "level 1 (output for relay)"
3	Reserve AD input "external nominal value potentiometer"
4	Fresh air/recirculation flap (-)
5	Passenger compartment blower "level 2 (output for relay)"
6	Output "fault lamp"
7	10 kOhm pull resistor for PWM output 18-pin plug connector, pin 7
8	Input "additional heating operation via time switch wake up"
9	Input "door signal"
10	not supported
11	Input "economy circuit wake up"
12	Input "remote actuation with remote supply for heating"
13	Temperature sensor "passenger compartment"
14	Blower temperature sensor "floor"
15	Ground "temperature sensors"
④ **12-pin plug connector**	
1	Water valve "floor DC motor (+)"
2	Water valve "floor DC motor (–)"
3	U_{ref} "potentiometer feedback water valve floor"
4	Ground "recirculation potentiometer"
5	Output "air conditioning (3A)"
6	Output "additional heating"
7	Output "additional heating energy saving level"
8	Output "water pump"
9	Water valve "floor DC motor potentiometer feedback"
10	CAN interface "heating bus high"
11	CAN interface "heating bus ground"
12	CAN interface "heating bus low"
⑤ **6-pin plug connector**	
not assigned	

5.2 Substation 446 196 002 0

The substations are part of the system for the Automatic Temperature Control in the Omnibus.

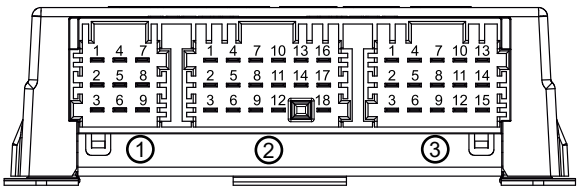
The substations are connected to the control panel with a special interface. This interface makes it possible to exchange operational data, such as sensor values, nominal values and diagnostic messages.

It is actuated via the terminal 15 connection, which is supplied independently of the control panel. This guarantees that the control panel e.g. can handle follow-up control.



Technical data

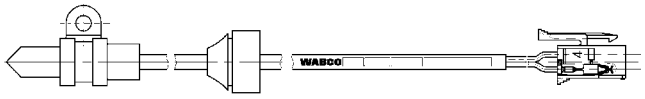
- Supply voltage via terminal 30
- Activation: Terminal 15



Pin	Meaning
① **9-pin plug connector**	
1	Terminal 30 "steady positive voltage"
2	Terminal 15 "ignition on – wake up"
3	Terminal 31 "vehicle ground"
4	Input "coding 1"
5	Input "coding 2"
6	120 Ohm termination resistor
7	CAN interface "heating bus high"
8	CAN interface "heating bus ground"
9	CAN interface "heating bus low"

Pin	Meaning
② **18-pin plug connector**	
1	Water valve "roof DC motor (+)"
2	Water valve "roof DC motor (-)"
3	Water valve "roof reference voltage for potentiometer feedback"
4	Output "roof hatches"
5	Water valve "floor DC motor (+)"
6	Water valve "floor DC motor (-)"
7	Output "roof blower Level 1"
8	Output "roof blower Level 2"
9	Output "compressor coupling (3 A)"
10	Output "passenger blower rear Level 1 (relay)"
11	Output "passenger blower rear Level 2 (relay)"
12	Input "water valve roof potentiometer feedback"
13	Input "water valve floor potentiometer feedback"
14	Input "low pressure switch"
15	not assigned
16	Input "high pressure switch"
17	Blowout sensor "floor rear"
18	Ground connection "temperature sensors and recirculation potentiometer"
③ **15-pin plug connector**	
1	Output "roof flap right (+)"
2	Output "roof flap left (+)"
3	PWM output "evaporator fan"
4	Output "roof flap right (-)"
5	Output "roof flap left (-)"
6	Output "condenser blower"
7	10 kOhm pull resistor for PWM output 15-pin plug connector, pin 3
8	Reference voltage "roof flap potentiometer"
9	Input "sensor fan monitor"
10	Input "potentiometer feedback roof flap right"
11	Input "potentiometer feedback roof flap left"
12	Blowout sensor "roof duct rear"
13	Icing sensor (evaporator temperature)
14	Room temperature sensor
15	Ground "temperature sensors and recirculation potentiometer"

5.3 Outside air temperature sensor 446 097 000 0



Technical data

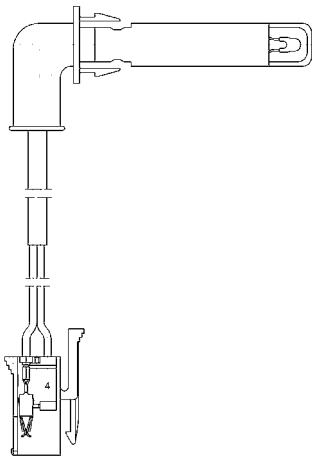
- Type: NTC
- Resistor at 25 °C: 10 kOhm ± 3 %

5.4 Temperature sensor "water" 446 097 001 0

Technical data

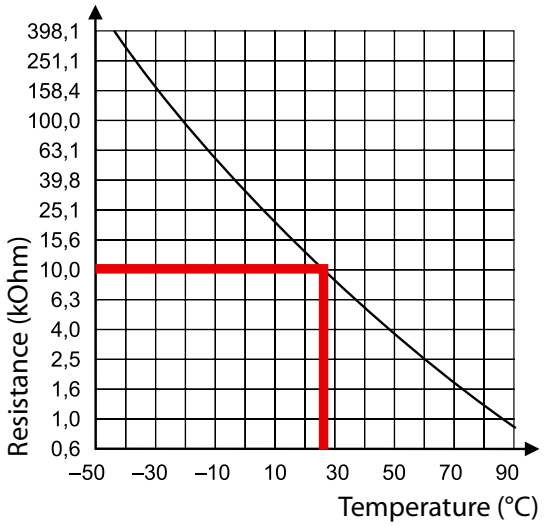
- Type: NTC
- Resistor at 25 °C: 10 kOhm ± 3 %

5.5 Temperature sensor "air outlet" 446 092 003 0

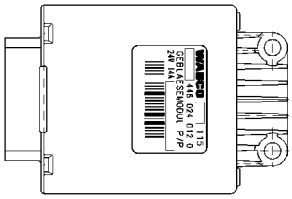


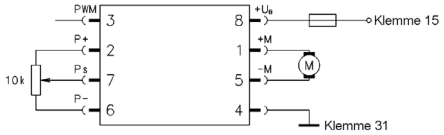
Technical data

- Type: NTC
- Resistor at 25 °C: 10 kOhm ± 3 %
- Characteristic curve



5.6 Blower module 446 024 012 0





Technical data

- Controlled via potentiometer or via PWM signal
- Voltage: 24 V
- Output: permitted steady current 14 A
- Required fuse: max. 15 A

5.7 Data interface of the CAN bus system

The 9-pin plug connector (X9) of the submodule is assigned as follows:

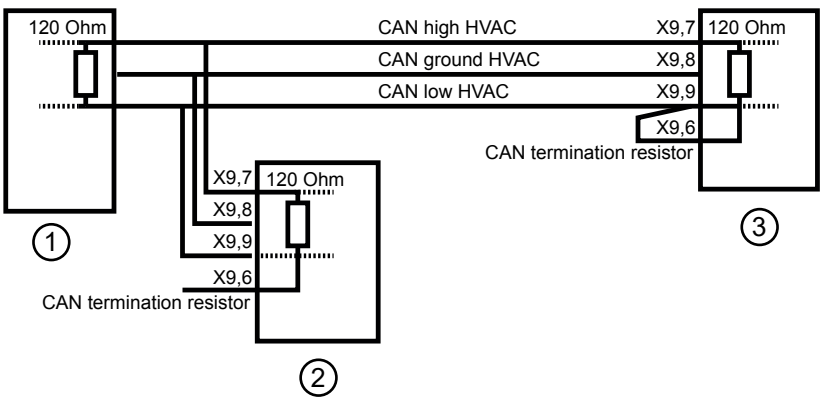
- Pin 6: CAN termination resistor
- Pin 7: CAN high
- Pin 8: CAN ground
- Pin 9: CAN low

Termination resistors are required for the CAN bus. Each substation already has this termination resistor integrated from the factory.

The resistor can be "called up" between CAN high and CAN low by activating the 120-Ohm resistor by bridging pin 6 with pin 9 of the 9 pin plug connector. A 120-Ohm termination resistor is integrated in the control panel at the beginning of the CAN bus line. This bridge is only to be set up at the end of the CAN line in the last substation of course.

The resistance measured between CAN high and CAN low should be 60 Ohm with the power supply switched off.

The electronic connection for the substation is done using three plug-in connectors with tinned contacts.

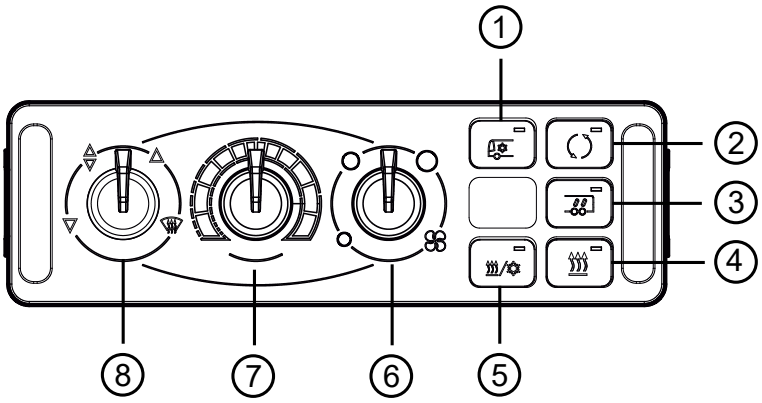


1 Control panel
2 Substation
3 Last substation with activated termination resistor

6 Operation of the control panel

6.1 Description of the buttons/rotary potentiometer

The control panel is comprised of three rotary potentiometers and five buttons. In order to relieve the driver of the switching responsibilities from the passenger compartment, he can only switch off the full-automatic functionality here. All other functions on the control panel serve for individual setting for the driver's workplace.



Number	Buttons/rotary potentiometers	Description
①	Button "Driver's seat air conditioning"	Switch on/off the refrigerating agent solenoid for the front box. With every "Switch ignition on" procedure, the front box flap is switched on for determining the respective end positions, i.e., the end positions are moved to and stored in the control panel. If the flap is actuated by the potentiometer then, the intermediate positions are then moved to. The button lights up when the function is activated.
②	Button "Smog"	Block addition of fresh air throughout the bus. The skylights and fresh air flaps are closed for a defined time period while the function is active. The button lights up when the function is activated
③	Button "Passenger compartment heating"	The driver no longer has the ability to access the fully automatic passenger compartment control. The passenger compartment control is only e.g. switched off for transferring buses. The button lights up when the function is activated.
④	Button "Additional heating"	The additional heating is only switched on manually by default. The button lights up when the function is activated.
⑤	Button "Reheat"	Switch on/off operation of the air conditioning. Drying of room air by cooling down and heating back up. The button lights up when the function is activated.
⑥	Rotary potentiometer "Blower speed"	Speed setting of the front box. The relationship between the angle of rotation and the PWM actuation is stored in a parameter definable characteristic curve. The speed can be set from 0 – 100 % adjustment values with the vehicle engine running.

Number	Buttons/rotary potentiometers	Description
⑦	Rotary potentiometer "Nominal value for the front box temperature"	Setting the air outlet temperature of the front box in a range between + 14 °C and + 60 °C. Left stop: Water valve closed Right stop: Water valve fully open
⑧	Rotary potentiometer "Front windscreen/footwell flap"	▽ Footwell flap: All of the air is sent to the footwell. △ ▽ Centre position: The air flow is distributed between the footwell and the front windscreen. △ Front windscreen flap: All air is directed onto the front windscreen. Defrost: Water valve completely open; flap on front windshield; Maximum blower speed Implementation is via characteristic curves, which also allow intermediate settings.

6.2 Change temperature nominal value for the passenger compartment

The temperature nominal value for the passenger compartment can be adjusted on the control panel as described in the following segment:

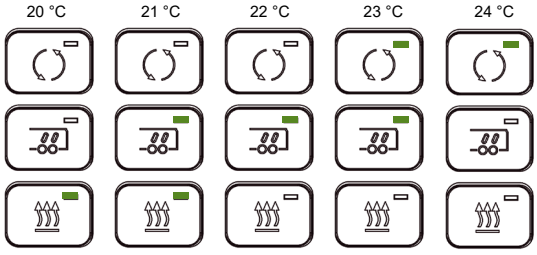
– Keep the "Passenger compartment heating" button pressed for at least 10 seconds.
  ⇨ After achieving the nominal value adjustment mode, the LEDs that are integrated in the three right-hand buttons flash according to the defined nominal value.

– Press the "Smog" button to increase the nominal value.

– Press the "Additional heating" button to decrease the nominal value.

The nominal value, which is allocated to the right, middle LED and the step interval parameters can be defined.

The currently defined nominal value is indicated with the respective function lighting for this button flashing. The assignment of flashing LEDs to a nominal value is indicated in an exemplary manner for an average nominal value of 22 °C and a step interval of 1 °C:



– Confirm the nominal value with the "Passenger compartment heating" button.
  ⇨ Setting mode is exited. The control panel goes back into normal operation mode.

As an alternative to the temperature nominal value adjustment for the passenger compartment via the keyboard, two additional nominal value adjustments are possible:

- Nominal value adjustment via external potentiometer: Optionally, an external nominal value potentiometer can be connected on pin 3 of the 15-pin plug connector of the control panel. In this case, you need the parameters changed accordingly by the vehicle manufacturer. The nominal value can be set within a fixed range for the passenger compartment temperature control in accordance with these parameter settings. The setting capability via the keyboard is then deactivated.
- Nominal value adjustment only via parameters: If this option is actuated for the nominal value setting, the nominal value can only be set with a parameter change (by the vehicle manufacturer).

7 Vehicle CAN bus in the MAN bus

The CAN Bus is a serial data bus system, which was developed for networking controllers in automobiles. Instead of using an electrical circuit for each transmitted signal, the "data bus" is based on a communication platform, which regulates the relaying of messages between several devices.

The complete parameter set is stored in the control panel. Only when replacing the control panel does the vehicle-specific parameter set have to be read again.

If only a substation has to be replaced, this is automatically provided with or "programmed with" the correct parameter set that is already set up for you.

The diagnosis is only possible via the vehicle CAN Bus. When the vehicle CAN bus is not used at the manufacturer's end, a termination resistor is required for the vehicle CAN bus.
The diagnostic interface should be connected directly to the vehicle CAN bus.

8 Diagnosis

WABCO provides PC diagnosis for the "Automatic Temperature Control" system.

If you have any questions, contact your WABCO contact person.

8.1 Diagnostic hardware

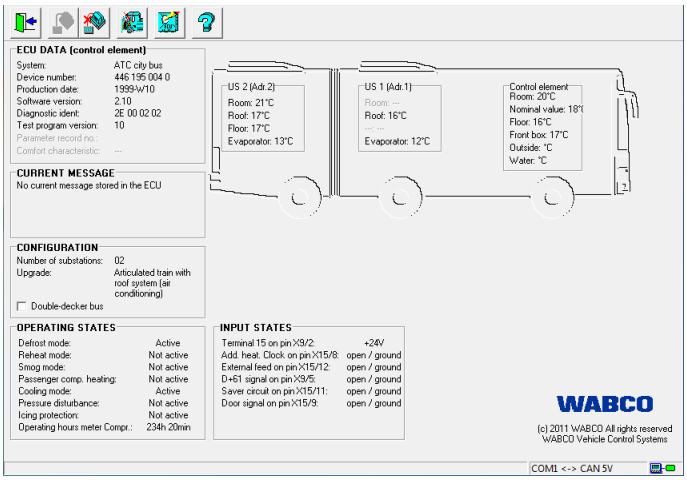
For the diagnosis, you will need:

- PC or laptop
- Diagnostic Interface
- Connecting cables to the vehicle
- Diagnostic software "Automatic Temperature Control CAN Standard"

8.2 Diagnostic Software

You can obtain the "Automatic Temperature Control CAN Standard" diagnostic software via the myWABCO page: http://www.wabco.info/i/1280

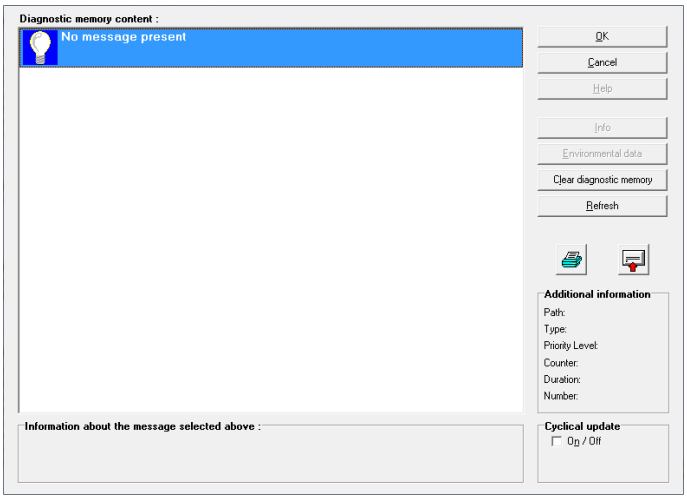
Start screen



The following information and more is contained on the start screen:

- ECU data
- Configuration
- Operating states
- Starting states

Messages in the diagnostic memory

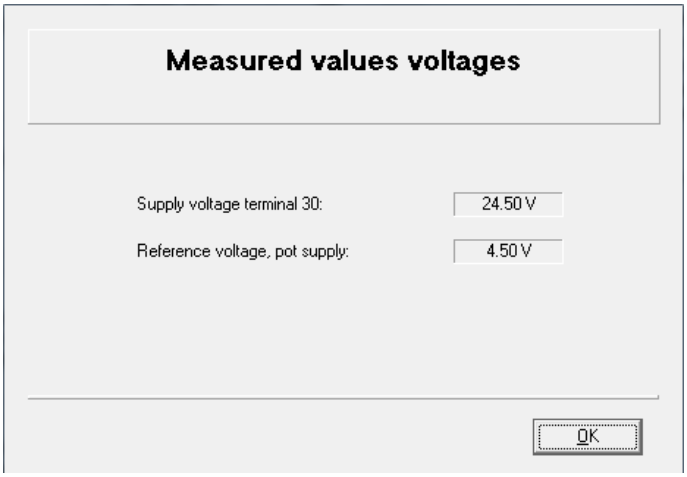


Display of diagnostic memory content.

Display of additional information:

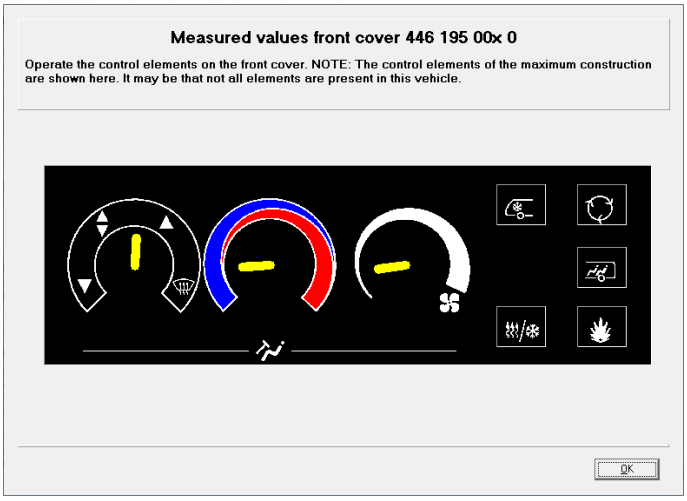
- Path: Recognised, problem-afflicted components
- Type: Type of recognised problem
- Priority Level: Importance of the problem: 0 > minor fault
- Counter: Definition of how much time (operating hours) has elapsed since the last diagnostics save

Measured values



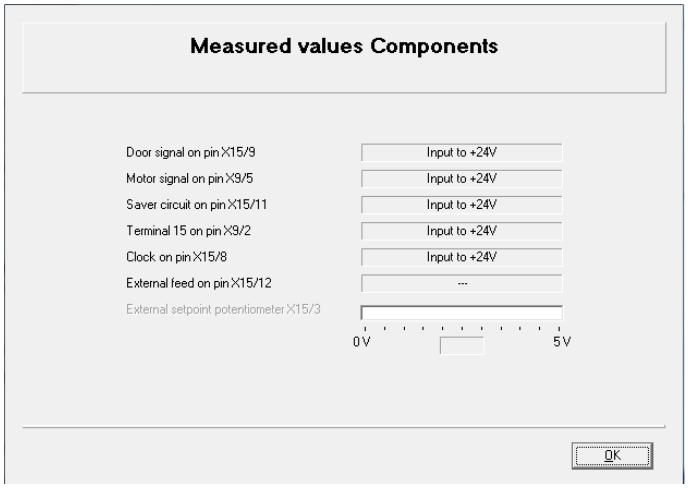
Voltages

Display of voltage measured values.



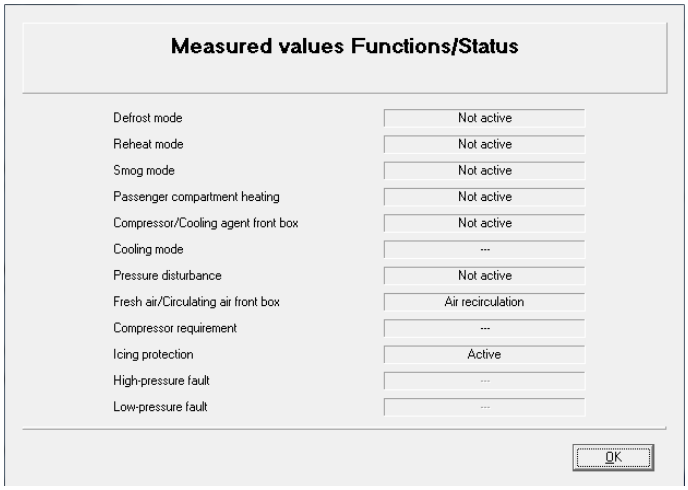
Front panel

Display of function elements of the front panel.



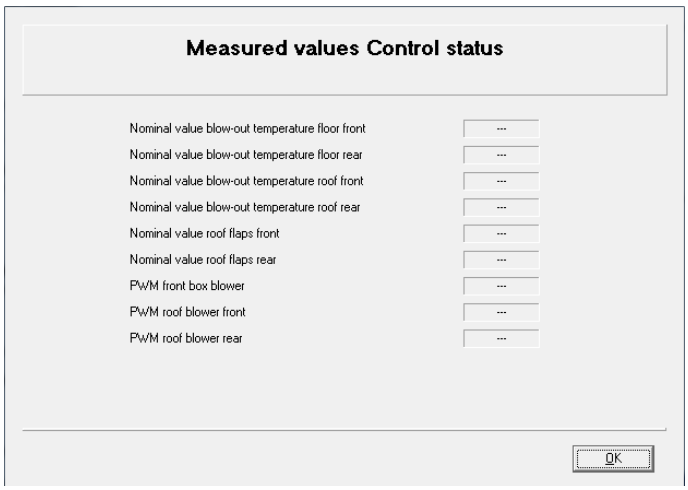
Components / Inputs

Display of input states on the control panel.



Function states

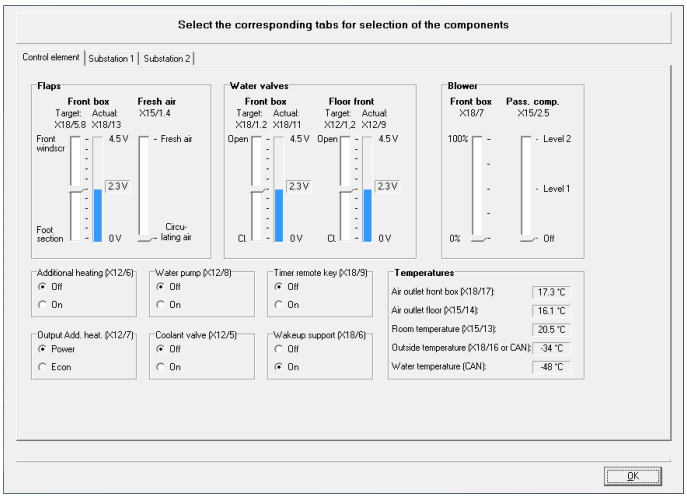
Display of function states.



Control states

Display of nominal values of the "Automatic Temperature Control" system.

Control



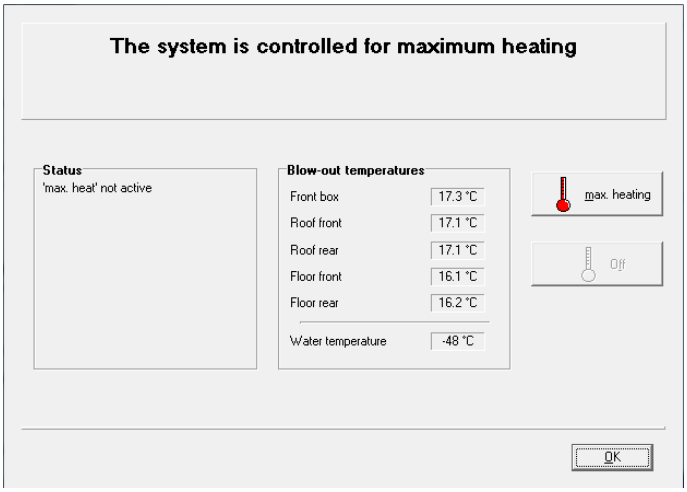
Components

Function checks: Changes made manually, e.g. flap positions.

"Blower" actuation is only possible with the appropriate parameter setting.

As of the diagnostics version higher than 1.3, the actuation is possible independent of the parameter setting.

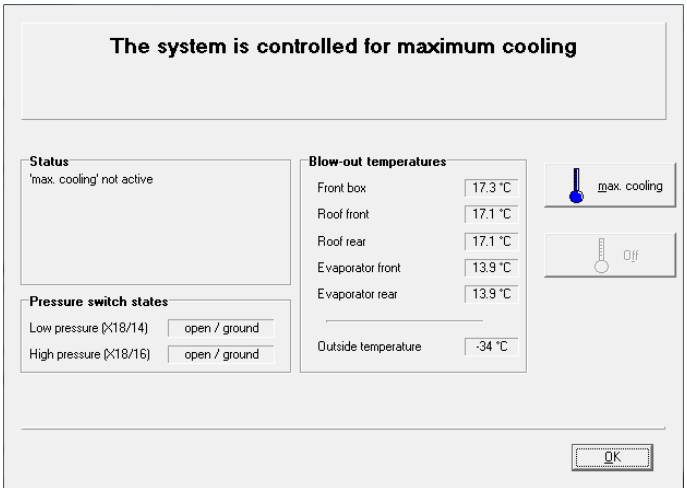
Checking of substations.



Maximum heat

Check that regular heating operation is ensured in the vehicle, i.e. all heating heat exchangers are supplied with hot water.

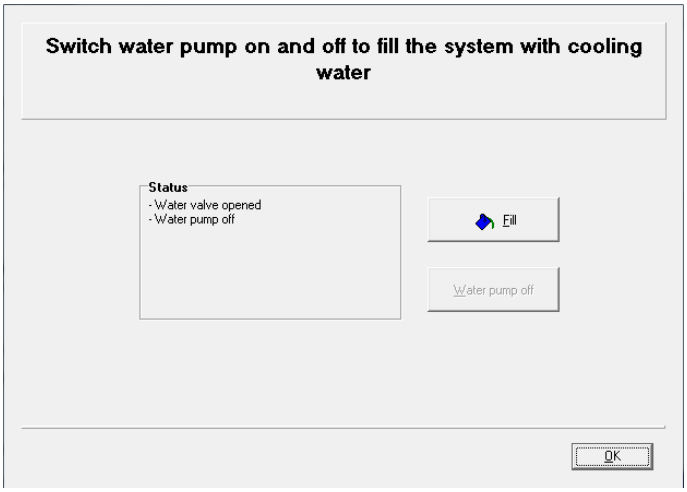
Requirement: Motor must be at operating temperature.



Maximum cooling

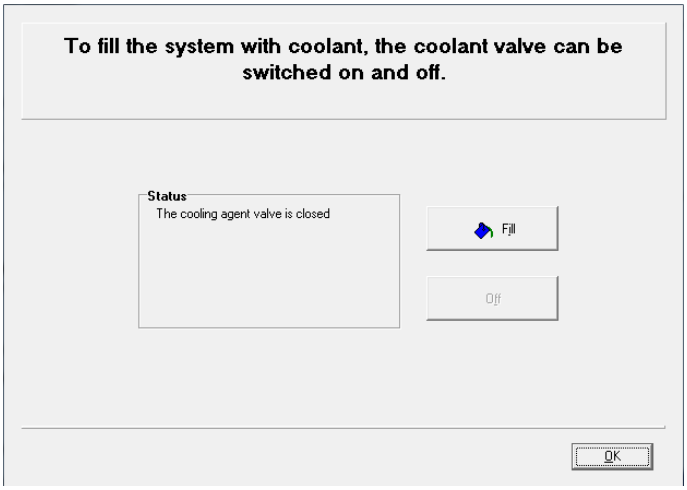
Checking the function of the air conditioning unit.

Requirement: Motor must be running.



Fill with cooling water

Filling the system with cooling water.

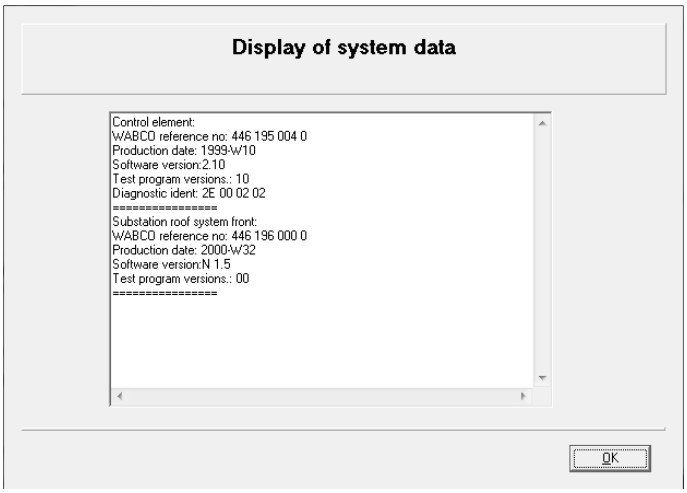


Fill with cooling agent

Filling the system with coolant.

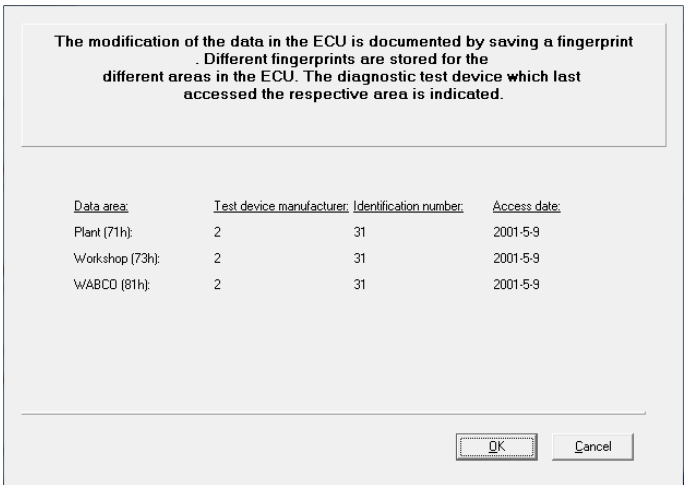
System data and test device identification (fingerprint)

Passing on of the data behind this information (Serial No., i.e. name of the user of the respective diagnostics program) is not fundamentally possible by WABCO. This data is subject to data protection conditions.



System data

Overview of all relevant data pertaining to installed or detected electronics.



Test device identification (fingerprint)

Display of test device identification (fingerprint).

When the "Automatic Temperature Control" system is parametrized, the diagnostic software writes the serial number into the electronics ("fingerprint"). This makes it possible, at a later date, to determine who was the last person to change the parameters.

The meaning of the fingerprint code is as follows:

- Test device manufacturer: Code of the test device manufacturer (WABCO = 2)
- Vehicle ident no.: Serial number of the diagnostic program used
- Access date

9 Parameter

9.1 PIN

Diagnosis can be carried out by any user. If parameters are to be changed however, authorisation is required (PIN). This PIN can be obtained through the "Electronic WABCO Systems in Powered Omnibuses" training at the WABCO Academy. With this PIN you can release enhanced functions in diagnostic software and change the settings in the controller electronics.

Additional information on the training at WABCO Academy is in the Internet:
http://www.wabco-academy.com

9.2 Saving and transferring parameter sets

Saving and transferring parameter sets refers to the complete 100 % parameter set. The parameter set, which can be called up and viewed from the start screen in the *System* menu point only returns approx. 25 % of the complete parameter. Normally, modifying a control panel parameter set only requires copying the set into the "new" device.

9.2.1 Save parameter sets

This function can be used to save the complete parameter set from the control panel on the PC, in order to transfer it back to (another) control unit at a later time with the Update function (Transferring parameter sets).

9.2.2 Transfer parameter sets

The stored data sets may not be changed because they will otherwise not be accepted by the diagnostic software. The parameters can also only be copied into control units with the same WABCO number and the same diagnostics version.

Control units with a newer software version are downwards compatible where parameter sets are concerned. If an attempt is made to copy a data record from a new control unit into an older version, the older device may not accept many parameters because they are not recognised.

9.2.3 Hint for the Workshop

The control panel contains the entire parameter set for the entire "Automatic Temperature Control" system; therefore all parameters for the substations.

If one or more substation(s) have to be replaced, no other settings are required, since these are defined by parameters in the control panel and will automatically be transferred to the substation(s).

To replace the control panel, the vehicle manufacturer must be contacted because the standard parameter set could have been changed or modified for the specific vehicle at line-end. Therefore, e.g. the respective parameter set must be determined using the chassis No. Naturally, the parameter set can also be read from the "old" ECU using the diagnostic software and then written to the new ECU again, to the greatest extent possible.

9.3 Setting options

When calling the system parameters, the setting options are shown in grey in the input mask. This means that they cannot be changed.

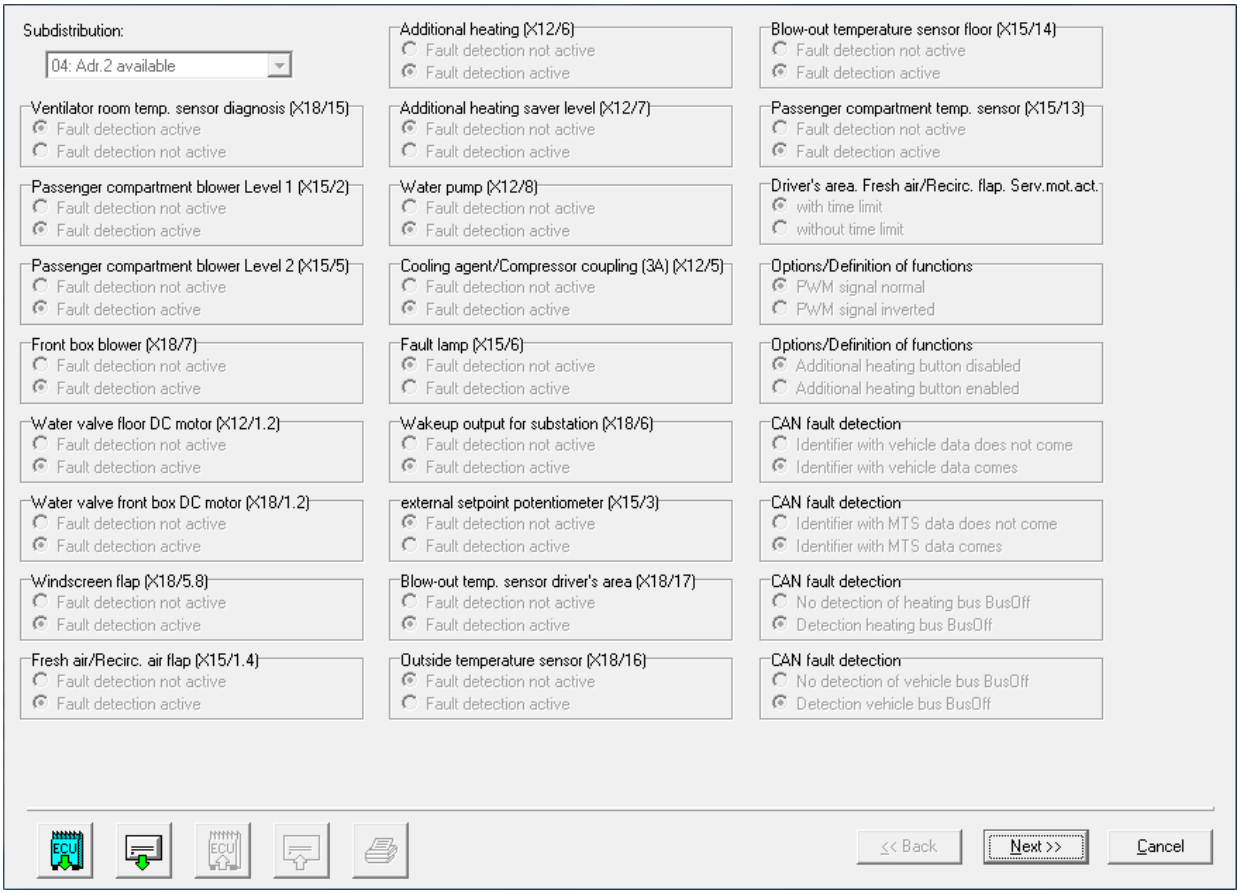
In the "Automatic Temperature Control CAN Standard" diagnostic software, no changes to the parameters are permitted by entering the PIN. The PIN only allows parameter sets to be copied to the control panel.

The parameter sets defined on the respective vehicle must either be prepared by the affected vehicle manufacturer or can also, if possible, be copied out of the control panel to be replaced.

Parameter changes must always be discussed with the vehicle manufacturer to i.e. guarantee suitable documentation, among other things.

Some options are described in the following.

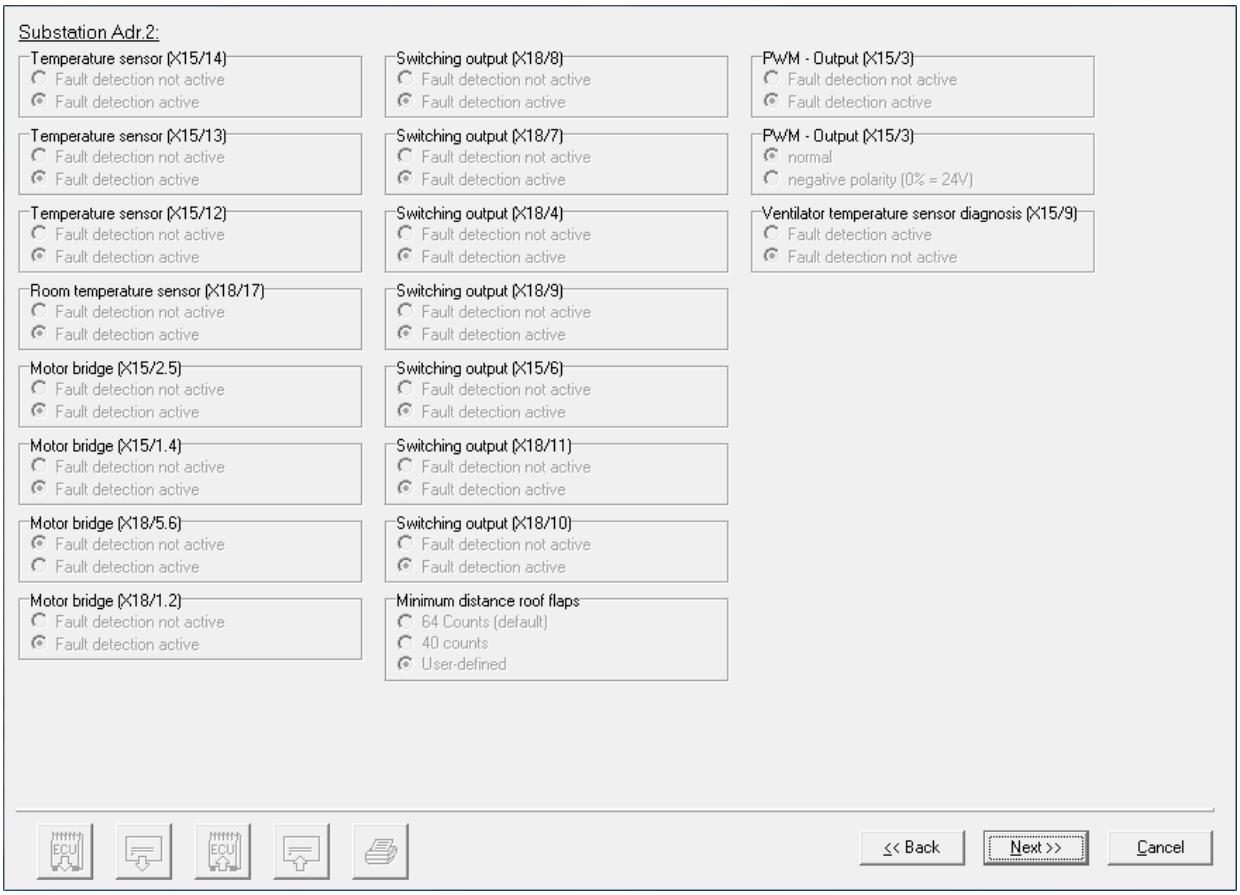
9.4 Control panel configuration



Parameter	Description
Subdistribution	Number of substations installed, or that should be installed, in the system.
Ventilator room temp. sensor diagnosis (X18/15)	If a normally closed room temperature sensor is used and it delivers a speed-proportional diagnostic signal, with which the function of the blower can be monitored, it creates the possibility of reading and evaluating this signal via the 18 pin plug connector, pin 15 on the control panel or the 15-pin plug connector, pin 9 on the substation. This requires that fault detection is activated. In all other cases, fault detection must be deactivated.

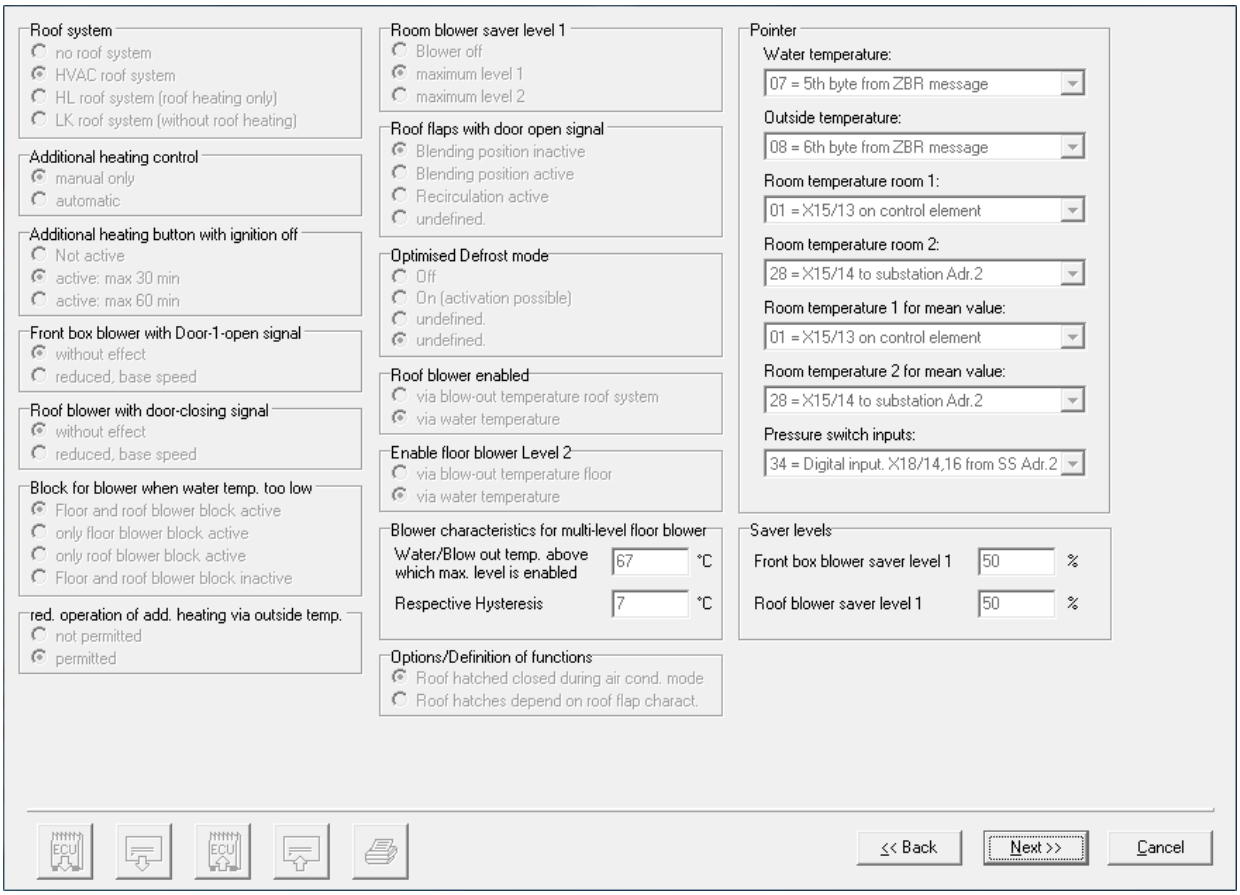
Parameter	Description
Digital switch outputs	For the function of the switch outputs, the fault detection does not necessarily have to be activated. If the output signals are read from a central computer for example, with suitable high-impedance inputs and the signals are to be processed by these, the fault detection must be switched off so that a line break fault message does not get detected by mistake.
Motor bridge/ Servo drives	The fault detection should be activated for the connected water valves and flap drives.
Temperature sensor inputs	If a temperature sensor is to be connected to the respective pin, the fault detection must also be activated so that the control can work with the real measured value.
Driver's area. Fresh air/ Recirc. flap Servo mot. act.	A motor drive for a fresh air/recirculation flap can be connected to the control panel at pins 1 and 4 of the 15-pin plug connector. This DC motor is either actuated with a time limitation of maximum 10 seconds in one direction or the other or without time restriction. In the latter case, the drive must switch itself powerless with a limit switch. Another possibility is with an electro-pneumatic drive. In this case, the option "without time limitation" is to be selected as well.
Front box blower	The PWM signal on the output at pin 7 of the 18-pin plug connector can be output as normal and as inverted. In this case, "Normal" means that the output voltage is approx. 0 volts at 0 % PWM and approx. 24 volts at 100 % PWM. When the signal is inverted, 0 % PWM corresponds with 24 volts and 100 % corresponds with approx. 0 volts output voltage.
Additional heating	In order to deactivate the Additional heating button, the button must be blocked on the one hand, and the fault detection for connector 12, pin 6 must also be deactivated. Deactivated, in this case, means that the LED for the button does not illuminate as a function indicator.
CAN fault detection	The control panel has two CAN interfaces, one for the vehicle CAN bus for communicating with a vehicle central computer and one for the heating or system bus for communication with the substations. Messages from the central computer and an MTS (Modular Door Control from WABCO) can be processed via the vehicle bus. If the control panel is to deliver a fault message, if one of the CAN messages is not received, the respective fault detection must be activated. Additionally, a Bus-off detection can be activated for both CAN buses.

9.5 Substations configuration



Parameter	Description
Temperature sensor *Motor bridge*	The parameter setting options are defined by these options as with the configuration of the control panel.
PWM - Output	The PWM signal on the output at pin 7 of the 18-pin plug connector can be output as normal and as inverted. In this case, "Normal" means that the output voltage is approx. 0 volts at 0 % PWM and approx. 24 volts at 100 % PWM. When the signal is inverted, 0 % PWM corresponds to 24 volts and 100 % corresponds to approx. 0 volts output voltage.
Ventilator temperature sensor diagnosis	If a normally closed room temperature sensor is used and it delivers a speed-proportional diagnostic signal, with which the function of the blower can be monitored, it allows this signal to be read and evaluated via the 18 pin plug connector, pin 15 on the control panel or the 18-pin plug connector, pin 15 on the substation. This requires that fault detection is activated. In all other cases, this must be deactivated.

9.6 Configuration System

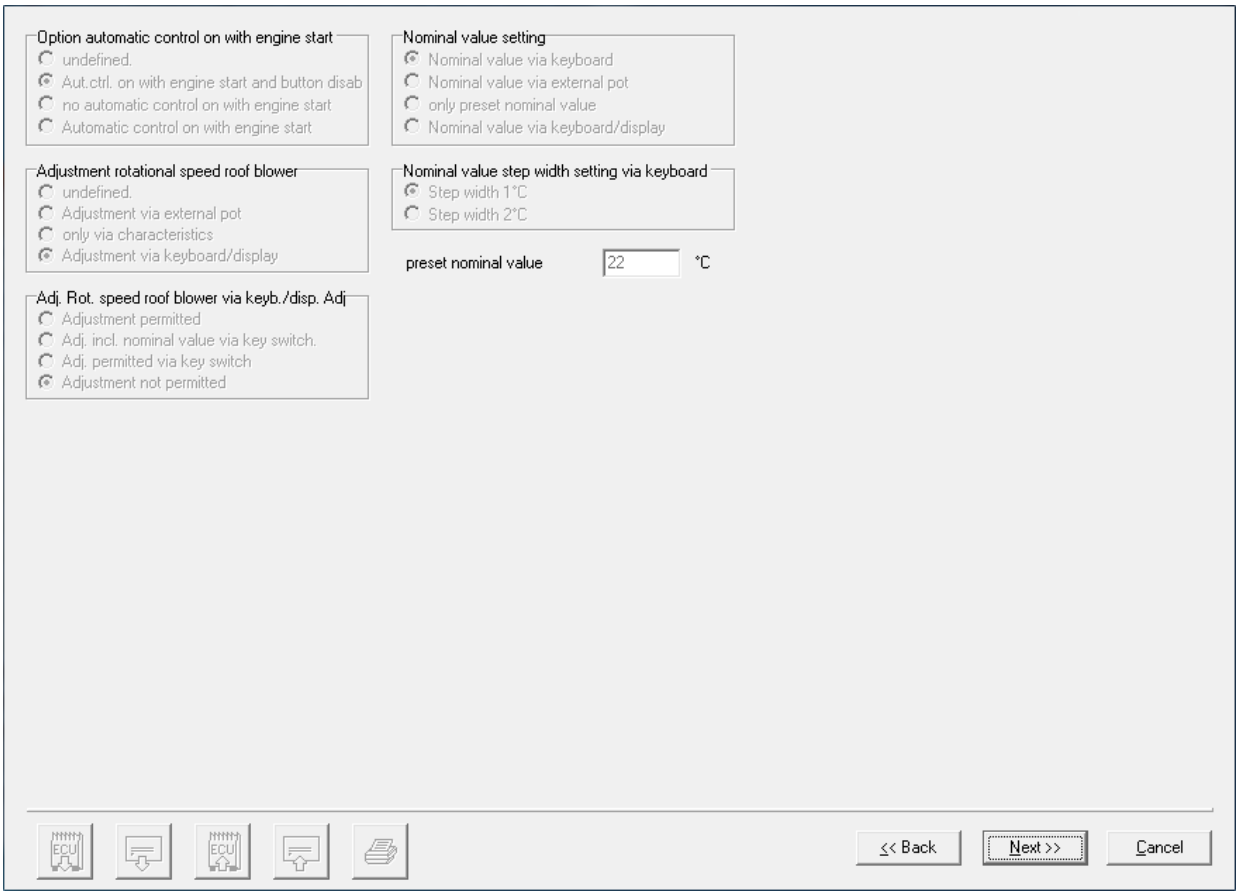


Parameter	Description
Roof system	Indicate here whether the bus has a roof system for heating and/or air conditioning. ■ HVAC = Heating / Ventilation / Air Conditioning, roof heating with evaporator (air conditioning) ■ HV = Heating / Ventilation, roof heating only ■ VAC = Ventilation / Air conditioning, without heat exchanger for heating system
Additional heating control	Manual operation means that the additional heating can only be activated via the button. In automatic mode, the additional heating is switched on, if either the outside temperature is under 20 °C with the passenger compartment control switched on or the air outlet temperature nominal value is greater than 40 °C for the front box (approximate middle position for the nominal value potentiometer). If the button is actuated one time, the control panel switches back to manual mode until the ignition is switched off and back on again.
Additional heating button with ignition off	The additional heating can be activated or deactivated during “ignition off”. Additionally, the time in which the additional heating is to run can also be selected during activation.
Front box blower with Door-1-open signal	The front box blower can be operated at reduced speed, e.g. to avoid banknotes being blown away in this situation.

Parameter	Description
Roof blower with door-closing signal	The combination of doors that seal well and a roof system in fresh air operating mode can lead to problems when closing these doors. For this reason, the roof blower can be reduced to minimum speed for a brief period when the "last door closing" signal is received by the MTS via the CAN bus or a corresponding signal is connected to pin 9 of the 15-pin plug connector.
Block for blower when water temp. too low	To prevent blowing cold with blower supported heating, the blower can be blocked or throttled if the water is still cold. It is possible to activate this block only for the roof system or only for the floor heating.
Red. operation of add. heating via outside temp.	If you choose reduced operation depending on the outside temperature, output pin 7 of the 12-pin plug connector on the control panel is activated for energy saving mode of the additional heating over an outside temperature of +5 °C.
Room blower saver Level 1	Replaced by load management via vehicle CAN bus. Load management recognises two energy saving modes. In stage 1, the blower speed is limited to a parameter defined maximum value, in stage 2, the blower is switched off.
Roof flaps with door open signal	The combination of doors that seal well and a roof system in fresh air operating mode can lead to problems when closing these doors. For this reason, the roof flaps can be run at mixed-air position for a brief period using this parameter when the "last door closing" signal is received by the MTS via the CAN bus or a corresponding signal is connected to pin 9 of the 15-pin plug connector.
Optimised Defrost mode	When in optimised defrost mode, the water valve of the floor circuit (in articulating units, only in the front section), is completely open and the blower is actuated in stage 1 if the motor is running, the passenger compartment control is switched off, the additional heating is switched on and defrost mode is activated. This causes the additional heating unit to cycle less in certain cases.
Roof blower enabled	For vehicles that cannot provide a water temperature to the control panel, there is the option to enable Level 1 of the floor blower only after the air outlet temperature of the floor heating has exceeded a minimum value.
Enable floor blower Level 2	Enabling Level 2 of the floor heating may also be coupled to exceed a defined water temperature. When dropping below the difference of the water temperature limit and hysteresis, Level 2 is once more blocked. For vehicles that cannot provide a water temperature to the control panel, there is the option to enable Level 2 of the floor blower only after the air outlet temperature of the floor heating has exceeded a minimum.
Blower characteristics for multi-level floor blower	If a water temperature is available, the limit value for the water temperature is entered, from which the floor blower is enabled, i.e. allowed to run. For vehicles that cannot provide a water temperature to the control panel, there is the option to enable Level 2 of the floor blower only after the air outlet temperature of the floor heating has exceeded a minimum. This is also entered here in this case.

Parameter	Description
Roof hatches	An actuation signal can be used for the skylights on pin 4 of the 18-pin plug connector of the substations. The actuation is either done via the vehicle CAN Bus and is overamplified in air conditioning mode in cases or it occurs according to the roof flap characteristic curve, whereby the output is active in the fresh-air position of the flaps. Accordingly, the output can then also be used for electro-pneumatically actuated fresh air/circulating air flaps.
Pointer	This indicates where the control panel gets the information on the room temperature, the outside temperature, water temperature and the pressure switch.
Front box fan saver level 1 *Roof blower saver level 1*	If an energy saving signal exists on pin 11 of the 15-pin plug connector of the control panel or if a respective request comes via the vehicle CAN Bus, the front box fan and in some cases the roof blower run at the PWM speeds defined here.

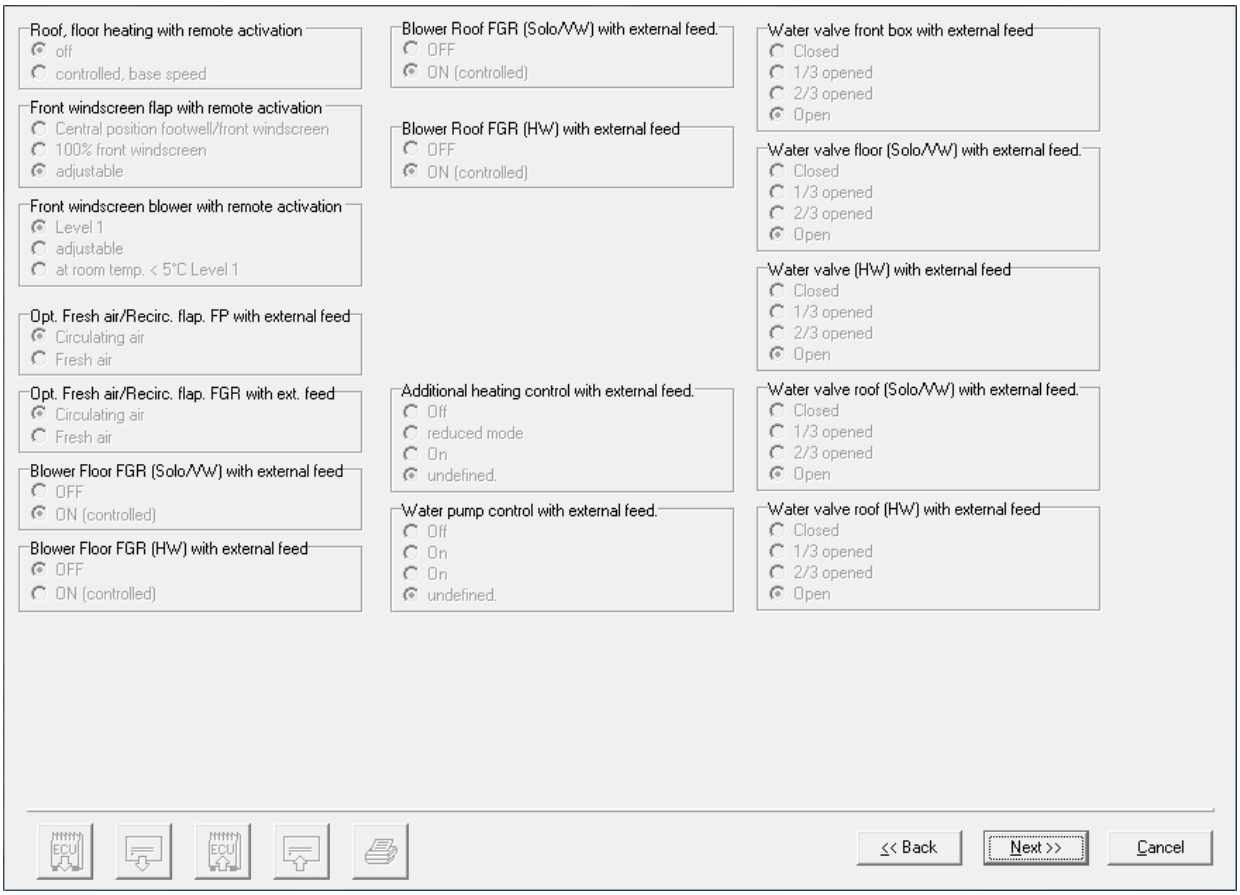
9.7 Operation



Parameter	Description
Option automatic control on with engine start	*Automatic on with engine start and button disabled*: If the vehicle engine is started, the passenger compartment control is activated automatically. If only the vehicle motor is stopped without switching the ignition off, the passenger compartment control is deactivated automatically. The driver can not switch the control on or off with a button. *No automatic On at motor start*: The driver can switch the control on or off at any time with a button. No automatic activation. *Automatic On at motor start*: If the vehicle engine is started, the passenger compartment control is activated automatically. If only the vehicle motor is stopped without switching the ignition off, the passenger compartment control is deactivated automatically. The driver can switch the control on or off at any time with a button.
Adjustment rotational speed roof blower	*Adjustment via external potentiometer*: An external blower nominal value potentiometer (Chapter "10 Overview plans / Wiring plans", page 40) can be optionally connected at pin 14 of the 18-pin plug connector. The speed for the roof blower or the evaporator fan defined via the fan/blower characteristic curve can be increased or decreased with this. *Only via characteristics*: Purely automatic operation according to blower characteristics. *Adjustment via keyboard/display*: This option only makes sense in connection with a display that responds to the vehicle CAN bus.

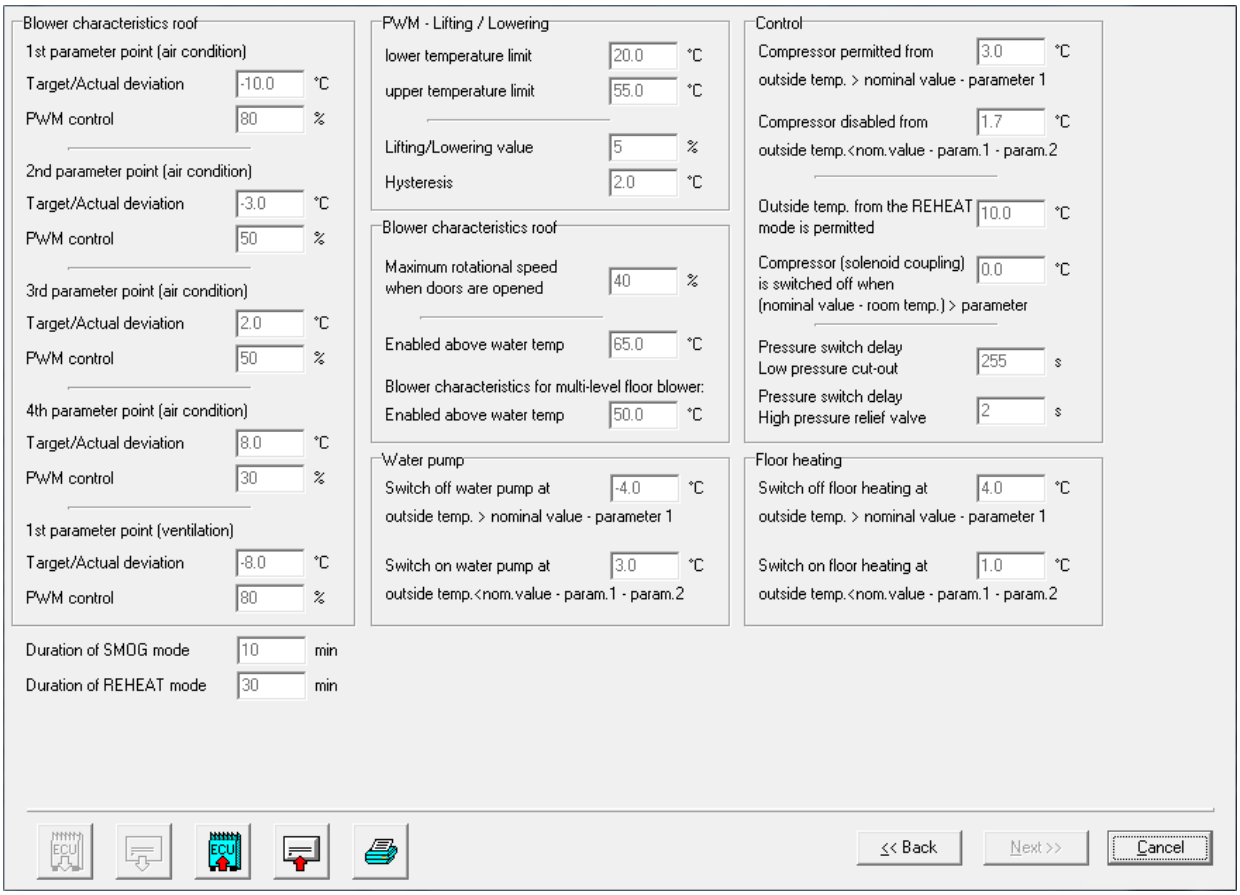
Parameter	Description
Adj. Rot. speed roof blower via keyb./disp. Adj.	*Adjustment allowed*: This option only makes sense in connection with a display that responds to the vehicle CAN bus. *Adj. incl. nominal value via key switch:* This option only makes sense in connection with a display that responds to the vehicle CAN bus. Additional locking of the nominal value and the blower adjustment is possible via the key switch on pin 14 of the 18-pin plug connector. *Adj. permitted via key switch*: This option only makes sense in connection with a display that responds to the vehicle CAN bus. Additional locking of the blower adjustment is possible via the key switch on pin 14 of the 18 connector. *Adjustment not allowed:* Standard setting if no display exists.
Nominal value setting	*Nominal value via keyboard:* In order to achieve the adjustment mode, the button for the passenger compartment heating must be pressed for at least 10 seconds. After entering adjustment mode, the LEDs for the three buttons on the right flash according to the defined nominal value. The nominal value can be increased or decreased with the "Smog" and "Additional heating" buttons. The preset nominal value, which is allocated to the middle LED and the step interval parameters can be defined. *Nominal value via external potentiometer*: An external nominal value potentiometer (Chapter "10 Overview plans / Wiring plans", page 40) can be optionally connected at pin 3 of the 15-pin plug connector. The nominal value for the passenger compartment temperature control can now be set in a range of 16 to 32 °C. The setting capability via the keyboard is then deactivated. *Only preset nominal value*: If this option is actuated for the nominal value setting, the nominal value can only be set with a parameter change (by the diagnostics device). *Nominal value via keyboard/display*: This option only makes sense in connection with a display that responds to the vehicle CAN bus.

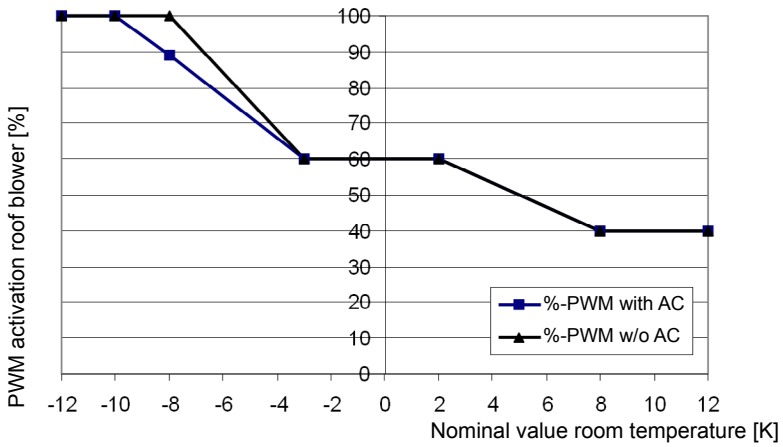
9.8 Remote activation and external feed



Parameter	Description
Remote activation	If the control panel is not activated via terminal 15 input but through the remote actuation input on pin 8 of the 15-pin plug connector, the additional heating is always switched on. All other functions and parameter setting capabilities correspond with those of remote supply operation. This remote actuation input mainly serves for actuating with a preset clock.
External feed	The control panel can be activated when the ignition is switched off via the remote supply input at pin 12 of the 15-pin plug connector. The remote supply input is used for setting the system to a defined state in case of remote supply with warm water and/or power. The option *Control of roof/floor heating with remote activation* is used to implement automatic room temperature control with reduced blower speeds. The other options then have no effect. These are then only active with option *Control of roof/floor heating with remote activation OFF*. Using the parameters shown here, the blower functions, the water valve settings, flap settings and the functionality of the additional heating and the water pump can then be set.

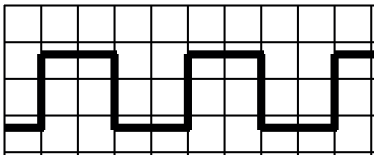
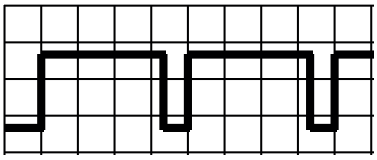
9.9 Characteristic curve control



Parameter	Description
Blower characteristics roof	

with AC = with air conditioning; without AC = without air conditioning

The blower characteristic curve is defined with four coordinate values. To the left of the first coordinate and to the right of the fourth coordinate, the characteristic curve always has an incline of 0. The first parameter coordinate exists twice, once for the ventilation operation and once for vehicles with air conditioning (AC).

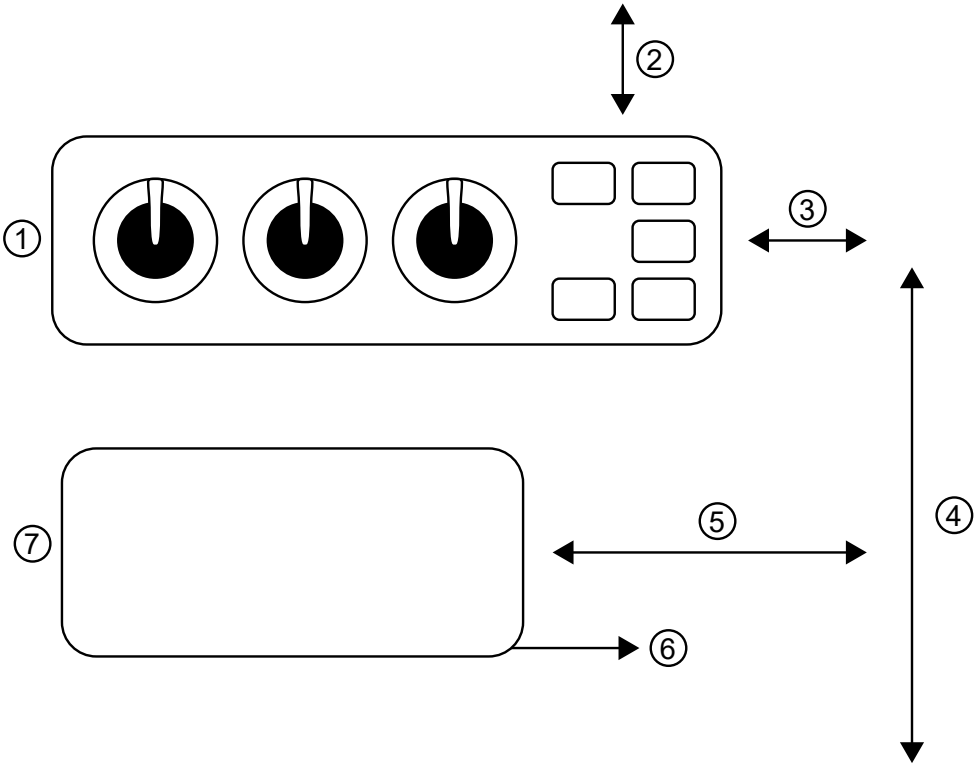
Parameter	Description
	The blower characteristic curve can also increase or decrease depending on the outside temperature. Therefore, we define an upper and lower limit for the outside temperature range, the value for the PWM offset and a hysteresis for the temperature limits. The maximum value for opened doors (for closing doors to more precise) only has an effect if the option *Roof blower with door-closing signal* is selected accordingly on the page *Configuration System*. If the blocks for the blower for water that is too cold are active, the water temperature limits, from which the blower is enabled, can be entered here. For vehicles that cannot provide water temperature for the control panel, it is only possible to enable the roof blower and Level 1 of the floor blower once the air outlet temperature in the roof has exceeded a minimum value. In this case, the air outlet temperature limit values are to be defined here.
Duration of SMOG mode *Duration of REHEAT mode*	If the Smog or Reheat function is activated with a button, the respective function duration is limited. This maximum duration is to be entered in minutes here.
PWM - Lifting / Lowering	The "PWM" percentage corresponds to the blower speed (e.g. 25 %). With roof systems with inverted PWM output, 25 % corresponds to PWM = > 75 % blower speed.  PWM = 50 %  PWM = 90 %
Control	The solenoid coupling of the cold compressor is actuated if a certain temperature (heat) is exceeded outside and inside the vehicle. *Compressor permitted from:* *Outside temp. > nominal value - 1st parameter* *Compressor disabled from:* *Outside temp. < nominal value - 1st parameter - 2nd parameter (hysteresis)* *The compressor (solenoid connection) is switched off when (nominal value - room temperature) > parameter* The 3rd parameter specifies the outside temperature beyond which reheat operating mode is permitted. The dependence of the room temperature can be set via the 4th parameter. Compressor is switched off: (nominal value - room temperature) > 4th parameter Compressor is once more permitted: (nominal value - room temperature) < 4th parameter - 2nd parameter (hysteresis)

Parameter	Description
Floor heating	The floor heating is switched off or back on depending on the difference between the nominal value and the outside temperature. Switch off: The water valves close for the floor circuits and the blower switches off if necessary. Switch on: The floor heating is in control mode. *Switch off floor heating at:* *Outside temp. > nominal value - 1st parameter* *Switch on floor heating at:* *Outside temp. < nominal value - 1st parameter - 2nd parameter (hysteresis)*

10 Overview plans / Wiring plans

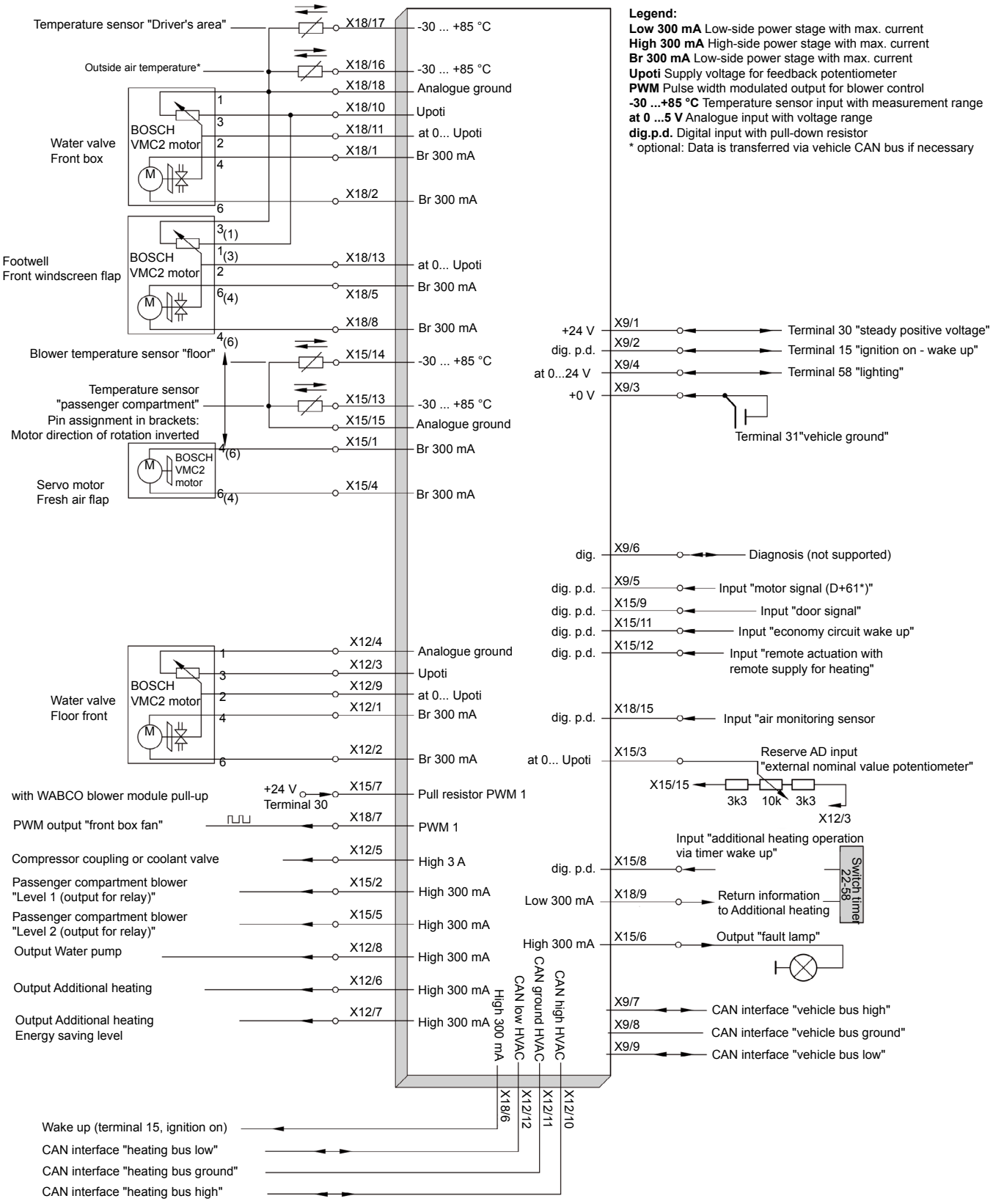
10.1 City bus power-driven vehicle

10.1.1 Overview plan

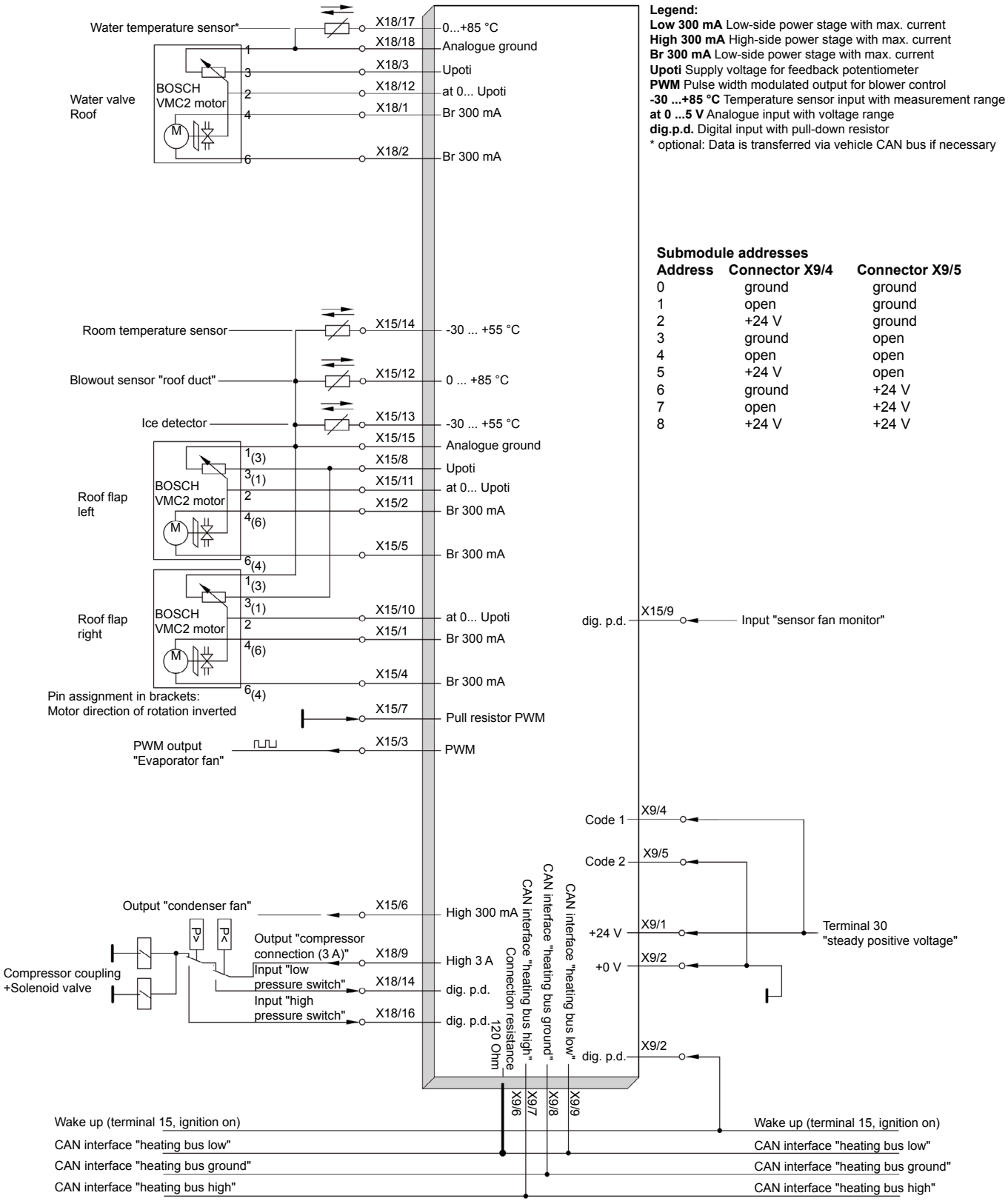


①	Control panel
②	CAN interface vehicle bus
③	CAN interface HVAC data bus
④	CAN interface (heating bus) low CAN interface (heating bus) ground CAN interface (heating bus) high
⑤	Extended with other substations e.g. possible for articulating unit
⑥	Connect CAN termination resistor (connection 9/6 - 9/9)
⑦	Roof substation (n/a for vehicles without roof system); address 2

10.1.2 Wiring plan control panel 446 195 00X 0

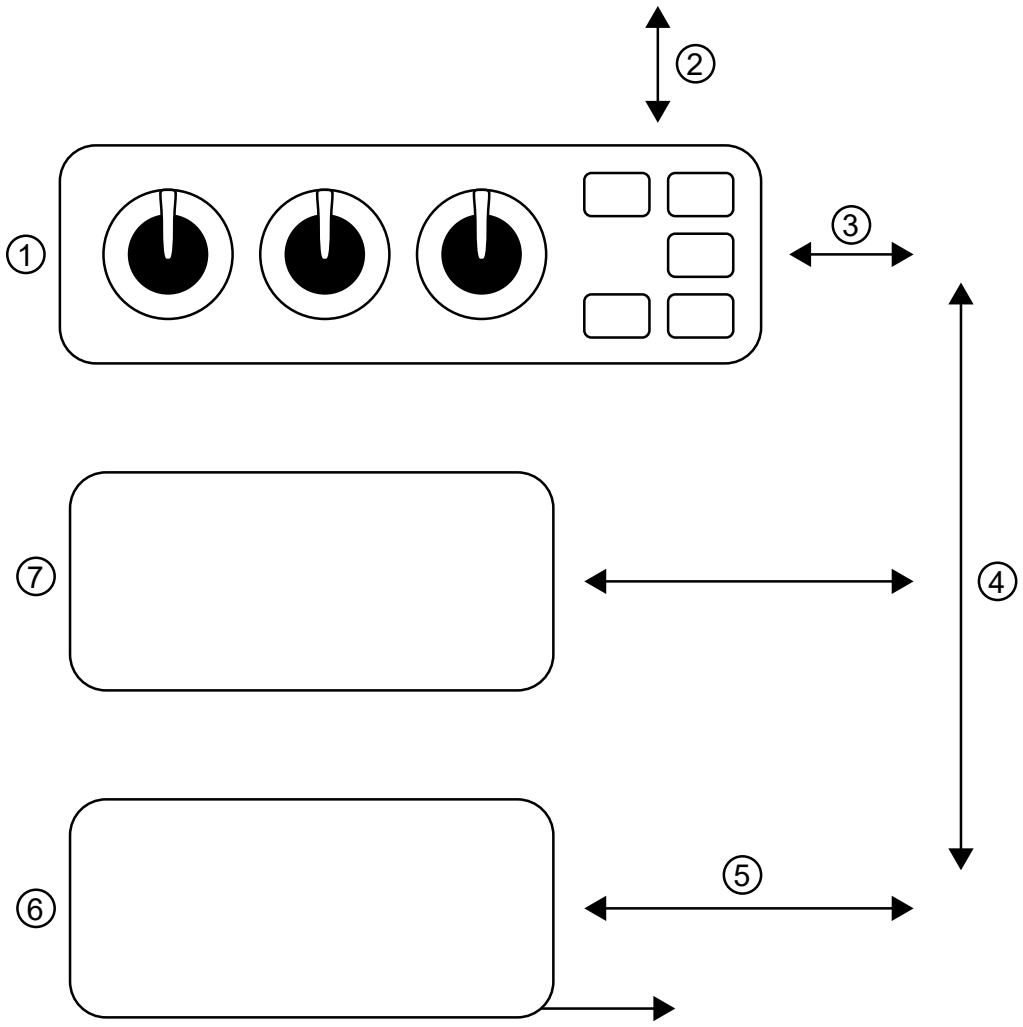


10.1.3 Wiring plan substation 446 195 000 0 roof; address 2



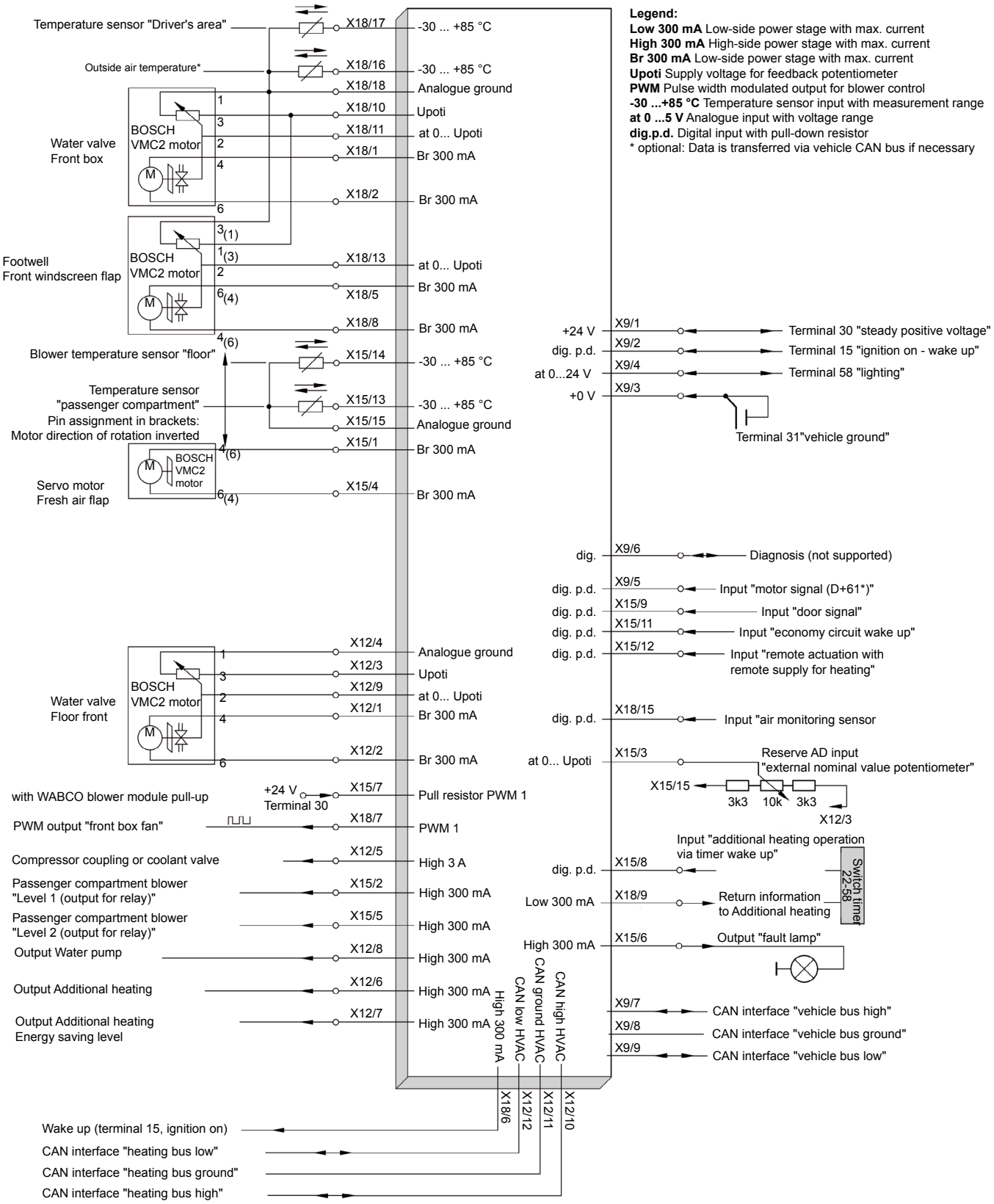
10.2 City bus Articulating vehicle

10.2.1 Overview plan

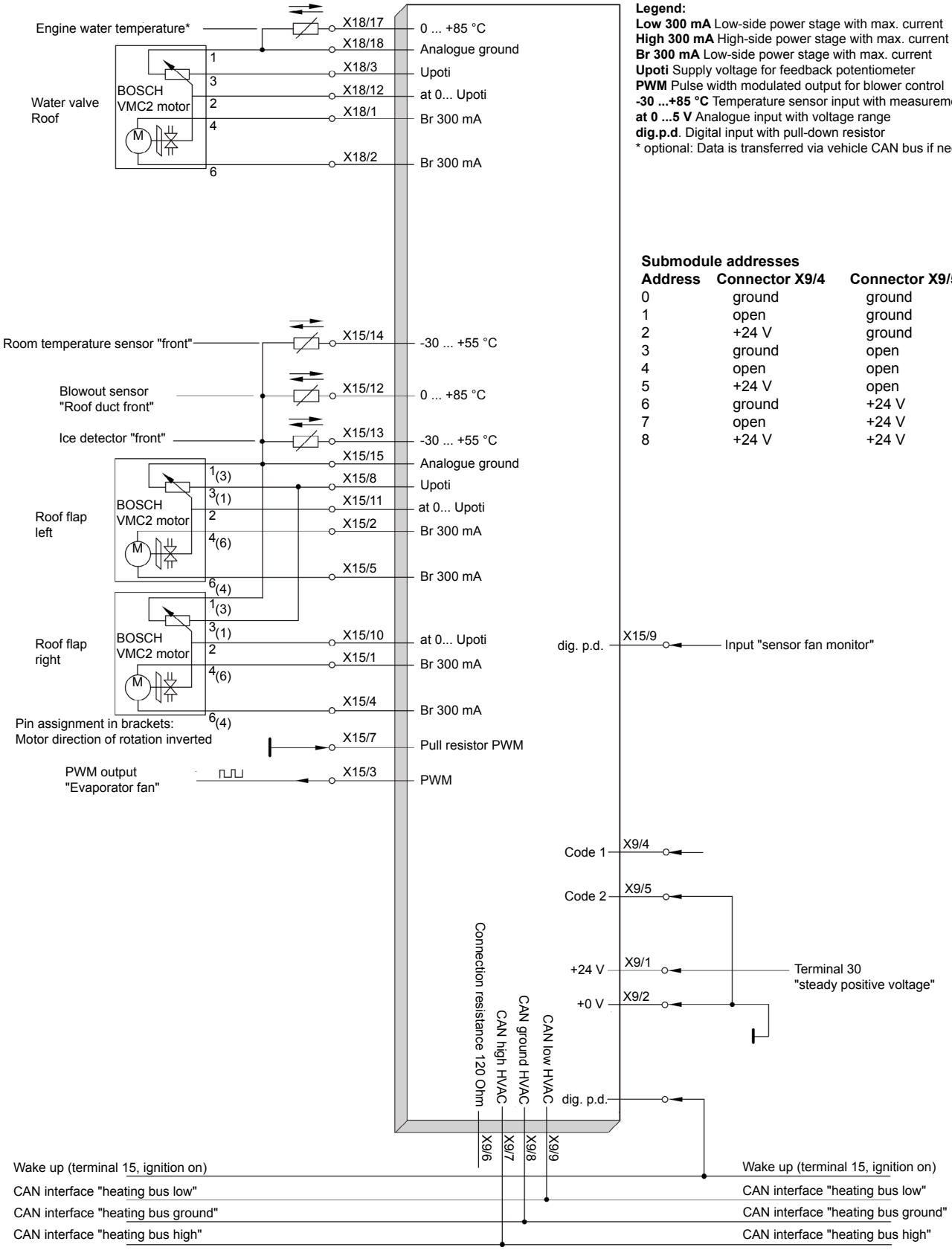


①	Control panel
②	CAN interface vehicle bus
③	CAN interface HVAC data bus
④	CAN interface (heating bus) low CAN interface (heating bus) ground CAN interface (heating bus) high
⑤	Connect CAN termination resistor (connection 9/6 - 9/9)
⑥	Roof rear section substation; address 2
⑦	Roof substation (n/a for vehicles without roof system); address 1

10.2.2 Wiring plan control panel



10.2.3 Wiring plan substation roof system front section; address 1

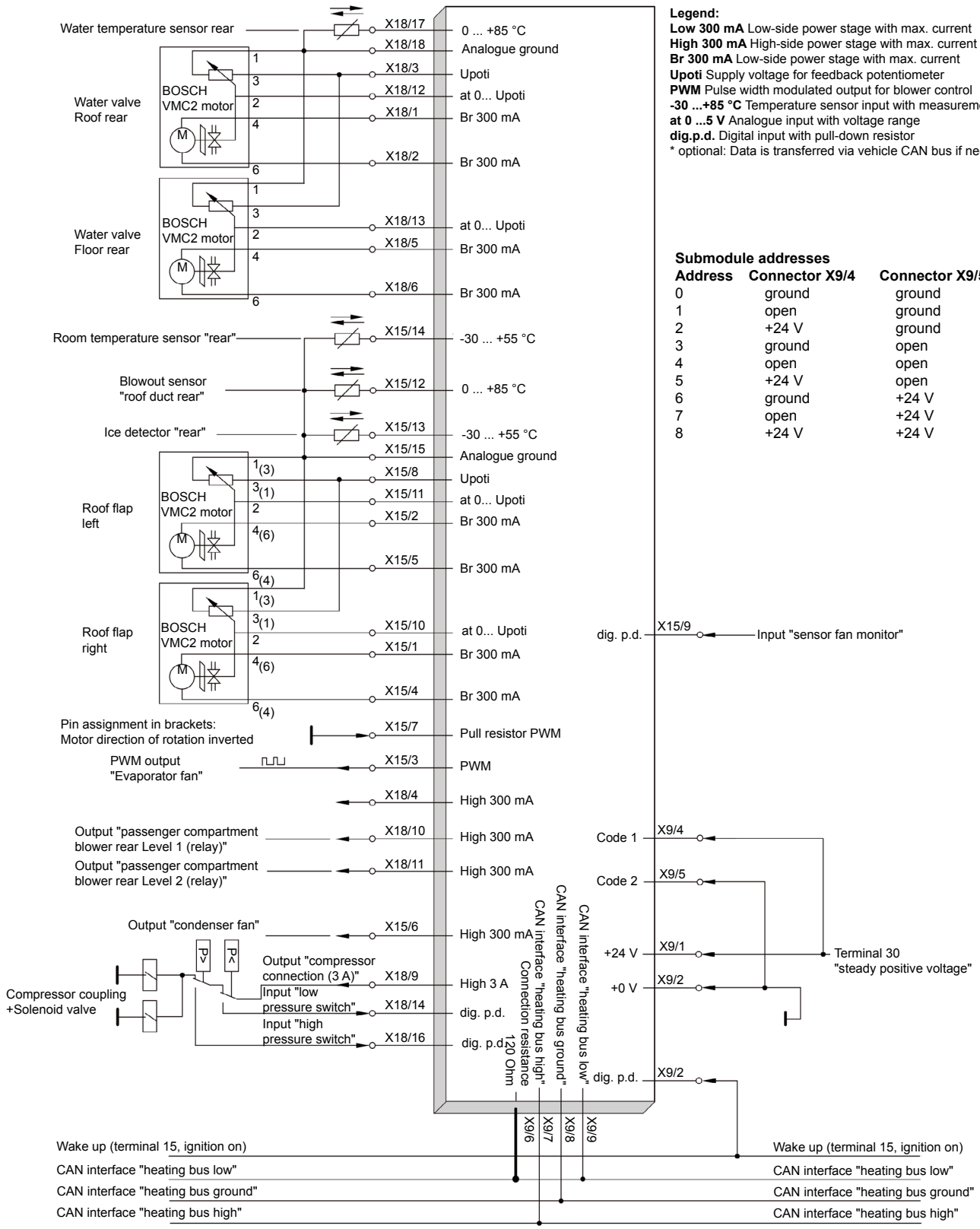


Legend:
Low 300 mA Low-side power stage with max. current
High 300 mA High-side power stage with max. current
Br 300 mA Low-side power stage with max. current
Upoti Supply voltage for feedback potentiometer
PWM Pulse width modulated output for blower control
-30 ...+85 °C Temperature sensor input with measurement range
at 0 ...5 V Analogue input with voltage range
dig.p.d. Digital input with pull-down resistor
* optional: Data is transferred via vehicle CAN bus if necessary

Submodule addresses

Address	Connector X9/4	Connector X9/5
0	ground	ground
1	open	ground
2	+24 V	ground
3	ground	open
4	open	open
5	+24 V	open
6	ground	+24 V
7	open	+24 V
8	+24 V	+24 V

10.2.4 Wiring plan substation roof system rear section; address 2



Legend:
Low 300 mA Low-side power stage with max. current
High 300 mA High-side power stage with max. current
Br 300 mA Low-side power stage with max. current
Upoti Supply voltage for feedback potentiometer
PWM Pulse width modulated output for blower control
-30 ...+85 °C Temperature sensor input with measurement range
at 0 ...5 V Analogue input with voltage range
dig.p.d. Digital input with pull-down resistor
* optional: Data is transferred via vehicle CAN bus if necessary

Submodule addresses

Address	Connector X9/4	Connector X9/5
0	ground	ground
1	open	ground
2	+24 V	ground
3	ground	open
4	open	open
5	+24 V	open
6	ground	+24 V
7	open	+24 V
8	+24 V	+24 V

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