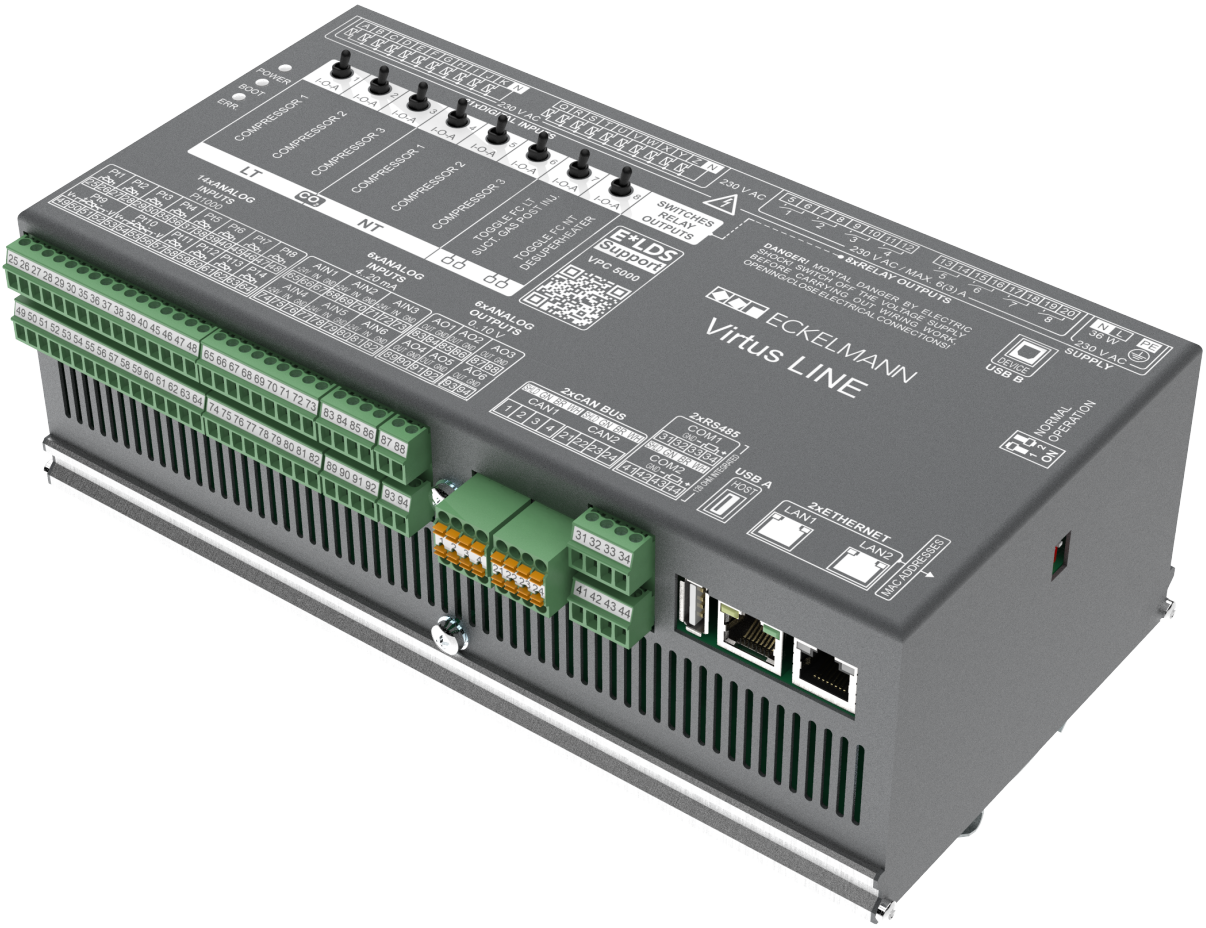
Eckelmann

Operating instruction

Pack Controller VPC 5000

For transcritical CO_2 systems



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Before commissioning and use, please check that this is the latest version of the document. With the publication of a new version of the documentation, all previous versions lose their validity. The current operating manual and information such as data sheets, more detailed documentation and FAQs are available for you on-line in E°EDP (Eckelmann ° Electronic Documentation Platform) at

www.eckelmann.de/elds

You reach all relevant documents for this component directly using the QR code:

https://edp.eckelmann.de/edp/lds/_a2xhYWBPaA

Information on safety and connection instructions are described in detail in chapter ”Industrial safety notes”.

Table of Contents

1 Conventions

1.1 Warning signs, symbols and text formatting used in this manual

Explanation of the warning signs, symbols and text formatting used in this operating and service manual:

- **DANGER**

> **DANGER**
>
> Instructions with this symbol and/or the signal word DANGER warn the user of situations that will cause severe injury or death if the specified instructions are not observed! *

- **WARNING**

> **WARNING**
>
> Instructions with this symbol and/or the signal word WARNING warn the user of situations that may cause severe injury or death if the specified instructions are not observed! *

- **CAUTION**

> **CAUTION**
>
> Instructions with this symbol and/or the signal word CAUTION warn the user of situations that may cause moderate or minor injury if the specified instructions are not observed! *

* If any of these symbols **DANGER/WARNING/CAUTION** is recognized, the user **must** refer to the operating manual in order to understand the type of potential **HAZARD** and the required actions for avoiding the **HAZARD**. Carefully observe all health and safety instructions and use particular caution in these situations. **Failure to observe the DANGER/WARNING/CAUTION symbols will cause injury (in the worst case, severe injury or death) and/or damage to property!**

- **ATTENTION**

> **ATTENTION**
>
> Instructions with this symbol and/or the signal word ATTENTION warn the user of situations that may cause damage to property if the specified instructions are not observed! The ATTENTION symbol highlights guidelines and regulations, instructions and proper working procedures that must be particularly observed in order to prevent damage to and destruction of components or malfunctioning. **Failure to observe the ATTENTION symbol will cause damage to property!**

- **NOTICE**

> **NOTICE**
>
> Instructions with this symbol and/or the signal word NOTICE provide tips and useful additional information.

- **ELECTRIC SHOCK**

Risk of fatal electric shock!

This symbol warns of danger from **dangerous voltage** with possible consequences such as severe injury and death. If this symbol is seen, the user **must** refer to the operating manual in order to understand the type of potential **HAZARD** and the required actions for avoiding the **HAZARD**. Carefully observe all health and safety instructions and use particular caution in these situations.
Failure to observe the WARNING symbol will cause injury (in the worst case, severe injury or death) and/or damage to property!

- **ESD - Electrostatic-sensitive components and control components**

Risk of destruction of the control component / controller!
Electronic components and control components (e.g. circuit boards) are sensitive to electrostatic charges. Circuit boards may only be replaced when the **power supply is disconnected**. Always hold circuit boards by the edges. The guidelines for the handling of electrostatic-sensitive components and control components **must** be observed at all times.
Failure to observe the ESD symbol will cause damage to property!

- **DISPOSAL**

Potential negative impact on people and the environment due to non-environmentally friendly disposal.

The strike-through dustbin symbol indicates the duty to dispose of items properly. Do not dispose of this product with other domestic waste, see chapter Disposal. Please inform yourself about the local regulations for the separate disposal of electrical and electronic products. The correct disposal of your old equipment protects people and the environment from possible negative impact. **Failure to observe the DISPOSAL symbol will cause damage to people and the environment!**

1.2 Explanation of text formatting

Safety instructions or hazard warnings are composed of four elements:

1. The symbol with text (e.g. for DANGER),
2. a concise description of the hazard and
3. a description of the possible consequences.
4. Where applicable, a catalogue with measures for avoiding the hazard.

For example:

DANGER

Warning of dangerous electrical voltage! Risk of fatal electric shock!
Beware of external voltage at the digital inputs and outputs! Connections/plug connectors of the device may only be plugged in, removed and/or wired when **no voltage is present**.

A **general instruction** consists of two elements:

1. The symbol with text (including NOTICE, if applicable) and
2. the text of the instruction:

For example:

NOTICE

The current operating manual is available online from the E°EDP (Eckelmann ° Electronic Documentation Platform) at www.eckelmann.de/elds.

2 Safety instructions

This operating manual is part of the device. It **must** be kept in the vicinity of the controller as well as for future use so that it can be consulted when required. The operating manual must be available to the operating and maintenance personnel at all times in order to avoid operating errors. The safety regulations, instructions and information **must be strictly observed and complied with.** During repairs on the entire E*LDS system, the accident prevention regulations and general safety regulations must be strictly complied with. Important information (safety instructions and hazard warnings) are indicated by appropriate symbols, see chapter Conventions. Follow these instructions in order to prevent accidents and danger to life and limb, as well as damage to the E*LDS system!

Always observe the following information:

DANGER

Warning of dangerous electrical voltage! Danger of electric shock!
Beware of external voltage at the digital inputs and outputs! Connections/plug connectors of the device may only be plugged in, removed and/or wired when **no voltage is present**.

- Work on the electrical system may only be performed by **authorised, skilled personnel** (according to the definition of skilled persons in DIN/VDE 0105 and IEC364) while observing the applicable
  - VDE regulations
  - Local safety regulations
  -Intended Use
  - Five safety rules according to DGUV Regulation 3
  - ESD measures
  - Operating manuals
- For safety reasons, the equipment must not be used for any applications other than described in the operating manual and only for the intended use.
- **Before** using the device, check whether it is suitable for your application with regard to its limit values.
- The equipment **must** be installed in an electrically shielded area within the switch cabinet.
- Before connecting the device, it **must** be checked whether the power supply is suitable for the device.
- Coded connectors **must** be used, as there is a possibility of plugging in non-coded connectors in such a way that there is a danger to life and limb!
- Specified ambient conditions (e.g. humidity and temperature limits, see chapter Technical Data) **must** be observed and complied with at all times to prevent malfunction.
- **Before** switching on the device, check the correct wiring of the connections.
- The device must **never be operated without** its housing. If the intended use requires opening the housing, the control unit **must** be disconnected from the power supply before opening the housing.
- Note the maximum load of the relay contacts, see chapter Technical Data.
- Note that all supply lines from and to the device, particularly those of the CAN bus and Modbus, must be shielded or installed sufficiently far away from live cables. This prevents faulty measurements and protects the device against electrical interference via the analogue inputs. Connection in parallel of RC elements is recommended for applications with critical environment.
- Contact the supplier in the case of any malfunction.

ATTENTION

Warning of damage to goods!
In our experience, the transmission of fault messages is not yet functional during the putting into service (no internet connection, no telephone line installed, etc.). It is strongly recommended in such cases to monitor the controller via the CAN bus using a system centre, a store computer or an operator terminal and to enable the transmission of fault messages, for example using a GSM modem via a mobile telephone system. In standalone operation, or as an alternative to monitoring via system centre / store computer / operator terminal, an available alarm contact on the controller must be used to enable the transmission of fault messages via a telephone network.
For more information, refer to E*LDS basics, safety instructions, CAN bus & Modbus.

2.1 Disclaimer in the event of non-compliance

These operating instructions contain information on the commissioning, function, operation and maintenance of the controls and of the associated components.

Observance of these operating instructions is a prerequisite for safe and trouble-free operation.

2.2 Requirements for the personnel

Special technical knowledge is required for planning, programming, installation, putting into service and maintenance work. This work may **only** be performed by skilled, specially trained personnel. The installation, putting into service and maintenance personnel must have training that authorises them to perform interventions in the system and the automation system. The planning and programming personnel must be familiar with the safety concepts of automation technology. Working on electrical systems **requires special technical knowledge**. Work on electrical systems may only be performed **by instructed electrically skilled persons** or under the guidance or supervision of such persons. The applicable regulations (e.g. DIN EN 60204, EN 50178, DGUV Regulation 3, DIN-VDE 0100/0113) must be observed. The operating personnel must be instructed in how to handle the system / machine and the controller and must be familiar with the operating instructions.

2.3 Intended Use

This controller has been designed exclusively for the intended use:
The VPC 5000 controller is designed for use as pack controller in commercial and industrial refrigeration facilities in accordance with the scope of functions and in accordance with the environmental conditions described in this operating manual.

Read the safety instructions and the instructions for installation and putting into service, operation and maintenance. THEN start the commissioning and/or operation of the machine / system.

The safety and functionality of the machine / system are only guaranteed for this intended application. Never use the machine / system, its components, control components or parts for any other purpose. The system must not be put into operation until conformity with the applicable EU Directives has been established for the entire system.

2.4 Five safety rules according to DGUV Regulation 3

The following rules must be strictly observed!

1. Disconnect: The entire system to be worked on must be disconnected from the power supply at all poles.

> **DANGER**
>
> **Warning of dangerous electrical voltage! Warning of dangerous electrical voltage! Danger of electric shock!**
> Beware of a possible external power supply! **BEFORE** connecting and disconnecting it must be checked that **no voltage is present** at the controller! Connections/plug connectors of the device may only be plugged in, removed and/or wired when **no voltage is present**.

2. Secure against reconnection: Attach information signs to the disconnected operating equipment stating:

- What has been disconnected.
- Reason for the disconnection.
- Name of the person who made the disconnection.
- Reconnection must be prevented using a suitable lock (e.g. padlock).

3. Prove dead (authorised skilled personnel only):

- Check voltmeter just before use.
- Prove dead on all poles at the disconnection point.
- Prove dead on all poles at the work area.

4. Ground and short-circuit: All electrical parts at the work area **must be grounded and then short-circuited**.

5. Cover or block off adjacent live parts: If there is live equipment adjacent to the work area, it must be covered using appropriate materials (e.g. insulation blankets / plates).

2.5 Electrostatic-sensitive components and control components (ESD)

All electrostatic-sensitive components and control components (referred to as "ESD" below) are labelled with the warning sign shown. Electrostatic charges arise from friction of insulating materials (e.g. floor covering, items of clothing made of synthetic fibres etc.). Even small charges can result in damage to or destruction of components. Such damage is not always immediately noticeable; in some cases, it does not lead to failure until after a certain operating time.

ATTENTION

Risk of destruction of the control component / controller! Electronic components and control components (e.g. circuit boards) are sensitive to electrostatic charges. Therefore, the guidelines for handling electrostatic-sensitive components and control components must be strictly observed.

2.5.1 ESD - Rules for handling and working

Transport and store ESDs only in the protective packaging provided.
Avoid materials that may produce electrostatic discharge, for example

- Plastic containers and table tops
- Synthetic fibre clothing
- Plastic-soled shoes
- Plastic file covers
- Styrofoam packaging
- Computer monitors, etc.

Preferably wear the following:

- Cotton work clothes
- ESD shoes with conductive soles or leather soles

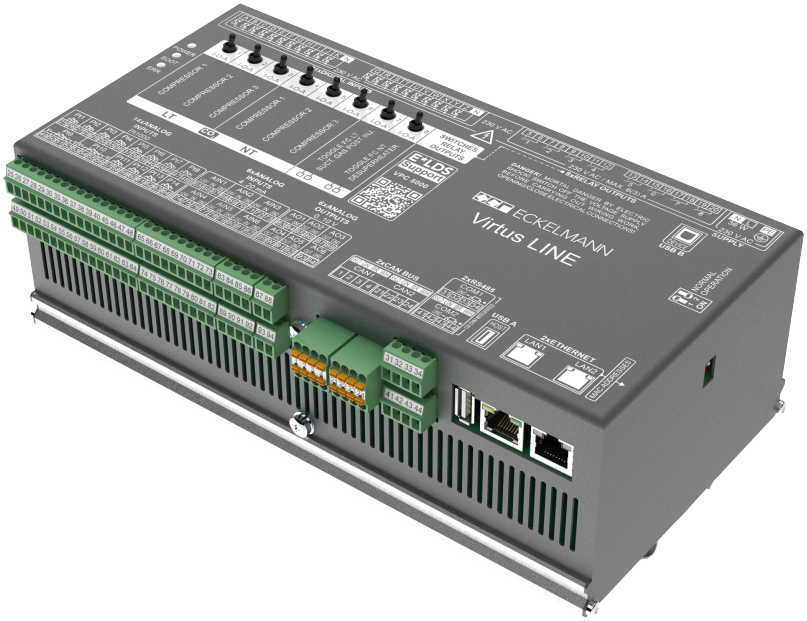
Use the following:

- Conductive flooring
- ESD workstations equipped with suitable tools (grounded soldering guns, antistatic wrist straps, etc.)
- Conductive ESD bags, conductive plastic containers, IC tubes or cartons lined with conductive foam
- Containers and worktops made of wood, metal or conductive plastics or paper bags

2.6 Abbreviations Used

- DGUV Regulation 3 - Accident Prevention Regulation for Electrical Systems and Equipment (previously: BGV A3 - Employer’s Liability Association Regulation for Occupational Health and Safety)
- DIN Deutsches Institut für Normung e.V. (German Standardisation Institute)
- E°EDP/EDP Electronic Documentation Platform of Eckelmann AG
- ESD Electrostatic-Sensitive Device
- ESD Electro-static discharge (Electro Sensitive Devices)
- IEC International Electric Committee
- VDE Verband der Elektrotechnik Elektronik Informationstechnik e.V. (German Association for Electrical, Electronic and Information Technologies)

3 System design VPC 5000

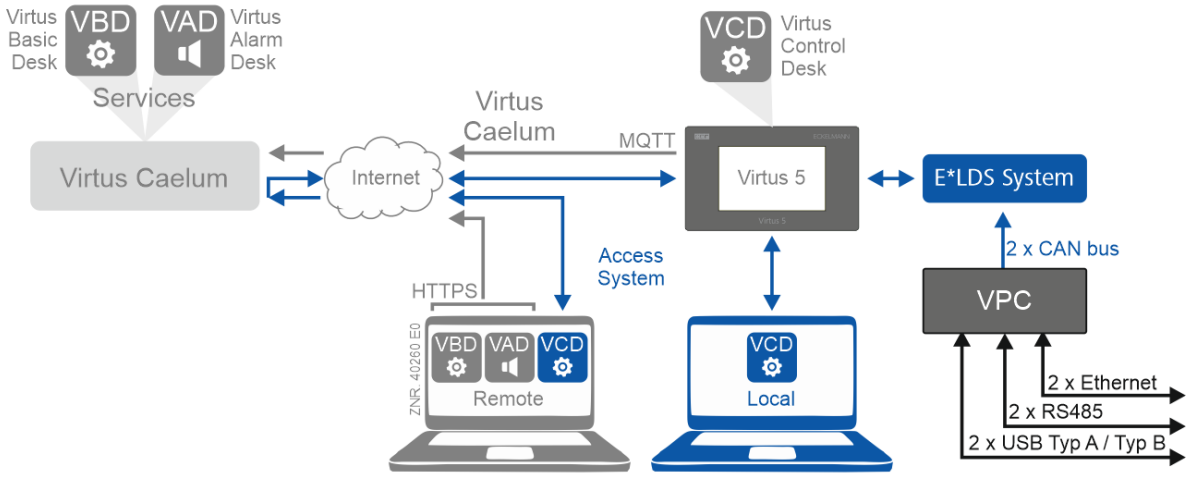


Pack Controller VPC 5000

3.1 Application

The Virtus Pack Controller VPC 5000 - a pack controller of the "Virtus LINE" - controls up to 3 LT, 3 NT compressors and up to 12 stages of 1x/2x/3x Modbus fans. The network-enabled component integrates all functions for the highly efficient and reliable operation of transcritical CO_2 systems. The pack controller - locally on site or remotely - is operated intuitively via the web interface of the Virtus Control Desk (VCD, an integral part of the Virtus 5 system centre). Remote maintenance via the Internet is possible with the VCD, for further details see chapter VPC 5000 operation.

The VPC 5000 pack controller in the E*LDS system and its interfaces:



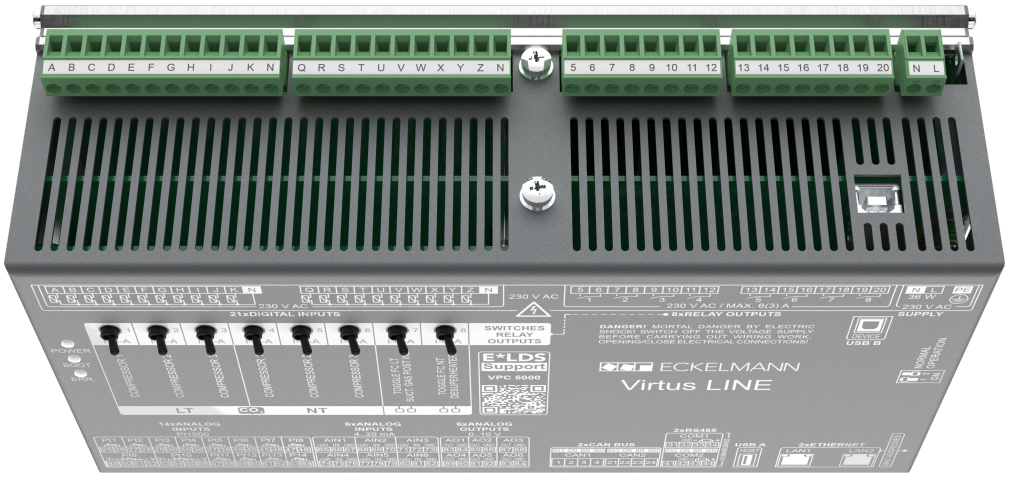
The following expansion stages are possible:

VPC 5000	• 3 LT compressors • 3 NT compressors • Fans via analogue output or Modbus

For more information about the expansion of the range of functions, see chapter VPC 5000 Functions.

3.2 Connectors

Top view - for details, see Connections for Safety Extra-low Voltage (top)



Digital inputs

- 21 x 230 V AC with common neutral conductor (not potential-free)

Relay outputs

- 8 x normally open contact 230 V AC

Power supply

- 230 V AC, PE / earth conductor (ring cable lug)

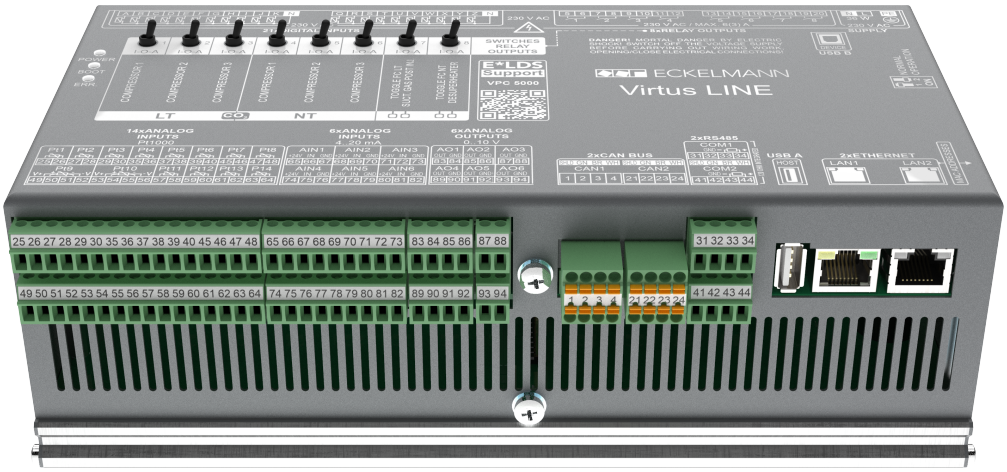
Interface

- 1 x USB DEVICE, Type B as service port

Manual control switch

- For manual override, see chapter Manual / automatic changeover to emergency power mode Manual / automatic changeover to emergency power mode

Bottom view - for details, see Connectors for 230 V AC (bottom)



Analogue inputs / outputs

- 12 x Pt1000 (2-wire) analogue inputs for connection of temperature sensors (e.g. cylinder head temperature)
- 2 x Pt1000 (4-wire) analogue inputs for connection of temperature sensors (room and outdoor temperature)
- 6 x 4..20 mA analogue inputs for connection of, for example, pressure transmitters)
- 6 x 0..10 V analogue inputs for connection of, for example, continuous pressure valves

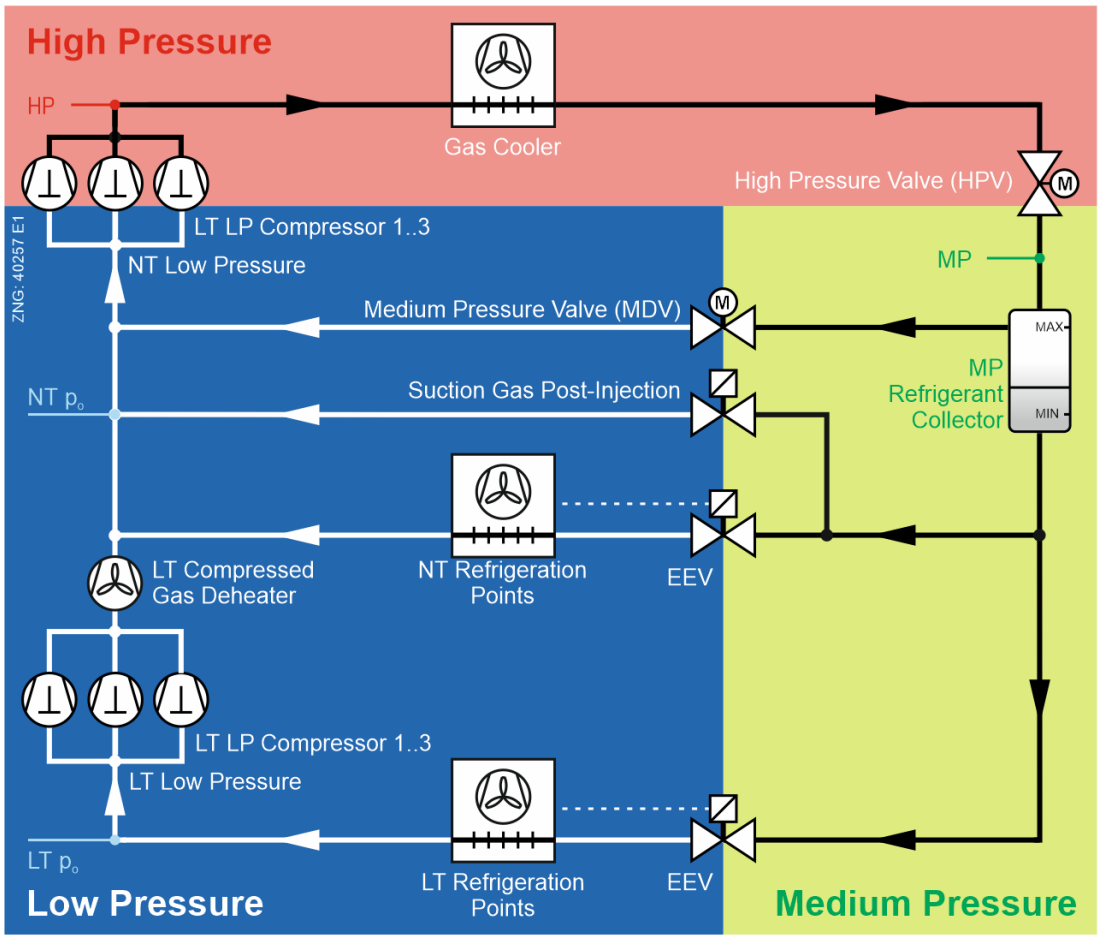
Interfaces

- 2 x CAN bus for communication in the E*LDS system
- 2 x RS485, for example, for control of the gas cooler fans via Modbus
- 1 x USB HOST, Type A for performing aFirmware Update
- 2 x Ethernet

> For further details about pin assignments, see chapter VPC 5000 connection and terminal assignment.

4 VPC 5000 Functions

The functions in the transcritical CO_2 system with Booster Mode can be shown schematically as follows:



The pack controller includes the following functions for the refrigeration compressor pack and condenser:

- Control functions
- Regulation functions
- Monitoring functions
- Fault signals
- Archiving of messages and operating data

These functions include the following:

Low pressure control / compressor control

- as step controller
- as combined control

Medium pressure control

High pressure control

Compressor control with max.

- 3 LT capacity stages
- 3 NT capacity stages

Gas cooler temperature control / fan control

- 0..10 V control variable via analogue output (speed controller)
- Up to 12 stages of 1x/2x/3x Modbus fans

Base load rotation

- Compressor
- Fan

Monitoring Functions

- Motor overload cut-out
  - compressor
  - gas cooler
- Compressor high pressure limiter
- Cylinder head temperature
- Low pressure control
- Medium pressure control
- High pressure control
- Compressor starts
- Control of minimum superheat by
  - suction gas post-injection
  - LT discharge gas desuperheater
- Opening degree high pressure valve (HPV)
- Refrigerant level control MIN/MAX

Load Shedding

Oil Equalisation

Data Archiving

- Messages
- Starts
- On times / operating hours
- Utilisation / activity

Operation via Virtus Control Desk (VCD)

- Wide range of options for operation and display on site / service centre using Virtus Control Desk (browser-based Service and part of the Virtus system centre) or Service notebook
- For support of the start-up: VCD with integrated IO Checker / Service Mode IO Checker / Service Mode

4.1 Booster Mode

When setting up refrigeration systems, a distinction is made between normal and booster operating modes.

In normal operation, the refrigeration circuits of different evaporator levels are operated in completely independent systems. Each circuit has a compressor set, a condenser set and connected refrigeration points

However, in booster mode, the various circuits are operated with only one condenser set and therefore with only one common high pressure line. The refrigeration points are fed from a common refrigerant collector, see diagram in chapter VPC 5000 Functions.

In a booster system, the NT and LT refrigeration points (normal temperature refrigeration and low temperature refrigeration) are supplied by a common liquid line. The refrigerant of the LT refrigeration points (LT circuit) is drawn in by the LT compressors. The pressure of the refrigerant is then increased to the pressure level of the suction lines of the NT refrigeration points (NT circuit) (fed through the "booster stage"), see chapter Switching times for NT/LT compressors. The refrigerant is then drawn in by the NT compressor and raised to the high pressure level.

> ⓘ As the LT compressors convey the refrigerant from the LT suction side to the NT suction side, **at least one NT compressor must** be loaded in the booster system when LT compressors are loaded so that the refrigerant can be compressed to the appropriate high pressure. For more details, see chapter Control algorithm with LP combined control.

5 VPC 5000 Function

5.1 Starting Characteristics

The following are distinguished for any start-up of the controller:

- First start
- Restart

5.1.1 First Start

The controller is reset to the factory settings during a first start.

> **ATTENTION**
>
> The configuration of the controller **must be backed up before any first start**!

A first start is initiated in the following ways:

- The factory settings are loaded by the controller when the system is switched on for the **first** time (see chapter Power supply).
- If the controller has established using an internal check that no correct parametrisation is available.
- After any Firmware Update.

The message 50 "First Start" is output after a first start.

5.1.2 Restart

The restart always takes place after restore of the power supply if the parametrisation has been retained.

> **ATTENTION**
>
> All variables (except the parameters) of the fault memory and all archive data are deleted.

Procedure
Switch off controller - wait for 2 seconds - switch on controller again, see chapter Power supply.

The message 51 "Restart" is output after a restart.

5.2 System Configuration

> **Parametrisation**
>
> **Category System Configuration**

The pack controller has two suction pressure control circuits (LT/NT, compressor control), a medium pressure control circuit (MP, pressure control in collection tank), a high pressure control circuit (HP) and a control circuit for the gas cooler (t_G). The pack controller basically consists of the following control and regulation functions:

Low pressure control (LP) - as step or combined control

- Base load rotation
- Compressor monitoring
- Load shedding
- Emergency power mode
- Safety chain

Medium pressure control (MP)

- Control of the pressure in the collector tank
- Control of the MP control valve

High pressure control (HP)

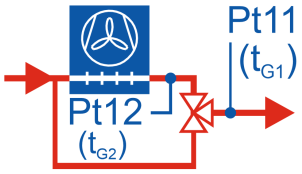
- Control of the high pressure control valve

Gas cooler control via the gas cooler outlet temperature (t_G)

The following options are available for controlling the gas cooler fans:

	Control	Monitoring
Analogue output 0..10 V	AO3	-
Modbus RTU	RS 485 (COM1)	RS 485

The gas cooler outlet temperature is determined via the analogue inputs Pt11 (t_{G1}) / Pt12 (t_{G2}):



For details, see Assignment of the analogue inputs Pt1000.

Basic configuration of the system parameters

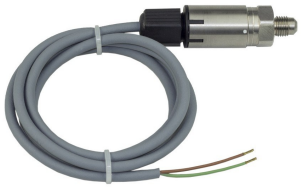
Parameter	Description	Input	Default	Dim.
Category System Configuration				
Components				
No. of LT Compressors	Number of LT Compressors	1..3	3	-
Input compressor capacity LT (Qo)	Enable input of the compressor power activity	YES / NO	NO	-
Enable LT-Control	LT compressor available	YES / NO	YES	-
No. of LT Compressors	Number of LT compressors	1..3	3	-
No. of Fan Stages	Number of fans	0..12	1	-
Compressor Monitoring				
Enable Motor Protection NT	NT compressor motor overload cut-out available and is monitored	YES / NO	NO	-
Enable Oil-/HP-Monitoring NT	NT oil differential pressure switch available and is monitored	YES / NO	NO	-
Alarm Delay Oil/HP Fault	Alarm delay HP compressor fault	0..10	0	min
Enable Motor Protection LT	LT compressor motor overload cut-out available and is monitored	YES / NO	NO	-
Enable Oil-/HP-Monitoring LT	LT oil differential pressure switch available and is monitored	YES / NO	NO	-
Emergency Power Mode				
Emergency power mode	Enable emergency power mode	YES / NO	NO	-
Active Compressor Stages in Emergency Power Mode	Number of active compressor stages in emergency power mode	1..2	2	-
Category Low Pressure Control NT				
Enable Compressor Capacity Stages NT				
NT Compressor Stage X	Enable NT compressor stage X	ON/OFF	ON	-
Activity Stage X	Input compressor capacity for NT compressor X (only if Compressor Capacity Input NT = YES)	5..95	5	%
Category Low Pressure Control LT				
Enable Compressor Capacity Stages LT				
LT Compressor Stage X	Enable LT compressor stage X	ON/OFF	ON	-
Qo LT Compressor Stage	Input compressor capacity for LT compressor X (only if Compressor Capacity Input LT = YES)	5..95	5	%
Category Gas Cooler Outlet Temperature Control				
Enable fan stages				
Fan Stage X	Enable fan stage X	ON/OFF	ON	-

5.3 Pressure Transmitter

Parametrisation

Category Pressure transmitter

The pack controller operates with continuous pressure transmitters (4..20 mA) with linear curves, see chapter Part numbers VPC 5000 and accessories.



The analogue inputs can be adjusted for various pressure transmitters with linear curves. The adjustment is made via the following parameters:

Parameter	Description	Input	Default	Dim.
LT LP Transmitter	LP low pressure transmitter on **AIN1**			
LT LP Transmitter Min.	Minimum pressure at 4 mA at the output of the pressure transmitter	0..2.0	1.0	bar
LT LP Transmitter Max.	Maximum pressure at 20 mA at the output of the pressure transmitter	25.0..80.0	26.0	bar
LT LP Transmitter	NT low pressure transmitter on **AIN2**			
NT-LP Sensor Min.	Minimum pressure at 4 mA at the output of the pressure transmitter	0..2.0	1.0	bar
LT LP Transmitter Max.	Maximum pressure at 20 mA at the output of the pressure transmitter	25.0..80.0	60.0	bar
MP Transmitter	Medium pressure transmitter on **AIN3**			
MP Transmitter Min	Minimum pressure at 4 mA at the output of the pressure transmitter	0..2.0	1.0	bar
MP Transmitter Max	Maximum pressure at 20 mA at the output of the pressure transmitter	23.0..100.0	60.0	bar
HP Transmitter	High pressure transmitter on **AIN4**			
HP Transmitter Min.	Minimum pressure at 4 mA at the output of the pressure transmitter	0..2.0	1.0	bar
HP Transmitter Max.	Maximum pressure at 20 mA at the output of the pressure transmitter	100.0..200.0	140.0	bar

ATTENTION

Damage to the system and stock loss: Incorrect parametrisation of the pressure transmitters can result in high impairments of the functions! The message "Sensor Type Change″ is displayed if any of these parameters is changed! For connector details, see Assignment of the 4..20 mA analogue inputs. Connected sensors and probes are monitored by the controller, see chapter Monitoring Measuring Circuits. In the event of a defect, a message is output, the priority of which can be configured, for details see chapter Message Priorities.
Note: After start-up of the pressure transmitters, the displayed pressures in the Virtus Control Desk should be checked for correctness by comparing them with the real pressures using a pressure gauge.

5.4 Low Pressure Control

> **Parametrisation**
>
> **Category LP control**

The low pressure control has the task of maintaining the suction side pressure at a specified setpoint. The suction pressure for both normal temperature refrigeration (NT) and low-temperature refrigeration (LT) is controlled in the low-pressure circuit.

Control Mode
For this control task, the controller provides two different methods for the normal temperature refrigeration (NT circuit):

- **Step controller**
  Control by loading and unloading compressor stages or compressor capacity stages
- **Combined control**
  Control using a speed-controlled compressor in combination with one or more fixed-speed compressors

For the control of the LT controller (LT circuit), only the control mode " combined control" is supported.

For both control modes,, the low pressure t_{0_Actual} measured by an A/D converter is compared with the setpoint $t_{0\_Setpoint}$.

Actual value t_{0_Actual}
The respective actual value is recorded via a Pressure Transmitter with continuous current output 4..20 mA, see chapter Assignment of the 4..20 mA analogue inputs. Thereby, the control variable t_{0_Actual} is measured

- for the LT circuit via the LT low pressure transmitter (analogue input AIN1, terminals 66/67)
- for the NT circuit via the NT low pressure transmitter (analogue input AIN2, terminals 69/70)

Setpoint $t_{0\_Setpoint}$
The setpoint $t_{0\_Setpoint}$

- for the LT circuit is either fixed or determined via setpoint shift.
- for the NT circuit is determined via the Setpoint Shift between a configurable t_0 - Min. and t_0 - Max. A fixed setpoint for t_0 results if the same value is set for t_0 - Min. and t_0 - Max.

Configuration and operation of the setpoint shift are explained in the chapter Setpoint Shift.

The setpoint for t_0 can be configured separately for daytime and night operation. The setpoint toggle is carried out via

- the internal clock, see chapter Setpoint Toggle, or
- the digital input Z (terminals Z/N), for details see chapter Terminal assignment of the digital inputs 230 V AC.

Control Algorithm

The cycle time of the controller is 200 milliseconds. The control algorithm depends on the control mode.

> In the wet vapour range, the temperature is a clear function of the pressure: t = f (p, R744). Temperatures (t_0/t_c) thus substitute for pressures (p_0/p_c) in this operating manual. The controller calculates the associated temperature using the pressure measured by the pressure transmitter.

Parametrisation NT circuit

Parameter	Description	Input	Default	Dim.
Category Low Pressure Control NT				
Control Mode	Control mode of the low pressure control	Step controller, combined control	Step controller	-

Parametrisation LT circuit

If the LT control is not enabled, the LT compressors are not active and also not monitored. If no pressure transmitter is connected for the LT circuit but the LT control is enabled, there is an error message, see chapter Monitoring.

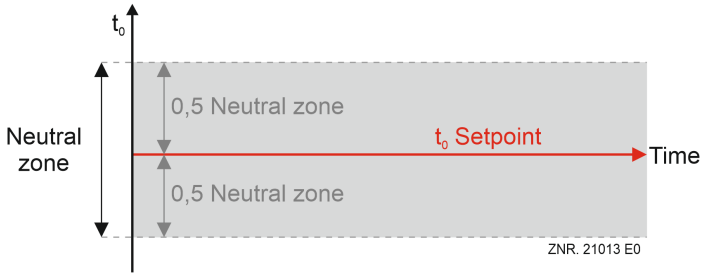
Parameter	Description	Input	Default	Dim.
Category System Configuration				
Enable LT-Control	Enable LT control	YES / NO	YES	-
Category Low Pressure Control LT				
t_0 Setpoint LT Compressor Day	fixed t_0 setpoint daytime operation	-50..-16	-38	°C
t_0 Setpoint LT Compressor Night	fixed t_0 setpoint night operation	-50..-16	-38	°C

5.4.1 Neutral Zone

A neutral zone exists for both control modes of the NT circuit. There is **no** neutral zone for the control of the LT circuit.

Neutral Zone Definition

The neutral zone for the low pressure circuit is a tolerance range within which the evaporation temperature t_0 can move without causing any switching operation of the compressors. If the control variable t_0) is within the range of the neutral zone (NZ), no changes are performed by the controller. The control setpoint is always in the middle of the neutral zone.



Step controller

The step controller shows the following behaviour in the neutral zone:

- No compressor switching operations are performed.
- The loading and unloading times for compressors (shifting up and shifting down times) are set up again.

Combined Control

The compressor combined control shows the following behaviour in the neutral zone:

- No compressor switching operations are performed.
- The loading and unloading times for the fixed-speed compressors are set up again.
- The control variable for the frequency-controlled compressor continues to be calculated

Starting the compressor switching times

The delay times for loading and unloading the NT compressors are not started until the setpoint of the evaporation temperature is outside the neutral zone (for more details about the switching times, see chapter Switching times for NT/LT compressors):

- The shifting up times for the compressor switching (base time and variable time) do not start until the evaporation temperature t_0 is greater than the t_0 setpoint plus half the neutral zone.
- The shifting down times for the compressor switching (base time and variable time) do not start until the evaporation temperature t_0 is less than the t_0 setpoint minus half the neutral zone.

Parametrisation

The neutral zone can be configured separately for daytime and night operation of the NT circuit.

Parameter	Description	Input	Default	Dim.
Category Low Pressure Control NT				
Neutral Zone Step Controller Day	Neutral zone step controller - day operation	1..10	4	K
Neutral Zone Step Controller Night	Neutral zone step controller - night operation	1..10	4	K
Neutral Zone Combined Control Day	Neutral zone combined control - day operation	0..6	0	K
Neutral Zone Combined Control Night	Neutral zone combined control - night operation	0..6	0	K

5.4.2 Switching times for NT/LT compressors

> **Parametrisation**
> **Category Low pressure control NT / LT**

On the one hand, the switching times for NT / LT compressors are there to minimise unnecessary switching cycles of the compressor stages, and on the other hand to optimally bring the performance of the pack (in terms of timing and control) up to the required refrigeration capacity.

Loading of fixed-speed compressors
Loading is performed if

- the **evaporation temperature** (t_0 actual value) deviates from the setpoint or setpoint range, i.e.
  - for the NT circuit has reached a value greater than the t_0 setpoint plus half the neutral zone, or
  - for the LT circuit has reached a value greater than the t_0 setpoint
- and a configured time (switch-on delay) for the **load** has elapsed
- and - only for combined control - the speed-controlled compressor has reached its **maximum speed**.

Shutdown of fixed-speed compressors
A shutdown is performed if

- the **evaporation temperature** (t_0 actual value) deviates from the setpoint or setpoint range, i.e.
  - for the NT circuit has reached a value less than the t_0 setpoint minus half the neutral zone, or
  - for the LT circuit has reached a value less than the t_0 setpoint
- and a configured switch-off delay for the **unload** has elapsed
- and - only for combined control - the speed-controlled compressor has reached its **minimum speed**.

Loading of the frequency-controlled compressor for combined control

- The frequency-controlled compressor has a separate, freely configurable off-time (time until restart).
- The off-time starts with the switch-off of the frequency-controlled compressor.
- In the case of positive control deviation, the frequency-controlled compressor is switched on immediately when the off-time has elapsed.

Loading and unloading times
The following applies to the NT circuit:
The loading or unloading time restarts in the neutral zone and only runs if the control variable is outside the neutral zone.

The following applies for the LT circuit:
if the maximum or minimum speed of the frequency-controlled compressor is reached and if t_0-Actual deviates from t_0-Setpoint, the loading or unloading time runs, otherwise the time is reset.

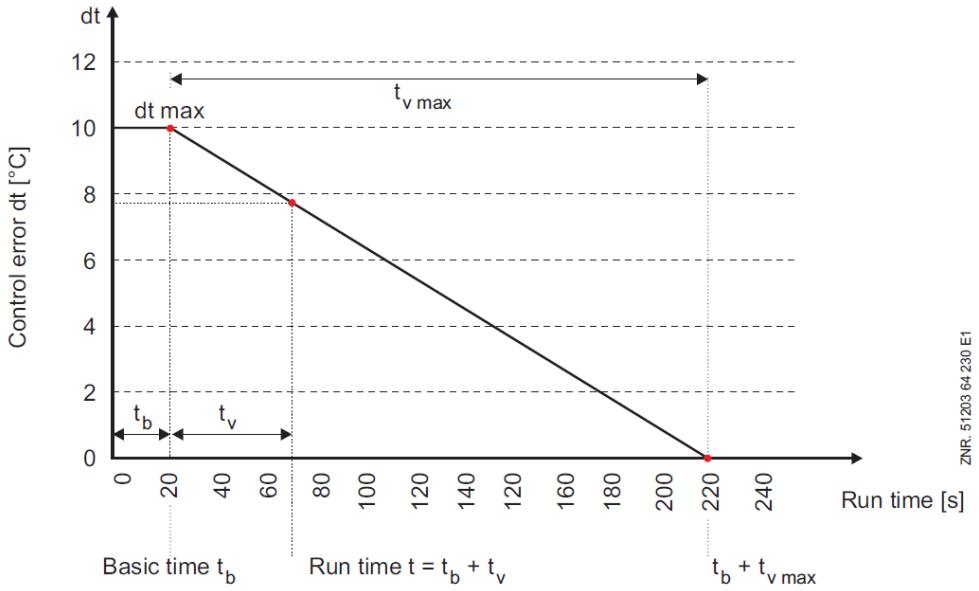
The loading or unloading time is calculated from the sum of

- basic time t_b and
- variable time t_v

Basic Time
The basic time can be configured and is always constant.

Variable Time
The variable time can be configured and is variable. The value range is between 0 and the configured value (in seconds). The duration of the variable time is calculated depending on the control constant.

Example for switching times: Basic time of 20 seconds and a variable time of 200 seconds. The control constant is parametrised to 10 K.



Parametrisation of NT compressor switching times

- The basic time and the maximum variable time for the shifting up (switching on) and shifting down (switching off) can be configured for each capacity stage.
- For day and night operation, there are separate parameters for switching times, each with a separate control constant.
- Switching times for day and night for NT compressors can be found in the category " Low Pressure Control NT".
- Only combined control: Off-Time S1 for NT compressors applies to day and night operation.

A compressor stage is loaded with the delay time of stage
(number of running compressors + 1).

Example
If 2 compressors are running,
the time "Basic time On, Stage 3" + "Variable On, Stage 3" is waited for **before** compressor 3 is switched on.

- The shifting down for step control always starts with the delay of the first stage.
- The switch-off times are directly assigned to the compressor stages for combined control.

Parameter	Description	Input	Default	Dim.
Category Low Pressure Control NT				
Compressor stages switching times NT				
Day				
Basic time On Day, Stage X	NT basic times t_b for NT compressor loading, day: compressors 1, 2, 3	0..250, 3..250	30, 60, 90	sec.
Variable On Day, Stage X	NT variable times t_v for NT compressor loading, day: compressors 1, X	0..250, 3..250	250, 250	sec.
Basic time Off Day, Stage X	NT basic times t_b for NT compressor unloading, day: compressors 1, X	3..250	20, 30	sec.
Variable Off Day, Stage X	LP variable times t_v for NT compressor unloading, day: compressors 1, 2, 3	3..250	30, 60, 90	sec.
Night				
Basic time On Night, Stage X	NT basic times t_b for NT compressor loading, night: compressors 1, X	0..250, 3..250	60, 180	sec.
Variable On Night, Stage X	NT variable times t_v for NT compressor loading, night: compressors 1, X	0..250, 3..250	250, 250	sec.
Basic time Off Night, Stage X	NT basic times t_b for NT compressor unloading, night: compressors 1, X	3..250	20, 30	sec.
Variable Off Night, Stage X	NT variable times t_v for NT compressor unloading, night: compressors 1, 2, 3	3..250	30, 60, 90	sec.
Day and Night				
Min. Off-time Stage 1 (S1)	Off-time for NT compressor stage 1 (only combined control) for day and night operation	10..250	140	sec.
Control parameters				
Control Constant Day	LP control constant day NT	1..15	10	K
Control Constant Night	LP control constant night NT	1..15	10	K

Booster Mode
If all NT compressors are at standstill and LT compressors are loaded, the first NT compressor is loaded immediately after exceeding the setpoint plus half of the neutral zone, i.e. the switching times are ignored! The switching times and off-times (off-time only for combined control) are ignored for the first compressor.

Every additional NT compressor is loaded following the elapse of the basic and the variable lead times. If the suction pressure drops in the NT zone, the NT compressors are switched off after expiry of the basic and variable unload times. However, one compressor remains in operation, independent of the suction pressure. The still controlled NT compressor is not switched off until after all LT compressors have been switched off.

> If at least one LT compressor is running,
> - then there is no starts limitation for the NT circuit (see chapter Monitoring of the starts) and
> - the off-time for the 1st compressor is not maintained in the case of combined control (forced loading of NT compressor).

Manual / automatic changeover
All LT and NT compressors can be controlled in manual mode. The following switch settings are available: "Manual ON", "Manual OFF" and "Automatic Operation" (I/O/A), for details, see chapter Manual / automatic changeover to emergency power mode.

> A corresponding alarm is generated if a manual control switch is set to a switch position other than "automatic operation".

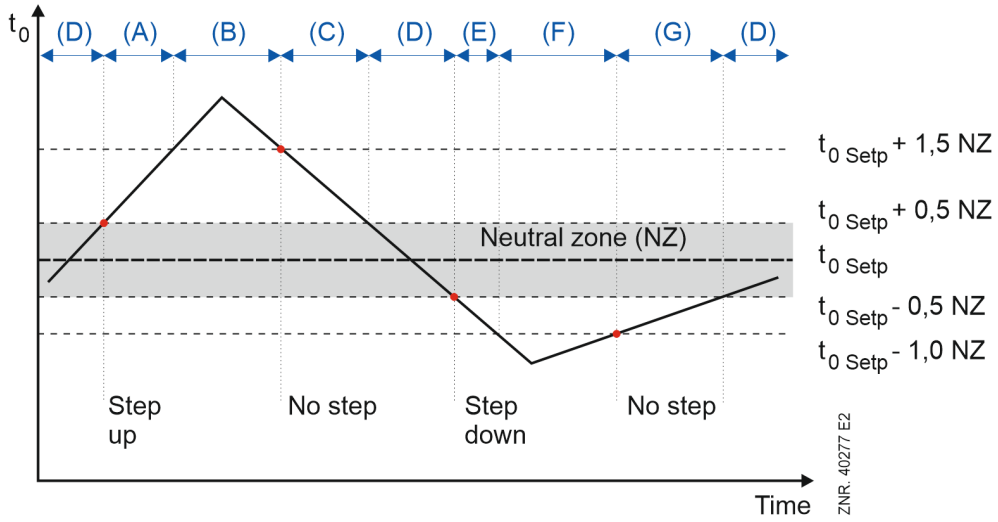
LT compressor switching times and off-times parametrisation

- The basic time and the maximum variable time for the shifting up (switching on) and shifting down (switching off) can be configured for each capacity stage.
- The control constant for calculating the variable times for LT compressors applies to day and night operation.
- A parametrisable off-time is complied with for the compressor with the frequency converter (compressor 1 or see chapter Base load rotation NT/LT compressor).

Parameter	Description	Input	Default	Dim.
Category Low Pressure Control LT				
Compressor stages switching times LT				
Basic time Off, Stage X	Basic times t_b for LT compressor loading, stage 1, 2, 3	3..250	30, 60, 90	sec.
Variable On, Stage X	Variable times t_v for LT compressor loading, stage 1, X	3..250	250, 250	sec.
Basic time Off, Stage X	Basic times t_b for LT compressor unloading, stage 1, 2, 3	3..250	20, 30, 30	sec.
Variable Off, Stage X	Variable times t_v for LT compressor unloading, stage 1, 2, 3	3..250	30, 60, 90	sec.
Min. Off-time LT	Minimum off-time of the LT compressor with FC after shutdown	10..360	120	sec.
Control parameters				
Control Constant LT Compressors	Max. control deviation for LT compressor switching times	1..15	2	K

5.4.3 Control algorithm with LP step controller

For the " step controller" control mode (only possible for NT compressors), the evaporation temperature t_0 and thus the suction pressure p_0 are controlled by loading and unloading compressor stages or compressor capacity stages. The low pressure measured by an A/D converter is converted as t_{0_Actual} and compared with the setpoint $t_{0\_Setpoint}$:



The following ranges are differentiated for the control:

- (A) At an evaporation temperature t_0 greater than the setpoint plus 0.5 times the Neutral Zone (NZ) and less than the setpoint plus 1.5 times the NZ, the step switching mechanism loads stages in the event of a **positive** pressure change.
- (B) At an evaporation temperature greater than the setpoint plus 1.5 times the NZ, the step switching mechanism loads stages **irrespective** of the pressure change. This results in the compressors being enabled in the order of their operating times (compressor with the shortest operating time first).
- (C) In the event of falling pressure and thus falling evaporation temperature, which is less than the setpoint plus 1.5 times NZ and greater than the setpoint plus 0.5 times NZ, no compressor switching takes place, as it is to be expected that the NZ will be reached in a short time.
- (D) If the control deviation is within a configurable NZ, **no** compressor switching takes place.
- (E) At an evaporation temperature t_0 less than the setpoint minus 0.5 times NZ and greater than the setpoint minus 1.0 times NZ, the step switching mechanism unloads stages in the event of a **negative** temperature change.
- (F) At t_0 less than the setpoint minus 1.0 times the NZ, the step switching mechanism unloads a stage **irrespective** of the pressure change. This results in the compressor with the longest operating time being disabled.
- (G) If the temperature rises between the setpoint -1.0 NZ and setpoint -0.5 NZ, no compressor switching takes place.

5.4.4 Control algorithm with LP combined control

Parametrisation
Category Low pressure control NT / LT

The low pressure measured by an A/D converter is compared with the setpoint for the control mode combined control:

Control deviation = actual value (t_{0_Actual}) - setpoint ($t_{0\_Setpoint}$)

Depending on the control deviation, a control variable is calculated which controls the speed of the compressor as a 0-10 V signal. The calculation of the FC control variable is performed using the PI controller. A P-component and an I-component are calculated for this using the parametrisable factors P-Value and I-Value.

P-component Calculation

$P_{component}$ = *P-Value * control deviation*

I-component Calculation
The P-component acts immediately on the speed in the case of a pressure change. The remaining control deviation is minimised by continuously increasing or reducing the control variable (ramp function). The adjusting speed of the ramp (I-component of the controller) is dependent on the control deviation. A ramp speed that is too high results in constant overshooting of the suction pressure.
A ramp speed that is too low results in the suction pressure setpoint not being reached until after a long time delay. The controller is then too slow. In order to adapt the I-component to the system, the ramp speed can be influenced using a parametrisable I-factor.

$I_{component}$ = $I_{component}$ + *I-Value * control deviation*

Adjustment speed for compressor speed output

- A speed increase for the NT compressors is performed using a ramp speed of max. 1 V/s, a speed reduction with max. 4 V/s.
- For LT compressors, the ramp speed can be parametrised between 0.1 and 5 V/s.

The control variable for the speed controller is calculated from the P-component and I-component.

Control variable = $P_{component}$ + $I_{component}$

If all compressor stages are switched off and the actual value is greater than the setpoint (positive control deviation), the first compressor stage (C1: enable of the frequency converter) is loaded after the Off Time has elapsed (see Switching times for NT/LT compressors). Here, first compressor stage means that a signal is sent to the frequency converter (FC) that controls the compressors with a continuous signal. The speed control is not activated until after expiry of a delay time (time = Basic Time ON C1).

- The LT compressor is operated with a parametrisable minimum speed during the time delay.
- There is no minimum speed for the LT compressors (minimum speed fixed at 0%).

The fixed-speed compressors are loaded on after the compressor switching times have elapsed (for more details, see Switching times for NT/LT compressors).

Parametrisation NT Compressor

Parameter	Description	Input	Default	Dim.
Category Low Pressure Control NT				
Control parameters				
P-value	P-value compressor combined control NT	0.0..3.0	0.7	V/K
I-value	I-value compressor combined control NT	0.00..1.00	0.05	V/(K·s)
Interval I-component	Interval I-component compressor combined control	1..30	1	s
Min. Speed Low Pressure	NT compressor minimum speed	0..15	0	%

Parametrisation LT Compressor

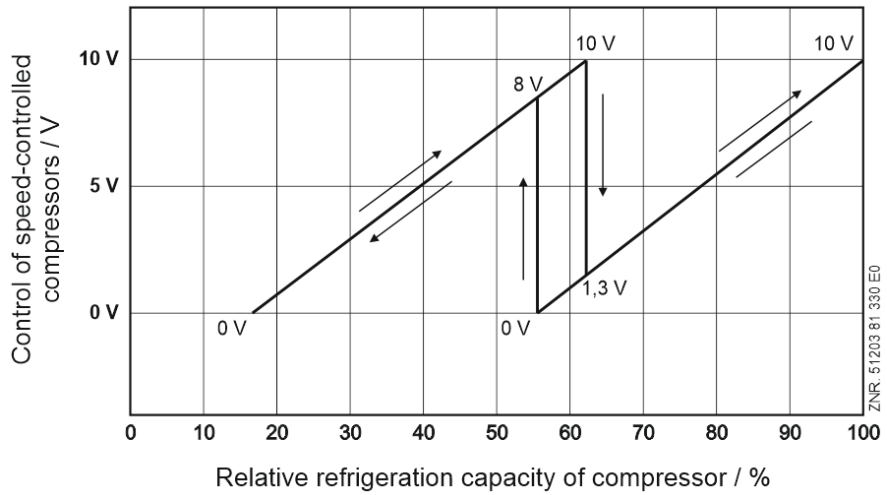
Parameter	Description	Input	Default	Dim.
Category Low Pressure Control LT				
Control parameters				
P-value	P-factor of the combined control for the LT compressors	0.0..3.0	0.7	V/K
I-value	I-factor of the combined control for the LT compressors	0.00..1.00	0.10	V/(K·s)
Ramp Speed LT Compressors	Ramp for the control variable of the frequency converter **Example:** With a parameter setting of 1, the rate of change of the FC control variable is 0.1 V/s	0.1..5.0	1.0	V/s

5.4.4.1 Loading / unloading of fixed-speed compressors

If the required capacity can no longer be provided by changing the compressor speed, fixed-speed compressors can be loaded or unloaded. If the speed-controlled compressor has reached its maximum speed, the fixed-speed compressor with the shortest operating time is loaded.

The speed-controlled compressor is slowed to a value which corresponds to the capacity without the additional fixed-speed compressor. Compressors that can be assigned to the speed controller using base load rotation are loaded last.
If the speed-controlled compressor has reached its minimum speed, the fixed-speed compressor with the longest operating time is unloaded. The speed-controlled compressor is accelerated to a value which corresponds to the capacity with the additional fixed-speed compressor.
Compressors that can be assigned to the speed controller using base load rotation are unloaded first.

The following graphic shows the controller process of a compressor pack with 2 single-stage compressors.



The characteristic curve of the frequency converter must be able to be parametrised for this so that an output signal of 0 V at the analogue output for compressor control corresponds to the minimum frequency and an output signal of 10 V to the maximum frequency. The input signal of the frequency converter must be parametrised as 0 V..10 V interface. The pack controller can be adapted to the frequency range of the FC using the "Max FC Frequency" and "Min FC Frequency" parameters. The parametrisation is only possible for the NT compressors.

Examples:

- Min FC Frequency = 30. The frequency to be output by the FC for 0 V control variable is set here (setting value must correspond to the value set on the FC; the example here uses 30 Hz).
- Max FC Frequency = 87. The frequency to be output by the FC for 10 V control variable is set here (setting value must correspond to the value set on the FC; the example here uses 87 Hz).
- Lower Bound Operation Frequency[Hz] = 35
  The minimum FC speed output by the pack controller is set here. This must be selected to be greater than or equal to the minimum frequency to be output by the FC.
- Upper Bound Operation Frequency[Hz] = 80
  The maximum FC speed output from the pack controller is set here. This must be selected to be less than or equal to the maximum frequency to be output by the FC.

Parametrisation of the frequency ranges for NT compressors

Parameter	Description	Input	Default	Dim.
Category Low Pressure Control NT				
Control parameters				
Max FC Frequency	Maximum FC frequency at 10 V	55..90, --	--	Hz
Min FC Frequency	Minimum FC frequency at 0 V	15..55, --	--	Hz
Upper Bound Operation Frequency FC	Upper bound operation frequency FC compressor	55..90	87	Hz
Lower Bound Operation Frequency FC	Lower bound operation frequency FC compressor	15..45	30	Hz

5.4.5 Setpoint Shift

> **Parametrisation**
>
> **Category Low pressure control NT / LT**

An optimally calculated setpoint for the operation can result in reduction of the energy costs. The controller also provides the option of adjusting the t_0 setpoint for the low pressure control within a configurable range (setpoint shift).

For the NT circuit, the t_0 shift and thus the determination of the current t_0 setpoint can be done via the following methods:

- room temperature sensor
- demand-dependent using case controller (consumer (E*COP+))
- signal via CAN bus

For the LT temperature range, the setpoint shift is only possible via "Consumer (E*COP+)".

> For general information about shifting via consumers, see E*COP+ in the EDP.

The range for the setpoint shift is always limited by t_0-Min and t_0-Max. These limits can be configured differently for day and night operation. The changeover between day and night operation is carried out using the switching clock.

Parameters for the setpoint shift in the NT circuit

Parameter	Description	Input	Default	Dim.
Category Low Pressure Control NT				
t_0-Adjustment NT				
Mode t_0-Adjustment	Mode of t_0-Shift for normal temperature refrigeration (NT)	Room temperature, Consumer (E*COP+), CAN bus	Consumer (E*COP+)	-
Characteristic curve NT [°C]				
t_0-Max. Day	Maximum setpoint for setpoint shift NT t_0 Day (t_0-Max)	-50..10	-8	°C
t_0-Max. Night	Maximum setpoint for setpoint shift NT t_0 Night (t_0-Max)	-50..10	-6	°C
t_0-Min. Day	Minimum setpoint for setpoint shift NT t_0 Day (t_0-Min)	-50..10	-12	°C
t_0-Min. Night	Minimum setpoint for setpoint shift NT t_0 Night (t_0-Min)	-50..10	-10	°C

Parameters for the setpoint shift in the LT circuit

Parameter	Description	Input	Default	Dim.
Category Low Pressure Control LT				
t_0-Adjustment LT				
Mode of to-Shift LT	Mode of t_0-Shift LT	OFF, Consumer (E*COP+)	Consumer (E*COP+)	-
Characteristic curve LT [°C]				
t_0-Max. Day	Maximum setpoint for setpoint shift LT t_0 Day (t_0-Max)	-50..10	-34	°C
t_0-Max. Night	Maximum setpoint for setpoint shift LT t_0 Night (t_0-Max)	-50..10	-34	°C
t_0-Min. Day	Minimum setpoint for setpoint shift LT t_0 Day (t_0-Min)	-50..10	-38	°C
t_0-Min. Night	Minimum setpoint for setpoint shift LT t_0 Night (t_0-Min)	-50..10	-38	°C

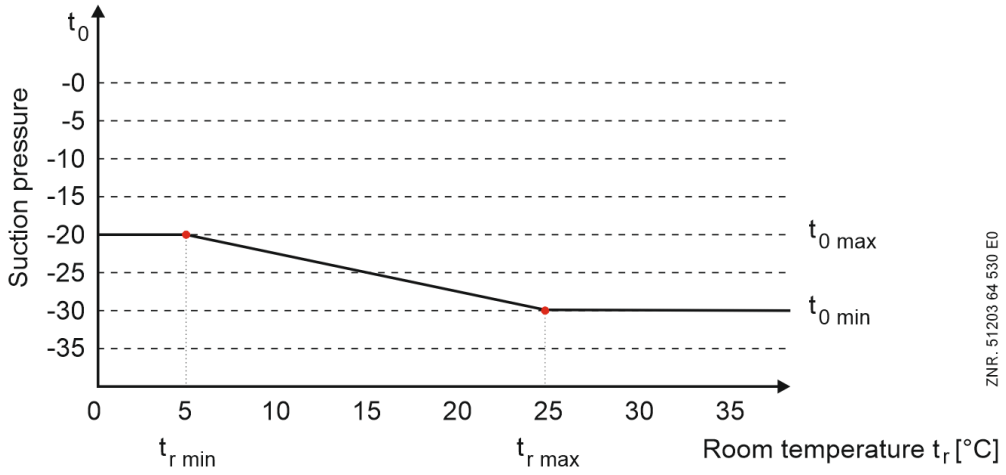
5.4.5.1 Setpoint shift via room temperature

If the "Room Temperature" mode has been selected for the setpoint shift, the t_0 setpoint for the NT range is determined depending on the room temperature. The room temperature is provided here either by a Pt1000 temperature sensor that is connected directly to the analogue input Pt9 (terminals 49/50/51/52) of the controller or provided via the CAN bus from another pack controller in the E*LDS system, see chapter Ambient data for the setpoint shift.

$$t_0 = t_{0\_min} + \frac{[(t_{0\_max} - t_{0\_min}) \cdot (t_r - t_{r\_max})]}{[(t_{r\_min} - t_{r\_max})]}$$

t_0 = t_0 setpoint
t_{0_max} = maximum t_0 setpoint
t_{0_min} = minimum t_0 setpoint
t_r = current room temperature
t_{r_max} = maximum room temperature for setpoint shift
t_{r_min} = minimum room temperature for setpoint shift

At a room temperature that is outside the set limits ($t_r > t_{r\_max}$ or $t_r < t_{r\_min}$), the setpoint t_0 is specified as a constant as follows:
for $t_r < t_{r\_min}$, $t_0 = t_{0\_max}$
for $t_r > t_{r\_max}$, $t_0 = t_{0\_min}$
t_{0_max}, t_{0_min}, t_{r_min} and t_{r_max} can be parametrised:



In order for the room temperature to be used for shifting, it should be ensured that the room temperature sensor is correctly connected (see chapter Pin Assignment) and enabled (category System Configuration). The setpoint for the pressure for the actual control is determined from a conversion table stored in the firmware. For the conversion of p_0 to the corresponding temperature value t_0, the refrigerant characteristic curve for CO_2 is used: $t_0=f(p_0, R744)$

Parameter	Description	Input	Default	Dim.
Category System Configuration				
Sensors				
Enable Room Temperature Sensor	Enable room temperature sensor	YES / NO	YES	-
Category Low Pressure Control NT				
Characteristic curve NT [°C]				
t_r-Max. Day	Maximum room temperature for setpoint shift t_0 Day (t_r-Max)	-18..35	25	°C
t_r-Max. Night	Maximum room temperature for setpoint shift t_0 Night (t_r-Max)	-18..35	25	°C
t_r-Min. Day	Minimum room temperature for setpoint shift t_0 Day (t_r-Min)	-25..20	15	°C
t_r-Min. Night	Minimum room temperature for setpoint shift t_0 Night (t_r-Min)	-25..20	15	°C

If the room temperature sensor for the setpoint shift is not connected to the controller, it can be made available as required from another controller, see chapter Ambient data for the setpoint shift.

5.4.5.2 Setpoint shift - demand-dependent via consumer

In order to guarantee optimum operation of a compressor pack with the associated refrigeration points with minimal operating costs, it is advisable that the suction pressure regulated by the compressor pack is set depending on the refrigeration needs of the refrigeration points (consumers). The refrigeration points signal their refrigeration requirements to the associated pack via CAN bus.

If a refrigeration point has not yet reached the required temperature, then a setpoint shift is initially prevented. The actual value "CAN Bus Address critical UA" then shows the CAN address of the critical case controller in the respective refrigeration circuit.

The suction pressure setpoint is adjusted within parametrisable limits using a parametrisable step size for increasing and decreasing the t_0 setpoint (parameters "t_0-Adjustment Step" and "Decreasing Step") as well as a parametrisable updating interval ("Interval" parameter). If the refrigeration of a case is subject to a forcibly actuated shutdown (defrost, external OFF etc.), the associated case controller does not influence the t_o-Shift. The same applies if the corresponding control sensor (supply air/return air/room air temperature) on the case controller fails.

Behaviour in the event of a fault

- **CAN bus fault of individual nodes**
  If no telegram is received from a specific case controller for a time period greater than the timeout for the reception, the associated case controller is not considered for the t_o shift until the receipt again of the corresponding telegram.
- **Global CAN bus fault**
  The current t_0 setpoint remains unchanged. After expiry of an alarm delay time of 10 minutes, the "No Load Level" error message is registered that will not be reset until receipt of new information from the refrigeration points via the CAN bus.

Parametrisation for the NT circuit

Parameter	Description	Input	Default	Dim.
Category Low Pressure Control NT				
t_0-Adjustment NT				
t_0 Adjustment Step	t_0 Increasing Step	0..10	1	K
t_0 Decreasing Step	Absolute t_0 decreasing step	0..10, --	0	K
Time Interval t_0-Adjustment	Time Interval t_0-Adjustment	1..20	5	min

Parametrisation for the LT circuit

In the LT circuit, the value for the step size applies to both the increase and the decrease.

Parameter	Description	Input	Default	Dim.
Category Low Pressure Control LT				
t_0-Shift LT				
t_0 Adjustment Step LT	t_0 Adjustment Step	0..10	1	K
Time Interval t_0-Adjustment	Time Interval t_0-Adjustment	1..20	5	min

5.4.5.3 Setpoint shift via CAN bus

If t_0 shift via CAN bus has been selected (parameter "Mode of t_0-Shift", category "Control low pressure NT"), information that the controller receives via the CAN bus is used for the t_0 setpoint shift. For example, this information can be provided from a higher-level controller (e.g. WRG 3010 E).

5.4.6 Base load rotation NT/LT compressor

> **Parametrisation**
> **Category Monitoring**

The operating time of each compressor is monitored internally. In order to achieve even operating time of the compressors, the compressor with the longest operating time is disabled and the compressor with the shortest operating time is enabled after expiry of a parametrisable cycle time.

For capacity-controlled compressors, base load rotation only occurs if the base load stage of an additional compressor is available. During base load rotation, the compressor with the longest operating time is disabled and the compressor with the shortest operating time is loaded. For base load rotation with capacity-controlled compressors, the switching state of the capacity stage(s) is also adopted for the new compressor. Compressors disabled due to load shedding are taken into account for the base load rotation. The number of running compressor stages is not changed during the base load rotation. The base load rotation is only active under the following conditions:

- If all parametrised compressors are enabled, base load rotation is only performed in the case of increasing pressure within the neutral zone.
- If compressors have been disabled due to load shedding, base load rotation is only performed in the case of increasing pressure.

The base load rotation can be adjusted using the "Cycle Time Base Load Rotation" parameter (category Monitoring). Particularly for screw compressors that have an oil return system that does not require any base load rotation, the value "–" can be assigned to the parameter and thus the base load rotation is deactivated.

> **ATTENTION**
>
> **Double assignment of the relay outputs 7 and 8**
> At the factory, the relay outputs 7 (terminals 17/18) and 8 (terminals 19/20) are assigned to the base load rotation of the NT/LT FC compressors and do **not** have to be parametrised before commissioning, see category Monitoring:
>
> - Parameter "Base Load Rotation FC NT" = YES and
> - Parameter "Base Load Rotation FC LT" = YES
>
> For details, see also chapter Basic configuration of the controller.
>
> If the relay outputs 7 and 8 are needed for the base load rotation of the NT/LT FC compressors, the functions for Suction gas post-injection and for the LT Discharge Gas Desuperheater are **not** available, see also chapter Assignment of the relay outputs 230 V AC.

Parametrisation

Parameter	Description	Input	Default	Dim.
Category Monitoring				
Base load rotation				
Cycle Time Base Load Rotation NT	Cycle time for base load rotation NT circuit	5..720,--	45	min
Base Load Rotation FC NT	Base load rotation FC compressor NT	YES / NO	YES	-
Cycle Time Base Load Rotation LT	Cycle time for base load rotation LT circuit	5..720,--	45	min
Base Load Rotation FC LT	Base load rotation FC compressor LT	YES / NO	YES	-

5.4.6.1 Base load rotation for speed controlled compressors

For systems with speed-controlled compressors, a speed controller can be assigned to the first two compressors (C1 and C2). The base load rotation of the fixed-speed compressors (C3) is performed according to the procedure described in chapter Base load rotation NT/LT compressor. Compressors (C1 and C2) that can be assigned to the speed controller are alternately switched on the speed controller following expiry of the cycle time or when all compressors are stopped via a relay output of the controller according to the following order.

Base load rotation with 2 running compressors (C1 + C2)	Base load rotation with 1 running compressor (C1 or C2)
Reduce speed to minimum value	-
Switch off compressor at the mains power supply	-
Reduce speed to 0	Reduce speed to 0
Switch off speed controlled compressor	Switch off speed controlled compressor
3 seconds delay	3 seconds delay
Base load rotation	Base load rotation
3 seconds delay	3 seconds delay
Switch on compressor at the mains power supply	-
Switch on speed controlled compressor	Switch on speed controlled compressor
Increase input signal (0..10 V) by 2 V / sec until the speed before switching is reached.	Increase input signal (0..10 V) by 2 V / sec until the speed before switching is reached.

If the cycle time for the base load rotation is specified as "--", no rotation is performed, even if all compressors are idle. If the cycle time is set to "--", the status of the relay output for the base load rotation ("Base Load Rotation LT FC compressor" terminals 17/18 or "Base Load Rotation NT FC compressor" terminals 19/20) at the time of the data input will also be maintained after a power failure (see chapter Assignment of the relay outputs 230 V AC). If there is any fault (motor overload cut-out or oil pressure switch) for the speed-controlled compressor (C1 or C2), any base load rotation is only performed once on the still available fixed-speed compressors. No base load rotation is performed if the compressor with the fault is a fixed-speed compressor.

Fault on	Base load rotation output	Perform base load rotation
Compressor 1	ON	NO
	OFF	YES
Compressor 2	ON	YES
	OFF	NO

Practical tip

For wiring example, see chapter Start-up of speed-controlled compressors / condenser fans.

5.4.7 Load Shedding

In order to prevent any defined energy consumption being exceeded, it may be necessary to initiate a forced shutdown of consumers. If this occurs, the controller receives a corresponding message via the CAN bus from the E*LDS system (e.g. from an HR controller). Compressors are switched off immediately after receiving the message via CAN bus.
For this purpose, **one** compressor (always the one with the highest running time) is always unloaded. Independently from the load shedding signal, a minimum refrigeration capacity **must** be guaranteed which requires a minimum number of enabled compressors. If there is only one compressor, it will not be unloaded. If the suction pressure control is speed-controlled, the compressor connected to the FC **cannot** be unloaded using load shedding.

5.5 Medium pressure control

Parametrisation

Category Medium Pressure Control

The controller regulates the medium pressure (MP) of a CO_2 system using a PI controller.

The required control variable for the control for the medium pressure valve (MPV) is provided via the analogue output AO4 (terminals 89/90, 0..10 V, see chapter Assignment of the 0..10 V analogue outputs).

5.5.1 Control algorithm for MP control

The medium pressure measured via an A/D converter is compared to the setpoint.

Control deviation = actual value ($MP_{\_Actual}$) - setpoint ($MP_{\_Setpoint}$)

The control variable for the MP control valve is calculated using a PI controller. The amplification factors for the P-component (parameter "P-Value") and the I-component (parameter "I-Value") can be adjusted.

> However, these parameters should only be adjusted by trained specialist personnel!

The control variable for the opening degree of the medium pressure valve can be limited with the parameters "Min. Control Variable MPV" and "Max. Control Variable MPV". The specification is entered as a percentage. If "Min. Control Variable MPV" = 0% and "Max. Control Variable MPV" = 100%, the control variable of the MP controller will not be limited.

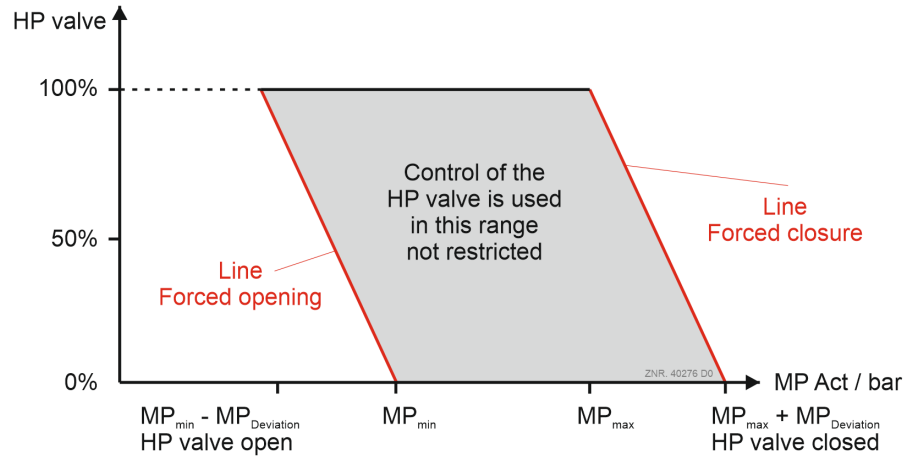
If the digital input "Fast Unload" (terminals Y/N) has been activated and all compressors have been unloaded, the analogue output AO4 "Medium Pressure Valve" (terminals 89/90) is set to 0 V.

> No MP control can take place in the event of failure of the MP pressure transmitter. A parametrisable emergency opening degree (parameter "Control Variable MPV in Emergency Mode", category "Medium Pressure Control") is then output for the MP valve.

Parameter	Description	Input	Default	Dim.
Category Medium Pressure Control				
MP Setpoint (Medium Pressure)	Setpoint medium pressure CO_2 with 1 NT refrigeration point	25..60	35	bar
P-value	P-factor for MP valve control with 2 NT refrigeration points	0..5	0.7	-
I-value	I-factor for MP valve control with 2 NT refrigeration points	0..0.99	0.08	-
Min. Control Variable MPV	Minimum control variable for the MP control valve	0..100	0	%
Max. Control Variable MPV	Maximum control variable for the MP control valve	0..100	100	%
Control Variable MPV in Emergency Mode	Control variable for the MP control valve in emergency power mode	0..100	40	%
Max. Control Deviation MPV	Max. permissible difference between the output control value and the retrieved control variable of the MPV	0..30	5	bar
Alarm Delay Control Deviation MPV	Alarm delay time for alarm signalling in the event of too great MPV control deviation	0..100	15	min

5.5.2 Medium pressure maintenance by limiting the HP valve

Depending on the medium pressure, the opening degree 0..100% of the HP valve is limited both downwards and upwards. The limitation is performed as shown in the following graph:



Parametrisation

Parameter	Description	Input	Default	Dim.
Category Medium Pressure Control				
MP Min	Lower medium pressure limit from which the HP valve is forcibly opened	10..60	32	bar
MP Deviation for HP Valve Open	Offset to MP-Min from which the HP valve is forcibly opened to 100%	0..20	3	bar
MP Max	Upper medium pressure limit from which the HP valve is forcibly closed	10..60	38	bar
MP Deviation for HP Valve Closed	Offset to MP-Max from which the HP valve is forcibly closed	0..20	2	bar

5.6 High pressure control

> **Parametrisation**
>
> **Category High Pressure Control**

The high pressure is controlled in the controller using a high pressure valve (HPV).

- The valve is controlled using a 0..10 V signal via the analogue output AO5 (terminals 91/92), see chapter Assignment of the 0..10 V analogue outputs.
- The control variable, the high pressure, is measured using a continuous pressure transmitter with linear characteristic at the analogue input AIN4 (terminals 75/76), see chapter Assignment of the 4..20 mA analogue inputs.
- The setpoint for the control is calculated depending on the gas cooler outlet temperature.

5.6.1 Control algorithm for HP control

The control variable, the high pressure, is measured by a continuous sensor with current output / voltage output in the high pressure line. The high-pressure measured via an A/D converter is compared with the setpoint. The following applies:

Control deviation = actual value (HP_{actual}*) - setpoint (*$HP_{setpoint}$*)*

A continuous high pressure valve (HP valve) is controlled via the analogue output AO5 (terminals 91/92) to keep the control deviation as small as possible. The continuous control variable (0..10 V) for the HP valve is calculated using a PI controller.

Refer to the following table for the parameters for the configuration of the PI controller for the control of the HP valve.

Parameter	Description	Input	Default	Dim.
Category High Pressure Control				
Control parameters				
HP Max.	Maximum HP-Setpoint (calculated) limit for control of HP control valve	23..100	61	bar
HP-Min.	Minimum HP-Setpoint (calculated) limit for control of HP control valve	30..70	45	bar
Subcooling HP Control	Subcooling	0..10	2	K
p-value HPV Control	Amplification factor Vp PI controller for HP control valve [V/bar]	0..5.00	0.40	V / bar
i-value HPV Control	Amplification factor Vi PI controller for HP control valve [V/s*bar]	0.0..0.99	0.05	V/s * bar
Interval I-component	Interval for calculating the I-component for the control of the HP valve	1..30	5	s
Max. Ramp HP Setpoint	Ramp speed (change speed) for the setpoint of the HP valve Note: A changeover to a rate of change of 6 bar/min is performed if the HP setpoint change is greater than 3 bar.	0.1..6.0	4.0	bar / min
HP valve limits				
Min. Control Variable HP Valve	Minimum control variable for HP control valve	0..100	0	%
Max. Control Variable HP Valve	Maximum control variable for HP control valve	0..100	100	%
Hysteresis HP Valve	HP control valve switching hysteresis (calculation of the HP setpoint, calculation of the I-component for HPV) with 1 NT refrigeration point	0..3	0.5	bar
Ramp HP Valve	Ramp speed of the control variable for the HP valve (limitation of the I-component)	0.04..1.00	0.16	V / s
HP Deviation for HP Valve Open	HP offset to the max. high pressure limit up to which the HPV is completely open.	0..10	5	bar
HP Deviation for HP Valve Closed	HP offset to the min. high pressure limit up to which the HPV is completely closed.	0..10	5	bar

ⓘ However, these parameters should only be changed by trained specialist personnel!

HP valve in emergency power mode

Emergency power mode is defined as the operating state in which the pressure transmitter of the high pressure has a measuring circuit error. In this case, the control variable of the HP valve is set to the configured value of the parameter "Control Variable HPV in Emergency Mode".

Parameter	Description	Input	Default	Dim.
Category High Pressure Control				
HP valve limits				
Control Variable HPV in Emergency Mode	Control variable for HP control valve in emergency power mode (in the case of high pressure measuring circuit error)	0..100	40	%

Connected sensors and probes are monitored by the controller, see chapter Monitoring Measuring Circuits. In the event of a defect, a message is output, the priority of which can be configured, for details see chapter Message Priorities.

5.6.1.1 Neutral zone HP control

In order to prevent very high activity of the controller control variable for the HP valve, a neutral zone is also provided for the continuous control of the high pressure. If the high pressure is lower than the calculated HP setpoint plus half the neutral zone and greater that the pressure setpoint minus half the neutral zone, the control variable 0..10 V of the HP valve (analogue output AO5, terminals 91/92) is not changed.

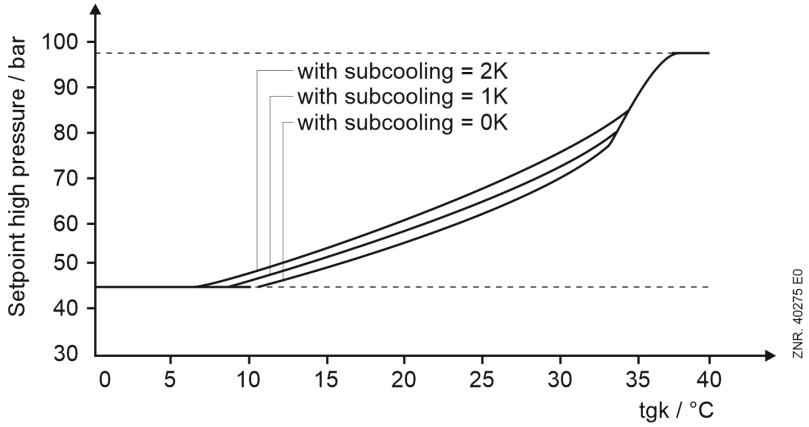
As soon as the HP actual value enters the neutral zone, the previously output control value 0..10 V remains the same.

If the value 0.0 bar is entered as the neutral zone for the HP control (parameter "Hysteresis HP Valve"), this function is deactivated. The PI controller of the HP valve control then acts directly on the servomotor of the high pressure valve.

5.6.1.2 High pressure setpoint calculation

The controller calculates a setpoint for the gas cooler outlet temperature for the fan control depending on the outdoor temperature. An optimal HP setpoint depending on the gas cooler outlet temperature is also calculated that is used for the control of the high pressure using a continuous high pressure valve. Required subcooling is taken into account for the determination of the HP setpoint in the subcritical range (parameter ″Subcooling HP Control″).

The following graph shows the progression of the high pressure setpoint over the gas cooler outlet temperature.



- If the sensor for the gas cooler outlet temperature is defective, a fixed setpoint of 80 bar is used for the HP control.
- No HP control can take place if the HP pressure transmitter is defective. A parametrisable emergency opening degree (parameter ″Control Variable HPV in Emergency Mode″) is then output for the HP valve. For details about monitoring, see chapter Measuring Circuits Monitoring.
- The calculated high pressure setpoint is limited by the parameters "HP Max." and "HP Min." .

ATTENTION

Risk of stock loss! The determination of the HP setpoint requires **correct measurement of the gas cooler outlet temperature**! In the event of measurement or measuring circuit errors (e.g. EMC interference in the measuring cable etc., see also the notes in the chapter Assignment of the analogue inputs or Measuring Circuits Monitoring) the refrigeration circuit can fall into an unstable state!
The consequence: There is **little to no** refrigeration capacity still available in the system!

5.7 Gas Cooler Outlet Temperature Control

> **Parametrisation**
>
> **Category Gas Cooler Outlet Temperature Control**

The refrigerant is cooled by the gas cooler fans. However, in transcritical operation of the system outside the saturated steam range, there is no direct relationship between the condensation temperature t_c and the high pressure p_c. Therefore, the high pressure and the gas cooler outlet temperature (t_{G1} and t_{G2}), i.e. the temperature of the hot gas, are measured and controlled independently of each other (see also chapter Temperature sensors for the control). The high pressure is controlled via a continuous HP valve (see chapter High pressure control). The gas cooler outlet temperature is controlled using the fans.

Control Modes
The following control modes are provided for the control of the gas cooler fans:

- **Step controller**
  Control by enabling or disabling gas cooler capacity stages.
- **Speed controller**
  Control using speed controller (continuous control). The gas cooler temperature is controlled here using an analogue signal that specifies the required speed to the speed controller. The fans are all permanently connected in parallel to the speed controller.
- **Combined control - parallel**
  Control using speed controller (continuous control). The gas cooler temperature is controlled here using an analogue signal that specifies the required speed to the speed controller. The fans are all connected in parallel to the speed controller, however they can be loaded or unloaded individually.
- **Combined control - stages**
  Combination of step controller and continuous control. The gas cooler temperature here is controlled by enabling or disabling fixed-speed fans and using a speed-controlled fan.

The gas cooler is controlled either via

- **a 0..10 V control signal** at the analogue output AO3 "Gas cooler" (only speed control)
  (see chapter Assignment of the 0..10 V analogue outputs) or
- **Modbus** (all control modes)
  (see chapter Gas cooler package with ebm-papst fans)
  When controlling via Modbus, up to 36 fans are possible, which can be distributed to 12 fan stages.

Parametrisation

Parameter	Description	Input	Default	Dim.
Category System Configuration				
Components				
No. of Fan Stages	Number of fan stages Note: the number of fan stages and fans must be checked / configured according to the gas cooler package! Please note: • for single-row Modbus fans: number of fan stages = number of Modbus fans • for two-row Modbus fans: number of fan stages = number of Modbus fans / 2 • for three-row Modbus fans: number of fan stages = number of Modbus fans / 3	0..12	4	-
Fan Control Mode	Control of the fans via analogue output (fan relay) or via Modbus (*ebm-papst*)	• fan relay • ebm-papst	fan relay	-
Modbus				
Modbus Parity	Parity of the Modbus RTU interface	• even • none • odd	even	-
Modbus Baud Rate	Baud rate of the Modbus interface	9600..19200	19200	Baud
Category Gas Cooler Outlet Temperature Control				
Fan control				
Control Mode	Control mode of the gas cooler fans	• Step controller • Speed controller • combined control - parallel • combined control - stages	Speed controller	-
Fan OFF on Fault	Fan OFF on Fault	YES / NO	NO	-
Ramp t_G Setpoint	Ramp speed for the fan setpoint t_G	1..20	1	K/min

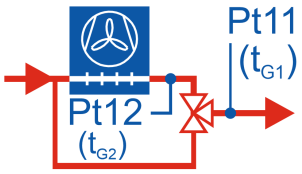
5.7.1 Temperature sensors for the control

There are two Pt1000 temperature sensors for the control of the gas cooler outlet temperature that are measured in the measuring range of -50 °C to +50 °C:

- t_{G1} - gas cooler outlet temperature 1 at the analogue input Pt11, terminals 57/58
- t_{G2} - gas cooler outlet temperature 2 at the analogue input Pt12, terminals 59/60
  For details, see chapter Assignment of the analogue inputs Pt1000 Assignment of the analogue inputs Pt1000

The control sensor for the gas cooler is t_{G2}. If this shows any measuring circuit error, t_{G1} is switched to. t_{G1} is used for calculation of the HP setpoint. If the gas cooler bypass valve is not active or not present, both temperature sensors usually show the same value. They are redundant.

Position of the gas cooler outlet sensors with gas cooler bypass valve
If the gas cooler of the refrigeration system can be bypassed using a gas cooler bypass valve (3-way valve), the gas cooler temperature sensors for measuring t_{G1} and t_{G2}**must** be positioned at the following places:



- Pt11 (for t_{G1}) is located directly after the gas cooler bypass valve
- Pt12 (for t_{G2}) is located directly after the gas cooler

ATTENTION

When using a gas cooler bypass valve, the correct positioning of the two gas cooler outlet sensors Pt11 and Pt12 **must always** be ensured!
Incorrect positioning of the two gas cooler outlet sensors can result in high impairments of the functions Gas Cooler Outlet Temperature Control and High pressure setpoint calculation!

5.7.2 Switching times for fan stages

Parametrisation
Category Gas cooler outlet temperature control

Neutral Zone

The neutral zone marks a tolerance range for the temperature to be controlled within which the control variable can move without stages being switched on or off. If the gas cooler outlet temperature rises or falls to a value outside the neutral zone, the first gas cooler capacity stage is immediately switched on or off. Any further switching is only performed if a specific time for the load or unload has elapsed and the control deviation has exceeded a specified value (neutral zone). The neutral zone can be configured separately for stage control and speed control. The value for the neutral zone for speed control is also used for the two combined control modes "Combined control parallel" and "Combined control staged".

Loading and unloading time

The loading or unloading time for fan loading or unloading depends on the actual control deviation. In the case of large control deviation, the switching is performed after a shorter time (i.e. faster) than for small control deviation. The switching time is calculated from the sum of a basic time t_b and a variable time t_v. A distinction is made between the controller shifting up and shifting down.
The variable time is inversely proportional to the control deviation. In the case of maximum control deviation, the variable time t_v approaches zero. If the control deviation is decreasing, the time t_v is automatically increased up to the preset maximum time.
If the positive control deviation (actual value > setpoint) is greater than 1.5 times the neutral zone, the fan is switched on after the configured switch-on delay, which, however, must not be longer than 30 seconds. If a delay of more than 30 seconds results from the basic time and the variable switch-on time, a fan stage is switched on.
As long as the control deviation is greater than 1.5 times the neutral zone, the maximum switch-on delay remains limited to 30 seconds. If the control deviation drops to less than 1.5 times the neutral zone due to the fans starting up, a switch-on does not take place again until the programmed switch-on delay has elapsed.
The basic time and the maximum variable time for shifting up (on) and shifting down (off) can be programmed as parameters for each switch-on/switch-off of a gas cooler capacity stage. The following apply for determination of the switching times:

$t = t_b + t_v$ *(t_b can be parametrised)*

The following applies for t_v:

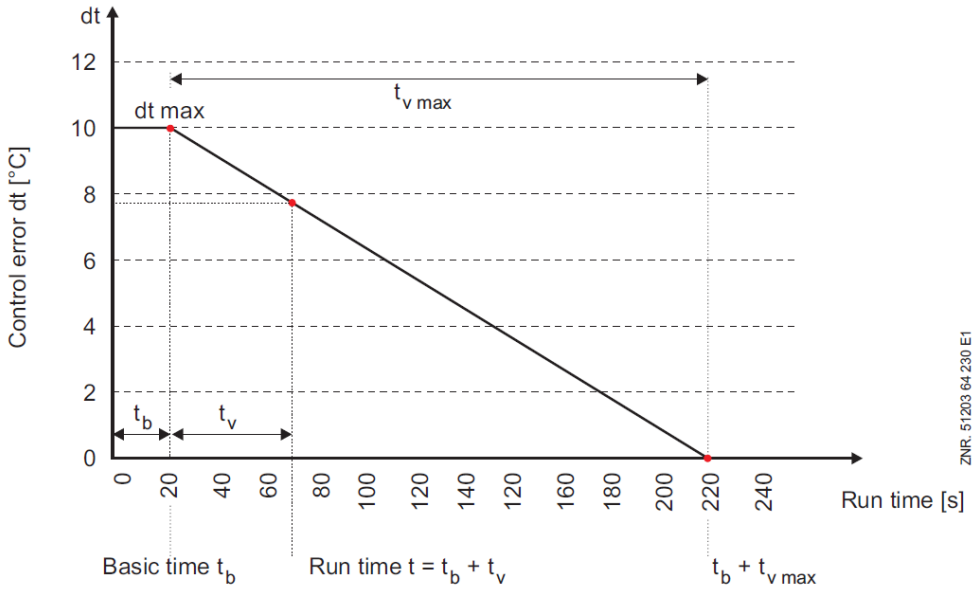
$$t_v = t_{v\_max} - \frac{(t_{v\_max} \cdot d_t)}{d_{t\_max}}$$

The following applies: if $d_t > d_{t\_max}$, $d_t = d_{t\_max}$

t_v = variable switching time
t_{v_max} = max. switching time (parametrisable for each stage)
d_t = control deviation
d_{t_max} = max. control deviation (parametrisable)

The switching time is calculated for each controller cycle. In each case, the variable time is recalculated and the elapsed time since the last switching point is compared with the calculated time. If the calculated switching time is less than or equal to the elapsed time, fan switching is performed if the control deviation is greater than the specified neutral zone.

The following diagram shows the switching time calculation of the condensers:



Parameters for fan switching times

Parameter	Description	Input	Default	Dim.
Category Gas Cooler Outlet Temperature Control				
Switching times for fan capacity stages				
Basic time On Stage X	Fixed switch-on delay for fan stage X	3..250	5	s
Variable On, Stage X	maximum variable switch-on delay time for fan stage X	3..250	5	s
Basic time Off, Stage X	Fixed switch-off delay for fan stage X	3..250	5	s
Variable Off, Stage X	maximum variable switch-off delay for fan stage X	3..250	5	s
Fan Control				
Control Constant Fan Control	HP control constant max. control deviation (d_{t_max})	1..15	10	K
Neutral Zone Step Controller	Neutral zone for gas cooler step control	1..20	4	K
Neutral Zone Speed Controller	Neutral zone for gas cooler speed control (also applies to "combined control parallel" and "combined control staged")	0..8	2	K

5.7.3 Control signal for frequency converter

> **Parametrisation**
>
> **Category Gas Cooler Outlet Temperature Control**

The calculation of the t_G setpoint is carried out as described in chapter Setpoint calculation for gas cooler outlet temperature. A setpoint for the fan speed is also calculated. The following applies for the calculation:

$U_{Setpoint} = P_{Component} + I_{Component}$

$U_{Setpoint}$ = speed controller setpoint (0..10 V)
$P_{Component}$ = proportional component of the controller
$I_{Component}$ = integral component of the controller

- With the P-component, the controller reacts directly to control deviations.
- The I-component prevents permanent control deviations.
- If very small I-components are required, the calculation interval can be extended (default = 10 sec.) using the "Interval I-component" parameter.
  Example:
  Interval i = 5
  means: the I-component will be updated every *5* seconds.
- P-Value = parametrisable value for the proportional component of the controller
  I-Value = parametrisable integral factor of the PI controller
  Interval i = time interval for calculation of the I-component

The minimum speed of the fan speed controller can be specified with the "Min. Speed HP″ parameter. The maximum fan speed can be configured separately for day and night operation (e.g. to control the sound level) via the parameters "Max. Speed Day" and "Max. Speed Night". The input is in percent and refers to the 0..10 V analogue output AO3 (terminals 87/88) of the controller or to the power signal for the Modbus fans. For wiring example, see chapter Start-up of speed-controlled compressors / condenser fans.

Parameter

Parameter	Description	Input	Default	Dim.
Category Gas Cooler Outlet Temperature Control				
Fan control				
Min. Speed	Minimum speed for speed-controlled fans	0..100	0	%
Max. Speed Day	Maximum speed for speed-controlled fans in day operation	0..100	100	%
Max. Speed Night	Maximum speed for speed-controlled fans in night operation	0..100	80	%
p-value Fan Control	P-factor continuous fan control	0.1..5	1	-
i-value Fan Control	I-factor continuous fan control	0..1	0.03	-
Interval I-component Fan Control	Interval I-component continuous fan control	1..60	10	s

5.7.4 Gas cooler package with ebm-papst fans

ebm-papst is a manufacturer of fan motors that are controlled by the pack controller via the Modbus; for further information, see https://edp.eckelmann.de/edp/lds/_VJlJWvle1k.

Requirements

The Modbus interface must be correctly wired; for detail, see chapter Assignment RS485.

Functionality

The control and the diagnostics of the *ebm-papst* fans in the gas cooler package are performed exclusively via the Modbus.

Commissioning of *ebm-papst* fans

1. Search

The following options are available in the fan wizard of the Virtus Control Desk (VCD) for searching for fans:

- **Complete Search** for all fans (recommended for initial commissioning)
  Note: the configuration of the switching sequence is lost for the complete search and must be checked / determined.

2. Determine switching sequence

In the first step, the complete search sorts the switching sequence of the individual fans in the gas cooler package in ascending order according to their serial numbers. As the fans in the gas cooler package have a fixed (physical) position, their switching sequence (assignment to a stage) must be determined.

Example with 4 fan stages and a **single-row** gas cooler package:

- The Modbus address allocation is performed automatically (not configurable), the fan with the lowest serial number always obtains the address 10, the next address 11 etc.
- The switching sequence is determined automatically, the fan with the lowest address is assigned switching sequence 1, the next switching sequence 2, etc.
- The switching sequence in this case is appropriate and does not have to be adjusted.

Single-row gas cooler package with 4 fans			
Stage 1	**Stage 2**	**Stage 3**	**Stage 4**
 **1** SN: JJWW00**0101** Modbus address: **10** Switching sequence: **1**	 **2** SN: JJWW00**0102** Modbus address: **11** Switching sequence: **2**	 **3** SN: JJWW00**0103** Modbus address: **12** Switching sequence: **3**	 **4** SN: JJWW00**0104** Modbus address: **13** Switching sequence: **4**

Example with 4 fan stages and a two-row gas cooler package:

- The Modbus address allocation is performed automatically (not configurable), the fan with the lowest serial number always obtains the address 10, the next address 11 etc.
- The switching sequence is determined automatically, the fan with the lowest address is assigned switching sequence 1, etc.
- The switching sequence is **not** appropriate in this case and must be adjusted for the fan pairs

> Note: In the case of a two-row gas cooler package, the fans arranged in pairs are controlled jointly, as **one stage**.

Two-row gas cooler package with 8 fans			
Stage 1 **Fan pair 1**	**Stage 2** **Fan pair 2**	**Stage 3** **Fan pair 3**	**Stage 4** **Fan pair 4**
Switching sequence: **1**	Switching sequence: **2**	Switching sequence: **3**	Switching sequence: **4**
 **1** SN: JJWW00**0101** Modbus address: **10**	 **3** SN: JJWW00**0103** Modbus address: **12**	 **5** SN: JJWW00**0105** Modbus address: **14**	 **7** SN: JJWW00**0107** Modbus address: **16**
Switching sequence: automatically assigned "1" remains and "2" becomes 1 *	Switching sequence: automatically assigned "3" and "4" become 2 *	Switching sequence: automatically assigned "5" and "6" become 3 *	Switching sequence: automatically assigned "7" and "8" become 4 *
 **2** SN: JJWW00**0102** Modbus address: **11**	 **4** SN: JJWW00**0104** Modbus address: **13**	 **6** SN: JJWW00**0106** Modbus address: **15**	 **8** SN: JJWW00**0108** Modbus address: **17**

* **Important**: The automatic switching sequence **must be corrected manually**!

> **Practical tip:** It is recommended to document the serial numbers, Modbus addresses and switching sequences of the *ebm-papst* fans in the gas cooler package. For other tips, see also chapter Putting fan control via Modbus into service.

3. Matching the number of *ebm-papst* fans to the number of fans in the system configuration

In the case of a two-row gas cooler package, the number of *ebm-papst* fans does not match those in the system configuration and must be adjusted. The number of fans (fan stages) in the system configuration must be half the number of the *ebm-papst* fans.
Up to 36 ebm-papst fans are supported.

4. Deletion of an *ebm-papst fan*

For example, this function is required for the replacement of a defective fan

5. Emergency operation function of an *ebm-papst* fan

Each ebm-papst fan has its own emergency operation function (refer to the manual of the ebm-papst fans for details). The emergency operation function is **always activated for every** fan automatically by the pack controller via the Modbus and is configured as follows:

- In the event of failure of the Modbus communication, the emergency operation starts after a delay time of 30 seconds
- The fan runs at 80% of its speed during emergency operation

> **NOTE**
>
> In the case of interrupted Modbus communication (e.g. during service work or switching off the pack controller), the fans **always go automatically** into emergency operation. If this should not happen for a fan (e.g. reserve fan), this fan must be disconnected from the power supply.

6. Alarm signalling

The pack controller outputs the following messages in the event of faults:

- A status is requested regularly from each *ebm-papst* fan via the Modbus. If this status contains an error code, then a message is sent for the respective fan in which this error code is transmitted.
  The following example shows the structure of the message:
  F yy A:zz xxxxxxxx
  F: fan
  yy: switching sequence of the fan from 1..12
  A:zz: address 10..33
  xxxxxxxx: hexadecimal error code (*refer to the manual of the ebm-papst* fans for details).

- If this fan error code describes an alarm, the alarm "Motor Overload Cut-out Fx" (x can have the values 1..12) is sent. The priority of the alarm "Motor Overload Cut-out Fan" can be configured.
- "Comm.Error with Fx":
  This message is output if no *ebm-papst* fans are registered in the controller or where the fan number "--" is registered for at least one fan.
- "Comm.Error with Fx" (x can be the values 1..12):
  This message is output if communication with fan Fx is not possible.
  Note: this response is evaluated for each request and an internal error counter is incremented for each error. An alarm is signalled if this value reaches 5.

7. Manual Mode

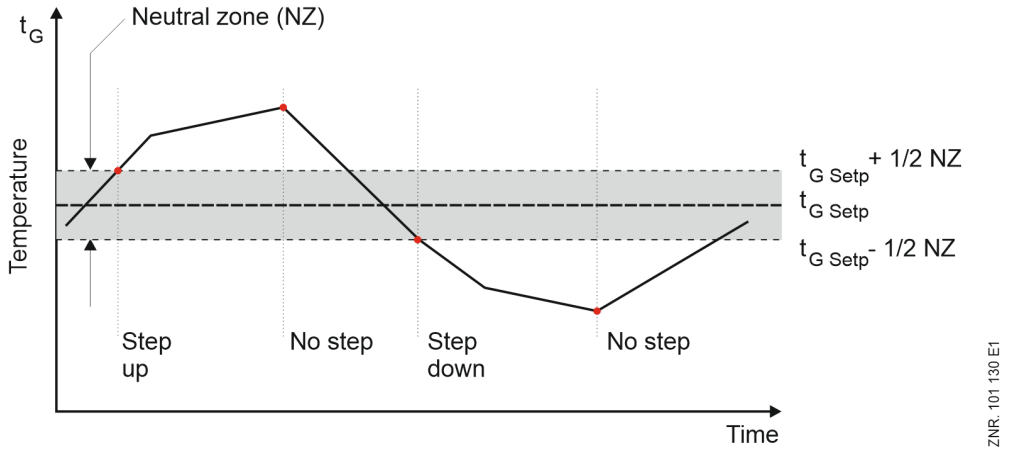
In manual mode, the fans can be controlled between 0..100% during the normal operation (see fan wizard Virtus Control Desk (VCD)). The message "Man. Fan Speed" is output if manual mode is activated. Manual mode is automatically deactivated after 60 minutes for the system safety.

5.7.5 Control algorithm tG with step controller

The gas cooler outlet temperature measured via an A/D converter is compared with the setpoint. The following applies:

control deviation = actual value (t_{G_Actual}) - setpoint ($t_{G\_Setpoint}$)

In the case of positive control deviation and increasing gas cooler outlet temperature, the step switch switches forward one stage. This means that an additional gas cooler capacity stage is enabled. In the case of negative control deviation and reducing gas cooler outlet temperature, the step switch switches back one stage. This means that a gas cooler capacity stage is disabled.



5.7.6 Control algorithm tG with speed control

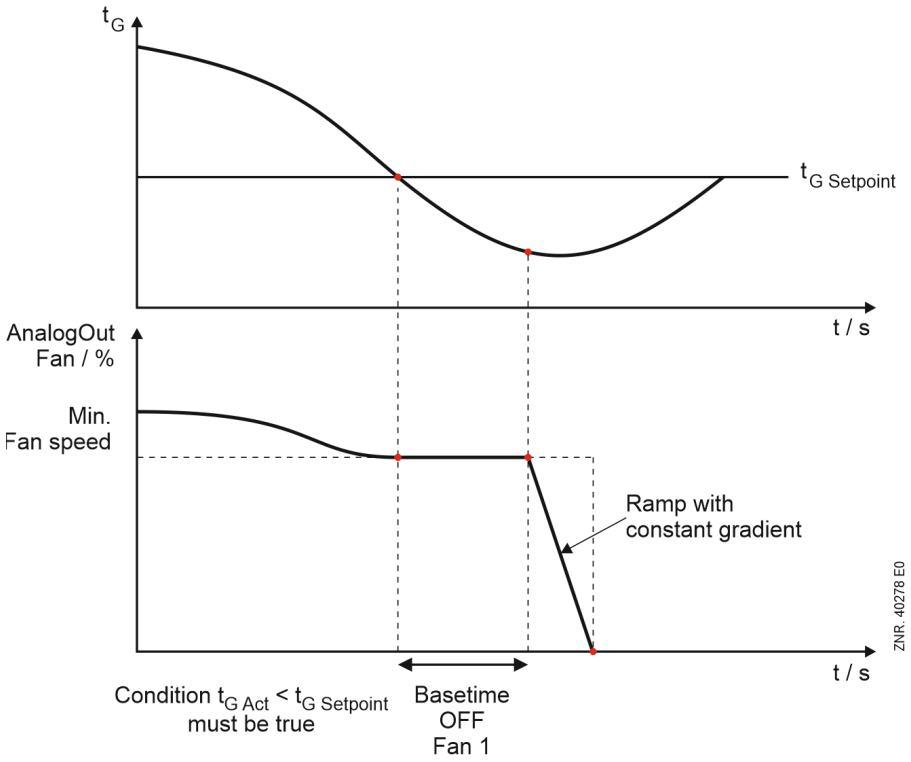
> **Parametrisation**
>
> **Category Gas Cooler Outlet Temperature Control**

The gas cooler outlet temperature measured via an A/D converter is compared with the setpoint. The following applies:

control deviation = actual value (t_{G_Actual}) - setpoint ($t_{G\_Setpoint}$)

In the event of a positive control deviation, a speed setpoint is calculated using a PI control algorithm that is output to the speed controller for the gas cooler via analogue output AO3 (0..10 V, terminals 87/88)). The speed controller controls the speed of the fans to the specified setpoint. If a minimum speed > 0 of the speed controller has been input using the parameter "Min. Speed", the speed is reduced to 0 using a ramp after a parametrisable time (parameter Basic time off Fan 1).

Switch off of the speed controller enable (for Min. Speed >0):



5.7.7 Control algorithm tG with parallel combined control

The gas cooler outlet temperature measured via an A/D converter is compared with the setpoint. The following applies:

control deviation = actual value (t_{G_Actual}) - setpoint ($t_{G\_Setpoint}$)

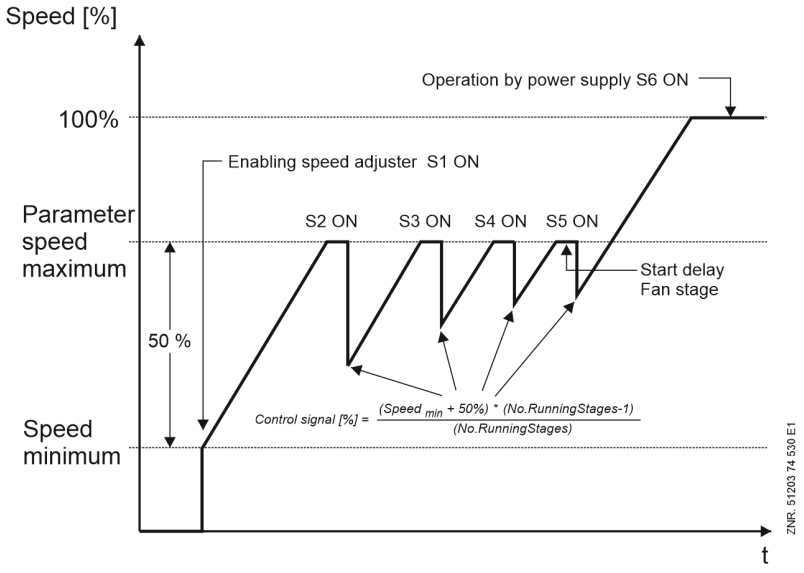
A speed setpoint is calculated via a PI control algorithm depending on the control deviation. This is used as the speed of all fans connected in parallel, which can be switched on and off individually. Depending on the expansion stage of the controller, **a maximum of 12 fan stages can be controlled via Modbus** for the control:

Start-up of the fan capacity

In the event of a positive control deviation (actual value > setpoint), the first fan capacity stage is enabled. Depending on the control deviation, a speed setpoint for the fan stages is calculated by a PI control algorithm. The control variable for the first to the last but one fan stage is limited to the specified minimum speed plus 50% of the maximum control variable. If a stage reaches this limit, another capacity stage is loaded after a time delay. The control variable for all now loaded fans is calculated according to the following formula:

$$\text{control variable}\,[\%] = \frac{(\text{speed}_{min} + 50}{\text{number of running stages}}$$

This results in a fan capacity that roughly corresponds to the capacity before the fan is loaded. If the last fan stage is loaded, the control variable can reach its maximum value. Fans which have been shut down via the motor overload cut-out will be ignored for the control. The following diagram shows the speed curve during start-up using the example of a system with five fans:



Shutting down the fan capacity

In the case of a negative control deviation (actual value < setpoint), the speed of all loaded fans is reduced to the minimum speed + 20%. If the gas cooler outlet temperature continues to remain below the setpoint, fan stages are switched off with a time delay.
If a minimum speed is entered using the parameter "Min. Speed", the speed is ramped down to 0 after a parametrisable time (parameter "Basic time OFF") and the last fan stage that is still active is switched off.

5.7.8 Control algorithm tG with stage combined control

The gas cooler outlet temperature measured via an A/D converter is compared with the setpoint. The following applies:

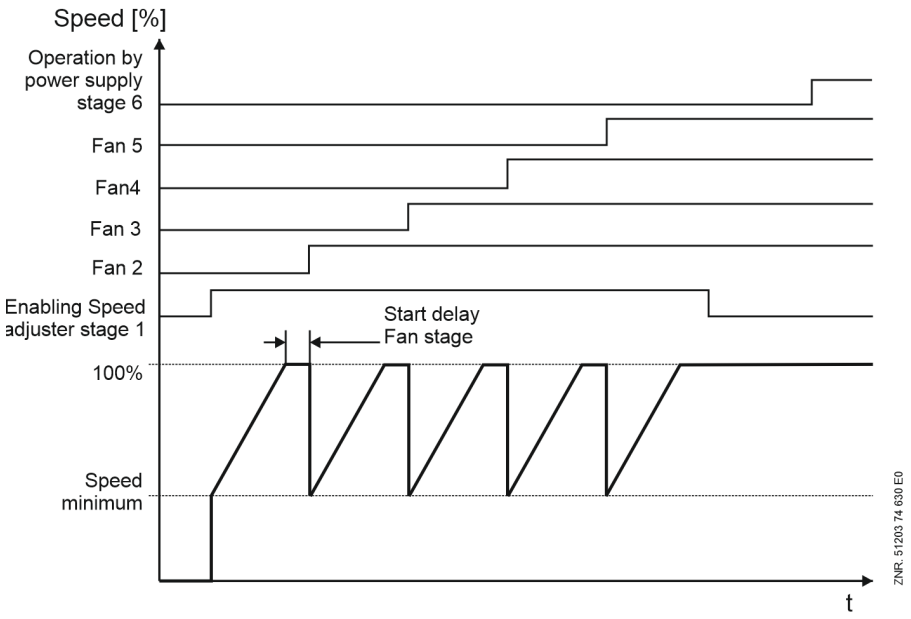
control deviation = actual value (t_{G_Actual}) - setpoint ($t_{G\_Setpoint}$)

A speed setpoint is calculated via a PI control algorithm depending on the control deviation. The fan control is performed with a fan speed that is controlled according to this speed. Other stages connected to the mains power supply can be switched on or off individually. Depending on the expansion stage of the controller, **a maximum of 12 fan stages can be controlled via Modbus** for the control:

Start-up of the fan capacity

In the event of a positive control deviation (actual value > setpoint), the first fan stage is enabled. Depending on the control deviation, a PI control algorithm calculates a speed setpoint that is switched to the first fan stage. If the speed reaches its maximum value, another fan stage is loaded after a time delay. The control variable for the first fan stage is then reduced to the minimum speed. Fans which have been shut down via the motor overload cut-out will be ignored by the controller.

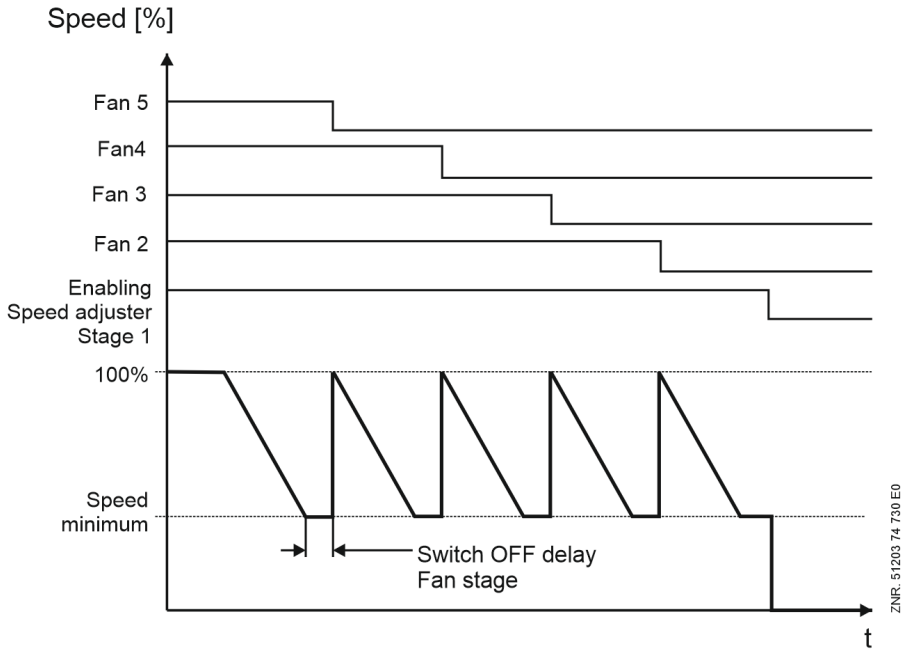
The following diagram shows the speed curve during start-up using the example of a system with five fans:



Shutting down the fan capacity

In the case of a negative control deviation (actual value < setpoint), the speed is reduced by the PI controller. If the minimum speed is reached, a fan capacity stage is unloaded after a time delay and the speed is increased to the maximum value at the same time. The first fan stage is the last to be disabled if the speed has dropped to 0.
If a minimum speed > 0 of the speed controller has been input using the parameter "Min. Speed", the speed is reduced to 0 using a ramp after a parametrisable time (parameter Basic time off Fan 1) and the fan stage is switched off.

The following diagram shows the speed curve during setback using the example of a system with five fans:



5.7.9 Setpoint calculation tG via outdoor temperature

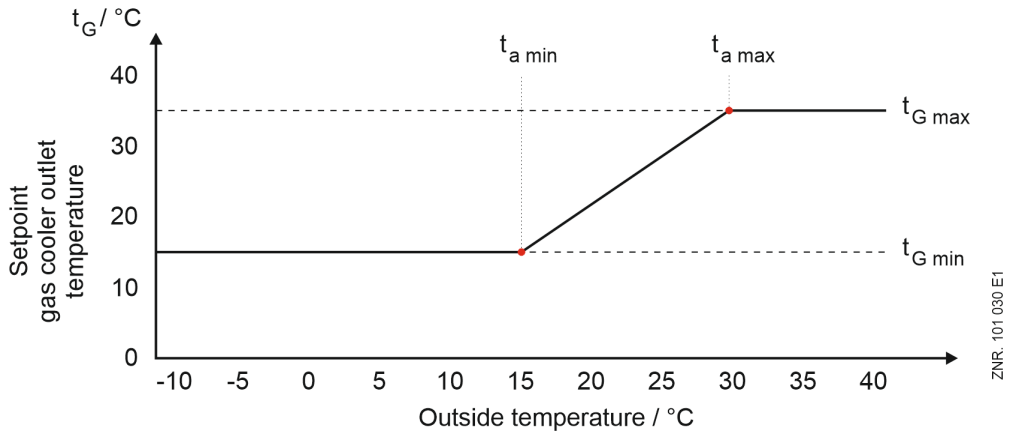
The setpoint for the gas cooler temperature t_G depending on the outdoor temperature is calculated according to a programmable characteristic curve. The outdoor temperature is provided here as follows:

- via a Pt1000 sensor that is connected directly to the analogue input Pt10 (terminals 53/54/55/56) of the controller or
- via the CAN bus from another pack controller in the system, see chapter Ambient data for the setpoint shift.

$$t_G = t_{G\_min} + \frac{[(t_{G\_max} - t_{G\_min}) \cdot (t_a - t_{a\_min})]}{(t_{a\_max} - t_{a\_min})}$$

t_G = t_G setpoint
t_{G_max} = maximum t_G setpoint
t_{G_min} = minimum t_G setpoint
t_a = current outdoor temperature
t_{a_max} = max. outdoor temperature for setpoint shift
t_{a_min} = min. outdoor temperature for setpoint shift

The following applies for an outdoor temperature $t_a > t_{a\_max}$ or $t_a < t_{a\_min}$
for $t_a > t_{a\_max}$: $t_G = t_{G\_max}$
for $t_a < t_{a\_min}$: $t_G = t_{G\_min}$



Setpoint increase t_G

If setpoint toggling is active, it is possible to enter an offset t_G to the temperature (parameter "Offset tG for Setpoint Toggling"), which is added to the setpoint temperature $t_{G\_Setpoint}$.

Parametrisation of setpoint shift t_G via outdoor temperature

Parameter	Description	Input	Default	Dim.
Category Gas Cooler Outlet Temperature Control				
Characteristic curve [°C]				
$t_{G\ min}$	Minimum t_G setpoint for setpoint shift	-10..45	5	°C
$t_{a\ min}$	Minimum outdoor temperature ta for setpoint shift tc	-16..43	3	°C
$t_{G\ max}$	Maximum t_G setpoint for setpoint shift	-10..50	28	°C
$t_{a\ max}$	Maximum outdoor temperature t_a for setpoint shift tc	-16..48	26	°C
Fan control				
Offset t_G for Setpoint Toggling	t_G offset for setpoint shift of the high pressure	0..15	0	K

5.8 Minimum Superheat Control

Superheat is the difference between the suction gas temperature (measured via a Pt1000 sensor) and the evaporation temperature t_0 (calculated from p_0, measured via a pressure transmitter on the suction side), for details, see also graphic in VPC 5000 Functions. If the suction gas temperature or superheat is too high, it can cause the cylinder head temperature to exceed a threshold, causing the compressors to become too hot and shut down as a result.

To prevent this, two functions are used to control the minimum superheat:

- Suction gas post-injection The suction gas temperature of the NT compressors can be reduced using suction gas post-injection.
  The control takes place via relay output 7.
  LT Discharge Gas Desuperheater: The function of an LT discharge gas desuperheater is to desuperheat the LT discharge gas temperature and consequently reduce the suction gas temperature of the NT compressors.
  The control takes place via relay output 8.

ATTENTION

Double assignment of the relay outputs 7 and 8
At the factory, the relay outputs 7 (terminals 17/18) and 8 (terminals 19/20) are assigned to the base load rotation of the NT/LT FC compressors and **must** be parametrised **before** commissioning, see category Monitoring:

- parameter "Base Load Rotation FC NT" = NO for the LT discharge gas desuperheater and
- parameter "Base Load Rotation FC LT" = NO for the suction gas post-injection
  For details, see also chapter Basic configuration of the controller.

If the relay outputs 7 and 8 are required for the suction gas post-injection or for the LT discharge gas desuperheater, the functions for base load rotation of the NT/LT FC compressors are **not** available, see also chapter Assignment of the relay outputs 230 V AC.

5.8.1 Suction gas post-injection

The suction gas temperature of the NT compressors can be reduced using suction gas post-injection. The valve for suction gas post-injection controls or influences the following two factors:

1. Hot gas temperature (equivalent to the cylinder head temperature)
2. Suction gas temperature or suction gas superheat

Requirements
The control is performed via the relay output 7 (terminals 17/18), see chapter Assignment of the relay outputs 230 V AC.

- The hot gas temperature is measured at the Pt1000 analogue input Pt7 (terminals 45/46).
- The suction gas temperature is measured at the Pt1000 analogue input Pt14 (NT) (terminals 63/64).
- Parameter "Base Load Rotation FC LT" = NO

Accordingly, the suction gas post-injection can be triggered both by exceeding the threshold value of the hot gas temperature (or cylinder head temperature) or by detected superheating of the suction gas temperature. The requirements for this are described below.

Enable of the injection valve for hot gas temperature or cylinder head temperature

- In order for the **valve** for suction gas injection to be **enabled** at all, there must first be a **minimum superheat** of the suction gas temperature (parameter "Min. Suction Gas Temperature SGI").
- The suction gas injection is then activated if the **hot gas temperature and the cylinder head temperature** exceed the associated parametrisable threshold values "Hot Gas Temperature for Enabling SGI" and/or "Cylinder Head Temp. for Enabling SGI". If one of the corresponding sensors does not provide a value or is not activated (parameter value "--"), it is determined whether the suction gas injection is enabled by exceeding the threshold value at the respective other sensor. The use of the cylinder head temperature is deactivated at the factory (parameter "Cylinder Head Temp. for Enabling SGI" = "--").
- In order to prevent cycling of the valve, hysteresis is provided (parametrisable difference downward from threshold value, parameter "Diff.-Temperature for Disabling SGI").
- If both sensors are deactivated or do not provide a value, then the suction gas injection is activated solely by exceeding the threshold value for minimum superheat (parameter "Min. Suction Gas Temperature SGI"). No hysteresis exists for this threshold value.

Enable of the injection valve via suction gas temperature too high (critical state)

Independent of the enable via hot gas temperature or cylinder head temperature, the injection valve is enabled if the **superheat** exceeds a **critical value**:

- The suction gas injection is activated if the superheat exceeds a parametrisable threshold value (parameter "Superheat for Enabling SGI").
- In order to prevent cycling of the valve, hysteresis is provided (parameter "Diff.-Superheat for Disabling SGI"). This hysteresis is a parametrisable difference downward from the threshold value "Superheat for Enabling SGI".
- The hot gas temperature or cylinder head temperature does not play any role here.

Additional criteria for enable of the valve

- HP limiter must be in good state
- LP limiter must be in good state
- Fast unload must not be active
- At least one compressor must be in operation
- I/O Checker must not be active

Parameters for the configuration of the suction gas injection

Parameter	Description	Input	Default	Dim.
Category Monitoring				
Suction Gas Injection (SGI)				
Min. Suction Gas Temperature SGI	Minimum superheat that must be present so that the valve for suction gas injection can be enabled.	5..40	5	K
Hot Gas Temperature for Enabling SGI	Threshold value for the enable of the suction gas injection valve depending on the hot gas temperature (Pt1000 input 9, terminals 45/46).	50..180, "--"	125	°C
Cylinder Head Temp. for Enabling SGI	Threshold value for the enable of the valve for suction gas injection depending on the cylinder head temperature.	50..180, "--"	--	°C
Diff.-Temperature for Disabling SGI	This is used for calculating the threshold value for disabling the valve for suction gas injection. The difference is subtracted from "Hot Gas Temperature for Enabling SGI" and "Cylinder Head Temp. for Enabling SGI".	1..20	5	K
Superheat for Enabling SGI	Threshold value for the enable of the valve for suction gas injection depending on too high suction gas superheat (SH).	5..40	25	K
Diff.-Superheat for Disabling SGI	This is used for calculating the threshold value for disabling the valve for suction gas injection. The difference is subtracted from "Superheat for Enabling SGI".	1..10	2	K

5.8.2 LT Discharge Gas Desuperheater

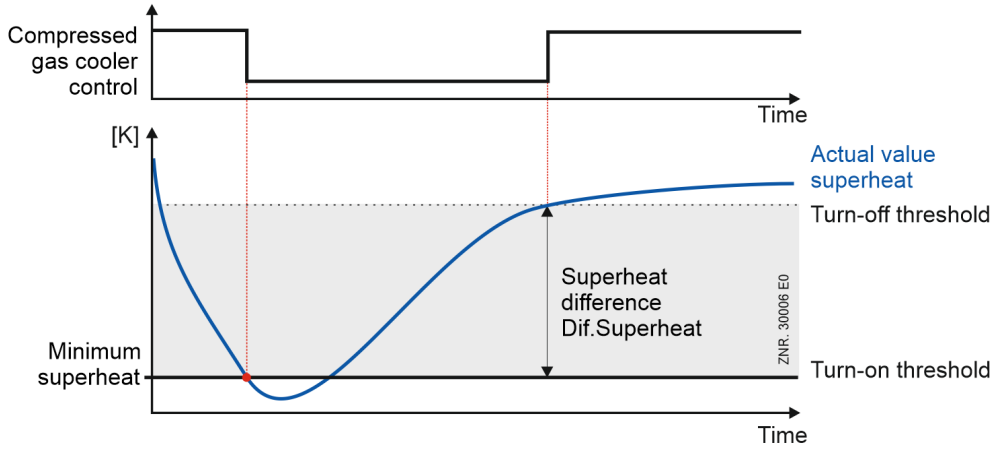
The function of an LT discharge gas desuperheater is to desuperheat the LT discharge gas temperature and consequently reduce the suction gas temperature of the NT compressors. The controller monitors the suction gas superheat to prevent wet operation. Too low suction gas superheat is registered in the fault memory and transferred to an appropriate alarm destination according to priority preselection. A discharge gas desuperheater gas cooler can also be controlled via the relay output 8 (terminals 19/20) on the controller. If the superheat is too low, this relay output can be used to deactivate e.g. an LT discharge gas desuperheater connected downstream of the LT compressors (for desuperheating the LT discharge gas **before** it enters the NT circuit).

Requirements
The control is performed via the relay output 8 (terminals 19/20), see chapter Assignment of the relay outputs 230 V AC.

- The suction gas temperature is measured at the Pt1000 analogue input Pt14 (NT) (terminals 63/64).
- Parameter "Base Load Rotation FC NT" = NO

Enable
The relay output 8 for discharge gas desuperheating is active while the specified minimum superheat is not undercut. The relay output is deactivated again if the superheat has undercut the "Min. Suction Gas Superheating" superheat setpoint. After undercutting "Min. Suction Gas Superheating", the discharge gas desuperheater is not activated again until the superheat has exceeded the value "Min. Suction Gas Superheating" plus the difference "Diff.-Superheat for DGD" again.

The following diagram shows the control of the relay output 8 of the discharge gas desuperheater graphically:



In the event of a fast unload, the signal is deactivated together with the last compressor.

Additional criteria for the enable of the discharge gas desuperheater

- HP limiter must be in good state
- LP limiter must be in good state
- Fast unload must not be active
- At least one compressor must be in operation
- I/O Checker must not be active

Parameters for control of the discharge gas desuperheater

Parameter	Description	Input	Default	Dim.
Category Monitoring				
Discharge Gas Desuperheater (DGD)				
Min. Suction Gas Superheating	Minimum permissible superheat on the pack side in Kelvin	2..15	4	K
Diff.-Superheat for DGD	Minimum permissible difference between t_0 and t_G	0.5..1.5	0.8	K
Alarm Delay Suction Gas Superheating	Delay message "Superheating (pack side) too Low" in minutes	1..30	10	min

5.9 Monitoring

Parametrisation

Category Monitoring

In addition to control and regulation functions, various monitoring functions are integrated in the controller. The following values and function units are monitored by the controller:

- Safety chain
  - Compressor oil differential pressure monitoring/ HP switch
  - Monitoring of the compressor motor overload cut-out
- Low Pressure Monitoring
  - Superheating too Low Monitoring
- Medium Pressure Monitoring
  - MP too High Monitoring
  - MP too low MP Monitoring
  - MP Control Deviation Monitoring
- High Pressure Monitoring
  - HP too High Monitoring
  - HP too Low Monitoring
  - HP Valve Monitoring
  - Monitoring of the HP control deviation
- Gas Cooler Outlet Temperature Monitoring
- Cylinder head temperature monitoring
- Monitoring of the starts
- LT/NT Frequency Converter Monitoring
- Gas Cooler Fans Monitoring
- Refrigerant Fill Level Monitoring
- Fast Unload (external OFF)
- Measuring Circuits Monitoring

Parameter

Parameter	Description	Input	Default	Dim.
Category Monitoring				
NT compressor				
Cylinder Head Temperature Compressor OFF	Switch-off temperature for NT compressor	80..180	145	°C
Cylinder Head Temperature Compressor ON	Enable temperature for NT compressor	50..120	110	°C
Alarm Delay Cylinder Head Temperature	Delay time for NT compressor "Cylinder Head Temp. too High" message	0..5	3	min
t_0 Compressor OFF	Lower NT limit t_0 from which the NT compressors will be switched off immediately	-50..2	-25	°C
Alarm Delay Low t_0	Delay time for message "Low LP" (after undercutting "t_0 Compressor OFF")	0..60	10	min
Max. Compressor Starts per Hour	Maximum starts NT compressor (info: always set to 16 for LT compressor)	4..16	6	-
LT compressors				
Superheating too Low LT	Limit for the monitoring of the minimum superheat	2.0..15.0	4.0	K

Parameter	Description	Input	Default	Dim.
Alarm Delay Superheating too Low LT	Delay time for the monitoring of the minimum superheat	0..15	1	min
Cylinder Head Temperature LT too High	Limit for monitoring of the cylinder head temperature of the LT compressors	70..160	130	°C
Alarm Delay High Cylinder Head Temperature	Delay time for the monitoring of the cylinder head temperature of the LT compressors	0..5	3	min
LP Max. for LT Compressor Shutdown	Limit for the LP monitoring	20.00.. 60.00	44.50	bar
t_0 Compressor OFF	Lower LT limit t_0 from which the LT compressors will be switched off immediately	-58.. 2	-46	°C
Alarm Delay Low t_0	Delay time for the message "LT t_0 too low"	0.. 60	10	min
Base load rotation				
Cycle Time Base Load Rotation Z1	Cycle time for base load rotation Z1-circuit compressors (NT)	5..720	45	min
Base load rotation FC	Base load rotation for FC compressors Z1 circuit (NT)	YES / NO	YES	-
Cycle Time Base Load Rotation Z2	Cycle time for base load rotation Z2 circuit (LT)	5..720	45	min
Base Load Rotation FC Z2	Base Load Rotation FC Z2 circuit (LT)	YES / NO	YES	-
Refrigerant				
Time Delay Low Refrigerant Liquid Level	Time delay for low refrigerant liquid level	1..120	60	min
Time Span for Determining Refrigerant Liquid Level	Interval within which the refrigerant monitoring takes place	2..60	30	min
Alarm Limit for Refrigerant Liquid Level	Limit for message "Low Refrigerant Liquid Level"	20..99	50	%
Monitoring Max. Refrigerant Liq. Level	Monitoring for too high refrigerant liquid level	ON/OFF	ON	-
Emergency Stop at Max. Refrigerant Liq. Level	Emergency Stop at Max. Refrigerant Liq. Level (only effective if "Monitoring Max. Refrigerant Liq. Level" = ON)	YES / NO	YES	-
Medium pressure				
MP Compressor OFF	Switch-off medium pressure for compressor	10..62	40	bar
MP Compressor ON	Enable medium pressure for compressor	5..60	35	bar
No. of Compressors When MP Alarm	Number of compressors still running at MP alarm	1..3	1	-
MP too Low	Limit for message MP too Low	10..60	30	bar
Alarm Delay Low MP	Alarm delay for message MP too Low	0..60	2	min
High pressure				
HP Emergency Stop	High pressure limit for emergency shutdown (HP Emergency Stop)	30..106	100	bar
HP Compressor ON	Min. HP for compressor enable	40..115	93	bar
HP Compressor OFF	Max. HP for compressor shedding	70..120	98	bar
Alarm Delay t_c / HP too High	Delay for message HP too High	0..60	1	min
HP too Low	Limit for message HP too Low	30..70	40	bar
Alarm Delay Low HP	Alarm delay for message HP too Low	0..60	2	min
High t_G	Limit for message Gas cooler outlet temperature High t_g	0..50	42	°C
Alarm Delay High t_g	Alarm delay for message Gas cooler outlet temperature High t_g	0..60	2	min

Parameter	Description	Input	Default	Dim.
Low t_G	Limit for message Low t_G	-20..20	-5	°C
Alarm Delay Low t_G	Alarm delay for message Low t_G	0..60	5	min

5.9.1 Safety chain

For reasons of redundancy of the monitoring system, precautionary measures, in addition to the monitoring functions of the controller, have been taken to disable all or individual compressors of a pack in critical operating conditions. The switching contacts of the controller used for this are prioritised as follows in descending order due to the type of wiring of the system:

Disable all compressors
1. HP switch (digital input Y, terminals)*
2. LP Limiter (digital inputs G (NT) and (LT))

*There is **no** HP switch for the LT circuit, however, the LT compressors are switched off using the HP switch of the NT circuit.

Disable relevant compressors
3. Oil / high pressure switch compressors (digital input terminals A, C, E, and Q, S and U)**
4. Motor overload cut-out compressors (digital input terminals B, D, F, and R, T and V)**

**The monitoring of this switch can be deactivated (see Compressor oil differential pressure monitoring/ HP switch and Monitoring of the compressor motor overload cut-out).

For connector details, see chapter Assignment of the digital inputs - 230 V AC.

The safety chain applies to NT **and** LT compressors. Due to their arrangement in the safety chain, when a high priority safety contact (e.g. HP switch) is tripped, all lower priority alarm contacts are also deenergised and thus active. The sending of low priority alarm signals at the same time when a higher priority alarm event occurs is blocked so that all secondary alarms are not sent by the controller in this case.

> At the beginning of the safety chain, an **HP safety limiter** is usually installed in the system (highest priority). If it trips, it must be reset manually on site.
> **Difference between limiter and switch**
> - A **limiter** must be reset manually (via push button or special tool) after it has been tripped.
> - A **switch** can automatically switch back to the good state after it has been tripped.

5.9.1.1 Compressor oil differential pressure monitoring/ HP switch

The oil differential pressure, the high pressure at the pressure ports of every compressor, or both, can be monitored via the digital inputs; for details see chapter Assignment of the digital inputs - 230 V AC. The pressure switches are monitored via the digital inputs. A message is generated if any of the signal inputs for the oil differential pressure switch / HP switch is tripped. The **messages** are

- for NT compressors "Oil/HP Fault Cx" (e,g. "Oil/HP Fault C1" for fault on compressor 1)
- for LT compressors "LT Oil/HP Fault x" (e,g. "LT Oil/HP Fault 2" for fault on compressor 2)

The **priority** of this message can be selected via the parameters "Oil Difference Pressure" (for NT compressors) or "LT Oil/HP-fault" (for LT compressors). The pressure switches are open in the alarm state. If the pressure switch trips, the compressor is switched off immediately and disabled for the following control processes. If it is reset, the compressor is enabled.
An **alarm delay** can be set for the switches on the NT compressors via the "Alarm Delay Oil/HP Fault" parameter ("System Configuration" category).

> If no oil differential pressure switches or HP limiters are used, monitoring can be activated / deactivated via the parameters
> - "Enable Oil-/HP-Monitoring" for NT compressors and
> - "Enable Oil-/HP-Monitoring LT" for LT compressors
>
> (both in category "System Configuration").

5.9.1.2 Monitoring of the compressor motor overload cut-out

The motor overload cut-outs of all compressors can be monitored via digital inputs; for details see chapter Assignment of the digital inputs - 230 V AC. The auxiliary contact is open in the alarm state (no signal at the digital inputs of the controller). If the motor overload cut-out trips, the compressor is switched off immediately and disabled for the following control processes. If the motor overload cut-out is reset, the compressor is automatically enabled and can be switched on as required.
The generated error message

- "Motortemp. Cx" (or "Mot.Temp 1/FC Fault" for compressor 1) for NT compressors or
- "LT Motortemp. x" (or "LT Mot.Temp 1/FC Fault" for compressor 1) for LT compressors

will not be deleted until after the motor overload cut-out has been reset.

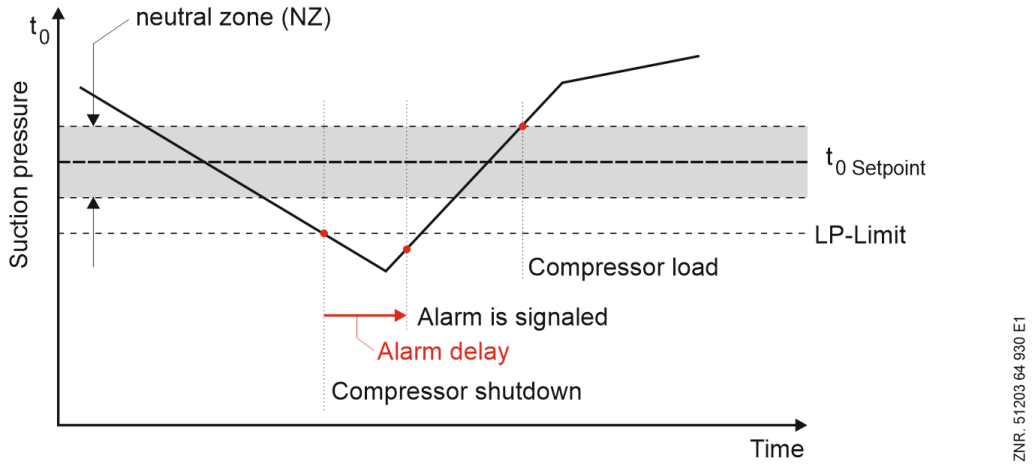
The monitoring of the motor overload cut-out for NT can be activated and deactivated with the parameter "Enable Motor Protection" = YES/NO (category "System Configuration").
The monitoring of the motor overload cut-out for LT compressors can be activated and deactivated with the parameter "Enable Motor Protection LT" = YES/NO (category "System Configuration").

5.9.2 Low Pressure Monitoring

> **Parametrisation**
>
> **Category Monitoring and category Message Priorities**

NT Compressor Low Pressure Monitoring

If the low pressure drops to a parametrisable limit "t_0 Compressor OFF" (category "Monitoring", all NT compressors are switched off. An alarm with the message " Low LP" is triggered after a delay time has elapsed. The delay time "Alarm Delay Low t_0" (category "Monitoring") and priority "Low t_0" (category "Message Priorities) of the message are parametrisable. If the low-pressure rises to the proportional $t_{0\_Setpoint}$ + NZ/2 pressure value, the compressors are switched on in stages in the step controller as already described. In the case of combined control, the neutral zone only applies to the fixed-speed compressors. The speed-controlled compressors are loaded as soon as $t_{0\_Setpoint}$ is exceeded. In addition, the LP limiter at the digital input W (terminals W/N) is evaluated; for details see chapter Assignment of the digital inputs - 230 V AC.



LT Compressor Low Pressure Monitoring

If the low pressure drops to a parametrisable limit "t_0 Compressor OFF Z2" (category "Monitoring", all LT compressors are switched off. An alarm "LT Low t0" is signalled after expiry of a delay time. The delay time "Alarm Delay Low t_0 Z2") and priority "Low t_0" (category "Message Priorities) of the message are parametrisable. The LT compressors are enabled again as soon as the limit "t_0 Compressor OFF Z2" is exceeded again.

> The priority "Low t_0" applies to both the message "Low LP" and the message "LT Low t0".

LT Compressor High Pressure Monitoring

The high pressure side of the LT compressors corresponds to the low pressure side of the NT compressors. If the actual value of p_0 is less than 2 bar below the configurable limit "LP Max. for LT Compressor Shutdown", the FC speed is first reduced. A compressor shutdown is performed if p_0 exceeds the limit for "Max. LP for LT Compressor Shutdown".

- The FC speed is reduced if the following applies:
  p_0-Actual> (LP Max. - 2 bar)
- A compressor shutdown is performed if the following applies:
  p_0-Actual > LP Max.

5.9.2.1 Superheating too Low Monitoring

Superheating too Low NT Monitoring
If the limit value "Min. Suction Gas Superheating" is undercut, then the message "Superheating too Low" is sent after the alarm delay "Alarm Delay Suction Gas Superheating" has elapsed.

Superheating too Low LT Monitoring
If the limit value "Superheating too Low LT" is undercut, then the message "LT Low Superheat" is sent after the alarm delay "Alarm Delay Superheating too Low LT" has elapsed.

5.9.3 Medium Pressure Monitoring

> **Parametrisation**
>
> **Category Monitoring**

5.9.3.1 MP too High Monitoring

The parameter "MP Compressor OFF" sets the maximum permissible medium pressure. The message "MP too High" is output if the pressure exceeds the specified limit. The parameter "No. of Compressors at MP-Alarm" defines the maximum number of compressors that may be loaded in the event of a medium pressure fault. If "MP Compressor OFF" is exceeded, the system then immediately steps down to the specified number of compressors (no unload).

If the parameter "No. of Compressors at MP-Alarm" is set to "--", only a fault message is output without compressors being switched off. The "MP too High" message is sent. The parameter "MP Compressor ON" specifies the pressure at which the compressors disabled by exceeding the pressure "MP Compressor OFF" are enabled again and the fault signal "MP too High" is reset. The compressor is switched on after previous compressor disabling due to MP malfunction after the programmed lead times have elapsed.

5.9.3.2 MP too low MP Monitoring

The medium pressure of the system should be within a certain range during normal operation. In addition to the MP too High Monitoring, the medium pressure is also monitored for undercutting a lower limit:

In the event of undercutting "Low MP", the message "MP too Low" is output after expiry of a configurable alarm delay time using the parameter "Alarm Delay Low MP". The message is transmitted according to priority preselection. This message is not output in the case of measuring circuit errors of the MP transmitter. The "MP too Low" message has no effects on the control and regulation processes.

5.9.3.3 MP Control Deviation Monitoring

> **Parametrisation**
>
> **Category Medium Pressure Control**

If the medium pressure deviates more than "Max. Control Deviation MPV" from the setpoint, the controller sends the message "Control Deviation MP" (set to Prio. 2" at the factory) after the alarm delay "Alarm Delay Control Deviation MPV" has elapsed.

In the event of a fast unload and with all compressors idle, the message is reset and the alarm delay time is restarted. This means that once the controller has returned to normal control operation from the fast unload, a new message cannot be generated until **after** expiry of the alarm delay time.

5.9.4 High Pressure Monitoring

Parametrisation

Category Monitoring

5.9.4.1 HP too High Monitoring

The high pressure is measured by a pressure transmitter in the high pressure line. The high pressure is also monitored using the high pressure switch (digital input Y, see chapter Assignment of the digital inputs - 230 V AC).

There are four different threshold values for monitoring via pressure transmitter. If the high pressure exceeds any of the threshold values, compressors are gradually switched off or the speed of the speed-controlled compressor is reduced. The individual monitoring stages of the high pressure control are as follows:

Exceeding "HP Compressor ON"
If the high pressure rises above the lowest threshold value "HP Compressor ON" (at the same time the enable threshold for decreasing pressure)

- the **compressor speed is reduced**
- no further compressor stages can be switched on (**compressor lockout**)

Exceeding the average value of "HP Compressor ON" and "HP Compressor OFF"
If the high pressure continues to rise above the average value between "HP Compressor ON" and HP Compressor OFF" ((HP Compressor ON + HP Compressor OFF) / 2), then

- the compressor speed will be reduced to **minimum speed**
- **all except one compressor will be switched off**

Exceeding HP Compressor OFF"
If the high pressure reaches the parametrisable limit "HP Compressor OFF", then

- the **alarm delay for "HP too High" starts** (parameter "Alarm Delay for High tc/HD", category "Monitoring")
- all consumers (refrigeration points) are switched off after alarm input "HP too High" (**consumer lockout**)

Sending a message
After exceeding the limit "HP Compressor OFF", the message "HP too High" is generated after a programmable delay time "Alarm Delay for High tc/HD". The priority of the message can be parametrised (parameter "HP too High", category Message Priorities - System Monitoring). In the event of any pending "HP too High" message, no additional compressor capacity stages are loaded.

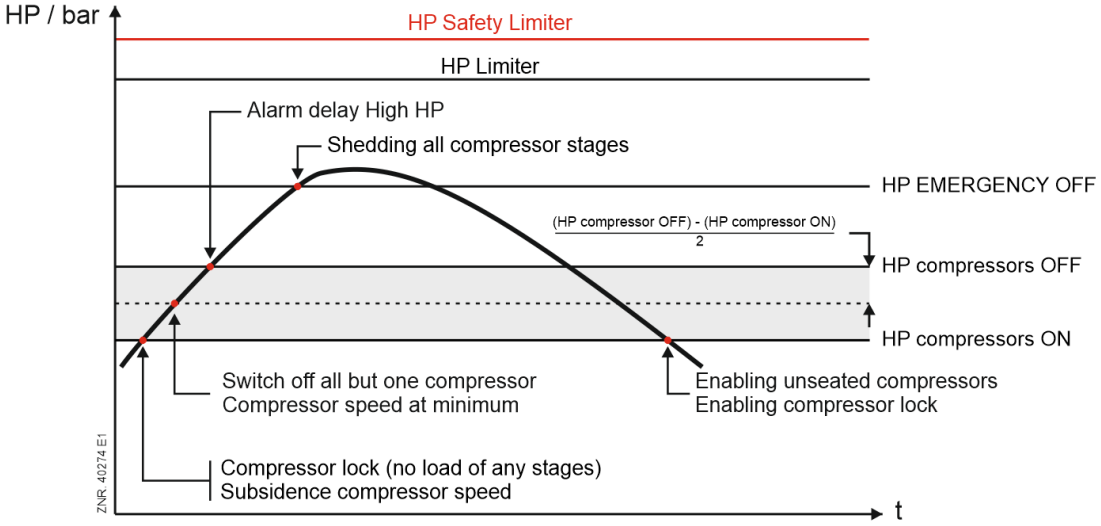
Exceeding "HP Emergency Stop"
If the measured high pressure also exceeds the limit "HP Emergency Stop", **all compressors will be switched off immediately**.

Enable when the pressure falls below "HP Compressor ON"
The measures taken are reversed when the high pressure has fallen below the value "HP Compressor ON" again.

- the alarm "HP too High" is reset
- the consumer lockout is removed (consumers are enabled again)
- unloaded compressors are enabled again
- the consumer lockout is removed

The compressors are then loaded in stages again via the step controller,

The following diagram shows the overall monitoring of the high pressure:



Forced shutdown at HPS limiter limit
If the limit of an external HPS limiter (high pressure safety limiter) is exceeded, all compressors are forcibly shut down. After mechanical unlocking of the pressure switches, the compressors are loaded again in stages (see chapter Safety chain).

5.9.4.2 HP too Low Monitoring

The high pressure of the system should be within a certain range during normal operation. In addition to the HP too High Monitoring, the high pressure is also monitored for undercutting a lower limit:

In the event of undercutting "Low HP", the message "HP too Low" is output after expiry of a configurable alarm delay time using the parameter "Alarm Delay Low HP". The message is transmitted according to priority preselection. This message is not output in the case of measuring circuit errors of the HP transmitter. The "HP too Low" message has no effects on the control and regulation processes.

5.9.4.3 HP Valve Monitoring

If the output opening degree for the high pressure valve (HPV) deviates from the read-back actual HP valve opening degree (analogue input AIN5, terminals 78/79) by more than "Max. Deviation Opening Degree HPV" (category HP Control), the controller sends the message "Error.OD.HPV" after expiry of a delay time "Alarm Delay Deviation Opening Degree HPV". The message has no influence on the control and control processes. The message priority can be configured using parameter "Error Opening Degree HP-Valve" (category Message Priorities), see chapter Message Priorities.

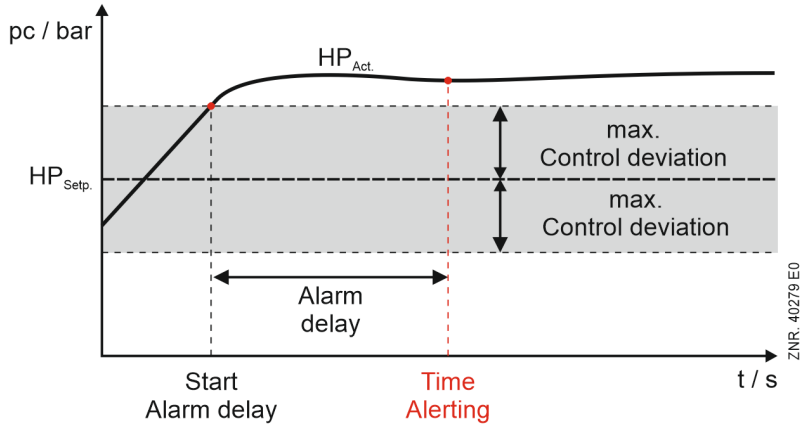
If there is a measuring circuit error at the analogue input AIN5 (e.g. due to short circuit or cable break), a message "MeasCirc OD HPV" is displayed, see chapter Measuring Circuits Monitoring. There is no "Error.OD.HPV" message during this time. The messages are transmitted according to priority preselection, see chapter Message Priorities.

Parameter	Description	Input	Default	Dim.
Category High Pressure Control				
HP valve limits				
Max. Deviation Opening Degree HPV	Max. permissible difference between the output control variable and the retrieved control variable (OD = Opening Degree) of the HPV If "--" is entered, the monitoring of the max. deviation can be deactivated.	0..100, --	15	%
Alarm Delay Deviation Opening Degree HPV	Delay time for the alarm signalling in the case of too great a deviation between the output and the read-back opening degree of the HPV.	0..100	15	min

5.9.4.4 Monitoring of the HP control deviation

The control deviation of the high pressure control is the difference between the HP actual value and the HP setpoint. If the control deviation for a parametrisable time "Alarm Delay Max. Control Deviation HPV" exceeds a parametrisable threshold value "Max. Control Deviation HPV", the controller generates the message "Deviation HP". The message has no influence on the control and regulation processes!

The following graph shows the relationship:



It can be established with the alarm whether

1. the controller is correctly configured for the high pressure control.
   Example: the max. control variable of the HP valve has been parametrised incorrectly.
2. there is any basic problem in the system.
   Example: HP valve in the system has a defect

The alarm message is reset

- in the event of a fast unload (230 V AC at digital input J/N, see chapter Assignment of the digital inputs - 230 V AC).
- during standstill of all compressors
- during a restart (de-energised state) of the controller

Configuration of the monitoring

Parameter	Description	Input	Default	Dim.
Category High Pressure Control				
HP valve limits				
Max. Control Deviation HPV	Maximum permissible control deviation in the HP circuit.	0..30	5	bar
Alarm Delay Max. Control Deviation HPV	Delay time for alarm signalling in the event of too great control deviation in the HP circuit.	0..100	15	min

5.9.5 Gas Cooler Outlet Temperature Monitoring

The two Pt1000 temperature sensors for measuring the gas cooler outlet temperature are monitored for short circuit and interruption:

- Sensor for gas cooler outlet temperature 1 at analogue input Pt11 for t_{G1}
- Sensor for gas cooler outlet temperature 2 at analogue input Pt12 for t_{G2}

The message priorities "Meas. Error Gas Cooler Outlet 1" and "Meas. Error Gas Cooler Outlet 2" (category "Message Priorities") of the two temperature sensors can be parametrised.

Monitoring for plausibility of the gas cooler temperature

The gas cooler outlet temperature used for the control should be in a specific range during normal operation of the system. The default is the gas cooler outlet temperature t_{gk2}. t_{G1} is only used in the event of a measuring circuit error (see chapter Temperature sensors of the control). Two limits are used to monitor the range (category "Monitoring"):

- Parameter "High t_G"
  If "High t_G" is exceeded, the message "t_G too High" is output after an alarm delay time that can be selected via the parameter "Time Delay High t_G" has elapsed.
- Parameter "Low t_G"
  If "Low t_G" is undercut, the message "t_G too Low" is output after an alarm delay time that can be selected via the parameter "Time Delay Low t_G" has elapsed.

- Both messages are transmitted according to priority preselection.
- In the event of a measuring circuit error of the temperature used for fan control, the messages "t_G too High" and "t_G too Low" are **not** output.
- The messages "t_G too High" and "t_G too Low" have **no** influence on the control and regulation processes.

5.9.6 Cylinder head temperature monitoring

To prevent damage to the compressors, the cylinder head temperatures of the NT and LT compressors are monitored for their upper maximum value using cylinder head sensors (see chapter Part Numbers VPC 5000 and Accessories.) The sensors are connected to the analogue inputs Pt1..Pt3 or Pt4..Pt6 (see chapter Assignment of the analogue inputs Pt1000).

Connected sensors and probes are monitored by the controller, see chapter Measuring Circuits Monitoring. In the event of a defect, a message is output, the priority of which can be configured, for details see chapter Message Priorities.

NT compressor cylinder head temperature monitoring
The maximum cylinder head temperature that causes an NT compressor to be disabled, as well as the enable value, must be specified via the parameters "Cylinder Head Temperature Compressor OFF″ and "Cylinder Head Temperature Compressor ON″ (category Monitoring). If the upper maximum value "Cylinder Head Temperature Compressor OFF″ is exceeded, the associated compressor is switched off and disabled for the following control processes. After a parametrisable delay "Alarm Delay High Cylinder Head Temperature″ has elapsed, a message "Cylinder Head Temp. too High Cx" is sent (cylinder head temperature too high on NT compressor x).

The compressor remains disabled until the temperature has dropped to the enable level ("Cylinder Head Temperature Compressor ON″). If the procedure is repeated multiple times within one day (5 switching operations) and there is still more than one compressor available in the refrigeration compressor pack, the compressor is permanently disabled and must be enabled again manually via "Stage x Compressor = ON" (category System Configuration / Enable Capacity Stages). The message ″Aut. Disable Sx″ (Automatic Disable Stage x NT) is output.

LT compressor cylinder head temperature monitoring
If the threshold value "Cylinder Head Temperature LT too High" is exceeded, the compressor is first switched off and remains disabled. If the cylinder head temperature does not drop below the threshold value again, then a message "High Cyl.temp LT x" (cylinder head temperature too high on LT compressor x) is generated after the expiry of the "Time Delay Cylinder Head Temperature Too High" time.

The compressor remains disabled until the temperature has dropped below the threshold value "Cylinder Head Temperature too High LT" again. If the procedure is repeated multiple times within one day (5 switching operations) and there is still more than one compressor available in the refrigeration compressor pack, the compressor is permanently disabled and must be enabled again manually via "Stage x Compressor = ON" (category LT Compressors / Enable Capacity Stages). The message ″LT Aut. Disable Sx″ (Automatic Disable Stage x LT) is output.

Compressor fault in the case of combined control
A compressor fault occurs under the following conditions:

- Tripping of a motor overload cut-out
- Tripping of a high pressure switch
- Exceeding the maximum permissible cylinder head temperature

In the event of any fault on any of the compressors that can be assigned to the frequency converter (compressors 1 and 2), a compressor shutdown is performed and the generation of a message depending on the state of the base load rotation output (relay outputs "Base Load Rotation NT FC Compressor" and "Base Load Rotation LT FC Compressor", see Assignment of the relay outputs 230 V AC.

Compressor fault for single-stage compressors
For speed controlled compressors, the frequency converter is always enabled with the first compressor stage. Using the base load rotation, compressor 1 or compressor 2 can be assigned to the FC. If no base load rotation was performed (output base load rotation OFF), a fault of compressor 1 causes the switch-off of the capacity stage 1 with the appropriate error message for compressor 1. A fault of compressor 2 results in the switch-off of capacity stage 2 with the appropriate fault message for compressor 2.

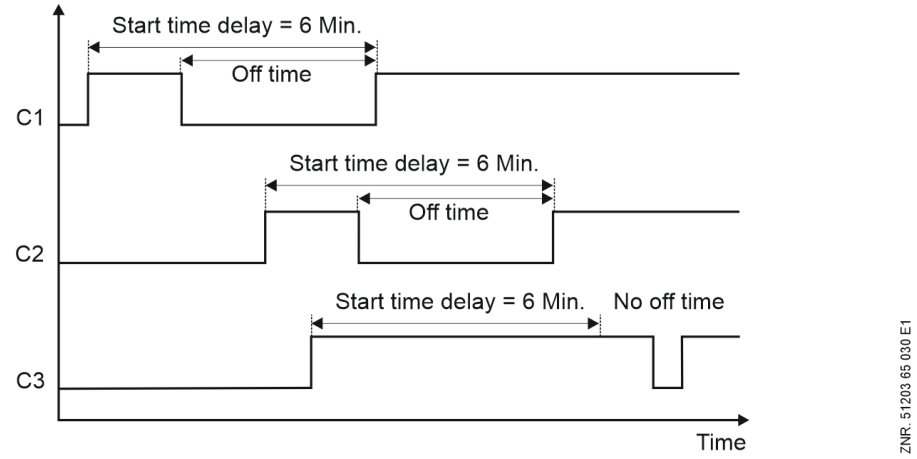
After any base load rotation (output base load rotation ON) a fault of compressor 1 causes the switch-off of the capacity stage 2 with the appropriate error message for compressor 1. A fault of compressor 2 results in the switch-off of capacity stage 1 with the appropriate fault message for compressor 2.

Fault on:	Base load rotation output	Capacity stage OFF output	Message
Compressor 1	ON	Stage 2	Message C1
	OFF	Stage 1	
Compressor 2	ON	Stage 1	Message C2
	OFF	Stage 2	

5.9.7 Monitoring of the starts

The number of compressor switching operations per hour is limited to prevent too many compressor starts.

Example:



Limitation of the starts
Using the parameter "Max. Compressor Starts per Hour" (category Monitoring), the minimum time intervals at which an NT compressor can be switched on (maximum permissible number of starts) are determined. For example, if the number of starts is 10 switching operations per hour, a compressor can be switched on at the earliest every 6 minutes. The maximum permissible number of starts for LT compressors is always fixed at 16 switching operations per hour and cannot be changed.

Monitoring of the starts
The starts limitation is deactivated for compressor combined control (however, the number of starts continues to be monitored). If a compressor exceeds its maximum permissible number of starts, the message "too many starts" is output.

> ⓘ The deactivated starts limitation for speed-controlled compressors is activated again in the event of any FC error.

5.9.8 LT/NT Frequency Converter Monitoring

Errors of the frequency converters are registered with the LT/NT compressor controller via the two digital inputs B and Q (terminals B/N and Q/N). In the event of a fault, one of the messages "MotTemp 1/FC-Fault LT Compressors" (LT frequency converter fault) or "Mot.Temp 1/FC-Fault" (NT frequency converter fault) is output.

> **Practical tip**
>
> A fault in the frequency converter is detected in parallel with motor overload protection 1 of the first compressor (applies to LT and NT).
> For wiring example, see chapter Start-up of speed-controlled compressors / condenser fans.

5.9.9 Gas Cooler Fans Monitoring

Speed Control
The digital input X (terminals X/N) is provided for monitoring the gas cooler fans. If the contact for monitoring the gas cooler fans or a motor overload cut-out (low active) opens, an error message is registered in the error message memory. The message is transmitted according to preselected priority.

5.9.10 Refrigerant Fill Level Monitoring

> **Parametrisation**
>
> **Category Monitoring**

The refrigerant fill level (refrigerant level) of the system is monitored via the two digital inputs H and I (terminals H/N and I/N), see chapter Assignment of the digital inputs 230 V AC.

The status of the level switch (ON/OFF) is sampled and recorded over a parametrisable time interval (parameter "Time Span for Determining Refrigerant Liquid Level") in second cycles. This parameter defines the duration of a measuring cycle. If the percentage of “good states” falls below the parameter "Alarm Limit for Refrigerant Liquid Level", an alarm is triggered.

> The tripping of the level switch has no influence on the control and regulation functions.

The level is calculated using the following formula:

*level [%] = (number of good states * 100%) / (interval * 60)*

After any power failure, the refrigerant level is set to 100%. A measurement result is not available until the interval time has elapsed. The calculated level can be checked in the "Actual Values" area.

Monitoring of refrigerant level MIN function
If the digital input H is de-energised, the message "Low Refrigerant Liquid Level" is output. The message is transmitted according to preselected priority.

Monitoring Max. Refrigerant Liq. Level function
If the parameter "Monitoring Max. Refrigerant Liq. Level" is set to "YES", the upper limit of the refrigerant fill level is also monitored:

- If the digital input I is de-energised, the message "Max. Refrigerant Liquid Level" is output. The message is transmitted according to preselected priority.
- If the parameter "Emergency Stop at Max. Refrigerant Liq. Level" = "YES", the system is disabled immediately in the event of tripping the alarm so that no liquid refrigerant reaches the compressor. The system is not enabled again until the alarm has been reset or the digital input I is energised with 230 V again (level switch for max. level monitoring is then in the good state again).
- If the parameter "Emergency Stop at Max. Refrigerant Liq. Level" = "NO", the tripping of the digital input I has no influence on the control and regulation functions.

5.9.11 Fast Unload (external OFF)

The regulation of the controller can be switched off via the digital input J "Fast unload (external OFF)" (terminals J/N), see chapter Assignment of the digital inputs - 230 V AC. The following occurs when the digital input is activated:

- Compressors and fans are unloaded in quick succession (2 seconds unload time).
- The consumer enable of the case controller associated with the refrigeration circuit is withdrawn: **Exception:** unless the low pressure is too low.
- The medium pressure valve (MPV) is closed if all compressors are switched off (analogue output AO4, terminals 89/90 at 0 volts).
- The fault signal "ext. unload" is output.

5.9.12 Measuring Circuits Monitoring

The controller monitors connected sensors and probes for proper function and plausible measured values:

- Pressure transmitter for monitoring high, medium and low pressure,
  for details, see chapter Assignment of the 4..20 mA analogue inputs.
- Sensor for measuring the cylinder head temperature of compressors,
  for details, see chapter Assignment of the analogue inputs Pt1000.
- Sensor for measuring the hot gas / gas cooler / suction gas temperature,
  for details, see chapterAssignment of the analogue inputs Pt1000.
- Sensor for measuring the opening degree of the HP valve,
  for details, see chapter HP Valve Monitoring.
- Sensor for measuring the room and outdoor temperature and the humidity,
  for details, see chapter Ambient data for the setpoint shift.

If a sensor or probe is **no longer** detected by the controller, a message "Meas. Error xxx or similar) is sent, the priority of which can be configured, see chapter Message Priorities.

Causes for measuring circuit errors

- Wire, cable, connection to sensor / probe is interrupted or short-circuited
- Sensor or probe defective

> **Practical tip**
>
> - Check electrical connection for possible wiring errors
> - Check cable / wire for interruption / short circuit
> - Valves: check the valve closes / opens correctly, check mechanism if necessary

Behaviour of the measured values in the event of a measuring circuit error

- **High pressure:**
  In the event of any error in the high pressure measuring circuit, condenser stages are switched off for stopped compressors and switched on for running compressors. If compressors have been switched on manually, capacity stages are also loaded. A switching operation is performed after expiry of the basic time. The variable times are not taken into account.
- **Low pressure:**
  In the event of any error in the low pressure measuring circuit, compressor capacity stages are loaded or unloaded until approx. 50% of all available compressor capacity stages is in operation. A switching operation is performed after expiry of the basic time. The variable times are not taken into account.
- **Other:**
  In the event of all other measuring circuit errors, the calculation continues with the **last valid** value for the duration of the error.

5.10 Setpoint Toggle

Parametrisation

Category Toggle Timer

It is possible to set a second (alternative) setpoint set of parameters, for example for day / night operation, for the low pressure control. The setpoint toggle can be activated

- via the internal week timer (parameter "Type of Setpoint Toggle" = INT) or
- via the digital input Z (terminals Z/N) of the controller (parameter "Type of Setpoint Toggle" = EXT), see chapter Assignment of the digital inputs - 230 V AC.

When setpoint toggle is activated, the following parameters in the controller are changed over:

- Temperature setpoints
- Neutral Zone
- Control constant
- Switching times
- Gas cooler control maximum speed

Parameter	Description	Input	Default	Dim.
Category Toggle Timer				
Type of Setpoint Toggle	Source for the switching times (internal weekly timer or external input)	INT, EXT	INT	-
Weekdays	Day of the week for switching to night operation, or Mon-Sun	Monday, Tuesday, .. , Sunday, Mon-Sun	Monday	-
Start	Start time for switching to night operation	hh:mm	00:00	-
Weekdays	Day of the week on which switching to night operation ends, or Mon-Sun	Monday, Tuesday, .. , Sunday, Mon-Sun	Monday	-
End	End time for switching to night operation	hh:mm	00:00	-

5.11 Ambient data for the setpoint shift

> **Parametrisation**
>
> **Category System Configuration**

The variables used for the setpoint shift are

- Room Temperature (shift of t_0, parameter "Enable Room Temperature Sensor", see chapter Setpoint Shift)
- Outdoor Temperature (shift of the gas cooler outlet temperature t_G, parameter "Enable Outdoor Temperature Sensor", see chapter Setpoint calculation tG via outdoor temperature)

This can either be provided via wall-mounted sensors connected to the pack controller (see chapter Accessories for VPC 5000) or received via the CAN bus from another pack controller.

Combined humidity sensor* (4..20 mA) and temperature sensor (4-wire Pt1000)**	**Outdoor temperaturesensor** (4-wire Pt1000)**
	

* For details, see Assignment of the 4..20 mA analogue inputs / ** Assignment of the analogue inputs Pt1000

The parameters "Enable Room Temperature Sensor", "Enable Outdoor Temperature Sensor" and "Enable Humidity Sensor" (category System Configuration) can be set to determine whether sensors directly connected to the controller are available. If any of these parameters is set to "NO", the additional parameter "VS Node No. for Sensor Data" is displayed. If required, this parameter can be used to specify from which pack controller the desired ambient data should be obtained. The entered parameter plus 100 results in the CAN bus address of this pack controller.

Example: "Node No. VS for sensor data" = "2" for the pack controller with the CAN bus address "102"

If **no ambient data** should be received via the CAN bus, the parameter "Node No. VS for sensor data" must be set to "–".

> **Note**: The data of the humidity sensor are **only** used for recording; they are **not** used for control!

Parametrisation

Parameter	Description	Input	Default	Dim.
Category System Configuration				
Sensors				
Enable Outdoor Temperature Sensor	Enable outdoor temperature sensor	YES / NO	YES	-
Enable Room Temperature Sensor	Enable room temperature sensor	YES / NO	YES	-
Enable Humidity Sensor	Enable of the humidity sensor	YES / NO	NO	-
Node No. VS for sensor data	CAN bus address 102..109 of the controller from which the sensor data are obtained.	2..9, --	--	-

ⓘ Connected sensors and probes are monitored by the controller, see chapter Measuring Circuits Monitoring. In the event of a defect, a message is output, the priority of which can be configured, for details see chapter Message Priorities.

5.12 Consumer lockout

In the event of any fault of the NT and the LT pack, the pack controller can send a consumer lockout via the CAN bus to **all** associated consumers (refrigeration points). Associated consumers are case controllers for which the CAN bus address of the associated pack and the NT/LT refrigeration circuit have been assigned in the configuration of the controller (if applicable, also referred to as "Compressor Pack Z1/Z2" in case controllers). The consumer lockout is sent to all associated consumers if no compressor or no refrigeration capacity is available. Possible causes of failure for a consumer lockout are:

- Tripping of the HP limiter
- Tripping of all motor overload cut-outs
- High pressure limiters of all compressors
- Manual shutdown of all compressors

ⓘ **Note**: **No** consumer lockout is performed for any suction pressure fault due to too low suction pressure **or** tripping of the LP limiter.

The following generally applies:

- A consumer lockout is sent to the assigned NT refrigeration points if the NT pack (all NT compressors) is disabled **or** in the event of an error message "HP too High", see chapter HP Monitoring.
- A consumer lockout is sent to the assigned LT refrigeration points if the LT pack (all LT compressors) is disabled.
- A consumer lockout is sent to **all** assigned NT/LT refrigeration points if the NT **and** the LT pack (all NT and LT compressors) are disabled.

5.13 Emergency Power Mode

Parametrisation
System Configuration

Emergency Power Mode function
The aim of emergency power mode is that the E*LDS components reduce power consumption and thus the load on the emergency power system in the event of a power supply failure or malfunction (e.g. operation of the store via emergency power generator or emergency power system / UPS). For the pack controller, emergency power mode is a variant of load shedding and supports the reduction of the network load by unloading compressor stages.

Enable Emergency Power Mode
Using the parameter "Emergency Power Mode" = "YES", the emergency power mode can be enabled and the additional parameter "Active Compressor Stages in Emergency Power Mode" is displayed. This parameter defines the maximum number of NT compressor stages that are permitted to run in emergency power mode. This parameter can be set between the following limits:

- Minimum of one compressor stage to ensure a minimum refrigeration capacity
- Maximum of one compressor stage less than is possible for maximum configuration

Emergency Power Mode Activation
The emergency power mode is activated via the digital input K (terminals K/N) by applying a voltage, see chapter Assignment of the digital inputs - 230 V AC. In this case, **all NT compressors are first switched off immediately** and the signal "Emergency power mode" is transmitted. Using the controller, up to "Active Compressor Stages in Emergency Power Mode" NT compressors are then switched on again so that in the event of a power failure, the emergency generator can start up with as little load as possible.

Parameter	Description	Input	Default	Dim.
Category System Configuration				
Emergency Power Mode				
Emergency Power Mode	Enable of the "Emergency Power Mode" operating mode	YES / NO	NO	-
Active Compressor Stages in Emergency Power Mode	Number of NT compressor stages that can be loaded in emergency power mode - only visible if parameter Emergency Power Mode = YES	1..2	1	-

The emergency power mode is signalled from the controller to the associated case controllers via CAN bus. The addressed case controllers – depending on their parametrisation – then interrupt their energy intensive processes such as defrosting, cooling, fan, ...). Further information about their settings can be found in the respective operating manual of the relevant case controller in the chapter Emergency Power Mode.

5.14 Operating data and archiving

> **Parametrisation**
>
> **Operating data**

The display and adjustment of the operating data is a component of the Virtus Control Desk (VCD).

Operating hours of compressors and fans
The operating hours of all compressors and fans are recorded and stored in 30-second intervals. The display is in hours. When replacing compressors or fans or the controller, the total operating hours can be set individually according to the conditions.

Daily running times, starts and activity (utilisation)
As well as the operating hours, the running times, compressor starts per day and the activity (utilisation) of the pack are recorded daily and stored with date.

The activity is calculated according to the following formula:

$Activity = L \ / \ (n \ (T_1 - T_0) \ )$

Activity: activity (utilisation) of compressor pack in percent
L: total of all compressor running time
s: number of available compressors
T_1 : current time
T_0 : day change

6 VPC 5000 Installation and Start-up

IMPORTANT SAFETY INSTRUCTIONS!

- **Before** the installation and start-up, chapter Safety instructions must be read carefully in its entirety and all safety instructions and hazard warnings must be observed.
- Furthermore, it must be noted that the safety of the system or the installation in which the controller is integrated is the **responsibility of the creator** of the system or installation. If the controller is used in any way not specified by Eckelmann AG, the protection supported by the controller can be compromised, see chapter Intended Use.
- Opening the device is **not** authorised! The device is **not** intended to be opened by the user, as possible dangers due to incorrect assembly cannot be ruled out. Any necessary maintenance or repair **may only** be carried out by the manufacturer Eckelmann AG!

ATTENTION

- **Instructions for transport**
  For carrying, the device should be gripped on the short sides and only placed on the back to avoid damage to the front switches or terminal blocks.
- **Before the start-up of the system, system-dependent settings must be made** on the hardware and software side of the controller.
- **Notes for configuration**
  The system centre acts as a gateway via Virtus Control Desk or LDSWin for configuration during commissioning or for adjustments during later operation. To be able to make changes to the controller, the user **must** be logged in to the system centre, for details see chapter Operation via touch screen of the system centre.

  Practical tip: The latest version of the system centre and LDSWin should always be used.

6.1 DIN rail mounting

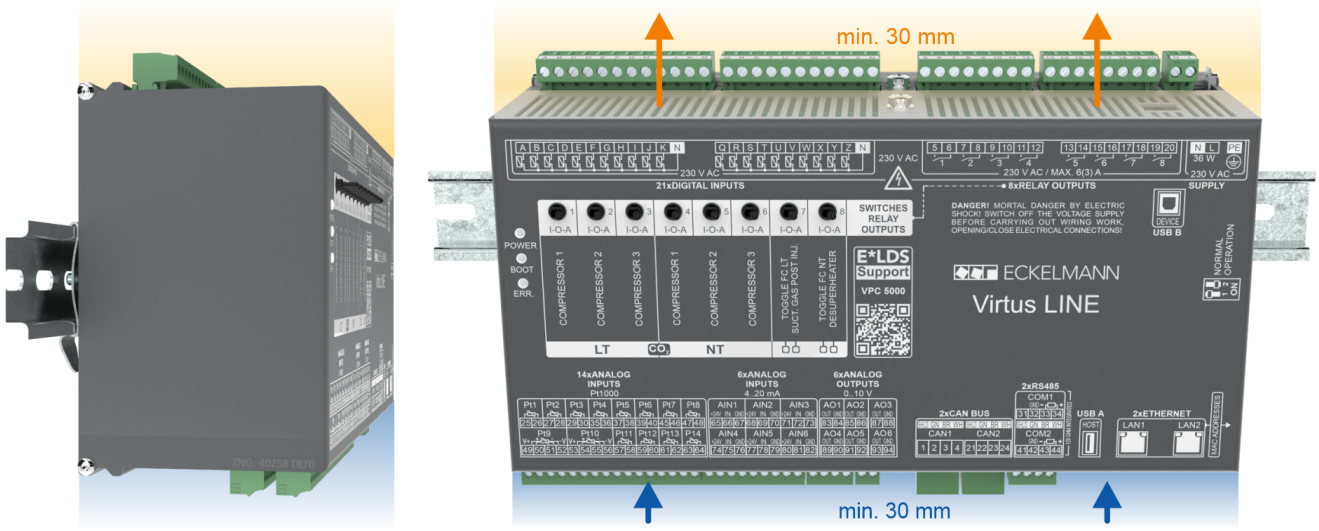
The controller is attached to a DIN rail using two claws on the back, for details see chapter Mounting on the DIN rail.

ATTENTION

The controller is **only permitted** to be operated on a DIN rail mounted in the switch cabinet as a built-in regulation and control device (EN 61010-1 and EN 61010-2-201).
The power loss of the controller is 24 W. The natural convection of the circulating air with free air exchange is sufficient to prevent overheating. An unobstructed air inlet/outlet **at least 30 mm below and above** the device **must always** be ensured. If this cannot be guaranteed, forced ventilation is required! The ventilation slots must **not** be covered! A lateral clearance from neighbouring equipment is not required, the device can be mounted in a row without clearance.
All supply lines from and to the device (with the exception of the 230 V power supply and signal lines) must be **shielded**! This particularly applies to the analogue inputs and outputs as well as to the twisted pair CAN bus and Modbus cabling; see operating manual *"Basics and General Safety and Connection Instructions*". These must also be installed with sufficient clearance from live cables. As a general rule, care should be taken to **ensure** that signal cables and cables carrying mains voltage are routed in separate cable channels.
For details about protection rating and dimensions, see chapter Technical Data VPC 5000.

Specified mounting position

The controller must be mounted on the DIN rail as follows:



6.1.1 Mounting on the DIN rail

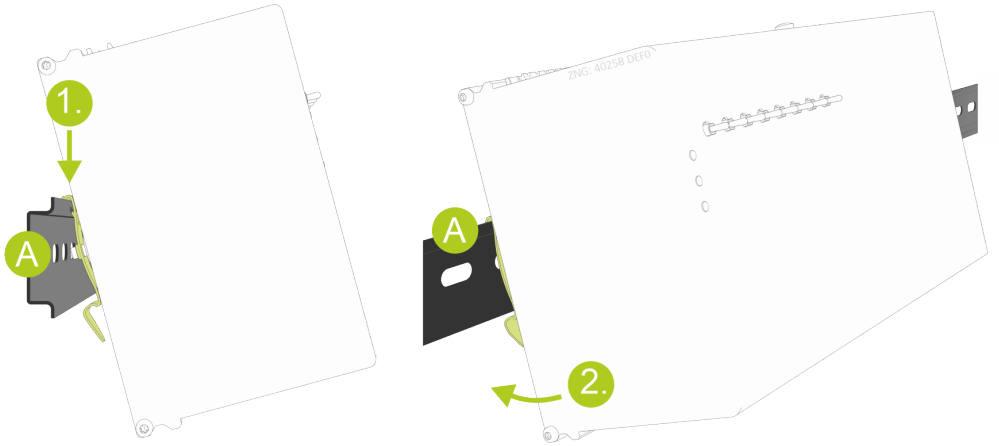
DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! The safety regulations and work safety instructions **must** be observed for the mounting. **All** plug connectors may only be inserted and removed in a de-energised state, see chapter Handling wide COMBICON plug.

Step 1: Underside of the controller (with mating connectors removed) with the two claws for mounting:

In order to ensure mounting / removal, a clearance of at least 30 mm to the next component (e.g. cable duct) **must** be maintained underneath the controller.
Note: The DIN rail (35 mm) must have a height of at least 5 mm.

Step 2: Place the controller on the upper edge **(1.)** of the DIN rail **(A)** and swivel it downwards **(2.)** until the controller snaps firmly onto the DIN rail.



6.1.2 Removal from the DIN rail

DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! The safety regulations and work safety instructions **must** be observed for the mounting. **All** plug connectors may only be inserted and removed in a de-energised state, see chapter Handling wide COMBICON plug.

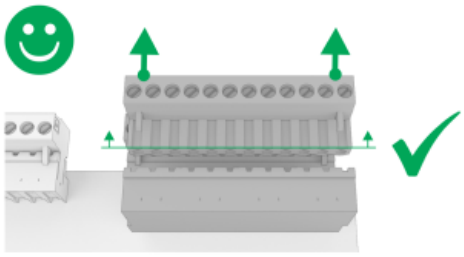
Step 1: Remove all mating connectors with cables from the controller.

Step 2: Remove the device from the DIN rail **(A)** by swivelling**(1.)** upwards.

6.1.3 Handling wide COMBICON plug

Correct handling

Mating connectors **must** be plugged or **unplugged vertically and without canting**.

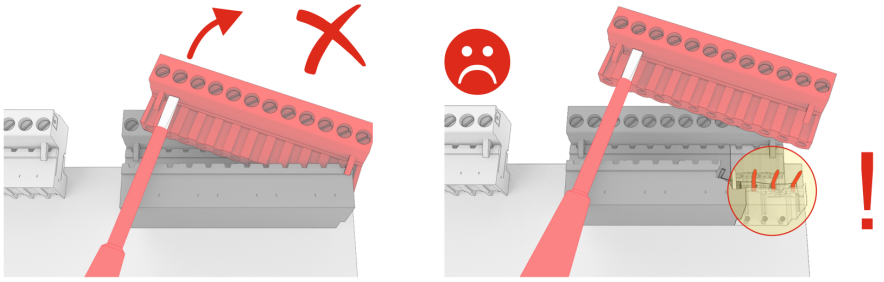


For detailed information on handling wide COMBICON connectors, see online in EDP.

Incorrect handling

ATTENTION

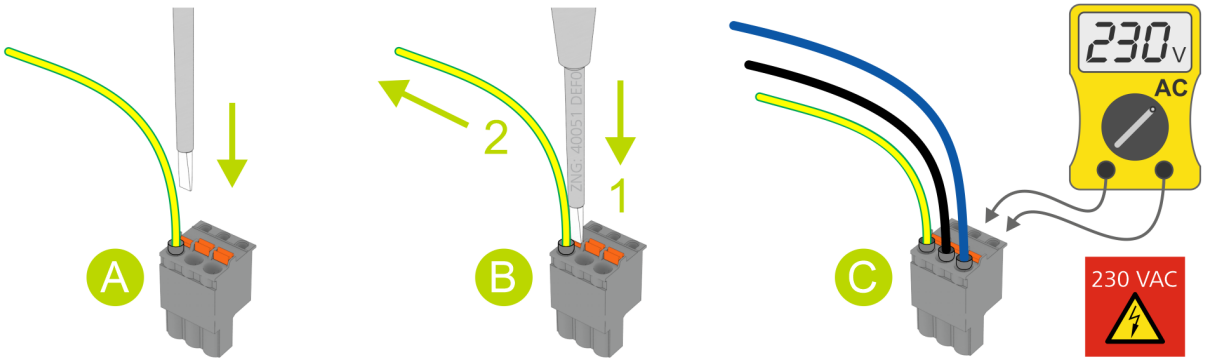
Incorrect handling leads to damage to the plug socket! Never detach the mating connector on one side, as this will damage the pins of the plug socket!



6.1.4 Handling of the spring-loaded terminals

Mating connectors with spring terminals (push-in spring connection) and has the following features:

- Conductors with cross sections between 0.25 and 2.5 mm² can be used.
- All mating connectors are coded and any reverse polarity is therefore ruled out.



A - Installation
For fast installation without tools, direct conductor connection of prefabricated cables (these with 10 mm wire end sleeves) by simply inserting into the spring terminal is also possible. The orange push button must also be pressed during insertion to connect flexible wires of 0.25 to 2.5 mm² without wire end sleeve.

B - Disconnetion
The wires are disconnected using a screwdriver (max. 3.5 mm width) via the orange push button at the terminal connection that has no direct contact to live parts.

Step 1: Press the orange push button vertically downwards using a screwdriver to detach the connection.
Step 2: Pull wire upwards.

C - Test
For voltage testing, each terminal connection has openings for probe tips of multimeters that are designed with protection against direct contact.

> **NOTICE**
>
> **Risk of damage!** All mating connectors **must always** be guided vertically and attached / disconnected without twisting so that the pins on the main board are not bent and damaged.

6.2 CAN bus address

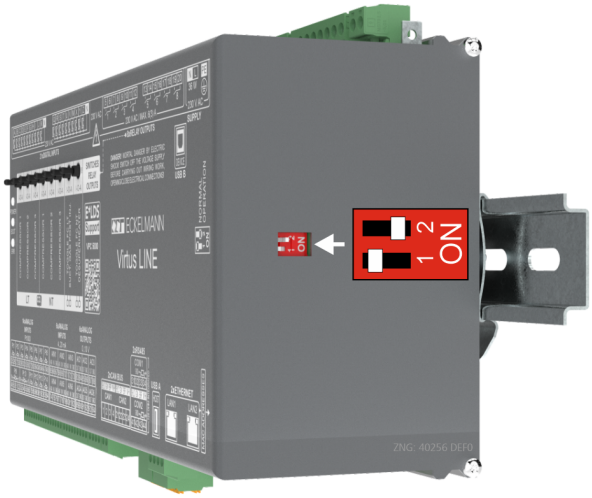
The CAN bus address of the controller is **permanently preconfigured to 101** and - unlike other components of the E*LDS system - **cannot be changed**.

> If another pack controller should be installed in the system, it **must** be assigned a CAN bus address between **102..109** (2..9) in order to avoid an address conflict.

6.3 DIP Switches

DIP switch settings in normal operation

The DIP switches are located on the right-hand side of the controller and **must** be set as follows for normal operation (factory setting):



- **DIP Switch 1: MUST** be set to OFF
- **DIP Switch 2: MUST** be set to ON

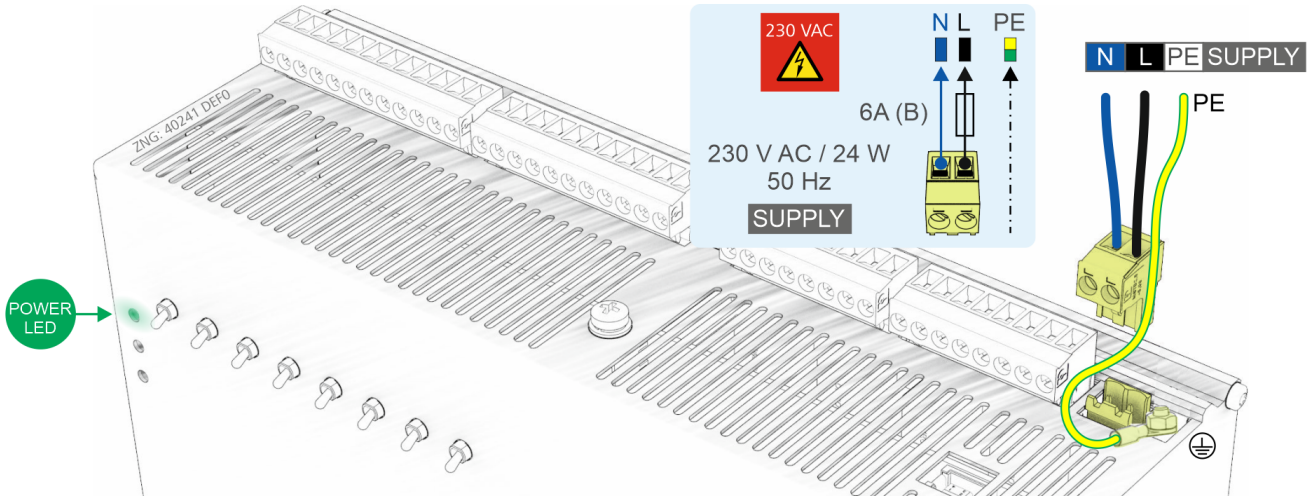
6.4 Power supply

DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! BEFORE connection and disconnection, it **must** be checked that the 230 V AC power supply cable is **disconnected from the power supply**! The controller is only permitted to be connected to the intended operating voltage of 230 V AC!

ATTENTION

A circuit breaker **must** be used to protect the mains cable and must not interrupt the earth conductor (PE). For details, see chapter Assignment of the 230 V AC power supply.



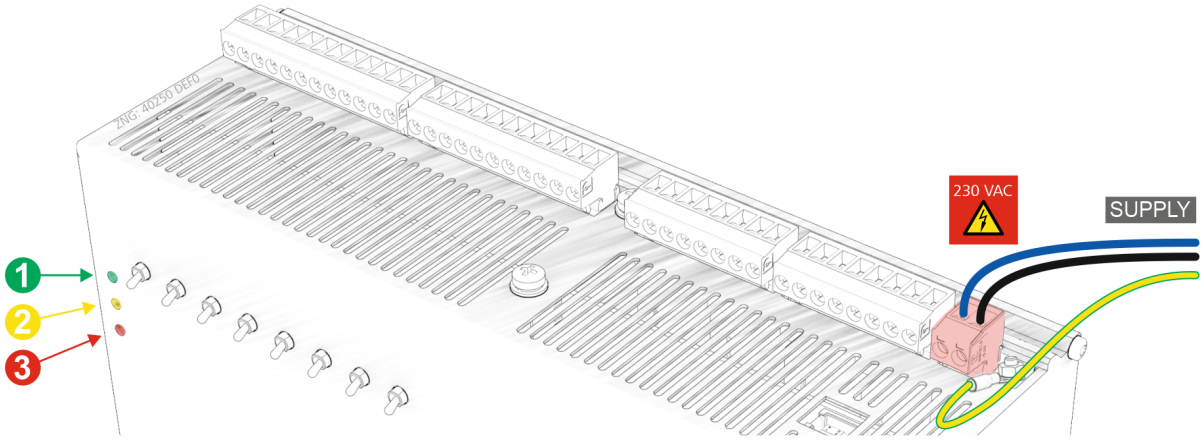
The controller can be put into operation after completion of the mechanical and electrical installation. After connection of the 230 V AC power supply, the green LED POWER lights, for details see chapter Status LEDs.

Note: As the controller itself does not have a switch for switching on or off, it **must** be disconnected from the power supply for e.g. a Restart for approx. 2 seconds (switch on/off the circuit breaker).

6.4.1 Status LEDs

DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! BEFORE connecting and disconnecting, it must be ensured that **no voltage** is present at all connections of the controller.



LED	Colour	Function	Description
1	green	POWER	ON: Power supply (SUPPLY) OK, controller is running, manual/automatic switching is possible OFF: Power supply interrupted or device defective For details, see chapter Assignment of the 230 V AC power supply Assignment of the 230 V AC power supply
2	yellow	BOOT	ON: New firmware update is being transferred OFF: Transfer of the firmware update finished
3	red	ERR.	ON: System is booting or firmware could not be loaded (ERROR), Manual/automatic switching is not possible OFF: Booting finished or firmware has been loaded

6.5 Basic configuration of the controller

The network-compatible controller integrates all functions for highly efficient and reliable operation of transcritical CO_2 systems and is already pre-configured at the factory. During initial commissioning of the controller, a basic configuration must be carried out for it in accordance with the system configuration (e.g. number of compressors, pressure transmitters used, etc.).

> **ATTENTION**
>
> **Damage to the system and stock loss!** Incorrect parametrisation can result in high impairments of the function.

Info CAN bus address / LAN

- The CAN bus address of the controller is **permanently preconfigured to 101** and cannot be changed.
- Furthermore, the controller must be connected to the system centre via LAN, see chapter Ethernet Connections.

The basic configuration - only the most important ones are listed here - is carried out in the following categories:

Category Pressure Transmitters

- Calibration of the pressure transmitters; for details, see chapter Pressure Transmitter.

Category System Configuration

- Enable of the available sensors, e.g. room temperature sensor
- Enable of monitoring functions, e.g. compressor motor overload cut-out
- Set number of NT compressors
- Select type of control of the fans and set number of fan stages

If LT compressors are available:

- Select Enable LT Control and
- set No. of LT Compressors
- Enable of monitoring functions, e.g. LT compressor motor overload cut-out

Category Low Pressure and category Fan Control

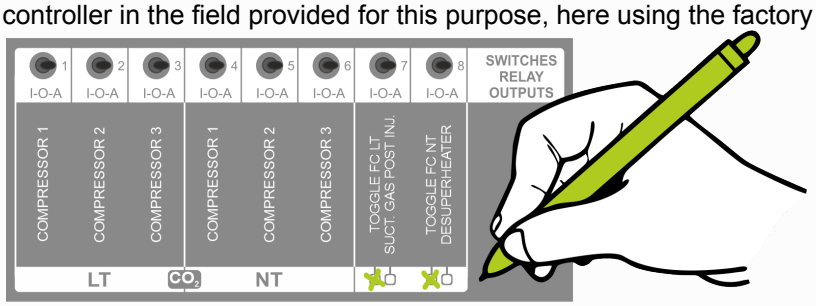
- Select Low Pressure Control Mode and High Pressure Control Mode

Category MP Control and category HP Control

- Set setpoints for medium and high pressure as well as associated limit values

Category Monitoring

- Configuration of the function of the relay outputs:
  - Relay output 7: Base Load Rotation NT/LT Compressors Base load rotation NT/LT compressor (factory setting) or
    Minimum Superheat Control Suction gas post-injection.
  - Relay output 8: Base Load Rotation NT/LT Compressors Base load rotation NT/LT compressor (factory setting) or
    Minimum Superheat Control via LT Discharge Gas Desuperheater.

> **Practical tip**
>
> The configured function modes of relay outputs 7 and 8 should be noted on the front of the controller in the field provided for this purpose, here using the factory setting as an example:
>
> 
>

- Disable the compressors in the event of overheating (parameter "Cylinder Head Temperature Compressor OFF")
- Disable the compressors in the event of high pressure too high (parameter "HP Compressor OFF")
- Disable the system in the event of high pressure too high (parameter "HP Emergency Stop")
- Alarm for low refrigerant liquid level (parameter "Alarm Limit for Refrigerant Liquid Level")
- t_0 limit for NT compressor disable (parameter "t_0 Compressor OFF"):
  The t_0 limit value for the NT compressor disable **must** be above the value manually set on the pressure transmitter.

6.6 Start-up of speed-controlled compressors / condenser fans

For the control of speed-controlled fans or compressors, a frequency converter (hereinafter referred to as FC) or speed controller is required in addition to the controller. The following circuit diagrams are simplified diagrams from the controller to the FC (using the example of the *smd* series from *Lenz*e) and to the speed controller (using the example of the *ADR* series from *Micro Nova*). Detailed safety precautions (e.g. interlocks) are not shown in the simplified diagrams and must be taken into account for the installation.

ATTENTION

Various other measures, particularly for interference suppression of the system, are required for the cabling of a system with FCs / speed controllers.

1. All signal cables for Pt1000 and all other analogue inputs and outputs must be shielded, as well as the cables to the CAN and RS485 data interfaces. Correct design of this shielding is particularly important for systems with FCs / speed controllers. In the case of inadequate shielding, high impairments of the measured values can occur due to the high interference emission of FCs / speed controllers.
2. Care must be taken with all analogue inputs and outputs that there is no connection between the sensor cables and the signal ground or shielding.
3. Analogue inputs and outputs are sensitive to external supply and reverse polarity! When connecting the pack controller to the control input of the FC / speed controller, the correct polarity **must be strictly** ensured. FCs / speed controllers also frequently provide a power supply for sensors or potentiometers, using which the speed can be specified.
   This supply must **never** be connected to any analogue output of the controller. In the event of a faulty connection between the controller and the FC / speed controller, control components in the controller can be permanently damaged.

The following signals from the controller are available for the control of the FC / speed controller:

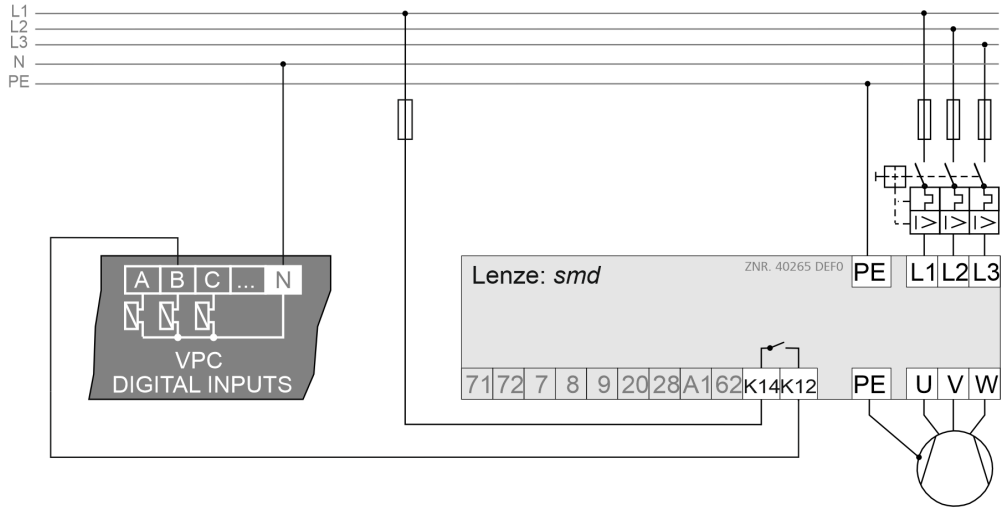
1. Digital inputs for monitoring the fault signal outputs of the FCs / speed controllers for speed-controlled compressors

In the case of compressor combined control, the fault signal outputs of the FCs / speed controllers can be monitored.

- For LT compressors, the monitoring is performed using digital input B of the controller (terminals B/N).
- For NT compressors, the monitoring is performed using digital input Q of the controller (terminals Q/N).

The message text for the *FC Fault* digital input when compressor combined control is parametrised is *Mot.Temp 1/FC-Fault*

Example for LT compressor at terminals B/N:



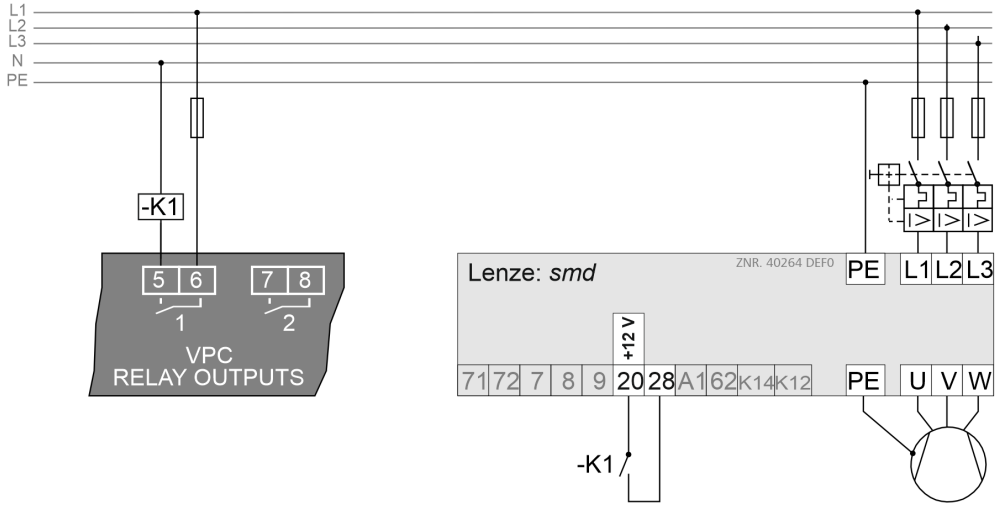
This fault signal is active when there is no voltage at the *LT motor cut-out 1 / FC Fault* input, i.e. the FC must be parametrised and connected so that 230 V AC is present at the digital input B of the controller in the good state.
For connector details, see chapter Assignment of the digital inputs - 230 V AC.

If the compressor control of the combined control is parametrised as speed control, the *NT motor cut-out 1 / FC Fault* input (digital input B) monitors the fault signal output of the frequency converter for the compressor control and must be wired accordingly.

2. Relay outputs for enable FC / speed controller

In the case of compressor combined control, the frequency converters are enabled via the relay output for LT compressor 1 (terminals 5/6) and NT compressor 1 (terminals 11/12). For speed-controlled condenser fans, the enable for the FCs/speed controllers is granted for the fans via Modbus; for details, see chapter Assignment RS485. In controlled operation, this enable is withdrawn in the case of too low suction gas or too low gas cooler outlet temperature.

Example for LT compressor:



DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! Low voltage **and** safety extra-low voltage must **not** be connected to the relay outputs, simultaneous operation of 230 VAC **and** low voltage / safety extra-low voltage is **not permitted**!
The enable (in the example here -K1) **must** be done via a coupling relay.

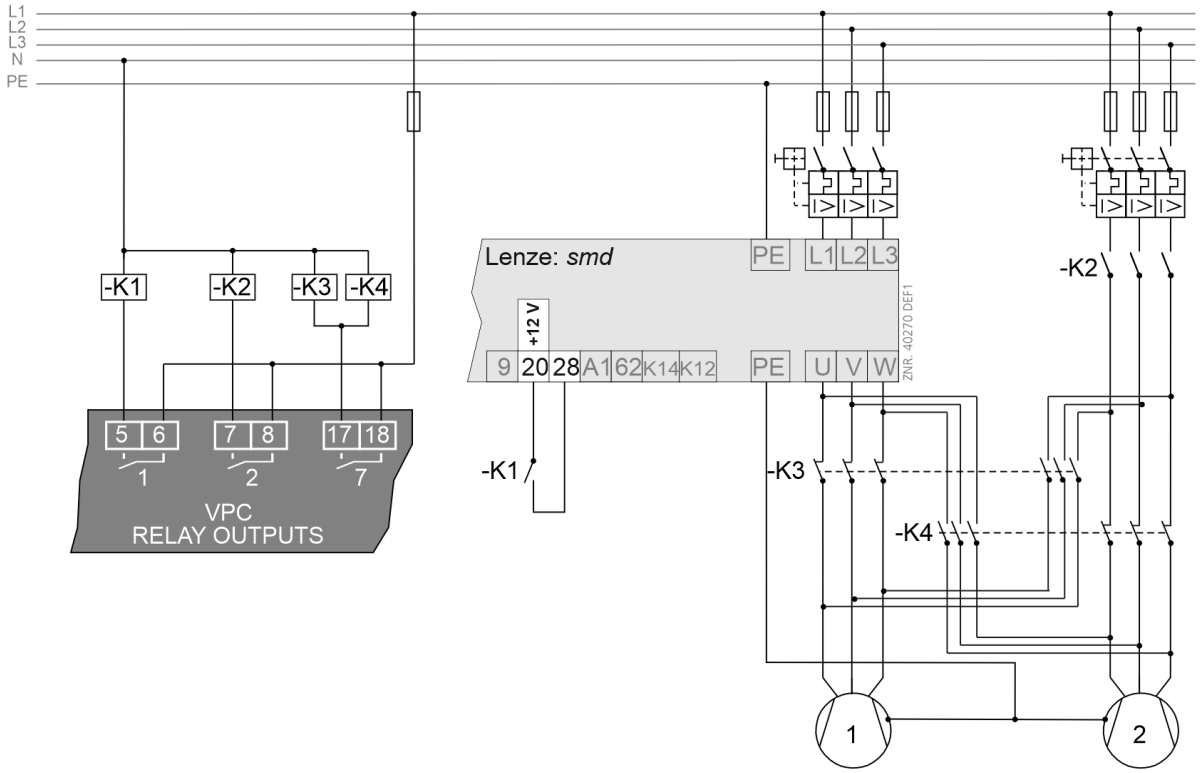
The FC / speed controller must be parametrised here so that the enable is issued in the case of closed contact, i.e. application of a voltage.
For connector details, see chapter Assignment of the relay outputs 230 V AC.

3. Relay outputs for base load rotation of speed-controlled compressors for compressor combined control

As the speed-controlled compressor in the control mode combined control shows the longest operating time, base load rotation of the speed-controlled compressor is performed as well as the base load rotation of the fixed-speed compressors. Compressor 1 and compressor 2 are alternately switched to the frequency converter for this using the parametrisable cycle time for the base load rotation.

- For LT FC compressors, the base load rotation of the fixed-speed compressors is done via relay output 7 (terminals 17/18).
- For NT FC compressors, the base load rotation of the fixed-speed compressors is done via relay output 8 (terminals 19/20).

Example for LT compressor:



The base load rotation of the speed controlled LT FC compressor is triggered via the relay output 7 (terminals 17/18).

- If the contact is closed, external wiring must be used to ensure that compressor 1 is in fixed-speed operation and compressor 2 is switched to the frequency converter.
- If the contact is open, compressor 1 is assigned to the frequency converter and compressor 2 on the mains power supply.

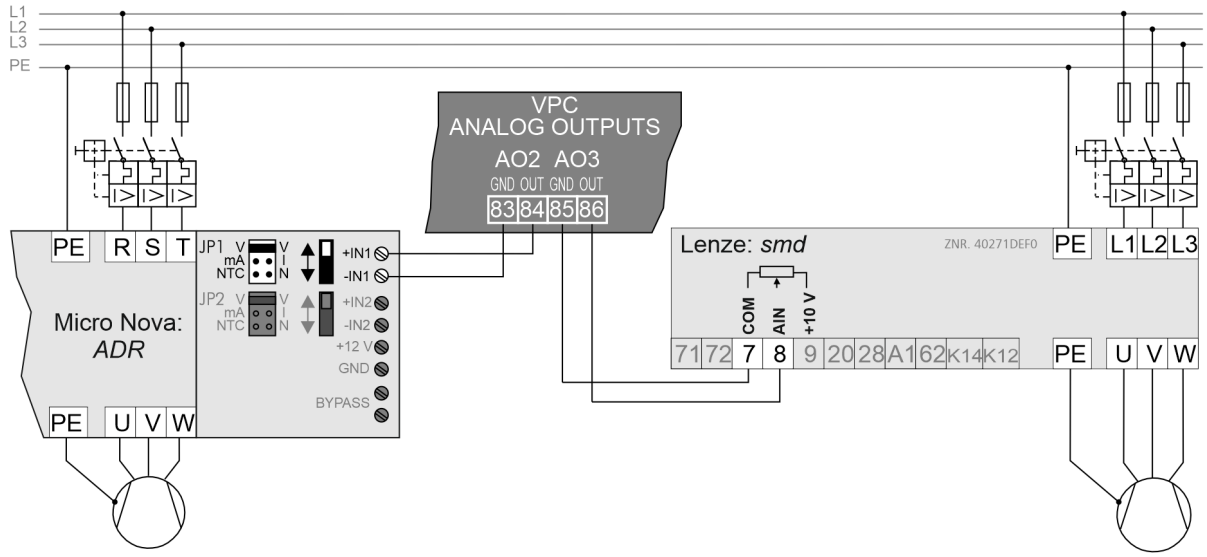
For connector details, see chapter Assignment of the relay outputs 230 V AC.

4. Analogue outputs as control variables 0..10 V for compressor / fan speed

0..10 V signals for the speed of the speed-controlled LT/NT FC compressor or the fan for the gas cooler are output via the analogue outputs AO1/AO2/AO3 of the controller:

- for compressor combined control, the signal for LT FC compressors is output via the analogue output AO1 (terminals 83/84)
- for compressor combined control, the signal for NT FC compressors is output via the analogue output AO2 (terminals 85/86)
- the output for the fan of the gas cooler is via the analogue output AO3 (terminals 87/88)

Example for LT/NT FC compressor:



ATTENTION

Special precautions must be taken for the connection of these outputs; for details, see chapter Assignment of the analogue outputs. For the frequency converter, an adjustment of the operating point of the FC / speed controller must be made in addition to the adjustment of the input to the reception of a 0-10 V signal. A request of the pack controller of 0 V at the analogue output here means minimum speed; a request of 10 V means maximum speed. The FC / speed controller here must be operated in the speed control operating mode, i.e. the output speed of the fans / compressors is directly proportional to the output voltage from the controller.

6.7 Care instructions for front panel

The front panel should be cleaned with a dry, soft microfibre cloth or with a suitable commercially available suitable cleaning cloth for monitors.

ATTENTION

Wet cleaning is not permitted! in addition, **no aggressive cleaning agents** are permitted to be used!

6.8 Firmware Update

The controller is delivered with the current firmware, ready for operation. Future software versions can be loaded into the controller as required using a firmware update, and thus updated.

ATTENTION

Damage to the system and stock loss! Before the firmware update, the affected system component or the system must be brought into a safe state as the shutdown of the controller during the firmware update can have undesired effects on the system component and/or the system.
Caution: data loss! When the firmware version is changed, **all** set setpoints are usually lost and replaced by factory settings. Therefore, **before updating the firmware,** the settings **must** always be saved in the LDSWin user interface. After the firmware update, the previously saved settings can be reloaded into the controller.
A firmware update must only be performed by trained personnel or at the factory by the manufacturer. Details about the current firmware can be found in E°EDP.

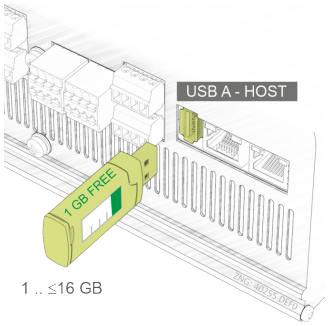
6.8.1 Execution of the firmware update

Execution of the firmware update locally on-site

DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! BEFORE connecting and disconnecting, it **must** be checked that surrounding connections are in a **de-energised** state!

The firmware update is carried out locally on site via a USB stick, which must be inserted into the USB slot A on the bottom of the controller while the controller **is in operation**:



Requirements

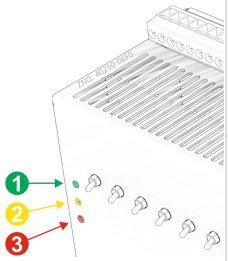
- **USB stick**
  - 1 GB .. <=16 GB / 1 GB free memory
  - For the firmware update, the USB stick and the configuration data **must** be formatted with **FAT32** as file system!
  Note: If the USB stick is not recognised, a tool such as "*gparted*" can be used to check whether the data partition of the USB stick is displayed as "*sd[a-z][0-9]*".

- **New firmware**
  - The new firmware is available at https://edp.eckelmann.de/edp/lds/_a2xhYWBPaA as a compressed ZIP archive and contains the file "*update.raucb*".
  The file must be unpacked/copied to the root directory of the USB stick using a PC.
  Note: The requirements are met if the unpacking and copying to the USB stick has taken has taken place as follows:
  The file, e.g. *F:\update.raucb* exists on the USB stick (if "F" is the drive letter for the plugged-in USB stick).

Execution of the firmware update

1. The USB stick **must** be plugged in during running operation (green POWER LED lights).
2. The controller recognises the USB stick and automatically starts transferring the new firmware and activates the yellow BOOT LED.
3. The transfer of the new firmware takes place during running operation, the control of the system is not interrupted during this time.
4. **After** successful transfer, the yellow BOOT LED goes out and the USB stick **must** be removed again.
5. The new firmware is not applied until **after** a Restart (switch off the power supply using controller - wait for 2 seconds - switch on controller again), which is followed by a First Start.

Status LEDs and messages during the execution of the firmware update

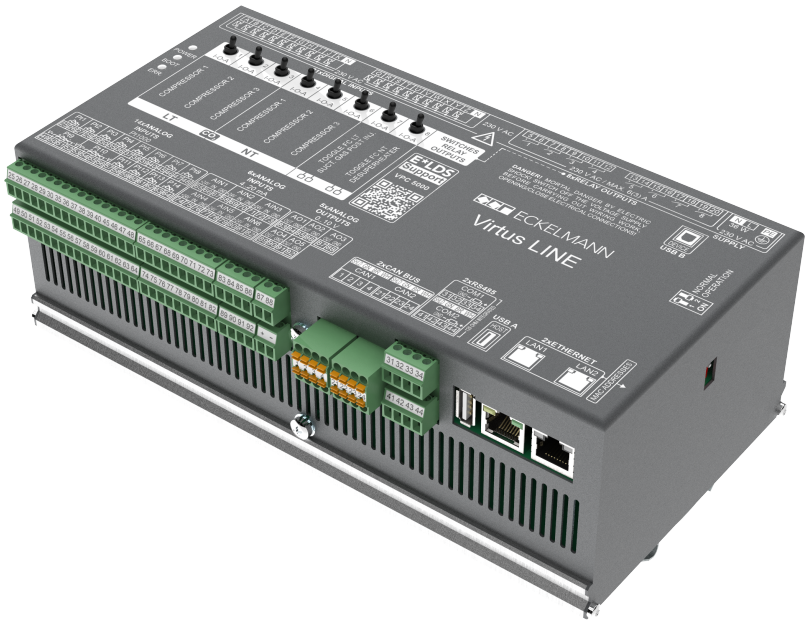
LEDs	Function	Description
 Fort further details, see chapter Status LEDs	1 green POWER	ON: Power supply OK, controller is running, the USB stick can be inserted, no previous steps in the user interfaces or on the controller are necessary. The controller automatically recognises the USB stick with the new firmware. The controller now automatically starts the transfer of the new firmware and the yellow BOOT LED (2) on the front of the controller lights continuously.
	2 yellow BOOT	ON: Transfer of the new firmware to the controller: Update runs, duration approx. 30 seconds. **Note:** If the yellow BOOT LED does not light 10 seconds after inserting the USB stick, the USB stick could not be mounted! OFF: If the yellow BOOT LED (2) goes out, the firmware has been **successfully** transferred to the controller and the USB stick **must** be removed again. **Note**: After the transfer, the controller continues to run with the **previous**, still active version! The installed new firmware is not applied until **after** a First Start. To adopt the new firmware, the controller **must** be started via a Restart (restore of power supply): Switch off controller - wait for 2 seconds - switch on controller again. **Check of the update process** • Message 50 "First Start" is displayed. The controller now starts with the new, updated firmware version.
	3 red ERR.	ON: If the red ERROR LED (3) lights, the transfer of the new firmware was **not successful**! **Information about the failed firmware transfer** • Message 51 "Restart" is displayed! In this case, the controller starts - also after a Restart - with the previous, active version (the "old" firmware remains) so that the system can continue to be operated. **Practical tip:** The necessary requirements for performing the firmware update (see above) **must** be checked and the update must be performed again.

7 VPC 5000 connection and terminal assignment

DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock or malfunction! The following points must be **strictly** observed for the cabling:

- **Observe the** Safety instructions**!**
- The system must be **disconnected from the power supply before** detaching or inserting plug contacts on the controller.
- For **analogue inputs and outputs** with current or voltage interface (4..20 mA / 0..10 V), it is essential to ensure **correct polarity**. Short circuits or a faulty power supply can result in impairments of the function or even destruction of components of the controller.
- **All connection cables** from and to the controller - with the exception of the relay outputs and the digital inputs – must be **shielded**. Otherwise malfunctions, e.g. faulty measurements, cannot be ruled out.
- In order to guarantee **reverse polarity protection,** only **coded** mating connectors may be used on the connectors of the controller.



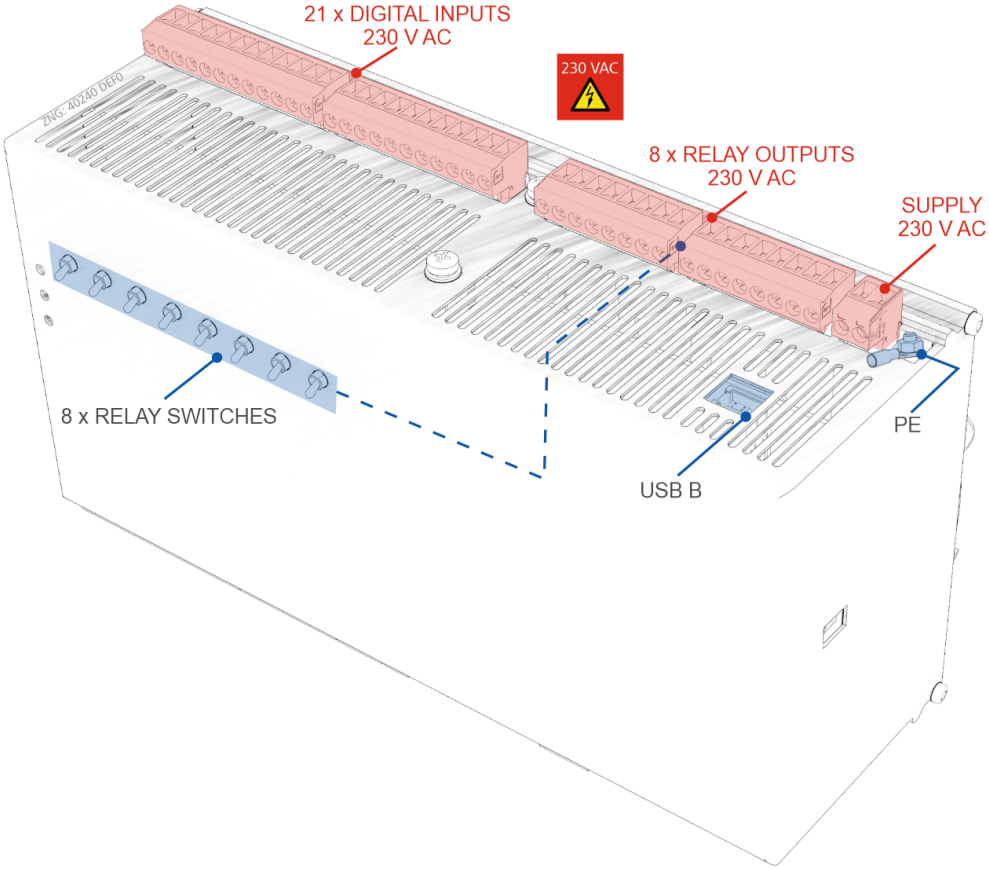
The illustrations and tables on the following pages show the terminal assignments of the controller:

- Connectors for 230 V AC (top)
- Connectors for safety extra-low voltage (bottom)

7.1 Connectors for 230 V AC (top)

DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! BEFORE connecting and disconnecting, it **must** be checked that surrounding connections are in a **de-energised** state!



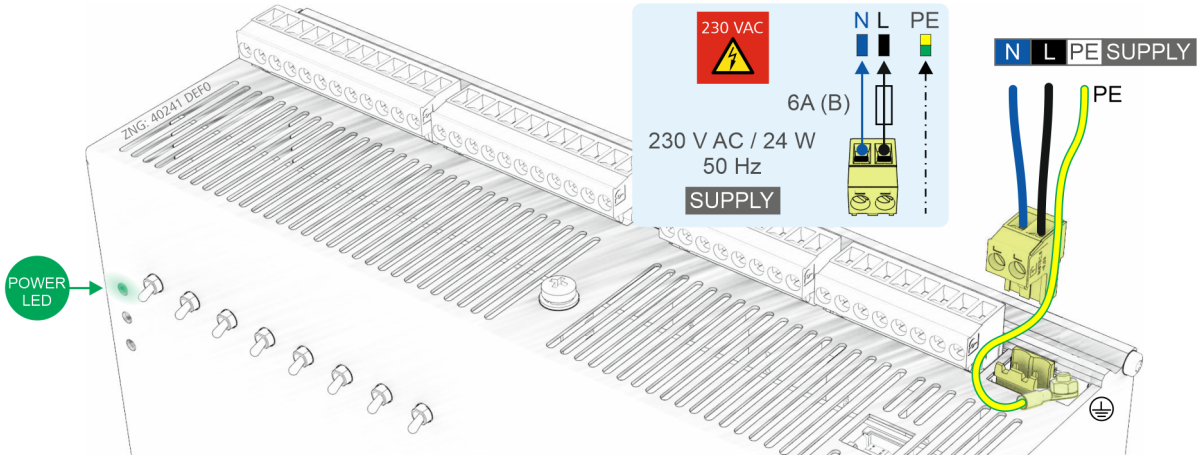
For details about the USB B socket, see chapter USB A/B ports.

7.1.1 Assignment of the 230 V AC power supply

DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! BEFORE connecting and disconnecting, it **must** be checked that surrounding connections are in a **de-energised** state! The controller is only permitted to be connected to the intended operating voltage of 230 V AC!

Connection to the power supply



SUPPLY			
Description	**Terminal No.**	**Connection**	**Function**
230 V AC	N L PE	Neutral conductor Phase 230 V AC Earth conductor (ring cable lug)	Operating voltage, supply voltage

In order to fuse the mains power line, a circuit breaker with the following characteristics **must** be used:

- Rated current for 230 V AC: 6 A
- Tripping characteristic (typical): B

Requirements for the connection cable
As the controller does not have an integrated disconnecting device in the form of a power switch, the following **must be ensured**

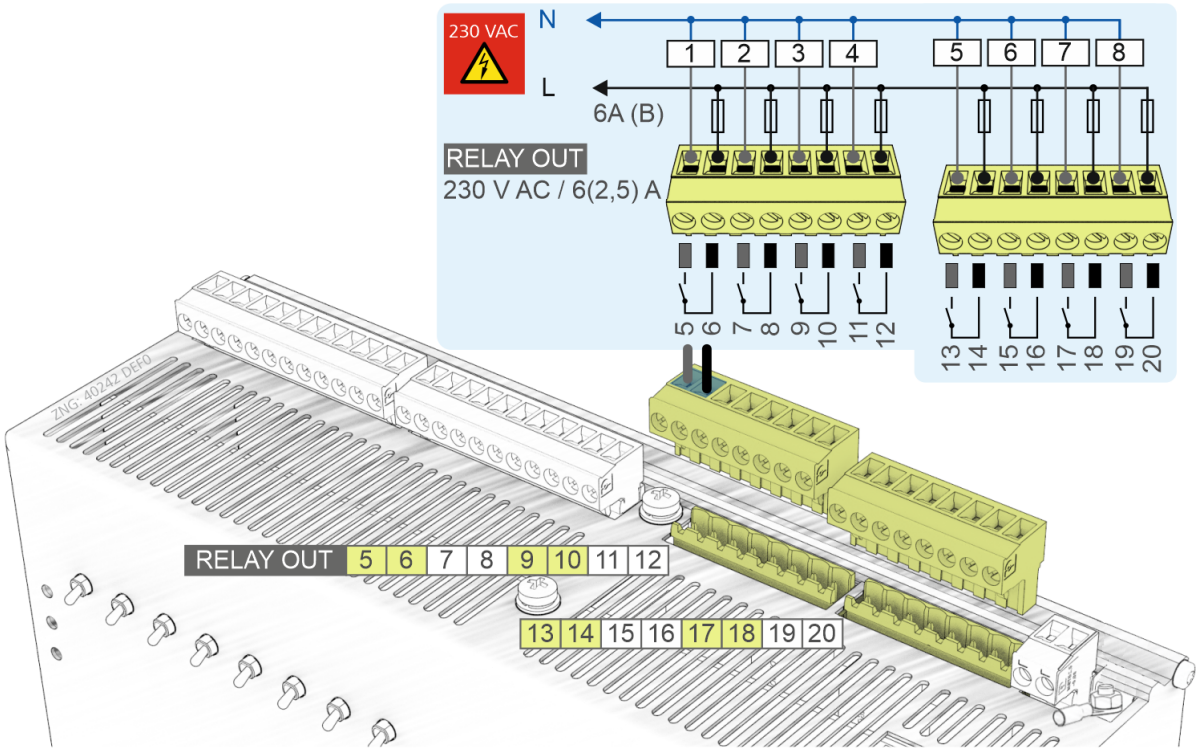
- a switch or circuit breaker - which must not interrupt the earth conductor (PE) - must be present in the system or building installation,
- this is suitably located and easily accessible for the user, and
- this is labelled as a disconnector for the device.

The controller can be put into operation after completion of the mechanical and electrical installation. After connection of the 230 V AC power supply, the green LED (POWER) lights, for details see chapter Status LEDs.
Note: As the controller itself does not have a switch for switching on or off, it **must** be disconnected from the power supply for e.g. a Restart for approx. 2 seconds (switch on/off the circuit breaker).

7.1.2 Assignment of the relay outputs 230 V AC

DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! BEFORE connecting and disconnecting, it **must** be checked that surrounding connections are in a **de-energised** state! Low voltage **and** safety extra-low voltage must **not** be connected to the relay outputs, simultaneous operation of 230 VAC **and** low voltage / safety extra-low voltage is **not permitted**! **Overvoltage category II / contamination degree 2:** All connections of the device provided for operation with 230 V AC supply voltage **must** be wired with the same outer conductor (L). 400 V AC between neighbouring connection terminals is **not** permitted!



In order to protect the supply line and relay outputs, a circuit breaker with the following characteristics **must** be used for each relay output:

- Rated current for 230 V AC: 6(2.5) A
- Tripping characteristic (typical): B

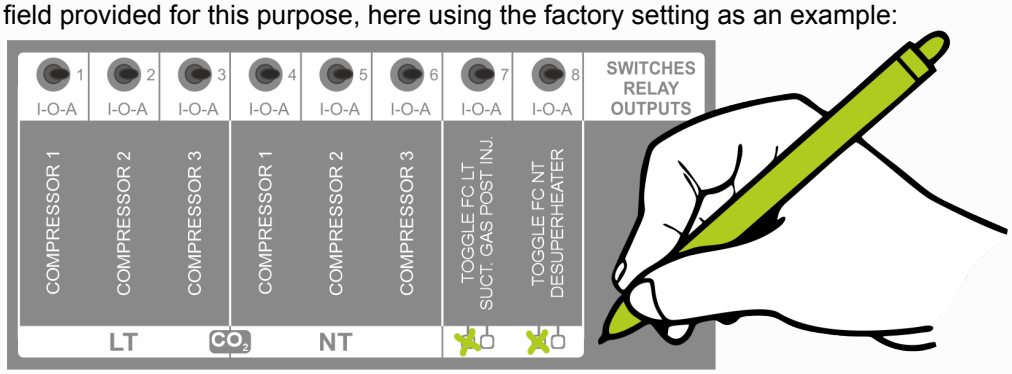
The total current of all relay outputs must not exceed 20 A.

RELAY OUTPUTS 230 V AC / 6(2.5) A			
Designation	**Terminal No.**	Manual control switch **I/O/A (In/Out/Auto)**	**Function**
1 **2** **3**	5, 6 7, 8 9, 10	1 2 3	LT Compressor 1 and Enable LT FC LT Compressor 2 LT Compressor 3
4 **5** **6**	11, 12 13, 14 15, 16	4 5 6	NT Compressor 1 and Enable NT FC NT Compressor 2 NT Compressor 3
7	17, 18	7	Base Load Rotation LT FC Compressor for compressor combined control* or Suction Gas Post-injection Suction gas post-injection
8	19, 20	8	Base Load Rotation NT FC Compressor for compressor combined control* or LT Discharge Gas Desuperheater LT Discharge Gas Desuperheater

* Factory setting

Practical tip

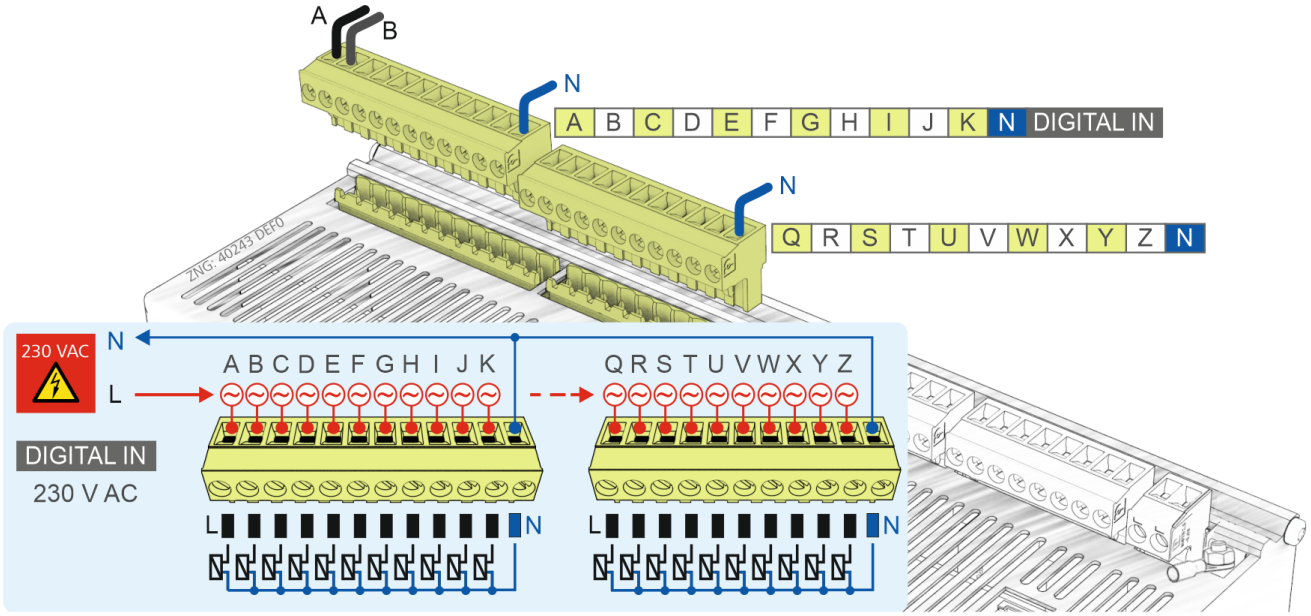
- All relay outputs 1..8 can be manually overridden via the manual control switches on the front, for details see chapter Manual / automatic changeover to emergency power mode.
- The configured function of relay outputs 7 and 8 should be noted on the front of the controller in the field provided for this purpose, here using the factory setting as an example:



7.1.3 Assignment of the digital inputs - 230 V AC

DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! BEFORE connecting and disconnecting, it **must** be checked that surrounding connections are in a **de-energised** state!
Overvoltage category II / contamination degree 2: All connections of the device provided for operation with 230 V AC supply voltage **must** be wired with the same outer conductor (L). 400 V AC between neighbouring connection terminals is **not** permitted!



DIGITAL INPUTS 230 V AC		
Designation	**Connection**	**Function**
A	**L**	LT Compressor 1 Oil/HP Switch
B		FC Fault LT* oder LT Compressor 1 Motor Cut-out
C		LT Compressor 2 Oil/HP Switch
D		LT Compressor 2 Motor Cut-out
E		LT Compressor 3 Oil/HP Switch
F		LT Compressor 3 Motor Cut-out
G		LT Pack Low Pressure Limiter
H		Refrigerant Fill Level MIN
I		Refrigerant Fill Level MAX
J		Fast unload (external OFF)
K		Emergency Power Mode
N - Common neutral conductor for A..K (not potential-free)		
Q	**L**	NT Compressor 1 Oil/HP Switch
R		FC Fault NT* or NT Compressor 1 Motor Cut-out
S		NT Compressor 2 Oil/HP Switch
T		NT Compressor 2 Motor Cut-out
U		NT Compressor 3 Oil/HP Switch
V		NT Compressor 3 Motor Cut-out
W		NT Pack Low Pressure Limiter
X		Gas Cooler Motor Cut-out
Y		High Pressure Limiter
Z		Setpoint Toggle
N - Common neutral conductor for Q-Z (not potential-free)		

* Factory setting

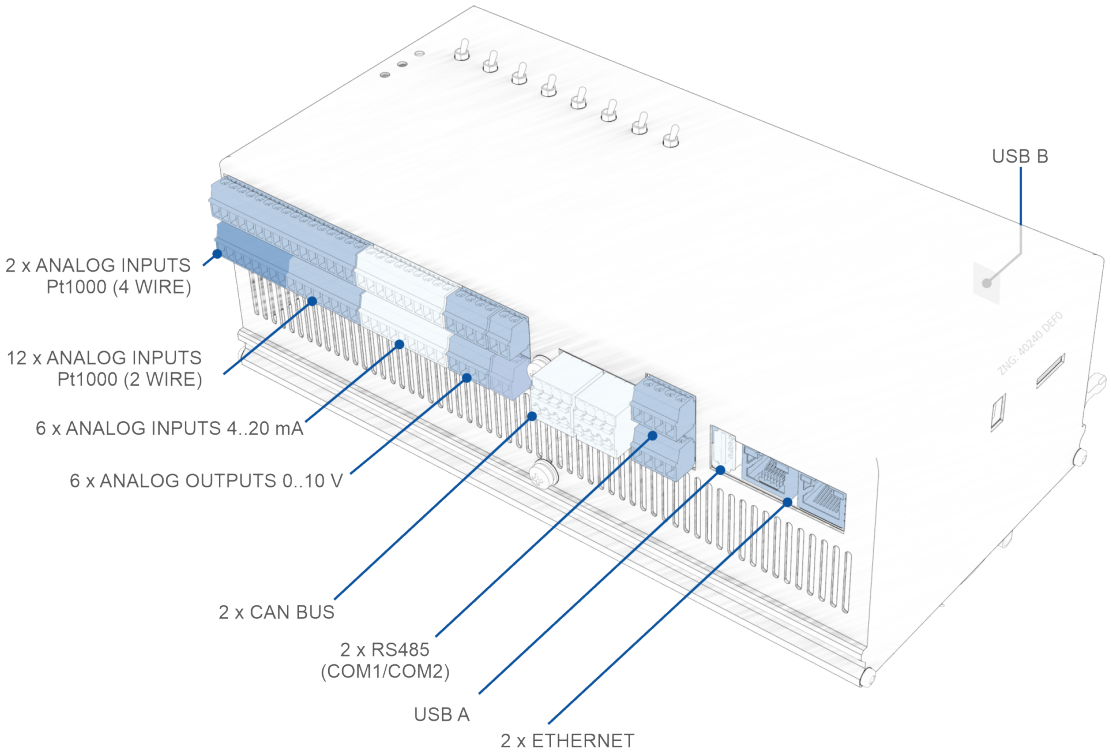
ATTENTION

If the digital input J "Fast unload (external OFF)" is used for any safety-critical application, additional measures for the monitoring must be taken.

7.2 Connectors for safety extra-low voltage (bottom)

DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! BEFORE connecting and disconnecting, it **must** be checked that surrounding connections are in a **de-energised** state!

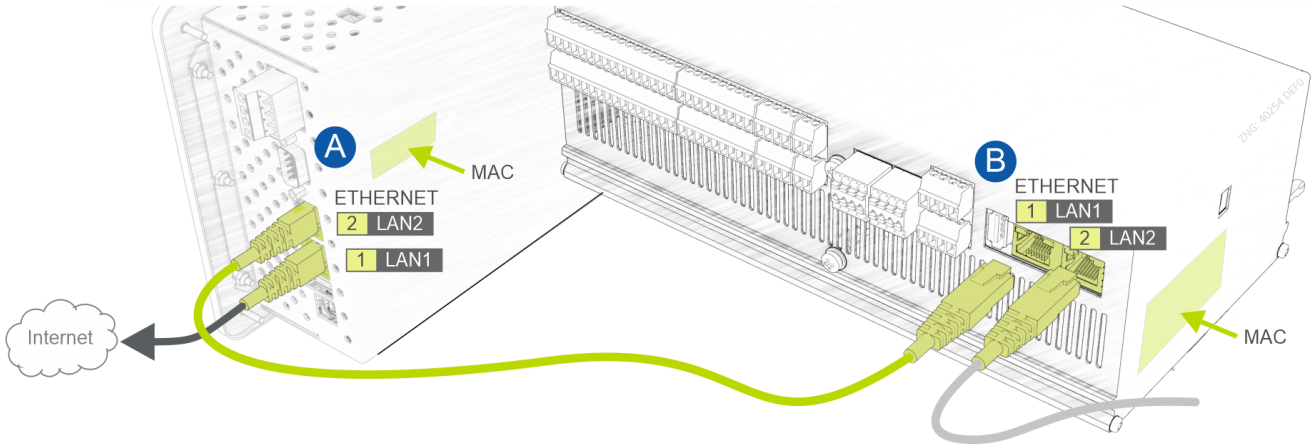


For details about the position of the USB B socket, see chapter Connectors for 230 V AC (top).

7.2.1 Ethernet Connections

DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! BEFORE connecting and disconnecting, it **must** be checked that surrounding connections are in a **de-energised** state!



Ethernet connection / wiring

ETHERNET		
Designation	**Type**	**Function**
(A) System centre		
LAN1	RJ45 socket	• **Integration in the LAN - access via Internet, remote maintenance - standard** The system centre is connected to the Internet/intranet via its LAN1 interface, for details see operating manual of the system centre. • **On site e.g. for service or maintenance - not recommended** Connect the LAN1 port of the system centre to the notebook. **ATTENTION** With this type of connection, access via the Internet or the **connection** to the remote maintenance centre is **interrupted**, the system centre is **offline** to the outside, services and monitoring functions no longer function, which may result in error messages in the service centre! The IP settings of the notebook must be configured to match the IP settings of the system centre, see (B). Approvals/authorisations may be required from the administrator of the notebook! **Important:** The system centre and the notebook **must be in the same subnet** and **must not have the same IP address**. **Practical tip:** • The connection for service or maintenance should be made **via PC direct connection via USB** to the system centre, for details see chapter Operation via Virtus Control Desk (VCD). • Finding the MAC addresses **00 05 7E xx xx** for e.g. configuration and integration in the LAN: • **(A) System centre**: sticker on the back of the case • **(B) Controller**: sticker on the right-hand side of the case
LAN2	RJ45 socket	For Operation via Virtus Control Desk (VCD) the LAN2 port of the system centre **must** be connected to the LAN1 port of the controller via a direct data cable*.
(B) Controller		
LAN1	RJ45 socket	For Operation via Virtus Control Desk (VCD) the LAN2 port of the system centre **must** be connected to the LAN1 port of the controller via a direct data cable*.
LAN2	RJ45 socket	No function

* See chapter Artikel-Nummern VPC 5000 und Zubehör.

7.2.2 USB A/B ports

DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! BEFORE connecting and disconnecting, it **must** be checked that surrounding connections are in a **de-energised** state!

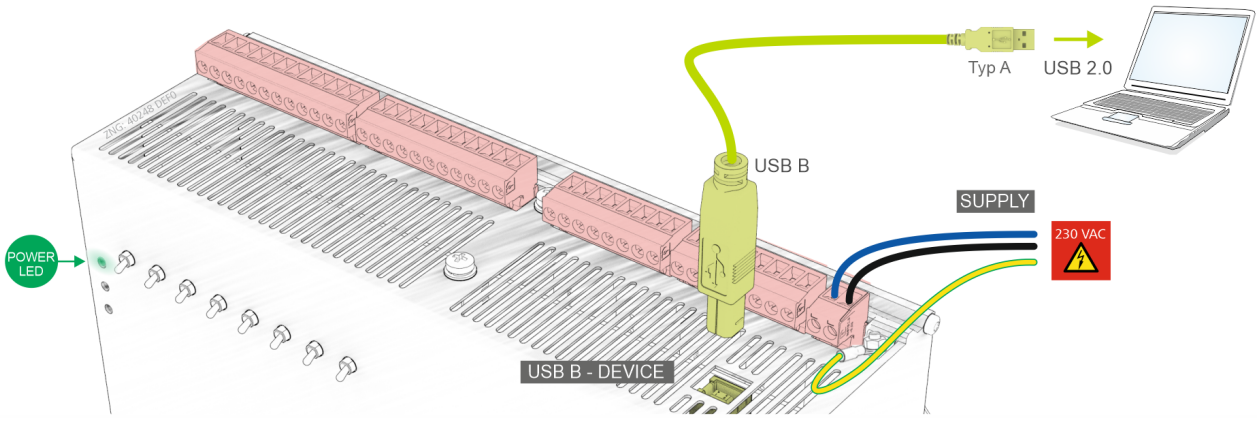
The controller has 2 USB ports located on the top of the device (USB B) and the bottom of the device (USB A).

USB B / USB A		
Designation	**Type**	**Function**
USB B DEVICE - top	USB 2.0 Type B	Service port, communication via USB cable, see chapter VPC 5000 Part Numbers and Accessories.
USB A HOST - bottom	USB 2.0 Type A	Firmware Update Firmware update via a USB stick

Service

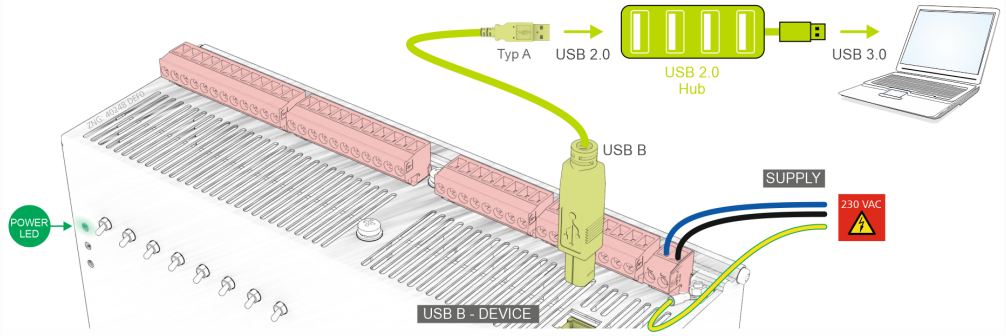
The two USB ports are **service ports** that are only required and used in the relevant service case.

USB B DEVICE - for details, see Connectors for 230 V AC (top) Connectors for 230 V AC (top)

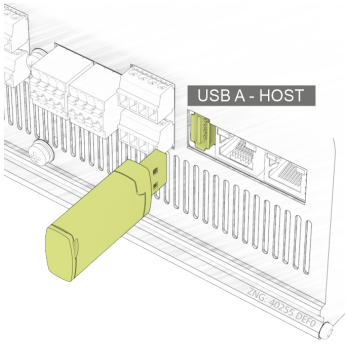


Practical tip

Problems with USB 3.0 ports on the notebook can possibly be resolved by using a USB 2.0 hub:



USB A HOST (bottom) - for details , see Execution of the firmware update.



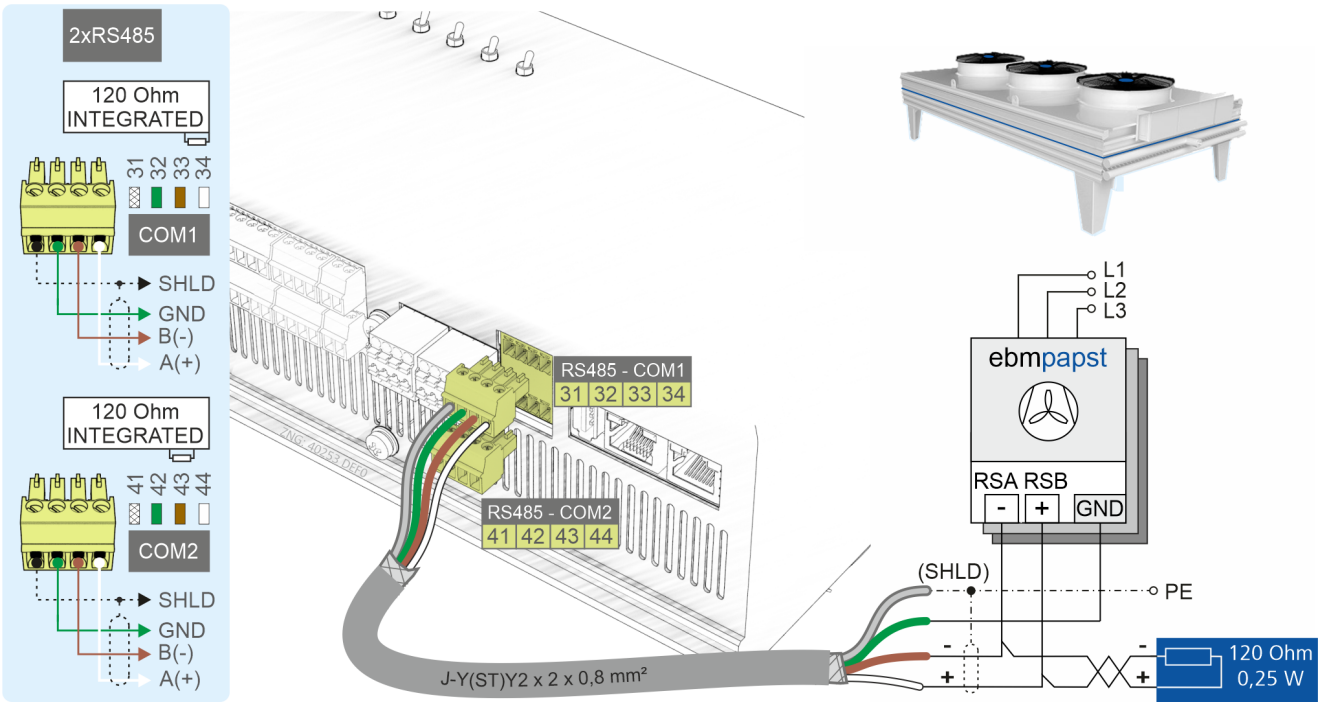
7.2.3 Assignment RS485

DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! BEFORE connecting and disconnecting, it **must** be checked that surrounding connections are in a **de-energised** state!

ATTENTION

All Modbus supply cables must be shielded and twisted pair (cable type: J-Y(ST)Y 2x2x0.8 mm**2**). As a general rule, care should be taken to ensure that signal cables and cables carrying mains voltage are routed in separate cable channels. Maximum length of the cable: 1000 m, for details, see operating manual "E*LDS Basics, Safety Instructions, CAN-Bus & Modbus".



Connection / cabling RS485

RS485				
Description	**Terminal No.**	**Connector**	**Wire colour**	**Function**
COM1				
	31 32 33* 34*	SHIELD GND (Ground) B(-) A(+)	Shield green **brown** **white**	Shield GND RSA (-) RSB (+)
COM2				**No function**
	41 42 43* 44*	SHIELD GND (Ground) B(-) A(+)	Shield green **brown** **white**	--

*** Special feature:**
A terminating resistor of **120 Ohm is already permanently installed** (integrated) in the controller between the terminals **33/43 B(-**) and **34/44 A(+)**. Thus this interface represents the beginning of the Modbus, a termination at these terminals is **not** required and must **not** be done! A terminating resistor of 100 ohms **must** only be installed **at the end of the line (at the last extension module)**.

7.2.4 CAN Bus Assignment

DANGER

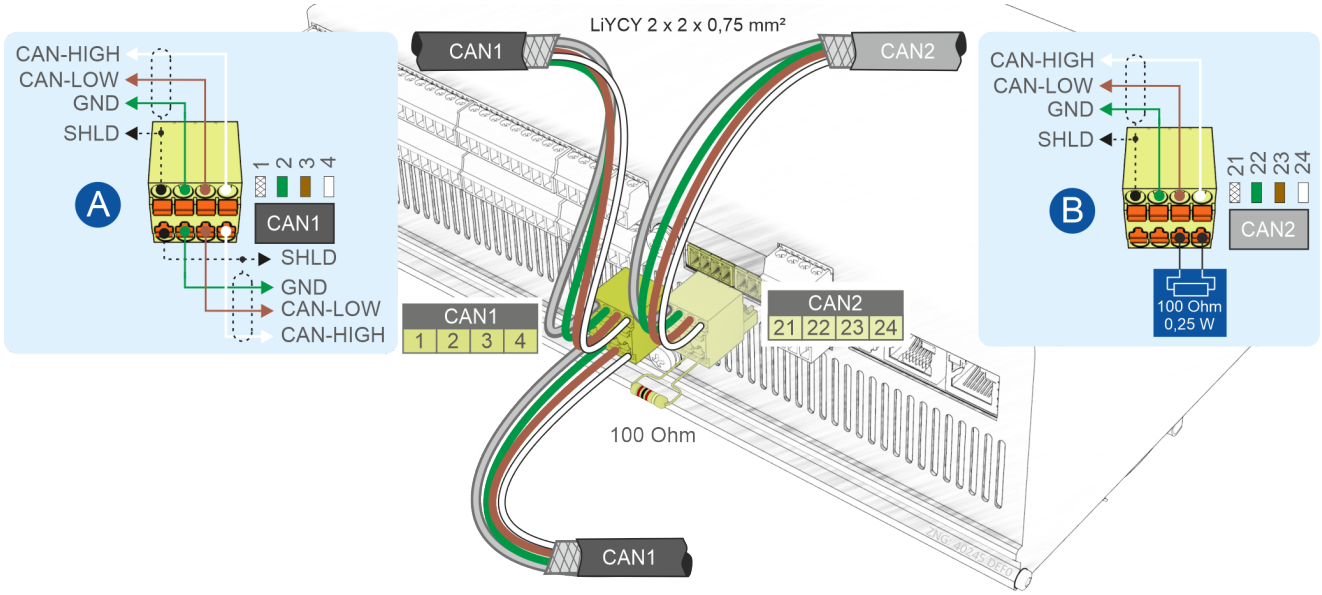
Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! BEFORE connecting and disconnecting, it **must** be checked that surrounding connections are in a **de-energised** state!

ATTENTION

All CAN bus supply lines must be shielded and twisted pair (cable type: **LiYCY 2x2x0.75 mm²**). As a general rule, care should be taken to ensure that signal cables and cables carrying mains voltage are routed in separate cable channels. Maximum length of the cable: 500 m, for details, see operating manual "E*LDS Basics, Safety Instructions, CAN Bus & Modbus".

- **Wiring Variant A**: Device is a node in a CAN bus segment, there are other nodes before and after it, **no terminating resistor** required.
  Shown here using the first CAN bus segment "CAN1" as an example. This also applies for the second CAN bus segment "CAN2".

- **Wiring Variant B**: Device is at the beginning / end of a CAN bus segment, **a terminating resistor 100 Ohm is required**, see chapter VPC 5000 Part Numbers and Accessories.
  Shown here using the second CAN bus segment "CAN2" as an example. This also applies for the CAN bus segment "CAN1".



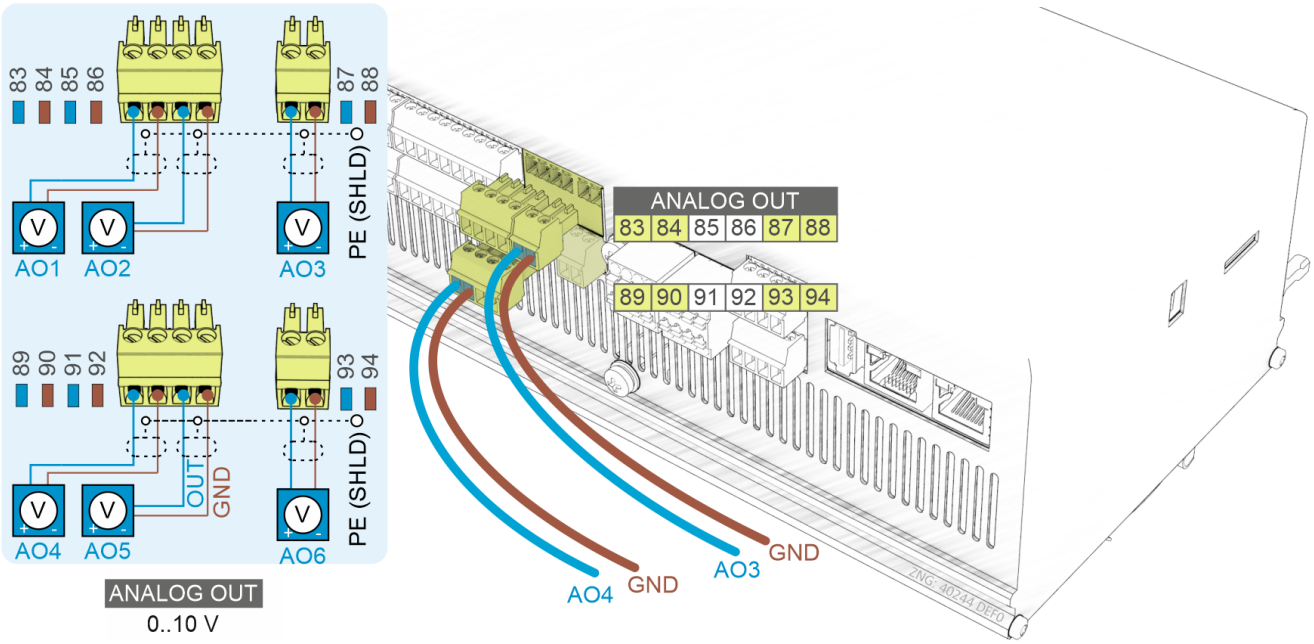
CAN bus connection / wiring

CAN BUS			
Designation	**Terminal No.**	**Connector**	**Wire colour**
First CAN bus segment **Standard, for connection to the E*LDS system - fixed CAN bus address 101**			
CAN1	1 2 3 4	SHIELD CAN-GND (Ground) CAN-LOW CAN-HIGH	shield green brown white
Second CAN bus segment **No function**			
CAN2	21 22 23 24	SHIELD CAN-GND (Ground) CAN-LOW CAN-HIGH	shield green brown white

7.2.5 Assignment of the 0..10 V analogue outputs

DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! BEFORE connecting and disconnecting, it **must** be checked that surrounding connections are in a **de-energised** state!
If supply voltage is connected to the analogue inputs, there is a risk of personal injury as the analogue inputs are **not** galvanically isolated from other system components (e.g. pressure transmitters). Furthermore, this will destroy the controller!



ATTENTION

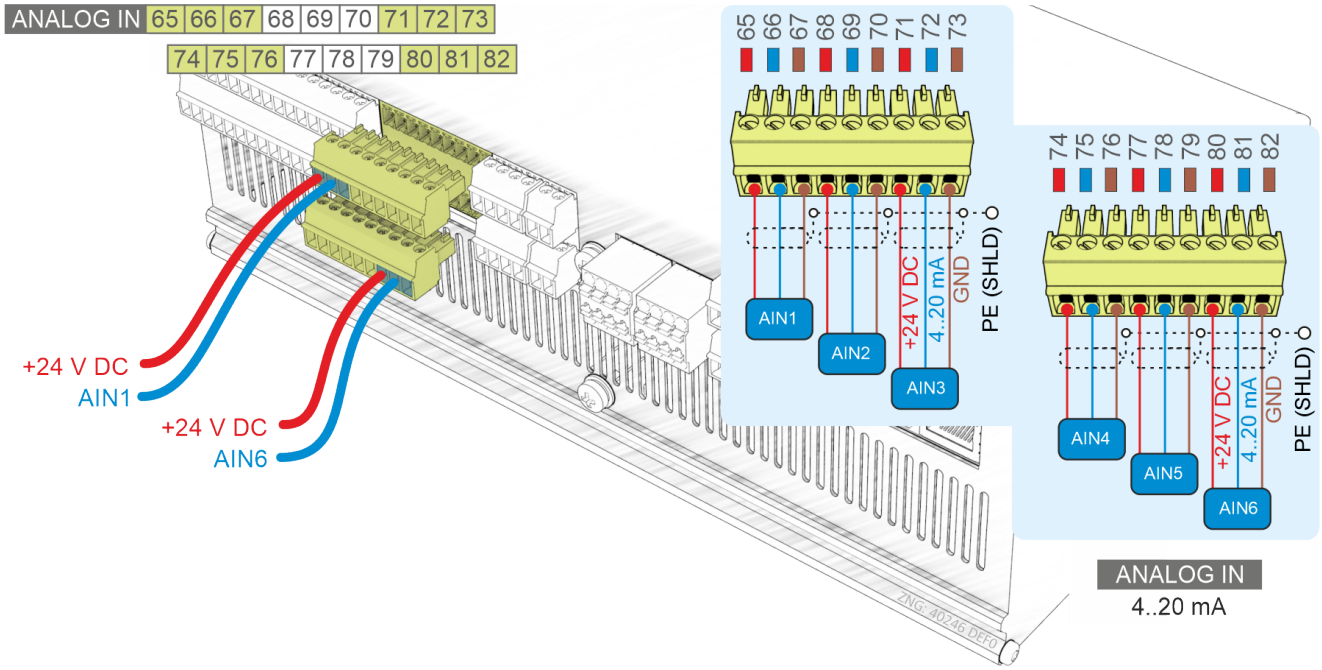
Malfunction due to interference! All supply lines from and to the controller (with the exception of the 230 V power supply and signal lines) must be shielded! This particularly applies for the analogue inputs and outputs (e.g. sensor supply cables) as well as the twisted pair CAN bus cabling (see Basics and General Safety and Connection Instruction). As a general rule, care should be taken to ensure that signal cables and cables carrying mains voltage are routed in separate cable channels. The permissible cable length of the analogue outputs is a maximum of 30 m.
Note: longer lengths and small cable cross section can cause greater interference.

ANALOGUE OUTPUTS 0..10 V			
Description	**Terminal No.**	**Connector**	**Function**
AO1	83 84	+0..10 V GND	Speed Frequency Converter LT Compressor
AO2	85 86	+0..10 V GND	Speed Frequency Converter NT Compressor
AO3	87 88	+0..10 V GND	Speed Frequency Converter Gas Cooler Fan
AO4	89 90	+0..10 V GND	Medium pressure valve (MPV)
AO5	91 92	+0..10 V GND	High pressure valve (HPV)
AO6	93 94	+0..10 V GND	No function

7.2.6 Assignment of the 4..20 mA analogue inputs

DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! BEFORE connecting and disconnecting, it **must** be checked that surrounding connections are in a **de-energised** state!
If supply voltage is connected to the analogue inputs, there is a risk of personal injury as the analogue inputs are not galvanically isolated from other system components (e.g. pressure transmitters). Furthermore, this will destroy the controller!



ATTENTION

Malfunction due to interference! All supply lines from and to the controller (with the exception of the 230 V power supply and signal lines) must be shielded (cable type LiYCY)! This particularly applies for the analogue inputs and outputs (e.g. sensor supply cables) as well as the CAN bus cabling (see Basics and General Safety and Connection Instructions). As a general rule, care should be taken to ensure that signal cables and cables carrying mains voltage are routed in separate cable channels. The following must also be observed for the installation of the analogue inputs:

- Correct sensor positioning
- Correct fixing of the sensors by using metal clamps and thermally conductive paste
- Insulation of the sensors (e.g. protect gas outlet temperature sensor against direct exposure to sunlight)
- Maximum cable length is 30 m - **Note**: longer lengths and small cable cross section may cause greater interference.

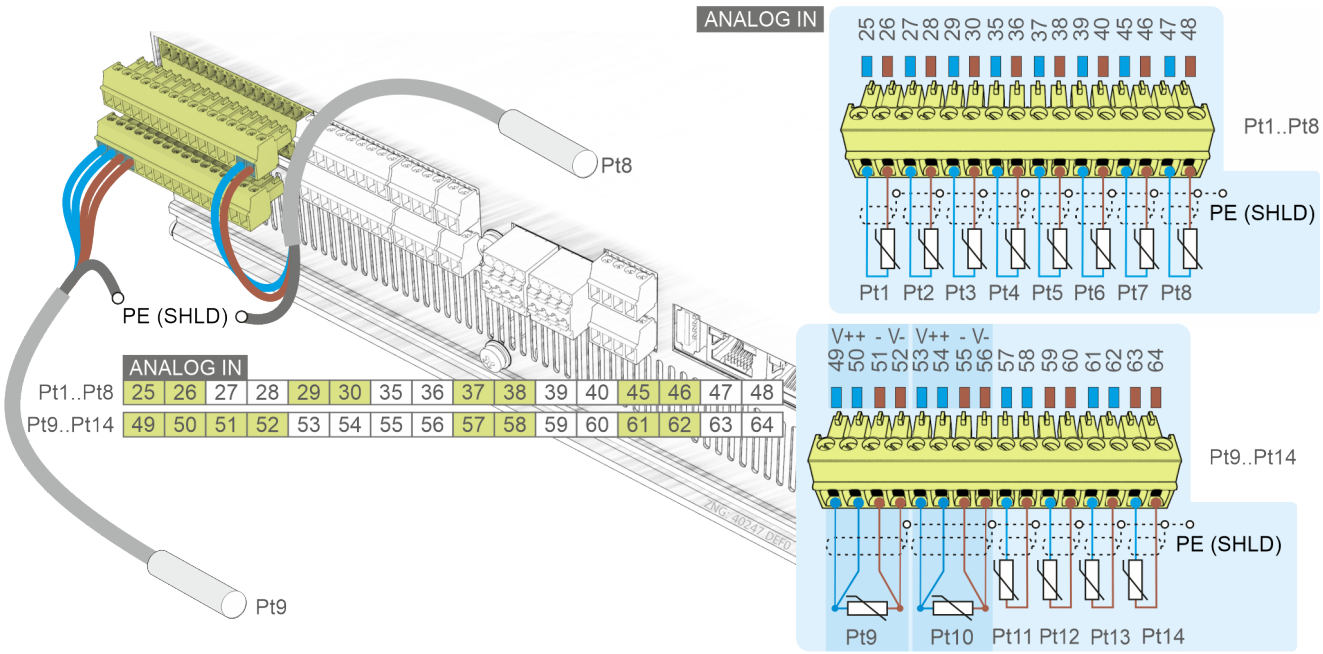
ANALOGUE INPUTS 4..20 mA			
Designation	**Terminal No.**	**Connectors**	**Function**
AIN1	65 66 67	+24 V DC 4..20 mA GND	LT low pressure transmitter *
AIN2	68 69 70	+24 V DC 4..20 mA GND	NT low pressure transmitter *
AIN3	71 72 73	+24 V DC 4..20 mA GND	Medium pressure transmitter *
AIN4	74 75 76	+24 V DC 4..20 mA GND	High pressure transmitter *
AIN5	77 78 79	+24 V DC 4..20 mA GND	Retrieval of the high pressure valve (HPV) opening degree
AIN6	80 81 82	+24 V DC 4..20 mA GND	Humidity sensor

For details about parametrisation, see chapter Pressure Transmitter.

7.2.7 Assignment of the analogue inputs Pt1000

DANGER

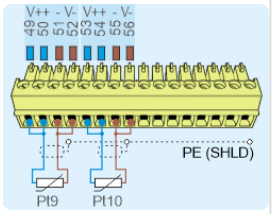
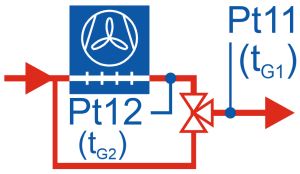
Warning about dangerous electrical voltage! Danger to life - Danger of electric shock! BEFORE connecting and disconnecting, it **must** be checked that surrounding connections are in a **de-energised** state!
If supply voltage is connected to the analogue inputs, there is a risk of personal injury as the analogue inputs are not galvanically isolated from other system components (e.g. pressure transmitters). Furthermore, this will destroy the controller!



ATTENTION

Malfunction due to interference! All supply lines from and to the controller (with the exception of the 230 V power supply and signal lines) must be shielded! This particularly applies for the analogue inputs and outputs (e.g. sensor supply cables) as well as the twisted pair CAN bus and RS485 cabling (see Basics and General Safety and Connection Instructions). As a general rule, care should be taken to ensure that signal cables and cables carrying mains voltage are routed in separate cable channels. The following must also be observed for the installation of the analogue inputs:

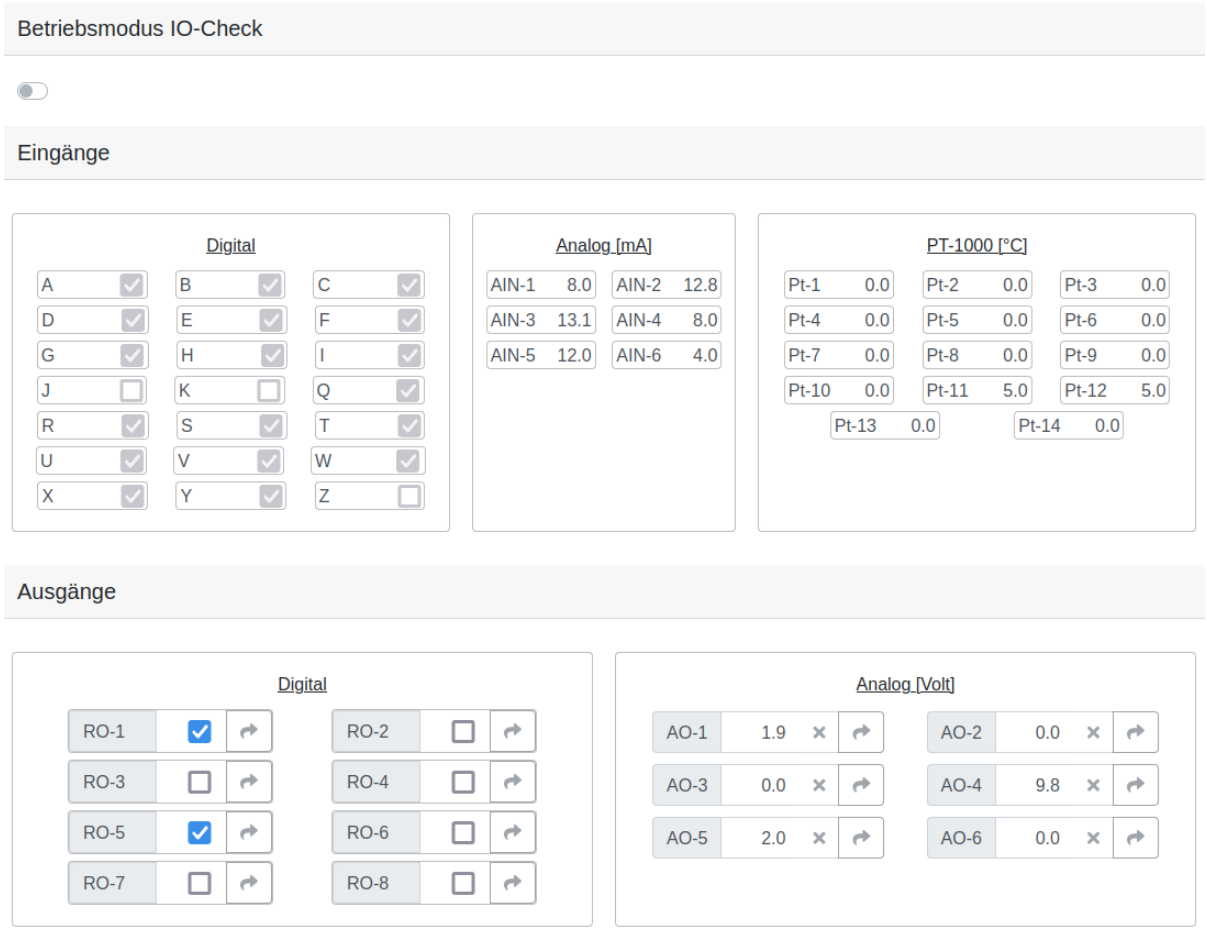
- Correct sensor positioning
- Correct fixing of the sensors by using metal clamps and thermally conductive paste
- Insulation of the sensors (e.g. protect gas outlet temperature sensor against direct exposure to sunlight)
- The cable length of the temperature sensors in 2-wire technology must not be longer than 30 m - **Attention**: depending on the sensor type and cable properties, longer lengths will result in measurement deviations, see EDP.

ANALOGUE INPUTS Pt1000				
Designation	**Terminal No.**	**Function**		
8 x 2-wire temperature sensors				
Pt1 **Pt2** **Pt3**	25, 26 27, 28 29, 30	LT compressor 1 cylinder head temperature LT compressor 2 cylinder head temperature LT compressor 3 cylinder head temperature		
Pt4 **Pt5** **Pt6**	35, 36 37, 38 39, 40	NT compressor 1 cylinder head temperature NT compressor 2 cylinder head temperature NT compressor 3 cylinder head temperature		
Pt7	45, 46	Hot gas temperature COP monitoring		
Pt8	47, 48	No function		
2 x 4-wire temperature sensors *				
Pt9	49 V+ **50 +** **51 -** 52 V-	Room temperature		*** Practical tip:** If 2-wire temperature sensors should be used for measuring the room and outdoor temperature (**not recommended**), these must be connected as shown in the picture on the left so that they can be monitored correctly. **Note:** The use of 2-wire temperature sensors for measuring the room and outdoor temperature results in large **measuring errors** over long distances, for more details see EDP.
Pt10	53 V+ **54 +** **55 -** 56 V-	Outdoor temperature		
4 x 2-wire temperature sensors				
Pt11 **Pt12**	57, 58 59, 60	Gas cooler outlet temperature 1 (t_{G1}) directly after the gas cooler bypass valve Gas cooler outlet temperature 2 (t_{G2}) directly after the gas cooler  For details, see chapter Temperature Sensors for the Control Temperature sensors for the control		
Pt13 **Pt14**	61, 62 63, 64	Suction Gas Temperature LT Suction Gas Temperature NT		

8 VPC 5000 Operating Modes

8.1 IO Checker / Service Mode

The IO Checker has been created to support for example commissioning engineers and installers, so that they can get a quick overview of the current operating status of the controller. The IO Checker is a component of the Virtus Control Desk (VCD) and displays the current status of all digital and analogue inputs as well as those of the relay and analogue outputs of the controller. **No** interventions are made on the system or any message is sent, as only a reading access takes place:



The function and position of the I/Os are described in more detail in the following chapters:

Connectors for 230 V AC (top)

- Assignment of the digital inputs - 230 V AC
- Assignment of the relay outputs 230 V AC
- Assignment of the 230 V AC power supply

Connectors for safety extra-low voltage (bottom)

- Assignment of the analogue inputs Pt1000
- Assignment of the 4..20 mA analogue inputs
- Assignment of the 0..10 V analogue outputs

If the relay or analogue outputs should be set manually in the course of a test, e.g. during commissioning or repair/maintenance work, the "IO Check operating mode" must be activated.

Activation of the "IO Check operating mode"

> **ATTENTION**
>
> **After activation** of the "IO Check operating mode", **all** functions of the controller become inactive and all relay and analogue outputs are reset in stages - **the system stops!** All switching commands to the relay outputs or the settings for the analogue outputs (0..10 V) are executed **directly (immediately)**! All digital and analogue inputs (motor overload cut-outs, oil differential pressure switches, pressure transmitters, cylinder head sensors, etc.) are thereby disregarded.
> **Practical tip:** While the I/O Checker is in use, the remote alarm function of the system centre can be suppressed for a limited time using the Service Mode.

After activation of the "IO Check operating mode", the desired relay and analogue outputs of the controller can now be set **manually** (write access). After activation, the message "Service Mode" is output and transmitted according to priority selection.

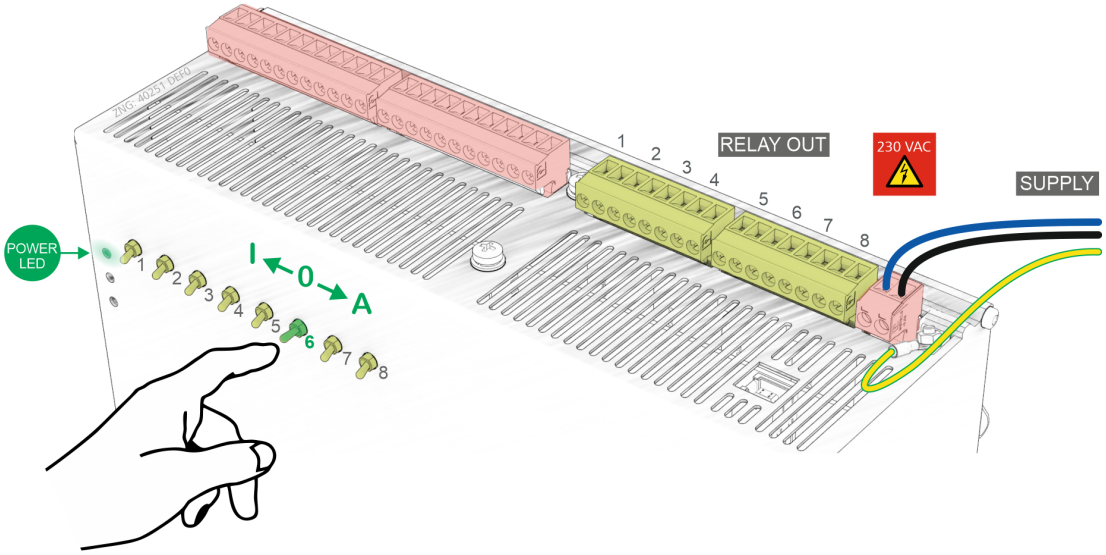
If the "IO Check operating mode" is deactivated, the controller switches back to normal operation.

8.2 Manual / automatic changeover to emergency power mode

In the event of a malfunction of the controller, emergency power mode via the manual/automatic changeover is only possible if the following conditions are met:

1. The controller is connected to the power supply.
2. The green POWER LED is lit.
3. The ERR. LED is not lit.

The manual/automatic changeover for the relay outputs is performed via switches 1..8:



For details about the assignment, see chapter Assignment of the relay outputs 230 V AC.

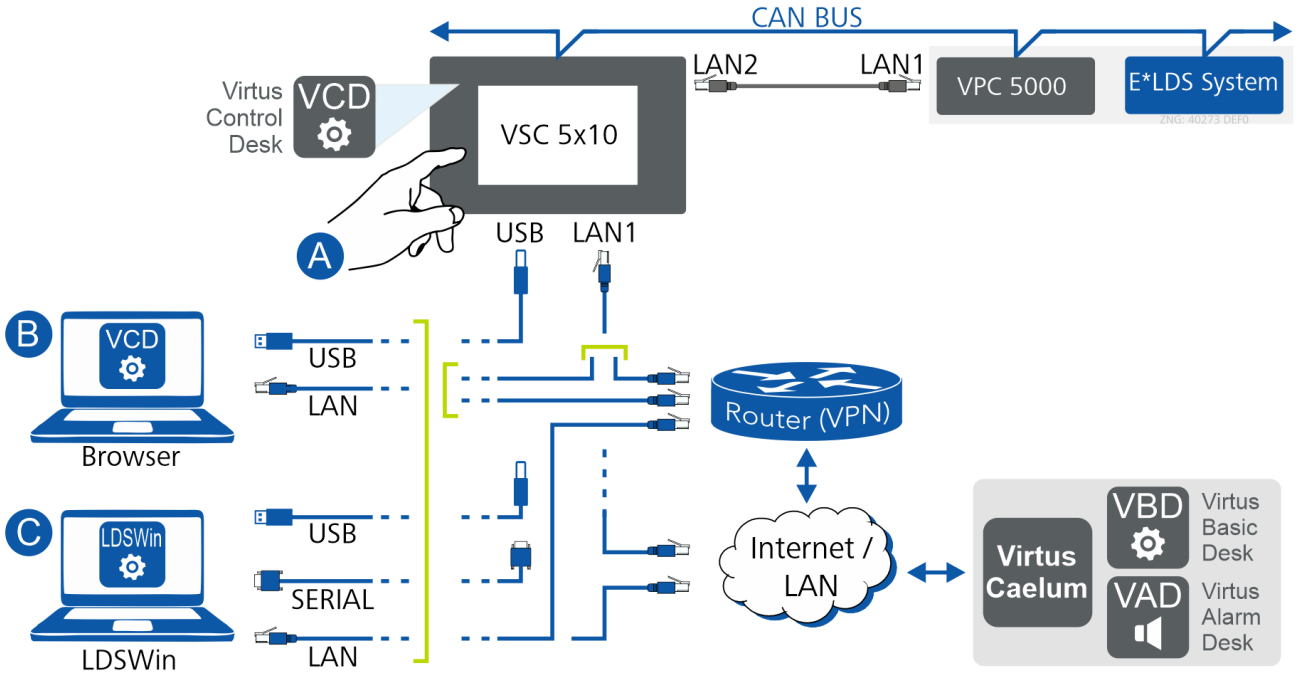
The following switch positions are possible:

- **A: Automatic operation - normal operation**
  If a switch is in the position A, the controller registers the logical state AUTOMATIC OPERATION:
  The connected equipment is controlled, **as envisaged by the regulation of the controller**.
- **O: Manual OFF**
  If a switch is in the position 0 (switch 6 in the example), the controller registers the logical state MANUAL OPERATION OFF:
  The connected equipments is not controlled - even if the regulation of the controller envisages this, the connected equipment **remains continuously switched off**!
- **I: Manual ON**
  If a switch is in the position I, the controller registers the logical state MANUAL OPERATION ON:
  The connected equipment is always controlled - even if the regulation of the controller does not envisage this,
  the connected equipment **remains continuously switched on**!

> The Manual ON (I) and Manual OFF (O) positions override the state desired by the controller! If a manual control switch is set to a switch position other than "Automatic", a corresponding message "*NT/LT Manual OFF/ON Sx*" is output.

9 VPC 5000 operation

Apart from Manual / automatic changeover to emergency power mode no operation is possible on the controller itself. The following options are available for commissioning, configuration, maintenance or service:



For details about the connection to the system centre and its interfaces, see the operating manual for the system centre.

(A) Locally on site via the Virtus 5 system centre, e.g. from the machine room
The touch screen (A) is used to log in/out of the system centre and to activate the Service mode. In addition, node information, status, alarms and messages from the controller can be viewed. Configuration of the controller is only possible via the Virtus Control Desk, the so-called "terminal mode" is no longer supported for controllers of the "Virtus LINE".

For details, see chapter Operation via System Centre.

(B) VCD - Virtus Control Desk - local on site / remote
The VCD is a browser-based integral service and part of the system centre, which acts as a gateway for communication with the controller. The browser-based service VCD is used locally on site or remotely. The VCD can be used remotely via Virtus Caelum, where other services such as VBD (Virtus Basic Desk) and VAD (Virtus Alarm Desk) are available.

The connection of the notebook to the system centre is made via

- USB port - local on site - or
- LAN (network) - local on site / remotely

For details, see chapter Operation via Virtus Control Desk (VCD).

Requirements for on-site operation (A/B)

- If any configuration of components is required, the input **must** previously be unlocked! **Without** logging in to the system centre, settings on controls and components can **only** be viewed (read-only!). - Changes and inputs are **not** possible!
- If the remote alarm function of the system centre will be suppressed for a limited period of time, the Service mode can be activated.

(C) PC Software LDSWin

LDSWin is a PC software application and can be used locally on site or remotely.

The connection of the notebook to the system centre is made via

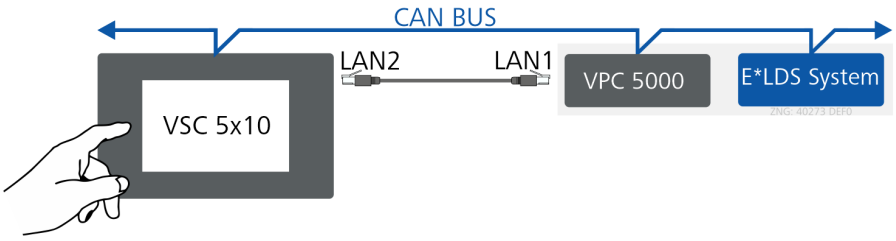
- the USB port or serial port - locally on site - or
- LAN (network) - local on site / remotely

For details about the software, see LDSWin Operating Manual.

9.1 Operation via touch screen of the system centre

Locally on site, for example from the machine room

Node information, status, alarms and messages from the controller in the system can be viewed via the touch screen of the system centre.



The most important symbols and tiles of the main menu:

- **1 Alarms and messages**
  
  This button can be used to display information about alarms and messages in the system and from controllers.
- **2 System overview**
  
  This button can be used to call up the submenu for the system overview and the most important information about the node name, position, CAN bus address and the status.
- **4 Configuration**
  
  Calling up this submenu is only possible if the user is logged in to the system centre, see chapter Logging in and out on the system centre. Otherwise, the button is greyed out.
  After logging in, this button can be used, among other things, to call up the submenu 4-1-5 "Interfaces" in order to determine the IP address assigned to the system centre (under "Ethernet"). Among other things, this information is needed for the VCD, as the IP address must be entered in the browser window; for details, see chapter Operation via Virtus Control Desk (VCD).

- **Logging in and out on the system centre**
  
  For details, see chapter Logging in and out on the system centre.

- **Activation of the Service mode**
  The remote alarm function of the system centre can be deactivated/activated here for a limited period of time.
  
  For details, see chapter Activate Service mode.

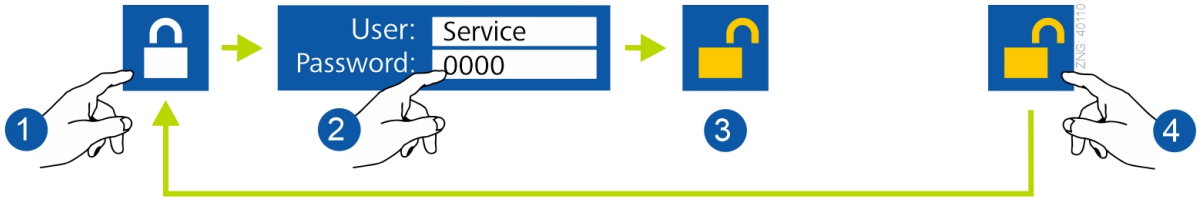
> For more detailed information see the System Centre operating manual.
> Configuration of "Virtus LINE" controllers is **only** possible via theVirtus Control Desk. The so-called "terminal mode" is **no longer supported** for these controllers.

9.1.1 Logging in and out on the system centre

If any configuration of components is required, the input **must** be unlocked. **Without** logging in to the system centre, settings on controllers and components can **only** be viewed (read-only!). Changes and inputs are **not** possible!

> **ATTENTION**
>
> **The deactivation of the lock is exclusively reserved for service personnel**! The lock is automatically reactivated 5 minutes after the last button tap. Logging in and out applies to all controllers and components in the E*LDS system. For more information see the System Centre operating manual.

Logging in and out on the system centre



1. **Login symbol** (unlock)
   Tap the button

2. **Screen for entry of the authorisation**
   - Standard (recommended)
   User (user name): Service
   Password: 0000
   - Advanced settings
   User (user name): Master
   Password: 0000

3. **Symbol for unlocked system centre**
   The configuration of controllers and components is now possible.

4. **Logout** (lock)
   - Tap the button or
   - Logout happens automatically after 5 minutes.

> **Practical tip:** Using the Service Mode, the service personnel can suppress the remote alarm function of the system centre for a limited period of time during repair/maintenance work.

9.1.2 Activate Service mode

Using the Service Mode, the service personnel can suppress the remote alarm function of the system centre for a limited period of time during repair/maintenance work.

> **ATTENTION**
>
> **The activation of the service mode is exclusively reserved for service personnel.** If there are still pending alarms (with the priority 1..99) after the time for the Service Mode has elapsed, the audible warning devices and the alarm relays are activated and the alarms are forwarded using the automatic transmission of alarms. For more information see the System Centre operating manual.

Activate/deactivate service mode

1. **Activate service mode symbol**
   Tap the button

2. **Enter delay time (delay):**
   Input between 1..255 minutes (e.g. 60 minutes)

3. **Service mode symbol is activated**
   The remote alarm is now suppressed for the set time,
   the counter counts down: 60, 59, 58, ... 0

4. **Deactivate service mode**
   - Tap the button and enter "0" or
   - wait until the counter has run down to "0" and the service mode is automatically ended (not recommended).

> **Practical tip:** The service mode is only visible (can be activated) if the system centre has previously been unlocked; see Logging in and out on the system centre.

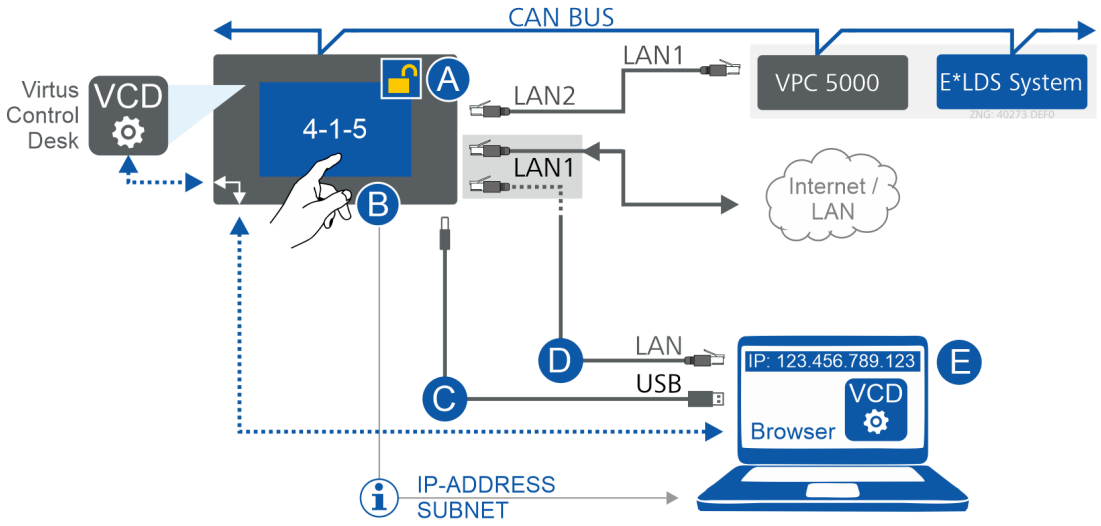
9.2 Operation via Virtus Control Desk (VCD)

The Virtus Control Desk (VCD) is a browser-based service and an integral part of the system centre that can be used **locally on site** or **remotely**. The VCD is used for configuration and operation of the system and of controllers in the E*LDS system. All that is needed is a web browser, e.g. Firefox http://www.firefox.com/.

> Access to the system or communication with controllers of the "Virtus LINE" **always** takes place via the system centre, which acts as a gateway. The so-called "terminal mode" is **no longer supported** by the system centre.

Locally on site

Using the browser, **local access** to the system and the controllers is via the VCD. The connection is made via the system centre using USB (C) or LAN (D). The simplest and most common connection is via USB (recommended).



Step 1: System Centre - Touch Screen

- Login to the system centre (A); for details, see chapter Logging in and out on the system centre.
  Practical tip: If the remote alarm function of the system centre will be suppressed for a limited period of time, the Service mode can be activated.
- Depending on the type of connection (USB or LAN), the IP address / subnet mask for USB or Ethernet must be determined in menu 4-1-5 (Configuration > System Centre > Interfaces) (B).
- Logout on the system centre (A); for details, see chapter Logging in and out on the system centre.

Step 2: Connect notebook

- **Connection via USB - recommended**
  Connect notebook to the USB port (C) of the system centre,
  for details, see *Direct Connection Notebook / System Centre via USB* at https://edp.eckelmann.de/edp/lds/_BAZIQhgb2h.
  Practical tip: Use long USB cable!
  or
- **Connection via LAN1 - Attention:** Internet connection of the system centre will be interrupted. Remote alarm signalling, Internet/web services, etc. are thus disabled!
  Notebook must be connected **directly** (**without** intermediate devices such as switch, hub, router...) to the LAN1 port (D) of the system centre,
  for details see *Direct Connection Notebook / Component via Network* at https://edp.eckelmann.de/edp/lds/_2YqrLxxxXw.
  The IP settings of the notebook must be configured to match the IP settings of the system centre, see (B). Approvals/authorisations may be required from the administrator of the notebook!
  Important: The system centre and the notebook **must be in the same subnet** and **must not have the same IP address**. The MAC addresses of the two interfaces are printed on the right-hand side of the case Anschlüsse Ethernet.

Step 3: Start Virtus Control Desk (VCD)

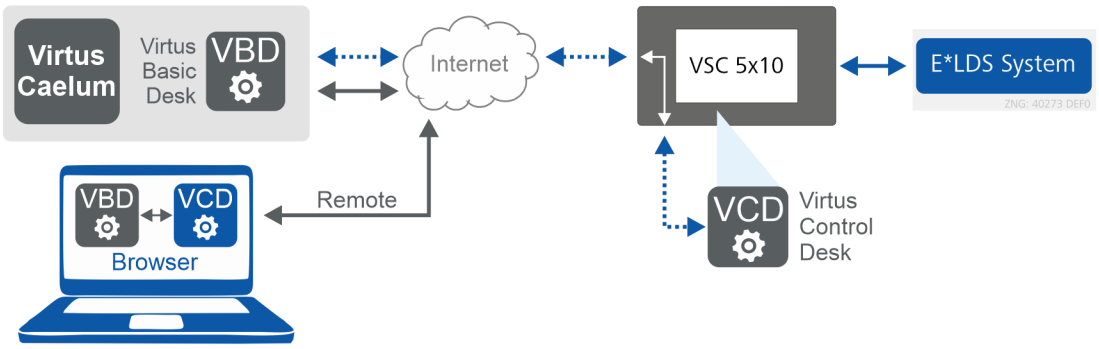
- Start the browser of the notebook (E) and enter the IP address of the system centre - see (B) - in the address field.
- Now the controller or other components of the E*LDS system can be operated and configured via the VCD integrated in the system centre.

Further information

- **System Centre**
  Operation using VCD, see the chapter "Remote control via Virtus Control Desk" in the operating manual for the system centre.
- **Virtus Control Desk**
  For information about VCD, see Virtus Caelum operating manual.

Remote

The connection to the Virtus Basic Desk (VBD) - a web-based app of Virtus Caelum - is made remotely via the browser. The VBD service provides the connection to the VCD and thus **remote access** to the installation and the controllers in the system.



Step 1: Login to Virtus Caelum

- In order to login and use the VBD as a service of Virtus Caelum*, please enter the following URL in your browser:
  https://virtuscaelum.eckelmanngroup.com/

- **Step 2: Start Virtus Control Desk (VCD)**
- After successfully logging in to Virtus Caelum, click on the "Virtus Basic Desk" service and select the desired facility.
- Click on "Virtus Control Desk" in the installation and log in with the access data for the system centre, for details see chapter Logging in and out on the system centre.
- Now the controller or other components of the system can be operated and configured via the VCD integrated in the system centre.

> * Access details (e-mail and password) are required for login. If you need these, please contact your administrator or your Account Manager at Eckelmann AG.
> For more information about operation or about the available services (apps), see the Virtus Caelum operating manual.

10 Decommissioning and Disposal

10.1 Decommissioning / Dismantling

The dismantling of the equipment may only be performed by authorised and trained personnel.

DANGER

Warning of dangerous electrical voltage! Danger to life - danger of electric shock!
During dismantling, the same safety instructions and hazard warnings must be observed as for installation, putting into service and maintenance, see chapter Safety instructions.

ATTENTION

For dismantlement, follow the steps for assembly in reverse order, see chapter Installation and Start-Up.

10.2 Disposal

NOTICE

WEEE Reg. No.
DE 12052799

Negative consequences for humans and the environment possible through environmentally unfriendly disposal!
The symbol for the separate disposal of electrical and electronic equipment represents a crossed-out wheeled trash bin and indicates that an electrical or electronic equipment marked with this symbol may not be disposed of with household waste at the end of its service life, but must be taken for separate disposal by the end user.

- In accordance with the contractual agreement, the customer is obliged to dispose of electrical and electronic waste in compliance with the statutory regulations based on the „Directive 2012/19/EU of the European Parliament on waste electrical and electronic equipment“.
- Dispose the packaging, the product and its components in an environmentally friendly manner at the end of their service life. Follow the national guidelines and laws that apply to you.

Users have the option of returning a B2B device distributed by us to us at the end of its service life. Please contact your customer service representative at Eckelmann AG to arrange for the device to be taken back and disposed of properly. Please inform yourself about the local regulations for the separate disposal of electrical and electronic products and batteries. Further information on the Electrical and Electronic Equipment Act can be found at www.elektrogesetz.de.

11 Alarms and messages VPC 5000

Message system

Alarms and messages* are recognised by the controller and stored in the internal message memory with, among other things, date, time and priority. The time resolution is one minute. The messages are stored in the log memory in the chronological order of their generation. The log memory has a capacity of 200 entries. If the log memory is filled, the latest message overwrites the oldest entry (ring buffer).

> The log memory is buffered so that no messages are lost in the event of power failure. The messages can be retrieved via the system centre or the Virtus Control Desk (VCD). The latest message is output as the first one. The contents of the log memory can be deleted using the system centre or the VPC.

* For details, see chapter Overview of all alarms and messages

Structure of the messages

Messages contain the following information:

- Time stamp "Coming/Going" with date and time
- Designation of the node and its position and CAN bus address
- Specific plain text and priority

Content of the message	Description
20/09/22 10:20 IN	Date and time of the message
20/09/22 10:45 OUT	Remedy / acknowledgement of the fault
VPC5000	Designation of the node
Pos: xxxxx	Position designation of the active controller that has output the message
101	CAN bus address
HP Limiter	Message text, in this case "High pressure limiter tripped"
Priority*	1

> * Up to 100 message priorities are provided in the system, which are subdivided into 10 alarm groups (decades) and thus enable a maintenance group oriented alarm management, for details see chapter "Alarms and messages" in the operating manual of the Virtus 5 system centre. The possible priorities for this controller are in the range **0..19**. The priority can also be set to "**--**" if no message should be generated. For details, see chapter Message Priorities.

11.1 Message Priorities

In addition to monitoring control functions, the connected sensors and probes are also monitored by the controller. For example, if a measured value is outside the control range or if implausible values are detected at the sensors or probes, then an alarm or a message is sent whose priority can be configured here.

The priorities in the range **0..19** and "**--**" are provided for the control, therefore only these can be assigned in the controller. Up to 100 message priorities are provided in the overall system itself, which are subdivided into 10 alarm groups (decades) and thus enable a maintenance group oriented alarm management, for details see chapter "*Alarms and messages*" in the operating manual of the Virtus 5 system centre.

Available priorities

- The priorities ending in the digit 1 or 2 (**1**/1**1** or **2**/1**2**)) are reserved for high-priority alarms that act directly on the alarm relays "PRIO1" and "PRIO2" of the system centre.
- The lowest priority (0/10) is reserved for messages that are only recorded in the message list.
- If the priority is set to "**--**", no message is generated.

The message priorities are preconfigured at the factory and can be changed if necessary. The message priorities are dimensionless.

Possible Messages	Description	Default
Category Message Priorities		
Power Supply		
Power Failure	Restart after power failure	0
First Start	First StartFirst Start, e.g. due to - start-up of the controller or -Firmware Update Firmware Update	2
System		
HP Limiter	High pressure limiter tripped	1
LP Limiter	NT low pressure limiter (switch) tripped	2
HP too High	Upper limit of the high pressure t_c exceeded, see chapter HP too High Monitoring HP too High Monitoring	2
HP too Low	Lower limit of the high pressure t_c undercut, see chapter HP too Low Monitoring HP too Low Monitoring	0
MP too High	Medium pressure too high, see chapter MP too High Monitoring MP too High Monitoring	2
MP too Low	Medium pressure too low, see chapter MP too Low Monitoring MP too low MP Monitoring	0
tG too High	Gas cooler outlet temperature tG is too high, see chapter Gas Cooler Outlet Temperature Monitoring Gas Cooler Outlet Temperature Monitoring	2
tG too Low	Gas cooler outlet temperature tG is too low, see chapter Gas Cooler Outlet Temperature Monitoring Gas Cooler Outlet Temperature Monitoring	0
t0 too Low	t0 too Low	2
Superheating too Low	Superheating too Low	0
Low Refrigerant Liquid Level	Refrigerant fill level (refrigerant level) of the system too low	2
Max. Refrigerant Liquid Level	Maximum refrigerant fill level exceeded **-> System will be shut down**	2
Control Deviation HP	High pressure control deviation too high	0

Possible Messages	Description	Default
Control Deviation MP	Medium pressure control deviation too high	0
Error Opening Degree HP Valve	Error of the opening degree of the high pressure valve	--
No Load Level	No LT load level received (t_0-shift)	0
Error Heat Recovery Signal	Heat recovery signal error	0
Error External Signal t_o-Shift	Error of the external signal for the t_0 shift	2
Error External Signal HP-Shift	Error of the external signal for the high pressure shift	2
Error Modbus	Error of the communication with components on the Modbus	0
Error Modbus Module	Error of a Modbus module	0
Setpoint Changed	A setpoint has been changed	0
Sensors		
Transmitter Type Change	A parameter for calibration of the pressure transmitters has been changed	2
Meas. Error HP	Error in the measuring circuit for measurement of the high pressure	2
Meas. Error MP	Error in the measuring circuit for measurement of the medium pressure	1
Meas. Error LP	Error in the measuring circuit for measurement of the low pressure	1
Meas. Error LP Z2	Error in the measuring circuit for measurement of the Z2 low pressure	2
Meas. Error Cylinder Head Temperature	Error in the measuring circuit for measurement of the cylinder head temperature, see chapter Cylinder Head Temperature Monitoring Cylinder head temperature monitoring	2
LT Meas. Error Cylinder Head Temp.	Error in the measuring circuit for measurement of the LT cylinder head temperature, see chapter Cylinder Head Temperature Monitoring Cylinder head temperature monitoring	2
Meas. Error Room Temperature	Error in the measuring circuit for measurement of the room temperature	2
Meas. Error Outdoor Temperature	Error in the measuring circuit for measurement of the outdoor temperature	2
Meas. Error Humidity	Error in the measuring circuit for measurement of the air humidity	2
Meas. Error Suction Gas Temp.	Error in the measuring circuit for measurement of the suction gas temperature	0
Meas. Error Suction Gas Temp. LT	Error in the measuring circuit for measurement of the suction gas temperature LT	0
Meas. Error Gas Cooler Outlet 1	Error in the measuring circuit for measurement of the gas cooler outlet temperature 1 (tG_1)	1
Meas. Error Gas Cooler Outlet 2	Error in the measuring circuit for measurement of the gas cooler outlet temperature 2 (tG_2)	1
NT compressors		
Motor Overload Cut-out	Motor temperature too high, Motor overload cut-out of NT compressor Cx tripped	2
Cylinder Head Temp. too High	Cylinder head temperature for NT compressor Cx upper limit exceeded	2
Oil/HP Fault	NT compressor Cx combination HP/oil monitoring tripped	2
Manual ON	Changeover to Manual ON of an NT compressor Cx	0
Manual OFF	Changeover to Manual OFF of an NT compressor Cx	0

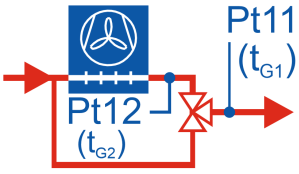
Possible Messages	Description	Default
Load Shedding	Compressor disabled due to load shedding (only if load shedding input is activated)	0
Autom. Disable of Compressors	Compressor stage Cx has been automatically disabled (5x Cylinder Head Temp. too High per day)	2
Too Many Compressor Starts	Too ManyCompressor Starts (only for NT compressor combined control)	0
LT compressors		
LP Limiter LT	LT low pressure limiter (switch) tripped	2
Motor Overload Cut-out LT	Motor temperature too high, Motor overload cut-out of LT compressor Cx tripped	2
Cylinder Head Temperature LT too High	Cylinder head temperature for compressor Cx upper limit exceeded	2
LT Oil/HP Fault	LT Compressor Cx combination HP/oil monitoring tripped	2
LT Manual ON	Changeover to Manual ON of an LT compressor Cx	2
LT Manual OFF	Changeover to Manual OFF of an LT compressor Cx	2
Too Many Compressor Starts LT	Too many compressor starts (only for LT compressor combined control)	2
Error Speed Control LT	Speed controller / external alarm has been activated (digital input B/N) and speed / combined control is activated	2
LT Superheating too Low	Minimum superheat LT undercut	2
Gas cooler		
Motor Overload Cut-out Fan	Condenser fan x motor overload cut-out tripped	2
Error Speed Control HP	Error of the speed controller (FC) for the high pressure	2
Operating modes		
Service Mode	IO Checker / Service Mode IO Checker / Service Mode has been activated	0
Fast Unload (external OFF)	Fast unload (external OFF) has been activated (digital input J/N)	0
Emergency Power Mode	Emergency Power Mode Emergency Power mode has been activated (digital input K/N)	0

11.2 Overview of all alarms and messages

In addition to monitoring control functions, the connected sensors and probes are also monitored by the controller, see chapter Measuring Circuits Monitoring. For example, if a measured value is outside the control range or if implausible values are detected at the sensors or probes, a message is sent whose priority can be configured, for details see chapter Message Priorities.

No.	Message	Cause	Remedy
0	MP too Low	Medium pressure too low	• Check compressor • Adjust parametrisation of medium pressure control
	HP too Low	High pressure too low	• Check compressor • Adjust parametrisation of high pressure control
	tG too Low	Gas cooler temperature tG too low	• Check gas cooler • Adjust parametrisation for the control of the gas cooler outlet temperature
	tG too High	Gas cooler temperature tG too high	
	Max.Ref.Liq.Lev.	Maximum refrigerant fill level exceeded	Check refrigerant system
	Err.HR Signal	HRC signal is cycling	Check HRC
	HRC failure	Error message from HRC	Check HRC
	Modbus RTU	Modbus RTU communication error	Check wiring and Modbus parametrisation
	Error.OD.HP-V	Error Opening Degree HP Valve	Check measuring circuit: • Electrical connection (possible wiring error) • Liquid solenoid valve closes / opens correctly • Check the control sensor for any wiring errors. For details, see chapter Measuring Circuits Monitoring Measuring Circuits Monitoring
	MeasCirc OD-HPV	Error in the measuring circuit for measurement of the opening degree of the HP valve	
50	First Start	First Start First start of the controller with loading of the factory settings	-
51	Power Failure	Restart Restart of the controller, e.g. after a power failure	Check 230 V power supply if necessary
142	Low Superheat	Minimum superheat NT undercut	Danger of compressor damage! Check pack for performance: if overloaded, deactivate associated refrigeration points
	LT Superheat too Low	Minimum superheat LT undercut	Danger of compressor damage! Check pack for performance: if overloaded, deactivate associated LT refrigeration points
150	Motor Overload Cut-out Cx	Compressor Cx motor overload cut-out tripped	Check compressor
	Motor Overload Cut-out LT x	LT compressor Cx motor overload cutout tripped	
	Mot.temp 1/FC Fault	Compressor 1 motor overload cut-out tripped / frequency converter fault	
	Mot.temp 1/FC Fault LT	Compressor 1 motor overload cut-out tripped / frequency converter fault LT	
153	F y A:z x	Modbus fan y with Modbus address z has reported error x	Check Modbus fan / check fan manual

No.	Message	Cause	Remedy
153	Man. Fan Speed	At least one Modbus gas cooler fan is controlled with manually specified speed	-
154	Oil/HP Fault Cx	Compressor Cx combination HP/oil monitoring tripped	Check compressor
	Oil/HP Fault LT x	LT Compressor Cx combination HP/oil monitoring tripped	Check compressor
157	Cyl. Temp.High Cx	Cylinder head temperature for compressor Cx upper limit exceeded	
	Cyl. Temp. too High LT x	Cylinder head temperature for LT compressor Cx upper limit exceeded	
160	HP Switch	High pressure switch tripped	Check HP valve
161	LP Limiter	Low pressure switch NT tripped	Check compressor
	LP Limiter LT	Low pressure switch LT tripped	
163	M.err.Suct.gasLT	Error in the measuring circuit for measurement of the LT suction gas temperature	Check measuring circuit • Check electrical connection (possible wiring error) • Replace sensor if necessary For details, see chapter Measuring Circuits Monitoring Measuring Circuits Monitoring
164	LP too Low	Lower limit NT t_0 undercut	Check parametrisation of the NT low pressure control
164	LT t0 too Low	Lower limit LT t_0 undercut	Check parametrisation of the LT low pressure control
167	HP too High	HP upper limit exceeded	Check HP valve or adjust parametrisation of high pressure control
168	Meas.Err. Cyl. Cx	Error in the measuring circuit for measurement of the NT compressor x cylinder head temperature	Check measuring circuit • Check electrical connection (possible wiring error) • Replace sensor if necessary For details, see chapter Measuring Circuits Monitoring Measuring Circuits Monitoring
	LT Meas. Error Cylinder Head Temp.	Error in the measuring circuit for measurement of the LT compressor x cylinder head temperature	
171	Meas. Error HP	Error in the measuring circuit for measurement of the high pressure	
172	Meas. Error LP	Error in the measuring circuit for measurement of the NT low pressure	
173	Meas. Error LP LT	Error in the measuring circuit for measurement of the LT low pressure	
175	Meas. Error Outdoor Temperature	Error in the measuring circuit for measurement of the outdoor temperature	
176	Meas. Error Room Temperature	Error in the measuring circuit for measurement of the room temperature	
177	Meas. Error Humidity	Error in the measuring circuit for measurement of the air humidity	
180	Service Mode	IO Checker / Service Mode IO Checker / Service Mode has been activated	-
181	ext. Unload	External unload has been activated	-
182	Load Shedding	Compressor has been disabled by Load Shedding - load shedding input is active	-
185	Low Refrigerant Liquid Level	Refrigerant level switch tripped	Check refrigerant system

No.	Message	Cause	Remedy
187	NT Manual OFF Sx	Changeover to Manual OFF - NT compressor stage Sx	Manual/Automatic changeover compressor stage Sx has been activated
	LT Manual OFF Sx	Changeover to Manual OFF - LT compressor stage Sx	
188	NT Manual ON Sx	Changeover to Manual ON - NT compressor stage Sx	
	LT Manual ON Sx	Changeover to Manual ON - LT compressor stage Sx	
193	Emergency Power Mode	Digital input Emergency Power Mode is active and emergency power mode is enabled	-
203	Sensor Type Change	Any parameter for the Pressure Transmitter has been changed	-
204	Aut. Disable Sx	NT compressor stage x has been automatically disabled (5x per day message "Cylinder Head Temp. too High")	-
	LT Aut. Disable Sx	LT compressor stage x has been automatically disabled (5x per day message "Cylinder Head Temp. too High")	-
219	Meas. Error MP	Error in the measuring circuit for measurement of the medium pressure	Check measuring circuit  • Electrical connection (possible wiring error) • Check the control sensor for any wiring errors. For details, see chapter Measuring Circuits Monitoring Measuring Circuits Monitoring
220	MeasErr.Gasc.Out	Error in the measuring circuit for gas cooler outlet temperature 1 (Pt11 sensor directly after bypass valve)	
	MeasErr.gas.out.2	Error in the measuring circuit for the gas cooler outlet temperature 2 (Pt12 sensor directly on the gas cooler)	
221	Too Many Starts	Too many compressor starts for compressor combined control LT	Check parametrisation of the NT low pressure control
	Too Many Compressor Starts LT	Too many compressor starts for compressor combined control LT	Check parametrisation of the LT low pressure control
222	No Load Level	No load level information received for t_0 shift via NT / LT consumer	Check parametrisation of the case controllers
	No Load Level LT		
225	Meas.Err.Suprheat	Error in the measuring circuit for measurement of the LT suction gas temperature/superheat	Check measuring circuit • Electrical connection (possible wiring error) • Check the control sensor for any wiring errors. For details, see chapter Measuring Circuits Monitoring Measuring Circuits Monitoring
233	MP too High	Medium pressure too high	• Check MP valve • Adjust parametrisation of medium pressure control
237	Deviation HP	High pressure control deviation too high	• Check HP valve • Adjust parametrisation of high pressure control
238	Deviation MP	Medium pressure control deviation too high	• Check MP valve • Adjust parametrisation of medium pressure control

No.	Message	Cause	Remedy
240	Setpoint Change	A setpoint has been changed	-
247	Motor Overload Cut-out Fan	Error speed controller for gas cooler fan	• Check digital input X "Gas cooler motor overload cut-out" • Check gas cooler fan

12 Technical Data VPC 5000

12.1 Electrical Data VPC 5000

DANGER

Warning about dangerous electrical voltage! Danger to life - Danger of electric shock!
Overvoltage category II / contamination degree 2: All connections of the device provided for operation with 230 V AC supply voltage **must** be wired with the same outer conductor. 400 V AC between neighbouring connection terminals is **not** permitted!

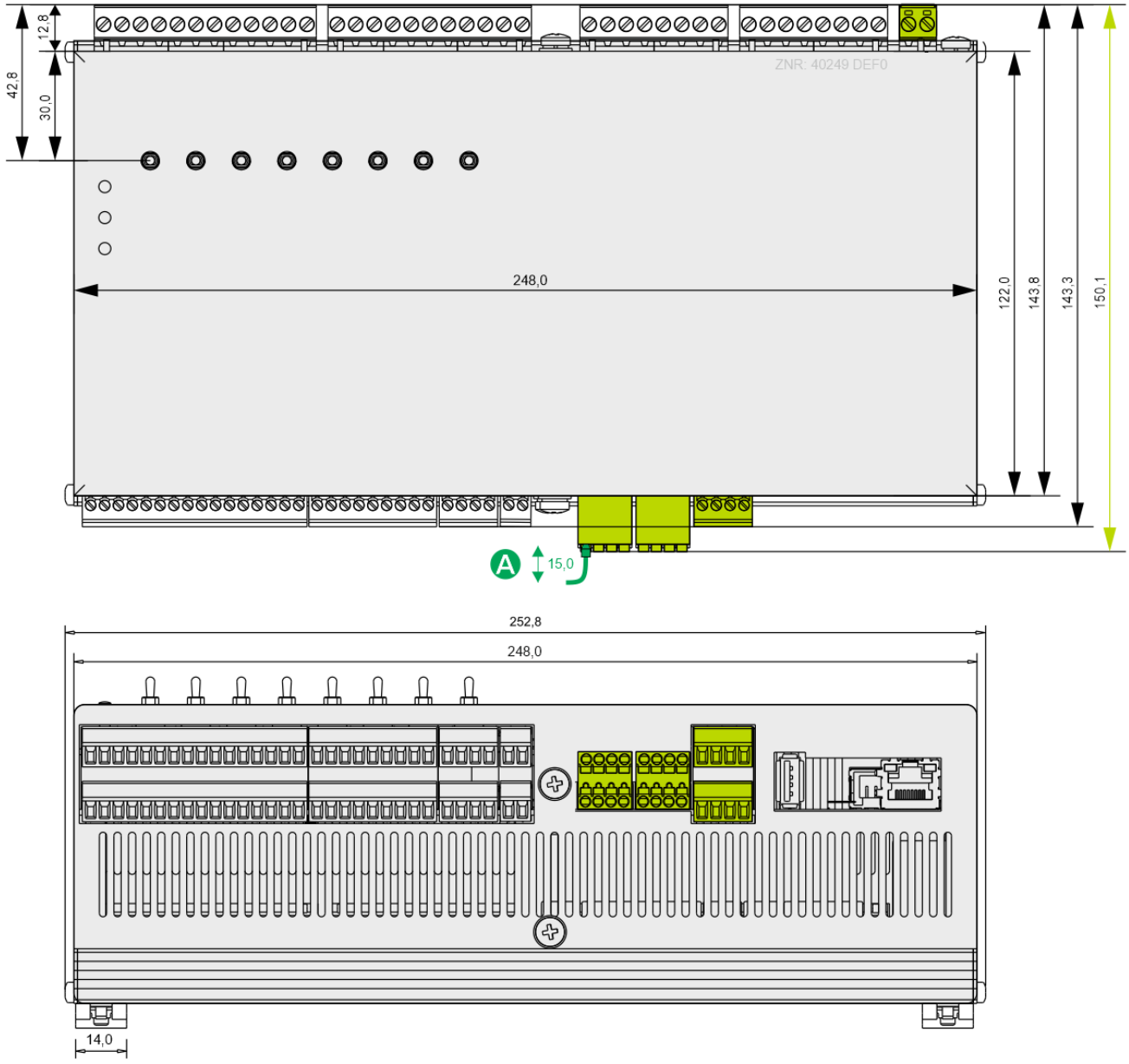
VPC 5000	
Operating voltage, supply voltage	230 V AC, 207 .. 253 V AC, 50 Hz
Rated power	24 W
Leakage current via PE	max 1 mA
Overvoltage category	Overvoltage category II
Digital inputs	21 x 230 V AC with common neutral conductor
Relay outputs	8 x normally open contact, 250 V AC, floating output, min 10 mA Load type: ohmic: max. 6 A, inductive: max. 2.5 A, cos phi = 0.4, total current max. 20 A
Manual control switch	8 x manual control switches so that the relay outputs can be manually overridden in emergency power mode; for details, see chapter Manual / automatic changeover to emergency power mode.
Analogue inputs [1)]	6 x analogue inputs 4 .. 20 mA 2 x Pt1000 4-wire temperature sensors 12 x Pt1000 2-wire temperature sensors
Analogue outputs [1)]	6 x analogue outputs 0 .. 10 V 0 .. 10 V (minimum load 1 kΩ)
Data interfaces	2 x Ethernet (LAN1=100 MBit / LAN2=1GigaBit), MAC addresses see sticker on the right-hand side of the case 2 x serial RS485 2 x USB (Host/Device)
Fieldbus interface	2 x CAN bus / floating output
Archive memory	Compressor run times, starts, activities, messages

1) Supply cables to analogue inputs / outputs must be shielded, see chapter DIN rail mounting.

VPC 5000	
Environmental conditions	
Use	Designed for mounting in the switch cabinet, see chapter VPC 5000 Installation and Start-up VPC 5000 Installation and Start-up
Weight	1600 g (sheet metal case)
Temperature range	Transport: -20 °C .. +80 °C Operation: 0 °C .. +50 °C
Temperature change	Transport: max. 20 K/h Operation: max. 10 K/h
Rel. humidity (non-condensing)	Transport: 8% .. 80% Operation: 20% .. 80%
Shock according to DIN EN 60068-2-27	Transport and operation: 30 g
Vibration 10..150 Hz according to DIN EN 60068-2-6	Transport and operation: 2 g
Atmospheric pressure	Transport: 660 hPa .. 1060 hPa Operation: 860 hPa .. 1060 hPa
Height position	0 .. 2000 m
Standards and Directives	
Contamination degree	2
Protection rating	Device and mating connectors: IP20 (EN 60529)
CE conformity	• Low Voltage Directive 2014/35/EU; Official Journal of the EU L96, 29/03/2014, pages 357-374 • EMC Directive 2014/30/EU; Official Journal of the EU L96, 29/03/2014, pages 79-106 • RoHS Directive 2011/65/EU; Official Journal of the EU L174, 01/07/2011, pages 88-110

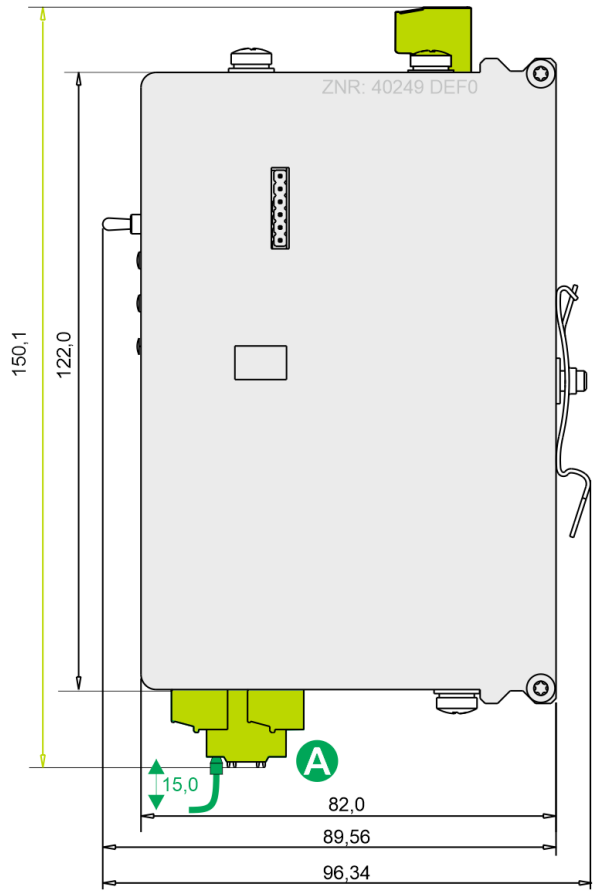
12.2 Mechanical Data VPC 5000

Front view / from below



All specifications in mm.
(A) = Connector with cable

View right side



All specifications in mm.
(A) = Connector with cable

13 Part numbers and Accessories VPC 5000

Product	Description	Part number
Pack Controller		
VPC 5000	Pack Controller VPC 5000	KGLVPC5000
Accessories		
Pressure transmitter	0..10 bar 1..26 bar 1..61 bar 1..161 bar	KGLZDRUCK3 KGLZDRUCK4 KGLZDRUCK5 KGLZDRUCK6
Cylinder head sensor	Cylinder head sensor (2-wire Pt1000), brass	KGLZPTZYLM
Outdoor / store sensor	Temperature sensor (4-wire Pt1000) for wall mounting	KGLZPT1000
Humidity and temperature sensor	Combined humidity sensor (4..20 mA) and temperature sensor (4-wire Pt1000) for wall mounting	KGLZPTHYGR
Terminating resistor 100 Ohm	Terminating resistor 100 Ohm for the CAN bus	W100R00004
USB-A-B-Kabel	USB A-B cable with ferrite core	PCZKABUSB1
Data cable	Data cable for connection to the system centre: 2,0 m 5,0 m	 KABLIND003 KABLIND007