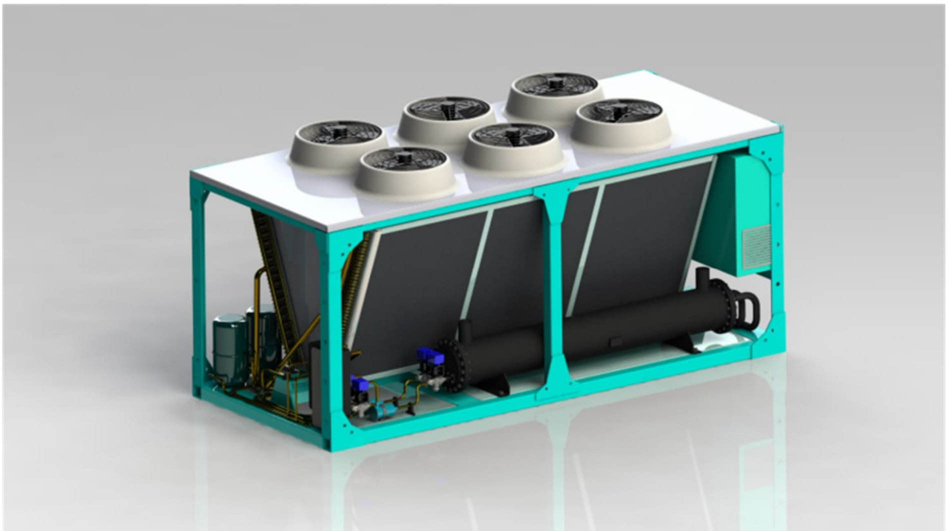

Climatix™

Chiller Application

Application Guide

A6V14793995_en_a

2024-01-20

Smart Infrastructure

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Cyber security disclaimer

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Legal note

Legal note concept

This guide includes notes that must be followed to prevent damage to property.

Notes dealing only with damage to property use the signal word NOTICE and an exclamation point.

They are depicted as follows:

NOTICE	
!	**Type and source of hazard** ● Measures/prohibitions to prevent the hazard

Qualified personnel

Only qualified personnel may commission the device/system. In this regard, qualified personnel have the training and experience necessary to recognize and avoid risks when working with this device/system.

Proper use

The device/system described here may only be used on building technical plants and only for the described applications.

The trouble-free and safe operation of the device/system described here requires proper transportation, correct warehousing, mounting, installation, commissioning, operation, and maintenance.

You must comply with permissible ambient conditions. You must comply with the information provided in the sections "Technical data" and "Notes" in the associated documentation.

Fuses, switches, wiring and grounding must comply with local safety regulations for electrical installations. Observe all local and currently valid laws and regulations.

Disclaimer

The content of this document was reviewed to ensure it matches the hardware and firmware described herein. Deviations cannot be precluded, however, so that we cannot guarantee that the document matches in full the actual device/system. The information provided in this document is reviewed on a regular basis and any required corrections are added to the next edition.

1 About this document

1.1 Revision history

Version	Date	Changes	Section
a	Current edition	First edition	

1.2 Application hardware and its documentation

ASN	Description	Documentation
Controller and Extension module		
POL688.10/STD	Controller with 27 I/Os	A6V10990076
POL688.80/STD	Controller with 27 I/Os and integrated HMI	A6V10990076
POL985.00/STD	Extension module 26 I/Os	N3921
HMIs		
POL895.51/STD	HMI-DM POL895.5x with cable - screen 96 x 208	N3941
POL871.61/STD	HMI-TM for magnetic mounting and mobile operation	A6V13923796
POL871.62/STD	HMI-TM for mounting in control panels	A6V13923796
Terminal sets and connectors		
POL068.85/STD	Terminal set POL688, screw connection	n/A
POL068.86/STD	Terminal set POL688, spring-cage connection	n/A
POL098.56/STD	Terminal set POL985, spring-cage connection	n/A
POL098.55/STD	Terminal set POL985, screw connection	n/A
POL002.43/STD	Board-to-wire connector, 50 pcs	n/A
Refrigerant valves		
MVL661.15-1.0	Modulating refrigerant valve, Kvs 0.4 m³/h	N4714
MVL661.20-2.5	Modulating refrigerant valve, Kvs 2.5 m³/h	N4714
MVL661.25-6.3	Modulating refrigerant valve, Kvs 6.3 m³/h	N4714
MVL661.32-10	Modulating refrigerant valve, Kvs 10 m³/h	N4714
Pressure sensors		
QBE2104-P10U	Pressure sensor, -1.. 9 bar, 4.. 20mA	A6V10434676
QBE2104-P25U	Pressure sensor, -1.. 24 bar, 4.. 20mA	A6V10434676
QBE2104-P30U	Pressure sensor, -1.. 29 bar, 4.. 20mA	A6V10434676
QBE2104-P60U	Pressure sensor, -1.. 59 bar, 4.. 20mA	A6V10434676

1.3 Validity

This documentation is valid for the Configurable Chiller application version V01.01.xx.

1.4 Before you start

1.4.1 Target audience

This document targets OEM expert customers specifying their project who are responsible for planning and executing projects.

1.4.2 Abbreviations

Term	Description
AI	Analog input
AO	Analog output
CapCtl	Capacity control. Determines the cooling/heating demand of a plant with several chillers/heat pumps
CH/HP	Chiller/Heat pump
Cns	Consumer
Crt	Circuit
Cpr	Compressor. Control of a single compressor
Consumer	Evaporator in cooling mode, condenser in heating mode
DI	Digital input
DO	Digital output
HX	Heat exchanger
EEV	Electronic expansion valve
HP	High pressure
Exps	Expansion. Control of superheat with an expansion valve (TEV, EEV-MVL, EEV stepper)
LOP	Lowest operating pressure
LP	Low pressure
MOP	Maximum operating pressure
MVL	Magnetic expansion valve
NO	Normally open
PEvp	Evaporation pressure
Sequence	Defined execution order of actions and functions during a transition
SH	Superheat
SM	Stepper motor
Source Heat Exchanger	Evaporator in heating mode, condenser in cooling mode
Src	Source side control; in cooling mode (refrigeration machine), this means condensing control, while in heating mode (heat pump) this is the evaporator
SuCtl	Supply control. Control of the water supply pump and management of the antifreeze function which protects the evaporator against frost
TEV	Thermostatic expansion valve
TEvp	Saturated evaporation temperature
Transition	State during which a system changes from one steady state to another. For instance, to change from Off to cooling mode, transition startup must be executed. This transition comprises a sequence of actions
TSuctGas	Suction gas temperature
VSD	Variable speed drive

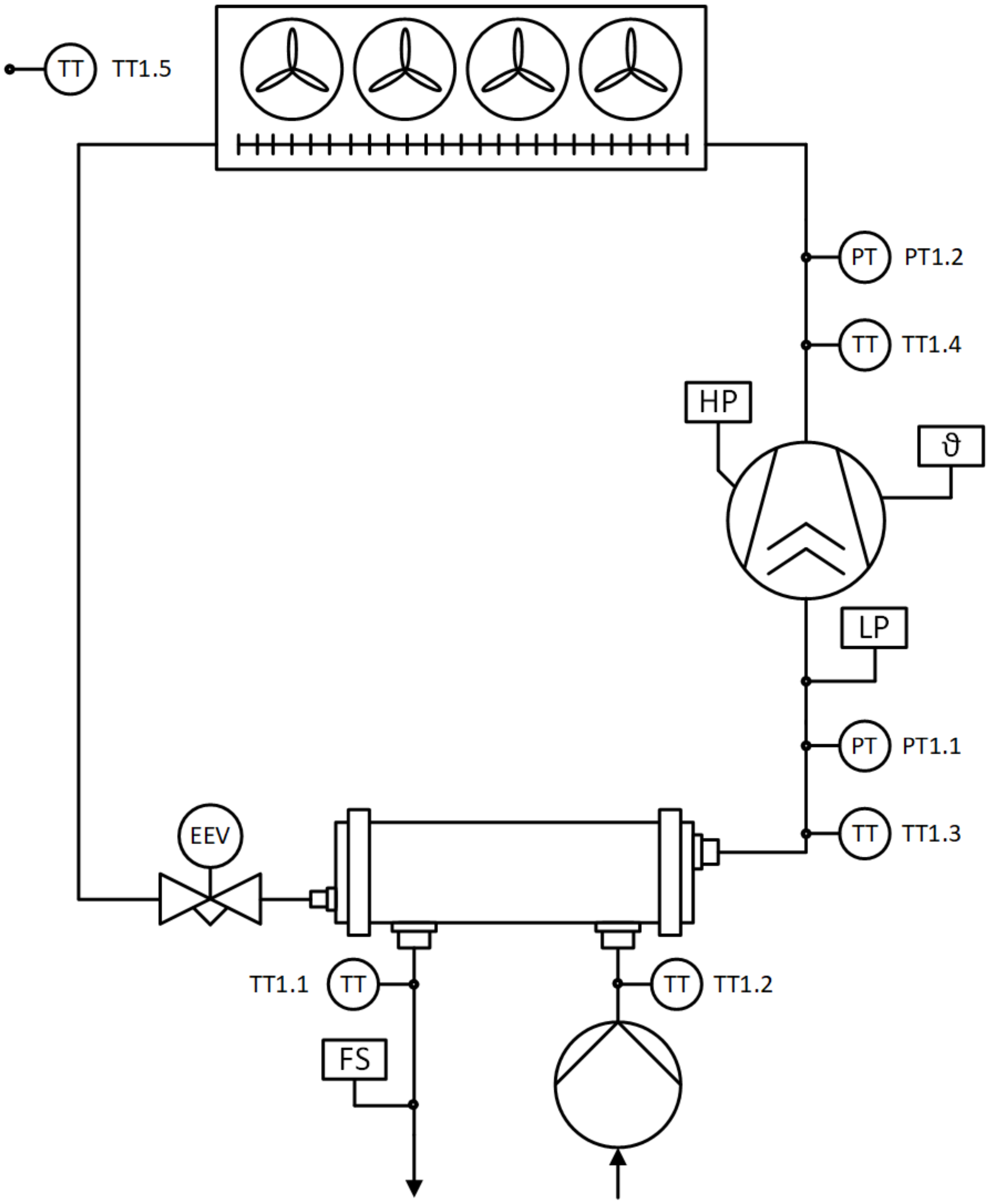
2 Application features

The 'Air to Water' screw chiller application is based on the Chiller Heat pump library. The current document describes the implemented features of “Screw Chiller” template.

The following features and functions are available and can be configured and /or parameterized according to customers' requirements:

- Operating modes Auto, Off, Cool
- Management of up to 3 refrigeration circuits
- Transitions for start-up, shut-down, incl. pump-down etc.
- Flow protection
- Frost protection
- Glycol operation
- Refrigerant-dependent settings
- Compressor protection functions: min. runtime, max. starts per hour, etc.
- Asymmetric and symmetric compressor management
- Different compressor rotation strategies
- Advanced capacity control logic: parallel compensation, part load avoidance
- Bitzer stage and VSD compressors with different start-up modes: direct start or part-winding for each refrigeration circuit
- Compressor (refrigeration circuit) envelope control including preventions
- Expansion devices: MVL661
- EEV functions: MOP, LOP, min. SH, EEV start up sequence, etc.
- Capacity control: supply temperature control, external control, capacity manipulation
- Alarm, alarm handling
- Emergency operation
- Pump: 0-1-2 supply pumps
- Separated condenser configuration
- Fans: Up to 7 fan stages, VSD fan support

3 Plant diagram



LP Low pressure switch
HP High pressure switch
FS Flow switch
ϑ Compressor overload

TT Temperatur transmitter
TT1.1 Suppply temperature
TT1.2 Return temperature
TT1.3 Suction gas temperature
TT1.4 Discharge temperature
TT1.5 Outdoor temperature

PT Pressure transmitter
PT1.1 Evaporator pressure
PT1.2 Condenser pressure

4 Input / Output layout

4.1 Configuration philosophy

Basic principles

- The below documented I/O layout is the reference for the correct wiring (done by OEM installer).
- The configuration WIZARD reduces hardware configuration to a minimum. If a function is chosen, the wizard assumes that the pin is wired with the correct and documented input / output type. Diagnostic functions report if not.
- Only in cases where multiple input/output types are possible (for example NTC, Pt1000, Ni1000 for X9) the program offers and requires the selection of the wanted type.
- The workflow 'Wiring test [→ 24]' (only available for directly connected HMIs for security reasons) offers to test the wired controller and extension module with its periphery.

Device layout

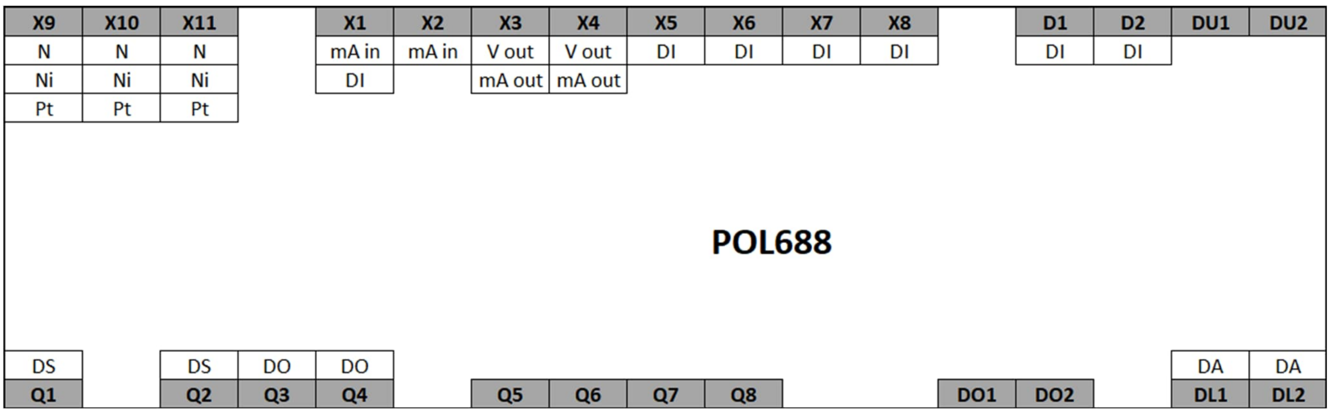
- The application uses a Climatix POL688 basic controller with 1, 2, or 3 POL985 extension modules.
- The IO Layout is structured in such a way that an additional circuit is represented by an additional (identically wired) extension module POL985. Central functions are wired on the basic device, POL688.
- The respective datasheets document the possible signal types in detail. This document offers only a short compilation of the technical facts.

Additional documentation

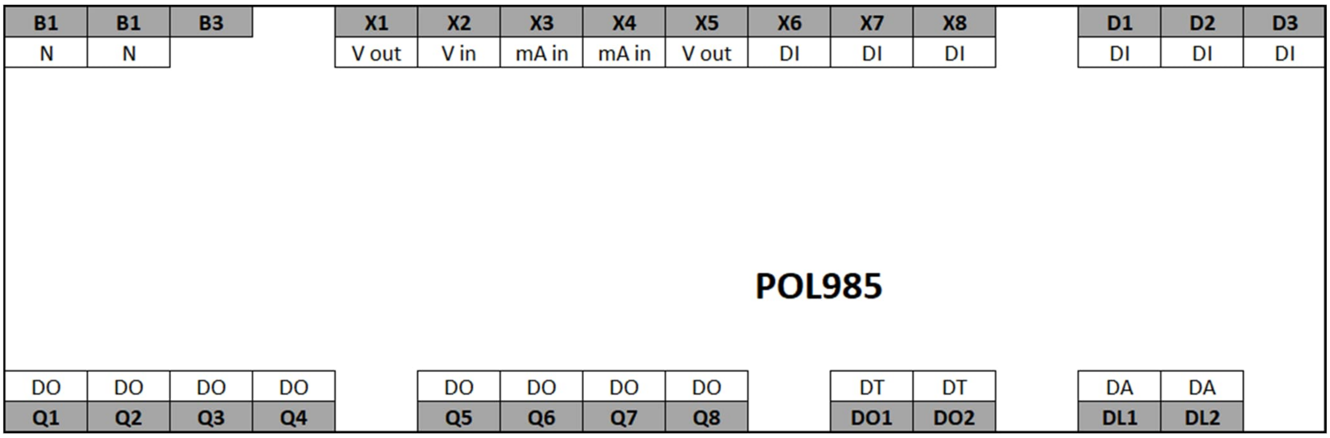
Document ID	Datasheet	Description
A6V10990076	C600 Climatix controller	Functions, use, technical data, terminal concept, and dimensions for the C600 controller product range
N3921	POL985.00: Climatix extension module 26 I/Os	Functions, use, technical data, terminal concept, and dimensions
CB1P3903	Climatix Controllers POL6XX and I/O modules POL9XX	Functions, use, technical data, terminal concept, and dimensions for the POL6XX and I/O modules POL9XX

4.2 IO layout

POL688



POL985



Main controller - Analog inputs

Pin	Description	Type
X9	Return water temperature	NTC10kΩB3977, NTC10kΩB3435, NTC100kΩB3978, Ni1000LG, Pt1000
X10	Supply water temperature	NTC10kΩB3977, NTC10kΩB3435, NTC100kΩB3978, Ni1000LG, Pt1000
X11	Outdoor temperature	NTC10kΩB3977, NTC10kΩB3435, NTC100kΩB3978, Ni1000LG, Pt1000
X1	Setpoint manipulation	4-20 mA
X2	Capacity limitation	4-20 mA

Main controller - Analog outputs

Pin	Description	Type
X3	Modulating compressor, circuit 1	0-10 V, 2-10 V, 0-20 mA, 4-20 mA
X4	Modulating compressor, circuit 2	0-10 V, 2-10 V, 0-20 mA, 4-20 mA

Main controller - Digital inputs

Pin	Description	Type
X5	Evaporator pump 1 overload	Voltage free
X6	Evaporator pump 2 overload	Voltage free
X7	Phase loss protection	Voltage free
X8	Flow switch	Voltage free
D1	Gas leak notification	Voltage free
D2	Emergency stop notification	Voltage free
DL1	Remote switch	Active digital input 115…230V
DL2	Unit switch	Active digital input 115…230V

Main controller - Digital outputs

Pin	Description	Type
Q1	Evaporator pump 1	Relay NO/NC
Q2	Evaporator pump 2	Relay NO/NC
Q3	Unit alarm	Relay NO
Q4	Evaporator pump 2	Relay NO

Extension module circuit 1/2/3 - Analog inputs

Pin	Description	Type
B1	Suction gas temperature	NTC10kΩB3977, NTC10kΩB3435, NTC100kΩB3978
B2	Discharge gas temperature	NTC10kΩB3977, NTC10kΩB3435, NTC100kΩB3978
X2	MVL feedback	0-10 V
X3	Evaporator pressure	4-20 mA (QBE-P10U; QBE-P25U)
X4	Condenser pressure	4-20 mA (QBE-P25U; QBE-P30U, QBE-P60U)

Extension module circuit 1/2/3 - Analog outputs

Pin	Description	Type
X1	MVL control	0-10 V
X5	Modulating fan	0-10 V

Extension module circuit 1/2/3 - Digital inputs

Pin	Description	Type
X6	Fan 1 overload	Voltage free
X7	Fan 2 overload	Voltage free
X8	Fan 3 overload	Voltage free
D1	Fan 4 overload	Voltage free
D2	Fan 5 overload	Voltage free
D3	Compressor overload	Voltage free
DL1	High pressure switch	Active digital input 115…230V
DL2	Low pressure switch	Active digital input 115…230V

Extension module circuit 1/2/3 - Digital outputs

Pin	Description	Type
Q1	Fan 1	Relay NO
Q2	Fan 2	Relay NO
Q3	Fan 3	Relay NO
Q4	Fan 4	Relay NO
Q5	Compressor part winding 1 / Direct start / enable VSD	Relay NO
Q6	Compressor part winding 2	Relay NO
Q7	Compressor capacity control valve CR1	Relay NO
Q8	Compressor capacity control valve CR2	Relay NO
DO1	Compressor capacity control valve CR3	Triac AC 24…230 V
DO2	Compressor capacity control valve CR4	Triac AC 24…230 V

4.3 Auxiliary functions, functional inputs

Unit switch (using DL2)

The unit switch is the main switch of the unit and is intended for manual activation of the machine.

When the unit switch is in the open position, the unit is disabled and the pump, fans and compressors remain disabled. Any control source and command will be ignored.

- By **triggering** the unit switch, the unit will be **enabled**. The unit starts the pump if
  - the remote switch is triggered
  - no critical alarm is present
  - the prioritized control source is set to ON
- In case the unit switch is **triggered** (**disabled**) during operation, the unit will be shut down in a regular way (invoking the shut-down sequence).

Remote switch (using DL1)

The remote switch is intended to start or stop the unit from remote locations.

When the remote switch is **triggered** (enabled) and any other control source is set to ON, the unit will be started (invoking the start-up sequence).

If the remote switch is **triggered** (disabled) during operation, the unit will be shut down in a regular way (invoking the shut-down sequence).

Control sources and priorities

The application supports different control sources.

The unit can be enabled or disabled by HMI, BMS or Scheduler. Each control source has the states AUTO, ON, and OFF.

- HMI has the highest priority, followed by BMS and Scheduler.
- Consequently, a unit set on HMI to OFF cannot be enabled by control sources having lower priority.
- Similarly, it cannot be disabled by BMS or Scheduler while the HMI operating mode is set to ON.

Highest prio		**Control source**			
Unit switch	**Remote switch**	**High prio**	**Low prio**	**Lowest prio**	
		HMI	**BMS**	**Scheduler**	**Unit status**
Open	Open/Close	AUTO/ON/OFF	AUTO/ON/OFF	AUTO/ON/OFF	**OFF**
Close	**Open**	AUTO/ON/OFF	AUTO/ON/OFF	AUTO/ON/OFF	**OFF**
Close	Close	**AUTO**	**AUTO**	**AUTO**	**OFF**
Close	Close	AUTO	AUTO	**ON**	**ON**
Close	Close	AUTO	**ON**	AUTO/OFF	**ON**
Close	Close	**ON**	AUTO/OFF	AUTO/OFF	**ON**
Close	Close	**OFF**	AUTO/ON	AUTO/ON	**OFF**

Note: the triggering factor is marked bold face.

Emergency stop notification (using D2)

For safety reasons the chiller unit may be equipped with an emergency switch for manual intervention.

The emergency switch is hard-wired with the control circuit. It interrupts the control circuits of the contactors and stops all loads directly to prevent any accidents.

For notification purposes, the application provides a potential-free digital input for 'emergency stop'.

When the digital input is **triggered** (disabled) during operation, the unit will be stopped immediately and all outputs switched off.

An emergency switch alarm will be raised (*AlmEmgStp*).

The unit can be restarted by clearing the alarm and disabling (triggering) the **emergency switch**.

NOTICE	
!	Emergency switches are safety relevant devices. Their usage, function and installation are prescribed by regulations. The emergency stop input is only for notification purposes. It cannot be used for switching off the loads.

General alarm (using Q3)

General alarm means a fault indication to an external BMS or signal lamp.

In case of the unit alarm (general alarm), this output is closed. The output remains closed as long as the alarm condition is present.

Gas leak notification (using D1)

The potential-free input is intended to indicate/notify gas leak alarms generated by a separate stand-alone gas leak detector.

If the digital input is **triggered**, the unit will be stopped immediately and an alarm (*AlmGasLeakDet*) raised. To restart the unit, a manual alarm reset is required.

NOTICE	
!	Gas leak detectors are safety relevant devices. Their usage, function and installation are prescribed by regulations. The gas leak notification is only an auxiliary function to generate alarms. The controller may not be used for emergency and/or safety control of fans or dampers related to gas leakage.

Phase monitoring alarm (using X7)

The potential-free input is intended to indicate/notify alarms generated by a separate stand-alone power supply system detector.

If the digital input is **triggered**, the unit will be stopped immediately and an alarm (*AlmPhLosPrt*) raised.

The alarm is released automatically 2 times / hour. Afterwards the unit will be locked and a manual reset is required.

5 HMI: configuration and testing

5.1 Configuration workflow

Access levels

The configuration and commissioning workflow is structured by access levels.

OEM engineers with access level **'Factory'** (indicated with **[factory]** in this document) define strategic parameters and assign hardware.

Commissioning engineer with access level **'Service'** (indicated with **[service]** in this document) adjust settings (e.g. for optimizations).

Structure of configuration and commissioning

The configuration and commissioning workflow consists of 2 parts:

1. 'Common Configuration': completed with Configuration1=done.
2. The individual 'Unit configurations' which are collectively completed with Configuration2=done.

'Common Configuration' itself is divided into:

- Cross-Unit, common parameters.
- So called Pre-Configurations of the individual units.

Configuration1 customizes parameter set of Configuration2

As a saved Configuration1 affects the parameter set of Configuration2, it is recommended:

- To complete Configuration1 completely, or at least
- To complete the respective Pre-Configuration, to be able to access the resulting parameter set in Configuration2.

5.1.1 Common Configuration, without pre-configuration

▷ You have access level Factory.

▷ The plant is not configured (state: Unit not Config).

1. Navigate to 'Main menu > Commissioning > Common Configuration'.
   ⇨ The menu is divided up into sections; common parameters are at the top.
2. Define the common plant parameters in the subsection -- Common Configuration – according to the following list:

[factory] Main menu > Commissioning > Common Configuration > -- Common Configuration –

Parameter	Range	Default	Description
Refrigerant type		R134A	Refrigerant type
R134A, R1234ze, R515B, R1234yf, R450A, R513A, R290, R448A, R449A, R407C, R407F, R407A, R404A, R507A, R454C			
Number of circuits	1, 2, 3	-	Number of circuits
Number of pumps	1, 2	1	Number of pumps
Pump Overload		No	Digital input for pump overload available, bit setting, X5/X6
No, Close=Alm, Open=Alm			
Remote switch		Open=On	Digital input for remote switch, bit setting, DL1
No, Close=On, Open=On			
Gas leak notification		No	Digital input for gas leak notification, bit setting, D1
No, Close=Alm, Open=Alm			
Unit switch		Close=On	Digital input for unit switch, bit setting, DL2
No, Close=On, Open=On			
Emergency stop notification		No	Digital input for emergency stop notification, bit setting, D2
No, Close=Alm, Open=Alm			
Capacity limitation		No	Unit capacity limitation, X2
No, Yes			
Setpoint manipulation		Dis	Supply water setpoint manipulation ● No setpoint manipulation ● In relation to outside temperature ● Direct manipulation by a 4..20 external signal ● Providing 2 setpoints; toggling with binary input
Dis, TOa, mA, DblSp			
Ambient temperature		NTC10KB3977	Assignment for ambient temp., X11
NTC10kB3435, NTC10kB3977, NTC100kB3978, Ni1000LG, Pt1000			
Supply temperature		NTC10KB3977	Assignment for supply temperature, X10
NTC10kB3435, NTC10kB3977, NTC100kB3978, Ni1000LG, Pt1000			
Return temperature		NTC10KB3977	Assignment for return temperature, X9
NTC10kB3435, NTC10kB3977, NTC100kB3978, Ni1000LG, Pt1000			
Flow switch		Open=Alm	Bit setting for flow switch, X8
Close=Alm, Open=Alm			
Phase loss protection		Open=Alm	Bit setting for phase loss protection, X7
Close=Alm, Open=Alm			
Unit alarm		Close=Alm	Bit setting for unit alarm, Q3
Close=Alm, Open=Alm			

Parameter	Range	Default	Description
Suction gas temperature		NTC10KB3435	Assignment for suction gas temperature sensor M_B1
NTC10kB3435, NTC10kB3977, NTC100kB3978			
Discharge gas temperature		NTC10KB3435	Assignment for discharge gas temperature sensor, M_B2
NTC10kB3435, NTC10kB3977, NTC100kB3978			
Evap. pressure sensor		QBE-P10U	Assignment for evaporator pressure sensor, MX_X3
QBE-P10U, QBE-P25U			
Cond. pressure sensor		QBE-P25U	Assignment for condensator pressure sensor, MX_X4
QBE-P25U, QBE-P30U, QBE-P60U			
HP detector		Open=Alm	Bit setting for high pressure supervision
Close=Alm, Open=Alm			
LP detector		Open=Alm	Bit setting for low pressure supervision
Close=Alm, Open=Alm			

◈ Complete this configuration step with Configuration1=Not done > Configuration1=Done.

⇨ The controller will be restarted.

5.1.2 Unit Configuration, with Pre-Configuration

▷ You have access level Factory. You configure strategic parameters and hardware assignments for the individual units (e.g. Compressor, Fan, etc.).

▷ Either you adjust the resulting settings of step2 in your factory role, or you can collaborate with the service role who adjusts the resulting settings in the field.

1. Navigate to 'Main menu > Commissioning > Common Configuration' to the respective Pre-Configurations (Compressor, Condenser-, Expansion Pre Configuration, etc.) and set up the strategic parameters as well as the hardware assignments.
2. Complete one or all Unit Pre-Configurations with Configuration1=Not done > Configuration1=Done.

⇨ The application calculates the possible and resulting settings for the Unit sub menu.

The following lists show the combined configurations in context:

(1) Capacity / Compressor

[factory] Main menu > Commissioning > Common configuration > -- Compressor Pre-configuration –

Parameter	Range	Default	Description
Compressor type		Step	The application supports different compressor types and combinations of them.
Step, CSVH, Vacon, Analog, CSVH+Step, Vacon+Step, Step+Analog			
SE-i1	Yes/No	No	Compressor protection and monitoring device
Compressor motor control		DirStt	Compressor motor control ● Part winding start motor control ● Direct start motor control
PartWdg, DirStt			
Compressor overload		Open=Alm	Compressor overload

Parameter	Range	Default	Description
Open=Alm, Close=Alm			
Rotation strategy		OpHrs	Circuit rotation strategy ● Start/stop determined by operating hours of each single compressor ● Defined sequence. Increase: 1, 2, 3. Decrease 3, 2, 1 ● Compr 1 always starts first and stops last. Compr 2 and 3 determined by operating hours
OpHrs, FixOrd, FixOrdOpHrs			
Capacity distribution		Prl	Capacity distribution between circuits ● Prl: compressors increase/decrease capacity equally, gradually in parallel ● PrlCmp: First compressor compensates capacity jump of next compressor.
Prl, PrlCmp			

[service] Main menu > Commissioning > Capacity control configuration
See the section 'Capacity control' of this document.

(2) Condenser

[factory] Main menu > Commissioning > Common Configuration > -- Condenser Pre-configuration –-

Parameter	Range	Default	Description
Fan type	Stage, VSD	Stage	Application supports two fan types
Fan stages	1..7	1	Number of fan stages
Number of fan overload	1..5	1	Number of fan overload
Fan overload		Open=Alm	Definition of status bit
Open=Alm, Close=Alm			
Condenser control type		FltgSpSeqStCtl	Condenser control type ● Fixed setpoint stage control is characterized by 1 setpoint that is valid for all fan stages. Fan stage up/down bands define the control range set. ● Floating setpoint fan stage-up bands are defined from setpoint, respective from previous fan stage-up value. Sum of all fan stage-up bands define the control differential. ● Proportional VSD control ● Proportional integral VSD control
FixdSpSeqStCtl, FltgSpSeqStCtl, PCtl, PICtl			
Condenser control variable		TCnd	Condenser control variable ● Saturated vapor temperature of condenser ● Temperature difference across condenser
TCnd, DTCnd			

[service] Main menu > Commissioning > Condenser control configuration
See the 'Condenser control' section of this document.

(3) Expansion

[factory] Main menu > Commissioning > Common configuration > -- Expansion Pre. Configuration –-

Parameter	Range	Default	Description
Common EEV parameter settings		Yes	Same setting for all producers. Parameter values are applied for all circuits. Condition: >1 circuit. To be able to enter, the parameters are duplicated
No, Yes			

[factory!] Main menu > Commissioning > Expansion control configuration

Parameter	Range	Default	Description
VlvTyp		MVL661.15-1.0	Type of expansion valve. See Siemens datasheets.
MVL661.15-1.0, MVL661.20-2.5, MVL661.25-6.3, MVL661.32-10			
PmpDnCnf		No	Pump-down function. Defines refrigerant liquid level control in evaporator during circuit shutdown ● Refrigerant circuit executing shut-down transition closes EEV and disables last compressor at same time ● Refrigerant circuit executing shut-down transition reaches minimum capacity, closes EEV and disables compressor after SpPmpDn is reached. ● EEV valve remains in closed position during circuit start-up transition until SpPmpDn is reached. ● Pump-down is executed during start-up and shut-down transition
No, End, Stt, Stt+End			
PmpDnRcCnf	Dis/En	Dis	Pump-down recovery function. In case of pump-down configurations (No) or (End), and if **PuDnRcCnf** is enabled, circuit performs regular (Stt) function during start-up.

[service] Main menu > Commissioning > Expansion control configuration > [Circuit]

See the 'Expansion control' section of this document.

(4) Pump

[factory] Main menu > Commissioning > Common configuration > -- Common Configuration –

Note: For the number of pumps and pump overload, see the 'Common configuration' section.

[factory!] Main menu > Commissioning > Pump control configuration

Parameter	Range	Default	Description
EvpPuCnf			Pump configuration ● 2 pumps rotated according to operating hours; the one with the lowest hours starting. ● Only 1st pump ● Only 2nd pump ● 1st is main pump, 2nd as backup ● 2nd pump is main, 1st as backup
PuRot, Pu1Sgl, Pu2Sgl, Pu1Mn, Pu2Mn			
EvpPuCho		Dis/En	Evaporator pump change-over enables automatic change of pump during evaporator flow monitoring in case of flow interruption. For proper operation, consider correct DlyAlmFl settings!

Parameter	Range	Default	Description
KickFnctEvpPu		Dis/En	Evaporator pump kick function; periodical command of evaporator pump during standstill

[service] Main menu > Commissioning > Pump control configuration >

See the 'Pump control' section of this document.

(5) Thermoregulation

[factory] Main menu > Commissioning > Common configuration > -- Common Configuration –

Note: For the number of circuits, capacity limitation and setpoint manipulation, see the 'Common configuration' section.

[factory!] Main menu > Commissioning > Common configuration > -- Thermoregulation Pre. Configuration –

Parameter	Range	Description
Glycol content vol %	0-30%	Influence to several setpoints and setpoint ranges (see tables below)

[service] Main menu > Commissioning > Thermoregulation configuration >

See the 'Thermo control' section of this document.

(6) Compressor interface configuration

Note: This is a supporting menu for configuration. For details, see the corresponding chapters of the units.

The menu appears in ‘Commissioning’ for all configurations except when only DirStt Cpr has been configured.

◈ Complete the configuration step with Configuration2=Not done > Configuration2=Done.

⇨ The controller will be restarted.

5.2 Wiring test

⚠ WARNING

Accidents due to direct switching of outputs

Wiring test enables the operator to control directly the controller I/Os.
During a wiring test the controller logic including protection functions are disabled.
Direct switching of outputs controlling loads can lead to accidents.
For security reasons, the wiring test menu can only be accessed with an HMI physically connected on site.

You can find the wiring test on your connected hard HMI under 'Main Overview > Main menu'.

Activating the wiring test

To activate the wiring test, select 'Wiring test: Active' and confirm with 'Apply'.

Immediately after activation, the number of currently inactive IOs becomes immediately available on the 'Num.IO out of s.' datapoint.

Evaluating read values / Manipulating write values

The IOs of the wiring test are organized into common and circuit(n) values.

In wiring tests, all inputs and outputs are displayed with physical values. For example, sensor values are given as raw information (Ohm values) for a deep research on the physical situation on the plant.

Ending the wiring test

To end the wiring test, select 'Wiring test: Passive' and confirm with 'Apply'.

6 Thermoregulation

For the basic and pre-configuration options see (5) Thermoregulation in section 'Configuration workflow [→ 18]'.

Introduction

Thermoregulation is the main function of a chiller unit.

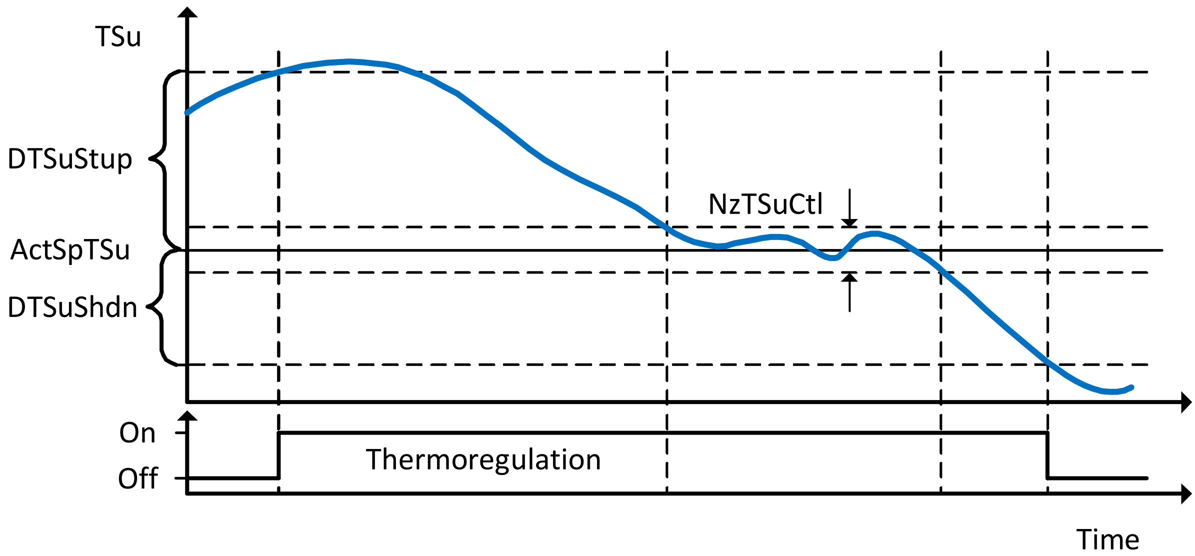
- The loop controller continuously compares the supply water temperature with the active setpoint and generates a capacity request determined by the temperature deviation.
- The capacity request is managed by the capacity control, where the availability of circuits and further considerations and functions are considered (see section 'Compressor and capacity control [→ 34]').

The application supports different control functions to ensure high system stability and efficient plant operation, including e.g. setpoint manipulation or frost protection.

6.1 Supply temperature control

6.1.1 Start and stop behavior

Configuration	Description	Unit	Default	Range
NzTSuCtl	Neutral zone for supply temperature control	K	0.4	0...5.0
DTSuStup	Start-up temperature difference for first circuit	K	2.5	0...7.0
DTSuShdn	Shut down temperature difference for last circuit (before standby mode)	K	2.0	0...4.0



Thermoregulation behavior at start (shows 1 circuit)

Legend:

TSu	Supply temperature	DTSuStup	Start-up temperature difference for first circuit
ActSpTSu	Active setpoint	DTSuShdn	Shut down temperature difference for last circuit (standby)
NzTSuCtl	Neutral zone for TSu control. **Note**: [NzTSuCtl / 2 < DTSuStup and DTSuShdn]		

Function profile:

- Controlling supply temperature
- Usable for all 16 configuration possibilities

Description:

Thermoregulation is activated when the controlled temperature exceeds the active setpoint plus the start-up temperature difference settings (*ActSpTSu + DTSuStup*).

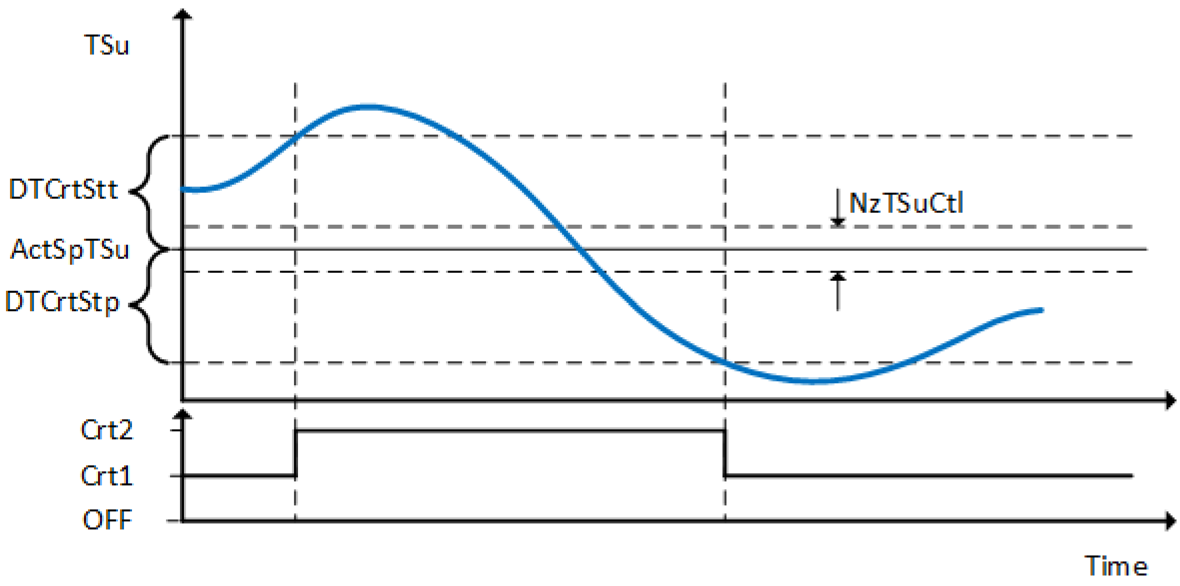
The thermoregulation starts the circuit when the calculated capacity request of the loop controller is higher than the minimum compressor capacity.

Once the controlled temperature is in the range of the neutral zone (*NzTSuCtl*), the cooling capacity stays unchanged.

If the controlled temperature drops below the active setpoint minus the shut-down temperature margin (*ActSpTSu – DTSuShdn*), the thermoregulation is deactivated and the last remaining circuit shuts down. The unit then enters standby mode.

6.1.2 Circuit staging

Configuration	Description	Unit	Default	Range
NzTSuCtl	Neutral zone for supply temperature control	K	0.4	0...5.0
DTCrtStt	Temperature difference to start next circuit	K	2.0	0...4.0
DTCrtStp	Temperature difference to stop other circuit	K	2.0	0...4.0



Circuit start / stop behavior

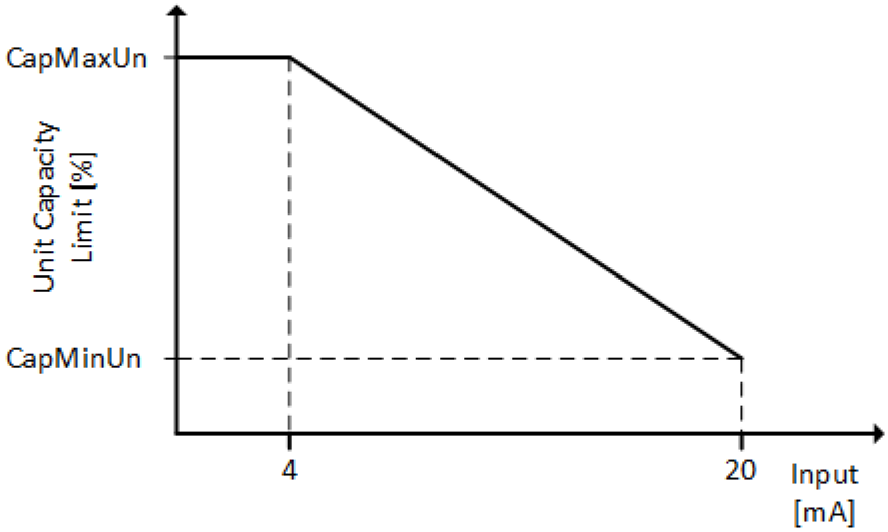
TSu	Supply temperature	DTCrtStt	Temperature difference to start next circuit
ActSpTSu	Active setpoint	DTCrtStp	Temperature difference to stop other circuit
Crt1, 2	Circuit 1, Circuit 2		
NzTSuCtl	Neutral zone for TSu control. **Note**: [NzTSuCtl / 2 < DTSuStup and DTSuShdn]		

Function profile:
- Controlling supply temperature
- Usable for multiple circuits (2..3)

Description:
In case the chiller unit features more than one circuit, staging up and down of circuits depends on the capacity request from thermoregulation and is additionally considering the circuit stage up and down temperature settings.
If the maximal available circuit capacity has been reached and the controlled temperature rises above the circuit start-up temperature difference (*DTCrtStt*), the next circuit is started.
When the chiller unit operates with more than one circuit and the controlled temperature drops below the circuit stop value (*DTCrtStp*), the next circuit is shut down.

6.2 Capacity limitation

Configuration	Description	Unit	Default	Range
CapMaxUn	Unit capacity limitation maximal capacity	%	100	50...100
CapMinUn	Unit capacity limitation minimal capacity	%	30	0...50



Unit capacity limitation

CapMaxUn	Unit capacity limitation, maximal capacity	CapMinUn	Unit capacity limitation, minimal capacity

Function profile:

- Capacity is strongly linked to thermoregulation. The function is used to improve efficiency for limited periods of time (e.g. to stabilize the electrical network).
- Can be used with all thermoregulatory configurations.

Function description:

The capacity limitation function reduces the available capacity in the unit via an external signal (4-20 mA).

The external signal sets the minimum and maximum unit capacity (*CapMinUn / CapMaxUn*).
The available capacity of the unit is limited according to the input signal.

The lowest minimal unit capacity is given by the compressor (capacity) settings. This means that only value settings above *CapMinUn* are accepted.

Otherwise, the lowest compressor capacity is the minimum unit capacity.

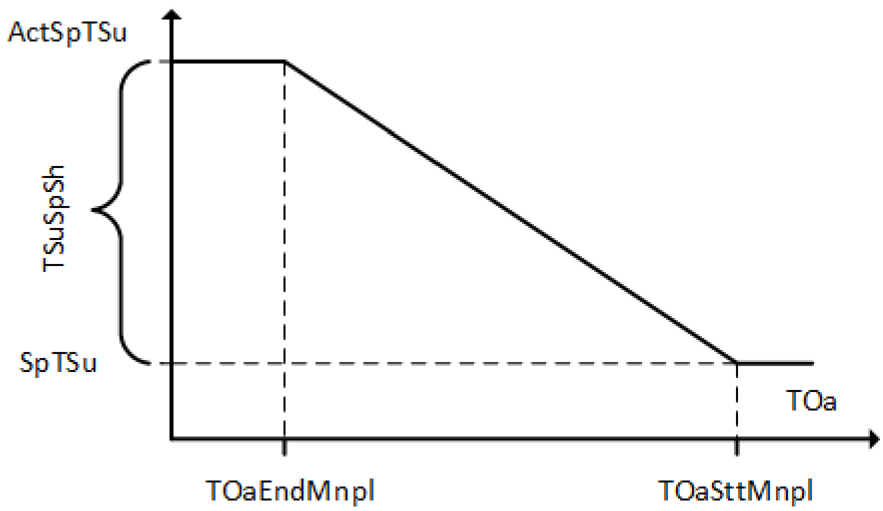
6.3 Setpoint manipulation strategies

Function profile of the various types of setpoint manipulations

- Setpoint manipulations can generally contribute to efficiency.
- Can be used with all thermoregulatory configurations.

6.3.1 Manipulation using outside temperature (TOa)

Configuration	Description	Unit	Default	Range
TSuSpSh	Range of setpoint shift (supply temperature)	K	4	0...10
TOaSttMnpl	Start value of setpoint manipulation (TOa)	°C	25	20...40
TOaEndMnpl	End value of setpoint manipulation (TOa)	°C	25	20...40



Setpoint manipulation by outside temperature

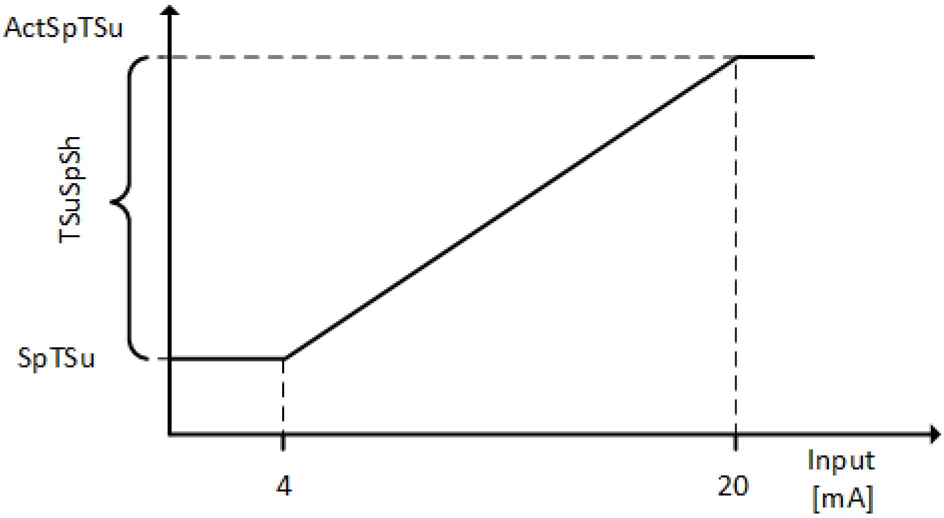
SpTSu	Supply temperature setpoint	TOaSttMnpl	Start value of setpoint manipulation (TOa)
ActSpTSu	Active supply temp setpoint	TOaEndMnpl	End value of setpoint manipulation (TOa)
TOa	Outside temperature	TSuSpSh	Range of setpoint shift (supply temperature)

Description:

- The function sets the supply water temperature setpoint in relation to the outside temperature (*TOa*).
- The supply water temperature setpoint is active for outside temperature ranges above the limit *TOaSttMnpl*.
- For outside temperatures between *TOaSttMnpl* and *TOaEndMnpl*, the supply temperature setpoint value increases according to the range of *TSuSpSh*.

6.3.2 Manipulation using direct signal 4..20 mA

Configuration	Description	Unit	Default	Range
TSuSpSh	Range of setpoint shift (supply temperature)	K	4	0...10



Setpoint manipulation by 4..20 mA signal

SpTSu	Supply temperature setpoint	TSuSpSh	Range of setpoint shift (supply temperature)
ActSpTSu	Active supply temperature setpoint		

Description:

- The setpoint for the controlled temperature can be manipulated directly by a 4..20 mA signal.
- For input values below 4 mA, no change of setpoint is applied.
- From 4 mA up to 20 mA, the active setpoint is set in linear relation to the setpoint shift (*TSuSpSh*).

6.3.3 Manipulation using 2 setpoints

Configuration	Description	Unit	Default	Range
SpTSu1	Supply temperature setpoint 1	°C	12.0	5...20.0*
SpTSu2	Supply temperature setpoint 2	°C	12.0	5...20.0*

Description:

- The 2 setpoint function provides the option of using two different setpoints that are controlled by a binary input.
- The first setpoint (*SpTSu1*) is active as long as the digital input is **open**, and the second setpoint (*SpTSu2*) becomes active when the digital input is **closed**.

6.4 Frost protection

Configuration	Description	Unit	Default	Range
SpFrPrt	Frost protection setpoint	°C	4.0	4.0...8.0*

*) depends on the glycol content.

Alarms	Description	Response	Reset
FrPrtAlm	Frost protection alarm	Unit OFF, pump continue	Auto

Function profile:
- Frost protection as a temperature issue is closely linked to thermoregulation.
- Can be used with all thermoregulation configurations; independent of other strategic thermoregulation parameters.

Description:
Frost protection prevents the water in the evaporator from freezing.

The function is always active, both in standby mode and during operation.

In case the supply or return water temperatures drop below the frost protection setpoint (*SpFrPrt*), the evaporator pump is automatically activated to prevent freezing damage of the evaporator.

If frost protection becomes active while the unit is in operating mode, the entire unit shuts down in response to the alarm (*FrPrtAlm*), while the evaporator pump remains operative.

The frost protection alarm is automatically cleared when both, supply and return water temperatures, rise 2 Kelvin above the frost protection setpoint (*SpFrPrt*).

Relationship of frost protection setpoint defaults to glycol content

The frost protection default **setpoint** (*SpFrPrt*) and its possible range are directly linked to the glycol content of the coolant, see following table:

X [vol %]	Freezing point [°C]	SpFrPrt [°C]	Range [°C]
0	0	**4.0**	4.0...8.0
10	-3.67	**0.0**	0...4.0
15	-6.09	**-2.0**	-2.0...2.0
20	-8.88	**-4.0**	-4.0...0
25	-12.10	**-8.0**	-8.0...-4.0
30	-15.79	**-10.0**	-10.0...-6.0

Table 1: Glycol content and frost protection setpoint

NOTICE	
!	**Freezing risk due to incorrect setpoint** ● When using any other coolant (than water/glycol), make sure that the frost protection setpoint is above the freezing point of that specific media. ● The properties of the coolant can change over time. Periodic checks of its properties are recommended to ensure that the freezing point does not increase. ● Please consider local safety regulations for chiller units. Additional fail-safe frost protection devices may be required to protect the evaporator from freezing.

6.5 Supply and return sensor inversion

Alarms	Description	Response	Reset
AlmTSenInv	Temperature sensor inversion alarm	Normal circuit shut down, unit lock	Manual

Function profile:

- Basic requirement function for any temperature/thermoregulation.
- Independent from other strategic thermoregulation parameters.

Description:

- Supply and return water temperature sensor inversion: To ensure a correct installation of supply and return water sensors, the temperature difference between both sensors is monitored.
- In case the return water temperature drops 1 K below the supply water temperature and at least one circuit is running, an alarm (*AlmTSenInv*) is triggered and the unit enters the normal shut-down procedure.
- A manual reset is required to clear the alarm.

6.6 Parameters and configurations

Parameters

Parameter	Description	Unit	Default	Range
SpTSu	Supply temperature setpoint	°C	12.0	5...20.0*
XpTSuCtl	Proportional band of supply temperature control	K	40	1...100
TnTSuCtl	Integral action time of supply temperature control	sec	60	0...600
NzTSuCtl	Neutral zone for supply temperature control NzTSuCtl/2 < DTSuStup and DTSuShdn!	K	0.4	0...5.0
DTSuStup	Start-up temperature difference for first circuit	K	2.5	0...7.0
DTSuShdn	Shut down temperature difference for last circuit (before standby mode)	K	2.0	0...4.0
DTCrtStt	Temperature difference to start next circuit	K	2.0	0...4.0
DTCrtStp	Temperature difference to stop other circuit	K	2.0	0...4.0
CapMaxUn	Unit capacity limitation maximal capacity	%	100	50...100
CapMinUn	Unit capacity limitation minimal capacity	%	30	0...50
TSuSpSh	Range of setpoint shift (supply temperature)	K	4	0...10
TOaSttMnpl	Start value of setpoint manipulation (TOa)	°C	25	20...40
TOaEndMnpl	End value of setpoint manipulation (TOa)	°C	25	20...40
SpTSu1	Supply temperature setpoint 1	°C	12.0	5...20.0*
SpTSu2	Supply temperature setpoint 2	°C	12.0	5...20.0*
SpFrPrt	Frost protection setpoint	°C	4.0*	4...8.0*

*) depends on the glycol content.

Configurations

See section (5) Thermoregulation in the chapter Configuration workflow [→ 18].

7 Compressor and capacity control

For basic and pre-configuration options, see the section (2) Capacity in the "HMI and Workflow" chapter.

The application supports different compressor combination types in order to provide optimal unit efficiency and best control stability.

Supported configurations

Conf#	Circuit1	Circuit2	Circuit3	Example (see addendum)	Section
1	Step			1 x Step compressor, default configuration	13.1
2	CSVH			1 x CSVH compressor, default configuration	13.2
3	VSD Vacon 100			corresponds to CSVH	13.2
4	Analog			corresponds to CSVH	13.2
5	Step	Step		2 x Step compressor, default configuration	13.3
6	CSVH	CSVH		2 x CSVH compressors, default	13.4
7	VSD Vacon 100	VSD Vacon 100		corresponds to CSVH	13.4
8	Analog	Analog		corresponds to CSVH	13.4
9	CSVH	Step		1 x CSHV Cpr, 1 x step Cpr, equal capa	13.5
10	VSD Vacon 100	Step		corresponds to CSVH	13.5
11	Analog	Step		corresponds to CSVH	13.5
12	Step	Step	Step	3 x step compressor, equal capacity, default	13.6
13	CSVH	CSVH	CSVH	3 x CSVH compressors, equal capacity, default	13.7
14	VSD Vacon 100	VSD Vacon 100	VSD Vacon 100	corresponds to CSVH	13.7

Supported compressor technologies

The application supports two different compressor technologies:

1. 4-step capacity control ("slider control") of step compressors.
2. Variable speed drive compressors.

7.1 Two compressor technologies

- VSD compressors
- Step compressors with 4-step capacity control

While variable speed drive compressors are commonly known, the 4-step capacity control of step compressors will be explained briefly.

4 screw compressors solenoid valves CR1…4 are controlled as shown as detailed in the table below:

	CR1	CR2	CR3	CR4
Start/Stop	OFF	OFF	ON	OFF
CapSt1	OFF	OFF	ON	P*
CapSt2	OFF	ON	OFF	P*
CapSt3	ON	OFF	OFF	P*
CapSt4	OFF	OFF	OFF	P*

*) Pulse: Intermittent 10s ON/10s OFF (*TiPulsVlv*)

In order to ensure the start of the compressor under unloaded conditions, a start delay of 5 minutes is applied to the compressor after each controller restart.

The time setting for the intermittent valve control (*TiPulsVlv*) is defined in the application with 10 seconds.

7.2 Overview of described functions

Function	Step	VSD	Documented in..
Circuit control and rotation strategies	x	x	Step compressor functions [→ 42]
Minimal running time	x	x	VSD compressor functions [→ 45], sec. min. running time
Minimal time of stand still	x	x	VSD compressor functions [→ 45], sec. min. time of stand still
Maximal cycling time	x	x	VSD compressor functions [→ 45], sec. max. cycling time
Emergency operating mode	x	x	VSD compressor functions [→ 45], sec. emergency op mode
Start, stop, shut down phase	x	x	VSD compressor functions [→ 45], sec. start / stop
Stage-up, stage-down times	x		VSD compressor functions [→ 45], section stage-up/down times
Capacity distribution	x		VSD compressor functions [→ 45], section capacity distribution
Capacity resolution		x	VSD compressor functions [→ 45], section capacity resolution
Motor control	x	x	VSD compressor functions [→ 45], section motor control

7.3 Common (Step and VSD) functions

7.3.1 Circuit control and rotation strategies

Available circuit control and rotation strategies for configurations

<table>
<tr><th rowspan="2">Rotation strategies</th><th colspan="14">Configurations</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th></tr>
<tr><td>Operating hours</td><td colspan="4" rowspan="3">-</td><td>x</td><td>x</td><td>x</td><td>x</td><td>-</td><td>-</td><td>-</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>Fix order</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>Fix order, Operating hours</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>x</td><td>x</td><td>x</td></tr>
</table>

Function profiles for strategies/functions (a)..(c):

- Usable for multiple circuits (2...3)
- For balancing compressor load

(a) Operating hours

Configuration	Range	Default	Description
Rotation strategy	… OpHrs	OpHrs	Order of compressor start/stop determined by operating hours for each single compressor

Description:

The order in which a compressor is started and stopped can be determined by the number of operating hours (*OpHrs*) of the single compressor.

The compressor with the lowest number of operating hours is started first, followed by other compressors with a low number of operating hours.

In the capacity reduction phase, the compressor with the highest number of operating hours is stopped first, followed by the compressors with the second highest number operating hours etc.

Each time all circuits are OFF, the operating hours are calculated and the rotation order is determined.

(b) Fix order

Configuration	Range	Default	Description
Rotation strategy	… FixOrd	OpHrs	Defined sequence. Increase 1, 2, 3. Decrease 3, 2, 1

Description:

In the fix order (*FixOrd*) compressor operating sequence, the operating hours are not considered. The capacity increase/decrease follows a pre-defined sequence:

- **Increase:** Compressor 1 - Compressor 2 - Compressor 3
- **Decrease:** Compressor 3 - Compressor 2 - Compressor 1

(c) Fix order with operating hours

Configuration	Range	Default	Description
Rotation strategy	… FixOrdOpHrs	OpHrs	Compressor 1 always starts first and stops last. Compressors 2 and 3 determined by operating hours.

Description:

In the fix order with operating hours (*FixOrdOpHrs*) configuration, compressor 1 is always started first and stopped last. The starting and stopping order of compressors 2 and 3 is performed according to operating hours.

- **Increase:** Compressor 1 - Compressor low *OpHrs* - Compressor high *OpHrs*
- **Decrease:** Compressor high *OpHrs* - Compressor low *OpHrs* - Compressor 1

7.3.2 Compressor functions

(a) Compressor minimal running time

Parameter	Description	Unit	Default	Range
TiMinOn	Compressor minimal running time. Common setting for all compressors in a unit.	sec	300	Fix in application

Function profile:

- Usable for all compressor configurations

Description:

- During the minimum running time (*TiMinOn*), a compressor is not switched off except if an alarm situation occurs.
- The minimum running time has higher priority than any rotation logic or capacity request.

(b) Compressor minimal time of standstill

Parameter	Description	Unit	Default	Range
TiMinOff	Minimum time compressor remains OFF after being shut down /stopped. Common setting for all compressors in a unit.	sec	300	Fix in application

Function profile:

- Usable for all Compressor configurations

Description:

- There is a minimum time when a compressor remains unavailable after having been switched off (*TiMinOff*).
- The minimum time of standstill has higher priority than any rotation logic or capacity request.

(c) Compressor maximal cycling rate

Parameter	Description	Unit	Default	Range
MaxNumStt/h	Compressor maximal cycling rate (common setting for all compressors in a unit)	-	4	Fix in application

Function profile:

- Usable for configurations with multiple types of compressors

Description:

- The maximum number of compressor starts per hour (*MaxNumStt/h*) has higher priority than any rotation logic or capacity request.

(d) Emergency operating mode

Parameter	Description	Unit	Default	Range
EmgOpM	Unit emergency operating mode	-	Dis	Dis/En

Function profile:

- Usable for all compressor configurations with 2 or 3 circuits.

Description:

For configurations with more than one circuit, there is the option of operating the unit at reduced capacity (emergency operating mode, *EmgOpM*) when one of the circuits is in an alarm condition (means the circuits not being in alarm are allowed to run).

- Any available circuit or circuits will then operate according to the regular settings.
- The thermoregulation control parameter will adapt to the available capacity to ensure the same unit performance.
- The emergency operating mode has no time limitation.

(e) Compressor start / stop (shut-down)

Parameter	Description	Unit	Default	Range
TiSttup	Compressors start up time at MinFq or CapSt1	sec	15	1...60
MinCapSt	Compressor min. operating capacity stage (MaxCapSt>MinCapSt)	-	St1	St1/St2
SwiFqMin	Compressor min. switch frequency SwiFqMin >/= MinFq	%	35	10...60
MinFq	Compressor min. operating frequency (Limit) MinFq ≤ SwiFqMin	%	25	10...50
TiMinOn	Compressor minimal running time. Common setting for all compressors in a unit.	sec	300	Fix setting in application

Function profile:

- Usable for all compressor configurations

Descriptions:

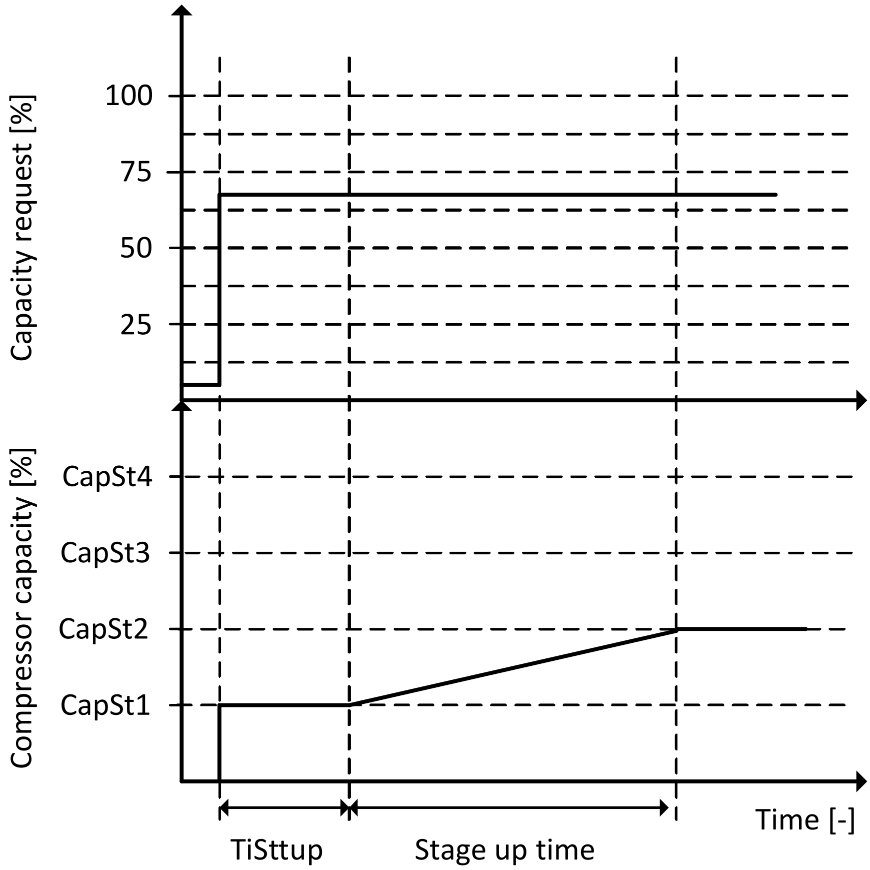
(1) Start phase

- Step compressors always start unloaded (at *CapSt1*)
- VSD compressors start at *MinFq*

The compressor remains at *CapSt1* or *MinFq* for the time *TiSttup* before the capacity is increased to the next higher capacity stage.

Note: If the demand request drops back to 0% during start-up of a compressor with *MinCapSt=St2*, the start-up transition is not interrupted.

Only after reaching *St2*, a capacity decreased or a shut-down is executed (considering *TiMinOn*).

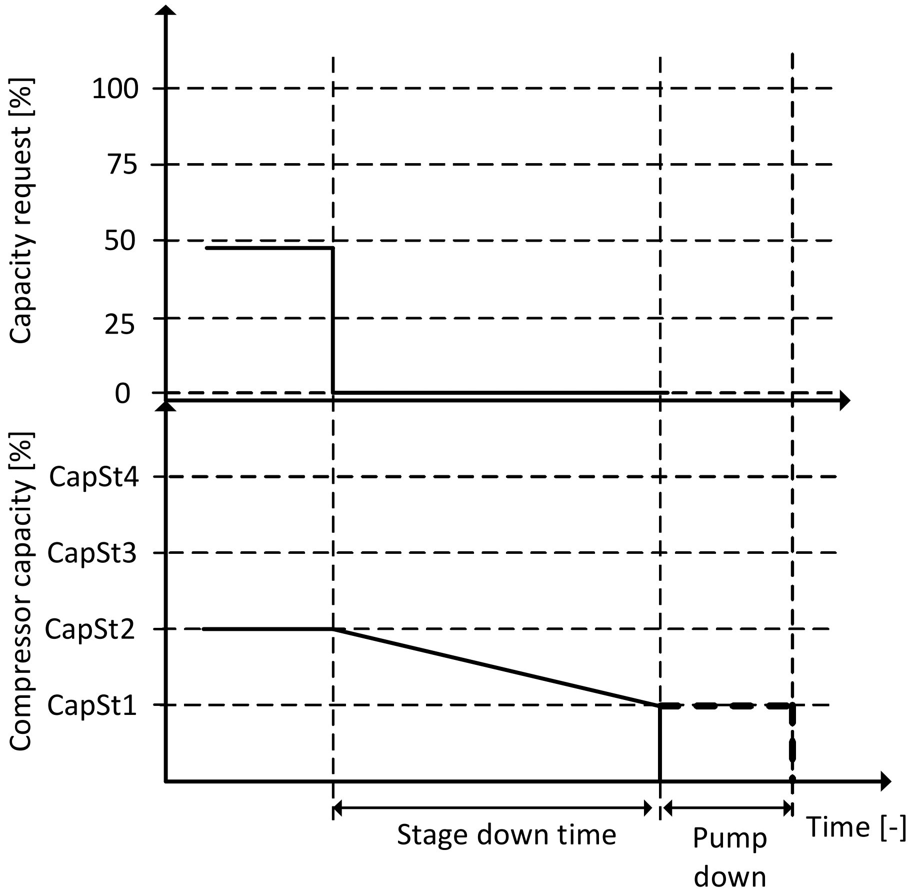


Compressor start up

(2) Stop, shut-down phase

- During the shut-down transition stage, compressors are always commanded into capacity stage 1 before the compressor is switched off.
- VSD compressors stop when reaching *SwiFqMin* or after performing pump-down at *MinFq*.

Note: Once the shut-down transition has started, any new capacity request is ignored. Thus, if the capacity request rises above 0% during shut-down, the shut-down will still continue.



Compressor shut down

(f) Compressor motor control

Configuration	Range	Default	Description
Compressor motor control	PartWdg DirStt	DirStt	Compressor motor control

Parameter	Description	Default	Range
DlyPartWdg*	Compressor motor part winding delay time	ms	500

* This parameter is placed in 'Commissioning > Compressor interface configuration' and refers to "PartWdg".

Function profile:

- Applicable only for step compressors

Description:

The application supports different types of motor controls.

Two relay outputs for each compressor are available to switch contactors for the following motor types:

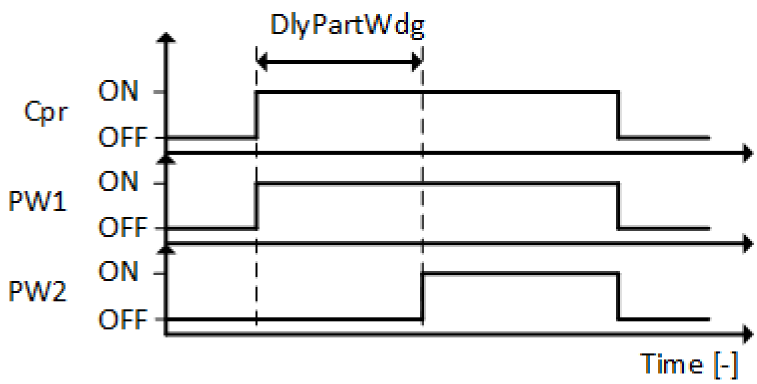
- Direct start
- Part winding

(1) Direct start

One output.

(2) Part winding (PW)

Both outputs are enabled sequentially, while respecting the delay time (*DlyPartWdg*) as shown in the picture below.



Example of parallel compensation and min. capacity stage 2

7.4 Step compressor functions

(a) Stage-up and stage-down times

Parameter	Description	Default	Range
Stage up / down time	**Note**: The fixed values are empirical values from compressor manufacturers		

Function profile:

- Usable for step compressor configurations

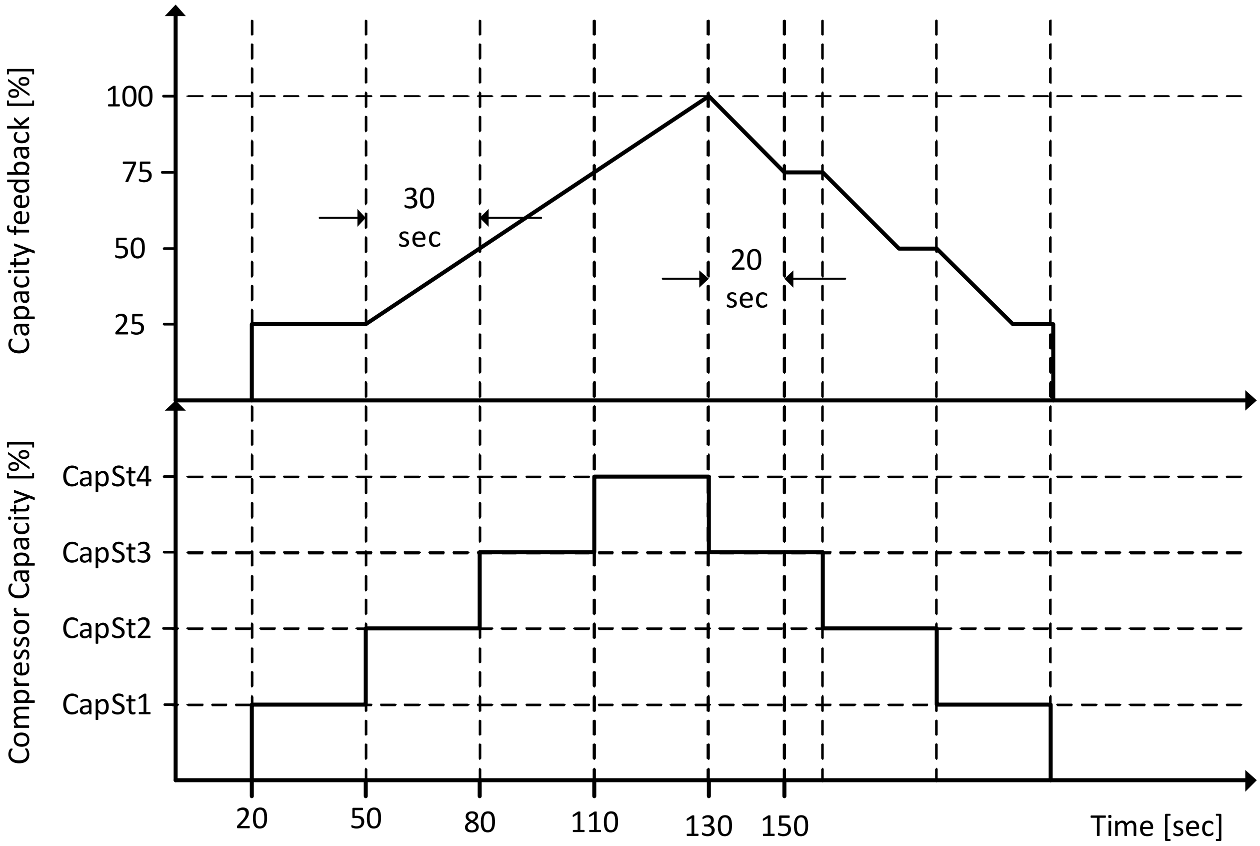
Description:

As step compressors usually do not provide a slider position, the dynamical behavior of the capacity control must be estimated.

Slider positioning speed is related to many factors, such as pressure difference, oil viscosity and mechanical design.

For the control logic, stage-up and stage-down time steps have to be estimated accordingly, as shown in next figure.

Note: The values are fixed for the Chiller application: with 30 seconds up, 20 seconds down.



Stage up (default: 30 sec) / down time (default: 20 sec)

(b) Capacity distribution with parallel comp

Parameter	Description	Default	Range
MinCapSt	Compressor minimum operating capacity stage (MaxCapSt > MinCapSt)	St1	St1/St2
UnLoCapSt	Lowest capacity stage for first and last stage compressor **in the unit** (UnLoCapSt </= MinCapSt)	St1	St1/St2

Configuration	Range	Default	Description
Capacity distribution	Prl PrlCmp	Prl	Capacity distribution between circuits ● compressors increase/decrease capacity equally, gradually in parallel ● First compressor compensates capacity jump of next compressor

Function profile:

- Usable for step compressor configurations, with multiple circuits.

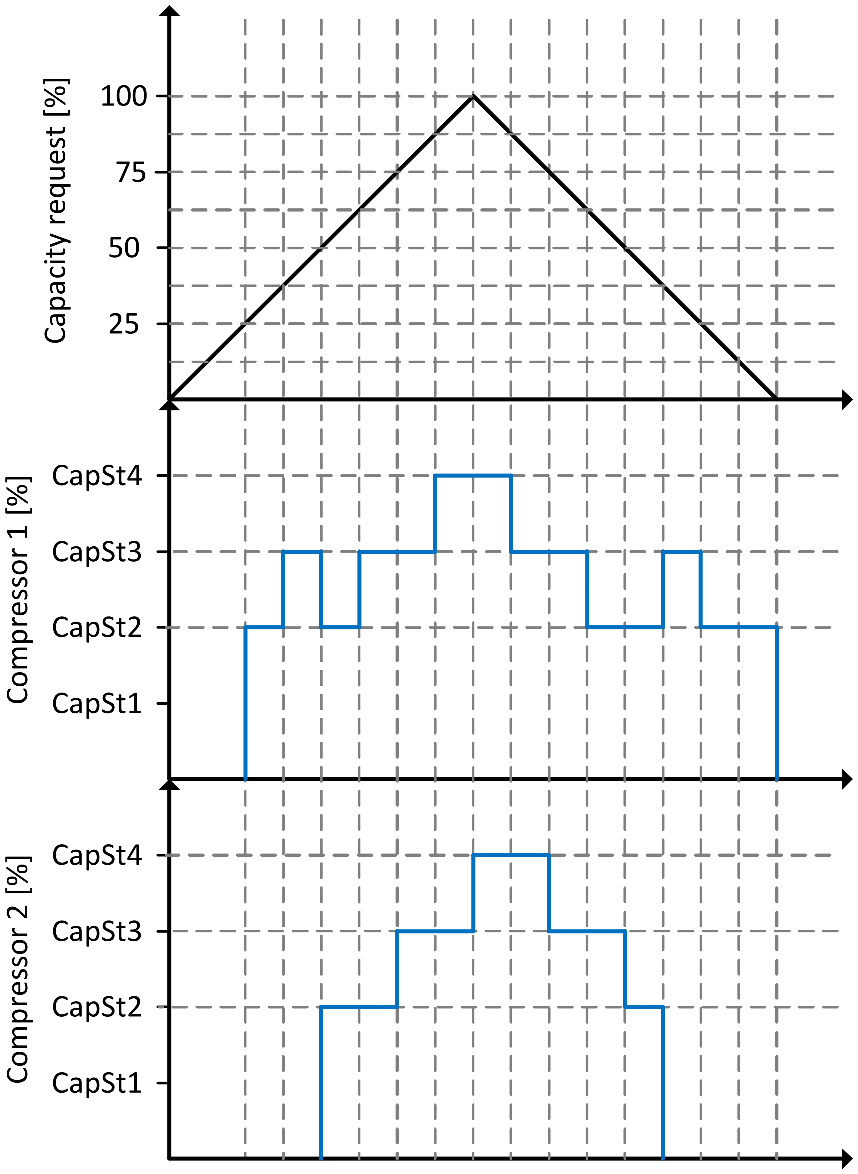
Description:

Unit configurations with 2 and 3 step compressors increase and decrease capacity in **parallel** order.

In case the minimal capacity stage is set by the application to *MinCapSt=St2*, the capacity resolution in partial load decreases.

Note: How flexible the stage in and decrease can be designed using the parameter UnLoCapSt can be found in the examples (see addendum).

By enabling 'parallel compensation' (*PrlCmp*), the first compressor compensates for the load when the second compressor is switched on.



Example of parallel compensation and minimum capacity stage 2

7.5 VSD compressor functions

(a) Compressor capacity resolution

Parameter	Description	Unit	Default	Range
CapRsl	Capacity resolution of modulating control	%	2	1...20 *

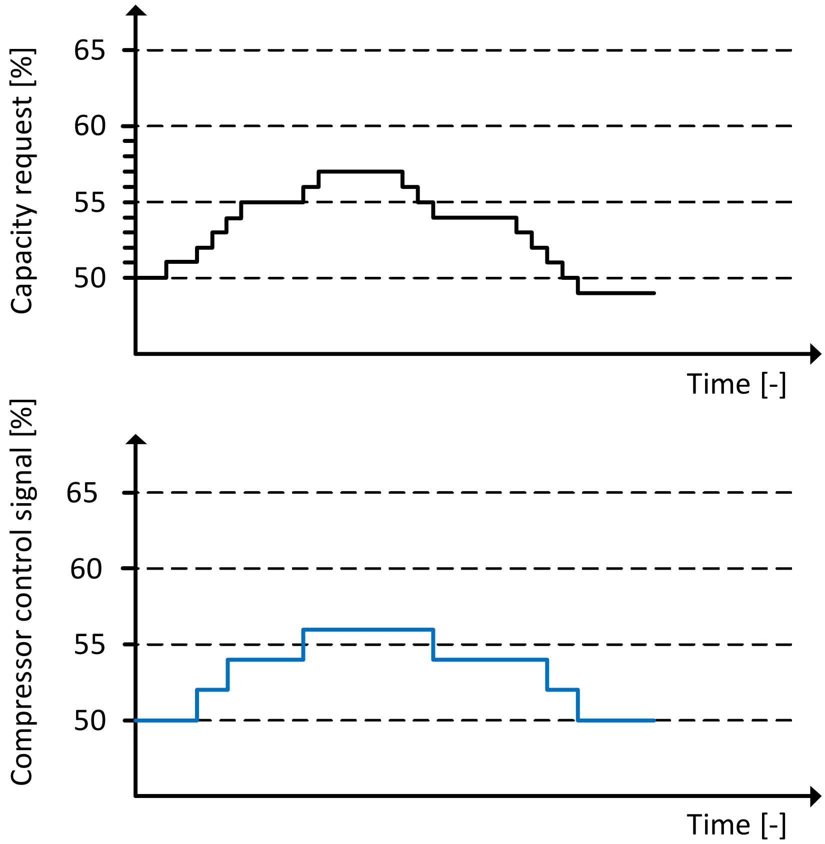
* A resolution of for example 2 percent means that the VSD compressor can accurately track 2 percent changes of the capacity request. For multiple VSD compressors the setting is common.

Function profile:

- Usable for VSD Compressor configurations

Description:

The parameter (*CapRsl*) defines the control signal resolution to a VSD compressor as illustrated below.



Compressor capacity resolution

Explanation: The figure shows a 2-percent resolution, as the VSD compressor reacts to 52%, 54%, 56% requests, and so on.

(b) VSD compressor CSVH (Bitzer)

Configuration	Range	Default	Description
Compressor type	Step **CSVH** …	-	The application supports different compressor types and combinations. Here, CSVH is selected. A combination with Step type is **not** possible for CSVH. Menu ‘Compressor interface configuration’ is used to define the Modbus interface.

Function profile:

- Usable for VSD Compressor configurations
- The menu ‘Compressor interface configuration’ is used for defining the Modbus interface. For example, a Modbus address (1..100) is set up for the built-in RS485:1.

Description:

The application supports Bitzer CSVH compressors controlled over Modbus.

The built-in inverter drive provides a capacity control range of 20 to 100%.

(c) VSD compressor VSD Vacon 100

Configuration	Range	Default	Description
Compressor type	Step … **VSD Vacon 100**	-	The application supports different compressor types and combinations. Here, VSD Vacon 100 is selected. A combination with Step type is possible for VSD Vacon 100. The menu ‘Compressor interface configuration’ is used for defining the Modbus interface.

Parameter	Description	Unit	Default	Range
MaxFq	Compressor max. operating frequency (Limit) MaxFq ≥ SwiFqMax	%	100	60...100
MinFq	Compressor min. operating frequency (Limit) MinFq ≤ SwiFqMin	%	25	10...40

Function profile:

- Usable for VSD compressor configurations.
- The menu ‘Compressor interface configuration’ is used for defining the Modbus interface.

Description:

The application supports the control of a Bitzer standard screw compressor in combination with an external frequency drive (Vacon 100).

The control sequence combines slider and compressor speed control.

The compressor starts under unloaded conditions (slider position 25%) and minimum compressor speed.

Directly after the start of the motor, the slider position is commanded to 100% and the compressor speed is released.

During regular operation the compressor runs between minimum and maximum frequency (specified by the compressor).

If the compressor is forced to shut down, the motor speed is reduced to minimum frequency before switching off the frequency drive.

The slider position is commanded to 25%.

(d) Control via analog signal

Configuration	Range	Default	Description
Compressor type	Step … **Analog**	-	The application supports different compressor types and combinations. Here Analog is selected. A combination with Step type is possible for Analog. **Note**: Not for 3 circuits. The signal is selected from the 'Compressor interface configuration' menu.

Parameter	Description	Unit	Default	Range
MaxFq	Compressor max. operating frequency (Limit) MaxFq ≥ SwiFqMax	%	100	60...100
MinFq	Compressor min. operating frequency (Limit) MinFq ≤ SwiFqMin	%	25	10...40

Function profile:

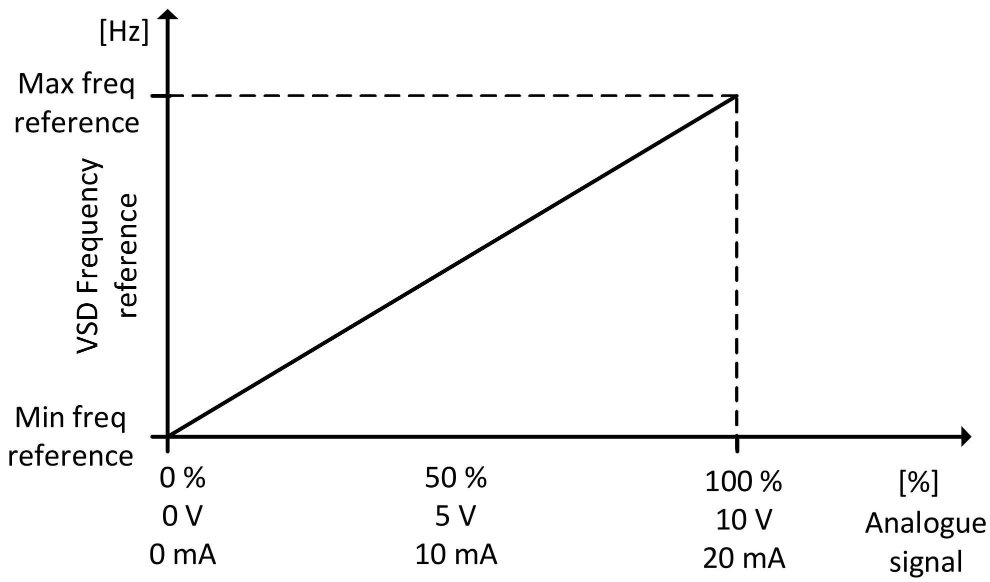
- Usable for VSD compressor configurations.
- The signal can be selected from the 'Compressor interface configuration' menu.

Description:

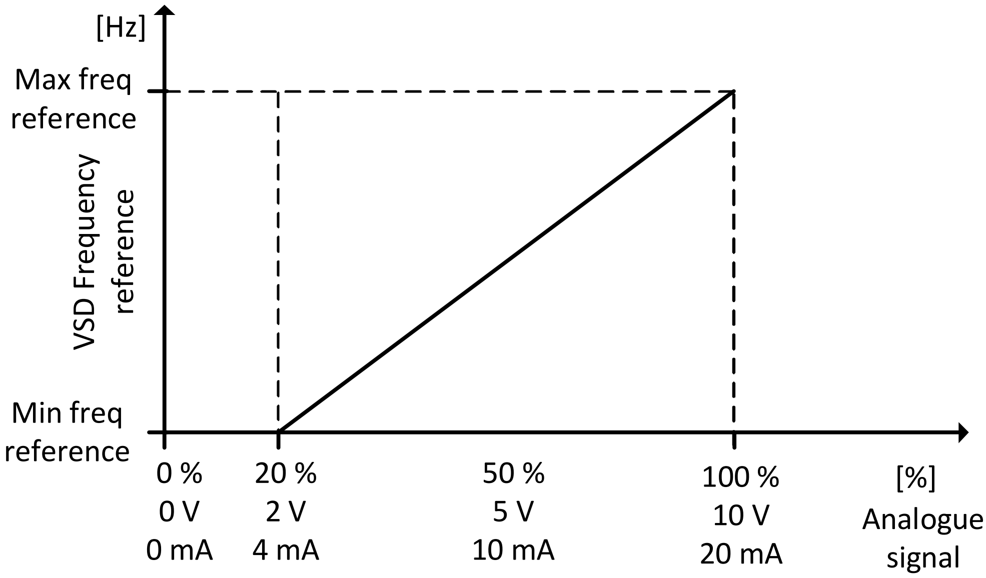
The following signals are supported: 0..10 V, 2..10 V, 0..20 mA, 4..20 mA.

Control via analog signal as compared to VSD Vacon 100

- Alternatively, frequency drives can be controlled by analog signals.
- By configuring '0-10 V control', the same compressor control logic as for VSD Vacon 100 is applied.
- This means that motor speed modulation as well as the slider control sequence are executed.



0..100 VSD compressors



20...100 VSD compressors

7.6 Parameters and configurations

Parameters

Parameter	Description	Unit	Default	Range
NomCap	Nominal cooling capacity. (To/Tc; 5/32°C)	kW	200	1...1000
MaxFq	Compressor max. operating frequency (Limit) MaxFq ≥ SwiFqMax	%	100	60...100
MinFq	Compressor min. operating frequency (Limit) MinFq ≤ SwiFqMin	%	25	10...50
SwiFqMax	Compressor max. switch frequency SwiFqMax ≤ MaxFq	%	90	40...100
SwiFqMin	Compressor min. switch frequency SwiFqMin ≥ MinFq	%	35	10...60
CapRsl	Capacity resolution of modulating control	%	2	1...20
TiRampDn	Ramp down time of modulating compressor (Speed)	%/sec	5	1...20
TiRampUp	Ramp up time of modulating compressor (Speed)	%/sec	5	1...20
TiSttup	Compressors start up time at MinFq or CapSt1	sec	15	1...60
CapSt1	Nominal capacity of compressor stage 1 (CapSt1 < CapSt2 < CapSt3 < CapSt4)	%	25	1...100
CapSt2	Nominal capacity of compressor stage 2 (CapSt1 < CapSt2 < CapSt3 < CapSt4)	%	50	1...100
CapSt3	Nominal capacity of compressor stage 3 (CapSt1 < CapSt2 < CapSt3 < CapSt4)	%	75	1...100
CapSt4	Nominal capacity of compressor stage 4 (CapSt1 < CapSt2 < CapSt3 < CapSt4)	%	100	1...100
MaxCapSt	Compressor max. operating capacity stage. Common setting for all stage compressors in the unit.	-	St4	St3/St4
MinCapSt	Compressor min. operating capacity stage (MaxCapSt > MinCapSt) Applicable only for single circuit. For multiple circuits MinCapSt is St2.	-	St1	St1/St2
UnLoCapSt	Lowest capacity stage for first and last stage compressor in the unit (UnLoCapSt ≤ MinCapSt)	-	St1	St1/St2
EmgOpM	Unit emergency operating mode	-	Dis	Dis/En
TiMinOn	Compressor minimal running time (common setting for all compressors in a unit)	sec	300	-
TiMinOff	Compressor max. operating capacity stage. Common setting for all stage compressors in the unit.	sec	300	-
MaxNumStt/h	Compressor maximal cycling rate (common setting for all compressors in a unit)	-	4	-
TiPulsVlv	Solenoid valve intermittent time	sec	10	fix
DlyPartWdg	Compressor motor part winding delay time	ms	500	0...5000

Configurations

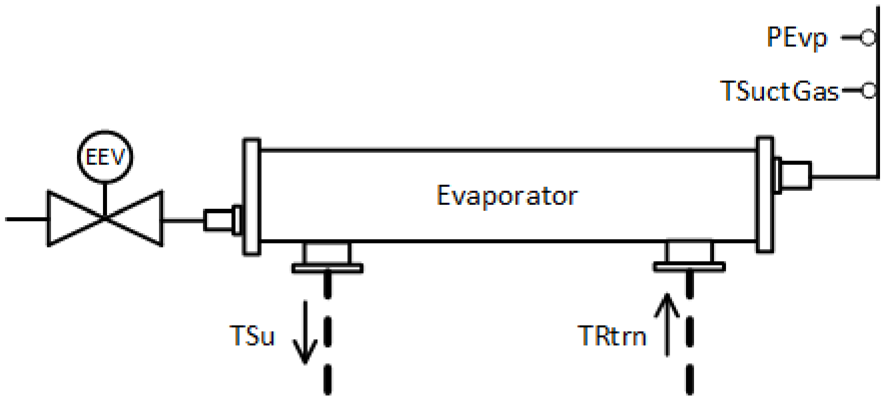
See section (1) Capacity/Compressor in the chapter 'Configuration workflow [→ 18]'.

8 Expansion control

The application supports the following expansion control functions:

- PID superheat (SH) control
- Electronic expansion valve (EEV) start-up sequence
- Low superheat (SH) protection
- Maximum operating pressure (MOP) control
- Low operating pressure (LOP) protection
- Pump-down configurations
- Load-dependent setpoint

A modulating control device, also called Electronic Expansion Valve (EEV) controls the refrigerant flow to the evaporator by continuously adjusting the opening degree of the valve.



System design of a superheat control

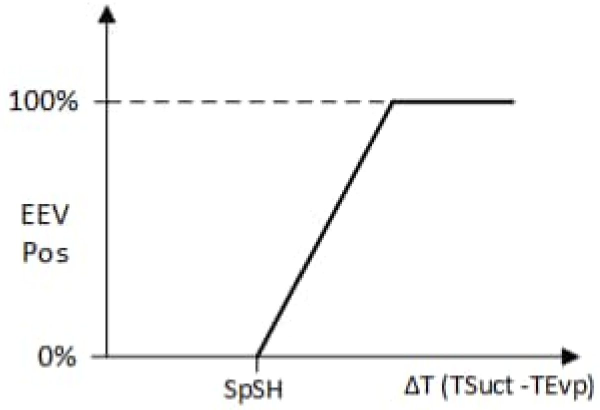
8.1 Superheat control

Parameter	Description	Unit	Default	Range
SpSH	PID superheat control setpoint ΔT = TSuct -TEvp	K	7.0	1...25.0
XpSHCtl	PID superheat control proportional band Xp	K	10	2...160
TnSHCtl	PID superheat control integral action time	sec	30	0...600
TvSHCtl	PID superheat control derivative action time	sec	0	0...100

The application supports a superheat (SH) control function for each single refrigerant circuit.

It monitors the temperature difference between the suction gas temperature and the calculated evaporation temperature (*TSuct -TEvp*) to maintain the adjusted setpoint *SpSH*.

The electronic expansion valve (EEV) is controlled via an analogue output signal.



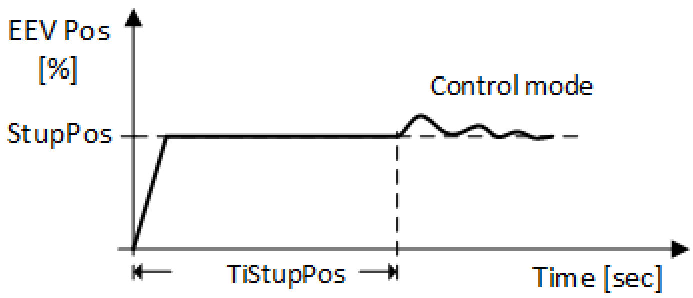
Superheat control

In general, the control and monitoring functions are enabled by starting the compressor of the corresponding circuit. The superheat control behavior is a PID loop control.

To achieve proper control performance, both *SpSH* and the PID settings must be adjusted considering the system dynamics. Factors like the EEV valve dimension, the evaporator type and dimensions, load and operating conditions must be taken into consideration.

8.2 EEV start up sequence

Parameter	Description	Unit	Default	Range
TiStupPos	Electronic expansion valve start-up delay time	sec	0	0...60
StupPos	Electronic expansion valve start-up position	%	0	0...50



EEV start up sequence

The application supports feed-forward control of the EEV during the start-up transition.

During the first seconds after the compressor was started, the superheat control loop can be affected by disturbances, such as flash gas or incorrect sensor values.

These effects can even be further amplified by the active superheat loop controller resulting in alarms.

The EEV start-up sequence allows the system to stabilize after the compressor was started and to transition smoothly into the superheat regulation mode.

Siemens EEV (MVL661) is a normally closed (NC) modulating valve. While the refrigerant circuit is inactive, the valve remains in a closed position ensuring that no refrigerant migrates from high- to low-pressure sides.

In case the EEV start-up sequence is parametrized, the EEV is commanded to the valve start-up position (*StupPos*) at the start of the compressor.

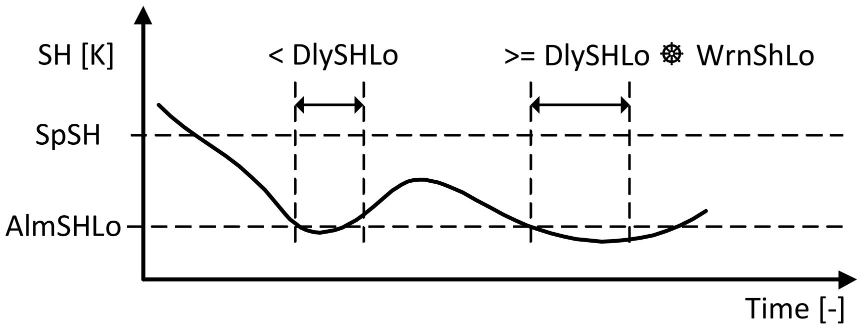
It remains there for the valve start-up delay time (*TiStupPos*). During that time, the superheat-related alarms (such as *AlmLoSh*, *AlmMOP*) are ignored, and the superheat control remains inactive. After expiration of the delay timer *TiStupPos*, the application enters the regular superheat regulation mode.

NOTICE	
!	During the EEV start up sequence, superheat-related warnings and alarms are ignored. Incorrect parameter settings for the EEV start-up sequence can lead to low pressure, low superheat and /or high evaporating pressure/temperature.

8.3 Low superheat protection

Configuration	Description	Unit	Default	Range
AlmSHLo	Low superheat limit	K	2	0...5
DlySHLo	Low superheat delay time	sec	2	0...5

Alarms	Description	Response	Reset
WrnShLo	Low superheat warning	EEV close	Auto 2 times/h
AlmShLo	Low superheat alarm	Circuit OFF	Manual / BMS reset



Low SH protection

To ensure the reliability of the unit and to prolong the life of the compressor, the application supports low superheat protection.

The superheat value is continuously monitored in regulation mode. In case the superheat value crosses the low superheat limit (*AlmShLo*), the protection is activated.

If the superheat value leaves the critical area within the time *DlySHLo*, there is no action.

In case the superheat value remains longer than *DlySHLo* below *AlmSHLo*, the EEV is commanded into close position. *WrnShLo* is notified and automatically reset while the superheat regulation mode continues.

In case *WrnShLo* occurs three times within one hour, the corresponding circuit and compressor are stopped. The alarm *AlmShLo* remains active until a manual or a BMS-generated reset is performed.

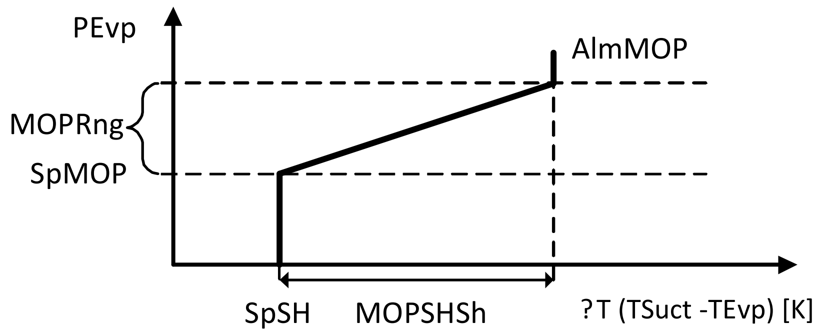
If the valve command does not cause any effect and the superheat value remains below *AlmSHLo* for another 2 seconds, the refrigerant circuit and the compressor are stopped immediately. An alarm *AlmShLo* remains active until a manual or BMS-generated reset has been performed.

NOTICE	
!	A low superheat alarm can result from unstable control behavior or incorrect parametrization of the loop controller. Please consider the safety margin during parametrization, as the real superheat value might differ from the control variable value due to sensor inaccuracy.

8.4 Maximum operating pressure (MOP) control

Configuration	Description	Unit	Default	Range
SpMOP	Maximum operating pressure setpoint, PEvp (TEvp)	°C	25.0*	0...70.0*
MOPSHSh	Maximum evaporation pressure superheat shift	K	5	1...80
MOPRng	Maximum operating pressure band	bar	1.0	1...5.0

Alarms	Description	Response	Reset
WrnMOP	Max operating pressure warning	Increase of ShStpt	Auto within 20 sec
AlmMOP	Max operating pressure alarm	Circuit OFF	Manual / BMS reset



MOP control

Evaporation pressure in combination with suction gas temperature determine the refrigerant density at the compressor inlet. To avoid extensive compressor load during operation, the refrigerant density must remain below a defined limit.

The application controls the maximum operating pressure (MOP) by increasing the superheat setpoint proportionally (the respective *SpSHRef*), ensuring a constant refrigerant density on the compressor inlet. The parameters *MOPSHSh* and *MOPRng* allow adjusting the control behavior to the refrigerant specific properties.

If, during MOP control, the superheat value exceeds the value of the sum *SpSH + MOPSHSh* and *SpMOP* by 0.3 bar, then a warning *WarnMOP* is given.

If that condition remains for more than 20 seconds, an Alarm *AlmMOP* is generated, and the circuit stops. A manual reset or a reset over BMS will be required to clear the alarm.

8.5 Low operating pressure (LOP) protection

Configuration	Description	Unit	Default	Range
SpLOP	Low operating pressure setpoint	°C	0.0**	0...10.0*
DlyLOP	Low operating pressure alarm delay time	sec	5	0...15

Alarms	Description	Response	Reset
WrnLOP			

The application supports low operating pressure (LOP) protection.

During compressor start but also during transitions, the evaporating pressure can drop below the circuit envelop limits for a short period of time. In order to avoid a sudden compressor stop, the LOP alarm delay time (*DlyLOP*) can be used.

Once the evaporating pressure decreases below *SpLOP*, the alarm delay (*DlyLOP*) is set and the warning *WrnLOP* logged.

If the evaporator pressure rises above *SpLOP* within defined delay time, the counter is reset.

In case the evaporating pressure remains below the setpoint *SpLOP* longer than the delay *DlyLOP*, the corresponding refrigerant circuit is shut down.

8.6 Pump-down

Configuration	Range	Default	Description
PmpCnCnf		No	Pump-down configuration. Pump-down logic for both start-up and shut-down transitions
No, End, Stt, Stt+End			
PmpCnRcCnf	Dis, En	En	Pump-down recovery configuration

Parameter	Description	Unit	Default	Range
SpPmpDn	Pump-down setpoint	°C	1.0**	1...30.0**
TioPmpDn	Pump-down time (timeout)	sec	20	1...180

Alarms	Description	Response	Reset
WrnPmpDnShdn	Pump down warning at shut down	Circuit OFF	Auto 2 times/d
AlmPmpDnShdn	Pump down alarm at shut down	Circuit OFF	Manual / BMS reset
WrnPmpDnStt	Pump down warning at start up	Circuit OFF	Auto 2 times/d
AlmPmpDnStt	Pump down alarm at start up	Circuit OFF	Manual / BMS reset
AlmPmpDnRc	Pump down recovery alarm at start up	Circuit OFF	Manual / BMS reset

(A) Pump-down configuration

Control of the refrigerant liquid level in the evaporator during circuit shutdown is provided by the pump-down function. The application supports pump-down logic for both, start-up and shut-down transitions.

Pump-down, setting No

In pump-down configuration *No*, the refrigerant circuit executing the shut-down transition closes the EEV and simultaneously disables the compressor.

Pump-down, setting End

In pump-down configuration *End*, the refrigerant circuit executing the shut-down transition closes the EEV after the compressor reaches its minimum capacity.

The compressor remains in operation until the pump-down setpoint *(SpPmpDn)* has been reached. In case *SpPmpDn* cannot be reached within the time defined by the pump-down time *(TioPmpDn)*, the compressor is stopped and the warning *WrnPmpDnShdn* triggered.

The pump-down warning is automatically reset 2 times per day. When the Alarm *AlmPmpDnShdn* has been generated, a manual or BMS-generated reset is required to clear it.

Pump-down, setting Stt

In pump-down configuration *(Stt)*, the EEV valve remains in its closed position during the circuit start-up transition until the pump-down setpoint *SpPmpDn* has been reached.

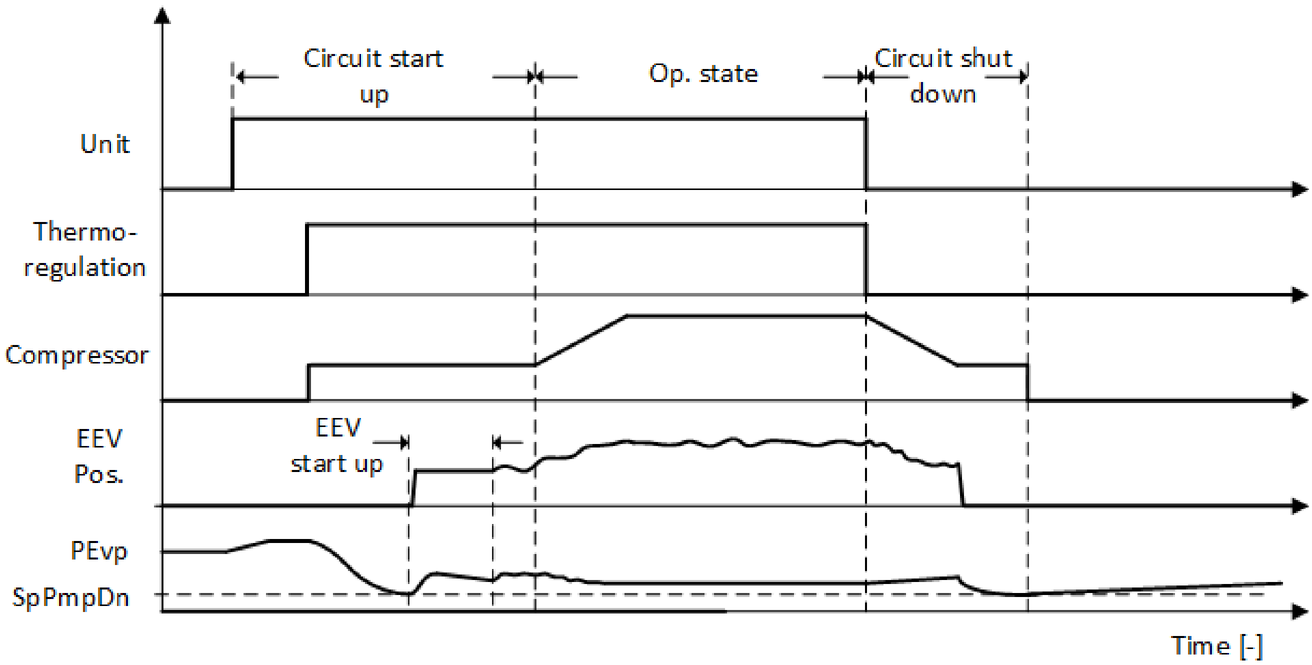
During that phase, superheat control-related alarms (MOP, SH) are ignored.

After that, the EEV enables superheat control mode or triggers the EEV start-up sequence (depending on configuration).

In case *SpPmpDn* cannot be reached within the pump-down time *(TioPmpDn)*, the compressor is stopped and the warning *WrnPmpDnStt* triggered.

Pump-down warnings are reset automatically 2 times per day. When the Alarm *AlmPmpDnStt* has been generated a manual or BMS-generated reset is required.

Pump-down, setting Stt + End



Pump-down behavior (Stt+End)

Pump-down is executed during both start-up and shut-down transitions. The same warning and alarm conditions are valid as described for the specific configurations.

(B) Pump-down recovery

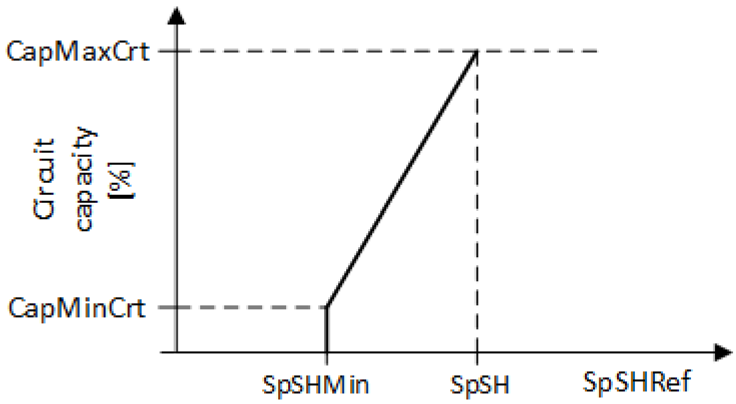
In addition to the described pump-down configurations, there is a pump-down recovery function (*PmpDnRcCnf=Enabled*) to activate pump-down at circuit start-up **after critical alarm conditions** (such as *FlSwiAlm*, *AlmHP*).

In the case pump-down configuration is *No* or *End*, and if the recovery configuration *PmpDnRcCnf is* enabled, the circuit performs a regular *Stt* function during start-up.

In case pump-down **Stt** cannot be performed before timeout *TioPmpDn*, an Alarm *AlmPmpDnRc* is raised and the compressor stops. To clear the alarm, a manual or BMS-generated reset is required.

8.7 Load-dependent superheat setpoint

Parameter	Description	Unit	Default	Range
SpSH	PID superheat control setpoint ΔT = TSuct -TEvp	K	7.0	1...25.0
SpSHMin	Minimum superheat setpoint (≤ SpSH, > AlmSHLo)	K	7.0	1...25.0



Load-dependent SH setpoint

The application supports load-dependent adjustment of the superheat setpoint.

In this case, the minimum superheat setpoint *SpSHMin* is used in linear relation to the circuit capacity. The superheat reference setpoint (*SpSHRef*) is the main control variable.

Also in MOP control, the setpoint *SpSHRef* is the main superheat reference variable.

The load-dependent superheat setpoint is always active. To ensure that the superheat control operates with a fixed value, the values of both setpoints *SpSH* and *SpSHMin* must be set equal.

8.8 EEV max opening alarm

Alarms	Description	Response	Reset
AlmEEVMax	EEV maximum opening alarm	Circuit OFF	Manual / BMS reset

To avoid extensive superheat values, the EEV position command is continuously monitored.

If the EEV position command remains during SH-control mode for more than 60 seconds at 100% (fully open), an Alarm (*AlmEEVMax*) is triggered and the circuit is shut down.

A manual or BMS-generated reset is required to clear the alarm.

8.9 Parameters and configurations

Parameters

Parameter	Description	Unit	Default	Range
SpSH	PID superheat control setpoint *ΔT = TSuct -TEvp*	K	7.0	1...25.0
XpSHCtl	PID superheat control proportional band Xp	K	10	2...160
TnSHCtl	PID superheat control integral action time	sec	30	0...600
TvSHCtl	PID superheat control derivative action time	sec	0	0...100
SpMOP	Maximum operating pressure setpoint, PEvp (TEvp)	°C	25.0*	0...70.0*
MOPSHSh	Maximum evaporation pressure superheat shift	K	5	1...80
MOPRng	Maximum operating pressure band	bar	1.0	1...5.0
SpLOP	Low operating pressure setpoint	°C	0.0**	0...10.0*
DlyLOP	Low operating pressure alarm delay time	sec	5	0...15
TiStupPos	Electronic expansion valve start-up delay time	sec	0	0...60
StupPos	Electronic expansion valve start-up position	%	0	0...50
AlmSHLo	Low superheat limit	K	2	0...5
DlySHLo	Low superheat delay time	sec	2	0...5
SpPmpDn	Pump-down setpoint	°C	1.0**	1...30.0**
TioPmpDn	Pump-down time (timeout)	sec	20	1...180
SpSHMin	Minimum superheat setpoint (≤ SpSH, > AlmSHLo)	K	7.0	1...25.0

*) Depends on the type of refrigerant. **) Depends on the glycol content.

Configurations

See section (3) Expansion in the chapter 'Configuration workflow [→ 18]'.

9 Condenser control

For basic and pre-configuration options, see section (2) Condenser of the Configuration workflow [→ 18] chapter.

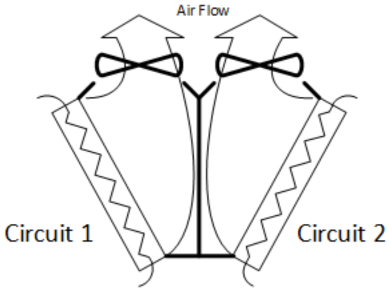
The application features a control of separated condenser, where each circuit is equipped with an assigned fan or fan group.

The control variable can be (1) the saturated vapor temperature of the condenser (*TCnd*) or (2) the temperature difference across the condenser (*DTCnd*).

The separated fan control applies independent control to each circuit.

The parameter settings are common to all loop controllers (that is, for all circuits).

Functions are available for staged fan types and VSD controlled fan types (see overview below).



Separated condenser control

Fan control configuration options

Conf #	Fan type	Condenser control type	Condenser control variable
1	Stage	FltgStptSeqStCtl	TCnd
2		FixdStptSeqStCtl	TCnd
3		FltgStptSeqStCtl	DTCnd
4		FixdStptSeqStCtl	DTCnd
5	VSD	PCtl	TCnd
6		PICtl	TCnd
7		PICtl	DTCnd

9.1 Common control functions and features

(a) Control variables

Parameter	Description	Default	Range
CndCtlVar	Condenser control variable	TCnd	TCnd/DTCnd

The application supports 2 different control variables.

The controlled variable can either be the condensing temperature (parameter *TCnd*) or the temperature difference across the condenser (parameter *DTCnd*).

The saturated vapor temperature of the condenser (parameter *TCnd*) is calculated from the high pressure value of the corresponding circuit. This allows operating the unit at a defined pressure value or in a defined pressure range.

The temperature difference across a condenser is calculated as follows:

DTCnd = TCnd - TOa

Temperature difference across a condenser (*DTCnd*) = Saturated vapor temperature of the condenser (*TCnd*) *minus* Outside temperature (*TOa*)

Hints:

- The formula shows the system always knows TCnd, even if DTCnd is selected.
- Therefore, the function TCndMax (see common, function c) can be used, even if DTCnd is used.
- Take into consideration that for VSD only DTCnd can be set in relation to Capacity (see modulating, function a).
- Also note that DTCnd comes with a DTCndMax and DTCndMin (see modulating, function a). When a DT setpoint is required (see for example staging, function d) DTCndMax can also be used as setpoint. To achieve this, set DTCndMin to DTCndMax.

(b) Malfunctions

The system supports alarm inputs for staged fan (groups) and VSD fans.

The alarm signals indicate malfunctions, such as thermal overload or cable disconnection.

If the safety circuit is cut out (open), the controller will raise an alarm.

In case of an alarm, the condenser control will continue with the remaining fans at reduced capacity.

Note: If fans are grouped to common safety circuits (fan stages), one individual faulty device cannot be identified from the signal/alarm.

(c) High condensing temperature protection

Parameter	Description	Unit	Default	Range
TCndMax	Protection. Maximum permissible condensing temperature/pressure (< HP switch)	°C	70.0 *	20...80*
SpTCnd	Setpoint condensing temperature	°C	30.0	5...65.0
DTCndMax	Setpoint for highest temperature difference across condenser (≥ DTCndMin)	K	12.0	3...30.0
NOTE: [SpDTCnd] is a construct for staging fans built with **DTCndMax.**				

* Refrigerant-related setting

Alarms	Description	Response	Reset
WrnTCndMax	Maximum condensing temperature warning	Warning indication	Auto
AlmTCndMax	Maximum condensing temperature alarm	Normal circuit shut down	Auto: 2 times / day.

To avoid high condensing pressure in the refrigerant circuit, a protection limit is available. For condensing pressures corresponding to condensing temperatures 2 K below the value *TCndMax*, a **warning** is logged (*WrnTCndMax*).

In case the condensing temperature (calculated from the condensing pressure) increases up to the value *TCndMax*, the corresponding circuit is shut down and the 'Maximum condensing temperature alarm' (*AlmTCndMax*) is raised.

The alarm *AlmTCndMax* is automatically cleared when TCnd decreases 10 K below TCndMax. If *AlmTCndMax* occurs 2 times / day, there are 2 automatic restarts. Afterwards, a manual acknowledge is required. This leads to a restart of the system.

NOTICE	
!	The condensing temperature protection is a complementary prevention mechanism of excessive pressure. It does not substitute the fail-safe function of the high-pressure switch prescribed by regulations.

(d) Start-up condensing temperature control

Parameter	Description	Unit	Default	Range
TOaMin	Minimal outside temperature for operation	°C	15.0	1...30.0
DlyStup1	Condensing temperature start up delay time. The value 0 disables start up condensing temperature control.	sec	100	0...100
DlyStup2	Delay time to nominal setpoint	sec	15	0...100
TCndStup	Start-up condensing temperature value (TCndStup ≥ SpTCnd)	°C	30.0	20...50.0

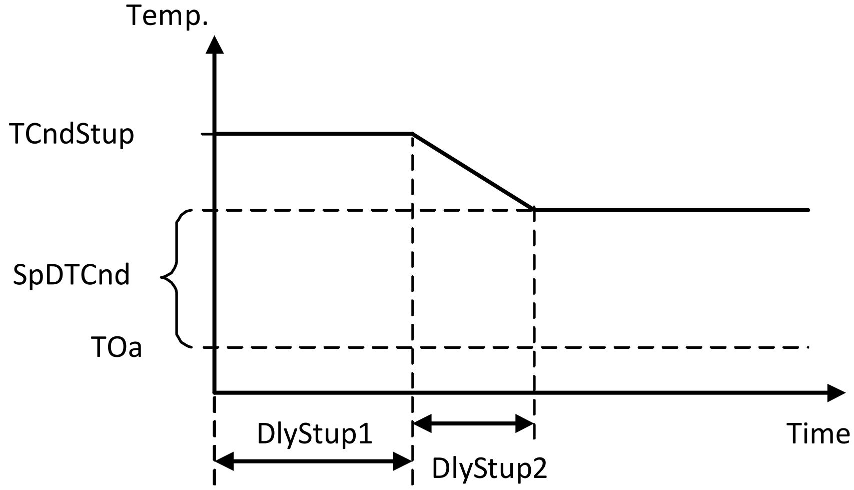
The condenser control is enabled when the outside temperature is above *TOaMin* and when compressor starts (machine status is then TOaLock).

In order to maintain the required pressure difference during the start-up procedure, a set of parameters is available.

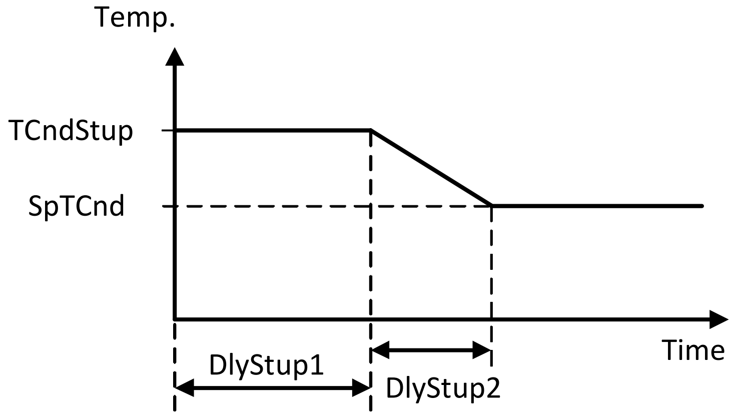
In case the condenser temperature is **below** the value *TCndStup* during start-up, the nominal setpoints ([SpDTCnd] or SpTCnd) are ignored.

The new setpoint *TCndStup* remains active for the delay time (*DlyStup1*), after which it is gradually reduced to the nominal setpoint in time (*DlyStup2*).

In case during start-up the condensing temperature is **above** or equal to the value *TCndStup*, the condenser control switches to the nominal setpoint.



Start-up condensing control



Start-up condensing control 2

(e) Minimum outside temperature TOaMin

Below the minimum outside temperature (parameter *TOaMin*), the machine is in state TOa-lock.

The implemented principles are:

- If the machine is running, temperatures below the minimum outside temperature are no reason to stop.
- If machine is in stopped state, the minimum outside temperature prevents the machine from starting up.

9.2 Stage fan control functions

Introduction

The application allows the assignment of single fans and/or groups of fans to fan stages.

The staging logic is characterized by (1) a setpoint and (2) stage-up and stage-down bands for each fan stage. Individual band settings for each fan stage can be used to adjust the capacity response.

Each circuit supports up to seven fan stages. The stage control is performed sequentially.

It starts with the first fan stage and increases capacity by activating stages in ascending order: stage 1, stage 2, stage 3, stage 4, etc.

The step-down is realized in the reverse order: stage 7, stage 6, stage 5, etc.

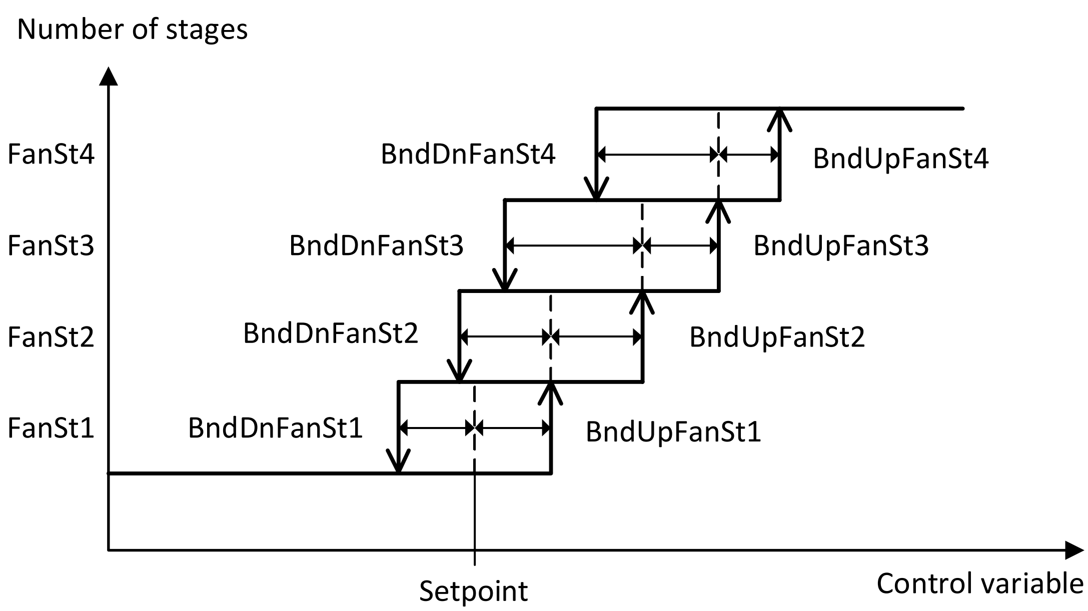
(a) Floating and fixed setpoints at sequential stage controls

Parameter	Description	Unit	Default	Range
SpTCnd	Setpoint condensing temperature	°C	30.0	5...65.0
DTCndMax	Setpoint for highest temperature difference across condenser (≥ DTCndMin)	K	12.0	3...30.0
Note: [SpDTCnd] is a construct for staging fans built with **DTCndMax**.				
BndUpFanSt 1...7	Fan stage 1..7 up-band	K	3.0	0...15.0
BndDnFanSt 1...7	Fan stage 1..7 down-band	K	3.0	0...15.0

The application supports 2 types of (closed-loop) sequential stage controls, with floating or fixed setpoints, as shown in the figures below.

(a1) In **floating setpoint** stage control, the fan stage up bands are defined from the setpoint and the previous fan stage-up values.

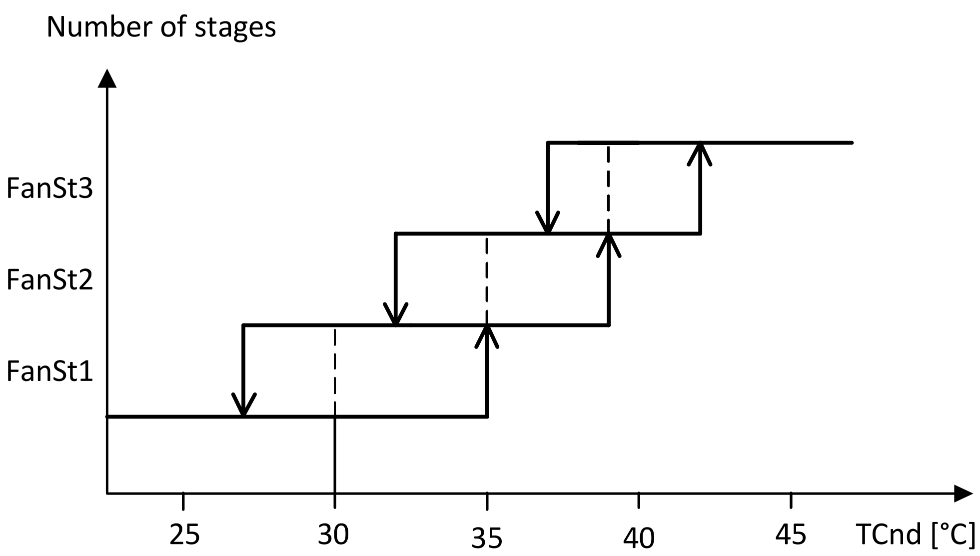
The sum of all fan **stage-up** bands defines the control range set.



Floating setpoint closed-loop sequential control

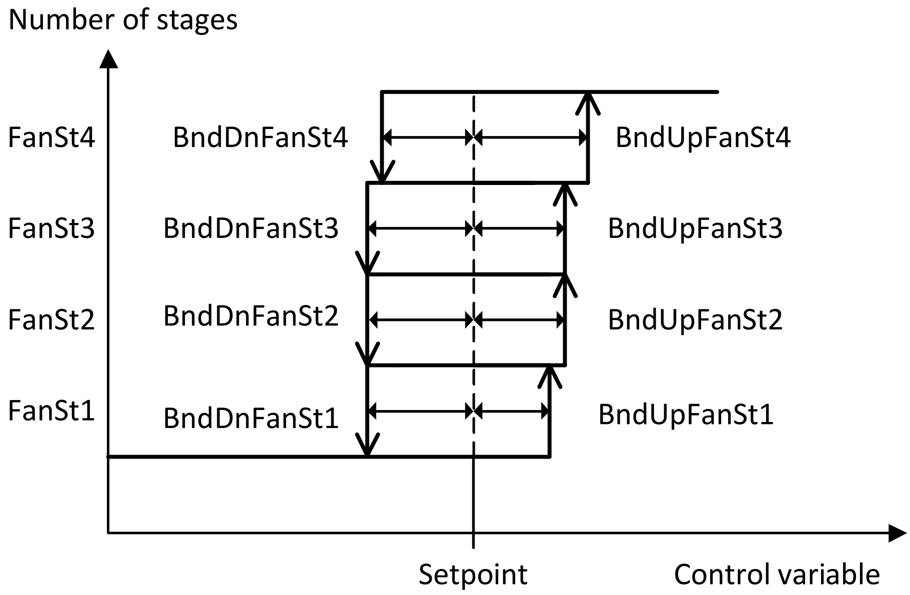
Example configuration 1 (floating, TCnd)

	Value/Setting
Condenser control type	Floating setpoint sequential stage control (*FltgSpSeqStCtl*)
Condenser control variable	Condensing temperature (*TCnd*)
Fan stages	3
Setpoint condensing temperature (*SpTCnd*)	30 °C
Fan stage 1 up band (*BndUpFanSt1*)	5 K
Fan stage 2 up band (*BndUpFanSt2*)	4 K
Fan stage 3 up band (*BndUpFanSt3*)	3 K
Fan stage 1 down band (*BndDnFanSt1*)	3 K
Fan stage 2 down band (*BndDnFanSt2*)	3 K
Fan stage 3 down band (*BndDnFanSt3*)	2 K



Example: Floating setpoint configuration

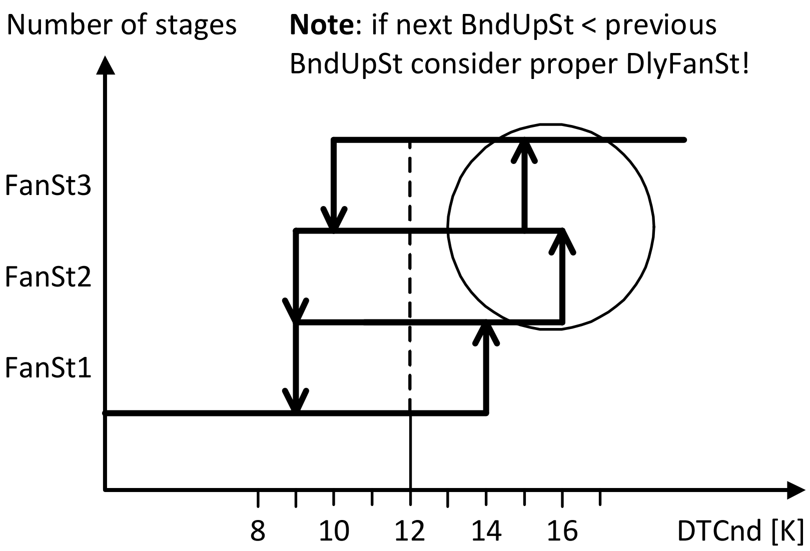
(a2) Fixed setpoint stage control is characterized by a single fan setpoint that is valid for all fan stages. The fan stage-up and stage-down bands define the control range.



Fixed setpoint closed-loop sequential stage control

Example configuration 2 (fixed, DTCnd)

Configuration/Parameter	Value/Setting
Condenser control type	Fixed setpoint sequential stage control (*FixdSpSeqStCtl*)
Condenser control variable	Temperature difference across the condenser (*DTCnd*)
Fan stages	3
Setpoint condensing temperature (*SpTCnd*)	12 °C
Fan stage 1 up band (*BndUpFanSt1*)	2 K
Fan stage 2 up band (*BndUpFanSt2*)	4 K
Fan stage 3 up band (*BndUpFanSt3*)	3 K
Fan stage 1 down band (*BndDnFanSt1*)	3 K
Fan stage 2 down band (*BndDnFanSt2*)	3 K
Fan stage 3 down band (*BndDnFanSt3*)	2 K



Example: Fixed setpoint configuration

(b) Fan stage delay time

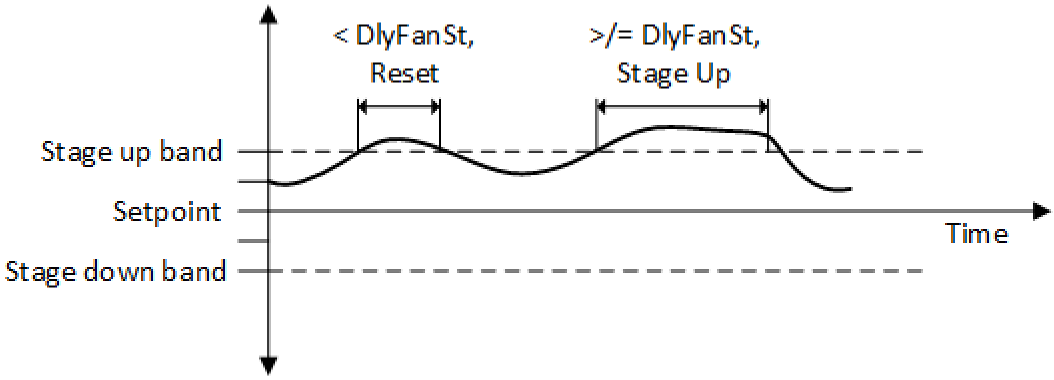
Parameter	Description	Unit	Default	Range
SpTCnd	Setpoint condensing temperature	°C	30.0	5...65.0
DTCndMax	Setpoint for highest temperature difference across condenser (≥ DTCndMin)	K	12.0	3...30.0
Note: [SpDTCnd] is a construct for staging fans built with **DTCndMax**				
DlyFanSt	Fan stage delay time	sec	2	1...15
BndUpFanSt 1...7	Fan stage 1..7 up-band	K	3.0	0...15.0
BndDnFanSt 1...7	Fan stage 1..7 down-band	K	3.0	0...15.0

To allow for an efficient response to the dynamical behavior of the condenser control, a delay time parameter (*DlyFanSt*) is used.

If the actual value is lower than the stage-up and stage-down bands, the condenser control remains in the actual fan stage.

When the in-band value is exceeded or underrun, a counter is set. If the actual value remains out-of-band for the 'Fan stage delay time', staging up or staging down commences. If the control value moves back into the in-band range, the counter is reset.

To avoid simultaneous stage-up and stage-down in case of a sudden change of the control variable, the delay parameter (*DlyFanSt*) is also valid for the time between the last and next stage-up (or stage-down) commands.



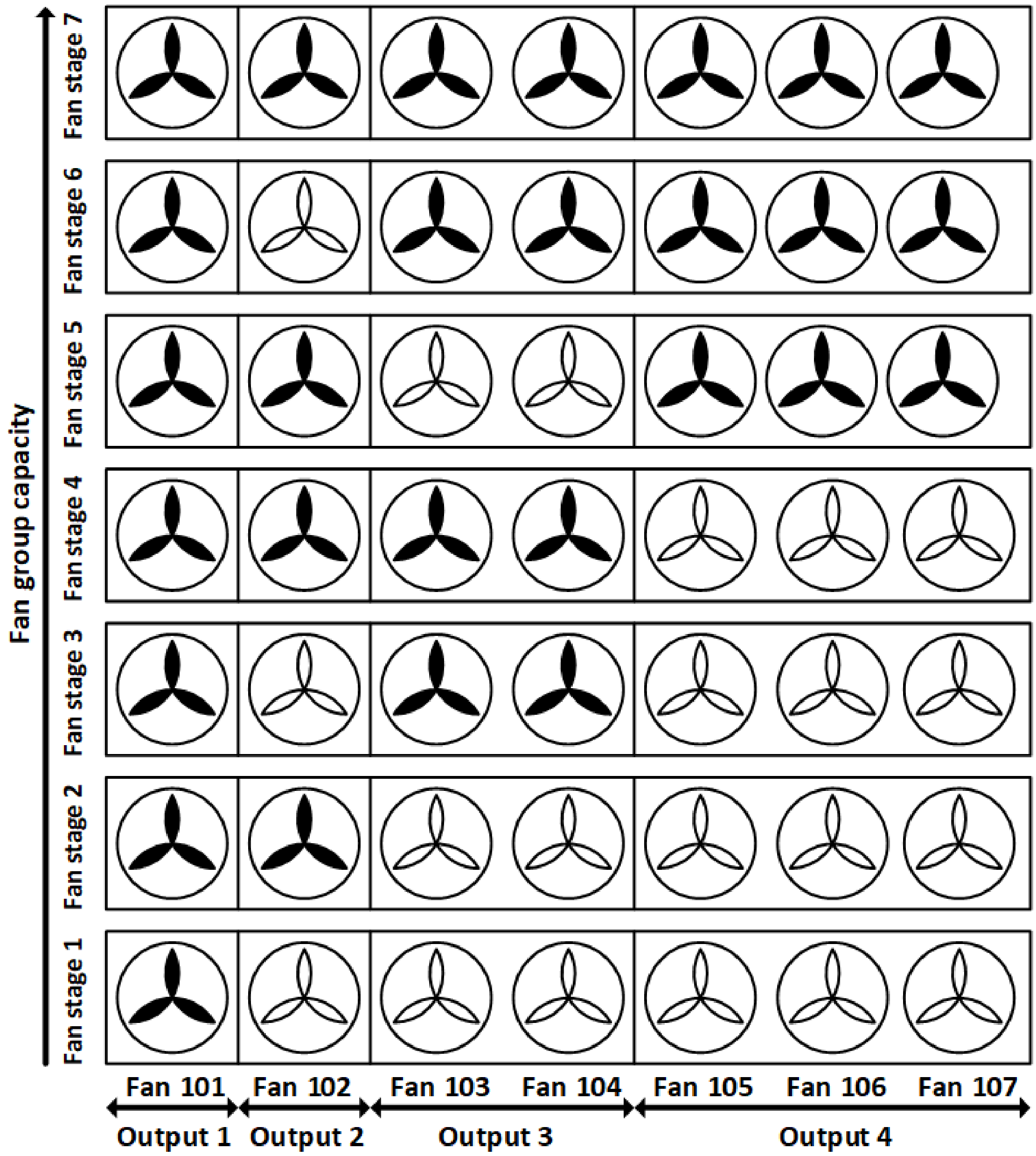
Fan stage delay time

(c) Output configuration

Parameter	Description	Unit	Default	Range
Fan stage 1..7	Defining groups by mapping devices to a stage			

Each circuit supports up to 7 fan stages, controlled by 4 digital outputs. Various wiring combinations of fans allow for a balanced load distribution as detailed in the following example of a stage control with seven fans arranged in fan groups:

- Fan stage 1: output 1
- Fan stage 2: output 1, output 2
- Fan stage 3: output 1, output 3
- Fan stage 4: output 1, output 2, output 3
- Fan stage 5: output 1, output 2, output 4
- Fan stage 6: output 1, output 3, output 4
- Fan stage 7: output 1, output 2, output 3, output 4



Example of fan control configuration

9.3 Modulating fan control functions

In addition to stage fans, the application also supports VSD fan control.

VSD control is used to drive one or multiple fans via an analog output (0...10V).

The speed control is enabled when (1) the control variable reaches the actual setpoint and (2) the time condition *DlyFanSt* is fulfilled.

Note: To reduce complexity, the 'Fan stage delay time' is also used for modulating fans, even though its name suggest that it can only be used for staged fans.

The fans will initially be commanded to the set minimum speed (parameter *FanMinSpd*).

VSD fans support P (Proportional) and PI (Proportional Integral) closed-loop control.

(a) Floating setpoint with VSD-controlled fans

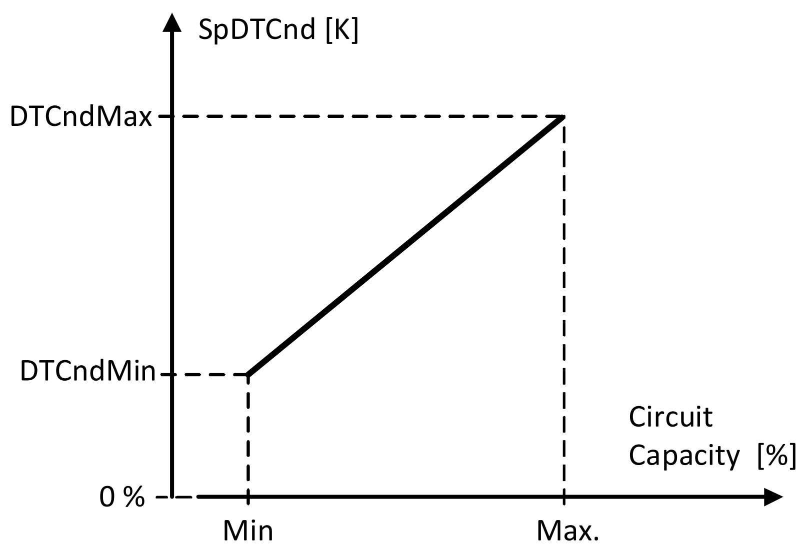
Parameter	Description	Unit	Default	Range
DTCndMax	Setpoint for highest temperature difference across condenser (≥ DTCndMin)	K	12.0	3...30.0
DTCndMin	Setpoint for lowest temperature difference across condenser (≤ DTCndMax)	K	6.0	3...20.0

In order to increase the efficiency of a unit, there is the option of setting the control variable (parameter *DTCnd*) in relation to the circuit capacity (compressor capacity).

By defining the minimum and maximum temperature difference across the condenser in relation to the minimum and maximum capacity of the compressor, respectively the circuit capacity, the setpoint [SpDTCnd] is continuously adjusted.

By setting DTCndMin = DTCndMax, the floating setpoint is disabled and the fixed setpoint becomes the control variable [SpDTCnd].

Note: The floating setpoint can be set only for the control variable *DTCnd*, but not for *TCnd*, and only applies to VSD fan configurations.

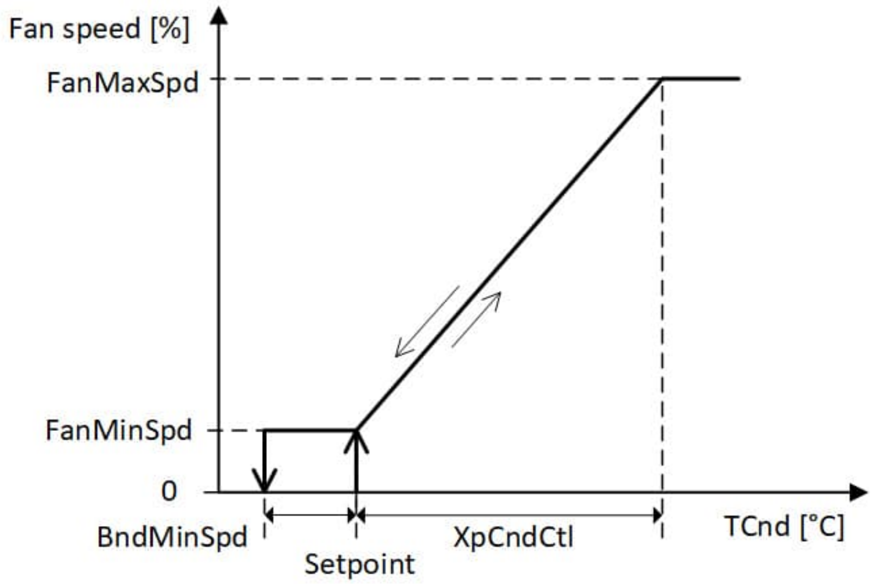


(b) VSD fan proportional (P) control

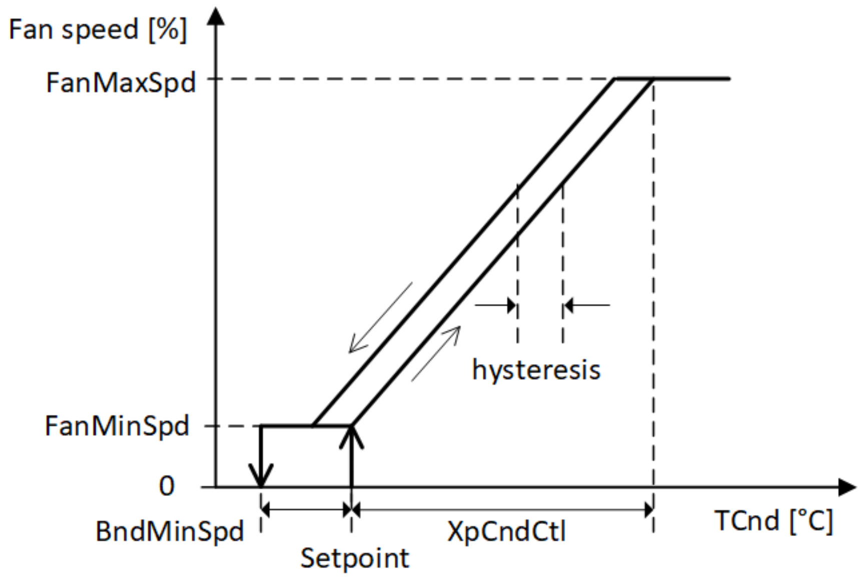
Parameter	Description	Unit	Default	Range
SpTCnd	Setpoint condensing temperature	°C	30.0	5...65.0
FanMinSpd	VSD fan minimal speed	V	2.0	0...5.0
FanMaxSpd	VSD fan maximal speed	V	10.0	5...10.0
BndMinSpd	Fan speed band	K	4	0...10
HysCndCtl	VSD fan hysteresis (0=no hysteresis)	K	1.0	0...10.0
XpCndCtl	VSD Fan proportional band	K	5.0	0...100.0

In proportional closed-loop control (*PCtl*), (see the figures below), the fan speed corresponds to the deviation of the actual value from the setpoint.

A VSD fan always starts at minimum speed. Depending on the deviation from the setpoint, it increases or decreases its speed within a control range defined by the minimum and maximum fan speed. To avoid control fluctuations, a hysteresis (*HysCndCtl*) can be set.



VSD fan with P control



VSD fan with P-control and hysteresis

(c) VSD fan PI controlled

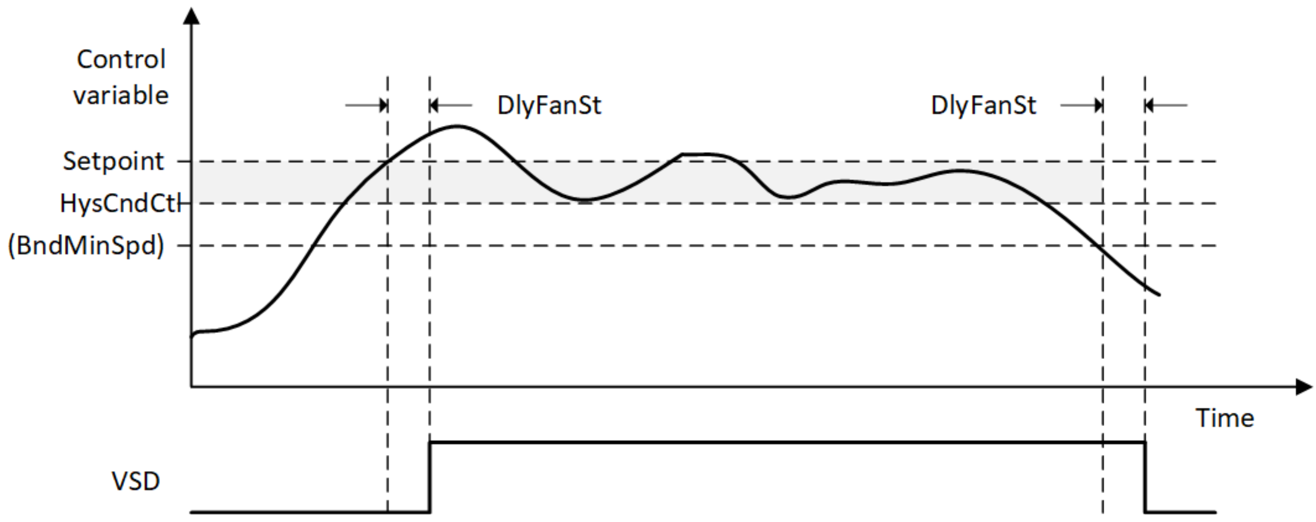
Parameter	Description	Unit	Default	Range
SpTCnd	Setpoint condensing temperature	°C	30.0	5...65.0
DTCndMax	Setpoint for highest temperature difference across condenser (≥ DTCndMin)	K	12.0	3...30.0
DTCndMin	Setpoint for lowest temperature difference across condenser (≤ DTCndMax)	K	6.0	3...20.0
DlyFanSt	Fan stage delay time	sec	2	1...15
FanMinSpd	VSD fan minimal speed	V	2.0	0...5.0
FanMaxSpd	VSD fan maximal speed	V	10.0	5...10.0
BndMinSpd	Fan speed band	K	4	0...10
HysCndCtl	VSD fan hysteresis (0=no hysteresis)	K	1.0	0...10.0
XpCndCtl	VSD Fan proportional band	K	5.0	0...100.0
TnCndCtl	VSD Fan integration time	sec	60	0...900

A **PI-controlled** VSD fan is additionally characterized by the integration time.

The VSD fan always starts at minimal speed when (1) the actual value reaches or exceeds the setpoint value **and** (2) the delay (*DlyFanSt*) condition is fulfilled.

In control mode, the fan speed will continuously be adjusted according to the deviation and the parameters *XpCndCtl* and *TnCndCtl*.

When reaching (1) minimum fan speed and (2) minimum speed band and (3) the delay condition (*DlyFanSt*) is met, the VSD fan will be switched off.



Example of PI controlled behavior

9.4 Parameters and configurations

Parameters

Parameter	Description	Unit	Default	Range
Common parameters				
TOaMin	Minimum outside temperature for operation. When below, machine goes into TOa-lock.	°C	15.0	1...30.0
TCndMax	Protection. Maximum permissible condensing temperature (< HP switch)	°C	70.0 *	20...80.0 *
TCndStup	Start-up condensing temperature value (TCndStup ≥ SpTCnd)	°C	30.0	20...50.0
DlyStup1	Condensing temperature start up delay time. The value 0 disables start up condensing temperature control.	sec	180	0...600
DlyStup2	Delay time to nominal setpoint	sec	15	0...100
Parameters for staging fans				
SpTCnd	Setpoint condensing temperature	°C	30.0	5...65.0
[SpDTCnd]	Construct: for staging fans built with **DTCndMax**			
DTCndMax	Setpoint for highest temperature difference across condenser (≥ DTCndMin)	K	12.0	3...30.0
BndUpFanSt1...7	Fan stage 1..7 up-band	K	3.0	0...15.0
BndDnFanSt1...7	Fan stage 1..7 down-band	K	3.0	0...15.0
Fan stage 1..7	Defining groups by mapping devices to a stage			
DlyFanSt	Fan stage delay time	sec	2.0	1...15
Parameters for modulating fans (VSD)				
SpTCnd	Setpoint condensing temperature	°C	30.0	5...65.0
DTCndMax	Setpoint for highest temperature difference across condenser (≥ DTCndMin)	K	12.0	3...30.0
DTCndMin	Setpoint for lowest temperature difference across condenser (≤ DTCndMax)	K	6.0	3...20.0
FanMinSpd	VSD fan minimal speed	V	2.0	0...5.0
FanMaxSpd	VSD fan maximal speed	V	10.0	5...10.0
BndMinSpd	Fan speed band	K	4	0...10
HysCndCtl	VSD fan hysteresis (0=no hysteresis)	K	1.0	0...10.0
XpCndCtl	VSD Fan proportional band	K	5.0	0...100.0
TnCndCtl	VSD Fan integration time	sec	60	0...900

*) Refrigerant-related setting

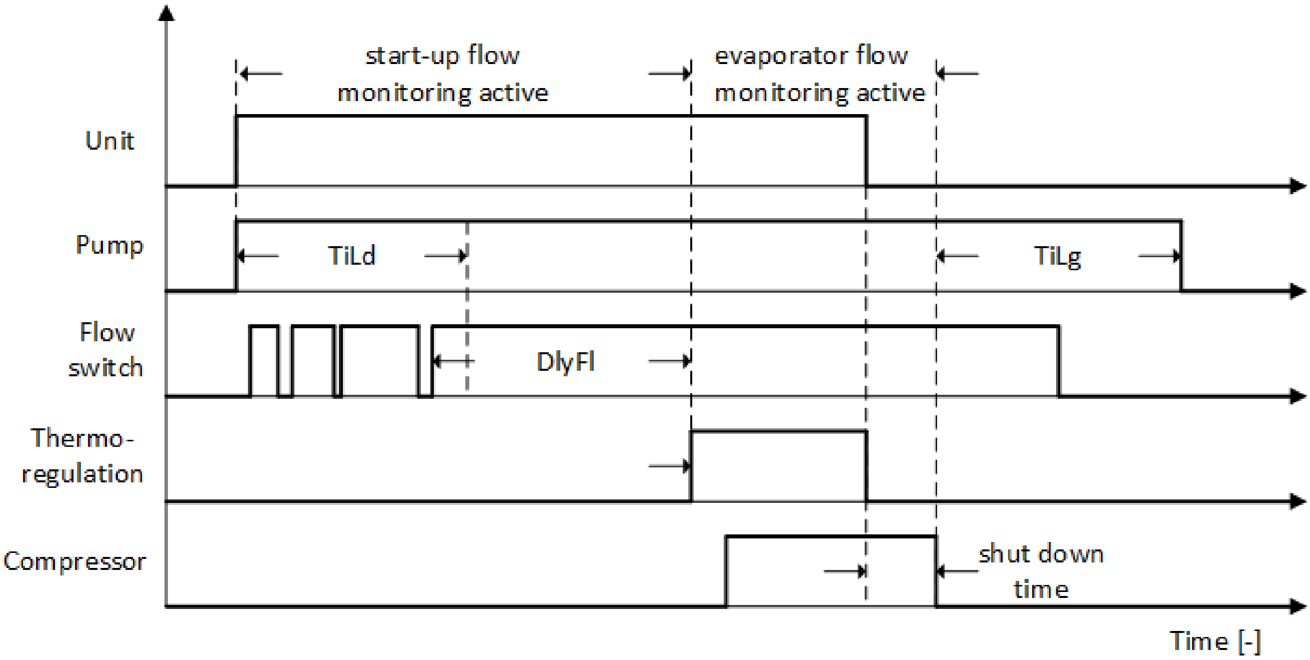
Configurations

Configuration	Default	Range
Fan type	Stage	Stage, VSD
Condenser control type	PCtl	FixdSpSeqStCtl, FltgSpSeqStCtl, PICtl, PCtl
Condenser control variable	TCnd	TCnd, DTCnd

10 Evaporator pump flow control

For the basic and pre-configuration see section (4) Pump of "Configuration workflow [→ 18]".

Evaporator flow control is characterized by two phases:
(A) Start-up flow monitoring
(B) Evaporator flow monitoring.



Evaporator pump flow control (flow switch 1 means flow)

(A) Start-up flow monitoring

Parameter	Description	Unit	Default	Range
DlyFl	Evaporator flow delay time	sec	20	5...300
TiLg	Evaporator pump lag time	sec	15	5...300
TiLd	Evaporator pump lead time	sec	15	1...300

Abbreviation	Description	Response	Reset
WrnEvpPu	Evaporating pump warning	Restart of pump or next pump	Auto 2 times
AlmEvpPu	Evaporating pump alarm	Unit lock	Manual / BMS reset
WrnEvpFlDet	Evaporator flow switch warning	Reset of EvpFlDlyTi time	Auto 2 times
AlmEvpFlDet	Evaporator flow switch alarm	Unit lock	Manual / BMS reset

(1) The evaporator pump starts first, directly after the unit has been enabled (in status "Auto: Wait for flow").

The preconditions are

- availability of a refrigerant circuit
- no alarms are active, and no lockouts (no status 'OFF: *TOaLock*') are in place. **Note:** For information on *TOaMin*, see the section 'Commissioning > Condenser'.

If the flow switch input remains open (0, no flow) during the entire evaporator pump lead time (*TiLd*), then the evaporator pump warning (*WrnEvpPu*) is activated.

The configured pump is restarted automatically, OFF and back ON to avoid sticking.

In case of a backup pump or rotation configuration, the backup pump is activated next.

If the flow cannot be established 3 consecutive times, an evaporator pump alarm (alarm *AlmEvpPu*) is raised which must be cleared through a manual or BMS-generated reset.

(2) If the flow switch input opens (0, no flow) after the evaporator pump lead time (*TiLd*) has elapsed **and** during the set evaporator flow delay time (*DlyFl*), an evaporator flow switch warning (alarm *WrnEvpFlDet*) is triggered.

In this case, the active pump remains in operation and the Evaporator flow delay time (*DlyFl*) counter is reset.

If the flow switch input opens again during the Evaporator flow delay time (*DlyFl*) for three consecutive times, an evaporator flow switch alarm (alarm *AlmEvpFlDet*) is raised. This requires a manual or BMS-generated alarm reset.

(3, positive case) In case there is flow through the evaporator, the respective flow switch input remains closed (1, flow) for the duration of the Evaporator flow delay time (*DlyFl*) **and** pump lead time (*TiLd*), then thermoregulation is enabled.

As a result, flow control changes from 'start-up' to 'evaporator flow monitoring'.

(B) Evaporator flow monitoring

Parameter	Description	Unit	Default	Range
TiLg	Evaporator pump lag time	sec	15	5...300

Thermoregulation starts with a demand initialization.

If the water temperature is above the current setpoint plus the 'start-up delta T' and the circuit conditions allow it (e.g. no waiting time) the first compressor or circuit is started.
Note: For information on *DTSuStup*, see the section 'Thermoregulation > Start/stop behavior'.

In case of no demand, the evaporator pump remains running (in status "Wait for load").

If the unit is switched off, the thermoregulation is disabled.

The unit switches to shut-down transition by reducing the capacity to the minimum and performing pump-down for each circuit.

Note: The shut-down time is variable and depends on initial operating conditions.

In case the pump-down function is not active, the corresponding circuit is switched off when the minimum capacity is reached.

After the last circuit has shut down, the evaporator pump remains in operation for the evaporator pump lag time (*TiLg*).

In case the unit is switched off while all circuits are inactive for a time that exceeds the lag time (*TiLg*), the evaporator pump is stopped immediately.

10.1 Pump control

Parameter	Description	Unit	Default	Range
DlyAlmFl	Evaporator flow switch alarm delay time	sec	0	1...10

Abbreviation	Description	Response	Reset
WrnEvpPu	Evaporating pump warning	Restart of pump or next pump	Auto 2 times
AlmEvpPu	Evaporating pump alarm	Unit lock	Manual / BMS reset
EvpFlAlm	Evaporator flow alarm	Unit OFF	Auto 2 times/d, after manual / BMS reset

The application monitors and controls up to 2 evaporator pumps that circulate chiller water or brine. The following configurations and functions are supported:

Pump rotation

Function profile: For 2 pumps; Configuration: *PuRot* and *EvpPuCho*.

In case a unit features 2 evaporator pumps and the configuration is set to rotation (*PuRot*), a rotation strategy according to operating hours is applied.

The number of operating hours of each pump is continuously counted and compared. Each time the unit is switched on, the pump with the lowest number of operating hours is activated first.
Note: To check the current number of operating hours, go to 'Main menu > Overviews > Operating hours'.

If an evaporator pump warning (alarm *WrnEvpPu*) occurs during the start-up transition, a second pump is activated next despite a higher number of operating hours.

If an active pump fails during evaporator flow monitoring and pump change-over (*EvpPuCho*) is enabled, the next pump is started immediately.

If this action cannot compensate for the flow within 0.5 of the evaporator flow switch alarm delay time (*DlyAlmFl*), the evaporator flow alarm (alarm *AlmEvpFl*) is triggered and the unit is restarted with the pump featuring the lowest number of operating hours.

Backup pump

Function profile: For 2 pumps; Configuration: *MnPu1, 2*.

In case 2 evaporator pumps are installed the first or the second pump can be configured as main pump while the other pump will be used for backup operation.

During configuration, *MnPu1* starts pump 1 always first, *MnPu2* accordingly starts pump 2 first.

If during the 'start-up transition' phase an evaporator pump alarm (alarm *AlmEvpPu*) occurs, the backup pump is started next.

If during the 'evaporator flow monitoring' phase the main pump fails and the evaporator flow monitoring and pump change-over (*EvpPuCho*) is enabled, the backup pump is started immediately to compensate for the flow interruption.

If the backup pump activation cannot compensate for the flow within 0.5 of the evaporator flow switch alarm delay time (*DlyAlmFl*), the evaporator flow alarm (alarm *AlmEvpFl*) is triggered and the unit restarts with the “main” pump.

Single pump

Function profile: For 1 single pump; Configuration: *Pu1Sgl* or *Pu2Sgl*

Note: A possible use case for defining one pump as single pump is when there are only two pumps available one of which is kept as a spare.

The single pump configurations *Pu1Sgl* and *Pu2Sgl* set pump 1 or pump 2 as the only pump.

In case of 3 successive failures, there is a pump failure (alarm *AlmEvpPu*). The unit will remain in the alarm state until there is a manual / BMS reset.

Pump kick

Function profile: For all set-ups; Configuration: *KickFnctEvpPu*

To avoid pump blockage during standstill, the evaporator pump(s) can be forced to run periodically.

The kick function is executed only when the unit is in standby.

A counter for each pump calculates the time from last pump stop.

General rule: After 176 hours, the pump is forced to run for 10 seconds. The pump kick function is not executed while another pump is in operation.

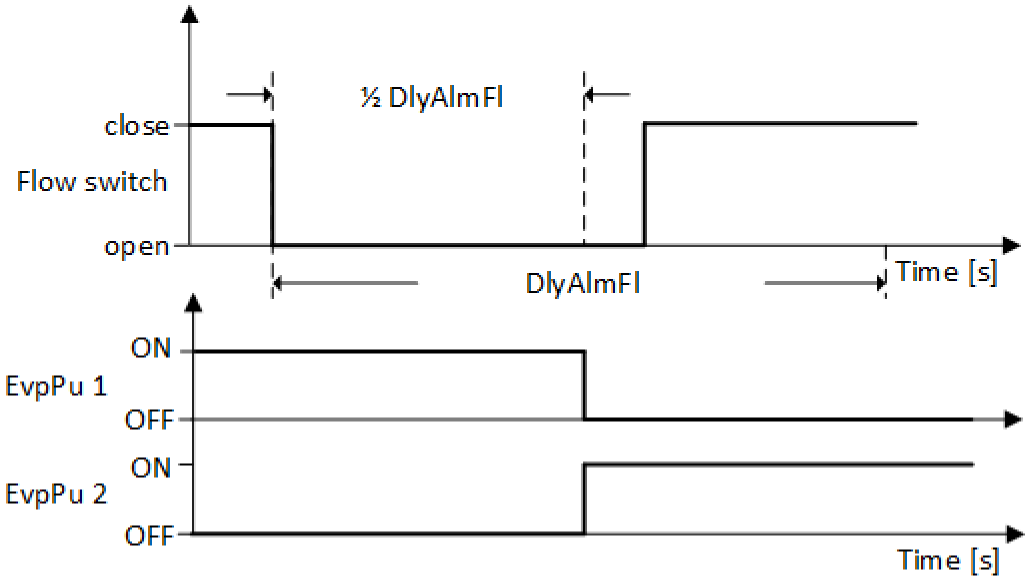
Pump change-over

Function profile: For 2 pumps; Configuration: *EvpPuCho, PuOvrld (input yes/no)*

To avoid flow interruption due to pump failure during unit operation, the application supports automatic evaporator pump change-over.

This function is available in set-ups with 2 evaporator pumps.

Engineering tip: In case the evaporator pumps do not provide active motor overload connectors (open contactor), the *flow switch status* can be used as an indicator and trigger of the change-over function.



Evaporator pump change-over

A pump change-over is triggered at 0.5 of the evaporator flow switch alarm delay time (*DlyAlmFl*).

If the flow switch opens (0, no flow) for a time exceeding 0.5 of the evaporator flow switch alarm delay time (*DlyAlmFl*) during evaporator flow monitoring, a second pump is started immediately.

If the interrupted flow cannot be compensated for within the remaining of the evaporator flow switch alarm delay time (parameter *DlyAlmFl*), an evaporator flow alarm (alarm *AlmEvpFl*) is generated.

General rule: To avoid frequent pump activation, the pump change-over function is executed only **1 time per hour**.

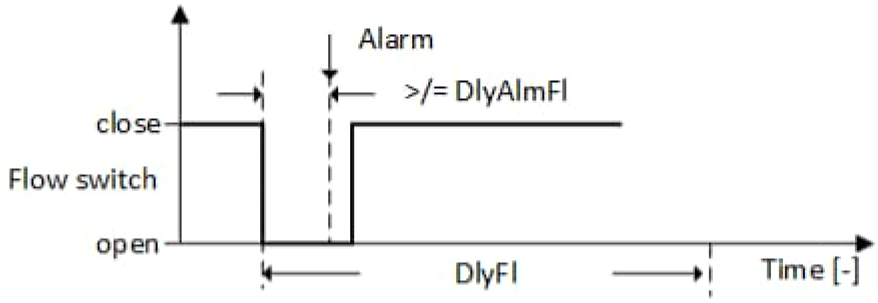
Automatic pump change-over (backup pump) during evaporator flow monitoring will be performed only when EvpPuCho is enabled.

10.2 Evaporator flow monitoring

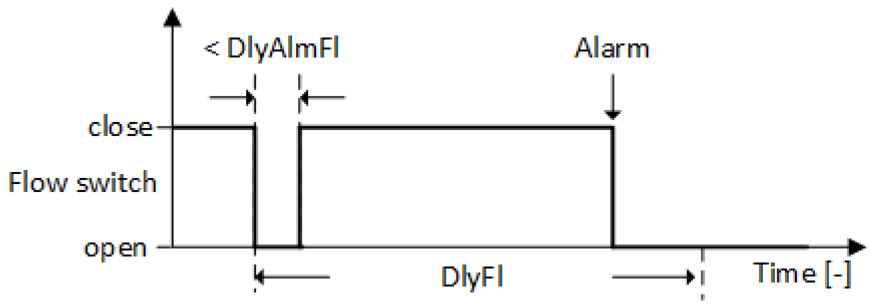
Parameter	Description	Unit	Default	Range
DlyFl	Evaporator flow delay time	sec	20	5...300
DlyAlmFl	Evaporator flow switch alarm delay time	sec	0	1...10
TiLd	Evaporator pump lead time	sec	15	1...300

Abbreviation	Description	Response	Reset
AlmEvpPu	Evaporating pump alarm	Unit lock	Manual / BMS reset
WrnEvpFl	Evaporator flow warning	Unit OFF	Auto 2 times/d, after manual / BMS reset
AlmEvpFl	Evaporator flow alarm	Unit OFF	Manual / BMS reset

Evaporator flow monitoring is active from the moment thermoregulation is started until the last circuit or compressor has been switched off (see also the introduction of this chapter).



(A) Evaporator flow monitoring



(B) Evaporator flow monitoring

The fluid flow through the evaporator is continuously monitored.

Note: Use a filter to avoid flow alarms caused by air bubbles in the hydraulic system.

During the evaporator flow delay time (parameter *DlyFl*), sudden flow interruptions/disturbances are ignored according to the following rules:

- If the flow switch input opens (0, no flow) for a time greater than the evaporator flow switch alarm delay time (parameter *DlyAlmFl*), an evaporator flow alarm (alarm *AlmEvpFl*) is generated (see figure A).
- If the flow switch input opens and closes within a time less than the evaporator flow switch alarm delay time (parameter *DlyAlmFl*), the evaporator flow alarm is ignored (see figure B). However, if the flow switch input opens again within the evaporator flow switch alarm delay time (parameter *DlyAlmFl*), an evaporator flow alarm (alarm *AlmEvpFl*) is generated.

About evaporator flow alarm (AlmEvpFl):

In the event of an evaporator flow alarm (alarm *AlmEvpFl*), all refrigerant circuits are stopped rapidly. The pumps remain in operation for the duration of the pump lead time (parameter *TiLd*).

Subsequently, the unit restarts in a regular way activating the single pump, the main pump or the pump with the lowest number of operating hours first, and the start-up flow monitoring is activated (parameter *TiLg*, *DlyFl*). If all conditions are met, then thermoregulation is restarted.

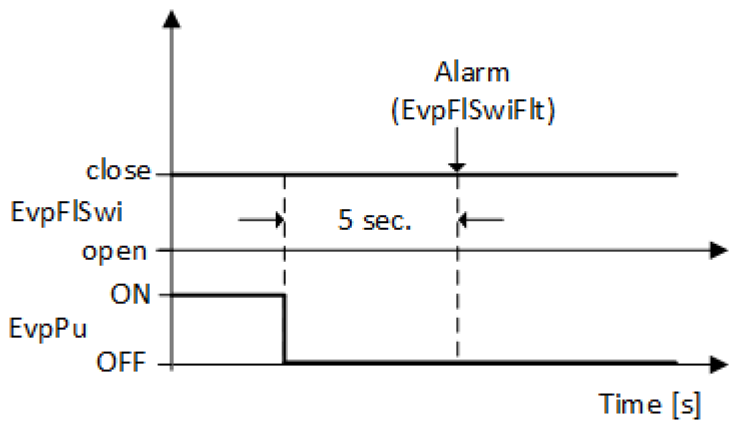
The alarm *AlmEvpFl* is reset automatically 2 times per day, after that a manual or BMS reset is required.

10.3 Evaporator flow switch fault

Abbreviation	Description	Response	Reset
AlmEvpFl	Evaporator flow switch fault	Unit lock	Manual / BMS reset

NOTICE	
!	The flow switch is a safety device. Incorrect flow switch dimensioning or bypassing the flow switch input can damage the evaporator by freezing. The flow switch functionality must be checked prior to starting up the unit.

The parameter settings for flow monitoring must be set carefully as incorrect values can damage the evaporator. For this reason, the operation conditions of the unit, the pump flow rate and the evaporator volume must be taken into consideration.



EvpFlSwiFlt = evaporator flow switch alarm

To avoid flow switch bypassing, incorrect wiring or flow switch malfunction, the application monitors flow switch and pump status during stand-by.

Each time the evaporator pump is disabled, the flow switch status is continuously monitored after a time delay period of 5 seconds.

If the flow switch remains closed (1, means flow) after pump stop or closes any time later during stand still, an evaporator flow switch alarm (alarm *EvpFlSwiFlt*) is generated.

This alarm must be cleared by a manual or BMS-initiated reset.

10.4 Parameters and configurations

Parameters

Parameter	Description	Unit	Default	Range
DlyFl	Evaporator flow delay time	sec	20	5...300
TiLg	Evaporator pump lag time	sec	15	5...300
DlyAlmFl	Evaporator flow switch alarm delay time	sec	0	1...10
TiLd	Evaporator pump lead time	sec	15	1...300

Configurations

Configuration	Description	Default	Range
EvpPuCnfg	Pump configuration	Pu1Sgl	PuRot/Pu1Sgl/Pu2Sgl/Pu1Mn/Pu2Mn
EvpPuCho	Evaporator pump change over enables automatic change of pump during evaporator flow monitoring in case of flow interruption. For proper operation consider correct EvpFlSwiAlmDlyTi and EvpFlDlyTi settings.	Dis	En/Dis
KickFnctEvpPu	Evaporator pump kick function, periodical command of evaporator pump during stand still	Dis	En/Dis
PuOvrld	Digital input for pump overload available	Yes	Yes/No

11 States

The following states can be displayed on the HMI (UI). That information is displayed centrally in 'Main overview'.

Unit status:
OFF: Unit Alarm
OFF: TOa Lock
OFF: Unit not Config
OFF: Wiring Test
OFF: Unit Switch
OFF: Emergency Stop
OFF: Remote Switch
Auto: Wait for Load
Auto: Wait for Flow
Auto: Thermoregulation
Auto: Pump Down
Auto: Capacity Limitation
Auto: Pump Kick
Auto: Emergency Operation

12 Alarming and operating at fault conditions

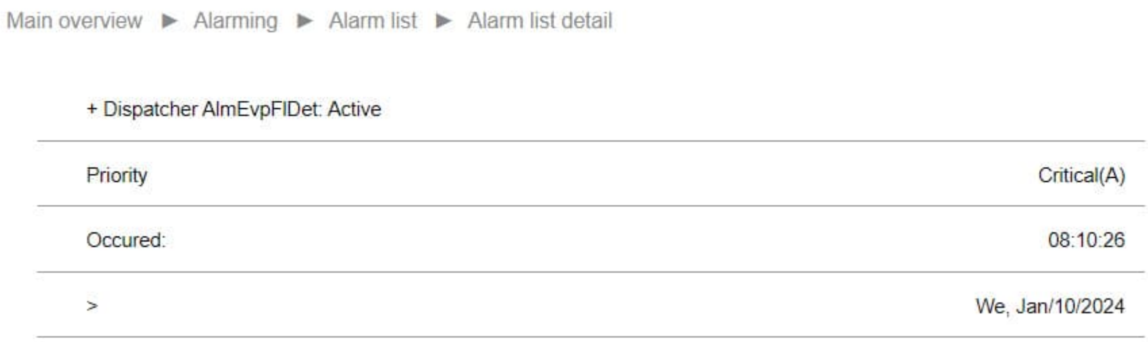
The here listed alarms and warnings are generated by the application logic.

Beside them the Climatix hardware features hardware related alarms and warnings.

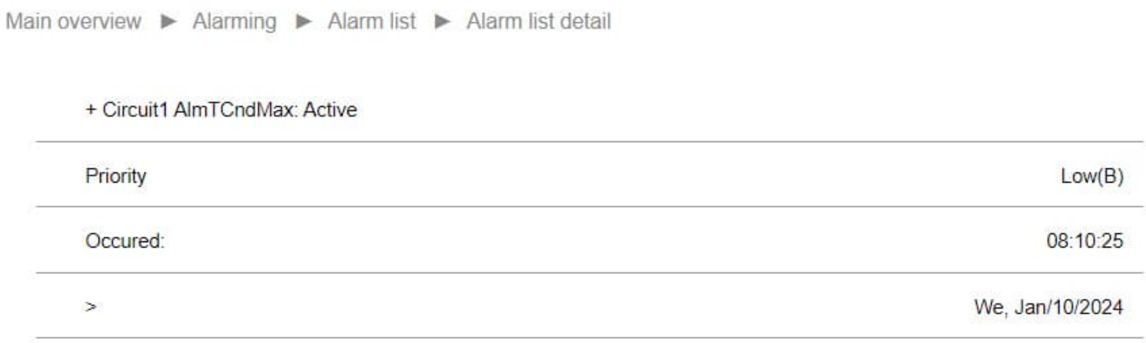
Abbreviation	Full Name	Response	Reset
WrnShLo	Low superheat warning	EEV close	Auto 2 times/h
AlmShLo	Low superheat alarm	Circuit OFF	Manual / BMS reset
WrnMOP	Max operating pressure warning	Increase of ShStpt	Auto within 20 sec
AlmMOP	Max operating pressure alarm	Circuit OFF	Manual / BMS reset
WrnLOP	Low operating pressure warning	No reaction for LOPAlmDlyTi	Auto within LOPAlmDlyTi
AlmLOP	Low operating pressure alarm	Circuit OFF	Manual / BMS reset
WrnPmpDnShdn	Pump down warning at shut down	Circuit OFF	Auto 2 times/d
AlmPmpDnShdn	Pump down alarm at shut down	Circuit OFF	Manual / BMS reset
WrnPmpDnStt	Pump down warning at start up	Circuit OFF	Auto 2 times/d
AlmPmpDnStt	Pump down alarm at start up	Circuit OFF	Manual / BMS reset
AlmPmpDnRc	Pump down recovery alarm at start up	Circuit OFF	Manual / BMS reset
AlmEEVMax	EEV maximum opening alarm	Circuit OFF	Manual / BMS reset
WrnEvpPu	Evaporating pump warning	Restart of pump or next pump	Auto 2 times
AlmEvpPu	Evaporating pump alarm	Unit lock	Manual / BMS reset
AlmOvrLdPu	Evaporator pump alarm	Unit OFF, unit lock	Manual / BMS reset
WrnEvpFlDet	Evaporator flow switch warning	Reset of EvpFlDlyTi	Auto 2 times
AlmEvpFlDet	Evaporator flow switch alarm	Unit lock	Manual / BMS reset
EvpFlSwiFlt	Evaporator flow switch fault	Unit lock	Manual / BMS reset
WrnEvpFl	Evaporator flow warning	Unit OFF	Auto 2 times/d, after manual /BMS reset
AlmEvpFl	Evaporator flow alarm	Unit lock	Manual / BMS reset
WrnTCndMax	Maximum condensing temperature warning	Warning indication	Auto
AlmTCndMax	Maximum condensing temperature alarm	Normal circuit shut down	Auto 2 times/d, after manual / BMS reset
Fan Overload	Fan / Fan group fault / overload	Alarm indication	Auto
WrnTOaLck	Minimum outside temperature alarm	Circuit will not start; but if already on, nothing happens	Auto
Compressor Overload	Compressor fault / overload	Circuit OFF	Manual / BMS reset
HPmax	High pressure alarm	Circuit OFF	Manual
HPmin	Low pressure alarm	Circuit OFF	Manual
AlmFrPrt	Frost protection alarm	Unit OFF, pump continue	Auto
AlmTSenInv	Temperature sensor inversion alarm	Normal circuit shut down, unit lock	Manual
UnCapLimFlt	Unit capacity limitation fault	Unit remain in operation, capacity limitation ignored	Auto
StptMnplFlt	Setpoint manipulation fault	Unit remain in operation, setpoint manipulation ignored	Auto
AlmEmgStp	Emergency stop alarm	Unit OFF (all devices)	Manual
AlmGasLeakDet	Gas leak detector alarm	Unit OFF	Manual
AlmPhLosPrt	Phase monitoring alarm	Unit OFF	Auto 2 times/h, after manual / BMS reset

Abbreviation	Full Name	Response	Reset
TOaSenFlt	Outside temperature sensor fault alarm	Unit shut down	Manual / BMS reset
TRtSenFlt	Return water temperature sensor fault alarm	Unit shut down	Manual / BMS reset
TSuSenFlt	Supply water temperature sensor fault alarm	Unit shut down	Manual / BMS reset
TSucGasSenFlt	Suction gas temperature sensor fault alarm	Circuit shut down	Manual / BMS reset
TDcrgGasSenFlt	Discharge gas temperature sensor fault alarm	Circuit shut down	Manual / BMS reset
PEvpSenFlt	Evaporating pressure sensor fault alarm	Circuit shut down	Manual / BMS reset
PCndSenFlt	Condensing pressure sensor fault alarm	Circuit shut down	Manual / BMS reset
ExtIOErr	Module x communication error	Unit OFF	Manual / BMS reset
MBComFlt	Modbus communication fault	..	

Typical display of alarms in HMI



AlmEvpFlDet

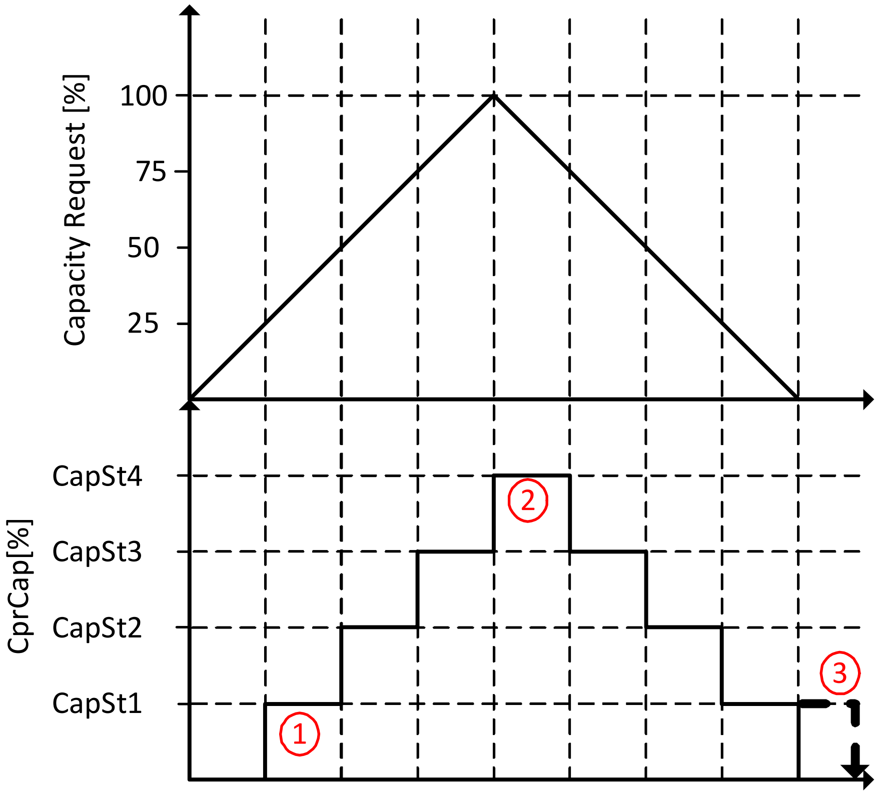


AlmTCndMax

13 Addendum I: Compressor configuration examples

13.1 1 x step compressor, default

	Range	Setting
NomCap	1...1000 kW	200
CapSt1	1...100%	25%
CapSt2	1...100%	50%
CapSt3	1...100%	75%
CapSt4	1...100%	100%
TiSttup	1...60 sec	15 sec
MaxCapSt	St3/St4	St4
MinCapSt	St1/St2	St1

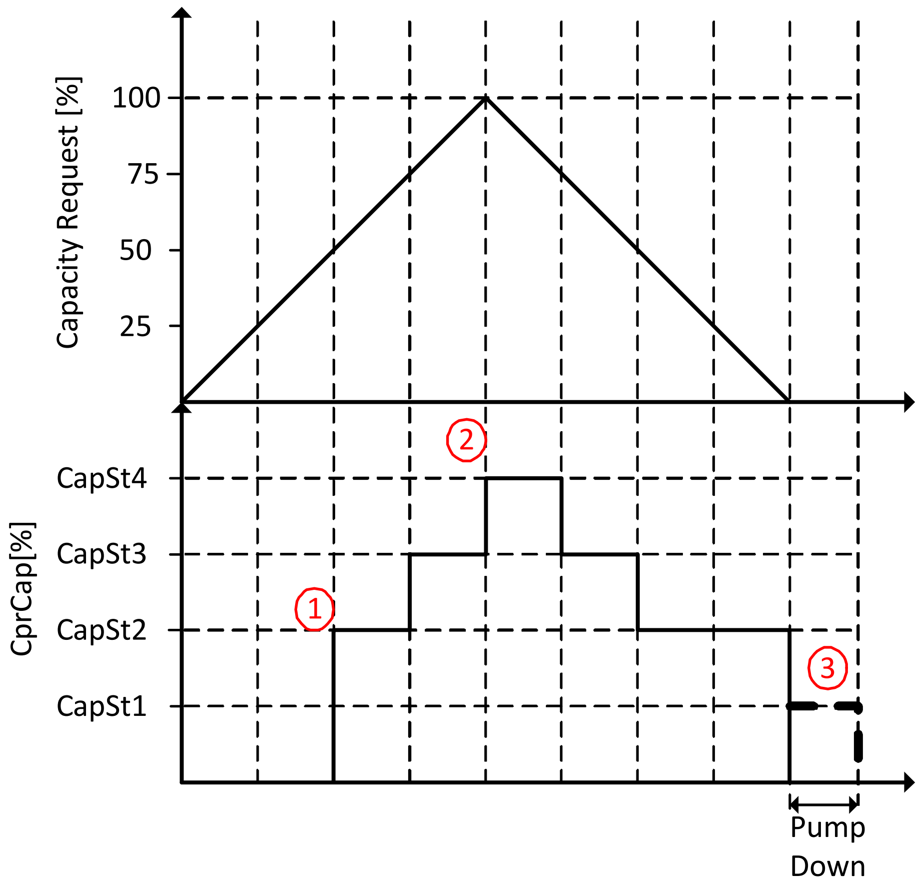


Step	Description
1	The compressor is started at CapSt1 (at 25% capacity request). It remains at CapSt1 for 15 seconds before following the capacity request.
2	The compressor capacity is increased up to the maximum capacity stage (CapSt4).
3	The compressor capacity is decreased down to CapSt1 and is shut down or performs pump down cycle at CapSt1 before shutting down.

13.1.1 1 x step compressor, variation 1

Note: Deviations from the default are marked in boldface.

	Range	Setting
NomCap	1...1000 kW	200 kW
CapSt1	1...100%	25%
CapSt2	1...100%	50%
CapSt3	1...100%	75%
CapSt4	1...100%	100%
TiSttup	1...60 sec	15 sec
MaxCapSt	St3/St4	St4
MinCapSt	**St1/St2**	**St2**

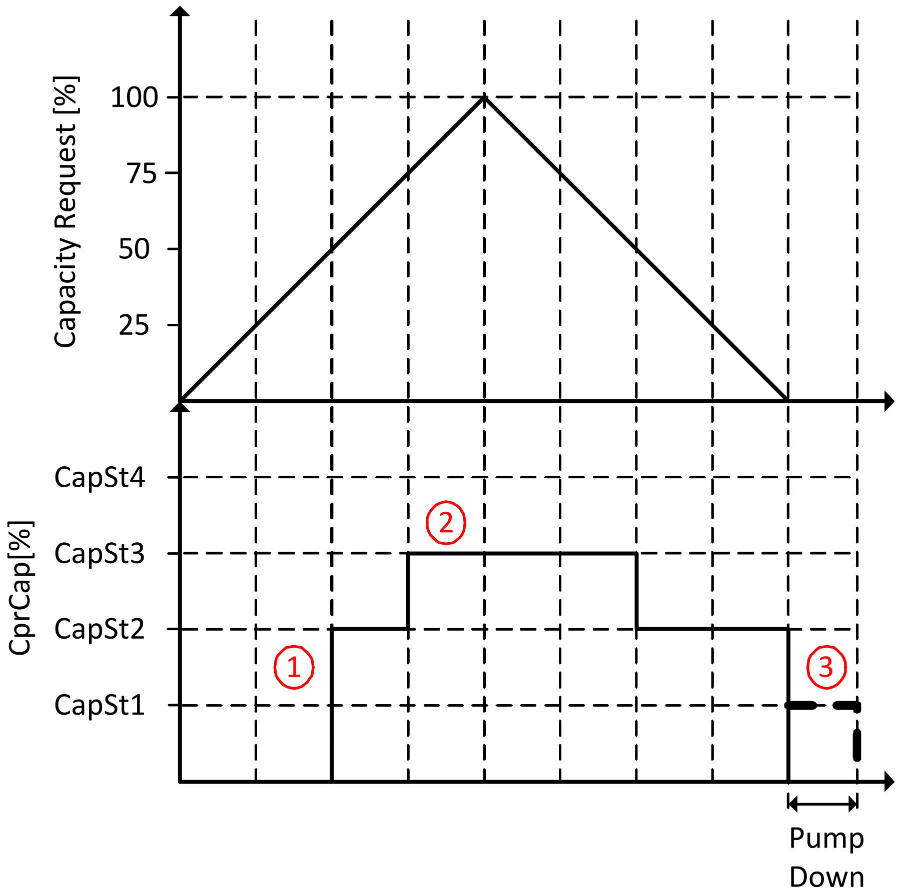


Step	Description
1	The compressor is started at CapSt1 at 50% capacity request. It remains there for 15 sec before Increasing to CapSt2.
2	The compressor capacity is increased up to the maximum capacity stage (CapSt4).
3	The compressor capacity is decreased down to CapSt2 and is shut down or performs pump down cycle at CapSt1 before shutting down.

13.1.2 1 x step compressor, variation 2

Note: Deviations from the default are marked in boldface.

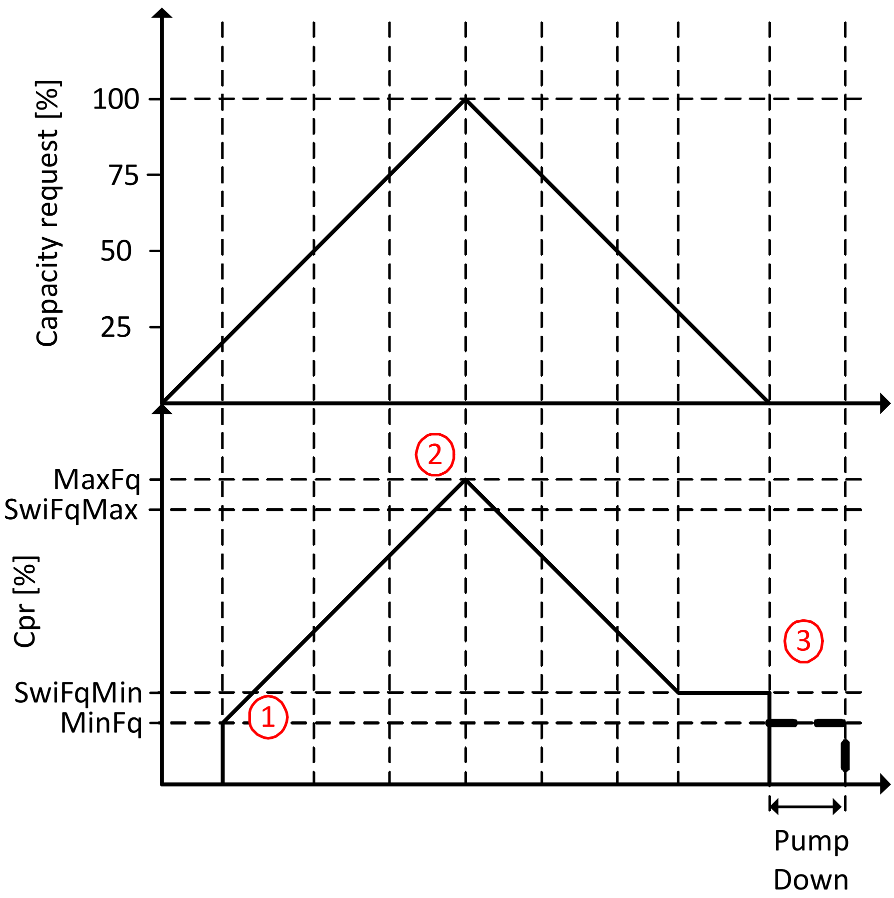
	Range	Setting
NomCap	1...1000 kW	200 kW
CapSt1	1...100%	25%
CapSt2	1...100%	50%
CapSt3	1...100%	75%
CapSt4	1...100%	100%
TiSttup	1...60 s	15 s
MaxCapSt	**St3/St4**	**St3**
MinCapSt	**St1/St2**	**St2**



Step	Description
1	The compressor is started at CapSt1 at 50% capacity request, it remains there for 15 sec before increasing to CapSt2.
2	The compressor capacity is increased up to the maximum capacity stage (CapSt3).
3	The compressor capacity is decreased down to CapSt2 and is shut down or or performs pump down cycle at CapSt1 before shut down

13.2 1 x CSVH compressor, default

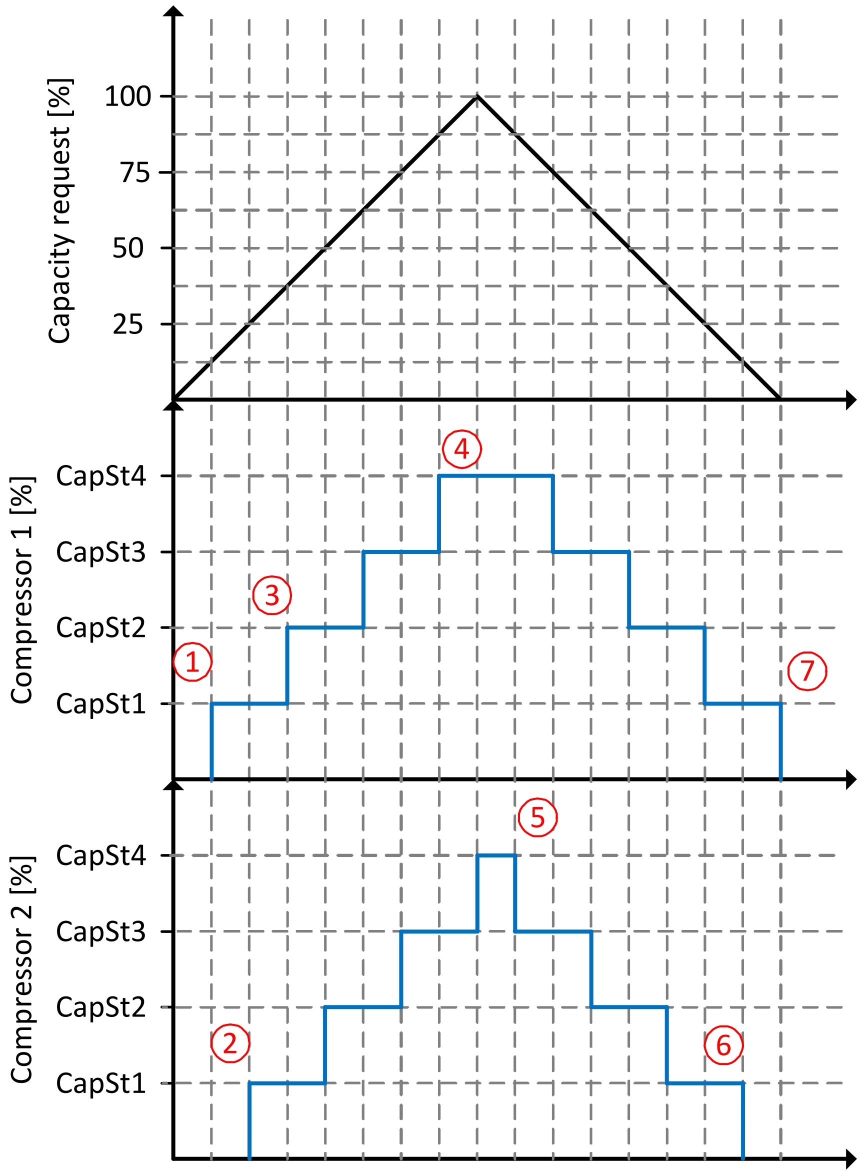
	Range	Setting
NomCap	1...1000 kW	200
MaxFq	60...100%	100%
MinFq	10...50%	25%
SwiFqMin	10...60%	35%
CapRsl	1...20%	2%
TiRampUp	1...20%	5%
TiRampDn	1...20%	5%
TiSttup	1...60 sec	15 sec



Step	Description
1	Compressor starts at MinFq = 25% (resulting from 25% capacity request). It remains at MinFq for 15 seconds; afterwards it directly follows the capacity request.
2	Compressor increases up to maximum frequency.
3	Compressor decreases down to SwiFqMin and shuts down or performs a pump down cycle at MinFq before shutting down.

13.3 2 x step compressor, default

	Range	Setting
Pre-Config: Rotation strategy	OpHrs/FixOrd/FixOrdOpHrs	OpHrs
Pre-Config: Capacity distribution	Prl/PrlCmp	Prl
NomCap	1...1000 kW	200 kW
UnLoCapSt	St1/St2	St1
CapSt1	1...100%	25%
CapSt2	1...100%	50%
CapSt3	1...100%	75%
CapSt4	1...100%	100%
MinCapSt	St1/St2	St1
MaxCapSt	St3/St4	St4
TiSttup	1...60 s	15 s
EmgOpM	En/Dis	Dis



Rotation order: Cpr1OpHrs < Cpr2OpHrs -> Cpr1 starts first, stops last.

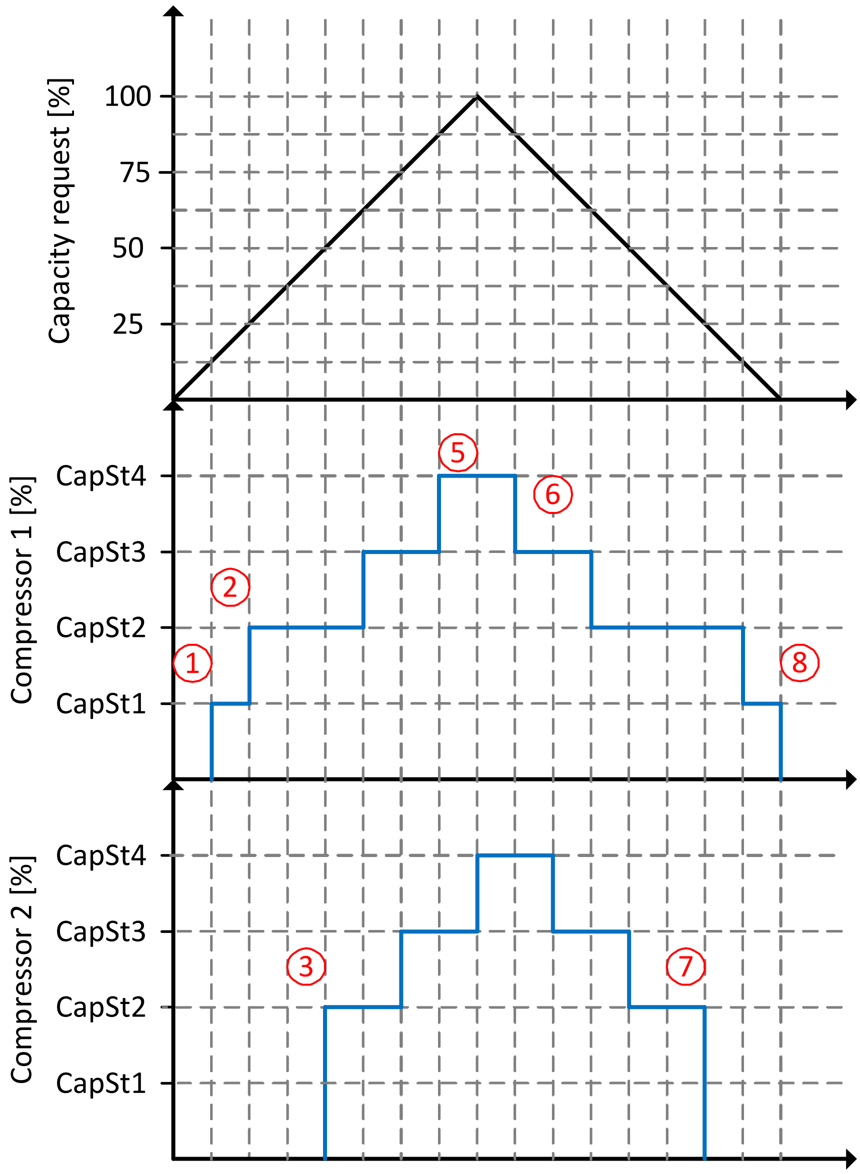
Step	Description
1	Compressor1 starts at CapSt1 (Capacity request 12.5 %), remains there for 15 seconds.
2	Compressor2 starts next at CapSt1, remains there for at least 15 seconds.
3	Both compressors increase capacity with alternating steps.
4	Compressor1 and Compressor2 reach maximum capacity (CapSt4).
5	Compressor2 decreases capacity first (due to rotation order)
6	Compressor2 shuts down or performs pump-down cycle at CapSt1 before shutting down.
7	Compressor1 shuts down or performs pump-down cycle at CapSt1 before shutting down.

13.3.1 2 x step compressor, variation 1

Note: Deviations from the default are marked in boldface.

	Range	Setting*
Pre-Config: Rotation strategy	OpHrs/FixOrd/FixOrdOpHrs	OpHrs
Pre-Config: Capacity distribution	Prl/PrlCmp	Prl
NomCap	1...1000 kW	200 kW
UnLoCapSt	St1/St2	St1
CapSt1	1...100%	25%
CapSt2	1...100%	50%
CapSt3	1...100%	75%
CapSt4	1...100%	100%
MinCapSt	**St1/St2**	**St2**
MaxCapSt	St3/St4	St4
TiSttup	1...60 s	15 s
EmgOpM	En/Dis	Dis

* Identical settings for Cpr 1 and Cpr 2



As UnLoCapSt is set to St1, the unit starts and stops with the St1. It provides wide capacity control range. The parameter setting MinCapSt =St2 ensures that next compressor operates at St2 and above improving unit efficiency.

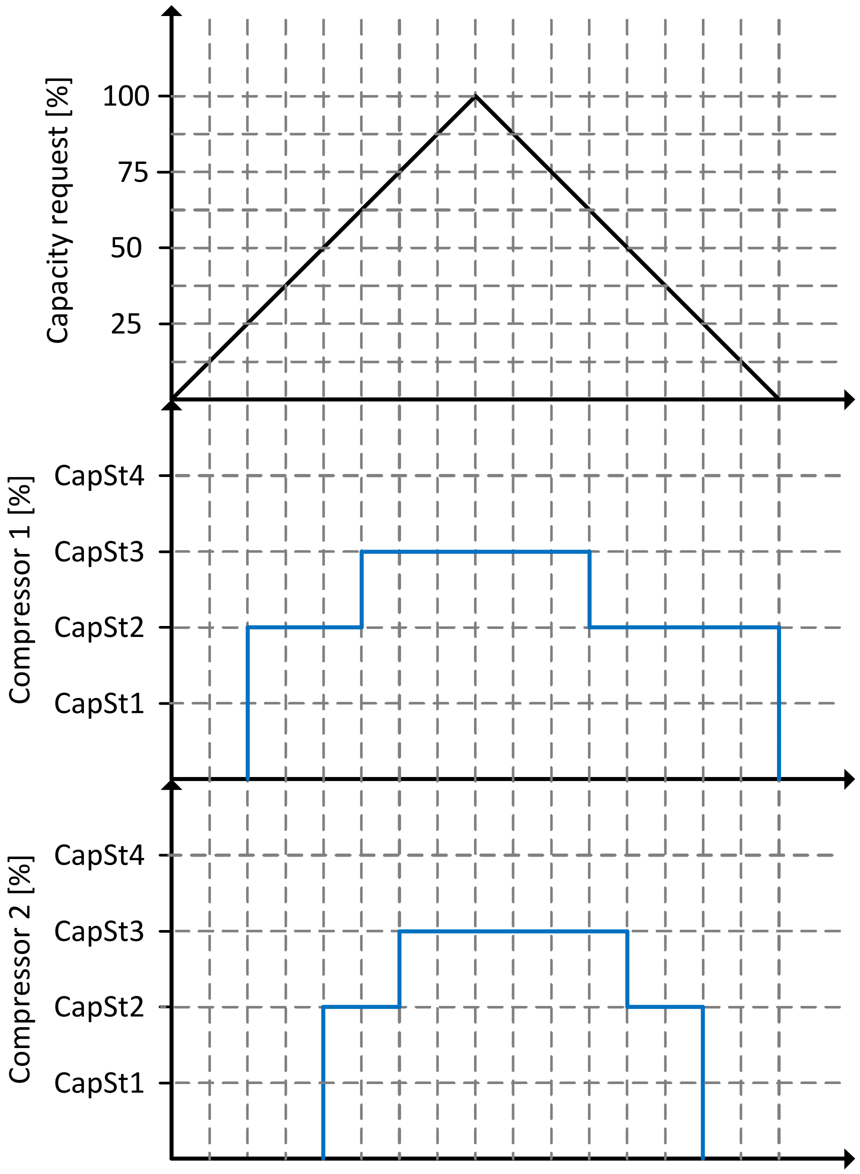
13.3.2 2 x step compressor, variation 2

Note: Deviations from the default are marked in boldface.

	Range	Setting*
Pre-Config: Rotation strategy	OpHrs/FixOrd/FixOrdOpHrs	OpHrs
Pre-Config: Capacity distribution	Prl/PrlCmp	Prl
NomCap	1...1000 kW	200 kW
UnLoCapSt	**St1/St2**	**St2**
CapSt1	1...100%	25%
CapSt2	1...100%	50%
CapSt3	1...100%	75%
CapSt4	1...100%	100%

	Range	Setting*
MinCapSt	**St1/St2**	**St2**
MaxCapSt	**St3/St4**	**St3**
TiSttup	1...60 s	15 s
EmgOpM	En/Dis	Dis

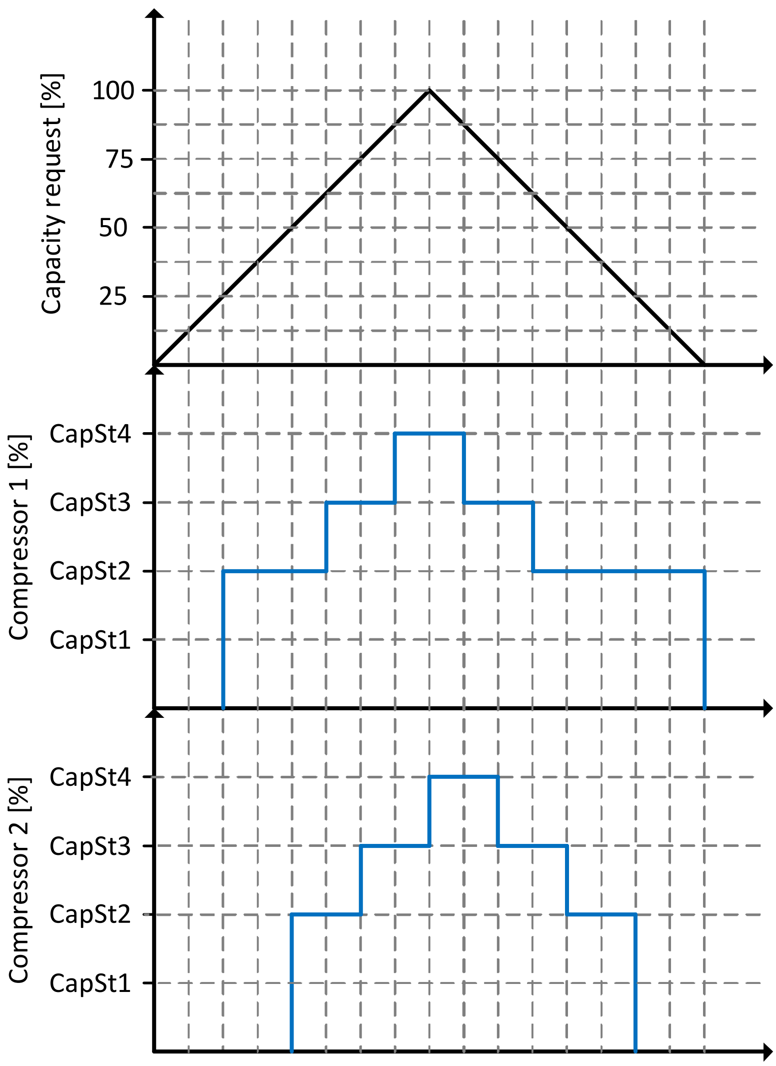
* Identical settings for Cpr1 and Cpr2



13.3.3 2 x step compressor, variation 3

Note: Deviations from the default are marked in boldface.

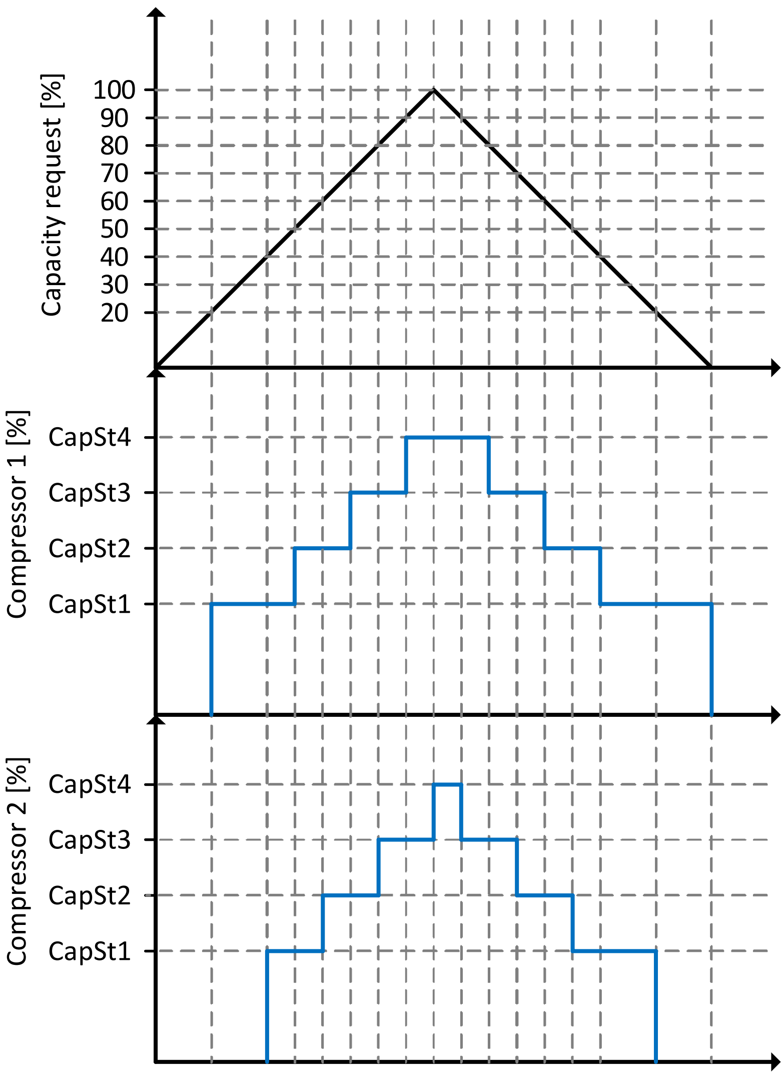
	Range	Setting
Pre-Config: Rotation strategy	OpHrs/FixOrd/FixOrdOpHrs	OpHrs
Pre-Config: Capacity distribution	Prl/PrlCmp	Prl
NomCap	1...1000 kW	200 kW
UnLoCapSt	**St1/St2**	**St2**
CapSt1	1...100%	25%
CapSt2	1...100%	50%
CapSt3	1...100%	75%
CapSt4	1...100%	100%
MinCapSt	**St1/St2**	**St2**
MaxCapSt	St3/St4	St4
TiSttup	1...60 s	15 s
EmgOpM	En/Dis	Dis



13.3.4 2 x step compressor, variation 4

Note: Deviations from the default are marked in boldface.

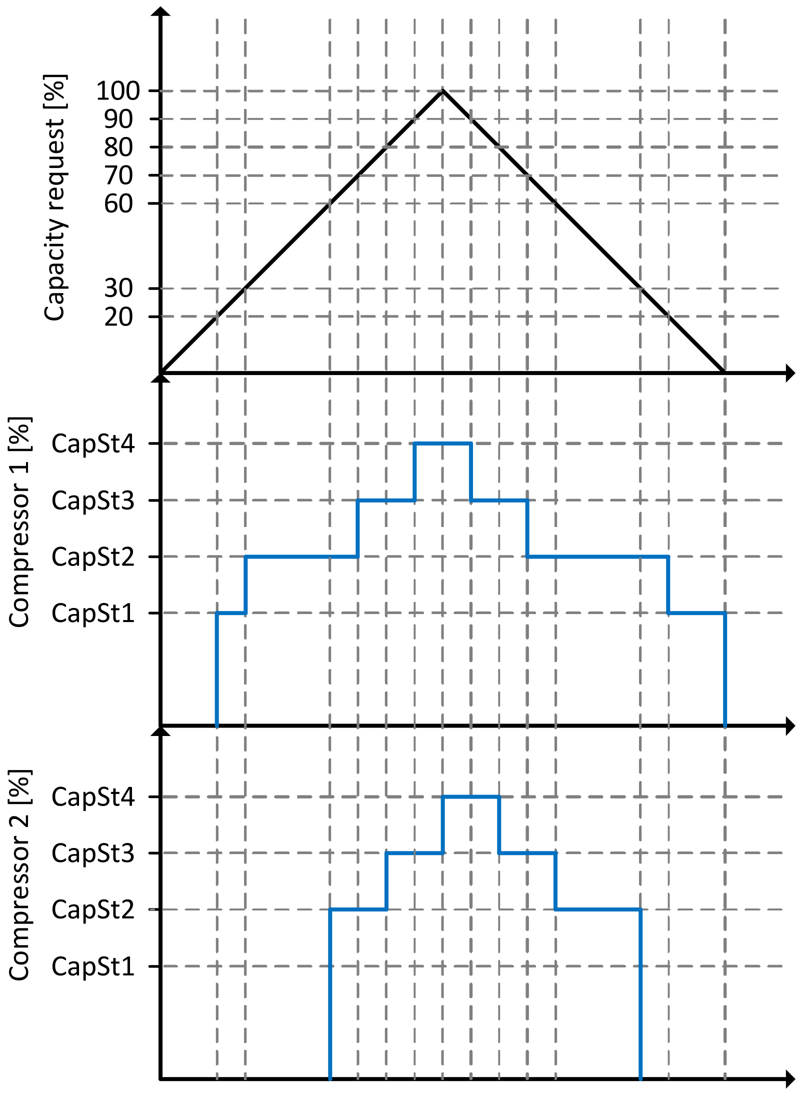
	Range	Setting
Pre-Config: Rotation strategy	OpHrs/FixOrd/FixOrdOpHrs	OpHrs
Pre-Config: Capacity distribution	Prl/PrlCmp	Prl
NomCap	1...1000 kW	200 kW
UnLoCapSt	St1/St2	St1
CapSt1	**1...100%**	**40%**
CapSt2	**1...100%**	**60%**
CapSt3	**1...100%**	**80%**
CapSt4	**1...100%**	**100%**
MinCapSt	St1/St2	St1
MaxCapSt	St3/St4	St4
TiSttup	1...60 s	15 s
EmgOpM	En/Dis	Dis



13.3.5 2 x step compressor, variation 5

Note: Deviations from the default are marked in boldface.

	Range	Setting
Pre-Config: Rotation strategy	OpHrs/FixOrd/FixOrdOpHrs	OpHrs
Pre-Config: Capacity distribution	Prl/PrlCmp	Prl
NomCap	1...1000 kW	200 kW
UnLoCapSt	St1/St2	St1
CapSt1	**1...100%**	**40%**
CapSt2	**1...100%**	**60%**
CapSt3	**1...100%**	**80%**
CapSt4	**1...100%**	**100%**
MinCapSt	**St1/St2**	**St2**
MaxCapSt	St3/St4	St4
TiSttup	1...60 s	15 s
EmgOpM	En/Dis	Dis

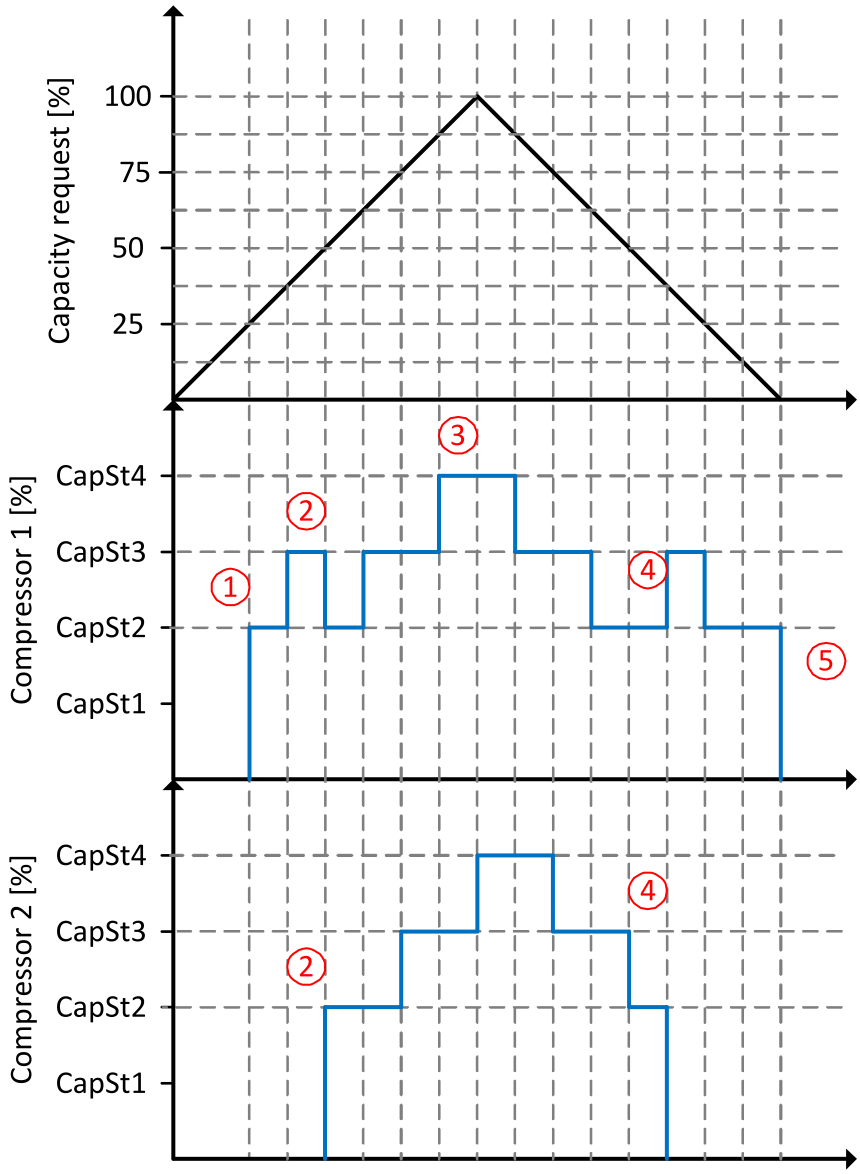


13.3.6 2 x step compressor, variation 6 (parallel compensation)

Note: Deviations from the default are marked in boldface.

	Range	Setting*
Pre-Config: Rotation strategy	OpHrs/FixOrd/FixOrdOpHrs	OpHrs
Pre-Config: Capacity distribution	**Prl/PrlCmp**	**PrlCmp**
NomCap	1...1000 kW	200 kW
UnLoCapSt	**St1/St2**	**St2**
CapSt1	1...100%	25%
CapSt2	1...100%	50%
CapSt3	1...100%	75%
CapSt4	1...100%	100%
MinCapSt	**St1/St2**	**St2**
MaxCapSt	St3/St4	St4
TiSttup	1...60 s	15 s
EmgOpM	En/Dis	Dis

* Identical settings for Cpr1 and Cpr2



Process description:

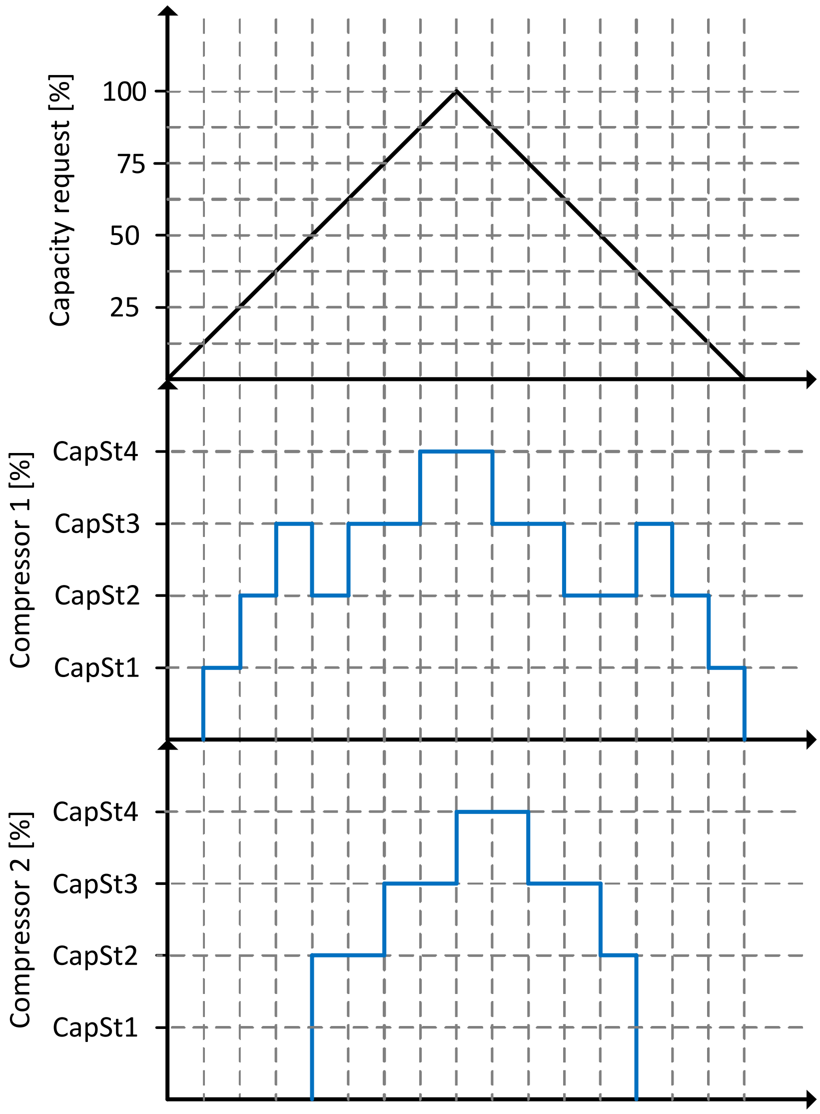
Rotation order: Cpr1OpHrs < Cpr2OpHrs □ Cpr1 starts first, stops last.

Step	Description
1	• In detail: At capacity request 25% Cpr1 starts at CapSt1, remains there for 15 seconds. • And increases to CapSt2
2	• Cpr1 increases to St3 and by reaching capacity request 50% reduces back to CapSt2. • At same time Cpr2 starts at CapSt1 for 15 second and increases to CapSt2.
3	Both compressors reach maximum capacity and Cpr1 decreases to CapSt3 (due to shut down order)
4	• Both compressors reach capacity stage 2. • Cpr2 is further shut down or commanded to pump down cycle, while Cpr 1 is compensating the load.
5	After reaching capacity request 0% Cpr1 shuts down or performs pump down cycle.

13.3.7 2 x step compressor, variation 7

Note: Deviations from the default are marked in boldface.

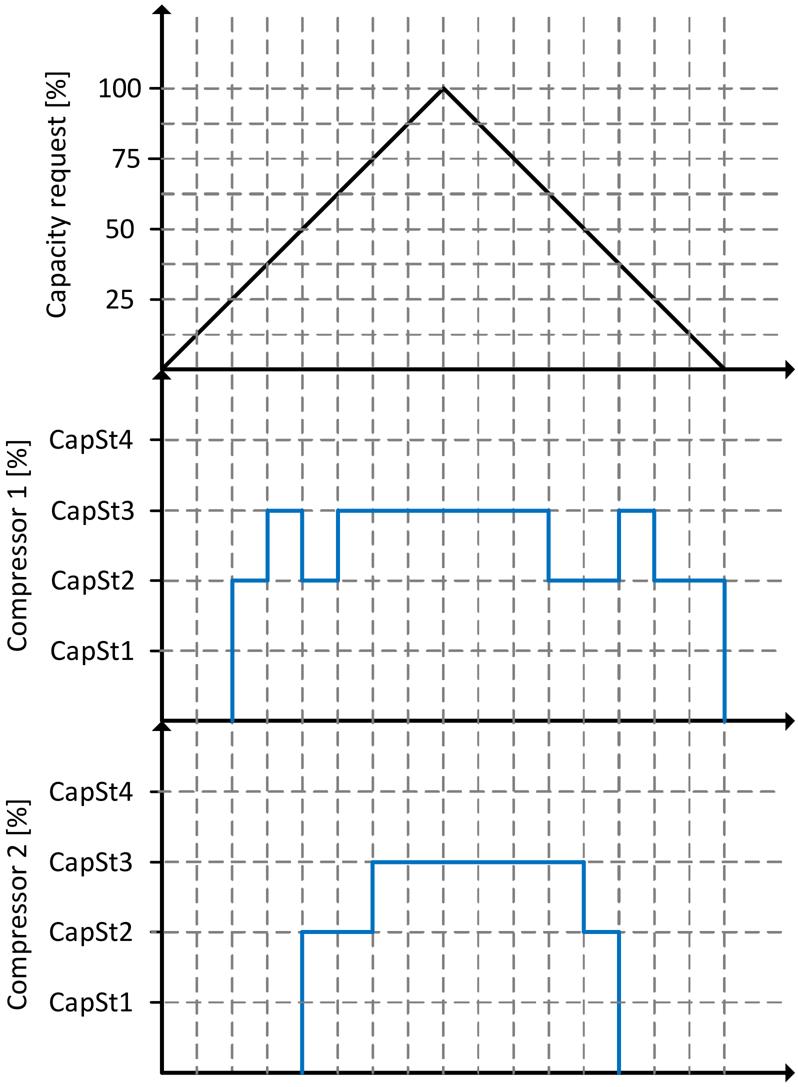
	Range	Setting
Pre-Config: Rotation strategy	OpHrs/FixOrd/FixOrdOpHrs	OpHrs
Pre-Config: Capacity distribution	**Prl/PrlCmp**	**PrlCmp**
NomCap	1...1000 kW	200 kW
UnLoCapSt	St1/St2	St1
CapSt1	1...100%	25%
CapSt2	1...100%	50%
CapSt3	1...100%	75%
CapSt4	1...100%	100%
MinCapSt	**St1/St2**	**St2**
MaxCapSt	St3/St4	St4
TiSttup	1...60 s	15 s
EmgOpM	En/Dis	Dis



13.3.8 2 x step compressor, variation 8

Note: Deviations from the default are marked in boldface.

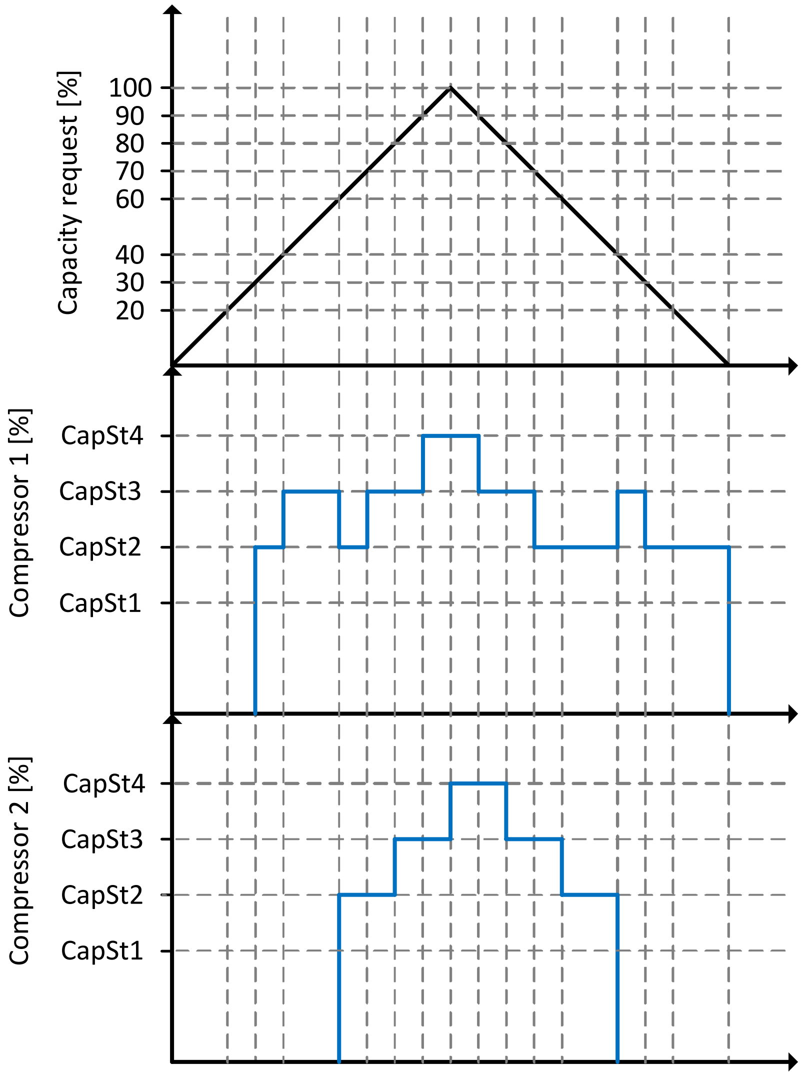
	Range	Setting*
Pre-Config: Rotation strategy	OpHrs/FixOrd	OpHrs
Pre-Config: Capacity distribution	**Prl/PrlCmp**	**PrlCmp**
NomCap	1...1000 kW	200 kW
UnLoCapSt	**St1/St2**	**St2**
CapSt1	1...100%	25%
CapSt2	1...100%	50%
CapSt3	1...100%	75%
CapSt4	1...100%	100%
MinCapSt	**St1/St2**	**St2**
MaxCapSt	**St3/St4**	**St3**
TiSttup	1...60 s	15 s
EmgOpM	En/Dis	Dis



13.3.9 2 x step compressor, variation 9

Note: Deviations from the default are marked in boldface.

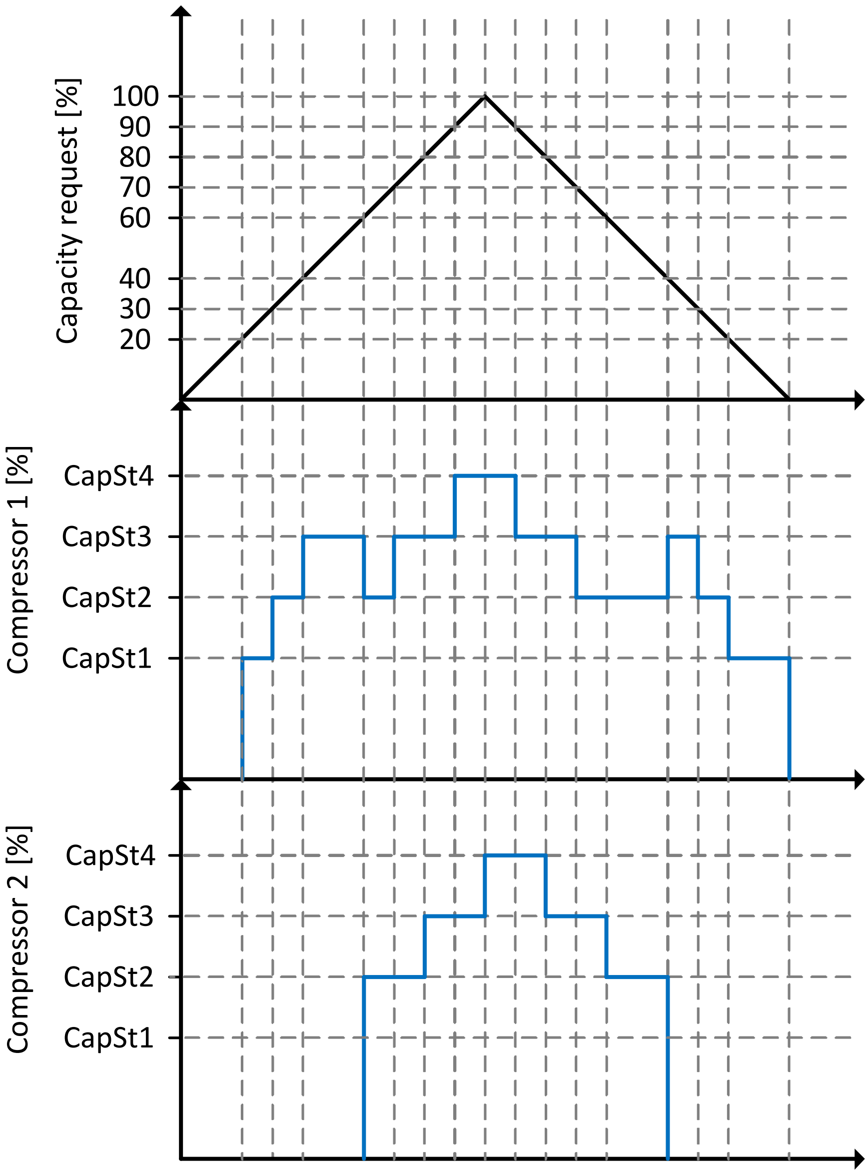
	Range	Setting*
Pre-Config: Rotation strategy	OpHrs/FixOrd	OpHrs
Pre-Config: Capacity distribution	**Prl/PrlCmp**	**PrlCmp**
NomCap	1...1000 kW	200 kW
UnLoCapSt	**St1/St2**	**St2**
CapSt1	**1...100%**	**40%**
CapSt2	**1...100%**	**60%**
CapSt3	**1...100%**	**80%**
CapSt4	1...100%	100%
MinCapSt	**St1/St2**	**St2**
MaxCapSt	St3/St4	St4
TiSttup	1...60 s	15 s
EmgOpM	En/Dis	Dis



13.3.10 2 x step compressor, variation 10

Note: Deviations from the default are marked in boldface.

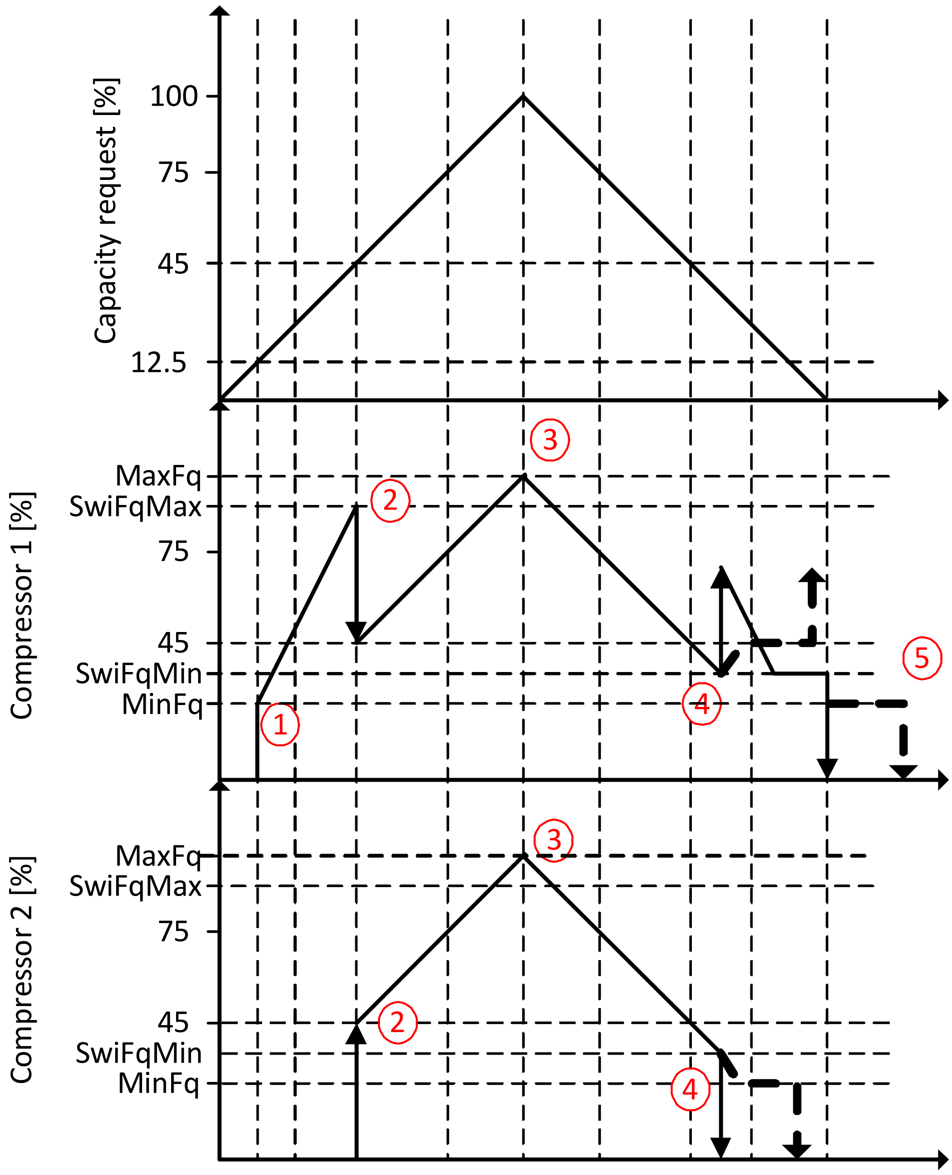
	Range	Setting
Pre-Config: Rotation strategy	OpHrs/FixOrd/FixOrdOpHrs	OpHrs
Pre-Config: Capacity distribution	**Prl/PrlCmp**	**PrlCmp**
NomCap	1...1000 kW	200 kW
UnLoCapSt	St1/St2	St1
CapSt1	**1...100%**	**40%**
CapSt2	**1...100%**	**60%**
CapSt3	**1...100%**	**80%**
CapSt4	1...100%	100%
MinCapSt	**St1/St2**	**St2**
MaxCapSt	St3/St4	St4
TiSttup	1...60 s	15 s
EmgOpM	En/Dis	Dis



13.4 2 x CSVH compressors, default

	Range	Setting
Pre-Config: Rotation strategy	OpHrs/FixOrd/FixOrdOpHrs	OpHrs
NomCap	1...1000 kW	200 kW
MaxFq	60...100%	100%
MinFq	10...40%	25%
SwiFqMax	40...100%	90%
SwiFqMin	10...60%	35%
CapRsl	1...20%	2%
TiRampUp	1...20%	5%
TiRampDn	1...20%	5%
TiSttup	1...60 sec	15 sec
EmgOpM	En/Dis	Dis

* Identical settings for Cpr1 and Cpr2



Process description:

Rotation order: Cpr1OpHrs < Cpr2OpHrs -> Cpr1 starts first, stops last.

Step	Description
1	Compressor1 starts at MinFq = 25% (resulting from 12.5 % capacity request). It remains at MinFq for 15 seconds; afterwards it follows the capacity request.
2	• Compressor1 reaches SwiFqMax and reduces capacity to 45 %. • At the same time compressor2 starts and increases to 45%. In detail: Cpr 1 goes directly to 45% In detail: Cpr 2 starts at MinFq and increases to 45%.
3	Both compressors increase capacity up to MaxFq (maximum frequency).
4	• Compressor1 and compressor2 decrease capacity down to SwiFqMin. • Compressor 2 shuts down or performs a pump-down cycle. • In both cases, compressor1 compensates for the capacity reduction.
5	Compressor1 shuts down by reaching SwiFqMin, or performs a pump-down.

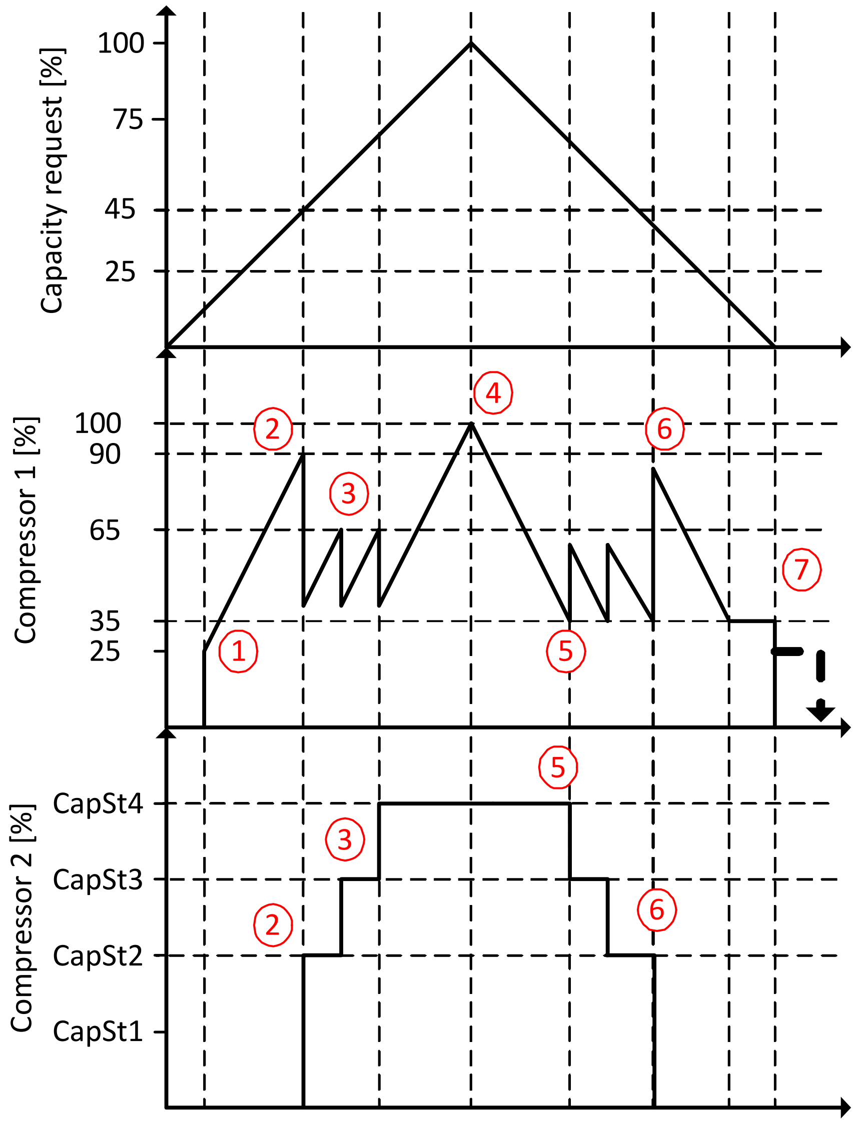
13.5 1 x CSVH, 1 x step compressor, equal capacity

Settings for CSVH compressor (*Cpr1*)

	Range	Setting
NomCap	1...1000 kW	**260 kW**
MaxFq	60...100%	100%
MinFq	10...50%	25%
SwiFqMax	40...100%	90%
SwiFqMin	10...60%	35%
CapRsl	1...20%	2%
TiRampUp	1...20% /sec	5% /sec
TiRampDn	1...20% /sec	5% /sec
TiSttup	1...60 sec	15 sec

Settings for step compressor (*Cpr2*)

	Range	Setting
NomCap	1...1000 kW	200 kW
CapSt1	1...100%	25%
CapSt2	1...100%	50%
CapSt3	1...100%	75%
CapSt4	1...100%	100%
TiSttup	1...60 sec	15 sec
MaxCapSt	St3/St4	St4
MinCapSt	St1/St2	**St2**
EmgOpM	En/Dis	Dis



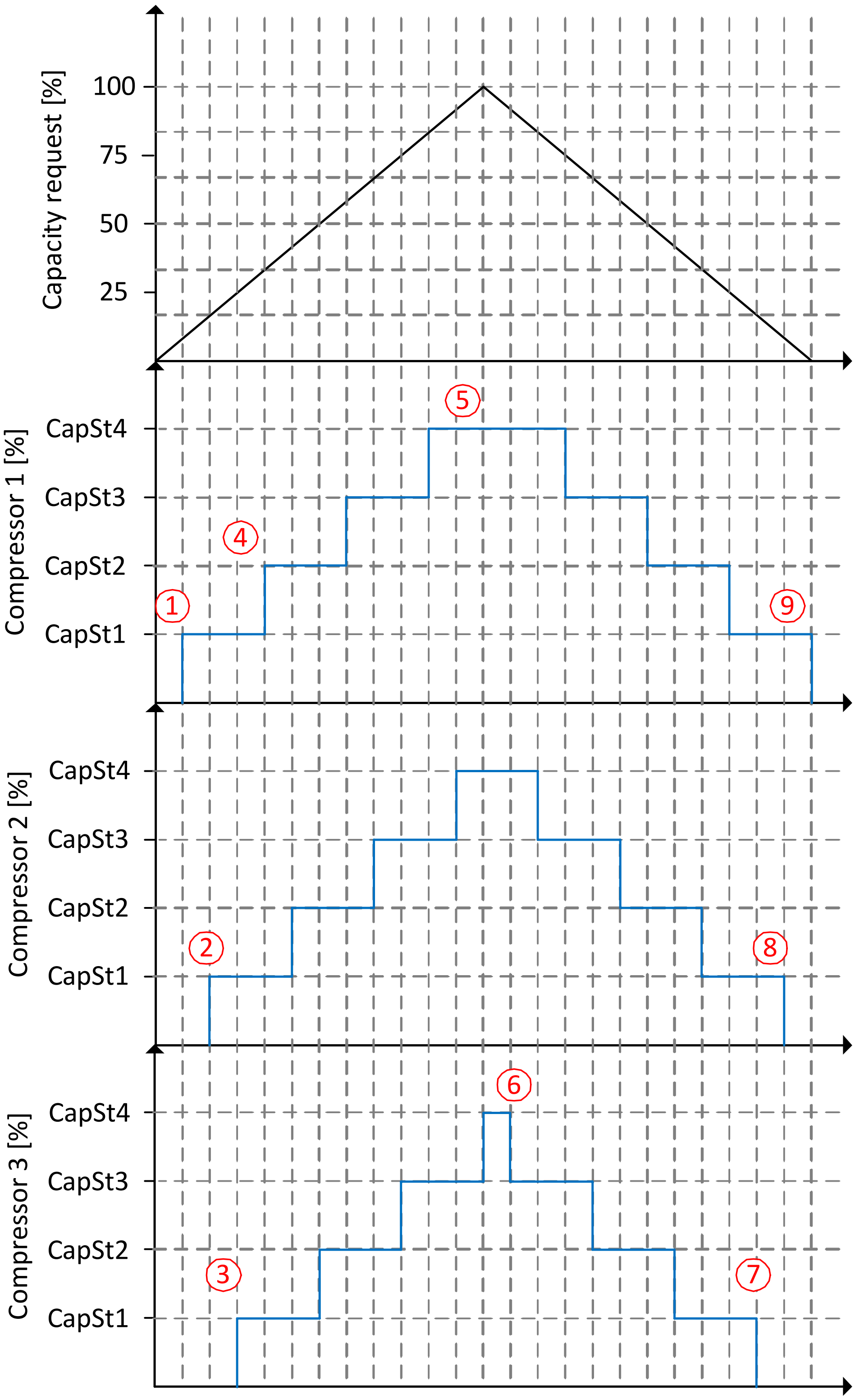
Process description:

Step	Description
1	Compressor1 starts at MinFq = 25% (resulting from 12.5 % capacity request). It remains at MinFq for 15 seconds; afterwards it is increased to SwiFqMax.
2	When SwiFqMax has been reached, Cpr2 starts at CapSt1 for TiSttup and increases to CapSt2. Cpr1 compensates first CapSt1 and after CapSt2 capacity.
3	Cpr 2 stages up and Cpr1 compensates the capacity accordingly.
4	Both compressors reach maximum capacity.
5	Cpr1 reduces capacity to SwiFqMin and Cpr2 switches down to CapSt3, then CapSt2.
6	Cpr2 is reduced to CapSt1 and then shut down or commanded into pump-down, while Cpr1 is compensating for the capacity reduction.
7	Cpr1 reaches SwiFqMin and shuts down or decreases to MinFq and performs pump down.

13.6 3 x step compressors equal capacity, default

	Range	Setting
Pre-Config: Rotation strategy	OpHrs/FixOrd/FixOrdOpHrs	OpHrs
Pre-Config: Capacity distribution	Prl/PrlCmp	Prl
NomCap	1...1000 kW	200 kW
UnLoCapSt	St1/St2	St1
CapSt1	1...100%	25%
CapSt2	1...100%	50%
CapSt3	1...100%	75%
CapSt4	1...100%	100%
MinCapSt	St1/St2	St1
MaxCapSt	St3/St4	St4
TiSttup	1...60 s	15 s
EmgOpM	En/Dis	Dis

* Identical settings for Cpr1, Cpr2 and Cpr3



Rotation Order: If Cpr1OpHrs < Cpr2OpHrs < Cpr3OpHrs -> Start order: Cpr1, Cpr2, Cpr3. Stop order: Cpr3, Cpr2, Cpr1.

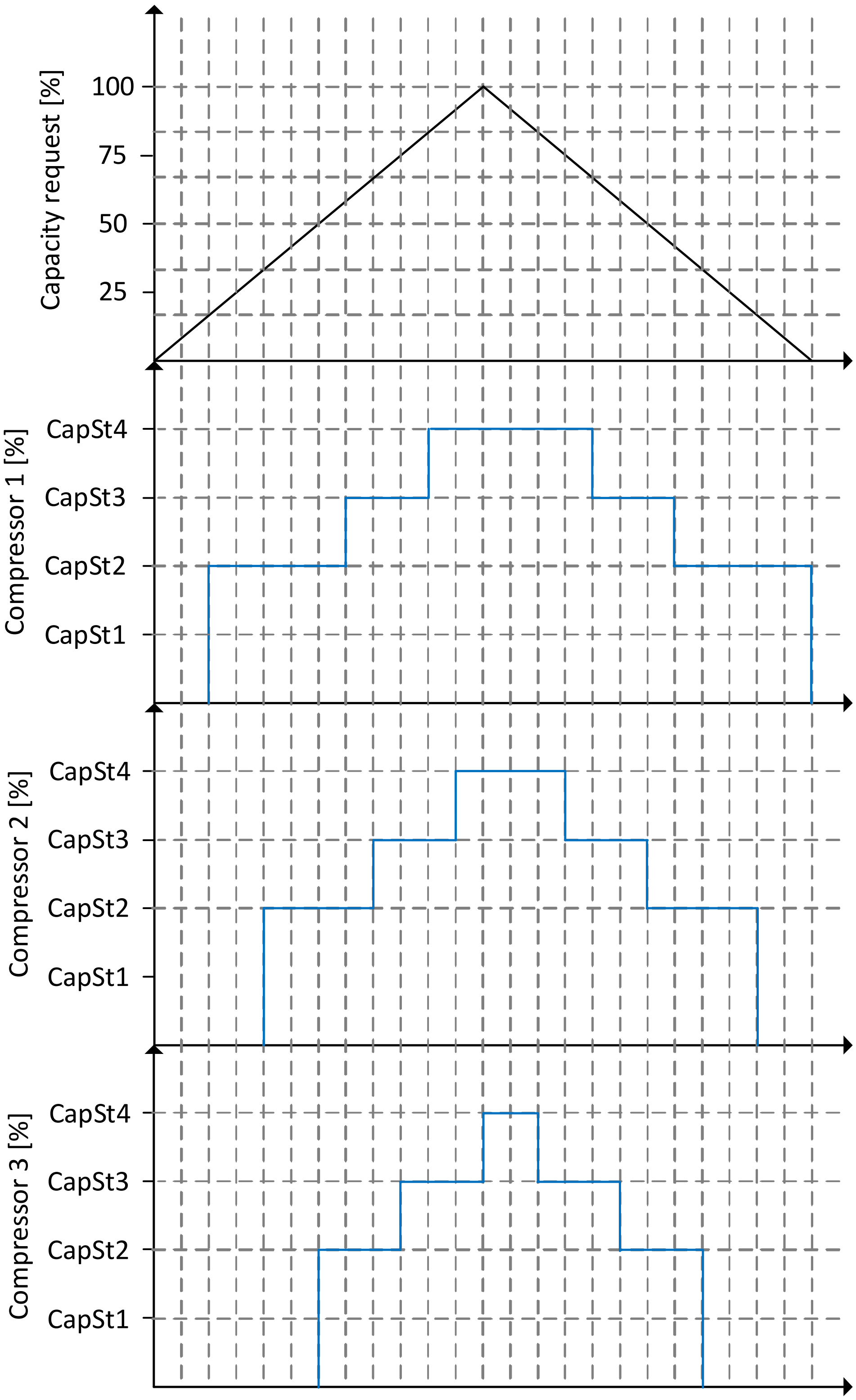
Step	Description
1	Compressor1 starts at CapSt1 (Capacity request 8.3 %), remains there for 15 seconds.
2	Compressor2 starts next at CapSt1, remains there for at least 15 seconds.
3	Cpr3 starts next at CapSt1, remains there for at least 15 seconds.
4	All tree compressors increase capacity alternately
5	Cpr1, Cpr2 and Cpr3 reach maximum capacity

Step	Description
6	Cpr3 decrease capacity first (due to rotation order)
7	Cpr3 shuts down after reaching CapSt1 or performs pump down.
8	Cpr2 shuts down after reaching CapSt1 or performs pump down.
9	Cpr1 shuts down after reaching CapSt1 or performs pump down.

13.6.1 3 x step compressor equal capacity, variation 1

	Range	Setting
Pre-Config: Rotation strategy	OpHrs/FixOrd/FixOrdOpHrs	OpHrs
Pre-Config: Capacity distribution	Prl/PrlCmp	Prl
NomCap	1...1000 kW	200 kW
UnLoCapSt	**St1/St2**	**St2**
CapSt1	1...100%	25%
CapSt2	1...100%	50%
CapSt3	1...100%	75%
CapSt4	1...100%	100%
MinCapSt	**St1/St2**	**St2**
MaxCapSt	St3/St4	St4
TiSttup	1...60 s	15 s
EmgOpM	En/Dis	Dis

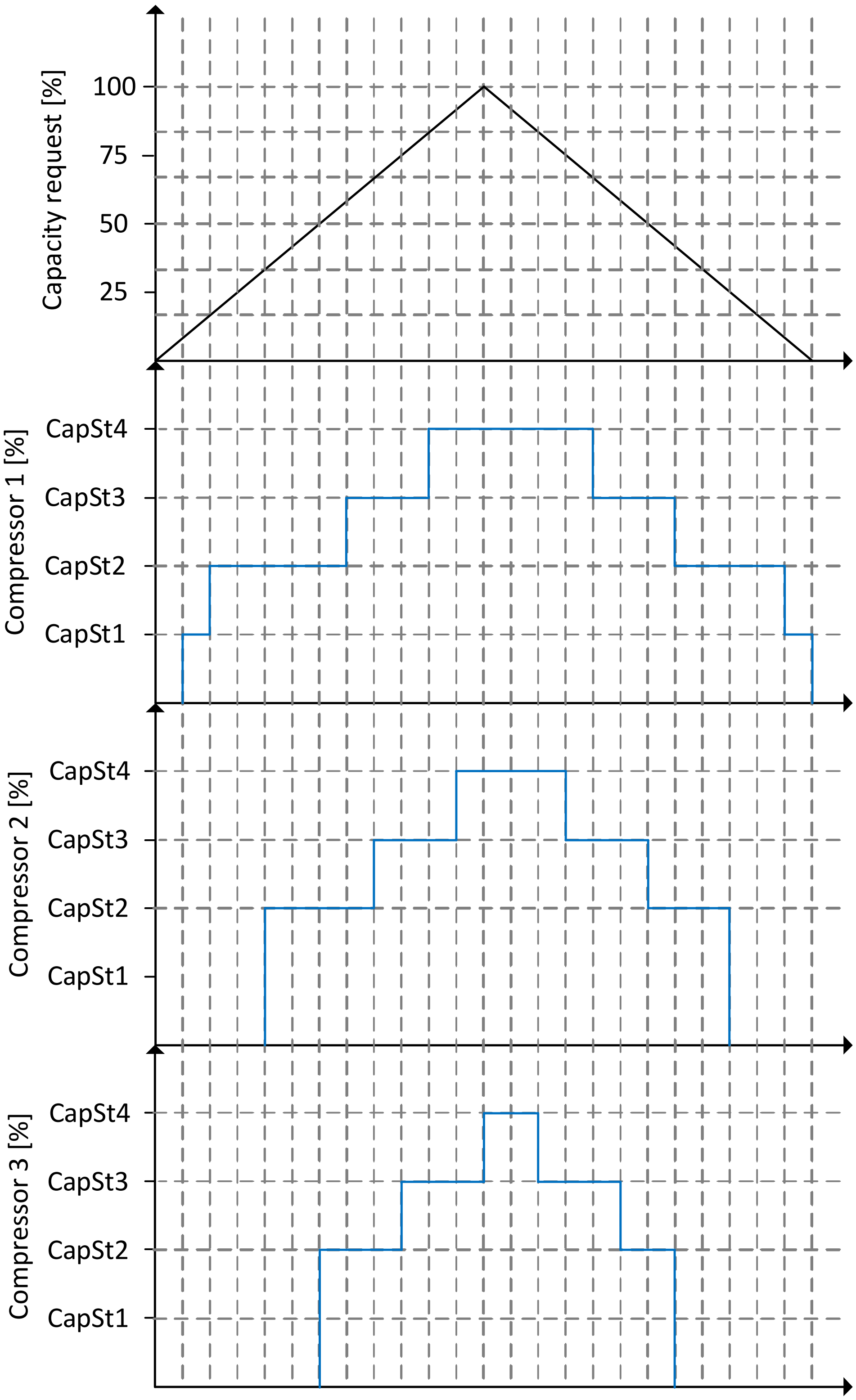
* Identical settings for Cpr1, Cpr2 and Cpr3


Capacity request [%]
100
75
50
25
Compressor 1 [%]
CapSt4
CapSt3
CapSt2
CapSt1
Compressor 2 [%]
CapSt4
CapSt3
CapSt2
CapSt1
Compressor 3 [%]
CapSt4
CapSt3
CapSt2
CapSt1

13.6.2 3 x step compressor equal capacity, variation 2

	Range	Setting
Pre-Config: Rotation strategy	OpHrs/FixOrd/FixOrdOpHrs	OpHrs
Pre-Config: Capacity distribution	Prl/PrlCmp	Prl
NomCap	1...1000 kW	200 kW
UnLoCapSt	St1/St2	St1
CapSt1	1...100%	25%
CapSt2	1...100%	50%
CapSt3	1...100%	75%
CapSt4	1...100%	100%
MinCapSt	**St1/St2**	**St2**
MaxCapSt	St3/St4	St4
TiSttup	1...60 s	15 s
EmgOpM	En/Dis	Dis

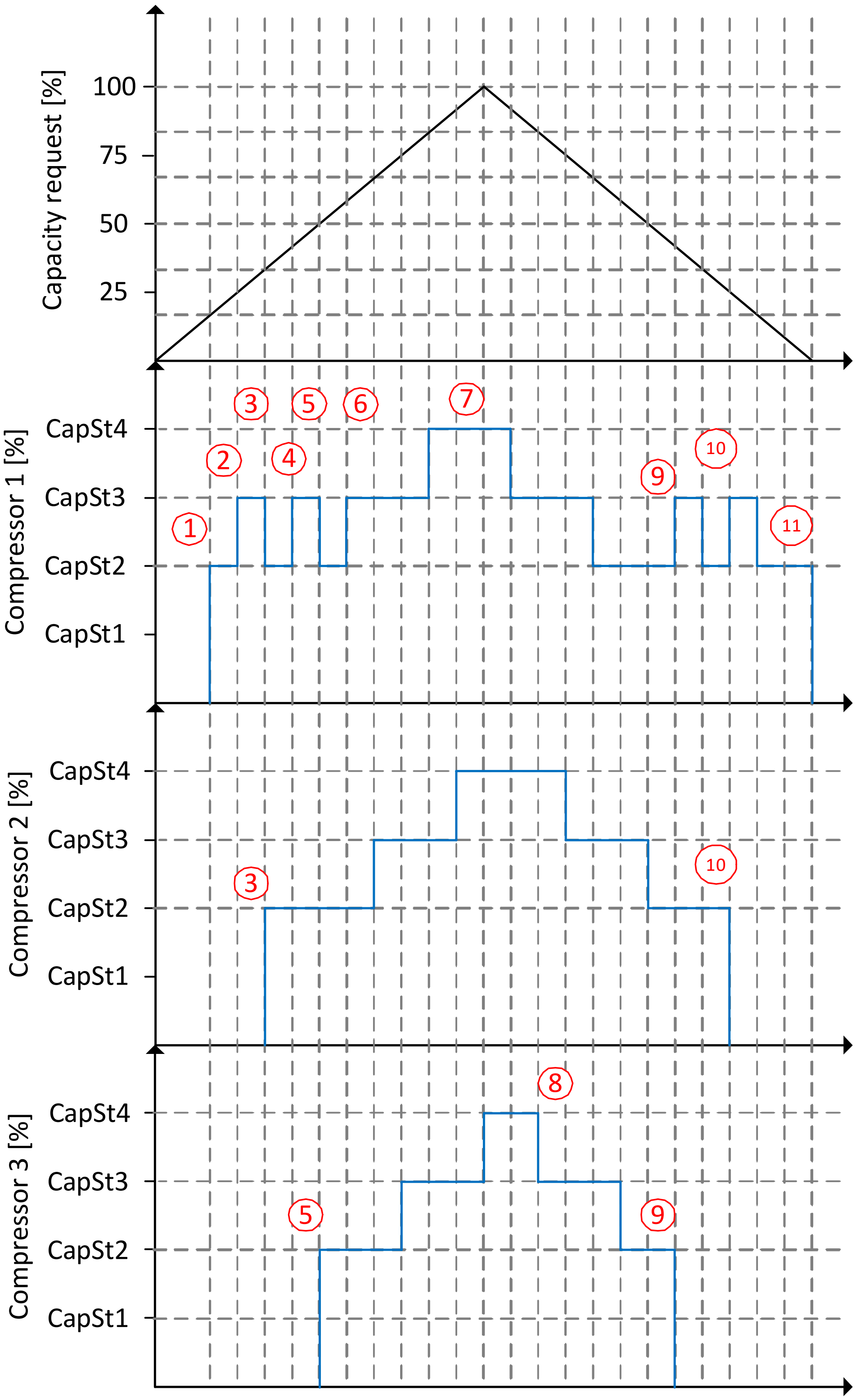
* Identical settings for Cpr1, Cpr2 and Cpr3


Capacity request [%]
100
75
50
25
Compressor 1 [%]
CapSt4
CapSt3
CapSt2
CapSt1
Compressor 2 [%]
CapSt4
CapSt3
CapSt2
CapSt1
Compressor 3 [%]
CapSt4
CapSt3
CapSt2
CapSt1

13.6.3 3 x step compressor equal capacity, variation 3

	Range	Setting
Pre-Config: Rotation strategy	OpHrs/FixOrd/FixOrdOpHrs	OpHrs
Pre-Config: Capacity distribution	**Prl/PrlCmp**	**PrlCmp**
NomCap	1...1000 kW	200 kW
UnLoCapSt	St1/St2	**St2**
CapSt1	1...100%	25%
CapSt2	1...100%	50%
CapSt3	1...100%	75%
CapSt4	1...100%	100%
MinCapSt	St1/St2	**St2**
MaxCapSt	St3/St4	St4
TiSttup	1...60 s	15 s
EmgOpM	En/Dis	Dis

* Identical settings for Cpr1, Cpr2 and Cpr3



Rotation Order: If Cpr1OpHrs < Cpr2OpHrs < Cpr3OpHrs -> Start order: Cpr1, Cpr2, Cpr3. Stop order: Cpr3, Cpr2, Cpr1.

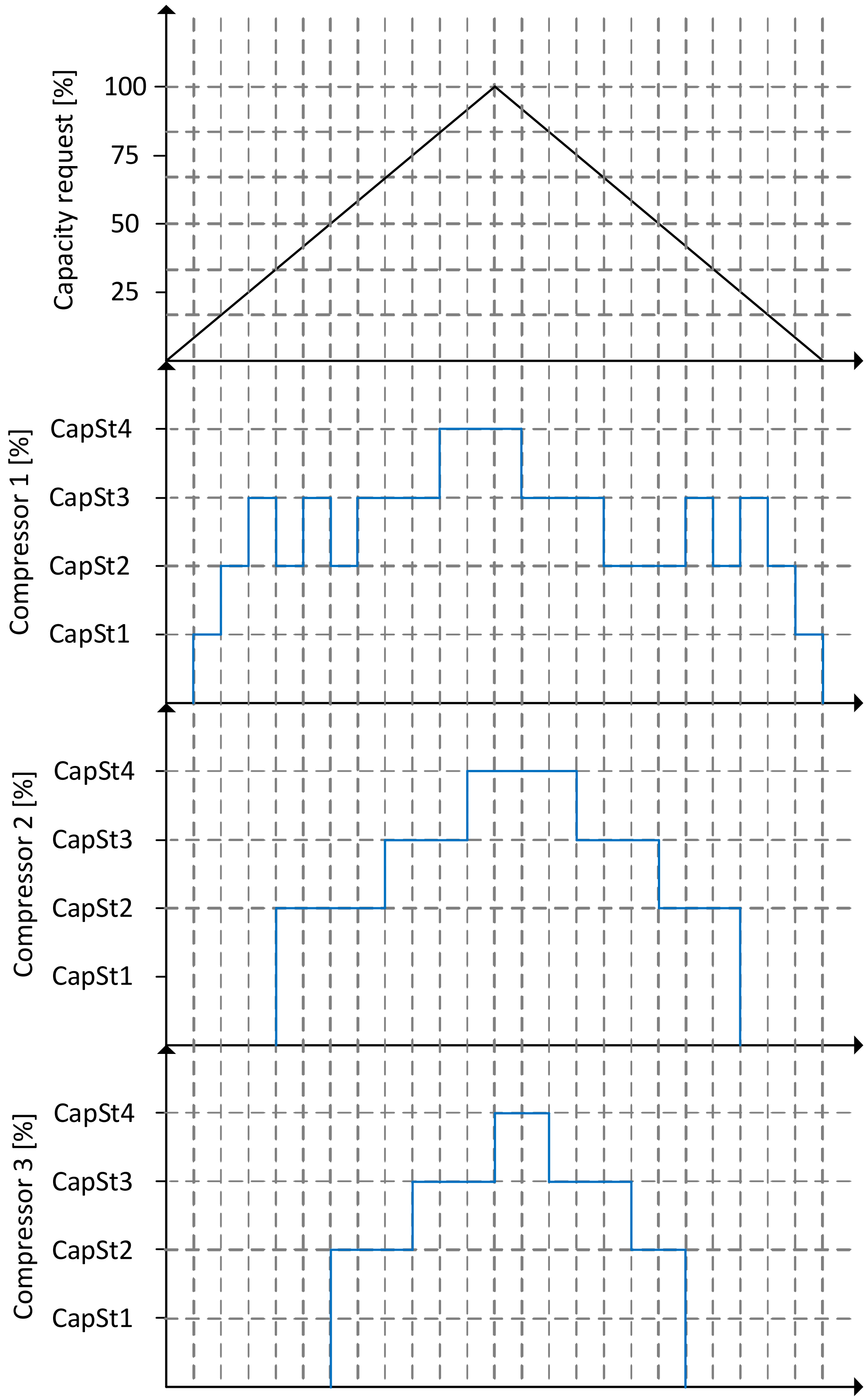
Step	Description
1	Compressor1 starts at CapSt1, remains there for 15 seconds and increases to St2 (Capacity request 16.6 %).
2	Compressor1 increases to St3.
3	Compressor2 starts next at CapSt1, remains there for at least 15 seconds and increases to CapSt2 while Cpr1 reduces capacity from St3 to St2.
4	Compressor1 increases to St3.

Step	Description
5	Compressor3 starts next at CapSt1, remains there for at least 15 seconds and increases to CapSt2 while Compressor1 reduces capacity from St3 to St2.
6	Compressor1 increases to St3 and Compressor2 and Compressor3 follow accordingly/ alternately.
7	Cpr1, Cpr2 and Cpr3 reach maximum capacity.
8	Compressor3 decreases capacity first (due to rotation order), Compressor2 and Compressor1 follow alternately.
9	Compressor3 shuts down reducing capacity from St2 to St1 or performs pump down while Compressor1 compensates capacity decrease.
10	Compressor2 shuts down reducing capacity from St2 to St1 or performs pump down while Compressor1 compensates capacity decrease.
11	Compressor1 shuts down after reaching CapSt1 or performs pump down.

13.6.4 3 x step compressor equal capacity, variation 4

	Range	Setting
Pre-Config: Rotation strategy	OpHrs/FixOrd/FixOrdOpHrs	OpHrs
Pre-Config: Capacity distribution	**Prl/PrlCmp**	**PrlCmp**
NomCap	1...1000 kW	200 kW
UnLoCapSt	St1/St2	St1
CapSt1	1...100%	25%
CapSt2	1...100%	50%
CapSt3	1...100%	75%
CapSt4	1...100%	100%
MinCapSt	**St1/St2**	**St2**
MaxCapSt	St3/St4	St4
TiSttup	1...60 s	15 s
EmgOpM	En/Dis	Dis

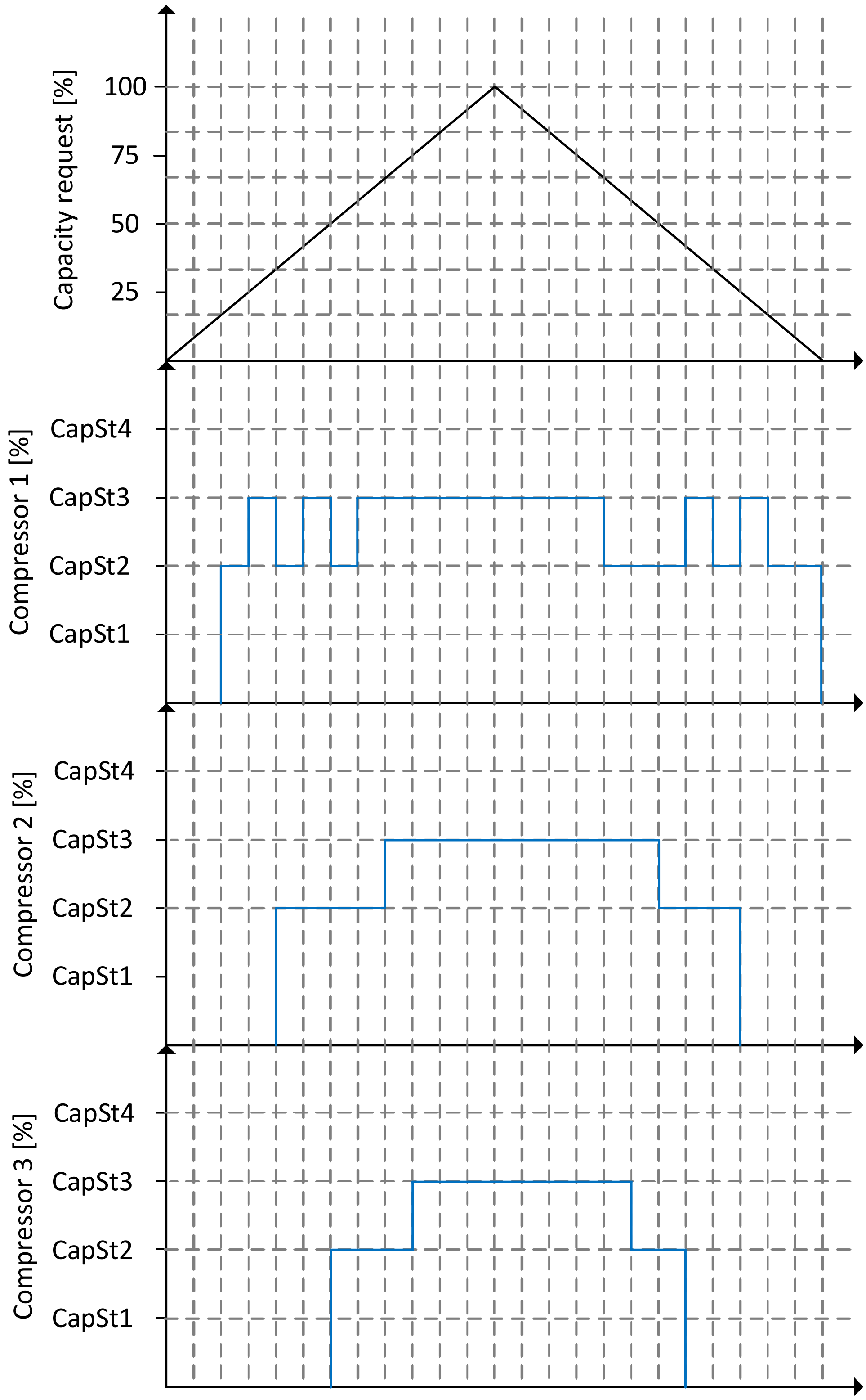
* Identical settings for Cpr1, Cpr2 and Cpr3


Capacity request [%]
100
75
50
25
Compressor 1 [%]
CapSt4
CapSt3
CapSt2
CapSt1
Compressor 2 [%]
CapSt4
CapSt3
CapSt2
CapSt1
Compressor 3 [%]
CapSt4
CapSt3
CapSt2
CapSt1

13.6.5 3 x step compressor equal capacity, variation 5

	Range	Setting
Pre-Config: Rotation strategy	OpHrs/FixOrd/FixOrdOpHrs	OpHrs
Pre-Config: Capacity distribution	**Prl/PrlCmp**	**PrlCmp**
NomCap	1...1000 kW	200 kW
UnLoCapSt	**St1/St2**	**St2**
CapSt1	1...100%	25%
CapSt2	1...100%	50%
CapSt3	1...100%	75%
CapSt4	1...100%	100%
MinCapSt	**St1/St2**	**St2**
MaxCapSt	**St3/St4**	**St3**
TiSttup	1...60 s	15 s
EmgOpM	En/Dis	Dis

* Identical settings for Cpr1, Cpr2 and Cpr3

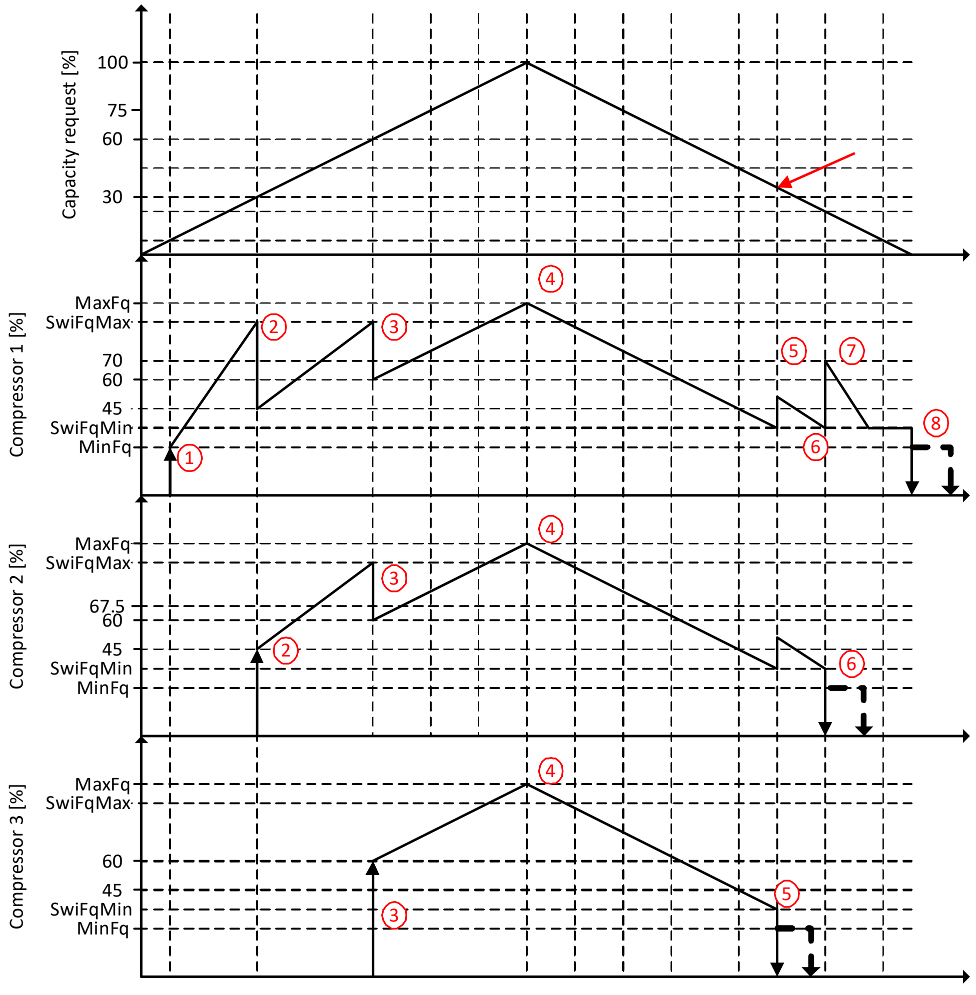


13.7 3 x CSVH compressors, equal capacity, default

	Range	Setting*
Pre-Config: Rotation strategy	OpHrs/FixOrd/FixOrdOpHrs	OpHrs
NomCap	1...1000 kW	200 kW
MaxFq	60...100%	100%

	Range	Setting*
MinFq	10...50%	25%
SwiFqMax	40...100%	90%
SwiFqMin	10...60%	35%
CapRsl	1...20%	2%
TiRampUp	1...20% / sec	5% / sec
TiRampDn	1...20% / sec	5% / sec
TiSttup	1...60 sec	15 sec
EmgOpM	En/Dis	Dis

* Identical settings for Cpr1, Cpr2 and Cpr3



Rotation order: If OpHrCpr1 < OpHrCpr2 < OpHrCpr3

□ Start order Cpr1, Cpr2 Cpr3, Stop order Cpr3, Cpr2, Cpr1

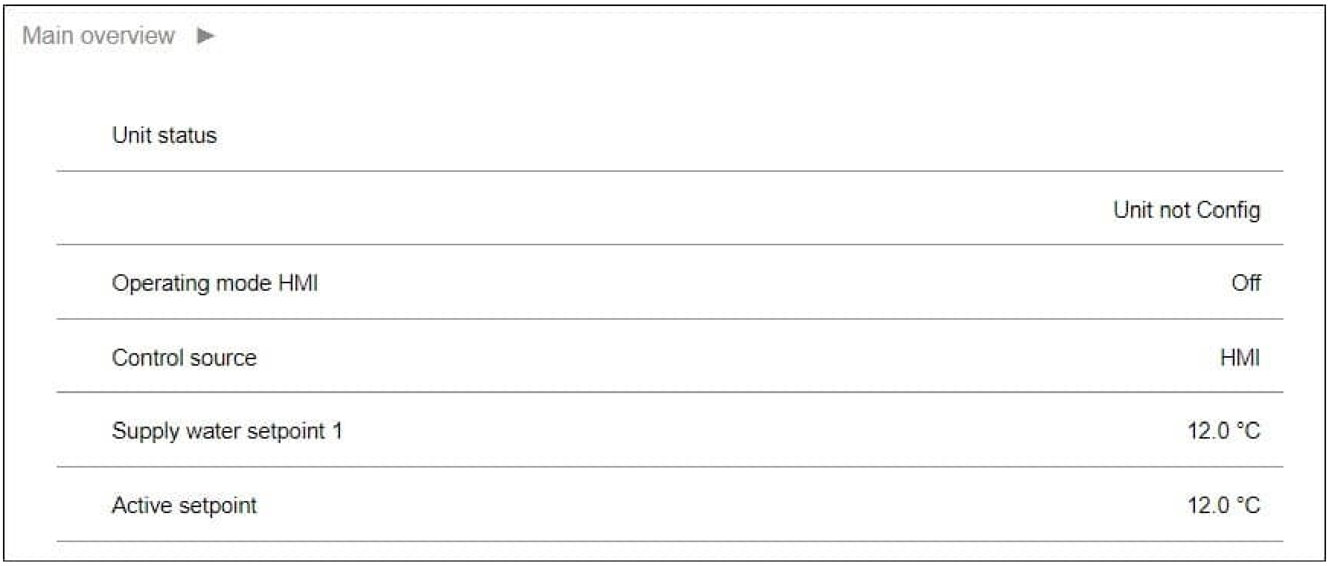
Step	Description
1	• Cpr1 start at MinFq = 25% (resulting form 8.3% capacity request) and remains there for 15 seconds. • After Cpr1 increases capacity up to SwiFqMax = 90%.
2	• After reaching SwiFqMax, Cpr1 reduces capacity to 45% (90% / 2 =45%) in two steps, compensating capacity impact of Cpr2 (MinFq, 45%) compensating capacity decrease of Cpr2. • At the same time Cpr 2 starts at MinFq=25%, remains there for 15 seconds and increases capacity to 45%. • That switching point is variable depending on Cpr1 and Cpr2 capacities

Step	Description
3	● Cpr1 and Cpr2 increase their capacity to SwiFqMax. ● After both compressors reach SwiFqMax they decrease to equalization same frequency (60 %), compensating capacity impact for Cpr2 Cpr3 in two steps (MinFq and 60%), ● At same time Cpr3 starts at MinFq, remains there for 15 seconds and increases to 60%.
4	When all (available) compressors in the circuit are active maximal capacity request (100 %) is available.
5	● All 3 compressor decrease capacity to SwiFqMin and Cpr3 shuts down or reduces capacity to MinFq and performs pump down. ● While Cpr1 and Cpr2 compensate the load (Cpr3 MinFq) and increase back to 52% (35% x 3 / 2 = 52.5%)
6	● Cpr1 and Cpr2 decrease capacity to SwiFqMin. ● Compressor 2 shuts down or performs pump down. ● Cpr1 compensates pump-down capacity and increases for that back to 70%.
7	Last Compressor decreases capacity to SwiFqMin.
8	Last compressor shuts down or performs pump down cycle at MinFq.

xxx

14 Addendum II: HMI structure

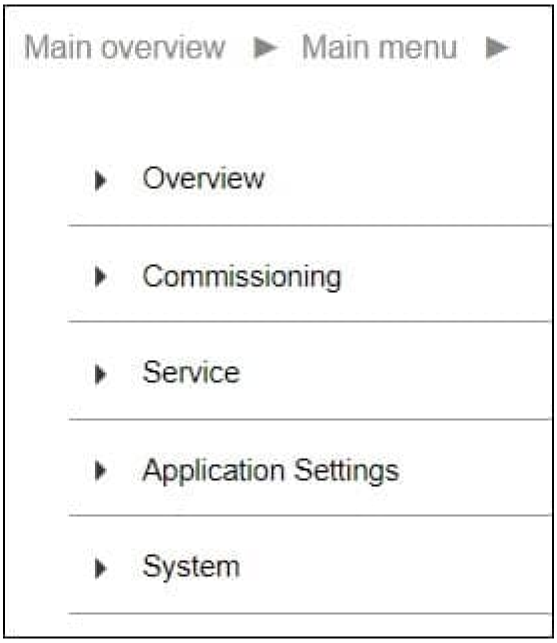
Main overview



The **Main overview** page provides an overview of the most important plant data as well as navigation to the submenus.

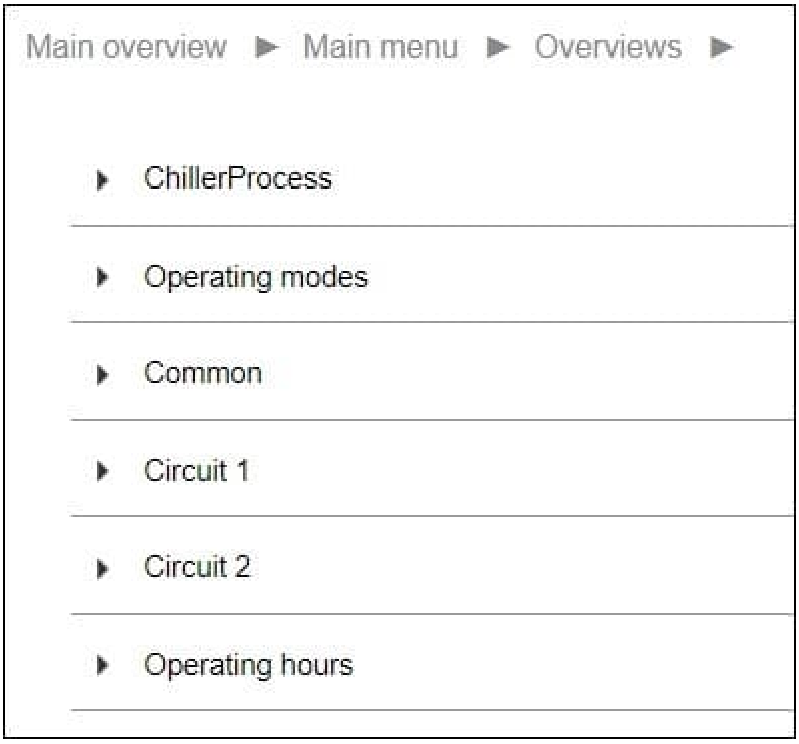
Menu	Enumerations	Description
Unit status	Unit not Config, etc. See section 11 ‘States’	
Operating Mode HMI	ON, OFF, Auto	
Control source	HMI, BMS, …	
Supply water setpoint [n]		
Active setpoint		
Supply water temperature		
Unit present capacity		
Unit available capacity		
Unit operating mode	Cool; Glycol; Test	
> Main Menu		Go to ‘Main menu’ page. □ see below!
> Alarming		Go to ‘Alarming’ page
> Enter Password		??? seems not to work !!!

Main menu



Menu	Description
Overview	Go to Overview page. All plant data. See below (A)
Commissioning	Go to Commissioning page. See below (B)
Service	Typical service activities, such as Service schedule etc.
Application Settings	Excerpt of service-related actions, from ‘System’. Access level ‘Service’. See below (C)
System	Full set of application system settings. Generic for all Climatix applications. See below (C)

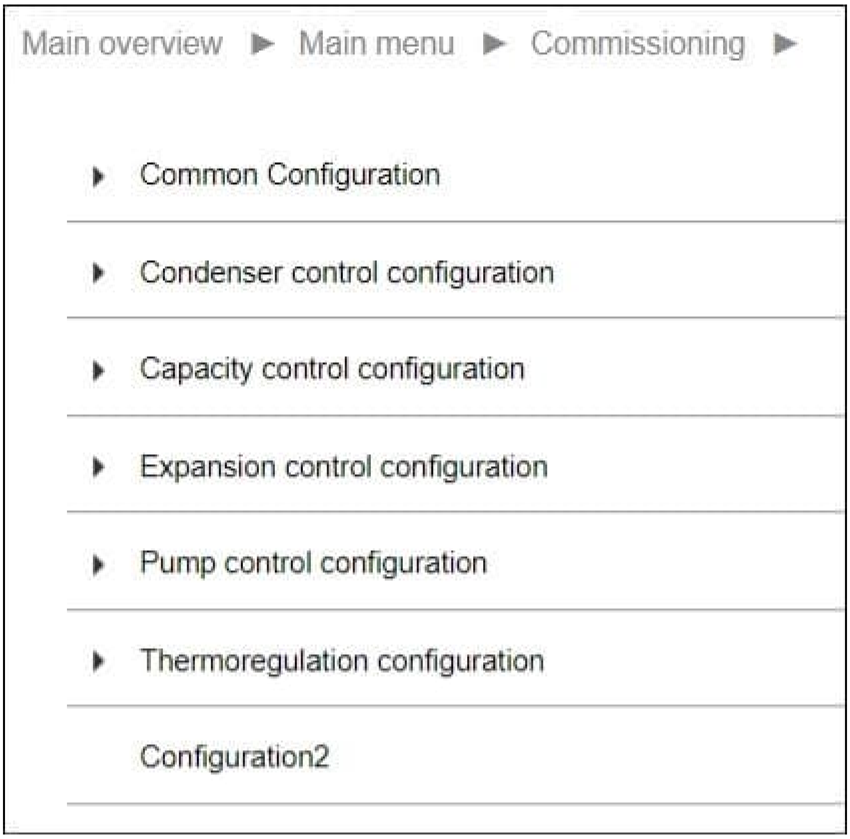
(A) Overview, and its categories



Overview is the navigation hub to plant data (**read-only**), sorted by categories:

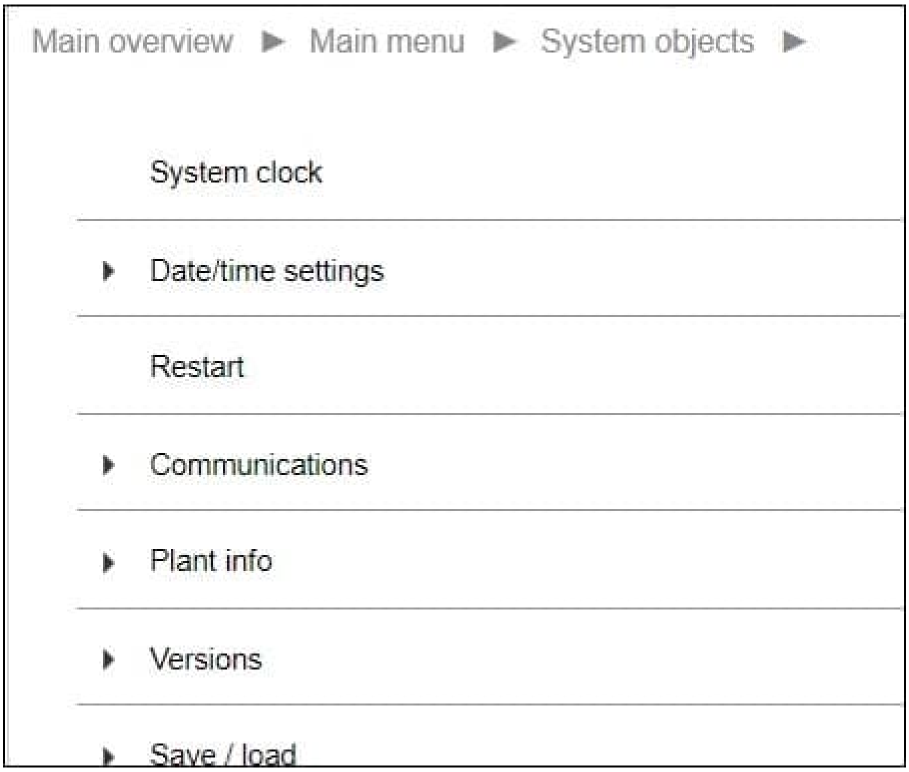
Overview category	Plant data point	Enumerations/description
Chiller process		
	Active setpoint	Also visible on HMI top level
	Supply water temperature	Also visible on HMI top level
	Return water temperature	
	Ambient temperature	
	etc.	
Operating modes		
	Operating mode HMI	[On, Off, Auto]. Also visible on HMI top level
	Operating mode communication	[On, Off, Auto]. Meaning/Background ???
	Supply control	[On, Off, Auto]. Meaning/Background ???
	Priority	For example 15 means: ??? Range and meaning of prios defined ???
	etc.	[On, Off, Auto]. Also visible on HMI top level
The following 2 menus reflect IOs: **Common** IOs wired at the main controller and **Circuit [n]** IOs wired at the each extension module		
Common (read-only)		
	Supply water temperature	See section 4.2 IO layout, main controller
	Return water temperature	See section 4.2 IO layout, main controller
	Ambient temperature	See section 4.2 IO layout, main controller
	Setpoint manipulation	See section 4.2 IO layout, main controller
	etc.	
Circuit [n] (read only)		
	Suction gas temperature	See section 4.2 IO layout, Extension module circuit 1/2/3
	Discharge temperature	See section 4.2 IO layout, Extension module circuit 1/2/3
	Evaporating pressure	See section 4.2 IO layout, Extension module circuit 1/2/3
	Condensing pressure	See section 4.2 IO layout, Extension module circuit 1/2/3
	MVL valve	See section 4.2 IO layout, Extension module circuit 1/2/3
Operating hours		**Read**: all levels. **Reset**: service/factory level
	Unit	
	Evaporator pump 1	
	Evaporator pump 2	
	Circuit 1…	
	Operating hours	
	Compressor 1	
	etc.	

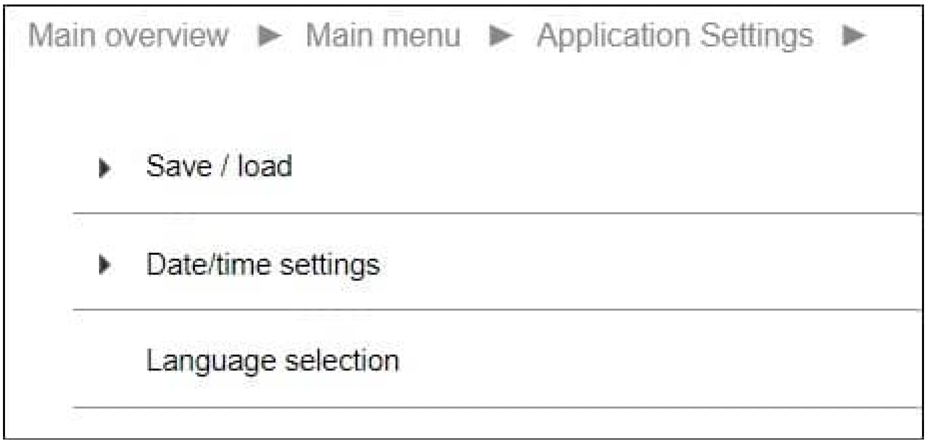
(B) Commissioning and related workflows



The commissioning workflow is completely described in section 5 **HMI: configuration and testing**.

(C) System settings with different access levels





The **System** menu **(System objects)** contains the full set of application system settings. These settings are generic for all Climatix applications. In future editions of the Chiller application, features of specific interest to customers will be documented in detail. All system menus are accessible at '**Factory'** level.

The **Application settings** menu offers a subset of system settings to be used at '**Service**' level in the field.

Menu	Description
Save / load	For the typical service use case of loading parameters
Date/time settings	For the typical service use case of setting date and time
Language selection	For the typical service use case of setting the UI language

15 Addendum III: Passive temp sensors

Characteristics of passive temperature sensors are as follows:

	Pt1000	Ni1000LG	NTC10KB3435	NTC10KB3977
T [°C]	R [Ω]	R [Ω]	R [Ω]	R [Ω]
-50	803.06	790.88	329500	658962
-45	822.90	810.75	247700	465011
-40	842.71	830.84	188500	332100
-35	862.48	851.15	144100	239904
-30	882.22	871.69	111300	175203
-25	901.92	892.47	86430	129289
-20	921.60	913.48	67770	96360
-15	941.24	934.74	53410	72502
-10	960.86	956.24	42470	55047
-5	980.44	977.99	33900	42158
0	1000.00	1000.00	27280	32555
5	1019.53	1022.26	22050	25339
10	1039.03	1044.79	17960	19873
15	1058.49	1067.59	14690	15699
20	1077.94	1090.65	12090	12488
25	1097.35	1113.99	10000	10000
30	1116.73	1137.62	8313	8059
35	1136.08	1161.52	6940	6535
40	1155.41	1185.71	5827	5330
45	1174.70	1210.20	4911	4372
50	1193.97	1234.98	4160	3605
55	1213.21	1260.06	3536	2989
60	1232.42	1285.45	3020	2490
65	1251.60	1311.14	2588	2084
70	1270.75	1337.15	2228	1753
75	1289.87	1363.47	1920	1481
80	1308.97	1390.12	1668	1256
85	1328.03	1417.09	1450	1070
90	1347.07	1444.39	1266	915
95	1366.08	1472.03	1110	786
100	1385.06	1500.01	973	677
105	1404.00	1528.32	860	586
110	1422.93	1556.98	758	508
115	1441.82	1586.00		443
120	1460.68	1615.37		387
125	1479.51	1645.10		339
130	1498.32	1675.19		298
135	1517.10	1705.65		262
140	1535.84	1736.48		232
145	1554.56	1767.68		206
150	1573.25	1799.27		183

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