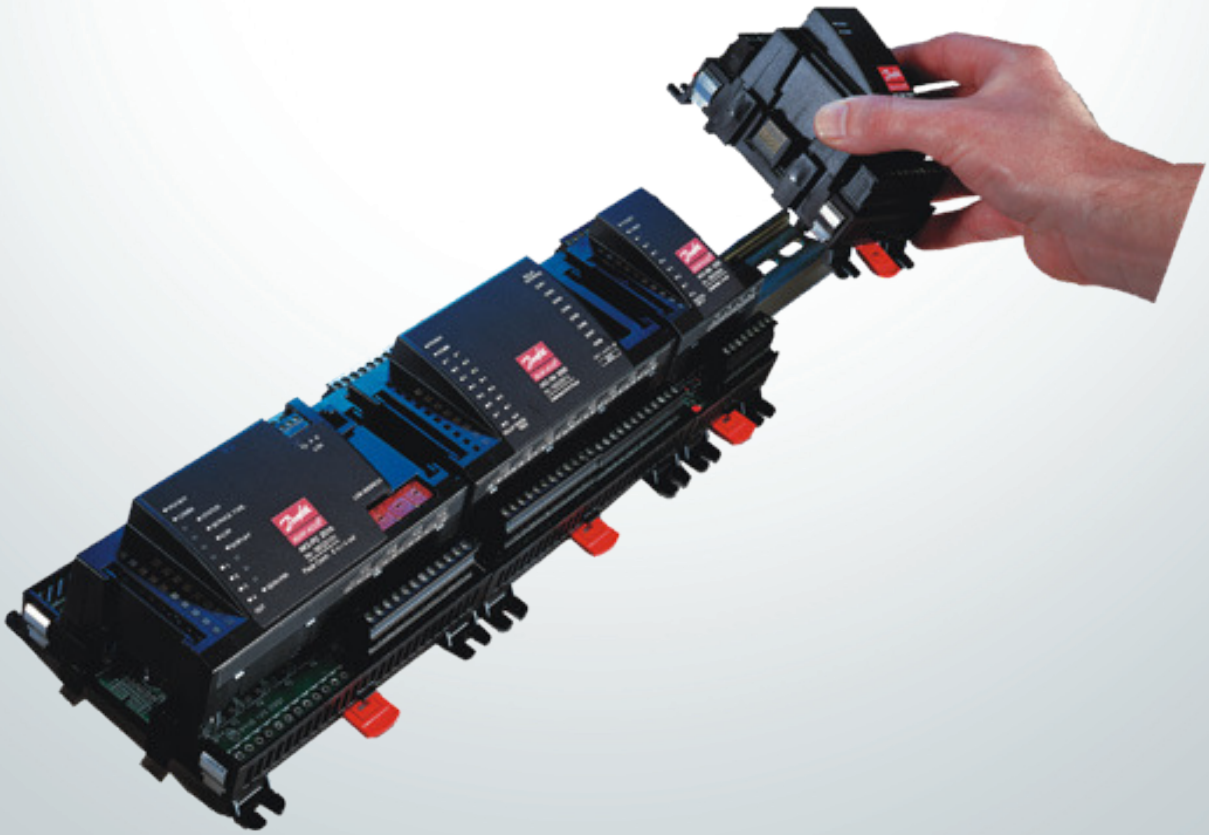
ENGINEERING
TOMORROW

Design Guide

Capacity controller with heat recovery function
AK-PC 781

ADAP-KOOL® Refrigeration control systems



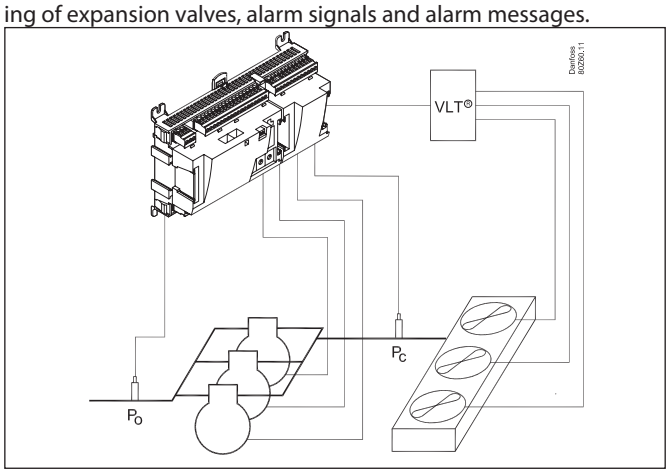
Contents

1. Introduction

SW = 4.5x

Application

AK-PC 781 is complete regulating units for capacity control of compressors and condensers in refrigeration systems. The controller is with oil management, heat recovery function and CO_2 gas pressure control.
In addition to capacity control the controllers can give signals to other controllers about the operating condition, e.g. forced closing of expansion valves, alarm signals and alarm messages.

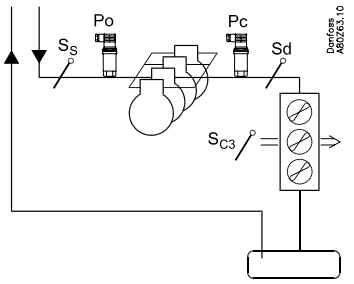


The controller's main function is to control compressors and condensers so that operation all the time takes place at the energy-optimum pressure conditions. Both suction pressure and condensing pressure are controlled by signals from pressure transmitters.
Capacity control can be carried out by suction pressure P0, media temperature S4 or separate control pressure Pctrl (for cascade).

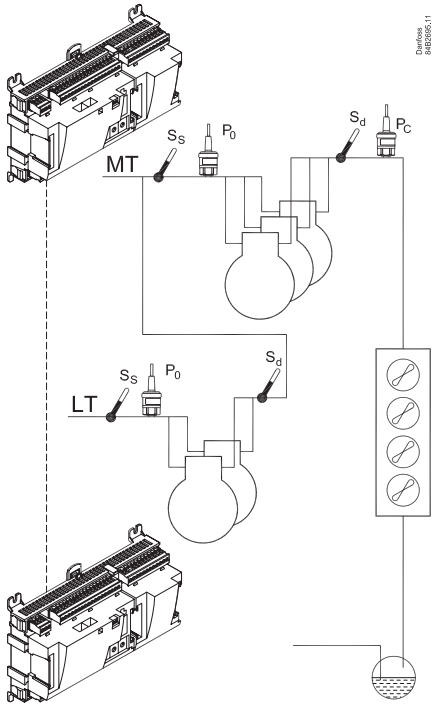
Among the different functions are:
- Capacity control of up to 8 compressors
- Up to 3 unloaders for each compressor
- Oil management. Either shared or individual for all of the compressor's oil valves. Receiver pressure control.
- Speed control of one or two compressors
- Up to 6 safety inputs for each compressor
- Option for capacity limitation to minimize consumption peaks
- When the compressor does not start, signals can be transmitted to other controllers so that the electronic expansion valves will be closed
- Regulation of liquid injection into suction line
- Start/stop of liquid injection in heat exchanger (cascade)
- MT/LT - coordination between controllers in cascade control
- Safety monitoring of high pressure / low pressure / discharge temperature
- Capacity control of up to 8 fans
- Floating reference with regard to outside temperature
- Heat recovery function
- CO2 gas cooler control and receiver control
- Parallel compression on transcritical CO2 system
- Step coupling, speed regulation or a combination
- Safety monitoring of fans
- The status of the outputs and inputs is shown by means of light-emitting diodes on the front panel
- Alarm signals can be generated via data communication
- Alarms are shown with texts so that the cause of the alarm is easy to see.
- Plus some completely separate functions that are totally independent of the regulation – such as alarm, thermostat ,pressure and PI-regulating functions.

Examples

Traditional capacity control

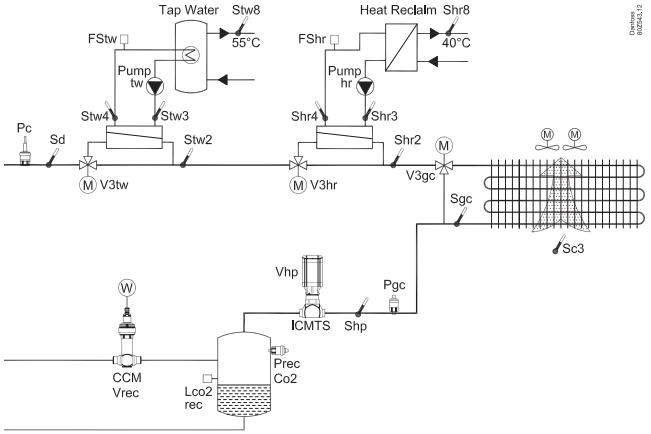


Booster control with 2 controls



(For pure booster control without MT cooling, the intermediate pressure must be connected to the receiver to prevent Pmin and Pmax cut-outs during the start-up).

Heat recovery functions, controlling the condensing pressure and receiver pressure of a CO2 plant

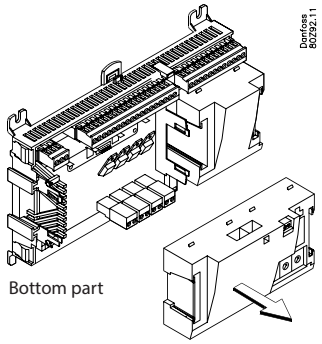


Principles

The great advantage of this series of controllers is that it can be extended as the size of the plant is increased. It has been developed for refrigeration control systems, but not for any specific application – variation is created through the read-in software and the way you choose to define the connections.
It is the same modules that are used for each regulation and the composition can be changed, as required. With these modules (building blocks) it is possible to create a multitude of various kinds of regulations. But it is you who must help adjusting the regulation to the actual needs – these instructions will assist you to find your way through all the questions so that the regulation can be defined and the connections made.

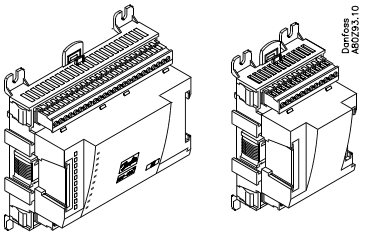
Advantages
- The controller's size can "grow" as systems grow
- The software can be set for one or more regulations
- Several regulations with the same components
- Extension-friendly when systems requirements are changed
- Flexible concept:
  - Controller series with common construction
  - One principle – many regulation uses
  - modules are selected for the actual connection requirements
  - The same modules are used from regulation to regulation

Controller

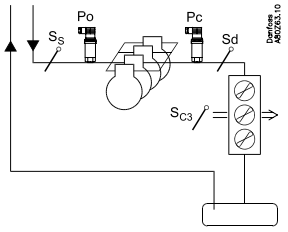


The controller is the cornerstone of the regulation. The module has inputs and outputs capable of handling small systems.
- The bottom part – and hence the terminals – are the same for all controller types.
- The top part contains the intelligence with software. This unit will vary according to controller type. But it will always be supplied together with the bottom part.
- In addition to the software the top part is provided with connections for data communication and address setting.

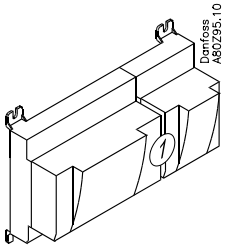
Extension modules



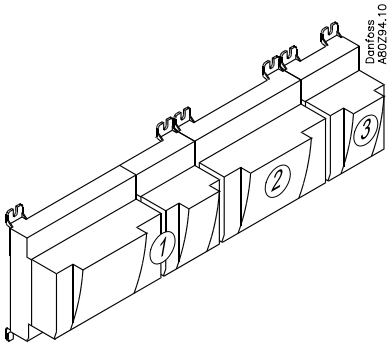
If the system grows and more functions have to be controlled, the regulation can be extended.
With extra modules more signals can be received and more relays cut in and out – how many of them – and which – is determined by the relevant application.



Examples



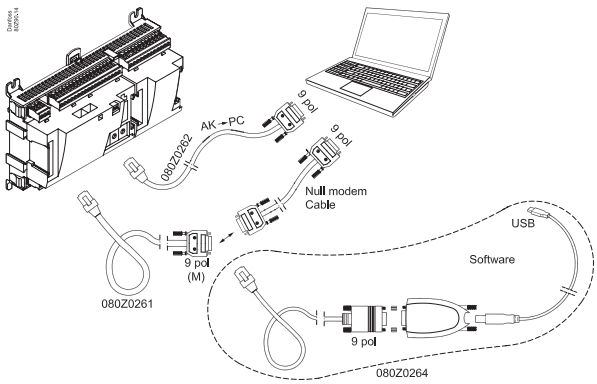
A regulation with few connections can be performed with the controller module alone



If there are many connections one or more extension modules have to be mounted

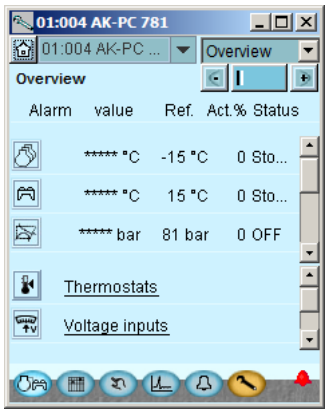
Direct connection
Setup and operation of an AK controller must be accomplished via the "AK-Service Tool" software program.

The program is installed on a PC, and setup and operation of the various functions are carried out via the controller's menu displays.

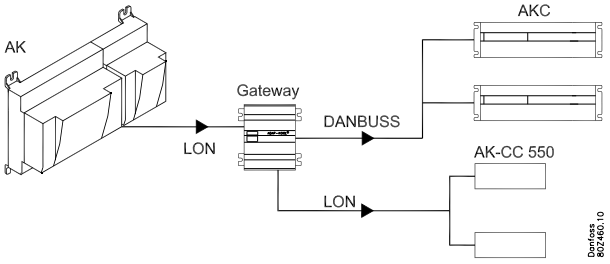


Displays
The menu displays are dynamic, so that different settings in one menu will result in different setting possibilities in other menus.

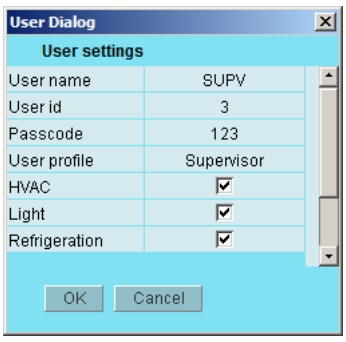
A simple application with few connections will give a setup with few settings.
A corresponding application with many connections will give a setup with many settings.
From the overview display there is access to further displays for the compressor regulation and the condenser regulation.
At the bottom of the display there is access to a number of general functions, such as "time table", "manual operation", "log function", "alarms", and "service" (configuration).



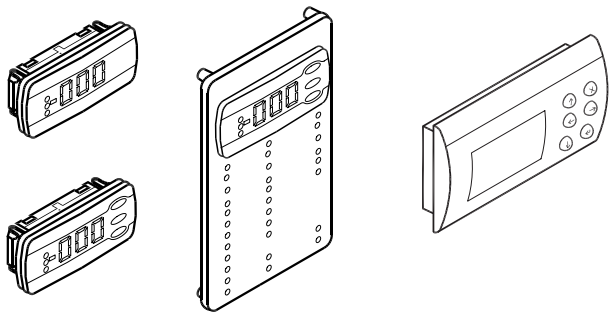
Network linking
The controller can be linked up into a network together with other controllers in an ADAP-KOOL® refrigeration control system. After the setup operation can be performed at a distance with, say, our software program type AKM.



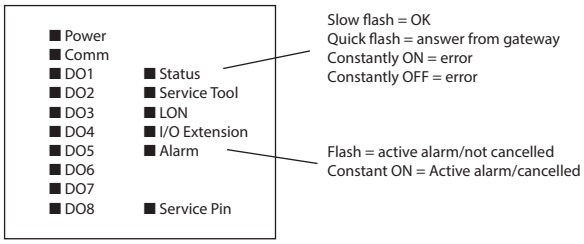
Users
The controller comes supplied with several languages, one of which can be selected and employed by the user. If there are several users, they may each have their choice of language. All users must be assigned a user profile which either gives access to full operation or gradually limits the operation to the lowest level that only allows you "to see".
Language selection is part of the service tool settings.
If the language selection is not available in the service tool for the current regulator, English texts will be displayed.



External display
An external display can be fitted in order for P0 (Suction) and Pc (Condensing) readings to be displayed.
A total of 4 displays can be fitted and with one setting it is possible to choose between the following readings: suction pressure, suction pressure in temperature, Pctrl, S4, Ss, Sd, condenser pressure, condenser pressure in temperature, S7 gas cooler temperature, hot tap water at heat recovery and heat exchanger temperature at heat recovery.
A graphical display with control buttons can also be fitted.

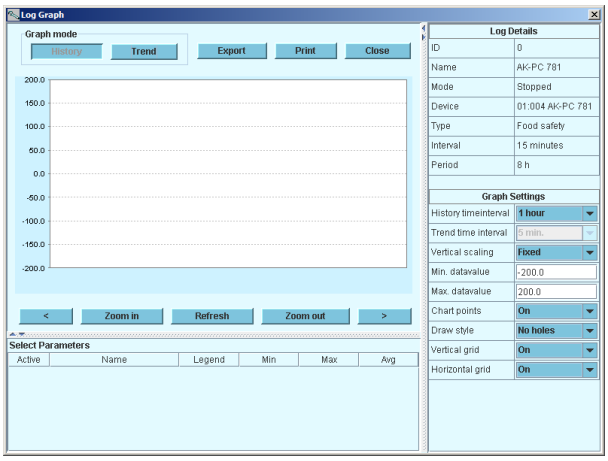


Light-emitting diodes
A number of light-emitting diodes makes it possible to follow the signals that are received and transmitted by the controller.



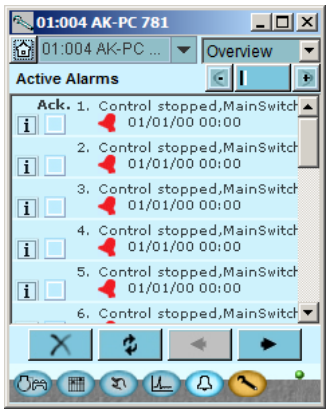
Log
From the log function you can define the measurements you wish to be shown.
The collected values can be printed, or you may export them to a file. You can open the file in Excel.

If you are in a service situation you can show measurements in a trend function. The measurements are then made real-time and displayed instantly.

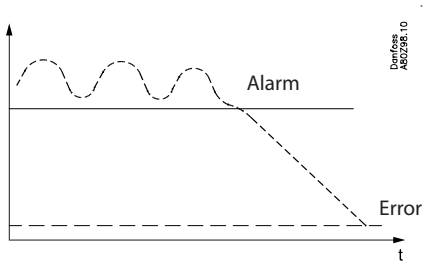


Alarm
The display gives you an overview of all active alarms. If you wish to confirm that you have seen the alarm you can cross it off in the acknowledge field.
If you want to know more about a current alarm you can click on it and obtain an information display on the screen.

A corresponding display exists for all earlier alarms. Here you can upload information if you need further details about the alarm history.



Trouble-shooting
The controller contains a function that continuously follows a number of measurements and deals with them. The result indicates whether the function is OK or whether an error may be expected within a given period of time ("the trip down the roller coaster has started"). At this time an alarm is transmitted about the situation – no error has appeared as yet, but it will come.
One example may be slow clogging-up of a condenser. When the alarm comes the capacity has been reduced, but the situation is not serious. There will be time to plan a service call.



2. Design of a controller

This section describes how the controller is designed.

The controller in the system is based on a uniform connection platform where any deviations from regulation to regulation is determined by the used top part with a specific software and by which input and output signals the relevant application will require. If it is an application with few connections, the controller module (top part with belonging bottom part) may be sufficient. If it is an application with many connections it will be necessary to use the controller module plus one or more extension modules.

This section will give you a survey of possible connections plus assistance in selecting the modules required by your actual application.

Module survey

• Controller module – capable of handling minor plant requirements.

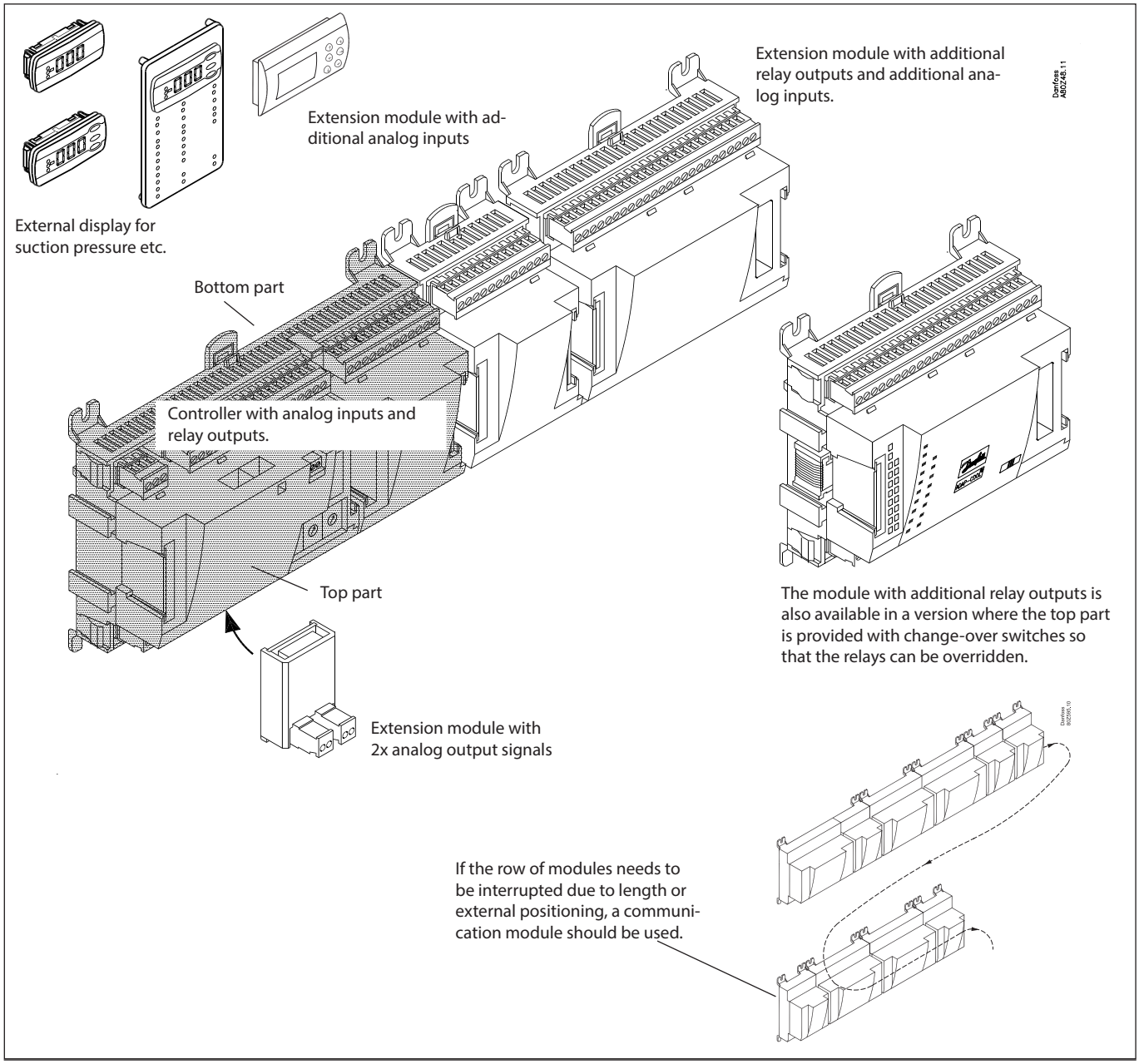
• Extension modules. When the complexity becomes greater and additional inputs or outputs are required, modules can be attached to the controller. A plug on the side of the module will transmit the supply voltage and data communication between the modules.

• Top part
The upper part of the controller module contains the intelligence. This is the unit where the regulation is defined and where data communication is connected to other controllers in a bigger network.

• Connection types
There are various types of inputs and outputs. One type may, for example, receive signals from sensors and switches, another may receive a voltage signal, and a third type may be outputs with relays etc. The individual types are shown in the table below.

• Optional connection
When a regulation is planned (set up) it will generate a need for a number of connections distributed on the mentioned types. This connection must then be made on either the controller module or an extension module. The only thing to be observed is that the types must not be mixed (an analog input signal must for instance not be connected to a digital input).

• Programming of connections
The controller must know where you connect the individual input and output signals. This takes place in a later configuration where each individual connection is defined based on the following principle:
- to which module
- at which point ("terminals")
- what is connected (e.g. pressure transmitter/type/ pressure range)



1. Controller

Type	Function	Application
AK-PC 781	Controller for capacity control of compressors and condensers 8 compressors with up to 3 unloaders, 8 fans, max. 120 inputs/outputs	Compressor / Condenser / Both/ Oil management / Heat recovery / CO2 gas pressure

2. Extension modules and survey of inputs and outputs

Type	Analog inputs	On/Off outputs		On/off supply voltage (DI signal)		Analog outputs	Stepper output	Module with switches
	For sensors, pressure transmitters etc.	Relay (SPDT)	Solid state	Low voltage (max. 80 V)	High voltage (max. 260 V)	0-10 V d.c.	For valves with step control	For override of relay outputs
Controller	11	4	4	-	-	-		-
Extension modules								
AK-XM 101A	8							
AK-XM 102A				8				
AK-XM 102B					8			
AK-XM 103A	4					4		
AK-XM 204A		8						
AK-XM 204B		8						x
AK-XM 205A	8	8						
AK-XM 205B	8	8						x
AK-XM 208C	8						4	
The following extension module can be placed on the PC board in the controller module. There is only room for one module.								
AK-OB 110						2		

3. AK operation and accessories

Type	Function	Application
Operation		
AK-ST 500	Software for operation of AK controllers	AK-operation
-	Cable between PC and AK controller	AK - Com port
-	Cable between zero modem cable and AK controller / Cable between PDA cable and AK controller	AK - RS 232
-	Cable between PC and AK controller	AK - USB
Accessories	**Power supply module 230 V / 115 V to 24 V d.c.**	
AK-PS 075	18 VA	Supply for controller
AK-PS 150	36 VA	
AK-PS 250	60 VA	
Accessories	**External display that can be connected to the controller module. For showing, say, the suction pressure**	
EKA 163B	Display	
EKA 164B	Display with operation buttons	
EKA 166	Display with operation buttons and LED for function cut in	
AK-MMI	Graphic display with operation	
-	Cable between display and controller	Length = 2 m, 6 m
	Cable between graphic display and controller	Length = 1.5 m, 3.0 m
Accessories	**Real time clock for use in controllers that require a clock function, but are not wired with data communication.**	
AK-OB 101A	Real time clock with battery backup.	To be mounted in an AK controller
Accessories	**Communication modules for controllers where modules cannot be connected continuously**	
AK-CM 102	Communication module	Data communication for external extension modules

On the following pages there is data specific to each module.

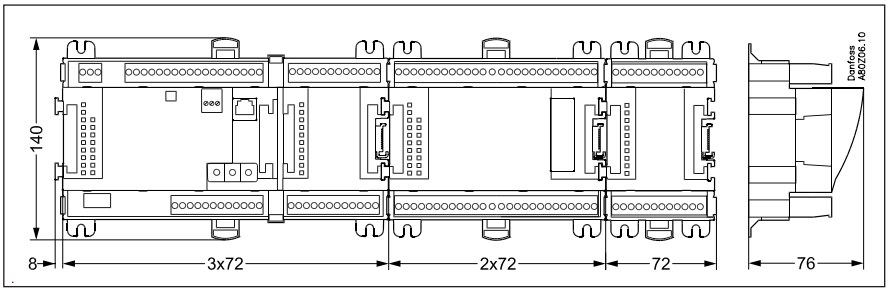
Common data for modules

Supply voltage	24 V d.c./a.c. +/- 20%	
Power consumption	AK-__ (controller)	8 VA
	AK-XM 101, 102, 103, 107, AK-CM 102	2 VA
	AK-XM 204, 205, 208	5 VA
Analog inputs	Pt 1000 ohm /0°C	Resolution: 0.1°C Accuracy: +/- 0.5°C
	Pressure transmitter type AKS 32R / AKS 2050 AKS 32 (1-5 V)	Resolution:1 mV Accuracy +/- 10 mV Max. connection of 5 pressure transmitters on one module
	Other pressure transmitter: Ratiometric signal Min. and Max. pressure must be set	
	Voltage signal 0-10 V	
	Contact function (On/Off)	On at R < 20 ohm Off at R > 2K ohm (Gold -plated contacts not necessary)
On/off supply voltage inputs	Low voltage 0 / 80 V a.c./d.c.	Off: U < 2 V On: U > 10 V
	High voltage 0 / 260 V a.c.	Off: U < 24 V On: U > 80 V
Relay outputs SPDT	AC-1 (ohmic)	4 A
	AC-15 (inductive)	3 A
	U	Min. 24 V Max. 230 V Low and high voltage must not be connected to the same output group
Solid state outputs	Can be used for loads that are cut in and out frequently, e.g. : Oil valves, fans and AKV valves	Max. 240 V a.c. , Min. 48 V a.c. Max. 0,5 A, Leak < 1 mA Max. 1 AKV
Stepper outputs	Used for valves with stepper input	20-500 step/s Separate supply to stepper outputs : 24 a.c./d.c. / 13 VA
Ambient temperature	During transport	-40 to 70°C
	During operation	-20 to 55°C , 0 to 95% RH (non condensing) No shock influences / vibrations
Enclosure	Material	PC / ABS
	Density	IP10 , VBG 4
	Mounting	For mounting on panel wall or DIN rail
Weight with screw terminals	Modules in 100- / 200- / controller-series	Ca. 200 g / 500 g / 600 g
Approvals	EU low voltage directive and EMC requirements are complied with	LVD tested according to EN 60730 EMC tested Immunity according to EN 61000-6-2 Emission according to EN 61000-6-3
	UL 873, c UL us	UL file number: E166834 for XM and CM-modules UL file number: E31024 for PC-modules

The mentioned data applies to all modules.
If data is specific, this is mentioned together with the module in question.

Dimensions

The module dimension is 72 mm.
Modules in the 100-series consist of one module
Modules in the 200-series consist of two modules
Controllers consist of three modules
The length of an aggregate unit = n x 72 + 8



Controller

Function
There are several controllers in the series. The function is determined by the programmed software, but outwardly the controllers are identical – they all have the same connection possibilities:
11 analog inputs for sensors, pressure transmitters, voltage signals and contact signals.
8 digital outputs, with 4 Solid state outputs and 4 relay outputs

Supply voltage
24 V a.c. or d.c. to be connected to the controller.
The 24 V must **not** be retransmitted and used by other controllers as it is not galvanically separated from inputs and outputs. In other words, you **must** use a transformer for each controller. Class II is required. The terminals must **not** be earthed.
The supply voltage to any extension modules is transmitted via the plug on the right-hand side.
The size of the transformer is determined by the power requirement of the total number of modules.

The supply voltage to a pressure transmitter can be taken either from the 5 V output or from the 12 V output depending on transmitter type.

Data communication
If the controller is to be included in a system, communication must take place via the LON connection.
The installation has to be made as mentioned in the separate instructions for LON communication.

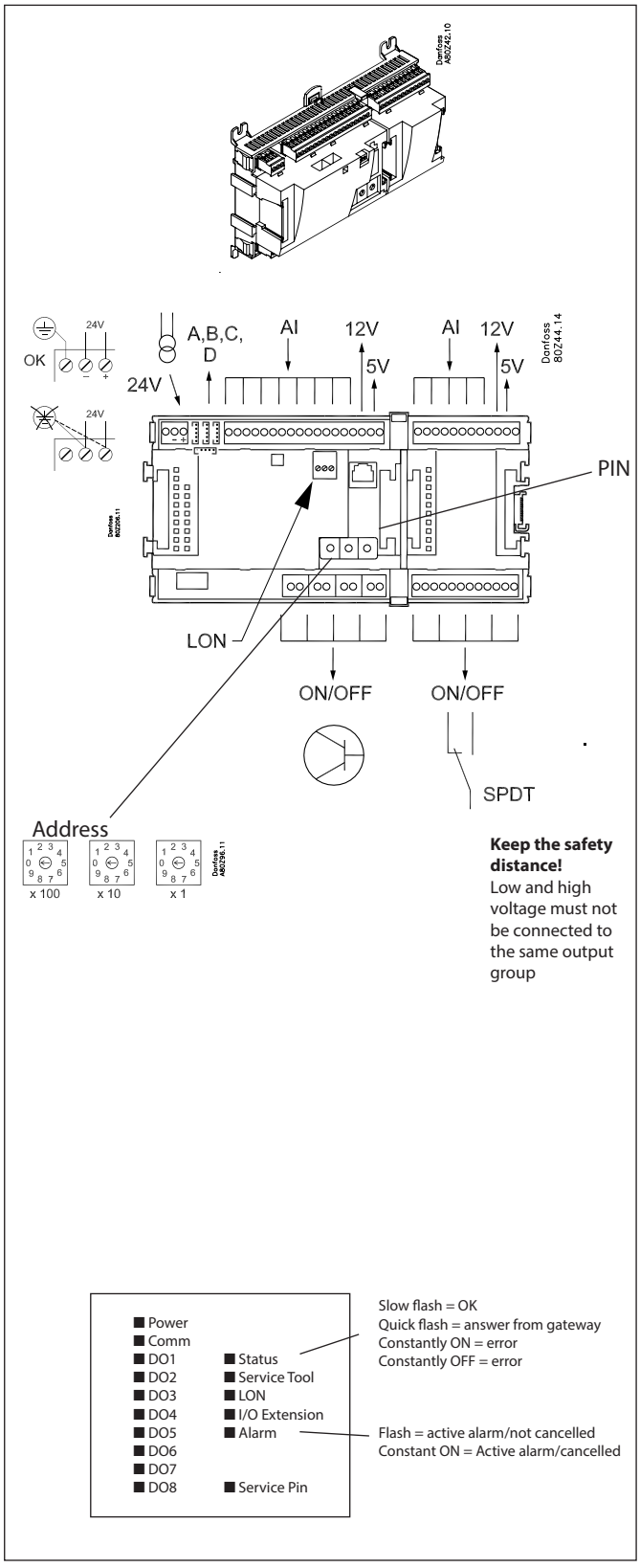
Address setting
When the controller is connected to a gateway type AKA 245, the controller's address must be set between 1 and 119. (If it is a system manager AK-SM .., then 1-999).

Service PIN
When the controller is connected to the data communication cable the gateway must have knowledge of the new controller. This is obtained by pushing the key PIN. The LED "Status" will flash when the gateway sends an acceptance message.

Operation
The configuration operation of the controller must take place from the software program "Service Tool". The program must be installed on a PC, and the PC must be connected to the controller via the network plug on the front of the unit.

Light-emitting diodes
There are two rows with LED's. They mean:
Left row:
- Voltage supply to the controller
- Communication active with the bottom PC board (red = error)
- Status of outputs DO1 to DO8

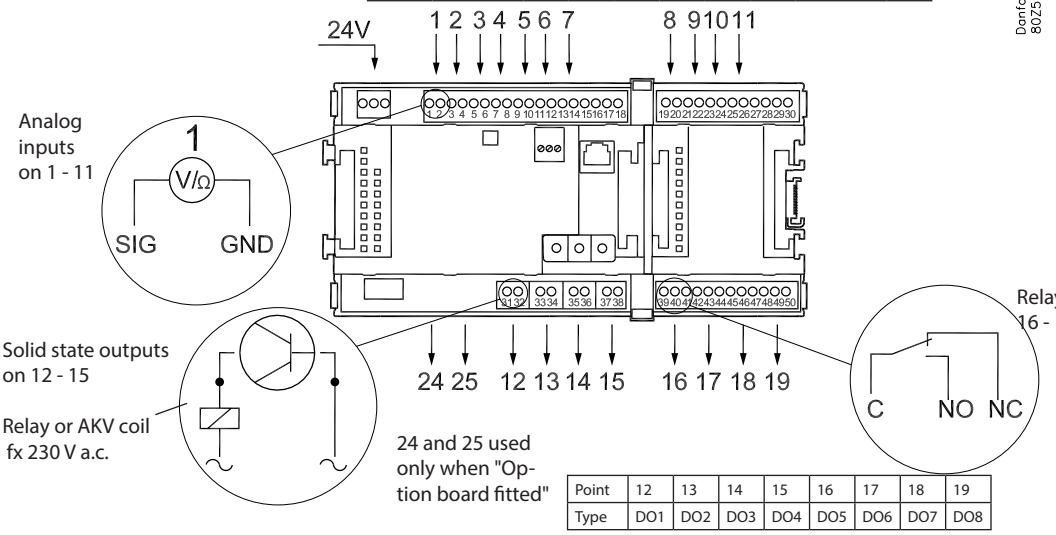
Right row:
- Software status (slow flash = OK)
- Communication with Service Tool
- Communication on LON
- Communication with AK-CM 102
- Alarm when LED flashes
- 2 LED's that are not used
- "Service Pin" switch has been activated



A small module (option board) can be placed on the bottom part of the controller. The module is described later in the document.

Point

Point	1	2	3	4	5	6	7	8	9	10	11
Type	AI1	AI2	AI3	AI4	AI5	AI6	AI7	AI8	AI9	AI10	AI11



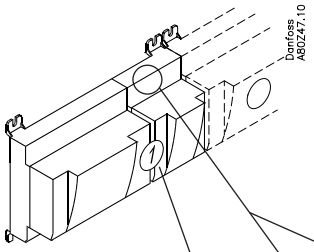
Terminal 15: 12 V
Terminal 16: 5 V

Terminal 27: 12 V
Terminal 28: 5 V

Terminal 17, 18, 29, 30: (Cable screen)

Point	12	13	14	15	16	17	18	19
Type	DO1	DO2	DO3	DO4	DO5	DO6	DO7	DO8

	Signal	Signal type
S Pt 1000 ohm/0°C SIG GND	S1 S2 Saux_ SsA SdA Shr Stw Sgc	Pt 1000
P AKS 32R 3: Brown SIG 2: Blue GND 1: Black 5V AKS 32 3: Brown SIG 2: Black GND 1: Red 12V	P0A P0B PcA PcB Paux Pgc Prec	AKS 32R / AKS 2050 -1 - xx bar AKS 32 -1 - zz bar
U + SIG – GND	...	0 - 5 V 0 - 10 V
On/Off SIG GND	Ext. Main switch Day/ Night Door Level switch	**Active at:** Closed / Open
DO AKV C NO NC	AKV Comp 1 Comp 2 Fan 1 Alarm Light Rail heat Defrost Solenoid valve	**Active at:** On / Off
Option Board	Please see the signal on the page with the module.	



Signal	Module	Point	Terminal	Signal type / Active at
	1	**1** (AI 1)	**1 - 2**	
		2 (AI 2)	**3 - 4**	
		3 (AI 3)	**5 - 6**	
		4 (AI 4)	**7 - 8**	
		5 (AI 5)	**9 - 10**	
		6 (AI 6)	**11 - 12**	
		7 (AI 7)	**13 - 14**	
		8 (AI 8)	**19 - 20**	
		9 (AI 9)	**21 - 22**	
		10 (AI 10)	**23 - 24**	
		11 (AI 11)	**25 - 26**	
		12 (DO 1)	**31 - 32**	
		13 (DO 2)	**33 - 34**	
		14 (DO 3)	**35 - 36**	
		15 (DO 4)	**37 - 38**	
		16 (DO 5)	**39 - 40- 41**	
		17 (DO6)	**42 - 43 - 44**	
		18 (DO7)	**45 - 46 - 47**	
		19 (DO8)	**48 - 49 - 50**	
		24	-	
		25	-	

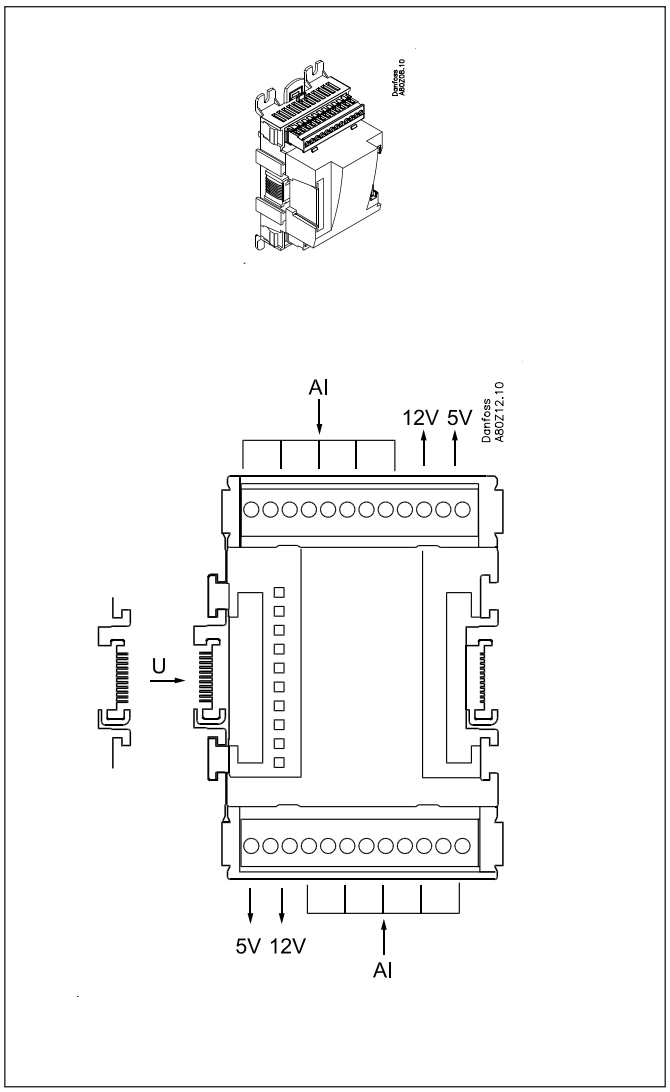
Extension module AK-XM 101A

Function
The module contains 8 analog inputs for sensors, pressure transmitters, voltage signals and contact signals.

Supply voltage
The supply voltage to the module comes from the previous module in the row.

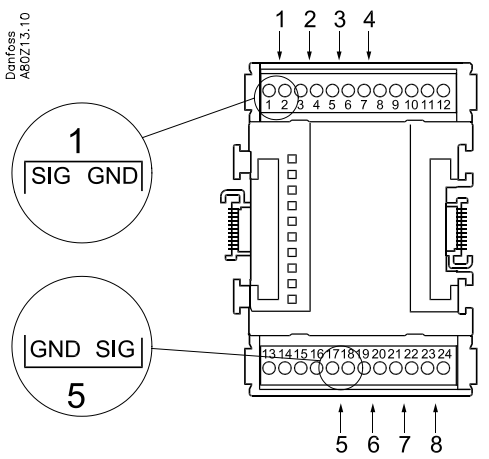
Supply voltage to a pressure transmitter can be taken from either the 5 V output or the 12 V output depending on transmitter type.

Light-emitting diodes
Only the two top LED's are used. They indicate the following:
• Voltage supply to the module
• Communication with the controller is active (red = error)



Point

Point	1	2	3	4
Type	AI1	AI2	AI3	AI4



At the top the signal input is the left of the two terminals.

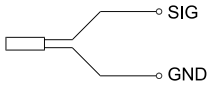
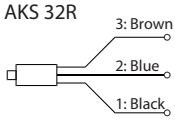
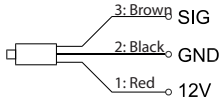
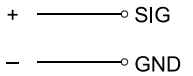
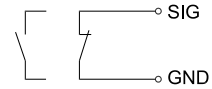
At the bottom the signal input is the right of the two terminals.

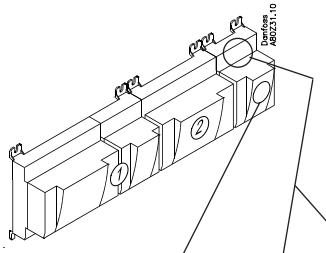
Point	5	6	7	8
Type	AI5	AI6	AI7	AI8

Terminal 9: 12 V
Terminal 10: 5 V

Terminal 15: 5 V
Terminal 16: 12 V

Terminal 11, 12, 13, 14: ⏚ (Cable screen)

	Signal	Signal type
S Pt 1000 ohm/0°C 	S1 S2 Saux SsA SdA Shr Stw Sgc	Pt 1000
P AKS 32R  AKS 32 	P0A P0B PcA PcB Paux Pgc Prec	AKS 32R / AKS 2050 -1 - xx bar AKS 32 -1 - zz bar
U 	...	0 - 5 V 0 - 10 V
On/Off 	Ext. Main switch Day/ Night Door Level switch	**Active at:** Closed / Open



Signal	Module	Point	Terminal	Signal type / Active at
		1 (AI 1)	**1 - 2**	
		2 (AI 2)	**3 - 4**	
		3 (AI 3)	**5 - 6**	
		4 (AI 4)	**7 - 8**	
		5 (AI 5)	**17 - 18**	
		6 (AI 6)	**19 - 20**	
		7 (AI 7)	**21 - 22**	
		8 (AI 8)	**23 - 24**	

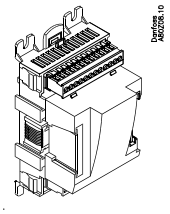
Extension module AK-XM 102A / AK-XM 102B

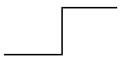
Function
The module contains 8 inputs for on/off voltage signals.

Signal
AK-XM 102A is for low voltage signals.
AK-XM 102B is for high voltage signals.

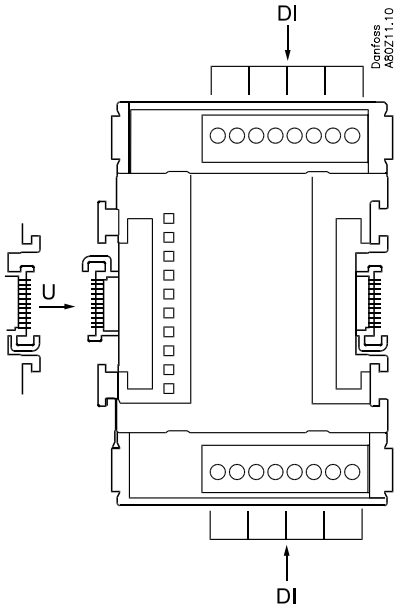
Supply voltage
The supply voltage to the module comes from the previous module in the row.

Light-emitting diodes
They indicate:
- Voltage supply to the module
- Communication with the controller is active (red = error)
- Status of the individual inputs 1 to 8 (when lit = voltage)



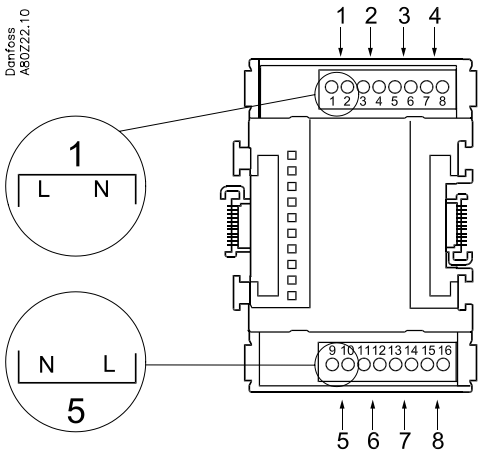


AK-XM 102A	AK-XM 102B
Max. 24 V	**Max. 230 V**
On/Off:	On/Off:
On: DI > 10 V a.c.	On: DI > 80 V a.c.
Off: DI < 2 V a.c.	Off: DI < 24 V a.c.

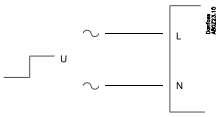


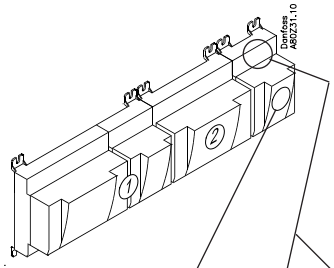
Point

Point	1	2	3	4
Type	DI1	DI2	DI3	DI4



Point	5	6	7	8
Type	DI5	DI6	DI7	DI8

	Signal	Active at
DI **AK-XM 102A: Max. 24 V** **AK-XM 102B: Max. 230 V** 	Ext. Main switch Day/ Night Comp. safety 1 Comp. safety 2 Level switch	**Closed** (voltage on) / **Open** (voltage off)



Signal	Module	Point	Terminal	Active at
		1 (DI 1)	**1 - 2**	
		2 (DI 2)	**3 - 4**	
		3 (DI 3)	**5 - 6**	
		4 (DI 4)	**7 - 8**	
		5 (DI 5)	**9 - 10**	
		6 (DI 6)	**11 - 12**	
		7 (DI 7)	**13 - 14**	
		8 (DI 8)	**15 - 16**	

Extension module AK-XM 103A

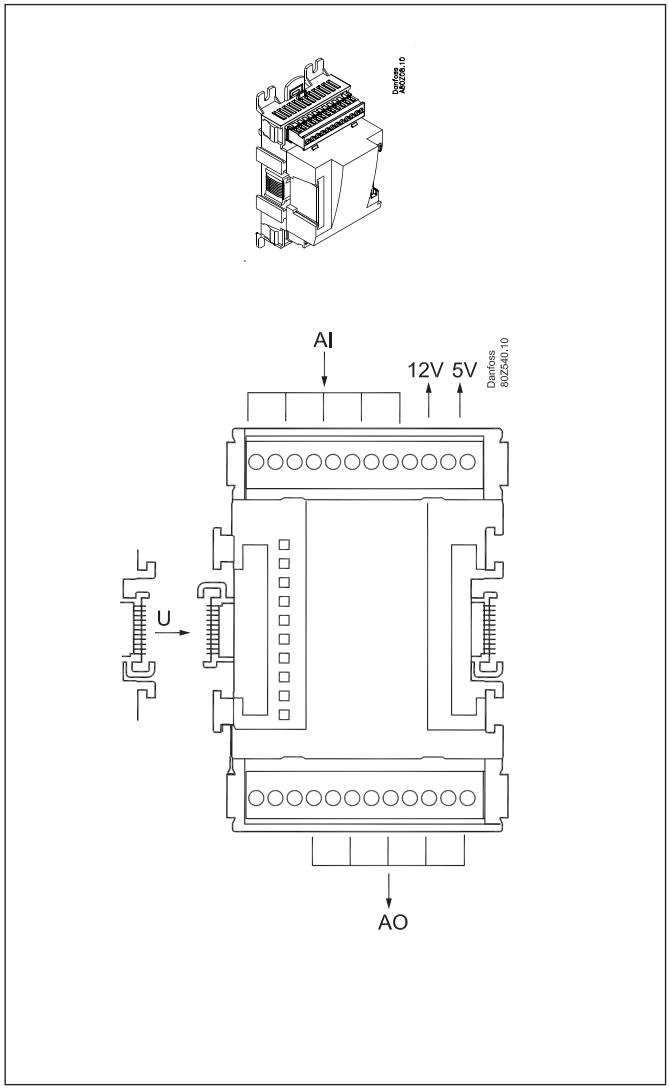
Function
The module contains :
4 analog inputs for sensors, pressure transmitters, voltage signals and contact signals.
4 analog voltage outputs of 0 - 10 V

Supply voltage
The supply voltage to the module comes from the previous module in the row.

Supply voltage to a pressure transmitter can be taken from either the 5 V output or the 12 V output depending on transmitter type.

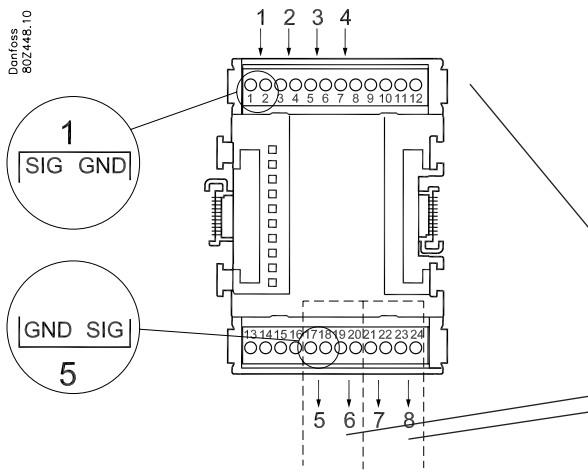
Galvanic isolation
The inputs are galvanically separated from the outlets.
The outlets AO1 and AO2 are galvanically separated from AO3 and AO4.

Light-emitting diodes
Only the two top LED's are used. They indicate the following:
• Voltage supply to the module
• Communication with the controller is active (red = error)



Point

Point	1	2	3	4
Type	AI1	AI2	AI3	AI4



At the top the signal input is the left of the two terminals.

At the bottom the signal input is the right of the two terminals.

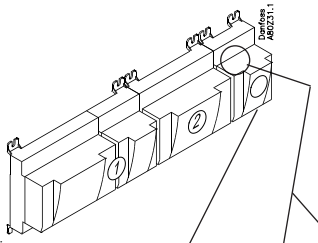
Terminal 9: 12 V
Terminal 10: 5 V

Terminal 11, 12: (Cable screen)

Galvanic isolation:
AI 1-4 ≠ AO 1-2 ≠ AO 3-4

Point	5	6	7	8
Type	AO1	AO2	AO3	AO4

	Signal	Signal type
S Pt 1000 ohm/0°C SIG GND	S1 S2 Saux SsA SdA Shr Stw Sgc	Pt 1000
P AKS 32R 3: Brown SIG 2: Blue GND 1: Black 5V AKS 32 3: Brown SIG 2: Black GND 1: Red 12V	P0A P0B PcA PcB Paux Pgc Prec	AKS 32R / AKS 2050 -1 - xx bar AKS 32 -1 - zz bar
U + SIG – GND	...	0 - 5 V 0 - 10 V
On/Off SIG GND	Ext. Main switch Day/ Night Door Level switch	**Active at:** Closed / Open
AO – 0-10 V +		0-10 V



Signal	Module	Point	Terminal	Signal type /Active at
		1 (AI 1)	**1 - 2**	
		2 (AI 2)	**3 - 4**	
		3 (AI 3)	**5 - 6**	
		4 (AI 4)	**7 - 8**	
		5 (AO 1)	**17 - 18**	
		6 (AO 2)	**19 - 20**	
		7 (AO 3)	**21 - 22**	
		8 (AO 4)	**23 - 24**	

Extension module AK-XM 204A / AK-XM 204B

Function
The module contains 8 relay outputs.

Supply voltage
The supply voltage to the module comes from the previous module in the row.

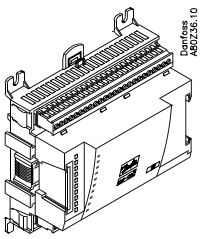
AK-XM 204B only
Override of relay
Eight change-over switches at the front make it possible to override the relay's function.
Either to position OFF or ON.
In position Auto the controller carries out the control.

Light-emitting diodes
There are two rows with LED's. They mean:
Left row:
- Voltage supply to the controller
- Communication active with the bottom PC board (red = error)
- Status of outputs DO1 to DO8

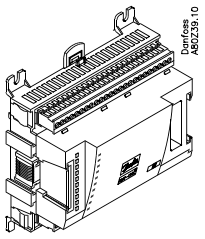
Right row: (AK-XM 204B only):
- Override of relays
  ON = override
  OFF = no override

Fuses
Behind the upper part there is a fuse for each output.

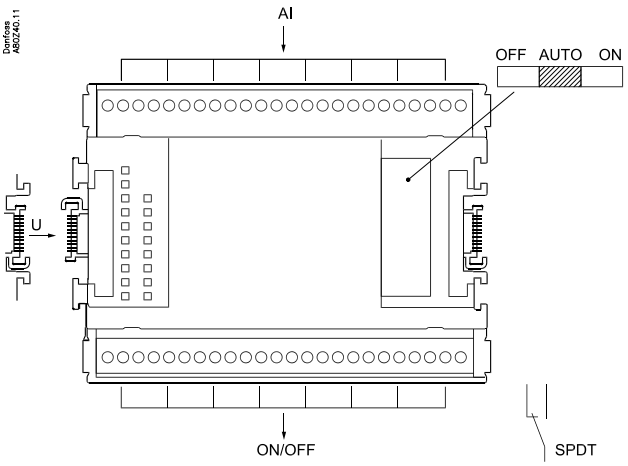
Note
If the changeovers are used to override the compressor operation, it is necessary to wire a safety relay into the circuit for oil management. Without this safety relay, the controller will fail to stop the compressor if it should run out of oil. See Regulating functions.



AK-XM 204A



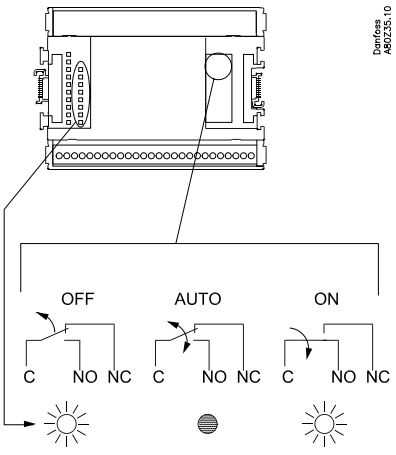
AK-XM 204B



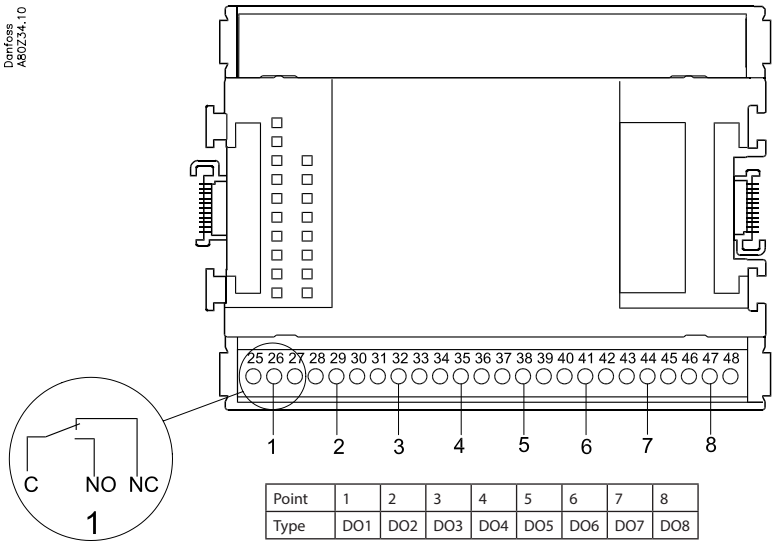
Max. 230 V
AC-1: max. 4 A (ohmic)
AC-15: max. 3 A (Inductive)

Keep the safety distance!
Low and high voltage must not be connected to the same output group

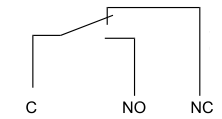
AK-XM 204B
Override of relay

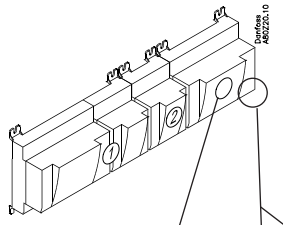


Point



Point	1	2	3	4	5	6	7	8
Type	DO1	DO2	DO3	DO4	DO5	DO6	DO7	DO8

	Signal	Active at
DO 	Comp. 1 Comp. 2 Fan 1 Alarm Solenoid valve	On / Off



Signal	Module	Point	Terminal	Active at
		1 (DO 1)	**25 - 27**	
		2 (DO 2)	**28 - 30**	
		3 (DO 3)	**31 - 33**	
		4 (DO 4)	**34 -36**	
		5 (DO 5)	**37 - 39**	
		6 (DO 6)	**40 - 41 - 42**	
		7 (DO 7)	**43 - 44 - 45**	
		8 (DO 8)	**46 - 47 - 48**	

Extension module AK-XM 205A / AK-XM 205B

Function
The module contains:
8 analog inputs for sensors, pressure transmitters, voltage signals and contact signals.
8 relay outputs.

Supply voltage
The supply voltage to the module comes from the previous module in the row.

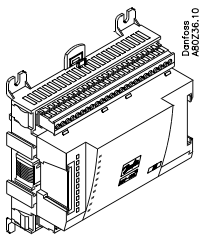
AK-XM 205B only
Override of relay
Eight change-over switches at the front make it possible to override the relay's function.
Either to position OFF or ON.
In position Auto the controller carries out the control.

Light-emitting diodes
There are two rows with LED's. They mean:
Left row:
- Voltage supply to the controller
- Communication active with the bottom PC board (red = error)
- Status of outputs DO1 to DO8

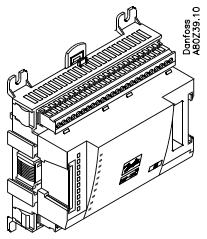
Right row: (AK-XM 205B only):
- Override of relays
  ON = override
  OFF = no override

Fuses
Behind the upper part there is a fuse for each output.

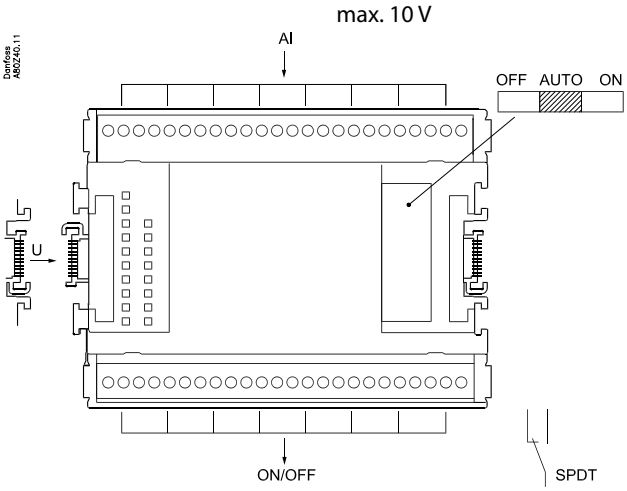
Note
If the changeovers are used to override the compressor operation, it is necessary to wire a safety relay into the circuit for oil management. Without this safety relay, the controller will fail to stop the compressor if it should run out of oil. See Regulating functions.



AK-XM 205A



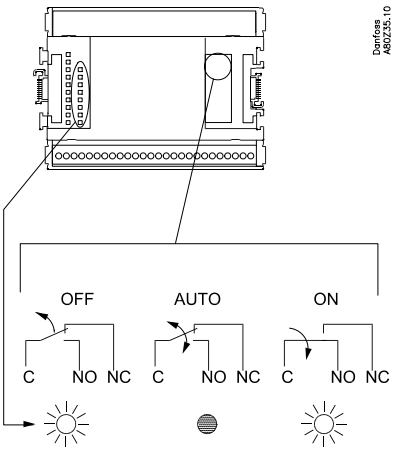
AK-XM 205B



Max. 230 V
AC-1: max. 4 A (ohmic)
AC-15: max. 3 A (Inductive)

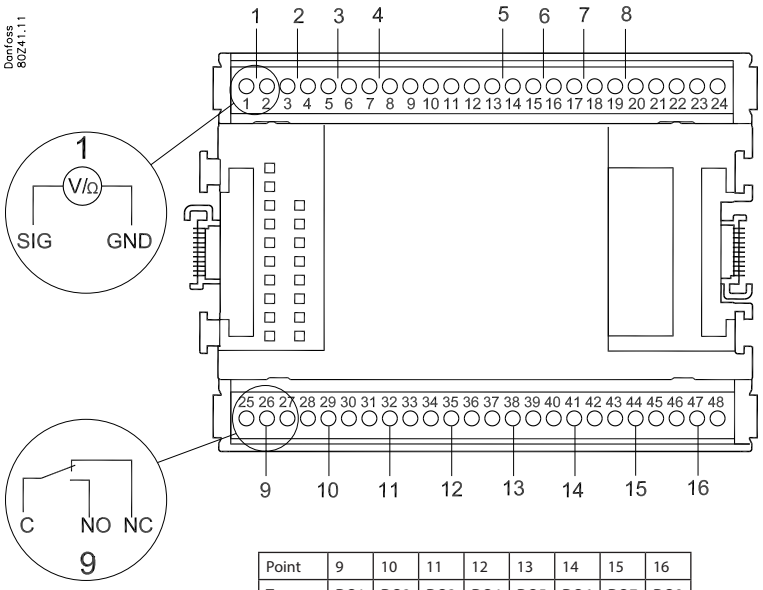
Keep the safety distance!
Low and high voltage must not be connected to the same output group

AK-XM 205B
Override of relay



Point

Point	1	2	3	4	5	6	7	8
Type	AI1	AI2	AI3	AI4	AI5	AI6	AI7	AI8

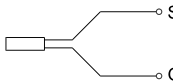
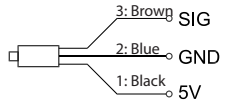
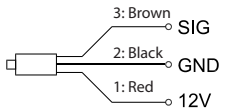
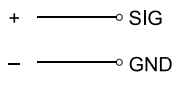
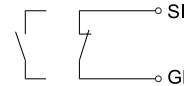
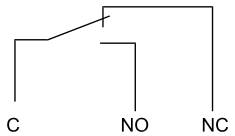


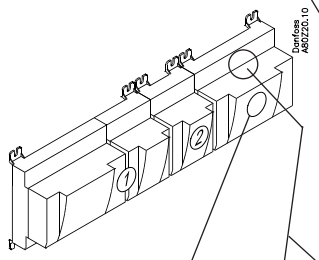
Terminal 9: 12 V
Terminal 10: 5 V

Terminal 21: 12 V
Terminal 22: 5 V

Terminal 11, 12, 23, 24 : ⏚
(Cable screen)

Point	9	10	11	12	13	14	15	16
Type	DO1	DO2	DO3	DO4	DO5	DO6	DO7	DO8

	Signal	Signal type
S Pt 1000 ohm/0°C 	S1 S2 Saux SsA SdA Shr Stw Sgc	Pt 1000
P AKS 32R  AKS 32 	P0A P0B PcA PcB Paux Pgc Prec	AKS 32R / AKS 2050 -1 - xx bar AKS 32 -1 - zz bar
U 	...	0 - 5 V 0 - 10 V
On/Off 	Ext. Main switch Day/ Night Door Level switch	**Active at:** Closed / Open
DO 	Comp 1 Comp 2 Fan 1 Alarm Light Rail heat Defrost Solenoid valve	**Active at:** on / Off



Signal	Module	Point	Terminal	Signal type / Active at
		1 (AI 1)	**1 - 2**	
		2 (AI 2)	**3 - 4**	
		3 (AI 3)	**5 - 6**	
		4 (AI 4)	**7 - 8**	
		5 (AI 5)	**13 - 14**	
		6 (AI 6)	**15 - 16**	
		7 (AI 7)	**17 - 18**	
		8 (AI 8)	**19 -20**	
		9 (DO 1)	**25 - 26 - 27**	
		10 (DO 2)	**28 - 29 - 30**	
		11 (DO 3)	**31 - 30 - 33**	
		12 (DO 4)	**34 - 35 - 36**	
		13 (DO 5)	**37 - 36 - 39**	
		14 (DO6)	**40 - 41 - 42**	
		15 (DO7)	**43 - 44 - 45**	
		16 (DO8)	**46 - 47 - 48**	

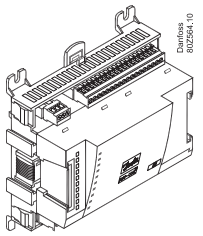
Extension module AK-XM 208C

Function
The module contains:
8 analog inputs for sensors, pressure transmitters, voltage signals and contact signals.
4 outputs for stepper motors.

Supply voltage
The supply voltage to the module comes from the previous module in the row.
The supply voltage to the valves must be from a separate supply, which must be galvanically separated from the supply for the control range.
24 V d.c. +/-20%.
(Power requirements: 7.8 VA for controller + 1.3 VA per valve).

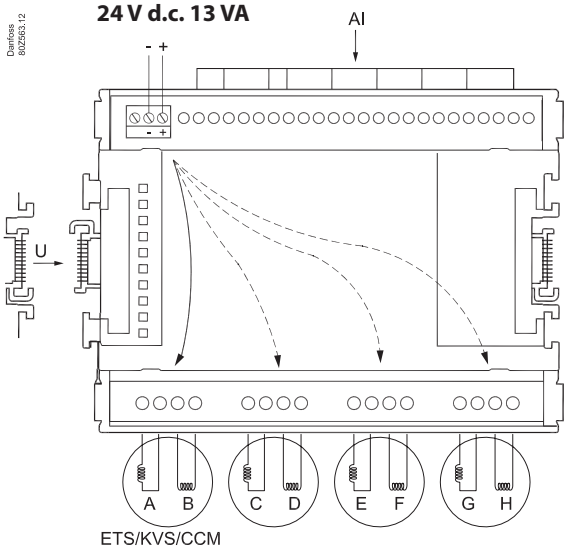
A UPS may be necessary if the valves need to open/close during a power failure.

Light-emitting diodes
There is one row with LED's. It indicate the following:
- Voltage supply to the module
- Communication active with the bottom PC board (red = error)
- Status of outputs step1 to step4



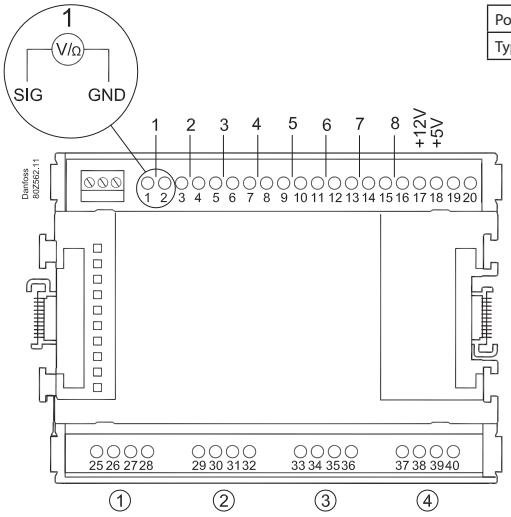
Separate voltage supply is required
24 V d.c. 13 VA

max. 10 V



Output:
24 V d.c.
$I_{max.}$ = 500 m A / coil
20-500 step/s

Point

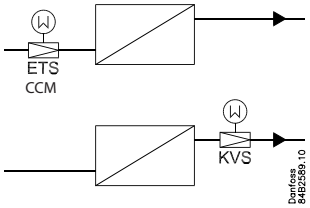


Point	1	2	3	4	5	6	7	8
Type	AI1	AI2	AI3	AI4	AI5	AI6	AI7	AI8

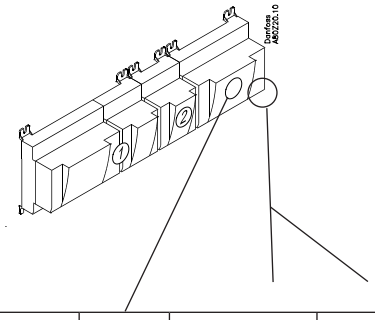
Terminal 17: 12 V
Terminal 18: 5 V

Terminal 19, 20: ⏚
(Cable screen)

Point	9	10	11	12
Step	1	2	3	4
Type	AO			



Step / Terminal					
	1	25	26	27	28
	2	29	30	31	32
	3	33	34	35	36
	4	37	38	39	40
ETS		White	Black	Red	Green
CCM / CCMT					
KVS 15		White	Black	Green	Red
KVS 42-54					



Valve		Module	Step	Terminal
A B ETS/KVS/CCM			**1 (point 9)**	**25 - 28**
			2 (point 10)	**29 - 32**
			3 (point 11)	**33 - 36**
			4 (point 12)	**37 - 40**

Extension module AK-OB 110

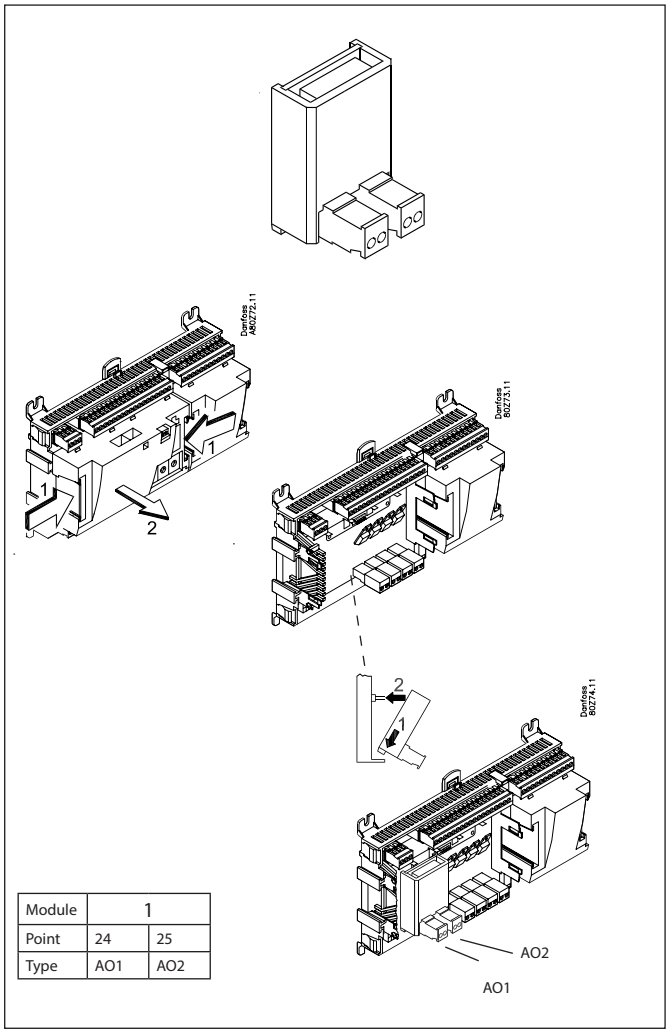
Function
The module contains two analog voltage outputs of 0 – 10 V.

Supply voltage
The supply voltage to the module comes from the controller module.

Placing
The module is placed on the PC board in the controller module.

Point
The two outputs have points 24 and 25. They are shown on the earlier page where the controller is also mentioned.

Max. load
I < 2.5 mA
R > 4 kohm



Module	1	
Point	24	25
Type	AO1	AO2

AO	– ○→ 0-10 V + ○→	AO	0 - 10 V

Extension module AK-OB 101A

Function
The module is a real time clock module with battery backup.

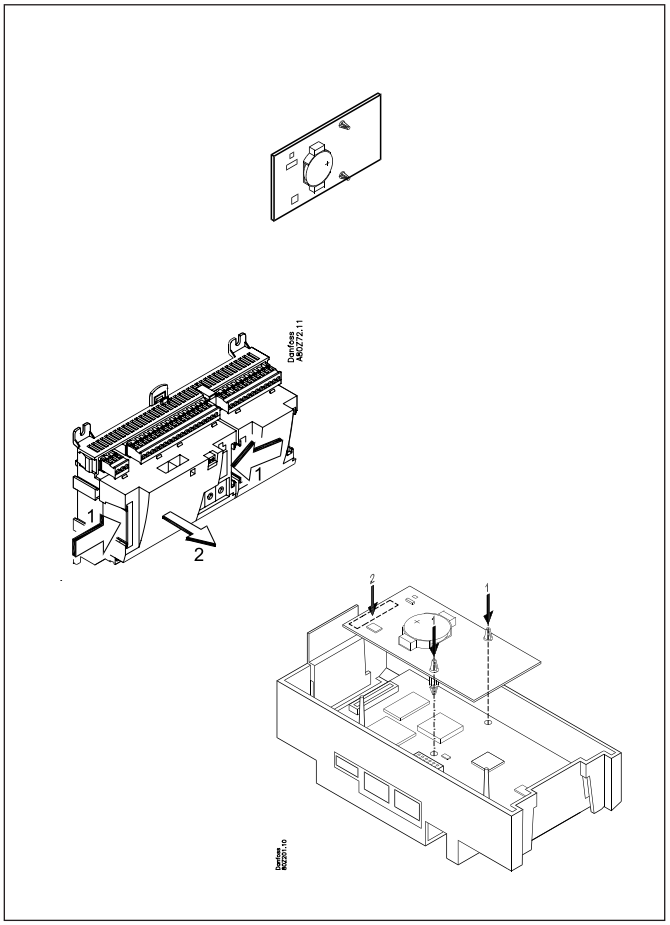
The module can be used in controllers that are not linked up in a data communication unit together with other controllers. The module is used here if the controller needs battery backup for the following functions
- Clock function
- Fixed times for day/night change-over
- Fixed defrost times
- Saving of alarm log in case of power failure
- Saving of temperature log in case of power failure

Connection
The module is provided with plug connection.

Placing
The module is placed on the PC board inside the top part.

Point
No point for a clock module to be defined – just connect it.

Working life of the battery
The working life of the battery is several years – even if there are frequent power failures.
An alarm is generated when the battery has to be replaced.
After the alarm there are still several months of operating hours left in the battery.



Extension module EKA 163B / EKA 164B / EKA 166

Function
Display of important measurements from the controller, e.g. appliance temperature, suction pressure or condensing pressure.
Setting of the individual functions can be performed by using the display with control buttons.
It is the controller used that determines the measurements and settings that can occur.

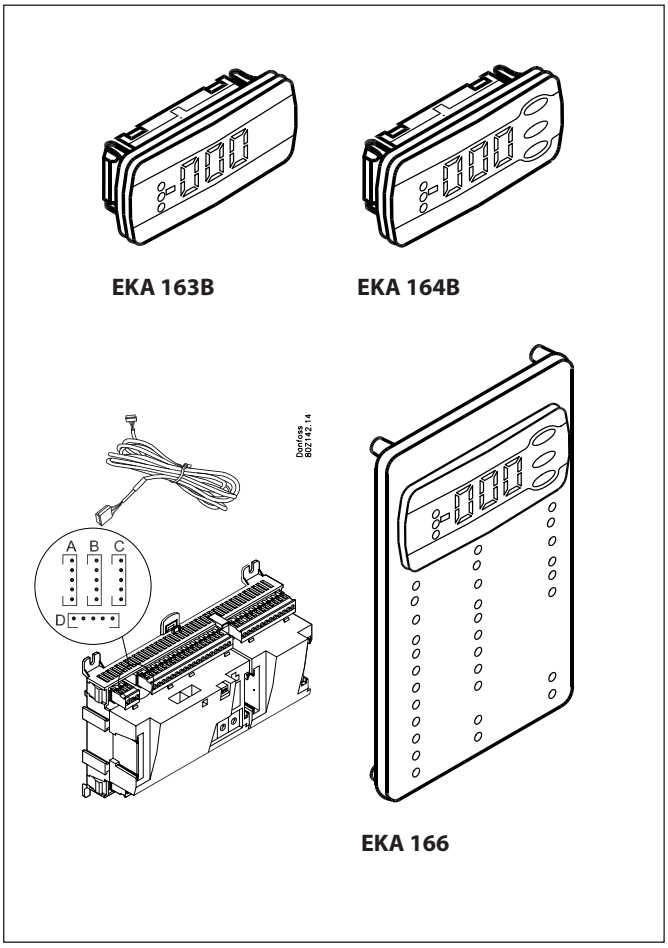
Connection
The extension module is connected to the controller module via a cable with plug connections. You have to use one cable per module. The cable is supplied in various lengths.

Both types of display (with or without control buttons) can be connected to either display output A, B, C and D.
Ex.
A: P0. Suction pressure in °C.
B: Pc. Condensing pressure in °C.

When the controller starts up, the display will show the output that is connected.
- - 1 = output A
- - 2 = output B
etc.

Placing
The extension module can be placed at a distance of up to 15 m from the controller module.

Point
No point has to be defined for a display module – you simply connect it.



Graphic display AK-MMI

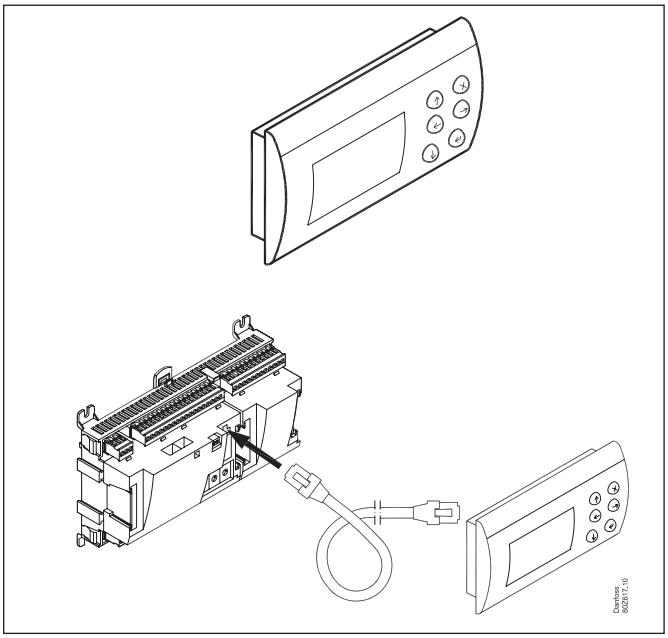
Function
Setting and display of values in the controller.

Connection
The display connects to the controller via a cable with plug connections. Use plug RJ45 to connect to the controller; the same plug is also used for service tool AK-ST 500.

Supply voltage
24 V a.c. / d.c. 1.5 VA.

Placing
The display can be placed at a distance of up to 3 m from the controller.

Point
No point has to be defined for a display – you simply connect it.

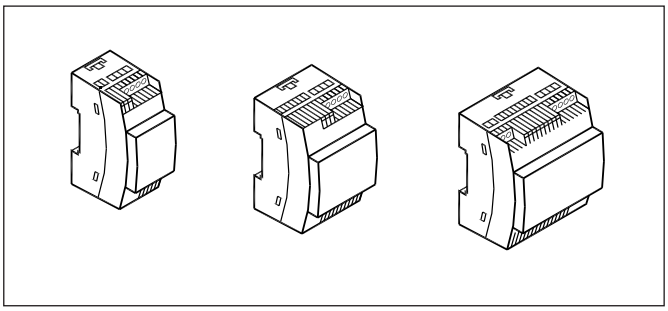


Power supply module AK-PS 075 / 150 / 250

Function
24 V supply for controller.

Supply voltage
230 V a.c or 115 V a.c. (from 100 V a.c. to 240 V a.c.)

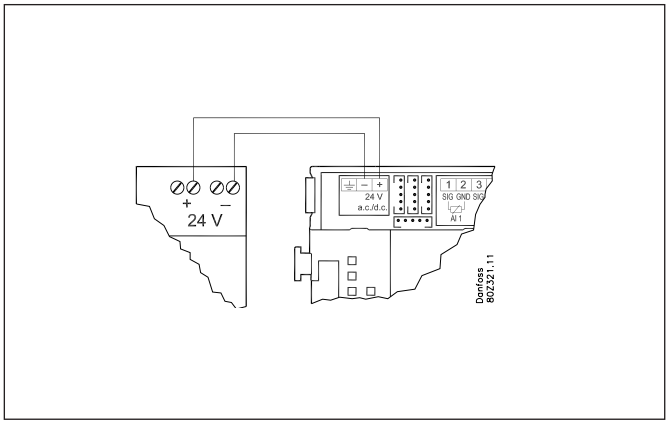
Placing
On DIN-rail



Effect

Type	Output tension	Output current	Power
AK-PS 075	24 V d.c.	0.75 A	18 VA
AK-PS 150	24 V d.c. (adjustable)	1.5 A	36 VA
AK-PS 250	24 V d.c. (adjustable)	2.5 A	60 VA

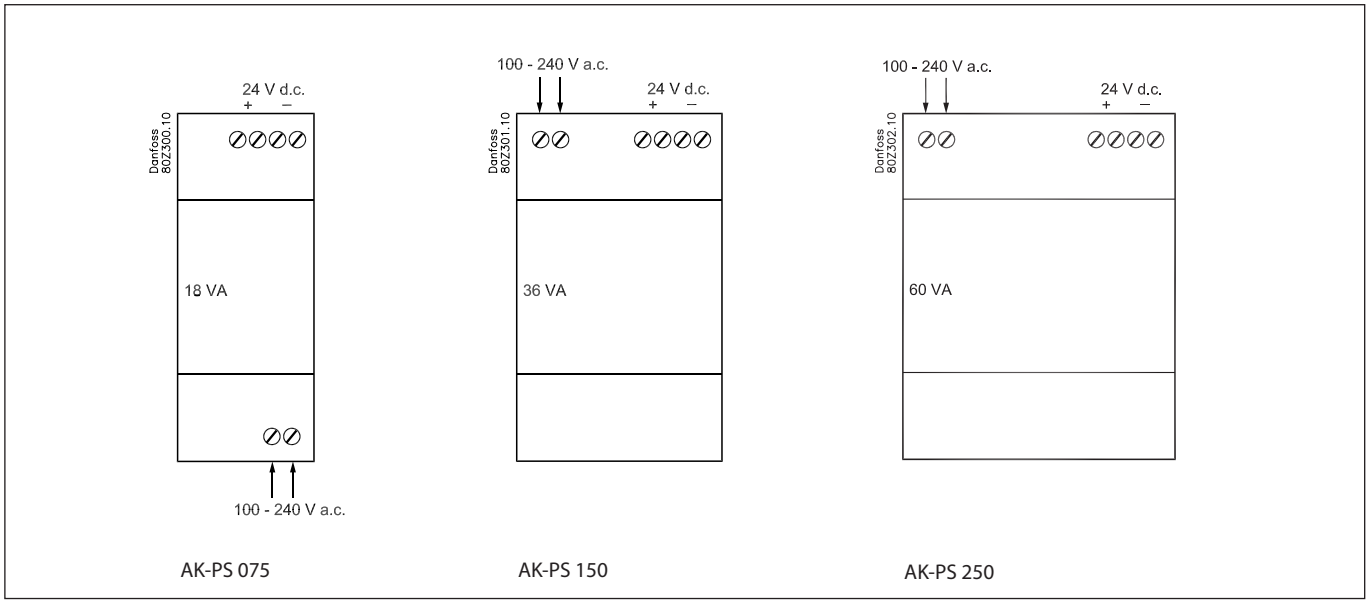
Supply to a controller



Dimension

Type	High	Width
AK-PS 075	90 mm	36 mm
AK-PS 150	90 mm	54 mm
AK-PS 250	90 mm	72 mm

Connections



Communication module AK-CM 102

Function
The module is a new communication module, meaning the row of extension modules can be interrupted.
The module communicates with the regulator via data communication and forwards information between the controller and the connected extension modules.

Connection
Communication module and controller fitted with RJ 45 plug connectors.
Nothing else should be connected to this data communication; a maximum of 5 communication modules can be connected to one controller.
The communication module can be used only with controllers of the type AK-PC 781.

Communication cable
One metre of the following is enclosed:
ANSI/TIA 568 B/C CAT5 UTP cable w/ RJ45 connectors.

Positioning
Max. 30 m from the controller
(The total length of the communication cables is 30 m)

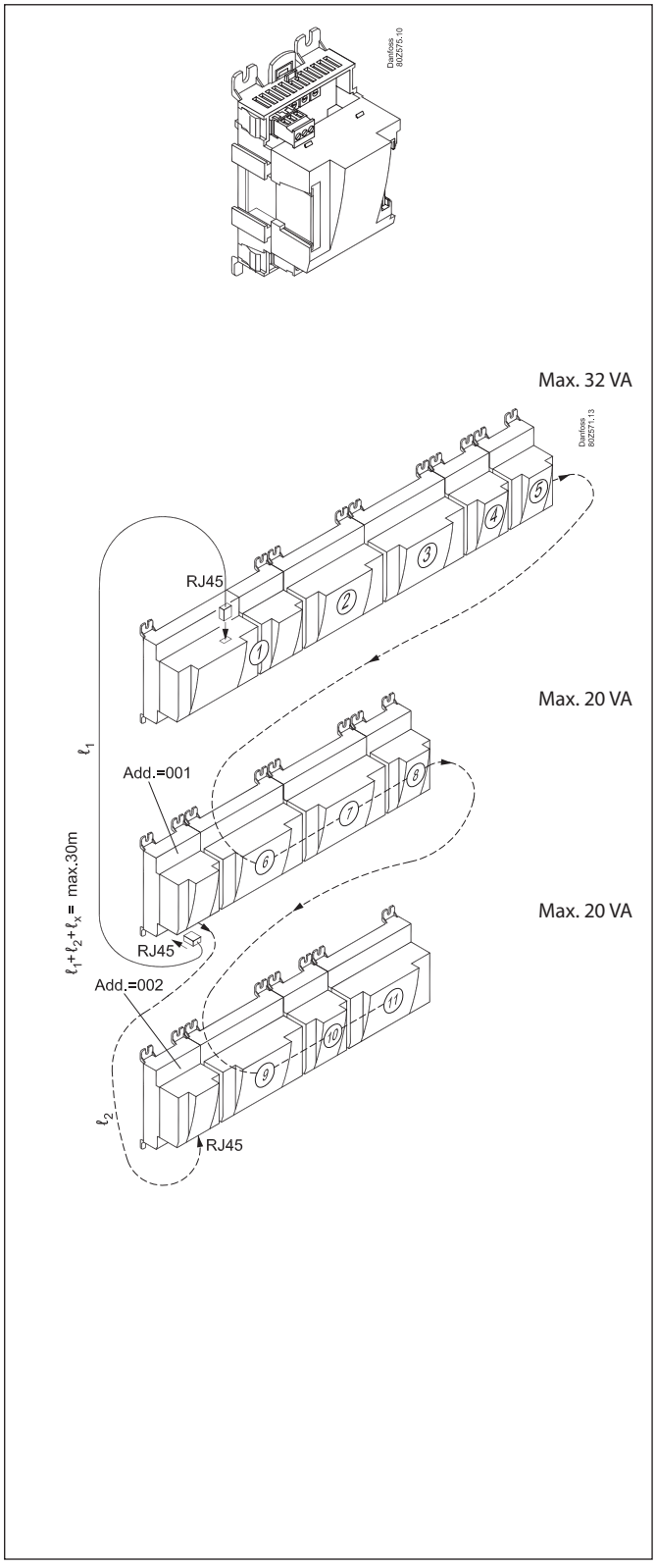
Supply voltage
24 volt AC or DC should be connected to the communication module.
The 24 V can be sourced from the same supply that supplies the controller. (The supply for the communication module is galvanically separated from the connected extension modules).
The terminals must **not** be earthed.
The power consumption is determined by the power consumption of the total number of modules.
The controller strand load must not exceed 32 VA.
Each AK-CM 102 strand load must not exceed 20 VA.

Point
Connection points on the I/O modules should be defined as if the modules were an extension of each other.

Address
The address for the first communication module should be set to 1. Any second module should be set to 2. A maximum of 5 modules can be addressed.

Termination
The termination switch on the final communication module should be set to ON.
The controller should permanently be set to = ON.

Warning
Additional modules may only be installed following the installation of the final module. (Here following module no. 11; see the sketch.)
After configuration, the address must not be changed.



Preface to design

Be aware of the following when the number of extension modules is being planned. A signal may have to be changed, so that an additional module may be avoided.

- An ON/OFF signal can be received in two ways. Either as a contact signal on an analog input or as voltage on a low or high-voltage module.
- An ON/OFF output signal can be given in two ways. Either with a relay switch or with solid state. The primary difference is the permitted load and that the relay switch contains a cutout switch.

Mentioned below are a number of functions and connections that may have to be considered when a regulation has to be planned. There are more functions in the controller than the ones mentioned here, but those mentioned have been included in order that the need for connections can be established.

Functions

Clock function
Clock function and change-over between summer time and winter time are contained in the controller.
The clock is zeroset when there is power failure.
The clock's setting is maintained if the controller is linked up in a network with a gateway, a system manager or a clock module can be mounted in the controller.

Start/stop of regulation
Regulation can be started and stopped via the software. External start/stop can also be connected.
Warning
The function stops all regulation, including any high-pressure regulation.
Excess pressure can lead to a loss of charge.

Start/stop of compressors
External start/stop can be connected.

Alarm function
If the alarm is to be sent to a signal transmitter, a relay output will have to be used.

I'm alive function
A relay can be reserved which is pulled during normal regulation. The relay will be released if the regulation stops with the main switch or if the controller fails.

Extra temperature sensors and pressure sensors
If additional measurements have to be carried out beyond the regulation, sensors can be connected to the analog inputs.

Forced control
The software contains a forced control option. If an extension module with relay outputs is used, the module's top part can be with change-over switches – switches that can override the individual relays into either OFF or ON position.
Wiring should be done with a safety relay. See Regulating functions.

Data communication
The controller module has terminals for LON data communication. The requirements to the installation are described in a separate document.

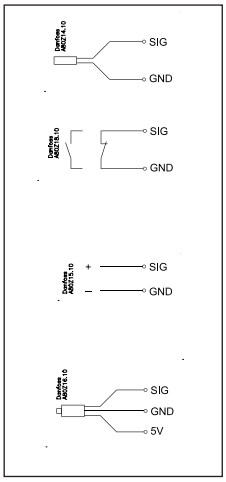
Connections

In principle there are the following types of connections:

Analog inputs "AI"

This signal must be connected to two terminals.
Signals can be received from the following sources:

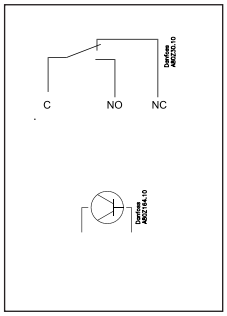
- Temperature signal from Pt 1000 ohm temperature sensor
- Contact signal where the input is short-circuited or "opened", respectively
- Voltage signal from 0 to 10 V
- Signal from pressure transmitter AKS 32, AKS 32R or AKS 2050
  The supply voltage is supplied from the module's terminal board where there is both a 5 V supply and a 12 V supply.
  When programming the pressure transmitter's pressure range must be set.



ON/OFF output signals "DO"

There are two types, as follows:

- Relay outputs
  All relay outputs are with change-over relay so that the required function can be obtained when the controller is without voltage.
- Solid state outputs
  Reserved for AKV valves, but output can cut an external relay in and out, as with a relay output.
  The output is only found on the controller module.



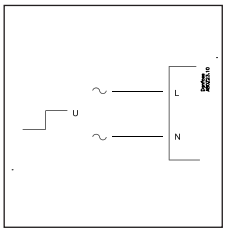
When programming the function must be set:

- Active when the output is activated
- Active when the output is not activated.

ON/OFF voltage inputs "DI"

This signal must be connected to two terminals.

- The signal must have two levels, either 0 V or "voltage" on the input.
  There are two different extension modules for this signal type:
  - low-voltage signals, e.g. 24 V
  - high-voltage signals, e.g. 230 V

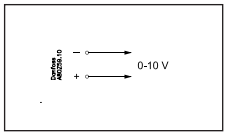


When programming the function must be set:

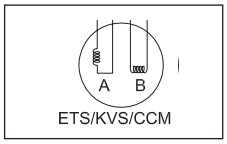
- Active when the input is without voltage
- Active when voltage is applied to the input.

Analog output signal "AO"

This signal is to be used if a control signal is to be transmitted to an external unit, e.g. a frequency converter.
When programming the signal range must be defined: 0-5 V, 1-5 V, 0-10 V or 2-10 V.



Pulse signal for the stepper motors.
This signal is used by valve motors of the type ETS, KVS and CCM.
The valve type should be set during programming.



Limitations

As the system is very flexible regarding the number of connected units you must check whether your selection complies with the few limitations there are.
The complexity of the controller is determined by the software, the size of the processor, and the size of the memory. It provides the controller with a certain number of connections from which data can be downloaded, and others where coupling with relays can be performed.

✔ The sum of connections cannot exceed **120** (AK-PC 781).

✔ The number of extension modules must be limited so that the total power in a row will not exceed **32** VA (including controller).
If the AK-CM 102 communication module is used, each row of AK-CM 102 must not exceed 20 VA (incl. AK-CM 102).
There must not be more than a total of 12 modules (controller + 11 modules).

✔ No more than **5** pressure transmitters may be connected to one controller module.

✔ No more than **5** pressure transmitters may be connected to one extension module.

Design of a compressor and condenser control

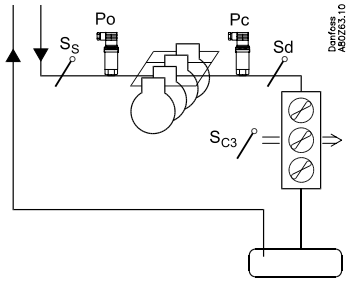
Procedure:

1. Make a sketch of the system in question
2. Check that the controller's functions cover the required application
3. Consider the connections to be made
4. Use the planning table. / Note down the number of connections ./ add up
5. Are there enough connections on the controller module? – If not, can they be obtained by changing an ON/OFF input signal from voltage signal to contact signal, or will an extension module be required?
6. Decide which extension modules are to be used
7. Check that the limitations are observed
8. Calculate the total length of modules
9. The modules are linked together
10. The connection sites are established
11. Draw a connection diagram or a key diagram
12. Size of supply voltage/transformer

Follow these 12 steps

1
Sketch

Make a sketch of the system in question.



2
Compressor and condenser functions

	AK-PC 781
Application	
Regulation of a compressor group	x
Regulation of a condenser group	x
Both compressor group and condenser group	x
Regulation of compressor capacity	
Regulation sensor. Either P0, S4 or Pctrl	x
PI-regulation	x
Max. number of compressor steps	8
Max. number of unloaders each compressor	3
Identical compressor capacities	x
Different compressor capacities	x
Speed regulation of 1 or 2 compressors	x
Run time equalisation	x
Min. restart time	x
Min. On-time	x
Liquid injection in suction line	x
Liquid injection in cascade heat exchanger	x
External start/stop of compressors	x
Oil management	
Oil injection in compressor. Shared or individual	x

Receiver pressure control	x
Monitoring of oil level in receiver	x
Management of oil level in oil separator	x
Reset of oil management	x
Cutout of compressors at oil failure	x
Safety relays during forced compressor control	x
Suction pressure reference	
Override via P0 optimization	x
Override via "night setback"	x
Override via "0 -10 V signal"	x
Regulation of condenser capacity	
Regulation sensor. Either: Pc, Sgc or S7	x
Step regulation	x
Max. number of steps	8
Speed regulation	x
Step and speed regulation	x
Speed regulation first step	x
Limitation of speed during night operation	x
Heat recovery function for tap water control	x
Heat recovery function for heating	x
Controlling the gas cooler (high pressure valve). parallel valve, if applicable	x

Trouble-shooting function FDD on condenser	x
Condenser pressure reference	
Floating condensing pressure reference	x
Setting of references for heat recovery functions	x
Safety functions	
Min. suction pressure	x
Max. suction pressure	x
Max. condensing pressure	x
Max. discharge gas temperature	x
Min. / Max. superheat	x
Safety monitoring of compressors	x
Common high pressure monitoring of compressors	x
Safety monitoring of condenser fans	x
General alarm functions with time delay	10
Miscellaneous	
Extra sensors	7
Inject On function	x
Option for connection of separate display	2
Separate thermostat functions	5
Separate pressostat functions	5
Separate voltage measurements	5
PI regulation	3
Max. input and output	120

A bit more about the functions

Compressor
Regulation of up to 8 compressors. And up to 3 unloaders each compressor.
Compressor No. 1 or 2 can be speed-regulated.
The following can be used as control sensor:
1) P0 - Suction pressure
2) S4 - Cold brine temperature
3) Pctrl - Condensing pressure in the low pressure circuit controls the high-pressure circuit for cascade control.
(P0 is also used for 2 and 3, but for low-pressure safety.)

Condenser
Regulation of up to 8 condenser steps.
Fans can be speed-regulated. Either all on one signal or only the first fan of several. EC motor can be used.
Relay outputs and solid state outputs may be used, as desired.
The following can be used as control sensor:
1) Pc - Condensing pressure
2) S7 - Warm brine temperature (Pc is used here for high-pressure safety.)
3) Sgc -Temperature at the gas cooler outlet.

Connection between high-pressure and low-pressure circuits (MT and LT circuits)
Capacity control of the high-pressure circuit can be adjusted by the condensing pressure in the low-pressure circuit.
The controller can give off a signal from a relay output so that the low-pressure circuit can only start when the high-pressure circuit is on.
The controller can receive a signal from the low-pressure circuit that there is a need for refrigeration.
Coordination is also required for parallel compression.

Speed regulation of condenser fans
The function requires an analog output module.
A relay output may be used for start/stop of the speed regulation.
The fans may also be cut in and out by relay outputs.

Digital scroll
When using a digital scroll, the unloading of the compressor should be connected to one of the four solid state outputs in the controller.

Heat recovery
There are adjustment options for hot water and heat containers for heating.
The controller manages, in order of priority: 1 -tap water 2-heating 3-gas cooler, which removes the remaining excess heat.

Safety circuit
If signals are to be received from one or more parts of a safety circuit, each signal must be connected to an ON/OFF input.

Day/night signal for raising the suction pressure
The clock function can be used, but an external ON/OFF signal may be used instead.
If the "P0 optimization" function is used, no signal will be given concerning the raising of the suction pressure. The P0 optimization will see to this.

"Inject ON" override function
The function closes expansion valves on evaporator controls when all compressors are prevented from starting.
The function can take place via the data communication, or it may be wired via a relay output.

Separate thermostat and pressure control functions
A number of thermostats can be used according to your wishes.
The function requires a sensor signal and a relay output. In the controller there are settings for cutin and cutout values. An associated alarm function may also be used.

Separate voltage measurements
A number of voltage measurements can be used according to your wishes. The signal can for example be 0-10 V. The function requires a voltage signal and a relay output. In the controller there are settings for cutin and cutout values. An associated alarm function may also be used.

If you want to know more about the functions, go to chapter 5.

3 Connections

Here is a survey of the possible connections. The texts can be read in context with the table on the following page.

Analog inputs
Temperature sensors
- S4 (Cold brine temperature)
  Must be used when the control sensor for compressor control has been selected as S4.
- Ss (suction gas temperature)
  Must always be used in connection with compressor regulation.
- Sd (discharge gas temperature)
  Must always be used in connection with compressor regulation.
- Sc3 (outdoor temperature)
  To be used when monitoring function FDD is used.
  To be used when regulation is performed with floating condenser reference.
- S7 (warm brine return temperature)
  Must be used when the control sensor for condenser has been selected as S7.
- Saux (1-4), any extra temperature sensors

Up to four additional sensors for monitoring and data collection may be connected. These sensors can be used for general thermostat functions.
- Stw2, 3, 4 and 8 (temperature sensors for heat recovery)
  Must be used when adjusting hot tap water.

Shr2, 3, 4 and 8 (temperature sensors for heat recovery)
Must be used when adjusting the heat receiver for heating.

- Sgc (temperature sensor for gas cooling controls)
  Shall be placed within one metre after the gas cooler.
- Shp (temperature sensor, if the refrigerant can be routed outside of the gas cooler)

Pressure transmitters
- P0 Suction Pressure
  Must always be used in connection with compressor regulation (frost protection).
- Pctrl (control pressure for cascade)
  Must only be used if the control sensor for compressor control has been selected as Pctrl (cascade)
- Pc Condensing Pressure
  Must always be used in connection with compressor or condenser regulation
- Prec. Oil receiver pressure. Must be used for receiver pressure regulation.
- Pgc Gas cooler pressure. Must be used for CO2 transcritical operation.
- Prec.CO2 Pressure reading in the CO2 receiver. Must be used for CO2 transcritical operation.
- Paux (1-5)
  Up to 5 extra pressure transmitters can be connected for monitoring and data collection.
  These sensors can be used for general pressure switch functions.

Note. A pressure transmitter type AKS 32 or AKS 32R can supply signals to a maximum of five controllers.

Voltage signal
- Ext. Ref
  Used if a reference override signal is received from another control.
- Voltage inputs (1-5)
  Up to 5 extra voltage signals can be connected for monitoring and data collection. These signals are used for general voltage input functions.

On/Off-inputs

Contact function (on an analog input) or
voltage signal (on an extension module)
- Common safety input for all compressors (e.g. common high-pressure/ low-pressure pressure switch)
- Up to 6 signals from the safety circuit of each compressor
- Compressor release signal on LT controller in cascade
- Compressor requirements signal on MT controller in cascade
- Signal from the condenser fans safety circuit
- Any signal from the frequency converter's safety circuit
- External start/stop of regulation
- External day/night signal (raise/lower the suction pressure reference). The function is not used if the "P0 optimization" function is used.
- DI alarm (1-10) inputs
  Up to 10 no. extra on/off signals for general alarm for monitoring and data collection can be connected.
- Flow switch for heat recovery
- Level contacts

On/off-outputs

Relay outputs
- Compressors
- Unloaders
- Fan motor
- Injection On function (signal for evaporator controls. One per suction group).
- Start/stop of liquid injection in heat exchanger
- Compressor release, output signal from MT controller in cascade
- Compressor request, output signal from LT controller in cascade
- Start/stop of liquid injection in suction line
- Start/stop of 3-way valves at heat recovery
- ON/OFF signal for start/stop of speed regulation
- Alarm relay. I'm alive relay.
- On/off signals from general thermostats (1-5), pressure switches (1-5) or voltage input functions (1-5).
- Oil valves
- Safety relays for cutouts of compressors at oil failure

Solid state outputs

The solid state outputs on the controller module may be used for the same functions as those mentioned under "relay outputs". (The output will always be "OFF" when the controller has a power failure).

Analog output
- Speed regulation of the condenser's fans.
- Speed regulation of the compressor
- Speed control of pumps for heat recovery
- Control signal for high pressure CO2 valve. (stepper signal. if applicable)
- Stepper signal for hot gas by-pass valve

Example

Compressor group:
- MT circuits
- Refrigerant CO2 (R744)
- 4 only compressors with "Best fit". One speed controlled
- Safety monitoring of each compressor
- Common high-pressure monitoring
- Po setting -15°C, night displacement 5 K
- Oil management of each compressor
- Pulse reset for stopped compressor (lack of oil)

High pressure controls:
- Heat recovery for tap water
- Heat recovery for heating circuit
- Gas cooler
- Fans, speed controlled
- Pc regulates based on temperature sensor Sc3 and Sgc

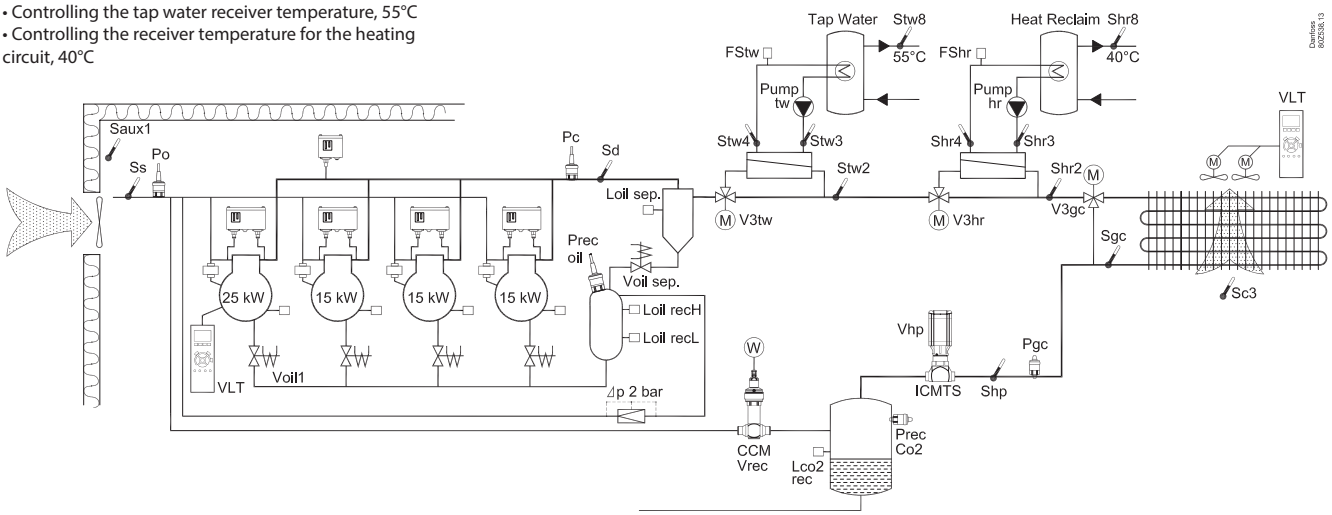
Receivers:
- Monitoring of CO2 level
- Control of pressure in oil receiver
- Controlling the tap water receiver temperature, 55°C
- Controlling the receiver temperature for the heating circuit, 40°C

Fan in plant room
- Thermostat control of fan in engine room

Safety functions:
- Monitoring of Po, Pc, Sd and superheat in suction line
- Po max = -5°C, Po min = -35°C
- Pc max = 50 °C
- Sd max = 120°C
- SH min = 5 °C, SH max = 35 °C
- Monitoring of low and high level in oil receiver

Other:
- Alarm output used
- External compressor stop used

Data from this example is used on the next page.
The result is that the following modules should be used:
- *AK-PC 781 controller*
- *AK-XM 205A input and output module*
- *AK-XM 208C stepper output module*
- *AK-XM 102B digital input module*
- *AK-XM 103B analog input and output module*
- *AK-OB 110 analog output module*



4 Planning table

The table helps you establish whether there are enough inputs and outputs on the basic controller.
If there are not enough of them, the controller must be extended by one or more of the mentioned extension modules.

Note down the connections you will require and add them up

	Analog input signal	Example	On/off voltage signal	Example	On/off voltage signal	Example	On/Off output signal	Example	Analog output signal 0-10 V	Stepper output	Example	7 Limitations
Analog inputs												
Temperature sensors, Ss, Sd, Sc3, S4, S7, Stw.., Shr.., Sgc		9										
Extra temperature sensor / separate thermostats /PI-regulation		1										
Pressure transmitters, P0, Pc, Pctrl. Prec / separate pressostats		5										P = Max. **5** / module
Voltage signal from other regulation, separate signals												
Heat recovery via thermostat												
On/off inputs	Contact		24 V		230 V							
Safety circuits, common for all compressors						1						Max.1
Safety circuits, Oil pressure												Max. 1/ Comp.
Safety circuits, comp. Motor protection												
Safety circuits, comp. Motor temp.												
Safety circuits, comp. High pres. thermostat												
Safety circuits, comp. High pres. pressostat												
Safety circuits, general for each compressor						4						
Safety circuits, condenser fans, frequency converter												Max. 1/ fan
Safety circuits, flow switch						2						
External start/stop		1										
LT release input / MT request input / IT release input												
Night setback of suction pressure												
Separate alarm functions via DI		1										
Load shedding												
Start of Heat recovery		1				1						
Liquid level, Oil level, Pulse reset of oil management		9										
On/off outputs												
Compressors, motors								4				
Unloaders												
Fan motors, circulation pumps								3				
Alarm relay, I'm alive relay												
Inject ON												Max. 1
Separate thermostat and pressostat functions and voltage measure-ments								1				Max. 5+5+5
Heat recovery function via thermostat												Max.1
Liquid injection in suction line / heat exchanger. Heat gas dump												Max.1
MT release output / LT request output / IT on-outp. / IT release outp.												
Solenoid valve for Oil.								5				
3-way valve								3				
Analog control signal, 0-10 V												
Frequency converter, Compressor, fans, pumps, valves etc.											5	
Valves with stepper motor. Parallel valves, if applicable											1	
Sum of connections for the regulation		27		0		8		16			5+1	Sum = max. **120**
Number of connections on a controller module	11	11	0	0	0	0	8	8	0	0	0	
5 Missing connections, if applicable		16		-		8		8			5+1	
6 The missing connections to be supplied by one or more extension modules:												Sum of power
AK-XM 101A **(8 analog inputs)**												___ pcs. á 2 VA = __
AK-XM 102A **(8 digital low voltage inputs)**												___ pcs. á 2 VA = __
AK-XM 102B **(8 digital high voltage outputs)**						1						___ pcs. á 2 VA = __
AK-XM 103A **(4 analog inputs, 4 analog outputs)**		1									1	___ pcs. á 2 VA = __
AK-XM 204A / B **(8 relay outputs)**												___ pcs. á 5 VA = __
AK-XM 205A / B **(8 analog inputs. + 8 relay output)**		1						1				___ pcs. á 5 VA = __
AK-XM 208C **(8 analog inputs + 4 stepper outputs)**		1									1	___ pcs. á 5 VA = __
AK_OB 110 **(2 analog outputs)**											1	___ pcs. á 0 VA = 0
												1 pcs. á 8 VA = 8
												Sum =
												Sum = max. **32** VA

The example:
None of the 3 limitations are exceeded => OK

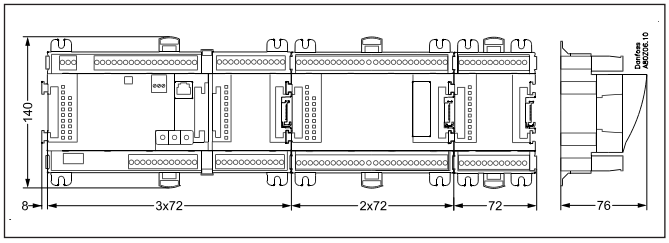
8 Length

If you use many extension modules the controller's length will grow accordingly. The row of modules is a complete unit which cannot be broken.
If the row becomes longer than desired, the row can be broken by using AK-CM 102.

The module dimension is 72 mm.
Modules in the 100-series consist of one module
Modules in the 200-series consist of two modules
The controller consist of three modules
The length of an aggregate unit = n x 72 + 8

or in an other way:

Module	Type	Number		at		Length
Controller module		1	x	224	=	224 mm
Extension module	200-series	_	x	144	=	___ mm
Extension module	100-series	_	x	72	=	___ mm
Total length					=	___ mm

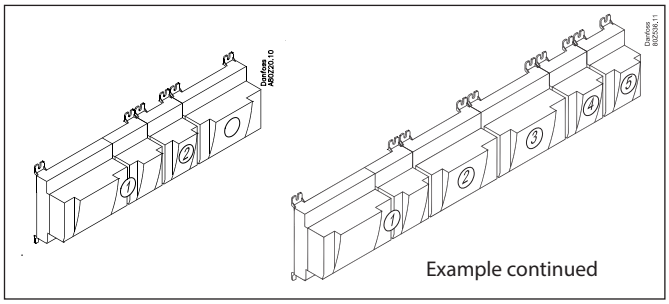


Example continued:
Controller module + 2 extension modules in 200-series + 2 extension module in 100 series =
224 + 144 + 144 + 72 + 72 = 656 mm.

9 Linking of modules

Start with the controller module and then mount the selected extension modules. The sequence is of no importance.

However, you must **not** change the sequence, i.e. rearrange the modules, after you have made the setup where the controller is told which connections are found on which modules and on which terminals.



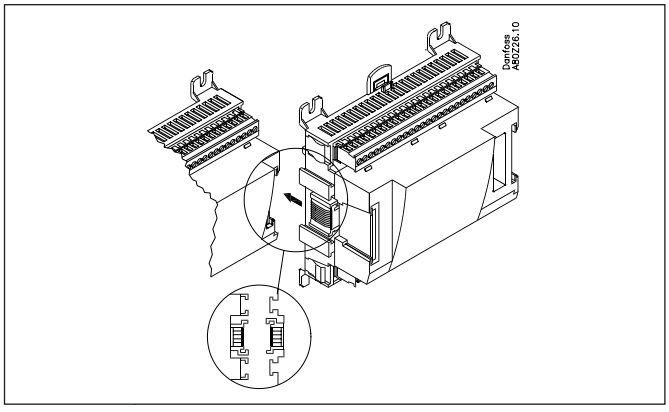
The modules are attached to one another and kept together by a connection which at the same time transmits the supply voltage and the internal data communication to the next module.

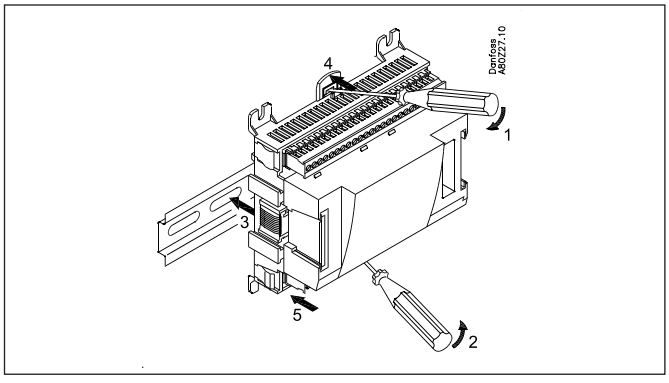
Mounting and removal must always be performed when there is no voltage.

The protective cap mounted on the controller's plug connection must be moved to the last vacant plug connection so that the plug will be protected against short-circuit and dirt.

When the regulation has started the controller will all the time check whether there is connection to the connected modules. This status can be followed by the light-emitting diode.

When the two catches for the DIN rail mounting are in open position the module can be pushed into place on the DIN rail – no matter where in the row the module is found.
Removal is likewise carried out with the two catches in the open position.





10 Determine the connection points

All connections must be programmed with module and point, so in principle it does not matter where the connections are made, as long as it takes place on a correct type of input or output.

- The controller is the first module, the next one is 2, etc.
- A point is the two or three terminals belonging to an input or output (e.g. two terminals for a sensor and three terminals for a relay).

The preparation of the connection diagram and the subsequent programming (configuration) should take place at the present time. It is most easily accomplished by filling in the connection survey for the relevant modules.

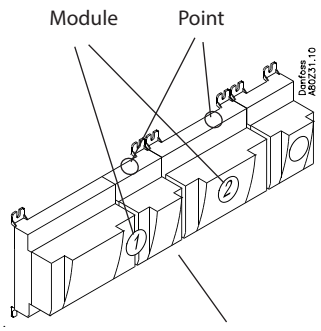
Principle:

Name	On module	On Point	Function
fx Compressor 1	*x*	*x*	*Close*
fx Compressor 2	*x*	*x*	*Close*
fx Alarm relay	*x*	*x*	*NC*
fx Main switch	*x*	*x*	*Close*
fx P0	*x*	*x*	*AKS 32R 1-6 bar*

The connection survey from the controller and any extension modules are uploaded from the paragraph "Module survey. E.g. controller module:

Signal	Modul	Punkt	Klemme	Signal type / Aktive ved
		1 (AI 1)	**1 - 2**	
		2 (AI 2)	**3 - 4**	
		3 (AI 3)	**5 - 6**	

- Columns 1, 2, 3 and 5 are used for the programming.
- Columns 2 and 4 are used for the connection diagram.



Mind the numbering.
The right-hand part of the controller module may look like a separate module. But it **isn't.**

Note
The safety relays should not be fitted onto a module with override changeovers, as they can be put out of operation by an incorrect setting.

Example continued

Signal	Module	Point	Terminal	Signal type / Active at
Discharge temperature - Sd	1	**1** (AI 1)	**1 - 2**	Pt 1000
Suction gas temperature- Ss		**2** (AI 2)	**3 - 4**	Pt 1000
Outdoor temperature - Sc3		**3** (AI 3)	**5 - 6**	Pt 1000
External compressor stop		**4** (AI 4)	**7 - 8**	Closed
Thermostat sensor in plant room - Saux1		**5** (AI 5)	**9 - 10**	Pt 1000
Suction pressure - Po		**6** (AI 6)	**11 - 12**	AKS 2050-59
Condensing pressure - Pc		**7** (AI 7)	**13 - 14**	AKS 2050-159
Level switch, oil, comp.1		**8** (AI 8)	**19 - 20**	Closed
Level switch, oil, comp.2		**9** (AI 9)	**21 - 22**	Closed
Level switch, oil, comp.3		**10** (AI 10)	**23 - 24**	Closed
Level switch, oil, comp.4		**11** (AI 11)	**25 - 26**	Closed
Solenoid valve, oil , comp. 1		**12** (DO 1)	**31 - 32**	ON
Solenoid valve, oil , comp. 2		**13** (DO 2)	**33 - 34**	ON
Solenoid valve, oil , comp. 3		**14** (DO 3)	**35 - 36**	ON
Solenoid valve, oil , comp. 4		**15** (DO 4)	**37 - 38**	ON
Solenoid valve, oil, Separator		**16** (DO 5)	**39 - 40 - 41**	ON
Circulation pump tw		**17** (DO6)	**42 - 43 - 44**	ON
Circulation pump hr		**18** (DO7)	**45 - 46 - 47**	ON
Room fan		**19** (DO8)	**48 - 49 - 50**	ON
Voltage signal to high pressure valve, ICMTS		**24**	-	0-10 V
		25	-	

Signal	Module	Point	Terminal	Signal type / Active at
Level switch, oil, receiver High	2	**1** (AI 1)	**1 - 2**	Closed
Level switch, oil, receiver Low		**2** (AI 2)	**3 - 4**	Closed
Level switch, oil, Separator		**3** (AI 3)	**5 - 6**	Closed
Level switch, CO2 receiver		**4** (AI 4)	**7 - 8**	Open
Pulse reset of stopped compressor		**5** (AI 5)	**13 - 14**	Pulse
		6 (AI 6)	**15 - 16**	
Refrigerant receiver, Prec CO2		**7** (AI 7)	**17 - 18**	AKS 2050-159
Oil receiver, Prec Oil		**8** (AI 8)	**19 - 20**	AKS 2050-159
Compressor 1		**9** (DO 1)	**25 - 26 - 27**	ON
Compressor 2		**10** (DO 2)	**28 - 29 - 30**	ON
Compressor 3		**11** (DO 3)	**31 - 32 - 33**	ON
Compressor 4		**12** (DO 4)	**34 - 35 - 36**	ON
Start /stop of VLT for fans		**13** (DO 5)	**37 - 38 - 39**	ON
3-way valve, tap water, V3tw		**14** (DO6)	**40 - 41 - 42**	ON
3-way valve, heat circuit, V3hr		**15** (DO7)	**43 - 44 - 45**	ON
3-way valve, gas cooler, V3gc		**16** (DO8)	**46 - 47 - 48**	ON

Signal	Module	Point/Step	Terminal	Signal type
Tap water temperature - Stw2	3	**1** (AI 1)	**1 - 2**	Pt 1000
Tap water temperature - Stw3		**2** (AI 2)	**3 - 4**	Pt 1000
Tap water temperature - Stw4		**3** (AI 3)	**5 - 6**	Pt 1000
Tap water temperature - Stw8		**4** (AI 4)	**7 - 8**	Pt 1000
Heat reclaim temperature Shr2		**5** (AI 5)	**9 - 10**	Pt 1000
Heat reclaim temperature Shr3		**6** (AI 6)	**11 - 12**	Pt 1000
Heat reclaim temperature Shr4		**7** (AI 7)	**13 - 14**	Pt 1000
Heat reclaim temperature Shr8		**8** (AI 8)	**15 - 16**	Pt 1000
Stepper signal to by-pass valve, CCM		**9** (step1)	**25 - 26 - 27 - 28**	CCM (ETS)
		10 (step 2)	**29 - 30 - 31 - 32**	
		11 (step 3)	**33 - 34 - 35 - 36**	
		12 (step 4)	**37 - 38 - 39 - 40**	

Continued next page

Signal	Module	Point	Terminal	Active at
Compressor 1 Gen. Safety	4	**1** (DI 1)	**1 - 2**	Open
Compressor 2 Gen. Safety		**2** (DI 2)	**3 - 4**	Open
Compressor 3 Gen. Safety		**3** (DI 3)	**5 - 6**	Open
Compressor 4 Gen. Safety		**4** (DI 4)	**7 - 8**	Open
Start/stop heat recovery hr		**5** (DI 5)	**9 - 10**	Closed
All compressors common safety		**6** (DI 6)	**11 - 12**	Open
Flow switch FStw		**7** (DI 7)	**13 - 14**	Open
Flow switch FShr		**8** (DI 8)	**15 - 16**	Open

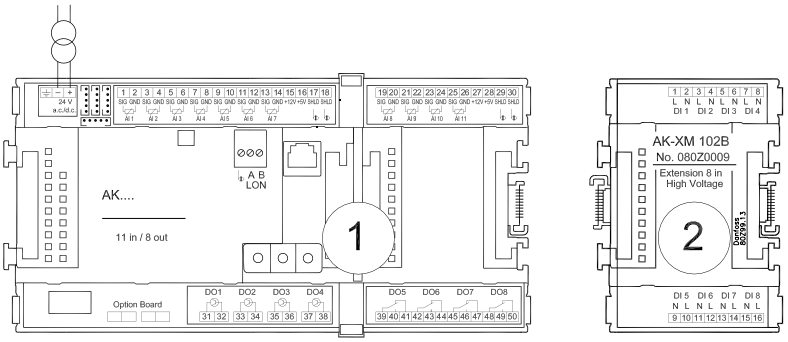
Signal	Module	Point	Terminal	Signal type
Temp. gas cooler outlet Sgc	5	**1** (AI 1)	**1 - 2**	Pt 1000
Temp. by-pased gas Shp		**2** (AI 2)	**3 - 4**	Pt 1000
Start/stop heat recovery tw		**3** (AI 3)	**5 - 6**	Closed
Gas cooler pressure Pgc		**4** (AI 4)	**7 - 8**	AKS 2050-159
Speed control, compressor		**5** (AO 1)	**9 - 10**	0 - 10 V
Speed control, gas cooler fan		**6** (AO 2)	**11 - 12**	0 - 10 V
Speed control, pump - tw		**7** (AO 3)	**13 - 14**	0 - 10 V
Speed control, pump - hr		**8** (AO 4)	**15 - 16**	0 - 10 V

11
Connection diagram

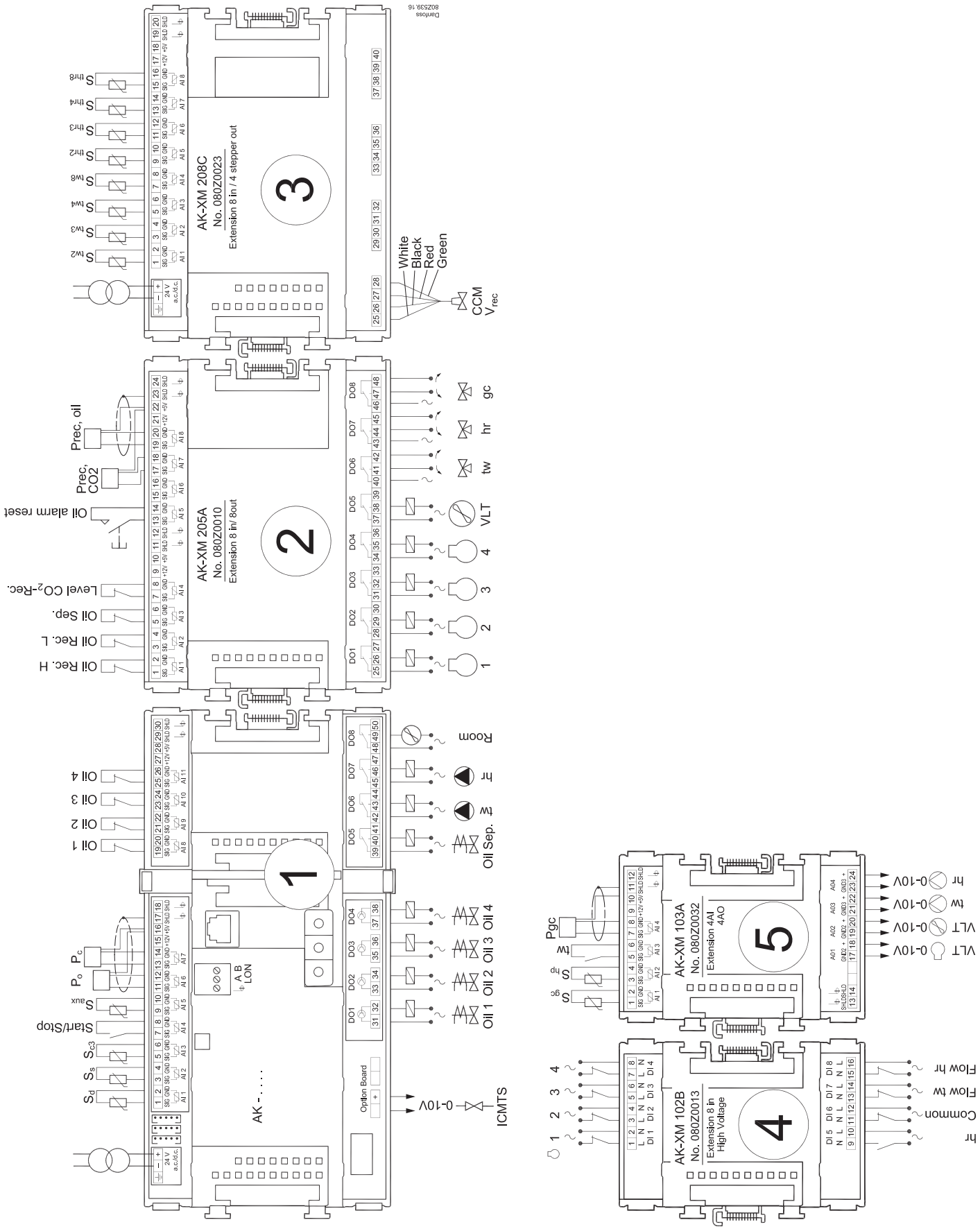
Drawings of the individual modules may be ordered from Danfoss.
Format = dwg and dxf.

You may then yourself write the module number in the circle and draw the individual connections.

The supply voltage for the pressure transmitter should be taken from the same module that receives the pressure signal.



Example continued:



12
Supply voltage

Supply voltage is only connected to the controller module. The supply to the other modules is transmitted via the plug between the modules.
The supply must be 24 V +/-20%. One power supply must be used for each controller. The power supply must be a class II.
The 24 V must not be shared by other controllers or units. The analog inputs and outputs are **not** galvanically separated from the supply.

The + and – 24V input must **not** be earthed.

If using stepper motor valves, the supply for these must be provided from a separate power supply.

For CO_2 facilities, it will also be necessary to safeguard the voltage to the controller and valves using UPS.

Power supply size

The power consumption grows with the number of modules used:

Module	Type	Number	á	Effect
Controller		1	x 8 =	8 VA
Extension module	200 series	_	x 5 =	__ VA
Extension module	100 series	_	x 2 =	__ VA
Total				___ VA

Example continued:

Controller module	8 VA
+ 2 extension modules in 200 series	10 VA
+ 2 extension modules in 100 series	4 VA

Power supply size (least)	22 VA

Ordering

1. Controller

Type	Function	Application	Language	Code no.	Example continued
AK-PC 781	Controller for capacity control of compressors and condensers. With oil management	Compressor / condenser / both	English, German, French, Dutch, Italian, Spanish, Portuguese, Danish, Finnish, Russian, Czech, Polish, Chinese	**080Z0186**	x

2. Extension modules and survey for inputs and outputs

Type	Analog inputs	On/Off outputs		On/off supply voltage (DI signal)		Analog outputs	Stepper outputs	Module with switches	Code no.	Example continued
	For sensors, pressure transmitters etc.	Relay (SPDT)	Solid state	Low voltage (max. 80 V)	High voltage (max. 260 V)	0-10 V d.c.	For valves with step control	For override of relay outputs	With screw terminals	
Controller	11	4	4	-	-	-		-	-	
Extension modules										
AK-XM 101A	8								**080Z0007**	
AK-XM 102A				8					**080Z0008**	
AK-XM 102B					8				**080Z0013**	x
AK-XM 103A	4					4			**080Z0032**	x
AK-XM 204A		8							**080Z0011**	
AK-XM 204B		8						x	**080Z0018**	
AK-XM 205A	8	8							**080Z0010**	x
AK-XM 205B	8	8						x	**080Z0017**	
AK-XM 208C	8						4		**080Z0023**	
The following extension module can be placed on the PC board in the controller module. There is only room for one module.										
AK-OB 110						2			**080Z0251**	x

3. AK operation and accessories

Type	Function	Application	Code no.	Example continued
Operation				
AK-ST 500	Software for operation of AK controllers	AK-operation	**080Z0161**	x
-	Cable between PC and AK controller	AK - Com port	**080Z0262**	x
-	Cable between zero modem cable and AK controller / Cable between PDA cable and AK controller	AK - RS 232	**080Z0261**	
-	Cable between PC and AK controller	AK - USB	**080Z0264**	
Accessories	**Power supply module 230 V / 115 V to 24 V d.c.**			
AK-PS 075	18 VA	Supply for controller	**080Z0053**	
AK-PS 150	36 VA		**080Z0054**	x
AK-PS 250	60 VA		**080Z0055**	
Accessories	**External display that can be connected to the controller module. For showing, say, the suction pressure**			
EKA 163B	Display		**084B8574**	
EKA 164B	Display with operation buttons		**084B8575**	
EKA 166	Display with operation buttons and LED's		**084B8578**	
AK-MMI	Graphic display with operation		**080G0311**	
-	Cable between display and controller	Length = 2 m	**084B7298**	
		Length = 6 m	**084B7299**	
-	Cable between graphic display and controller	Length = 1.5 m	**080G0075**	
		Length = 3 m	**080G0076**	
Accessories	**Real time clock for use in controllers that require a clock function, but are not wired with data communication.**			
AK-OB 101A	Real time clock with battery backup.	To be mounted in an AK controller	**080Z0252**	
Accessories	**Communication modules for controllers where modules cannot be connected continuously**			
AK-CM 102	Communication module	Data communication for external extension modules	**080Z0064**	

3. Mounting and wiring

This section describes how the controller:
• Is fitted
• Is connected

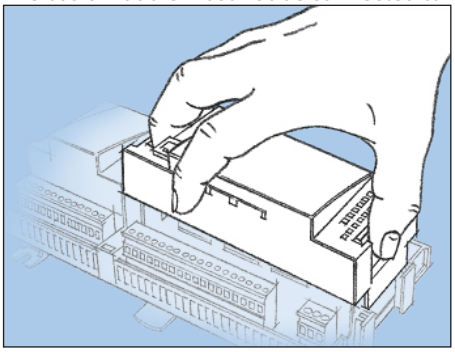
We have decided to work on the basis of the example we went through previously, i.e. the following modules:
• AK-PC 781 controller module
• AK-XM 205A input and output module
• AK-XM 208C analog input module + stepper output module
• AK-XM 102B digital input module
• AK-XM 103B analog input and output module
• AK-OB 110 analog output module

Mounting

Mounting of analog output module

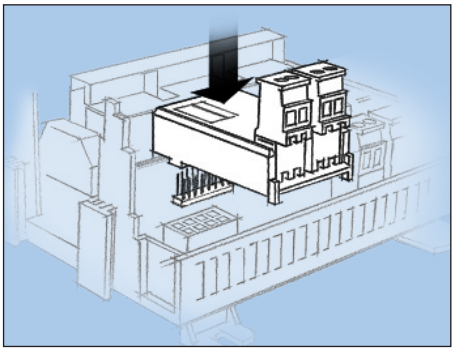
1. Lift the top part off the basic module

The basic module must not be connected to voltage.



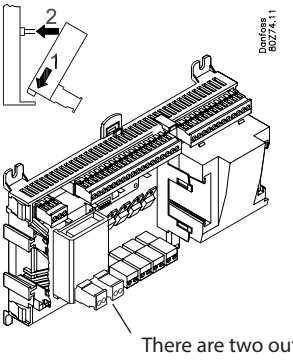
Press in the plate on the left-hand side of the light-emitting diodes and the plate on the right-hand side for the red address changers.
Lift the top part off the basic module.

2. Mount the extension module in the basic module



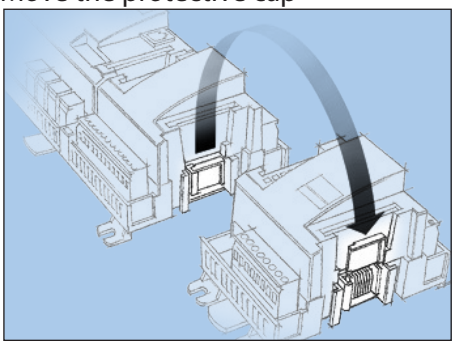
3. Put the top part back on the basic module

The analog extension module will supply a signal to the ICMTS valve



Mounting of extension module on the basic module

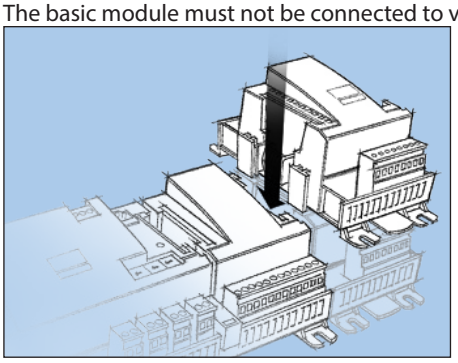
1. Move the protective cap



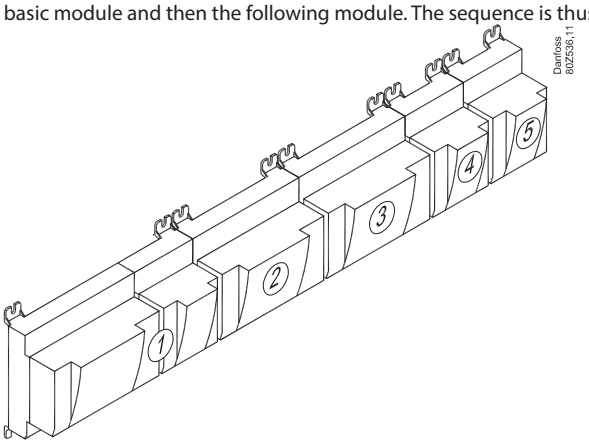
Remove the protective cap from the connection plug on the right-hand side of the basic module.
Place the cap on the connection plug to the right of the extension module that is to be mounted on the extreme right-hand side of the AK assembly.

2. Assemble the extension module and the basic module

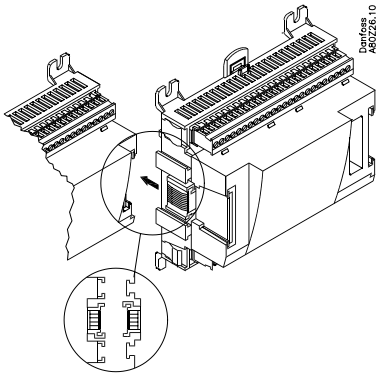
The basic module must not be connected to voltage.

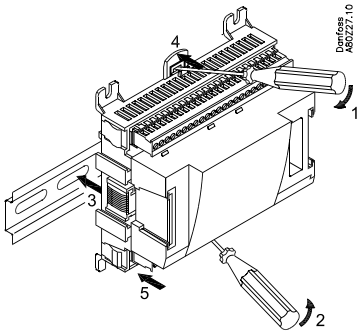


In our example four extension modules are to be fitted to the basic module. We have chosen to fit the module with relays directly on the basic module and then the following module. The sequence is thus:



All the subsequent settings that affect the four extension modules are determined by this sequence.





When the two snap catches for the DIN rail mounting are in the open position, the module can be pushed into place on the DIN rail – regardless of where the module is on the row.
Disassembly is thus done with the two snap catches in the open position.

Wiring

Decide during planning which function is to be connected and where this will be.

1. Connect inputs and outputs

Here are the tables for the example:

Remember the isolation amplifier
If signals are received from different controls, e.g. heat recovery for one of the inputs, a galvanically insulated module should be inserted.

Signal	Module	Point	Terminal	Signal type / Active at
Discharge gas temperature - Sd	1	**1** (AI 1)	**1 - 2**	Pt 1000
Suction gas temperature - Ss		**2** (AI 2)	**3 - 4**	Pt 1000
Outdoor temperature - Sc3		**3** (AI 3)	**5 - 6**	Pt 1000
External compressor stop		**4** (AI 4)	**7 - 8**	closed
Thermostat sensor in plant room - Saux1		**5** (AI 5)	**9 - 10**	Pt 1000
Suction pressure - P0		**6** (AI 6)	**11 - 12**	AKS 2050-59
Condenser pressure - Pc		**7** (AI 7)	**13 - 14**	AKS 2050-159
Level switch, oil, comp. 1		**8** (AI 8)	**19 - 20**	closed
Level switch, oil, comp..2		**9** (AI 9)	**21 - 22**	closed
Level switch, oil, comp..3		**10** (AI 10)	**23 - 24**	closed
Level switch, oil, comp..4		**11** (AI 11)	**25 - 26**	closed
Solenoid valve, oil, Comp. 1		**12** (DO 1)	**31 - 32**	ON
Solenoid valve, oil, Comp. 2		**13** (DO 2)	**33 - 34**	ON
Solenoid valve, oil, Comp. 3		**14** (DO 3)	**35 - 36**	ON
Solenoid valve, oil, Comp. 4		**15** (DO 4)	**37 - 38**	ON
Solenoid valve , oil, Separator		**16** (DO 5)	**39 - 40 - 41**	ON
Circulation pump tw		**17** (DO6)	**42 - 43 - 44**	ON
Circulation pump hr		**18** (DO7)	**45 - 46 - 47**	ON
Room fan		**19** (DO8)	**48 - 49 - 50**	ON
Voltage signal to high pressure valve, ICMTS		**24**	-	0-10 V
		25	-	

The function of the switch functions can be seen in the last column.

There are pressure transmitters AKS 32R and AKS 2050 available for several pressure ranges.
Here there are two different ones. One up to 59 bar and two up to 159 bar.

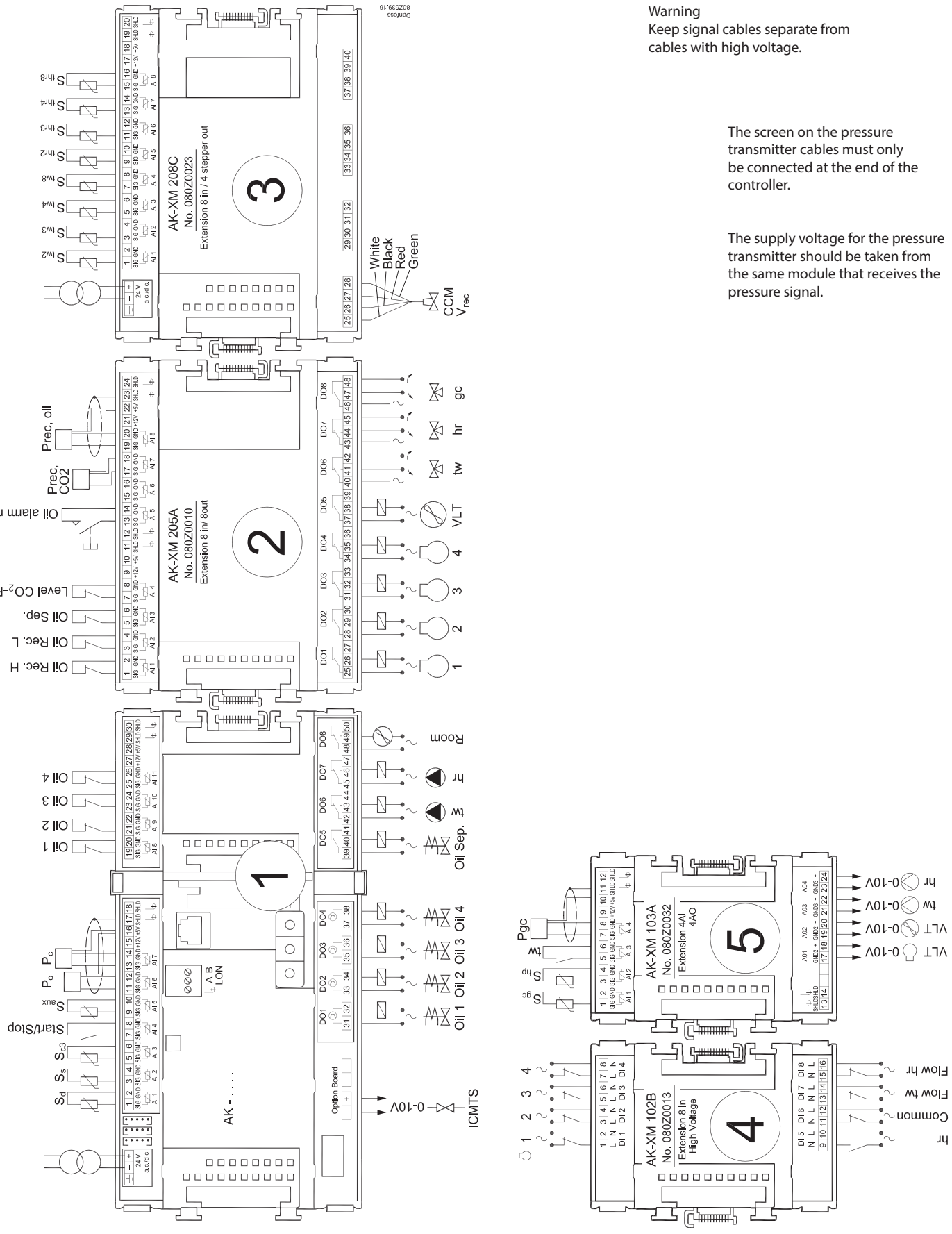
Signal	Module	Point	Terminal	Signal type / Active at
Level switch, oil, receiver High	2	**1** (AI 1)	**1 - 2**	closed
Level switch, oil, receiver Low		**2** (AI 2)	**3 - 4**	closed
Level switch, oil, Separator		**3** (AI 3)	**5 - 6**	closed
Level switch, CO2 receiver		**4** (AI 4)	**7 - 8**	Open
Pulse reset of stopped compressor		**5** (AI 5)	**13 - 14**	Pulse
		6 (AI 6)	**15 - 16**	
Refrigerant, receiver, Prec CO2		**7** (AI 7)	**17 - 18**	AKS 2050-159
Oil receiver, Prec Oil		**8** (AI 8)	**19 - 20**	AKS 2050-159
Compressor 1		**9** (DO 1)	**25 - 26 - 27**	ON
Compressor 2		**10** (DO 2)	**28 - 29 - 30**	ON
Compressor 3		**11** (DO 3)	**31 - 32 - 33**	ON
Compressor 4		**12** (DO 4)	**34 - 35 - 36**	ON
Start /stop of VLT to fans		**13** (DO 5)	**37 - 38 - 39**	ON
3-way valve, tap water, V3tw		**14** (DO6)	**40 - 41 - 42**	ON
3-way valve, heat circuit, V3hr		**15** (DO7)	**43 - 44 - 45**	ON
3-way valve, gas cooler, V3gc		**16** (DO8)	**46 - 47 - 48**	ON

Signal	Module	Point	Terminal	Active at
Compressor 1 Gen. safety	4	**1** (DI 1)	**1 - 2**	Open
Compressor 2 Gen. safety		**2** (DI 2)	**3 - 4**	Open
Compressor 3 Gen. safety		**3** (DI 3)	**5 - 6**	Open
Compressor 4 Gen. safety		**4** (DI 4)	**7 - 8**	Open
Start/stop heat recovery hr		**5** (DI 5)	**9 - 10**	closed
All comp. common safety		**6** (DI 6)	**11 - 12**	Open
Flow switch FStw		**7** (DI 7)	**13 - 14**	Open
Flow switch FShr		**8** (DI 8)	**15 - 16**	Open

Signal	Module	Point/Step	Terminal	Signal type
Tap water temperature - Stw2	3	**1** (AI 1)	**1 - 2**	Pt 1000
Tap water temperature - Stw3		**2** (AI 2)	**3 - 4**	Pt 1000
Tap water temperature - Stw4		**3** (AI 3)	**5 - 6**	Pt 1000
Tap water temperature - Stw8		**4** (AI 4)	**7 - 8**	Pt 1000
Heat reclaim temperature Shr2		**5** (AI 5)	**9 - 10**	Pt 1000
Heat reclaim temperature Shr3		**6** (AI 6)	**11 - 12**	Pt 1000
Heat reclaim temperature Shr4		**7** (AI 7)	**13 - 14**	Pt 1000
Heat reclaim temperature Shr8		**8** (AI 8)	**15 - 16**	Pt 1000
Stepper signal to by-pass valve, CCM		**9 (step 1)**	**25 - 26 - 27 - 28**	CCM (ETS)
		10 (step 2)	**29 - 30 - 31 - 32**	
		11 (step 3)	**33 - 34 - 35 - 36**	
		12 (step 4)	**37 - 38 - 39 - 40**	

Signal	Module	Point	Terminal	Signal type
Temp. gas cooler outlet Sgc	5	**1** (AI 1)	**1 - 2**	Pt 1000
Temp. by-passed gas Shp		**2** (AI 2)	**3 - 4**	Pt 1000
Start/stop heat recovery tw		**3** (AI 3)	**5 - 6**	closed
Gas cooler pressure Pgc		**4** (AI 4)	**7 - 8**	AKS 2050-159
Speed control, compressor		**5** (AO 1)	**9 - 10**	0 - 10 V
Speed control, gas cooler fans		**6** (AO 2)	**11 - 12**	0 - 10 V
Speed control, pump - tw		**7** (AO 3)	**13 - 14**	0 - 10 V
Speed control, pump - hr		**8** (AO 4)	**15 - 16**	0 - 10 V

The connections for the example can be seen here.



Warning
Keep signal cables separate from cables with high voltage.

The screen on the pressure transmitter cables must only be connected at the end of the controller.

The supply voltage for the pressure transmitter should be taken from the same module that receives the pressure signal.

2. Connect LON communication network

The installation of the data communication must comply with the requirements set out in document RC8AC.

3. Connect supply voltage

Is 24 V, and the supply must not be used by other controllers or devices. The terminals must not be earthed.

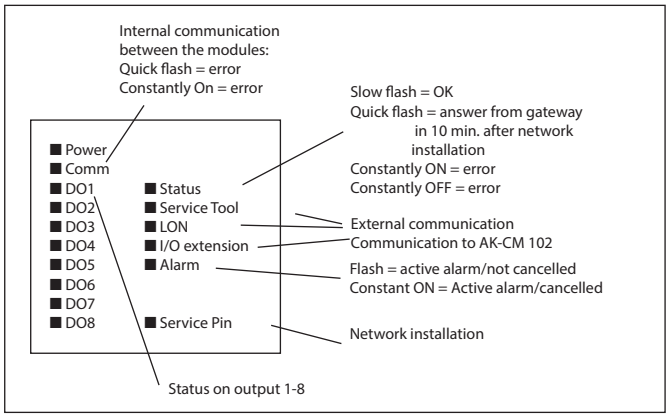
4. Follow light-emitting diodes

When the supply voltage is connected the controller will go through an internal check. The controller will be ready in just under one minute when the light-emitting diode "Status" starts flashing slowly.

5. When there is a network

Set the address and activate the Service Pin.

6. The controller is now ready to be configured.



4. Configuration and operation

This section describes how the controller:
• Is configured
• Is operated

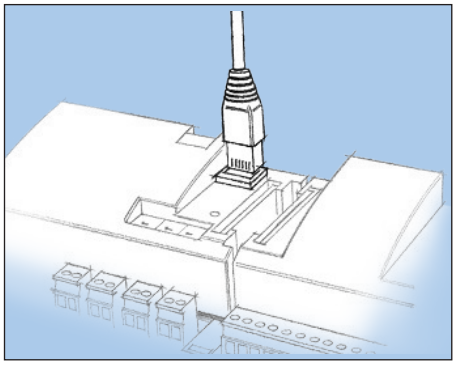
We have decided to work on the basis of the example we went through previously, i.e. compressor control with 4 compressors and high pressure control using heat recovery and gas cooler.

The example is shown two pages in.

Configuration

Connect PC

PC with the program "Service Tool" is connected to the controller.

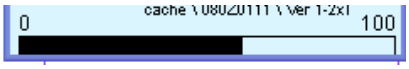


The controller must be switched on first and the LED "Status" must flash before the Service Tool program is started.

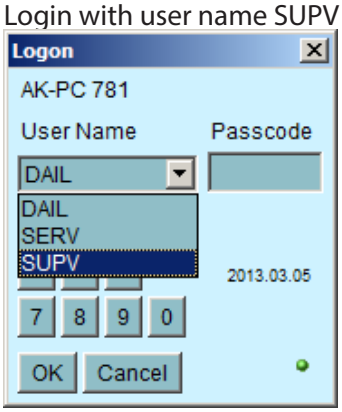
For connecting and operating the "AK service tool" software, please see the manual for the software.

Start Service Tool programme

The first time the Service Tool is connected to a new version of a controller the start-up of the Service Tool will take longer than usual while information is retrieved from the controller.
Time can be followed on the bar at the bottom of the display.

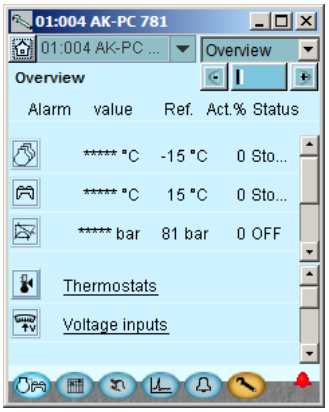


Login with user name SUPV



Select the name **SUPV** and key in the access code.

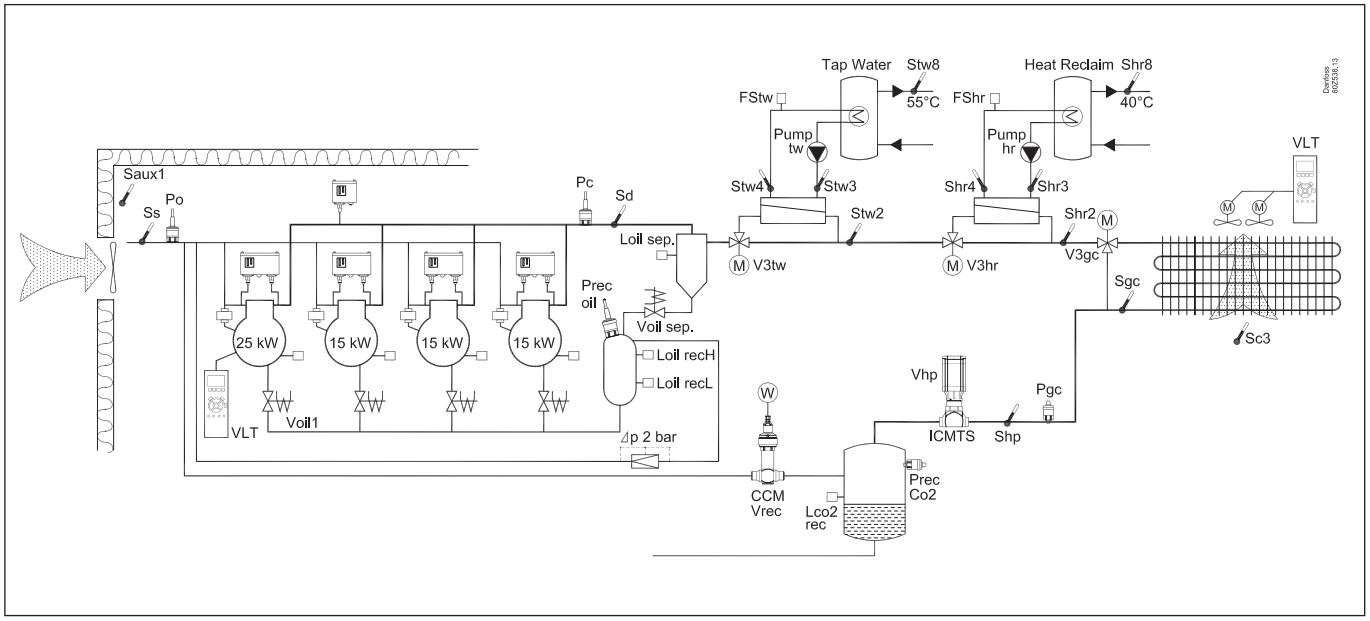
When the controller is supplied the SUPV access code is 123.
When you are logged into the controller an overview of it will always appear.



In case the overview is empty. This is because the controller has not yet been set up.
The red alarm bell at the bottom right tells you that there is an active alarm in the controller. In our case the alarm is due to the fact that the time in the controller has not yet been set.

Refrigerating plant example

We have decided to describe the setup by means of an example comprising a MT compressor group and a high pressure control. The example is the same as the one given in the "Design" section, i.e. the controller is an AK-PC 781 + extension modules.



Compressor Group
- MT circuit
- Refrigerant CO2 (R744)
- Variable compressor and 3 single step compressors
- 4 only compressors with "Best fit"
- Safety monitoring of each compressor
- Common high-pressure monitoring
- Po setting -15°C, night displacement 5 K
- Oil management of each compressor

High pressure control:
- Gas cooler with speed controlled fans (Pgc Max. = 100 bar)
- High pressure control with signal from Sgc and Shp
- Pc regulates floating based on outdoor temperature sensor Sc3
- Control of high pressure valve ICMTS
- Heat recovery for hot tap water. Relay and 0-10 V
- Heat recovery for heating. Relay and 0-10 V

Receivers:
- Monitoring of liquid level of refrigerant
- Control of pressure in refrigerant receiver (reference 34 bar)
- Control of pressure in oil receiver

Fan in plant room
- Thermostat control of fan in engine room

Safety functions:
- Monitoring of Po, Pc, Sd and superheat in suction line
- Po max = -5°C, Po min = -35°C
- Pc max = 103.5 bar
- Sd max = 120°C
- SH min = 5 °C, SH max = 35 °C
- Monitoring of low and high level in oil receiver

Other
- Start/stop of heat recovery tw and hr
- External compressor stop used

There is also an internal main switch as a setting. Both, this and the external compressor stop must be "ON" before any adjustment is made.

Warning
The main switch will stop all regulations, including high-pressure regulation.

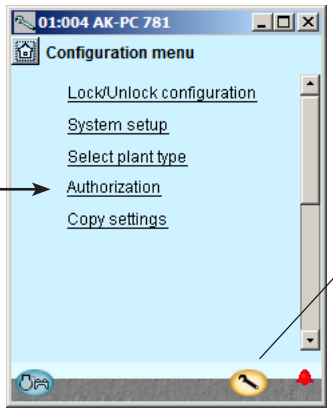
Authorization

1. Go to Configuration menu

Press the orange setup button with the spanner at the bottom of the display.

When the controller is supplied it has been set with standard authorization for different user interfaces. This setting should be changed and adapted to the plant. The changes can be made now or later.

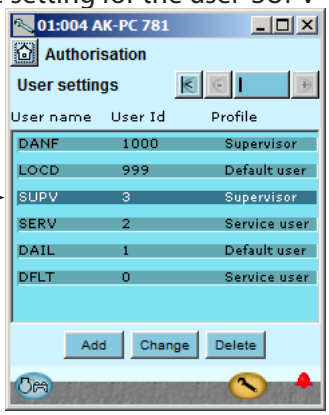
2. Select Authorization



You will use this button again and again whenever you want to get to this display.
On the left-hand side are all the functions not shown yet. There will be more here the further into the setup we go.

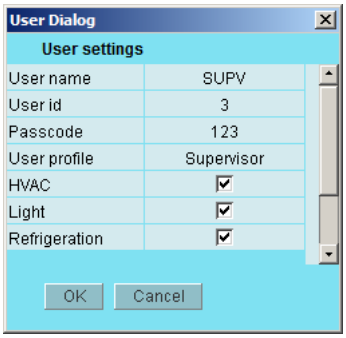
Press the line **Authorization** to get to the user setup display.

3. Change setting for the user 'SUPV'



Mark the line with the user name **SUPV**.
Press the button **Change**

4. Select user name and access code



This is where you can select the supervisor for the specific system and a corresponding access code for this person.

The controller will utilize the same language that is selected in the service tool but only if the controller contains this language. If the language is not contained in the controller, the settings and readings will be shown in English.

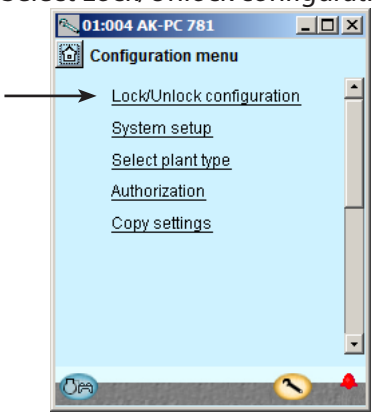
5. Carry out a new login with the user name and the new access code

To activate the new settings you must carry out a new login to the controller with the new user name and the relevant access code.
You will access the login display by pressing the padlock at the top left corner of the display.

Unlock the configuration of the controllers

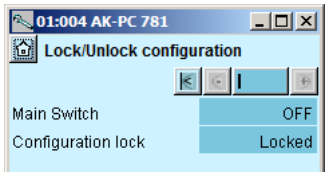
1. Go to Configuration menu

2. Select Lock/Unlock configuration



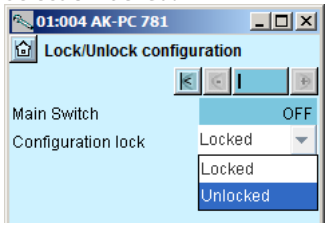
3. Select Configuration lock

Press the blue field with the text **Locked**



4. Select Unlocked

Select **Unlocked.**



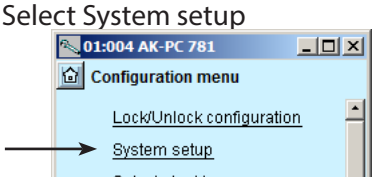
The controller can only be configured when it is unlocked.

The values can be changed when it is locked, but only for those settings that do not affect the configuration.

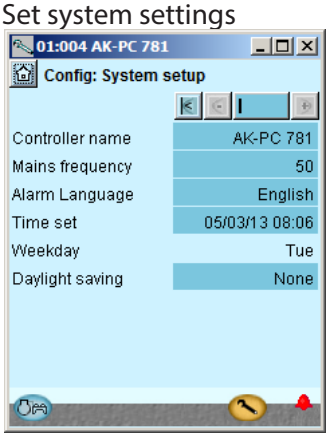
System setup

1. Go to Configuration menu

2. Select System setup



3. Set system settings



All settings can be changed by pressing in the blue field with the setting and then indicating the value of the required setting.

In the first field you enter a name for what the controller will be controlling. The text written in this field can be viewed at the top of all screens, together with the controller's address.

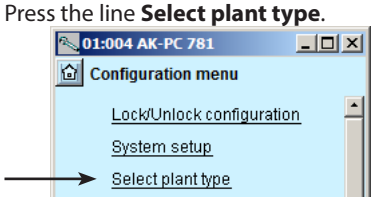
When the time is set the PC's time can be transferred to the controller.
When the controller is connected to a network, date and time will automatically be set by the system unit in the network. This also applies to change-over Daylight saving.

Set plant type

1. Go to Configuration menu

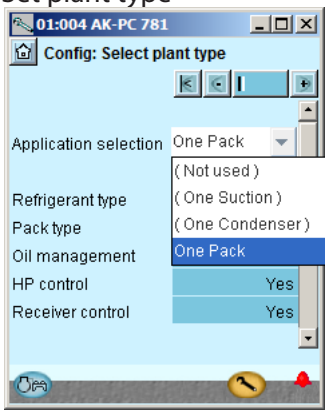
2. Select plant type

Press the line **Select plant type**.



Our example
The comments for the example are shown on the following pages, in the middle column.

3. Set plant type



In our example we want the controller to control both a compressor group and a condenser group. We therefore select the plant type **One pack**.

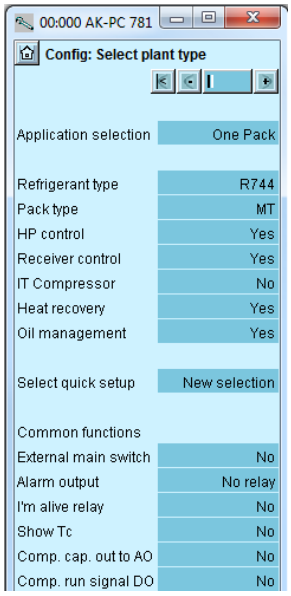
Subsequent options are then available, but only those options allowed by the current selection.

Select the refrigerant type, here CO2, further options are made available, etc.

In our example, the cooling (MT) is regulated..
(If it was a cascade control/two step system, the other controller would need to be set to "LP".)

The settings for our example can be viewed in the display.

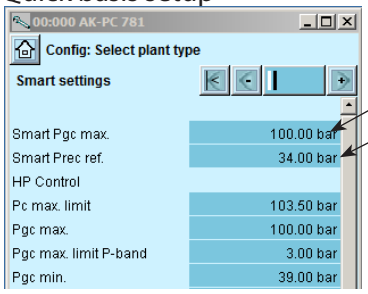
4. Set Common functions



This setting is special.
Here the user can select a pre-defined system. We do not use this function in our example, but perform the adjustments individually.

Press the +-button to go on to the next page

6. Quick basis setup

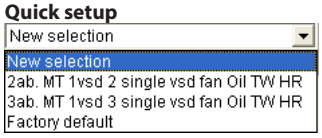


Adjust only the two lines with "Smart"
(Only when the refrigerant selected is CO2)
Here you can adjust the overall pressure values for the system
- *Regulation Pgc max*
- *Regulation Receiver reference.*

The controller will then suggest values for all settings connected with this.
The values can be seen in this display, but also later in the relevant setup.
Fine adjustments can be made if necessary.

General
If you want to know more about the different configuration options, they are listed in the right column.
The number refers to the number and picture in the column on the left.
As the screen only shows the settings and readings that are required for a given setup, all possible settings have also been included in the right column.

3 - Plant type
Application selection
Select between "One Suction", "One condenser" or both "One Pack"
4- Plant type continued
Refrigerant
Select refrigerant type
Refrigerant factors K1, K2, K3
Only used if "Po refrigerant type" is set to custom (contact Danfoss for information)
Pack type
MT = Medium temperature. LT = Low temperature
HP control
High pressure control enabled. To be adjusted later on.
Receiver control
Receiver control enabled. To be adjusted later on.
IT Compressor
Parallel compressor (there are special settings; see the section on page 122).
Heat recovery
Heat recovery enabled. To be adjusted later on.
Oil management
Oil control enabled. To be adjusted later on.
Quick setup

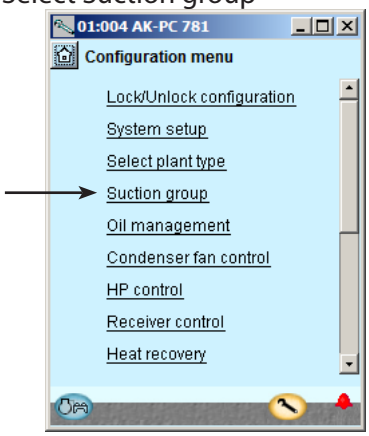


A choice will give a number of predefined combinations, which at the same time determine the connection points. The display options depend on previous settings.
At the end of the manual there is an overview of the options and connection points.
After configuration of this function, the controller will shut down and restart. After the restart, a large number of settings will have been made. These include the connection points. Continue with the settings and check the values.
If you change some of the settings, the new values will come into force.
External main switch
A switch may be connected for starting and stopping the regulation.
Mon. Ext. Power loss (signal from an UPS)
Monitoring of external voltage. When selecting "yes", a digital input is allocated.
Alarm output
Here you may set whether or not it should be an alarm relay, and which priorities will activate it.
I'm alive relay
A relay will "release" if the regulation is stopped.
Show Tc
If selecting "yes" the Pc pressure will also be shown as temperature.
Comp. cap. out to AO
If selecting "yes" indicate the current capacity of an output.
Comp. run signal DO
If "yes" is selected, an output is reserved that shows if the compressors are operating.
5 – Quick relative setup
Smart = Setting the controller's overall pressure values. The remaining pressure values will be set automatically.

Set control of compressors

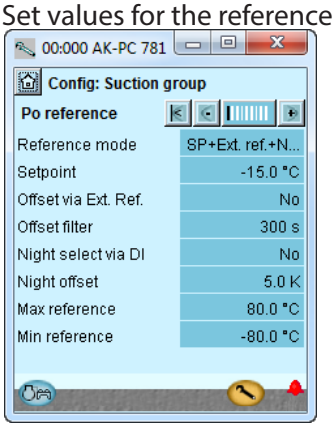
1. Go to Configuration menu

2. Select Suction group



The configuration menu in the Service Tool has changed now. It shows the possible settings for the selected plant type.

3. Set values for the reference



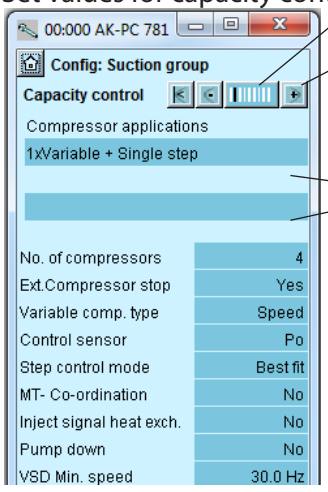
In our example we select the settings:
- Suction set point = -15°C
- Night offset value = 5 K.

The settings are shown here in the display.

Press the +-button to go on to the next page

There are several pages, one after the other.
The black bar in this field tells you which of the pages is currently displayed.
Move between the pages using the + and - buttons.

4. Set values for capacity control



If a screw compressor is chosen in the first line, its type must be determined in the next line.

In our example we select:
- External compressor stop
-VSD + single step
- 4 compressors
- P0 as signal to the regulation
- Best fit

Press the +-button to go on to the next page

3 - Reference mode
Displacement of suction pressure as a function of external signals
0: Reference = set reference + night offset + offset from external 0-10 V signal
1: Reference = set reference + offset from P0 optimization
Setpoint (-80 to +30°C)
Setting of required suction pressure in °C
Offset via Ext. Ref
Select whether a 0-10V external reference override signal is required
Offset at max input (-100 to +100 °C)
Displacement value at max. signal (10)
Offset at min input (-100 to +100 °C)
Displacement value at min. signal (0 V)
Offset filter (10 - 1800 Sec)
Here you can set how quickly the reference must become effective.
Night Offset via DI
Select whether a digital input is required for activation of night operation. Night operation can alternatively be controlled via internal weekly schedule or via a network signal
Night Offset (-25 to +25 K)
Displacement value for suction pressure in connection with an active night setback signal (set in Kelvin)
Max reference (-50 to +80 °C)
Max. permissible suction pressure reference
Min reference (-80 to +25 °C)
Min. permissible suction pressure reference

4 - Compressor application
Select one of the available compressor configuration here

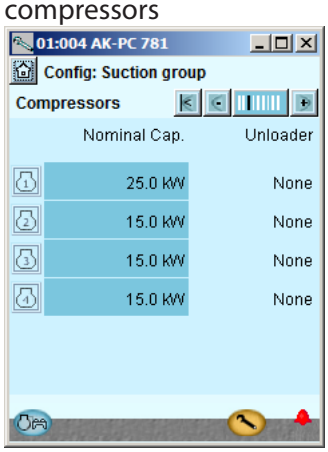
Single step only
(1xComp. w. unloaders + Single step)
(2xComp. w. unloaders + Single step)
(Comp. w. unloaders only)
1xVariable + Single step
(1xVariable + Comp. w. unloaders)
2xVariable + Single step
(1xScrew + Single step)
(2xScrews + Single step)
(3xScrews + Single step)

Screw compressorer
The following options are available for screw compressors

Screw w. 2 steps (1 unl.) OSKA
Screw w. 3 steps (2 unl.) HSK/HSN/OSKA
Screw w. 4 steps (3 unl. + PWM) CSH

No. of compressors
Set number of compressors (total)
No. of unloaders
Set number of unloader valves
Ext. compressor stop
An external switch can be connected which will start and stop the compressor control.
Variable compressor type
Choose between speed control or PWM (digital scroll).
Control sensor
Po: Suction pressure Po is used for control
S4: Media temperature S4 is used for control
Pctrl: Control pressure from the low-pressure circuit for cascade
Po refrigerant type
Select refrigerant type
P0 Refrigerant factors K1, K2, K3
Only used if "Po refrigerant type" is set to custom (contact Danfoss for information)
Pctrl refrigerant type
Select refrigerant type
Pctrl refrigerant factors K1, K2, K3
Only used if "Pctrl refrigerant type" is set to custom (contact Danfoss for information)
Step control mode
Select coupling pattern for compressors
Cyclic: Runtime equalisation between compressors (FIFO)
Best fit: Compressors are cut in/out in order to make the best possible fit to actual load
MT/LT coordination
Control methods between cold and frost for cascade.
MT Release: MT-control. The controller must connect to a relay so that a signal can be sent to the controller in the LT circuit.
LT Release:LT-control. The controller must receive a signal from the controller in the MT-circuit.
MT Coord: MT-control. A signal must both be received and sent.
LT Coord: LT-control. A signal must both be received and sent.
MT Coord release before start: LT starts and MT following. A signal must be both received and sent.
LT-Comp.request delay
LT-control. Delay on output signal to MT

5. Set values for capacity of the compressors



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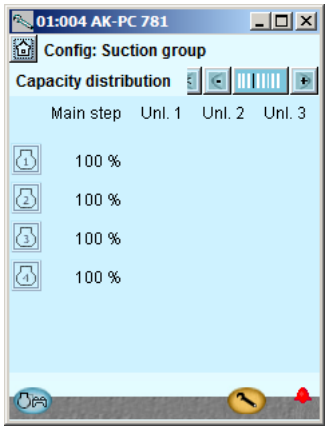
6. Set values for main step and any unloaders



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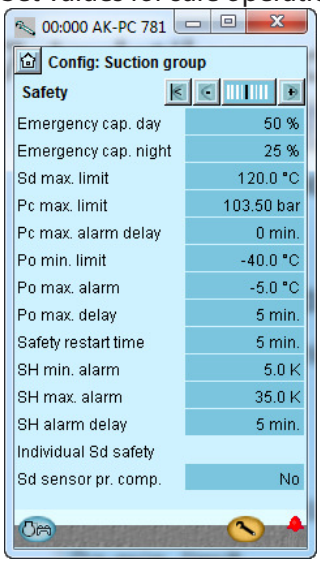
7. Set values for safe operation



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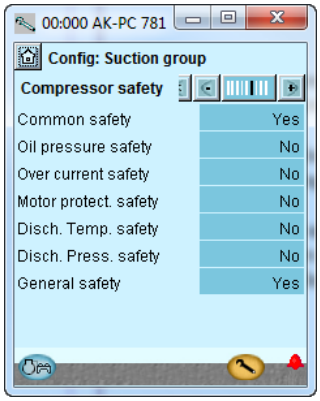
In our example there are no unloaders and hence no changes.

In our example we select:
- Safety limit for discharge temperature = 120°C
- Safety limit for high condensing pressure = 103.5 bar
- Safety limit for low suction pressure = -40°C
- Alarm limit for high suction pressure = -5°C
- Alarm limit for min. and max. superheat, respectively = 5 and 35 K.

LT Comp. release delay
LT-control. Delay on input signal from MT
MT-Comp.request delay
MT-control. Delay on input signal from LT
MT Comp. release delay
MT-control. Delay on output signal to LT
Injection heat exchanger
Selects whether an output signal is to be sent for start/stop of liquid injection in a cascade heat exchanger
Pump down
Select whether a pump down function is required on the last running compressor
Pump down limit Po (-80 to +30 °C)
Set the actual pump down limit
VSD min speed (0.5 – 60.0 Hz)
Min. speed where the compressor must cutout
VSD start speed (20.0 – 60.0 Hz)
Minimum speed for start of Variable speed drive (Must be set higher than "VSD Min. Speed Hz")
VSD max speed (40.0 – 120.0 Hz)
Highest permissible speed for the compressor motor
VSD safety monitoring
Select this if input for monitoring of the frequency converter is required
PWM period time
Period time for bypass valve (on time + off time)
PWM Min. capacity
Minimum capacity in the period time (without a minimum capacity the compressor will not be cooled)
PWM Max. capacity
Limitation of capacity during period time (100 = no limit)
Load shed limits
Select which signal is to be used for load limitation (only via network, a DI + network or two DI + network)
Load limitation period
Set the maximum time permitted for load limitation
Load shed limit 1
Set max capacity limit for load shed input 1
Load shed limit 2
Set max capacity limit for load shed input 2
Override limit Po
Any load below the limit value is freely permitted. If the P0 exceeds the value, a time delay is started. If the time delay runs out, the load limit is cancelled
Override delay 1
Max. time for capacity limit, if P0 is too high
Override delay 2
Max. time for capacity limit, if P0 is too high
Kp Po (0.1 – 10.0)
Amplifications factor for PI regulation
Advanced control settings
Select whether the advanced capacity control settings should be visible
Po filter
Reduce changes in the Po reference
Pc filter
Reduce changes in the Pc reference
Minimize cycling
The control zone may vary for connections and disconnections when regulating with step coupling. See Section 5.
Initial start time (15 – 900 s)
The time after start-up where the cut-in capacity is limited to the first compressor step.
Unloading mode
Select whether one or two capacity controlled compressors are allowed to be unloaded at the same time at decreasing capacity
5 - Compressors
In this screen the capacity distribution between the compressors is defined.
Capacities that need to be set depend upon the "compressor application" and "Step control mode" that has been selected.
Nominal capacity (0.0 – 100000.0 kW)
Set the nominal capacity for the compressor in question. For compressors with variable speed drive the nominal capacity must be set for the mains frequency (50/60 Hz)
Unloader
Number of unload valves for each compressor (0-3)
6 - Capacity distribution
The installation is dependent on the combination of compressors and coupling pattern.
Main step
Set the nominal capacity of the main step (Set the percentage of the relevant compressor's nominal capacity) 0 - 100%.

8. Set monitoring of compressor



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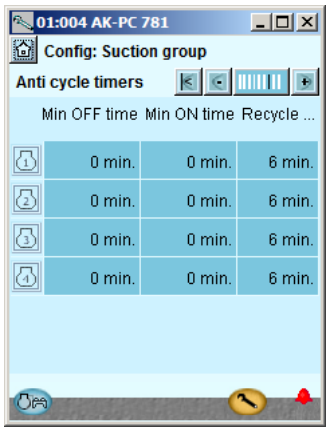
9. Set operation time for compressor



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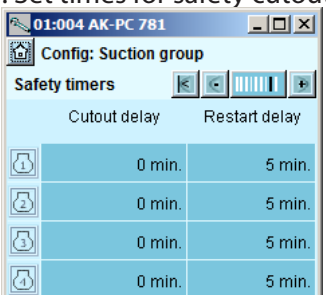
10. Set times for safety cutouts



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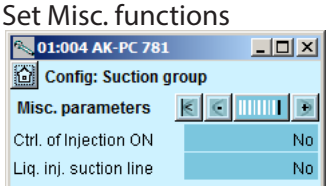
11. Set Misc. functions



In our example we use:
- Common high-pressure pressure control for all compressors
- One general safety monitoring unit for each compressor

(The remaining options could have been selected if specific safety controls for each compressor had been required).

Set min. OFF-time for the compressor relay
Set min. ON-time for the compressor relay
Set how often the compressor is allowed to start

The settings only apply to the relay that cuts the compressor motor in and out.
They do not apply to unloaders.

If the restrictions overlap, the controller will use the longest restriction time.

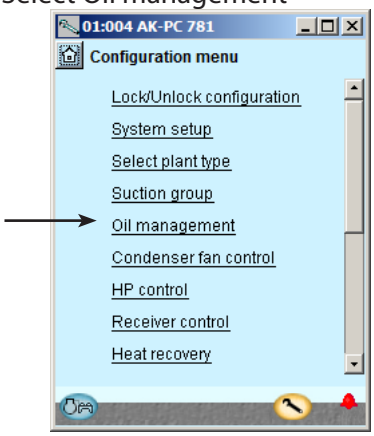
In our example we do not use these functions.

Unload
Readout of the capacity on every unloading 0-100%.
7 - Safety
Emergency cap. day
The desired cut-in capacity for daily use in the case of emergency operations resulting from error in the suction pressure sensor/ media temperature sensor.
Emergency cap. night
The desired cut-in capacity for night operations in the case of emergency operations resulting from error in the suction pressure sensor/ media temperature sensor.
Sd max limit
Max. value for discharge gas temperature
10 K below the limit, the compressor capacity should be reduced and the entire condenser capacity will be cutin.
If the limit is exceeded, the entire compressor capacity will be cutout
Pc Max limit
Maximum value for the condenser pressure in °C
3 K below the limit, the entire condenser capacity will be cutin and the compressor capacity reduced.
If the limit is exceeded, the entire compressor capacity will be cutout.
Pc Max delay
Time delay for the alarm Pc max
P0 Min limit
Minimum value for the suction pressure in °C
If the limit is reduced, the entire compressor capacity will be cutout.
P0 Max alarm
Alarm limit for high suction pressure P0
P0 Max delay
Time delay before alarm for high suction pressure P0.
Safety restart time
Common time delay before restarting the compressor. (Applicable to the functions: "Sd max. limit", Pc max. limit" and "P0 min. limit).
SH Min alarm
Alarm limit for min. superheat in suction line.
SH Max alarm
Alarm limit for max. superheat in suction line.
SH alarm delay
Time delay before alarm for min./max. superheat in suction line.
Individuel Sd pr. compressor
Select whether an Sd measurement should be made for each compressor.
Sd cut out temperature
Set the desired cut-out temperature.
8 - Compressor safety
Common safety
Choose whether an overall, common safety input for all compressors is desired. If the alarm is activated, all compressors will be cutout.
Oil pressure etc
Define here whether this type of protection should be connected.
For "General", there is a signal from each compressor.
9 - Minimum operation times
Configure the operation times here so "unnecessary operation" can be avoided.
Restart time is the time interval between two consecutive starts.
10 - Safety timer
Cutout delay
The time delay resulting from drop-out of automated safety measures and until the compressor-error is reported. This setting is common for all safety inputs for the relevant compressor.
Restart delay
Minimum time that a compressor should be OK after a safety cut-out. After this interval it can start again.
11 - Misc. functions
Injection On
Select this function if a relay must be reserved for the function. (The function must be wired to controllers with expansion valves in order to close liquid injection for the safety cut-out of the last compressor.)
Network: The signal is sent to the controllers via data communication.
Liq. inj suction line
Select the function if a liquid injection is required in the suction line in order to keep the discharge gas temperature down.
Regulation can be done either using a solenoid valve and a TEV, or using an AKV valve.

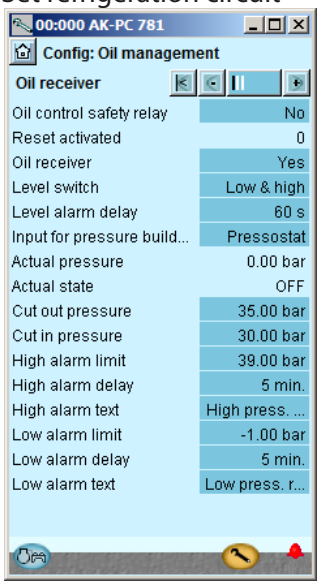
Set oil management

1. Go to Configuration menu

2. Select Oil management



3. Set refrigeration circuit

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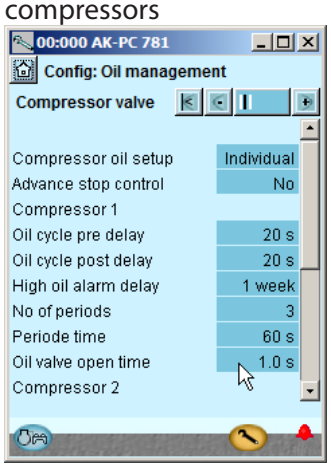
We do not use safety relays in our example.

In this example, we want to control the oil receiver.
This is done with a pressostat.
Here, we have chosen a pressostat.
The pressostat should be set as follows:
- Select pressure transmitter
When the pressure drops in the receiver, the valve should open.
- Set the pressure level at which the valve should open. Set at 30 bar, here.
- Set the pressure level, at which the valve should close completely again. Set at 35 bar, here.

In the example, we have two level switches in the receiver. Both one high and one low.

3
LP sync to HP
Select this if the controller is on low pressure control and should be synchronised with high pressure regulation.
Use oil equalization
(Only possible with cyclic operation)
Interval time
Set how often a compressor must pause during full operation.
Equalization time
Set the duration of the oil equalisation (the pause).
Oil control safety relay
If this setting is set to YES, the controller will reserve a safety relay for each compressor. The relay terminal is connected in series to the compressor relay. The relay can hereby stop the compressor, if a lack of oil is registered when the compressor is force controlled. (Forced controlled to ON with the setting "Manual" or with the "changeover" on an extension module.)
Danfoss recommends this function to avoid any compressor damages due to lack of care.
(In order to keep things simple, this function is not used as an example.)
Oil receiver
Select whether you wish to activate pressure regulation in one of the oil receivers.
Level switch receiver
Define the desired level sensors. High / Both Low and High
Level alarm delay
Delay time tor level alarm
Input for pressure build
Select whether the pressure is controlled by a pressostat or signal from the pulse counter.
Comp. per. to start seq.
(For pulse counter): Percentage value of total pulses of the different compressors
Pressure buildup seq.
(For pulse counter) Select between:
Only pulses from the HP circuit. Pulses from both HP and LP are included
Actual pressure
Measured value
Actual state
Status of oil separation
Cut out pressure
Receiver pressure for shutting off oil
Cut in pressure
Receiver pressure for turning on oil
High alarm limit
An alarm is given if a higher pressure is registered
High alarm delay
Time delay for alarm
High alarm text

4. Set oil management for the compressors



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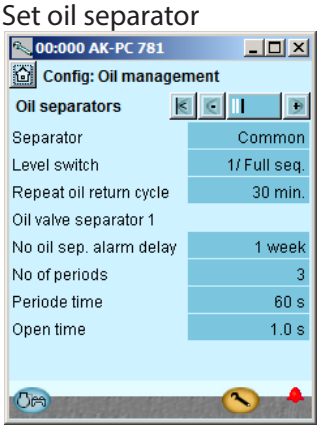
5. Set oil separator



In our example, the oil supply is controlled separately for each individual compressor.
The settings are shown here in the diagram.
The process is as follows:
20 seconds after the signal from the level switch is given, the oil injection starts. This pulsates three times with one minute intervals. Each pulse lasts one second. Then there is a pause for 20 seconds. If the level switch has not registered any oil at this point, the compressor is stopped.

In our example, there is only one single separator that has just one level switch.
The settings are shown here in the diagram.
The process is as follows:
When a signal is given from the level switch, the discharging process to the receiver commences. This pulsates three times with one minute intervals. Each pulse lasts one second. If the level switch does not register an oil drop at this point, an alarm is given when the delay time has expired.

Write an alarm text
Low alarm limit
An alarm is given if a lower pressure is registered
Low alarm delay
Time delay for alarm
Low alarm text
Write an alarm text

4
Compressor oil setup
Select whether the oil supply to all the compressors is to be shared at the same time or whether each compressor is to be controlled separately.

Advanced stop
'Yes' means pulses will be allowed following compressor stop

Oil cycle pre delay
Delay time before oil pulses commence

Oil cycle post delay
Delay time for signal that will stop oil pulses

High oil alarm delay
If an activation of the level switch is not registered before the time has expired, an alarm will be given. (the compressor not use the oil).

No of periods
No. of pulses that are to be enabled in a oil filling sequence

No of periods before stop (Advanced stop = yes)
If oil is still missing after this number of pulses, the compressor is stopped. The remaining number of pulses will then be permitted.

Period time
Time between pulses

Oil valve open time
The valve's opening time for each pulse.

5
Separator
Select whether there should be one shared separator for all the compressors or one separator for each compressor.

Level detection
Select whether the separator is to be controlled by "Full sequence", "To Level" or "low and high" level switches.

Level alarm delay
Alarm given when using a level switch for low level.

Repeat oil return cycle
Time period between repeat emptying processes from the separator if the level switch stays at high level.

No oil sep. alarm delay
Alarm delay when a signal is given that oil is not being separated ("high" level contact not activated)

No of periods
No. of times the valve should open in emptying sequence

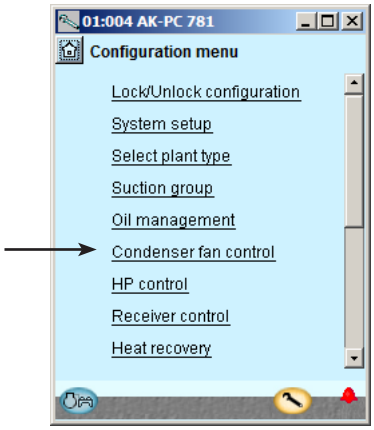
Period time
Time between valve openings.

Open time
The open time of the valve

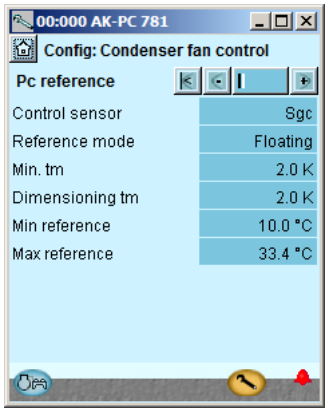
Setup control of condenser fans

1. Go to Configuration menu

2. Select Condenser fan control



3. Set control mode and reference



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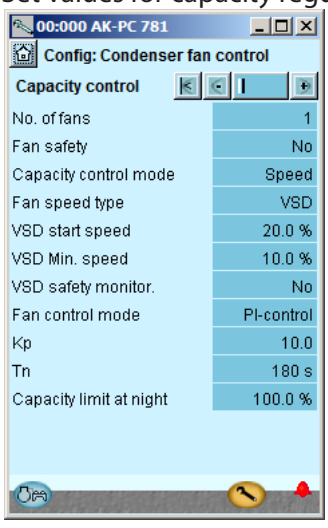
4. Set values for capacity regulation



In our example the condenser pressure is controlled on the basis of the Sgc and from Sc3 (floating reference).
The settings shown here in the display.

In our example we use a number of fans that are all speed-controlled in parallel.
The settings shown here in the display.

For your information the function "Monitor fan safety" will require an input signal from each fan.

3 - PC reference

Control sensor
Pc: The condensing pressure PC is used for regulation
Sgc: The temperature at the outlet of the gas cooler (CO2 transcritical only)
S7: Media temperature is used for regulation

Reference Mode
Choice of condenser pressure reference
Fixed setting: Used if a permanent reference is required = "Setting"
Floating: Used if the reference is changed as a function of Sc3 the external temperature signal, the configured "Dimensioning tm K"/"Minimum tm K" and the actual cut in compressor capacity. (Liquid is recommended for CO2 and heat recovery.)

Setpoint
Setting of desired condensing pressure in bar

Min. tm
Minimum average temperature difference between Sc3 air and Pc condensing temperature with no load.

Dimensioning tm
Dimensioning average temperature differential between Sc3 air and Pc condensing temperature at maximum load (tm difference at max load, typically 8-15 K).

Min reference
Min. permitted condenser pressure reference

Max reference
Max. permitted condenser pressure reference

4 - Capacity control

No of fans
Set number of fans.

Monitoring fan safety
Safety monitoring of fans. A digital input is used to monitor each fan.

Capacity control mode
Select control mode for condenser
Step: Fans are step-connected via relay outputs
Step/speed: The fan capacity is controlled via a combination of speed control and step coupling
Speed: The fan capacity is controlled via speed control (frequency converter)
Speed 1.step: First fan speed controlled, rest step coupling

Fan speed type
VSD (and normal AC motors)
EC motor = DC controlled fan motors

VSD start speed
Minimum speed for start of speed control (Must be configured higher than "VSD Min. Speed %")

VSD min Speed
Minimum speed whereby speed control is cut-out (low load).

VSD safety monit.
Choice of safety monitoring of frequency converter. A digital inlet is used for monitoring the frequency converter.

EC Start capacity
The regulation awaits this need to arise before supplying voltage to the EC motor

EC voltage min
Voltage value at 0% capacity

EC voltage max
Voltage value at 100% capacity

EC Voltage abs. max
Permissible live voltage for EC motor (overcapacity)

Absolut max Tc
Max value for Tc. If this Tc value is exceeded, the EC voltage will be raised to the value in "EC Voltage abs. max."

Control type
Choice of control strategy
P-band: The fan capacity is regulated via P-band control. The P band is configured as "Proportional band Xp"
PI-Control: The fan capacity is regulated by the PI controller.
Continues

Continued

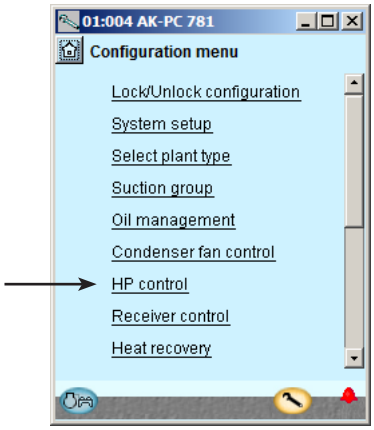
Kp
Amplification factor for P/PI controller
Tn
Integration time for PI controller
Capacity limit at night
Setting of maximum capacity limit during night operations. Can be used to limit fan speed at night in order to limit the noise level.

The following settings are not available when the refrigerant selected is CO2.
Monitor Air flow
Choose whether monitoring is required of the condenser's air flow via an intelligent error-detection method. Monitoring requires the use of a Sc3 outer temperature sensor, which must be fitted by the condenser's air inlet.
FDD setting
Set error-detection function
Tuning: The controller makes an adjustment to the condenser concerned. Note that tuning should only be done when the condenser is operating under normal operating conditions.
ON: Tuning is completed and monitoring has commenced.
OFF: Monitoring is cut out.
FDD sensitivity
Set the sensitivity of error-detection on the condenser's air flow. Must only be changed by trained staff.
Air flow tuning value
Actual tuning values for air flow.

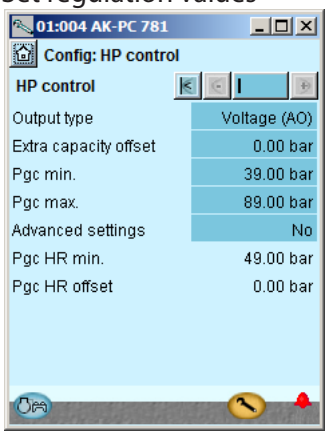
Setup control of high pressure

1. Go to Configuration menu

2. Select HP control



3. Set regulation values



The settings are shown here in the display

3 - HP control
Output type
Select the signal type for controlling the ICMTS valve.
- Voltage signal (ICMTS must have 0-10 V signal)
- Stepper motor signal via AK-XM 208C
- 2 Stepper motor signals for parallel valves

Extra capacity offset
Adjust how much the pressure shall be increased by when the function "Extra capacity offset" is activated.

Pgc min.
Min. acceptable pressure in the gas cooler

Pgc max.
Max. acceptable pressure in the gas cooler

Advanced settings
Opens up the following selection possibilities

Pgc max. limit P-band
P-band under "Pgc max" where the valve's degree of opening is increased

dT Subcool
Desired subcooling temperature

Kp
Amplification factor

Tn
Integration time

Valve min. OD
Restriction of the ICMTS valve's degree of closing

Valve max. OD
Restriction of the ICMTS valve's degree of opening

Pgc HR min.
Read the min. acceptable pressure in the high pressure circuit during heat recovery

Pgc HR offset
Read the pressure increase during heat recovery

Ramp down bar/min.
Here you may select how quickly the reference must be changed after a completed heat recovery

Temp. at 100 bar
Temperature at 100 bar. Here you may define the regulation curve during transcritical operation. Set the required temperature value.

V3gc
Indicates whether a gas bypass valve is used on the gas cooler.

Bypass low limit
If the sensor Sgc records a temperature that is lower than the selected value, the gas will be routed outside of the gas cooler (e.g. startup during very low ambient temperatures).

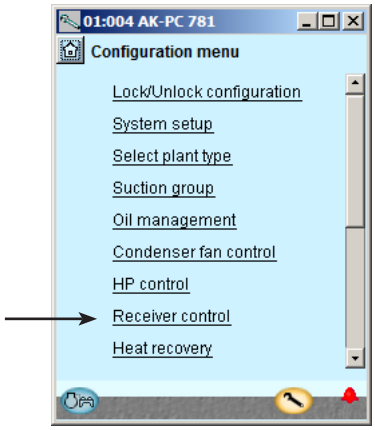
Bypass permitted after
Minimum time during which the gas must be fed through the gas cooler before bypass is permitted.

Warning
If the regulation is stopped during high-pressure regulation, the pressure will rise.
The system must be dimensioned to the higher pressure; otherwise, there will be a loss of charge.

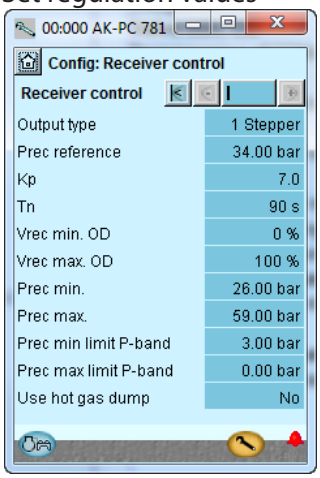
Setup control of receiver pressure

1. Go to Configuration menu

2. Select Receiver control



3. Set regulation values



The settings are shown here in the display

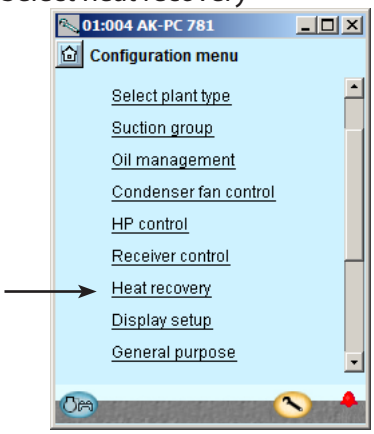
3 - Receiver control
Output type
Select the signal type for controlling the gas bypass valve:
- Voltage signal
- Stepper motor signal via AK-XM208C
- 2 stepper motor signal for parallel valves

Prec reference
Select the reference for the pressure in the receiver
Kp
Amplification factor
Tn
Integration time
Valve min. OD
Limitation of the CCM valve's degree of closing
Valve max. OD
Limitation of the CCM valve's degree of opening.
Prec min.
Min. permissible pressure in the receiver
Prec max.
Max. permissible pressure in the receiver
(Also becomes regulation reference if the compressors are stopped with the "External compressor stop" function)
Prec min. limit P-band
P-band under "Prec min" where the ICMTS valve's degree of opening is increased
Prec max. limit P-band
P-band over "Prec max" where the ICMTS valve's degree of opening is decreased
Use hot gas dump
Select whether hot gas should be supplied if the receiver pressure falls too low
Prec hot gas dump
Receiver pressure at which hot gas is turned on
Prec gas dump diff.
Difference at which hot gas is turned off again
IT comp. state
The signal received from the IT controller can be read here
IT comp. start
Opening degree for the Vrec valve when the IT compressor is to start.
IT comp. delay
The opening degree of the Vrec must be higher during the entire delay time before the relay pulls, thereby sending a signal to the IT controller.
IT comp. Sgc min.
The temperature limit for operation with IT compressor. Will not start when a lower value is detected, regardless of the opening degree of the Vrec valve.

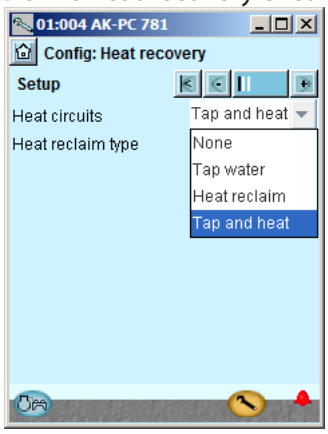
Setup control of heat recovery

1. Go to Configuration menu

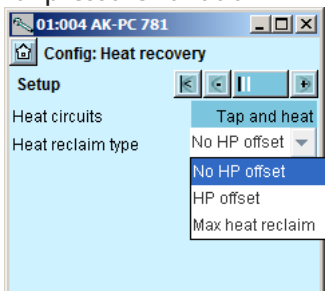
2. Select heat recovery



3. Define heat recovery circuits



4. Define heat circuit requirement for pressure variation



Press the +-button to go on to the next page

In our example, we have selected CO2 as the refrigerant. This opens for the displayed settings. In our example we have both a circuit for hot tap water and a circuit for heating.

HFC

3 -Heat recovery

Heat recovery mode (applies only when the refrigerant selected is not CO2). See also page 111.
Choice of method for heat recovery
No: Heat recovery not used
Thermostat: Heat recovery operated from thermostat
Digital input: Heat recovery operated from signal on a digital input.

Heat recovery relay
Choose whether an output is required that should be activated during heat recovery.

Heat recovery ref
Reference for the condensing pressure, when heat recovery is activated.

Heat recovery ramp down
Configure how quickly the reference for the condenser pressure should be ramped down to normal level after heat recovery. Configure in Kelvin per minute.

Heat recovery cutout
Temperature value where the thermostat cuts-out the heat recovery.

Heat recovery cutin
Temperature value where the thermostat cuts-out the heat recovery.

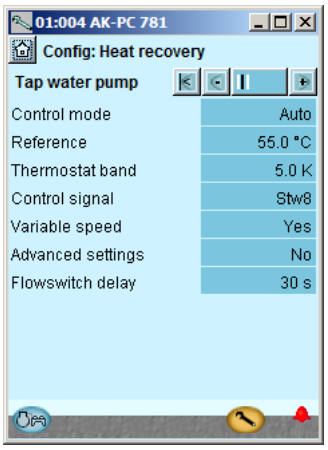
CO_2

Heat recovery circuit (applies only when the refrigerant selected is CO2). See also page 116.
Here you select which recovery circuits shall be regulated:
- None
- Circuit for hot tap water
- Circuit for heating
- Both hot tap water and heating

4 - Heat reclaim type

Here you define how the condensing pressure (HP) shall be regulated when the recovery circuit for heating requires heat:
- No HP offset (simple control)
- HP offset. Here the controller must receive a voltage signal. The offset values that apply to the max. value must be defined in the heat circuit settings. See next page.
- Max heat reclaim. Here the controller must receive a voltage signal, but the regulation is increased to also control the pump, fans and gas cooler bypass.

5. Setup values for tap water circuits

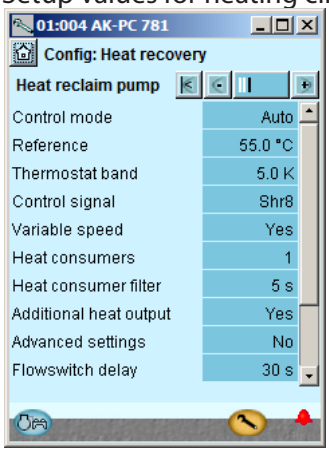


Press the +-button to go on to the next page

In our example we use the settings shown

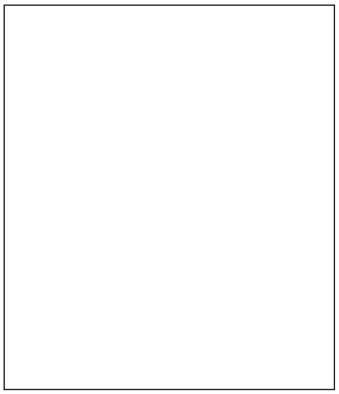
5 - **Tap water circuits** (settings are available only when the refrigerant selected is CO2, and shall be regulated on a circuit for tap water).
Control mode: Here the regulation of the circuit can be started (auto) and stopped (off).
Reference: The required temperature for the sensor Stw8 can be set here.
Thermostat band: The acceptable temperature variation around the reference:
Control signal. . Choose between:
Stw8: if regulation shall be done using only this sensor.
S4-S3: (and a Delta T value) if the controller shall regulate using this temperature difference, until the Stw8 reference is met. (During S4-S3 regulation, the pump must always be speed-regulated).
Stw8 + Stw8A: if two temperature sensors are installed in the hot water receiver.
Variable speed: Here the pump type is selected. Either variable speed or on/off.
Advanced settings: The following options are made available:
Flow switch: Must normally be selected for safety purposes
Kp: Amplification factor
Tn: Integration time
Min. pump speed: Pump speed for start/stop
Max. pump speed: The pump's max. permissible speed
Flowswitch delay: Duration of stable signal before the new status is used in the regulation.

6. Setup values for heating circuit



In our example we use the settings shown

6 - **Heat reclaim circuits** (settings are available only when the refrigerant chosen is CO2, and regulation shall be done using a circuit for heating).
Control mode: Here the regulation of the circuit can be started (auto) and stopped (off).
Reference: Here the required temperature of sensor Shr8 (or Shr4) is set.
Thermostat band: The permissible temperature variation around the reference:
Control signal: Choose between:
Shr8: if regulation shall be done using only this sensor.
S4-S3: (and a Delta T value) if the controller shall regulate using this temperature difference, until the Shr8 reference has been met.
Shr4: regulation is done using this sensor, but Shr8 shall also be installed. (During S4-S3 regulation or Shr4 regulation the pump shall always be speed-regulated).
Variable speed: Here the pump type is selected. Either variable speed or on/off.
Heat consumers: (Only when the condensation pressure shall be increased during heat recovery). The number of signals that can be received is set here. The signal can be either 0-10 V or 0-5 V. (Settings under "Advanced" will be used 0-100% for the signal).
Heat consumer filter
The highest of the received signals are made known over this period
Additional heat output
The function will reserve a relay. The relay will pull in when the signal for the heat removers reaches 95%.
Advanced settings: The following options are made available:
Flow switch: Must normally be selected for safety purposes
Kp: Amplification factor
Tn: Integration time
Tc max HR: Value at which the bypass of the gas cooler will terminate.
HR PUMP CONTROL
Min. pump speed: Pump speed for start/stop
Max. pump speed: The pump's max. permissible speed
Pump stop limit: Signal in % at which the pump is stopped again
Pump start limit: Signal in % at which the pump is started
HP CONTROL
Pgc HR min: Basic reference for the pressure when external voltage signal is received.



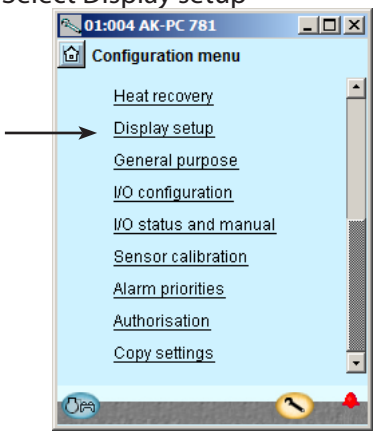
Pgc HR offset: Pressure displacement at max. voltage signal
HP low limit: Signal in % at which "Pgc HR min." comes into force.
HP high limit: Signal in % at which "Pgc HR offset" value is used.
FAN CONTROL
Fan - Max Cond. Ref offset: Set the displacement at which the fans shall fully stop.
Fan low limit: Signal in % at which throttling of the fans commences
Fan high limit: Signal in % at which the fans are stopped
BYPASS CONTROL
V3gc bypass stop limit: Signal in % at which the gas cooler connects again after completed disconnect.
V3gc bypass start limit: Signal in % at which the gas cooler is disconnected.

Flowswitch delay: Duration of stable signal before the new status is used in the regulation.

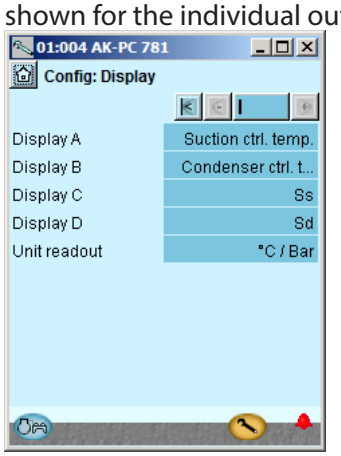
Setup Display

1. Go to Configuration menu

2. Select Display setup



3. Define which readings are to be shown for the individual outputs



In our example, separate displays are not used. The setting is included here for information.

3 - Display setup

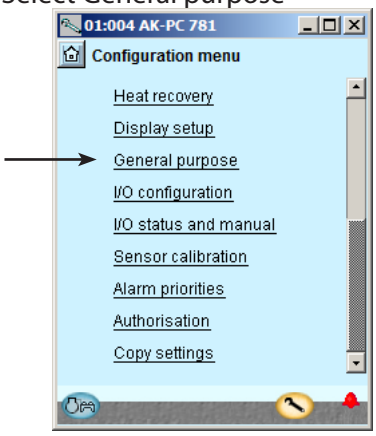
Display
The following can be read for the four outputs..
Comp. control sensor
P0 in temperature
P0 i bar-absolute
Pctrl bar-absolute
S4
Ss
Sd
Cond. control sensor
Tc
Pc bar-absolute
S7
Sgc
Shp
Pgc bar-absolute
Prec bar-absolute
Stw8
Shr8
Speed Compressor

Unit readout
Choose whether readings are to be in SI units (°C and bar) or (US-units °F and psi)

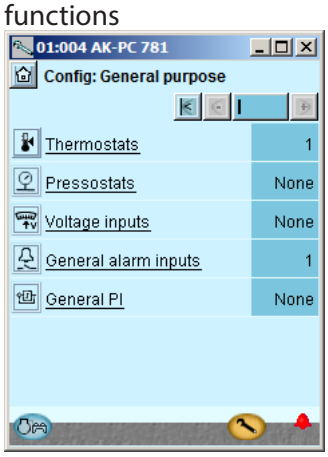
Setup Functions for General purpose

1. Go to Configuration menu

2. Select General purpose



3. Define number of required functions

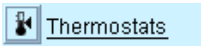


In our example we select one thermostat function for temperature control in the compressor room and one alarm function for monitoring the liquid level in the receiver.

The following number of different functions can be defined:
5 thermostats
5 pressostats
5 voltage signal
10 alarm signals
3 PI-regulations

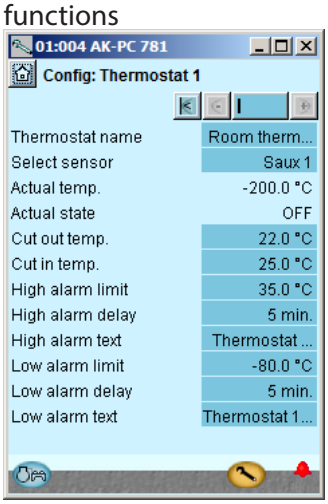
Separate thermostats

1. Select thermostats



2. Select actual thermostat

3. Define the required thermostat functions



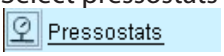
In our example we select one thermostat function for monitoring the plant room temperature.

We have subsequently entered a name for the function.

3 - Thermostats
The general thermostats can be used to monitor the temperature sensors that are used, as well as 4 extra temperature sensors. Each thermostat has a separate outlet to control external automation.
For each thermostat adjust
• Name
• Which of the sensors is used
Actual temp.
Temperature measurement on the sensor that is attached to the thermostat
Actual state
Actual status on the thermostat outlet
Cut out temp.
Cut-out value for the thermostat
Cut in temp.
Cut-in value for the thermostat
High alarm limit
High alarm limit
Alarm delay high
Time delay for high alarm
Alarm text high
Indicate alarm text for the high alarm
Low alarm limit
Low alarm limit
Alarm delay low
Time delay for low alarm
Alarm text low
Indicate alarm text for low alarm

Separate pressostats

1. Select pressostats



2. Select actual pressostat

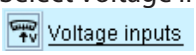
3. Define the required pressostat functions

In our example, separate pressostat functions are not used.

3 - Pressostats
Settings as the thermostats

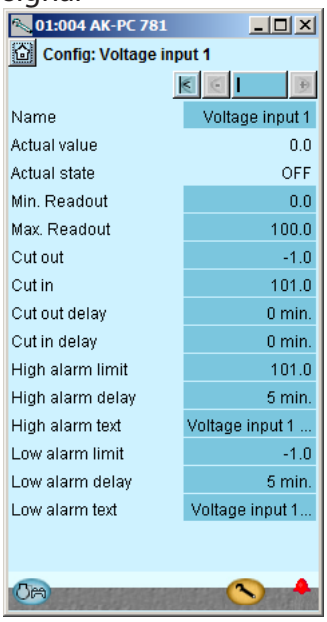
Separate voltage signals

1. Select Voltage inputs



2. Select actual voltage signal

3. Define the required names and values attached to the signal



In our example we do not use this function, so the display has been included for your information only.
The name of the function may be xx and further down in the display the alarm texts may be entered.

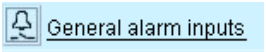
The values "Min. and Max. Readout" are your settings representing the lower and upper values of the voltage range. 2V and 10V, for example. (The voltage range is selected during the I/O setup).

For each voltage input defined the controller will reserve a relay output in the I/O setup. It is not necessary to define this relay if all you require is an alarm message via the data communication.

3 - Voltage inputs
The general volt inlet can be used to monitor external voltage signals. Each volt inlet has a separate outlet to control external automatic controls.
Set the number of general voltage inputs, specify 1-5:
Name
Actual value
= read-out of the measurement
Actual state
= read-out of outlet status
Min. readout
State read-out values at minimum voltage signal
Max. readout
State read-out values at maximum voltage signal
Cutout
Cut-out value for outlet (scaled value)
Cutin
Cut-in value for outlet (scaled value)
Cutout delay
Time delay for cut-out
Cut in delay
Time delay for cut-in
High alarm limit
High alarm limit
High alarm delay
Time delay for high alarm
High alarm text
Set alarm text for high alarm
Low alarm limit
Low alarm limit
Low alarm delay
Time delay for low alarm
Low alarm text
Indicate alarm text for low alarm

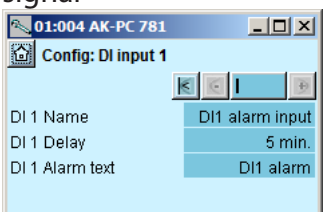
Separate alarm inputs

1. Select General alarm inputs



2. Select actual alarm signal

3. Define the required names and values attached to the signal

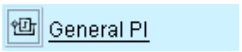


In our example we select one alarm function for monitoring the liquid level in the receiver. We have subsequently selected a name for the alarm function and for the alarm text.

3 - General alarm input
This function can be used to monitor all kinds of digital signals.
No. of inputs
Set the number of digital alarm inputs
Adjust for each input
• Name
• Delay time for DI alarm (common value for all)
• Alarm text

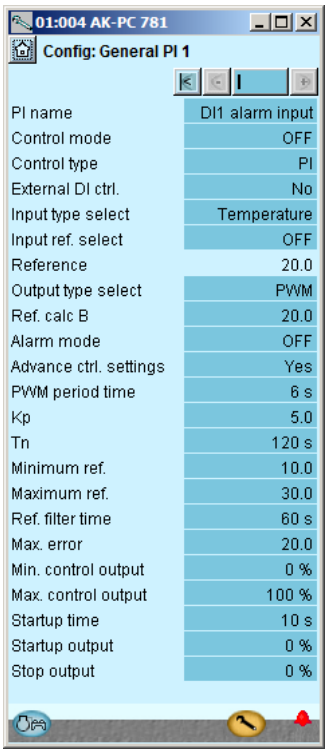
Separate PI functions

1. Select PI functions



2. Select actual PI-function

3. Define the required names and values attached to the function



In our example we do not use this function, so the display has been included for your information only.

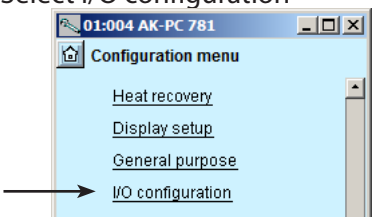
3 - General PI Control
The function can be used for optional regulation.
Adjust for each regulation

- Name
- Control mode: Off, Manual or Auto
- Control type: P or PI
- External DI ctrl: Adjusted to On if there is an external switch that can start/stop the regulation.
- Input type: Choose which signal the regulation shall receive: Temperature, pressure, pressure converted to temperature, , voltage signal, Tc, Pc, Ss or Sd.
- Signal at variable reference: Choose between: : Non, temperature, pressure, pressure converted to temperature, voltage signal, Tc, Pc, Ss or DI.
- Reading the signal for the variable reference (not shown in the display)
- Reading the total reference
- Output. Here you select the outlet function (PWM = pulse width modulated (fx AKV valve)), Stepper signal for a step-per motor or voltage signal.
- Ref. calc A: Constant for variable value included in the refer-ence. (Reference = Ax + B)
- Ref. calc B: Fixed value included in reference
- Alarm mode: Choose whether an alarm shall be attached to the function. If it is set to ON, alarm texts and alarm limits can be entered.
- Advanced ctrl. settings: Regulation parameters can now be selected.
- PWM period time: Period during which the signal has been on and off.
- Kp: Amplification factor
- Tn: Integration time
- Minimum reference: Lowest permitted reference
- Maximum reference: Maximum permitted reference
- Filter for reference: Duration for smooth changes to the reference
- Max. error: Maximum permissible fault signal at which the integrator remains in the regulation
- Min. control output: Lowest permitted output signal
- Max. control output: Maximum permitted output signal
- Start up time: Time at startup at which the output signal is force-controlled
- Startup output: The output signal size at the startup time.

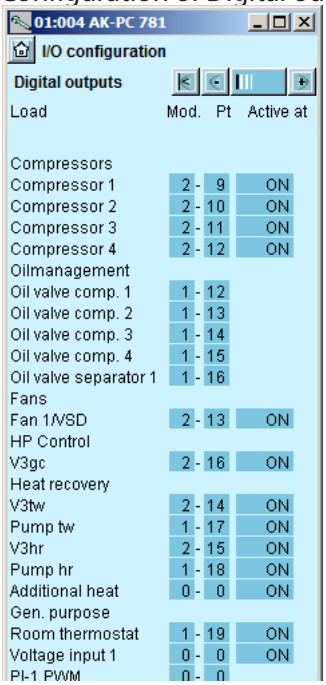
Configuration of inputs and outputs

1. Go to Configuration menu

2. Select I/O configuration

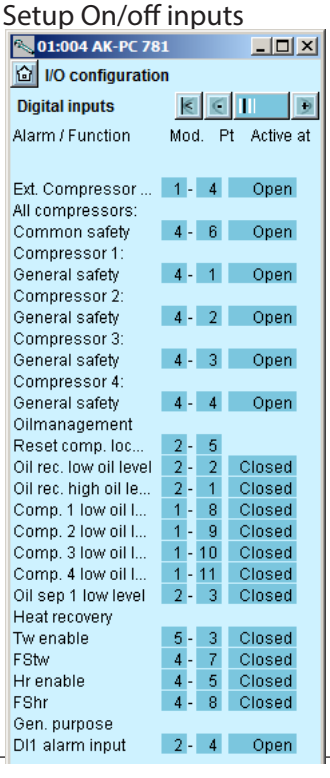


3. Configuration of Digital outputs



Press the +-button to go on to the next page

4. Setup On/off inputs



The following displays will depend on the earlier definitions. The displays will show which connections the earlier settings will require. The tables are the same as shown earlier.

- Digital outputs
- Digital inputs
- Analog outputs
- Analog inputs

Load	Output	Module	Point	Active at
Solenoid valve, oil, Comp. 1	DO1	1	12	ON
Solenoid valve, oil, Comp. 2	DO2	1	13	ON
Solenoid valve, oil, Comp. 3	DO3	1	14	ON
Solenoid valve, oil, Comp. 4	DO4	1	15	ON
Solenoid valve, oil separator	DO5	1	16	ON
Circulation pump tw	D06	1	17	ON
Circulation pump hr	DO7	1	18	ON
Room fan	DO8	1	19	ON
Compressor 1	DO1	2	9	ON
Compressor 2	DO2	2	10	ON
Compressor 3	DO3	2	11	ON
Compressor 4	DO4	2	12	ON
Start /stop of VLT for fans	DO5	2	13	ON
3-way valve, tap water, V3tw	DO6	2	14	ON
3-way valve, Heat circuit, V3hr	DO7	2	15	ON
3-way valve, gas cooler, V3gc	DO8	2	16	ON

We set up the controller's digital outputs by keying in which module and point on this module each one of these has been connected to.
We furthermore select for each output whether the load is to be active when the output is in pos. **ON** or **OFF**.

Function	Input	Module	Point	Active at
External compressor stop	AI4	1	4	Closed
Level switch, oil, comp.1	AI8	1	8	Closed
Level switch, oil, comp.2	AI9	1	9	Closed
Level switch, oil, comp.3	AI10	1	10	Closed
Level switch, oil, comp.4	AI11	1	11	Closed
Level switch, oil, receiver High	AI1	2	1	Closed
Level switch, oil, receiver Low	AI2	2	2	Closed
Level switch, oil, Separator	AI3	2	3	Closed
Level switch, CO2 receiver	AI4	2	4	Open
Reset of compressor stop	AI5	2	5	Pulse pressure
Compressor 1 Gen. Safety	DI1	4	1	Open
Compressor 2 Gen. Safety	DI2	4	2	Open
Compressor 3 Gen. Safety	DI3	4	3	Open
Compressor 4 Gen. Safety	DI4	4	4	Open
Start/stop of heat recovery hr	DI5	4	5	Closed
All compressors common safety	DI6	4	6	Open
Flow switch FStw	DI7	4	7	Open
Flow switch FShr	DI8	4	8	Open
Start/stop of heat recovery tw	AI2	5	3	Closed

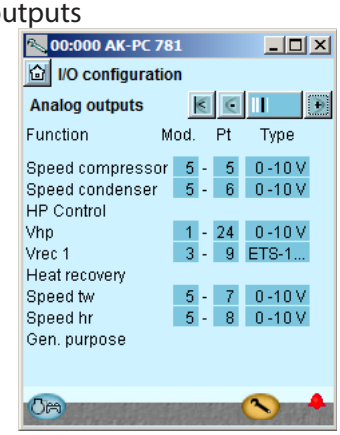
We set up the controller's digital input functions by keying in which module and point on this module each one of these has been connected to.
We furthermore select for each output whether the function is to be active when the output is in pos. **Closed** or **Open**.
Open has been selected here for all the safety circuits. This means that the controller will receive signal under normal operation and register it as a fault if the signal is interrupted.

3 - Outputs
The possible functions are the following:
Comp. 1
Unloader 1-1
Unloader 1-2
Unloader 1-3
Do for Compressor. 2-8
Oil valve comp. 1-8
Lp comp. oil pulse
Oil valve 1-4 (8)
Oil valve separat. 1-8
MT Comp. release
LT Comp. request
Injection heat exchanger
Injection suction line
Injection ON
Fan 1 / VSD
Fan 2 - 8
HP Control
Valve gas cooler V3gc
Heat recovery
Valve tap water V3tw
Pump tap water tw
Valve heat recov. V3hr
Pump heat recov. hr
Additional heat
Alarm
I'm alive relay
Thermostat 1 - 5
Pressostat 1 - 5
Volt input 1 - 5
PI 1-3

4 - Digital inputs
The possible functions are the following:
Ext. Main switch
Ext. compr. stop
Ext. power loss
Night setback
Load shed 1
Load shed 2
LT Comp. Release
MT Comp. Request
All compressors:
Common safety
Comp. 1
Oil pressure safety
Over current safety
Motor protect. safety
Disch. temp. safety
Disch. press. safety
General safety
VSD comp. Fault
Do for Comp. 2-8
Fan 1 safety
Do for fan 2-8
VSD cond safety
Reset comp. lockout
LP comp.oil counter
Oil receiver low
Oil receiver high
Oil level comp.1-8
Oil separator low 1-8
Oil separator high 1-8
Heat recovery
tw enable
hr enable
Flow switch tw
Flow switch hr
DI 1 Alarm input
DI 2-10 ...
PI-1 Di ref
External DI PI-1

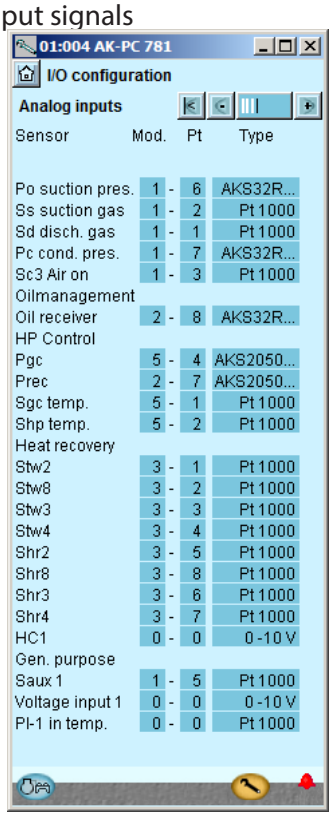
Press the +-button to go on to the next page.

5. Configuration of Analog outputs



Press the +-button to go on to the next page

6. Configuration of Analog Input signals



Function	Output	Module	Point	Type
Voltage signal for high pressure valve, ICMTS	AO1	1	24	0-10 V
Stepper signal for by-pass valve, CCM	Step 1	3	9	CCM
Speed control, compressor	AO1	5	5	0 - 10 V
Speed control, gas cooler fan	AO2	5	6	0 - 10 V
Speed control, pump - tw	AO3	5	7	0 - 10 V
Speed control, pump - hr	AO4	5	8	0 - 10 V

Sensor	Input	Module	Point	Type
Disch. gas temperature - Sd	AI1	1	1	Pt 1000
Suction gas temperature - Ss	AI2	1	2	Pt 1000
Outdoor temp. - Sc3	AI3	1	3	Pt 1000
Thermostat sensor in plant room - Saux1	AI5	1	5	Pt 1000
Suction pressure - Po	AI6	1	6	AKS 2050-59
Condenser pressure - Pc	AI7	1	7	AKS 2050-159
Refrigerant receiver, Prec-CO2	AI7	2	7	AKS 2050-159
Oil receiver, Prec-Oil	AI8	2	8	AKS 2050-159
Tap water temperature - Stw2	AI1	3	1	Pt 1000
Tap water temperature - Stw3	AI2	3	2	Pt 1000
Tap water temperature - Stw4	AI3	3	3	Pt 1000
Tap water temperature - Stw8	AI4	3	4	Pt 1000
Heat reclaim temperature Shr2	AI5	3	5	Pt 1000
Heat reclaim temperature Shr3	AI6	3	6	Pt 1000
Heat reclaim temperature Shr4	AI7	3	7	Pt 1000
Heat reclaim temperature Shr8	AI8	3	8	Pt 1000
Temp. gas cooler outlet Sgc	AI1	5	1	Pt 1000
Temp. by-pased gas Shp	AI2	5	2	Pt 1000
Gas cooler pressure Pgc	AI4	5	4	AKS 2050-159

5 - Analog outputs
The possible signals are the following:
0 -10 V
2 – 10 V
0 -5 V
1 – 5V
Stepper output
Stepper output 2
Stepper user defined: See section "Miscellaneous"

6 - Analog inputs
The possible signals are the following:
Temperature sensors:
• Pt1000
• PTC 1000

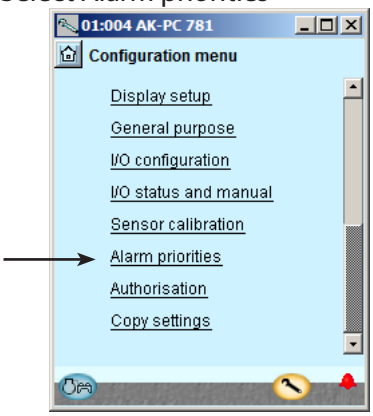
Pressure transmitters:
• AKS 32, -1 – 6 bar
• AKS 32R, -1 – 6 bar
• AKS 32, - 1 – 9 bar
• AKS 32R, -1 – 9 bar
• AKS 32, - 1 – 12 bar
• AKS 32R, -1 – 12 bar
• AKS 32, - 1 – 20 bar
• AKS 32R, -1 – 20 bar
• AKS 32, - 1 – 34 bar
• AKS 32R, -1 – 34 bar
• AKS 32, - 1 – 50 bar
• AKS 32R, -1 – 50 bar
• AKS 2050, -1 – 59 bar
• AKS 2050, -1 – 99 bar
• AKS 2050, -1 – 159 bar
• User defined (only ratiometric, min. and max value of the pressure range must be set)

S4 Cold brine
Pctrl
Po suction pres.
Ss suction gas
Sd disch. temp.
Pc Cond. Pres.
S7 Warm brine
Sc3 air on
Ext. Ref. Signal
• 0 – 5 V,
• 0 -10 V
Olie receiver
HP control
Pgc
Prec
Sgc
Shp
Stw2,3,4,8
Shr2,3,4,8
HC 1-5
Heat recovery
Saux 1 - 4
Paux 1 - 3
Voltage input 1 - 5
• 0 -5 V,
• 0 -10 V,
• 1 – 5 V,
• 2 – 10 V
PI-in temp
PI-ref temp
PI- in voltage
PI-in pres.
PI-ref pres.

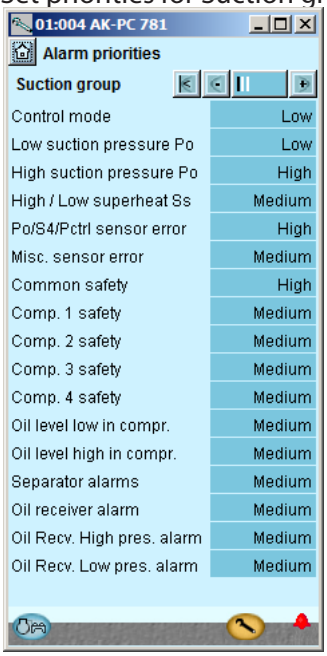
Set alarm priorities

1. Go to Configuration menu

2. Select Alarm priorities

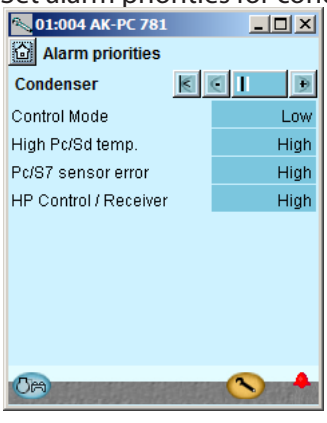


3. Set priorities for Suction group




Press the +-button to go on to the next page

4. Set alarm priorities for condenser



Very many functions have an alarm connected.
Your choice of functions and settings has connected all the relevant alarms that are current. They will be shown with text in the three pictures.
All alarms that can occur can be set for a given order of priority:
- "High" is the most important one
- "Log only" has lowest priority
- "Disconnected" gives no action

The interdependence between setting and action can be seen in the table.

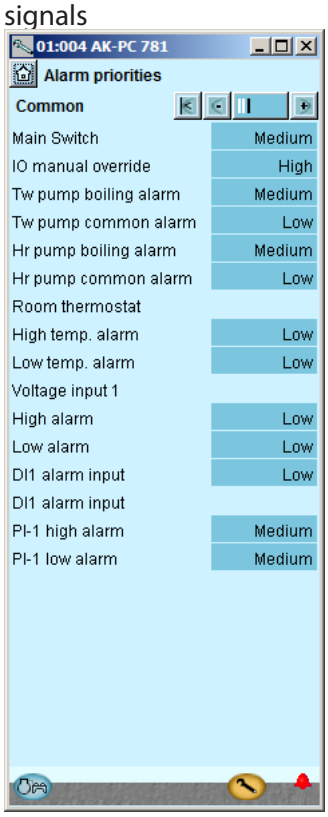
Setting	Log	Alarm relay selection			Net-work	AKM-dest.
		Non	High	Low - High		
High	X		X	X	X	1
Medium	X			X	X	2
Low	X			X	X	3
Log only	X					4
Discon-nected						

Se also alarm text page 136.

In our example we select the settings shown here in the display

Press the +-button to go on to the next page

5. Set alarm priorities for thermostat and extra digital signals

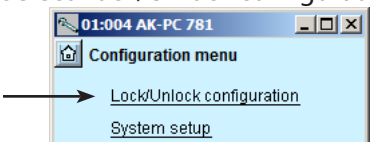


In our example we select the settings shown here in the display

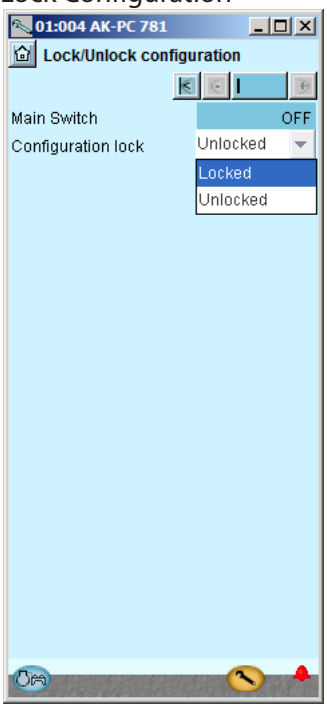
Lock configuration

1. Go to Configuration menu

2. Select Lock/Unlock configuration



3. Lock Configuration



Press in the field against **Configuration lock.**

Select **Locked**.

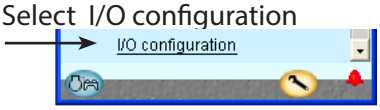
The setup of the controller has now been locked. If you subsequently want to make any changes in the controller's setup, remember first to unlock the configuration.

The controller will now make a comparison of selected functions and define inputs and outputs. The result can be seen in the next section where the setup is controlled.

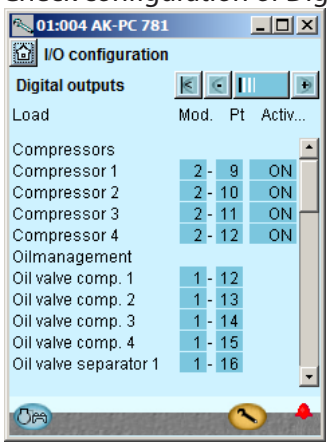
Check configuration

1. Go to Configuration menu

2. Select I/O configuration

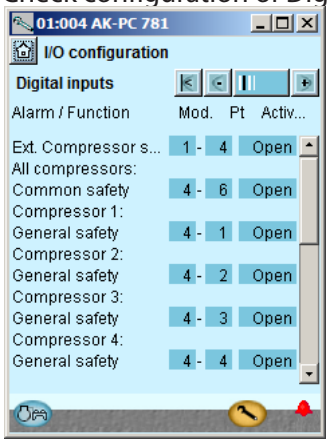


3. Check configuration of Digital Outputs




Press the +-button to go on to the next page

4. Check configuration of Digital Inputs



This control requires that the setup is locked

(Only when the setup is locked are all settings for in- and outputs activated.)

The setup of the digital outputs appears as it is supposed to according to the wiring made.

The setup of the digital inputs appears as it is supposed to according to the wiring made.

An error has occurred, if you see the following:

A **0 – 0** next to a defined function.
If a setting has reverted to 0-0, you must control the setup again.
This may be due to the following:

- A selection has been made of a combination of module number and point number that does not exist.
- The selected point number on the selected module had been set up for something different.

The error is corrected by setting up the output correctly.

Remember that the setup must be unlocked before you can change module and point numbers..

The settings are shown on a **RED** background.
If a setting has turned red, you must control the setup again.
This may be due to the following:

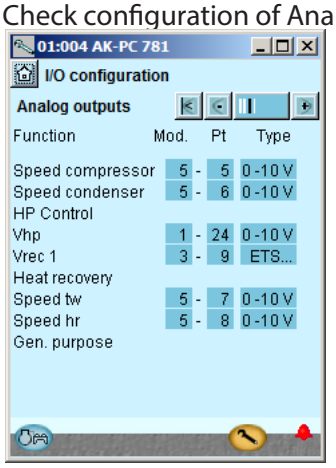
- The input or the output has been set up; but the setup has later been changed so that it should no longer be applied.

The problem is corrected by setting **module number to 0 and point number to 0.**

Remember that the setup must be unlocked before you can change module and point numbers.

Press the +-button to go on to the next page

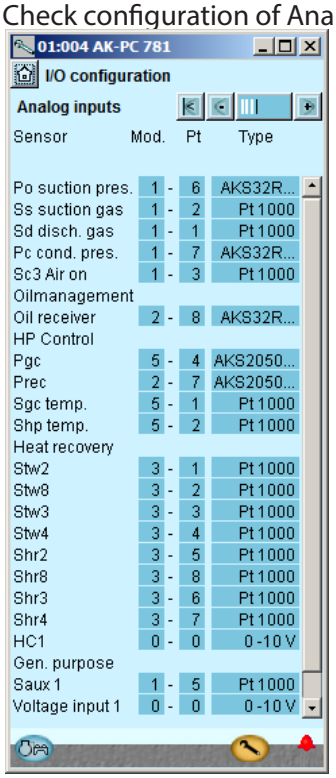
5. Check configuration of Analog Outputs



The setup of the analog outputs appears as it is supposed to according to the wiring made.

Press the +-button to go on to the next page

6. Check configuration of Analog Inputs

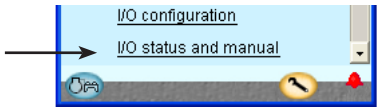


The setup of the analog inputs appears as it is supposed to according to the wiring made.

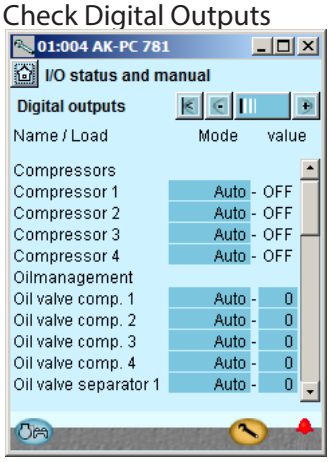
Check of connections

1. Go to Configuration menu

2. Select I/O status and manual

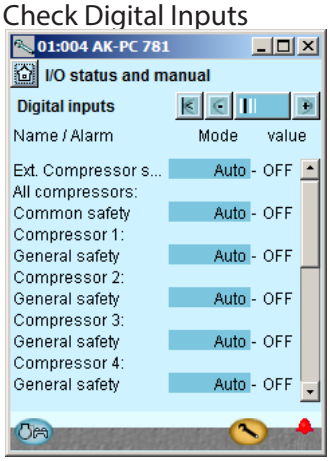


3. Check Digital Outputs



Press the +-button to go on to the next page

4. Check Digital Inputs



Press the +-button to go on to the next page

Before the control is started we check that all inputs and outputs have been connected as expected.

This controls requires that the setup is locked

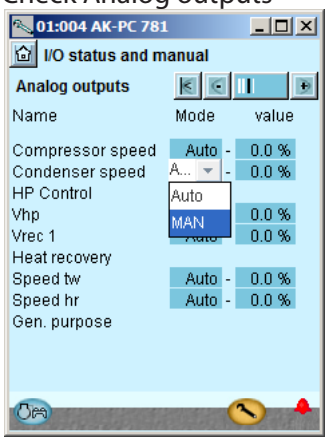
By means of the manual control of each output it can be checked whether the output has been correctly connected.

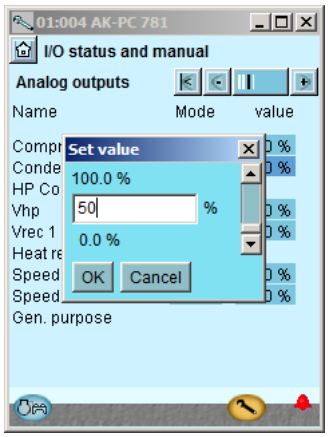
AUTO	The output is controlled by the controller
MAN OFF	The output is forced to pos. OFF
MAN ON	The output is forced to pos ON

Cut out the safety circuit for compressor 1.
Check that LED DI1 on the extension module (module 2) goes out.

Check that the value of the alarm for the safety monitoring of compressor 1 changes to **ON.**
The remaining digital inputs are checked in the same way.

5. Check Analog outputs

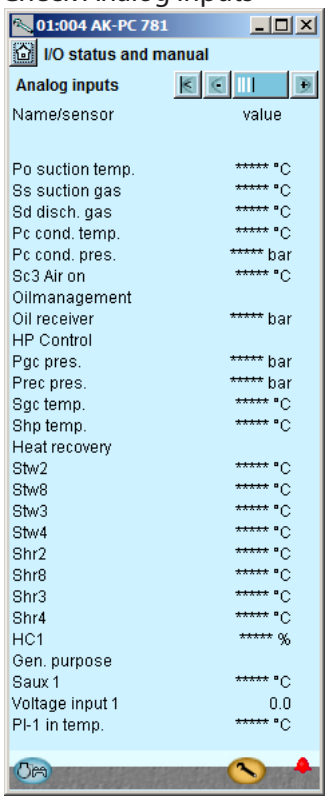




6. Put the control of the output voltage back to automatic

Press the +-button to go on to the next page

7. Check Analog inputs



Set Control of output voltage to manual
Press in the **Mode** field.

Select **MAN**.

Press in the **Value** field
Select for example **50%**.

Press **OK**.

On the output you can now measure the expected value: In this example 5 volts

Example of the connection between a defined output signal and a manual set value.

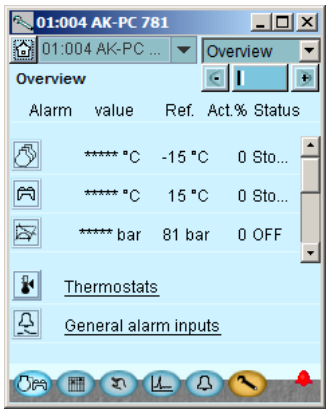
Definition	Setting		
	0 %	50 %	100 %
0 - 10 V	0 V	5 V	10 V
1 - 10 V	1 V	5.5 V	10 V
0 - 5 V	0 V	2.5 V	5 V
2 - 5 V	2 V	3.5 V	5 V

Check that all sensors show sensible values.
In our case we have no values. This may be due to the following:

- The sensor has not been connected.
- The sensor is short-circuited.
- The point or module number has not been set up correctly.
- The configuration is not locked.

Check of settings

1. Go to the overview

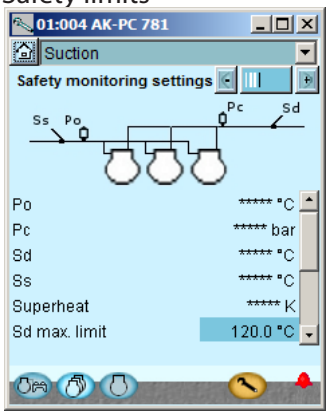


2. Select suction group

3. Move on through all the individual displays for the suction group

Change displays with the +- button. Remember the settings at the bottom of the pages – the ones that can only be seen via the "Scroll bar".

4. Safety limits



5. Go back to the overview

6. Select condenser group

Before the control starts, we check that all the settings are as they should be.

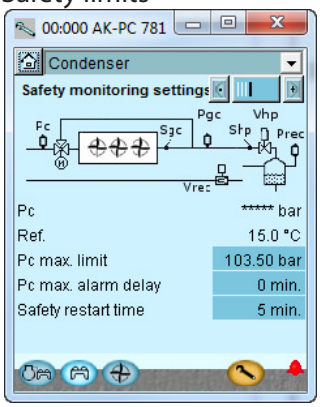
The overview display will now show one line for each of the general functions. Behind each icon there is a number of displays with the different settings. It is all these settings that have to be checked.

The last page contains safety limits and restart times.

7. Move on through all the individual displays for the condenser group.

Change displays with the +- button. Remember the settings at the bottom of the pages – the ones that can only be seen via the "Scroll bar".

8. Safety limits



The last page contains safety limits and restart times.

9. Go back to the overview and Move on to the thermostat group

Check the settings.

10. Go back to the overview and Move on to the pressostat group

Check the settings.

11. Go back to the overview and on to the general alarm inputs

Check the settings.

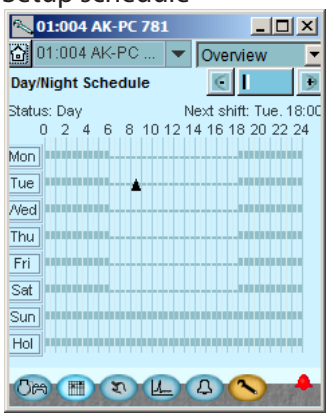
12. The controller setup has been completed.

Schedule function

1. Go to Configuration menu

2. Select schedule

3. Setup schedule



Before regulation is started we will set the schedule function for the night setback of the suction pressure.
In other cases where the controller is installed in a network with one system unit, this setting may be made in the system unit which will then transmit a day/night signal to the controller.

Press a weekday and set the time for the day period.

Continue with the other days.

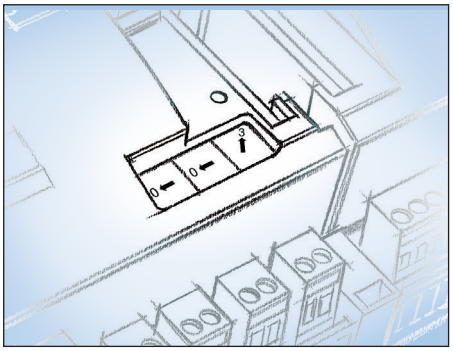
A complete weekly sequence is shown in the display.

Installation in network

1. Set the address (here, for example 3)

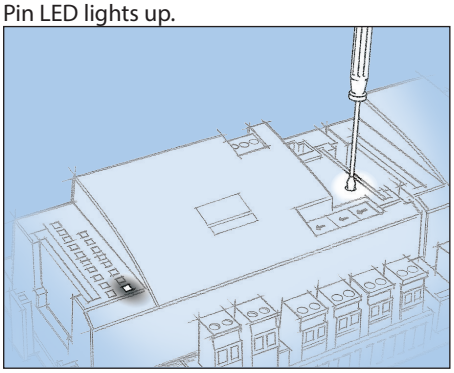
   Turn the right-hand address switch so that the arrow will point at 3.

   The arrow of the two other address switches must point at 0.



2. Push the Service Pin

   Press down the service pin and keep it down until the Service Pin LED lights up.



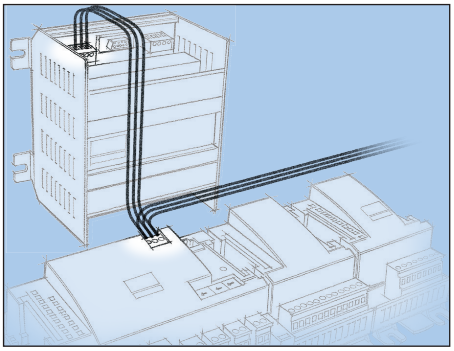
3. Wait for answer from the system unit

   Depending on the size of the network it may be up to one minute before the controller receives an answer as to whether it has been installed in the network.

   When it has been installed the Status LED will start to flash faster than normal (once every half second). It will continue with this for about 10 minutes

4. Carry out new login via Service Tool

   If the Service Tool was connected to the controller while you installed it in the network, you must carry out a new login to the controller via the Service Tool.



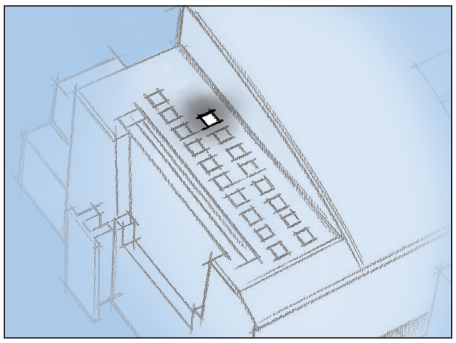
The controller has to be remote-monitored via a network. In this network we assign address number 3 to the controller.

The same address must not be used by more than one controller in the same network.

Requirement to the system unit

The system unit must be a gateway type AKA 245 with software version 6.0 or higher. It is capable of handling up to 119 AK controllers.

Alternatively, it can be an AK-SM 720. It is capable of handling up to 200 AK controllers.



If there is no answer from the system unit

If the Status LED does not start flashing faster than normal, the controller has not been installed in the network. The reason for this may be one of the following:

The controller has been assigned an address out of range

Address 0 cannot be used.

If the system unit in the network is an AKA 243B Gateway only the addresses between 1 and 10 can be used.

The selected address is already being used by another controller or unit in the network:

The address setting must be changed to another (vacant) address.

The wiring has not been carried out correctly.

The termination has not been carried out correctly.

The data communication requirements are described in the document: "Data communication connections to ADAP-KOOL® Refrigeration Controls" RC8AC.

First start of control

Check alarms

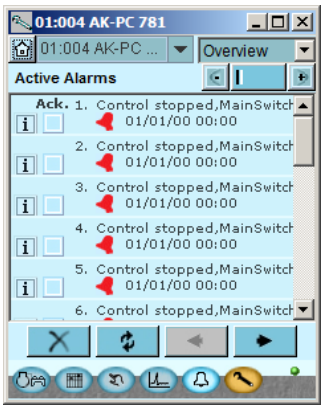
1. Go to the overview

Press the blue overview button with the compressor and condenser at the bottom left of the display.

2. Go to the Alarm list

Press the blue button with the alarm bell at the bottom of the display.

3. Check active alarms

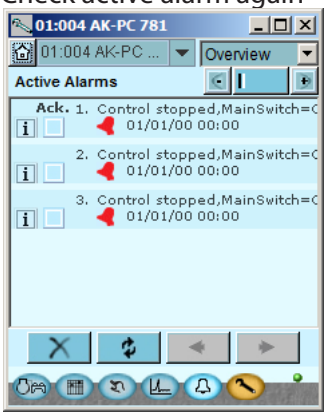


In our case, we have a series of alarms. We will tidy them up so that we only have those that are relevant.

4. Remove cancelled alarm from the alarm list

Press the red cross to remove cancelled alarms from the alarm list.

5. Check active alarm again



In our case an active alarm remains because the control has stopped. This alarm must be active when control has not started. We are now ready for the startup of control.

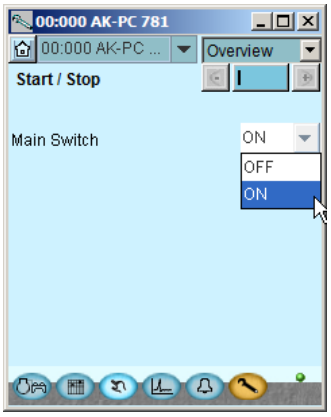
Please note that active plant alarms are automatically cancelled when the main switch is in pos. OFF.
If active alarms appear when the control is started the reason for these should be found and remedied.

Start the control

1. Go to Start/Stop display

Press the blue manual control button at the bottom of the display.

2. Start control



Press in the field against **Main switch**.
Select **ON**.

The controller will now start controlling the compressors and the fans.

Note:
Control does not start until both the internal and external switch are "ON".

Any external compressor stop breaker must be ON for the compressors to start.

Manual capacity control

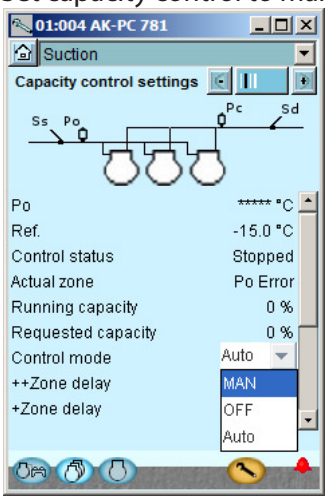
1. Go to overview

2. Select suction group

Press the suction group button for the suction group that is to be controlled manually.

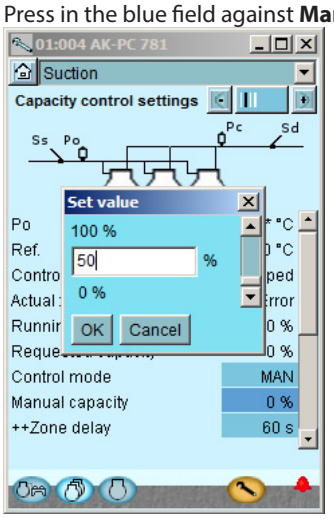
Press the +-button to go on to the next page

3. Set capacity control to manual



4. Set capacity in percent

Press in the blue field against **Manual capacity**.



If you need to manually adjust the capacity of the compressors, you can use the following procedure:

WARNING!
If you force control the compressors, the oil management will be shut down. This could cause compressor damages.
(If the wiring of the compressors includes safety relays, monitoring will continue. See Regulating functions.)

Press the blue field against **Control mode**
Select **MAN**.

Set the capacity to the required percentage.
Press **OK**.

5. Regulating functions

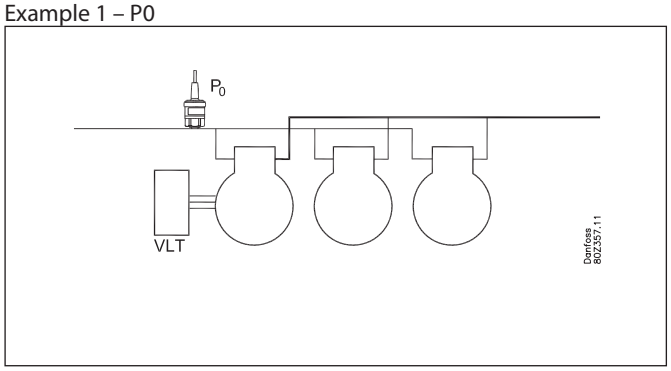
This section describes how the different functions work

Suction group

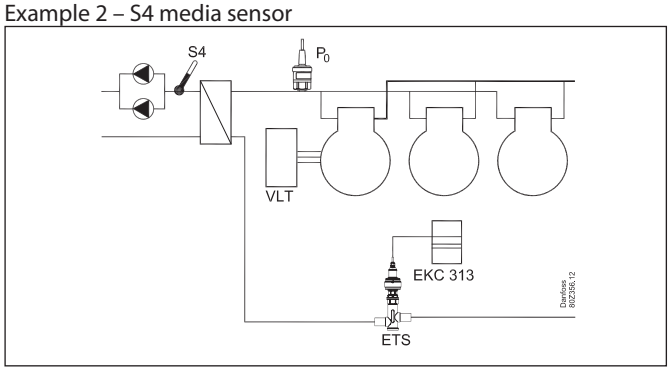
Controlling sensor selection

Depending on use, the capacity distributor can regulate according to the suction pressure P0, a media temperature S4 or separate control pressure Pctrl in a different refrigeration circuit, e.g. cascade system.
Cap. Ctrl sensor = P0 / S4 /Pctrl

Example 1 – P0

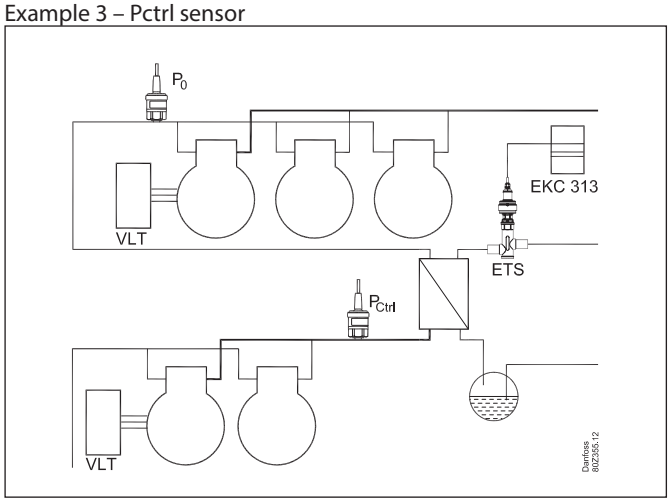


Example 2 – S4 media sensor



When the controlling sensor is selected as S4, P0 is used as a safety function for low suction pressure and will ensure disconnection of compressor capacity (frost protection).

Example 3 – Pctrl sensor



When Pctrl is used as controlling sensor, a refrigerant type for this pressure transmitter must be set, e.g. CO2.
P0 is used as a safety function against insufficient suction pressure and will ensure disconnection of compressor capacity.
On cascade systems the signal from Pctrl can be used by both the high-pressure and low-pressure controls either for the controlling sensor or high-pressure monitoring.

Parallel compression
(Only on CO2 system and control of receiver pressure)
If the controller is to control an IT compressor for parallel compression, the following regulation settings will be required:
- The system type must be set to LT
- The regulation sensor must be set to Po (the signal received from the receiver - Prec).

Handling of sensor error

Cap. Ctrl. Sensor = P0
When P0 is used as the regulating sensor, an error in the signal will mean that regulation continues with 50% cutin in daily operation and 25% cut-in at night, but for a minimum of one step.

Cap. Ctrl. Sensor = S4
Provided that S4 is used as a regulating sensor, an error in this sensor will mean that regulation continues from the P0 signal, but in accordance with a reference that lies 5K under the real reference. If there is an error on both S4 and P0, regulation will continue with 50% cut-in in daily operations and 25% of cut-in in night operations, but for a minimum of one step.

Cap. Ctrl. Sensor = Pctrl
When Pctrl is used as a controlling sensor, an error in this sensor will mean that regulation continues after the P0 signal, but in accordance with a reference that lies 5 K under the real reference. If there is an error on both Pctrl and P0, regulation will continue with e.g. 50% cut-in in daily operations and e.g. 25% cut-in in night operations, but for a minimum of one step.

Reference

The reference for the regulation can be defined in 2 ways:

Either
P0Ref = P0 setting + P0 optimization + night displacement
or
P0Ref = P0 setting + night displacement + Ext. Ref

P0 setting
A basic value for the suction pressure is set.

P0 optimization
This function displaces the reference so that regulation will not take place with a lower suction pressure than required.
The function cooperates with controllers on the individual refrigeration appliances and a system manager. The system manager obtains data from the individual regulations and adapts the suction pressure to the optimum energy level. The function is described in the manual for the System manager.
With this function you can read which appliance is most heavily loaded at the moment as well as the displacement allowed for the suction pressure reference.

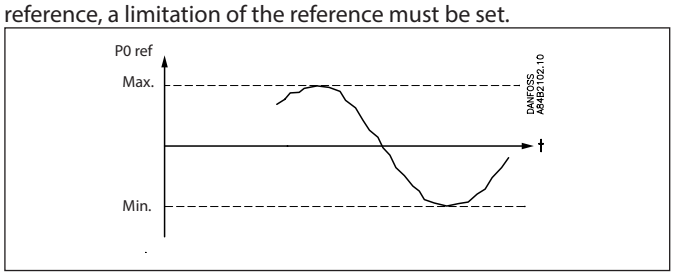
Night displacement
The function is used to change the suction pressure reference for night time operation as an energy saving function.
With this function the reference can be displaced by up to 25 K in positive or negative direction. (When you displace to a higher suction pressure, a positive value is set).
Displacement can be activated in three ways:
- Signal on an input
- From a master gateway's override function
- Internal time schedule

The "night displacement" function should not be used when regulation with the override function "P0-optimisation" is performed. (Here the override function will itself adapt the suction pressure to the max. permissible).

If a short change in the suction pressure is needed (for example, up to 15 minutes in connection with defrosting) the functions can be applied. Here the PO-optimisation will not have time to compensate for the change.

Override with a 0 - 10 V signal
When a voltage signal is connected to the controller the reference can be displaced. In the setup it is defined how big a displacement is to take place at max. signal (10 V) and at min. signal.

Limitation of reference
To safeguard yourself against a too high or too low regulation reference, a limitation of the reference must be set.



Forced operation of the compressor capacity in the suction group
A forced operation of the capacity can be carried out which disregards the normal regulation.
Depending on the selected form of forced operation, the safety functions will be cancelled.

Forced operation via overload of requested capacity
The control is set to manual and the desired capacity is set in % of the possible compressor capacity.

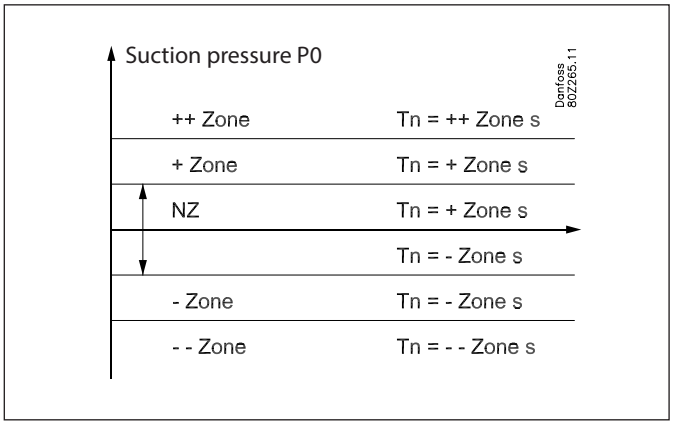
Forced operation via overload of digital outlets
The individual outputs can be set to MAN ON or MAN OFF in the software. The control function disregards this but an alarm is sent out that the outlet is being overridden.

Forced operation via change-over switches
If the forced operation is done with the switch-over on the front of an expansion model, this is not registered by the control function and no alarm is sounded. The controller continues to run and couples with the other relays.

Capacity control of compressors

PI-control and control zones
AK-PC 781 can control up to 8 compressors. Each compressor can have up to 3 unloaders. One or two of the compressors can be equipped with speed regulation.

The calculation of the requested compressor capacity takes place on the basis of a PI control, but the set up is carried out in the same way as for a neutral zone which is divided into 5 different control zones as shown in below sketch.



The width of some of the zones can be set via the settings "+ Zone K", "NZ K" and "- Zone K".
Furthermore it is possible to adjust zone timers which is equal to the Tn integration time for the PI controller whenever the suction pressure is in the zone in question (please see sketch above).

By setting a zone timer to a higher value will make the PI controller slower in this zone and by setting the zone timer lower will make the PI controller faster in this zone.

The amplification factor Kp is adjusted as parameter "Kp Po"
In the neutral zone the controller is only allowed to increase or decrease the capacity by means of speed control and/or switching of unloader valves.
In the other zones the controller is also allowed to increase/ decrease capacity by means of starting and stopping compressors.

Operation time first step
At start-up the refrigeration system must have time to be stable before the PI controller takes over the control. For this purpose at start-up of a plant a limitation is made of the capacity so that only the first capacity step will cutin after a set period (to be set via "runtime first step").

Requested capacity
The readout "Requested capacity" is the output from the PI controller and it shows the actual requested compressor capacity by the PI controller. The rate of change in the requested capacity depends upon in which zone the pressure is and whether the pressure is stable or whether it is constantly changing.

The Integrator is looking at the deviation between the set point and the current pressure only and increases/reduces the requested capacity correspondingly. The amplification factor Kp on the other hand only looks at the temporary pressure changes.

In the "+ Zone" and "++ Zone" the controller will normally increase the requested capacity as the suction pressure is above the set point. But if the suction pressure is decreasing very fast the requested capacity might decrease also in these zones.

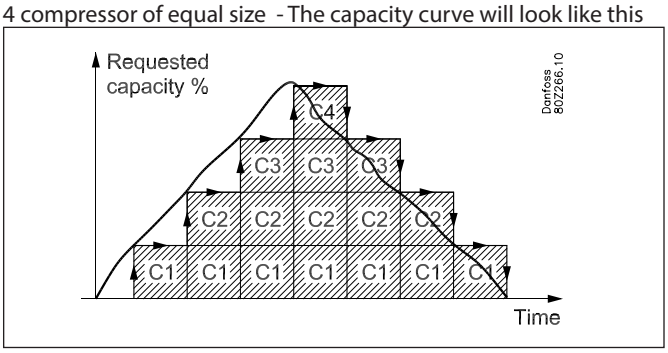
In the "- Zone" and "-- Zone" the controller will normally decrease the requested capacity as the suction pressure is below the set point. But if the suction pressure is increasing very fast the requested capacity might increase also in these zones.

Change capacity
The controller will cutin or cutout capacity based on these basic rules:

Increase capacity:
The capacity distributor will start extra compressor capacity as soon as the requested capacity has increased to a value, which allows the next compressor step to start. Referring to below example - a compressor step is added as soon as there is "Room" for this compressor step below the requested capacity curve.

Decrease capacity:
The capacity distributor will stop compressor capacity as soon as the requested capacity has decreased to a value, which allows the next compressor to stop. Referring to below example - a compressor step is stopped as soon as there is no more "Room" for this compressor step above the requested capacity curve.

Example:
4 compressor of equal size - The capacity curve will look like this



Cut-out of the last compressor stage:
Normally, the last compressor step will only be cut-out when the required capacity is 0% and the suction pressure is at "-Zone" or in "—Zone"

Pump down function:
To avoid too many compressor starts/stops with low load, it is possible to define a pump down function for the last compressor.

If the pump down function is used, the compressors will be cut-out when the actual suction pressure is down to the configured pump down limit.

Note that the configured pump down limit should be set higher than the configured safety limit for low suction pressure "Min Po".

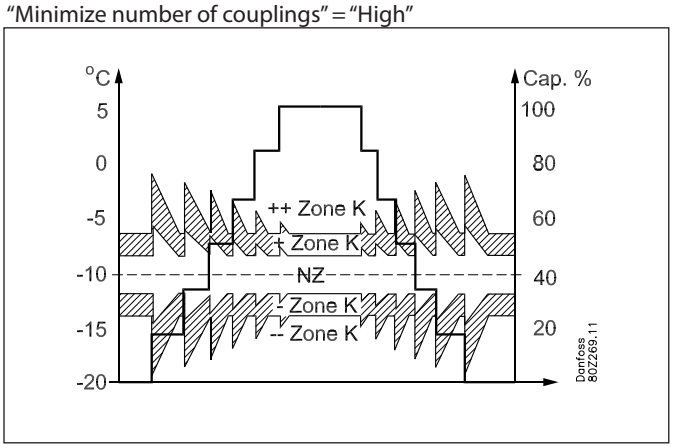
Dynamic extension of the neutral zone
All refrigeration systems have a dynamic response time when starting and stopping compressors. In order to avoid that the controller will start/stop compressors shortly after each other, the controller must be allowed some extra time after a compressor start/stop to see the effect of the previous change in running capacity.

In order to achieve this, a dynamic extension of the zones is added.

The zones will be extended for a short period of time when starting or stopping a compressor. By extending the zones the PI controller will be slowed down in a short period of time after a change in compressor capacity.

The amplitude of the zone extension depends upon the actual running compressor capacity and upon the size of the compressor step which is being stopped/started. The amplitude of the zone extension is bigger when running with low compressor capacity and when starting/stopping big compressor capacity steps. However the time period for the zone extension is constant – after a fixed time period after a compressor start/stop the dynamic zone extension is reduced to 0.
Via the "Minimize number of couplings" setting it is possible to influence how big the amplitude of the dynamic zone extension should be in order to minimize the cycling of the compressors.
By setting "Minimize number of couplings" to "No reduction" there will be no dynamic extension of the zones.
By setting "Minimize number of couplings" to "Low", "Medium" or "High" the dynamic extension of the zones will be activated. The amplitude of the zone extension will be highest when "Minimize number of couplings" is set to "High". Please refer to the next sketch which shows an example with 6 compressor steps and with "Minimize number of couplings" set to "High". Please also note that the dynamic extension of the zones is highest at low compressor capacity.

"Minimize number of couplings" = "High"



Actual band
As a consequence of the dynamic extension of the zones the suction pressure might very well change zone for a period of time when the controller is starting/stopping a compressor i.e. the suction pressure is in the +Zone, but as the controller starts a compressor, the zones are extended for a period of time and during this period of time the suction pressure will be in the NZ.

In the controller the readout "Actual band" will show in which zone the PI controller is operating – this includes the extension of the zones.

The dynamic expansion of the neutral zone is not used when one of the compressors in the group is speed-regulated.

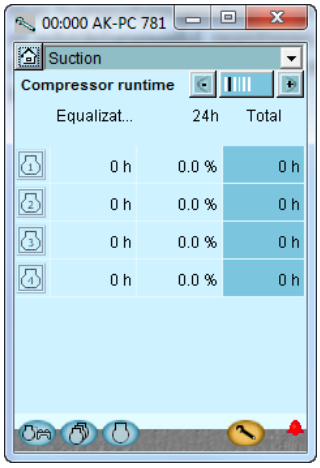
Capacity distribution methods

The capacity distributor can work based on 2 distribution principles.

Coupling pattern – Cyclical operation:
This principle is used if all compressors are of the same type and size.
The compressor cuts-in and cuts-out in accordance with the "First In First Out" principle (FIFO) to equalise operating hours between the compressors.
Speed-regulated compressors will always be cut in first, and the variable capacity is used to fill capacity gaps between the subsequent steps.

Timer restrictions and safety cut outs
If a compressor is prevented from starting because it is "hanging" on the restart timer or is safety cut out, this step is replaced by another compressor.

Operating time equalisation
The operating hour equalizing is carried out between compressors of the same type with the same total capacity.
-At the different startups the compressor with the lowest number of operating hours will be started first.
- At the different stops the compressor with the highest number of operating hours will be stopped first.
- For compressors with several steps, the operating time equalizing is carried out between the compressors' main steps.



- The left column shows the operating hours, according to which the controller equalises.
- The middle column shows (as a percentage) to what extent the individual compressor has been activated within the last 24 hours.
- The right column shows the compressor's current operating time. The value should be reset when the compressor is replaced.

Coupling pattern – Best fit operation
This principle is used if the compressors are of different sizes.
The capacity distributor will cut-in or cut-out the compressor capacity in order to ensure the least possible capacity jump.
Speed-regulated compressors will always be cut in first, and the variable capacity will be used to fill capacity gaps between the subsequent steps.

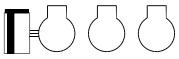
Timer restrictions and safety cut outs
If a compressor is prevented from starting because it is "hanging" on the restart timer or is safety-cut out, this step is replaced by another compressor or another combination.

Power pack types – compressor combinations

The controller is able to control power packs with up to 8 compressors of various types:

- One or two speed controlled compressor
- Capacity controlled piston compressors with up to 3 unloader valves
- Single step compressors – piston

The chart below shows the compressor combination which the controller is capable of controlling. The chart also shows which coupling pattern can be set for the individual compressor combinations.

Combination	Description	Coupling pattern	
		Cyclical	Best fit
	One-step compressors. *1	x	x
	A compressor with an unload valve, combined with one-step compressors. *2	x	
	Two compressors with unload valves, combined with one-step compressors. *2	x	
	All compressors with unload valves. *2	x	
	A speed-regulated compressor combined with one-step compressors. *1 and *3	x	x
	A speed-regulated compressor combined with several compressors with unload valves. *2 and *3	x	
	Two speed-regulated compressors combined with one-step compressors *4	x	x
	Screw compressor combined with one-step compressors	x	
	Two screw compressors combined with one-step compressors	x	
	Three screw compressors combined with one-step compressors	x	

The following types of screw compressor may be used for regulation		
		
Screw with unloader 0%, 50%, 100%	Screw with two unloaders 0, 33%, 66%, 100%	Screw with three unloaders + PWM 0 - 100%

*1) For a cyclical coupling pattern, the one-step compressors must be the same size.
*2) For compressors with unload valves, it is generally true that they must have the same size, the same number of unload valves (max 3) and the same sized main steps. If compressors with unload valves are combined with one-step compressors, all compressors should be the same size.
*3) Speed-regulated compressors can have different sizes in relation to subsequent compressors.
*4) When two speed-regulated compressors are used, they must have the same frequency range.
For cyclical coupling patterns, the two speed-regulated compressors should be the same size and the subsequent one-step compressors should also be the same size.

In appendix A there is a more detailed description of the coupling patterns for the individual compressor applications with associated examples.

The following is a description of some general rules for handling capacity-regulated compressors, speed-regulated compressors and also for two speed-regulated compressors.

Capacity-regulated compressors with unload valves

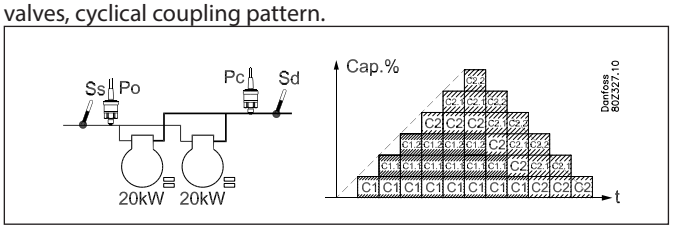
"Unloader control mode" determines how the capacity distributor should handle these compressors.

Unloader control mode = 1

Here the capacity distributor allows only one of the compressors to be unloaded at a time. The advantage of this setting is that it avoids operating with several compressors unloaded , which is not energy efficient.

For example:

Two capacity-regulated compressors of 20 kW, each with 2 unload valves, cyclical coupling pattern.



- For decreasing capacity, the compressor with the most operating hours is unloaded (C1).
- When C1 is completely unloaded, it is cut-out before compressor C2 is unloaded.

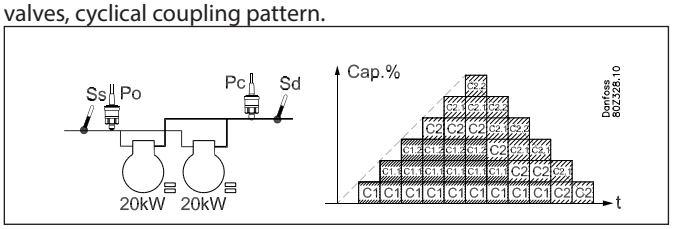
Unloader control mode = 2

Here the capacity distributor allows two compressors to be unloaded while capacity is decreasing.

The advantage of this setting is it reduces the number of compressor start/stops.

For example:

Two capacity-regulated compressors of 20 kW, each with 2 unload valves, cyclical coupling pattern.



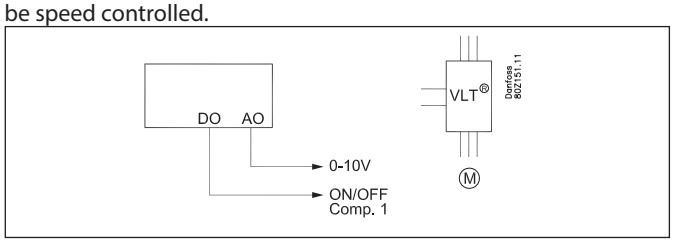
- For decreasing capacity, the compressor with the most operating hours is unloaded (C1).
- When C1 is completely unloaded , compressor C2 with one-step is unloaded before C1 is cut out.

Speed control compressors:
The controller is able to use speed control on the leading compressor in different compressor combinations. The variable part of the speed controlled compressor is used to fill in capacity gaps of the following compressor steps.

General regarding handling:

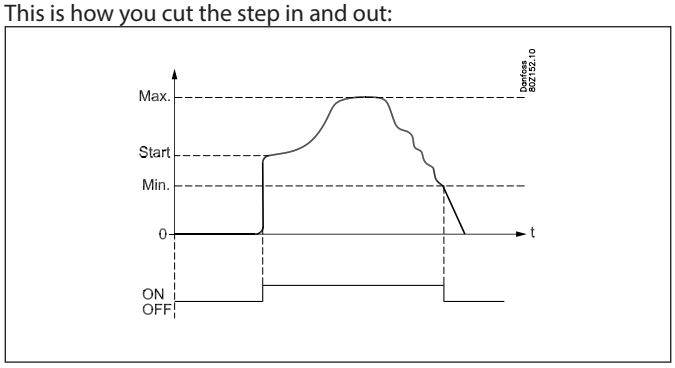
One of the defined capacity steps for the compressor regulation may be connected to a speed control unit that may be a frequency converter type VLT, for example.

An output is connected to the frequency converter's ON/OFF input and at the same time an analog output "AO" is connected to the frequency converter's analog input.
The ON/OFF signal will start and stop the frequency converter and the analog signal will indicate the speed.
It is only the compressor defined as compressor 1 (1+2) that can be speed controlled.



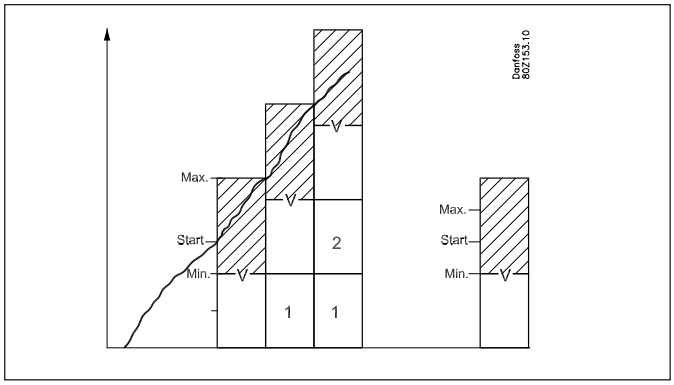
When the step is in operation it will consist of a fixed capacity and a variable capacity. The fixed capacity will be the one that corresponding to the mentioned min. speed and the variable one will lie between the min. and max. speed. To obtain the best regulation the variable capacity must be bigger than the subsequent capacity steps it has to cover during the regulation. If there are major short-term variations in the plant's capacity requirement it will increase the demand for variable capacity.

This is how you cut the step in and out:



Cutin
The speed-controlled compressor will always be the first to start and the last to stop. The frequency converter will be started when a capacity requirement corresponding to the mentioned "Start speed" arises (the relay output changes to ON and the analog output is supplied with a voltage corresponding to this speed).
It is now up to the frequency converter to bring the speed up to "Start speed".
The capacity step will now be cut in and the required capacity determined by the controller.
The start speed always ought to be set so high that a fast lubrication of the compressor is obtained during the start.

Controlling – increasing capacity
If the need for capacity becomes larger than "Max. Speed" then the subsequent compressor step will be cut-in. At the same time, the speed on the capacity step will be reduced so the capacity is reduced with a size that corresponds to exactly the cut-in compressor step. Thereby a completely "frictionless" transition is achieved without capacity holes (refer also to sketch).



Controlling – decreasing capacity
If the capacity requirement becomes less than "Min. speed" then the subsequent compressor step will be cut-out. At the same time, the speed on the capacity step is increased so the capacity is increased with a size that corresponds to exactly the cut-out compressor step.

Cut-out
The capacity step will be cut-out when the compressor has reached "Min. Speed" and the requested capacity has dropped to 1%.

Timer restriction on speed controlled compressor
If a speed controlled compressor is not allowed to start due to a timer restriction, no other compressor is allowed to start. When the timer restriction has expired the speed controlled compressor will start.

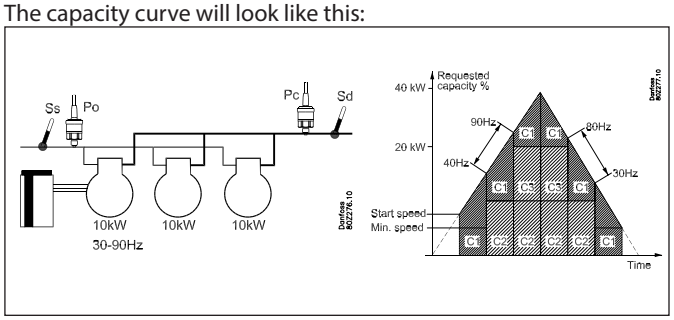
Safety cutout on speed controlled compressor
If the speed controlled compressor is cutout on safety other compressors are allowed to start. As soon as the speed controlled compressor is ready to start it will be the first compressor to start.

As mentioned before the variable part of the speed capacity should be bigger than the capacity of the following compressor steps in order to achieve a capacity curve without "holes". In order to illustrate how the speed control will react at different pack combinations a couple of examples will be given here:

a) Variable capacity bigger than following compressor steps:
When the variable part of the speed controlled compressor is bigger than the following compressors there will be no "holes" in the capacity curve.
Example:
1 speed controlled compressor with a nominal capacity at 50Hz of 10kw - Variable speed range 30 – 90Hz
2 one step compressors of 10 kW

Fixed capacity = 30 HZ / 50 HZ x 10 kW = 6 kW
Variable capacity = 60 HZ / 50Hz x 10 kW = 12 kW

The capacity curve will look like this:



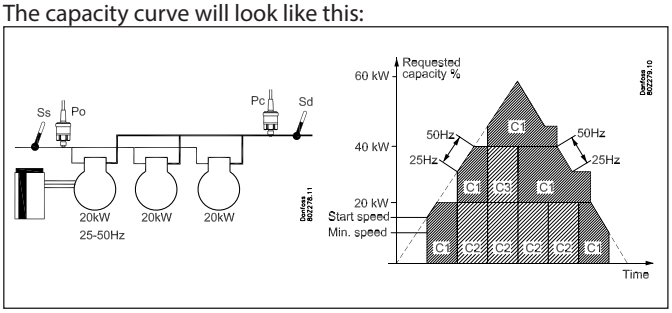
As the variable part of the speed controlled compressor is bigger than the following compressor steps, the capacity curve will be without holes.

1) The speed controlled compressor will be cutin when the requested capacity has reached the start speed capacity.
2) The speed controlled compressor will increase speed until it reaches max speed at a capacity of 18 kW.
3) The one step compressor C2 of 10 kW is cut in and the speed on C1 is reduced too so that it corresponds to 8kW (40Hz)
4) The speed controlled compressor will increase speed until the total capacity reaches 28 kw at max speed
5) The one step compressor C3 of 10 kW is cut in and the speed on C1 is reduced too so that it corresponds to 8kW (40Hz)
6) The speed controlled compressor will increase speed until the total capacity reaches 38 kw at max speed
7) When reducing capacity the one step compressors will be cut out when the speed on C1 is at minimum

b) Variable part smaller than following compressor steps:
If the variable part of the speed controlled compressor is smaller than the following compressors there will be "holes" in the capacity curve.

Example:
1 speed controlled compressor with a nominal capacity at 50Hz of 20kw - Variable speed range 25 – 50Hz
2 one step compressors of 20 kW
Fixed capacity = 25 HZ / 50 HZ x 20 kW = 10 kW
Variable capacity = 25 HZ / 50Hz x 20 kW = 10 kW

The capacity curve will look like this:



As the variable part of the speed controlled compressor is smaller than the following compressor steps the capacity curve will have some holes that can not be filled out by the variable capacity.

1) The speed controlled compressor will be cutin when the requested capacity has reached the start speed capacity.
2) The speed controlled compressor will increase speed until it reaches max speed at a capacity of 20 kw.
3) The speed controlled compressor will stay at max speed until the requested capacity has increased to 30 kW.
4) The one step compressor C2 of 20 kW is cut in and the speed on C1 is reduced to min. so that it corresponds to 10kW (25Hz). Total capacity = 30 kW.
5) The speed controlled compressor will increase speed until the total capacity reaches 40 kW at max speed
6) The speed controlled compressor will stay at max speed until the requested capacity has increased to 50 kW.
7) The one step compressor C3 of 20kW is cut in and the speed on C1 is reduced to min. so that it corresponds to 10kW (25Hz). Total capacity = 50 kW
8) The speed controlled compressor will increase speed until the total capacity reaches 60 kw at max speed
9) When reducing capacity the one step compressors will be cut out when the speed on C1 is at minimum speed.

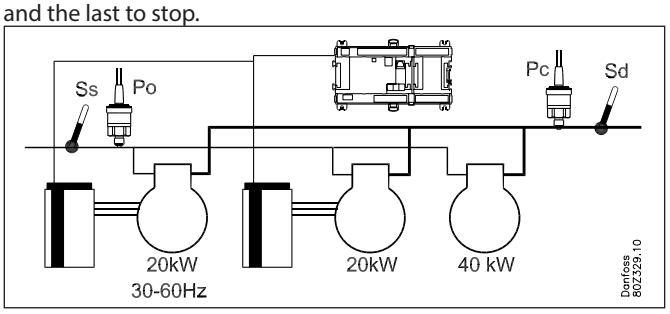
Two speed-regulated compressors
The controller is capable of regulating the speed of two compressors of the same or different sizes. The compressors can be combined with one-step compressors of the same or different sizes, depending on the choice of coupling pattern.

General regarding handling:
Generally, the two speed-regulated compressors are managed according to the same principle as for one speed-regulated compressor. The advantage of using two speed-regulated compressors is that it allows for a very low capacity, which is an advantage for low loads. At the same time, it produces a very large, variable regulating area.

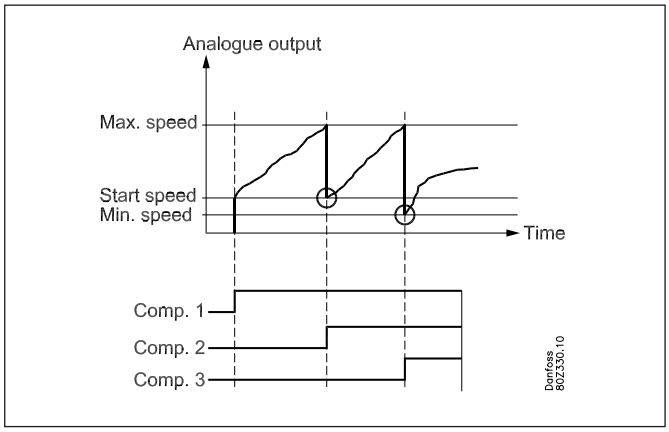
Compressor 1 and 2 both have their own relay outlets to start/stop separate frequency converters, for example of type VLT.
Both frequency converters use the same analog output signal AO which is connected to the frequency converters' analog signal input. The relay outputs will start and stop the frequency converter and the analog signal will indicate the speed.

The precondition for using this regulating method is that both compressors have the same frequency range.

The speed-regulated compressors will always be the first to start and the last to stop.



Cut-in
The first speed-regulated compressor will be started when there is a capacity requirement which matches the setting.
The "Start speed" (relay outlet changes to on and the analog outlet is supplied with a voltage that matches this speed). It is now up to the frequency converter to bring the speed up to the "Start speed".
The capacity step will now be cut in and the desired capacity determined by the controller.
The start speed should always be set so high that a good lubrication of the compressor is quickly reached during start-up.
For a cyclical coupling pattern, the subsequent speed-regulated compressor will be cut in when the first compressor runs at max. speed and the desired capacity has reached a value that allows the cut-in of the next speed-regulated compressor at start speed. Afterwards, both compressors will be cut in together and will run in parallel. The following one-step compressors will be cut in and out in accordance with the selected coupling pattern.



Controlling – decreasing capacity
The speed-regulated compressors will always be the last compressors running.
When the capacity requirement during cyclical operations becomes less than "Min. speed" for both compressors, the speed-regulated compressor with the most operating hours will be cut-out. At the same time, the speed of the last speed-regulated compressor increases so that the capacity is increased to the level that matches the cut-out compressor's step.

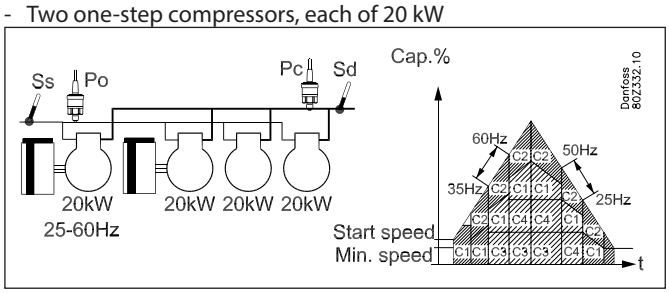
Cutout
The last speed-regulated compressor will be cut-out when the compressor has reached "Min. speed" and the capacity requirement (desired capacity) has decreased to under 1% (see however the section on the pump down function).

Timer restriction and safety cut-outs
Timer limits and safety cut-outs on speed-regulated compressors should be managed in accordance with the general rules for individual coupling patterns.

Short descriptions and examples are given below of the handling of two speed-regulated compressors for the individual coupling patterns. For a more detailed description, refer to the appendix at the end of the chapter.

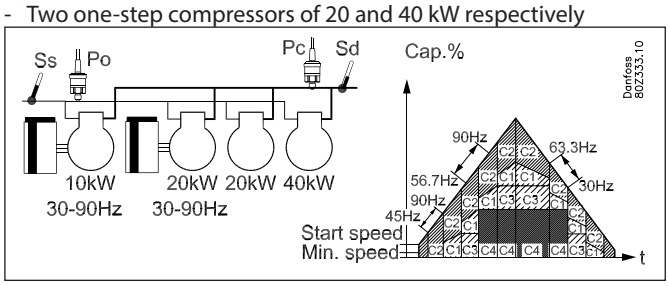
Cyclical operation
For cyclical operations, both speed-regulated compressors will have the same size and operating hours will be equalized between the compressors in accordance with the First-in-First-Out Principle (FIFO). The compressor with the least operating hours will be the first to start. The following speed-regulated compressor will be cut in when the first compressor runs at max. speed and the desired capacity has reached a value that allows the cut-in of the next speed-regulated compressor at start speed. Afterwards, both compressors will be cut in together and they will run in parallel. The following one-step compressors will be cut in and out in accordance with First-In-First-Out principle in order to equalise operating hours.

Example:
- Two speed-regulated compressors with a nominal capacity of 20 kW and frequency range 25-60 Hz
- Two one-step compressors, each of 20 kW

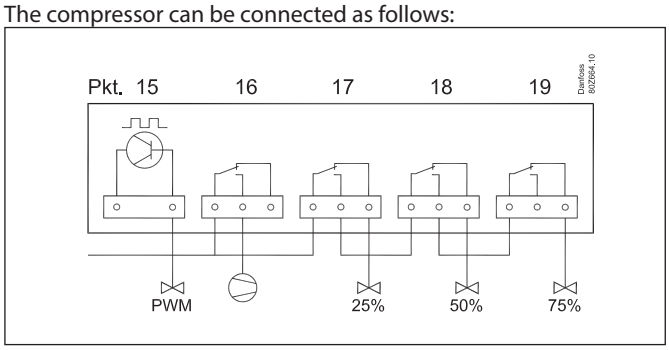


Best fit
During best-fit operations, the speed-regulated compressors can have different sizes and they will be handled in such a way that the best possible capacity adjustment is achieved. The smallest compressor will be started first, then the first will be cut-out and the second compressor will cut in. Finally, both compressors will be cut in together and will run in parallel.
The following one-step compressors will, in every case, be handled in accordance with the best-fit coupling pattern.

Example:
- Two speed-regulated compressors with a nominal capacity of 10 kW and 20 kW respectively
- Frequency range of 25-60 Hz
- Two one-step compressors of 20 and 40 kW respectively



Screw compressor with pulse width modulation (PWM)
The compressor can be connected as follows:



The PWM signal must be obtained from a solid state output.
The compressor motor and unloaders must be connected to the relay outputs as shown.

Compressor timers

Time delays for cutins and cutouts
To protect the compressor against frequent restarts three time delays can be put in.
- A minimum time to run from a compressor's startup and until it may be restarted.
- A minimum time (ON-time) for the compressor to operate before it may be stopped again.
- A minimum OFF time to run from a compressor stops and until it may be restarted

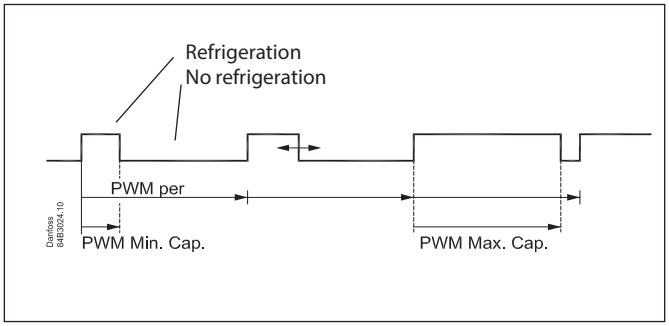
When unloaders are cut in and out, the time delays will not be used.

Timer
The operating time of a compressor motor is registered continuously. You can read out:
- operating time for the previous 24-hour period
- total operating time since the timer was last set to zero-set.

Coupling counter
The number of relay cutins and cutouts is registered continuously. The number of starts can be read out here:
- Number during the previous 24-hour period
- Total number since the counter was last set to zero-set.

The capacity from the digital scroll compressor

The capacity is divided into period times as "PWM per". 100% capacity is delivered when cooling takes place for the whole period. An off time is required by the by-pass valve within the period and an on time is also permitted. There is "no cooling" when the valve is on.
The controller itself calculates the capacity needed and will then vary it according to the cut-in time of the by-pass valve.
A limit is introduced if low capacity is needed so that the cooling does not go below 10%. This is because the compressor can cool itself. This value can be increased if necessary.
The capacity can similarly be limited so that the compressor cannot deliver 100% capacity. It is not normally necessary to limit this max. capacity.



Load shedding

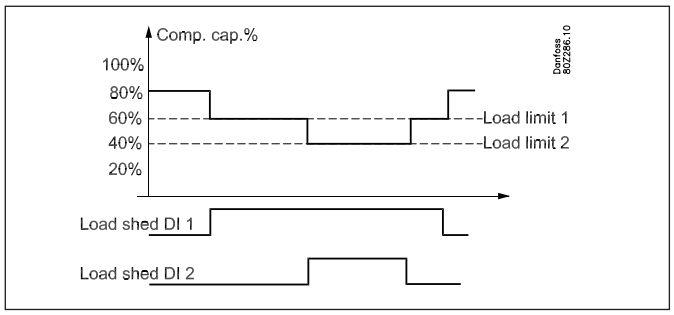
On some installations there is the desire to limit the cut-in compressor capacity so that one can limit the total electrical load in the store for periods.

This limitation can be activated in the following way:
- Via signal from the network
- Via signal on one DI input + signal via the network
- Via signal on two DI inputs + signal via the network

The signal via the network will result in the same function as if the signal were received on DI 1.

For each digital inlet a limit value is attached for the maximum allowable cut-in compressor capacity so that one can carry out the capacity limitation in 2 steps.

When a digital inlet is activated, the maximum allowable compressor capacity is limited to the set limit. This means that if the actual compressor capacity upon activation of the digital inlet is higher than this limit, then so much compressor capacity is cut-out that it will then be on or under the set maximum limit value for this digital inlet.
The threshold value may not be set lower than the compressor's lowest capacity step/"Start speed".



When both load-shedding signals are active, the lowest limit value for the capacity will be the one that is applicable.

Max. time
A max. period with low compressor capacity can be set. When the period expires, the system switches to normal regulation until the suction pressure is once again in place. Load shedding will then be permitted.

Overriding of load shedding:
To avoid load shedding leading to temperature problems for the chilled products, an overriding function is fitted.

A overriding limit is set for the suction pressure as well as a delay time for each digital inlet.

If the suction pressure during load shedding exceeds the set P0 overriding limit and the attached delay times for the two digital inlets expire then load shedding overrides the signals so that the compressor capacity can be increased until the suction pressure is again under the normal reference value. The load shedding can then be activated again.

Alarm:
When a load shedding digital inlet is activated, an alarm will be activated to inform that the normal control has been bypassed. This alarm can however be suppressed if so desired.

Cascade systems – coordination and injection

On cascade systems coordination is necessary between the two compressor groups for low temperature (LT) and middle temperature (MT) respectively –LT compressors must not start before the MT compressors are running.

In addition it is necessary to give a signal to the injection control of the cascade refrigerator so that injection is started and stopped in synchronisation with start/stop of the compressors

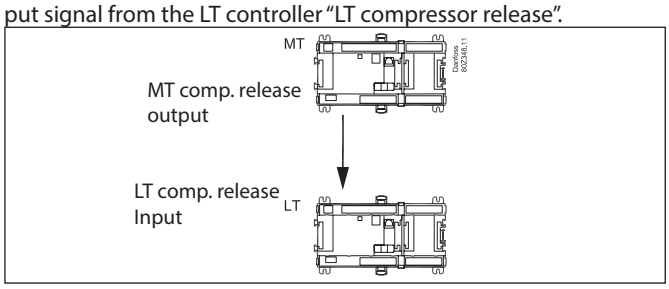
(Coordination with parallel compression on CO2 system (MT and IT) is described under parallel compression on page 122.)

Coordination

The coordination between LT and MT compressors can be carried out in three ways:

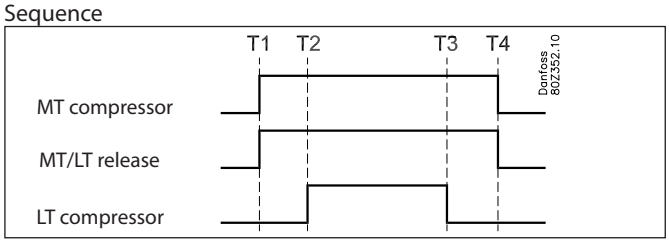
1) MT/LT compressor release

Here the MT group is the controlling circuit.
The MT compressors must not start before the load on the MT circuit requires it and the LT group must not be allowed to start before at least one MT compressor has been started.
This function is achieved by connecting the output signal from the MT controller "MT compressor release" to the input signal from the LT controller "LT compressor release".



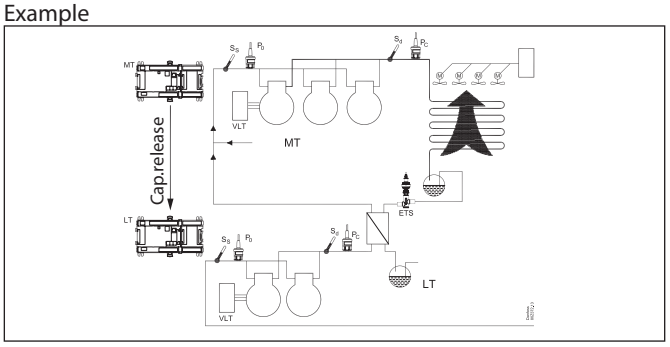
When a compressor is running in the MT circuit, the controller will also pull the relay with the release signal into the LT circuit.
The LT controller must receive the signal as an On/Off signal. Either as a contact signal on analogue input or as voltage signal on a DI input.
Thread the connections between the two controllers so that the controllers are kept galvanically separate.

Sequence



T1: First MT compressor starts and the release signal is activated
T2: When the need arises, the first low-pressure compressor starts
T3: Last LT compressor stops
T4: Last MT compressor stops
(If the last MT compressor stops "before T3", the release signal will drop out and thereby stop the LT compressors.)

Example



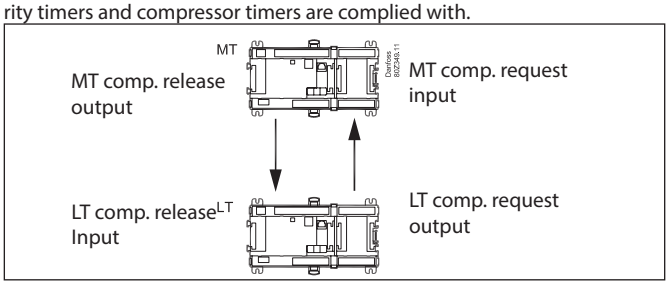
MT controller:
- LT/MT coordination = MT compressor release
- MT controller uses an output "MT compressor release", which is activated when the first MT compressor starts.

LT controller:
- LT/MT coordination = LT compressor release
- The LT controller uses an input "LT compressor release", which is connected to the output signal from the MT controller. When the input receives the signal from the MT controller, the first LT compressor is released for start.

2) LT/MT coordination

Here the MT compressors can start either as a result of:
- Load on the MT circuit
- Requirements from the LT circuit

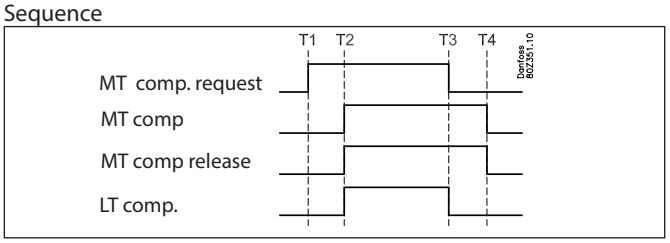
The MT circuit will still ensure that the LT circuit is only permitted to start when at least one MT compressor has started. It will also ensure that security timers and compressor timers are complied with.



Here both a relay output and an On/off input are used on both controllers.
(Thread the connections between the two controllers so that the controllers are kept galvanically separate.)
- The output signal from the MT controller "MT compressor release" gives a signal for the input signal of the LT controller "LT compressor release".
- The LT controller's output signal "LT compressor requirement" gives a signal to the MT controller's input signal "MT compressor requirement".

When the LT controller requires a compressor to start, it will activate the "LT compressor requirement signal".
When the MT controller receives the signal, it will start the compressor and simultaneously send a release signal to the LT controller via the relay output "MT compressor relay".

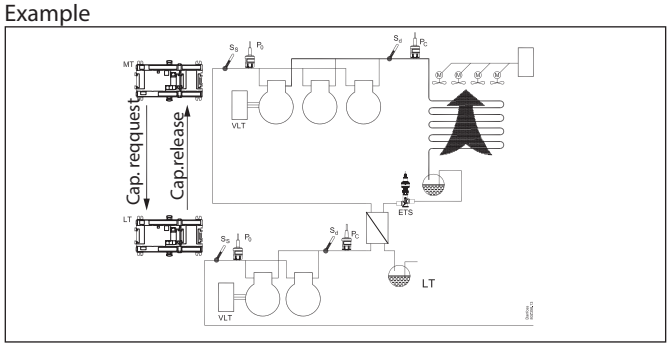
Sequence



T1: The load on the LT circuit requires that compressor capacity be connected.

The LT circuit requests compressor start for the high-pressure circuit.
T2: First MT compressor starts after expiry of recycle hours
T3: Last LT compressor stops
T4: Last MT compressor stops

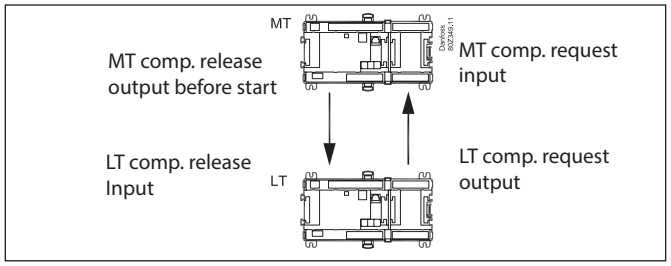
Example



MT controller:
- LT/MT coordination = MT coordination
- The MT controller uses:
  - An output "MT compressor release", which is activated when the first MT compressor starts.
  - An input "MT compressor requirement", which receives a signal from the low-pressure controller.

LT controller:
- LT/MT coordination = LT coordination
- The LT controller uses:
  - An input "LT compressor release" which is connected to the output "MT compressor release" on the MT controller.
  - An input "LT compressor requirement" which is connected to the output "MT compressor requirement" on the MT controller.

3) LT/MT coordination - LT-release before MT start
The LT compressors can start when the MT has signalled that it is ready but has yet to start the compressors. The MT sends a signal to the LT that MT is ready and that LT must start as needed. MT then awaits LT starting up. When this takes place, MT will register the pressure increase and immediately start the MT compressors acc. to requested pressure.



Here both a relay output and an on/off input on both controllers are used.
(Make the connections between the two controllers, so that the controllers are kept galvanically separate).

The LT controller is adjusted for LT coordination
The MT controller is set for MT coordination release before start.

Time delays on signals
To achieve optimum coordination between the MT and LT circuits it is possible to define time delays on all input and output signals. Generally, though, the MT circuit's suction pressure will also influence whether the release times for the LT circuit are met.
- If the MT pressure is over the neutral zone, LT must wait until the pressure drops into the neutral zone.
- If the MT pressure is below the neutral zone, the LT must start before MT starts.

MT release delay
Here the output signal from the MT controller is delayed.
This means that the MT compressors will be permitted to run for the set delay before the LT compressors are released for start.

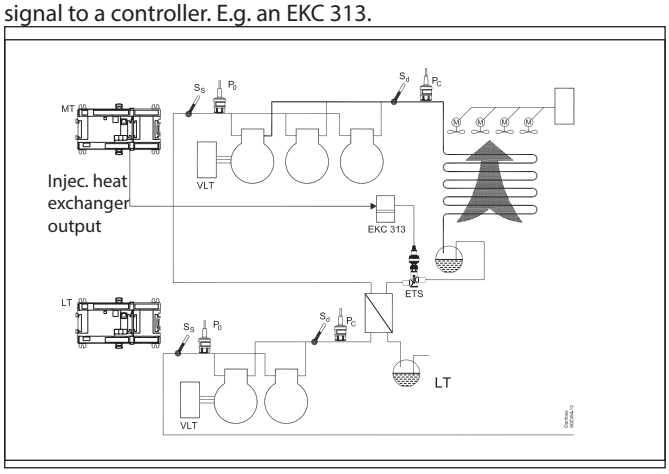
MT compressor requirement delay
Here the input signal "MT compressor requirement" is delayed on the MT controller and thereby the start-up of the first MT compressor.
This delay can be used if the LT circuit requires start-up of MT compressors too often.

LT compressor release delay
Here the input signal "LT compressor release" is delayed on the LT controller.
This means that the MT compressors will be permitted to run for the set delay before the LT compressors are released for start.

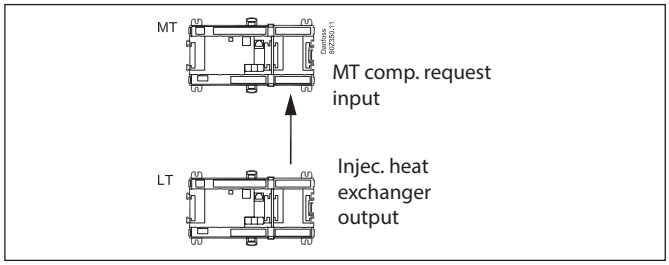
LT compressor requirement delay
Here the output signal "LT compressor requirement" is delayed from the LT controller. This delay can be used if the LT circuit requires start-up of MT compressors too often.

Injection signal to heat exchanger control
An injection into the cascade heat exchanger must usually be coordinated with the start-up of the first compressor.
AK-PC 781 allows the injection to begin when the controller is ready to run with the first compressor.
Depending on system type/design, it will be advantageous to synchronise the injection with the signal "MT comp.release output before start"..

The relay output can e.g. be used to control a magnet valve or to signal to a controller. E.g. an EKC 313.

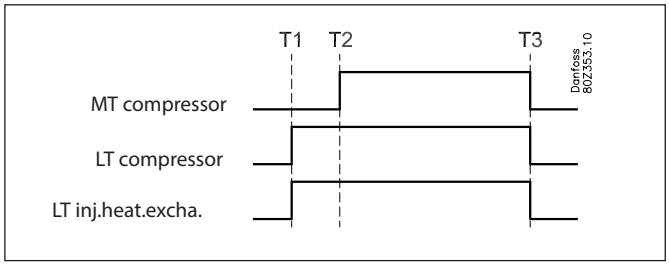


Here an injection signal from the LT controller can be used to request start of MT compressors.



- The LT controller's injection signal is connected to the MT controller's input signal "MT compressor requirement".

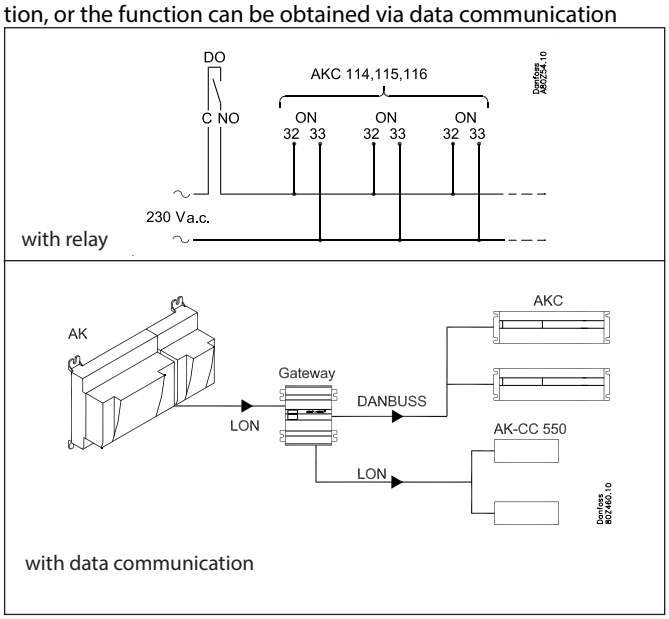
When the LT controller starts the first compressor, the injection signal will be activated and thereby request MT compressor start. When any delay in the MT control has expired, the first MT compressor will start.



T1: The load on the LT circuit requires compressor capacity. LT starts compressor and activates injection signal and thereby the input "MT request" on the MT controller.
T2: First MT compressor starts after expiry of delays.
T3: Last LT compressor stops which removes the compressor requirement signal and the last MT compressor stops.

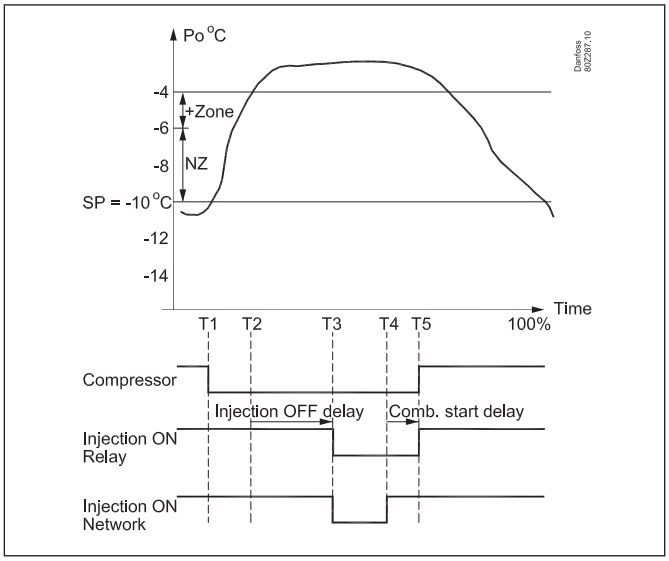
Injection ON

The electronic expansion valves in the refrigeration appliances must be closed when all the compressors are prevented from starting. In this way the evaporators will not be filled with liquid which is subsequently passed on to a compressor when regulation is restarted.
One of the compressor control relays may be used for this function, or the function can be obtained via data communication



The function is described based on the sequence of events below:
T1) The last compressor is cut-out
T2) The suction pressure has increased to a value corresponding to Po Ref + NZ + "+Zone K" but no compressor can start due to re-start timers or safety cut-out
T3) The time delay "Injection OFF delay" elapses and the injection valves are forced to close via relay signal or via network signal.
T4) The first compressor is now ready to start. The forced closure signal via the network is now cancelled.
T5) The time delay "Comp. Start delay" expires and the forced closure signal via the relay switch is cancelled simultaneously with the first compressor being allowed to start.

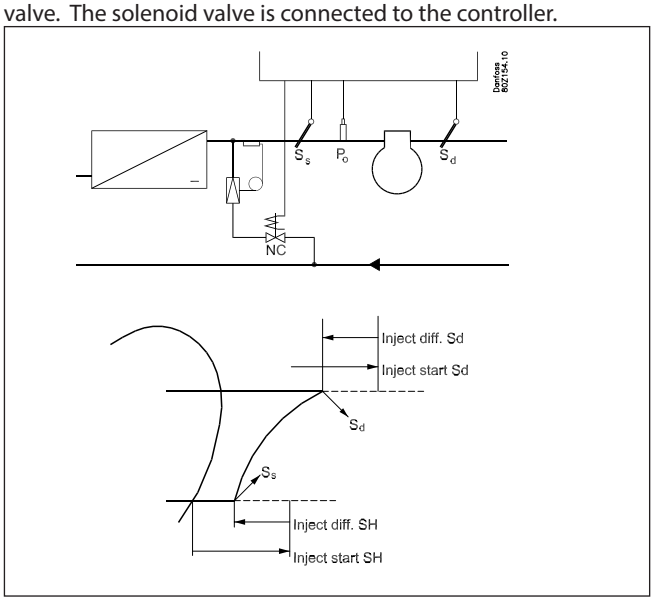
The reason why the forced closure signal via the network is cancelled before the first compressor starts, is that it will take some time to distribute the signal to all appliance controllers via the network.



Liquid injection in suction line

The discharge pressure gas temperature can be kept down by means of liquid injection into the suction line..

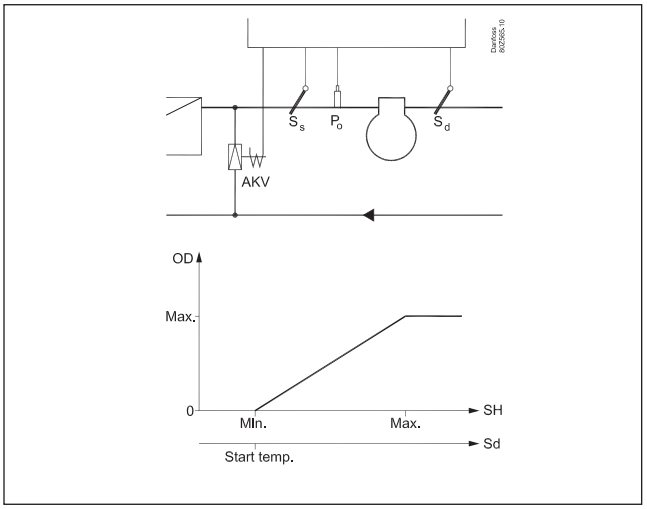
•With a thermostatic expansion valve in series with a solenoid valve. The solenoid valve is connected to the controller.



Control can be carried out in two ways:

1. The liquid injection is exclusively controlled on the basis of the superheat in the suction line. Two values are set – a starting value and a differential where the injection is stopped again.
2. The liquid injection is both controlled by the superheat (as described above) and by discharge temperature Sd. Four values are set – two as mentioned above and two for the Sd function, a starting value and a differential. The liquid injection is started when one of the starting values have been passed, and is stopped again when just one of the two functions cuts out.

• Direct using an electrically operated expansion valve of the type AKV



Four values are adjusted -- a start value for the Sd temperature, min. and max. values for overheating and a period time for the AKV valve.

The pulse width modulating signal for the AKV valve shall be taken from one of the controller's four solid state outputs.

Time delay

A time delay can be set which ensures that the injection is delayed during start up.

Safety functions

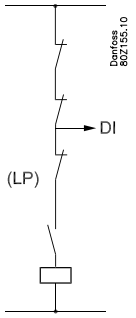
Signal from the compressor's safety controls

The controller can monitor the status of each compressor's safety circuit. The signal is taken directly from the safety circuit and connected to an input.

(The safety circuit must stop the compressor without involving the controller).

If the safety circuit is cut out the controller will cut out all output relays for the compressor in question and give an alarm. Regulation will continue with the other compressors.

General safety circuit



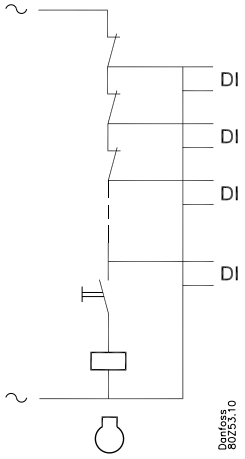
If a low-pressure switch is placed in the safety circuit it must be placed at the end of the circuit. It must not cut out the DI signals. (There is a risk that the regulation will become locked and that it will not start again). This also applies to the example below.

If an alarm is needed which also monitors the low-pressure thermostat, a "general alarm" can be defined (an alarm that does not affect the control).
See the following section "General monitoring functions".

Extended safety circuit

Instead of a general monitoring of the safety circuit this monitoring function can be extended. In this way a detailed alarm message is issued which tells you which part of the safety circuit has dropped out.

The sequence of the safety circuit must be established as shown, but not all of them need necessarily be used.



Oil pressure safety

Over current safety

Motor protect. safety

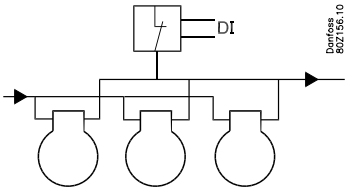
Discharge temp. safety

Discharge pressure safety

Common safety circuit

A common safety signal can also be received from the whole suction group. All compressors will be cut out when the safety signal cuts out.

The function may not be connected to an external main switch.



Time delays with safety cut-out:
In connection with safety monitoring of a compressor it is possible to define two delay times:

Cut-out delay time: Delay time from alarm signal from the safety circuit until the compressor outlet cuts out (note that the delay time is common to all security inlets for the compressor concerned)

Safety re-start time: The minimum time a compressor must be OK after a safety cut-out until it may start again.

Monitoring of superheat
This function is an alarm function which continuously receives measured data from suction pressure P0 and suction gas Ss.
If superheat is registered which is lower or higher than the set limit values, an alarm will be given when the time delay has passed.

Monitoring of max. discharge gas temperature (Sd)

Common Sd monitoring
The function gradually cuts out compressor steps if the discharge temperature becomes higher than permitted. The cutout limit can be defined in the range from 0 to +195°C.

The function is started at a value that is 10 K below the set value. At this point the entire condenser capacity is cut in at the same time as 33% of the compressor capacity is cut out (but minimum one step). This is repeated every 30 seconds. The alarm function is activated.
If the temperature rises to the set limit value all compressor steps are immediately cut out.

The alarm is cancelled and renewed cutin of compressor steps is permitted when the following conditions are met:
- the temperature has dropped to 10 K below the limit value
- the time delay prior to restart has been passed. (see later)

Normal condenser control is permitted again when the temperature has dropped to 10 K below the limit value.

Individual Sd monitoring
The affected compressor will be disconnected here when the temperature exceeds the threshold value.
- The piston compressor will be reconnected when the temperature has dropped 10 K.
- The screw compressor will be reconnected when the temperature has dropped 20 K.
- Scroll compressors will be reconnected when the temperature has dropped 10 K.
  If signals are also obtained from the embedded NTC sensor, the disconnect value for this temperature will always remain at 130°C and the reconnect value at 120°C.

Monitoring of min. suction pressure (P0)
The function promptly cuts out all compressor steps if the suction pressure becomes lower than the permitted value.
The cutout limit can be defined in the range from -120 to +30°C.
The suction is measured with pressure transmitter P0.

At cutout the alarm function is activated:

The alarm is cancelled and renewed cutin of compressor steps is permitted when the following conditions are met:
- the pressure (temperature) is above the cutout limit
- the time delay has elapsed (see later).

Monitoring of max. condensing pressure (Pc)
The function cuts in all condenser steps and cuts out compressor steps one by one if the condensing pressure becomes higher than permitted. The cutout limit is set in bar. The condensing pressure is measured with pressure transmitter Pc_.

The function takes effect at a value which is 3 K below the set value. At this time the entire condenser capacity is cut in at the same time as 33% of the compressor capacity is cut out (but min. one step). This is repeated every 30 seconds. The alarm function is activated.

If the temperature (pressure) rises to the set limit value, the following will happen:
- all compressor steps will immediately be cut out
- the condenser capacity will remain cut in

The alarm will be cancelled and renewed cutin of compressor steps is permitted when the following conditions are met:
- the temperature (pressure) falls to 3 K below the limit value
- the time delay for restart has been passed.

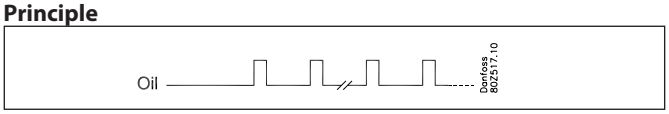
Delay of Pc max alarms
It is possible to delay the “Pc max alarm" message.
The controller will still disconnect the compressors, but the sending of the alarm itself is delayed.
The delay is useful on cascade systems where the max. Pc limit is used to disconnect compressors in the low-pressure circuit if the high-pressure compressors have not started.

Time delay
There is a joint time delay for “Monitoring of max. discharge gas temperature” and “Min. suction pressure”.
After a cutout, regulation cannot be recommenced until the time delay has been passed.
The time delay starts when the Sd temperature has again dropped to 10 K below the limit value or P0 has risen above the P0 min. value.

Alarm for too high suction pressure
An alarm limit can be set which will become effective when the suction pressure becomes too high. An alarm will be transmitted when the set time delay has been passed. The regulation continues unchanged.

Oil management

Principle

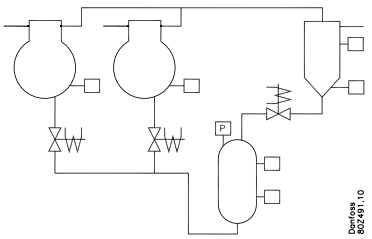


The controller turns on the oil flow for e.g. 1 second. The system then pauses while the oil once again settles. This is repeated a certain number of times, which will be determined by the plant and control principles.
The pulse time, pause time and number of pulses can be adjusted.

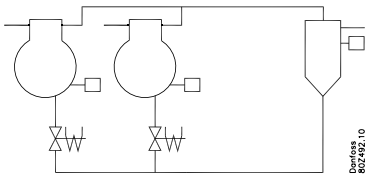
The system can be controlled by signal from:
- Level switch on compressor
- Level switch on oil separator
- Level switch on oil receiver
- Pressure transmitter on oil receiver
- In special circumstances the pulse counter can also be used to control, but this is not energy efficient.

Examples of oil circuits

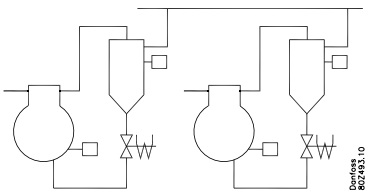
One oil separator and one oil receiver



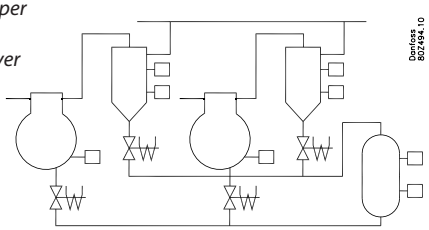
One oil separator



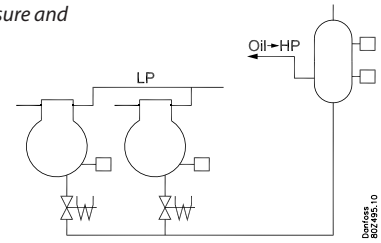
One oil separator per compressor



One oil separator per compressor and common oil receiver

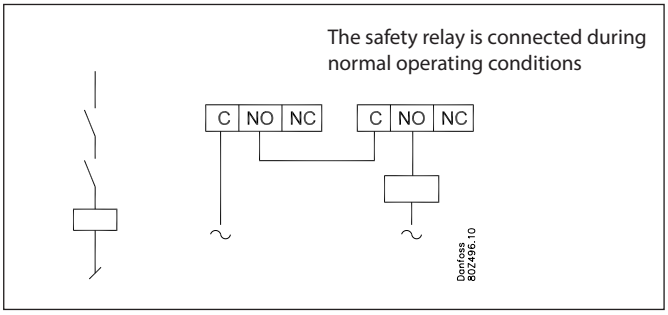


Both high and low pressure and common oil receiver (+ oil separator)

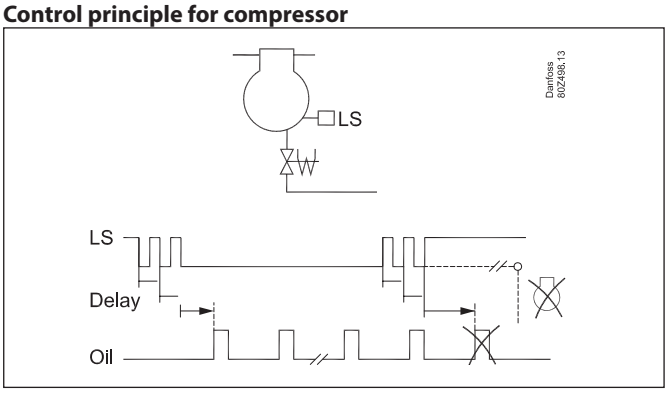


Safety relays

The controller can manage the oil supply to the compressors during normal regulation. However if the compressors are force controlled, this will be done outside the normal regulation. To avoid compressor damages, a safety relay can be incorporated in the control circuit so the controller can cutout the compressor if the oil supply is absent during forced control.
The function "Safety relay" can be selected under setup and wiring should be done as shown.

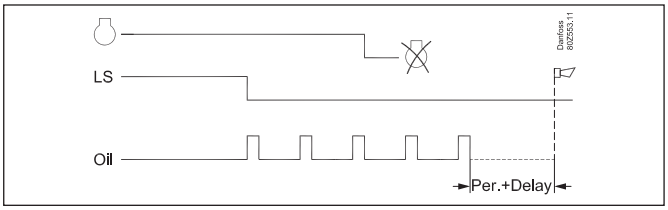


Control principle for compressor



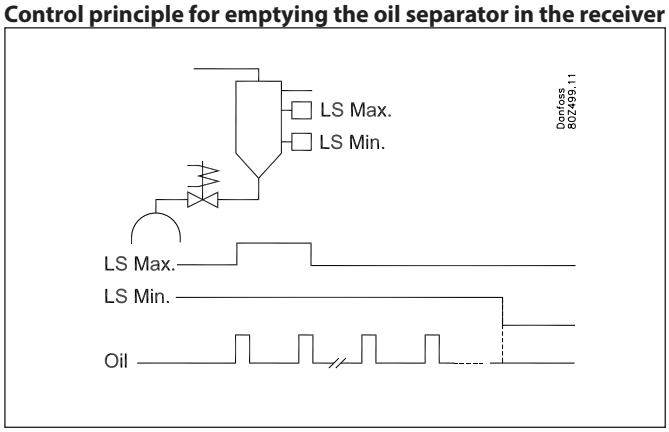
A compressor that is shut down does not receive any oil.
When the compressor is in operation, a signal from the compressors oil-level switch is expected. When the signal is given, the following process is carried out:
- Adjustable delay time, re-started in case of chatter.
- Oil injection commences after delay time sequence.
- The solenoid valve follows the pulse process and the oil is injected. Pulse time, period time and the total number of pulses are set for the current plant.
- After the defined number of pulses, the oil injection is stopped again. If the level switch registers a stable oil signal before the sequence of the defined number of pulses finishes, the remaining pulses are omitted.
- If the level switch registers a lack of oil when the last pulse has stopped, the compressor will be shut down and an alarm will be given. If the oil level is deemed to be OK again, the alarm will be cancelled and the compressor can restart.
  If an OK on oil level is absent, the compressor will stop and can then only be manually started using the reset function.
- Advanced stop. (allows pulses when the compressor is stopped)

This function divides the pulse count by two. The compressor will then stop, after which the remaining pulses will be made.



Simpel oil equalisation (cyclical systems)
The function only begins when all compressors are in operation. Here you can set an interval time at which the compressors will alternate in pausing for a given period of time, so that the oil equalisation can be performed.

Control principle for emptying the oil separator in the receiver



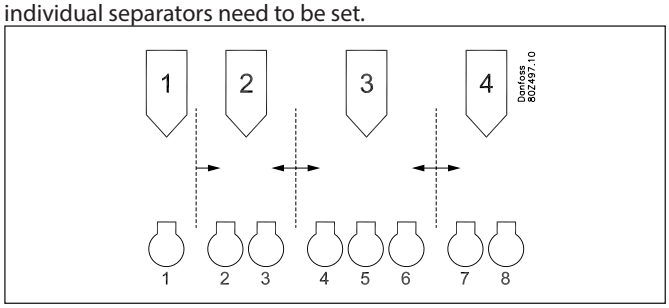
The system can then be controlled by signal(s) from one or two-level switches:
• One-level switch:
- Full sequence. When the level switch registers oil, the oil is emptied over in the receiver in a user-defined pulse sequence. The system determines the pulse length, period time between pulses and number of pulses.
- To level. Here a user-defined pulse sequence starts, but the sequence stops immediately once the oil level falls below the level switch.

• Two-level switches
Here, the high-level switch will start the pulse sequence, and the low-level switch will stop the pulse sequence.

If the high level switch is still registering oil after the total number of pulses has finished, an alarm is given for high oil level in the separator.
If the low level switch is still registering oil after the total number of pulses is finished, an alarm is given for remaining oil in the separator.
An alarm for signal failure is also given if the high level switch registers oil while a low level switch does not register oil.
If either the high or low level switch is activated in the set time interval, a "no oil separated" alarm is given.

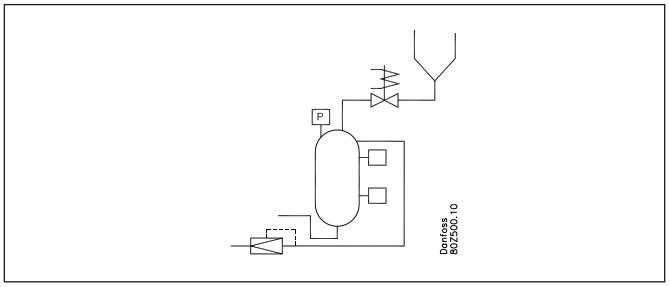
If an oil separator has been fitted for each compressor, it is the level switch in the compressor, that determines the emptying process of oil into the compressor. The level switch in the separator can be used for monitoring.

If "partial shared oil separators" have been fitted, the distribution from compressor 1 and up will be as follows: The order **cannot** be changed but the number of compressors that belong to the individual separators need to be set.



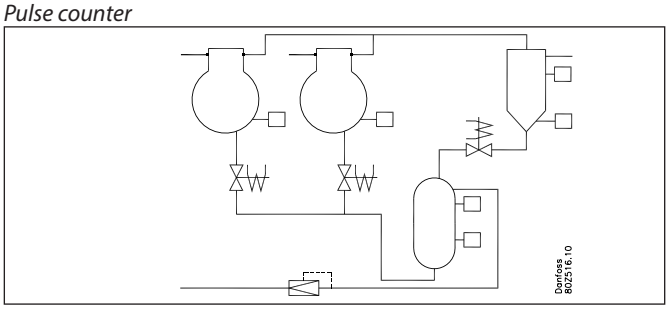
Control principle for pressure in the receiver

Pressostat



- In the case of lack of pressure difference to fill the MT compressors, the solenoid valve is opened in user defined pulses and the pressure is taken from the oil separator. The pulse length and the period time between the pulses is determined by the system and are the same as those set for the oil separator.
- When the pressure transmitter registers the required pressure, the pulses are stopped.
- Alarm limits and texts for maximum and minimum pressure, respectively, can be set.

Pulse counter



Here, the controller uses a pulse count to determine the pressure build-up in the receiver.
Basis: The controller has counted the number of the set pulses in a period time for all compressors. This value is divided by the number of compressors.
Reading: The controller registers the number of pulses sending oil to the compressors.
Action: When the measured number of pulses reaches a percentage of the basis (factory setting = 50%), the pulse sequence is started from the separator to the receiver.

The function is normally used only with MT compressors, but can also be used in MT+LT operation. This requires, however, an extra extension module, AK-XM 107A, which counts pulses from the LT circuit (the pressostat function is recommended instead).

Level signal
High and low level signals can also be received from the receiver. These signals are only used for monitoring and alarms.

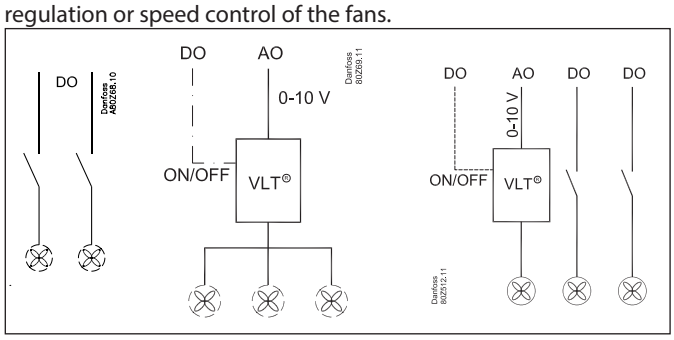
Miscellaneous
All oil valves are closed when the "Main switch" is off.

If you wish to carry out a manual oil injection, this can be done via the function "Manual operation". Here, you can send one or more pulses. The length of the pulse can be set in milliseconds.

If a compressor falls out due to lack of oil, it can be reconnected manually in the plant itself. This can be done via a pulse pressure on a defined input. There is one reset and this applies to all compressors. Upon reset, all the counters are reset.
It can also be reconnected via the service tool indicated in the “Safety monitoring” picture.

Condenser

Capacity control of the condenser can be accomplished via step regulation or speed control of the fans.



- Step regulation
  The controller can control up to 6 condenser steps that are cut in and out sequentially.
- Speed control
  The analog output voltage is connected to a speed control. All fans will now be controlled from 0 to max. capacity. If an ON/OFF signal is required it can be obtained from a relay output. Regulation can be carried out based on one of the following principles:
  - all fans operate at the same speed
  - Only the necessary number of fans is cut in.
  - Combination with one fan speed regulated and the rest step regulated.

Capacity control of condenser

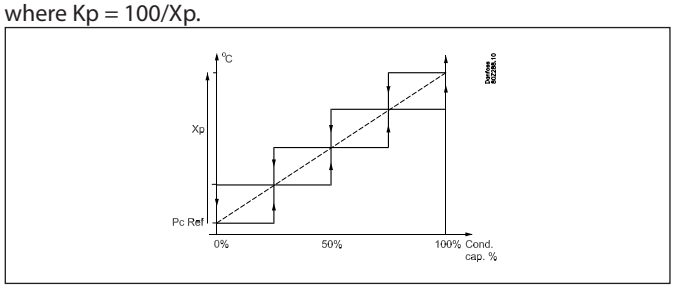
The cut-in condenser capacity is controlled by the condenser pressure's actual value and depends on whether the pressure is rising or falling. Regulation is performed by a PI controller which may however be changed into a P controller if the design of the plant necessitates this.

PI regulation

The controller cuts in capacity in such a way that the deviation between the actual condensing pressure and the reference value becomes as small as possible.

P regulation

The controller cuts in capacity that depends on the deviation between the actual condensing pressure and the reference value. The proportional band Xp indicates the deviation at 100% condenser capacity.
The adjustments are carried out using amplification factor Kp, where Kp = 100/Xp.



Regulating sensor selection

The capacity distributor can either regulate from the condenser pressure PC or from the average temperature S7. If the refrigerant is CO2 and transcritically regulated, use a temperature sensor Sgc, located at the outlet for the gas cooler.

Cap. Ctrl sensor = Pc / S7 / Sgc

If the regulation sensor is selected for media temperature S7, then Pc is still used as the safety function for high condenser pressure and will therefore ensure cut-out of the compressor capacity when condenser pressure is too high.

Handling sensor errors:
Cap. Ctrl. Sensor = Pc
If Pc is used as the regulation sensor, an error in the signal will result in condensator capacity being controlled as a function of the connected compressor capacity. The compressor regulation will remain normal.
Cap. Ctrl. Sensor = S7
If S7 is used as the regulation sensor, an error in this sensor will result in further regulation that follows the Pc signal, but in accordance with a reference that is 5K over the actual reference. If there is an error on both S7 and Pc, 100% condenser capacity cuts-in, but the compressor regulation remains normal.
Cap. Ctrl. Sensor = Sgc
In the event of failure this sensor switches over to Shp if installed. If Shp cannot provide a signal, the controller switches over to an "emergency cooler sequence" that attempts to maintain regulation.

Reference for condensing pressure

The reference for the regulation can be defined in two ways. Either as a fixed reference or as a reference that varies according to the outdoor temperature.

Fixed reference

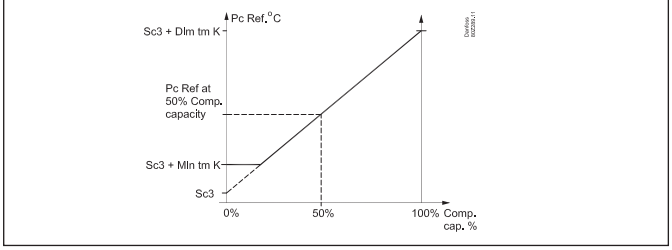
The reference for the condensing pressure is set in °C.

Floating reference

This function allows the condensing pressure's reference value to vary within a defined range. The reference varies according to the outdoor temperature and the connected compressor capacity. By combining floating condensing pressure with electronic expansion valves a lot of energy saving can be achieved. The electronic expansion valves enables the controller to decrease the condensing pressure according to outdoor temperature and thereby reduce energy consumption by around 2% for each degree the temperature can be decreased.
The measured outdoor temperature is also used by the controller to optimise the regulation algorithm. The function can be compared to a variable Kp value, which is higher during warm periods and lower during cold periods. There is no setting.

PI regulation

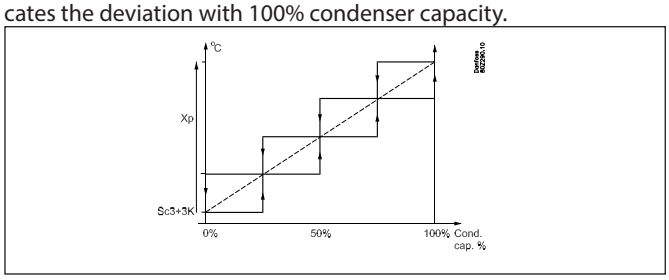
The reference is based on:
- the outdoor temperature measured with Sc3 sensor
- The minimum temperature difference between the air temperature and the condensing temperature at 0% compressor capacity.
- the condenser's dimensioned temperature difference between the air temperature and the condensing temperature at 100% compressor capacity (Dim tmK)
- how large a part of the compressor capacity has been cut in.



The minimum temperature difference (min tm) at low load should be set at approximately 6 K as this will eliminate the risk that all fans will be running when no compressors are running.
Set the dimensioned difference (dim tm) at max. load (e.g. 15 K).

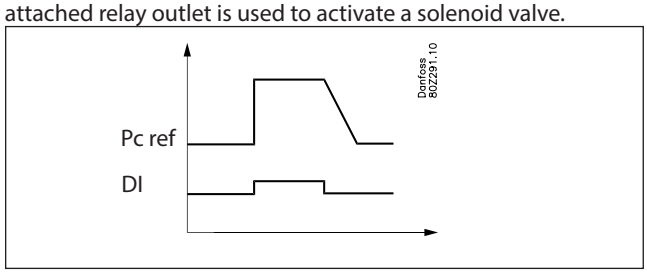
The controller will now contribute with a value to the reference which depends on how large a part of the compressor capacity has been cut in.

P-regulation
With P regulation the reference will be three degrees above the measured outdoor temperature. The proportional band Xp indicates the deviation with 100% condenser capacity.

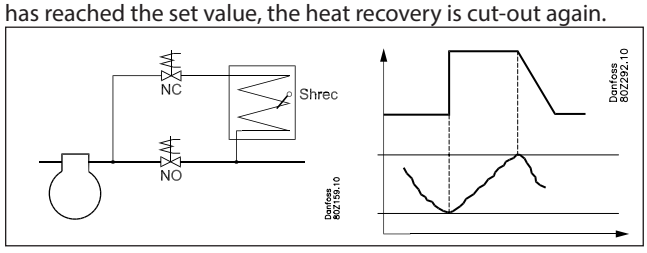


Heat recovery function (for all refrigerants except CO2. For CO2 see later section in the condensation description).
The heat recovery function can be used on the installation when you want to make use of warm gas for heating purposes. When the function is activated the reference for the condenser temperature will be raised to a set value and the attached relay outlet is used to activate a solenoid valve.
The function can be activated in two ways:

1. A digital input signal is received
   In this instance, the heat recovery function is activated via an external signal from, for example a building management system. When the function is activated the reference for the condenser temperature will be raised to a set value and the attached relay outlet is used to activate a solenoid valve.

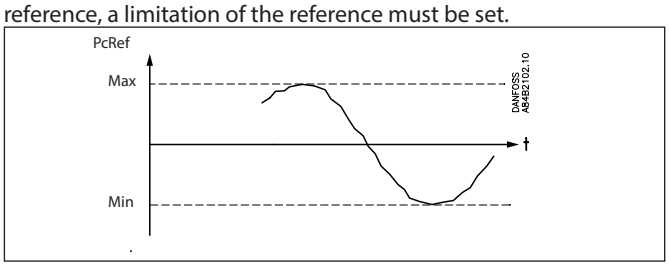


2. Use of a thermostat for the function.
   This function can be used with advantage where the heat recovery is used to warm up a water tank. A temperature sensor is used to activate/deactivate the heat recovery function. When the temperature sensor becomes lower than the set cut in limit, the heat recovery function is activated and the reference for the condenser temperature will be raised to a set value and simultaneously the chosen relay outlet is used to activate a solenoid valve which leads the warm gas through the heat exchanger in the water tank. When the temperature in the tank has reached the set value, the heat recovery is cut-out again.



In both cases it applies that when the heat recovery function is de-activated, the reference for the condensing temperature will then decline slowly in accordance with the set rate in Kelvin/minute.

Limitation of the reference
To safeguard yourself against a too high or too low regulation reference, a limitation of the reference must be set.



Forced operation of condenser capacity
Forced operation of the capacity can be arranged where the normal regulation is ignored.

The safety functions are cancelled during forced operation.

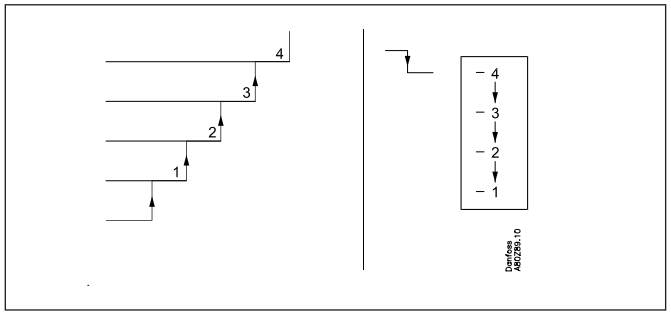
Forced operation via setting
The regulation is set to Manual.
The capacity is set in percent of the regulated capacity.

Forced operation of relays
If the forced operation is carried out with the switches at the front of an extension module, the safety function will register any exceeding of values and transmit alarms, if required, but the controller cannot cut the relays in or out in this situation.

Capacity distribution

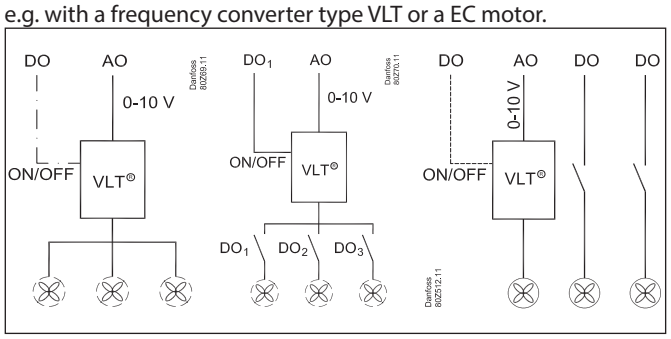
Step regulation

Cut-ins and cutouts are carried out sequentially. The last cut-in unit will be cut out first.



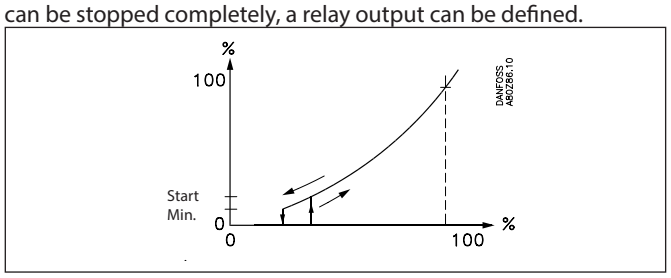
Speed regulation

When an analog output is used the fans can be speed regulated, e.g. with a frequency converter type VLT or a EC motor.



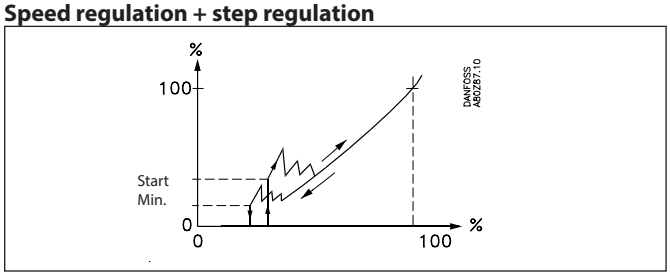
Joint speed regulation

The analog output voltage is connected to the speed regulation. All fans will now be regulated from 0 to max. capacity. If an ON/OFF signal is required for the frequency converter, so that the fans can be stopped completely, a relay output can be defined.

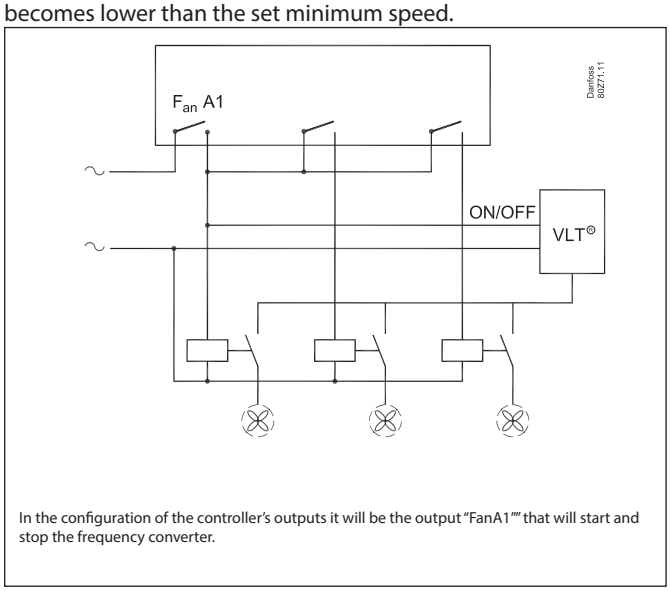


The controller starts the frequency converter when the capacity requirement corresponds to the set starting speed. The controller stops the frequency converter when the capacity requirement becomes lower than the set minimum speed.

Speed regulation + step regulation

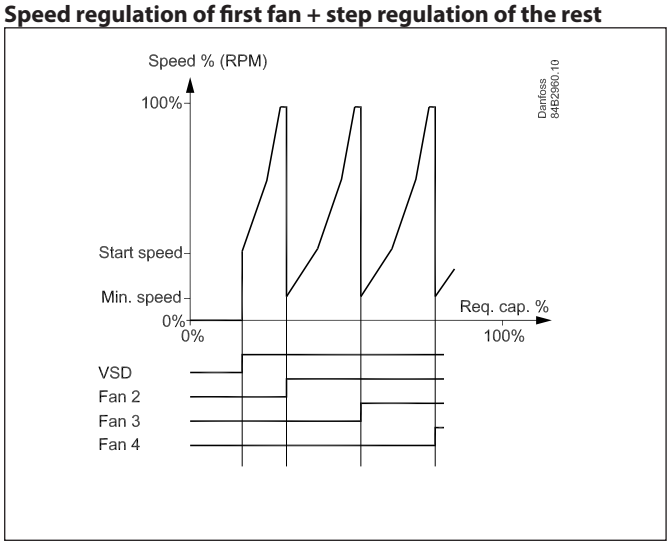


The controller starts the frequency converter and the first fan when the capacity requirement corresponds to the set starting speed.
The controller cuts in several fans step by step as the capacity requirement grows and then adapts the speed to the new situation.
The controller cuts out fans when the capacity requirement becomes lower than the set minimum speed.



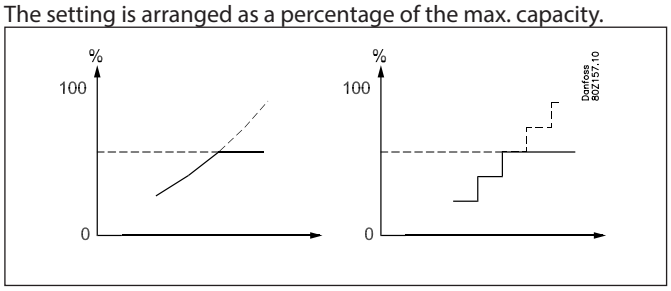
In the configuration of the controller's outputs it will be the output "FanA1"" that will start and stop the frequency converter.

Speed regulation of first fan + step regulation of the rest



The controller starts the frequency converter and increases the speed of the first fan.
If additional capacity is required, the next fan cuts in at the same time as the first fan switches to minimum speed. From here, the first fan can increase speed again, etc.

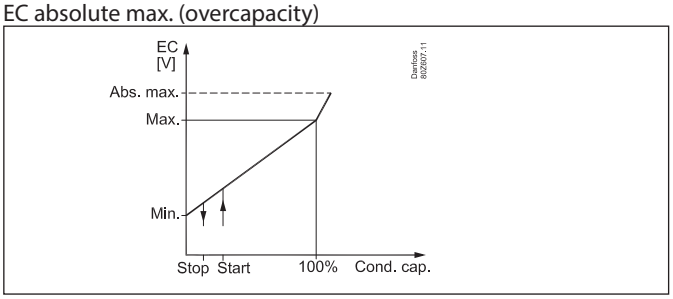
Capacity limitation during night operation
The function is used to reduce the noise from the fans to a minimum. It is primarily used in conjunction with a speed control, but it will also be active when steps are cut in and out.
The setting is arranged as a percentage of the max. capacity.



The limitation will be disregarded when safety functions Sd max. and Pc max. take effect.

EC motor

The voltage signal to the EC motor is defined by the following settings:
EC min (0%)
EC max (100%)
EC absolute max. (overcapacity)



Condenser couplings

Coupling of condenser steps
There are no time delays in connection with cutin and cutout of condenser steps beyond the time delay inherent in the PI/P-regulation.

Timer
The operating time of a fan motor is registered continuously. You can read out:
- operating time for the previous 24-hour period
- total operating time since the timer was last set to zero-set.

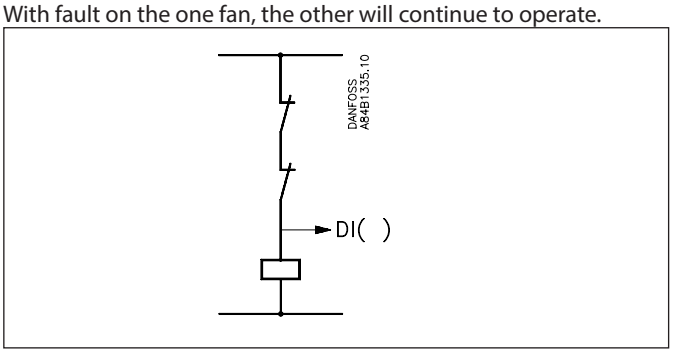
Coupling counter
The number of couplings is registered continuously. Here the number of starts can be read out:
- number during the previous 24-hour period
- total number since the counter was last set to zero-set.

Exercising fans
The last fans are unlikely to be activated during winter months. To ensure that the fans are 'exercised' a test will be carried out every 24 hours to check whether all relays have been in operation. The relays that have not been used will now be activated for 5 minutes (from 13:00) but with a pause of one hour between individual relays. A speed control is run at "Start speed".

Safety functions for condenser

Signal from fan and frequency converter's safety controls
The controller can receive signals on the status of each individual condenser step's safety circuit.
The signal is obtained directly from the safety circuit and connected to a "DI" input.
If the safety circuit is cut out the controller will give alarm.
Regulation continues with the remaining steps.

The ancillary relay outlet is not cut-out. The reason for this is that the fan are often connected in pairs but with one safety circuit. With fault on the one fan, the other will continue to operate.



Intelligent fault detection (FDD) on the condenser's air flow
(The function is not active when the selected refrigerant is CO2).
The controller collects measurements from the condenser control and will advise if/when the condenser's capacity is reduced. The most frequent reasons for the information will be:
- gradual accumulation of dirt on the fins
- foreign body in the suction
- fan stop

The function requires a signal from an outdoor temperature sensor (Sc3).

In order to detect accumulation of dirt it is necessary for the monitoring function to be connected to the relevant condenser. This is accomplished by tuning the function when the condenser is clean. The tuning must not be started until the plant has been run in and runs under normal operation conditions.

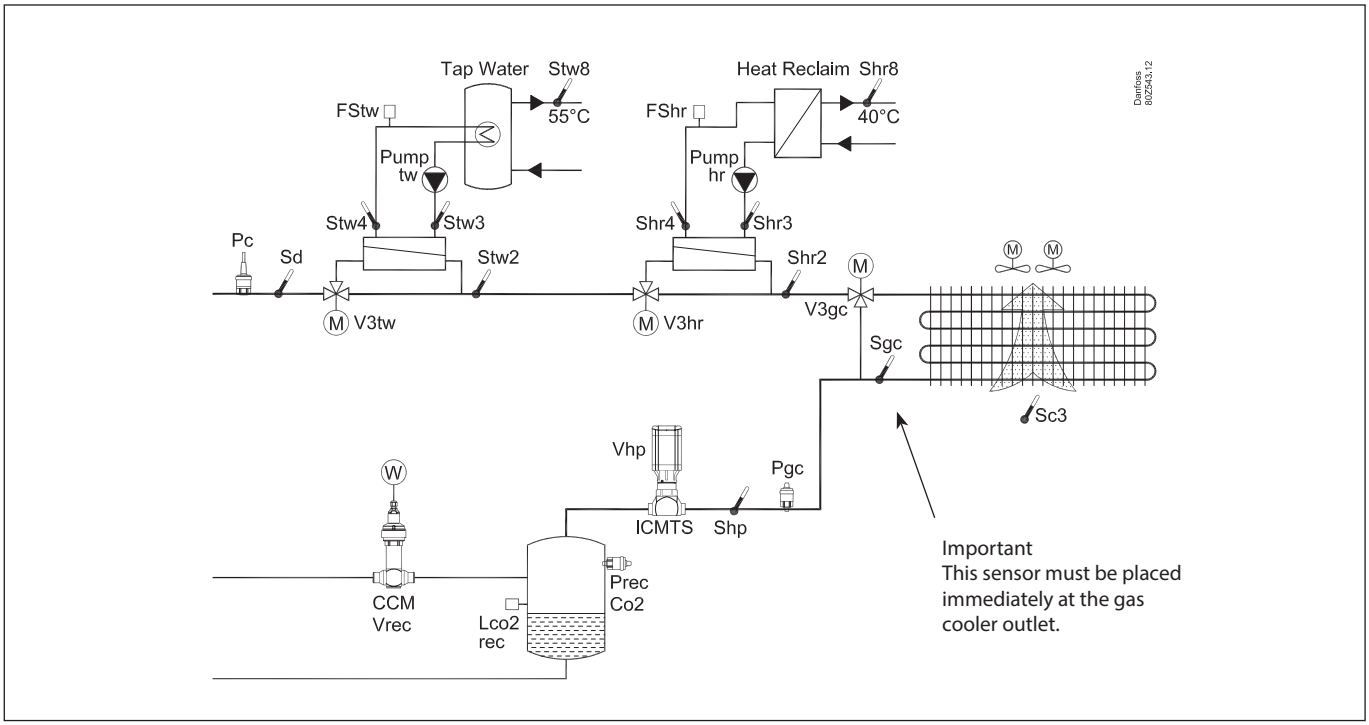
CO_2 transcritical system and heat recovery

General
When the refrigerant in the system is CO_2, the higher pressure and temperature make it possible to recover heat for tap water and heating. The excess heat is removed using a gas cooler.
Regulation is carried out during transcritical and subcritical states and the controller will control the gas pressure/condensing pressure so that the system achieves the optimum COP when the recovered heat is taken into account.

The regulation of the heat recovery circuits is done with regard to the cooling system. In the event of conflict, the safety situation is that the cooling system has higher priority than the recovery circuits.

The two heat recovery circuits can be considered as independent circuits - also with regard to the cooling system.
First, the circuit for hot tap water will take the energy it needs to use. The remaining energy is then available for use by the next circuit. This also takes what is available. If there is then any excess energy this is removed via the gas cooler.

There must be a cooling requirement in order to supply for heat recovery.



Info
In normal operating conditions, the temperature at Sd will be between 60 and 70°C - depending on whether it is winter or summer. If the "Heat reclaim" function is to raise the condensing pressure, the temperature may increase to 90° or higher.

The Sc3 sensor should be positioned so that it measures the air intake temperature for the gas cooler. If it measures a temperature that is too high, the system's COP will become impaired.

The Sgc signal must be stable. If this cannot be done using a system sensor, it may be necessary to use an immersion tube sensor.

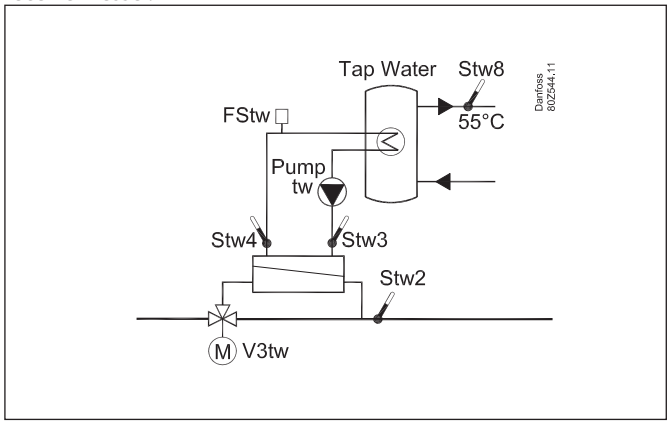
If the power supply to AK-PC 781 or the high pressure valve Vhp fails, the system cannot be controlled. We recommend installing an emergency supply (UPS) for both the controller and the valve to avoid faults. A relay in the UPS should be incorporated into the controllers safety circuit so that it can restart safely.

Remember the isolation amplifier
If signals are received from different controls, e.g. heat recovery for one of the inputs, a galvanically insulated module should be inserted.

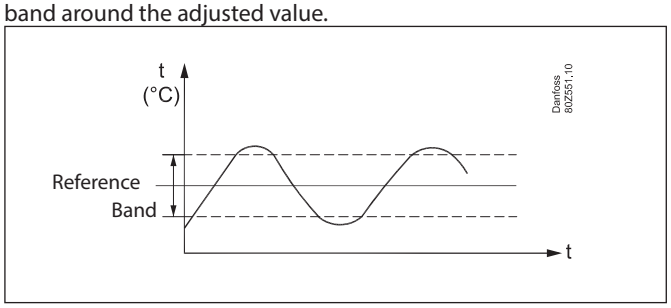
There are safety functions for the individual regulation functions, for example:
- Boiling at S3, S4 and S8
- A S3 temperature must be lower than the gas temperature that can be sent into the heat exchanger. If the S3 temperature is higher, the circuit is not connected.
The pump is kept running for a little while before and after the gas valves connect. It can take up to 2 minutes for the gas valve to change position.

Circuit for heat recovery or hot tap water

Application
This regulation can only be carried out when the selected refrigerant is CO_2, which makes it possible to supply hot gas for heating a receiver vessel.

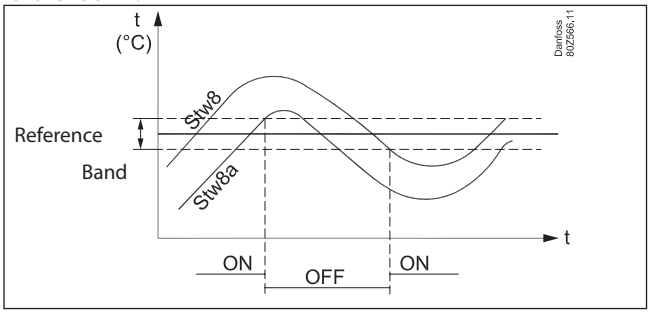


Reference
Regulation is done for a tap water temperature of typically 55°C, where the value is adjustable. A temperature sensor Stw8 is installed in the hot water receiver, and the temperature is held in a band around the adjusted value.



Valve - V3tw
When tap water heating is required, the gas valve changes over and routes the gas in through the heat exchanger.
When the temperature goes above the reference plus half the band, the gas will be routed outside of the heat exchanger.

Regulation
Regulation can be done using one of the following principles:
- Only Stw8. The temperature here is regulated using an on/off thermostat. The pump can be controlled on/off or variably.
- Stw4 - Stw3. Here "Delta T" over the heat exchanger is used for regulation. Here the pump must be controlled using variable speed. When the Stw8 temperature has been achieved, the gas is routed outside of the heat exchanger.
- Stw8 and Stw8a. Here regulation is done using the two temperature sensors in the receiver. Stw8 is placed at the top and Stw8a further down.



The pump is controlled via on/off and is connected when Stw8 is below the reference plus half the difference. It is disconnected when Stw8a is above the reference plus half the difference.

The pump - Pump tw
It is recommended to use a pump with variable speed, so that the regulation flows and does not display great fluctuations in the condensing pressure.

Flow switch - FStw
A flow switch should be installed for safety reasons, in case of pump failure. The controller will then disconnect the entire recovery circuit.

Sensors - Stw2, Stw3, Stw4 and Stw8
All sensors must be installed due to safety reasons:
Stw2: The controller must know the temperature of the gas that is sent for condensation
Stw3:Heat exchanger cold access. Used for temperature regulation
Stw4: Heat exchanger hot outlet Used for temperature regulation
Stw8: Receiver temperature and in relation to the reference.

Circuit for recovery for heating

Application
This regulation can only be carried out when the selected refrigerant is CO_2, which makes it possible to supply hot gas for heating a receiver vessel.
Regulation can be carried out using one of the following three principles, when the circuit calls for heat:
- 1. Basic control (no offset).
- 2. Offset of the condensing pressure (HP offset)
- 3. Offset and regulation of the gas cooler and pump (max. hr)

Generally, for all three principles:

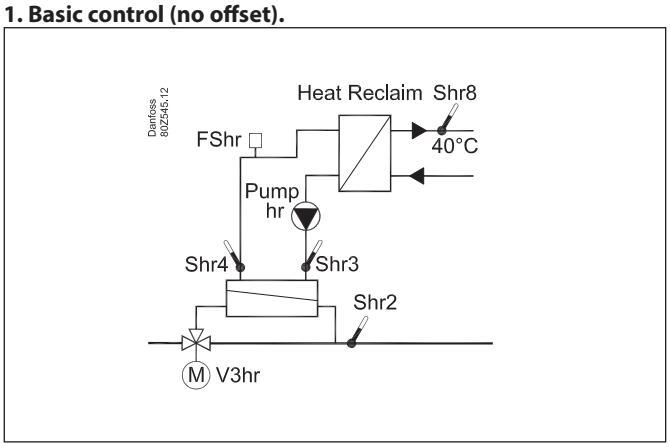
Valve - V3hr
When heating of the circuit is required, the gas valve will change over and route the gas in through the heat exchanger.
When the temperature goes above the reference plus half the band, the gas will be routed outside of the heat exchanger.

Pump - Pump hr
It is recommended to use a pump with variable speed, so that the regulation flows and does not display great fluctuations in the condensation pressure.

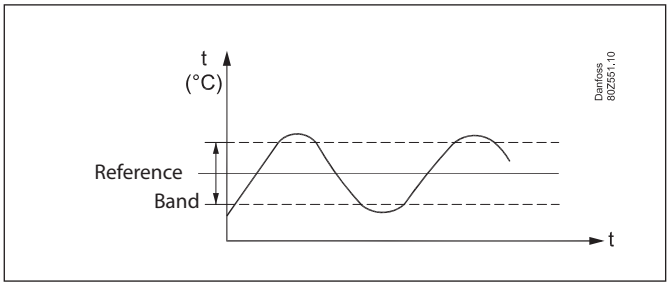
Flow switch - FShr
A flow switch should be installed for safety reasons, in case of pump failure. The controller will then disconnect the entire recovery circuit.

Sensors - Shr2, Shr3, Shr4 and Shr8 (Stw2/Sd)
All sensors must be installed due to safety reasons:
Shr2: The controller must know the temperature of the gas that is sent for condensation.
Shr3: Heat exchanger cold access. Used for temperature regulation
Shr4: Heat exchanger hot outlet Used for temperature regulation
Shr8: Receiver temperature and in relation to the reference.
Stw2 or Sd: The regulation must know the temperature of the gas that is sent into the heat exchanger.

1. Basic control (no offset).



Reference
Regulation is done using a receiver temperature of e.g. 40°C, the value is adjustable. A temperature sensor Shr8 is installed in the receiver, and the temperature is maintained in a band around the selected value.

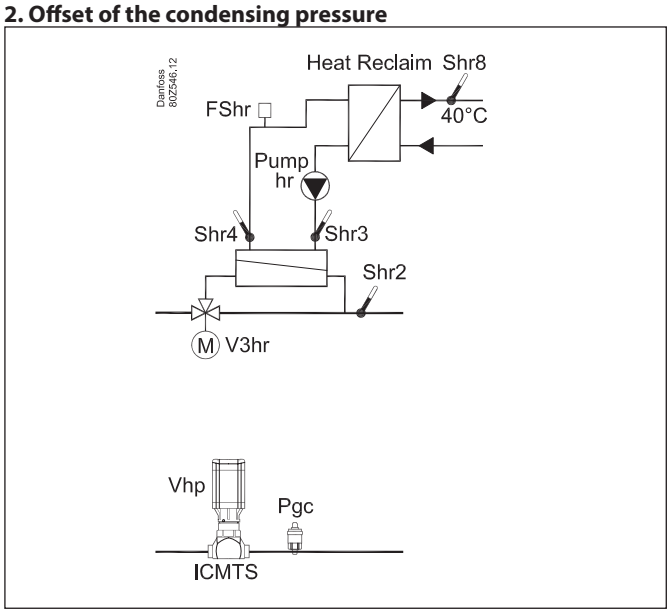


When the temperature goes above the reference plus half the band, the gas will be routed outside of the heat exchanger.

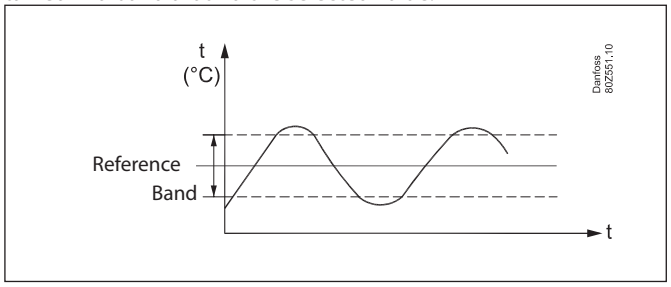
Regulation
The following can be used as a regulation sensor:
- Shr8 only
- Shr4
- Delta T via heat exchanger (Shr4-Shr3) of e.g. 4K, but still using Shr8 as a reference.

The pump can be controlled on/off or variably. For Shr4 or DeltaT regulation it must be controlled variably. During variable operation the pump will stop when the regulation desires a lower capacity than the selected min. speed capacity for the pump.

2. Offset of the condensing pressure



Reference
Regulation is done using a heat exchanger temperature/receiver temperature of e.g. 40°C, the value is adjustable. A temperature sensor Shr is installed in the receiver and the temperature is maintained in a band around the selected value.

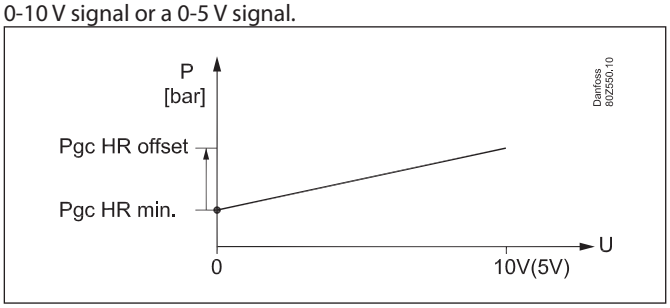


When the temperature goes above the reference plus the half band, the gas is routed around the heat exchanger.

Regulation
The following can be used as a regulation sensor:
- Shr8 only
- Shr4
- Delta T via the heat exchanger (Shr4-Shr3) of e.g. 4K, but still using Shr8 as the thermostat sensor.

The pump can be controlled on/off or variably. For Shr4 or DeltaT regulation it **must** be variably controlled. During variable operation the pump will stop when the regulation request a lower capacity than the selected min. speed capacity for the pump. .

Increasing the condensing pressure
When the temperature is below the reference and heat recovery is carried out, the condensation pressure may be increased.
The pressure is measured using the pressure transmitter Pgc and the controller at the valve Vhp.
How much the pressure shall be increased by is determined using a setting and an analogue voltage signal. The signal must be a 0-10 V signal or a 0-5 V signal.



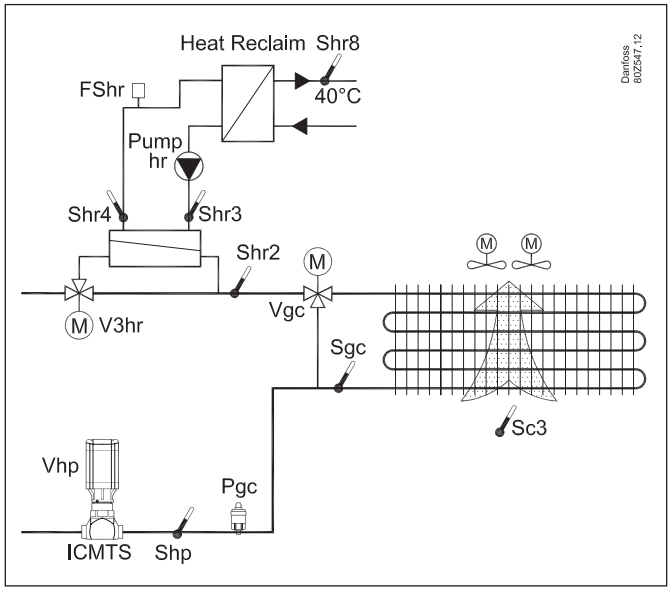
During heat recovery and a signal of 0 V, the pressure is increased to "Pgc HR min."
At max. signal (e.g. 10 V) the pressure will increase according to the setting "Pgc HR offset".
.

Up to 5 signals can be received from external regulations. They can all increase the pressure, and the controller will use the signal that requires the largest offset. The signal employed is filtered over a time period. The length of the period can be set.

Relay output
A relay can be reserved that will pull in if the received signal exceeds 9.5 V (4.75 V) for more than 10 minutes.
The relay is defined in the function: "Additional heat output".

Remember the isolation amplifier
If signals are received from different controls, e.g. heat recovery for one of the inputs, a galvanically insulated module should be inserted.

3. Offset and regulation of the gas cooler and pump (max. heat recovery)



Reference
Regulation is done using a heat exchanger temperature/receiver temperature of e.g. 40°C, the value is adjustable. A temperature sensor Shr is installed in the receiver, and the pump speed is controlled so that the temperature is kept to the set value.
The controller does not start until a signal has been received from the external controller and the signal has started the pump.

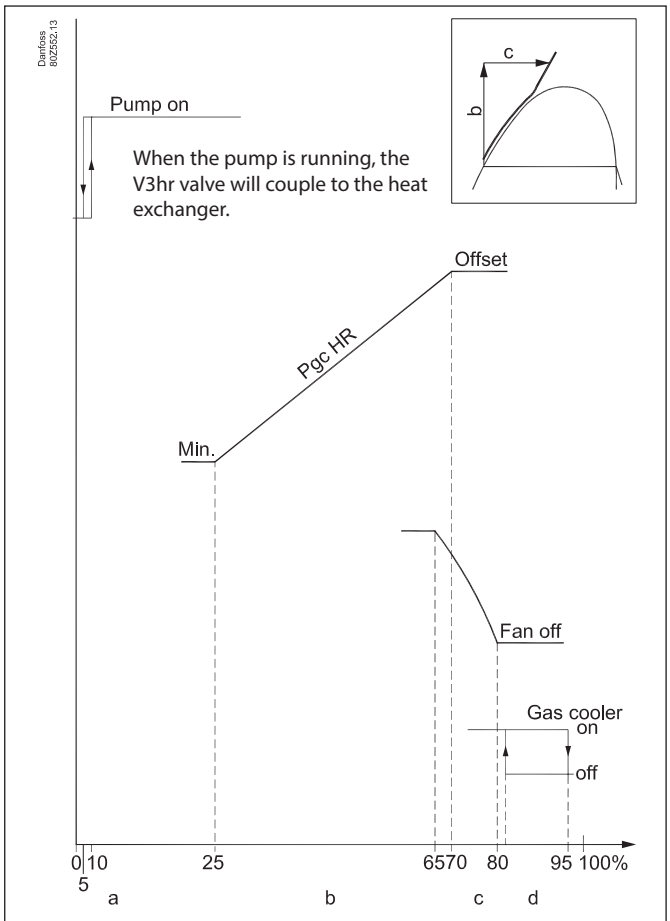
Regulation
The following can be used as a regulation sensor:
- Shr8
- Shr4
- Delta T via heat exchanger (Shr4-Shr3) of e.g. 4K.

The pump can be controlled on/off or variably (recommended). For Shr4 or Delta T regulation it **must** be controlled variably. During variable operation the pump will stop when the regulation require a lower capacity than the selected min. speed capacity for the pump.

Increasing the condensation pressure
The external controller will emit a signal between 0 and 10 V (0-5 V), which the controller will use to start the following functions in order to achieve maximum heat recovery:

1. Signal on DI input for heat recovery is received
2. The pressure Pgc is increased to Pgc HR min.
3. The external voltage signal is registered (the higher the value, the greater the need for heat).
   The signal must be a 0-10 V signal or a 0-5 V signal. The signal is converted by the controller to 0-100% capacity and will have the following impact:
   a. Control of the pump
      The pump is released to operation. The valve is coupled up.
   b. Pressure increase
      The pressure is measured using the pressure transmitter Pgc and the controller at the valve Vhp. If necessary, the pressure will be kept at a value between Pgc HR min. and Pg HR offset.
   c. Fan control
      The fan's capacity is tuned down so the temperature is increased. The temperature is measured with Sgc.
      If necessary, the temperature reference will not be increased to the value Max. Cond. Ref. Offset. At this value, the fans will stop completely.
   d. Disconnect the gas cooler
      The valve V3gc routes the gas outside the gas cooler and the sensor Shp now registers the temperature instead of Sgc.
      (If the controller has had the gas cooler disconnected, a timer function will start when the system switches over once again to gas cooler operation. The timer function will keep the regulation in gas cooler mode for 3,600 seconds, until a disconnection is permitted again.)

The "Heat recovery status" picture shows the current regulation status.



The values for the various capacity points are adjustable.

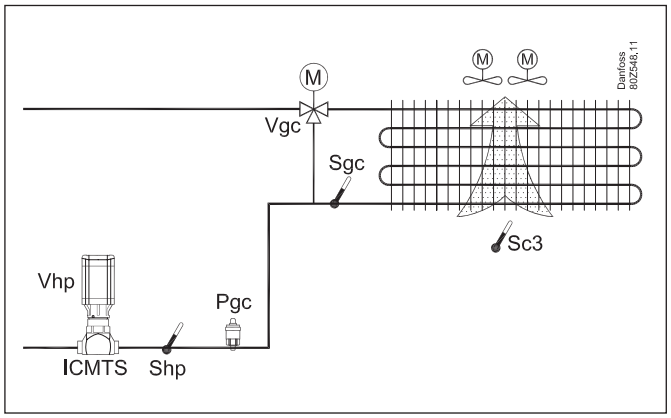
Up to 5 signals can be received from external regulations. The controller will use the signal that requires the most capacity.
The signal employed is filtered over a time period. The length of the period can be set.

Relay output
A relay can be reserved that will pull in if the received signal exceeds 9.5 V (4.75 V) for more than 10 minutes.
The relay is defined in the function: "Additional heat output".

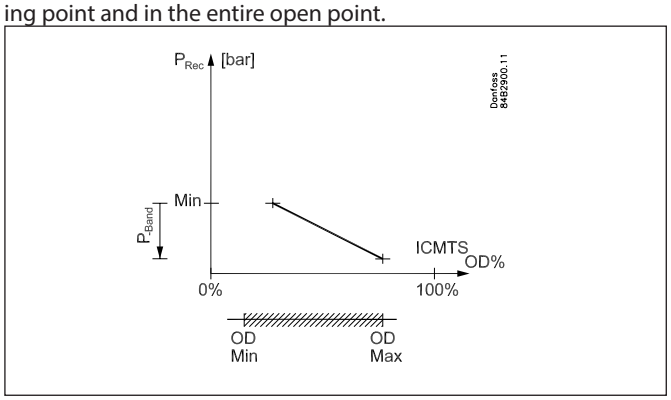
Circuits for control of CO2 gas pressure

Application

The function can be used in systems with transcritical and subcritical cooling control systems where CO2 is used as a refrigerant. The controller regulates the pressure in the gas cooler (condenser) so that the system achieves the optimal COP.
The controller will always optimise to a subcritical state.



The pressure in the gas cooler is controlled by the valve.
Instead of an ICMTS valve, a CCMT valve with stepper motor can be used.
Regulation must have inputs from both a pressure transmitter Pgc and a temperature sensor Sgc. Both must be fitted in the outlet immediately after the gas cooler. If the gas can be routed outside of the gas cooler, a Shp sensor **must** be installed. Should the Shp sensor record too high a temperature, the gases will be routed through the gas cooler once again.
The valve is an ICMTS valve, which has been specially developed for the pressure conditions that exist in a transcritical CO2 system.
The motor section of the valve is an ICAD actuator and is controlled by a 0-10 V signal from the controller.
The valve's degree of opening can be restricted both at the closing point and in the entire open point.

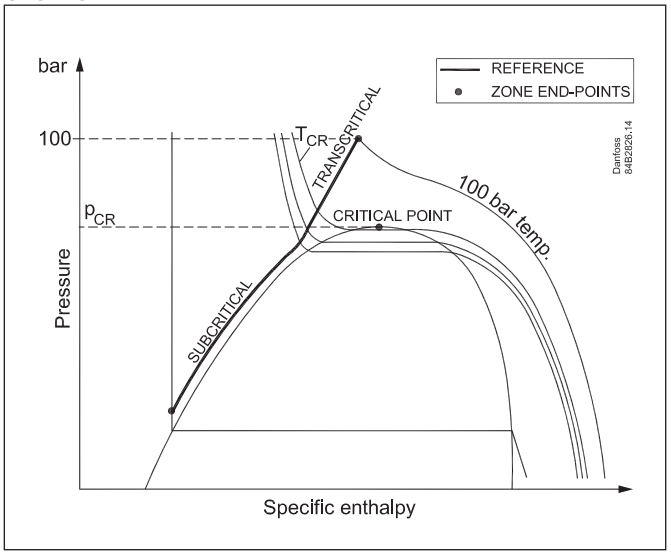


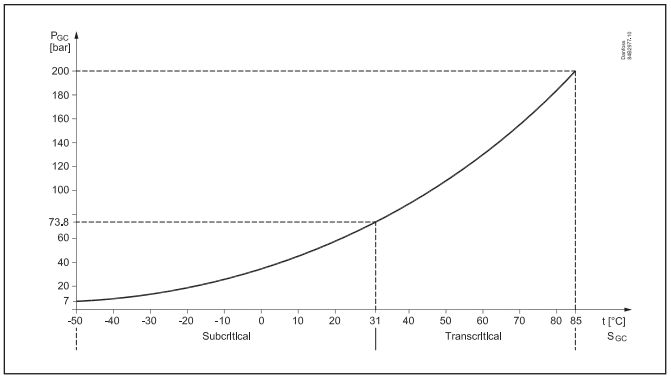
The settings OD Min. and OD max. are adjusted as % of the degree of opening and will restrict the voltage signal for the valve.

Maximum COP control

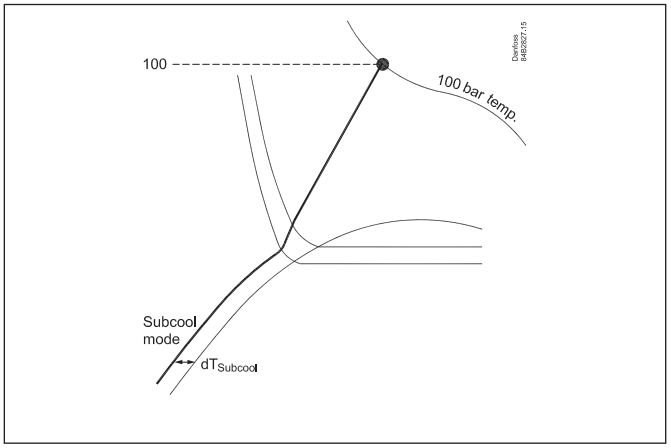
During normal operation without override, the controller will maintain the optimum pressure in the transcritical area.

Overview





Reference curve

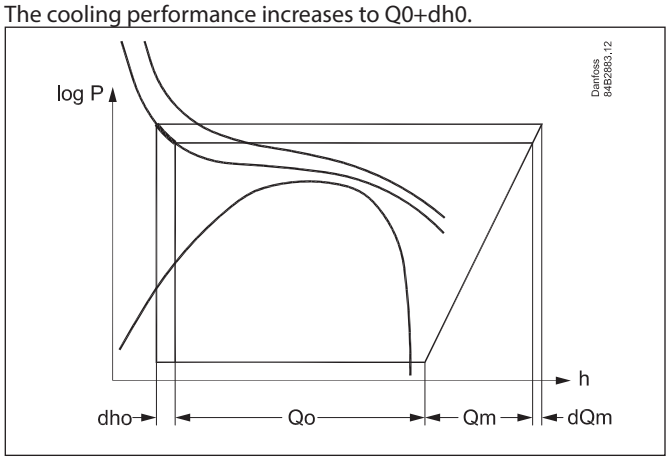


The controller is pre-programmed to follow the optimal COP from the pressure/enthalpy chart. The top point is defined at 100 bar, 39°C. (Optimal theoretical COP is achieved at the curve that passes through 100 bar and 39°C. The point of intersection can be changed by setting a value other than the default).
Regulation will now follow the set reference curve, but will never go above the set permitted max. pressure for the gas cooler.
The current reference can be read from the controller's overview screen.

Subcooling

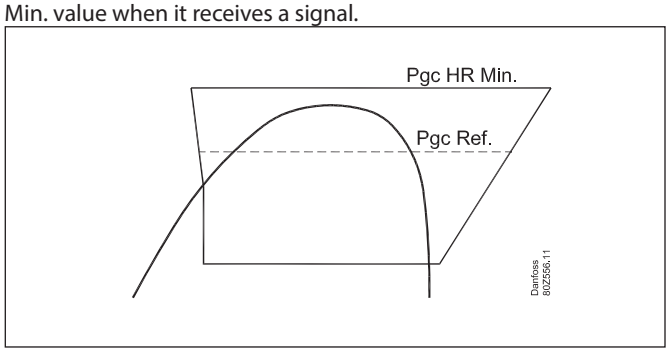
Subcooling can be used in the subcritical range.

Extra refrigeration capacity ("extra compressor")
This function improves the system's refrigeration capacity by increasing the pressure in the gas cooler. The function will start when the compressor capacity has been at 100% for 5 minutes. The cooling performance increases to Q0+dh0.



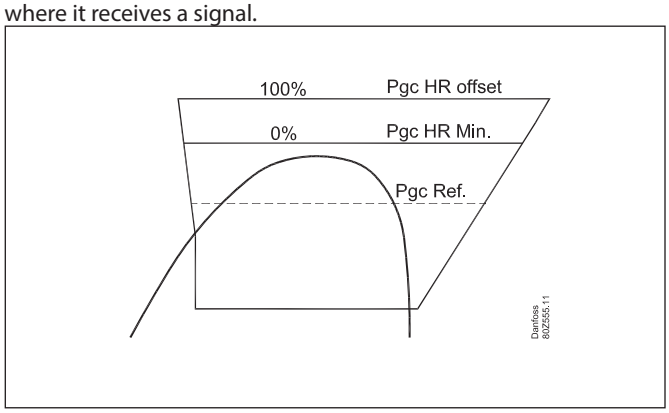
The function also increases the load on the compressor motor as pressure increases. Power consumption increases to Qm+dQm.

Increasing pressure reference with heat recovery
The function will increase the gas pressure reference to the Pgc HR Min. value when it receives a signal.



The function is activated by signal from the heat recovery

Increasing pressure reference with heat recovery, variable reference
The function will increase the gas pressure reference to the value where it receives a signal.



The function is activated by a signal from the heat recovery.
- From ON at 0%: Here the reference is changed to "Pgc HR Min."
- To ON at 100%: Here the reference will increase further using the setting "Pgc HR offset".
- Between 0 and 100% the reference is variable.

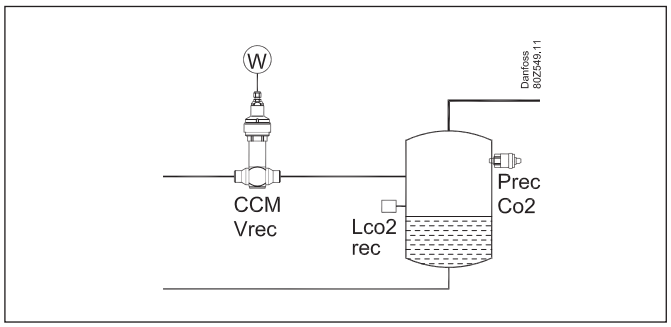
Start-up at a very low temperature
It will be necessary to route the gas outside of the gas cooler if the gas temperature is too low.
Temperature limits are set under the function **"Bypass low limit".** When the function is active, the gas temperature is measured by the Shp sensor. When the sensor records a value that is 5K higher than the set value, it will switch back again so that the gas is routed through the gas cooler. The switch will only take place after the pre-set delay time **"Bypass permitted after"** has passed.

Warning
Remember that the controller controls the gas pressure. If the regulation is stopped by the internal or external main switch, this control will stop as well.
Risk of loss of charge.

If the compressors are stopped via the function "External compressor stop", control of the gas pressure will continue.

Receiver control

The receiver pressure can be controlled so that it is kept at a set reference point. This control requires the installation of an CCM valve a (ETS valve) and a pressure transmitter. It is possible to regulate using two parallel valves.
If only monitoring and not control is required, the valve should not be installed. Install the pressure transmitter only.



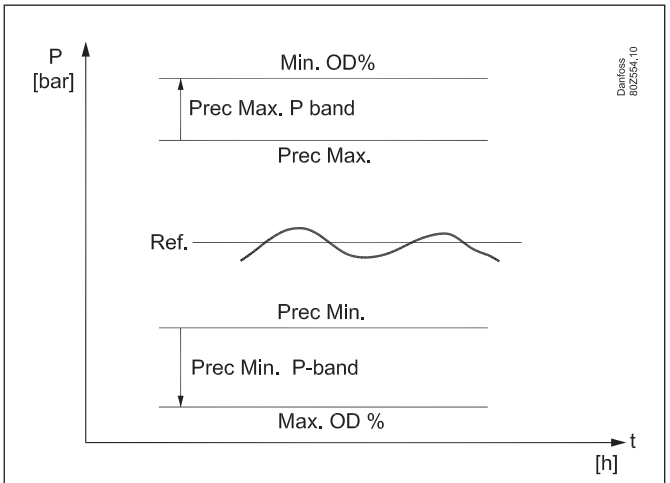
There are two safety functions for the receiver. They are only available for gas-cooled regulation.
A P-belt must be installed to be able to regulate the function, but both are standard set to zero, which makes the function inactive.

Receiver pressure's max. limit
Set a max. receiver pressure. If the controller register receiver pressure beyond the set value, the ICMTS valve will be closed. The opening degree will be linear through the p-band so that the ICMTS valve will be closed by pressing 'set max. receiver pressure' plus 'set-p-band'.
If the valve's opening degree is set to a limited value and cannot be fully closed, the set opening degree value will be at the pressure 'set max. receiver pressure' plus 'set p-band'.
As such, gas can still be sent through the valve.

Receiver pressure's min. limit:
A minimum receiver pressure limit can be set. If the controller register receiver pressure below the set value, the ICMTS valve will be opened. The opening degree will be linear through the p-band, and the maximum permitted opening degree of the ICMTS will be present by pressing 'set min. receiver pressure' minus 'set-p-band'.
If the setting of the valve's opening degree is limited and it cannot be fully opened, the set opening degree value will be at the pressure 'set min. receiver pressure' minus 'set p-band'.

Hot gas dump
The controller has a function that can turn on the hot gas to the receiver if the pressure becomes lower than the set value. The hot gas will shut off again when the pressure exceeds the difference.

Stop of compressors
If the compressors are stopped via the function "External compressor stop", the reference for the receiver control will be to the setting "Max. receiver pressure".



Regulation limitations of the receiver pressure

Note
The PI regulation of the receiver pressure must have space to regulate without restrictions.
This means that there should be sufficient space for the PI regulation to move around the reference, i.e. at least 2-3 bars – both over and below the reference.
The value is very dependent on the tuning of the PI regulation and the system dynamics.
An example may be a 40-bar plant in which the receiver's reference pressure is set to 35 bars. Here the system can interfere with normal regulation because the high pressure limit is very stringent.

COP optimisation
As a transition to this receiver control, a separate compressor control can be installed, which will optimise COP via parallel compression.
This function is described on the next page.

Parallel compression

Principle
On transcritical systems installed in slightly warmer surroundings than normal, the COP will be significantly improved by using parallel compression.
One or more compressors are used to help maintain the receiver pressure during warm periods when the outdoor temperature becomes high — primarily during the summer months.

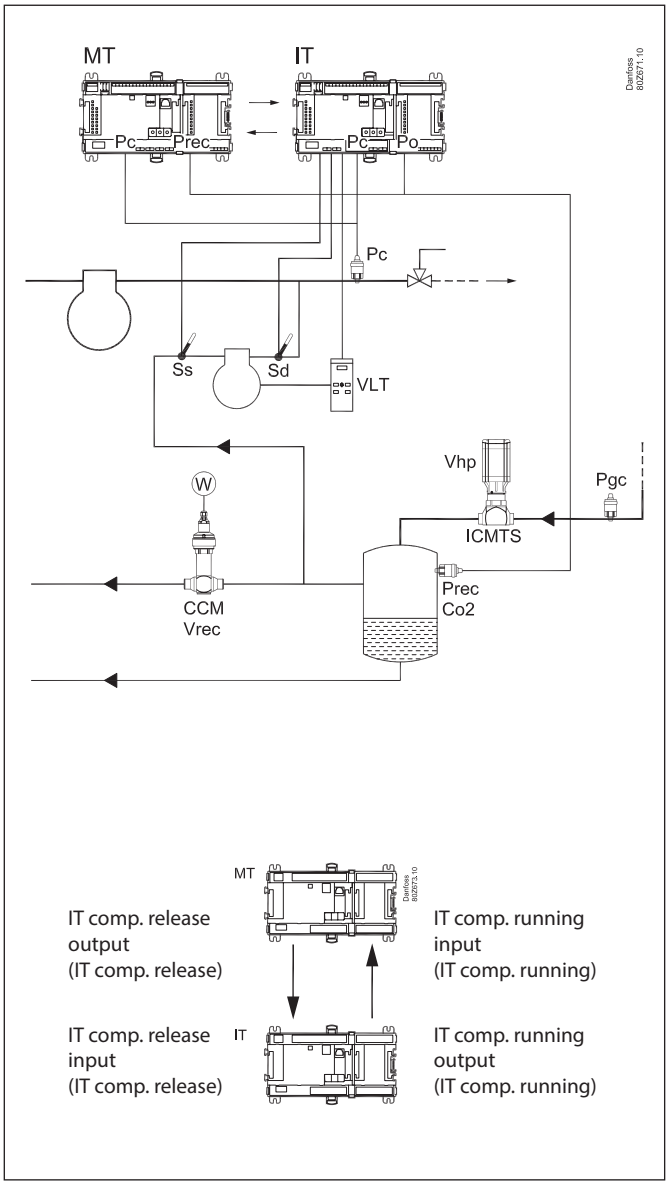
The ordinary capacity regulation is carried out by two AK-PC 781 units. One is for low temperature regulation (LT), and the other is for medium temperature regulation (MT). MT regulation also controls the entire condenser circuit, with heat recovery, gas cooling and receiver pressure.

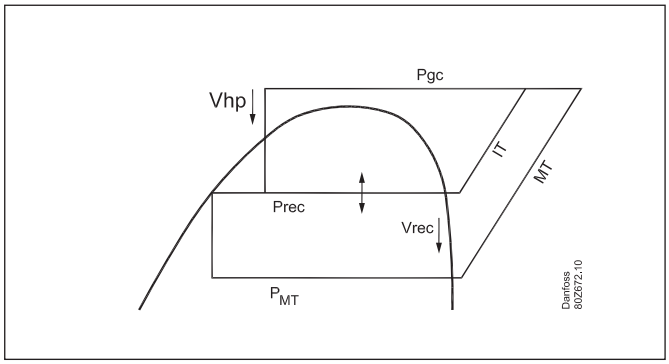
The parallel compression (intermediate temperature, 'IT') is controlled by the third AK-PC 781. It receives signals from two pressure transmitters and from the controller on the MT circuit, and it will start the compressor as needed, so that the receiver pressure is kept at the desired level. The compressor capacity will be variable, and the controller will emit a 0-10 V signal that indicates the desired capacity.

The function is activated by the MT controller, which regularly records the opening degree of the Vrec valve. When the opening degree is greater than the set value, the MT controller will pull a relay. This signal is recorded by the IT controller, which starts the IT compressor. The controller will now speed-regulate the IT compressor so that the pressure in the receiver is kept at the desired level.

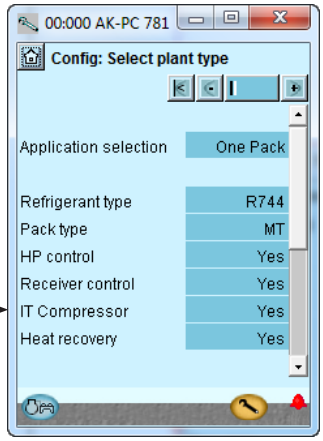
When the IT compressor is running, the IT controller will pull a relay. This is recorded by the MT controller, which then closes the Vrec valve.
The reference for the receiver pressure is raised to the max. when the IT compressor is running.

When the IT capacity's need drops to min. capacity, the compressor will stop, the signal (IT relay) to the MT controller will disappear, and the MT controller will assume pressure control of the receiver by regulation of the Vrec valve.

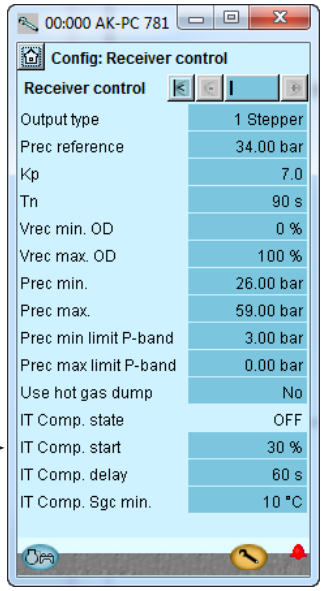




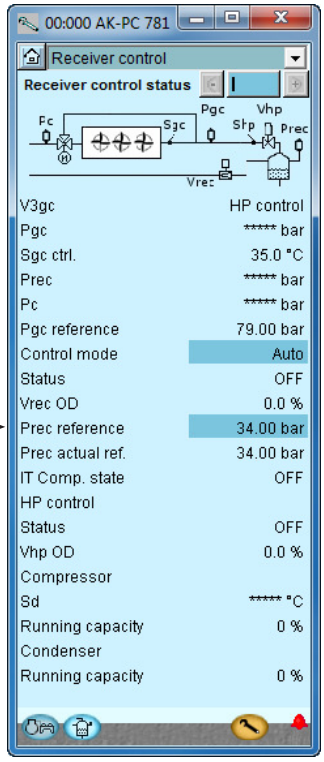
Settings in MT controller



Initiates coordination with the IT controller.
- Relay output, which emits signals.
- DI input, which receives signals when the IT compressor is running.



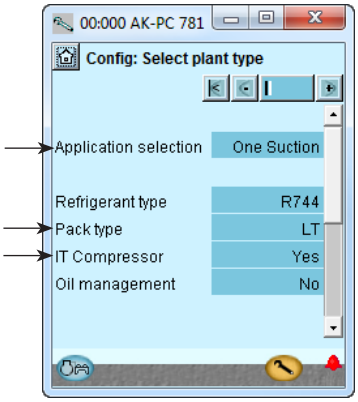
The Vrec valve's opening degree when the parallel compression is to start.
The start signal is first emitted when the opening degree is higher during the entire delay period.
The function will not come into effect if Sgc detects a temperature that is lower than the set value.



The reference for the receiver pressure is set in relative bar.

(The "IT comp. state" read-out is the signal received from the IT controller.)

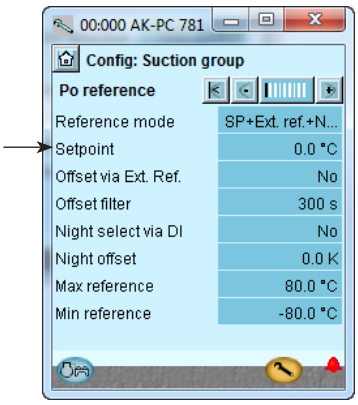
Settings in IT controller



Select suction group

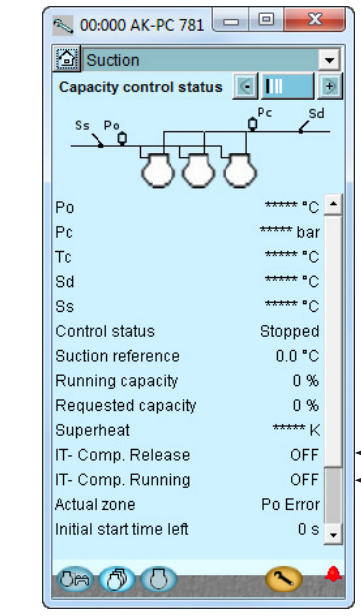
Select LT

Select IT compressor
From where the coordination with the MT controller is initiated.
- DI input, which receives signals when the IT compressor is to begin.
- Relay output, which emits signals when the compressor is running.



The reference in the IT controller is set in °C.
(The receiver pressure is set in relative bar.)

Receiver pressure [bar relativ]	Po Ref [°C]
34	0
35	1
36	2
37	3
38	4
39	5
40	6
41	7
42	8

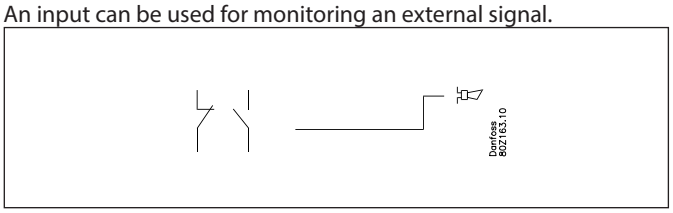


The receiver pressure, Prec, must be connected to the Po input on the IT controller.

Signal from MT
Signal to MT

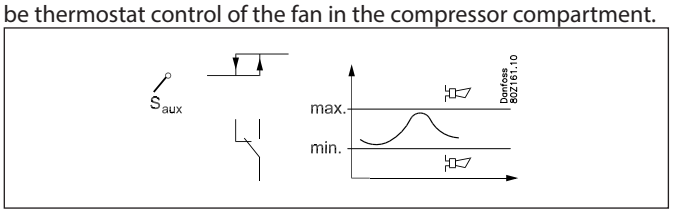
General monitoring functions

General alarm inputs (10 units)
An input can be used for monitoring an external signal.



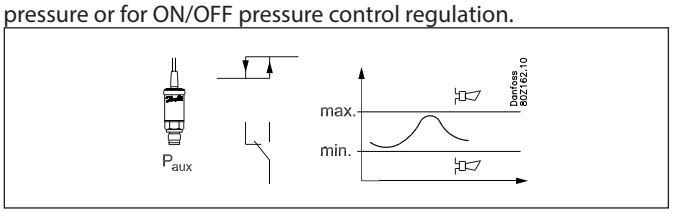
The individual signal can be adapted to the relevant use as it is possible to give the alarm function a name and to indicate your own alarm text.
A time delay can be set for the alarm.

General thermostat functions (5 units)
The function may freely be used for alarm monitoring of the plant temperatures or for ON/OFF thermostat control. An example could be thermostat control of the fan in the compressor compartment.



The thermostat can either use one of the sensors used by the regulation (Ss, Sd, Sc3) or an independent sensor (Saux1, Saux2, Saux3, Saux4).
Cutin and cutout limits are set for the thermostat. Coupling of the thermostat's output will be based on the actual sensor temperature. Alarm limits can be set for low and high temperature, respectively, including separate alarm delays.
The individual thermostat function can be adapted to the relevant application as it is possible to give the thermostat a name and to indicate alarm texts.

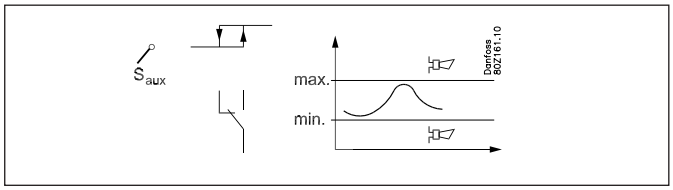
General pressure control functions (5 units)
(If the receiver is being pressure controlled, one of the five is used for this function. This means that there subsequently are four general pressure switches.)
The function may freely be used for alarm monitoring of plant pressure or for ON/OFF pressure control regulation.



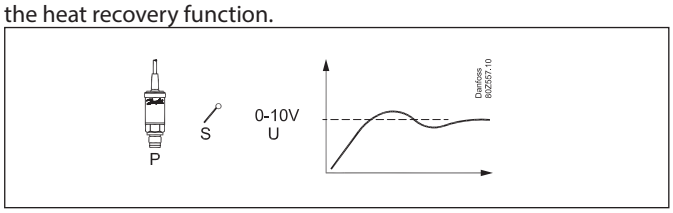
The pressure control can either use one of the sensors used by the control function (Po, Pc) or an independent sensor (Paux1, Paux2, Paux3).
Cutin and cutout limits are set for the pressure control. Coupling of the pressure control's output will be based on the actual pressure. Alarm limits can be set for low and high pressure, respectively, including separate alarm delays.
The individual pressure control function can be adapted to the relevant application as it is possible to give the pressure control a name and indicate alarm texts.

General voltage input with ancillary relay (5 units)
5 general voltage inputs are accessible for monitoring of various voltage measurements of the installation. Examples are monitoring of a leak detector, moisture measurement and level signal - all with ancillary alarm functions. The voltage inputs can be used to monitor standard voltage signals (0-5V, 1-5V, 2-10V or 0-10V). If required, one can also use 0-20mA or 4-20mA if external resistance is placed at the inlet to adjust the signal to the voltage. A relay outlet can be attached to the monitoring so that one can control external units.

For each inlet, the following can be set/read out:
- Freely definable name
- Selection of signal type (0-5V, 1-5V, 2-10V, or 0-10V)
- Scaling of read-out so it corresponds to measuring unit
- High and low alarm limit including delay times
- Freely definable alarm text
- Attach a relay output with cut in and cut-out limits including delay times



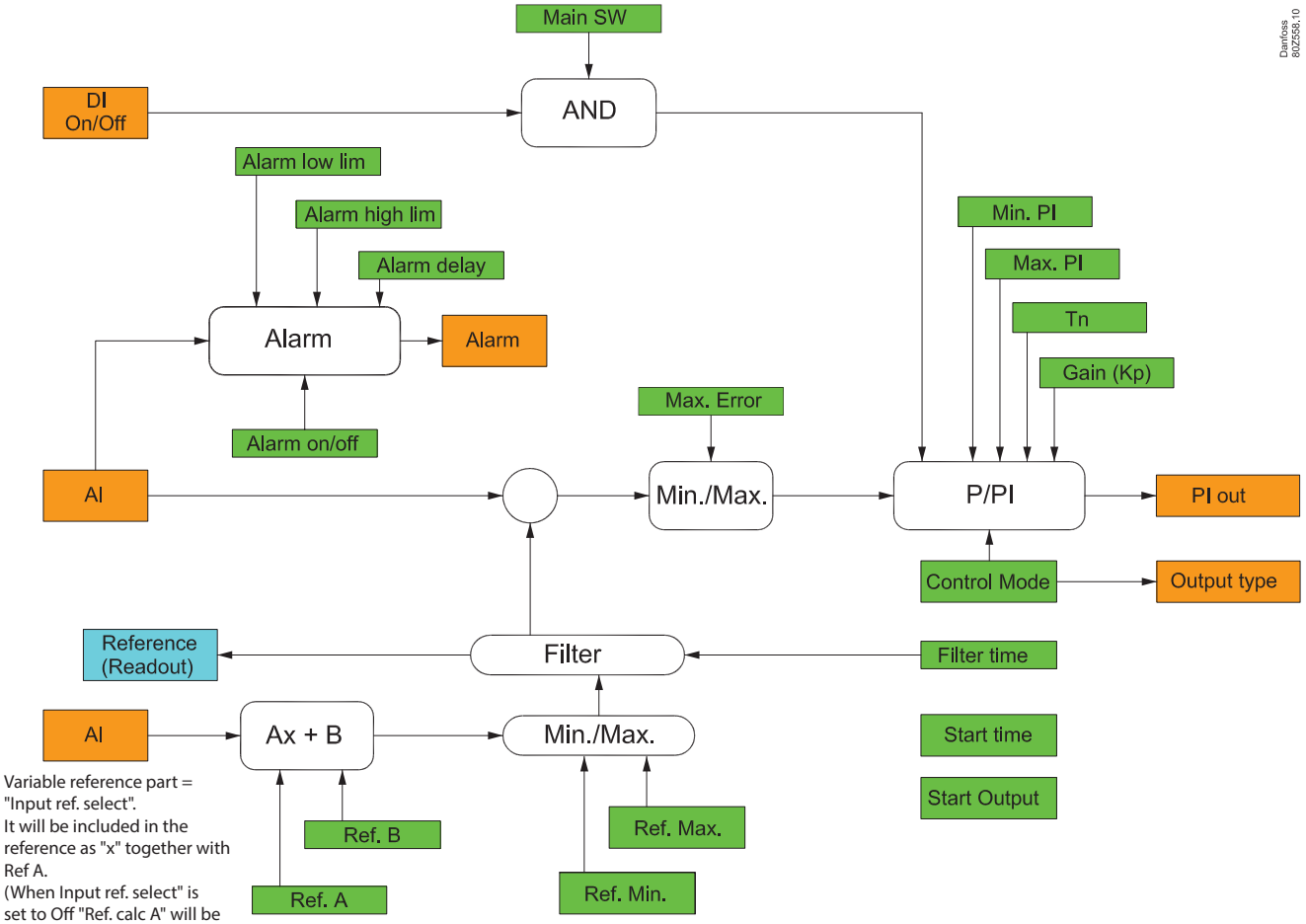
General PI functions (3 units)
The function can be freely used for controlling a required function, or it can be used to send signals to the controller regarding operating states. An example could be an out/in control for the use of the heat recovery function.



Signals can be received from the following:
- Temperature sensor
- Pressure transmitter
- Saturation temperature
- Voltage signal
- Internal signals such as: Tc, Pc, Ss and Sd

Signals can be sent to the following:
Voltage signal
Valve with stepper motor
PWM (pulse width modulated) signal for AKV valve.

The PI function is shown overleaf.



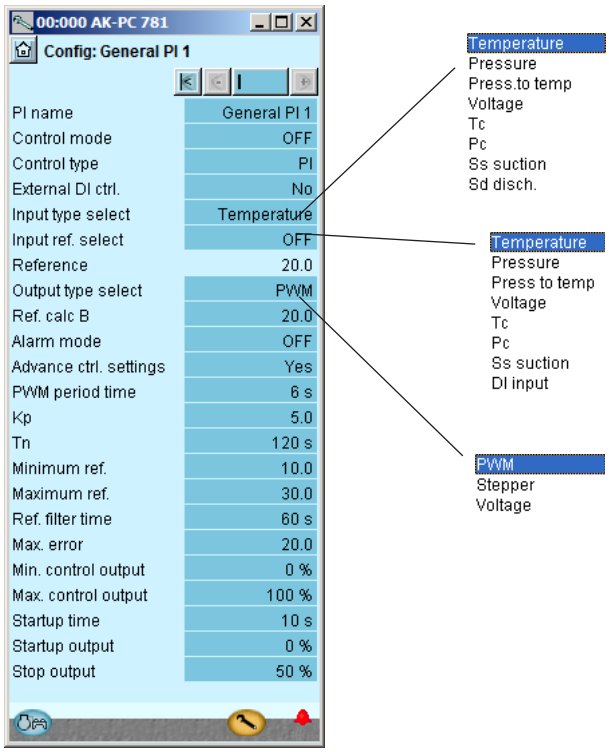
General

Signal and setting values are converted and adjusted as a percentage value of the signal.

A slow process will normally not be critical for the setting of P-part and I-part.
However, if the process is quick, more careful setup is required.

A general balancing might be:
- Check max. and min. settings
- Increase the integration time so that it is not mixed up with the balancing
- Reduce Kp to start with
- Start the process
- Adjust Kp until the process starts fluctuating and is constantly fluctuating
- Adjust Kp to half the value
- Adjust Tn down until the process starts fluctuating again
- Adjust Tn to double values

Settings



Miscellaneous

Main switch
The main switch is used to stop and start the controlling function.

The switch-over has 2 positions:
- Normal controlling state (Setting = ON)
- Control stopped. (Setting = OFF)

In addition, one can also choose to use a digital input as an external main switch.

If the switch-over or the external main switch is set at OFF, all the control's functions are inactive and an alarm is generated to draw attention to this – all other alarms cease.

External switch for stopping compressors
The switch will stop the compressors, but all other functions will continue to be regulated.

Refrigerant
Before regulation can be commenced, the refrigerant must be defined.
You can select one of the following refrigerants:

1 R12	11 R114	21 R407A	31 R422A
2 R22	12 R142b	22 R407B	32 R413A
3 R134a	13 User defined	23 R410A	33 R422D
4 R502	14 R32	24 R170	34 R427A
5 R717	15 R227	25 R290	35 R438A
6 R13	16 R401A	26 R600	36 R513A
7 R13b1	17 R507	27 R600a	37 R407F
8 R23	18 R402A	28 R744	38 R1234ze
9 R500	19 R404A	29 R1270	39 R1234yf
10 R503	20 R407C	30 R417A	

The refrigerant can only be changed if the "Main switch" is set at "stopped control".
A set glide value for all refrigerants in the R400 series.

Warning: Incorrect selection of refrigerant can cause damage to the compressor.

Sensor failure
If lack of signal from one of the connected temperature sensors or pressure transmitters is registered an alarm will be given.
- When there is a P0 error regulation will continue with 50% cut-in capacity during day operation and 25% cut-in capacity during night operation – but minimum one step.
- When there is a Pc error 100% condenser capacity will be cut in, but the compressor regulation will remain normal.
- When there is an error on the Sd sensor the safety monitoring of the discharge gas temperature will be discontinued.
- When there is an error on the Ss sensor the monitoring of the superheat on the suction line will be discontinued.
- When there is an error on the outdoor temperature sensor Sc3 the "FDD" function will cease. Regulation with variable condensing pressure reference cannot either be carried out. Instead you use the PC ref. min. value as reference.
- In the event of Sgc faults, further adjustments are carried out using the Shp signal.

Note: An incorrect sensor must be in order for 10 minutes before the sensor alarm deactivates.

Safety disconnection signal
Unexpected disconnection of the compressor, condensation fan or frequency convertor can result in unexpected temperature increases in the system. If necessary, use the necessary safety signals to ensure that the controller receives signals about disconnections.

Sensor calibration:
The input signal from all connected sensors can be corrected. A correction will only be necessary if the sensor cable is long and has a small cross-sectional area. All displays and functions will reflect the corrected value.

Clock function
The controller contains a clock function.
The clock function is used only to change between day/night.
The year, month, date, hour and minutes must be set.

Note: If the controller is not equipped with a RTC module (AK-OB 101A) the clock must be reset after each mains voltage outage.
If the controller is connected to an installation with an AKA-gateway or an AK system manager, this will automatically reset the clock function.

Alarms and messages
In connection with the controller's functions, there are a number of alarms and messages that become visible in cases of fault or erroneous operation.

Alarm history:
The controller contains an alarm history (log) that contains all active alarms as well as the last 40 historical alarms. In the alarm history you can see when the alarm began and when it stopped. In addition, one can see the priority of each alarm as well as when the alarm has been acknowledged and by which user.

Alarm priority:
Differentiation is made between important and not-so-important information. The importance – or priority – is set for some alarms whilst others can be changed voluntarily (this change can only be done with attachment of AK-ST service tool software to the system and settings must be made in each individual controller).

The setting decides which sorting / action must be carried out when an alarm is sounded.
- "High" is the most important
- "Log only" is the lowest
- "Interrupted" results in no action

Alarm relay
One can also choose whether one requires an alarm output on the controller as a local alarm indication. For this alarm relay it is possible to define on which alarm priority it must react to – one can choose between the following:

- "Non" – no alarm relay is used
- "High' – Alarm relay is activated only with alarms with high priority
- "Low - High' – Alarm relay is activated only with alarms with "low" priority, "medium" or "high" priority.

The relationship between alarm priority and action appears in the schedule below.

Setting	Log	Alarm relay			Send	AKM des-
		Non	High	Low-High	Network	tination
High	X		X	X	X	1
Medium	X			X	X	2
Low	X			X	X	3
Log only	X					4
Inter-rupted						

Alarm acknowledgement
If the controller is connected to a network with an AKA gateway or an AK system manager as alarm receiver, these will automatically acknowledge the alarms that are sent to them.

If the controller on the other hand is not included in a network, the user must acknowledge all alarms.

Alarm LED
The alarm LED on the front of the controller indicates the controller's alarm status.

Blinking: There is an active alarm or an unacknowledged alarm.
Fixed light: There is an active alarm that has been acknowledged.
Switched off: There are no active alarms and no unacknowledged alarms.

I'm alive relay
The function reserves a relay that is pulled under normal regulation.
The relay will be released if:
- The regulation is stopped by the internal or external main switch
- The controller fails

IO Status and manual
The function is used in connection with installation, servicing and fault-finding on the equipment.
With the help of the function, the connected outputs are controlled.

Measurements
The status of all inlets and outlets can be read and controlled here.

Forced operation
One can carry out an override of all outlets here to control whether these are correctly attached.

Note: There is no monitoring when the outlets are overridden.

Logging/registration of parameters
As a tool for documentation and fault-finding, the controller provides the possibility of logging of parameter data in the internal memory.
Via AK-ST 500 service tool software one can:
a) Select up to 10 parameter values the controller will continuously register
b) State how often they must be registered

The controller has a limited memory but as a rule of thumb, the 10 parameters can be saved, which are registered every 10 minutes for 2 days.

Via AK-ST 500 one can subsequently read the historical values in the form of graph presentations.

(The log only works when the clock has been set.)

Forced operation via network
The controller contains settings that can be operated from the gateway's forced operation function via data communication.

When the forced operation function asks about one change, all the connected controllers on this network will be set simultaneously.
There are the following options:
- Change to night operation
- Forced closure of injection valves (Injection ON)
- Optimization of suction pressure (Po)

Operating AKM / Service tool
The setup of the controller itself can only be carried out via AK-ST 500 service tool software. The operation is described in fitters on site guide.

If the controller is included in a network with an AKA gateway one can subsequently carry out the daily operation of the controller via AKM system software, i.e. one can see and change daily read-outs/settings.

Note: AKM system software does not provide access to all configuration settings of the controller. The settings/read-outs that may be made appear in the AKM menu operation (see also Literature overview).

Authorisation / Passwords
The controller can be operated with System software type AKM and service tool software AK-ST 500.

Both methods of operation provide the possibility for access to several levels according to the user's insight into the various functions.

System software type AKM:
The various users are defined here with initials and key word. Access is then opened to exactly the functions that the user may operate.
The operation is described in the AKM manual.

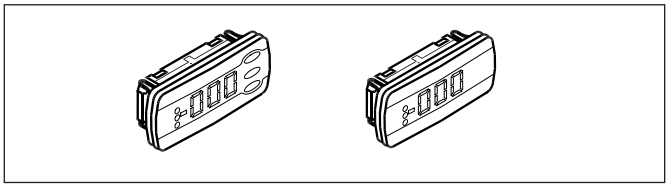
Service tool software AK-ST 500:
The operation is described in fitters on site guide.

When a user is created, the following must be stated:
a) State a user name
b) State a password
c) Select user level
d) Select units – either US (e.g. °F and PSI) or Danfoss SI (°C and Bar)
e) Select language

Access is given to four user levels.

1) DFLT – Default user – Access without use of password
See daily settings and read-outs.
2) Daily – Daily user
Set selected functions and carry out acknowledgement of alarms.
3) SERV – Service user
All settings in the menu system except for creation of new users
4) SUPV – Supervisor user
All settings including the creation of new users.

Display of suction pressure and condensing pressure



One to four separate displays can be connected to the controller. Connection is accomplished by means of wires with plug connections. The display may be placed in a control box front, for example.

When a display is connected, it will show the value for what is indicated in the setup. It can be:
compressors regulation sensor
P0 i temperature
P0 i bar-absolute
Pctrl bar-absolute
S4
Ss
Sd
Condensors regulation sensor
Tc
Pc bar-absolute
S7
Sgc
Shp
Pgc bar-absolute
Prec bar-absolute
Stw8
Shr8
Speed Compressor

Display	Primary readout *	Secondary readout
A	Regulation sensor suction pressure	Regulation sensor condenser
B	Regulation sensor condenser	Regulation sensor suction pressure
C	SS	None
D	SD	None

* The primary reading can be changed to other measurements, if required.

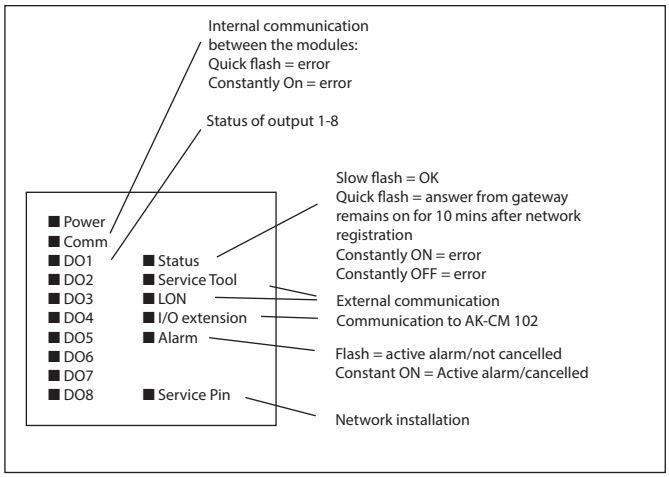
When (on plug A) a display with control buttons is chosen, a simple operation via a menu system can be performed in addition to the display of suction pressure and condensing pressure:

No.	Function	Cond.	Suction	Pack
o57	Capacity settings for condenser 0: MAN, 1: OFF, 2: AUTO	x		x
o59	Capacity setting for suction group 0: MAN, 1: OFF, 2: AUTO		x	x
h15	High pressure. Setting of Pgc minimum			x
h16	High pressure. Setting of HP-control mode: Automatic / manual			x
h17	High pressure. Manuel mode. Setting of valves opening degree			x
h18	Heat recovery. Reference for Shr8-temperature			x
h19	Heat recovery. Setting of heat recovery control mode: Automatic / off			x
o30	Refrigerant setting	x	x	x
058	Manual setting of condenser capacity	x		x
o60	Manual setting of suction capacity		x	x
o62	Select of predefined configuration This setting will give a selection of predefined combinations which at the same time establish the connections points.. At the end of the manual an overview of options and connection points is shown. After the configuration of this function the controller will shut down and restart	x	x	x
o93	Lock of configuration It is only possible to select a predefined configuration or change refrigerant when the configuration lock is open. 0 = Configuration open 1 = Configuration locked	x	x	x
r12	Main switch 0: Controller stopped 1: Regulating	x	x	x
r23	Set point suction pressure Setting of required suction pressure reference in °C		x	x
r24	Suction pressure reference Actual reference temperature for compressor capacity		x	x
r28	Set point condenser Setting of required condenser pressure in °C	x		x
r29	Condenser reference Actual reference for temperature for condenser capacity	x		x
r57	Po evaporating pressure in °C		x	x
r86	Receiver control. Reference for Prec			x
r87	Receiver control. Setting of the receiver control mode : Automatic / manual			x
r88	Receiver control. Manual mode. Setting of the valves opening degree			x
t49	Hot water. Reference for Stw8-temperature			x
t50	Hot water. Setting of hot water control mode: Automatic / off			x
u16	Actual media temperature measured with S4		x	x
u21	Superheat in suction line		x	x
u44	Sc3 out door temperature in °C	x		x
u48	Actual regulation status on condenser 0: Power up 1: Stopped 2: Manuel 3: Alarm 4: Restart 5: Standby 6: Unloaded 7-9: Part loaded 10: Full loaded 11: Running	x		x
u49	Cut in condenser capacity in %	x		x
u50	Reference for condenser capacity in %	x		x
u51	Actual regulation status on suction group 0: Power up 1: Stopped 2: Manuel 3: Alarm 4: Restart 5: Standby 6-10: Status_RUN_Timer 11: Unloaded 12-14: Unloads cut-in 15: Full loaded 16: Running		x	x
u52	Cut in compressor capacity in %		x	x
u53	Reference for compressor capacity		x	x
u54	Sd discharge gas temperature in °C		x	x
u55	Ss Suction gas temperature in °C		x	x
u98	Actual temperature for S7 media sensor		x	x
u99	Pctrl pressure in °C (cascade pressure)		x	x
U01	Actual Pc condensing pressure in °C	x		x
AL1	Alarm suction pressure		x	x
AL2	Alarm condenser	x		x
- - 1	Initiation, Display is connected to output "A", (- - 2 = output "B" etc.)	x	x	x

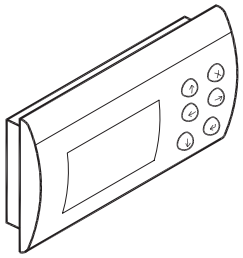
If you want to see one of the values for what is given under "function" you should use the buttons in the following way:
1. Press on the upper button until a parameter is shown
2. Press on the upper or lower button and find the parameter you want to read
3. Press on the middle button until the value of the parameter is displayed.

After a short time, the display will return automatically to the "Read out display".

Light-emitting diodes on the controller



Graphic display AK-MMI



With the display is access to most of the controller functions.

Stepper Motor Valves

When selecting a Danfoss stepper motor valve, all settings are factory set. Here, it is only necessary to select the type of valve.
If a valve from other manufacturers is used the following settings has to be made. Get data from the valve manufacturer:

Max Operating Steps.
The number of steps that correspond to a valve position of 100%.
This value is limited to a range of 0 - 10,000 steps.

Hysteresis
The number of steps needed to correct for mechanical hysteresis when a reduction gear is part of the valve design.
This adjustment is only applied, if an additional opening of the valve is requested.
If this is the case the valve opens an additional amount equal to this value, before driving the valve in the closing direction by this same value.
This value is limited to 0 – 127 steps.

Step Rate
The desired valve drive rate in steps per second.
This value is limited to 20 – 500 steps / sec.

Holding Current
The percent of the programmed Max Phase Current that should be applied to each phase of the stepper output when the valve is stationary. If required, this current ensures that the valve maintains its last programmed position. This value is limited to a range of 0 – 70% given in 10% steps.

Overdrive at Valve Init
During valve initialization, the amount to overdrive the valve, beyond the 0% position, to ensure that the valve has fully closed.
This value is limited to a range of 0 - 31%.

Phase Current
The current applied to each phase of the stepper motor during actual valve movement. This value is limited to 7 bits and a range of 0 – 1000 mA given in 10ma steps. Verify the range against the stepper valve controller in the actual design.

Please be aware, that this value hat to be set in a RMS value. Some valve manufacturers are using peak current!

Soft Landing after Valve Init
At power on the valve is performing a valve Initialization i.e. closing the valve with "Max Operating Steps" plus "Overdrive At Valve Init "steps to generate a zero point calibration of the system . Hereafter a "Soft landing after Valve Init" is made to minimize the closing force on the valve seat with a few opening steps according to setting of "Hysteresis" or min 20 steps

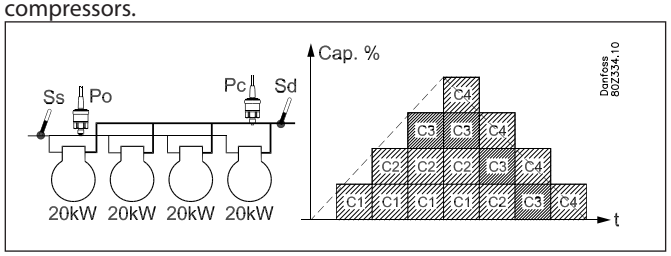
Failsafe Position
During failsafe mode of operation (e.g., resulting from a loss of communications to this module), specifies the default valve position. This value is limited to a range of 0 – 100%.

Appendix A – Compressor combinations and coupling patterns

In this section, there is a more detailed description of the compressor combinations and the associated coupling patterns.

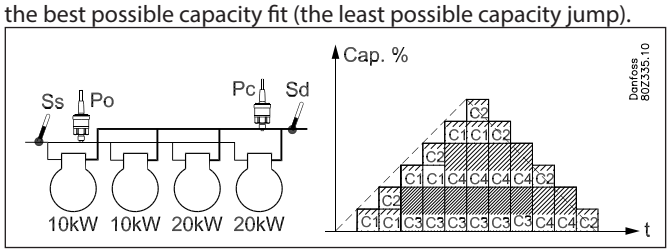
Compressor application 1 – single step
The capacity distributor is capable of managing up to 8 one-step compressors according to the following coupling patterns:
• Cyclical
• Best fit

Cyclical operation - example
Here, all compressors are of the same size and the compressors are cut in and cut-out in accordance with the First-In-First-Out (FIFO) principle, in order to equalise operating hours between the compressors.



- There is operating time equalizing between all compressors
- The compressor with the fewest running hours starts first
- The compressor with the most running hours stops first.

Best fit - example
Here are at least two compressors are of different sizes. The capacity distributor will cut in and cut-out the compressors to produce the best possible capacity fit (the least possible capacity jump).



- There is operating time equalizing between the compressors 1 and 2 (same size in example).
- There is operating time equalizing between the compressors 3 and 4 (same size in example).

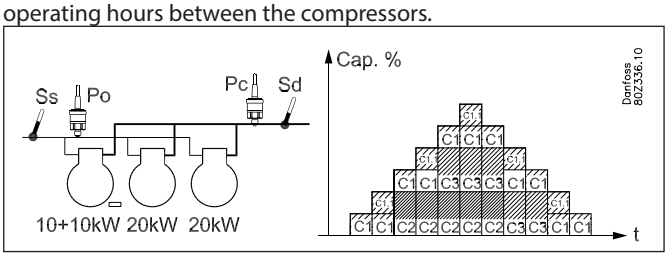
Compressor application 2 – 1 x unload + single step
The controller is able to control a combination of one capacity controlled and multiple single step compressors. The advantage of this combination is that the unloader valves will be used to fill in capacity gaps and thereby achieve many capacity steps via few compressors.

Preconditions for using this compressor application are:
• All compressors are the same size
• The capacity-regulated compressor can have up to three unload valves.
• The main step and the unload valves can be different sizes, i.e. 50%, 25% and 25%.

This compressor combination can be handled in the following coupling patterns:
• Cyclical

General regarding Handling:
Cutin
The capacity-regulated compressors with unloader valves start before one-step compressors. The capacity controlled compressor will always be fully loaded before cutting-in of subsequent one-step compressors.
Cutout
The capacity regulated compressor will always be the last to stop. The capacity controlled compressor will always be fully loaded before cut-in of subsequent one-step compressors.
Unloader valves
At cyclical operation unloader valves are used to close capacity holes from the subsequent one-step compressors.
Anti-cycle timer restrictions
In case a capacity controlled compressor is prevented in starting due to anti-cycle timer restrictions, then the start of any subsequent one-step compressors is not allowed. The capacity controlled compressor is started when the timer restriction has expired.

Cyclical operation - example
The one-step compressors will be cut in and cut-out in accordance with The First-In-First-Out (FIFO) principle in order to equalise operating hours between the compressors.



- The capacity controlled compressor is the first to start and the last to stop.
- Unloader valves are used to close capacity holes
- There is operating time equalizing between the compressors 2 and 3 (same size in example).

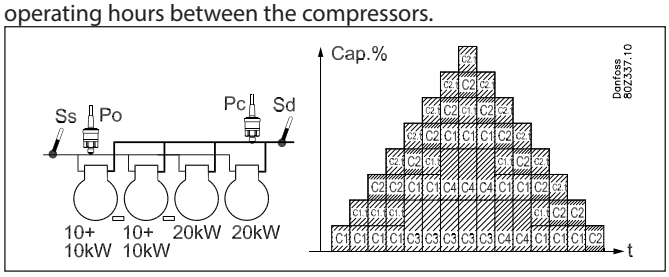
Compressor application 3 – 2 x unload + single step
The controller is able to control a combination of capacity controlled and multiple single step compressors. The advantage of this combination is that the unloader valves will be used to fill in capacity gaps and thereby achieve many capacity steps via few compressors.

Preconditions for using this compressor application are:
- All compressors are the same size
- The capacity-regulated compressors have the same number of unload valves (max 3)
- The main step on the capacity-regulated compressors have the same size
- The main step and the unload valves can be different sizes, i.e. 50%, 25% and 25%.

This compressor combination can be handled in accordance with the following coupling patterns:
- Cyclical

In general, regarding handling of the capacity-regulated compressors:
Cutin
The capacity-regulated compressors with unloader valves start before one-step compressors. The capacity controlled compressor will always be fully loaded before cutting-in of subsequent one-step compressors.
Cutout
The capacity regulated compressor will always be the last to stop. Handling of the unload valves depends on the setting of "unloader ctrl mode".
Unloader valves
At cyclical operation unloader valves are used to close capacity holes from the subsequent one-step compressors.
Anti-cycle timer restrictions
In case a capacity controlled compressor is prevented in starting due to anti-cycle timer restrictions, then the start of any subsequent one-step compressors is not allowed. The capacity controlled compressor is started when the timer restriction has expired.

Cyclical operation - example
The one-step compressors will be cut in and cut out in accordance with the First-In-First-Out (FIFO) principle in order to equalise operating hours between the compressors.



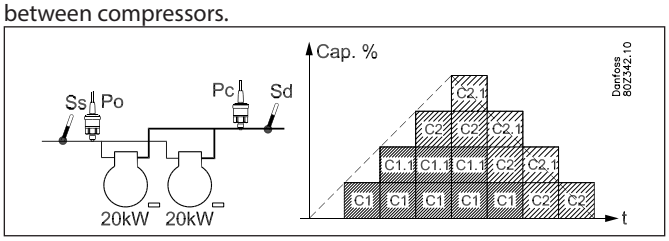
- The capacity controlled compressor is the first to start and the last to stop.
- Operating hours are equalised between the capacity-regulated compressors
- The unload valve on the capacity-regulated compressor is used to fill capacity gaps
- Operating hours are equalised between the one-step compressors 3 and 4.

Compressor application 4 – Only capacity controlled compressors
The controller is capable of controlling capacity-regulated piston compressors of the same size with up to 3 unload valves.

Preconditions for using this compressor application are:
- All compressors are the same size
- The capacity-regulated compressors have the same number of unload valves (max 3)
- The main step on the capacity-regulated compressors are the same size
- The main step and the unload valves can be different sizes, i.e. 50%, 25% and 25%.

This compressor combination can be handled in the following coupling patterns:
- Cyclical

Cyclical operation - example
The compressors are cut in and cut out in accordance with the First-In-First-Out (FIFO) principle to equalise operating hours between compressors.



- For cyclical operation, the compressor with the fewest running hours starts (C1)
- Only when compressor C1 is completely loaded, should compressor C2 be cut in
- For cut-out, the compressor with the most operating hours should be unloaded (C1)
- When this compressor is completely unloaded, the second compressor is unloaded by one step before the main step on the completely unloaded compressor (C1) is cut out.

Compressor application 5 – 1 x Speed + single step
The controller is capable of controlling one speed-regulated compressor combined with one-step compressors of the same or different sizes.

Preconditions for using this compressor application are:
- A speed-regulated compressor that can be of a different size than the following one-step compressors
- Up to 3 one-step compressors of the same or different capacity (depending on coupling pattern)

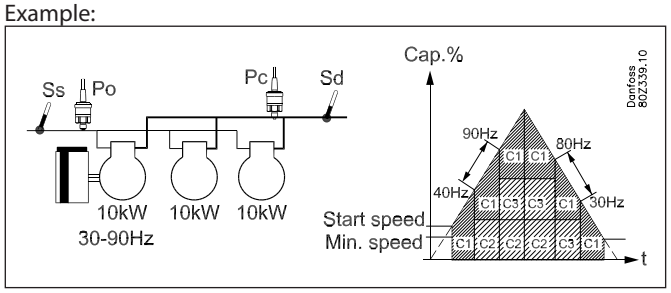
This compressor combination can be handled in accordance with the following coupling patterns:
- Cyclical
- Best fit

Handling the speed-regulated compressor.
For more information on the general handling of the speed-regulated compressor, refer to section "Power pack types".

Cyclical operation - example
Here, the one-step compressors are of the same size.
The speed-regulated compressor is always the first to start and the last to stop.
One-step compressors should be cut in and cut out in accordance with the First-In-First-out principle in order to equalise operating hours.

The speed-regulated compressor is used to fill the capacity gaps between the one-step compressors.

Example:

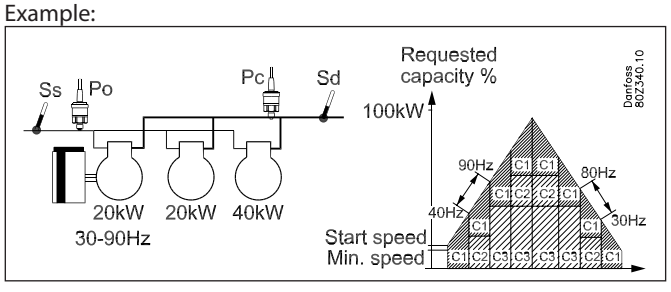


Increasing capacity:
- The speed-regulated compressor starts when the desired capacity equals the start speed
- The following one-step compressor with the smallest number of operating hours cut in when the speed-regulated compressor is running at full speed (90 Hz)
- When a one-step compressor cuts in, the speed-regulated compressor reduces speed (40 Hz) equivalent to the capacity of the one-step compressor.

Decreasing capacity:
- The following one-step compressors with the most operating hours should be cut out when the speed-regulated compressor reaches minimum speed (30 Hz)
- When a one-step compressor is cut out, the speed- regulated compressor's speed increases (80 Hz), equivalent to the capacity of the one-step compressor
- The speed-regulated compressor is the last compressor to be cut out when the preconditions for this are fulfilled.

Best fit - example:
Here, at least two of the one-step compressors are of different sizes.
The speed-regulated compressor is always the first to start and last to stop.
The capacity distributor cuts in and cuts out the one-step compressors in order to achieve the best possible capacity fit (least possible capacity jump)
The speed-regulated compressor is used to fill out the capacity gaps between the one-step compressors.

Example:



Increasing capacity:
- The speed-regulated compressor starts when the desired capacity matches the start speed
- The smallest one-step compressor is cut in when the speed-regulated compressor runs at full-speed (90 Hz).
- When the speed-regulated compressor again reaches max. speed (90 Hz), the smallest one-step compressor is cut out (C2) and the big one-step compressor (C3) is cut in.
- When the speed-regulated compressor again reaches max speed (90 Hz), the smallest one-step compressor (C2) is cut in again.
- When the one-step compressor is cut in, the speed is reduced on the speed-regulated compressor (40 Hz) equivalent to the capacity of the cut in capacity

Decreasing capacity:
- The small one-step compressor is cut out when the speed-regulated compressor has reached minimum speed (30 Hz)
- When the speed-regulated compressor again reaches minimum speed (30 Hz), the smallest one-step compressor (C2) is cut out and the big one-step compressor (C3) is cut in.
- When the speed-regulated compressor again reaches min. speed (30 Hz), the large one-step compressor (C3) is cut out and the small one-step compressor (C2) is cut in again.
- When the speed-regulated compressor again reaches min. speed (30 Hz), the small one-step compressor (C2) is cut in.
- The speed-regulated compressor is the last compressor to be cut out when the requirements for this are fulfilled.
- When the one-step compressor's capacity is cut out, the speed-regulated compressor increases speed (80 Hz) equivalent to the cut out capacity.

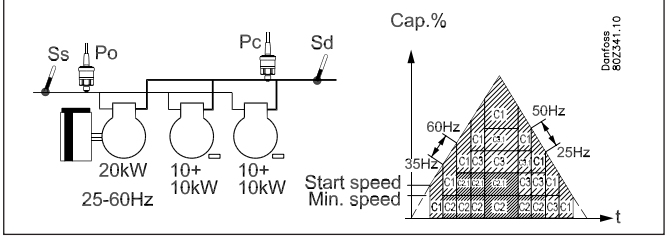
Compressor application 6 – 1 x Speed + unloader
The controller can operate one speed-regulated compressor combined with several capacity-regulated compressors of the same size and with the same number of unloaders.
The advantage of this combination is that the variable part of the speed-regulated compressor only needs to be large enough to cover the following unload valves in order to achieve a capacity curve without gaps.

Preconditions for using this compressor application are:
- A single speed-regulated compressor that can be of a different size than the following compressors
- The capacity-regulated compressors are the same size and have the same number of unload valves (max. 3)
- The main step on the capacity-regulated compressors are the same size
- The main step and the unload valves can be different sizes, i.e. 50%, 25% and 25%.

This compressor combination can be handled in the following coupling patterns:
- Cyclical

Handling the speed-regulating compressor.
For further information on the general handling of the speed-regulated compressor, refer to section "Power pack types".

Cyclical operation - example
The speed-regulated compressor is always the first to start and last to stop.
The capacity-regulated compressors are cut in and cut out in accordance with the First-in-First-Out principle in order to equalise operating hours
The speed-regulated compressor is used to fill the capacity gaps between the unload valves/main steps.



Increasing capacity:
- The speed-regulated compressor starts when the desired capacity matches the start speed
- The main step on the capacity-regulated compressor with fewest operating hours (C1) is cut in when the speed-regulated compressor runs at full speed (60 Hz)
- The unload valves are cut in gradually as the speed-regulated compressor again reaches max. speed (60 Hz)
- The main step on the last capacity-regulated compressor (C2) is cut in when the speed-regulated compressor again reaches max. speed (60 Hz)
- The unload valves are cut in gradually as the speed-regulated compressor again reaches max. speed (60 Hz)
- When the main step or unload valves are cut in, the speed is reduced on the speed-regulated compressor (35 Hz) is equivalent to the capacity of the cut in capacity.

Decreasing capacity:
- The capacity-regulated compressor with the most operating hours (C2) cuts out an unload valve when the speed-regulated compressor has reached min. speed (25 Hz)
- When the speed-regulated compressor again reaches min. speed (25 Hz), the unload valve is cut out on the next capacity-regulated compressor (C3)
- When the speed-regulated compressor again reaches min. speed (25 Hz), the main step is cut out on the capacity-regulated compressor with the most operating hours (C2)
- When the speed-regulated compressor again reaches min. speed (25 Hz), the main step is cut out on the last capacity-regulated compressor (C3)
- The speed-regulated compressor is the last compressor that is cut out when the conditions for this are fulfilled
- When the main step or unload valves are cut out, the speed of the speed-regulated compressor increases (50 Hz) to equivalent to the cut out capacity

Compressor application 7 – 2 x Speed + single

The controller can control two speed-regulated compressors combined with several one-step compressors that may be the same or different in size (depending on the selected coupling pattern).
The advantage of using two speed-regulated compressors is that it is then possible to reach a very low capacity, which is an advantage with low loads while at the same time a very high variable regulating range is possible.

Preconditions for using this compressor application are:
- Two speed-regulated compressors which can be of a different size than the following one-step compressors
- The speed-regulated compressors can be the same or different sizes (depending on the choice of coupling pattern)
- The same frequency band for both speed-regulated compressors
- One-step compressors of the same or different sizes (depending on the choice of coupling pattern)

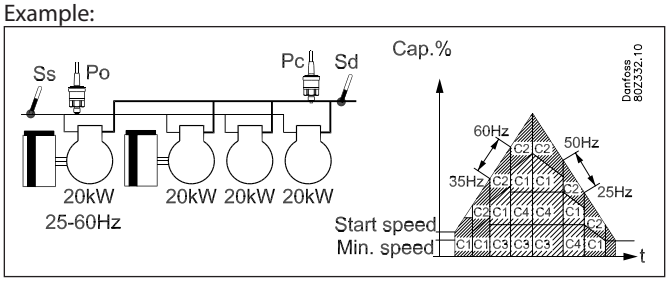
This compressor combination can be handled in accordance with the following coupling patterns:
- Cyclical
- Best fit

Handling the speed-regulated compressor.
For more information on the general handling of the speed-regulated compressors, refer to section "Power pack types".

Cyclical operation - example
Here the speed-regulated compressors are the same size
The one-step compressors should also be the same size.

The speed-regulated compressor is always the first to start and the last to stop.
The other compressors cut in and cut out in accordance with the operating time (First-In-First-Out principle).
The speed-regulated compressor is used to fill the capacity gaps between the following one-step compressors.

Example:

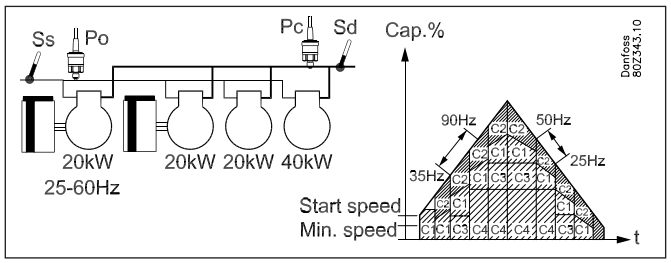


Increasing capacity:
- The speed-regulated compressor with the least operating hours (C1) starts when the desired capacity equals the start speed
- The following speed-regulated compressor C2 is cut in when the first speed-regulated compressor (C1) has reached max. speed (60 Hz) so that the compressors run in parallel.
- When the two speed-regulated compressors reach full speed (60 Hz) the one-step compressor with the fewest operating hours is cut in (C3)
- When the two speed-regulated compressors again reach full speed (60 Hz) the last one-step compressor cuts in (C4)
- When one-step compressors are cut in , the speed is reduced on the speed-regulated compressor (35 Hz) equivalent to the cut in capacity.

Decreasing capacity:
- The one-step compressor with the most operating time (C3) is cut out when the speed-regulated compressor reaches min speed (25 Hz)
- When the two speed-regulated compressors again reach min speed (25 Hz), the last one-step compressor is cut out (C4)
- When the two speed-regulated compressors again reach min speed (25 Hz), the speed-regulated compressor with the most operating hours is cut out (C1)
- The last speed-regulated compressor (C2) is cut out when the requirements for this are fulfilled
- When one-step compressors are cut out, the speed-regulated compressors' speed increases (50 Hz), equivalent to the cut out capacity.

Best fit - examples
Here, either the two speed-regulated compressors are of different sizes, or the following one-step compressors are of different sizes.
The speed-regulated compressors are always the first to start and the last to stop.
The capacity distributor cuts in and cuts out both speed-regulated and one-step compressors in order to reach the best possible capacity adjustment (least possible capacity jump).

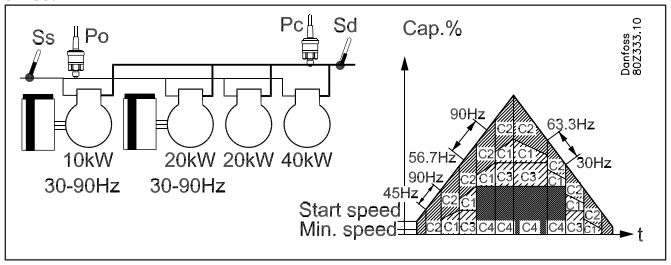
Example 1
In this example, the speed-regulated compressors are of the same size and the following one-step compressors are of different sizes



Increasing capacity:
- The speed-regulated compressor with the least operating hours (C1) starts when the desired capacity equals the start speed
- When the first speed-regulated compressor (C1) has reached max. speed (60 Hz), the second speed-regulated compressor (C2) cuts in so that the compressors run in parallel
- When the two speed-regulated compressors reach full speed (60 Hz), the small one-step compressor (C3) is cut in
- When the two speed-regulated compressors again reach full speed (60 Hz), the large one-step compressor (C4) is cut in and the small one-step compressor (C3) is cut out
- When the two speed-regulated compressors again reach full speed (60 Hz), the small one-step compressor (C4) is cut in again.
- When the one-step compressor is cut in, the speed is reduced on the speed-regulated compressor (35 Hz) corresponding to the cut in capacity

Decreasing capacity:
- The small one-step compressor (C3) is cut out when the speed-regulated compressor reaches the min. speed (25 Hz)
- When the two speed-regulated compressors again reach min. speed (25 Hz), the big one-step compressor (C4) is cut out and the small one-step compressor (C3) is cut in
- When the two speed-regulated compressors again reach min. speed (25 Hz), the small one-step compressor (C3) is cut out
- When the two speed-regulated compressors again reach min speed (25 Hz), the speed-regulated compressor with the most operating hours (C1) is cut out
- The last speed-regulated compressor (C2) is cut out when the requirements for this are fulfilled
- When one-step compressors cut out, the speed-regulated compressors increase speed (50 Hz), corresponding to the cut out capacity

Example 2:
In this example, the speed-regulated compressors are of different sizes and the following one-step compressors are also of different sizes.



Increasing capacity:
- The smallest speed-regulated compressor (C1) starts when the desired capacity equals the start speed
- When the smallest speed-regulated compressor (C1) has reached max. speed (90 Hz), the large speed-regulated compressor (C2) cuts in and the small speed-regulated compressor cuts out.
- When the large speed-regulated compressor reaches max. speed (90 Hz), the small speed-regulated compressor (C1) cuts in again so that the compressors run in parallel
- When the two speed-regulated compressors reach full speed (90 Hz), the small one-step compressor (C3) is cut in
- When the two speed-regulated compressors again reach full speed (90 Hz), the big one-step compressor (C4) cuts in and then the small one-step compressor (C3) cuts out
- When the two speed-regulated compressors again reach full speed (90 Hz), the small one-step compressor (C3) is cut in again.
- When the one-step compressors are cut in, the speed decreases on the speed-regulated compressor (56.7 Hz) corresponding to the cut in capacity

Decreasing capacity:
- The small one-step compressor (C3) is cut out when the speed-regulated compressor reaches min. speed (30 Hz)
- When the two speed-regulated compressors again reach min. speed (30 Hz) the big one-step compressor (C4) cuts out and the small one-step compressor (C3) cuts in.
- When the two speed-regulated compressors again reach min. speed (30 Hz), and the small one-step compressor (C3) cuts out.
- When the two speed-regulated compressors again reach min. speed (30 Hz), the small speed-regulated compressor (C1) cuts out.
- When the big speed-regulated compressor reaches min. speed (30 Hz), it is cut out and the small speed-regulated compressor is cut in (C1)
- The small speed-regulated compressor (C1) is cut out when the conditions for this are met.
- When the one-step compressors are cut out, the speed-regulated compressors' speed increases (63.3 Hz) equivalent to the cut out capacity.

Appendix B - Alarm texts

Settings	Priority (factory)		English alarm texts	Description
Suction group				
Low suction pressure P0	Low		Low pressure P0	Minimum safety limit for suction pressure P0 has been exceeded
High suction pressure P0	High		High pressure P0	High alarm limit for P0 has been exceeded
High/Low superheat Ss	Medium		High superheat suction A	Superheat in suction line too high
			Low superheat section A	Superheat in suction line too low
Load shedding	Medium		Load Shed active	Load shedding has been activated
P0/S4/Pctrl sensor error	High		P0A sensor error	Pressure transmitter signal from P_0 is defective
			S4A sensor error	Temperature signal from S4 media temp. sensor defective
			Pctrl sensor error	Pressure transmitter signal from Pctrl is defective
			Sgc sensor error	Temperature signal from gas cooler is defective
			Prec sensor error	Pressure transmitter signal from the receiver is defective
			Pgc sensor error	Pressure transmitter signal from the gas cooler is defective
Misc. sensor error	Medium		SsA sensor error	Temperature signal from Ss suction gas temp. is defective
			SdA sensor error	Temperature signal from Sd discharge gas temp. is defective
			Sc3 sensor error	Temperature signal from Sc3 air on condenser defective
			Heat recovery sensor error	Temperature signal from Shrec heat recovery thermostat defective
			Stw sensor error	Temperature signal from hot water circuit is defective
			Shr sensor error	Temperature signal from heat circuit is defective
			Saux_ sensor error	Signal from extra Temp.sensor Saux_ is defective
			Paux_ sensor error	Signal from extra pressure sensor Paux_ is defective
All compressors				
Common safety	High		Common compr. Safety cutout	All compressors have been cut out on common safety input
Comp. 1 safety Comp. 2 safety Comp. 3 safety ——————— Comp. 12 safety	Medium		Comp. X oil pressure cut out	Compressor no. x has been cut out on oil pressure safety
			Comp. x over current cut out	Compressor no. x has been cut out on over current safety
			Comp. 1 motor prot. cut out	Compressor no. x has been cut out on motor protection safety
			Comp. 1 disch. Temp cut out	Compressor no. x has been cut out on discharge temperature safety
			Comp. 1 disch. Press. Cut out	Compressor no. x has been cut out on discharge pressure safety
			Comp. 1 General safety cut out	Compressor no. x has been cut out on general safety
VSD safety	Medium		Comp. 1 FCD safety error	Variable speed drive for comp. x has been cut out on safety
Comp. Low oil lvl	Medium		Low oil level comp. x	Oil level too low in compressor x
Comp. High oil lvl	Medium		High oil level in compressor x	Oil level too high in compressor x
Separator alarms	Medium		Low oil in separator x	Oil level too low in separator x
			No oil separated sep. x	No oil in oil separator x
			To high oil in separator x	Oil level too high in separator x
			Remaining oil separator x	Separator x can not be emptying total for oil
Receiver alarm	Medium		Oil recv. high level	Oil level too high in receiver
			Oil recv. low level	Oil level is too low in receiver
Rec. high pressure	Medium		Recv. High pressure alarm	Pressure too high in receiver
Rec. low pressure	Medium		Recv. Low pressure alarm	Pressure too low in receiver

Condensor

High Sd temp.	High		High disch. temp. SdA	Safety limit for discharge temperature has been exceeded
High Pc pressure	High		High pressure Pc	High safety limit for condensing pressure Pc has been exceeded
Pc/S7 Sensor error	High		PcA sensor error	Pressure transmitter signal from Pc is defective
			S7A sensor error	Temperature signal for S7 media temperature sensor is defective
Detect blocked air flow	Medium		Air flow reduced cond. A	The intelligent air flow monitoring of the condenser reports that a cleaning is due
Fan/VSD safety	Medium		Fan Alarm 1	Fan no. X is reported defective via safety input
			Fan VSD alarm	Variable speed drive for condenser fans has been cut out on safety

Various alarms

Standby mode	Medium		Control stopped, MainSwitch=OFF	The control has been stopped via the setting "Main switch" = Off or the external Main switch is off
Thermostat x – Low temp. alarm	Low		Thermostat x - Low alarm	The temperature for thermostat no. x has been below the low alarm limit for longer time than set delay
Thermostat x – High temp. alarm	Low		Thermostat x - High alarm	The temperature for thermostat no. x has been above the high alarm limit for longer time than set delay
Pressostat x – Low pressure alarm	Low		Pressostat x - Low alarm	The pressure for pressostat no. x has been below the low alarm limit for longer time than set delay
Pressostat x – alarm limit high pressure	Low		Pressostat x - High alarm	The pressure for pressostat no. x has been above the high alarm limit for longer time than set delay
Voltage input x – Low alarm	Low		Analog input x - Low alarm	The voltage signal has been below the low alarm limit for longer time than set delay
Voltage input x – High alarm	Low		Analog input x - High alarm	The voltage signal has been above the high alarm limit for longer time than set delay
User def. alarm text	Low		Custom alarm x -define text	Alarm on general alarm input DI x
No flow	High		Flow switch alarm	There is no flow in the heating circuit Check the pump
Boiling alarm	High		Boiling alarm	The temperature in the heat circuit is too high
Receiver alarm	High		Prec...	Alarm from the receiver
External power loss	High		External power loss	Supply is interrupted. A message alert. All other alarms stopped.
Steppervalve	High		Stepper - Vhp, Vrec, PI, Vliq. Open coil, Shorted output, Error, Power failure	Check the supply to the current valve. In the event of an error or power failure: check the supply to the stepper module.

System alarms

The alarm priority can not be altered on system alarms				
Control mode	Low		Manual comp. cap. Control A	Compressors capacity control runs i manual mode
Control mode	Low		Manual cond. cap. Control A	Condense capacity control runs i manual mode
	Low		Refrigerant A not selected	Refrigerant has not been selected
Refrigerant changed	Low		Refrigerant changed	Refrigerant type has been changed
	Medium		Time has not been set	Time has not been set
	Medium		System Critical exception	A unrecoverable critical system failure has occurred – exchange the controller
	Medium		System alarm exception	A minor system failure has occurred – power off controller
	Medium		Alarm destination disabled	When this alarm is activated the alarm transmission to the alarm receiver has been deactivated. Check and wait. When the alarm is cleared the alarm transmission to the alarm receiver has been activated again
	Medium		Alarm route failure	Alarms can not be transmitted to alarm receiver – check communication
	High		Alarm router full	The internal alarm buffer has an overrun – this might occur if the controller can not send the alarms to the alarm receiver. Check communication between controller and system unit.
	Medium		Device is restarting	The controller is restarting after flash updating of the software
	Medium		Common IO Alarm	There is a communication fault between the controller module and the extension modules – the fault must be corrected as soon as possible
Manual control				
	Low		MAN DI…….	The in put in question has been put in manual control mode via the AK-ST 500 service tool software
	Low		MAN DO……	The output in question has been put in manual control mode via the AK-ST 500 service tool software
	Low		Man set	The output in question has been put in manual control mode via the AK-ST 500 service tool software
	Low		Man control	The output in question has been put in manual control mode via the AK-ST 500 service tool software

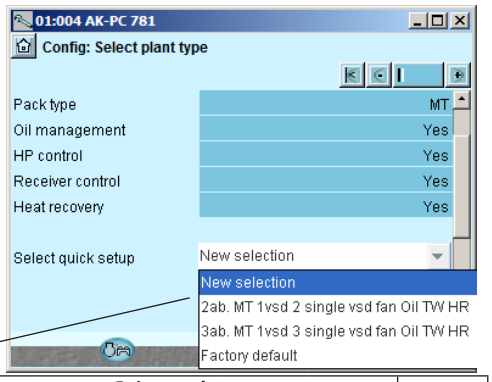
Appendix C - Recommended connection - AK-PC 781

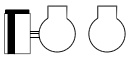
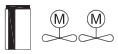
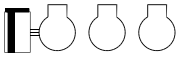
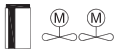
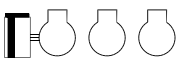
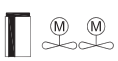
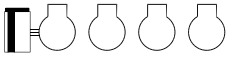
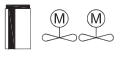
Function

The controller has a setting where you can choose between various types of installation. If you use these settings, the controller will suggest a series of connection points for the different functions. These points are shown below. (The options shown are determined by previous settings in the menu, e.g. cooling agent and "Pack type".)

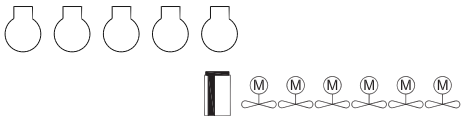
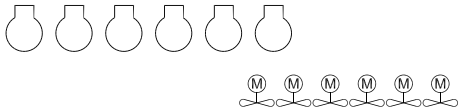
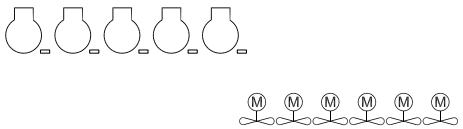
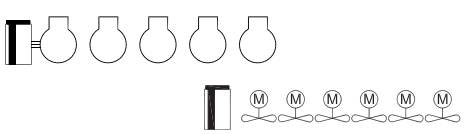
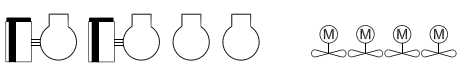
Even if your installation is not 100% as described below, you can still use the function. After use, you need only adjust the divergent settings.

The given connection points in the controller can be changed if you wish.



Appl.	Compressor	Fan	Description	Module	Point number					
					1	2	3	4	5	6
1			LT 1 vsd comp. 1 single	Modul 1 - Controller	LT Comp. Release	Loadshed 1	Loadshed 2			Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety			VSD C.1 safety	
1a			LT 1 vsd comp. 1 single CO2, Oil valve	Modul 1 - Controller	LT Comp. Release	Loadshed 1	Loadshed 2	Oil lvl. Comp. 1	Oil lvl. Comp. 2	Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 1 safety			VSD C.1 safety	
2			MT 1 vsd comp. 2 single vsd-fans Boost Gas cooler Receiver	Modul 1 - Controller	MT Comp. Request	Loadshed 1	Loadshed 2	Sgc	Shp	Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	Comp. 3 safety		VSD C.1 safety	Fan 1 safety
				Modul 3 - AK-XM 103A		Volt input 1		Power loss	Vhp ICMTS	
				Modul 4 - AK-XM 208C						
				Modul 5 - AK-XM 205A						Saux 1
2a			MT 1 vsd comp. 2 single vsd-fans Boost Gas cooler Receiver Oil sep. Oil receiver Oil valve	Modul 1 - Controller	MT Comp. Request	Loadshed 1	Loadshed 2	Sgc	Shp	Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	Comp. 3 safety		VSD C.1 safety	Fan 1 safety
				Modul 3 - AK-XM 103A	Reset Kom lockout	Oil Low Receiver	Oil Hi Receiver	Power loss	Vhp ICMTS	
				Modul 4 - AK-XM 208C						
				Modul 5 - AK-XM 205A	Oil lvl. comp. 1	Oil lvl. comp. 2	Oil lvl. comp. 3		Oil Low Separ. 1	Oil Hi Separ. 1
				Modul 6 - AK-XM 205A						Saux 1
2b			MT 1 vsd comp. 2 single vsd-fans Boost Gas cooler Receiver TW HR	Modul 1 - Controller	MT Comp. Request	Loadshed 1	Loadshed 2	Sgc	Shp	Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	Comp. 3 safety		VSD C.1 safety	Fan 1 safety
				Modul 3 - AK-XM 103A		Volt input 1		Power loss	Vhp ICMTS	
				Modul 4 - AK-XM 208C	TW Stw2	TW Stw3	TW Stw4	TW Stw8	HR Shr2	HR Shr3
				Modul 5 - AK-XM 205A	TW enable	Flow Sw. TW	HR enable	Flow Sw. HR		Saux 1
2ab			MT 1 vsd comp. 2 single vsd-fans Boost Gas cooler Receiver Oil sep. Oil receiver Oil valve TW HR	Modul 1 - Controller	MT Comp. Request	Loadshed 1	Loadshed 2	Sgc	Shp	Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	Comp. 3 safety		VSD C.1 safety	Fan 1 safety
				Modul 3 - AK-XM 103A	Reset Kom lockout	Oil Low Receiver	Oil Hi Receiver	Power loss	Vhp ICMTS	
				Modul 4 - AK-XM 208C	TW Stw2	TW Stw3	TW Stw4	TW Stw8	HR Shr2	HR Shr3
				Modul 5 - AK-XM 205A	Oil lvl. comp. 1	Oil lvl. comp. 2	Oil lvl. comp. 3		Oil Low Separ. 1	Oil Hi Separ. 1
				Modul 6 - AK-XM 205A	TW enable	Flow Sw. TW	HR enable	Flow Sw. HR		Saux 1
3			MT 1 vsd comp. 3 single vsd-fans Boost Gas cooler Receiver	Modul 1 - Controller	MT Comp. Request	Loadshed 1	Loadshed 2	Sgc	Shp	Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	Comp. 3 safety	Comp. 4 safety	VSD C.1 safety	Fan 1 safety
				Modul 3 - AK-XM 103A		Volt input 1		Power loss	Vhp ICMTS	
				Modul 4 - AK-XM 208C						
				Modul 5 - AK-XM 205A						Saux 1
3a			MT 1 vsd comp. 3 single vsd-fans Boost Gas cooler Receiver Oil sep. Oil receiver Oil valve	Modul 1 - Controller	MT Comp. Request	Loadshed 1	Loadshed 2	Sgc	Shp	Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	Comp. 3 safety	Comp. 4 safety	VSD C.1 safety	Fan 1 safety
				Modul 3 - AK-XM 103A	Reset Kom lockout	Oil Low Receiver	Oil Hi Receiver	Power loss	Vhp ICMTS	
				Modul 4 - AK-XM 208C						
				Modul 5 - AK-XM 205A	Oil lvl. comp. 1	Oil lvl. comp. 2	Oil lvl. comp. 3	Oil lvl. comp. 4	Oil Low Separ. 1	Oil Hi Separ. 1
				Modul 6 - AK-XM 205A						Saux 1

Appl.	Point number														
	7	8	9	10	11	12	13	14	15	16	17	18	19	24	25
1		Sd	Ss	P0	Pc	Comp. 1	Comp. 2					Alarm	LT comp. Request	Comp. speed	
1a	Reset lockout	Sd	Ss	P0	Pc	Comp. 1	Comp. 2	Oil Valve C1	Oil Valve C2	Oil lvl. Safety C1	Oil lvl. Safety C2	Alarm	LT comp. Request	Comp. speed	
2	Sc3	Sd	Ss	P0	Pc	Comp. 1	Comp. 2	Comp. 3	Liq. Inject suction	Fan 1	Fan 2	Alarm	MT Comp. Release		
	Fan 2 safety	VSD cond safety													
	Speed comp.	Speed fan													
			Vrec CCM												
	GasCool Prec	Receiver Prec						GasCool V3gc	Thermost 1						
2a	Sc3	Sd	Ss	P0	Pc	Comp. 1	Comp. 2	Comp. 3	Liq. Inject suction	Fan 1	Fan 2	Alarm	MT Comp. Release		
	Fan 2 safety	VSD cond safety													
	Speed comp.	Speed fan													
			Vrec CCM												
	Volt input 1	Poil rec	Oil Valve C1	Oil Valve C2	Oil Valve C3		Oil lvl. Safety C1	Oil lvl. Safety C2	Oil lvl. Safety C3						
	GasCool Prec	Receiver Prec					Oil valve Separat.1	GasCool V3gc	Thermost 1						
2b	Sc3	Sd	Ss	P0	Pc	Comp. 1	Comp. 2	Comp. 3	Liq. Inject suction	Fan 1	Fan 2	Alarm	MT Comp. Release	Comp. speed	Fan speed
	Fan 2 safety	VSD cond safety													
	Speed tw	Speed hr													
	HR Shr4	HR Shr8	Vrec CCM												
	GasCool. Pgc	Receiver Prec	HR tw V3tw	HR tw Pump tw	HR V3hr	HR pump hr		GasCool. V3gc	Thermost. 1						
2ab	Sc3	Sd	Ss	P0	Pc	Comp. 1	Comp. 2	Comp. 3	Liq. Inject suction	Fan 1	Fan 2	Alarm	MT Comp. Release	Comp. speed	Fan speed
	Fan 2 safety	VSD cond safety													
	Speed tw	Speed hr													
	HR Shr4	HR Shr8	Vrec CCM												
	Volt input 1	Poil rec	Oil Valve C1	Oil Valve C2	Oil Valve C3		Oil lvl. Safety C1	Oil lvl. Safety C2	Oil lvl. Safety C3						
	GasCool. Pgc	Receiver Prec	HR tw V3tw	HR tw Pump tw	HR V3hr	HR pump hr	Oil valve Separat.1	GasCool. V3gc	Thermost. 1						
3	Sc3	Sd	Ss	P0	Pc	Comp. 1	Comp. 2	Comp. 3	Liq. Inject suction	Fan 1	Fan 2	Comp. 4	MT Comp. Release		
	Fan 2 safety	VSD cond safety													
	Speed comp.	Speed fan													
			Vrec CCM												
	GasCool. Pgc	Receiver Prec						GasCool. V3gc	Thermost. 1	Alarm					
3a	Sc3	Sd	Ss	P0	Pc	Comp. 1	Comp. 2	Comp. 3	Liq. Inject suction	Fan 1	Fan 2	Comp. 4	MT Comp. Release		
	Fan 2 safety	VSD cond safety													
	Speed comp.	Speed fan													
			Vrec CCM												
	Volt input 1	Poil rec	Oil Valve C1	Oil Valve C2	Oil Valve C3	Oil Valve C4	Oil lvl. Safety C1	Oil lvl. Safety C2	Oil lvl. Safety C3	Oil lvl. Safety C4					
	GasCool. Pgc	Receiver Prec					Oil valve Separat.1	GasCool. V3gc	Thermost. 1	Alarm					

Appl.	Comp.	Fan	Description	Module	Point number					
					1	2	3	4	5	6
3b			MT 1 vsd comp. 3 single vsd-fans Boost Gas cooler Receiver TW HR	Modul 1 - Controller	MT Comp. Request	Loadshed 1	Loadshed 2	Sgc	Shp	Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	Comp. 3 safety	Comp. 4 safety	VSD C.1 safety	Fan 1 safety
				Modul 3 - AK-XM 103A		Volt input 1		Power loss	Vhp ICMTS	
				Modul 4 - AK-XM 208C	TW Stw2	TW Stw3	TW Stw4	TW Stw8	HR Shr2	HR Shr3
				Modul 5 - AK-XM 205A	TW enable	Flow Sw. TW	HR enable	Flow Sw. HR		Saux 1
3ab			MT 1 vsd comp. 3 single vsd-fans Boost Gas cooler Receiver Oil sep. Oil receiver Oil valve TW HR	Modul 1 - Controller	MT Comp. Request	Loadshed 1	Loadshed 2	Sgc	Shp	Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	Comp. 3 safety	Comp. 4 safety	VSD C.1 safety	Fan 1 safety
				Modul 3 - AK-XM 103A	Reset Kom lockout	Oil Low Receiver	Oil Hi Receiver	Power loss	Vhp ICMTS	
				Modul 4 - AK-XM 208C	TW Stw2	TW Stw3	TW Stw4	TW Stw8	HR Shr2	HR Shr3
				Modul 5 - AK-XM 205A	Oil lvl. comp. 1	Oil lvl. comp. 2	Oil lvl. comp. 3	Oil lvl. comp. 4	Oil Low Separ. 1	Oil Hi Separ. 1
				Modul 6 - AK-XM 205A	TW enable	Flow Sw. TW	HR enable	Flow Sw. HR		Saux 1
11			LT 3 single Cascade	Modul 1 - Controller	LT Comp. Release	Loadshed 1	Loadshed 2	Night		Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	Comp. 3 safety			
12			MT 4 single 4 fan HFC Cascade HR	Modul 1 - Controller	MT Comp. Request	Loadshed 1	Loadshed 2	Night	Heat recovery	Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	Comp. 3 safety	Comp. 4 safety		
				Modul 3 - AK-XM 205A						
13			MT 5 single vsd-fan HFC Cascade HR	Modul 1 - Controller	MT Comp. Request	Loadshed 1	Loadshed 2	Night	Heat recovery	Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	Comp. 3 safety	Comp. 4 safety	Comp. 5 safety	
				Modul 3 - AK-XM 205A						
14			MT 6 single 6 fan HFC Cascade HR	Modul 1 - Controller	MT Comp. Request	Loadshed 1	Loadshed 2	Night	Heat recovery	Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	Comp. 3 safety	Comp. 4 safety	Comp. 5 safety	Comp. 6 safety
				Modul 3 - AK-XM 204A	Fan 1	Fan 2	Fan 3	Fan 4	Fan 5	Fan 6
15			MT 1x1 unload 3 single 4 fan HFC Cascade HR	Modul 1 - Controller	MT Comp. Request	Loadshed 1	Loadshed 2	Night	Heat recovery	Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	Comp. 3 safety	Comp. 4 safety		
				Modul 3 - AK-XM 205A						
16			MT 2x1 unload 2 single 4 fan HFC Cascade HR	Modul 1 - Controller	MT Comp. Request	Loadshed 1	Loadshed 2	Night	Heat recovery	Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	Comp. 3 safety	Comp. 4 safety		
				Modul 3 - AK-XM 204	Fan 1	Fan 2	Fan 3	Fan 4		
17			MT 5x1 unload 6 fan HFC Cascade HR	Modul 1 - Controller	MT Comp. Request	Loadshed 1	Loadshed 2	Night	Heat recovery	Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	Comp. 3 safety	Comp. 4 safety	Comp. 5 safety	
				Modul 3 - AK-XM 205A						
				Modul 4 - AK-XM 204	Comp. 5	Comp. 5 Aflast. 1	Fan 5	Fan 6	MT Comp. Release	
18			MT 1 vsd comp. 4 single vsd-fans HFC Cascade HR	Modul 1 - Controller	MT Comp. Request	Loadshed 1	Loadshed 2	Night	Heat recovery	Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	Comp. 3 safety	Comp. 4 safety	Comp. 5 safety	VSD. 1 safety
				Modul 3 - AK-XM 204	Fan 1	Fan 2	Fan 3	Fan 4	Fan 5	Fan 6
19			MT 2 vsd comp. 4 fan HFC	Modul 1 - Controller		Loadshed 1	Loadshed 2	Night		Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	VSD. 1 safety	VSD. 2 safety		
20			MT 2 vsd comp. 2 single 4 fan HFC	Modul 1 - Controller		Loadshed 1	Loadshed 2	Night		Main Sw.
				Modul 2 - AK-XM 102B	Comp. 1 safety	Comp. 2 safety	Comp. 3 safety	Comp. 4 safety	VSD. 1 safety	VSD. 2 safety

Appl.	Point number														
	7	8	9	10	11	12	13	14	15	16	17	18	19	24	25
3b	Sc3	Sd	Ss	P0	Pc	Comp. 1	Comp. 3	Comp. 3	Liq. Inject suction	Fan 1	Fan 2	Comp. 4	MT Comp. Release	Comp. speed	Fan speed
	Fan 2 safety	VSD cond safety													
	Speed tw	Speed hr													
	HR Shr4	HR Shr8	Vrec CCM												
	GasCool. Pgc	Receiver Prec	HR tw V3tw	HR tw Pump tw	HR V3hr	HR pump hr		GasCool. V3gc	Thermost. 1	Alarm					
3ab	Sc3	Sd	Ss	P0	Pc	Comp. 1	Comp. 2	Comp. 3	Liq. Inject suction	Fan 1	Fan 2	Comp. 4	MT Comp. Release	Comp. speed	Fan speed
	Fan 2 safety	VSD cond safety													
	Speed tw	Speed hr													
	HR Shr4	HR Shr8	Vrec CCM												
	Volt input 1	Poil rec	Oil Valve C1	Oil Valve C2	Oil Valve C3	Oil Valve C4	Oil lvl. Safety C1	Oil lvl. Safety C2	Oil lvl. Safety C3	Oil lvl. Safety C4					
	GasCool. Pgc	Receiver Prec	HR tw V3tw	HR tw Pump tw	HR V3hr	HR pump hr	Oil valve Separat.1	GasCool. V3gc	Thermost. 1	Alarm					
11		Sd	Ss	P0	Pc	Comp. 1	Comp. 2	Comp. 3				Alarm	LT comp. Request		
12	Sc3	Sd	Ss	P0	Pc	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Fan 1	Fan 2	Fan 3	Fan 4		
	Volt input 1	Saux 1					MT Comp. Release	Liq. Inject Heat Ex.	Thermost. 1	Heat recovery					
13	Sc3	Sd	Ss	P0	Pc	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5	Fan 1	Fan 2	Fan 3		Fan speed
	Volt input 1	Saux 1		Fan 4	Fan 5	Fan 6	MT Comp. Release	Liq. Inject Heat Ex.	Thermost. 1	Heat recovery					
14	Sc3	Sd	Ss	P0	Pc	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5	Comp. 6	Alarm	MT Comp. Release		
	Liq. Inject Heat Ex.	Heat recovery													
15	Sc3	Sd	Ss	P0	Pc	Comp. 1	Comp. 1 Aflast. 1	Comp. 2	Comp. 3	Comp. 4			MT Comp. Release		
		Saux 1	Fan 1	Fan 2	Fan 3	Fan 4		Liq. Inject Heat Ex.	Thermost. 1	Heat recovery					
16	Sc3	Sd	Ss	P0	Pc	Comp. 1	Comp. 1 Aflast. 1	Comp. 2	Comp. 2 Aflast. 1	Comp. 3	Comp. 4		MT Comp. Release		
	Liq. Inject Heat Ex.	Heat recovery													
17	Sc3	Sd	Ss	P0	Pc	Comp. 1	Comp. 1 Aflast. 1	Comp. 2	Comp. 2 Aflast. 1	Comp. 3	Comp. 3 Aflast. 1	Comp. 4	Comp. 4 Aflast. 1		
		Saux 1	Fan 1	Fan 2	Fan 3	Fan 4		Liq. Inject Heat Ex.	Thermost. 1	Heat recovery					
18	Sc3	Sd	Ss	P0	Pc	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5		Alarm	MT Comp. Release	Comp. speed	Fan speed
		VSD cond safety													
	Liq. Inject Heat Ex.	Heat recovery													
19	Sc3	Sd	Ss	P0	Pc	Comp. 1	Comp. 2	Alarm		Fan 1	Fan 2	Fan 3	Fan 4	Comp. speed	
20	Sc3	Sd	Ss	P0	Pc	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Fan 1	Fan 2	Fan 3	Fan 4	Comp. speed	

Installation considerations

Accidental damage, poor installation, or site conditions, can give rise to malfunctions of the control system, and ultimately lead to a plant breakdown.

Every possible safeguard is incorporated into our products to prevent this. However, a wrong installation, for example, could still present problems. Electronic controls are no substitute for normal, good engineering practice.

Danfoss will not be responsible for any goods, or plant components, damaged as a result of the above defects. It is the installer's responsibility to check the installation thoroughly, and to fit the necessary safety devices.

Special reference is made to the necessity of signals to the controller when the compressor is stopped and to the need of liquid receivers before the compressors.

Your local Danfoss agent will be pleased to assist with further advice, etc.