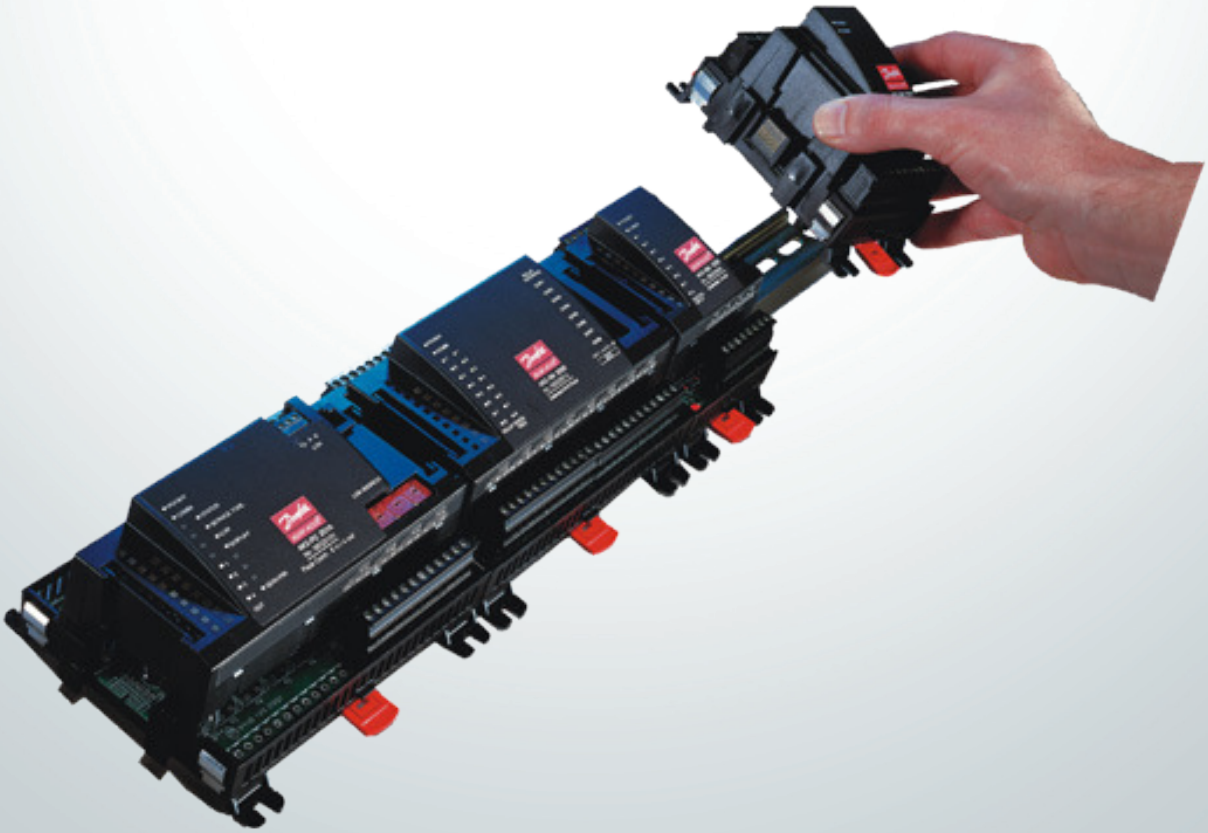
ENGINEERING
TOMORROW

Design Guide

Heat pump controller with oil management
AK-HP 780

ADAP-KOOL® Refrigeration control systems



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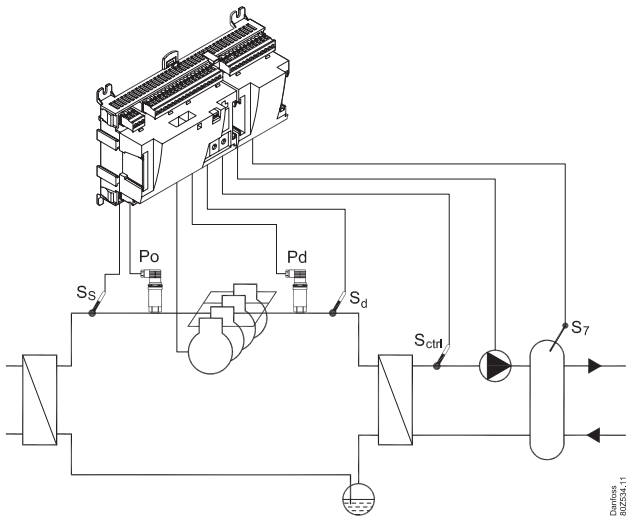
1. Introduction

Application

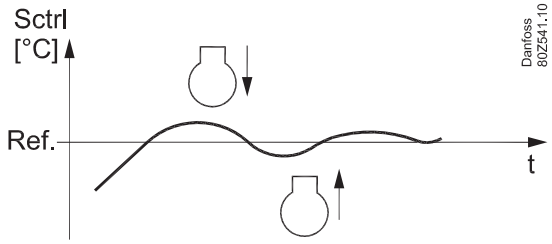
AK-HP 780 is a complete heat pump regulating for capacity control of compressors and temperature regulating of a receiver. The controller is with oil management, making it suitable for CO2 plants.

The controller's main function is to control compressors and pump, so that operation all the time takes place at the energy-optimum pressure conditions. Both suction pressure and discharge pressure are monitored with the belonging safety function and alarm function. Capacity control can be carried out by media temperature Sctrl and S7.

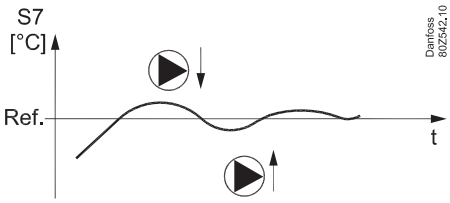
Among the different functions are:
- Capacity control of up to 8 compressors
- Up to 3 unloaders for each compressor
- Oil management. Either shared or individual for all of the compressor's oil valves. Receiver pressure control.
- Speed control of one or two compressors
- Up to 6 safety inputs for each compressor
- Option for capacity limitation to minimize consumption peaks
- Safety monitoring of high pressure / low pressure / discharge temperature
- Capacity control of a pump. Either On/Off or speed control
- Safety monitoring of pump flow
- The status of the outputs and inputs is shown by means of light-emitting diodes on the front panel
- Alarm signals can be generated directly from the controller and 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 and pressure control functions, safety functions at cold start up, P0 limitation.



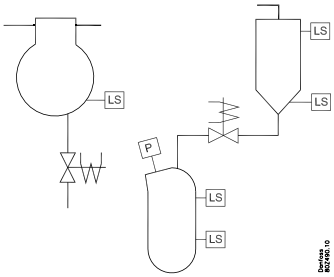
Example



Compressor control



Pump control



Oil management

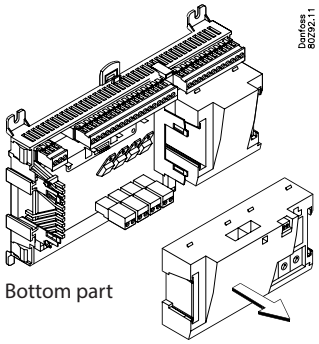
SW = 1.4x

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 heat pump control, 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.

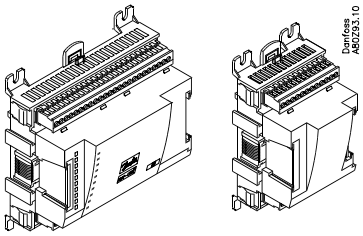
Advantages
- The controller's size can "grow" as systems grow
- The software can be set for one or more regulations
- Several regulations with the same components
- Extension-friendly when systems requirements are changed
- Flexible concept:
  - Controller series with common construction
  - One principle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

Controller

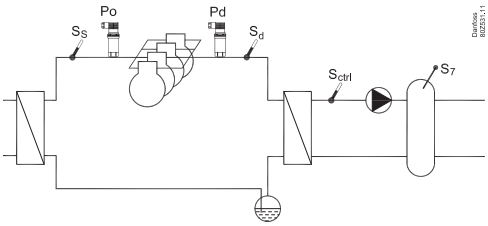


The controller is the cornerstone of the regulation. The module has inputs and outputs capable of handling small systems.
- The bottom part – and hence the terminals – are the same for all controller types.
- The top part contains the intelligence with software. This unit will vary according to controller 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.

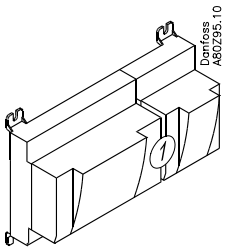
Extension modules



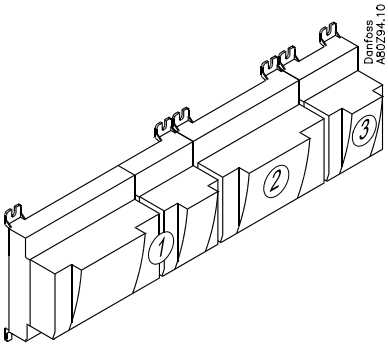
If the system grows and more functions have to be controlled, the regulation can be extended.
With extra modules more signals can be received and more relays cut in and out – how many of them – and which – is determined by the relevant application.



Examples



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

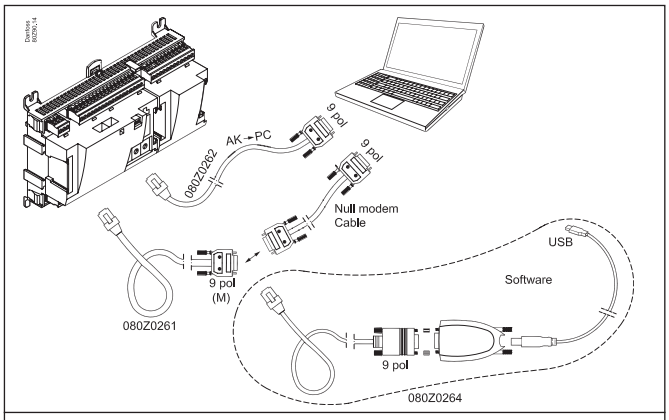


If there are many connections one or more extension modules have to be mounted

Direct connection

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

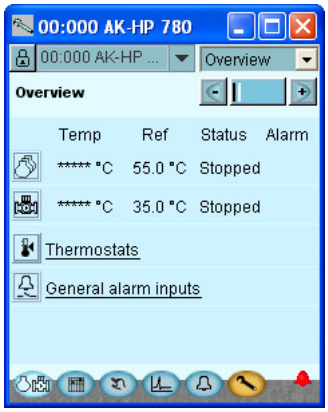
The programme is installed on a PC, and setup and operation of the various functions are carried out via the controller's menu displays.



Displays

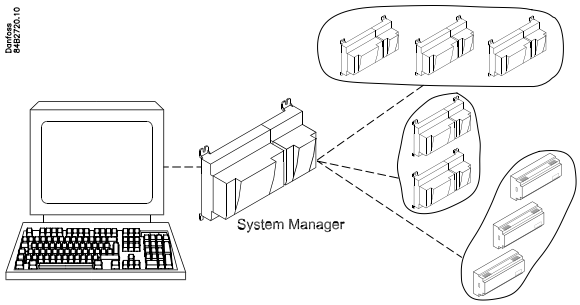
The menu displays are dynamic, so that different settings in one menu will result in different setting possibilities in other menus.

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 pump 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.

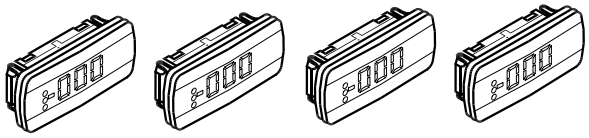


Users

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.

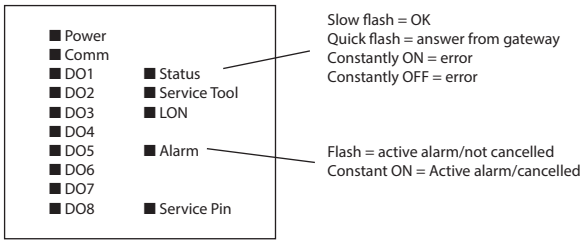
External display

An external display can be fitted in order for S7 (receiver temperature), P0 (suction pressure) and Pd (discharge pressure) 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,, Sctrl, Ss, Sd, discharge pressure, discharge pressure in temperature and S7.



Light-emitting diodes

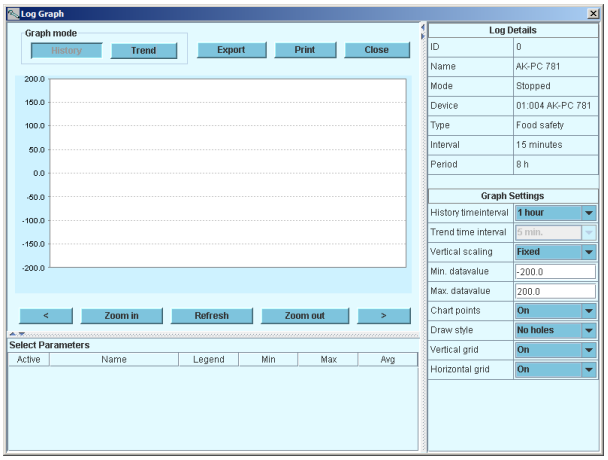
A number of light-emitting diodes makes it possible to follow the signals that are received and transmitted by the controller.



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.

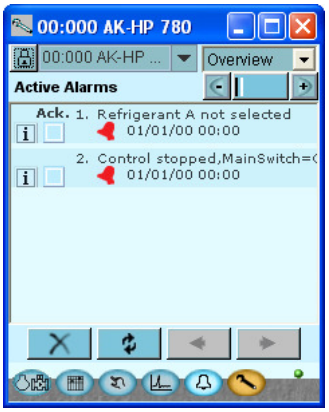
If you are in a service situation you can show measurements in a trend function. The measurements are then made real-time and displayed instantly.



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.



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.

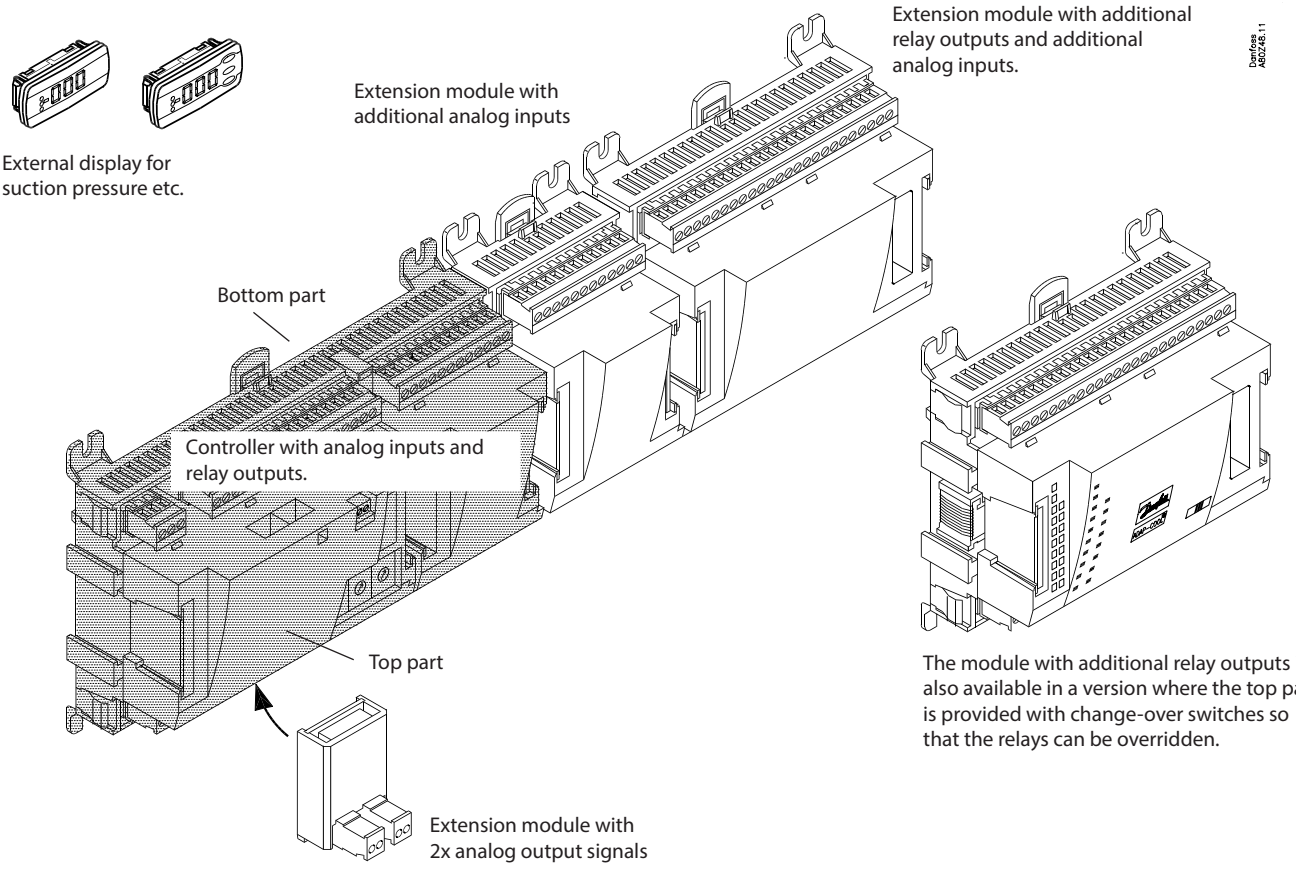
- Extension modules. When the complexity becomes greater and additional inputs or outputs are required, modules can be attached to the controller. A plug on the side of the module will transmit the supply voltage and data communication between the modules.

- 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)



The module with additional relay outputs is also available in a version where the top part is provided with change-over switches so that the relays can be overridden.

1. Controller

Type	Function	Application
AK-HP 780	Controller for heat pump control	Capacity control for heat pump operation. Control of pump for hot water receiver. Oil management

2. Extension modules and survey of inputs and outputs

Type	Analog inputs	On/Off outputs		On/off supply voltage (DI signal)		Analog outputs	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 override of relay outputs
Controller	11	4	4	-	-	-	-
Extension modules							
AK-XM 101A	8						
AK-XM 102A				8			
AK-XM 102B					8		
AK-XM 204A		8					
AK-XM 204B		8					x
AK-XM 205A	8	8					
AK-XM 205B	8	8					x
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
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	
Accessories	**External display that can be connected to the controller module. For showing, say, the receiver temperature**	
EKA 163B	Display	
EKA 164B	Display with operation buttons	
-	Cable between display and controller	Length = 2 m
		Length = 6 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

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-HP (controller)	8 VA
	AK-XM 101, 102, 107	2 VA
	AK-XM 204, 205	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	Max. 240 V a.c. , Min. 48 V a.c. Max. 0,5 A, Leak < 1 mA Max. 1 AKV
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
	Class	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

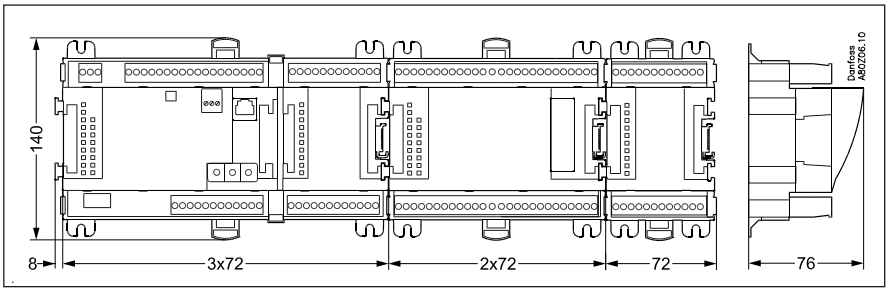
The mentioned data applies to all modules.
If data is specific, this is mentioned together with the module in question.

Capacitive load
The relays cannot be used for the direct connection of capacitive loads such as LEDs and on/off control of EC motors.
All loads with a switch mode power supply must be connected with a suitable contactor or similar.

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.

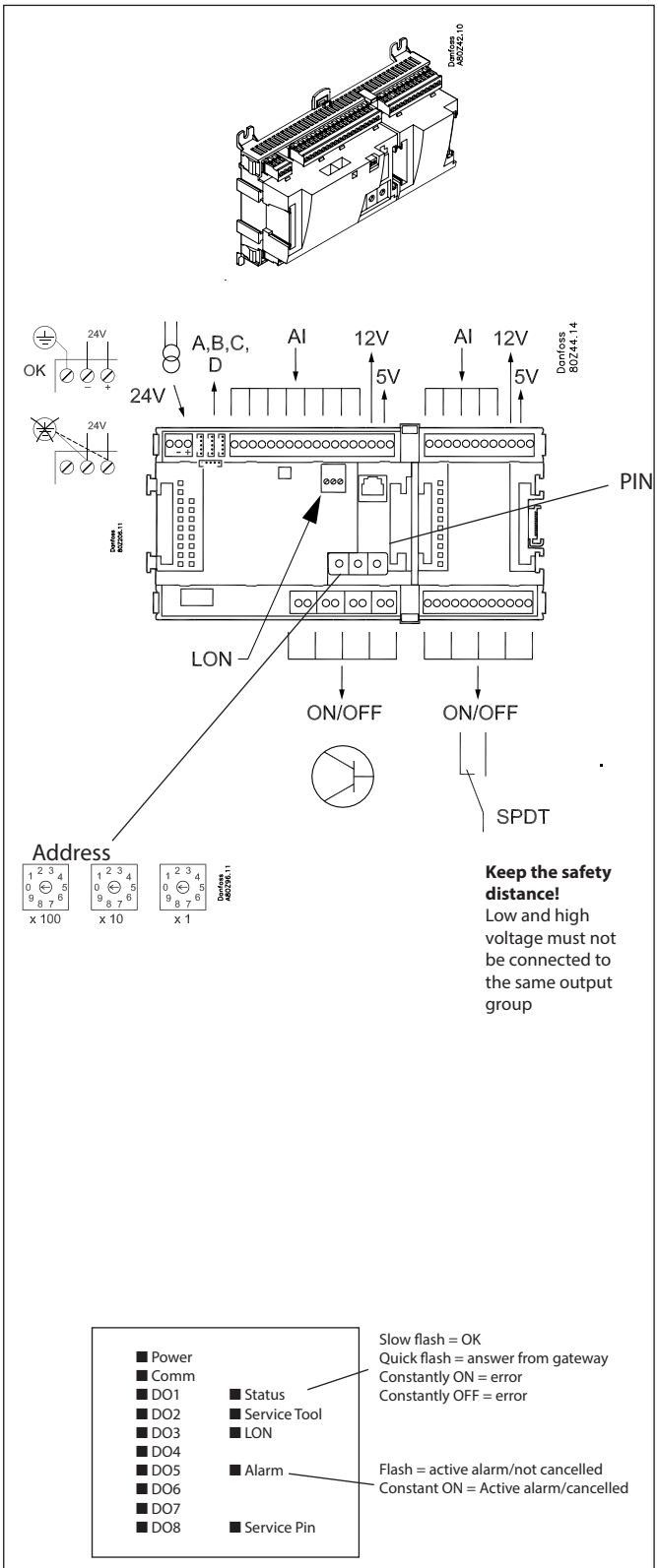
Address setting
When the controller is connected to a gateway type AKA 245, the controller's address must be set between 1 and 119. (If it is a system manager AK-SM .., then 1-999).

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 programme "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

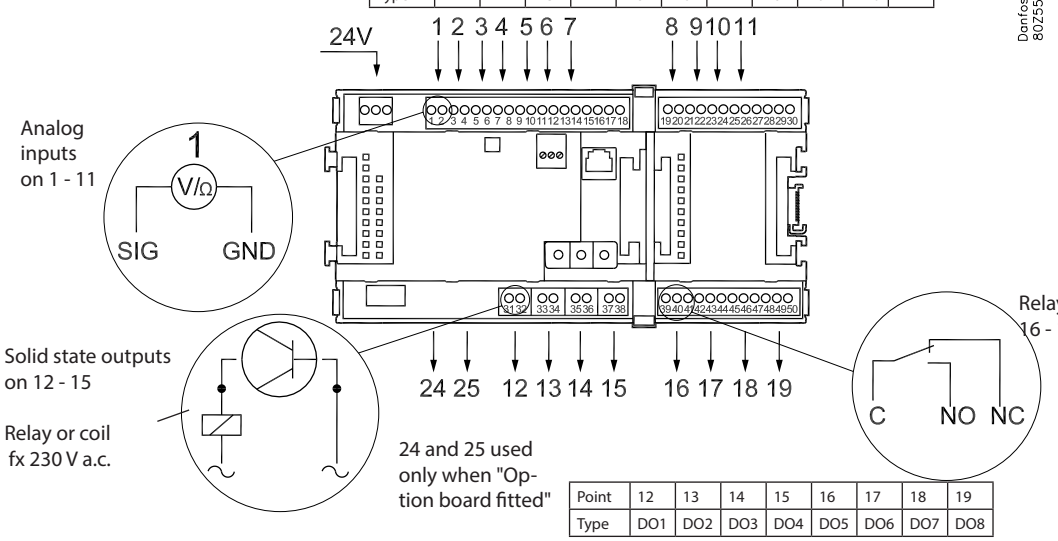
Right row:
- Software status (slow flash = OK)
- Communication with Service Tool
- Communication on LON
- Alarm when LED flashes
- 3 LED's that are not used
- "Service Pin" switch has been activated



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



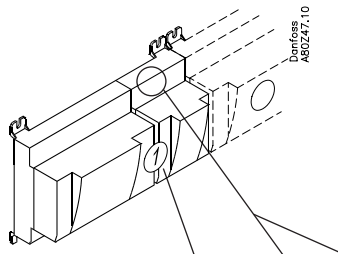
Terminal 15: 12 V
Terminal 16: 5 V

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	Sctrl S7 Saux1 Saux2 SS Sd	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	P0 Pd 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 Level switch	**Active at:** Closed / Open
DO C NO NC	Comp 1 Comp 2 Pump Alarm 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	**-**	

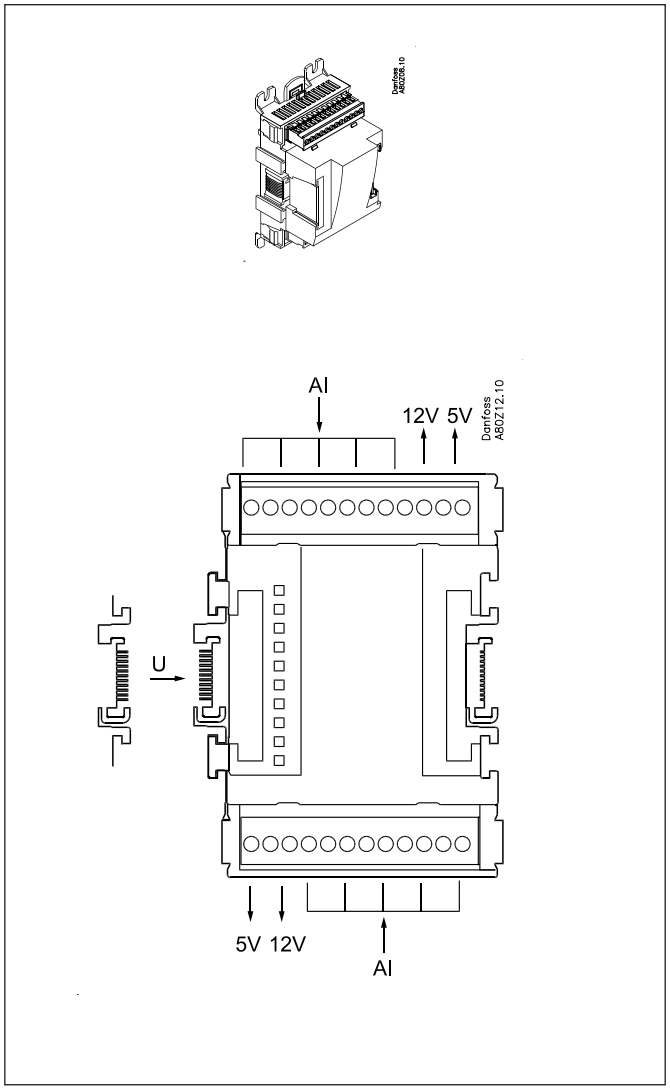
Extension module AK-XM 101A

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.

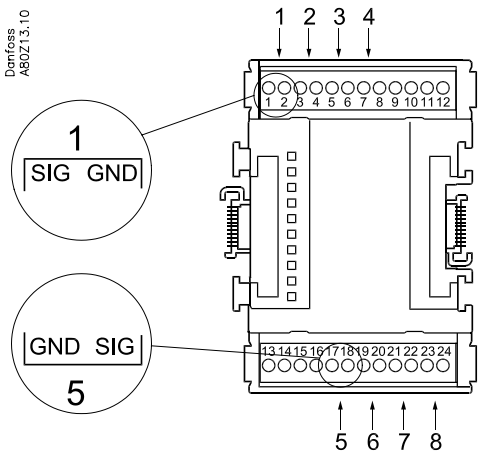
Supply voltage to a pressure transmitter can be taken from either the 5 V output or the 12 V output depending on transmitter type.

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.

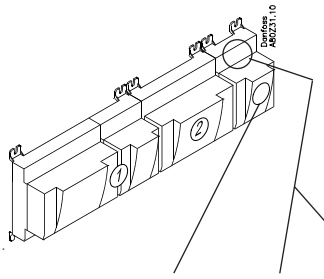
Terminal 9: 12 V
Terminal 10: 5 V

Terminal 15: 5 V
Terminal 16: 12 V

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

Point	5	6	7	8
Type	AI5	AI6	AI7	AI8

	Signal	Signal type
S Pt 1000 ohm/0°C SIG GND	Sctrl S7 Saux1 Saux2 SS Sd	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	P0 Pd 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 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**	

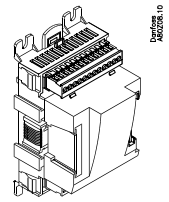
Extension module AK-XM 102A / AK-XM 102B

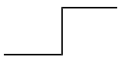
Function
The module contains 8 inputs for on/off voltage signals.

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

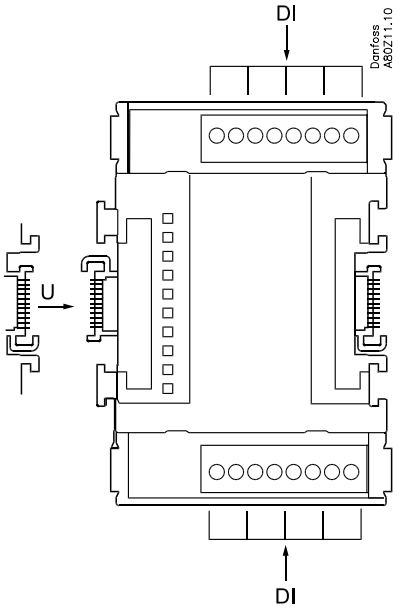
Supply voltage
The supply voltage to the module comes from the previous module in the row.

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)



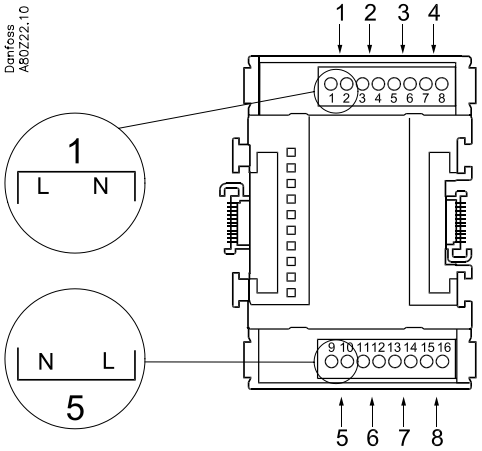


AK-XM 102A	AK-XM 102B
Max. 24 V	**Max. 230 V**
On/Off:	On/Off:
On: DI > 10 V a.c.	On: DI > 80 V a.c.
Off: DI < 2 V a.c.	Off: DI < 24 V a.c.



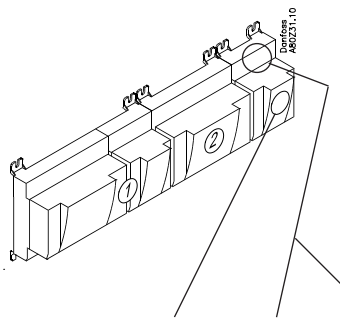
Point

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 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.

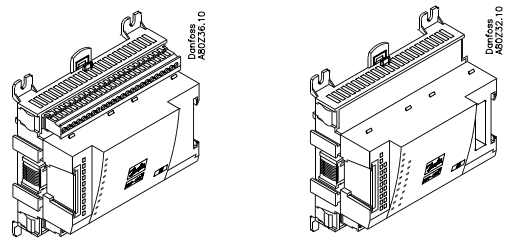
AK-XM 204B only
Override of relay
Eight change-over switches at the front make it possible to override the relay's function.
Either to position OFF or ON.
In position Auto the controller carries out the control.

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

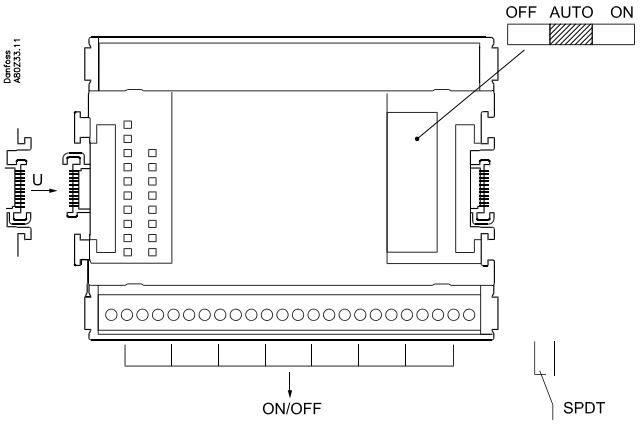
Right row: (AK-XM 204B only):
- Override of relays
  ON = override
  OFF = no override

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.



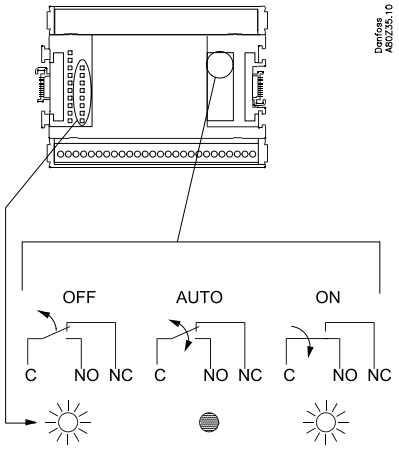
AK-XM 204A AK-XM 204B



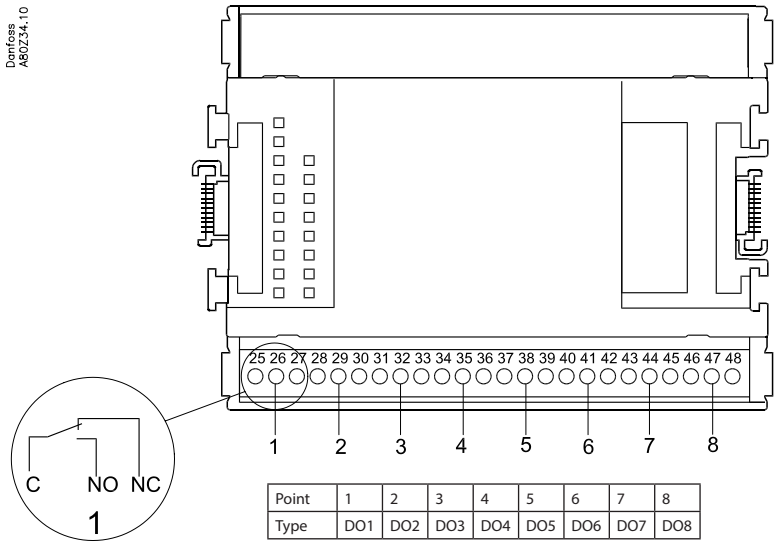
Max. 230 V
AC-1: max. 4 A (ohmic)
AC-15: max. 3 A (Inductive)

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

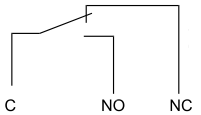
AK-XM 204B
Override of relay

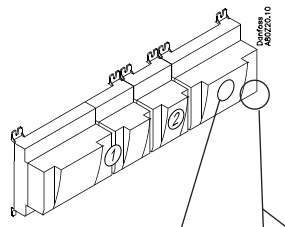


Point



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 Pump 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.

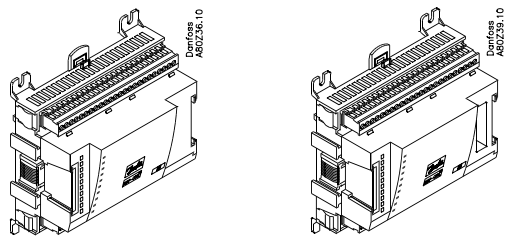
AK-XM 205B only
Override of relay
Eight change-over switches at the front make it possible to override the relay's function.
Either to position OFF or ON.
In position Auto the controller carries out the control.

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

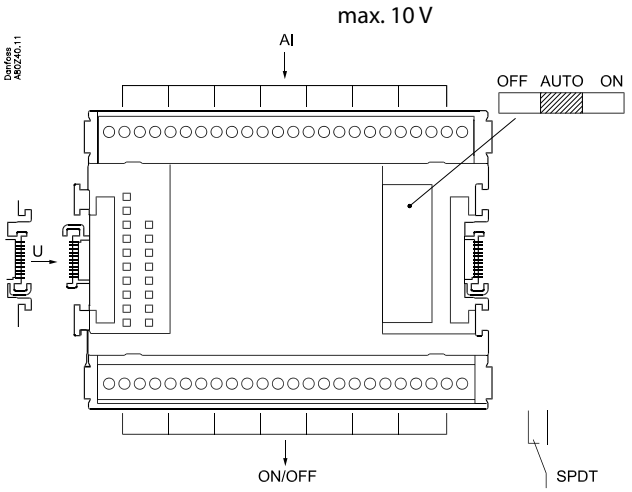
Right row: (AK-XM 205B only):
- Override of relays
  ON = override
  OFF = no override

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.



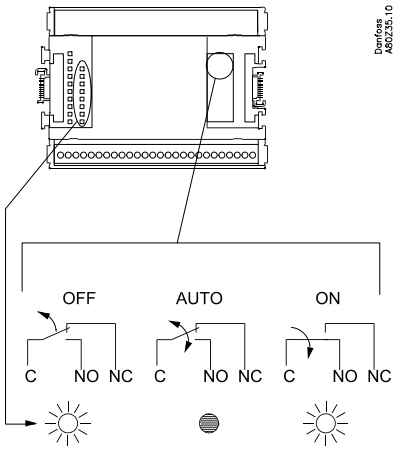
AK-XM 205A AK-XM 205B



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

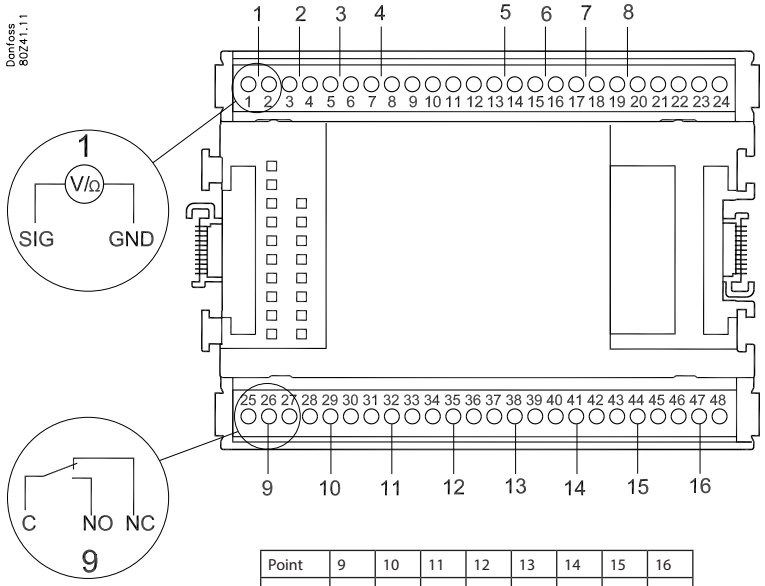
Keep the safety distance!
Low and high voltage must not be connected to the same output group

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



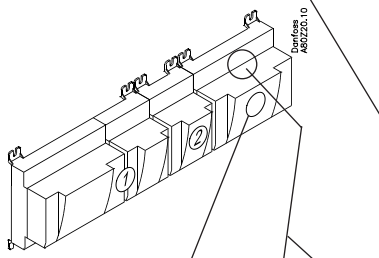
Terminal 9: 12 V
Terminal 10: 5 V

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 SIG GND	Sctrl S7 Saux1 Saux2 SS Sd	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	P0 Pd 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 Level switch	**Active at:** Closed / Open
DO C NO NC	Comp 1 Comp 2 Pump Alarm 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-OB 110

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

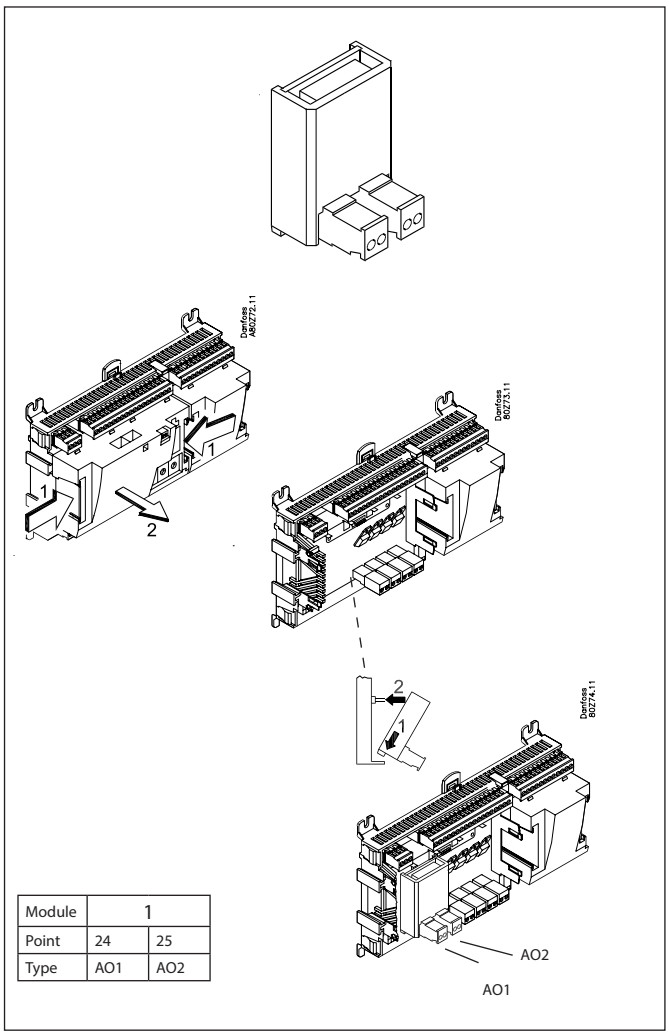
Supply voltage
The supply voltage to the module comes from the controller module.

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

AO	− ○——► 0-10 V + ○——►	AO	0 - 10 V



Module	1	
Point	24	25
Type	AO1	AO2

Extension module AK-OB 101A

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

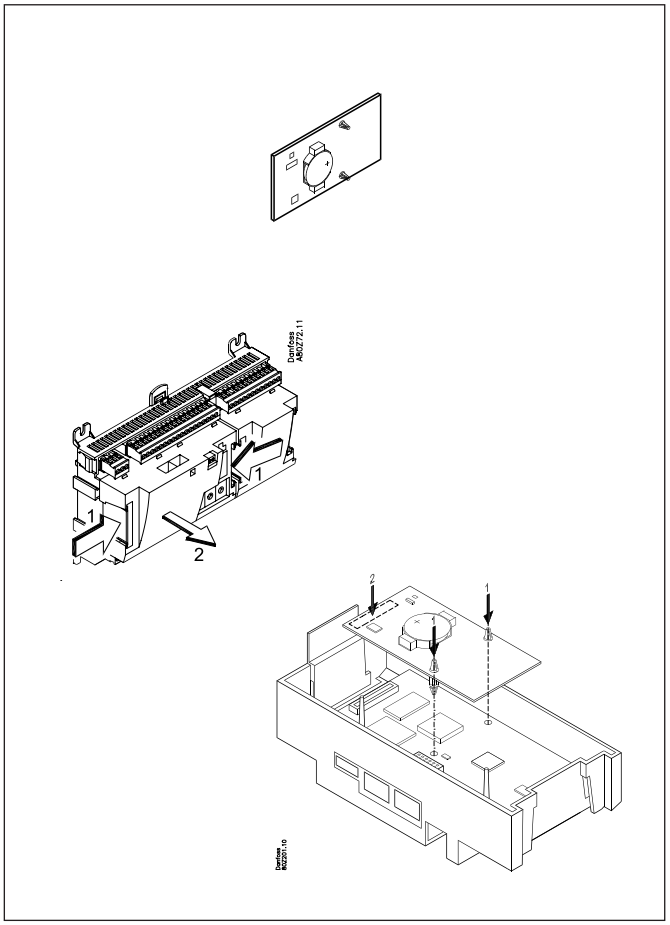
The module can be used in controllers that are not linked up in a data communication unit together with other controllers. The module is used here if the controller needs battery backup for the following functions
• Clock function
• Fixed times for day/night change-over
• Saving of alarm log in case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

Function
Display of important measurements from the controller, e.g. receiver temperature, suction pressure or discharge gas 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.

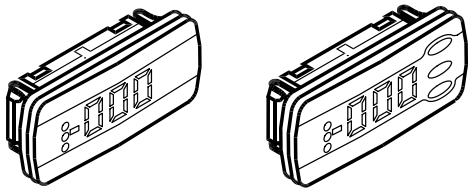
Connection
The extension module is connected to the controller module via a cable with plug connections. You have to use one cable per module. The cable is supplied in various lengths.

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

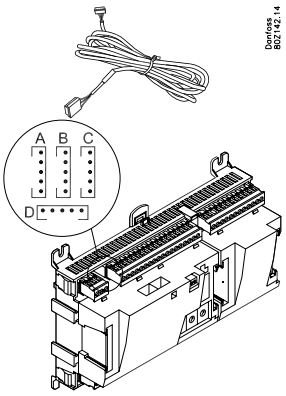
When the controller starts up, the display will show which output is connected. - - 1 = output A, - - 2 = output B, etc.

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.



EKA 163B EKA 164B



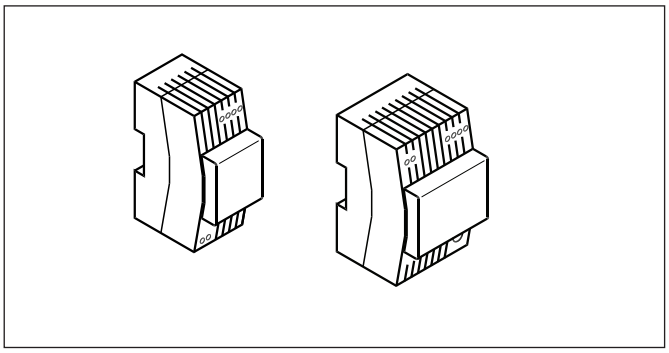
Module	1	
Point	-	-
Type	-	-

Power supply module AK-PS 075 / 150

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



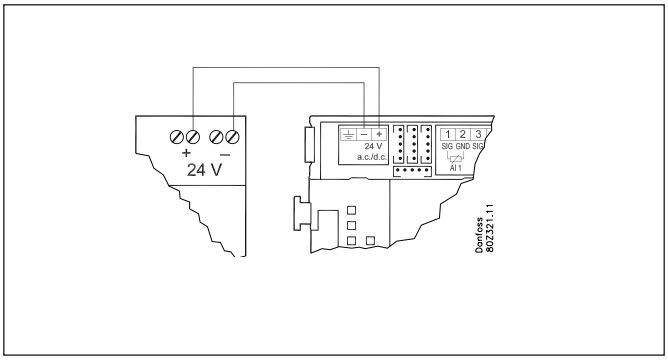
Effect

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

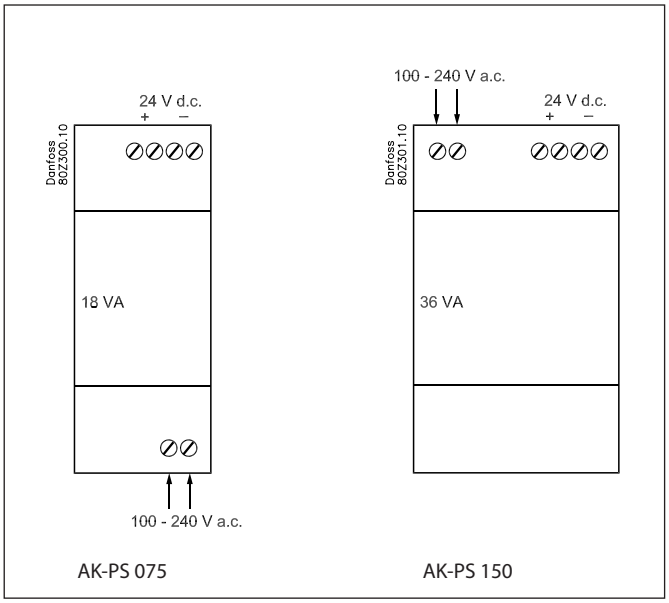
Dimension

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

Supply to a controller



Connections



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 is 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.

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

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.

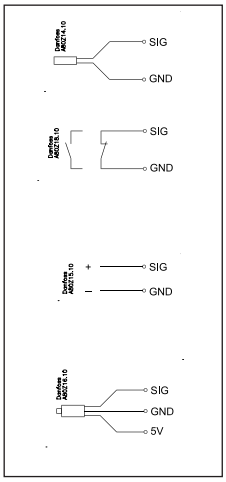
Forced control
The software contains a forced control option. If an extension module with relay outputs is used, the module's top part can be with change-over switches – switches that can override the individual relays into either OFF or ON position.
Wiring should be done with a safety relay. See Regulating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

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

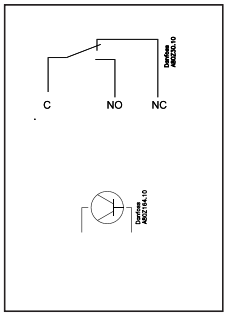
Connections

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.

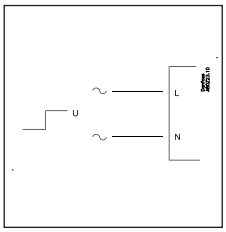


ON/OFF output signals "DO"
There are two types, as follows:
- Relay outputs
  All relay outputs are with change-over relay so that the required function can be obtained when the controller is without voltage.
- Solid state outputs
  Reserved for AKV valves, but output can cut an external relay in and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



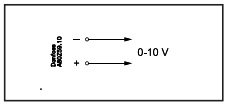
When programming the function must be set:
- Active when the output is activated
- Active when the output is not activated.

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.



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 **100**

✔ The number of extension modules must be limited so that the total power will not exceed **32** VA (including controller).

✔ 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.

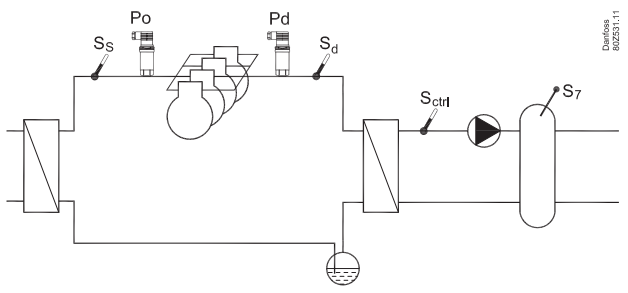
Design of a compressor and pump control

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 Functions

	AK-HP 780
Application	
Regulation of a compressor group	x
Regulation of receiver temperature	x
Regulation of compressor capacity	
Regulation sensor = Sctrl	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
Sequential operation (first in / last out)	x
Speed regulation of 1 compressor or 2 parallel compressors	x
Run time equalisation	x
Min. restart time	x
Min. On-time	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
Temperature reference for Sctrl	
Override via "night setback"	x
Override via "0 -10 V signal"	x
Regulation of receiver temperature	
Regulation sensor. = S7	x
On/off control of pump	x
Speed regulation of pump	x
Safety functions	
Min. suction pressure	x
Max. suction pressure	x
Max. discharge pressure	x
Max. discharge gas temperature	x
Min. / Max. superheat	x
Safety monitoring of compressors	x
Common high pressure monitoring of compressors	x
General alarm functions with time delay	10
Miscellaneous	
Extra sensors	7
Option for connection of separate display	4
Separate thermostat functions	5
Separate pressostat functions	5
Separate voltage measurements	5
Max. input and output	100

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.
A signal is required from pressure transmitters P0 and Pd.
A signal is required from temperature sensors Ss and Sd.
P0 is also used to protect against a too low pressure.
Pd is also used to protect against a too high pressure.

Temperature reference
Sctrl is used as a regulating sensor.
The cut in and cut out of the compressors is determined by the measured temperature.

Receiver
S7 is used as a regulating sensor.
One pump can be controlled based on the measured signal. Signals can be delivered so that the pump can be speed-controlled.

Speed regulation
The function requires an analog output module.
A relay output may be used for start/stop of the speed regulation.

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 lowering the temperature reference Sctrl.
The clock function can be used, but an external ON/OFF signal may be used instead.

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 page 31.

Analog inputs

Temperature sensors
- Sctrl
  Must always be used as a regulating sensor for compressor regulation.
- Ss (suction gas temperature)
  Must always be used.
- Sd (discharge gas temperature)
  Must always be used.
- S7 (receiver temperature)
  Must always be used for regulation sensor for pump control.
- Saux (1-5), any extra temperature sensors
  Up to five additional sensors for monitoring and data collection may be connected. These sensors can be used for general thermostat functions.

Pressure transmitters
- P0 Suction Pressure
  Must always be used.
- Pd Discharge pressure
  Must always be used.
- Prec. Oil receiver pressure. Must be used for oil receiver pressure regulation.
- 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
- Signal from the pumps safety circuit
- Any signal from the frequency converter's safety circuit
- External start/stop of regulation
- External day/night signal (raise/lower the Sctrl- reference).
- DI alarm (1-10) inputs
  Up to 10 no. extra on/off signals for general alarm for monitoring and data collection can be connected.

On/off-outputs
Relay outputs
- Compressors
- Unloaders
- Pump
- Start/stop of liquid injection in heat exchanger

• ON/OFF signal for start/stop of speed regulation
• Alarm 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

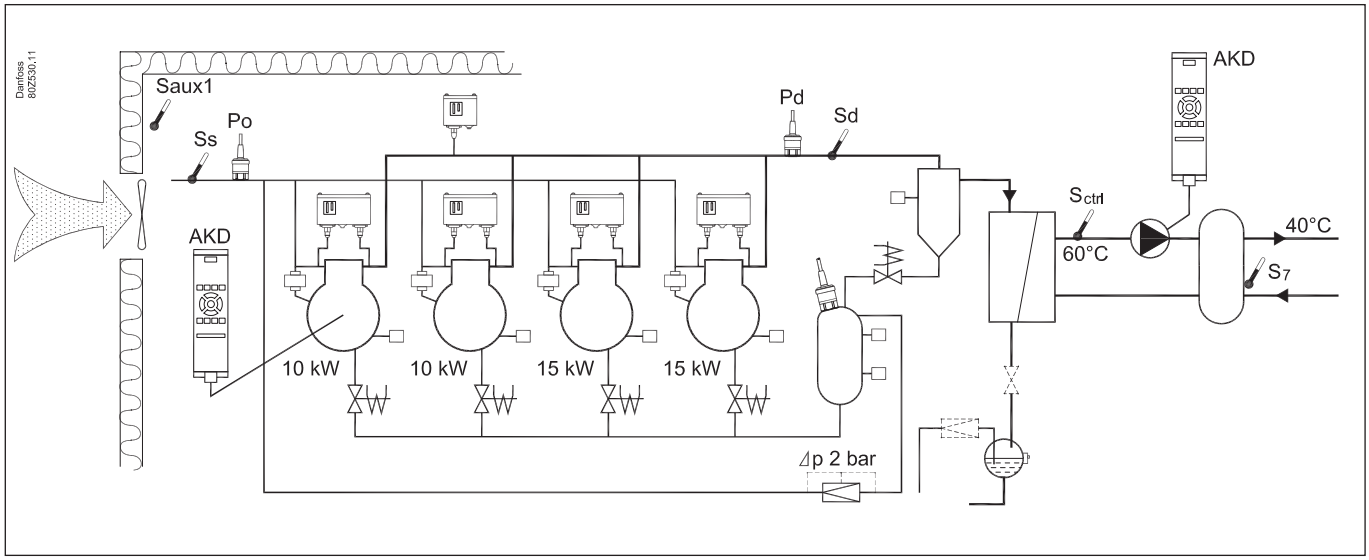
Solid state outputs

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 pump.
• Speed regulation of the compressor

Example



Compressor Group
• Refrigerant CO2 (R744)
• 4 only compressors with "Best fit". Speed control of one.
• Safety monitoring of each compressor
• Common high-pressure monitoring
• Sctrl setting 60°C, Night setback of 5 K
• Oil management of each compressor
• Pulse reset for stopped compressor (lack of oil)

Receiver
• Pump with speed control
• S7 reference 40°C

Oil Receiver:
• Monitoring of liquid level
• Control of pressure in oil receiver

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

Safety functions:
• Monitoring of P0, Pd, Sd and superheat in suction line
• P0 max = 10°C, P0 min = -2°C
• Pd 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 main switch used

Data from this example is used on the next page.
The result is that the following modules should be used:

• AK-HP 780 controller
• AK-XM 102B digital input module
• AK-XM 205B input and output module
• AK-OB 110 analog extension 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	Example	7 Limitations
Analog inputs											
Temperature sensors, Ss, Sd, S7, Sctrl		4									
Extra temperature sensor / separate thermostats		1									
Pressure transmitters,, P0, Pd, Prec / Separate pressostats		3									P = Max. **5** / module
Voltage signal from other regulation, separate signals											
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, flow switch for the pump											Max. 1/ fan
Safety circuits, frequency converter											
External start/stop						1					
Night setback Sctrl-temperature											
Separate alarm functions via DI		1									
Load shedding											
Liquid level, Oil level, Pulse reset of oil management		9									
On/off outputs											
Compressors, motors								4			Max. 8
Unloaders											
Pump								1			Max. 8
Alarm relay								1			Max. 1
Separate thermostat and pressostat functions and voltage measurements								1			Max. 5+5+5
Liquid injection in heat exchanger											Max.1
Solenoid valve for Oil. Safety relays for comp.								5			
Analog control signal, 0-10 V											
Frequency converter, Comp.1 + (comp.2 or pump)										2	Max. 2
Sum of connections for the regulation		18		0		6		12		2	Sum = max. **100**
Number of connections on a controller module	11	11	0	0	0	0	8	8	0	0	
Missing connections, if applicable		7		-		6		4		2	
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 204A / B **(8 relay outputs)**											___ pcs. á 5 VA = __
AK-XM 205A / B **(8 analog inputs + 8 relay outp.)**		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

5

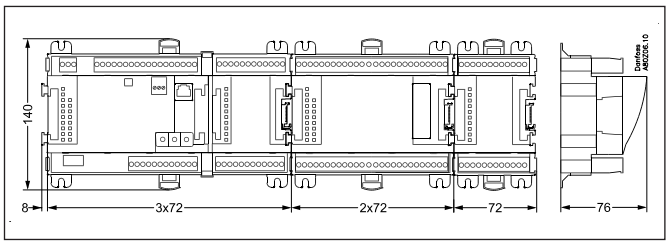
6

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.

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:

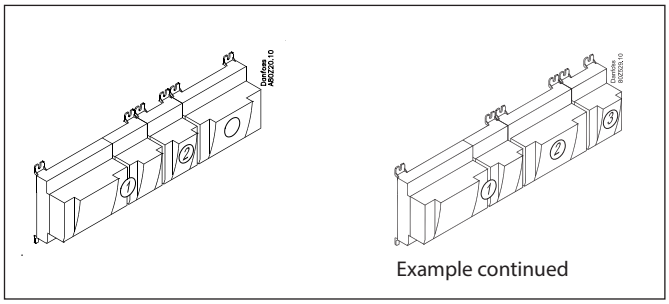
Module	Type	Number		at		Length
Controller module		1	x	224	=	224 mm
Extension module	200-series	_	x	144	=	___ mm
Extension module	100-series	_	x	72	=	___ mm
Total length					=	___ mm

Example continued:
Controller module + 1 extension modules in 200-series + 1 extension module in 100 series =
224 + 144 + 72 = 440 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.



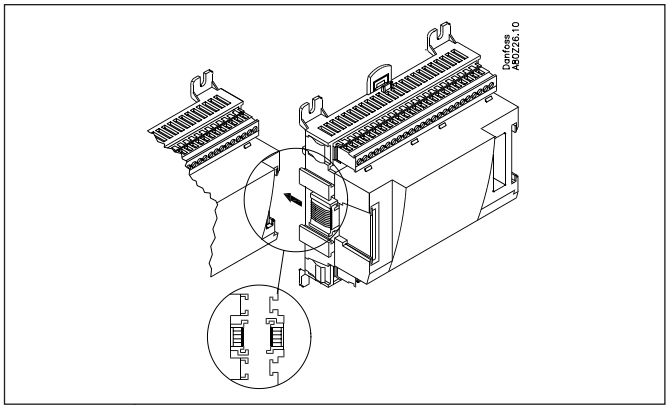
Example continued

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.

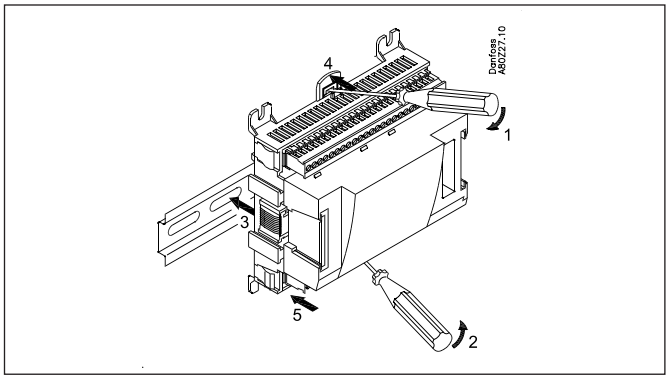
Mounting and removal must always be performed when there is no voltage.

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

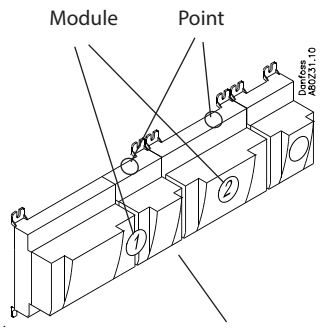
All connections must be programmed with module and point, so in principle it does not matter where the connections are made, as long as it takes place on a correct type of input or output.

- 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*



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.

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

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**	

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

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
Compressor control - Sctrl		**3** (AI 3)	**5 - 6**	Pt 1000
External main switch		**4** (AI 4)	**7 - 8**	Closed
"Pump control" - S7		**5** (AI 5)	**9 - 10**	Pt 1000
Suction pressure - P0		**6** (AI 6)	**11 - 12**	AKS 2050-59
Discharge pressure - Pd		**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, Receiver		**16** (DO 5)	**39 - 40 - 41**	ON
		17 (DO6)	**42 - 43 - 44**	ON
Alarm		**18** (DO7)	**45 - 46 - 47**	OFF
Room fan		**19** (DO8)	**48 - 49 - 50**	ON
AKD compressor control		**24**	-	0-10 V
AKD pump control		**25**	-	0-10 V

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
Thermostat sensor in engine room - Saux1		**6** (AI 6)	**15 - 16**	Pt 1000
		7 (AI 7)	**17 - 18**	
Oil receiver, Prec		**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 signal to AKD for the pump		**13** (DO 5)	**37 - 38 - 39**	ON
		14 (DO6)	**40 - 41 - 42**	
		15 (DO7)	**43 - 44 - 45**	
		16 (DO8)	**46 - 47 - 48**	

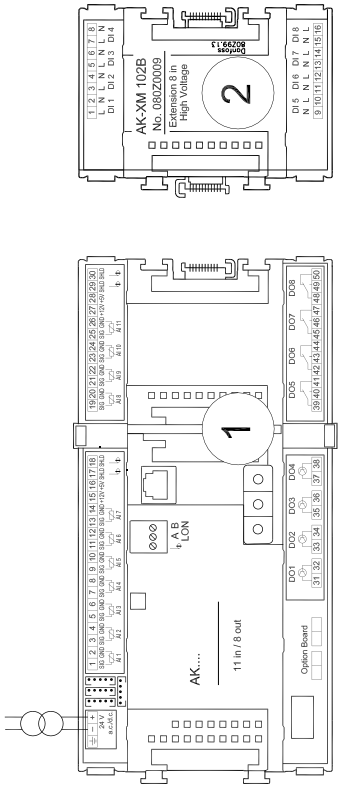
Signal	Module	Point	Terminal	Active at
Compressor 1 Gen. Safety	3	**1** (DI 1)	**1 - 2**	Open
Compressor 2 Gen. Safety		**2** (DI 2)	**3 - 4**	Open
Compressor 3 Gen. Safety		**3** (DI 3)	**5 - 6**	Open
Compressor 4 Gen. Safety		**4** (DI 4)	**7 - 8**	Open
		5 (DI 5)	**9 - 10**	
All compressors common safety		**6** (DI 6)	**11 - 12**	Open
		7 (DI 7)	**13 - 14**	
		8 (DI 8)	**15 - 16**	

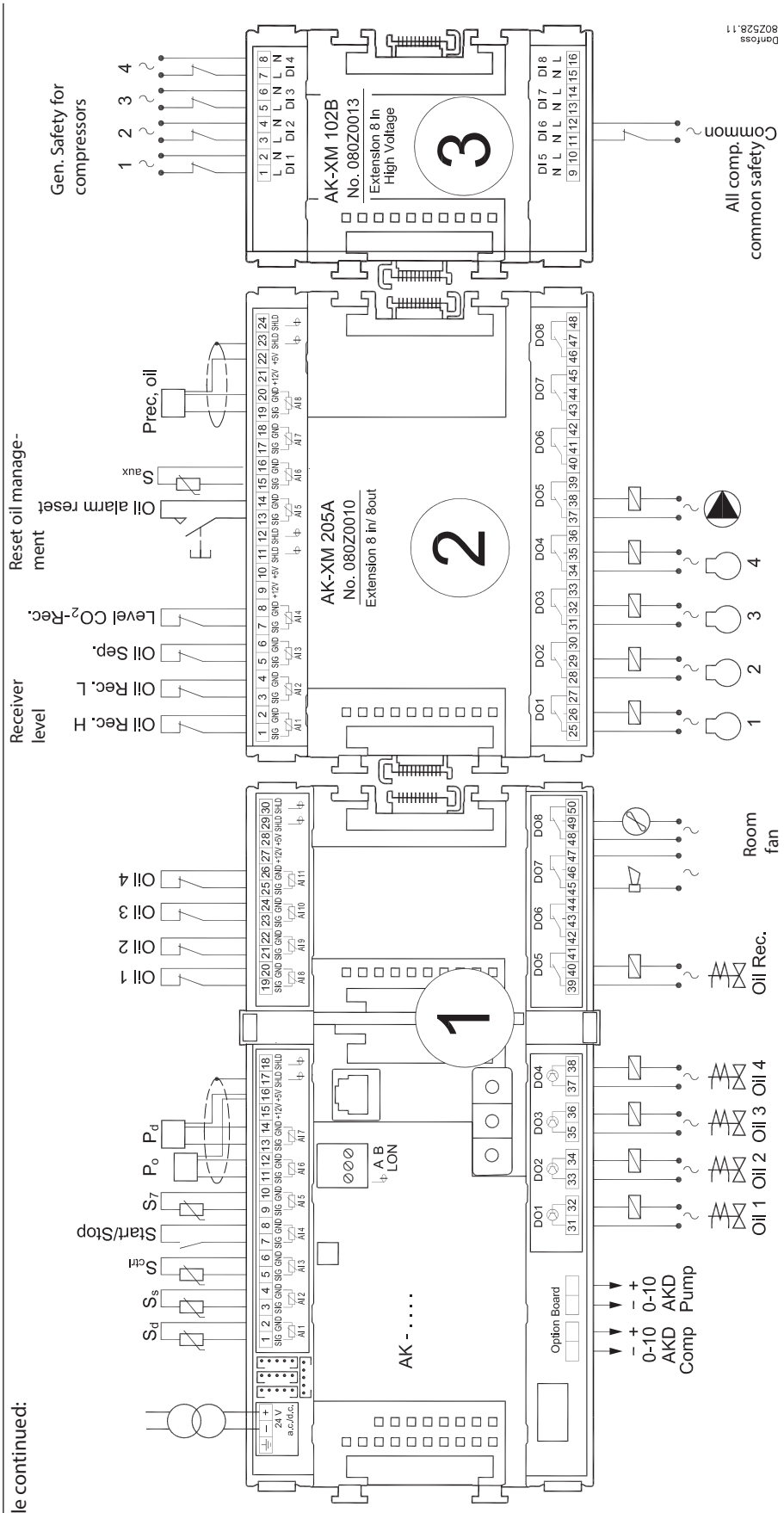
11

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.





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 transformer must be used for each controller. The transformer 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.

Transformer 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
+ 1 extension modules in 200-series	5 VA
+ 1 extension module in 100-series	2 VA

Transformer size (least)	15 VA

Ordering

1. Controller

Type	Function	Application	Language	Code no.	Example continued
AK-HP 780	Controller for heat pump control	Capacity control for compressors. Control of pump for liquid receiver. Oil management	English, German, French, Dutch, Italian	**080Z0156**	x
			English, Danish, Finnish	**080Z0158**	

2. Extension modules and survey for inputs and outputs

Type	Analog inputs	On/Off outputs		On/off supply voltage (DI signal)		Analog 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 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 204A		8						**080Z0011**	
AK-XM 204B		8					x	**080Z0018**	
AK-XM 205A	8	8						**080Z0010**	x
AK-XM 205B	8	8					x	**080Z0017**	
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**	
Accessories	**Power supply module 230 V / 115 V to 24 V d.c.**			
AK-PS 075	18 VA	Supply for controller	**080Z0053**	x
AK-PS 150	36 VA		**080Z0054**	
Accessories	**External display that can be connected to the controller module. For showing, say, the receiver temperature**			
EKA 163B	Display		**084B8574**	
EKA 164B	Display with operation buttons		**084B8575**	
-	Cable between display and controller	Length = 2 m	**084B7298**	
		Length = 6 m	**084B7299**	
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**	

3. Mounting and wiring

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

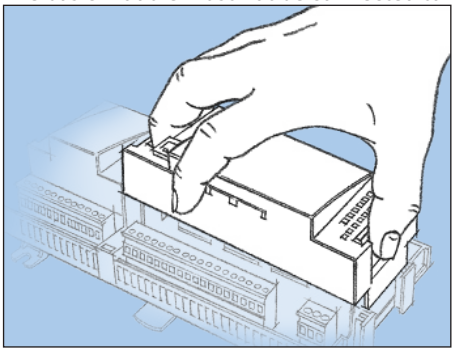
We have decided to work on the basis of the example we went through previously, i.e. the following modules:
• AK-HP 780 controller module
• AK-XM 205A input and output module
• AK-XM 102B digital input module
• AK-OB 110 analog output module

Mounting

Mounting of analog output module

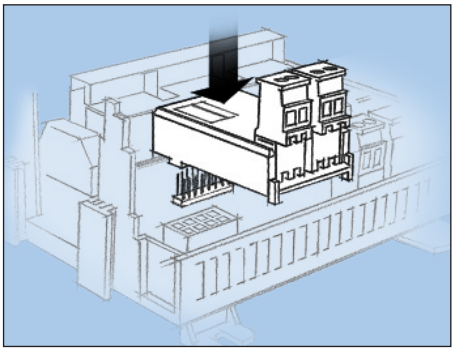
1. Lift the top part off the basic module

   The basic module must not be connected to voltage.



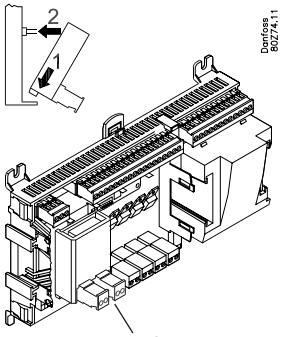
   Press in the plate on the left-hand side of the light-emitting diodes and the plate on the right-hand side for the red address changers.
   Lift the top part off the basic module.

2. Mount the extension module in the basic module



3. Put the top part back on the basic module

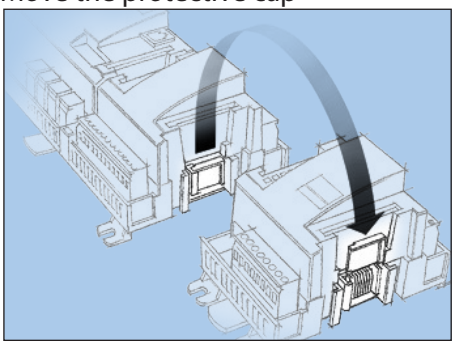
The analog extension module will supply a signal to the variable frequency drive.



There are two outputs.

Mounting of extension module on the basic module

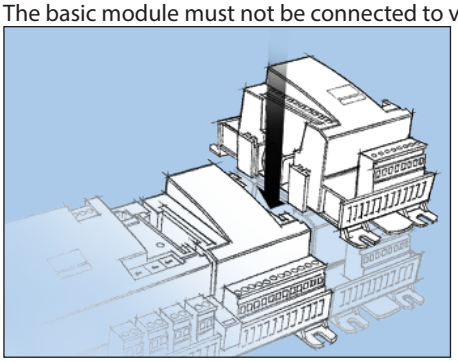
1. Move the protective cap



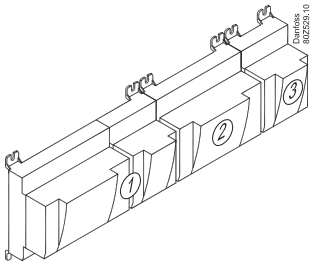
Remove the protective cap from the connection plug on the right-hand side of the basic module.
Place the cap on the connection plug to the right of the extension module that is to be mounted on the extreme right-hand side of the AK assembly.

2. Assemble the extension module and the basic module

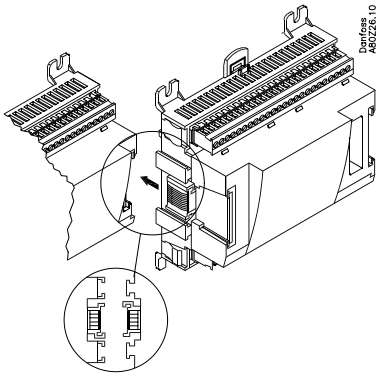
The basic module must not be connected to voltage.

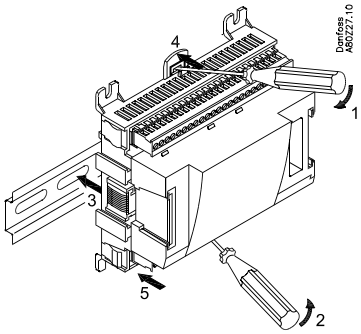


In our example two extension modules are to be fitted to the basic module. We have chosen to fit the module with relays directly on the basic module and then the module with input signals. The sequence is thus:



All the subsequent settings that affect the two 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:

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
Compressor control - Sctrl		**3** (AI 3)	**5 - 6**	Pt 1000
External main switch		**4** (AI 4)	**7 - 8**	closed
"Pump control" - S7		**5** (AI 5)	**9 - 10**	Pt 1000
Suction pressure - P0		**6** (AI 6)	**11 - 12**	AKS 2050-59
Discharge pressure - Pd		**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, Receiver		**16** (DO 5)	**39 - 40 - 41**	ON
		17 (DO6)	**42 - 43 - 44**	ON
Alarm		**18** (DO7)	**45 - 46 - 47**	OFF
Room fan		**19** (DO8)	**48 - 49 - 50**	ON
AKD compressor control		**24**	-	0-10 V
AKD pump control		**25**	-	0-10 V

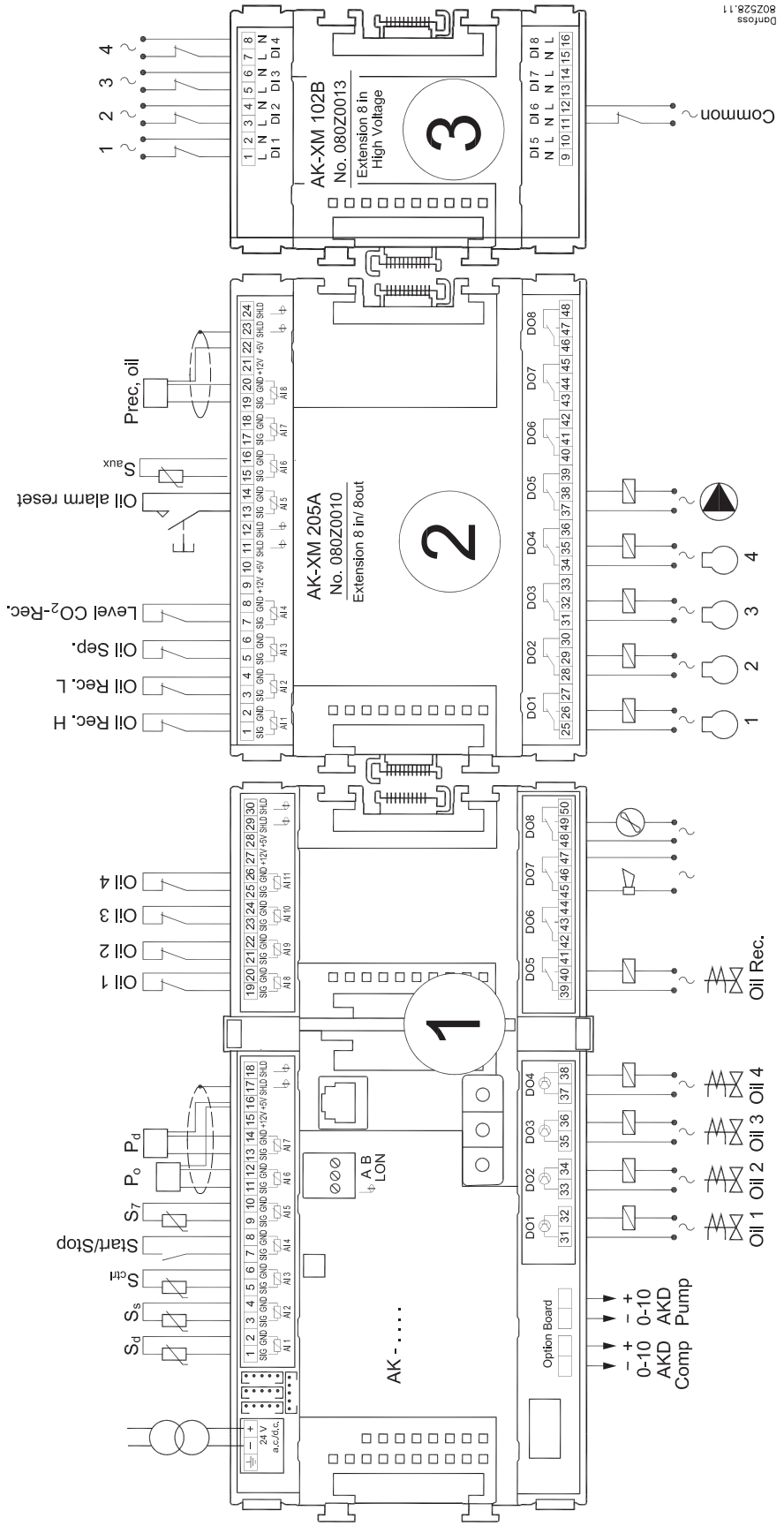
The function of the switch functions can be seen in the last column.

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
Thermostat sensor in engine room- Saux1		**6** (AI 6)	**15 - 16**	Pt 1000
		7 (AI 7)	**17 - 18**	
Oil receiver, Prec		**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 signal to AKD for the pump		**13** (DO 5)	**37 - 38 - 39**	ON
		14 (DO6)	**40 - 41 - 42**	
		15 (DO7)	**43 - 44 - 45**	
		16 (DO8)	**46 - 47 - 48**	

Signal	Module	Point	Terminal	Active at
Compressor 1 Gen. safety	3	**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
		5 (DI 5)	**9 - 10**	
All comp. common safety		**6** (DI 6)	**11 - 12**	Open
		7 (DI 7)	**13 - 14**	
		8 (DI 8)	**15 - 16**	

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.

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.

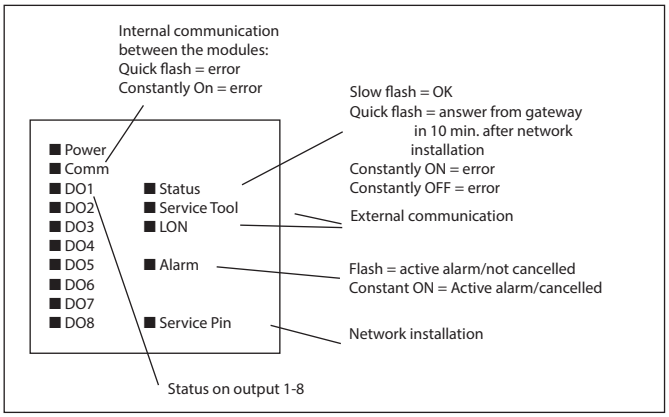
4. Follow light-emitting diodes

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

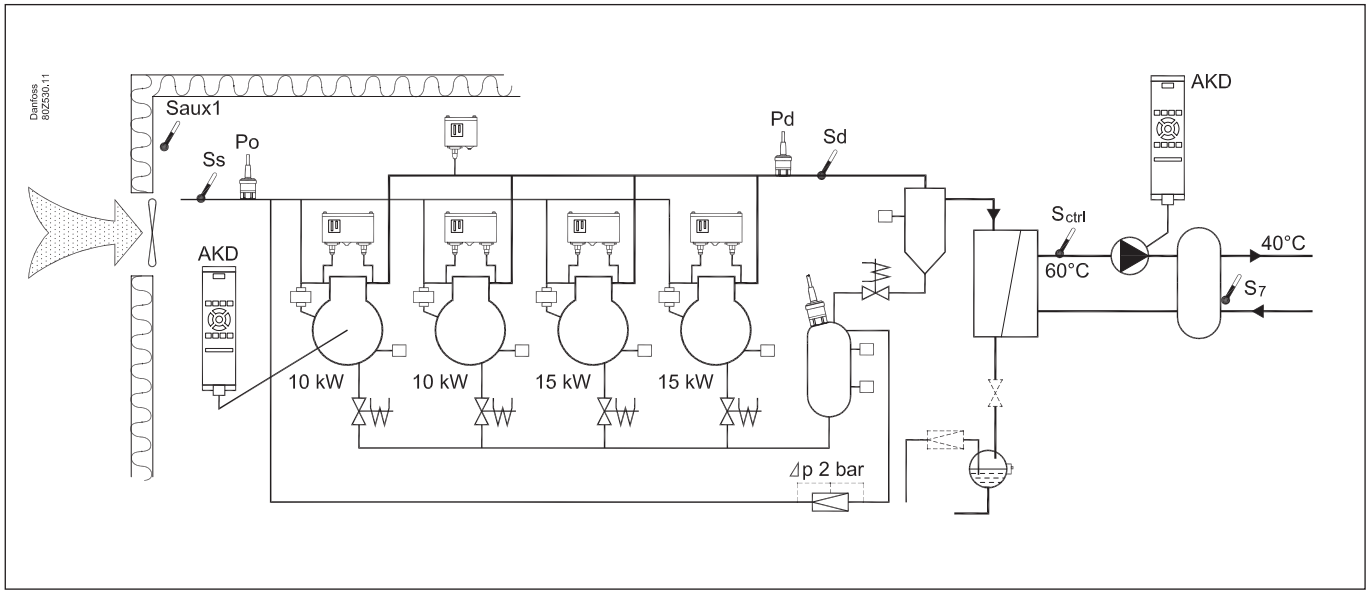
This section describes how the controller:
• Is configured
• Is operated

We have decided to work on the basis of the example we went through previously, i.e. compressor control with 4 compressors and control of one pump.

The example is shown overleaf.

Heat pump plant example

We have decided to describe the setup by means of an example comprising a compressor group and a "pump".
The example is the same as the one given in the "Design" section, i.e. the controller is an AK-HP 780 + extension modules.



Compressor Group
- Refrigerant CO2 (R744)
- 4 only compressors with "Best fit". Speed control on one.
- Safety monitoring of each compressor
- Common high-pressure monitoring
- Sctrl setting 60°C, Night setback on 5 K
- Oil management of each compressor
- Pulse reset of stopped compressor (oil shortage)

Pump:
- Pump with speed control
- S7 setting 40°C

Receiver:
- Monitoring of liquid level of refrigerant
- Control of pressure in oil receiver

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

Safety functions:
- Monitoring of P0, Pc, Sd and superheat in suction line
- P0 max = 10°C, P0 min = -2°C
- Pd 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 main switch used

For the example shown we use the following modules:
- AK-HP 780 controller
- AK-XM 102B digital input module
- AK-XM 205B input and output module
- AK-OB 110 analog extension module

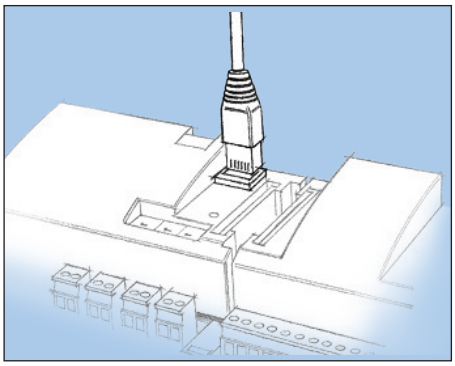
There is also an internal main switch as a setting. Both must be "ON" before any adjustment is made.

The modules used are selected in the design phase.

Configuration

Connect PC or PDA

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

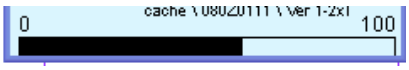


The controller must be switched on first and the LED "Status" must flash before the Service Tool programme is started.

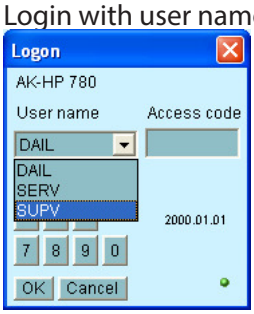
For connecting and operating the "AK service tool" software, please see the manual for the software.

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.

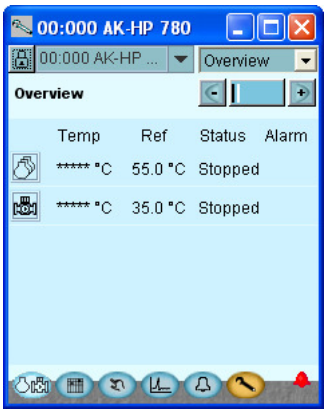


Login with user name SUPV



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 this 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.

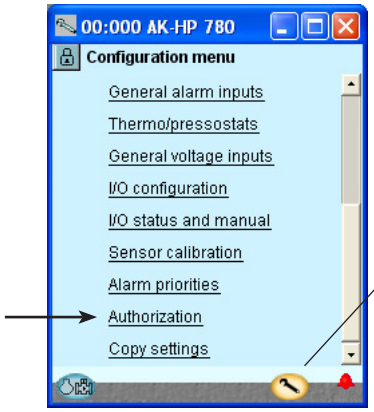
Authorization

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.

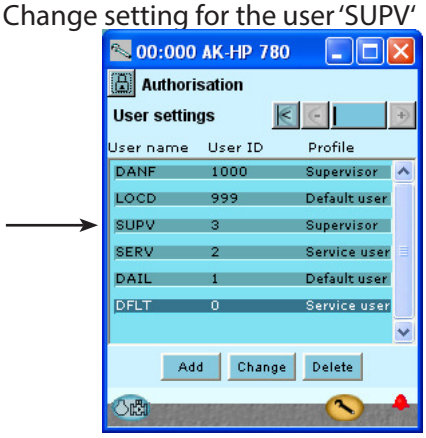
2. Select Authorization



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.

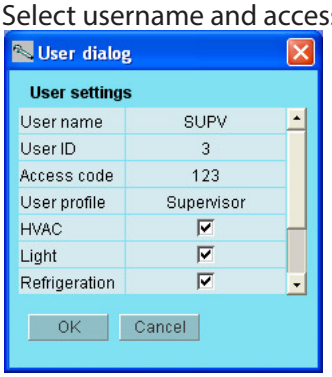
Press the line **Authorization** to get to the user setup display.

3. Change setting for the user 'SUPV'



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

4. Select username 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.

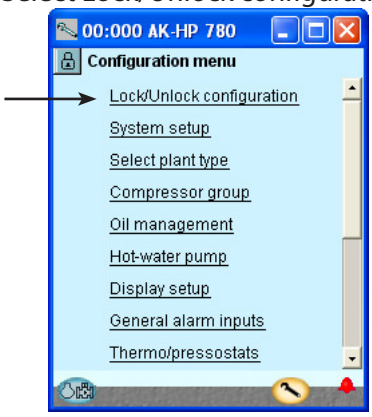
5. Carry out a new login with the user name and the new access code

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

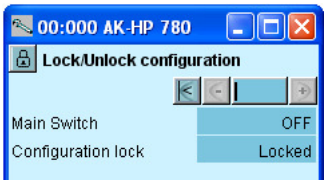
1. Go to Configuration menu

2. Select Lock/Unlock configuration



3. Select Configuration lock

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



4. Select Unlocked

Select **Unlocked** and press **OK.**

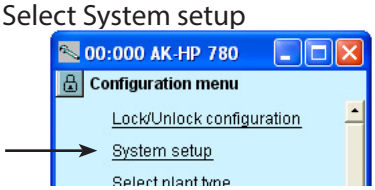
The controller can only be configured when it is unlocked.

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

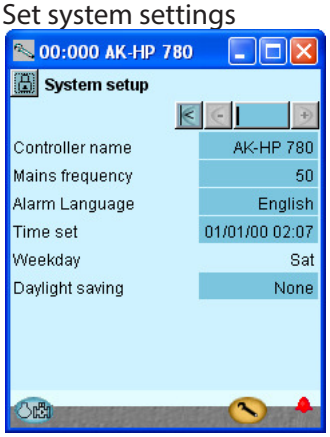
System setup

1. Go to Configuration menu

2. Select System setup



3. Set system settings



All system 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.

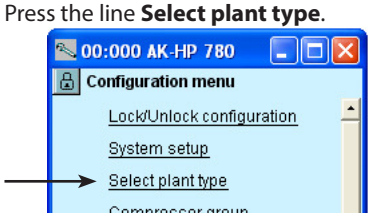
When the time is set the PC's time can be transferred to the controller. When the controller is connected to a network, date and time will automatically be set by the system unit in the network. This also applies to change-over Daylight saving.

Set plant type

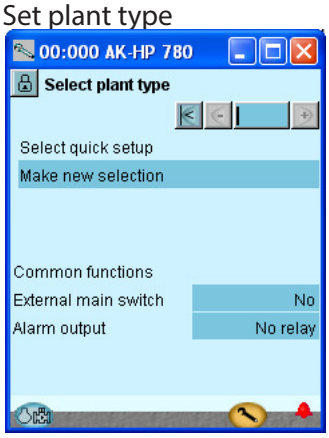
1. Go to Configuration menu

2. Select plant type

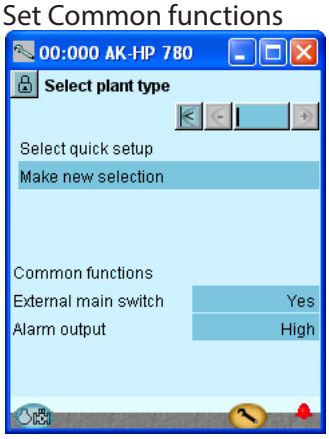
Press the line **Select plant type**.



3. Set plant type



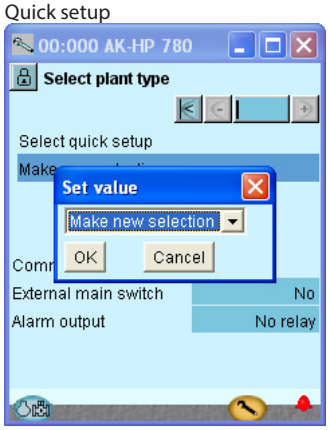
4. Set Common functions



When the installation type is to be configured, it can be done in two ways:

Either

Quick setup



Here you can make a choice between a number of predefined combinations, which at the same time determine the connection points.
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.

Or

All settings can be entered on the following pages.
In the example, we select this set-up mode to get through the descriptions of the functions.

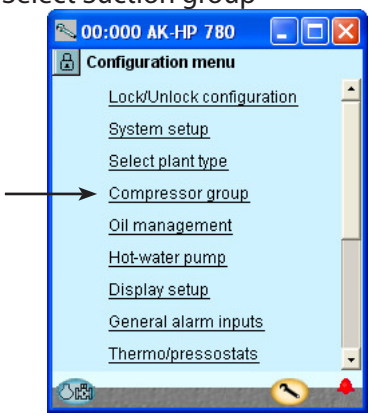
Further settings:
External main switch to **Yes**
Use Alarm output to **High.** (At "High" the relay is only activated for high-priority alarms).

Set control of compressors

f you want to know more about the different configuration options, they are listed below.
The number refers to the number and picture in the column on the left.
The screen only shows the settings and readings that are required for a given set-up.

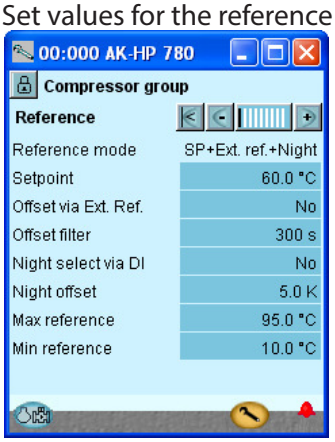
1. Go to Configuration menu

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



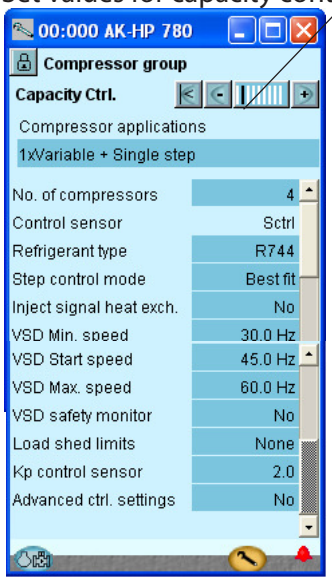
In our example we select the settings:
- Set point = 60°C
- Night setback value = 5 K.

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



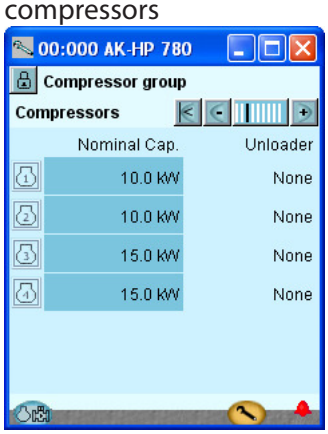
In our example we select:
- 4 compressors
- Refrigerant = R744
- Best fit

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

3 - Reference
Reference = set reference + night offset + offset from external 0-10 V signal
Setting (-80 to +120°C)
Setting of required Sctrl temperature 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

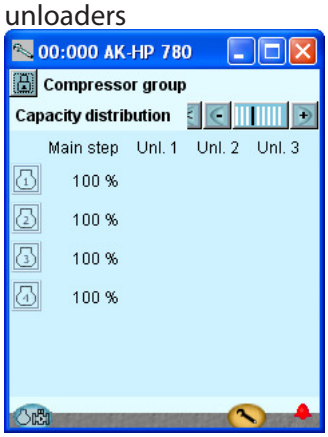
4 - Compressor application
Select the compressor application required
No. of compressors
Set number of compressors
No. of unloaders
Set number of unloader valves
Control sensor
= Sctrl
P0 refrigerant type
Select refrigerant type
P0 refrigerant factors K1, K2, K3
Only used if "Po refrigerant type" is set to custom (contact Danfoss for information)
Step control mode
Select coupling pattern for compressors
Sequential: Compressors are cut in/out in strict accordance with compressor number (FILO)
Cyclic: Runtime equalisation between compressors (FIFO)
Best fit: Compressors are cut in/out in order to make the best possible fit to actual load
Injection heat exchanger
Selects whether an output signal is to be sent for start/stop of liquid injection in a cascade heat exchanger
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
Load shed limits
Select how many load shedding inputs are required
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

5. Set values for capacity of the compressors



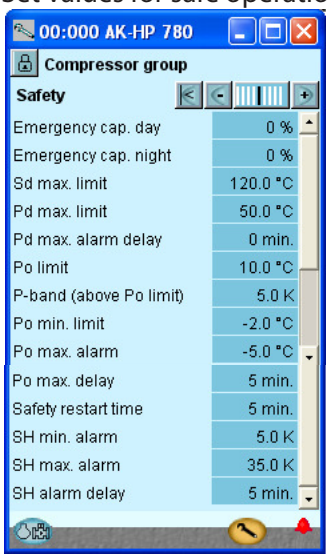
Press the +-button to go on to the next page

6. Set values for main step and any unloaders



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

7. Set values for safe operation



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

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 too high discharge pressure = 50°C
- Safety limit for low suction pressure = -2°C
- Alarm limit for high suction pressure = 10°C
- Alarm limit for min. and max. superheat, respectively = 5 and 35 K.

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
Advanced control settings
Select whether the advanced capacity control settings should be visible
Kp Po (0.1 – 10.0)
Amplification factor for P0 regulation
Min. capacity change (0 – 100 %)
Set the minimum capacity change needed before the capacity distributor connects or disconnects compressors
Minimize cycling
The control zone may vary for connections and disconnections. 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%.
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 pump capacity will be cutin.
If the limit is exceeded, the entire compressor capacity will be cutout
Pd Max limit
Maximum value for the discharge pressure in °C.
3 K below the limit, the entire pump 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 Pd max limit
P0 Limit
Regulation parameter which protects against low suction pressure.
P-band (above P0 limit)
Regulation parameter which protects against low suction pressure.

8. Set monitoring of compressor

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

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).

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", "Pd 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.

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. Set operation time for compressor

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

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

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. Set times for safety cutouts

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

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.

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. Set Misc. functions

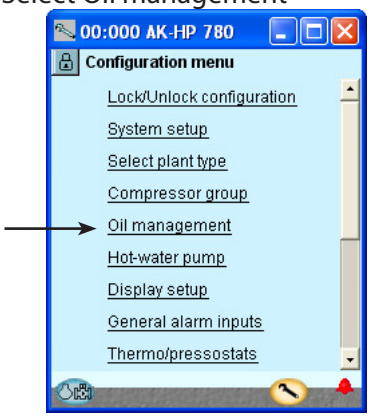
In our example we do not use these functions.

11 - Misc. functions
(Currently, there are no functions.)

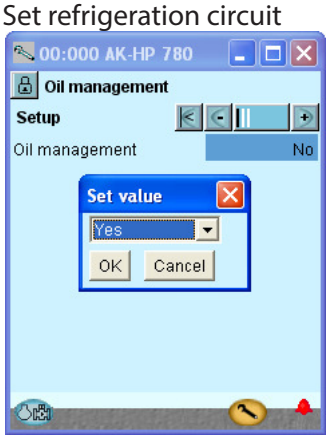
Set oil management

1. Go to Configuration menu

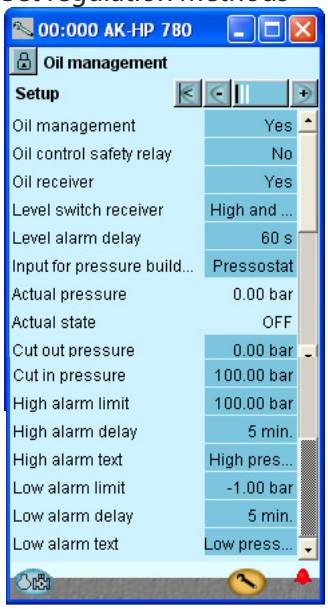
2. Select Oil management



3. Set refrigeration circuit



4. Set regulation methods



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

In our example, oil management is selected

We do not use safety relays in our example.

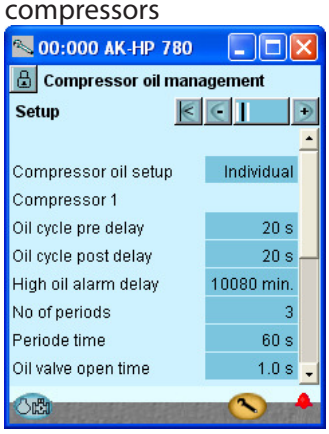
In this example, we want to control the oil receiver.
This is done with a pressostat. Here, we have chosen a pressostat.
The pressostat should be set as follows:
- Select pressure transmitter

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.

4
Oil management
Select whether you wish to activate oil management.
Oil control safety relay
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. Only High / High and low
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
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

5. Set oil management for the compressors



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

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.

5
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.

Oil cycle pre delay
(Prel period) Oil pulses will start after a stable signal from the level switch in the entire delay time.

Oil cycle post delay
(Prel period) Oil pulses will stop after a stable signal from the level switch in the entire delay time. (Alarm if the level switch is still giving a signal for more oil.)

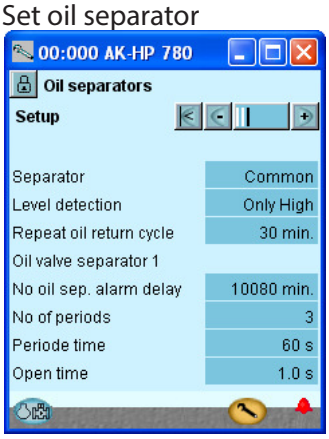
High oil alarm delay
If an activation of the level switch is not registered before the time has expired, an alarm will be given. (the compressor not use the oil).

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

Period time
Time between pulses

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

6. Set oil separator



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.

6
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 one or two 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

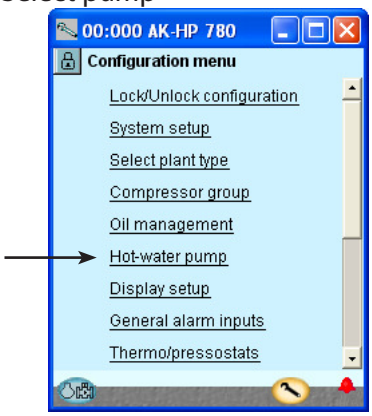
Period time
Time between valve openings.

Open time
The open time of the valve

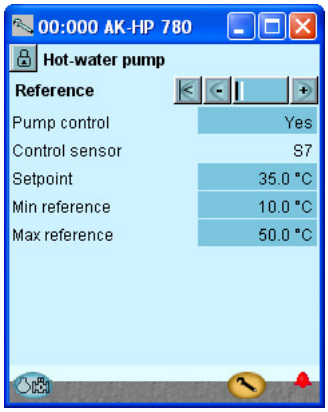
Setup control of the pump

1. Go to Configuration menu

2. Select pump

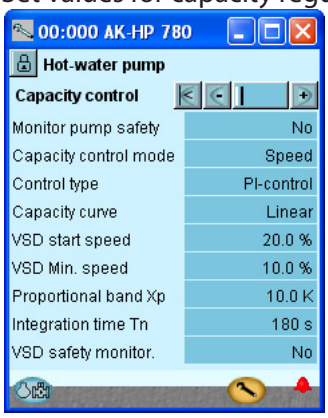


3. Set control mode and reference



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

4. Set values for capacity regulation



We select "speed" in our example.

3 - Reference
Control sensor
S7: Media temperature is used for regulation
Setting
Setting of setpoint
Min reference
Min. permitted reference
Max reference
Max. permitted reference

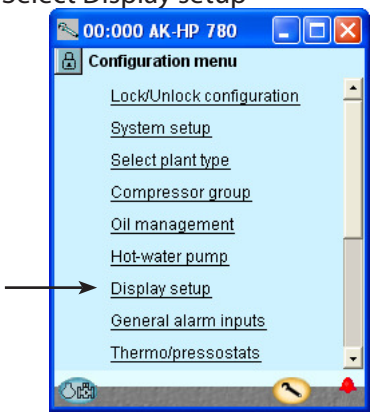
4 - Capacity control
No pumps
It is only possible to connect to one pump.
Monitoring of the pump
Safety monitoring of the pump. A digital input must used
Capacity control mode
Select control mode for the pump
On/Off: The pump is connected via a relay outlet
Speed: The pump is controlled via speed control (frequency converter)

Control type
Choice of control strategy
P-band: The pump capacity is regulated via P-band control. The P band is configured as "Proportional band Xp"
PI-Control: The pump capacity is regulated by the PI controller.
Capacity curve
Choice of capacity curve type
Linear: The same amplification in the entire area
Square: Square curve shape, which gives higher amplification at higher loads.
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).
Proportional band Xp
Proportional band for P/PI controller
Integration time Tn
Integration time for PI controller
VSD safety monit.
Choice of safety monitoring of frequency converter. A digital inlet is used for monitoring the frequency converter.

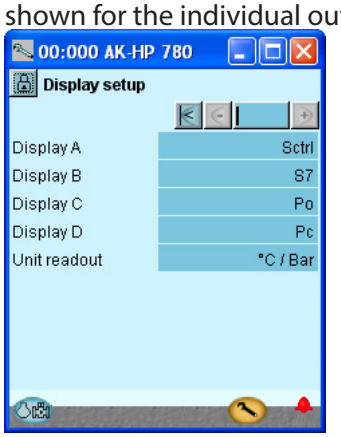
Setup Display

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

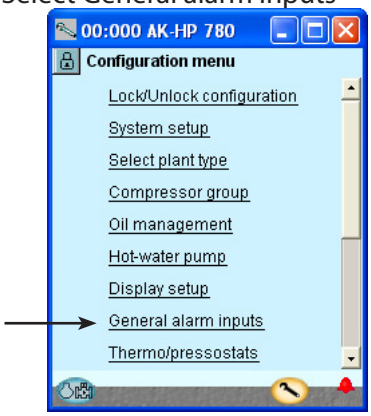
Display
The following can be read for the four outputs..
Comp. control sensor
P0
P0 bar (abs)
Sctrl
Ss
Sd
Cond. control sensor
Pd
Pd bar (abs)
S7

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

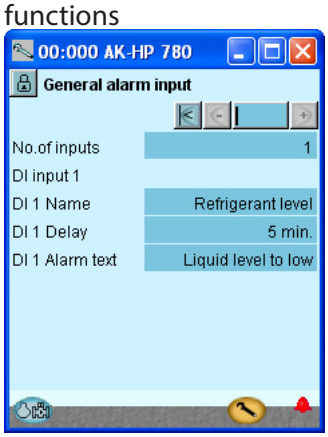
Setup general alarm inputs

1. Go to Configuration menu

2. Select General alarm inputs



3. Define the required alarm functions



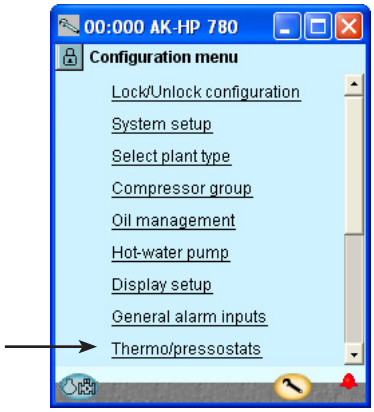
In our example we select one alarm function for monitoring the liquid level in the receiver.
We have subsequently selected a name for the alarm function and for the alarm text.

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

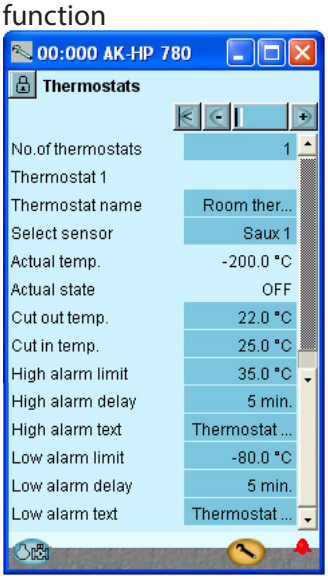
Setup separate thermostat functions

1. Go to Configuration menu

2. Select Thermostats



3. Define the required thermostat function



4. Define the required pressostat function

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

We have subsequently entered a name for the function.

Via the +- button you can move to similar settings for the pressure control functions.

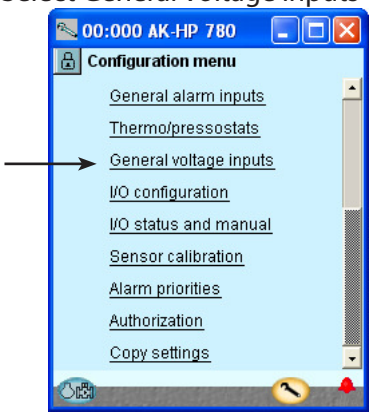
3 - Thermostats
The general thermostats can be used to monitor the temperature sensors that are used, as well as 4 extra temperature sensors. Each thermostat has a separate outlet to control external automation.
No. of thermostats
Set the number of general thermostats.
For each thermostat adjust
• Name
• 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

4 - Pressostats
Settings as the thermostats

Setup separate voltage functions

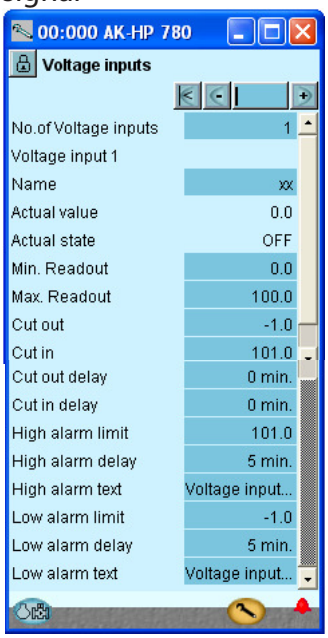
1. Go to Configuration menu

2. Select General Voltage inputs



(In our example we do not use this function).

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).

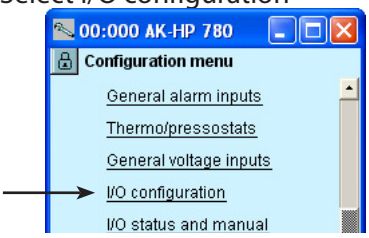
For each voltage input defined the controller will reserve a relay output in the I/O setup. It is not necessary to define this relay if all you require is an alarm message via the data communication.

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.
No. of voltage inp.
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

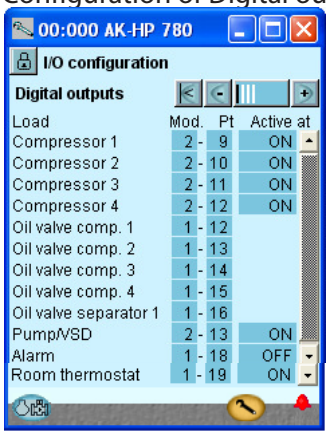
Configuration of inputs and outputs

1. Go to Configuration menu

2. Select I/O configuration

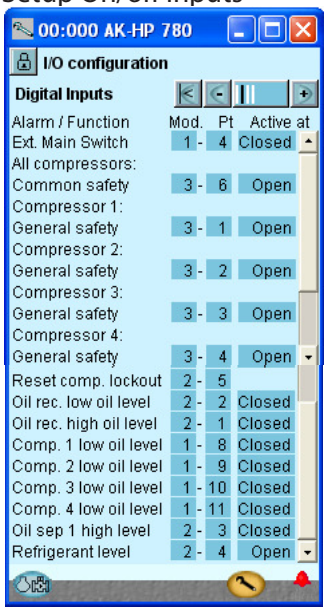


3. Configuration of Digital outputs



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

4. Setup On/off inputs



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

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	Mod-ule	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
Alarm	DO7	1	18	OFF !!!
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 signal to AKD for the pump	DO5	2	13	ON

!!! The alarm is inverted so that there will be an alarm if the supply voltage to the controller fails.

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**.

3 - Outputs
The possible functions are the following:
Comp. 1
Unloader 1-1
Unloader 1-2
Unloader 1-3
Comp. 2-8
Oil safety comp. 1-8
Oil valve comp. 1-8
Oil valve separat 1-8
Injection heat exchanger
Pump / VSD
Alarm
Thermostat 1 - 5
Pressostat 1 - 5
Volt input 1 - 5

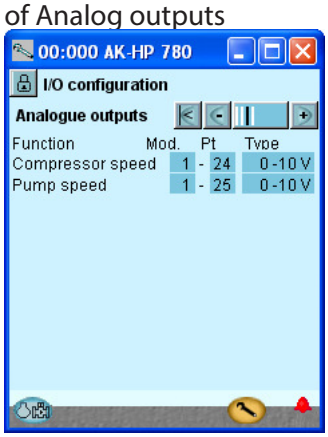
Function	Input	Mod-ule	Point	Active at
External main switch	AI4	1	4	Closed
Level switch, oil, comp.1	AI8	1	8	Closed
Level switch, oil, comp.2	AI9	1	9	Closed
Level switch, oil, comp.3	AI10	1	10	Closed
Level switch, oil, comp.4	AI11	1	11	Closed
Level switch, oil, receiver High	AI1	2	1	Closed
Level switch, 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 pres-sure
Compressor 1 Gen. Safety	DI1	3	1	Open
Compressor 2 Gen. Safety	DI2	3	2	Open
Compressor 3 Gen. Safety	DI3	3	3	Open
Compressor 4 Gen. Safety	DI4	3	4	Open
All compressors common safety	DI6	3	6	Open

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.

4 - Digital inputs
The possible functions are the following:
Ext. Main switch
Night setback
Load shed 1
Load shed 2
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
Comp. 2-8
do

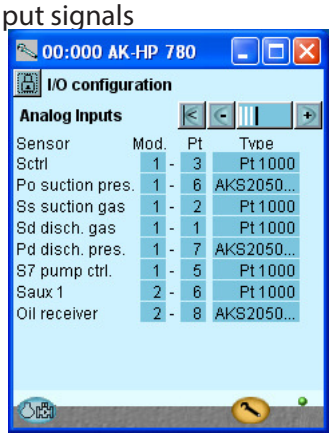
Pump protection
Reset comp. lockout
Oil receiver low
Oil receiver high
Oil level comp.1-8
Oil separator low 1-8
Oil separator high 1-8
DI 1 Alarm input
DI 2-10 ...

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
AKD compressor control	AO1	1	24	0-10
AKD pump control	AO2	1	25	0-10

Sensor	Input	Module	Point	Type
Disch. gas temperature - Sd	AI1	1	1	Pt 1000
Suction gas temperature - Ss	AI2	1	2	Pt 1000
Compressor control - Sctrl	AI3	1	3	Pt 1000
Pump control - S7	AI5	1	5	Pt 1000
Suction pressure - P0	AI6	1	6	AKS 2050-59
Discharge pressure - Pd	AI7	1	7	AKS 2050-159
Thermostat sensor in engine room - Saux1	AI6	2	6	Pt 1000
Oil receiver, Prec (Paux1)	AI8	2	8	AKS 2050-159

5 - Analog outputs
The possible signals are the following:
0 -10 V
2 – 10 V
0 -5 V
1 – 5 V

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

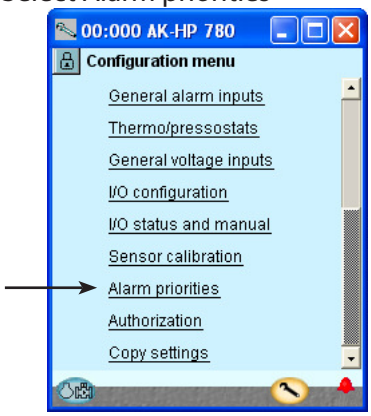
Pressure transmitters:
• AKS 32, -1 – 6 bar
• AKS 32R, -1 – 6 bar
• AKS 32, - 1 – 9 bar
• AKS 32R, -1 – 9 bar
• AKS 32, - 1 – 12 bar
• AKS 32R, -1 – 12 bar
• AKS 32, - 1 – 20 bar
• AKS 32R, -1 – 20 bar
• AKS 32, - 1 – 34 bar
• AKS 32R, -1 – 34 bar
• AKS 32, - 1 – 50 bar
• AKS 32R, -1 – 50 bar
• AKS 2050, -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)

Sctrl compressor control
Po suction pres.
Ss suction gas
Sd disch. gas temp.
Pd discharge pressure
S7 receiver temperature
Ext. Ref. Signal
• 0 – 5 V,
• 0 -10 V
Saux 1 - 4
Paux 1 - 3
Volt input 1 - 5
• 0 -5 V,
• 0 -10 V,
• 1 – 5 V,
• 2 – 10 V

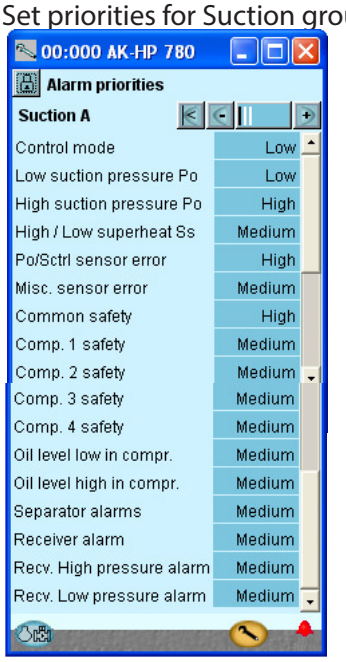
Set alarm priorities

1. Go to Configuration menu

2. Select Alarm priorities

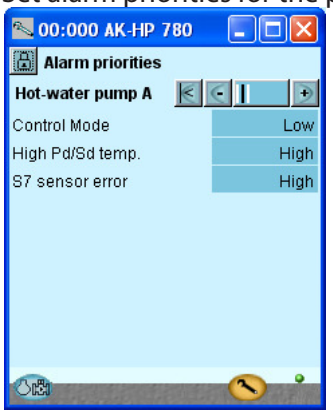


3. Set priorities for Suction group



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

4. Set alarm priorities for the pump



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.

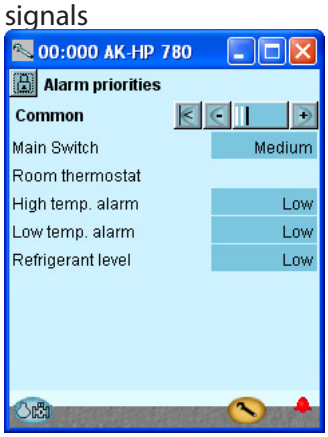
Setting	Log	Alarm relay selection			Net-work	AKM-dest.
		Non	High	Low - High		
High	X		X	X	X	1
Medium	X			X	X	2
Low	X			X	X	3
Log only	X					
Discon-nected						

Se also alarm text page 102

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

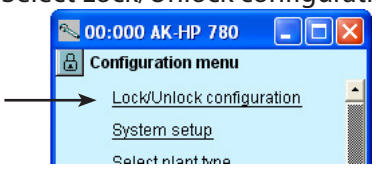


In our example we select the settings shown here in the display

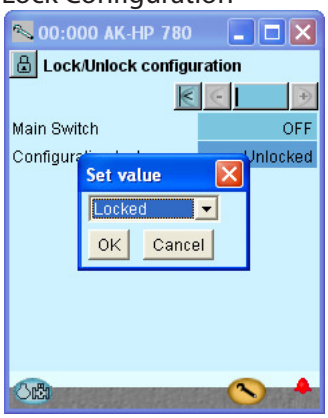
Lock configuration

1. Go to Configuration menu

2. Select Lock/Unlock configuration



3. Lock Configuration



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.

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

Select **Locked**.

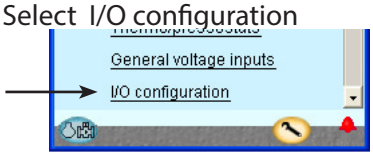
Press **OK**.

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.

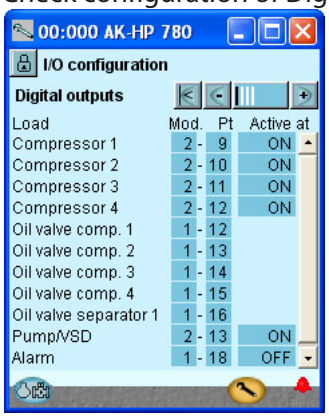
Check configuration

1. Go to Configuration menu

2. Select I/O configuration

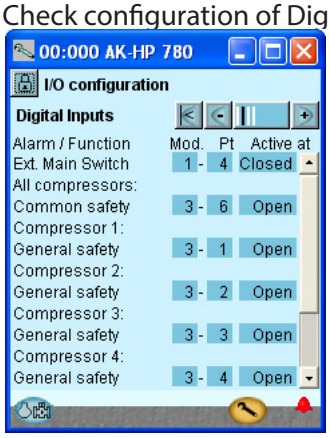


3. Check configuration of Digital Outputs



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

4. Check configuration of Digital Inputs



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

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..

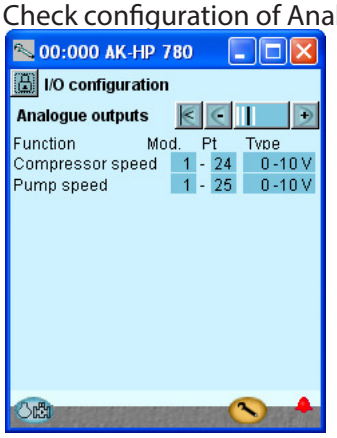
The settings are shown on a **RED** background.
If a setting has turned red, you must control the setup again.
This may be due to the following:

- 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.

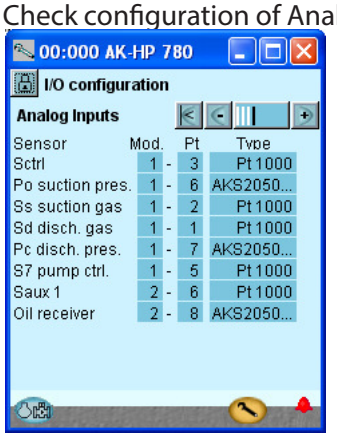
5. Check configuration of Analog Outputs



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

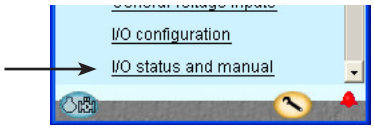


The setup of the analog inputs appears as it is supposed to according to the wiring made.

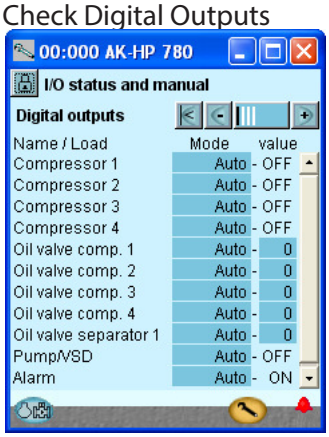
Check of connections

1. Go to Configuration menu

2. Select I/O status and manual

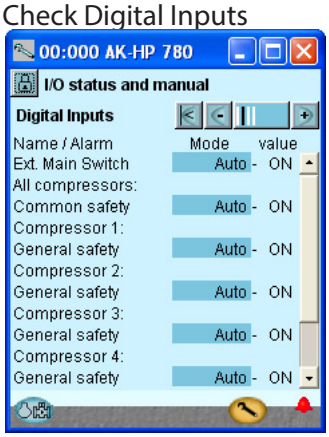


3. Check Digital Outputs



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

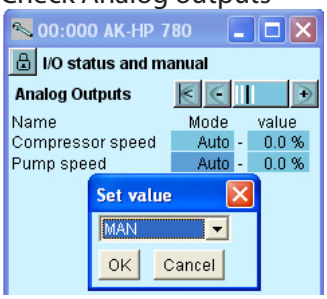
By means of the manual control of each output it can be checked whether the output has been correctly connected.

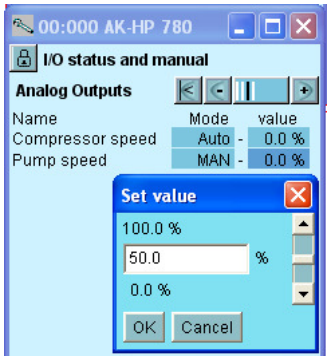
AUTO	The output is controlled by the controller
MAN OFF	The output is forced to pos. OFF
MAN ON	The output is forced to pos ON

Cut out the safety circuit for compressor 1.
Check that LED DI1 on the extension module (module 3) 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





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

Select **MAN**.

Press **OK**.

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

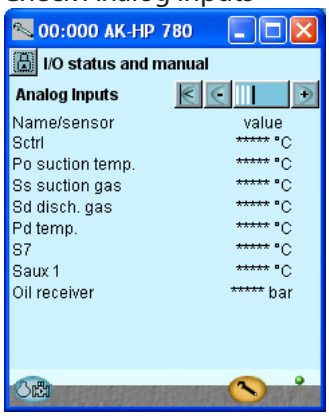
Example of the connection between a defined output signal and a manual set value.

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

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

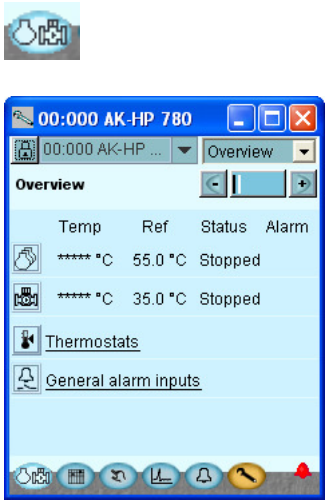


Check that all sensors show sensible values.
In our case we have no values. This may be due to the following:

- 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

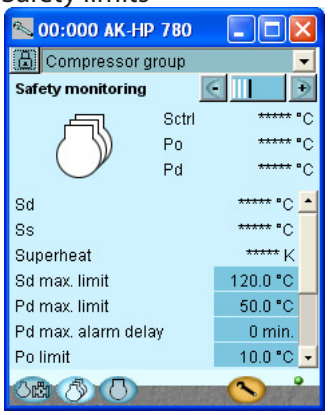


2. Select suction group

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

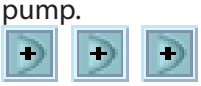
6. Select the pump

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.

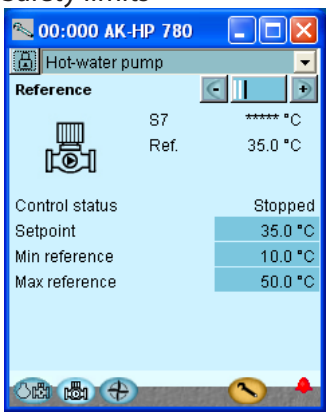
The last page contains safety limits and restart times.

7. Move on through all the individual displays for the pump.



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



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.

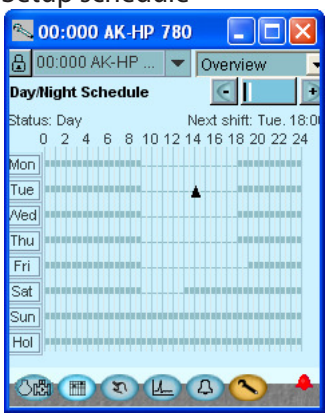
The last page contains reference settings

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 reference.
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.

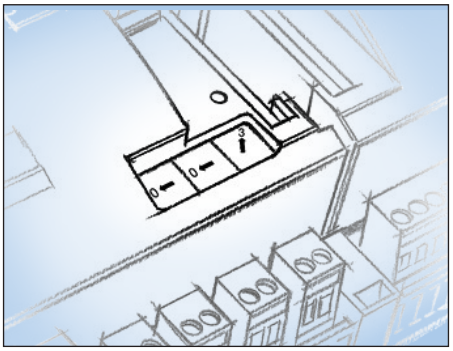
A complete weekly sequence is shown in the display.

Installation in network

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

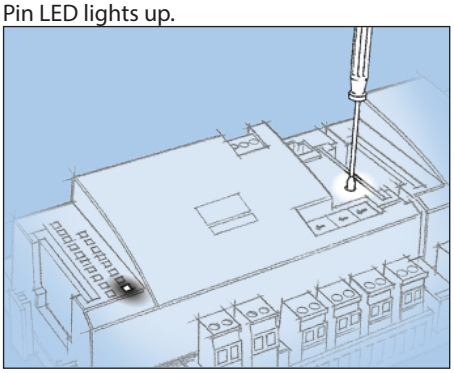
   Turn the right-hand address switch so that the arrow will point at 3.

   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.



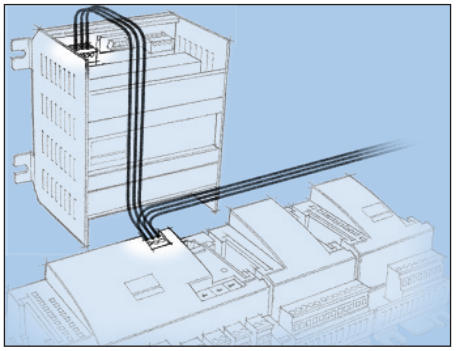
3. Wait for answer from the system unit

   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.



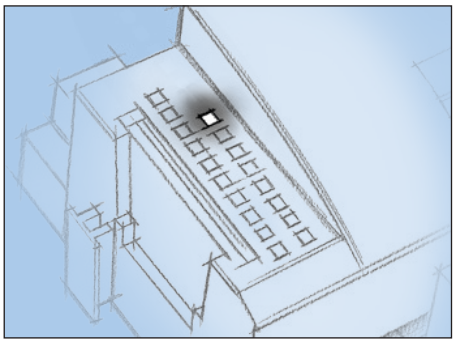
The controller has to be remote-monitored via a network. In this network we assign address number 3 to the controller.

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

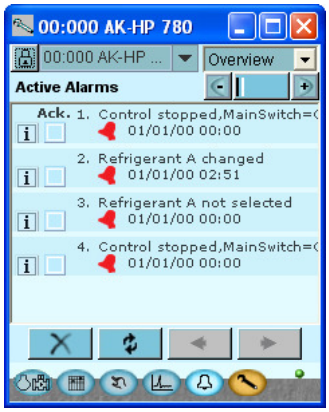
1. Go to the overview

Press the blue overview button with the compressor and the pump 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

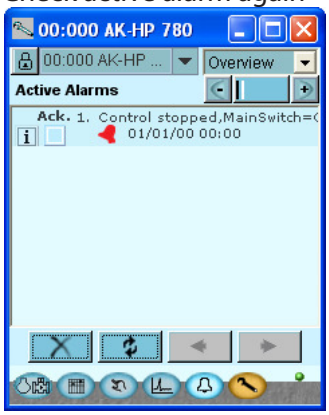


In our case, we have a series of alarms. We will tidy them up so that we only have those that are relevant.

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.

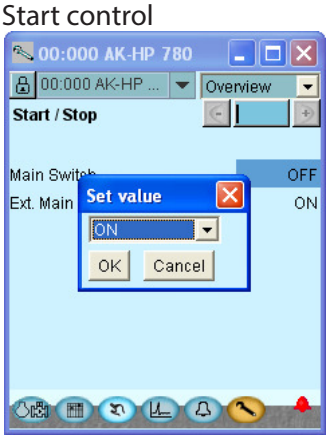
Please note that active plant alarms are automatically cancelled when the main switch is in pos. OFF.
If active alarms appear when the control is started the reason for these should be found and remedied.

Start 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**.
Press **OK**.
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".

Manual capacity control

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

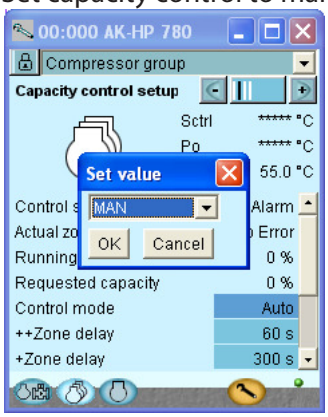
1. Go to overview

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

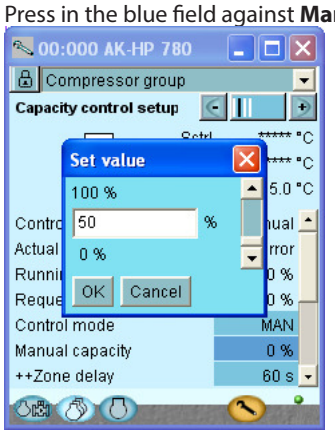


WARNING!
If you force control the compressors, the oil management will be shut down. This could cause compressor damages.
(If the wiring of the compressors includes safety relays, monitoring will continue. See Regulating functions.)

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

4. Set capacity in percent

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



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

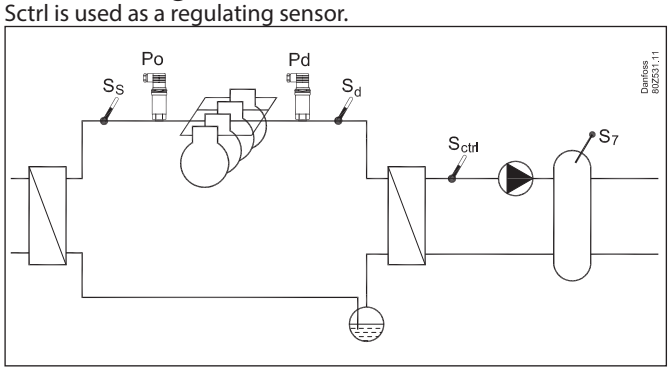
5. Regulating functions

This section describes how the different functions work

Suction groupe

Controlling sensor

Sctrl is used as a regulating sensor.



P0 is used as a safety function for low suction pressure and will ensure disconnection of compressor capacity

Handling of sensor error

In the event of an error in the Sctrl sensor, regulation will continue by the P0 signal, though in accordance with a reference that is 5 K below the real reference.
If an error occurs in the both Sctrl and P0, the regulation will be stopped.

Reference

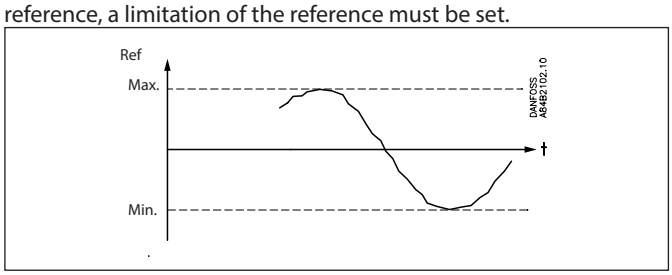
The reference for the regulation is
Set point + night displacement + Ext. Ref

Set point
A basic value for the required temperature is set.

Night displacement
With this function the reference can be displaced by up to 25 K in positive or negative direction.
Displacement can be activated in three ways:
- Signal on an input
- From a master gateway's override function
- Internal time schedule

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.

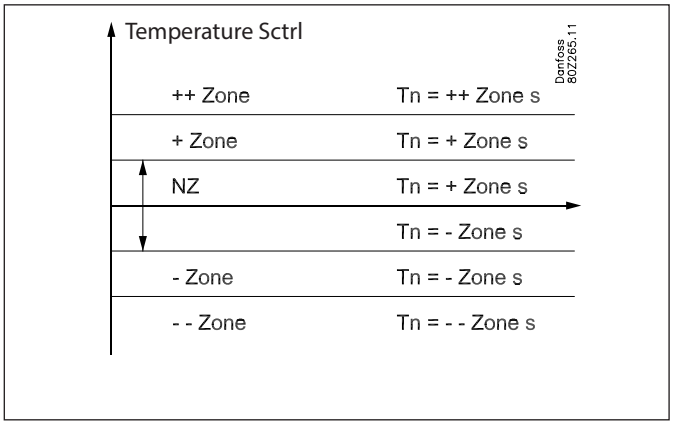
Forced operation via overload of digital outlets
The individual outputs can be set to MAN ON or MAN OFF in the software. The control function disregards this but an alarm is sent out that the outlet is being overridden.

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-HP 780 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 temperature 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.
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 temperature only and increases/reduces the requested capacity correspondingly. The amplification factor Kp on the other hand only looks at the temporary temperature changes.

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

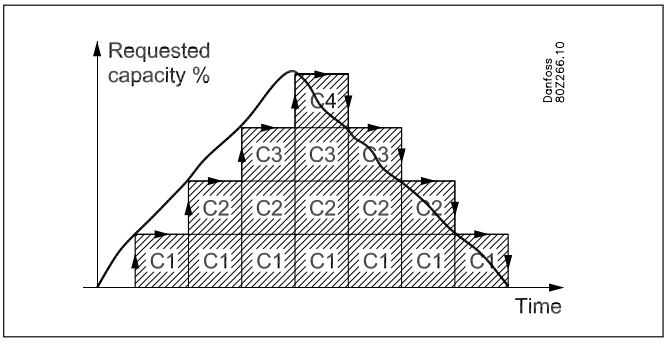
In the "- Zone" and "-- Zone" the controller will normally increase the requested capacity as the temperature is below the set point. But if the temperature is increasing very fast the requested capacity might decrease also in these zones.

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 temperature is at "+Zone" or in "++Zone"

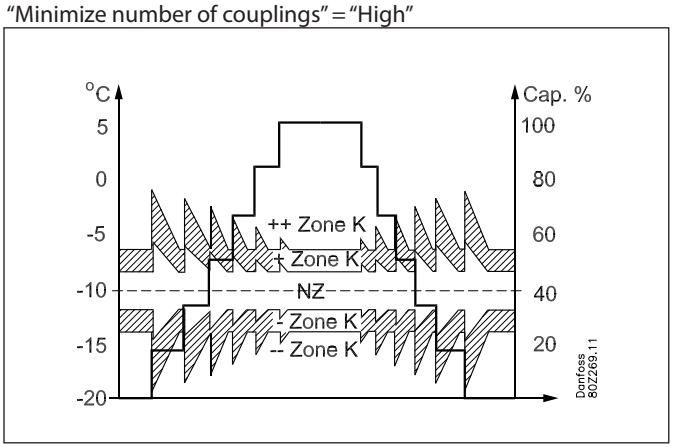
Dynamic extension of the neutral zone
All refrigeration systems have a dynamic response time when starting and stopping compressors. In order to avoid that the controller will start/stop compressors shortly after each other, the controller must be allowed some extra time after a compressor start/stop 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 Sctrl-temperature might very well change zone for a period of time when the controller is starting/stopping a compressor i.e. the temperature 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 temperature 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.

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.

Capacity distribution methods

The capacity distributor can work based on 3 distribution principles.

Coupling pattern – sequential operation:
The compressors are cut in and cut-out following the "First in, Last out" (FILO) principle in accordance with the sequence defined in the set-up.
Any speed-regulated compressors are used to close capacity gaps.

Timer restrictions
If a compressor is prevented from starting because it "hangs" on the re-start timer, this step is not replaced by another compressor but the step switch waits until the timer has lapsed.

Safety cutout
If on the other hand there is a safety switch on this compressor, this is excluded and the step switch immediately selects the following step in the sequence.

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.

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.

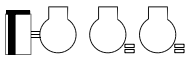
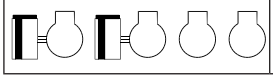
Minimum capacity change
To prevent the capacity distributor from selecting a new compressor combination (cut-out and cut-in compressors) due to a small change in capacity requirements, it is possible to set a minimum change in capacity requirement that will operate before the capacity distributor changes to a new compressor 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 or scroll

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		
		Sequence	Cyclical	Best fit
	One-step compressors. *1	x	x	x
	A compressor with an unload valve, combined with one-step compressors. *2	x	x	
	Two compressors with unload valves, combined with one-step compressors. *2	x	x	
	All compressors with unload valves. *2	x	x	
	A speed-regulated compressor combined with one-step compressors. *1 and *3	x	x	x
	A speed-regulated compressor combined with several compressors with unload valves. *2 and *3	x	x	
	Two speed-regulated compressors combined with one-step compressors *4	x	x	x

*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.

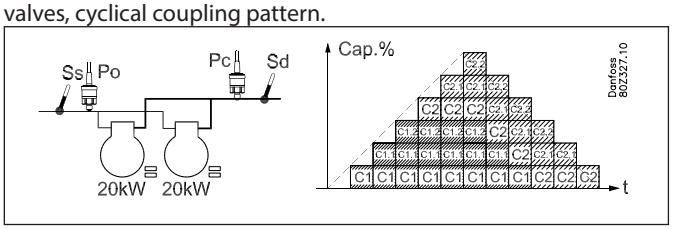
In appendix A there is a more detailed description of the coupling patterns for the individual compressor applications with associated examples.

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.

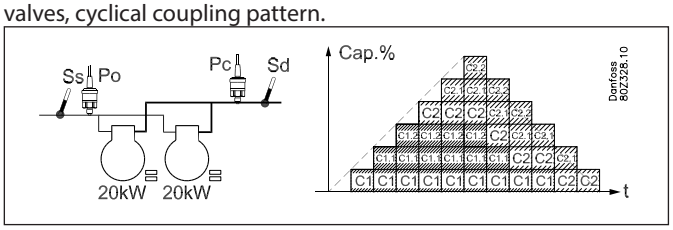
For example:
Two capacity-regulated compressors of 20 kW, each with 2 unload valves, cyclical coupling pattern.



- 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.



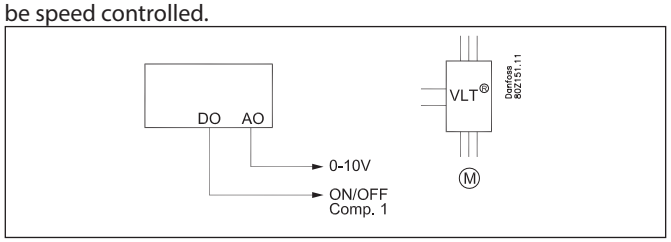
- For decreasing capacity, the compressor with the most operating hours is unloaded (C1).
- When C1 is completely unloaded , compressor C2 with one-step is unloaded before C1 is cut out.

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:

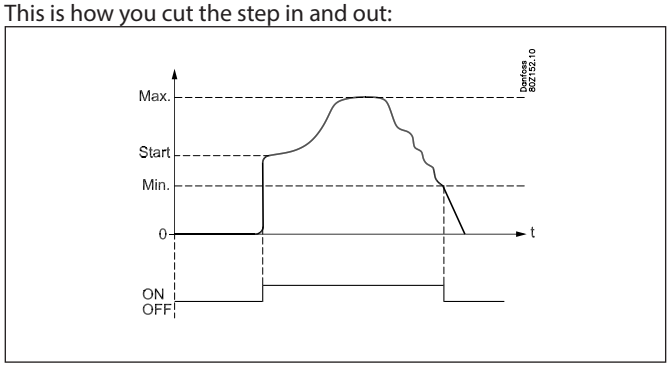
One of the defined capacity steps for the compressor regulation may be connected to a speed control unit that may be a frequency converter type AKD, for example.

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.



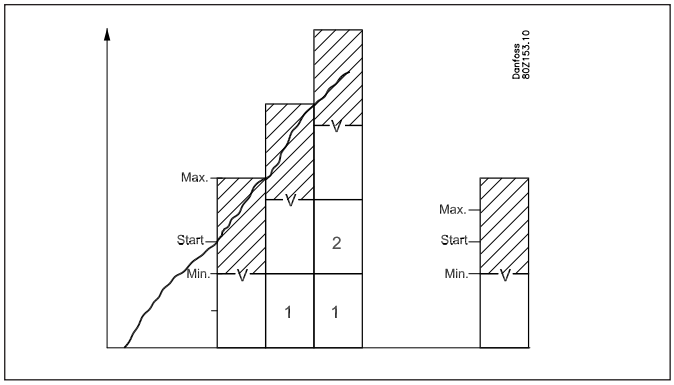
When the step is in operation it will consist of a fixed capacity and a variable capacity. The fixed capacity will be the one that corresponding to the mentioned min. speed and the variable one will lie between the min. and max. speed. To obtain the best regulation the variable capacity must be bigger 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.

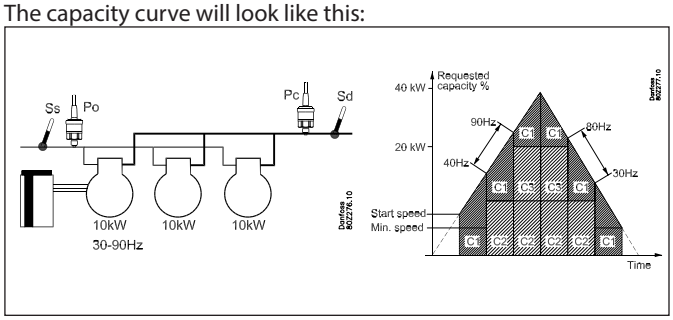
Safety cutout on speed controlled compressor
If the speed controlled compressor is cutout on safety other compressors are allowed to start. As soon as the speed controlled compressor is ready to start it will be the first compressor to start.

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:

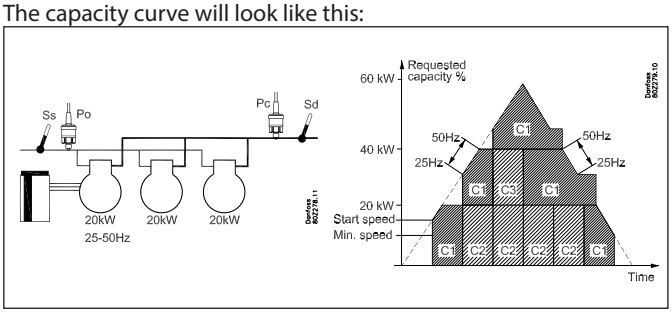


As the variable part of the speed controlled compressor is bigger than the following compressor steps, the capacity curve will be without holes.
1) The speed controlled compressor will be cutin when the requested capacity has reached the start speed capacity.
2) The speed controlled compressor will increase 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 10kW 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.

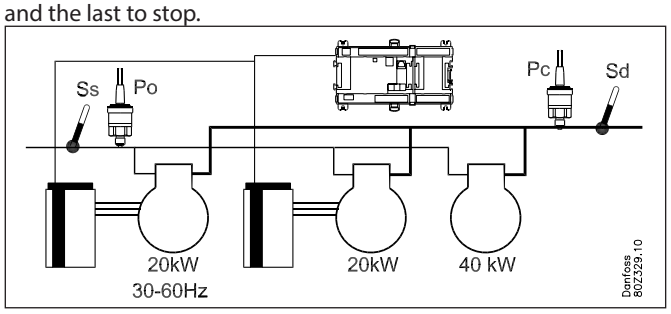
Two speed-regulated compressors
The controller is capable of regulating the speed of two compressors of the same or different sizes. The compressors can be combined with one-step compressors of the same or different sizes, depending on the choice of coupling pattern.

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.

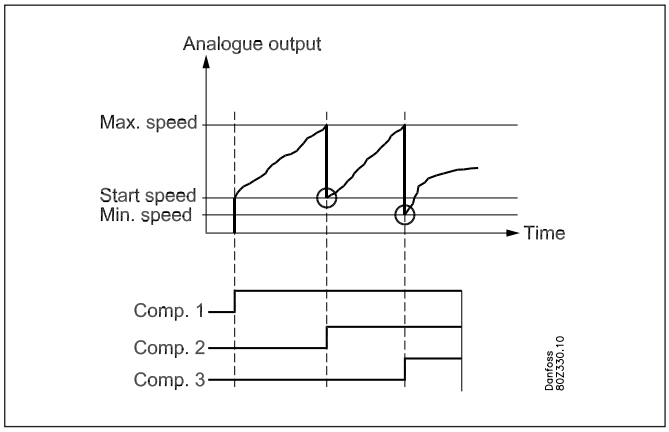
Compressor 1 and 2 both have their own relay outlets to start/stop separate frequency converters, for example of type AKD. Both frequency converters use the same analog output signal AO which is connected to the frequency converters' analog signal input. The relay outputs will start and stop the frequency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

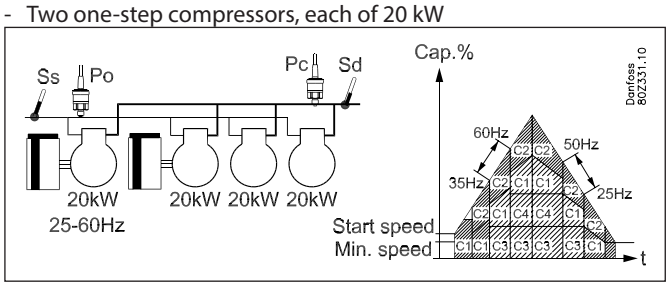
Cutout
The last speed-regulated compressor will be cut-out when the compressor has reached "Min. speed" and the capacity requirement (desired capacity) has decreased to under 1% (see however the section on the pump down function).

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.

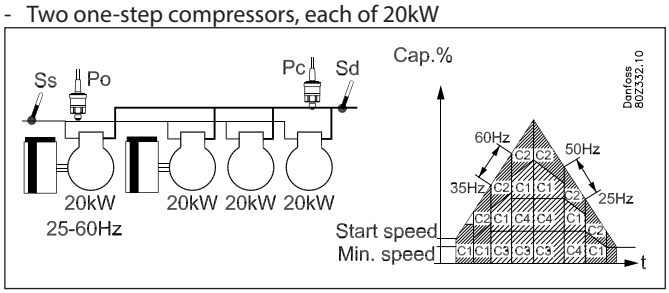
Sequential operation
During sequential operations, the first speed-regulated compressor will always start first. The following speed-regulated compressor will be cut in when the first compressor runs at max. speed and the desired capacity has reached a level that allows the cut-in of the next speed-regulated 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 The First-In-Last-Out principle.

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



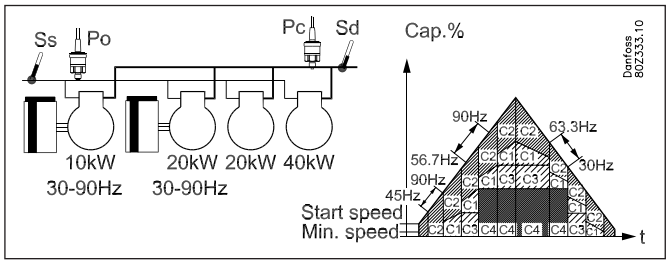
Cyclical operation
For cyclical operations, both speed-regulated compressors will have the same size and operating hours will be equalized between the compressors in accordance with the First-in-First-Out Principle (FIFO). The compressor with the least operating hours will be the first to start. The 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 20kW



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



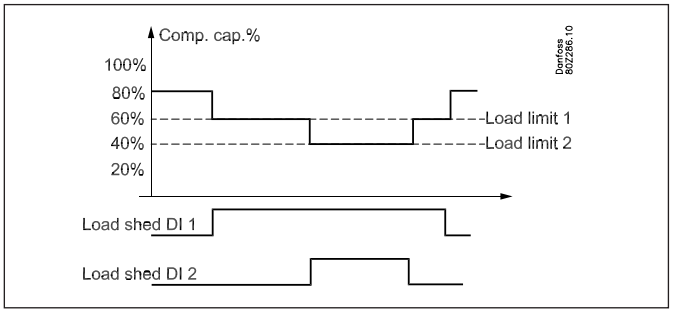
Load shedding

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.

There are 1 or 2 digital inlets available for this purpose.

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.



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

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.

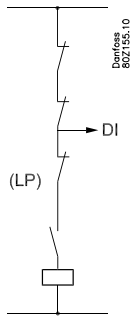
If the suction pressure during load shedding exceeds the set overriding limit and the attached delay times for the two digital inlets expire then load shedding overrides the signals so that the compressor capacity can be increased until the suction pressure is again under the normal reference value.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

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.

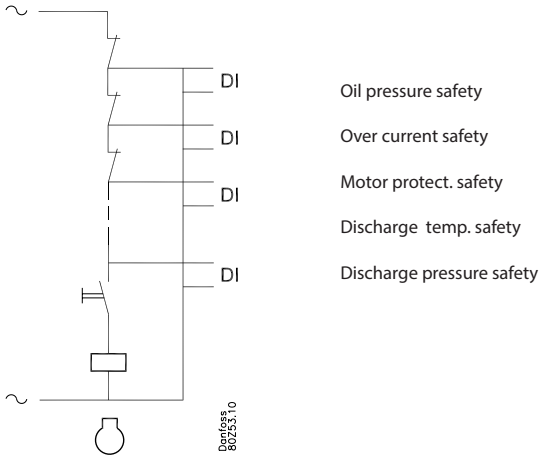
General safety circuit



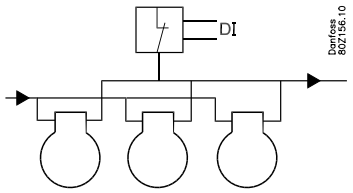
If a low-pressure switch is placed in the safety circuit it must be placed at the end of the circuit. It must not cut out the DI signals. (There is a risk that the regulation will become locked and that it will not start again). This also applies to the example below.

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.



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.



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

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 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. discharge pressure (Pd)
The function cuts out compressor steps one by one if the discharge pressure becomes higher than permitted. The cutout limit can be defined in the range from –30 to +100°C.

The discharge pressure is measured with pressure transmitter Pd_.

The function takes effect at a value which is 3 K below the set value. At this time 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 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.

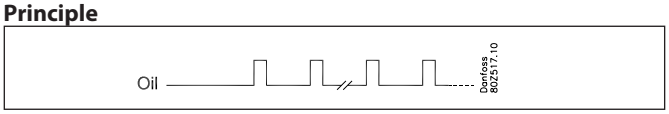
Delay of Pd max alarms
It is possible to delay the "Pd max alarm" message.
The controller will still disconnect the compressors, but the sending of the alarm itself is delayed.

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

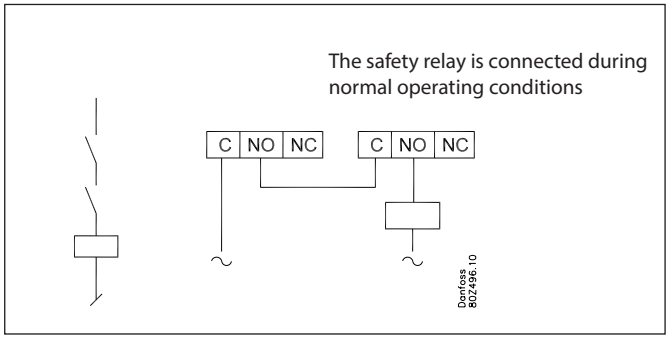


The controller turns on the oil flow for e.g. 1 second. The system then pauses while the oil once again settles. This is repeated a certain number of times, which will be determined by the plant and control principles.
The pulse time, pause time and number of pulses can be adjusted.

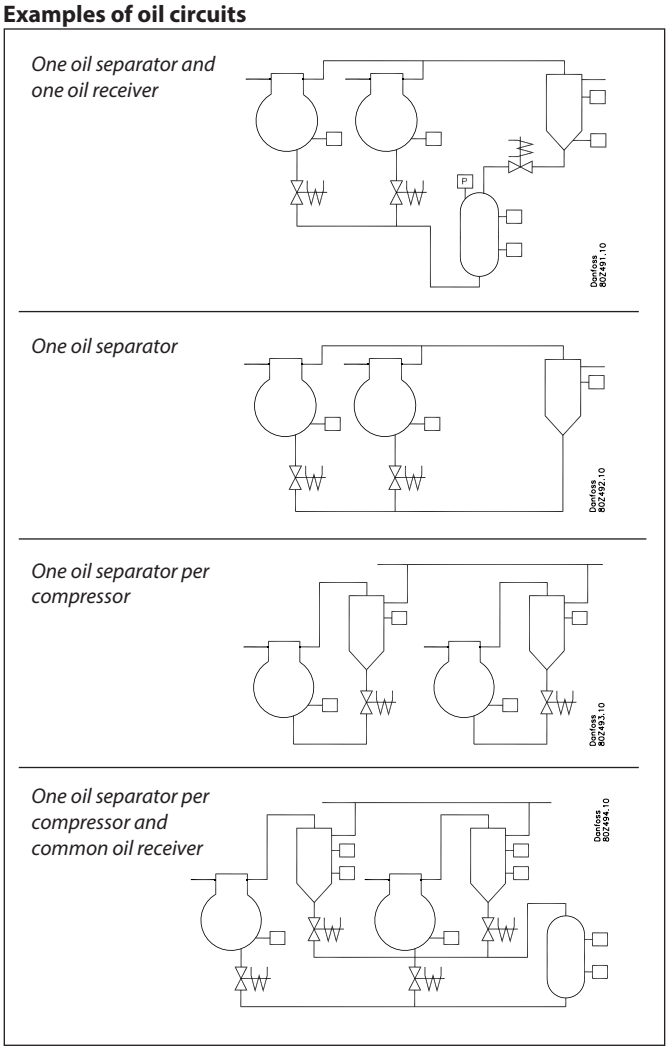
The system can be controlled by signal from:
- Level switch on compressor
- Level switch on oil separator
- Level switch on oil receiver
- Pressure transmitter on oil receiver
- In special circumstances the pulse counter can also be used to control, but this is not energy efficient.

Safety relays

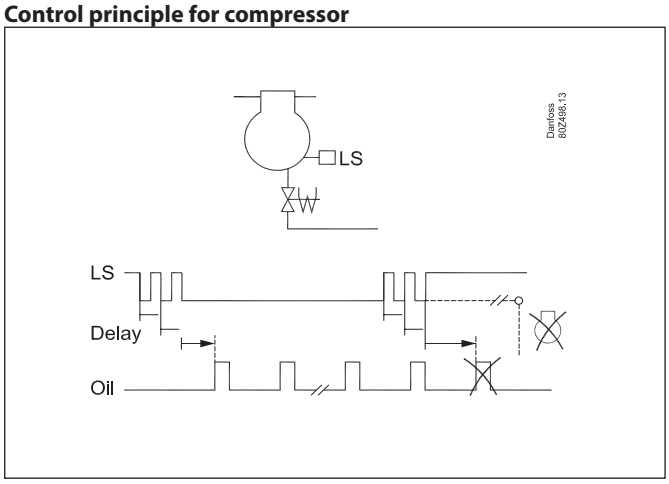
The controller can manage the oil supply to the compressors during normal regulation. However if the compressors are force controlled, this will be done outside the normal regulation. To avoid compressor damages, a safety relay can be incorporated in the control circuit so the controller can cutout the 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.



Examples of oil circuits

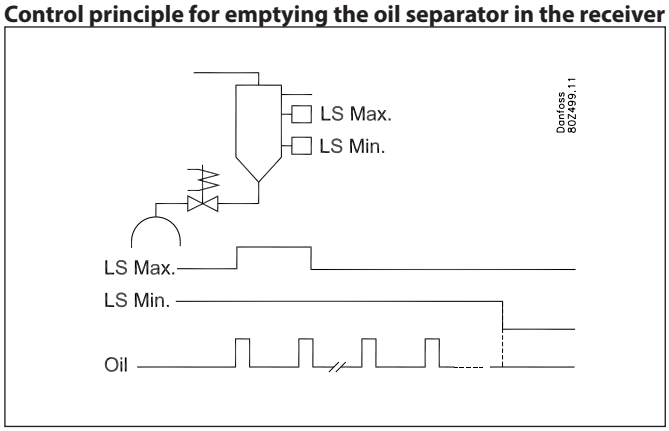


Control principle for compressor



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:
- 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.

Control principle for emptying the oil separator in the receiver



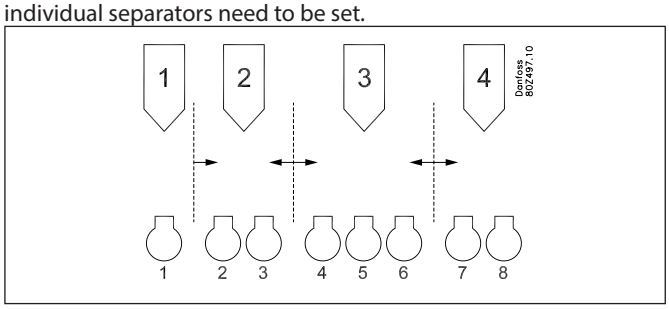
The system can be controlled by a signal from a high level switch or it can be controlled by a signal from both a high and a low level switch.

- In the case of a high level switch, the solenoid valve is opened and the oil is emptied into the receiver in user defined a pulse process. The system determines the pulse length, period time and number of pulses.
- If a low level switch is installed and it registers a low level of oil before the number of pulses has finished, the pulses stop and the emptying process is terminated.

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.

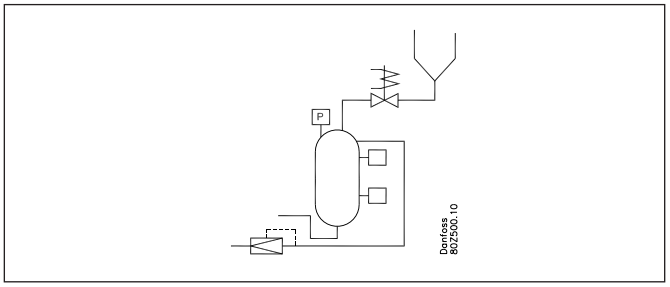
If an oil separator has been fitted for each compressor, it is the level switch in the compressor, that determines the emptying process of oil into the compressor. The level switch in the separator can be used for monitoring.

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.



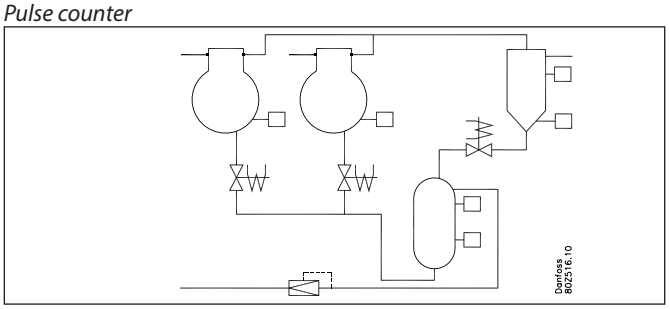
Control principle for pressure in the receiver

Pressostat



- In the case of lack of pressure difference to fill the HT 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.

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

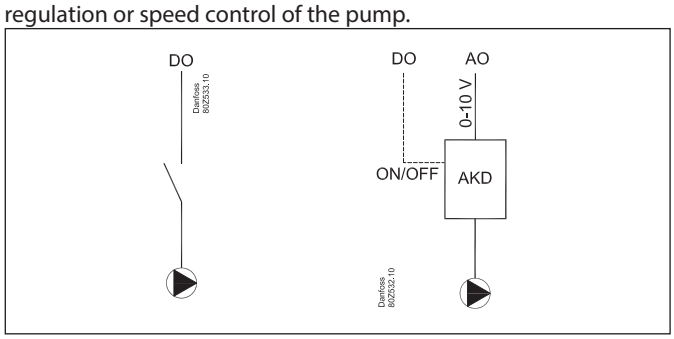
Miscellaneous
All oil valves are closed when the "Main switch" is off.

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 **only** 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.

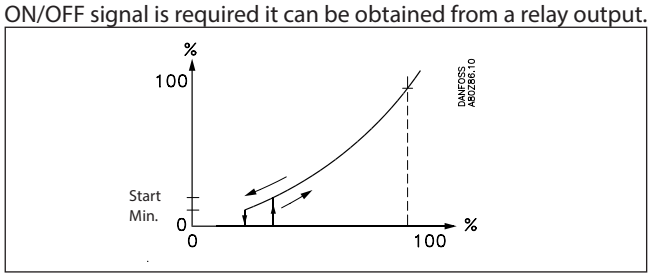
Pumpe

Capacity control of the pump can be accomplished via on/off regulation or speed control of the pump.



• On/off
The controller can control one pump.
Cut-in and cut-out are performed following a signal from the S7 temperature sensor and the set reference.

• Speed control
The analog output voltage is connected to a speed regulation. The pump will now be regulated from 0 to max. capacity. If an ON/OFF signal is required it can be obtained from a relay output.

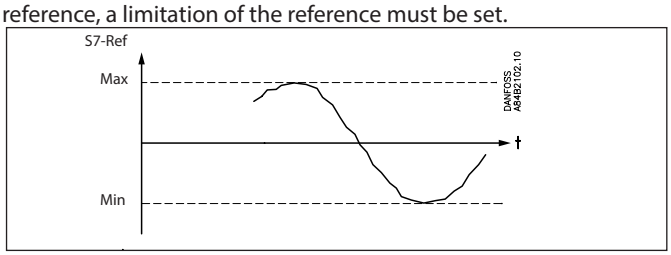


The controller starts the frequency converter when the capacity requirement corresponds to the set starting speed. The controller stops the frequency converter when the capacity requirement becomes lower than the set minimum speed.

PI-regulation / P-regulation
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 temperature and the reference value becomes as small as possible.
• P-regulation
The controller cuts in capacity that depends on the deviation between the actual temperature and the reference value.
The proportional band Xp indicates the deviation at 100% condenser capacity.

Regulating sensor
S7 is used as a regulating sensor.
The set point for the S7 temperature is set in °C.

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 the pump
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.

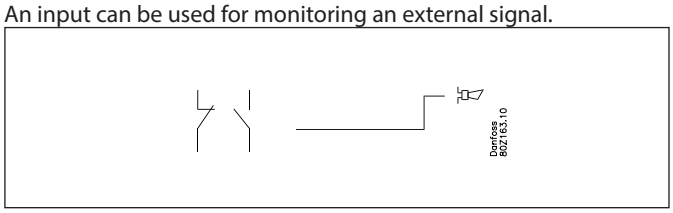
Forced operation of relays
If the forced operation is carried out with the switches at the front of an extension module, the safety function will register any exceeding of values and transmit alarms, if required, but the controller cannot cut the relays in or out in this situation.

Timer
The operating time of the pump 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 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.

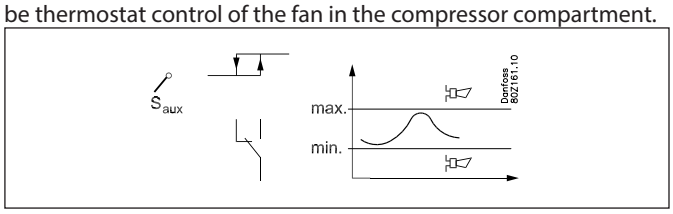
General monitoring functions

General alarm inputs (10 units)
An input can be used for monitoring an external signal.



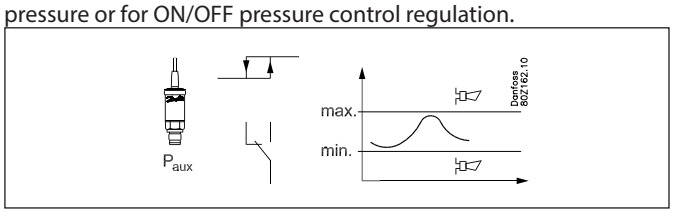
The individual signal can be adapted to the relevant use as it is possible to give the alarm function a name and to indicate your own alarm text.
A time delay can be set for the alarm.

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, S7) 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.

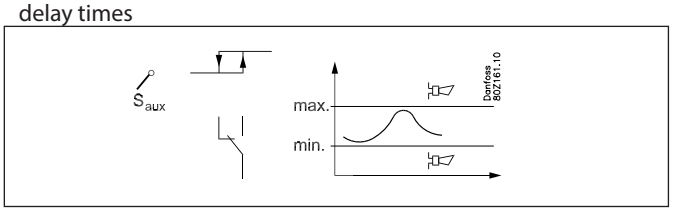
General pressure control functions (5 units)
(If the receiver is being pressure controlled, one of the five is used for this function. This means that there subsequently are four general pressure switches.)
The function may freely be used for alarm monitoring of plant pressure or for ON/OFF pressure 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



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.

Refrigerant
Before regulation can be commenced, the refrigerant must be defined.
You can select one of the following refrigerants:

1 R12	9 R500	17 R507	25 R290
2 R22	10 R503	18 R402A	26 R600
3 R134a	11 R114	19 R404A	27 R600a
4 R502	12 R142b	20 R407C	28 R744
5 R717	13 User defined	21 R407A	29 R1270
6 R13	14 R32	22 R407B	30 R417A
7 R13b1	15 R227	23 R410A	
8 R23	16 R401A	24 R170	

The refrigerant can only be changed if the "Main switch" is set at "stopped control".

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.
- In the event of a Pd error, 0% of the pump capacity cuts in, though the compressor regulation remains 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.

Note: An incorrect sensor must be in order for 10 minutes before the sensor alarm deactivates.

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 Network	AKM destination
		Non	High	Low-High		
High	X		X	X	X	1
Medium	X			X	X	2
Low	X			X	X	3
Log only	X					
Interrupted						

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.

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 is the following option:
- Change to night operation

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.

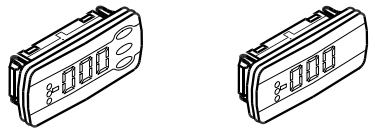
Service tool software AK-ST 500:
The operation is described in fitters on site guide.

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 pressure and temperatures



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
- P0
- Sctrl
- Ss
- Sd
- Pd
- S7
- P0 bar
- Pd bar

Display	Primary readout *	Secondary readout
A	Sctrl	S7
B	S7	Sctrl
C	Ss	None
D	Sd	None

* The primary reading can be changed to other measurements, if required.

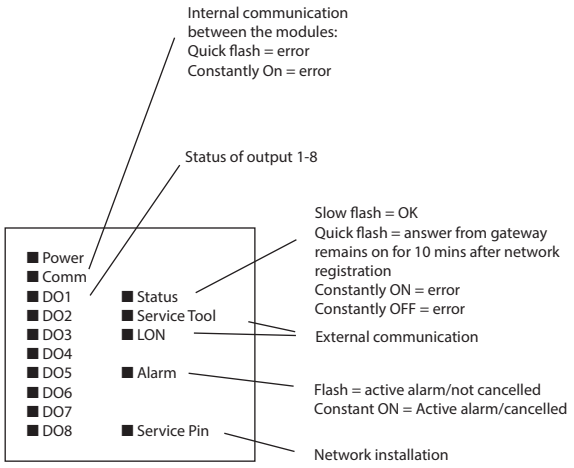
When a display with control buttons is chosen, a simple operation via a menu system can be performed in addition to the display of pressure and temperatures.

No.	Function
o30	Refrigerant setting
o57	Capacity settings for the pump 0: MAN, 1: OFF, 2: AUTO
058	Manual setting of pump capacity
o59	Capacity setting for suction group 0: MAN, 1: OFF, 2: AUTO
o60	Manual setting of suction capacity
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
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
r12	Main switch 0: Controller stopped 1: Regulating
r23	Set point suction pressure Setting of required suction pressure reference in °C
r24	Suction pressure reference Actual reference temperature for compressor capacity
r28	Set point S7 ISetting of required temperatures in °C
r29	S7- reference Actual reference for temperature regulation
r57	Po evaporating pressure in °C
u16	Actual media temperature measured with Sctrl
u21	Superheat in suction line
u48	Actual regulation status on the pump 0: Power up 1: Stopped 2: Manual 3: Alarm 4: Restart 5: Standby 10: Full loaded 11: Running
u49	Cutin pump capacity in %
u50	Reference for pump capacity in %
u51	Actual regulation status on suction group 0: Power up 1: Stopped 2: Manuel 3: Alarm 4: Restart 5: Standby 10: Full loaded 11: Running
u52	Cut in compressor capacity in %
u53	Reference for compressor capacity
u54	Sd discharge gas temperature in °C
u55	Ss Suction gas temperature in °C
u98	Actual temperature for S7 media sensor
U01	Actual Pd discharge pressure in °C
AL1	Alarm suction pressure
AL2	Alarm for discharge pressure
- - 1	Initiation. Display is connected to output A. (- - 2 = output B, etc.)

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

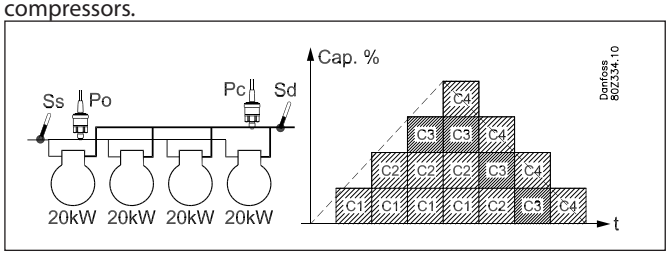


Appendix A – Compressor combinations and coupling patterns

In this section, there is a more detailed description of the compressor combinations and the associated coupling patterns. Sequential operation is omitted from the examples since the compressors are only connected in accordance with their compressor number (First In - Last Out principle) and only speed-regulated compressors are used to fill capacity gaps.

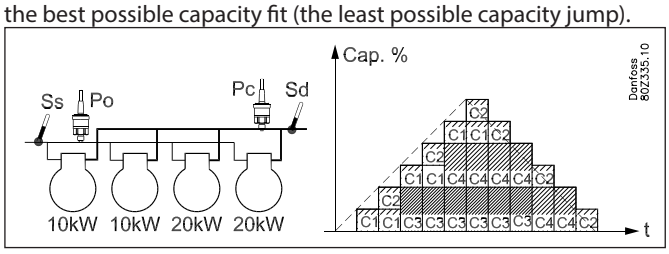
Compressor application 1 – single step
The capacity distributor is capable of managing up to 8 one-step compressors according to the following coupling patterns:
• Sequential
• Cyclical
• Best fit

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).

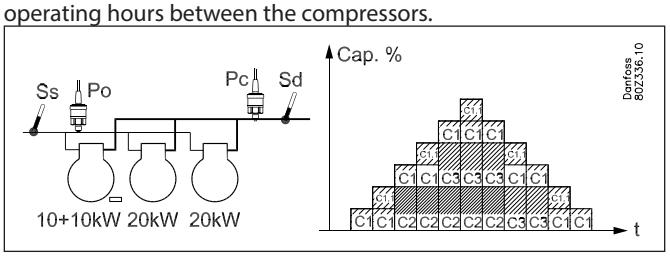
Compressor application 2 – 1 x unload + single step
The controller is able to control a combination of one capacity controlled and multiple single step compressors. The advantage of this combination is that the unloader valves will be used to fill in capacity gaps and thereby achieve many capacity steps 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:
• Sequential
• 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).

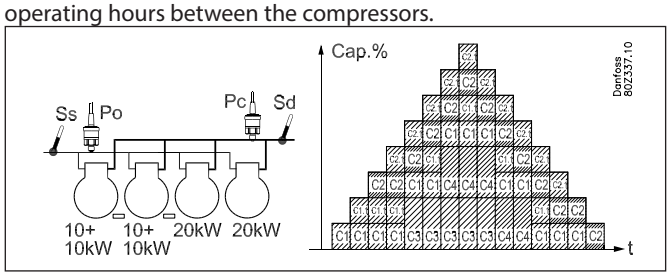
Compressor application 3 – 2 x unload + single step
The controller is able to control a combination of capacity controlled and multiple single step compressors. The advantage of this combination is that the unloader valves will be used to fill in capacity gaps and thereby achieve many capacity steps 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:
- Sequential
- 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.



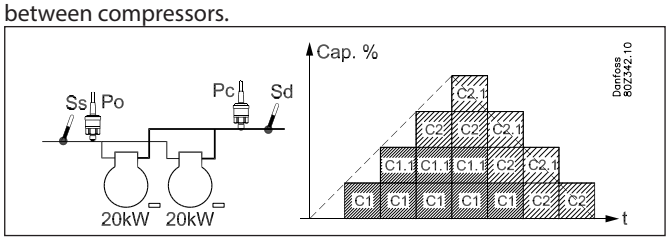
- The capacity controlled compressor is the first to start and the last to stop.
- Operating hours are equalised between the capacity-regulated compressors
- The unload valve on the capacity-regulated compressor is used to fill capacity gaps
- Operating hours are equalised between the one-step compressors 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:
- Sequential
- 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)

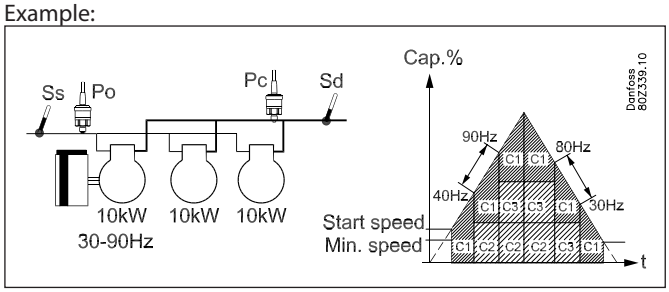
This compressor combination can be handled in accordance with the following coupling patterns:
- Sequential
- Cyclical
- Best fit

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:

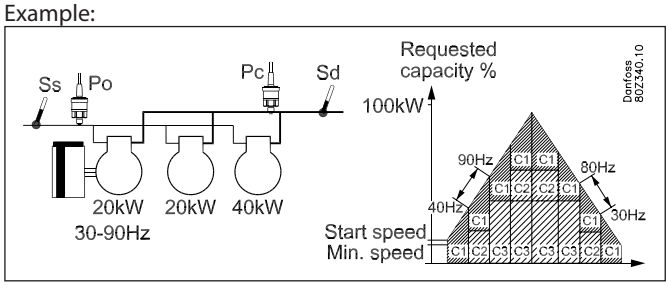


Increasing capacity:
- The speed-regulated compressor starts when the desired capacity equals the start speed
- The following one-step compressor with the smallest number of operating hours cut in when the speed-regulated compressor is running at full speed (90 Hz)
- When a one-step compressor cuts in, 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.

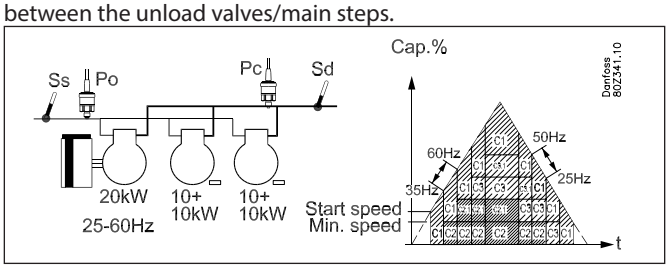
Compressor application 6 – 1 x Speed + unloader
The controller can operate one speed-regulated compressor combined with several capacity-regulated compressors of the same size and with the same number of unloaders.
The advantage of this combination is that the variable part of the speed-regulated compressor 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:
- Sequential
- 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)

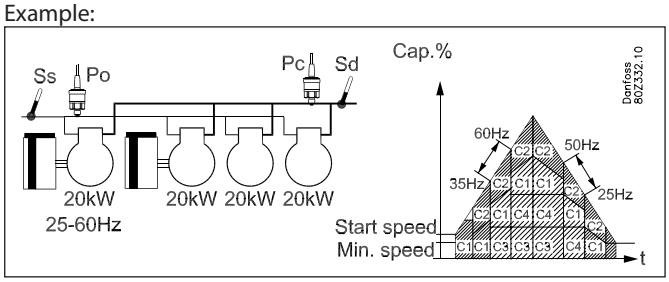
This compressor combination can be handled in accordance with the following coupling patterns:
- Sequential
- Cyclical
- Best fit

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:

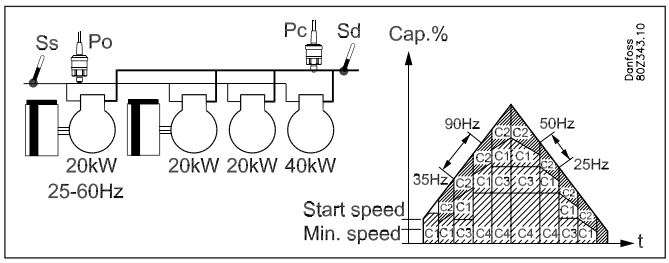


Increasing capacity:
- The speed-regulated compressor with the least operating hours (C1) starts when the desired capacity equals the start speed
- The following speed-regulated compressor C2 is cut in when the first speed-regulated compressor (C1) has reached max. speed (60 Hz) so that the compressors 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).

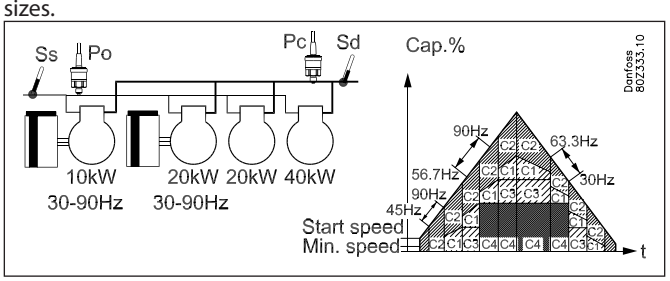
Example 1
In this example, the speed-regulated compressors are of the same size and the following one-step compressors are of different sizes



Increasing capacity:
- The 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.

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/Sctrl/sensor error	High		P0A sensor error	Pressure transmitter signal from P_0 is defective
			Sctrl sensor error	Sctrl media temp. sensor signal 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
			Saux1 sensor error	Signal from extra Temp. sensor Saux1 is defective
			Saux2 sensor error	Signal from extra Temp. sensor Saux2 is defective
			Saux3 sensor error	Signal from extra Temp. sensor Saux3 is defective
			Saux4 sensor error	Signal from extra Temp. sensor Saux4 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

Discharge part

High Sd temp.	High		High disch. temp. SdA	Safety limit for discharge temperature has been exceeded
High Pd press..	High		High pressure Pd	High safety limit for discharge pressure Pd has been exceeded
Pd/S7 sensor error	High		PdA sensor error	Pressure transmitter signal from Pd is defective
			S7A sensor error	Temperature signal for S7 media temperature sensor is defective

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
Dlx alarm input	Low		Custom alarm x -define text	Alarm on general alarm input DI x

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 pump. cap. Control A	Pump capacity regulation 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

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 wil 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.

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