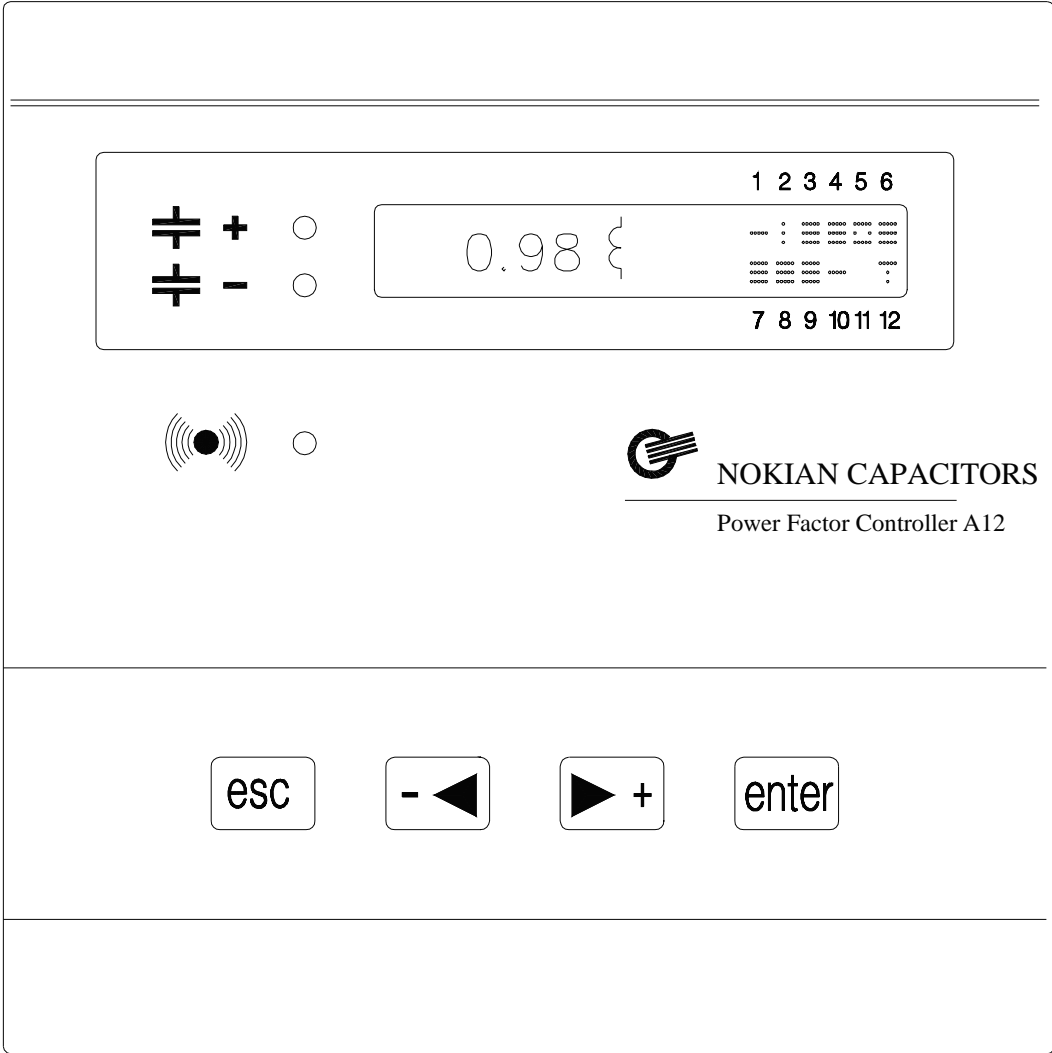


INSTRUCTION MANUAL

Power Factor Controller - 12 steps
Model A12



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1. FEATURES

- Panel mounting according to DIN 43700 or 35 mm DIN-rail mounting according to EN 50022
- 12 steps
- Automatic CT polarity retrieval
- Automatic search of C/K – values
- Different C/K ind and cap values
- Automatic frequency selection 50/60 Hz
- THD(U) and I_{rms}/I_n distortion measurements
- Detection of a step with decreased capacitance
- Hunting detection
- Setting for target power factor ($\cos \varphi$)
- Four-quadrant operation
- Easy-to-use menu-driven user interface
- Five-language menus
- Setting of reconnection delay
- 16-character alphanumeric liquid-crystal display with graphical symbols
- Plug-in connectors at rear side
- Separate alarm relay with potential-free contacts
- Possibility to operate steps manually and to set steps permanently on/off
- Serial communication option
- Protective momentary no-voltage reset function
- State-of-the-art microprocessor technology
- Complies with EN 50082-2 and EN 50081-2 EMC standards

2. INSTALLATION, CONNECTION AND APPLYING POWER

The controller is designed for either panel or DIN-rail installation. It is locked to the rail by a screw-driver-operated fixing spring and to a panel by a ratchet side fitting spring. Connect the voltage and current transformer exactly according to connection diagrams, see fig. 7 and fig. 8 on page 15. The controller detects the base frequency and changes its operation automatically for 50 Hz or 60 Hz.

The LN-operation (measuring voltage between one phase and neutral) the voltage must be taken from the same phase where the CT is connected. In LL-operation (measuring voltage between two phases) the CT must *not* be connected to either of the phases where the voltage is taken from.

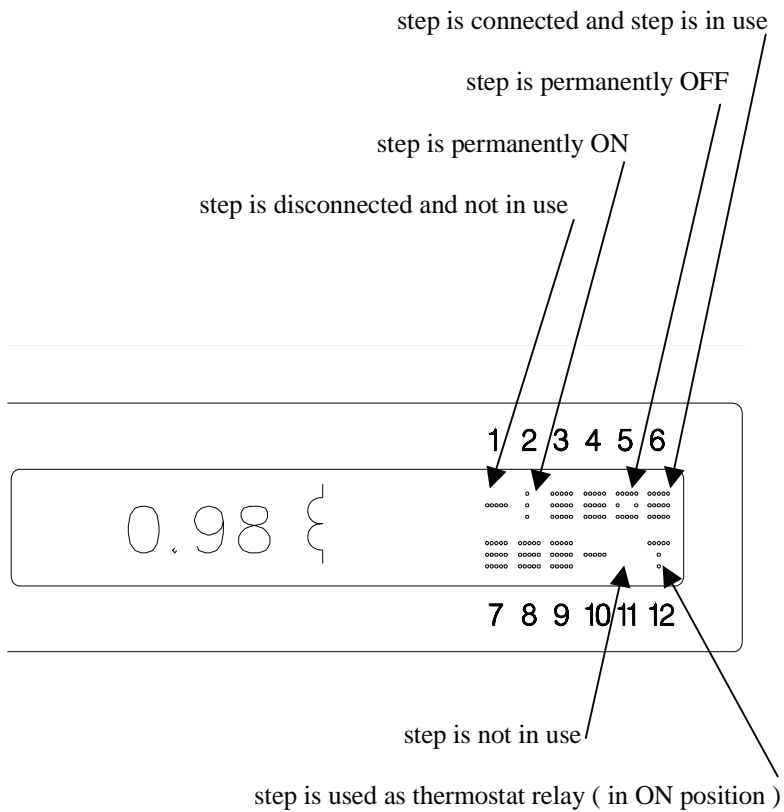
Check the setting of menu item *Connection* from *Programming*-menu: this must be set to LL when voltage is measured between two phases (factory default), or to LN when voltage is measured between one phase and neutral line. Refer to chapter 5 “Menu Operations”.

If needed, the controller automatically reverses the polarity of current measurement provided that there is sufficient current (1% of nominal 5 A) flowing in the measurement circuit. If the wiring of measurement signals to the regulator is not made according to instructions (this means that the rotation order of phases is incorrect).

3. DISPLAY

After the connections are correct and power is applied to the controller, it will enter to the $\cos \varphi$ basic display which displays the power factor of the system and step connection status. The symbols ξ and $=$ indicate inductive or capacitive power factor. The states of output relays are displayed in two rows one on the other. The special symbols indicate various states as follows:

Basic cos φ display



5. MENU OPERATIONS

The display of measured quantities as well as the input and editing of the operation parameters has been placed into four menus as follows:

a) *Measurements* menu

- apparent current
- reactive current
- distortion THD(U)
- step status

b) *Commissioning* menu

- target cos φ setting
- C/K auto search
- manual setting of C/K ratio
- manual operation
- language setting

- c) *Programming* menu
 - number of steps
 - stepping method
 - connection of voltage measurement
 - reconnection delay
 - automatic polarity detect
 - input voltage
 - low capacitance detection
 - direct-on-line setup

- d) *Alarms* menu (enable/disable and status)
 - low power factor
 - hunting
 - abnormal $\cos \varphi$
 - undervoltage
 - overvoltage
 - overtemperature
 - THD(U) high
 - capacitor overload
 - capacitor output low

The *Measurements* menu is entered by pressing the **enter** button. The *Commissioning* menu is entered only from the *Measurements* menu by pressing \blacktriangleright for at least two seconds. The *Programming* menu is entered from *Commissioning* by pressing keys \blacktriangleleft and \blacktriangleright simultaneously for at least two seconds. The *Alarms* menu is entered by pressing \blacktriangleright . See Appendix A for complete menu diagram

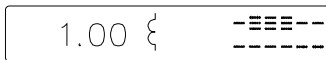
The regulation continues normally regardless of menu operations, with the exception of autosearch operation.

5.1 Using submenus and editors

To enter a submenu from the main level, press **enter**. Then you can step through all submenu items in that menu by pressing \blacktriangleright as many times as required. By pressing \blacktriangleleft you can step in the opposite direction. The value involved in that particular submenu item is shown on the right side of the display.

To enter the editor, press **enter** while in the submenu. An underscore $_$ appears below the edited value to indicate that you are in the edit mode. Now you can change the value by pressing button \blacktriangleright to increase or button \blacktriangleleft to decrease it. A short keystroke affects the least significant digit (first digit from right). A long keystroke moves to the second digit from the right allowing a faster change of the value to be edited. When the desired value is on the display, press **enter** to accept the value. The display returns back to the submenu level and the underscore disappears.

Example: Setting the target $\cos \varphi$



Basic display

Press **▶** to enter *Measurements* menu

Ψ MEASUREMENTS

Now press **▶** for two seconds to enter the *Commissioning* menu

◇ COMMISSIONING

Then press **enter** to the submenu level

◇ Cos Ψ 0.98 ξ

press **enter** once more to access the editor

◇ Cos Ψ 0.98 ξ

Now the underscore is below the value to be edited. Now press **▶** two times to increase the value to 1.00. The display should now look as follows:

◇ Cos Ψ 1.00 ξ

Now press **enter** to accept the value. The underscore disappears.

Now you can exit to *Commissioning* of the main menu level by pressing **esc**. Pressing **esc** again you return to the basis cos φ display.

5.2 Using the Measurements Menu

The Measurements menu is entered from basic cos φ display by pressing **▶**. This menu contains no editable variables, only basic measurement values obtained from network.

As the first item, apparent current display is shown.

Ψ Load I 1271 A

The apparent current flowing through the CT is shown. The actual value from the CT is multiplied with the CT ratio (if entered in Commissioning menu) to obtain the correct network value. If the CT ratio is not defined, this display shows percentages scaled to 5A according to the following example:

Ψ Load I 23%

The next key press of \blacktriangleright shows the next menu item, reactive current display. The remark of CT setting presented

Ψ React I 1329 A

applies also to this display.

Pressing \blacktriangleright again shows the total harmonic distortion in the network used

Ψ THD(U) 1.3%

Finally, pressing \blacktriangleright once more shows the last item in the Measurements menu, the step status display

Ψ $\frac{1}{T}$ Status 

The step status display shows the condition of the capacitors in bank as detected by the step capacitance survey feature of the controller. A fully functional step is shown with a small solid box whereas a step with decreased capacitance is marked with a small cross.

Now pressing **esc** returns back to the $\cos \varphi$ display and pressing \blacktriangleright for two seconds enters you to the next menu.

5.3 Using the Commissioning Menu

The *Commissioning* menu is entered from *Measurements* menu by pressing \blacktriangleright for two second. Using this menu you can edit the most common operating parameters required during commissioning a P.F.C. bank

The main menu level looks as follows:

◇ COMMISSIONING

To enter the submenus, press **enter**.

The first menu item in Commissioning menu is the target power factor

◇ Cos Ψ 0.98 ξ

To edit this value, press **enter**. Refer to the editing instructions given in 5.1.

The target power factor value can be adjusted between 0.85 ind ... 1.00 ... 0.90 cap. Values between 0.97 inductive and 1.00 are most commonly used. The signs ξ and $=$ indicate the inductive or capacitive setting value. See fig. 1 for the effect of different target power factor settings.

By pressing \blacktriangleright the next menu item, *C/K Auto Search*, appears on the display

◇ C/K Auto

To initiate the automatic search of C/K value, press **enter**. Now the controller first disconnects all steps displaying

C/K Search
0

and starts the autosearch process by connecting and disconnecting the first step several times and measuring the change of reactive power in network. The time this operation takes depends on the stability of the reactive power on network and the selected reconnection time delay (explained later in this text). During this operation, the display shows the cumulative number of connections/disconnections of the first step. The autosearch operation can be stopped any time during operation by pressing the **esc** button and the display shows

C/K Search
Stop

If the automatic search was successful, the following display shows for a short time and the menu item display is re-entered.

OK C/K=0.23

You can exit the display immediately by pressing any key. The regulation restarts automatically using the calculated C/K value, which is displayed with the OK message shown above. If the controller was not able to find a proper C/K value, the following alarm message is displayed and the user must verify this by pressing a button

C/K Search
Error

To enter the third menu item, *Response Values*, press \blacktriangleright

\blacktriangleleft Resp Values

Press **enter** to view and edit the capacitive C/K value

\blacktriangleleft \times ξ C/K 0.36

The editor mode is entered by pressing **enter**. In edit mode, the value on the display can be modified in the usual manner by buttons \blacktriangleleft and \blacktriangleright . The edited value is accepted by pressing **enter**. After leaving the editor, the capacitive C/K submenu is displayed

Editing this value is a similar procedure as with the inductive C/K setting.

\blacktriangleleft \times $\frac{1}{T}$ C/K 0.30

For more information, see section 6.1, "Calculating C/K settings" on page 15.

By pressing \blacktriangleright , the next menu item *CT Setting* appears on the display

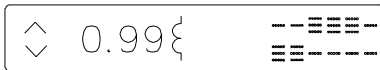
\blacktriangleleft CT 1000/5

The value of the CT ratio can be edited from 100/5 up to 6000/5 range. Also a percentage value can be selected, meaning that all the current values displayed in *Measurements* menu show percentage values with respect to 5 A. The percentage display is the factory default.

Now press \blacktriangleright to enter the *Manual Override* submenu



By pressing **enter** the display appears



By pressing **enter**, the user can insert one step into the network. The step will be actually inserted after a response delay, depending on reconnection delay, normally 10 seconds. As a confirmation to this, a + will appear on display, immediately after the $\cos \varphi$ value. When the step is connected, the + disappears. By pressing \blacktriangleleft , a step will be disconnected. This is indicated with a - sign on the display. The disconnection takes place after the response delay. You can cancel the connection/disconnection before it takes place by pressing the opposite direction key, \blacktriangleleft or \blacktriangleright .

During the manual operation of the controller, the connection/disconnections of steps use the stepping method and delay that was selected before manual stepping mode was entered. If no key is pressed during five minutes, the controller returns back to basic $\cos \varphi$ display.

The last item in *Commissioning* menu is the selection of language. Pressing \blacktriangleright the name of the language used appears on display



To change the language, press **enter** to display the editing cursor, then select the language with the \blacktriangleleft and \blacktriangleright buttons and confirm the selection by pressing **enter**.

5.4 Using the Programming Menu

The Programming menu can be entered only from item *Commissioning* of the main menu by pressing simultaneously buttons \blacktriangleleft and \blacktriangleright for at least two seconds. The first item of the menu appears on display



To edit the value, press the **enter** button.

The number of steps in use is indicated also in the basic $\cos \phi$ display: A connected existing step is indicated by a 3 line block and an unconnected existing step is indicated by a single horizontal line.

To enter the next menu item, press ▶



This is the selection of the stepping sequence used. To edit the value, press the **enter** button.

The four stepping methods are presented on display as follows:

N	Normal stepping method (1:2:4 sequence)
CA	Circulating Operation A (1:1:1 sequence)
CB	Circulating Sequence B (1:2:2 sequence)
S	Stack Operation (1:1:1 sequence)

For further details refer to Section "Setting the stepping sequence" later in this text.

To enter the next menu item, press ▶



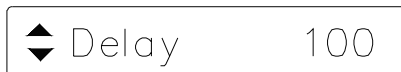
This is the selection of the connection of the voltage measurement inputs. To edit the value, press the **enter** button

The alternatives are:

LN: Line to Neutral

LL: Line to Line

To enter the next menu item, press ▶



This is the selection of reconnection delay.

The selection of reconnection delay also affects the response delay of each step. The response delay is one fifth of the reconnection delay, the minimum value is 10 seconds, even when the reconnection time was selected less than 50 seconds.

To enter the next menu, press ▶

◆ Auto Polar ON

This submenu is used to enable/disable the automatic CT polarity retrieval.

In case the ON-state is selected, the controller automatically reverses the CT polarity at controller startup if the CT is connected at reverse polarity. When disabled (OFF), the bank installer must take care of the proper phasing of the CT.

Note: If you intend to use the four-quadrant operation of the controller, the autopolarity feature and alarm 3 must be set to OFF.

To enter the next menu item press ▶

◆ Input V 400V

This is the reference setting for under and over voltage and I_{rms}/I_n distortion alarms. This is the nominal value of the voltage connected to voltage measurement terminals of the controller.

To enter the next menu item, press ▶

◆ Cap Loss Setup

This submenu contains all the necessary settings needed for the step capacitance survey function. All these variables must be set properly to facilitate the correct operation of this function.

When pressing **enter**, the first submenu item appears

This is actually the same CT setting as presented in the *Commissioning* menu but is duplicated here as part of a group of settings mandatory for setting up the step survey function.

To enter the next menu item, press ▶

⬆️⬇️⬆️ Step V 400V

This is the voltage at which the kvar values of the step sizes presented in the next menu item are defined. This does not have to be the actual voltage of the network used.

To enter the next menu item, press ▶

⬆️⬇️⬆️ Step Power

Now press **enter** to browse through the entire step size list

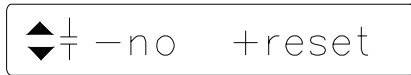
⬆️⬇️⬆️ 1 : 50 kvar

You can change this value by pressing -◀ or ▶ or discard it by pressing **esc**. Press **enter** when the value on display is correct and the next step appears on the display.

⬆️⬇️⬆️ 2 : 100 kvar

This value can be edited in similar manner as the previous one. Once entered, the user is forced to browse through the entire step size list. Step sizes that do not need editing can be bypassed by **esc** or **enter**. When the last step is edited, the menu control is returned to the upper level in menu. The step survey function is enabled by setting the corresponding alarm mask to the ON position in the *Alarms* menu.

To quit the Cap Loss Setup menu, press **esc**. The following display appears



This means that the user must press **▶** to accept the edited values in use and initialize the history collected step size information. If the **-◀** key is pressed, the new values are accepted but the previous history is maintained. To set this survey operation, the alarm 12 must be activated (set to ON state) from the *Alarms* menu.

The step sizes are initialized to zero as a default factory setting and the corresponding alarm mask is set to the OFF state. When the user enters the step list for the first time and modifies the value of the first step, the value entered is copied immediately to the rest of the steps. If the second value is changed from the value of the first one, it is copied to the rest of the steps. Thus the user does not have to individually enter every step value since in most cases the values of steps from the 3rd to the Nth (N = No. of the last step) are the same value. If this menu is entered later on, the copying process of step sizes does not take place any longer.

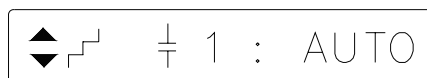
12

The last item in *Programming* menu is *Direct On Line Setup*. It is entered by pressing **▶**



This means that the user can define for each capacitor step used to operate as permanently ON (1), permanently OFF (0), or as an automatically operated (AUTO) step

To enter the editor, press **enter**



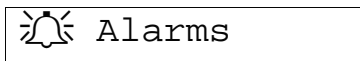
Now pressing **-◀** sets the step to the "permanently OFF" state. If instead you press **▶**, the step goes to the "permanently ON" state. Confirm your selection by pressing **enter**. The next step appears for editing. As with the *Step Power* submenu, you are forced to browse through the entire list of steps. If you do not want to change any particular step, just press **esc** or **enter** to bypass that step.

After browsing through the list, press **enter** to return to the main menu level.

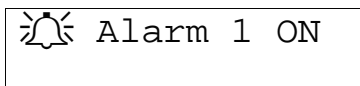
Number of Alarm	Description of alarm
1	Low Power Factor - The controller has connected all steps available but $\cos \phi$ still remains low
2	Hunting - The controller continuously connects/disconnects step(s) due to narrow C/K range
3	Abnormal $\cos \phi$ - The power factor is abnormally low due to e.g. miswiring of the controller
4	Undervoltage - The measured voltage is less than 80% of nominal
5	Overcapacitive - The controller has disconnected all steps but $\cos \phi$ still remains capacitive
6	Wrong Frequency - The controller has detected a wrong frequency at startup
7	Overcurrent - The measured current has exceeded 120% of the nominal value
8	Overvoltage - The measured voltage is higher than 110/120% of nominal
9	Overtemperature - The temperature measured by the internal transducer has exceeded the alarm level
10	THD(U) The voltage harmonic distortion of the network has exceeded the alarm level
11	Capacitor Overload - The I_{rms}/I_n value of distortion has exceeded the alarm level
12	Capacitor Output Low - The capacitance of the step shown in $\cos \phi$ display has fallen below 75% of nominal

5.5 Using the Alarms Menu

The *Alarms* menu is entered with a single key press of **▶** button from the item *Programming* of the main menu level.



The alarms are arranged as a list of 12 individual alarms. To start viewing and editing the state of each alarm, press **enter**



To enable/disable the alarm, press **enter**. Now you can switch between ON and OFF states with **◀** and **▶** keys. Finally, press **enter** to confirm the selection and **▶** to move to the next item.

The small rectangle in the right most character position of the display shows the state of that particular alarm. The states expressed with the character are as follows

- alarm is active
- alarm is passive (no alarm)

All the twelve alarms are edited as described above. The complete list of alarms is given above.

Press **esc** twice to quit to the basic $\cos \phi$ display.

6.0 SETTINGS

6.1 Calculating C/K settings

The activating current setting, C/K, determines on which reactive current level the regulator starts to operate the capacitor steps. The first capacitor step in the bank must be the smallest. The correct C/K is calculated as follows

$$C/K = \frac{Q_1}{I_1/5A * U_{LL} * \text{sqrt}(3)}$$

Where Q_1 = size of 1st step in vars
 U_{LL} = line to line voltage in volts
 $I_1/5A$ = ratio of secondary currents of main current transformer

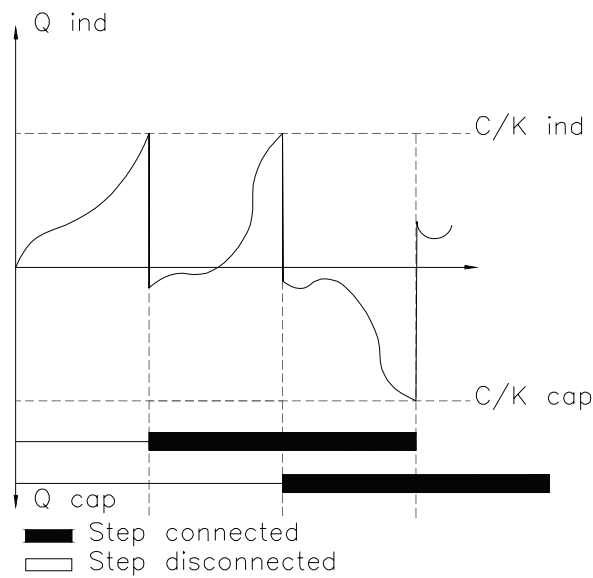


Figure 1: Controller Operation (Stepping method N)

If C/K setting is adjusted too low, this will cause hunting with the time intervals of the reconnection delay. This can be avoided by calculating and adjusting the settings correctly. A special alarm, ALARM 2, appears flashing on the display if the regulator starts to hunt (see section 7 "Alarms")

Table for C/K selection: These values are calculated for 400 V operation and can be used for voltage between 380 V 415 line-to-line

Smallest Step (kvar)

n1/n2	12.5	20	25	30	40	50	60	100
100/5	0.91	1.44						
150/5	0.60	0.96	1.20	1.44				
200/5	0.45	0.72	0.90	1.08	1.44			
250/5	0.36	0.58	0.72	0.87	1.15	1.44		
300/5	0.30	0.48	0.60	0.72	0.96	1.20	1.44	
400/5		0.36	0.45	0.54	0.72	0.90	1.08	
500/5		0.29	0.36	0.43	0.58	0.72	0.87	1.44
600/5			0.30	0.36	0.48	0.60	0.72	1.20
800/5				0.27	0.36	0.45	0.54	0.90
1000/5					0.29	0.36	0.43	0.72
1500/5						0.24	0.29	0.48
2000/5							0.22	0.36
2500/5								0.29
3000/5								0.24

Adjust C/K setting according to these values

6.2 Target power factor (cos φ) setting

The target power factor value can be adjusted between 0.85 ind 1.000.90 cap. Values between 0.97 inductive and 1.00 are most commonly used. See Fig. 2.

Note ! When calculating the correct values for C/K setting and target power factor, take care that there will not be heavy over compensation. This is especially important with relatively weak network.

6.3 Reconnection delay setting

The reconnection delay can be adjusted within the range of 10 to 900 seconds. The response time of a step is one fifth of reconnection delay, however with delays shorter than 50 seconds the response time is always 10 seconds. The reconnection delay protects the capacitors by preventing a step being connected to network before it is sufficiently discharged.

Warning ! The short reconnection delays are used, the capacitors and contactors or circuit breakers may be damaged. Never use a shorter delay time than recommended before consulting the manufacturer of the capacitor bank.

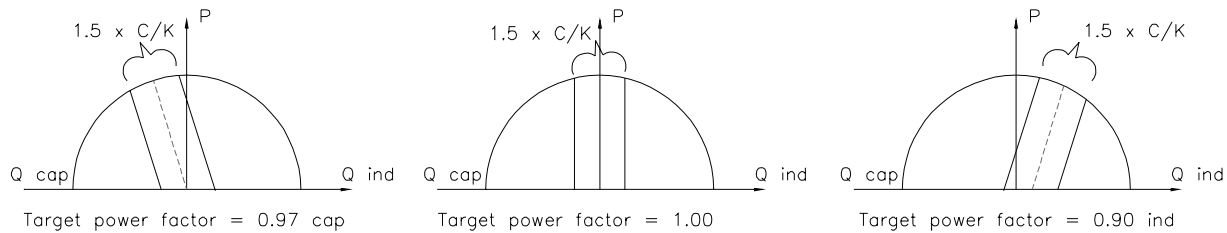


Figure 2 The effect of power factor setting

6.4 Setting of voltage measurement system

The voltage measuring system can be programmed to either LN (line-to-neutral) or LL (line-to-line) from the menu. Make sure that this setting complies with the connection of voltage inputs.

6.5 Setting the number of capacitor steps, thermostat operation

This facility is needed when a circular operation sequence is selected (described in detail later). The number of used steps is easily selected from the *Programming* menu.

Another significant feature involved with the number of steps setting is the operation of a cooling fan. If the number of steps programmed is less than the maximum number of steps available, the last relay (12th relay) can be used to drive a fan. When the temperature sensed by the internal transducer exceeds 35° C, the relay is activated.

6.6 Setting the operation sequence

Four different operation sequences can be selected from the menu. The 1:2:4 sequence is the *normal* one, refer to Fig. 3. If all the steps are of the same size, then 1:1:1 sequence can be selected. In this operation sequence, the steps are operated as a stack, refer to Fig. 4. With the step ratio 1:1:1 a *circulating* sequence can also be used. Here all the steps will be connected an equal number of times, see Fig. 5. Another circulating sequence can be used with step ratio 1:2:2, where the first step is used as a fine adjustment step and the rest of the steps are connected in circular fashion, refer to Fig. 6.

1:2:4 sequence (normal operation, N)

The controller always tries to switch on or off the first step and next the second after the activating limit is exceeded. The next steps (3, 4, ...) are switched on or off in sequence. Switching on will start from 3, 4, ... if the first and second steps are already on. Switching off will start from the last step if the first and the second steps are already off. Refer to Fig. 3.

The other allowable step size combinations for use with 1:2:4 sequence are as follows

1:1:1:1:1:1 1:2:2:2:2:2 1:1:2:2:2:2 1:2:3:3:3:3 1:2:3:4:4:4

Step Command	Step Number					
	1	2	3	4	5	6
+	X					
+	X	X				
+	X	X	X			
+	X	X	X	X		
-		X	X	X		
-			X	X		
+	X		X	X		
+	X	X	X	X		
+	X	X	X	X	X	
-		X	X	X	X	
-			X	X	X	
-			X	X		
-			X			

Figure 3: Operation sequence 1:2:4

1:1:1 sequence (stack operation)

When all the capacitor steps are of equal size it is possible to use this operation sequence which obeys the last-in-first-out principle. The first step connected will be the last one to be disconnected and the last step connected will be the first one to be disconnected. Refer to Fig. 4. This method is especially useful with harmonic filters.

Step Command	Step Number					
	1	2	3	4	5	6
+	X					
+	X	X				
+	X	X	X			
+	X	X	X	X		
-	X	X	X			
-	X	X	X			
+	X	X	X			
+	X	X	X	X		
+	X	X	X	X	X	
-	X	X	X	X		
-	X	X	X			
-	X	X	X			
-	X					

Figure 4: Operation sequence 1:1:1 (stack operation)

1.1.1 sequence (circulating operation A, CA)

If all the steps are equal in size and a first-in-first-out operation is required, then the circulating sequence is to be selected. With this operation sequence, the number of times for each capacitor step to be connected and disconnected will be equal. The number of hours connected is not calculated but the number of switchings on or off will eventually be the same for each capacitor step. For this sequence, in order to operate correctly, the number of steps must be programmed otherwise there will be empty steps in case the number of capacitor steps in the bank do not exactly match with those in the controller. Refer to Fig. 5.

Step Command	Step Number					
	1	2	3	4	5	6
+	X					
+	X	X				
+	X	X	X			
+	X	X	X	X		
-		X	X	X		
-			X	X		
+			X	X	X	
+			X	X	X	X
-				X	X	X
-					X	X
+	X				X	X
+	X	X			X	X
-	X	X				X

Figure 5: Operation sequence 1:1:1 (circulating operation)

1:2:2 sequence (1 + circulating operation B, CB)

Similar to 1:1:1 circulating operation with the exception that the step one is used as fine adjustment step. The regulator first always tries to switch on or off step number one after the activating limit is exceeded. The next steps are switched on or off with the circulating principle. See Fig 6.

Step Command	Step Number					
	1	2	3	4	5	6
+	X					
+	X	X				
+	X	X	X			
-		X	X			
+	X	X	X			
+	X	X	X	X		
-		X	X	X		
-			X	X		
-				X		
+	X			X		
+	X			X	X	
+	X			X	X	X
-				X	X	X
-					X	X
-						X
-						

Figure 6: Operation sequence 1:2:2 (1 + circulating operation) 19

7.0 ALARMS

A comprehensive set of alarm messages has been provided to pin point the possible abnormal situations in network and in usage of the controller.

The possible alarm conditions can rise from the following situations

- insufficient compensation power
- the regulation system is hunting
- controller inputs are not correctly wired
- over/under voltage or current has been detected
- the measured voltage contains harmonics
- capacitor steps are overloaded due to excessive harmonic currents
- the network is over compensated
- the temperature in the bank has exceeded alarm limit
- the output power of a capacitor step has degraded
- wrong frequency during startup

7.1 The alarm display

Once an alarm condition is detected, the appropriate alarm code appears on display, the red alarm LED is lit and the alarm relay is activated. The alarm display stays on as long as the condition prevails and can not be cleared until the alarm condition is removed. The alarm relay will be deactivated after a delay of one minute from the disappearance of the alarm condition but the alarm message stays on the display until it is manually cleared.

Also, three alarms have been provided. The warning message does not operate the alarm relay and disappears automatically after the condition that caused the warning has disappeared. The warning messages originate from the following circumstances:

- input current too low for proper operation of the controller (I low)
- input current is too high (I High)
- input voltage is too low (U Low)

7.2 Clearing of an alarm

Press - ◀ to clear an alarm message. The alarm message will not disappear if the alarm condition is still on

7.3 List of alarm codes

Low power factor

ALARM 1

The controller has switched all steps on. Network is still inductive and a request to switch on more steps exists. Check the voltage measurement setting and external wiring of the controller.

Hunting

ALARM 2

One or more capacitor steps are switched on and off in time intervals of reconnection delay. The C/K settings are too low. Calculate and adjust correct C/K settings or use the Auto-C.K feature as described in section 5.3 " Using the Commissioning menu". The activation time is 30 x response time.

Abnormal $\cos \varphi$

ALARM 3

The cause of this alarm in most cases is that the voltage inputs are connected to wrong phases with respect to the CT. For correct connections, see Figs. 7 and 8. Also a highly varying reactive power load can trigger this alarm. The activation time is 3 x reconnection delay. The alarm must be disabled in four-quadrant applications.

Low Voltage

ALARM 4

Line voltage is below 80% of nominal. The activation time is approximately 1 second. All steps are disconnected simultaneously.

Network too capacitive

ALARM 5

The controller has switched all steps off. Network still stays on capacitive side and a request to switch off more steps exists. Check the voltage measurement setting and external wiring of the controller and the possible fixed compensation used.

Wrong frequency

ALARM 6

The controller has not been able to detect a correct network frequency, 50 or 60 Hz. at startup. The frequency must be correct within a +/- 2 Hz limit

Over current alarm

ALARM 7

The input current is higher than 115/120 % of nominal. The activation time for 115% limit is 180 seconds whereas the time for 120% limit is 30 seconds. The controller will recover automatically from this alarm. Check the CT.

Over Voltage

ALARM 8

The network voltage is higher than 110/120% of nominal. The activation time for 110% over voltage is 30 minutes and for 120% is 1 minute. As a protection action, the controller will disconnect all steps and will recover automatically after a delay of 10 minutes.

Over temperature

ALARM 9

The controller measures the temperature in the bank with its internal temperature transducer. If the temperature is above 35 ° C and below 50 ° C, the controller switches on relay 12 to start cooling of the bank using a fan, provided that the number of steps adjustment is lower than the maximum number of available steps. When the temperature is above 50 ° C, alarm 9 is issued. The controller disconnects all steps and recovers automatically after the bank temperature has fallen below the alarm level.

THD(U)

ALARM 10

The controller measures continuously the voltage harmonic distortion of the network used. If the THD(U) value exceeds 7%, an alarm is generated.

Capacitor overload

ALARM 11

Using the results of the THD(U) measurements, a capacitor overload factor I_{rms}/I_n is calculated. If this factor exceeds 1.5, the controller will disconnect steps, enters a 10 minute shutdown period and issue alarm 11. The normal regulation continues after the 10 minute period.

Capacitor output low

ALARM 12

Every time a capacitor step is switched on or off, the difference in reactive power is measured. Using these values as input to a low-pass filter, the condition of each capacitor step can be evaluated. If the capacitor output has fallen below 75% of nominal, alarm 12 is generated.

7.4 List of warnings

Input current too low

I Low

The CT current has dropped below 0.75% of the nominal current making $\cos \varphi$ measurements vague and prevents automatic polarity detection. If the load current during controller startup is low, setting autopolarity detection to OFF state is recommended.

Input current too high



The input current is higher than 110% of nominal. This can be due to an under dimensioned CT or internal failure

Input voltage too low



The controller has not detected input voltage between its input terminals during startup. The frequency of the network has not been detected.

8.0 COMMISSIONING

8.1 Operational test

Note: The factory default settings are assumed to be left intact when starting this test

1. Make sure that the main fuses of the capacitor bank are open.
2. When power is connected to controller, the alarm relay contact should be open and the display should indicate power factor.
3. The $\cos \varphi$ step display should indicate that there are no steps connected yet
4. Select *Manual override* from the *Commissioning* menu (see section 5.3 for instructions). Switch on the first step. Check the response delay which should be around 10 seconds. Switch off the step. The response time should again be 10 seconds. Switch on the first step again. The reconnection delay should now be approximately 50 seconds due to reconnection delay. Switch off the step.
5. From the *Commissioning* menu, adjust both C/K settings to zero and target power factor to 0.90 capacitive. Now the controller should connect all the steps available. Adjust the target power factor to 0.8 inductive. Unless the $\cos \varphi$ of the network is not very inductive, the controller will start disconnecting steps.
6. Check that the power factor of the network is within reasonable limits.
7. Check and adjust all the settings in *Commissioning* and *Programming* to suit your needs. If you choose to use automatic C/K (autosearch), set the manual C/K values back to factory default setting 0.50

8. Disconnect the controller power
9. Install the main fuses of the capacitor bank.

8.2 Starting the operation

1. Switch on the power to the controller
2. The controller should now start operation by switching steps on, depending on the reactive power level in the network and selected C/K values
3. Now an autosearch operation can be selected and started from *Commissioning* menu. (see section 5.3 for instructions). If needed, the C/K-settings are updated with new values.

9.0 TROUBLESHOOTING

1. Power factor reading is low or very unstable. Possible alarms involved: 3, 1, 5.
 - LN-operation (measuring voltage between phase and neutral): check that the voltage is taken from the same phase where the CT is situated.
 - LL-operation (measuring voltage between two phases): check that the CT is not situated in either of the phases voltage is taken from.
 - check that the CT is connected properly
 - check that the correct voltage measuring system is selected

2. Display is blank, controller does not react to pushbuttons. Possible alarms involved: none
 - check the power supply connection of the controls

3. Message I Low on display. Possible alarms involved: none
 - current transformer circuit faulty. Check the circuit with a clamp ammeter
 - no current flowing on secondary side

4. Controller does not operate though inductive load is heavy. Possible alarms involved: none
 - check the settings of the controller

5. Controller does not disconnect step during small load. Possible alarms involved: none
 - C/K settings too high

6. One or more capacitor step(s) is (are) connected on and off in intervals of response/reconnection delay Possible alarms involved: 2
 - C/K values are adjusted too low. Calculate and adjust the correct settings or use the autosearch feature to find correct C/K values.

7. Cos ϕ display indicates that some steps are connected but capacitor contactors are not activated. Possible alarms involved: 1
 - check the control circuit of the contactor
 - check fuses

8. Controller does not complete the autosearch procedure successfully. Possible alarms involved: None; message C/K Search Error
 - check the operation of contactors
 - check fuses
 - network is unstable. Wait for the network to stabilize or obtain C/K settings manually.

9. The cos ϕ is less than target cos ϕ although all steps are connected
 - connection (LN/LL) incorrectly programmed
 - check the operation of contactors
 - check fuses
 - measure the current of each capacitor with a clamp ammeter
 - bank under dimensioned

10.0 DISPOSAL AND RECYCLING

The controller casing is made of ABS plastic and can be recycled or disposed in accordance with the local regulations.

The controller package is made of corrugated cardboard and thus is an excellent material for recycling. It can also be incinerated.

The printed circuit board contains no recyclable parts and must be disposed.

11. SCHEMATICS

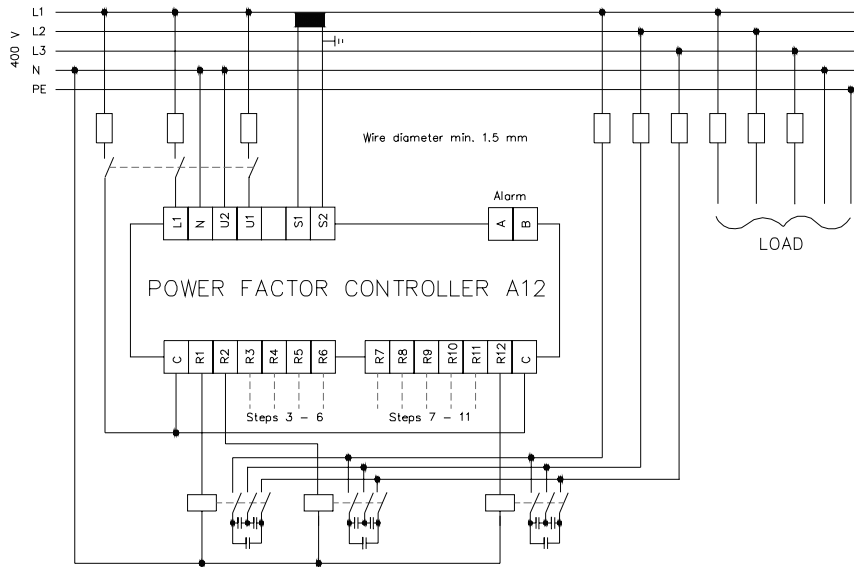


Figure 7: Connection of the controller, line-to-neutral

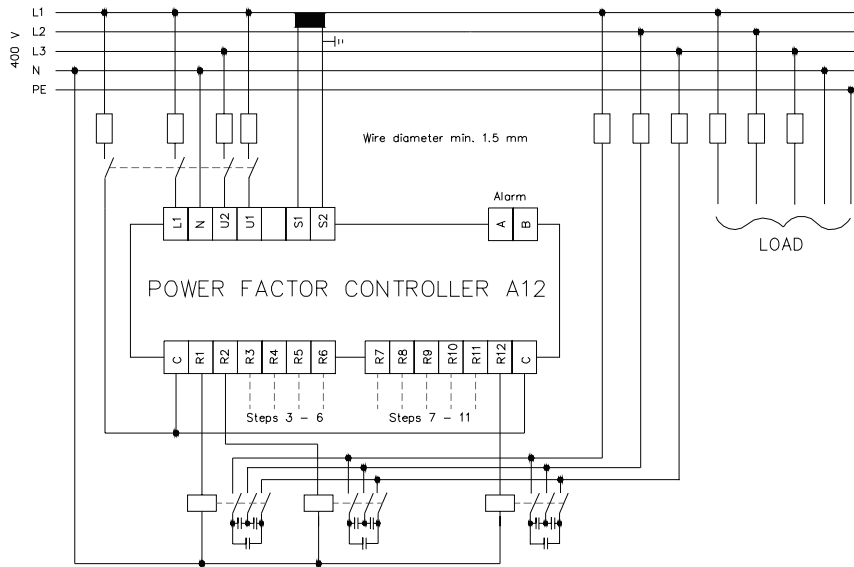


Figure 8: Connection of the controller, line-to-line

12.0 TECHNICAL DETAILS

Power supply	230 V +/- 15%, burden 8 VA
Measurement Voltage	120 V +/- 15% or, 230 V +/- 15% or, 400V +/- 15% or 415 V +/- 15% or 440 V +/- 15%
Connection	with or without neutral line
Frequency	50 Hz or 60 Hz +/- 2 Hz, automatic selection
CT	5 A, burden 0.7 VA
Manual Operation	Manual operation with momentary push-buttons
Operation sequence	user-selectable from menu normal 1:2:4:4 stack 1:1:1:1 circulating A 1:1:1:1 circulating B 1:2:2:2
Output Relays	2.0 A, 400 VAC, normally open 0.3 A, 110 VDC 0.6 A, 60 VDC 5.0 A, 30 VDC 5.0 A, 24 VDC
Alarm Relay	2.0 A, 400 VAC, normally open 0.3 A, 110 VDC 0.6 A, 60 VDC 5.0 A, 30 VDC 5.0 A, 24 VDC
Accuracy class	1.5%
Ambient Temperature	0 to + 50 °C
Protection class	IP 40 at panel installation IP 20 DIN-rail installation
Dimensions	144 x 144 mm, depth 90 mm
Panel cut-out	138 x 138 mm, -0...+1 mm
Weight	0.9 kg