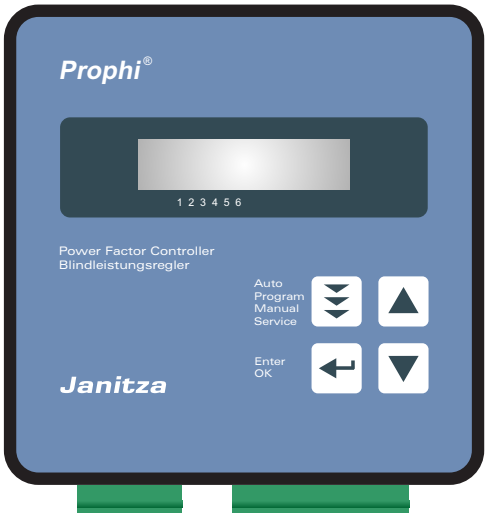
Power Factor Controller

Prophi® 6R

Manual



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Section1 General

The power factor controller Prophi-6R is a modern control device of innovative design with a variety of functions.
It is designed for a measuring voltage of 30...525V (L-N) or (L-L) and a supply voltage of 110...230VAC (+/- 15%)
It features a user interface with a menu-driven display in plain text for maximum ease of operation. Straightforward symbols and alphanumeric displays in the language of the country of use (ten languages) combine maximum ease of handling with convenient presentation of results.
Display of various grid parameters, storage of various values and a test run option make it easy to analyse errors and monitor the system.
An automatic initialization is available which will reduce the commissioning to a minimum.

Main features:

- ☑ 6 switching outputs, 1 alarm relay
- ☑ Twenty pre-programmed control series with a self-optimized intelligent control response
- ☑ Control-series editor for user-defined control series
- ☑ Complete menu-guided operation and display
- ☑ Illuminated graphic display with 2 x 16 characters
- ☑ Four-quadrant operation
- ☑ Automatic initialization
- ☑ Display of various line parameters (V, I, F, Q, P, S...)
- ☑ Display of voltage and current harmonics
- ☑ Display and monitoring of temperature
- ☑ Monitoring of the individual capacitor power values
- ☑ Storage of maximum line-parameter and switching-operation values as well as of the turn-on times of individual capacitor contactors
- ☑ Manual / automatic operation
- ☑ Programming of fixed stages and the option of skipping individual outputs
- ☑ No-voltage turn-off
- ☑ Error detection for various states and interference-message output
- ☑ Test run of PFC system with error analysis
- ☑ Switchboard-integrated housing 144 x 144 x 55 mm

CAUTIONS:

1. High voltage !
2. The device may only be used indoor !
3. Make sure that the discharge time set in controller matches capacitor discharge time !

The controller is supplied as standard for an operating voltage of 110...230 VAC (+-15%), a measuring voltage of 30...525 VAC (L-N) or (L-L), 50/60Hz and a measuring current of 5A or 1A. A voltage converter is required for different measuring voltages.

Caution!
Voltages which exceed the specified voltage range can damage the device!

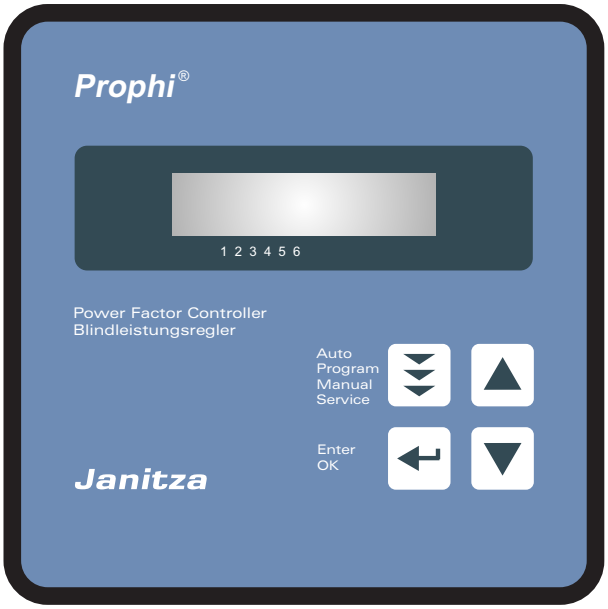


Fig.1 Front view

Operating mode
- Automatic
- Programming
- Manual operation
- Service
- Expert mode

Enter / OK
Confirm and store values

Increase selected parameter

Reduce selected parameter

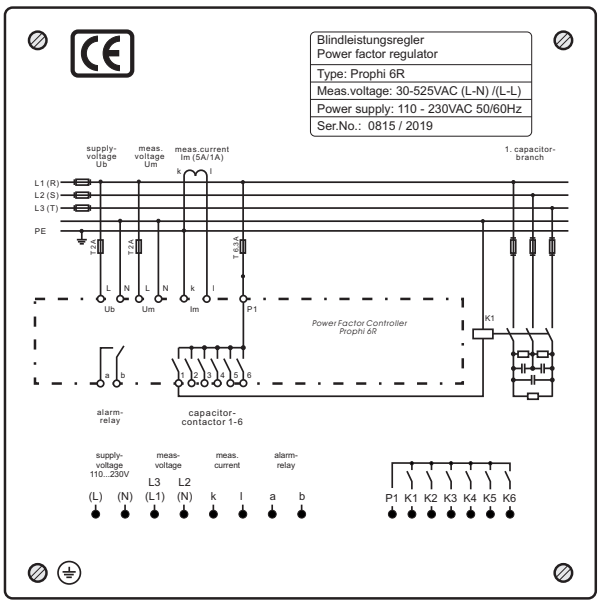


Fig. 2 Rear view

Section 2 Installation and connection of the controller

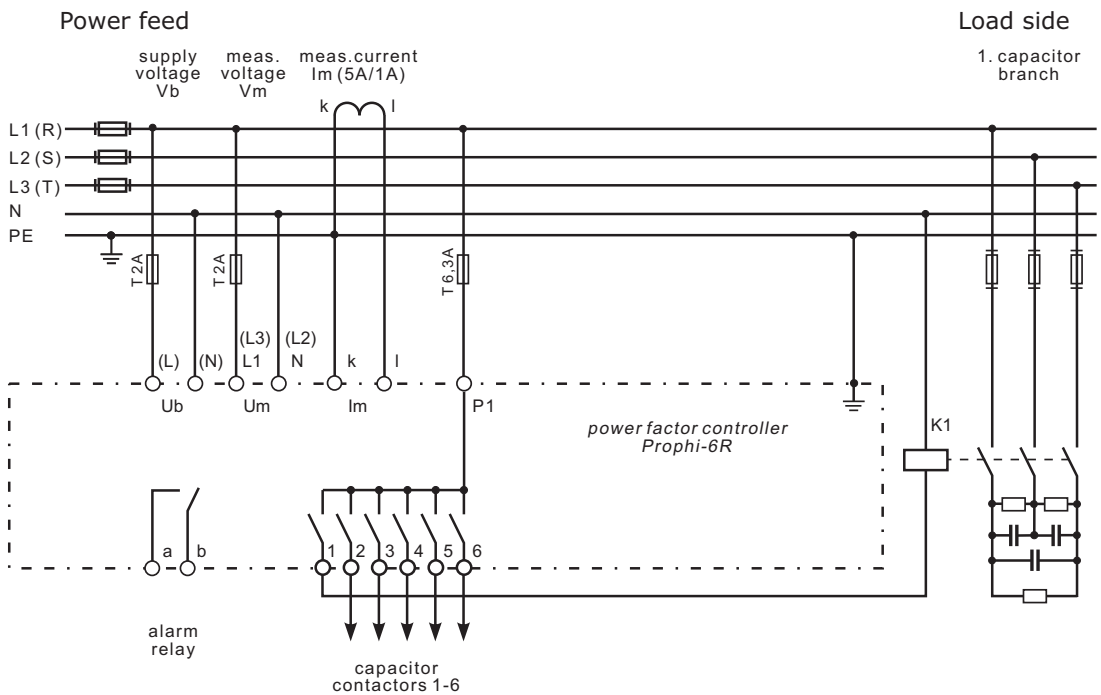
The controller is designed to be incorporated into the front panel of a PFC-cabinet. It requires a switchboard section of 138 x 138 mm to DIN 43700/ IEC 61554. The controller is inserted from the front and is attached by means of the appended clamps. It may be inserted only by qualified technicians and must be operated in accordance with the specified safety regulations.
Before the *Prophi-6R* is connected up, all leads and cables must be checked to ensure that no current is flowing through them and the current converter must be short-circuited. Care should be taken to ensure that the measuring voltage and current are in the correct phase position. The measuring-current circuit must be wired with copper leads of 2.5mm^2. The connection should be set up as shown in Fig. 3. The specified safety regulations must be observed.

The measuring voltage may lie in the range from 30 - 525 VAC and can be connected between L - N (default) or between L - L (programming of phase correction needed)

The supply voltage is 110...230 VAC +/- 15% and can be connected between L - N or L -L (depending of the grid).

The coil voltage for the capacitor contactors and the measuring voltage must be drawn from the same phase conductor, as only the measuring voltage is monitored. (Protection against direct reconnection of the capacitor contactors in the event of momentary single-phase power failure)

Fig. 3: Connection plan

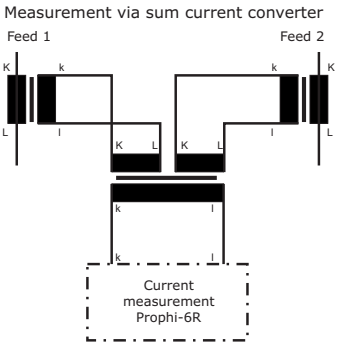


2.1 Current measurement

When installing the current converter, care should be taken to ensure that the load current flows through it. The outputs of the compensation network must be installed behind the current converter (in the direction of current flow). If the device is connected up via sum-current converters, the overall conversion ratio is entered.

Example:
C.converter 1: 1000/5A
C.converter 2: 1000/5A
Sum-current converter: 5A+5A/5A

C.converter ratio is: 2000/5A

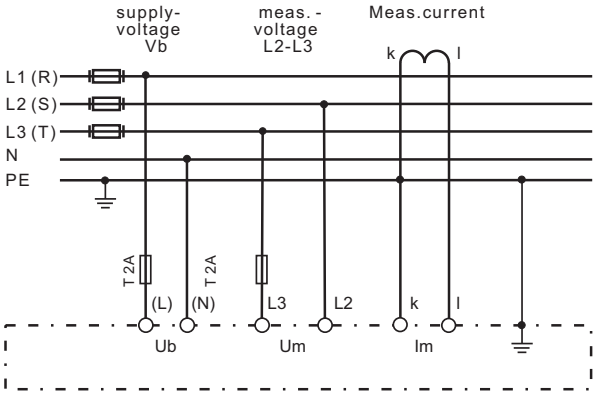


2.2 Programming of phase-correction - e.g. connection directly L-L (400V)

Adjustment of phase-correction between voltage and current in the meas. system is done in expert mode 1 (page 17)

Example :

Meas.current: L1
Meas. Voltage L3-L2
Phase U/I [90°]



using	meas. current	meas. voltage	phase-angle
Preset:	L1	L1 - N	0°
	L1	L1 - L2	30°
	L1 (k<->l)	L2 - N	60°
s. example	L1	L3 - L2	90°
	L1	L3 - N	120°
	L1	L3 - L1	150°
	L1 (k<->l)	L1 - N	180°
	L1 (k<->l)	L1 - L2	210°
	L1	L2 - N	240°
	L1	L2 - L3	270°
	L1 (k<->l)	L3 - N	300°
	L1 (k<->l)	L3 - L1	330°

2.3 Alarm output / error messages

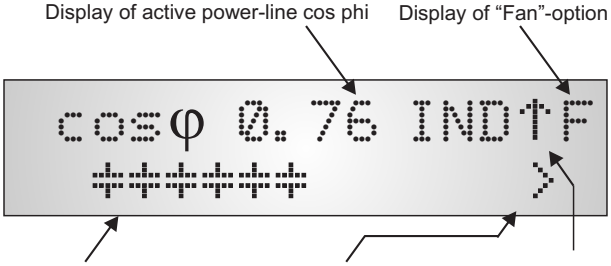
The alarm contact is closed in normal operation and opens in the event of a fault. The relevant fault is simultaneously shown on the display in plain text (alternating with the standard display in automatic operation)

UNDER-COMPENSATED missing reactive power	Display and relay output
OVER-COMPENSATED	Display and relay output
OVERCURRENT	Display and relay output
MEASURING VOLTAGE ?	Display and relay output
OVERTEMPERATURE	Display and relay output
OVERVOLTAGE	Display and relay output
UNDERVOLTAGE	Display and relay output
HARMONICS	Display and relay output

Additionally several messages for different operation states are generated. An individual adjustment resp. suppression of particular messages is possible in expert mode 2. During suppression, the indication of the message in the display, a possible release via alarm-relays and effects on the controlling process will be prevented.

Section 3 Operating modes

When the operating voltage is switched on, the device briefly displays its designation and software version, then changes to its normal operating status (automatic operation). The active cos-phi value is always displayed in the upper line and the currently connected capacitors are shown as symbols in the lower line (operating display).



The control direction is symbolized by a closed arrow

Connecting-in
Connecting-out

The connecting-in arrow is always located after the maximum possible number of stages (end stop)

An open arrow indicates that the required blocking time (discharge time) is running before an impending switching step

A double arrow symbolizes fast switching of several branches

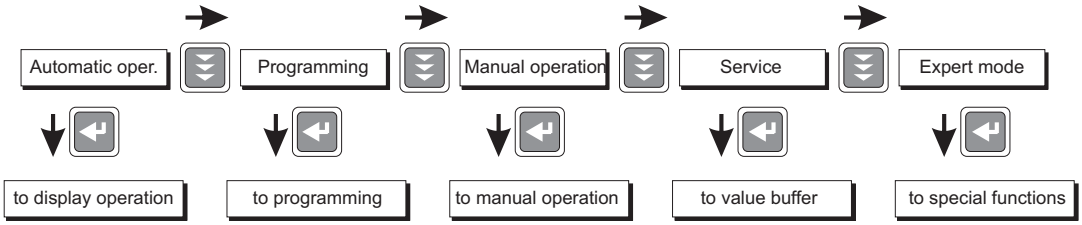
By pressing the cursor buttons, the display of capacitor stages can be changed:

Display of activated stages in kvar and in percent of total output of PFC system

Display of activated stages as bar-graph display in percent of total output of PFC-system

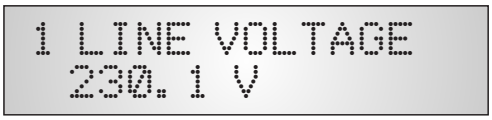
The power values of the individual capacitors are monitored constantly. **If a capacitor is defective or if the deviation from the rated power is excessive, the corresponding capacitor is displayed inversely.**

Repeated pressing of the "Operating Mode" key takes the user to the various menus in sequence: **Auto**matic operation - **Program**ming - **Manual** (manual operation)- **Service - Expert** mode and back**.**



Section 4 Automatic operation - display of grid parameters

The device is set to automatic operation as standard (not AUTO-INIT). Capacitor stages are then automatically connected in or out in order to reach the target power factor. This happens when the required reactive power exceeds the value of the smallest capacitor stage.
In automatic operation, various network parameters can be displayed by repeatedly pressing the "ENTER" key:



Action	Display		
ENTER	1 LINE VOLTAGE	in V	/%
ENTER	2 APPARENT CURRENT	in A	/%
ENTER	3 REACTIVE POWER	in kvar	/%
ENTER	4 ACTIVE POWER	in kW	/%
ENTER	5 APPARENT POWER	in kVA	/%
ENTER	6 DIFF. kVAR TO TARGET COS		
ENTER	7 FREQUENCY	in Hz	
ENTER	8 TEMPERATURE	in °C / °F	
ENTER	9 HARMONICS (3.-19) Selection via arrow-keys	V / %, I / %	
ENTER	10 THD-V, THD-I	in %	
ENTER	12 ENERGY in kWh, kvarh, (+/-) reset in: Service / max.value reset		
ENTER			
ENTER	Return to: 1		

The power value specifies the total power (3-phase) assuming symmetrical load. If no key is pressed for 60 seconds, the display automatically returns to the operating status!

Section 5 Programming

Pressing the "Operating mode" key once takes the user from automatic operation to **Program**ming mode. Parameter 1 (I-CONVERTER) is reached by pressing "ENTER".
The upper display always shows the parameter and the lower one the set value. The values are changed by pressing the ↑ / ↓ keys. Subsequent pressing of the "ENTER" key stores the value and takes the user to the next parameter.
Description of the parameters: **See the next page**
To quit programming mode in any step, press the "Operating mode" key.

5.1. Automatic initialization (not usable in case of external voltage converter)

With the automatic initialization the device will automatically recognize the parameters of the PFC-system. It also serves as plausibility check and storage of these parameters - the user only has to make very little or even no adjustments.
Start of the initialization process is done from the menu point "PROGRAMMING" by pressing the button "↑"
AUTO-INIT [YES] to be confirmed with pressing the ENTER button.

If the values of the current transformer OR the value of the first stage of the PFC-system are known, they should be entered here. This later enables a display of all values of the net in the correct electrical term. If no value is programmed (selection: unknown), values of current and output can later only be indicated as percent.
After entering of the a.m. values (selection via "↑ / ↓" buttons,confirmation with ENTER) the automatic test-run is performed.

3 test-runs will be performed during which all stages are being switched on and off. All necessary parameters are collected, evaluated and stored. Under certain circumstances 3 additional test-runs may be required for a proper initialization.
After successful finalization of AUTO-INIT the controller will switch into normal operation.

In case of recognition of any discrepancies (plausibility) or of inaccurate connection, the detected error will be displayed in plain text after finalization of AUTO-INIT and can be eliminated. (see possible error messages at the end of the manual). AUTO-INIT may be repeated then.

NOTE: If the *Prophi-6R* has been put into operation successfully by AUTO-INIT with all values unknown, some values will be shown as "????" and this can not be changed. If a new programming is required, a reset is needed before: Programming/Basic settings [YES]

5.2. Manual programming (program menu)

LANGUAGE SELECTION: This selects the language of the operating menu
(German, English, Spanish, Portuguese, French, RU, Cz, NL, PL, TR)

1 I-CONVERTER PRIM: [5...13000]A
This selects the primary current of the current converter. Adjustment is via the ↑ / ↓ keys. Save and continue with ENTER

2 I-CONVERTER SEC: [5 or 1]A
This sets the secondary current of the current converter
Selection via ↑ / ↓. Save and continue with ENTER

3 END STOPP: [6/7] switching to 7.stage in expert-mode 2
By setting the end stopp, the number of active capacitor branches is matched to the respective capacitor bank. This is done via the ↑ / ↓ keys. The visible symbols of the capacitors correspond to the connected outputs. The maximum possible number of capacitor branches is pre-set at the works (6 branches). Save and continue with ENTER

4 CONTROL SERIES: [1...20 + E]
The ratio of the capacitor branch power determines the control series, the power of the first capacitor always being assigned the value 1. The control series required for the compensation network is again selected via the ↑/↓ keys. If the required control series should exceptionally not be present (Annex 1), the user may define a special one (control series "E").More on this point in the control-series editor in Annex 1.

5 CONTROL PRINCIPLE: The control preference may be selected here:

SEQUENTIAL connection
LOOP connection
INTELLIGENT loop connection (default setting)
COMBINED CHOKE
See Section 9 for an explanation of the various control modes.
Selection with ↑ / ↓ keys. Save and continue with ENTER

6 POWER 1. STAGE: [0.01 ... 255.99] kvar
To determine the controller's response sensitivity, the dimensions of the network's smallest capacitor (stage 1) must be known. They are entered in two steps in kvar. The integral kvar values (before the comma) are initially selected via the ↑ / ↓ keys and saved with ENTER. The positions after the comma are then selected, again via the ↑ / ↓ keys. If the response sensitivity is being undercut, a warning will occur (indication of **"!"** in the display)
Save and continue with ENTER

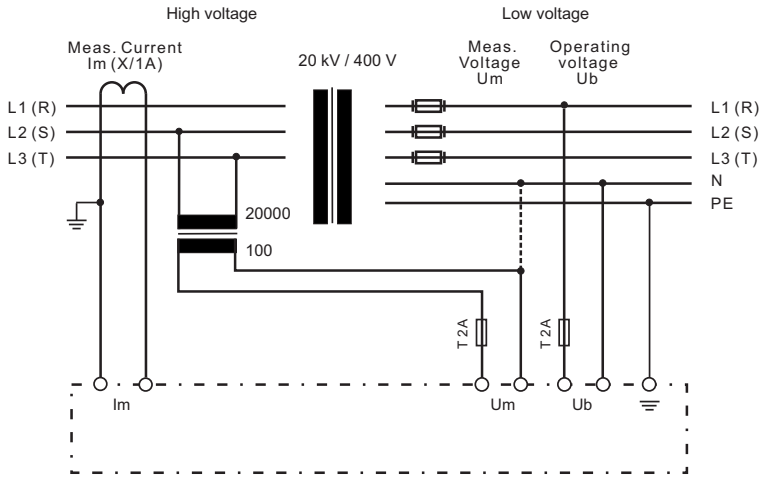
7 TARGET COS PHI: [0.1 ind ... 0.1 cap]
By setting the target cos phi, the power factor to be attained via the PF correction is defined. It is also set via the ↑ / ↓ keys.

8 MEASURING VOLTAGE [30 ... 525]V

Programming the measuring voltage of the system.
The values programmed here always refer to the voltage at the clamps !
The voltage is selected via the ↑/↓ keys. Save and continue with ENTER.

9 V - CONVERTER RATIO [NO / 230V ... 380kV]

When a measuring-voltage converter (e.g. for HV- measurement) is used, its conversion ratio should be programmed here.
(Input of prim.voltage is here, sec. voltage is automatically from item 8)
Selection via the ↑/↓ keys. Save and continue with ENTER.



10 CONNECTING TIME

This refers to the time between connecting the capacitors to increase the momentary network capacitance. It should be noted that in practical operation the real connection time is affected by the discharge time (locking time).
Setting range: 1 sec. ... 20 min. (long time for HV- networks)
Default setting: 40 sec.
Selection is performed via the ↑/↓ keys. Continue with ENTER

11 DISCONNECTING TIME

This refers to the time between disconnecting the capacitors to reduce the momentary network capacitance.
Setting range: 1 sec. ... 20 min. (long time for HV- networks)
Default setting: 40 sec.
Selection is performed via the ↑/↓ keys. Continue with ENTER

12 DISCHARGE TIME

This is the time for which an individual output is blocked between connecting and disconnecting. This blocking time has priority over connecting and disconnecting times. It depends on the capacitor discharge rating and thus is specified by the compensation network. The discharge time of a conventional network without additional fast-discharge resistors or chokes should be set to no less than 40 seconds.
Setting range: 1 sec ...20 min. Default setting: 60 sec.
Selection is performed via the ↑/↓ keys. Continue with ENTER

13 ALARM TEMP [50...85]°C

The alarm temperature programmed here is the temperature at which the capacitor stages are disconnected in steps. The controller's **alarm relay** responds after ten minutes. At the same time the display shows the cause of the alarm (over-temperature). If the temperature drops again, the required branches are automatically re-connected in steps.
The selection is performed with the ↑ /↓ keys. Save and continue with ENTER.

14 MESSAGE RELAY
this item appears if in ExpertMode2 the „alarm-relay" is set as „message-relay"

The message relay can be programmed for ***one*** of the following options as required:

"Fan": Relay switches the external cabinet fan.
(Default) The switching threshold can be programmed under point 15.
Display: **"F"**

"Supply": Message when active power is supplied. Display: **"S"**

"Undercurrent" This message appears whenever the measuring current is not reached. Display: **"U"** The signal is generated when the value drops below the response sensitivity of the controller.

"Harmonics": This message appears when the limit of the total harmonic distortion THD-V is exceeded. This value can be set under "27 Harmonics" in%

15 FAN TEMP* [15...70]°C
Input of the switching threshold for the fan.
* Only active if option 'Fan' is selected

27 HARMONICS (harmonic limit) [7]% (0.5 ... 25,5)%
A limit for the total harmonic distortion THD-V (in%) can be entered here. When this threshold is exceeded, a message is given. THD-V is the ratio of the geometric sum of the uneven harmonics to the fundamental. A warning is always shown in the display; an output via message relay only takes place when this was selected in point 14.

BASIC SETTING: [NO] (YES / NO)
When the selection is made with YES and confirmed with ENTER, all parameters are reset to the basic setting made by the PFC-system manufacturer.
(Optimal network values when the controller was supplied with a complete PFC-system). If the controller is supplied from the works, this point corresponds to the default setting. **CAUTION: All user settings are lost!**

5.3 Programming lock (active / inactive / automatic after 24 h)

The device is equipped with a programming lock to ensure protection from unauthorized or inadvertent changes to the system parameters. The lock can be activated in expert mode. If the lock is active, all parameters can be checked but not changed.

Section 6 Manual operation (initial operation, maintenance, service) Programming of fixed stages

In manual operation, capacitor branches can be connected/disconnected **in the set control series and switching time -** irrespective of prevailing power-line conditions. The starting condition is STOPP (no stages connected). Connections are made by pressing the ↑ key. Pressing ↓ initially leads back to STOPP mode. Repeated pressing of ↓ leads to the disconnection of stages. The active operating status and active power factor are always shown on the display (self-explanatory).

Manual operation

Pressing ENTER takes the user to the menu point "Programming of fixed stages".
In the normal case, all stages are programmed for automatic operation (default setting).

Setting of fixed stages

AUTO OFF FIX (Currently selected stage blinks)

In special cases, all controller outputs (C1-C6) may be permanently defined in succession (continued switching via ENTER) for the following statuses:

AUTO: Automatic (normal) operation
The relevant output is marked by a capacitor symbol.
FIXED: The output is continuously connected, e.g. for fixed PFC. The output is marked by an underlined capacitor symbol.
OFF: The output is continuously disconnected - e.g. for temporarily disconnecting a defective capacitor. The capacitor symbol for this output is faded out. Underlining appears.

The active stage is blinking. The required status is set via ↑ /↓. By pressing ENTER, the user saves this step and moves to the next stage.
The programmed statuses for the outputs also remain visible on the display in automatic operation.
After the required settings have been made, pressing the "Operating Mode" key takes the user to the next menu ("Service") or further to "Automatic Operation".

Section 7 Service menu

The service menu is reached by the operating-mode key.
The stored maximum values of the network parameters can be displayed here as well as the number of switching operations of the individual capacitors and their operating time. The desired stages [in square brackets] can be selected via the arrow keys.
In addition, a fault memory is available, in which the last fault states of the system are stored with fault code and in plain text. (This allows, for example, capturing short lived events of overtemperature or overvoltage)

Action	Display	
ENTER	1 min/max. VOLTAGE	in V
ENTER	2 max. REACTIVE POWER	in kvar
ENTER	3 max. ACTIVE POWER	in kW
ENTER	4 max. APPARENT POWER	in kVA
ENTER	5 max. TEMPERATURE	in °C / °F
ENTER	6 max. THD - V / THD - I	in %
ENTER	7 RESET the maximum and energy values	
ENTER	8 SWITCHING OPERATIONS	C [1] - ...
+/-	to C [6]	
ENTER	9 OPERATING TIME	C [1] - ... in h
+/-	to C [6]	
ENTER	ERROR MEMORY E [1] -	in plaintext
ENTER	ERROR MEMORY RESET	
ENTER	TEST RUN	
ENTER	C-POWER (only after a test-run or AUTO-INIT)	
ENTER	Back to 1	

TEST-RUN
This menu point allows the user to check the settings of the PFC controller. After activation of the test run, the controller switches each stage on and off successively and calculates the output of the capacitors connected (this procedure is done three times to eliminate possible errors). The values calculated are stored and can be retrieved in the following menu item (C-POWER). At the same time, a plausibility check is conducted with the values programmed.
Any discrepancies found are evaluated and displayed in plain text. The following errors can be displayed:

- No measuring voltage present
- Measuring voltage too high - check programming
- Measuring voltage too low - check programming
- No measuring current? - Short circuit link in current transformer?
- Phase angle current transformer? k/l or phase transposed ?
- Current transformer ratio / 1. Step power wrong ?
- Control series? - check programming
- End stop? - check programming
- Capacitor defect or wrong power input

Note: The results displayed are messages intended to help the user trace the cause of the error. Final evaluation remains the responsibility of the user. Under complicated (high load fluctuations) grid conditions, 100% error recognition cannot be guaranteed.

Section 8 Expert mode 1 and 2

The expert mode is meant for the adjustment of values which normally should not be changed. As a protection against mal-operation this level has an access code branching out in Expert mode 1 or 2.

Password: Expert mode 1: " 6343" Expert mode 2: "2244"

8.1. Expert mode 1

2 BASIC SETTING NEW [NO] (available: NO/YES)
Storage of active programming as a new basic setting (usually performed by the PFC-system manufacturer). Caution: The original values are overwritten in the process!

3 SWITCHING OPERATIONS RESET [NO] (available: NO/YES)
The stored switching operations of all capacitor stages are reset to zero. Caution: No information is then available about the switching frequency of the stages and thus the status of the network. (Reset of individual stages in Expert-mode 2)

4 OPERATING TIME RESET [NO] (available: NO/YES)
The stored operating times of all outputs are set to zero.
(Reset of individual stages in Expert-mode 2)

5 INTEGRATION TIME [1] s (1...255 sec.)
The integration time (the time required to form the average values of a measurement) can be changed for special applications here.

6 SWITCHING POWER max [100] kvar (multiples of the smallest stage)
This factor specifies the maximum power which may be switched in one switching step. It can be used to control the intelligent control system, which switches several stages as a function of the power-factor requirement.

7 SWITCH.TRIGGER [66]% (30...100%)
Threshold for switching on of next stage. It should not be changed in the normal case!

8 OPERATING LOCK [NO] (NO / YES / 24H)
24H means, that it will be locked automatically after 24 hours

9 SWITCHING OPERATIONS WARNING [50000] (1000 ... 255000)
After an output has performed this number of switching operations, a warning message is displayed. (Abrasion of capacitor contactors and capacitors)

10 FAST DISCHARGE [NO] (NO or X for the desired stages)
If only some stages of a network are equipped with fast discharge equipment, those stages can here be indicated with X. In this case, the desired discharge time for these stages can be specified in the next menu point. Otherwise, menu point 11 is omitted.

11 DISCHARGE TIME [1] s (1s ..programmed normal discharge time)
Only available when fast discharge is programmed. The specified discharge time is then also included in the normal display.

12 PHASE I [0°]
[L1] - L1 - N] Adjustment of current phase position

13 PHASE V [0°]
L1 - [L1 - N] Adjustment of voltage phase position

Phase correction between voltage and current in the measuring system. (refer p.6)

14 C-TEST [YES] (YES / NO)

The power of the particular capacitor stage is calculated during each switching operation and compared with the stage output of the capacitor. If the result varies from the nominal value, an error message is generated. This test can be stopped here.

15 C-FAULT [40] % (10...75 %)

The deviation from the rated value of the capacitor, for which a fault message is generated, can be specified here (see point 14)

16 TEST ATTEMPTS [5] (1...9)

When at least this number of successive measurements has resulted in a fault in the capacitor power, a C-fault message is output.

17 OUTPUT 1. STEP [0...255] (0...2550)

The range for entering the stage output can be increased to [0...2550] here, (e.g. for medium voltage measurement)

18 CONTROL [3] PHASE (3 / 1)

The measuring system of the controller is generally based on single-phase measurement. For all standard settings (three-phase), the measurement is converted and all outputs displayed as three-phase values (symmetry in grid assumed). In the single-phase setting, display and control apply only to the single-phase value measured (application: single-phase correction in asymmetrical grids)

19 DISPLAY cos φ / tan φ

Switched over between cosinus or tangens φ in the display

8.2. Expert mode 2 (Password: 2244)

The additional 2nd expert mode includes all messages for operation, warning and error which are displayed by the controller. Here they may be deactivated separately. When deactivated, the indication of the message in the display as well as possible activation of the relay or effects on the control behavior are suppressed (detailed list of all messages s. menu plan last page).
Also, the alarm relay may be programmed here as 7.stage or as message relay.
Switching operations/operation time of the capacitors can be set back separately.

EXPERT MODE 2 ENTER

2 ALARM RELAY (ERROR) (Error / 7. stage / Message relay)
Selection whether the alarm relay should be used for error message or as additional 7th stage or as message relay for the standard controller.

Activation of particular operation, warning and error messages (s. above)

Example

3 ALARM DELAY TIME [10] min. (1...255min.)
Time after which the alarm relay will respond

4 UNDERVOLTAGE [50] % (20 ...100 %)
meas. voltage below this threshold will switch OFF all stages at the same time

5 OVERVOLTAGE [115] % (105 ...140 %)
meas. voltage above this threshold will switch OFF the stages step by step

If measure voltage returns to the permissible range, stages will stepwise switch ON again.

6 FREQUENCY [40...80 Hz] (50Hz / 60Hz)
Measurement by the controller is done automatically in grids of 40 ... 80 Hz.
In grids with extremely poor voltage quality it is recommend to select a fix frequency (50 or 60 Hz) to avoid measuring errors due to voltage sags.

7 SWITCH. OPERATIONS **C 1** RESET [NO] (YES/NO)
to
C 6 RESET [NO] (YES/NO)
Reset of switching operations of particular capacitors possible,
e.g. after replacement of particular capacitors or contactors

8 OPERATION TIME **C 1** RESET [NO] (YES/NO)
to
C 6 RESET [NO] (YES/NO)
Reset of operation time of particular capacitors possible,
e.g. after replacement of particular capacitors

Section 9 Control principle

The control response of the *Prophi-6R* can be selected in programming mode. In principle, the controller has four different control modes:

1. Sequential connection
In sequential connection, the required capacitor stages are successively connected and disconnected in stages (last in - first out). The ranking of each step always corresponds to the power of the smallest stage.
Advantage: Exact definition of the next capacitor to be connected in each case
Disadvantage: Long settling time, high switching frequency of the small stages

In order to shorten the settling time, the BR6000 switches several stages simultaneously for a large power-factor requirement. This applies to all control types. The maximum dimensions of the simultaneously switching branches can be changed in expert mode. If the value of the smallest stage is pre-selected, the conventional sequential connection is obtained.

2. Loop connection
In this variant, the controller operates in loop mode (first in - first out) which minimizes the wear on the capacitor bank, i.e. where stages are of equivalent dimensions, the stage which was disconnected for the longest period of time is always connected next.
Advantage: Balanced utilization of equivalent stages and thus an increased operating life of the capacitor bank.
Disadvantage: This mode can only be used in control series with groups of the same stage power and long settling time, as every switching step corresponds to the value of the smallest stage.

3. Intelligent loop connection (default setting)
The intelligent control principle combines the advantages of the network-sparing loop connection (first in - first out) with a much faster settling time, even for large load skips, and reaches this goal with the fewest possible switching operations of the capacitor stages. The optimized time response is achieved by the simultaneous switching of several or larger capacitor groups as a function of the missing power factor in the power line. Both the number of real switching frequencies of the capacitors as well as the turn-on times of the branches are considered.
Advantage: Reaches the target cos phi in a fast-optimized settling time with a low switching frequency of the capacitors.

4. Combined de-tuning (special case for combined de-tuned banks)
Within a combined de-tuned application, 2 adjoining equal steps are switched with just one joint choke. This pairwise de-tuning requires an appropriate closed control series (i.e. 1:1:1:1..., 1:1:2:2..., 1:1:2:2:4:4... or similar)
The condition for the switching behavior is defined in such a way that the number of activated odd steps is always greater than or equal to the number of activated even steps. The controller complies with the requirements of the control regime while largely conforming to the intelligent switching behavior.

Section 10 Interface (not applicable)

Section 11 Initial operation

The controller must have been installed before being set up and operated.
All network-specific parameters are fully programmed as described in section 5 (Programming) by being entered in sequence and stored. The controller is then set to automatic operation with the operating mode key. It is now ready for operation.

Section 12 Maintenance and warranty

The controller should need no maintenance if the operating conditions are observed. However, it is recommended that a functional check of the controller be performed in conjunction with the regular checking of the capacitor bank. In the event of any interventions in the controller during the warranty period, all warranty claims lapse.

Section 13 Troubleshooting

Fault	Check / Solution
At target cos phi=1 and inductive load, switch-off or connection of capacitor in the corrected line Supply / Drawing mismatched	Check terminals of the measuring voltage and current (l and k)! Check phase position
Wrong line cos phi is displayed	See above
Display:"UNDER CURRENT"	Current in measuring range? Line interruption? Wrong current-converter factor? Current transformer short-circuited?
Display: "OVERCURRENT" Alarm relay: after 10 min.	Check current-converter ratio Go through measuring current range
Display: "UNDERCOMPENSATED" Alarm relay: after 10 min.	Check connection and phase position! All stages connected - target cos phi not reached: compensation network sufficiently dimensioned?
Display: "OVERCOMPENSATED" Alarm relay: after 10 min.	Check connection and phase position! Capacitive grid, although all stages disconnected
Display: "MEASUREMENT VOLTAGE ???" Alarm relay: after 10 min.	No measurement voltage!
Display: "OVERTEMPERATURE" Alarm relay: after 10 min.	Cabinet temperature too high: Outputs are switched off in stages irrespective of power-line conditions
Stages are disconnected for an inductive line or connected for a capacitive line	If a target cos phi is set which deviates from 1 despite an inductive line load, the display < (disconnect stages) may light up. The arrows indicate the control direction and not the line conditions.
The controller does not connect all stages, or cos phi does not change at the last stages	Check END STOPP !
In automatic operation, individual stages are not connected or disconnected	Check whether individual stages are programmed as fixed stages or OFF in the "Manual operation / Fixed stages" menu!
In strongly asymmetrically loaded lines, differences may occur between control response and power-factor measurement, as the power factor is measured in single phase.	Line measurements allow the most favorable phase for measuring the power factor to be determined. The current converter is set accordingly for the measuring current.
No operating voltage	Note: No display, alarm relay is activated (open)

Section 14 Technical data

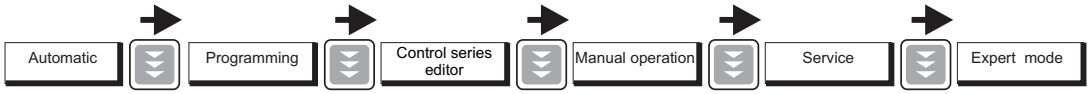
Type series	Prophi-6R
Outputs	6 (7)
Languages	D / E / ES / RU / NL / CZ / PL / F / PT / TR
Switching power of relay outputs	250 VAC, 1000 W
Number of active outputs	Programmable
Operation and display	Illuminated graphic display 2 x 16 characters with convenient operating level
Number of control series	20
User-defined control series	1
Control principle	Sequential connection, loop connection or self-optimized switching response Four-quadrant operation
Auto-Init	YES
Operating voltage	110...230 VAC +/-15%, 50 / 60Hz
Measuring voltage	30...525 VAC, 50 / 60Hz
Measuring current	X : 5 / 1A selectable
Power drawn	< 5 VA
Sensitivity	20 mA / 10 mA
Target cos phi	0.1 inductive to 0.1 capacitive adjustable
Connecting time	Selectable from 1 sec ... 20 min.
Disconnecting time	Selectable from 1 sec ... 20 min.
Discharge time	Selectable from 1 sec ... 20 min.
Fixed stages/ skipped stages	Programmable
Alarm relay	Standard
No-voltage triggering	Standard
Display of power-line parameters	Power factor, voltage, apparent current, frequency, reactive-, active-, apparent power, missing kvar, temperature, harmonics
Storage of maximum values	Voltage, reactive power, active power, apparent power, temperature, THD-V, THD-I
Storage of switching number	Yes, each output, individual reset possible
Storage of operating time	Yes, each capacitor, individual reset possible
Temperature measurement range	-30°C ... 100°C
Error memory	Last 40 error states are stored
Accuracy	Current, voltage: 1% Reactive-, active-, apparent power: 2%
Housing	Switchboard-integrated housing DIN 43 700, 144 x 144 x 53 mm
Weight	1 kg
Operating ambient temperature	-20 to +60°C
Protection type to IEC 60529	Front: IP 54, Rear: IP 20
Safety guidelines	IEC 61010-1
Sensitivity to interference (industrial areas)	IEC 61000-6-2; EN 61326 IEC 61000-4-2: 8kV IEC 61000-4-4: 4kV

Annex 1: Table of control series

No.	Control series	Loop connection
1	1 : 1 : 1 : 1 : 1 : 1 : 1	Possible
2	1 : 2 : 2 : 2 : 2 : 2 : 2	Possible
3	1 : 2 : 3 : 3 : 3 : 3 : 3	Possible
4	1 : 2 : 3 : 4 : 4 : 4 : 4	Possible
5	1 : 2 : 4 : 4 : 4 : 4 : 4	Possible
6	1 : 2 : 3 : 6 : 6 : 6 : 6	Possible
7	1 : 2 : 4 : 8 : 8 : 8 : 8	Possible
8	1 : 1 : 1 : 1 : 2 : 2 : 2	Possible
9	1 : 1 : 1 : 1 : 1 : 6 : 6	Possible
10	1 : 1 : 2 : 2 : 2 : 2 : 2	Possible
11	1 : 1 : 2 : 2 : 2 : 4 : 4	Possible
12	1 : 1 : 2 : 2 : 4 : 4 : 4	Possible
13	1 : 1 : 1 : 2 : 2 : 2 : 2	Possible
14	1 : 1 : 2 : 3 : 3 : 3 : 3	Possible
15	1 : 1 : 2 : 4 : 4 : 4 : 4	Possible
16	1 : 1 : 2 : 4 : 8 : 8 : 8	Possible
17	1 : 2 : 2 : 3 : 3 : 3 : 3	Possible
18	1 : 2 : 3 : 4 : 4 : 8 : 8	Possible
19	1 : 2 : 2 : 4 : 4 : 4 : 4	Possible
20	1 : 2 : 2 : 2 : 4 : 4 : 4	Possible
"E"	Control-series editor	Possible

Control -series editor (programming up to a rating of 30)

The control-series editor allows the user to simply define his/her own control series if the required control series is not available for any reason.
The last control series - Control Series E - is selected by pressing the "Programming" key (point 4: Control series) and confirmed with ENTER. This leads to the insertion of an additional menu point in the main menu -> the control-series editor. It may be reached via the "Operating Mode" key.



In the control-series editor, all stages can be set in succession to the desired value with the selection keys ↑ / ↓. The next stage in each case is reached by pressing ENTER.
In the control series editor, the various steps may be programmed up to a rating of 30 (!).
The rating >9 is indicated in the display as follows:
10=A, 11=B, 12=C, 13=D, 14=E, 15=F, 16=G .... 30=U

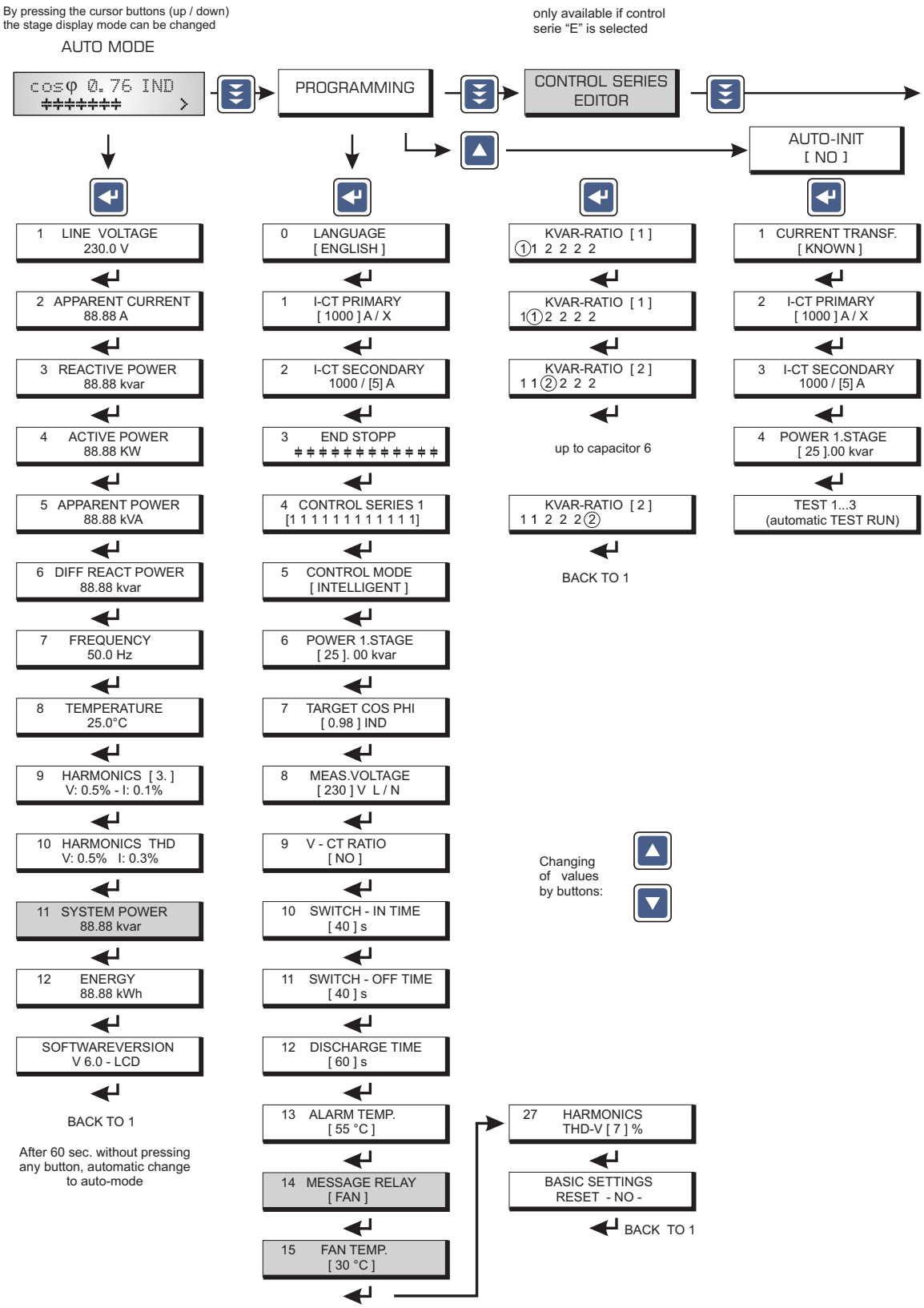
ALL control series can be generated (even downwards). The customer will decide whether the generated control series is of sense.

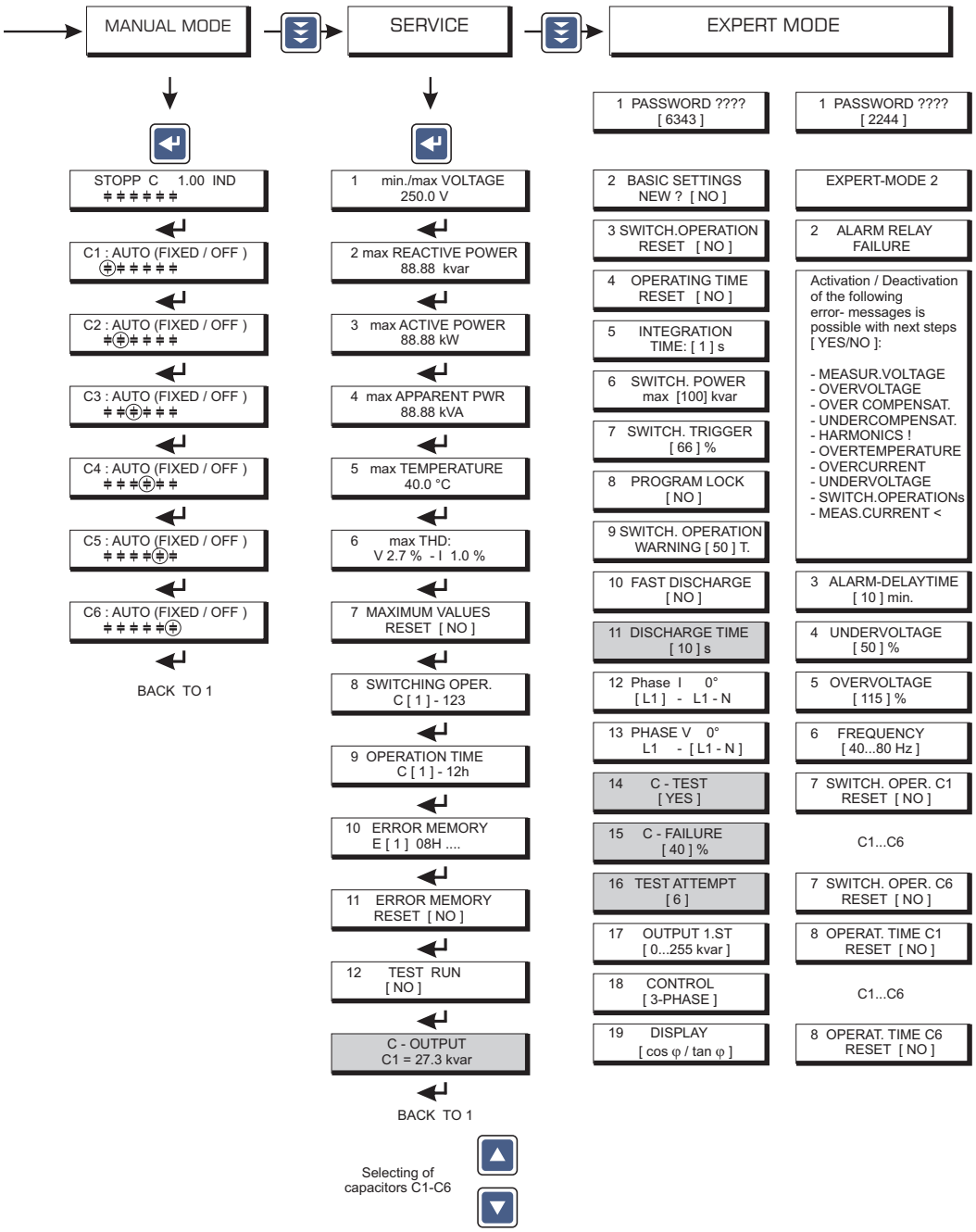
The maximum number of stages can be limited by a programmed END STOPP < 6.

Annex 2: Default settings

Note: The following values for the default settings apply only if the controller is supplied directly from the manufacturer. Otherwise, these values may have been replaced by settings made by the manufacturer of the compensation network (optimal values for the relevant network).

No.	Parameter (* as option)	Default setting	Programmed values of this system (to be entered by manufacturer or operator)	
0	LANGUAGE	ENGLISH		
1	I CONVERTER prim.	1000 A		
2	I CONVERTER sec.	5 A		
3	END STOPP	6		
4	CONTROL SERIES	1		
5	CONTROL PRINCIPLE	INTELLIGENT		
6	POWER 1. STAGE	25.00 kvar		
7	TARGET COS-PHI	0.98 IND		
8	MEASURING VOLTAGE	230 V L-N		
9	V- CONVERTER RATIO	- NO -		
10	SWITCH- IN TIME	40 sec.		
11	SWITCH- OFF TIME	40 sec.		
12	DISCHARGE TIME	60 sec.		
13	ALARM TEMP.	55 °C		
14	MESSAGE RELAY *	FAN		
15	TEMP. FAN ON	30 °C		
27	HARMONICS THD-V	7,0 %		
	Capacitor stages	AUTO		
	Password Expert mode 1	6343	Cannot be changed	
	Password Expert mode 2	2244	Cannot be changed	
	Integration time	1 sec.		
	Trigger value	66%		
	Max.simult.switch.power	4 x smallest stage		
	Operating lock	- NO -		
	Switch.operations warning	50,000		
	Fast discharge	- NO -		
	Phase shift U/I	0 °		
	C - Test	- YES -		
	C - Fail	40 %		
	Test Attempts	5		
	Power 1. stage	0...255 kvar		
	Control	3 - phase		


By pressing the cursor buttons (up / down)
the stage display mode can be changed
AUTO MODE
cosφ 0.76 IND
PROGRAMMING
CONTROL SERIES EDITOR
only available if control serie "E" is selected
AUTO-INIT [NO]
1 LINE VOLTAGE 230.0 V
2 APPARENT CURRENT 88.88 A
3 REACTIVE POWER 88.88 kvar
4 ACTIVE POWER 88.88 KW
5 APPARENT POWER 88.88 kVA
6 DIFF REACT POWER 88.88 kvar
7 FREQUENCY 50.0 Hz
8 TEMPERATURE 25.0°C
9 HARMONICS [3.] V: 0.5% - I: 0.1%
10 HARMONICS THD V: 0.5% I: 0.3%
11 SYSTEM POWER 88.88 kvar
12 ENERGY 88.88 kWh
SOFTWAREVERSION V 6.0 - LCD
BACK TO 1
After 60 sec. without pressing any button, automatic change to auto-mode
0 LANGUAGE [ENGLISH]
1 I-CT PRIMARY [1000] A / X
2 I-CT SECONDARY 1000 / [5] A
3 END STOPP
4 CONTROL SERIES 1 [1 1 1 1 1 1 1 1 1 1 1 1 1]
5 CONTROL MODE [INTELLIGENT]
6 POWER 1.STAGE [25]. 00 kvar
7 TARGET COS PHI [0.98] IND
8 MEAS.VOLTAGE [230] V L / N
9 V - CT RATIO [NO]
10 SWITCH - IN TIME [40] s
11 SWITCH - OFF TIME [40] s
12 DISCHARGE TIME [60] s
13 ALARM TEMP. [55 °C]
14 MESSAGE RELAY [FAN]
15 FAN TEMP. [30 °C]
KVAR-RATIO [1] ①1 2 2 2 2
KVAR-RATIO [1] 1①2 2 2 2
KVAR-RATIO [2] 1 1②2 2 2
up to capacitor 6
KVAR-RATIO [2] 1 1 2 2 2②
BACK TO 1
Changing of values by buttons:
27 HARMONICS THD-V [7] %
BASIC SETTINGS RESET - NO -
BACK TO 1
1 CURRENT TRANSF. [KNOWN]
2 I-CT PRIMARY [1000] A / X
3 I-CT SECONDARY 1000 / [5] A
4 POWER 1.STAGE [25].00 kvar
TEST 1...3 (automatic TEST RUN)



Operating diagram (Brief programming)
Power Factor Controller Prophi-6R

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