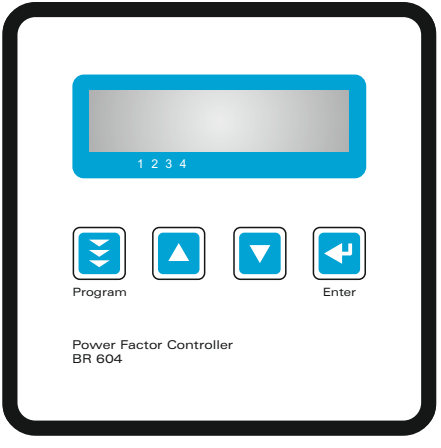
Power Factor Controller BR 604



Manual

Version 3.0 E

CAUTIONS:

1. High voltage !

2. BR604 may only be used indoor !

3. Make sure that discharge time set in controller matches capacitor discharge time !

Version 3.0 E; 2021

CONTENTS

Section1 General

BR 604 is distinguished by user-friendly operation based on menu-guided displays in plain text. Its new features permit an intuitive mode of operation. Easy-to-understand symbols and texts in the local language combine simplest operability with self-evident displays.

The display of diverse line parameters as well as storage of various values of the compensation network permit simple fault analysis and system monitoring.

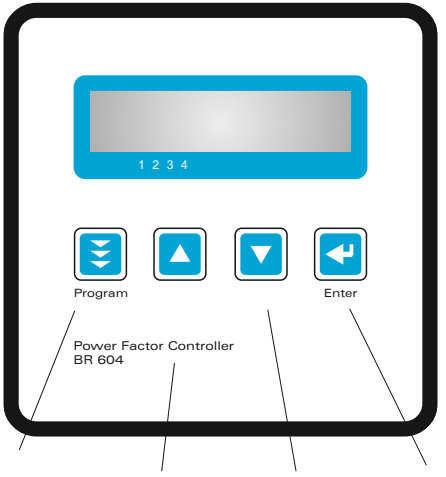
BR 604 contains a number of additional features:

- ☑ 4 switching outputs (depending on the version)
- ☑ 23 pre-programmed control series with a self-optimized intelligent control response
- ☑ Complete menu-guided operation and display
- ☑ Graphic display with 2 x 16 characters
- ☑ Four-quadrant operation
- ☑ Display of various line parameters (V, I, Q, P, S...)
- ☑ Storage of maximum line-parameter
- ☑ Manual / automatic operation
- ☑ Programming of fixed stages and the option of skipping individual outputs
- ☑ No-voltage turn-off
- ☑ Fault messages
- ☑ Switchboard-integrated housing 100x100x40 mm

The controller is supplied for a voltage of 230 VAC (L-N), 50/60 Hz and a measuring current of 5A or 1A (programmable). A voltage converter is required for different operating voltages. Operating voltage = measuring voltage !

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

Fig. 1 BR 604 front view



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

Increase selected parameter

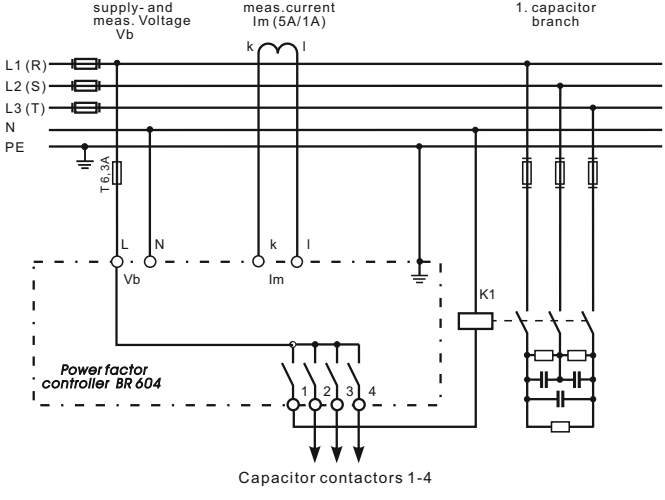
Reduce selected parameter

Enter / ok confirm and store values

Section 2 Installation and connection of the controller

The BR 604 is designed to be incorporated into the front panel of a PFC-cabinet. It requires a switchboard section of 92 x 92 mm to DIN 43 700. The controller is inserted from the front and is attached by means of the appended clamps.
Before the BR 604 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 1.5mm^2. The connection should be set up as shown in Fig. 2. The specified safety regulations must be observed.

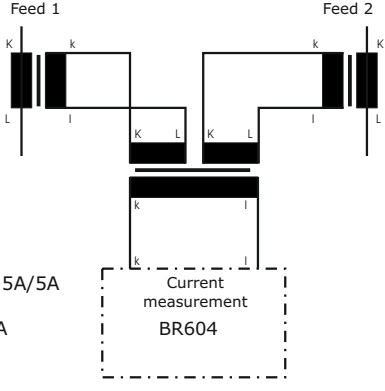
Fig. 2: BR 604 Connection plan



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 BR 604 is connected up via sum-current converters, the overall conversion ratio is entered.

Measurement via sum current converter



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

C.converter ratio is: 2000/5A

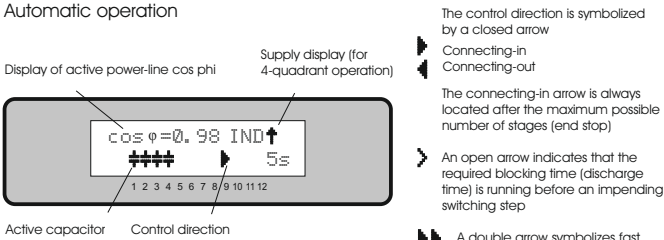
2.2 Fault messages

The fault is shown on the display in plain text (alternating with the standard display in automatic operation). The following fault messages are displayed:

- ☑ UNDER-COMPENSATED
- ☑ OVER-COMPENSATED
- ☑ OVERCURRENT
- ☑ OVERVOLTAGE
- ☑ UNDERVOLTAGE
- ☑ MEASURING CURRENT <

Section 3 Operating modes and programming

When the operating voltage is switched on, the BR 604 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).



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**.**

3.1 Automatic operation - display functions

The BR 604 is set to automatic operation as standard. 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	Software version	
ENTER	Return to: 1 LINE VOLTAGE	

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!

3.2 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.
To quit programming mode in any step, press the "Operating mode" key.

0 LANGUAGE SELECTION: This selects the language of the operating menu (English, German, Spanish, Portuguese))

1 I-CONVERTER PRIM: This selects the primary current of the current converter. Adjustment is via the ↑ / ↓ keys. (5...7500A) Save and continue with ENTER

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

3 END STOPP: 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 setting is confirmed and saved with ENTER.

4 CONTROL SERIES: The ratio of the capacitor branch powers 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. The selected series is entered with the ENTER key, which also takes the user to the next step.

5 CONTROL PRINCIPLE: Control preference may be selected here:

- ☑ **SEQUENTIAL connection**
- ☑ **LOOP connection**
- ☑ **INTELLIGENT loop connection** (default)

See Section 8 for an explanation of the various control modes.
Selection with ↑ / ↓ keys and confirmation with ENTER leads to the next point:

6 POWER 1. STAGE: 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. Saving with ENTER..

7 TARGET COS PHI: 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. The range may be selected from 0.3 inductive to 0.3 capacitive. Confirming and saving the value with ENTER leads to the next point.

8 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 ...255 sec.
Default setting: 40 sec.
Selection is performed via the ↑ /↓ keys. Continue with ENTER

9 DISCONNECTING TIME: This refers to the time between disconnecting the capacitors to reduce the momentary network capacitance.
Setting range: 1 ...255 sec.
Default setting: 40 sec.
Selection is performed via the ↑ /↓ keys. Continue with ENTER

10 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.
For setting of a second discharge time see 'Expert Mode' point 10
Setting range: 1 ...255 sec .
Default setting: 60 sec.
Selection is performed via the ↑ /↓ keys. Continue with ENTER

CONTRAST

The display contrast can be changed with this menu point. The contrast depends to a certain degree on the viewpoint of the observer, i.e. on the insertion height of the equipment in the switching cabinet. The ↑ /↓ keys can be used to set an optimal contrast. The contrast changes after a slight delay.

BASIC SETTING: Selection 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!

Programming is now completed. The controller has returned to point 1 of the programming menu.

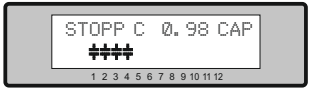
3.3 Programming lock

The BR 604 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 4 Manual operation, 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

Currently selected stage blinks

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

AUTO: Automatic (normal) operation. Output 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. The capacitor symbol for this output is faded out. Underlining appears.

The active stage is marked by blinking. The required status is set via ↑ /↓. Save by pressing ENTER, and move 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 5 Service menu

The service menu is reached by the operating-mode key.
The stored maximum values of the network parameters can be displayed here.

Action	Display	
ENTER	1 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. Value RESET	
ENTER	Back to 1	

Section 6 Expert mode

Expert mode is used to set values which remain unchanged for normal operation. This level has an access code to protect it from improper operation.

1 PASSWORD 6343

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

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

Phase correction between voltage and current in the measuring system. (see table 1 at page 18)
This setting allows to measure also in systems without neutral. However, the measuring voltage may not exceed 300 V (if necessary, a voltage converter must be used).

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

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

7 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.

8 PROGRAM LOCK [NO] (NO / YES)

9 CONTROL [3] PHASE (3/1)

Section 7 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 3.2 (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 8 Control principle

The control response of the BR 604 can be selected in programming mode. In principle, the controller has 3 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

In order to shorten the settling time, the BR 604 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.

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.

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.

Section 9 Troubleshooting Check / Solution

At target cos phi=1 and inductive load, switch-off or connection of capacitor in the corrected line Supply / Drawing mismatched Wrong line cos phi is Displayed	Check terminals of the measuring voltage and current (I and k)! Check phase position
Display:"UNDER CURRENT"	Current in measuring range? Line interruption? Wrong current-converter factor? Current transformer short-circuited?
Display: "OVERCURRENT"	Check current-converter ratio Go through measuring current range
Display: "UNDERCOMPENSATED"	Check connection and phase position! Compensation network sufficiently dimensioned?
Display: "OVERCOMPENSATED"	Check connection and phase position! Capacitive grid, although all stages disconnected
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	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.

Section 10 Maintenance and warranty

The BR 604 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.

Annex 1:

Phase correction between voltage and current in the measuring system. (compare with expert-mode: programming of phase shifting)

meas.current	meas.voltage		phase angle
L1	L1 - N	---	0°
L1 (k<->l)	L3 - N	---	300°
L1	L2 - N	---	240°
L1 (k<->l)	L1 - N	---	180°
L1	L3 - N	---	120°
L1 (k<->l)	L2 - N	---	60°

Section 11 Technical data

Outputs	4
Switching power of relay	250 VAC, 1000 W
Number of outputs	Programmable
Operation and display	Graphic display 2 x 16 characters with convenient operating level
No of control series	23
Control principle	Sequential connection, loop connection,self-optimized switching response, Four-quadrant operation
Supply and Measuring voltage	230 VAC, 50 / 60Hz (L-N) Phase - shift possible
Measuring current	X : 5 / 1A selectable
Power drawn	< 5 VA
Sensitivity	40 mA / 10 mA
Target cos phi	0.3 inductive to 0.3 capacitive
Connecting time	Selectable from 1 ...255 sec.
Disconnecting time	Selectable from 1 ...255 sec.
Discharge time	Selectable from 1 ...255 sec.
Fixed stages/ skipped stages	Programmable
No-voltage trigger	Standard
Display of power-line parameters	Power factor, V, I, Q, P, S ...
Storage of maximum values	Voltage, reactive power, active power, apparent power
Accuracy	Current / voltage: 1% Power: 2%
Housing	Switchboard-integrated housing DIN 43 700, 100 x 100 x 40 mm
Weight	0.5 kg
Operating temperature	-10 to +60°C
Protection type to DIN 40 050	Front: IP 54, Rear: IP 20
Safety guidelines	IEC 61010-1:2001
Sensitivity to interference	EN 50082-1 IEC 61000-4-2: 8kV IEC 61000-4-4: 4kV

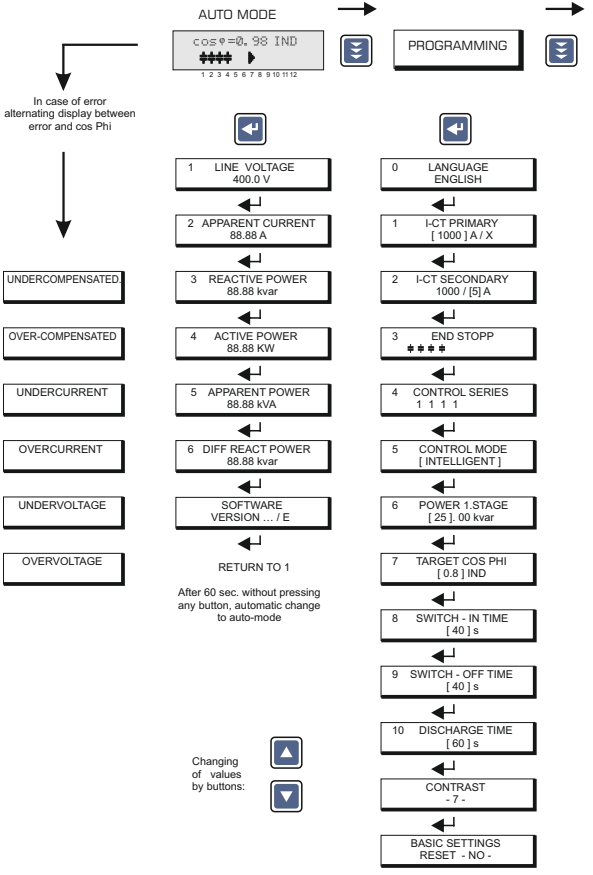
Annex 2: Table of control series

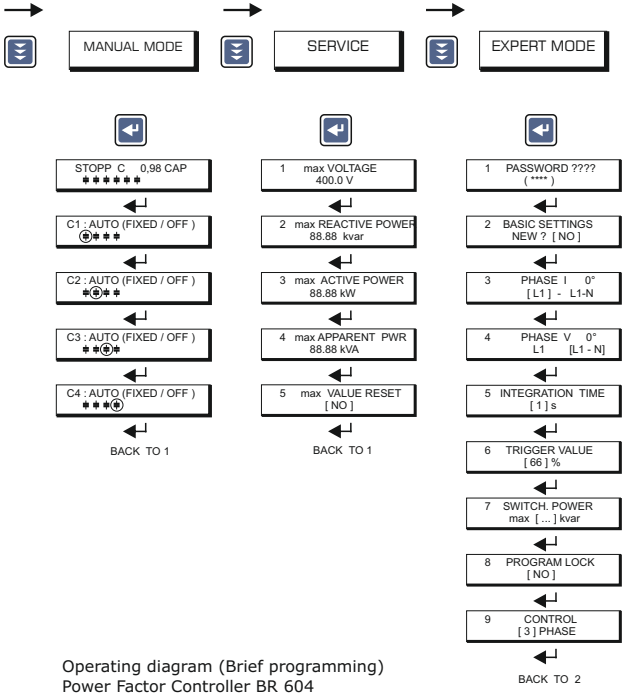
No.	Control series	Loop connection
1	1 : 1 : 1 : 1	Possible
2	1 : 2 : 2 : 2	Possible
3	1 : 2 : 2 : 3	Possible
4	1 : 2 : 2 : 4	Possible
5	1 : 2 : 2 : 5	Possible
6	1 : 2 : 2 : 6	Possible
7	1 : 2 : 3 : 3	Possible
8	1 : 2 : 3 : 4	Possible
9	1 : 2 : 3 : 5	Possible
10	1 : 2 : 3 : 6	Possible
11	1 : 2 : 3 : 7	Possible
12	1 : 2 : 4 : 4	Possible
13	1 : 2 : 4 : 5	Possible
14	1 : 2 : 4 : 6	Possible
15	1 : 2 : 4 : 7	Possible
16	1 : 2 : 4 : 8	Possible
17	1 : 1 : 2 : 2	Possible
18	1 : 1 : 2 : 3	Possible
19	1 : 1 : 2 : 4	Possible
20	1 : 1 : 2 : 5	Possible
21	1 : 1 : 1 : 2	Possible
22	1 : 1 : 1 : 3	Possible
23	1 : 1 : 1 : 4	Possible

Annex 3: Default settings

No.	Parameter	Default setting
0	LANGUAGE	ENGLISH
1	I CONVERTER prim.	1000 A
2	I CONVERTER sec.	5 A
3	END STOPP	4
4	CONTROL SERIES	1
5	CONTROL PRINCIPLE	INTELLIGENT
6	POWER 1. STAGE	25.00 kvar
7	TARGET COS-PHI	0.98 IND
8	SWITCH- IN TIME	40 sec.
9	SWITCH- OFF TIME	40 sec.
10	DISCHARGE TIME	60 sec.
	CONTRAST	- 7 -
	Capacitor stages	AUTO
	PASSWORD	6343
	INTEGRATION TIME	1 sec.
	TRIGGER VALUE	0.66
	Max. simultaneous switching power	4 x smallest stage power
	Operating lock	- NO -
	Phase shift U/I	0 °

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


AUTO MODE
cosφ=0.98 IND
1 2 3 4 5 6 7 8 9 10 11 12
PROGRAMMING
In case of error alternating display between error and cos Phi
UNDERCOMPENSATED
OVER-COMPENSATED
UNDERCURRENT
OVERCURRENT
UNDERVOLTAGE
OVERVOLTAGE
1 LINE VOLTAGE 400.0 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
SOFTWARE VERSION ... / E
RETURN TO 1
After 60 sec. without pressing any button, automatic change to auto-mode
Changing of values by buttons:
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
5 CONTROL MODE [INTELLIGENT]
6 POWER 1.STAGE [25]. 00 kvar
7 TARGET COS PHI [0.8] IND
8 SWITCH - IN TIME [40] s
9 SWITCH - OFF TIME [40] s
10 DISCHARGE TIME [60] s
CONTRAST - 7 -
BASIC SETTINGS RESET - NO -
BACK TO 1



Operating diagram (Brief programming)
Power Factor Controller BR 604