

# Power Factor Controller BR6000-T6R6

*for combined dynamic and standard compensation*



Manual  
Version 6.0 E



CAUTIONS:

1. High voltage !
2. BR6000 may only be used indoor !
3. Make sure that discharge time set in controller matches capacitor discharge time !

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## Section1 General

The mixed dynamic power factor controller BR6000-T6R6 represents the consequent follow-up development in the BR6000-series bringing innovative ideas und a multitude of new functions-now in version 6.0.

It is designed for a measuring voltage of 30...525V (L-N) or (L-L) and a supply voltage of 110...230VAC.

This type is especially designed for triggering of up to 6 thyristor modules and at the same time up to 6 standard capacitor contactors in combined standard-dynamic PFC-systems.

The switching time of < 20 ms for the dynamic steps delivers extremely fast compensation adjustment for fast changing loads.

Several parameters that can be edited allow an optimized adjustment to different thyristor modules.

The controller 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 10 local languages combine simplest operability with self-evident displays.

Main features:

- 6 transistor- and 6 relais- switching outputs
- 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
- Display of various line parameters (V, I, F, Q, P, S...)
- Display and monitoring of temperature
- Monitoring of capacitor power values with accessory MMI6000
- Storage of maximum line-parameter
- 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
- Error memory
- 2nd target power-factor possible
- Switchboard-integrated housing 144x144x55 mm

### Type series and accessories

BR6000-T6R6	6 transistor outputs, 6 relay outputs, 1 alarm relay
BR6000-T6R6/S	- 6 transistor outputs, 6 relay outputs, 1 alarm relay - 1 additional user programmable message relay, - input for second target power factor - with an additional interface RS485
Accessories	- MMI6000 - MultiMeasuringInterface (for measurement of inherent current of capacitor bank ) - Interface converter "USB - RS485" for connecting PCs - Interface converter "RS485-RS232" (using with older Pcs)

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



Caution!

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

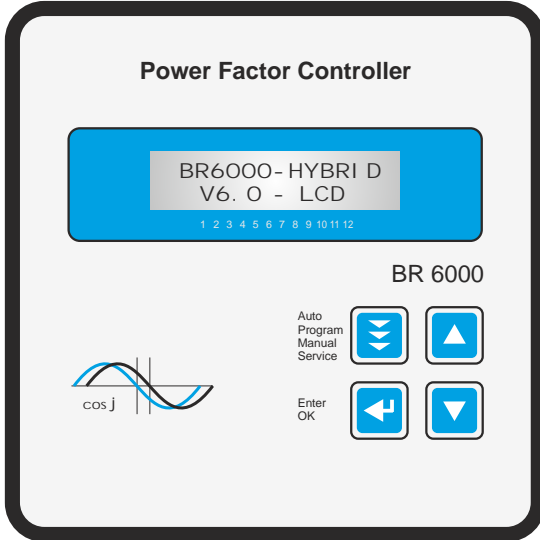


Fig.1 BR6000 front view

Operating mode

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



Enter / OK  
Confirm and store values



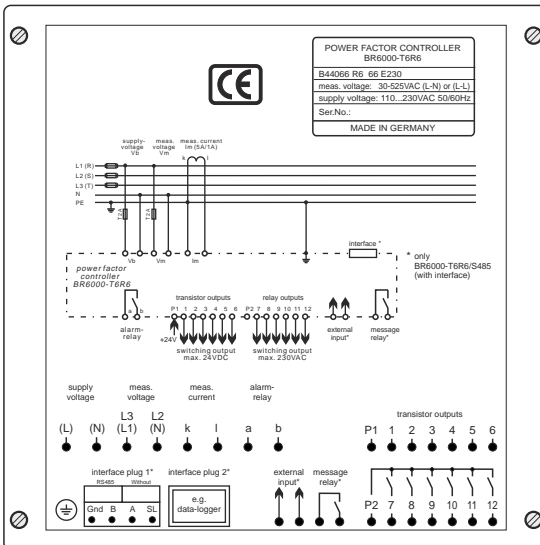
Increase selected parameter



Reduce selected parameter



Fig. 2 BR6000 rear view



## Section 2 Installation and connection of the controller

The BR6000 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. The controller may be inserted only by qualified technicians and must be operated in accordance with the specified safety regulations.

Before the BR6000 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<sup>2</sup>. The connection should be set up as shown in Fig. 3. The specified safety regulations must be observed.

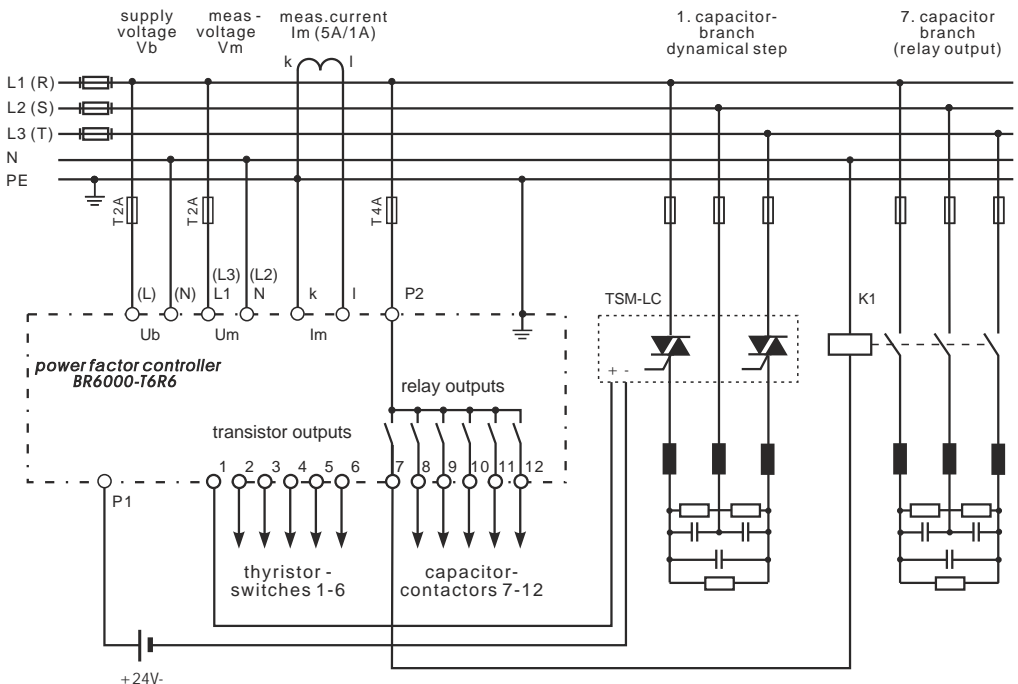
The measuring voltage may lie in the range from 30 - 525 V and is connected between L1-N (default) or L-L. (programming of phase correction needed)

The operating voltage is 110...230 V +/-15%.



The coil voltage for the capacitor contactors and the measuring voltage is monitored. (Protection against direct reconnection of the capacitor contactors in the event of momentary single-phase power failure)

Fig. 3: BR6000 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 BR6000 is connected up via sum-current converters, the overall conversion ratio is entered.



**Caution !**  
Current converter clamps should be grounded on one side !

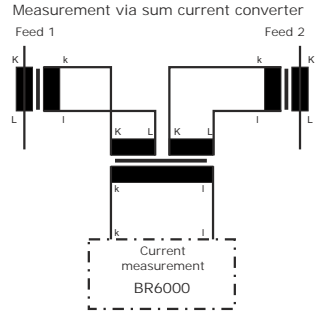
Example:

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)

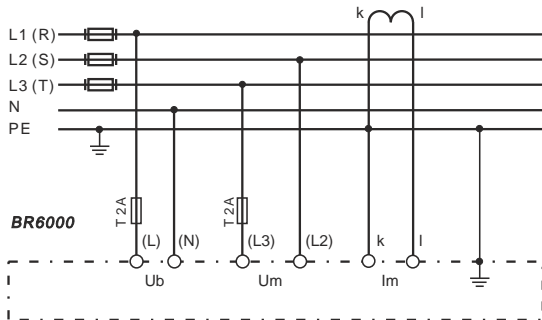
Adjustment of phase-correction between voltage and current in the meas. system is done in expert mode 1 (page 13)

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°
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:

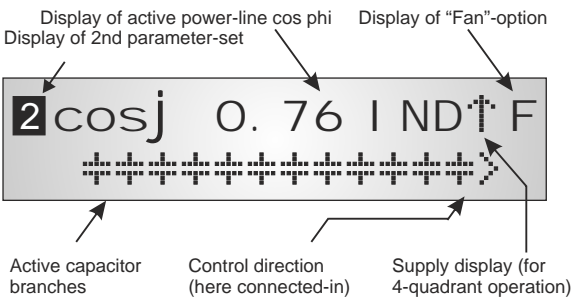
UNDER-COMPENSATED	Display and relay output
OVER-COMPENSATED	Display and relay output
OVERCURRENT	Display and relay output
MEASURING VOLTAGE ?	Display and relay output
OVERTEMPERATURE	Display and relay output
OVERVOLTAGE	Display and relay output
UNDERVOLTAGE	Display and relay output
HARMONICS	Display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

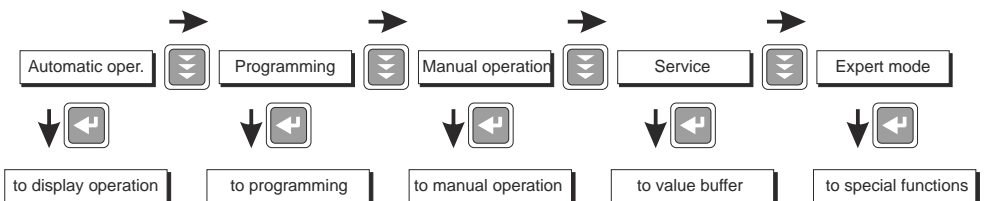
When the operating voltage is switched on, the BR6000 briefly displays its designation and software version, then changes to its normal operating status (automatic operation). The active cos-phi value is always displayed in the upper line and the currently connected

#### Automatic operation



- 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
- ◼ Transfer-mode dynamic -> static section

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





Section 4 Automatic operation - display of network parameter

The BR6000 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:

1 LINE VOLTAGE  
230.1 V

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.) V/%, I/%
ENTER	10 THD-V; THD-I in %
ENTER	Software version
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!

Switching outputs

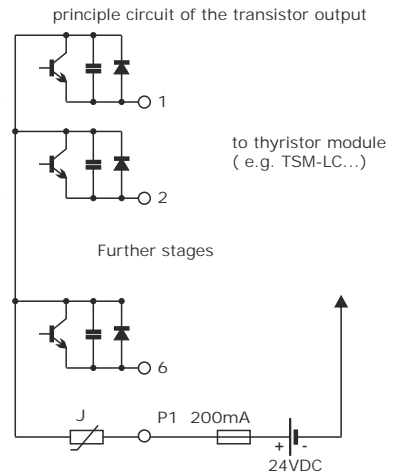
Switching outputs:

The first 6 switching outputs of the BR6000-T6R6 are executed as transistor outputs.

These are used via an additional auxiliary voltage (10...24 VDC) for direct triggering of thyristor modules for dynamic power factor correction.

Max. current for a single output: 40 mA  
Total current of all outputs: max 150 mA

Outputs 7...12 are relay outputs with potential free, normally open contact for max. 250 VAC  
Max. current for a single output: 6A  
Max. current of all outputs: 10 A



**WARNING:** Mixing-up of outputs and thus applying of 230 VAC on the transistor outputs will destroy the internal transistors !  
P1= +24 VDC for transistors, P2 = L1 (230VAC) for relays

## Section 5 Programming

Pressing the "Operating mode" key once takes the user from automatic operation to Programming mode.

The upper display always shows the parameter and the lower one the set value. The values are changed by pressing the  $\uparrow$  /  $\downarrow$  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.

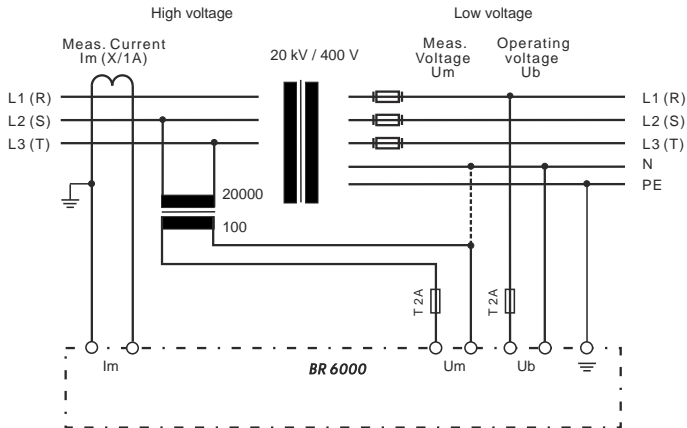
Selection of different values for the transistor resp. relay section is marked by symbols **T** resp. **R**.

### 5.1. Program Menu

- 0 LANGUAGE: This selects the language of the operating menu  
(German, English, Spanish, French, Russian, Czech, Dutch, Polish, Portuguese, Turkish)
- 1 I-CONVERTER PRIM: [ 1000]A (5...13000) A  
This selects the primary current of the current converter. Adjustment is via the  $\uparrow$  /  $\downarrow$  keys. Save and continue with ENTER
- 2 I-CONVERTER SEC: [ 5]A (5 / 1)  
This sets the secondary current of the current converter  
Selection via  $\uparrow$  /  $\downarrow$ . Save and continue with ENTER
- 3 END STOPP: (dynamical part) (1...6)  
**T** By setting the end stopp, the number of active capacitor branches is matched to the respective capacitor bank. This is done via the  $\uparrow$  /  $\downarrow$  keys. The visible symbols of the capacitors correspond to the connected outputs.
- 4 CONTROL SERIES: (dynamical part) (1...20 + E)  
**T** 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  $\uparrow$ / $\downarrow$  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.  
Save and continue with ENTER
- 5 CONTROL PRINCIPLE: (dynamical part)  
**T** The control preference may be selected here:
- SEQUENTIAL connection
  - LOOP connection
  - INTELLIGENT loop connection (default setting)
- See Section 9 for an explanation of the various control modes.

- 6 POWER 1. STAGE: (dynam. part) ( 0.01 ... 255.99 ) kvar  
**T** 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 of the BR6000 is being undercut, a warning will occur ( indication of "!" in the display )
- 7 CONNECTING TIME (dynam. part) ( 20 ... 1000 ) ms  
**T** 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).  
 Default setting: 1000 ms  
 Selection is performed via the **↑** / **↓** keys. Continue with ENTER
- 8 DISCONNECTING TIME (dynam. part) ( 20 ... 1000 ) ms  
**T** This refers to the time between disconnecting the capacitors to reduce the momentary network capacitance..  
 Default setting: 1000 ms  
 Selection is performed via the **↑** / **↓** keys. Continue with ENTER
- 9 DISCHARGE TIME (dynam. part) ( 20 ... 1000 ) ms  
**T** 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.  
 Default setting: 200 ms  
 Selection is performed via the **↑** / **↓** keys. Continue with ENTER
- 10 END STOPP (relay part) (7...12)  
**R** Default: 12
- 11 CONTROL SERIES (relay part) (1...20 + E)  
**R** Default: 1: 1: 1: 1: 1: 1
- 12 CONTROL PRINCIPLE (relay part)  
**R** Default: Intelligent
- 13 POWER 1. STAGE (relay part) (0.01...255.99) kvar  
**R** Default: 25.00 kvar
- 14 CONNECTING TIME (relay part) (1...1200) sec.  
**R** Default: 40 sec
- 15 DISCONNECTING TIME (relay part) (1...1200) sec.  
**R** Default: 40 sec
- 16 DISCHARGE TIME (relay part) (1...1200) sec.  
**R** Default: 60 sec
- 17 EXTERNAL INPUT [without function]  
 possible:  
 - "2nd target cosPhi": input-signal activite 2nd target cos Phi  
 - "external Error": input-signal switched off the controller  
 step by step

- 18 TARGET COS PHI : [0.98 IND] (0.3 ind ... 0.3 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  $\uparrow$  /  $\downarrow$  keys.  
 Save and continue with ENTER
- 18 TARGET COS PHI 2\* : [0.95 IND] (0.3 ind ... 0.3 cap)  
 \*Only available if 17 EXTERNAL INPUT is set as "2nd target cosPhi".
- 19 MEASURING VOLTAGE [230] V (30 ... 525)V  
 Programming the measuring voltage of the system. The values programmed here always refer to the voltage at the clamps of the BR6000 !  
 The voltage is selected via the  $\uparrow$  /  $\downarrow$  keys. Save and continue with ENTER.
- 20 V - CONVERTER RATIO [ NO ] (230V...380kV / Umeas.)  
 When a measuring-voltage converter (e.g. for HV- measurement) is used, its conversion ratio should be programmed here.  
 The prim. voltage can be set here directly,  
 the sec. voltage will be set automatically from 19 MEASURING VOLTAGE  
 Selection via the  $\uparrow$  /  $\downarrow$  keys. Save and continue with ENTER.



- 21 ALARM TEMP [ 60 ] °C (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 120 seconds. 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  $\uparrow$  /  $\downarrow$  keys. Save and continue with ENTER.

## 22 MESSAGE RELAY (available only at version with Interface)

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

"OFF"

"External cap.": Relay switches an external static stage with respect of a discharge time of 40 sec.

"Fan option": Relay switches the external cabinet fan.

(Default) The switching threshold can be programmed under point 23.  
Display: "F"

"Energy 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": Message appears when the limit of THD-V is exceeded. Can be set in "25 Harmonics" in%

"Module error": Display of a default signal taken via MMI6000 (only applicable with MMI6000 connected), e.g. "overload system"  
Control display "M"

"13.Step": Message relay is programmed as 13th capacitor-stage

23 TEMP FAN\* [30]°C (15...70)°C

Input of the switching threshold for the fan.

\* Only active if 'Fan option' in 22 is selected

24 DELAY-TIME OF ERROR-MESSAGES [10]sec. (0...255) sec.

The delay time for error-messages in the display can be changed here.

Default: 10 sec.

25 HARMONICS (harmonic limit) [ 7 ]% (0.5...25.5)%

A limit for 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.

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!

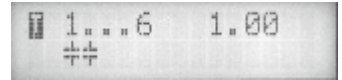
## 5.2 Programming lock

The BR6000 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. Connections are made by pressing the  $\uparrow$  or  $\downarrow$  key. 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 - C12) may be permanently defined in succession (continued switching via ENTER) for the following statuses:

- OFF: The output is continuously disconnected - e.g. for temporarily disconnecting a defective capacitor. Cap-symbol for this output is faded out. Underlining appears.
- AUTO: Automatic (normal) operation (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.

The active stage is blinking. The required status is set via  $\uparrow$  /  $\downarrow$ . 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.

Section 7    Service menu

The stored maximum values of the network parameters can be displayed here. In addition, a fault memory is available, in which the last 40 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 RESET the maximum values
ENTER	ERROR MEMORY E [1] - .....        in plaintext
ENTER	ERROR MEMORY RESET
ENTER	Back to 1

## 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]                    ( 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 POWER max            [100/100] 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.  
(This message will be displayed separately for dynamic and static part, but the value has to be the same)
- 4 SWITCH.TRIGGER                    [66]%                    (30...100%)  
Threshold for switching on of next stage.  
It should not be changed in the normal case!
- 5 OPERATING LOCK                    [NO]                    (NO / YES )
- 6 PHASE I                    [0°]  
                                  [L1] - L1 - N                    Adjustment of current phase position
- 7 PHASE U                    [0°]  
                                  L1 - [L1 - N]                    Adjustment of voltage phase position  
  
Phase correction between voltage and current in the measuring system.  
This setting allows to measure also in systems without neutral. (example p.5)
- 8 OUTPUT 1. STEP [0...255]                    (0...2550)  
The range for entering the stage output can be increased to [0...2550] here.
- 9 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 single-phase setting, display and control apply only to the single-phase value measured. (e.g. Single-phase correction in asymmetrical grids)

10 DISPLAY [cos Phi] (cos Phi/ tan Phi)  
Changeover between cos/tan Phi for all displays and calculations in the device

11 HARMONICS [NO] (NO/ YES)  
Release of calculation and display of harmonics.

12 PROTOCOL \*only with option interface  
[ - - - - - ] Interface OFF  
[ MODBUS RTU ] MODBUS protocol for individual usage  
[ ASCII OUT ] output of grid-values as ASCII-file (s.page 16)  
[ MASTER MMI ] for communication with MMI6000  
(available only if switching time is set >200ms)

Depending on the protocol selection, the appropriate configuration-menu is offered:

13 BAUD RATE	[38400]	(4800...38400)	Transmission rate
14 Number of MMI	[ 1 ]	(1 ... 3)	Nos of connected MMI
15 ADDRESS	[ 1 ]	(1 ... 32)	Address
16 UPPER VALUE	[130]%	(110 ...200%)	Switch. threshold MMI
17 LOWER VALUE	[60]%	(30 ... 95%)	Switch. threshold MMI
18 TEST ATTEMPT	[10]	(3 ... 255)	
19 TEST-TIME	[10]	(3 ... 255)	
20 ASCII time	[10]sec.	(1 ... 255)	Repetition-time ASCII

## 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 BR6000. Here they may be deactivated separately.

EXPERT MODE 2 [YES] (YES/NO)

*Activation of particular operation, warning and error messages  
(list of all messages in menu plan last page) - 20 messages in total*

2 ALARM TIME [120] sec. (1...255 sec.)  
Time after which the alarm relay will respond

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

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

5 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.



## Section 9 Control principle

The BR6000-T6R6 features 6 transistor outputs for the dynamic (fast switching) components and 6 relay outputs for the conventional capacitor steps switched via capacitor contactor.

If needed (target  $\cos\phi$  not yet achieved) always the dynamic steps will be switched in to compensate the very fast changing loads.

In case the dynamic steps are switched in for a longer time, they transfer their load to the conventional capacitor outputs switched by relay. This happens with respect to the pre-set on- and off switching times of the relay section.

By transferring the loads the steps switched by transistors are free for the dynamic compensation.

The advantage of a mixed-dynamic compensation is the combination of a dynamic section (fast compensation of dynamic loads) and a conventional section of the system (for the ground load resp. for slow changing loads) in a single PFC system. By this combination a significantly better economic solution is achieved than compared to a purely dynamic system.

The control response of the BR6000 can be selected in programming mode. In principle, the controller has following 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.

### 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 10 Interface (option)

The BR6000-T6R6 is equipped with an RS 485 interface as an option. It can be used to implement the following functions:

- Full parametrization of the controller via a PC
- Remote read-out of all parameters during operation and displays via a PC Display, logging and analysis of all grid parameters with software "*BR7000-Soft*" for Windows.  
( see separate description of the software )
- Connection of system accessories (e.g. data-logger)
- Selection of MODBUS (see Annex 4) or ASCII (see table below) for permanent display of grid parameters in ASCII format. Any ASCII editor can be used.
- Using with MMI6000 e.g. for measurement of inherent current of capacitor bank

ASCII protocol:

The following data are permanently displayed and refreshed via ASCII:

Voltage	e.g.	"230 V"	
Current	e.g.	" 85 A"	
Power factor	e.g.	"-0.98"	minus means "CAP"
Reactive power	e.g.	"100 kvar"	
Active power	e.g.	"100 kW"	
Apparent power	e.g.	"100 kVA"	
Outputs	e.g.	"XXX-----"	means: 3 steps active

## 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 BR6000 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
<p>At target <math>\cos \phi = 1</math> and inductive load, switch-off or connection of capacitor in the corrected line Supply / Drawing mismatched Wrong line <math>\cos \phi</math> is displayed</p>	<p>Check terminals of the measuring voltage and current (l and k)! Check phase position</p>
<p>Display: "UNDER CURRENT"</p>	<p>See above</p>
<p>Display: "OVERCURRENT" Alarm relay: after 1 min.</p>	<p>Current in measuring range? Line interruption? Wrong current-converter factor? Current transformer short-circuited?</p>
<p>Display: "UNDERCOMPENSATED" Alarm relay: after 1 min.</p>	<p>Check current-converter ratio Go through measuring current range</p>
<p>Display: "OVERCOMPENSATED" Alarm relay: after 1 min.</p>	<p>Check connection and phase position! All stages connected - target <math>\cos \phi</math> not reached: compensation network sufficiently dimensioned?</p>
<p>Display: "MEASUREMENT VOLTAGE ???" Alarm relay: after 1 min.</p>	<p>Check connection and phase position! Capacitive grid, although all stages disconnected No measurement voltage!</p>
<p>Display: "OVERTEMPERATURE" Alarm relay: after 1 min.</p> <p>Stages are disconnected for an inductive line or connected for a capacitive line</p>	<p>Cabinet temperature too high: Outputs are switched off in stages irrespective of power-line conditions If a target <math>\cos \phi</math> is set which deviates from 1 despite an inductive line load, the display &lt; (disconnect stages) may light up. The arrows indicate the control direction and not the line conditions.</p>
<p>The controller does not connect all stages, or <math>\cos \phi</math> does not change at the last stages In automatic operation, individual stages are not connected or disconnected</p>	<p>Check END STOPP ! Check whether individual stages are programmed as fixed stages or OFF in the "Manual operation / Fixed stages" menu!</p>
<p>In strongly asymmetrically loaded lines, differences may occur between control response and power-factor measurement, as the power factor is measured in single phase.</p>	<p>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.</p>
<p>No operating voltage</p>	<p>Note: No display, alarm relay is activated (open)</p>

## Section 14 Technical data

Type series	BR6000-T6R6
Outputs	6 transistor, 6 relays
Languages	G / E / ES / RU / NL / CZ / PL / F / PT /TR
Switching power of outputs	6x transistor: 24 VDC, max. 40mA 6x relay: max. 230VAC / 6A
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
Operating voltage	110...230 VAC, +/-15%, 50/60Hz
Measuring voltage	30...525 VAC (L-N) or (L-L), 50/60Hz
Measuring current	X : 5 / 1A selectable
Power drawn	< 5 VA
Sensitivity	50 mA / 10 mA
Target cos phi	0.3 inductive to 0.3 capacitive adjustable
Connecting time	separate selection for dynamic and relay section
Disconnecting time	separate selection for dynamic and relay section
Discharge time	separate selection for dynamic and relay section
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
Temperature measurement range	-30 ... 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 55 mm
Weight	1 kg
Operating ambient temperature	-20 to +60°C
Protection type to DIN 40 050	Front: IP 54, Rear: IP 20
Safety guidelines	IEC 61010-1:2001, EN 61010-1:2001
Sensitivity to interference (industrial areas)	EN 50082-1:1995 IEC 61000-4-2: 8kV IEC 61000-4-4: 4kV
Option /S	Interface RS485

Annex 1: Table of control series

No.	control series <b>T</b>	control series <b>R</b>	Loop connection
1	1 : 1 : 1 : 1 : 1 : 1	1 : 1 : 1 : 1 : 1 : 1	Possible
2	1 : 2 : 2 : 2 : 2 : 2	1 : 2 : 2 : 2 : 2 : 2	Possible
3	1 : 2 : 3 : 3 : 3 : 3	1 : 2 : 3 : 3 : 3 : 3	Possible
4	1 : 2 : 3 : 4 : 4 : 4	1 : 2 : 3 : 4 : 4 : 4	Possible
5	1 : 2 : 4 : 4 : 4 : 4	1 : 2 : 4 : 4 : 4 : 4	Possible
6	1 : 2 : 3 : 6 : 6 : 6	1 : 2 : 3 : 6 : 6 : 6	Possible
7	1 : 2 : 4 : 8 : 8 : 8	1 : 2 : 4 : 8 : 8 : 8	Possible
8	1 : 1 : 1 : 1 : 2 : 2	1 : 1 : 1 : 1 : 2 : 2	Possible
9	1 : 1 : 1 : 1 : 1 : 6	1 : 1 : 1 : 1 : 1 : 6	Possible
10	1 : 1 : 2 : 2 : 2 : 2	1 : 1 : 2 : 2 : 2 : 2	Possible
11	1 : 1 : 2 : 2 : 2 : 4	1 : 1 : 2 : 2 : 2 : 4	Possible
12	1 : 1 : 2 : 2 : 4 : 4	1 : 1 : 2 : 2 : 4 : 4	Possible
13	1 : 1 : 1 : 2 : 2 : 2	1 : 1 : 1 : 2 : 2 : 2	Possible
14	1 : 1 : 2 : 3 : 3 : 3	1 : 1 : 2 : 3 : 3 : 3	Possible
15	1 : 1 : 2 : 4 : 4 : 4	1 : 1 : 2 : 4 : 4 : 4	Possible
16	1 : 1 : 2 : 4 : 8 : 8	1 : 1 : 2 : 4 : 8 : 8	Possible
17	1 : 2 : 2 : 3 : 3 : 3	1 : 2 : 2 : 3 : 3 : 3	Possible
18	1 : 2 : 3 : 4 : 4 : 8	1 : 2 : 3 : 4 : 4 : 8	Possible
19	1 : 2 : 2 : 4 : 4 : 4	1 : 2 : 2 : 4 : 4 : 4	Possible
20	1 : 2 : 2 : 2 : 4 : 4	1 : 2 : 2 : 2 : 4 : 4	Possible
"E"	Editor	Editor	Possible

Control series for the dynamic and the relay section are set independently from each other.

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  $\uparrow$  /  $\downarrow$ . 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 < 12.

## 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 (* only version /S485)	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	<b>T</b> END STOPP	6	
4	<b>T</b> CONTROL SERIES	1	
5	<b>T</b> CONTROL PRINCIPLE	INTELLIGENT	
6	<b>T</b> POWER 1. STAGE	25.00 kvar	
7	<b>T</b> SWITCH- IN TIME	1000 ms	
8	<b>T</b> SWITCH- OFF TIME	1000 ms	
9	<b>T</b> DISCHARGE TIME	200 ms	
10	<b>R</b> END STOPP	12	
11	<b>R</b> CONTROL SERIES	1	
12	<b>R</b> CONTROL PRINCIPLE	INTELLIGENT	
13	<b>R</b> POWER 1. STAGE	25.00 kvar	
14	<b>R</b> SWITCH- IN TIME	40 s	
15	<b>R</b> SWITCH- OFF TIME	40 s	
16	<b>R</b> DISCHARGE TIME	60 s	
17	EXTERNAL INPUT*	WITHOUT FUNCT.	
18	TARGET COS-PHI (1 / 2)	0.98 / 0.95 IND	
19	MEASURING VOLTAGE	230 V L-N	
20	V- CONVERTER RATIO	- NO -	
21	ALARM TEMP.	60 °C	
22	MESSAGE RELAY *	OFF	
23	TEMP. FAN ON *	30 °C	
24	DELAY ERROR MESSAGE	10 sec.	
	Capacitor stages	AUTO	
	Password Expert mode 1	6343	Cannot be changed
	Password Expert mode 2	2244	
	Trigger value	66%	Cannot be changed
	Max. simult. switch. power	4 x smallest stage	
	Operating lock	- NO -	
	Phase shift U/I	0 °	
	Power 1. stage	0... 255 kvar	
	Control	3 - phase	
	Protocol*	MODBUS-RTU	
	Baudrate / Parity*	38400 / NONE	
	Address*	1	
	Numbers of MMI6000*	1	
	ASCII delivery time*	10 sec.	

## Annex 3: Capacitor current monitoring using MMI 6000

### Application

For permanent current monitoring inside the compensation system the MMI6000 is recommended as an accessory for the BR6000. This measuring device is able to determine the sum current of the complete PFC system as well as the current of single capacitor branches.

By monitoring the current of the installed capacitors, extraordinary grid conditions (e.g. harmonic currents which may cause an overload of capacitors) can be identified. In such a case, the power factor controller switches off the relevant compensation stages as long as the extraordinary situation continues. Monitoring of the capacitor current also means monitoring of the capacitor condition (damages, aging ...) and thus gives the opportunity to avoid consequential damages.

The MMI6000 will improve the reliability and safety of a PFC-system.

### Method of operation:

The MMI6000 measures the sum current inside the PFC system. For this a current transformer has to be installed at the power input of the compensation system. During each switching operation, the actual current change is measured and compared to the rated current of the switched capacitor(s). In between the switching operations the current of the complete system is monitored.

If the measured current of a step is too low (default 60%), this step is switched off. The relay is deactivated and the BR6000 display shows "E" (error) for this step. The alarm relay is activated. A reactivation of the step is possible in manual mode.

In case the current of a step is too high (default 130%), this step is also switched off. The BR6000 display shows an inverted capacitor symbol. The current is further on checked periodically. If the rated current reached again, the step is reactivated.

If the sum current of the complete PFC system is too high, stages are switched off one after another and alarm relay is set. Periodical measurements are performed to check whether the current reaches the nominal value again. If so, the step is reactivated.

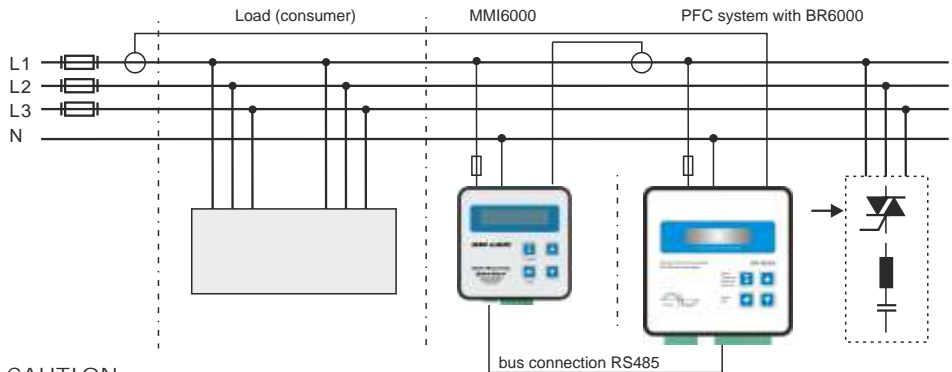
### Settings MMI6000:

- Operation mode: Coupling MMI-BR6000-T
- Grid: 3-phase
- Baudrate: 38400

### Settings BR6000-T6R6: (ExpertMode)

- Protocol: Master-MMI
- Baud rate: 38400
- Number of MMI connected
- Upper limit (%), lower limit (%)  
(limits of the capacitor / system output)

### Principle circuit diagram:



### **CAUTION:**

- For the bus-connection a shielded cable has to be used!
- Bus-connections (in and out) have always to be made directly to the relevant device!
- The terminating resistors inside the connected devices at the end of the bus-connection have to be activated (DIP-switch ON).
- Smallest switching time in this mode has to be  $\geq 200$  ms !

## Annex 4: Register MODBUS Protocol

A detailed description of the MODBUS-protocol parameters (last version) is available at the software-CD, which is included in delivery with each BR6000 device with interface.

### MODBUS protocol - example

MODBUS - Functioncode 3 (only-read-register) example meas. voltage				MODBUS - Functioncode 6 ( only-write-register ) example remote-control ( Remote-ON )			
answer				answer			
Byte 1:	Slave Adresse	1	Sl. Adress	1	Slave Adresse	1	1
Byte 2:	Functioncode	3	Funct. code	3	Functioncode	6	6
Byte 3:	Reg.start adress "H"	0	No of Bytes	2	Registeradr. "H"	0	0
Byte 4:	Reg.start adress "L"	20	Data H	0	Registeradr. "L"	40	40
Byte 5:	Reg. number "H"	0	Data L	233	Reg.value H (Data1)	1*	1
Byte 6:	Reg. number "L"	1	CRC L	121	Reg.value L (Data2)	3*	3
Byte 7:	CRC testcode "L"	196	CRC H	202	CRC testcode "L"	72	72
Byte 8:	CRC testcode "H"	14			CRC testcode "H"	83	83

### NOTE:

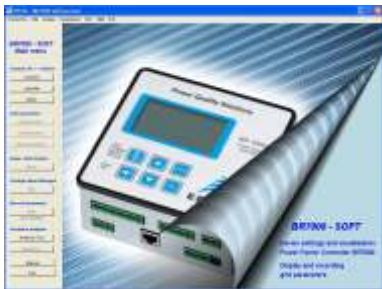
Due to the priority of the control function of the power factor controller before data exchange, please consider that per command 12 consecutive values maximum (s. table) are transferred blockwise. Also, parameters should not be retrieved more than 1 x /second.

**Settings:** 8 data bit, 1 stop bit, no parity



Annex 5: Screens of Windows-software “ BR7000-Soft”

Software and description at CD - included in delivery with “BR6000-T6R6/S485”



Software supports BR6000/ BR7000



Display-Mode

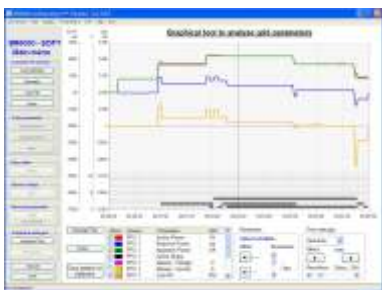


Configuration manager

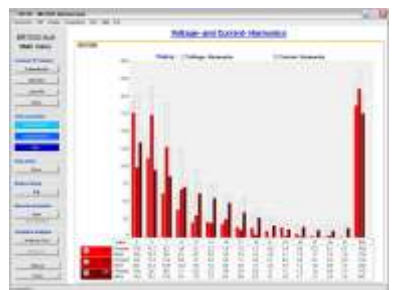
The screenshot displays the 'Grid parameter table - only information' window, which provides a detailed overview of the grid parameters. The table includes the following data:

Parameter	Value	Unit
Grid Voltage	230V	V
Grid Frequency	50 Hz	Hz
Grid Power	1000 VA	VA
Grid Power Factor	0,95	
Grid Impedance	0,1 Ω	Ω
Grid Reactance	0,01 Ω	Ω
Grid Inductance	0,0001 H	H
Grid Capacitance	0,0001 F	F
Grid Resistance	0,01 Ω	Ω
Grid Inductance	0,0001 H	H
Grid Capacitance	0,0001 F	F
Grid Impedance	0,1 Ω	Ω
Grid Reactance	0,01 Ω	Ω
Grid Inductance	0,0001 H	H
Grid Capacitance	0,0001 F	F

Grid parameter table



Analysis tool



Harmonics diagram

AUTO MODE

cosj 0.76 I ND  
++++++>

PROGRAMMING

only available if control  
serie "E" is selected  
in programming 4 resp. 11

CONTROL SERIES  
EDITOR

- 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. TO PF  
88.88 kvar
  - 7 FREQUENCY  
50.0 Hz
  - 8 TEMPERATURE\*\*  
25.0°C
  - 9 HARMONICS [ 3 ]  
V:0.5% - I:0.5%
  - 10 THD-V - THD-I  
V 1.6% - I 0.9%
  - 11 SYSTEM POWER  
88.88 kvar
  - SOFTWAREVERSION  
V 6.x - LCD
- BACK TO 1

- 0 LANGUAGE  
[ ENGLISH ]
- 1 I-CT PRIMARY  
[ 1000 ] A / X
- 2 I-CT SECONDARY  
1000 / [ 5 ] A
- 3 ENDSTOPP [ 6 ]  
I #####
- 4 CONTROL SERIES 1  
[ 1 1 1 1 1 ]
- 5 CONTROL MODE  
[ INTELLIGENT ]
- 6 POWER 1.STAGE  
[ 25 ]. 00 kvar
- 7 SWITCH - IN TIME  
[ 1000 ] ms
- 8 SWITCH - OFF TIME  
[ 1000 ] ms
- 9 DISCHARGE TIME  
[ 200 ] ms
- 10 ENDSTOPP [ 12 ]  
R #####
- 11 CONTROL SERIES 1  
[ 1 1 1 1 1 ]
- 12 CONTROL MODE  
[ INTELLIGENT ]
- 13 POWER 1.STAGE  
[ 25 ]. 00 kvar
- 14 SWITCH - IN TIME  
[ 40 ] sec.
- 15 SWITCH - OFF TIME  
[ 40 ] sec.
- 16 DISCHARGE TIME  
[ 60 ] sec.

- KVAR-RATIO [ 1 ]  
1 ① 2 2 2 2 2 2 2 2 2 2
  - KVAR-RATIO [ 2 ]  
11 ② 2 2 2 2 2 2 2 2 2 2
  - KVAR-RATIO [ 2 ]  
11 2 ② 2 2 2 2 2 2 2 2
  - KVAR-RATIO [ 2 ]  
11 2 2 ② 2 2 2 2 2 2 2 2
  - up to capacitor 6 / 12  
BACK TO 1
  - 17 EXTERNAL INPUT  
[ without function ]
  - 18 TARGET COS PHI  
[ 0.98 ] IND
  - 19 MEAS.VOLTAGE  
[ 230 ] V L / N
  - 20 V - CONVERTER  
[ NO ]
  - 21 ALARM TEMP.  
[ 60 °C ]
  - 22 MESSAGE RELAY  
[ FAN OPTION ]
  - 23 TEMP. FAN ON  
[ 30 °C ]
  - 24 DELAY A-MESS.  
[ 10 ] sec
  - 25 HARMONICS  
THD-V [ 7.0 ] %
  - BASIC SETTINGS  
- NO -
- BACK TO 1

Changing  
of values  
by buttons:

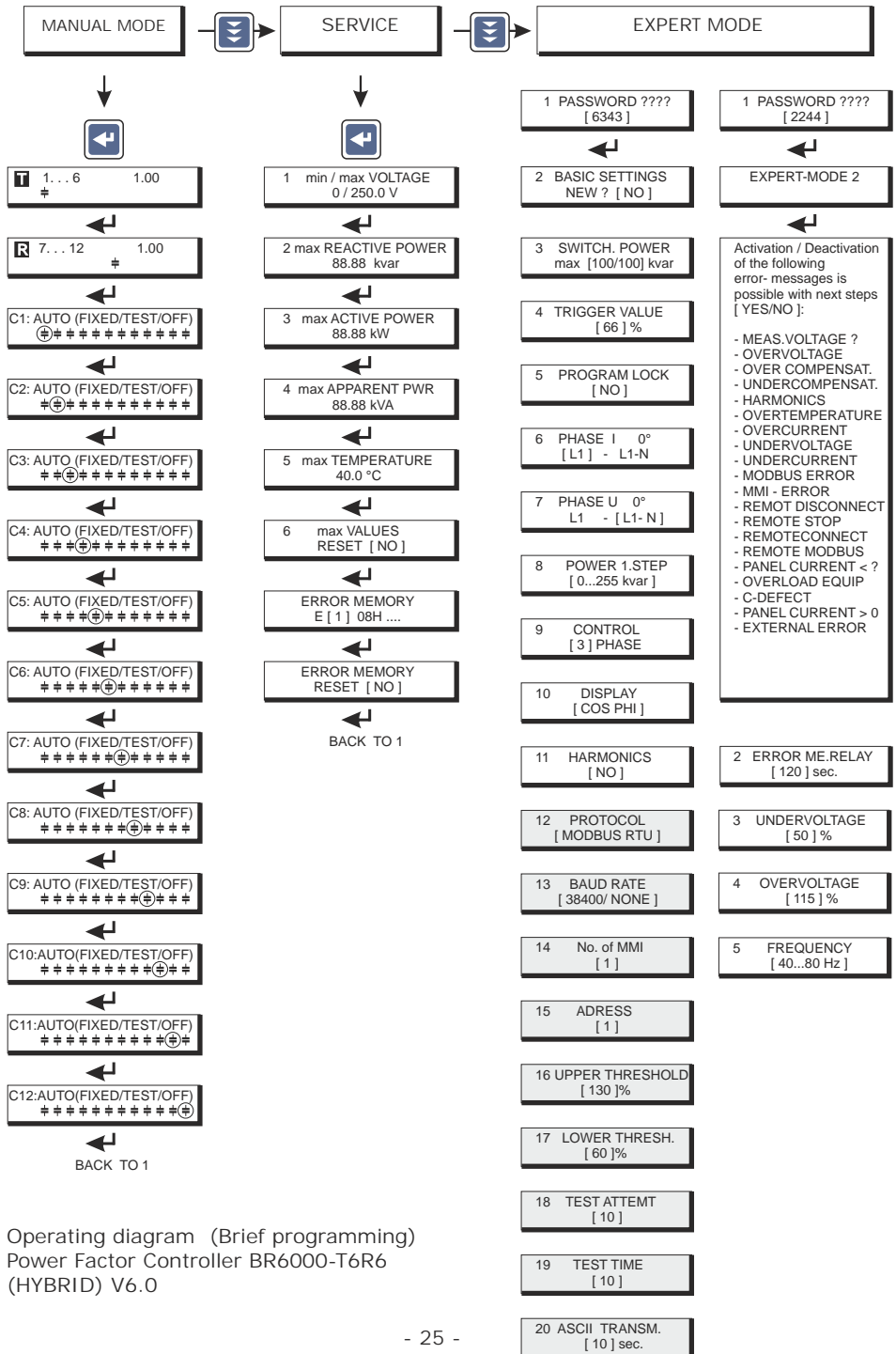



\*\* Display of temperature:  
Change between °C / °F  
by buttons UP/DOWN

In case no buttons are pressed  
within 60 seconds controller  
goes to automatic mode

The fields marked in grey  
are only active in relation to  
special settings and will be  
suppressed if not needed.

Manual switching on  
of steps in  
with buttons UP and DOWN

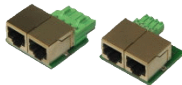


Operating diagram (Brief programming)  
Power Factor Controller BR6000-T6R6  
(HYBRID) V6.0

## Accessories

### Multi Measuring Devices

MMI 6000 & MMI 7000



RJ45 adapter connectors for PF controllers and MMIs.  
Terminal to RJ45 converter to connect the devices via RJ45-standard cable.



USB to RS485 converter to connect the PF controllers or other devices with Interface RS485 to a PC with USB-interface.

Thyristor-switches  
different types: TSM-LC / TSM-HV  
10 ... 200kvar / 400 ... 690V

