

EPCOS Product Profile 2015

# Power Factor Correction

Power Quality Solutions



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## Power Quality Solutions



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# Preview



## General

The increasing demand of electrical power and the awareness of the necessity of energy saving is very up to date these days. Also the awareness of power quality is increasing, and power factor correction (PFC) and harmonic filtering will be implemented on a growing scale. Enhancing power quality – improvement of power factor – saves costs and ensures a fast return on investment. In power distribution, in low- and medium-voltage networks, PFC focuses on the power flow ( $\cos \varphi$ ) and the optimization of voltage stability by generating reactive power – to improve voltage quality and reliability at distribution level.

## How reactive power is generated

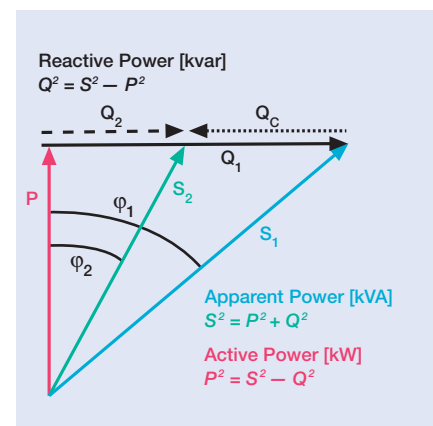
Every electric load that works with magnetic fields (motors, chokes, transformers, inductive heating, arc welding, generators) produces a varying degree of electrical lag, which is called inductance. This lag of inductive loads maintains the current sense (e.g. positive) for a time even though the negative-going voltage tries to reverse it. This phase shift between current and voltage is maintained, current and voltage having opposite signs. During this time, negative power or energy is produced and fed back into the network. When current and voltage have the same sign again, the same amount of energy is again needed to build up the magnetic fields in inductive loads. This magnetic reversal energy is called reactive power.

In AC networks (50/60 Hz) such a process is repeated 50 or 60 times a second. So an obvious solution is to briefly store the magnetic reversal energy in capacitors and relieve the network (supply line) of this reactive energy. For this reason, automatic

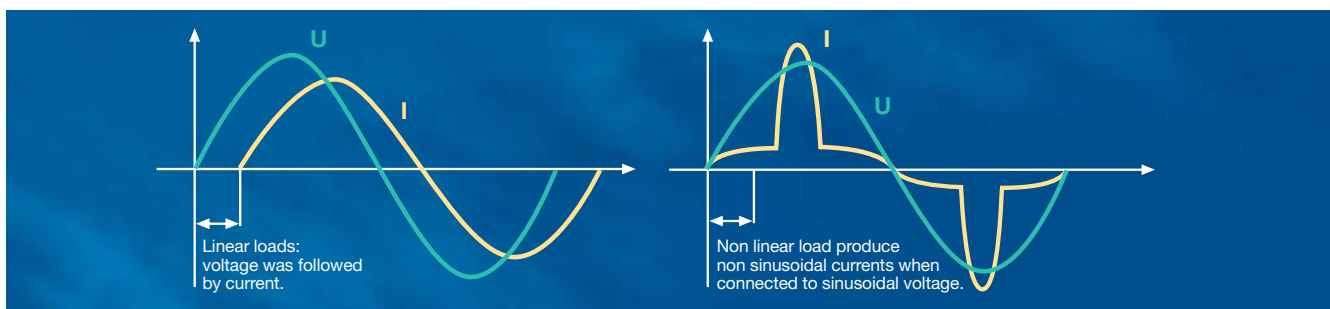
reactive power compensation systems (detuned/conventional) are installed for larger loads like industrial machinery. Such systems consist of a group of capacitor units that can be cut in and cut out and which are driven and switched by a power factor controller.

$$\begin{aligned} \text{Apparent power } S &= \sqrt{P^2 + Q^2} \\ \text{Active power } P &= S \cdot \cos \varphi \\ \text{Reactive power } Q &= S \cdot \sin \varphi \end{aligned}$$

With power factor correction the apparent power  $S$  can be decreased by reducing the reactive power  $Q$ .



# Preview



## PQS strategy

Along with the emerging demand for power quality and a growing awareness of the need for environmental protection, the complexity in the energy market is increasing: users and decision-makers are consequently finding it increasingly difficult to locate the best product on the market and to make objective decisions. It is in most cases not fruitful to compare catalogs and data sheets, as many of their parameters are identical in line with the relevant standards. Thus operating times are specified on the basis of tests under laboratory conditions that may differ significantly from the reality in the field. In addition, load structures

have changed from being mainly linear in the past to non-linear today. All this produces a clear trend: the market is calling increasingly for customized solutions rather than off-the-shelf products. This is where Power Quality Solutions come into the picture. It offers all key components for an effective PFC system from a single source, together with:

- Application know-how
- Technical skills
- Extensive experience in the field of power quality improvement
- A worldwide network of partners
- Continuous development
- Sharing of information

These are the cornerstones on which Power Quality Solutions are built. On the basis of this strategy, EPCOS is not only the leading manufacturer of power capacitors for PFC applications but also a PQS supplier with a century of field experience, reputation and reliability.

# PhaseCap Premium PFC Capacitors

Gas-impregnated • Dry type • Concentric winding • Wavy cut • Triple safety system



## General

PhaseCap capacitors in cylindrical aluminum cases have been designed for power factor correction in low-voltage applications.

Loads like motors and transformers consume active power as well as reactive power.

Generators, supply cables and other electrical distribution equipment, in turn, should be relieved of reactive power.

The MKK (metalized plastic compact) AC series is intended to increase packing density per bank and cut component costs.

Improved thermal response and simplified installation are advantages of the cylindrical aluminum case.



## Applications

- Automatic PFC equipment, capacitor banks
- Individual fixed PFC (e.g. motors, transformers, lighting)
- Group fixed PFC
- Tuned and detuned capacitor banks
- Dynamic PFC

## Features

- Compact design in cylindrical aluminum can with stud
- Concentric winding
- MKK-technology with wavy cut and heavy edge
- Voltage range 230 V ... 800 V
- Output range 5.0 kvar ... 33 kvar

## Electrical

- Long life expectancy
- High pulse current withstand capability

## Mechanical and maintenance

- Reduced mounting costs
- Maintenance-free
- Highest packing density thanks to compact dimensions

## Safety

- Self-healing
- Overpressure disconnecter
- Shock hazard protected terminals
- Longterm approved
- cUL approval
- Ceramic discharge resistor pre-mounted

## Environmental

- Dry design, inert gas
- No oil leakage

# PhaseCap Premium PFC Capacitors

Gas-impregnated • Dry type • Concentric winding • Wavy cut • Triple safety system



Technical data and limit values		
Standards IEC 60831-1+2, EN 60831-1+2, UL 810 5 <sup>th</sup> edition		
<b>Overvoltage</b>	$V_{\max}$	$V_R + 10\%$ (up to 8 h daily) / $V_R + 15\%$ (up to 30 min daily) / $V_R + 20\%$ (up to 5 min daily) / $V_R + 30\%$ (up to 1 min daily)
<b>Overcurrent</b>	$I_{\max}$	Up to $1.6 \cdot I_R$ including combined effects of harmonics, overvoltages and capacitance tolerance
<b>Inrush current</b>	$I_S$	up to $300 \cdot I_R$
<b>Losses:</b> – Dielectric – Total*		< 0.2 W/kvar < 0.45 W/kvar
<b>Rated frequency</b>	f	50/60 Hz
<b>Capacitance tolerance</b>		–5% / +10%
<b>Test voltage, terminal / terminal</b>	$V_{TT}$	$2.15 \cdot V_{R1}$ , AC, 10 s
<b>Test voltage, terminal / case</b>	$V_{TC}$	up to $V_R \leq 660$ V: 3000 V AC, 10 s; above $V_R = 660$ V: 6000 V AC, 10 s
<b>Mean life expectancy</b>	$t_{LD(Co)}$	up to 180 000 h (temp. class –40/C); up to 130 000 h (temp. class –40/D)
<b>Ambient temperature</b>		–40/D; max. temp. +55 °C; max. mean 24 h = +45 °C; max. mean 1 year = +35 °C; lowest temperature = –40 °C
<b>Cooling</b>		natural or forced
<b>Humidity</b>	$H_{rel}$	max. 95%
<b>Altitude</b>		max. 4000 m above sea level
<b>Mounting position</b>		upright / horizontal
<b>Mounting and grounding</b>		threaded M12 stud on bottom of case
<b>Safety</b>		dry technology, overpressure disconnecter, self-healing, maximum allowed fault current 10 000 A in accordance with UL 810 standard
<b>Discharge device</b>		ceramic discharge resistor pre-mounted up to 660 V; external discharge module for > 660 V
<b>Case</b>		extruded aluminum can
<b>Enclosure</b>		IP20, indoor mounting (optionally with terminal cap for IP54)
<b>Dielectric</b>		polypropylene film
<b>Impregnation</b>		inert gas, Nitrogen (N <sub>2</sub> )
<b>Terminals</b>		optimized capacitor safety terminal with electric shock protection (IP20), (VDE 0106 part 100), max. 25 mm <sup>2</sup> cable cross-section, max. current 80 A
<b>Certification</b>		cUL file # E238746, GOST
<b>Number of switching operations</b>		max. 7500 switchings per year

\* Without discharge resistor

# PhaseCap Premium PFC Capacitors

Gas-impregnated • Dry type • Concentric winding • Wavy cut • Triple safety system



Three-phase capacitors									
Type	50 Hz		60 Hz		C <sub>R</sub> μF	d x h mm	Weight kg	Ordering code	Packing unit*
	Output kvar	I <sub>R</sub> A	Output kvar	I <sub>R</sub> A					
<b>Rated voltage 260 V AC, 50 / 60 Hz, delta connection</b>									
MKK230-D-5.0-01	6.4	14	7.6	17	3 · 100	116 x 164	1.3	B25667C3297A375	6
MKK230-D-7.5-01	9.6	21	11.5	25	3 · 150	116 x 164	1.3	B25667C2457A375	6
MKK230-D-10.4-01	13.3	29	16.0	35	3 · 209	116 x 164	1.5	B25667C2627A375	6
MKK230-D-12.5-01 <sup>3)</sup>	16.0	36	19.2	43	3 · 251	116 x 200	1.7	B25667C2757A375	4
<b>Rated voltage 400 V AC, 50 / 60 Hz, delta connection</b>									
MKK400-D-5.0-01	5.0	7	6.0	9	3 · 32	116 x 164	1.1	B25667C5966A375	6
MKK400-D-7.5-01	7.5	11	9.0	13	3 · 50	116 x 164	1.2	B25667C3147A375	6
MKK400-D-10.0-01	10.0	14	12.0	17	3 · 64	116 x 164	1.2	B25667C4197A375	6
MKK400-D-12.5-01	12.5	18	15.0	22	3 · 83	116 x 164	1.1	B25667C3247A375	6
MKK400-D-15.0-01	15.0	22	18.0	26	3 · 100	116 x 164	1.3	B25667C3297A375	6
MKK400-D-20.0-01	20.0	30	24.0	36	3 · 133	116 x 164	1.5	B25667C3397A375	6
MKK400-D-25.0-01	25.0	36	–	–	3 · 165	116 x 200	1.8	B25667C3497A375	4
<b>Rated voltage 415 V AC, 50 / 60 Hz, delta connection</b>									
MKK415-D-5.0-01	5.0	7	6.0	8	3 · 32	116 x 164	1.1	B25667C5966A375	6
MKK415-D-6.2-01	6.2	8	7.5	10	3 · 39	116 x 164	1.2	B25667C5127A375	6
MKK415-D-10.4-01	10.4	15	12.5	17	3 · 64	116 x 164	1.2	B25667C4197A375	6
MKK415-D-12.5-01	12.5	17	15.0	21	3 · 77	116 x 164	1.3	B25667C4237A375	6
MKK415-D-15.0-01	15.0	21	18.0	25	3 · 93	116 x 164	1.4	B25667C4287A375	6
MKK415-D-16.7-01	16.7	23	20.0	28	3 · 103	116 x 164	1.5	B25667C4307A375	6
MKK415-D-20.0-01	20.8	29	25.0 <sup>2)</sup>	35 <sup>2)</sup>	3 · 128	116 x 200	1.7	B25667C4387A375	4
MKK415-D-25.0-01	25.0	35	–	–	3 · 154	136 x 200	2.1	B25667C4467A375	4
<b>Rated voltage 440 V AC, 50 / 60 Hz, delta connection</b>									
MKK440-D-5.0-01	5.0	7	6.0	8	3 · 27	116 x 164	1.2	B25667C4826A375	6
MKK440-D-7.5-01	7.5	10	9.0	12	3 · 41	116 x 164	1.2	B25667C4127A375	6
MKK440-D-10.4-01	10.4	14	12.5	16	3 · 57	116 x 164	1.3	B25667C4177A375	6
MKK440-D-12.5-01	12.5	16	15.0	20	3 · 69	116 x 164	1.4	B25667C4207A375	6
MKK440-D-14.2-01	14.2	19	17.0	22	3 · 77	116 x 164	1.3	B25667C4237A375	6
MKK440-D-15.0-01	15.0	20	18.0	24	3 · 83	116 x 164	1.4	B25667C4247A375	6
MKK440-D-16.7-01	16.7	22	20.0	26	3 · 92	116 x 200	1.8	B25667C4277A375	4
MKK440-D-18.8-01	18.8	25	22.6	30	3 · 103	116 x 164	1.5	B25667C4307A375	6
MKK440-D-20.0-01	20.0	26	24.0	31	3 · 111	116 x 200	1.7	B25667C4337A375	4
MKK440-D-25.0-01	25.0	33	30.0	39	3 · 137	136 x 200	2.0	B25667C4417A375	4
MKK440-D-28.1-01 <sup>3)</sup>	28.1	37	–	–	3 · 154	136 x 200	2.1	B25667C4467A375	4
MKK440-D-30.0-01 <sup>3)</sup>	30.0 <sup>1)</sup>	39 <sup>1)</sup>	–	–	3 · 164	136 x 200	2.4	B25667C4497A375	4
MKK440-D-33.0-01 <sup>3)</sup>	33.0 <sup>1)</sup>	43 <sup>1)</sup>	–	–	3 · 181	136 x 200	2.5	B25667C4547A375	4

Types for voltages 220 V, 240 V, 600 V, 660 V and other kvar-outputs are available upon request.

<sup>1)</sup> Temperature class deviation –40/C max. +50 °C

<sup>2)</sup> Temperature class deviation –40/B max. +45 °C

<sup>3)</sup> Discharge time ≤ 75 V in 90 s

\* Packing units for capacitors equal minimum order quantity.  
Orders will be rounded up to packing unit or multiple thereof.

# PhaseCap Premium PFC Capacitors

Gas-impregnated • Dry type • Concentric winding • Wavy cut • Triple safety system



Three-phase capacitors									
Type	50 Hz		60 Hz		C <sub>R</sub> μF	d x h mm	Weight kg	Ordering code	Packing unit*
	Output kvar	I <sub>R</sub> A	Output kvar	I <sub>R</sub> A					
<b>Rated voltage 480 V AC, 50 / 60 Hz, delta connection</b>									
MKK480-D-6.25-01	6.25	8	7.5	9	3 · 29	116 x 164	1.2	B25667C4866A375	6
MKK480-D-8.3-01	8.3	10	10.0	12	3 · 39	116 x 164	1.2	B25667C5127A375	6
MKK480-D-10.4-01	10.4	12	12.5	14	3 · 48	116 x 164	1.3	B25667C5147A375	6
MKK480-D-12.5-01	12.5	15	15.0	18	3 · 58	116 x 164	1.5	B25667C5177A375	6
MKK480-D-15.0-01	15.0	18	18.0	22	3 · 69	116 x 164	1.4	B25667C4207A375	6
MKK480-D-16.7-01	16.7	20	20.0	24	3 · 77	116 x 200	1.8	B25667C5237A375	4
MKK480-D-20.0-01	20.0	24	24.0	29	3 · 92	116 x 200	1.8	B25667C4277A375	4
MKK480-D-25.0-01	25.0	30	30.0	36	3 · 115	136 x 200	2.2	B25667C4347A375	4
MKK480-D-30.0-01 <sup>2)</sup>	30.0 <sup>1)</sup>	36 <sup>1)</sup>	–	–	3 · 138	136 x 200	2.4	B25667C4417A365	4
<b>Rated voltage 525 V AC, 50 / 60 Hz, delta connection</b>									
MKK525-D-8.3-01	8.3	9	10.0	11	3 · 32	116 x 164	1.1	B25667C5966A375	6
MKK525-D-10.0-01	10.0	11	12.0	13	3 · 39	116 x 164	1.2	B25667C5127A375	6
MKK525-D-12.5-01	12.5	14	15.0	17	3 · 48	116 x 164	1.3	B25667C5147A375	6
MKK525-D-15.0-01	15.0	17	18.0	20	3 · 58	116 x 164	1.5	B25667C5177A375	6
MKK525-D-16.7-01	16.7	18	20.0	21	3 · 64	116 x 164	1.6	B25667C5197A375	6
MKK525-D-20.0-01	20.0	22	24.0	26	3 · 77	116 x 200	1.8	B25667C5237A375	4
MKK525-D-25.0-01	25.0	28	30.0	33	3 · 96	136 x 200	2.3	B25667C5287A375	4
MKK525-D-30.0-01 <sup>2)</sup>	30.0 <sup>1)</sup>	33 <sup>1)</sup>	–	–	3 · 115	136 x 200	2.4	B25667C5347A375	4
<b>Rated voltage 570 V AC, 50 / 60 Hz, delta connection</b>									
MKK570-D-27.5-01	27.5	27	33	32.4	3 · 90	136 x 200	2.5	B25667C5277A375	4
<b>Rated voltage 600 V AC, 60 Hz, delta connection</b>									
MKK600-D-25.0-01	–	–	25.0	24.0	3 · 61.4	116 x 200	1.8	B25667C5197H375	4
MKK600-D-30.0-01	–	–	30.0	29.0	3 · 74	136 x 200	2.1	B25667C5227H375	4
MKK600-D-35.0-01	–	–	35.0	34.0	3 · 86	136 x 200	2.3	B25667C5267H375	4
<b>Rated voltage 690 V AC, 50 / 60 Hz, delta connection</b>									
MKK690-D-5.0-01	5.0	4.2	6	5.0	3 · 11	116 x 164	1.3	B25667C6336A375	6
MKK690-D-10.0-01	10.0	8.4	12	10.1	3 · 23	116 x 164	1.4	B25667C6676A375	6
MKK690-D-12.5-01	12.5	10.5	15	12.6	3 · 28	116 x 164	1.5	B25667C6836A375	6
MKK690-D-15.0-01	15.0	12.6	18	15.1	3 · 34	116 x 164	1.5	B25667C6107A375	6
MKK690-D-20.8-01	20.8	17.5	25	21.0	3 · 47	136 x 200	2.0	B25667C6137A375	4
MKK690-D-25.0-01	25.0	21.0	30	25.1	3 · 56	136 x 200	2.2	B25667C6167A375	4
<b>Rated voltage 765 V AC, 50 / 60 Hz, delta connection</b>									
MKK765-D-30.0-01	30	23	36	28	3 · 55	136 x 200	2.4	B25667C7167A375	4
<b>Rated voltage 800 V AC, 50 / 60 Hz, delta connection</b>									
MKK800-D-5.0-01	5.0	3.6	6	4.3	3 · 8	116 x 164	1.2	B25667C7246A375	6
MKK800-D-7.5-01	7.5	5.4	9	6.5	3 · 12.4	121 x 164	1.2	B25667C7376A375	6
MKK800-D-10.0-01	10.0	7.2	12	8.7	3 · 17	116 x 164	1.3	B25667C7496A375	6
MKK800-D-12.5-01	12.5	9.0	15	11.0	3 · 21	116 x 164	1.4	B25667C7626A375	6
MKK800-D-15.0-01	15.0	11.0	18	13.0	3 · 25	116 x 164	1.5	B25667C7746A375	6
MKK800-D-20.0-01	20.0	14.5	24	17.3	3 · 33	136 x 200	2.0	B25667C7996A375	4
MKK800-D-25.0-01	25.0	18.0	30	22.0	3 · 41	136 x 200	2.3	B25667C7127A375	4
MKK800-D-28.0-01	28.0	20.0	33	24.0	3 · 46	136 x 200	2.4	B25667C7137A375	4

Types for voltages 220 V, 240 V, 600 V, 660 V and other kvar-outputs are available upon request.

<sup>1)</sup> Temperature class deviation –40/C max. +50 °C

<sup>2)</sup> Temperature class deviation –40/B max. +45 °C

<sup>3)</sup> Discharge time ≤ 75 V in 90 s

\* Packing units for capacitors equal minimum order quantity.

Orders will be rounded up to packing unit or multiple thereof.



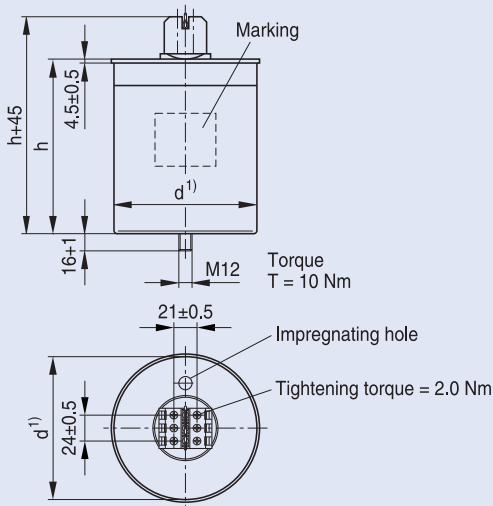
# PhaseCap Premium PFC Capacitors

Gas-impregnated • Dry type • Concentric winding • Wavy cut • Triple safety system



## Dimensional drawings

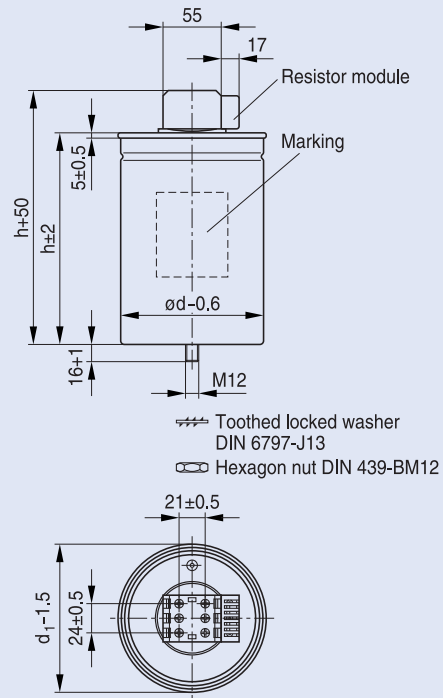
### Capacitor up to 660 V AC



¹) Seaming adds 5.5 mm in diameter

KLK1841-1-E

### Capacitor > 660 V AC

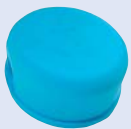


/// Toothed locked washer  
DIN 6797-J13  
⊞ Hexagon nut DIN 439-BM12

d<sub>1</sub>: seaming adds 5.5 mm in diameter

KLK1863-W-E

### Protective terminal cover IP54



### Protective case for capacitor



### Ceramic discharge resistors

Pre-mounted for series B25667, B25673 and B32344;  
available as spare parts upon request



# PF Controllers BR6000 Series

Intelligent • User-friendly • Cost-effective • Version 6.0



## General

Controllers for PFC are of major importance in the PFC system. They measure the actual power factor and connect or disconnect capacitor stages to achieve a specific desired value ( $\cos \varphi$ ).

The PF controller series BR6000 (six and twelve stages) offer highly intelligent control behavior and are very user-friendly thanks to menu-driven handling (plain language). Their multifunctional display greatly simplifies installation, handling and maintenance.

Different versions of the BR6000 series provide solutions to various applications:

- BR6000-R6 and BR6000-R12 for conventional applications with slowly changing loads
- BR6000-T6 for dynamic PFC in applications with fast-changing loads



BR6000

## Features

- Display
  - Multifunctional LCD (2 x 16 characters)
  - Graphic and alphanumeric
  - LCD illumination\*
- Intelligent control
- Menu-driven handling (plain language)
- Self-optimizing control capability
- Recall function of recorded values
- Four-quadrant operation (e.g. stand-by generator)
- Large measuring voltage range\*
- Powerful alarm output\*
- Display of numerous of system parameters
  - System voltage (V AC)
  - Reactive power (kvar)
  - Active power (kW)
  - Frequency\*
  - Energy
  - THD-V, THD-I\*
  - Individual harmonics up to 19<sup>th</sup>\*
  - Monitoring of individual capacitor currents\*
  - Apparent power (kVA)
  - Apparent current (A)
  - Temperature (°C)\*
  - Real-time  $\cos \varphi$
  - Target  $\cos \varphi$
  - kvar value to target  $\cos \varphi$
- Alarm output\*
  - Insufficient compensation
  - Overcompensation
  - Undercurrent
  - Overcurrent
  - Overtemperature
  - Harmonics exceeded
  - Threshold value programmable
  - Internal error storage
  - Programming of 2nd signal relay random
- Recall recorded values
  - Number of contactor switching operations\*
  - Maximum voltage V ( $V_{max}$ )
  - Maximum reactive power, Q (kvar)
  - Maximum value of harmonic\*
  - Maximum active power, P (kW)
  - Maximum apparent power, S (kVA)
  - Maximum temperature (°C)\*
  - Operation time of all capacitors\*
- Automatic initialization\*
- Dynamic PFC (transistor output)\*\*
  - Thyristor switching

## ⚠ Cautions:

1. Discharge time: Make sure that the discharge time set in controller matches the capacitor discharge time. See page 101.
2. Number of switchings: LV PFC capacitors according to standard IEC 60831 are designed for up to 5000 switching operations. Make sure that 5000 switching operations per year are not exceeded.
3. Controller hunting must be avoided at any case (see page 103)!

\* Only for BR6000 series

\*\* Only for BR6000-T series

# PF Controllers BR6000 Series

Intelligent • User-friendly • Cost-effective • Version 6.0



Selection table			
	BR6000-R6 <sup>1)</sup>	BR6000-R12 <sup>1)</sup>	BR6000-T6
Ordering code	B44066R6006E230	B44066R6012E230	B44066R6106E230
	<b>BR6000-R6/HD</b>	<b>BR6000-R12/HD</b>	
Ordering code	B44066R6506E230	B44066R6512E230	
Supply voltage	110 ... 230 V AC		
Measurement voltage range	30 ... 525 V AC (L-N) or (L-L)		
LCD illumination	yes	yes	yes
Plain language	Czech / Dutch / English / French / German / Polish / Portuguese / Russian / Spanish / Turkish		
Number of relay outputs	6	12	–
Number of transistor outputs	–	–	6
Alarm output	yes	yes	yes
• Insufficient compensation	yes	yes	yes
• Overcompensation	yes	yes	yes
• Under-/overvoltage	yes	yes	yes
• Overcurrent	yes	yes	yes
Automatic initialization	yes	yes	no
Parameters displayed			
• System voltage	yes	yes	yes
• Reactive power	yes	yes	yes
• Active power	yes	yes	yes
• Frequency	yes	yes	yes
• THD-V, THD-I	yes	yes	no
• Energy	yes	yes	yes
• Individual harmonics up to 19th	yes	yes	no
• Monitoring of individual capacitor currents	yes	yes	no
• Apparent power	yes	yes	yes
• Apparent current	yes	yes	yes
• Temperature °C / °F)	yes	yes	yes
• Real time cos φ	yes	yes	yes
• Target cos φ	yes	yes	yes
• kvar value to target cos φ	yes	yes	yes
Recall recorded values			
• Number of contactor switching operations	yes	yes	no
• Maximum voltage	yes	yes	yes
• Maximum active power	yes	yes	yes
• Maximum reactive power	yes	yes	yes
• Maximum value of harmonic	yes	yes	no
• Maximum apparent power	yes	yes	yes
• Maximum temperature (°C)	yes	yes	yes
• Operation time of all capacitors	yes	yes	no
Switching and discharge time range	1 ... 1200 seconds		20 ... 1000 ms
Number of control series	20 series preset and control series editor for free programming		
Weight	1 kg		
Dimensions	144 x 144 x 55 mm		
Suitable for dynamic PFC	no	no	yes

<sup>1)</sup> For types with OLED-display, please contact our local sales office.

# PF-controllers BR7000-I Series

Intelligent • Cost-effective • Standard, mixed and dynamic compensation



## General

The PF controller-series BR7000-I features all characteristics of the well proven BR6000 series in combination with the advantages of a better visualization of the BR7000 series. Some additional innovative characteristics offer the possibility of customized PFC solutions.

The new series BR7000-I-TH and BR7000-I-TH/S485 with 12 relay and 12 transistor outputs are perfectly suited for dynamic and mixed compensation. The BR7000-I-TH/S485 with its additional RS485 interface allows controlling of up to 32 thyristor modules type TSM-LC-S.



BR7000-I

## Features

- Intelligent control
- Menu-driven handling, plain language: CZ/EN/ES/FR/GER/NL/PL/PT/RU/TR
- Self-optimizing control capability
- Automatic initialization
- Test-run possible
- Large voltage measuring range
- Recall function for recorded values
- Four quadrant operation (e.g. standby generator)
- Powerful alarm output
- Second parameter set
- Control series editor
- Detailed expert modes
- Controlling of inductive compensation systems possible
- Large number of system parameters displayed:
  - System voltage (V AC)
  - Reactive power (kvar)
  - Active power (kW)
  - Frequency
  - Apparent power (kVA)
  - Apparent current (A)
  - Temperature (°C)
  - Real-time  $\cos\phi$
  - Target  $\cos\phi$
  - kvar value to target  $\cos\phi$
  - Energy
  - Odd Harmonics (3<sup>rd</sup> ... 33<sup>th</sup>) V (%), I (%)
  - Even and odd harmonics (2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> – 17<sup>th</sup>)

- Extended supply voltage 110 ... 230 V
- BR7000-I-TH and BR7000-I-TH/S485 for mixed and dynamic compensation
- BR7000-I-TH/S485 for direct triggering of up to 32 thyristor switches TSM-LC-S at the bus

## Additional characteristics

- Large graphical display (128 x 64 dots) – like PF controller series BR7000
- HELP-button for context related help text
- ESCAPE-button allows backspace whilst navigating in the menu
- Outputs:
  - BR7000-I: always 12 relay outputs, 1 alarm relay
  - BR7000-I/TH and BR7000-I/TH/S: 12 relay and 12 transistor outputs, 1 alarm/fan relay output
- 3-digit display of the power factor ( $\cos\phi$ )/switchable display as  $\tan\phi$

- Display-Mode:
  - Simultaneous large display of 3 measuring values for additional usage as measuring and display device; the desired display values editable
  - Uneven harmonics measurable up to 33<sup>rd</sup> harmonic
  - Even harmonics measurable up to 16<sup>th</sup> harmonic
  - Graphical display of selected harmonics as bar graph
  - Message/alarm relay programmable with shutter or opener function
- Code number (Password) programmable by the customer
- Update firmware possible

The version BR7000-I/S485 and BR7000-I-TH/S485 even allow visualization, programming and data proceeding via PC with evaluation software BR7000-SOFT included in the delivery. These types feature an additional external input (function programmable for example for a 2<sup>nd</sup> parameter set and additional freely programmable message relay (e.g. for fan or status message). The serial interface RS485 can be used for controller coupling or embedding into networks.

# PF-controllers BR7000-I Series

Intelligent • Cost-effective • Standard, mixed and dynamic compensation



Technical data			
	BR7000-I	BR7000-I/S485	BR7000-I-TH BR7000-I-TH/S485
Operating voltage	110 ... 230 V AC +/- 15%, 50 and 60 Hz		
Measuring voltage	30 ... 440 V AC (L-N); 50 ... 760 V AC (L-L); 50/60 Hz		
Measuring current	X:5A / X:1A selectable		
Power consumption	< 5 VA		
Sensitivity	50 mA/10 mA		
<b>Switching outputs</b>			
Relay outputs	12		12
Transistor outputs	–		12
Alarm relay	1		1
Switching power of relays	250 V AC, 1000 W		
Number of active outputs	programmable		
<b>Operation and display</b>			
Display	illuminated full graphic display 128 x 64 dots		
Menu languages	CZ/EN/ES/F/GER/NL/PL/PT/RU/TR		
Freely editable control series	1 via Editor		
<b>Control</b>			
Control principle	sequential switching, circle switching, intelligent switching behavior, 4-quadrant operation		
Automatic initialization/test-run	possible		no
Target cos-φ	0.3 inductive up to 0.3 capacitive adjustable		
Switch on time	selectable from 1 sec. to 20 min.		Dynamic/relay 20 ... 1000 ms / 1 sec ... 20 min
Switch off time	selectable from 1 sec. to 20 min.		Dynamic/relay 20 ... 1000 ms / 1 sec ... 20 min
Discharge time	selectable from 1 sec. to 20 min.		Dynamic/relay 20 ... 1000 ms / 1 sec ... 20 min
Manual operation	yes		
Fixed steps/skip steps	programmable		
Zero voltage release	standard		
<b>Display/display functions</b>			
Display of grid parameters	cos-φ, V, I, F, W, Q, P, S, ΔQ, THD-V, THD-I		
Display of harmonics	3 <sup>rd</sup> to 33 <sup>rd</sup> harmonics of V and I / even harmonics 2 <sup>nd</sup> to 16 <sup>th</sup>		
Accuracy	current/voltage: 1% active, apparent and reactive power: 2%		
Integrated help function	context dependent		

# PF Controllers BR7000/BR7000-T

15 outputs • Three-phase measuring and controlling



## General

The PF controllers BR7000/BR7000-T are a follow-up development of the PF controller BR6000-series, featuring two devices in one: it can be used as a controller as well as a grid measuring tool.

The BR7000 offers 15 relay outputs for the steps and three message/ alarm relays. The BR7000-T features 15 transistor outputs for usage in dynamic PFC-systems with thyristor modules TSM-series. Due to the possibility of programming, the 15 outputs can be used for a broad range of applications, for example:

- 15 conventional steps, each for one three-phase capacitor
- 15 steps for single-phase capacitors, where each output will switch a single-phase capacitor to N (usually 5 per phase, balancing of grid is possible)
- Mixed operation: e. g. 6 single-phase capacitors (2 per phase) for balancing plus 9 steps for conventional compensation (three-phase capacitors)

The controller can be connected to a PC via an RS485 interface. The Windows-based software BR7000-SOFT allows the readout

of acquired data. The possibility of graphical display of all values offers a comfortable visualization.



BR7000

## Features

- LCD full graphic display  
128 x 64 dots, 8 lines, versions BR7000-HD and BR7000-T/HD with OLED-display
- Self explanatory menu navigation in five languages
- Three-phase measuring and controlling; display of following grid parameters:
  - Voltage
  - Current
  - Frequency
  - Energy
  - Real power
  - Reactive power
  - Apparent power
  - Power factor
  - Missing reactive power
  - Harmonic of voltage and current (up to 31<sup>st</sup>)
  - THD-V
  - THD-I
  - Temperature
- HELP-button for interactive help text
- 15 switching outputs
- 3 additional alarm/message relays
- 2 isolated interfaces
- Detailed error messages with time stamp
- Automatic initialization/test run<sup>1)</sup>
- Automatic and manual operation, service operation, expert mode
- Three-phase and single-phase controlling; mixed mode possible
- Display and storage of maximum values
- Display of switching operations and operating time<sup>1)</sup>
- Display of date and time
- Time-controlled functions possible by internal timer
- Oscilloscope mode for graphical display
- Quick programming<sup>1)</sup>

<sup>1)</sup> Only for BR7000 and BR7000-HD series

# PF Controllers BR7000/BR7000-T

15 outputs • Three-phase measuring and controlling



Technical data	
<b>BR7000/BR7000-T</b>	
<b>Supply voltage</b>	110 ... 230 V AC 50/60 Hz
<b>Measurement voltage range</b>	3 · 30 ... 440 V AC (L-N); 50 ... 760 V AC (L-L)
<b>Power consumption</b>	< 3 VA
<b>Operating ambient temperature</b>	-20 ... +60 °C
<b>Display</b>	illuminated graphic display, 128 x 64 dots, 8 lines, HD versions with OLED display
<b>Large display of 3 grid parameters</b>	selection in display editor
<b>Plain language</b>	E / ES / GER / RU / TR
<b>In- and outputs</b>	
<b>Number of outputs</b>	BR7000: 15 relay outputs freely programmable for switching of 1- or 3-phase capacitors BR7000-T: 15 transistor outputs freely programmable for switching of 1- or 3-phase capacitors, suitable for dynamic PFC
<b>Alarm/message relay</b>	1/1
<b>Additional separate fan relay</b>	1
<b>Interface</b>	2 independent isolated RS485-interfaces
<b>Input 2nd parameter-set switchover target PF</b>	yes
<b>Special functions</b>	
<b>Measuring</b>	three-phase
<b>Controlling</b>	single-phase, three-phase, mixed mode
<b>Automatic initialization</b>	yes <sup>1)</sup>
<b>Test-run of complete PFC-system</b>	yes <sup>1)</sup>
<b>Quick-program</b>	yes <sup>1)</sup>
<b>Internal timers</b>	yes
<b>Oscilloscope (graphical display) mode</b>	yes
<b>Display editor</b>	yes
<b>Backwards navigation ESCAPE button</b>	yes
<b>HELP button for interactive help text</b>	yes
<b>Number of control series</b>	20 series pre-set
<b>Control series editor for free programming</b>	yes

<sup>1)</sup> Only for BR7000 and BR7000-HD series

# Switching Devices – Thyristor Modules for Dynamic PFC, TSM-Series



## General

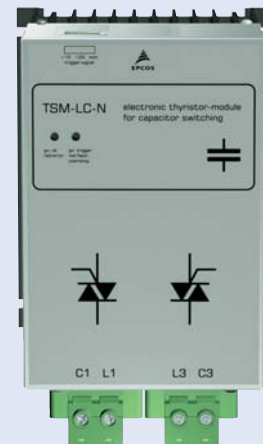
Conventional systems for power factor correction are used to optimize the power factor and reduce the level of harmonics in the grid. The usage of new technologies in modern industry has negative impacts on electric power quality of the main supply networks, e.g. frequent high load fluctuations and harmonic oscillation.

Excessive currents, increased losses and flickering will not only influence the supply capacity but will also have a significant impact on the operation of sensitive electronic devices.

The solution for this are dynamic power factor correction systems.

With the thyristor module series TSM-LC and TSM-HV, we provide the main component – “the electronic switch” – for dynamic power factor correction.

The TSM module series offers fast electronically controlled, self-observing thyristor switches for capacitive loads up to 200 kvar, that are capable to switch PFC capacitors within a few milliseconds nearly without a limitation to the number of switchings during the capacitor lifetime.



## Applications

- Main supply networks with high load fluctuations for dynamic PFC systems
- Presses
- Welding machines
- Elevators
- Cranes
- Wind turbines

## Features

- Easy installation: it can be used similar to a contactor
- All the intelligence needed is offered within the thyristor module itself
- Reaction time: 5 milliseconds only
- Permanent self-controlling of:
  - voltage parameter
  - phase sequence
  - capacitor output
- Display of
  - operation
  - faults
  - activation
- TSM-LC-I: Single-phase, for direct 2-phase switching of capacitive loads (L-N) or (L-L)
- TSM-LC-S: Triggering of the module via system bus (patch cable) from PF-controller BR7000-I-TH/S485
  - Up to 32 devices at supported by controller
  - Display and monitoring of V, I, Q, temperature, switching state
  - Error display and evaluation via bus directly at PF-controller
  - Direct monitoring of temperature switch of filter reactor
- Voltage range:
  - TSM-LC-I: 230 ... 525 V
  - TSM-LC-N: 380 ... 440 V
  - TSM-LC-S: 200 ... 440 V
  - TSM-LC-N690: 380 ... 690 V
  - TSM-HV: 690 V
- Output range:
  - TSM-LC-I: 10 ... 22 kvar, depending on the voltage
  - TSM-LC: 10, 25, 50, 100, 200 kvar
  - TSM-HV: 50 and 200 kvar



# Switching Devices – Thyristor Modules for Dynamic PFC, TSM-Series



Selection table TSM-series					
	TSM-LC-I <sup>3)</sup>	TSM-LC10	TSM-LC-N	TSM-LC-N690	TSM-LC-S
<b>Ordering code</b>	B44066T1022E520	B44066T0010E402	B44066T3050E402	B44066T3050E690	B440661050E402
<b>Rated voltage</b>	230 ... 525 V	380 ... 400 V	380 ... 440 V AC	380 ... 690 V AC	200 ... 440 V AC
<b>Max. grid voltage: – in conventional PFC systems (without reactors)</b>	525 V	440 V	440 V	690 V	440 V
<b>– in detuned PFC system (7% detuning)</b>	525 V	440 V	440 V	690 V	440 V
<b>– in detuned PFC system (14% detuning)</b>	525 V	400 V	max. 440 V	max. 690 V	max. 440 V
<b>Frequency</b>	50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz
<b>Maximum power / at nominal voltage</b>	depending on the voltage 10 to 22 kvar	12.5 kvar	50 kvar	40 to 75 kvar depend- ing on the voltage	15 to 55 kvar depending on the voltage
<b>Power circuit</b>	Connection via plug connector; conduc- tor cross section steep or flexible max 2 x 35 mm <sup>2</sup> )	Direct connection 4 pole via terminal clamps (D = 6 mm <sup>2</sup> resp. 4 mm <sup>2</sup> )	Direct connection via high current plug; connection from the bottom	Direct connection via high current plug; connection from the bottom	Direct connection via high current plug; connection from the bottom
<b>Neutral required</b>	no	no	no	no	no
<b>Aux. supply voltage required</b>	24 V DC	no	no	230 V~/10 VA	24VDC via power supply module ESP24
<b>Connection</b>	from front	from bottom	Connection of main current lines via high current plug connections (included in the delivery); can be connected via lines (max. 35 mm <sup>2</sup> ) directly to the main fuse resp. capacitor		
<b>Losses (PD in W)</b>	Pv (in W) = 1.0 x I (in A); at nominal power: approx. 45 W (thermal)	Pv (in W) = 2.0 x I (in A); at 400 V/ 12.5 kvar approx. 35 W (thermal)	Pv (in W) = 2.0 x I (in A); at nominal voltage approx. 150 W thermal	Pv (in W) = 2.4 x I (in A); appr. 150 W thermal at nominal current	Pv (in W) = 2.0 x I (in A); at nominal voltage approx. 150 W thermal
<b>Recommended fuses “superfast”</b>	1x electronic fuse (NH00 AC 690 V) 63 A	3x electronic fuse (NH00 AC 690 V) 35 A	3x electronic fuse (NH00 AC 690 V) 50 kvar: 125 A 25 kvar: 63 A	3x electronic fuse (NH00 AC 690 V) 125 A	3x electronic fuse (NH00 AC 690 V) 125 A
<b>Dimensions in mm (w x h x d)</b>	70 x 200 x 150	163 x 152 x 75	157 x 200 x 173	157 x 200 x 190	157 x 200 x 180
<b>Weight</b>	1.5 kg	1.75 kg	approx. 4.8 kg	approx. 4.8 kg	approx. 5 kg
<b>Display per phase</b>	3 LED	2 LED	2 LED	2 LED	OLED-Display 2 x 16 characters
<b>Ambient temperature</b>	-10 °C ... +55 °C	-10 °C ... +55 °C	-10 °C ... +55 °C	-10 °C ... +55 °C	-10 °C ... +55 °C
<b>Discharge resistors EW-22 needed</b>	not needed	1	1	2	1
<b>Current limitation reactor BD-*** needed<sup>2)</sup></b>	1	2	2 x BD100	2 x BD100	2 x BD100

<sup>1)</sup> Only for operation with single-phase capacitors. <sup>2)</sup> For PFC systems without detuning reactors mandatory.

<sup>3)</sup> Single-phase, for direct 2-phase switching of capacitive loads (L-N) or (L-L).

Accessories for TSM modules					
	BD-050 <sup>1)</sup>	BD-050/480 <sup>1)</sup>	BD-100	BD-100/480 <sup>1)</sup>	BD-200 <sup>2)</sup>
<b>Ordering code</b>	B44066T0050E400	B44066T0050E480	B44066T0100E400	B44066T0100E480	B44066T0200E400
<b>Nominal voltage</b>	400/440 V	480 V	400/440 V	480 V	400/440 V
<b>Nominal current</b>	50 A	50 A	85 A	85 A	170 A
<b>Frequency</b>	50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz
<b>Dimensions (w x d x h)</b>	56 x 71 x 70 mm	65 x 58 x 82 mm	75 x 75 x 88 mm	75 x 75 x 88 mm	104 x 114 x 125 mm
<b>Weight</b>	approx. 1.5 kg	approx. 1.5 kg	approx. 2 kg	approx. 2 kg	approx. 6 kg

<sup>1)</sup> Production only after ordering. <sup>2)</sup> Only suitable for TSM-LC100.

# Switching Devices – Thyristor Modules for Dynamic PFC, TSM-Series



TSM-LC100	TSM-LC200	TSM-HV50	TSM-HV200
B44066T0100E402	B44066T0200E402	B44066T0050E690	B44066T0200E690
380 ... 400 V	380 ... 400 V	690 V	690 V
440 V	440 V	690 V	690 V
440 V	440 V	690 V	690 V
400 V	400 V	690 V	690 V
50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz
100 kvar	200 kvar	60 kvar	200 kvar
Direct connection 4 pole via busbar (cable lug 70 mm <sup>2</sup> , D = 10 mm)	Direct connection 4 pole via busbar (cable lug 185 mm <sup>2</sup> , D = 12 mm)	Direct connection 4 pole via busbar (cable lug 25 mm <sup>2</sup> , D = 8 mm)	Direct connection 4 pole via busbar (cable lug)
no	no	yes <sup>1)</sup>	no
230 V AC (needed for fan) via terminal clamp	230 V AC	230 V AC	no
from bottom	from top	from bottom	from bottom
Pv (in W) = 2.0 x I (in A); typical 300 W (thermal)	Pv (in W) = 2.0 x I (in A); at 400 V/200 kvar approx. 580 W (thermal)	Pv (in W) = 3.0 x I (in A); at 690 V/ 50 kvar approx. 125 W (thermal)	Pv (in W) = 2.0 x I (in A); at 690 V/ 200 kvar typical 350 W (thermal)
3 x NH1 (AC 690 V) 250 A	3 x NH2 (AC 690 V) 125 kvar: 315 A 150 kvar: 350 A 200 kvar: 450 A	3 x NH00 (AC 690 V) 25 kvar: 63 A 50/60 kvar: 100 A	3 x NH2 (AC 690 V) 100 kvar: 160 A 200 kvar: 250 A
157 x 240 x 195	250 x 480 x 160	157 x 200 x 195	410 x 400 x 250
5.5 kg	11.5 kg	5 kg	17 kg
2 LED	2 LED	1 LED	6 LED
-10 °C ... +55 °C	-10 °C ... +55 °C	-10 °C ... +55 °C	-10 °C ... +50 °C
1-2 in parallel	2-4 in parallel	standard-resistor sufficient	4 – refer to connection diagram in the data sheet
Standard applications require a special current limitation reactor.	Standard applications require a special current limitation reactor.	not needed	only for systems with detuning-reactors

## Accessories for TSM modules

### Type / Description

Discharge resistors EW-22 at least 1 piece per step to be used for all types of TSM if fast re-switching time is required.<sup>1)</sup> For higher rated steps please contact our local sales office.

#### EW-22:

Dimensions (w x d x h): 90 x 50 x 100 mm

Weight (approx.): 0.3 kg

Design panel: for mounting on heat sink/fitting

Connection: screw terminal, ready for three-phase connection to the capacitor

### Ordering code

B44066T0022E400

<sup>1)</sup> Consisting of two single resistors of 22 kΩ each



EW-22



BD-100

#### BD-Series:

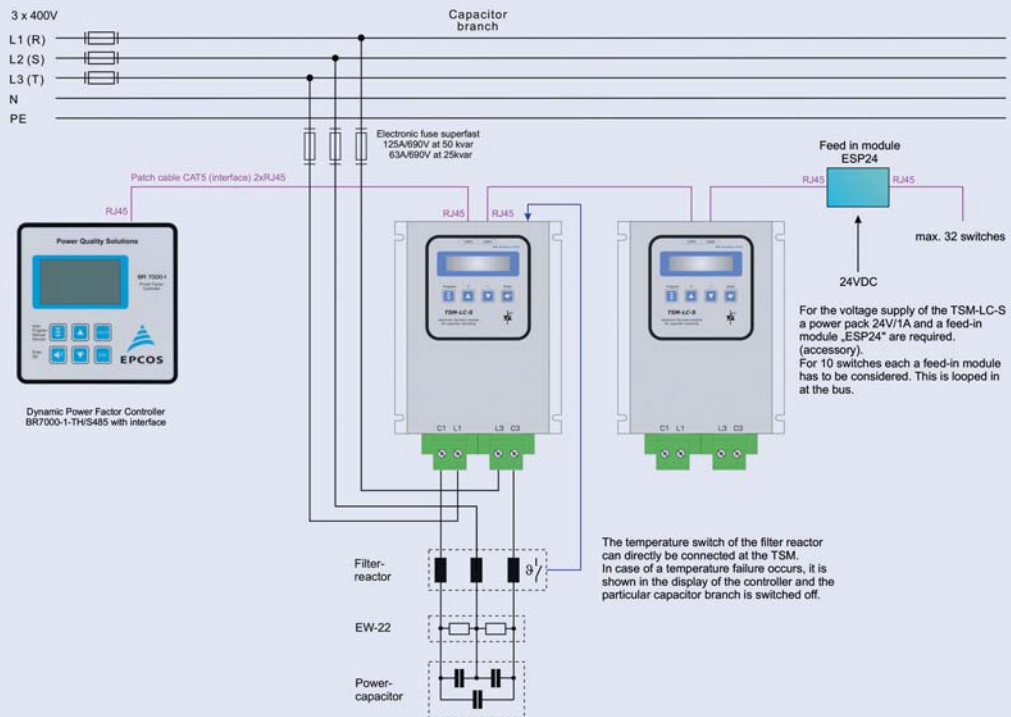
Single phase current limitation reactor for thyristor modules  
TSM-series in conventional dynamic PFC-systems without reactor

- Used for limitation of the pace of current increase  $di/dt$  in the thyristors to the maximum permissible value
- Protection of thyristor modules series TSM-LC

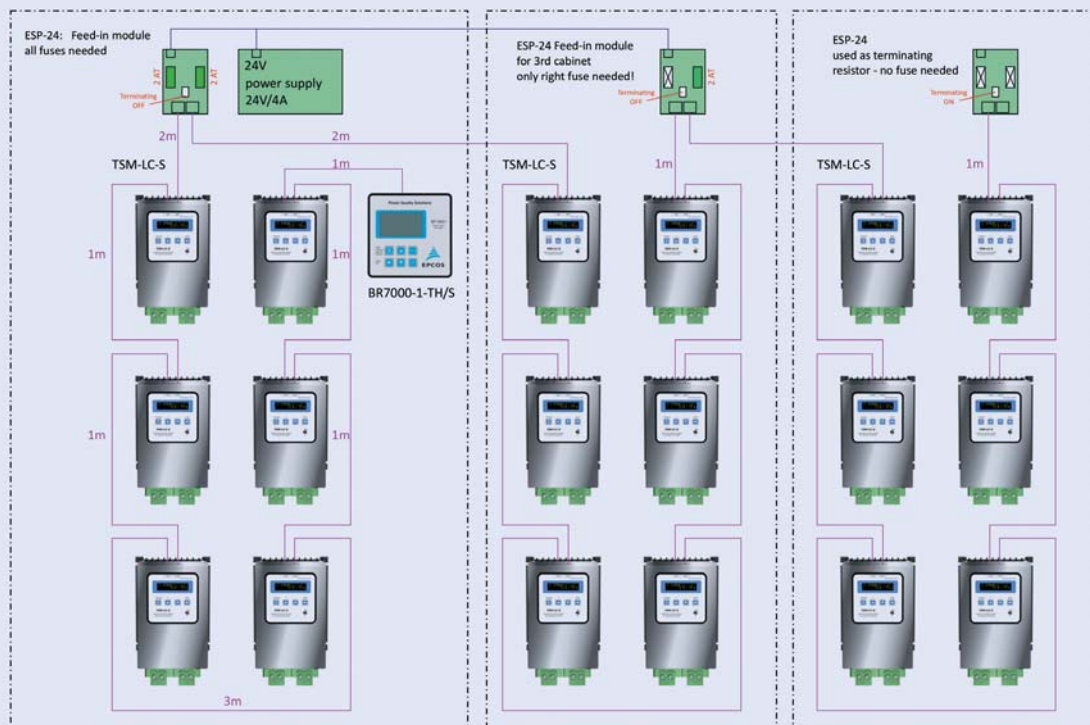
BD-200/480 <sup>2)</sup>
B44066T0200E480
480 V
170 A
50/60 Hz
104 x 114 x 125 mm
approx. 6 kg

# Switching Devices – Thyristor Modules for Dynamic PFC, TSM-Series

## Dynamic PFC network with TSM-LC-S



## Dynamic PFC network: complete system; easy connection with standard patch-cable



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