EPCOS

Product Profile 2009

Power Factor Correction

Power Quality Solutions

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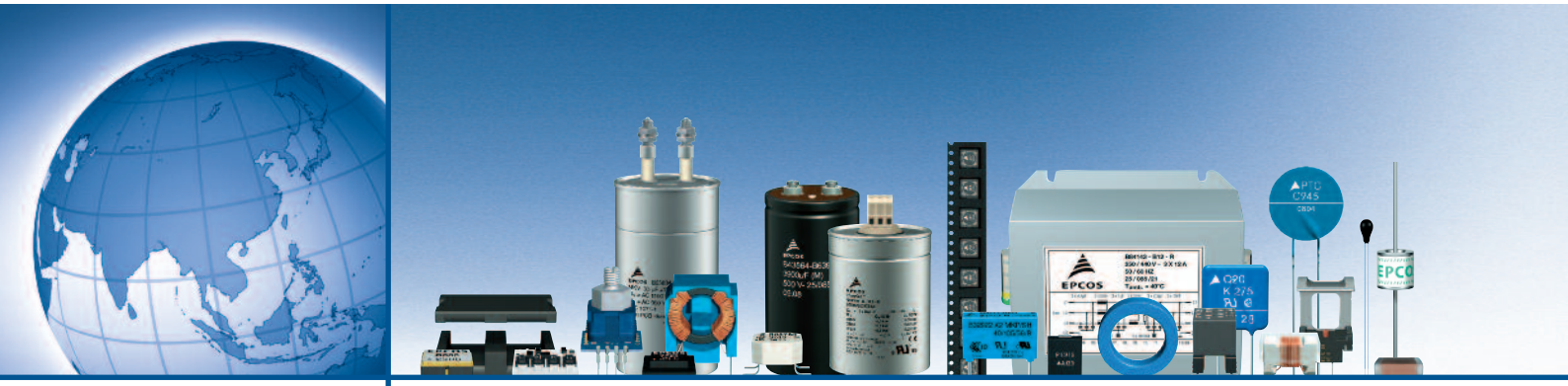
Welcome to the World of Electronic Components and Modules



EPCOS is a leading manufacturer of electronic components, modules and systems. Our broad portfolio includes capacitors, inductors and ferrites, EMC filters, sensors and sensor systems, nonlinear resistors, and arresters, as well as SAW and BAW components and RF modules. As an innovative technology-driven company, EPCOS focuses technologically demanding growth markets in the areas of information and communications technology, automotive, industrial, and consumer electronics. We offer our customers both standard components as well as application-specific solutions.

EPCOS has design, manufacturing and marketing facilities in Europe, Asia and the Americas. We are continuously strengthening our global research and development network by expanding R&D activities at our production locations, primarily in Eastern Europe, China and India. With our global presence we are able to provide our customers with local development and manufacturing know-how and support in the early phases of their projects.

EPCOS is continually improving its processes and thus the quality of its products and services. The Group is ISO/TS 16949 certified and remains committed to constantly reviewing and systematically improving its quality management system.

Power Quality Solutions

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Preview

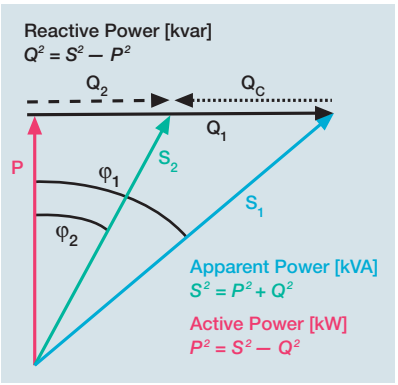
General

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 φ) 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.

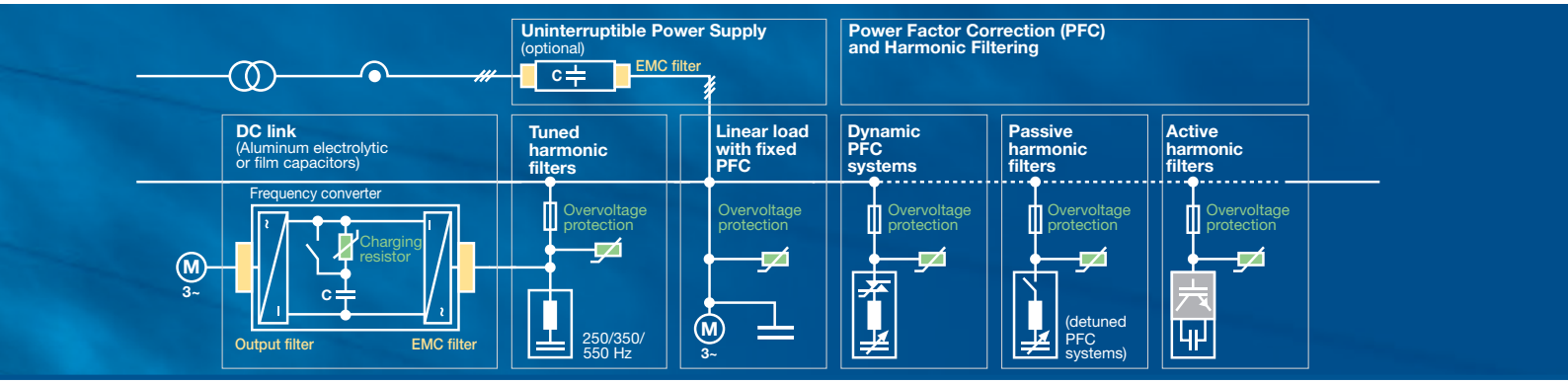
In AC networks (50/60 Hz) such a process is repeated 50 or 60 times a second. So an obvious solution is to briefly store the magnetic reversal energy in capacitors and relieve the network (supply line) of this reactive energy. For this reason, automatic reactive power compensation systems (detuned/conventional)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



Apparent power $S = \sqrt{P^2 + Q^2}$
Active power $P = S * \cos \varphi$
Reactive power $Q = S * \sin \varphi$

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

Preview



Power factor
Low power factor (cos φ)

Low cos φ results in

- higher energy consumption and costs,
- less power distributed via the network,
- power loss in the network,
- higher transformer losses,
- increased voltage drop in power distribution networks.

Power factor improvement

Power factor improvement can be achieved by

- compensation of reactive power with capacitors,
- active compensation – using semiconductors,
- overexcited synchronous machine (motor / generator).

Types of PFC
(detuned or conventional)

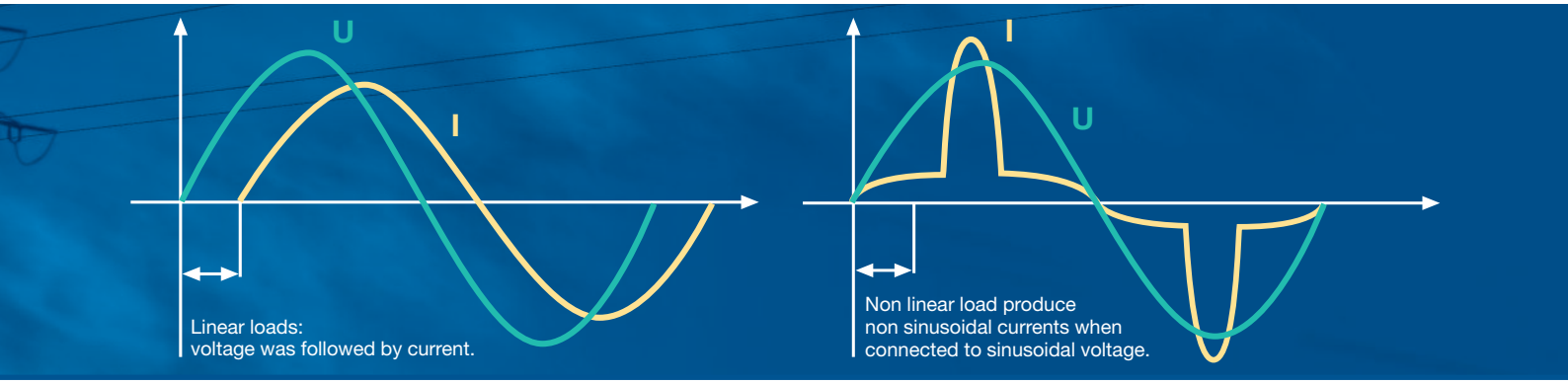
- individual or fixed compensation (each reactive power producer is individually compensated),
- group compensation (reactive power producers connected as a group and compensated as a whole),
- central or automatic compensation (by a PFC system at a central point),
- mixed compensation.

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

Preview



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.

PFC Capacitor Series Overview

PFC capacitor series for power factor correction and detuned filter				
Parameter		**PhaseCap Premium**	**PhaseCap Compact**	**PhaseCap HD**
Power	Q_R	5.0 … 36.0 kvar	5.0 … 33.0 kvar	40.0 ... 60.0 kvar
Rated voltage	V_R	230 … 800 V AC	230 … 525 V AC	400 ... 525 V AC
Inrush current	I_S	up to 200 · I_R for B25667 series up to 300 · I_R for B25668 series	up to 300 · I_R	up to 200 · I_R
Temperature class	[A]	**–40/D:** max. temp. 55 °C max. mean 24 h = 45 °C max. mean 1 year = 35 °C	**–40/D:** max. temp. 55 °C max. mean 24 h = 45 °C max. mean 1 year = 35 °C lowest temperature = –40 °C **–40/C:** max. temp. 50 °C max. mean 24 h = 40 °C max. mean 1 year = 30 °C lowest temperature = –40 °C	**–40/D:** max. temp. 55 °C max. mean 24 h = 45 °C max. mean 1 year = 35 °C
Losses: **– Dielectric** **– Total***	 Q_L Q_L	 < 0.2 W/kvar < 0.45 W/kvar	 < 0.2 W/kvar < 0.45 W/kvar	 < 0.2 W/kvar < 0.45 W/kvar
Max. humidity	H_{rel}	95%	95%	95%
Safety	–	triple (self-healing, overpressure disconnector, dry technology)	dual: self-healing, 3-phase overpressure disconnector	triple (self-healing, overpressure disconnector, dry technology)
Impregnation	–	inert gas	semi-dry biodegradable resin	inert gas, Nitrogen (N_2)
Mean life expectancy	$t_{LD\ (co)}$	up to 115 000 h for B25667 series up to 130 000 h for B25668 series	up to 180 000 h at temperature class –40/C, up to 130 000 h at temperature class –40/D	up to 130 000 h
Connection	–	SIGUT™, block-type, safety terminal	terminal strip with electric shock protection (IP20), (VDE 0106 part 100), for current and connection cable details and the terminal type / capacitor type association, see terminal drawings and the capacitor type list	SIGUT™, block-type, safety terminal
Cooling	–	natural or forced	natural or forced	natural or forced
Case / shape	–	aluminum / cylindrical	aluminum / cylindrical	aluminum / cylindrical
Enclosure		IP20, optionally IP54	IP20, indoor mounting, optionally with terminal cap for IP54 (for diameter 116 and 136 mm)	IP20
Standard		IEC 60831-1+2, UL 810 5th edition, cUL file # E238746 (for B25667; for B25668 up to 690 V)	IEC 60831-1+2, EN 60831-1+2	IEC 60831-1+2, UL 810 5th edition
Ordering code		B25667B* B25668A*	B25673A*	B25669*
Page		13	19	25
				

* Without discharge resistor

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

PFC Capacitor Series Overview

PFC capacitor series for power factor correction and detuned filter		
PhiCap	**MKV**	**MKP AC Filter**
0.5 ... 30.0 kvar	4.2 … 30.0 kvar	n/a
230 ... 525 V AC	400 … 800 V AC	250 … 600 V AC_{RMS}
up to 200 · I_R	up to 500 · I_R	n/a
–25/D: max. temp. 55 °C max. mean 24 h = 45 °C max. mean 1 year = 35 °C lowest temperature = –25 °C	**–40/D:** max. temp. 70 °C max. mean 24 h = 55 °C max. mean 1 year = 45 °C lowest temperature = –40 °C	40/70/21 θstg: –40 °C ... 85 °C θmin: –40 °C θmax: 70 °C θhs: 85 °C
< 0.2 W/kvar < 0.45 W/kvar	< 0.2 W/kvar < 0.35 W/kvar	n/a
95%	95%	95%
dual (self-healing, overpressure disconnector)	dual (self-healing, overpressure disconnector)	dual (self-healing, overpressure disconnector)
biodegradable soft resin, semi-dry	oil	soft polyurethane
up to 100 000 h	up to 300 000 h at temperature class -40/D	up to 100 000 h at V_{RMS} $\lvert\Delta C/C\rvert \leq 3\,\%$
B32344 series: SIGUT™, block-type, safety terminal **B32340 / B32343 series:** fast-on terminals	SIGUT™, block-type safety terminal	B32360 series: fast-on terminals B32361 series: M6 screw terminals B32362 series: M10 screw terminals B32363 series: quadruple fast-on terminals B32364 series: M8 screw terminals
natural or forced	natural or forced	natural or forced
aluminum / cylindrical	aluminum / cylindrical	aluminum / cylindrical
IP00, IP20, optionally IP54	IP20, optionally IP54	n/a
IEC 60831-1+2, UL 810 5th edition cUL file # E106388 CSA file # C22.2 N°190 MC # 236094	IEC 60831-1+2 EN 60831-1+2	IEC1071 UL file E106388
B32340C* B32343C* B32344D*	B25836B*	B3236*
28	35	38
		

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

PQS Key Components Overview

PF controller					
Parameter	**Power factor controller BR604 and BR6000**				**Multi measuring interface MMI6000**
Supply voltage	230 V AC				230 V AC
Measurement voltage range	30 … 300 V AC phase to neutral (i.e. 50 … 525 V phase to phase)				230 V AC
Measurement current	X/5 or X/1 selectable				X/5 or X/1 selectable
Frequency	50 and 60 Hz				50 and 60 Hz
Sensivity	50 mA / 10 mA				40 mA
	Output stages	**Relay outputs**	**Transistor outputs**	**Interface**	
	BR604	4	–		
	BR6000-R6	6	–		
	BR6000-R12	12	–		
	BR6000-T6	–	6		
	BR6000-T12	–	12		
	BR6000-T12/S485	–	12	RS485	
	BR6000-R12/F*	12	–		
	BR6000-R12/S485	12	–	RS485	
	BR6000-T6R6	6	6		
	BR6000-T6R6/S485	6	6	RS485	
Ordering code	B44066R****E23*				B44066M6***E230
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* Second message relay

PQS Key Components Overview

Switching devices			
Parameter	**Capacitor contactors**	**Thyristor modules**	**Reactors – Antiresonance harmonic filter**
		Thyristor switch for dynamic PFC systems	
Voltage	230 … 690 V	TSM-LC: 3 · 400 V TSM-HV: 3 · 690 V	400 and 440 V
Output range	12.5/20/25/33/50/75/100 kvar	TSM-LC: 10, 25, 50, 100, 200 kvar TSM-HV: 50 and 200 kvar	10 … 100 kvar
Frequency	50 / 60 Hz	50 / 60 Hz	50 or 60 Hz
De-tuning		suitable for detuned and conventional systems	factor: 5.67%, 7%, 14%
Ordering code	B44066S****J230 for all PFC systems B44066S****N230 for detuned PFC systems	TSM-LC: B44066T****E402 TSM-HV: B44066T****E690	B44066D****S400/440 (50 Hz) B44066D****S441 (60 Hz) B44066D****M400/440 (50 Hz) B44066D****M441 (60 Hz)
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	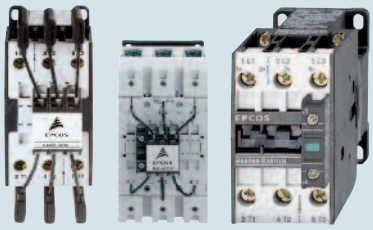		

Important Notes

The following applies to all products named in this publication:

1. Some parts of this publication contain **statements about the suitability of our products for certain areas of application**. These statements are based on our knowledge of typical requirements that are often placed on our products in the areas of application concerned. We nevertheless expressly point out **that such statements cannot be regarded as binding statements about the suitability of our products for a particular customer application**. As a rule, EPCOS is either unfamiliar with individual customer applications or less familiar with them than the customers themselves. For these reasons, it is always ultimately incumbent on the customer to check and decide whether an EPCOS product with the properties described in the product specification is suitable for use in a particular customer application.
2. We also point out that **in individual cases, a malfunction of electronic components or failure before the end of their usual service life cannot be completely ruled out in the current state of the art, even if they are operated as specified**. In customer applications requiring a very high level of operational safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health (e.g. in accident prevention or life-saving systems), it must therefore be ensured by means of suitable design of the customer application or other action taken by the customer (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of malfunction or failure of an electronic component.
3. **The warnings, cautions and product-specific notes must be observed**.
4. In order to satisfy certain technical requirements, **some of the products described in this publication may contain substances subject to restrictions in certain jurisdictions (e.g. because they are classed as hazardous)**. Useful information on this will be found in our Material Data Sheets on the Internet (www.epcos.com/material). Should you have any more detailed questions, please contact our sales offices.
5. We constantly strive to improve our products. Consequently, **the products described in this publication may change from time to time**. The same is true of the corresponding product specifications. Please check therefore to what extent product descriptions and specifications contained in this publication are still applicable before or when you place an order.

   We also **reserve the right to discontinue production and delivery of products**. Consequently, we cannot guarantee that all products named in this publication will always be available.

   The aforementioned does not apply in the case of individual agreements deviating from the foregoing for customer-specific products.
6. Unless otherwise agreed in individual contracts, **all orders are subject to the current version of the "General Terms of Delivery for Products and Services in the Electrical Industry" published by the German Electrical and Electronics Industry Association (ZVEI)**.
7. The trade names EPCOS, BAOKE, Alu-X, CeraDiode, CSMP, CSSP, CTVS, DSSP, MiniBlue, MKK, MLSC, MotorCap, PCC, PhaseCap, PhaseCube, PhaseMod, SIFERRIT, SIFI, SIKOREL, SilverCap, SIMDAD, SIMID, SineFormer, SIOV, SIP5D, SIP5K, ThermoFuse, WindCap are **trademarks registered or pending** in Europe and in other countries. Further information will be found on the Internet at www.epcos.com/trademarks.

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
- Filter applications
- 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 … 36 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 disconnector
- Shock hazard protected terminals
- Longterm approved
- cUL approval for B25667; for B25668 up to 690 V
- Ceramic discharge resistor pre-mounted

Environmental

- Dry design, inert gas
- No oil leakage

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

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 5th edition		
Overvoltage	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)
Overcurrent	I_{max}	up to 1.3 · I_R (up to 1.5 · I_R including combined effects of harmonics, overvoltages and capacitance tolerance)
Inrush current	I_S	up to 200 · I_R (B25667); up to 300 · I_R (B25668)
Losses: **– Dielectric** **– Total***		 < 0.2 W/kvar < 0.45 W/kvar
Rated frequency	f	50 / 60 Hz
Capacitance tolerance		–5% / +10%
Test voltage, terminal / terminal	V_{TT}	2.15 · V_{R1}, AC, 10 s
Test voltage, terminal / case	V_{TC}	up to $V_R \leq$ 660 V: 3000 V AC, 10 s; above V_R = 660 V: 6000 V AC, 10 s
Mean life expectancy	$t_{LD(Co)}$	up to 115000 h (B25667); up to 130000 h (B25668)
Ambient temperature		–40/D; max. temp. 55 °C; max. mean 24 h = 45 °C; max. mean 1 year = 35 °C; lowest temperature = –40 °C
Cooling		natural or forced
Humidity	H_{rel}	max. 95%
Altitude		max. 4000 m above sea level
Mounting position		upright / horizontal
Mounting and grounding		threaded M12 stud on bottom of case
Safety		dry technology, overpressure disconnector, self-healing, maximum allowed fault current 10000 A in accordance with UL 810 standard
Discharge module		ceramic discharge module pre-mounted, discharge time ≤ 75 V in 60 s; ≤ 75 V in 90 s for types marked with [4] in the ordering code table page 15 ff.
Case		extruded aluminum can
Enclosure		IP20, indoor mounting (optionally with terminal cap for IP54)
Dielectric		polypropylene film
Impregnation		inert gas, Nitrogen (N_2)
Terminals		SIGUT terminal strip with electric shock protection (IP20), (VDE 0106 part 100), max. 16 mm² cable cross-section, max. current 50 A
Certification		cUL file # E238746 for B25667; for B25668 up to 690 V
Number of switching operations		max. 5000 switchings per year according to IEC 60831-1+/2

* Without discharge resistor

PhaseCap Premium PFC Capacitors

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Three-phase capacitors

Type	50 Hz		60 Hz		C_R	d x h	Weight	Ordering code	Packing unit*
	Output kvar	I_R A	Output kvar	I_R A	µF	mm	kg		
Rated voltage 230 V AC, 50/60 Hz, delta connection									
MKK230-D-5-01	5.0	13	6.0	16	3 · 100	116 x 164	1.3	B25667B3297A375	6
MKK230-D-7.5-01	7.5	19	9.0	23	3 · 150	116 x 164	1.3	B25667B2457A375	6
MKK230-D-10.4-01	10.4	26	12.5	31	3 · 209	116 x 164	1.5	B25667B2627A375	6
MKK230-D-12.5-01[4]	12.5	31	15.0	37	3 · 251	116 x 200	1.7	B25667B2757A375	4
Rated voltage 400 V AC, 50/60 Hz, delta connection									
MKK400-D-5-01	5.0	7	6.0	9	3 · 32	116 x 164	1.1	B25667B5966A375	6
MKK400-D-7.5-01	7.5	11	9.0	13	3 · 50	116 x 164	1.2	B25667B3147A375	6
MKK400-D-10-01	10.0	14	12.0	17	3 · 64	116 x 164	1.2	B25667B4197A375	6
MKK400-D-12.5-01	12.5	18	15.0	22	3 · 83	116 x 164	1.1	B25667B3247A375	6
MKK400-D-15-01	15.0	22	18.0	26	3 · 100	116 x 164	1.3	B25667B3297A375	6
MKK400-D-20-01	20.0	30	24.0	36	3 · 133	116 x 164	1.5	B25667B3397A375	6
MKK400-D-25-01	25.0	36	–	–	3 · 165	116 x 200	1.8	B25667B3497A375	4
Rated voltage 415 V AC, 50/60 Hz, delta connection									
MKK415-D-5-01	5.0	7	6.0	8	3 · 32	116 x 164	1.1	B25667B5966A375	6
MKK415-D-6.2-01	6.2	8	7.5	10	3 · 39	116 x 164	1.2	B25667B5127A375	6
MKK415-D-10.4-01	10.4	15	12.5	17	3 · 64	116 x 164	1.2	B25667B4197A375	6
MKK415-D-12.5-01	12.5	17	15.0	21	3 · 77	116 x 164	1.3	B25667B4237A375	6
MKK415-D-15-01	15.0	21	18.0	25	3 · 93	116 x 164	1.4	B25667B4287A375	6
MKK415-D-16.7-01	16.7	23	20.0	28	3 · 103	116 x 164	1.5	B25667B4307A375	6
MKK415-D-20-01	20.8	29	25.0[2]	35[2]	3 · 128	116 x 200	1.7	B25667B4387A375	4
MKK415-D-25-01[3]	25.0	35	–	–	3 · 154	136 x 200	2.1	B25667B4467A375	4
Rated voltage 440 V AC, 50/60 Hz, delta connection									
MKK440-D-5-01	5.0	7	6.0	8	3 · 27	116 x 164	1.2	B25667B4826A375	6
MKK440-D-7.5-01	7.5	10	9.0	12	3 · 41	116 x 164	1.2	B25667B4127A375	6
MKK440-D-10.4-01	10.4	14	12.5	16	3 · 57	116 x 164	1.3	B25667B4177A375	6
MKK440-D-12.5-01	12.5	16	15.0	20	3 · 69	116 x 164	1.4	B25667B4207A375	6
MKK440-D-14.2-01	14.2	19	17.0	22	3 · 77	116 x 164	1.3	B25667B4237A375	6
MKK440-D-15-01	15.0	20	18.0	24	3 · 83	116 x 164	1.4	B25667B4247A375	6
MKK440-D-16.7-01	16.7	22	20.0	26	3 · 92	116 x 200	1.8	B25667B4277A375	4
MKK440-D-18.8-01	18.8	25	22.6	30	3 · 103	116 x 164	1.5	B25667B4307A375	6
MKK440-D-20-01	20.0	26	24.0	31	3 · 111	116 x 200	1.7	B25667B4337A375	4
MKK440-D-25-01	25.0	33	30.0	39	3 · 137	136 x 200	2.0	B25667B4417A375	4
MKK440-D-28.1-01[3]	28.1	37	–	–	3 · 154	136 x 200	2.1	B25667B4467A375	4
MKK440-D-30-01[4]	30.0[1]	39[1]	–	–	3 · 164	136 x 200	2.4	B25667B4497A375	4
MKK440-D-33-01[3, 4]	33.0	43	–	–	3 · 181	136 x 200	2.5	B25667B4547A375	4

Types for voltages 220 V, 240 V, 480 V, 600 V, 660 V and other kvar-outputs are available upon request.

[1] Temperature class deviation –40/C max. 50 °C
[2] Temperature class deviation –40/B max. 45 °C
[3] Useful life up to 100 000 h
[4] 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.

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

PhaseCap Premium PFC Capacitors

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

PhaseCap Premium

Three-phase capacitors

Type	50 Hz		60 Hz		C_R	d x h	Weight	Ordering code	Packing unit*
	Output kvar	I_R A	Output kvar	I_R A	µF	mm	kg		
Rated voltage 480 V AC, 50/60 Hz, delta connection									
MKK480-D-6.25-01	6.25	8	7.5	9	3 · 29	116 x 164	1.2	B25667B4866A375	6
MKK480-D-8.3-01	8.3	10	10.0	12	3 · 39	116 x 164	1.2	B25667B5127A375	6
MKK480-D-10.4-01	10.4	12	12.5	14	3 · 48	116 x 164	1.3	B25667B5147A375	6
MKK480-D-12.5-01	12.5	15	15.0	18	3 · 58	116 x 164	1.5	B25667B5177A375	6
MKK480-D-15-01	15.0	18	18.0	22	3 · 69	116 x 164	1.4	B25667B4207A375	6
MKK480-D-16.7-01	16.7	20	20.0	24	3 · 77	116 x 200	1.8	B25667B5237A375	4
MKK480-D-20-01	20.0	22	24.0	26	3 · 92	116 x 200	1.8	B25667B4277A375	4
MKK480-D-25-01	25.0	30	30.0	36	3 · 115	136 x 200	2.2	B25667B4347A375	4
MKK480-D-30-01[3]	30.0[1]	36[1]	–	–	3 · 138	136 x 200	2.4	B25667B4417A365	4
Rated voltage 525 V AC, 50/60 Hz, delta connection									
MKK525-D-8.3-01	8.3	9	10.0	11	3 · 32	116 x 164	1.1	B25667B5966A375	6
MKK525-D-10-01	10.0	11	12.0	13	3 · 39	116 x 164	1.2	B25667B5127A375	6
MKK525-D-12.5-01	12.5	14	15.0	17	3 · 48	116 x 164	1.3	B25667B5147A375	6
MKK525-D-15-01	15.0	17	18.0	20	3 · 58	116 x 164	1.5	B25667B5177A375	6
MKK525-D-16.7-01	16.7	18	20.0	21	3 · 64	116 x 164	1.6	B25667B5197A375	6
MKK525-D-20-01	20.0	22	24.0	26	3 · 77	116 x 200	1.8	B25667B5237A375	4
MKK525-D-25-01	25.0	28	30.0	33	3 · 96	136 x 200	2.3	B25667B5287A375	4
MKK525-D-30-01[4]	30.0[1]	33[1]	–	–	3 · 115	136 x 200	2.4	B25667B5347A375	4
Rated voltage 570 V AC, 50/60 Hz, delta connection									
MKK570-D-27.5-11	27.5	27	33	32.4	3 · 90	136 x 200	2.5	B25668A5277A375	4
Rated voltage 690 V AC, 50/60 Hz, delta connection									
MKK690-D-5-11	5.0	4.2	6	5.0	3 · 11	116 x 164	1.3	B25668A6336A375	6
MKK690-D-10-11	10.0	8.4	12	10.1	3 · 23	116 x 164	1.4	B25668A6676A375	6
MKK690-D-12.5-11	12.5	10.5	15	12.6	3 · 28	116 x 164	1.5	B25668A6836A375	6
MKK690-D-15-11	15.0	12.6	18	15.1	3 · 34	116 x 164	1.5	B25668A6107A375	6
MKK690-D-20.8-11	20.8	17.5	25	21.0	3 · 47	136 x 200	2.0	B25668A6137A375	4
MKK690-D-25-11	25.0	21.0	30	25.1	3 · 56	136 x 200	2.2	B25668A6167A375	4
Rated voltage 765 V AC, 50/60 Hz, delta connection									
MKK765-D-30-11	30	23	36	28	3 · 55	136 x 200	2.4	B25668A7167J375	4
Rated voltage 800 V AC, 50/60 Hz, delta connection									
MKK800-D-5-11	5.0	3.6	6	4.3	3 · 8	116 x 164	1.2	B25668A7246A375	6
MKK800-D-10-11	10.0	7.2	12	8.7	3 · 17	116 x 164	1.3	B25668A7496A375	6
MKK800-D-12.5-11	12.5	9.0	15	11.0	3 · 21	116 x 164	1.4	B25668A7626A375	6
MKK800-D-15-11	15.0	11.0	18	13.0	3 · 25	116 x 164	1.5	B25668A7746A375	6
MKK800-D-20-11	20.0	14.5	24	17.3	3 · 33	136 x 200	2.0	B25668A7996A375	4
MKK800-D-25-11	25.0	18.0	30	22.0	3 · 41	136 x 200	2.3	B25668A7127A375	4
MKK800-D-28-11	28.0	20.0	33	24.0	3 · 46	136 x 200	2.4	B25668A7137A375	4

Types for voltages 220 V, 240 V, 480 V, 600 V, 660 V and other kvar-outputs are available upon request.

[1] Temperature class deviation –40/C max. 50 °C
[2] Temperature class deviation –40/B max. 45 °C
[3] Useful life up to 100 000 h
[4] 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.

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

PhaseCap Premium PFC Capacitors

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

Single-phase capacitors

Type	50 Hz		60 Hz		C_R	d x h	Weight	Ordering code	Packing unit*
	Output kvar	I_R A	Output kvar	I_R A	µF	mm	kg		
Rated voltage 230 V AC, 50/60 Hz									
MKK230-I-5-01	5.2	23	6.2	28	313	116 x 164	1.1	B25667B2317A175	6
MKK230-I-6.6-01	6.6	29	7.9	34	397	116 x 164	1.4	B25667B2397A175	6
MKK230-I-7.5-01	7.5	32	9.0	38	457	116 x 164	1.3	B25667B2457A175	6
MKK230-I-8.3-01	8.3	36	10.0	43	502	116 x 164	1.3	B25667B2507A175	6
MKK230-I-9.1-01[1)]	9.1	38	–	–	548	116 x 164	1.4	B25667B2557A175	6
Rated voltage 400 V AC, 50/60 Hz									
MKK400-I-10.4-01	10.4	26	12.5	31	207	116 x 164	1.2	B25667B3207A175	6
MKK400-I-12.5-01	12.5	31	15.0	37	249	116 x 164	1.3	B25667B3247A175	6
Rated voltage 440 V AC, 50/60 Hz									
MKK440-I-6.9-01	6.9	16	8.3	19	116	116 x 164	1.3	B25667B5117A175	6
MKK440-I-8.3-01	8.3	19	10.0	23	144	116 x 164	1.5	B25667B5147A175	6
Rated voltage 525 V AC, 50/60 Hz									
MKK525-I-10-01	10.0	19	12.0	23	116	116 x 164	1.3	B25667B5117A175	6
MKK525-I-12.5-01	12.5	24	15.0	29	144	116 x 164	1.5	B25667B5147A175	6
MKK525-I-15-01[1)]	15.0	29	18.0	35	173	116 x 200	1.7	B25667B5177A175	4
MKK525-I-18.6-01[1)]	18.6	36	22.3	43	215	136 x 200	2.0	B25667B5217A175	4

Plastic protective case for capacitor

Capacitor Ø	Protection class	Cable diameter outside	Dimensions				Ordering code
			l_1	l_2	l_3	h	
mm		mm	mm	mm	mm	mm	
116 x 164	IP54	9–13	134	110	177	243	B44066X9122A000
116 x 200 / 136 x 200	IP54	10–18	154.5	130.5	186	280	B44066X9142A000

Plastic protective terminal cover

Capacitor Ø	For cable gland	Cable diameter outside	Dimensions		Ordering code
			Ø d_1	Ø d_2	
mm		mm	mm	mm	
116 x 164	PG 13.5	9–13	116	125	B44066K1211
116 x 200	PG 16	10–14	116	125	B44066K1212
136 x 200	PG 21	14–18	137	145	B44066K1421

Types for voltages 220 V, 240 V, 480 V, 600 V, 660 V and other kvar-outputs are available upon request.

[1)] Discharge time ≤ 75 V in 90 s

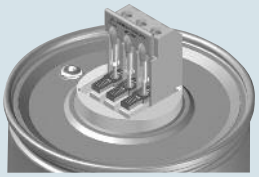
* Packing units for capacitors equal minimum order quantity. Orders will be rounded up to packing unit or multiple thereof.

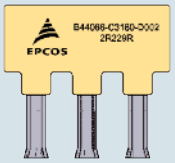
Protective terminal cover IP54

Protective case for capacitor

Ceramic discharge resistors

Pre-mounted for series B25667, B25668, B25673, B32344D and B25836; available as spare parts upon request





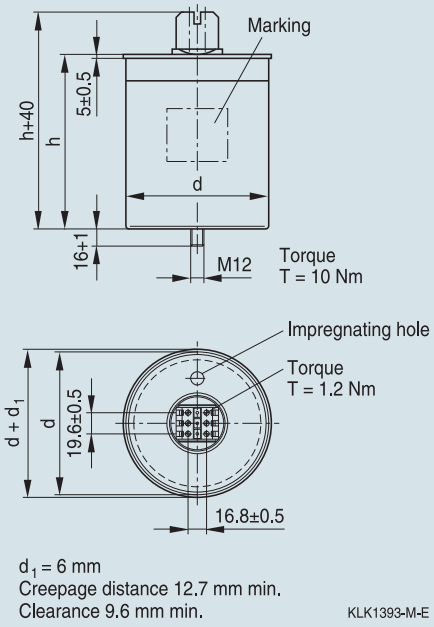
Please read *Important notes* on page 12 and *Cautions* on page 82–85.

PhaseCap Premium PFC Capacitors

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

Dimensional drawings

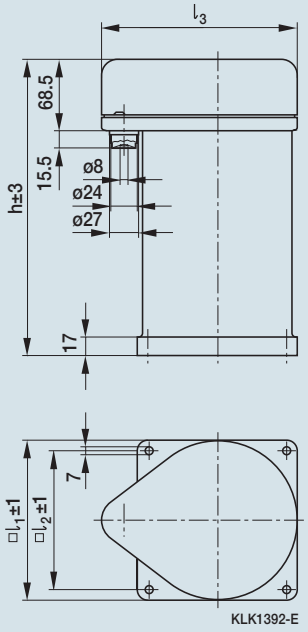
Capacitor



d_1 = 6 mm
Creepage distance 12.7 mm min.
Clearance 9.6 mm min.

KLK1393-M-E

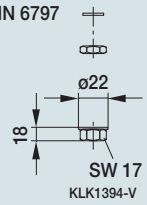
Protective case for capacitor



KLK1392-E

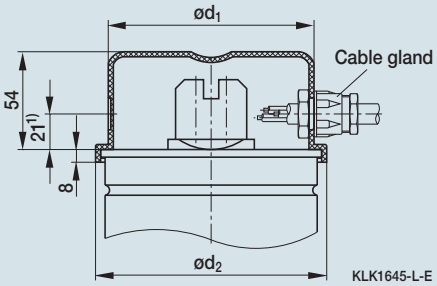
Mounting

Toothed washer J 12.5 DIN 6797
Hex nut BM12 DIN 439
or
nut C61010-A415-C15



KLK1394-V

Protective cover for terminal



KLK1645-L-E

1) Perforation for second cable gland

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

PhaseCap Compact PFC Capacitors

Semi-dry biodegradable resin ■ Concentric winding ■ Wavy cut ■ Dual safety system

General

The new PhaseCap Compact PFC capacitor is based on the EPCOS MKK technology known for many years from the successful PhaseCap series with its unique concentric windings. Based on years of experience in PFC and millions of sold capacitors, EPCOS presents the next step in PFC capacitor evolution.

Using polypropylene as dielectric and semi-dry biodegradable resin as impregnation agent, the PhaseCap Compact offers higher inrush current capability (up to 300 · I_R) and over current capability (up to 2.0 · I_R) even compared to PhaseCap. With an output of up to 33 kvar at very small height it meets the dimensional requirements of panel builders. Its new enhanced terminals permit the connection of a broader variety of cables and cable sizes. Depending on the operating conditions PhaseCap Compact provides a life expectancy of up to 180 000 hours more than any other capacitor in the EPCOS PFC capacitor portfolio besides MKV.

Applications

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

Features

- Compact design in cylindrical aluminum can with stud
- Concentric winding
- MKK-technology with wavy cut and heavy edge

Electrical features

- Very high life expectancy
- High inrush current capability (up to 300 · I_R)
- High overcurrent capability (up to 1.5 … 2.0 · I_R)

Mechanical and maintenance

- Reduced mounting costs
- Maintenance-free
- Compact dimensions
- Mounting position upright/ horizontal

Safety

- Self healing
- Overpressure disconnector
- Shock hazard protected terminals
- Pre-mounted ceramic discharge resistor

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

PhaseCap Compact PFC Capacitors

Semi-dry biodegradable resin ■ Concentric winding ■ Wavy cut ■ Dual safety system

Technical data and limit values		
Standards IEC 60831-1+2, EN 60831-1+2		
Overvoltage	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)
Overcurrent	I_{max}	up to 1.5 … 2.0 · I_R (including combined effects of harmonics, overvoltages and capacitance tolerance) depending on the individual type
Inrush current	I_S	up to 300 · I_R
Losses: **– Dielectric** **– Total***		 < 0.2 W/kvar < 0.45 W/kvar
Rated frequency	f	50 / 60 Hz
Capacitance tolerance		–5% / +10%
Test voltage, terminal / terminal	V_{TT}	2.15 · V_{R1}, AC, 10 s
Test voltage, terminal / case	V_{TC}	up to V_R ≤ 660 V: 3 000 V AC, 10 s; above V_R = 660 V: 6 000 V AC, 10 s
Mean life expectancy	$t_{LD(Co)}$	up to 180 000 h (temperature class –40/C) up to 130 000 h (temperature class –40/D)
Ambient temperature		Temperature class –40/D: Max. short time 55 °C, max. mean 24 h = 45 °C; max. mean 1 year = 35 °C; lowest temperature = –40 °C Temperature class –40/C: Max. short time 50 °C, max. mean 24 h = 40 °C; max. mean 1 year = 30 °C; lowest temperature = –40 °C
Cooling		natural or forced
Humidity	H_{rel}	max. 95%
Altitude		max. 4 000 m above sea level
Mounting position		upright / horizontal
Mounting and grounding		threaded bolt M12
Safety		self-healing, overpressure disconnector
Discharge module		ceramic discharge module pre-mounted ≤ 75 or less in 60 s
Case		extruded aluminum can with stud
Enclosure		IP20, indoor mounting (optionally with terminal cap for IP54)
Dielectric		polypropylene film
Impregnation		semi-dry biodegradable resin
Terminals		Terminal strip with electric shock protection (IP20), (VDE 0106 part 100), for current and connection cable details and the terminal type – capacitor type association please refer to the terminal drawings and the capacitor type list
Certification		n/a
Number of switching operations		max. 10 000 switchings operations per year according to IEC 60831

* Without discharge resistor

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

PhaseCap Compact PFC Capacitors

Semi-dry biodegradable resin ■ Concentric winding ■ Wavy cut ■ Dual safety system

Three-phase capacitors

Type	50 Hz		60 Hz		C_R	Terminal type	d x h	Weight	Ordering code	Pack. unit*
	Output kvar	I_R A	Output kvar	I_R A	µF		mm	kg		
Rated voltage 230 V AC, 50/60 Hz, delta connection										
MKK230-D-5-02	5.0	13.0	6.0	15.0	3 · 100	A	85 x 200	1.2	B25673A2052A040	9
MKK230-D-7.5-02	7.5	19.0	9.0	23.0	3 · 150	B	100 x 200	1.7	B25673A2072A540	6
MKK230-D-10-02	10.0	25.0	12.0	30.0	3 · 201	B	116 x 200	2.2	B25673A2102A040	4
MKK230-D-12.5-02	12.5	31.0	15.0	38.0	3 · 251	B	116 x 200	2.2	B25673A2122A540	4
Rated voltage 400 V AC, 50/60 Hz, delta connection										
MKK400-D-5-02	5.0	7.0	6.0	9.0	3 · 33	A	85 x 125	0.7	B25673A4052A000	9
MKK400-D-7.5-02	7.5	11.0	9.0	13.0	3 · 50	A	85 x 162	1.0	B25673A4072A500	9
MKK400-D-10-02	10.0	14.0	12.0	17.0	3 · 66	A	85 x 162	1.0	B25673A4102A000	9
MKK400-D-12.5-02	12.5	18.0	15.0	22.0	3 · 83	B	100 x 162	1.4	B25673A4122A500	6
MKK400-D-15-02	15.0	22.0	18.0	26.0	3 · 99	B	100 x 162	1.4	B25673A4152A000	6
MKK400-D-20-02	20.0	29.0	24.0	35.0	3 · 133	B	100 x 200	1.7	B25673A4201A000	6
MKK400-D-25-02	25.0	36.0	30.0	43.0	3 · 166	B	116 x 200	2.2	B25673A4252A000	4
Rated voltage 415 V AC, 50/60 Hz, delta connection										
MKK415-D-5-02	5.0	7.0	6.0	8.0	3 · 31	A	85 x 125	0.7	B25673A4052A010	9
MKK415-D-6.2-02	6.2	9.0	7.4	10.0	3 · 38	A	85 x 162	1.0	B25673A4062A010	9
MKK415-D-10.4-02	10.4	15.0	12.5	17.0	3 · 64	B	100 x 162	1.4	B25673A4102A010	6
MKK415-D-12.5-02	12.5	18.0	15.0	21.0	3 · 77	B	100 x 200	1.7	B25673A4122A510	6
MKK415-D-15-02	15.0	21.0	18.0	25.0	3 · 93	B	100 x 200	1.7	B25673A4152A010	6
MKK415-D-20-02	20.8	29.0	25.0	35.0	3 · 128	B	116 x 200	2.2	B25673A4202A810	4
MKK415-D-25-02	25.0	35.0	–	–	3 · 154	C	136 x 200	3.2	B25673A4282A140	2
Rated voltage 440 V AC, 50/60 Hz, delta connection										
MKK440-D-5-02	5.0	7.0	6.0	8.0	3 · 27	A	85 x 125	0.7	B25673A4052A040	9
MKK440-D-7.5-02	7.5	10.0	9.0	12.0	3 · 41	A	85 x 162	1.0	B25673A4072A540	9
MKK440-D-10.4-02	10.4	14.0	12.5	16.0	3 · 57	B	100 x 162	1.4	B25673A4102A040	6
MKK440-D-12.5-02	12.5	16.0	15.0	20.0	3 · 69	B	100 x 162	1.4	B25673A4122A540	6
MKK440-D-15-02	15.0	20.0	18.0	24.0	3 · 82	B	100 x 200	1.7	B25673A4152A040	6
MKK440-D-20-02	20.0	26.0	24.0	31.0	3 · 110	B	116 x 200	2.2	B25673A4202A040	4
MKK440-D-25-02	25.0	33.0	30.0	39.0	3 · 137	B	116 x 200	2.2	B25673A4252A040	4
MKK440-D-28.1-02	28.1	37.0	–	–	3 · 154	C	136 x 200	3.2	B25673A4282A140	2
MKK440-D-30-02	30.0	39.0	–	–	3 · 164	C	136 x 200	3.2	B25673A4302A040	2
MKK440-D-33-02	33.0	43.0	–	–	3 · 181	C	136 x 200	3.2	B25673A4332A040	2

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

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

PhaseCap Compact PFC Capacitors

Semi-dry biodegradable resin ■ Concentric winding ■ Wavy cut ■ Dual safety system

PhaseCap Compact

Three-phase capacitors

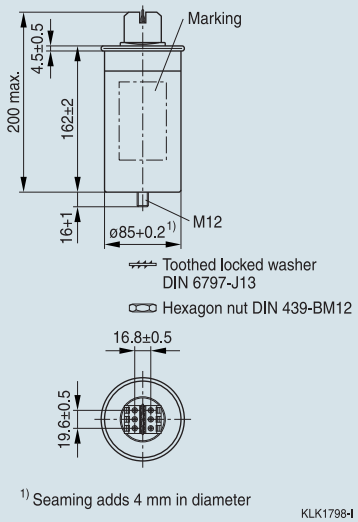
Type	50 Hz		60 Hz		C_R	Terminal type	d x h	Weight	Ordering code	Pack. unit*
	Output kvar	I_R A	Output kvar	I_R A	µF		mm	kg		
Rated voltage 480 V AC, 50/60 Hz, delta connection										
MKK480-D-6.3-02	6.3	8.0	7.6	9.0	3 · 29	A	85 x 162	1.0	B25673A4062A380	9
MKK480-D-8.3-02	8.3	11.0	10.0	12.0	3 · 38	B	100 x 162	1.4	B25673A5102A020	6
MKK480-D-10-02	10.4	14.0	12.0	15.0	3 · 48	B	100 x 200	1.7	B25673A5122A520	6
MKK480-D-12.5-02	12.5	15.0	15.0	18.0	3 · 58	B	100 x 200	1.7	B25673A4122A580	6
MKK480-D-15-02	15.0	18.0	18.0	22.0	3 · 69	B	100 x 200	1.7	B25673A4152A080	6
MKK480-D-20-02	20.0	24.0	24.0	29.0	3 · 92	B	116 x 200	2.2	B25673A4202A080	4
MKK480-D-25-02	25.0	30.0	30.0	36.0	3 · 115	C	136 x 200	3.2	B25673A4252A080	2
MKK480-D28-02	28.0	34.0	–	–	3 · 129	C	136 x 200	3.2	B25673A4282A080	2
MKK480-D-30-02	30.0	36.0	–	–	3 · 138	C	136 x 200	3.2	B25673A4302A080	2
Rated voltage 525 V AC, 50/60 Hz, delta connection										
MKK525-D-8.3-02	8.3	9.0	10.0	11.0	3 · 32	B	100 x 162	1.4	B25673A5082A320	6
MKK525-D-10-02	10.0	11.0	12.0	13.0	3 · 38	B	100 x 162	1.4	B25673A5102A020	6
MKK525-D-12.5-02	12.5	14.0	15.0	16.0	3 · 48	B	100 x 200	1.7	B25673A5122A520	6
MKK525-D-15-02	15.0	16.0	18.0	20.0	3 · 58	B	100 x 200	1.7	B25673A5152A020	6
MKK525-D-16.7-02	16.7	18.0	20.0	22.0	3 · 64	B	116 x 200	2.2	B25673A5162A720	4
MKK525-D-20-02	20.0	22.0	24.0	26.0	3 · 77	B	116 x 200	2.2	B25673A5202A020	4
MKK525-D-25-02	25.0	28.0	–	–	3 · 96	C	136 x 200	3.2	B25673A5252A020	2
MKK525-D-30-02	30.0	33.0	–	–	3 · 115	C	136 x 200	3.2	B25673A5302A020	2

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

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

Dimensional drawings

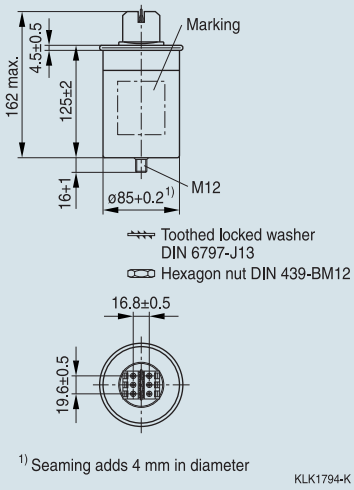
Terminal type A, d x h = 85 x 162 mm, current up to 50 A
Terminal cross section 16 mm² (without cable end lug)



1) Seaming adds 4 mm in diameter

KLK1798-I

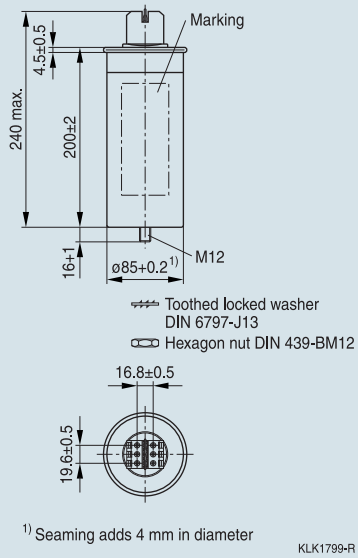
Terminal type A, d x h = 85 x 125 mm, current up to 50 A
Terminal cross section 16 mm² (without cable end lug)



1) Seaming adds 4 mm in diameter

KLK1794-K

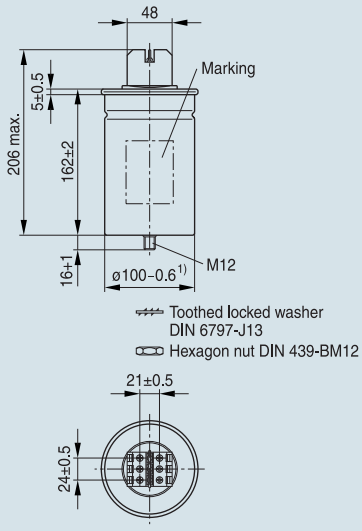
Terminal type A, d x h = 85 x 200 mm, current up to 50 A
Terminal cross section 16 mm² (without cable end lug)



1) Seaming adds 4 mm in diameter

KLK1799-R

Terminal type B, d x h = 100 x 162 mm, current up to 60 A
Terminal cross section 25 mm² (without cable end lug)



1) Seaming adds 5.5 mm in diameter

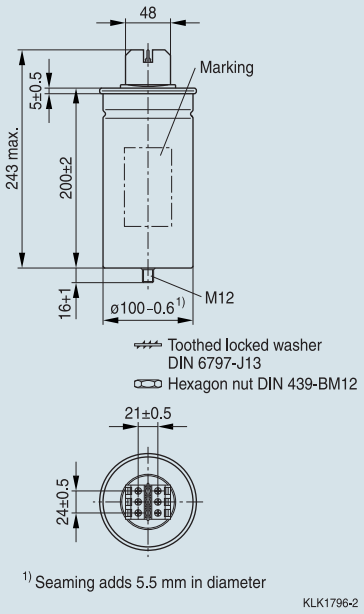
KLK1797-A

PhaseCap Compact PFC Capacitors

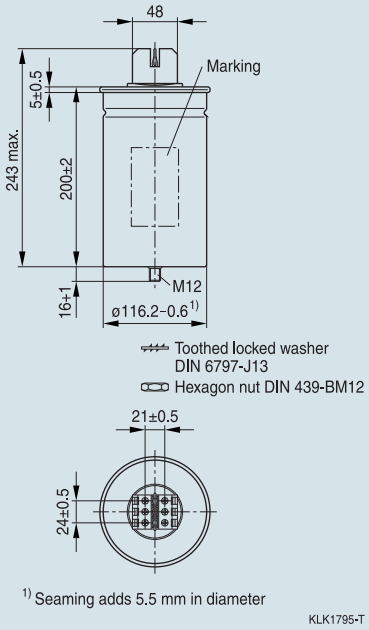
Semi-dry biodegradable resin ■ Concentric winding ■ Wavy cut ■ Dual safety system

Dimensional drawings

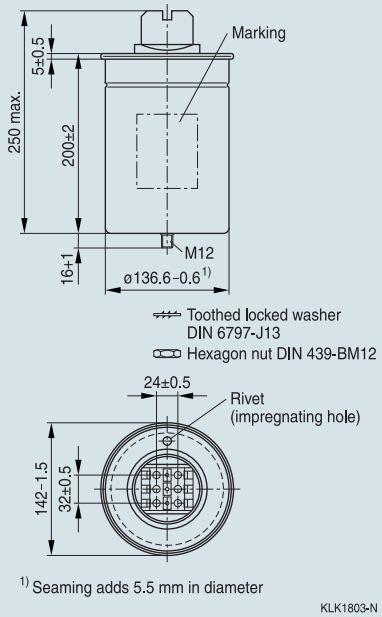
Terminal type B, d x h = 100 x 200 mm, current up to 60 A
Terminal cross section 25 mm² (without cable end lug)



Terminal type B, d x h = 116 x 200 mm, current up to 60 A
Terminal cross section 25 mm² (without cable end lug)



Terminal type C, d x h = 136 x 200 mm, current up to 130 A
Terminal cross section 35 mm² (without cable end lug)



Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

PhaseCap HD PFC Capacitors

High density type ■ Up to 60 kvar ■ Gas-impregnated ■ Wavy cut ■ Triple safety system

General

The PhaseCap HD series is a follow-on development of the MKK AC series, covering the power range above 40 through 60 kvar with just one capacitor in a cylindrical aluminum case.

The PhaseCap HD is especially intended for industrial applications with demands for long life, constant capacitance and high inrush current withstand capability up to 200 · I_R.

Such applications require typical power steps of 25 or 50 kvar switched by a PFC controller via each capacitor contactor.

This MKK AC series was developed to increase packing density per bank and cut component costs.

Applications

- Automatic PFC equipment, capacitor banks
- Individual fixed PFC (e.g. motors, transformers, lighting)
- Group fixed PFC
- Tuned and detuned capacitor banks
- Filter applications
- Dynamic PFC
- PFC systems with space constraints

Features

- Compact design in cylindrical aluminum can with stud
- Stacked winding
- MKK-technology with wavy cut and heavy edge
- Voltage range 400 V … 525 V
- Output range 40 kvar (50 Hz) … 60 kvar (60 Hz)

Electrical

- Low losses
- High pulse current withstand capability (up to 200· I_R)

Mechanical and maintenance

- Reduced mounting costs
- Maintenance-free

Safety

- Self-healing
- Overpressure disconnector
- Shock hazard protected terminals
- Long-term approved

Environmental

- Dry design, inert gas
- No oil leakage

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

PhaseCap HD PFC Capacitors

High density type ■ Up to 60 kvar ■ Gas-impregnated ■ Wavy cut ■ Triple safety system

Technical data and limit values

Standards IEC 60831-1+2, EN 60831-1+2, UL 810 5th edition		
Overvoltage	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)
Overcurrent	I_{max}	up to 1.3 · I_R (up to 1.5 · I_R including combined effects of harmonics, overvoltages and capacitance tolerance)
Inrush current	I_S	up to 200 · I_R
Losses: **– Dielectric** **– Total***		 < 0.2 W/kvar < 0.45 W/kvar
Rated frequency	f	50 / 60 Hz
Capacitance tolerance		–5% / +10%
Test voltage, terminal / terminal	V_{TT}	2.15 · V_{R1}, AC, 10 s
Test voltage, terminal / case	V_{TC}	up to $V_R \leq$ 660 V: 3000 V AC, 10 s
Mean life expectancy	$t_{LD(Co)}$	up to 130000 h
Ambient temperature		–40/D; max. temp. 55 °C; max. mean 24 h = 45 °C; max. mean 1 year = 35 °C; lowest temperature = –25 °C
Cooling		natural or forced
Humidity	H_{rel}	max. 95%
Altitude		max. 4000 m above sea level
Mounting position		upright
Mounting and grounding		threaded M12 stud on bottom of case
Safety		dry technology, overpressure disconnector, self-healing, maximum allowed fault current 10000 A in accordance with UL 810 standard
Discharge resistors		discharge module included in delivery
Case		extruded aluminum can
Enclosure		IP20, indoor mounting
Dielectric		polypropylene film
Impregnation		inert gas, Nitrogen (N_2)
Terminals		SIGUT terminal strip with electric shock protection (IP20), (VDE 0106 part 100), max. 35 mm² cable cross-section, max. current 130 A
Number of switching operations		max. 5000 switchings per year according to IEC 60831-1+/2

* Without discharge resistor

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

PhaseCap HD PFC Capacitors

High density type ■ Up to 60 kvar ■ Gas-impregnated ■ Wavy cut ■ Triple safety system

Three-phase capacitors

Type	50 Hz		60 Hz		C_R	d x h	Weight	Ordering code	Packing unit[2]
	Output kvar	I_R A	Output kvar	I_R A	µF	mm	kg		
Rated voltage 400 V AC, 50/60 Hz, delta connection									
MKK400-D-40-21	40	58	48	69	3 · 265	136 x 317	4.4	B25669A3796J375	2
MKK400-D-50-21	50	72	60[1]	87[1]	3 · 332	136 x 355	4.7	B25669A3996J375	2
(Suitable also for 415 V with 7.6% higher output)									
Rated voltage 440 V AC, 50/60 Hz, delta connection									
MKK440-D-40-21	40	52	48	63	3 · 219	136 x 317	4.4	B25669A4657J375	2
MKK440-D-50-21	50	66	60[1]	79[1]	3 · 274	136 x 355	4.7	B25669A4827J375	2
MKK440-D-56-21	56	74	–	–	3 · 307	136 x 355	4.7	B25669B4927J375	2
Rated voltage 525 V AC, 50/60 Hz, delta connection									
MKK525-D-40-21	40	44	48	53	3 · 154	136 x 355	4.7	B25669A5467J375	2

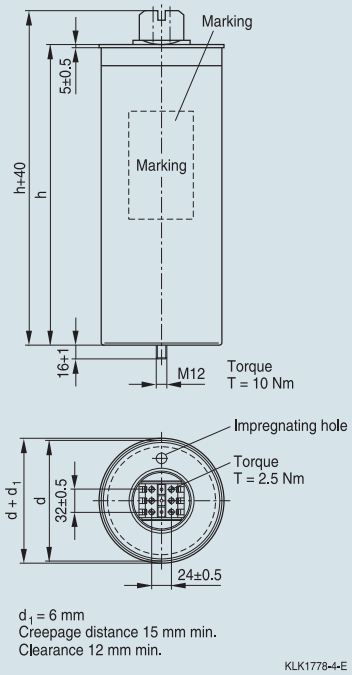
Customized products available upon request.

[1] Temperature class deviation –25/B max. 45 °C

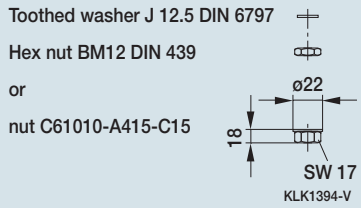
[2] Packing units for capacitors equal minimum order quantity. Orders will be rounded up to packing unit or multiple thereof.

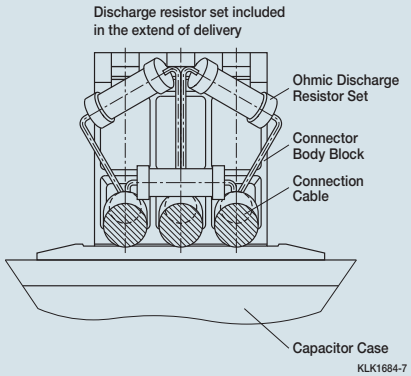
Dimensional drawings

Capacitor



Mounting





PhiCap PFC Capacitors

Biodegradable soft resin impregnated ■ Stacked winding ■ Dual safety system

General

PhiCap capacitors are a tried and tested series of MKP (metalized polypropylene) capacitors from EPCOS which have been used for PFC applications for more than 15 years.

The power range varies from 0.5 to 30.0 kvar and 0.7 to 6.0 kvar per single capacitor can, depending on a three-phase or single-phase capacitor design.

The PhiCap capacitor is especially intended for power factor correction in industrial and semi-industrial applications.

The capacitors are manufactured using metalized polypropylene film as the dielectric and housed in a cylindrical aluminum case.

Applications

- Power Factor Correction (PFC)
- Automatic capacitor banks
- Fixed PFC applications, e.g. motor compensation
- Detuned PFC systems
- Dynamic PFC systems

Features

- Compact desing in cylindrical aluminum can with stud
- Stacked winding
- MKP technology
- Voltage range 230 … 525 V
- Output range 0.5 … 30 kvar

Electrical

- Up to 30 kvar per case for three-phase applications
- Up to 6 kvar per case for single-phase applications
- Long life expectancy of up to 100 000 hours
- High pulse current withstand capability (up to 200 · I_R)

Mechanical and maintenance

- Reduced mounting costs, easy installation and connection
- Low weight and compact volume
- Maintenance-free

Safety

- Self-healing
- Overpressure disconnector
- Shock hazard protected SIGUT-terminal for B32344 series

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

PhiCap PFC Capacitors

Biodegradable soft resin impregnated ■ Stacked winding ■ Dual safety system

Technical data and limit values

Standards IEC 60831-1+2, IS: 13340/41		
Overvoltage	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)
Overcurrent	I_{max}	up to 1.3 · I_R (up to 1.5 · I_R including combined effects of harmonics, overvoltages and capacitance)
Inrush current	I_S	up to 200 · I_R
Losses: **– Dielectric** **– Total***		 < 0.2 W/kvar < 0.45 W/kvar
Rated frequency	f	50 / 60 Hz
Capacitance tolerance		–5% / 10%
Test voltage, terminal / terminal	V_{TT}	2.15 · V_R, AC, 2 s
Test voltage, terminal / case	V_{TC}	3000 V AC, 10 s
Mean life expectancy	$t_{LD(Co)}$	up to 100000 h
Ambient temperature		–25/D; max. temp. 55 °C; max. mean 24 h = 45 °C; max. mean 1 year = 35 °C; lowest temperature = –25 °C
Cooling		natural or forced
Humidity	H_{rel}	max. 95%
Altitude		max. 4000 m above sea level
Mounting position		upright
Mounting and grounding		threaded M12 (10 Nm) for case size diam. > 53 mm M8 (4 Nm) for case size diam. ≤ 53 mm
Safety		Self-healing technology, overpressure disconnector, maximum allowed fault current 10000 A in accordance with UL 810 standard
Discharge resistors		discharge module included; pre-mounted for B32344 series
Case		extruded aluminum can
Enclosure		IP20, indoor mounting (IP54 for B32344 with plastic terminal cap; for other series please refer to page 34)
Dielectric		polypropylene film
Impregnation		biodegradable soft resin, semi-dry
Terminals		SIGUT screw terminals for B32344 series, max. current 60 A, max. 16 mm² cable cross-section, fast-on terminals for B32340 and B32343 series
Number of switching operations		max. 5000 switchings per year according to IEC 60831-1+/2

* Without discharge resistor

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

PhiCap PFC Capacitors

Biodegradable soft resin impregnated ■ Stacked winding ■ Dual safety system

PhiCap

Three-phase capacitors

Type	50 Hz		60 Hz		C_R	d x h	Weight	Ordering code	Packing unit*
	Output kvar	I_R A	Output kvar	I_R A	µF	mm	kg		
Rated voltage 230 V AC, 50/60 Hz, delta connection									
MKP230-D-0.5	0.5	1.3	0.6	1.6	3 · 10	53 x 114	0.3	B32343C2002A530	12
MKP230-D-0.7	0.7	1.9	0.9	2.3	3 · 15	53 x 114	0.3	B32343C2002A730	12
MKP230-D-1.0	1.0	2.5	1.2	3.0	3 · 20	63.5 x 129	0.3	B32343C2012A030	12
MKP230-D-1.5	1.5	3.8	1.8	4.6	3 · 30	63.5 x 129	0.4	B32343C2012A530	12
MKP230-D-2.0	2.0	5.0	2.4	6.0	3 · 42	75 x 138	0.4	B32344D2022A030	6
MKP230-D-2.5	2.5	6.3	3.0	7.5	3 · 50	75 x 138	0.4	B32344D2022A530	6
MKP230-D-5.0	5.0	12.6	6.0	15.1	3 · 100	75 x 198	0.6	B32344D2052A030	6
MKP230-D-7.5	7.5	18.8	9.0	22.6	3 · 150	85 x 198	0.8	B32344D2072A530	4
MKP230-D-10.0	10.0	25.1	12.0	30.2	3 · 200	85 x 273	1.2	B32344D2102A030	4
MKP230-D-12.5	12.5	31.4	15.0	37.7	3 · 250	85 x 348	1.5	B32344D2122A530	4
MKP230-D-15.0	15.0	37.7	–	–	3 · 300	85 x 348	1.5	B32344D2152A030	4
Rated voltage 400 V AC, 50/60 Hz, delta connection									
MKP400-D-1.0	1.0	1.4	1.2	1.7	3 · 7	53 x 114	0.3	B32343C4012A000	12
MKP400-D-1.5	1.5	2.2	1.8	2.6	3 · 10	53 x 114	0.3	B32343C4012A500	12
MKP400-D-2.0	2.0	2.9	2.4	3.5	3 · 13	63.5 x 129	0.4	B32343C4022A000	12
MKP400-D-2.5	2.5	3.6	3.0	4.3	3 · 17	63.5 x 129	0.4	B32343C4022A500	12
MKP400-D-5.0	5.0	7.2	6.0	8.6	3 · 33	63.5 x 129	0.4	B32343C4052A000	12
MKP400-D-6.3	6.3	9.1	7.5	11.0	3 · 42	75 x 160	0.5	B32344D4071A500	6
MKP400-D-7.5	7.5	10.8	9.0	13.0	3 · 50	75 x 160	0.5	B32344D4072A500	6
MKP400-D-8.3	8.3	12.0	10.0	14.5	3 · 55	75 x 160	0.5	B32344D4101A000	6
MKP400-D-10.0	10.0	14.5	12.0	17.3	3 · 67	75 x 198	0.6	B32344D4102A000	6
MKP400-D-12.5	12.5	18.1	15.0	21.7	3 · 83	85 x 198	0.8	B32344D4122A500	4
MKP400-D-15.0	15.0	21.7	18.0	26.0	3 · 100	85 x 198	0.8	B32344D4152A000	4
MKP400-D-16.7	16.7	24.1	20.0	28.9	3 · 111	85 x 198	0.8	B32344D4201A000	4
MKP400-D-20.0	20.0	28.9	24.0	34.7	3 · 133	85 x 273	1.1	B32344D4202A000	4
MKP400-D-25.0	25.0	36.1	–	–	3 · 166	85 x 273	1.5	B32344D4252A000	4
Rated voltage 415 V AC, 50/60 Hz, delta connection									
MKP415-D-1.0	1.0	1.4	1.2	1.6	3 · 6	53 x 114	0.3	B32343C4012A010	12
MKP415-D-1.5	1.5	2.1	1.8	2.4	3 · 9	53 x 114	0.3	B32343C4012A510	12
MKP415-D-2.0	2.0	2.8	2.4	3.4	3 · 12	53 x 114	0.4	B32343C4022A010	12
MKP415-D-2.5	2.5	3.5	3.0	4.2	3 · 15	63.5 x 129	0.4	B32343C4022A510	12
MKP415-D-5.0	5.0	7.0	6.0	8.4	3 · 31	63.5 x 154	0.4	B32343C4052A010	12
MKP415-D-6.3	6.3	8.8	7.5	10.6	3 · 39	75 x 160	0.5	B32344D4071A510	6
MKP415-D-7.5	7.5	10.4	9.0	12.5	3 · 46	75 x 198	0.6	B32344D4072A510	6
MKP415-D-10.0	10.0	13.9	12.0	16.7	3 · 62	75 x 198	0.6	B32344D4102A010	6
MKP415-D-12.5	12.5	17.4	15.0	20.9	3 · 77	85 x 198	0.8	B32344D4122A510	4
MKP415-D-15.0	15.0	20.9	18.0	25.1	3 · 92	85 x 273	1.2	B32344D4152A010	4
MKP415-D-20.0	20.0	27.9	24.0	33.4	3 · 123	85 x 273	1.2	B32344D4202A010	4
MKP415-D-25.0	25.0	34.8	–	–	3 · 154	85 x 348	1.5	B32344D4252A010	4
Rated voltage 440 V AC, 50/60 Hz, delta connection									
MKP440-D-0.9	0.9	1.2	1.0	1.3	3 · 5	53 x 114	0.3	B32343C4011A040	12
MKP440-D-1.0	1.0	1.3	1.2	1.6	3 · 6	53 x 114	0.3	B32343C4012A040	12
MKP440-D-1.2	1.2	1.6	1.5	2.0	3 · 7	53 x 114	0.3	B32343C4011A540	12

Types for voltages 220, 240, 480, 600, 660 V and other kvar-values available upon request.

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

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

PhiCap PFC Capacitors

Biodegradable soft resin impregnated ■ Stacked winding ■ Dual safety system

Three-phase capacitors

Type	50 Hz		60 Hz		C_R	d x h	Weight	Ordering code	Packing unit*
	Output kvar	I_R A	Output kvar	I_R A	µF	mm	kg		
Rated voltage 440 V AC, 50/60 Hz, delta connection									
MKP440-D-1.5	1.5	2.0	1.8	2.3	3 · 8	53 x 114	0.3	B32343C4012A540	12
MKP440-D-2.1	2.1	2.7	2.5	3.3	3 · 11	53 x 114	0.4	B32343C4021A540	12
MKP440-D-2.5	2.5	3.3	3.0	3.9	3 · 14	63.5 x 129	0.3	B32343C4022A540	12
MKP440-D-4.2	4.2	5.5	5.0	6.6	3 · 23	63.5 x 129	0.4	B32343C4051A040	12
MKP440-D-5.0	5.0	6.5	6.0	7.8	3 · 27	63.5 x 154	0.5	B32343C4052A040	12
MKP440-D-6.3	6.3	8.3	7.5	9.9	3 · 34	75 x 160	0.5	B32344D4071A540	6
MKP440-D-7.5	7.5	9.9	9.0	11.8	3 · 41	75 x 160	0.5	B32344D4072A540	6
MKP440-D-8.3	8.3	10.9	10.0	13.1	3 · 46	75 x 198	0.6	B32344D4101A040	6
MKP440-D-10.0	10.0	13.1	12.0	15.8	3 · 55	75 x 198	0.6	B32344D4102A040	6
MKP440-D-10.4	10.4	13.7	12.5	16.4	3 · 57	75 x 198	0.6	B32344D4121A540	6
MKP440-D-12.5	12.5	16.4	15.0	19.7	3 · 69	85 x 198	0.8	B32344D4151A040	4
MKP440-D-15.0	15.0	19.7	18.0	23.6	3 · 82	85 x 273	1.2	B32344D4152A040	4
MKP440-D-16.7	16.7	21.9	20.0	26.3	3 · 92	85 x 273	1.2	B32344D4201A040	4
MKP440-D-20.8	20.8	27.3	25.0	32.8	3 · 114	85 x 273	1.2	B32344D4251A040	4
MKP440-D-25.0	25.0	32.8	30.0	40.0	3 · 138	85 x 348	1.5	B32344D4252A040	4
MKP440-D-28.0	28.0	36.8	–	–	3 · 154	85 x 348	1.5	B32344D4282A040	4
MKP440-D-30.0	30.0	39.0	–	–	3 · 165	85 x 348	1.6	B32344D4302A040	4
Rated voltage 480 V AC, 50/60 Hz, delta connection									
MKP480-D-1.5	1.5	1.8	1.8	2.2	3 · 7	63.5 x 129	0.4	B32343C4012A580	12
MKP480-D-2.0	2.0	2.4	2.4	2.9	3 · 9	63.5 x 129	0.4	B32343C4022A080	12
MKP480-D-2.5	2.5	3.0	3.0	3.6	3 · 11	63.5 x 129	0.4	B32343C4022A580	12
MKP480-D-4.2	4.2	5.1	5.0	6.1	3 · 19	63.5 x 154	0.5	B32343C4051A080	12
MKP480-D-5.0	5.0	6.0	6.0	7.2	3 · 23	75 x 160	0.5	B32344D4052A080	6
MKP480-D-6.3	6.3	7.6	7.6	9.1	3 · 29	75 x 160	0.5	B32344D4071A580	6
MKP480-D-7.5	7.5	9.0	9.0	10.8	3 · 35	75 x 198	0.6	B32344D4072A580	6
MKP480-D-8.3	8.3	10.0	10.0	12.0	3 · 38	75 x 198	0.6	B32344D4101A080	6
MKP480-D-10.4	10.4	12.5	12.5	15.0	3 · 48	85 x 198	0.8	B32344D4121A580	4
MKP480-D-12.5	12.5	15.1	15.0	18.1	3 · 58	85 x 198	0.8	B32344D4151A080	4
MKP480-D-15.0	15.0	18.1	18.0	21.7	3 · 69	85 x 273	1.2	B32344D4152A080	4
MKP480-D-16.7	16.7	20.1	20.0	24.1	3 · 77	85 x 273	1.2	B32344D4162A780	4
MKP480-D-20.8	20.8	25.0	25.0	30.1	3 · 96	85 x 273	1.2	B32344D4202A080	4
MKP480-D-25.0	25.0	30.1	30.0	36.1	3 · 115	85 x 348	1.5	B32344D4252A080	4
MKP480-D-30.0	30.0	36.1	–	–	3 · 138	85 x 348	1.5	B32344D4302A080	4
Rated voltage 525 V AC, 50/60 Hz, delta connection									
MKP525-D-1.0	1.0	1.1	1.2	1.3	3 · 4	53 x 114	0.3	B32343C5012A020	12
MKP525-D-1.5	1.5	1.6	1.8	2.0	3 · 6	53 x 114	0.3	B32343C5012A520	12
MKP525-D-2.0	2.0	2.2	2.4	2.6	3 · 8	63.5 x 129	0.4	B32343C5022A020	12
MKP525-D-2.5	2.5	2.7	2.7	3.0	3 · 9	63.5 x 129	0.4	B32343C5022A520	12
MKP525-D-5.0	5.0	5.5	6.0	6.6	3 · 19	75 x 160	0.3	B32344D5061A020	6
MKP525-D-6.3	6.3	6.9	7.6	8.3	3 · 24	75 x 160	0.5	B32344D5071A520	6
MKP525-D-8.3	8.3	9.1	10.0	11.0	3 · 32	75 x 198	0.6	B32344D5101A020	6
MKP525-D-10.4	10.4	11.5	12.5	13.7	3 · 40	85 x 198	0.8	B32344D5121A520	4
MKP525-D-12.5	12.5	13.8	15.0	16.5	3 · 48	85 x 273	1.2	B32344D5151A020	4
MKP525-D-16.7	16.7	18.3	20.0	21.9	3 · 64	85 x 273	1.2	B32344D5201A020	4
MKP525-D-20.8	20.8	22.9	25.0	27.5	3 · 80	85 x 348	1.5	B32344D5202A020	4
MKP525-D-25.0	25.0	27.5	30.0	33.0	3 · 96	85 x 348	1.5	B32344D5252A020	4

Types for voltages 220, 240, 480, 600, 660 V and other kvar-values available upon request.

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

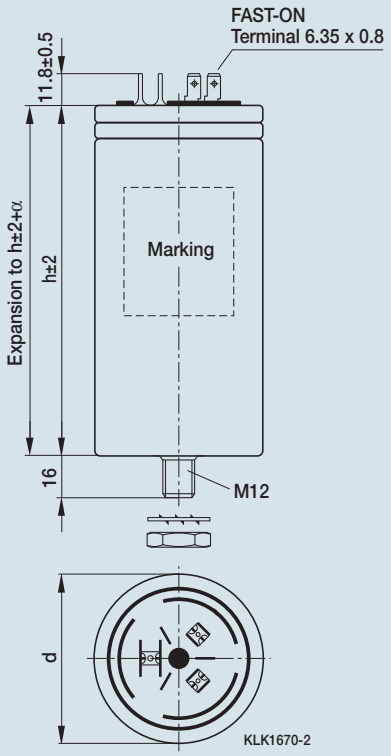
Please read *Important notes* on page 12 and *Cautions* on page 82–85.

PhiCap PFC Capacitors

Biodegradable soft resin impregnated ■ Stacked winding ■ Dual safety system

Dimensional drawings: three-phase capacitors

Capacitor B32343 series

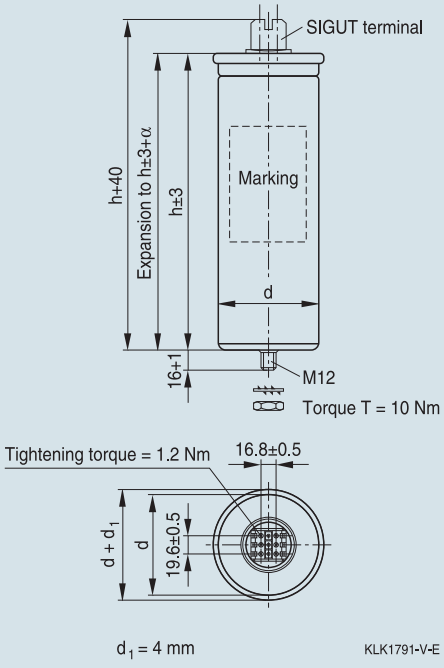


Creepage distance	10.5 mm (ø 53) 10.0 mm (ø 63.5)
Clearance	13.0 mm (ø 53) 16.5 mm (ø 63.5)
Diameter (ø)	53.0 mm 63.5 mm
Expansion α	max. 12 mm

Mounting

	M12 (ø 63.5 mm)	M8 (ø 53.0 mm)
Torque	T = 10 Nm	T = 4 Nm
Toothed washer	J12.5 DIN 6797	J8.0 DIN 6797
Hex nut	BM12 DIN 439	BM 8 DIN 439

Capacitor B32344 series



Creepage distance	9.6 mm
Clearance	12.7 mm
Diameter d (ø)	79.5 mm / 89.5 mm
Diameter d1 (ø)	75.0 mm / 85.0 mm
Expansion α	max. 13 mm

Mounting

	M12	M5
Torque	T = 10 Nm	T = 2.5 Nm
Toothed washer	J12.5 DIN 6797	
Hex nut	BM12 DIN 439	

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

PhiCap PFC Capacitors

Biodegradable soft resin impregnated ■ Stacked winding ■ Dual safety system

Single-phase capacitors

Type	50 Hz		60 Hz		C_R	d x h	Weight	Ordering code	Packing unit*
	Output kvar	I_R A	Output kvar	I_R A	µF	mm	kg		
Rated voltage 230 V AC, 50/60 Hz									
MKP230-I-0.8	0.8	3.6	1.0	4.3	50	63.5 x 105	0.30	B32340C2002A830	12
MKP230-I-1.7	1.7	7.2	2.0	8.7	100	63.5 x 142	0.40	B32340C2012A730	12
MKP230-I-2.5	2.5	10.9	3.0	13.1	150	63.5 x 142	0.50	B32340C2022A530	12
Rated voltage 400 V AC, 50/60 Hz									
MKP400-I-0.8	0.8	2.0	1.0	2.3	15	63.5 x 68	0.30	B32340C3001A880	12
MKP400-I-1.7	1.7	4.2	2.0	5.0	33	63.5 x 68	0.30	B32340C4012A700	12
MKP400-I-2.5	2.5	6.3	3.0	7.5	50	63.5 x 105	0.40	B32340C4022A500	12
MKP400-I-3.3	3.3	8.4	4.0	10.0	66	63.5 x 105	0.40	B32340C4032A300	12
MKP400-I-4.2	4.2	10.4	5.0	12.5	83	63.5 x 142	0.40	B32340C4051A000	12
MKP400-I-5.0	5.0	12.4	6.0	15.0	99	63.5 x 142	0.50	B32340C4052A000	12
Rated voltage 415 V AC, 50/60 Hz									
MKP415-I-0.8	0.8	2.0	1.0	2.4	15	63.5 x 68	0.35	B32340C4082A310	12
MKP415-I-1.7	1.7	4.0	2.0	4.8	31	63.5 x 105	0.45	B32340C4012A710	12
MKP415-I-2.5	2.5	6.0	3.0	7.2	46	63.5 x 105	0.50	B32340C4022A510	12
MKP415-I-3.3	3.3	8.0	4.0	9.7	62	63.5 x 142	0.50	B32340C4032A310	12
MKP415-I-5.0	5.0	12.0	6.0	14.5	91	63.5 x 142	0.60	B32340C4052A010	12
Rated voltage 440 V AC, 50/60 Hz									
MKP440-I-0.7	0.7	1.6	0.8	1.9	11	63.5 x 68	0.30	B32340C4001A840	12
MKP440-I-1.4	1.4	3.2	1.7	3.8	23	63.5 x 68	0.30	B32340C4011A740	12
MKP440-I-2.1	2.1	4.7	2.5	5.7	34	63.5 x 105	0.40	B32340C4021A540	12
MKP440-I-2.8	2.8	6.4	3.3	7.6	46	63.5 x 105	0.40	B32340C4031A340	12
MKP440-I-3.3	3.3	7.6	4.0	9.1	55	63.5 x 142	0.50	B32340C4032A340	12
MKP440-I-4.2	4.2	9.5	5.0	11.4	68	63.5 x 142	0.50	B32340C4051A040	12
MKP440-I-5.0	5.0	11.4	6.0	13.6	82	63.5 x 142	0.60	B32340C4052A040	12
Rated voltage 480 V AC, 50/60 Hz									
MKP480-I-0.7	0.7	1.5	0.8	1.7	10	63.5 x 105	0.30	B32340C4001A880	12
MKP480-I-1.4	1.4	2.9	1.7	3.5	19	63.5 x 105	0.30	B32340C4011A780	12
MKP480-I-2.1	2.1	4.3	2.5	5.2	29	63.5 x 105	0.50	B32340C4021A580	12
MKP480-I-2.8	2.8	5.8	3.3	6.9	38	63.5 x 142	0.50	B32340C4031A380	12
Rated voltage 525 V AC, 50/60 Hz									
MKP525-I-1.4	1.4	2.6	1.7	3.1	15	63.5 x 105	0.30	B32340C5011A720	12
MKP525-I-2.8	2.8	5.2	3.3	6.2	31	63.5 x 142	0.50	B32340C5031A330	12
MKP525-I-3.3	3.3	6.3	4.0	7.6	38	63.5 x 142	0.60	B32340C5032A320	12
MKP525-I-4.2	4.2	8.0	5.0	9.5	48	63.5 x 142	0.70	B32340C5051A020	12

Types for voltages 220, 240, 480, 600, 660 V and other kvar-values available upon request.

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

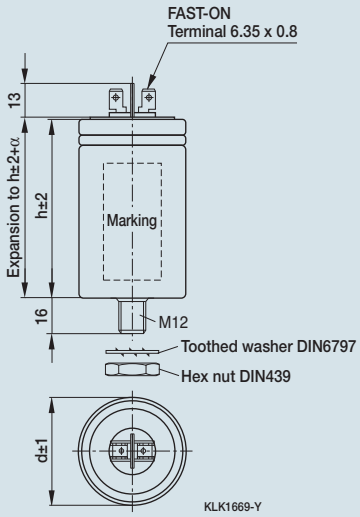
Please read *Important notes* on page 12 and *Cautions* on page 82–85.

PhiCap PFC Capacitors

Biodegradable soft resin impregnated ■ Stacked winding ■ Dual safety system

Dimensional drawings: single-phase capacitors

Capacitor B32340 series

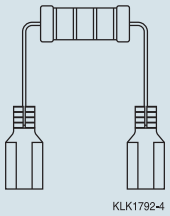


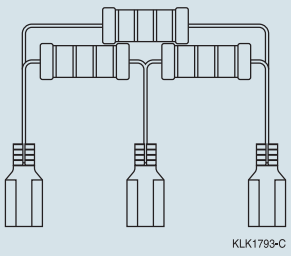
Creepage distance	10.0 mm
Clearance	16.5 mm
Diameter (ø)	63.5 mm
Expansion α	max. 12 mm

Mounting

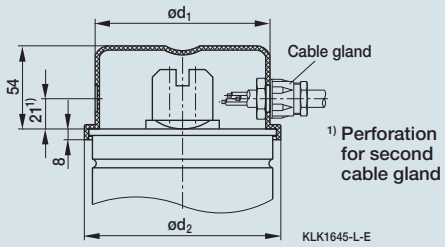
	M12
Torque	T = 10 Nm
Toothed washer	J12.5 DIN 6797
Hex nut	BM12 DIN 439

Discharge resistors for B32340 and B32343 series





Protective cover for terminal, protection class / IP54



Ø in mm	Ordering code
53.0	B44066K0530A000*
63.5	B44066K0635A000*
75	B44066K0795A000
85	B44066K0895A000

* For B32340- and B32343-series (diameter 53.0 and 63.5 mm), terminal covers with cable entry on top

For IP54 additional cable gland at cable entry required.

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

MKV PFC Capacitors

Oil impregnated ■ Stacked winding ■ Metallized paper technology ■ Dual safety system

General

The winding element of the MKV capacitor consists of a dielectric of polypropylene film and an electrode of double-sided metalized paper.

This winding construction achieves low losses and a high pulse-current withstand capability. Oil is used for impregnation of the capacitor.

The oil impregnation (due to the paper film) enables good heat dissipation from the winding element to the aluminum can's surface, thus preventing hot spots in the winding element.

The capacitor is designed to cover ambient temperatures of up to 70 °C max.

Applications

- Power Factor Correction to improve the power quality
  - Applications with high thermal loading
  - PFC systems dealing with high harmonic loads
- AC applications in industrial electronics, e.g. high dv/dt
- Tuned harmonic filter

Features

Electrical

- Long life expectancy (up to 300 000 h)
- Maximum pulse current withstand capability (up to 500 · I_R)

Mechanical and maintenance

- Easy installation and connection
- Maintenance-free

Safety

- Self-healing
- Overpressure disconnector
- Shock hazard protected terminals

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

MKV PFC Capacitors

Oil impregnated ■ Stacked winding ■ Metallized paper technology ■ Dual safety system

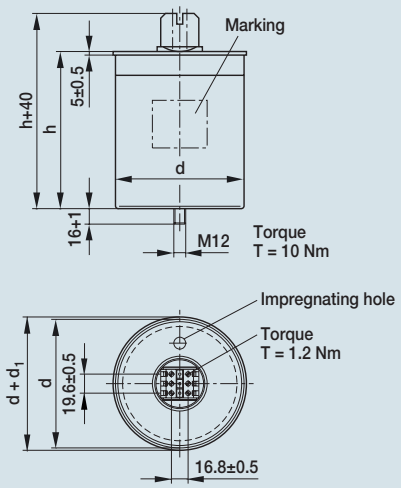
MKV

Technical data and limit values

Standards IEC 60831-1+2		
Overvoltage	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)
Overcurrent	I_{max}	up to 3 · I_R depending on the exact capacitor type (including combined effects of harmonics, overvoltages and capacitance tolerance)
Inrush current	I_S	up to 500 · I_R
Losses: **– Dielectric** **– Total***		 < 0.2 W/kvar < 0.35 W/kvar
Rated frequency	f	50 / 60 Hz
Capacitance tolerance		–5% / +10%
Test voltage, terminal / terminal	V_{TT}	2.15 · V_{R1}, AC, 10 s
Test voltage, terminal / case	V_{TC}	up to $V_R \leq$ 500 V: 3 000 V AC, 10 s, above V_R = 500 V: 4 000 V AC, 10 s
Mean life expectancy	$t_{LD(Co)}$	up to 300 000 h @ temperature class –40/D
Ambient temperature		up to 70 °C environmental temperature permanently** Temperature class –40/D: max. mean 24 h = 45 °C; max. mean 1 year = 35 °C; lowest temperature = –40 °C
Cooling		natural or forced
Humidity	H_{rel}	max. 95%
Altitude		max. 4 000 m above sea level
Mounting position		upright or horizontal
Mounting and grounding		threaded M12 stud on bottom of case
Safety		overpressure disconnector, self-healing
Discharge module		discharge module pre-mounted
Case		extruded aluminum can
Enclosure		IP20, indoor mounting (optionally with terminal cap for IP54)
Dielectric		polypropylene film with paper as electrode carrier
Impregnation		oil
Terminals		SIGUT terminal strip with electric shock protection (IP20), (VDE 0106 part 100), max. 16 mm² cable cross-section, max. current 50 A
Number of switching operations		max. 20 000 switchings per year according to IEC 60831-1+/2 max. 50 000 switchings per year according to IEC 60831-1+/2 in case standard PFC reactors are additionally applied

* Without discharge resistor ** Inflicting an respective shorter life time

Dimensional drawings



d_1 = 2 ... 6 mm (depending on the capacitor type; for details please refer to the data sheet)
Creepage distance 12.7 mm min.
Clearance 9.6 mm min.

KLK1393-M-E

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

MKV PFC Capacitors

Oil impregnated ■ Stacked winding ■ Metallized paper technology ■ Dual safety system

Three-phase capacitors

Type	50 Hz		60 Hz		$I_{max\ RMS}$	C_R	d x h	Weight	Ordering code	Pack. unit*
	Output kvar	I_R A	Output kvar	I_R A	A	µF	mm	kg		
Rated voltage 400 V AC, 50/60 Hz, delta connection										
MKV400-D-5-02	5.0	7.2	6.0	8.7	55	3 · 33.2	95.2 x 248	2.3	B25836B4996A305	2
MKV400-D-10-02	10.0	14.4	12.0	17.3	55	3 · 66.3	116.2 x 248	3.1	B25836B4197A305	2
MKV400-D-12.5-02	12.5	18.0	15.0	21.7	55	3 · 82.9	116.2 x 248	3.1	B25836B4247A305	2
MKV400-D-15-02	15.0	21.7	18.0	26.0	55	3 · 99.5	116.2 x 248	3.1	B25836B3297A305	2
MKV400-D-20-02	20.0	28.9	24.1	34.7	55	3 · 133.0	116.2 x 325	4.5	B25836B3397A305	2
MKV400-D-25-02	25.0	36.1	30.0	43.4	55	3 · 166.0	116.2 x 325	4.5	B25836B3497A305	2
Rated voltage 440 V AC, 50/60 Hz, delta connection										
MKV440-D-6-02	6.1	7.9	7.3	9.5	55	3 · 33.2	95.2 x 248	2.3	B25836B4996A305	2
MKV440-D-12-02	12.1	15.9	14.5	19.0	55	3 · 66.3	116.2 x 248	3.1	B25836B4197A305	2
MKV440-D-15-02	15.1	19.8	18.2	23.8	55	3 · 82.9	116.2 x 248	3.1	B25836B4247A305	2
MKV440-D-20-02	20.2	26.5	24.2	31.7	55	3 · 110.5	116.2 x 325	4.5	B25836B4337A305	2
MKV440-D-25-02	25.0	32.8	30.0	39.4	55	3 · 137.0	116.2 x 325	4.5	B25836B4417A305	2
Rated voltage 480 V AC, 50/60 Hz, delta connection										
MKV480-D-4-02	4.2	5.0	5.0	6.0	55	3 · 19.3	95.2 x 248	2.3	B25836B5576A305	2
MKV480-D-10-02	10.4	12.6	12.5	15.1	55	3 · 48.1	116.2 x 248	3.1	B25836B5147A305	2
MKV480-D-12.5-02	12.6	15.1	15.1	18.2	55	3 · 58.0	116.2 x 248	3.1	B25836B5177A305	2
MKV480-D-15-02	15.0	18.0	18.0	21.6	55	3 · 69.0	116.2 x 248	3.1	B25836B4207A305	2
MKV480-D-20-02	20.0	24.1	24.0	28.9	55	3 · 92.2	116.2 x 325	4.5	B25836B4277A305	2
MKV480-D-25-02	25.0	30.0	30.0	36.0	55	3 · 115.0	116.2 x 325	4.5	B25836B4347A305	2
Rated voltage 525 V AC, 50/60 Hz, delta connection										
MKV525-D-5-02	5.0	5.5	6.0	6.6	55	3 · 19.3	95.2 x 248	2.3	B25836B5576A305	2
MKV525-D-10-02	10.0	11.0	12.0	13.2	55	3 · 38.5	95.2 x 248	2.3	B25836B5117A305	2
MKV525-D-12.5-02	12.5	13.7	15.0	16.5	55	3 · 48.1	116.2 x 248	3.1	B25836B5147A305	2
MKV525-D-15-02	15.1	16.6	18.1	19.9	55	3 · 58.0	116.2 x 248	3.1	B25836B5177A305	2
MKV525-D-20-02	20.0	22.0	24.0	26,4	55	3 · 77.0	116.2 x 325	4.5	B25836B5237A305	2
MKV525-D-25-02	25.0	27.5	30.0	33.0	55	3 · 96.2	116.2 x 325	4.5	B25836B5287A305	2
Rated voltage 600 V AC, 50/60 Hz, delta connection										
MKV600-D-10.4-02	10.4	10.0	12.5	12.0	55	3 · 30.7	116.2 x 248	3.1	B25836B6926A305	2
Rated voltage 690 V AC, 50/60 Hz, delta connection										
MKV690-D-5-02	5.0	4.2	6.0	5.0	55	3 · 11.2	95.2 x 248	2.3	B25836B6336A305	2
MKV690-D-10-02	10.1	8.4	12.1	10.1	55	3 · 22.5	95.2 x 248	2.3	B25836B6666A305	2
MKV690-D-12.5-02	12.5	10.5	15.0	12.6	55	3 · 27.9	116.2 x 248	3.1	B25836B6836A305	2
MKV690-D-15-02	15.0	12.6	18.0	15.1	55	3 · 33.5	116.2 x 248	3.1	B25836B6107A305	2
MKV690-D-20-02	20.0	16.7	24.0	20.0	55	3 · 44.5	116.2 x 325	4.5	B25836B6137A305	2
MKV690-D-25-02	25.0	21.0	30.0	25.1	55	3 · 55.8	116.2 x 325	4.5	B25836B6167A305	2
Rated voltage 800 V AC, 50/60 Hz, delta connection										
MKV800-D-5-02	5.0	3.6	6.0	4.3	55	3 · 8.3	95.2 x 248	2.3	B25836B8246A305	2
MKV800-D-10-02	10.0	7.2	12.0	8.7	55	3 · 16.6	116.2 x 248	3.1	B25836B8496A305	2
MKV800-D-12.5-02	12.7	9.1	15.2	11.0	55	3 · 21.0	116.2 x 248	3.1	B25836B8636A305	2
MKV800-D-15-02	15.0	10.8	18.0	13.0	55	3 · 24.8	116.2 x 248	3.1	B25836B8746A305	2
MKV800-D-17-02	16.9	12.2	20.3	14.6	55	3 · 28.0	116.2 x 325	4.5	B25836B8846A305	2
MKV800-D-20-02	20.0	14.5	24.0	17.3	55	3 · 33.2	116.2 x 325	4.5	B25836B8996A305	2

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

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

MKP AC Filter Capacitors

Resin (Polyurethane) impregnated ■ Five terminal types ■ Safety device

MKP

General

The MKP series is a standard component used in AC filter application. The best cost design is available also as customer driven configurations for general industrial applications where long life time and constant capacitance values are required. The high quality and reliability is, after years out in the field, proved by different applications.

Applications

- UPS – uninterruptible power supplies
- Frequency converters – drives
- Cardiac defibrillators DC
- Regenerative energy (e.g. wind power, solar)

Features

- Compact design in cylindrical aluminum can with bottom stud
- Self healing MKP technology with reinforced edge
- Voltage range 250 … 600 V AC_{RMS}
- Capacitance values 3 … 600 µF

Customer Benefits

- Very high reliability
- High peak current capability
- Maintenance free
- Customized configurations
- Standard products available
- Overpressure disconnector

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

MKP AC Filter Capacitors

Resin (Polyurethane) impregnated ■ Five terminal types ■ Safety device

Single-phase capacitors

Type	C_R	I_{max}	Î	I_S	Rs	d	h	Stud	Weight	Ordering code	Pack. unit[1)]
	µF	A	A	kA	mΩ	mm	mm		kg		
Rated voltage 350 V AC, 250 V AC_{RMS}*											
B32360	10	6	300	0.9	6.9	40	68	M8	0.1	B32360A2106J050	45
	15	10	450	1.3	5.6	40	68	M8	0.1	B32360A2156J050	45
	20	10	500	1.5	5.4	40	68	M8	0.1	B32360A2206J050	45
	25	12	600	1.9	6.8	40	80	M8	0.2	B32360B2256J050	45
	30	15	750	2.2	4.6	53	70	M8	0.2	B32360A2306J050	12
	40	16	1000	3.0	4.2	53	70	M8	0.2	B32360A2406J050	12
	50	16	900	2.8	5.1	53	82	M8	0.2	B32360A2506J050	12
	60	16	1100	3.3	4.8	53	82	M8	0.2	B32360A2606J050	12
	70	16	1300	3.8	4.6	63.5	82	M12	0.3	B32360A2706J050	12
	80	16	1500	4.4	4.4	63.5	82	M12	0.3	B32360A2806J050	12
	100	16	1200	3.6	6.0	63.5	107	M12	0.4	B32360A2107J050	12
	150	16	1300	4.0	7.0	63.5	132	M12	0.5	B32360B2157J050	12
Rated voltage 350 V AC, 250 V AC_{RMS}*											
B32361	50	25	1250	3.8	3.7	63.5	70	M12	0.3	B32361A2506J050	12
	60	25	1500	4.5	3.6	63.5	70	M12	0.3	B32361A2606J050	12
	70	25	1300	3.8	4.2	63.5	82	M12	0.3	B32361A2706J050	12
	80	25	1500	4.4	4.1	63.5	82	M12	0.3	B32361A2806J050	12
	100	25	1200	3.6	5.5	63.5	107	M12	0.4	B32361A2107J050	12
	150	25	1300	4.0	6.3	63.5	132	M12	0.5	B32361A2157J050	12
	200	25	1600	4.8	5.8	63.5	142	M12	0.6	B32361B2207J050	12
Rated voltage 350 V AC, 250 V AC_{RMS}*											
B32362	150	35	1800	5.4	2.5	75	117	M12	0.7	B32362A2157J050	6
	200	50	2400	7.2	2.1	85	117	M12	0.8	B32362B2207J050	4
	250	40	2000	6.0	3	75	152	M12	0.9	B32362A2257J050	6
	300	50	3600	10.8	1.7	75	197	M12	1.1	B32362A2307J050	6
	400	50	4800	14.4	1.5	85	197	M12	1.3	B32362A2407J050	4
	500	50	4400	13.3	1.9	85	247	M12	1.7	B32362B2507J050	4
	600	50	5300	16.0	1.8	85	247	M12	1.7	B32362B2607J050	4
Rated voltage 350 V AC, 250 V AC_{RMS}*											
B32364	60	25	1520	4.6	2.3	63.5	70	M12	0.3	B32364A2606J050	12
	80	25	1480	4.4	2.7	63.5	82	M12	0.3	B32364A2806J050	12
	100	25	1200	3.6	3.8	63.5	107	M12	0.4	B32364A2107J050	12
	150	35	1800	5.4	3.1	75	117	M12	0.7	B32364A2157J050	6
	200	35	1777	5.3	3.7	75	142	M12	0.8	B32364B2207J050	6
	250	35	2000	6.0	3.8	75	152	M12	0.9	B32364A2257J050	6
	300	35	3600	10.8	2.5	75	197	M12	1.1	B32364A2307J050	6
Rated voltage 460 V AC, 330 V AC_{RMS}*											
B32360	10	6	300	0.9	6.9	53	70	M8	0.2	B32360A3106J030	12
	15	10	450	1.3	5.6	53	70	M8	0.2	B32360A3156J030	12
	20	12	600	1.8	5.0	53	70	M8	0.2	B32360A3206J030	12
	25	15	750	2.3	4.6	53	70	M8	0.2	B32360A3256J030	12
	30	15	650	2.0	5.7	53	82	M8	0.2	B32360A3306J030	12
	40	12	850	2.7	5.1	53	82	M8	0.2	B32360B3406J030	12
	50	15	700	2.2	7.3	53	107	M8	0.3	B32360A3506J030	12
	60	16	850	2.6	6.8	53	107	M8	0.3	B32360B3606J030	12
	70	16	1000	3.0	6.4	63.5	107	M12	0.4	B32360A3706J030	12
	80	16	1150	3.5	6.1	63.5	107	M12	0.4	B32360A3806J030	12
	100	16	1050	3.2	7.6	63.5	132	M12	0.5	B32360B3107J030	12

*) up to 600 V AC_{RMS} upon request. 1) Packing units for capacitors equal minimum order quantity. Orders will be rounded up to packing unit or multiple thereof.

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

MKP AC Filter Capacitors

Resin (Polyurethane) impregnated ■ Five terminal types ■ Safety device

MKP

Single-phase capacitors

Type	C_R	I_{max}	Î	I_S	Rs	d	h	Stud	Weight	Ordering code	Pack. unit[1)]
	µF	A	A	kA	mΩ	mm	mm		kg		
Rated voltage 460 V AC, 330 V AC_{RMS}*											
B32361	50	15	920	2.7	4.4	63.5	82	M12	0.3	B32361B3506J030	12
	60	18	720	2.1	6.2	63.5	107	M12	0.4	B32361A3606J030	12
	70	20	840	2.5	5.8	63.5	107	M12	0.4	B32361A3706J030	12
	80	25	960	2.8	5.5	63.5	107	M12	0.4	B32361A3806J030	12
	100	25	880	2.6	6.9	63.5	132	M12	0.5	B32361B3107J030	12
Rated voltage 460 V AC, 330 V AC_{RMS}*											
B32362	100	30	1450	4.3	2.8	75	117	M12	0.7	B32362A3107J030	6
	150	30	1450	4.3	3.7	75	152	M12	0.9	B32362A3157J030	6
	200	40	1900	5.8	3.1	85	152	M12	1.0	B32362B3207J030	4
	250	50	3600	10.8	1.7	85	197	M12	1.3	B32362A3257J030	4
	300	50	4300	12.9	1.6	85	197	M12	1.3	B32362A3307J030	4
	400	50	3850	11.6	2.2	85	267	M12	1.8	B32362A3407J030	4
Rated voltage 460 V AC, 330 V AC_{RMS}*											
B32364	50	25	1110	3.3	3.0	63.5	82	M12	0.7	B32364A3506J030	12
	80	25	1150	3.5	3.9	63.5	107	M12	0.9	B32364A3806J030	12
	100	30	1440	4.3	3.4	75	117	M12	1.0	B32364B3107J030	6
	150	30	1450	4.3	4.5	75	152	M12	1.3	B32364A3157J030	6
	200	35	2880	8.6	2.6	75	197	M12	1.3	B32364A3207J030	6
Rated voltage 680 V AC, 480 V AC_{RMS}*											
B32360	3	3	120	0.4	12.9	40	68	M8	0.1	B32360A4305J080	45
	5	5	200	0.6	8.9	40	68	M8	0.1	B32360A4505J080	45
	10	10	400	1.2	6.0	53	70	M8	0.2	B32360A4106J080	12
	15	15	600	1.8	5.0	53	70	M8	0.2	B32360A4156J080	12
	20	15	600	1.7	6.0	53	82	M8	0.2	B32360A4206J080	12
	25	12	500	1.4	9.0	53	107	M8	0.3	B32360A4256J080	12
	30	15	600	1.7	8.2	53	107	M8	0.3	B32360A4306J080	12
	40	16	750	2.3	7.1	63.5	107	M12	0.4	B32360A4406J080	12
	50	16	950	2.9	6.5	63.5	107	M12	0.4	B32360A4506J080	12
	60	16	850	2.6	8.4	63.5	132	M12	0.5	B32360A4606J080	12
	70	16	900	2.7	8.8	63.5	142	M12	0.6	B32360A4706J080	12
Rated voltage 680 V AC. 480 V AC_{RMS}*											
B32361	20	20	800	2.4	4.3	63.5	70	M12	0.3	B32361A4206J080	12
	25	25	750	2.2	5.2	63.5	82	M12	0.3	B32361A4256J080	12
	30	25	800	2.6	4.8	63.5	82	M12	0.3	B32361A4306J080	12
	40	20	750	2.3	6.6	63.5	107	M12	0.4	B32361A4406J080	12
	50	25	950	2.9	6.0	63.5	107	M12	0.4	B32361A4506J080	12
	60	25	850	2.6	7.7	63.5	132	M12	0.5	B32361A4606J080	12
	70	25	900	2.7	8.0	63.5	142	M12	0.6	B32361A4706J080	12
Rated voltage 680 V AC, 480 V AC_{RMS}*											
B32362	60	30	1150	3.4	3.2	75	117	M12	0.7	B32362A4606J080	6
	70	50	2050	6.2	4.5	75	142	M12	0.9	B32362A4706J080	6
	80	50	1350	7.1	4.1	75	142	M12	0.9	B32362A4806J080	6
	100	50	1900	5.7	2.3	75	197	M12	1.1	B32362A4107J080	6
	150	50	2850	8.6	1.9	85	197	M12	1.3	B32362A4157J080	4
	200	50	2850	8.5	2.3	85	247	M12	1.7	B32362A4207J080	4
	250	50	3200	9.6	2.3	85	267	M12	1.8	B32362A4257J080	4

*) up to 600 V AC_{RMS} upon request. 1) Packing units for capacitors equal minimum order quantity. Orders will be rounded up to packing unit or multiple thereof.

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

MKP AC Filter Capacitors

Resin (Polyurethane) impregnated ■ Five terminal types ■ Safety device

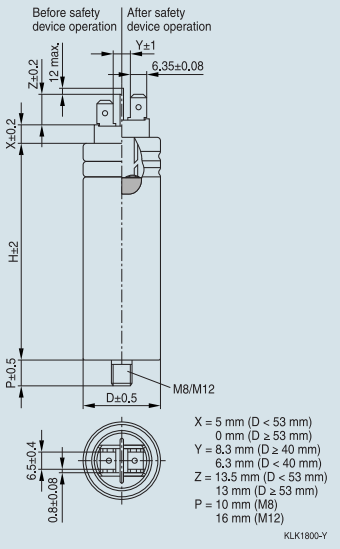
Single-phase capacitors

Type	C_R	I_{max}	Î	I_S	Rs	d	h	Stud	Weight	Ordering code	Pack. unit[1)]
	µF	A	A	kA	mΩ	mm	mm		kg		
Rated voltage 680 V AC, 480 V AC_{RMS}*											
B32364	30	20	890	2.7	3.4	63.5	82	M12	0.3	B32364A4306J080	12
	50	20	960	2.9	4.3	63.5	107	M12	0.4	B32364A4506J080	12
	60	25	1150	3.5	3.9	75	117	M12	0.7	B32364A4606J080	6
	80	35	2368	7.1	2.2	75	147	M12	0.9	B32364A4806J080	6
	100	35	1921	5.8	3.1	75	197	M12	1.1	B32364B4107J080	6

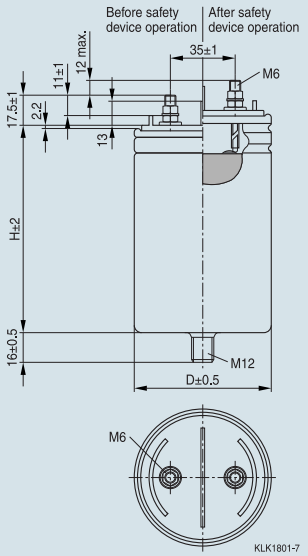
*) up to 600 V AC_{RMS} upon request. 1) Packing units for capacitors equal minimum order quantity. Orders will be rounded up to packing unit or multiple thereof.

Dimensional drawings: single-phase capacitors

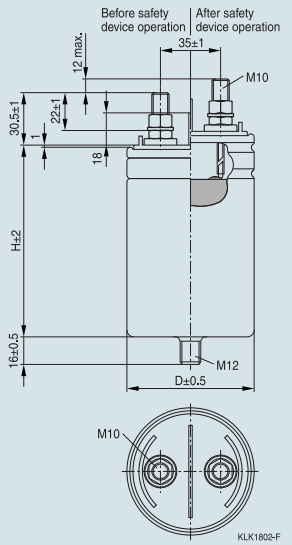
Capacitor B32360 Fast-on terminals



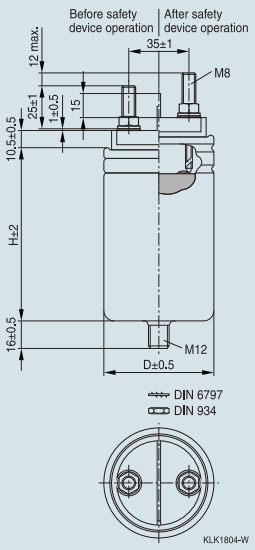
Capacitor B32361 M6 screw terminals



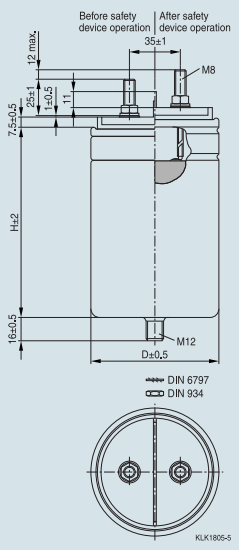
Capacitor B32362 M10 screw terminals



Capacitor B32364 M8 screw terminals, d < 75 mm



Capacitor B32364 M8 screw terminals, d > 75 mm



Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

PF Controllers BR604 and BR6000 Series

Intelligent ■ User-friendly ■ Cost-effective ■ Version 4.0

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 φ).

The PF controller series BR604 (four stages) and 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 (optionally with RS485 interface)
- BR6000-T6 and BR6000-T12 for dynamic PFC in applications with fast-changing loads
- BR6000-T6R6 for mixed PFC systems with both slowly and fast-changing loads (optionally with RS485 interface)

PF controllers BR6000-F, S, T even allow coupling, for instance in cascading two systems with two inputs and a single coupling switch.

BR604

BR6000

Features

- Display
  - Large and 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*
  - THD-V, THD-I*
  - Individual harmonics up to 19th*
  - Monitoring of individual capacitor currents*
  - Apparent power (kVA)
  - Apparent current (A)
  - Temperature (°C)*
  - Real-time cos φ
  - Target cos φ
  - kvar value to target cos φ
- 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*
- Complete 2nd parameter set available*
- 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 83.
2. Number of switchings: LV PFC capacitors according to standard IEC 60831 are designed for up to 5 000 switching operations. Make sure that 5 000 switching operations per year are not exceeded.
3. Controller hunting must be avoided at any case (see page 85)!

* Only for BR6000 series

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

Accessories: adapter for PF controller BR6000

Characteristics	
Design	compact form, all connections as screw type clamp
Mounting	snap on top hat rail
Technical data Input voltage	 grid without neutral max. 3 x 525 V
Output voltage 1	L1-N
Output voltage 2	1/2 L1-N (to use this output, a V-transformer ratio of 2 has to be programmed on the BR6000)
Protection	necessary external according to cable cross-section
Max. ambient temperature	–20 ... 55 °C
Dimensions	height 76 mm, width 45 mm, depth 110 mm
Ordering code	B44066R9999E230

This adapter is used to align the PF controller BR6000 to grids without neutral conductor. To achieve this, the input of the adapter is connected to the three phases of the grid, and the output is connected to the measuring voltage input of the controller.

The voltage at the measuring input must not exceed 525 V. At output “1/2 L1” half measuring voltage L-N is disposable.

Adapter BR6000

Accessories: USB to RS485 converter

Characteristics	
Design	compact form in plastic casing
Dimensions	height 28 mm, width 66 mm, depth 66 mm
Weight	approx. 0.1 kg
Connection	RS485 four pole terminal with mating plug for 1:1-conncection with BR6000
Signals	A, B, GND
USB	USB-B standard bushing, one USB cable 1 m length included in delivery
Power supply	via USB-connection of the PC
Power consumption	auxiliary power approx. 40 mA, depending on number of connected devices and cable length
Compatibility	USB 2.0, downward compatible
Configuration	Plug and play
Ambient temperature	–10 ... 60 °C
Storage temperature	–20 ... 75 °C
Ordering code	B44066R3333E230

USB to RS485 converter to connect the power factor controller BR6000 or other devices with Interface RS485 to a PC with USB-interface. Connection of several devices at RS485 possible.

USB to RS485 converter

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

PF Controllers BR604 and BR6000 Series

Intelligent ■ User-friendly ■ Cost-effective

Selection table

	BR604	BR6000-R6	BR6000-T6	BR6000-R12
Ordering code	B44066R6004E230	B44066R6006E230	B44066R6106E230	B44066R6012E230
Supply voltage	230 V AC	230 V AC	230 V AC	230 V AC
Measurement voltage range	= supply voltage: 230 V AC (L-N)	30 … 300 V AC (i.e. 50 ... 525 V phase to phase)		
LCD illumination	no	yes	yes	yes
Plain language	German/English	Czech / Dutch / English / French / German / Polish / Russian / Spanish / Portuguese		
Number of relay outputs	4	6	–	12
Number of transistor outputs	–	–	6	–
Alarm output	no	yes	yes	yes
■ Insuffient compensation	n/a	yes	yes	yes
■ Overcompensation	n/a	yes	yes	yes
■ Undercurrent	n/a	yes	yes	yes
■ Overcurrent	n/a	yes	yes	yes
Switchover target cos φ 1/2	n/a	no	no	no
Automatic initialization	n/a	yes	yes	yes
Complete 2nd parameter set programmable / switchable	n/a	yes	yes	yes
Test-run of complete PFC-system	n/a	yes	yes	yes
Interface	no	no	no	no
Parameters displayed				
■ System voltage	yes	yes	yes	yes
■ Reactive power	yes	yes	yes	yes
■ Active power	yes	yes	yes	yes
■ Frequency	no	yes	yes	yes
■ THD-V, THD-I	no	yes	yes	yes
■ Individual harmonics up to 19th	no	yes	yes	yes
■ Monitoring of individual capacitor currents	no	yes	yes	yes
■ Apparent power	yes	yes	yes	yes
■ Apparent current	yes	yes	yes	yes
■ Temperature ° C / ° F)	no	yes	yes	yes
■ Real time cos φ	yes	yes	yes	yes
■ Target cos φ	yes	yes	yes	yes
■ kvar value to target cos φ	yes	yes	yes	yes
Recall recorded values				
■ Number of contactor switching operations	no	yes	yes	yes
■ Maximum voltage	yes	yes	yes	yes
■ Maximum active power	yes	yes	yes	yes
■ Maximum reactive power	yes	yes	yes	yes
■ Maximum value of harmonic	no	yes	yes	yes
■ Maximum apparent power	yes	yes	yes	yes
■ Maximum temperature (° C)	no	yes	yes	yes
■ Operation time of all capacitors	no	yes	yes	yes
Switching and discharge time range	1 … 255 seconds	1 … 1200 seconds		
Number of control series	23 series preset	20 series preset and control series editor for free programming		
Weight	0.5 kg	1 kg		
Dimensions	100 x 100 x 40 mm	144 x 144 x 55 mm		
Suitable for dynamic PFC	no	no	yes	no

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

PF Controllers BR604 and BR6000 Series

Intelligent ■ User-friendly ■ Cost-effective

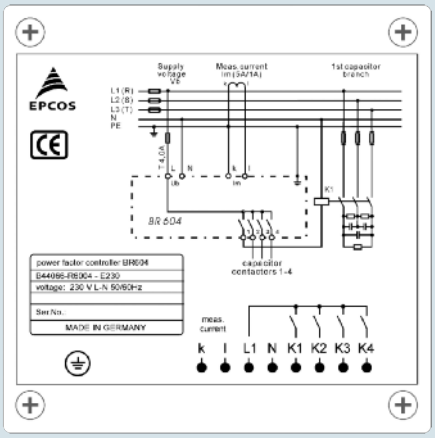
	BR6000-T12	BR6000-R12/F	BR6000-R12/S485	BR6000-T6R6	BR6000-T6R6/S485	BR6000-T12/S485
	B44066R6112E230	B44066R6212E230	B44066R6412E230	B44066R6066E230	B44066R6466E230	B44066R6412E231
	230 V AC	230 V AC	230 V AC	230 V AC	230 V AC	230 V AC
	30 … 300 V AC (i.e. 50 ... 525 V phase to phase)					
	yes	yes	yes	yes	yes	yes
	Czech / Dutch / English / French / German / Polish / Russian / Spanish / Portuguese					
	–	12	12	6	6	–
	12	–	–	6	6	12
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	no	RS485	RS485
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	yes	yes	yes	yes	yes	yes
	1 … 1200 seconds					
	20 series preset and control series editor for free programming					
	1 kg					
	144 x 144 x 55 mm					
	yes	no	no	yes	yes	yes

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

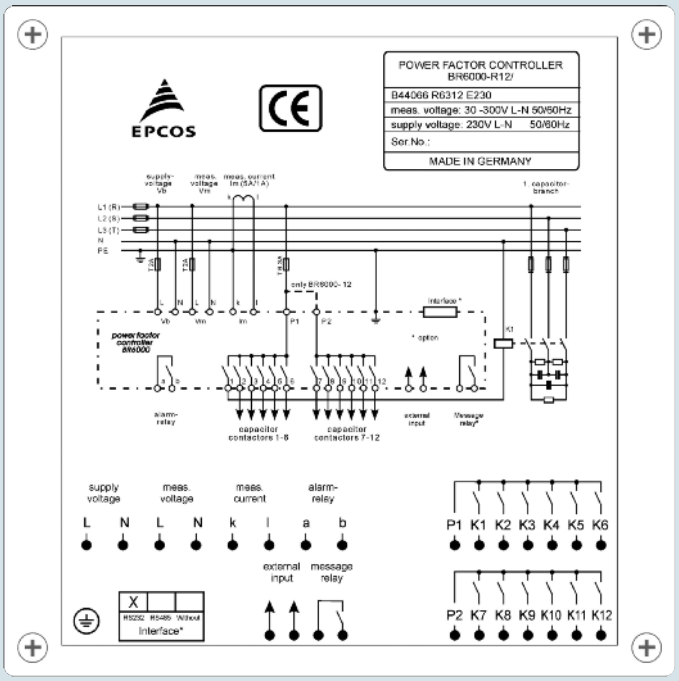
PF Controllers BR604 and BR6000 Series

Intelligent ■ User-friendly ■ Cost-effective

PF controller BR604



PF controller BR6000



Please read *Important notes* on page 12 and *Cautions* on page 82–85.

Multi Measuring Interface (MMI6000)

Stand-alone device as trigger ■ Accessory for PF controller BR6000 and BR6000-T

General

The MMI6000 is an external meter combining many devices in one. Combined with a PF controller BR6000 or BR6000-T (V4.0), the MMI6000 monitors the input lead of the PFC system. Both available versions

– standard version with a standard relay MMI6000R
– dynamic version with optocoupler MMI6000T

feature an interface RS485, allowing the processing of measured parameters via PC.

It allows direct recognition of dangerous network conditions and will switch off capacitor steps as long as the potential hazardous situation exists.

This means an additional protection for the capacitor as well as for the complete PFC system. As a stand-alone-device, the MMI6000 can also operated as a meter, a signal trigger or as a switch for a single PFC-step.

Menu driven handling (plain language) in English and German.

Applications

MMI6000R / MMI6000T

Coupling MMI6000 – BR6000-R via RS485 interface

■ Genuine monitoring of the particular capacitor currents offers additional protection for the whole PFC-system.

Coupling MMI6000 – BR6000-T via RS485 interface

■ All stages switched by TSM-thyristor switches monitored in real time for additional protection of switches and PFC-system.

MMI6000 – Modbus RTU

■ Usage as separate measuring device allows display of all network parameters and delivery via Modbus-RTU-protocol.

MMI6000 – ASCII OUT

■ Measured values are provided in ASCII code via interface; usage also as a trigger relay.

MMI6000T

Dyna-I-trigger

■ Triggering of TSM-thyristor switches in real time, providing the switching within 1 ms.

Features

■ Compact dimensions
■ Panel mounting instrument
■ LCD-Display, English/German
■ Indication of various parameters:
  – Voltage
  – Current
  – Power factor
  – Active power
  – Reactive power
  – Apparent power
  – Frequency
  – Temperature
  – Energy
■ Storage of maximum values:
  – Voltage
  – Current
  – Active power
  – Reactive power
  – Apparent power
  – Temperature
  – Energy

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

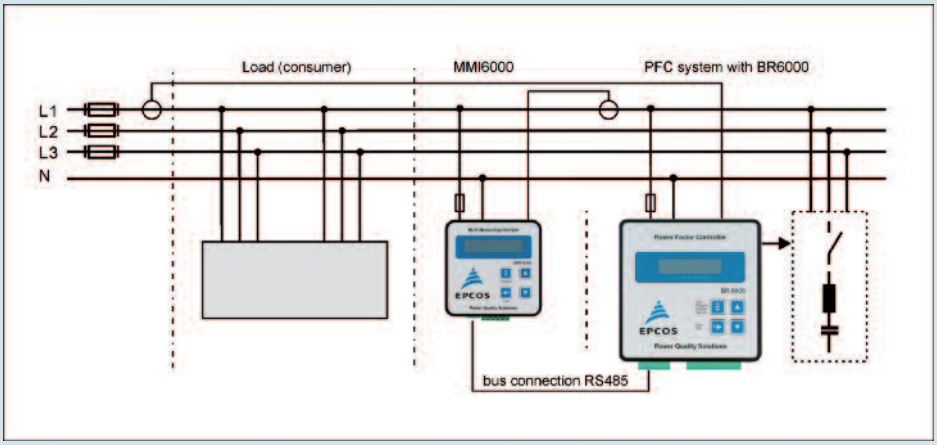
Multi Measuring Interface (MMI6000)

Stand-alone device as trigger ■ Accessory for PF controller BR6000 and BR6000-T

Technical data

Weight	0.5 kg
Case	panel mounting instrument 100 x 100 x 45 mm
Interface	RS485/4-pole terminal
Output capacity: **MMI6000-R** **MMI6000-T**	 250 V AC, 1,000 W 60 V DC, 150 mA
Display	graphical, 2 x 16 characters, illuminated
Supply and measuring voltage	230 V AC
Frequency	50 / 60 Hz
Power consumption	< 4 VA
Measurement current	X/5 A and X/1 A
Measuring temperature range	0 ... 100 °C
Ambient temperature range	–10 ... 55 °C
Storage temperature range	–20 ... 75 °C
Overvoltage class	II
Pollution degree	2
Humidity class	15% ... 95% without dew
Mounting position	Any
Protection class to IEC 60529	Front IP54, Rear IP20
Safety guidelines	IEC 61010-1:2001, EN 61010-1:2001
Sensitivity to interferences (industrial areas)	IEC 61000-4-2:8 kV, IEC 61000-4-4:4 kV
Ordering code **MMI6000-R** **MMI6000-T**	 B44066M6000E230 B44066M6100E230

MMI6000



Please read *Important notes* on page 12 and *Cautions* on page 82–85.

Switching Devices – Capacitor Contactors

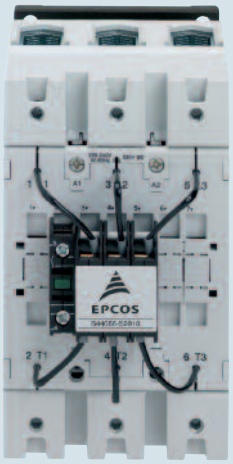
Specially designed for damping of inrush current in LV PFC systems

General

When a capacitor is switched to an AC voltage, the result is a resonant circuit damped to a greater or lesser degree. The switching of capacitors can cause high inrush currents, particularly when they are switched in parallel to others already activated in the power line, and if high short-circuit powers are present on the line.

Capacitor contactors with damping resistors make use of pre-switching auxiliary contacts. They close before the main contacts and pre-load the capacitor thus avoiding current peak values.

This influences positively the life expectancy of the capacitor significantly in addition to the positive impact on the power quality (avoiding transients and voltage sags that otherwise may be caused by switching in capacitors).



Applications

- Damping of inrush current in low-voltage PFC systems
- For PFC systems with and without reactors

Features

- Excellent damping of inrush current
- Improved power quality (e.g. avoidance of voltage sags)
- Longer useful service life of main contacts of capacitor contactor
- Soft switching of capacitor and thus longer useful service life
- Enhanced mean life expectancy of PFC system
- Reduced ohmic losses
- Leading contacts with wiper function
- Tamper-proof and protected resistors
- Easy access for cable connection
- Voltage range: 400 … 690 V
- Output range: 12.5 … 100 kvar
- Series J110/J230 for PFC systems without reactors
- Series N110/N230 for PFC systems with reactors only

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

Switching Devices – Capacitor Contactors

Specially designed for damping of inrush current in LV PFC systems

Technical data

Type Main contacts			B44066*****J230/J110/N230/N110 S1810	S2410	S3210	S5010	S6210	S7410	S9910
Rated insulation voltage V_I **Admissible frequency of operation** **Contact life**	V_{IS}	[V AC] 1/h million operations	690[1)] 120 0.25	690[1)] 120 0.15	690[1)] 120 0.15	690[1)] 120 0.15	690[1)] 120 0.15	690[1)] 80 0.12	1,000[1)] 80 0.075
Cable cross-section solid or standard	▨	[mm²]	1.5–6	2.5–25	2.5–25	4–50	4–50	4–50	0.5–95/10–120
flexible	▨	[mm²]	1.5–4	2.5–16	2.5–16	10–35	10–35	10–35	0.5–70/10–95
flexible with multicore cable end	▨	[mm²]	1.5–4	2.5–16	2.5–16	6–35	6–35	6–35	0.5–70/10–95
Cables per clamp			2	1	1	1	1	1	2
Operating range of magnet coils in multiples of control voltage	V_S		0.85–1.1	0.85–1.1	0.85–1.1	0.85–1.1	0.85–1.1	0.85–1.1	0.85–1.1
Auxiliary contacts[1)] **Rated insulation voltage V_I**	V_{IS}	[V AC]	690[1)]	690[1)]	690[1)]	690[1)]	690[1)]	690[1)]	690[1)]
Rated current I_{th} at ambient temperature max. 40 °C		I_{coth} [A]	16	10	10	10	10	10	10
max. 60 °C		I_{coth} [A]	12	6	6	6	6	6	6
Utilization category AC15 220 to 240 V		I_{coth} [A]	12	3	3	3	3	3	3
380 to 440 V		I_{coth} [A]	4	2	2	2	2	2	2
Short circuit protection Highest fuse rating slow, gL (gG) Auxiliary contacts		I_{coth} [A] NO/NC	25 1/0	20 1/0	20 1/0	20 1/0	20 1/0	20 1/0	20 1/0

IEC 947-4-1, IEC 947-5-1, EN 60947-4-1, EN 60947-5-1, VDE 0660
Dimensional drawing: see datasheet

[1)] Applies to networks with grounded star point, overvoltage category I to IV, pollution severity 3 (industrial standard), V_{imp} = 8 kV. Values for other conditions on request.

Main technical parameters

Capacitor power at ambient temperature, voltage, 50/60 Hz 380–400 V		415–440 V		660–690 V		Current max.		Weight	Ordering code
50 °C kvar	60 °C kvar	50 °C kvar	60 °C kvar	50 °C kvar	60 °C kvar	50 °C A	60 °C A	kg	
110 V coil									
0–12.5	0–12.5	0–13	0–13	0–20	0–20	18	18	0.34	B44066S1810J110
10–20	10–20	10.5–22	10.5–22	17–33	17–33	28	28	0.60	B44066S2410J110
10–25	10–25	10.5–27	10.5–27	17–41	17–41	36	36	0.60	B44066S3210J110
20–50	20–50	23–53	23–53	36–82	36–82	72	72	1.10	B44066S6210J110
20–75	20–60	23–75	23–64	36–120	36–100	105	87	1.10	B44066S7410J110
33–100	33–90	36–103	36–93	57–170	57–148	144	130	2.30	B44066S9910J110
230 V coil									
0–12.5	0–12.5	0–13	0–13	0–20	0–20	18	18	0.34	B44066S1810J230
10–20	10–20	10.5–22	10.5–22	17–33	17–33	28	28	0.60	B44066S2410J230
10–25	10–25	10.5–27	10.5–27	17–41	17–41	36	36	0.60	B44066S3210J230
20–33.3	20–33.3	23–36	23–36	36–55	36–55	48	48	1.10	B44066S5010J230
20–50	20–50	23–53	23–53	36–82	36–82	72	72	1.10	B44066S6210J230
20–75	20–60	23–75	23–64	36–120	36–100	105	87	1.10	B44066S7410J230
33–100	33–90	36–103	36–93	57–170	57–148	144	130	2.40	B44096S9910J230

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

Switching Devices – Capacitor Contactors

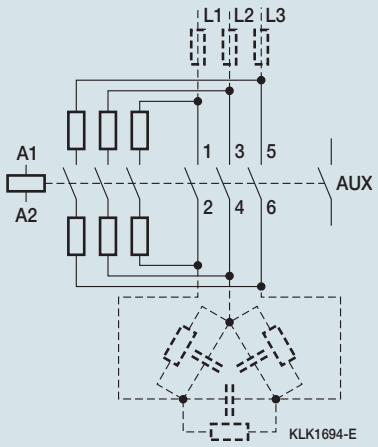
Specially designed for damping of inrush current in LV PFC systems

Main technical parameters

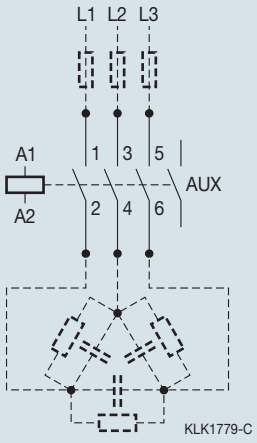
Capacitor power at ambient temperature, voltage, 50/60 Hz						Current max.		Weight	Ordering code
380–400 V		415–440 V		660–690 V					
50 °C kvar	60 °C kvar	50 °C kvar	60 °C kvar	50 °C kvar	60 °C kvar	50 °C A	60 °C A	kg	
110 V coil									
0–12.5	0–12.5	0–13	0–13	0–20	0–20	18	18	0.23	B44066S1810N110
10–20	10–20	10.5–22	10.5–22	17–33	17–33	28	28	0.50	B44066S2410N110
10–25	10–25	10.5–27	10.5–27	17–41	17–41	36	36	0.90	B44066S3210N110
20–50	20–50	23–53	23–53	36–82	36–82	72	72	0.90	B44066S6210N110
20–75	20–60	23–75	23–64	36–120	36–100	105	87	0.90	B44066S7410N110
33–100	33–90	36–103	36–93	57–170	57–148	144	130	2.30	B44066S9910N110
230 V coil									
0–12.5	0–12.5	0–13	0–13	0–20	0–20	18	18	0.23	B44066S1810N230
10–20	10–20	10.5–22	10.5–22	17–33	17–33	28	28	0.50	B44066S2410N230
10–25	10–25	10.5–27	10.5–27	17–41	17–41	36	36	0.50	B44066S3210N230
20–33.3	20–33.3	23–36	23–36	36–55	36–55	48	48	0.90	B44066S5010N230
20–50	20–50	23–53	23–53	36–82	36–82	72	72	0.90	B44066S6210N230
20–75	20–60	23–75	23–64	36–120	36–100	105	87	0.90	B44066S7410N230
33–100	33–90	36–103	36–93	57–170	57–148	144	130	2.40	B44096S9910N230

Connection diagrams

All types B44066S**J*** (with preload resistors), B44066S1810J230 and B44066S1810J110 with wires on the bottom, B44066S9910J230 with resistors inside housing**



All types B44066S**N*** (without preload resistors)**



Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

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

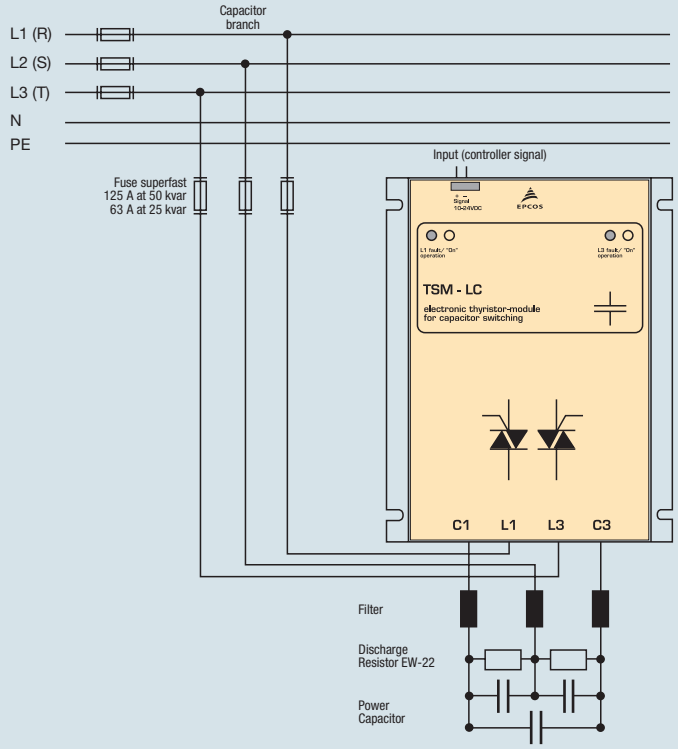
Features

- 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
- Voltage range: 400 V and 690 V
- Output range:
  400 V: 10, 25, 50, 100, 200 kvar
  690 V: 50 and 200 kvar

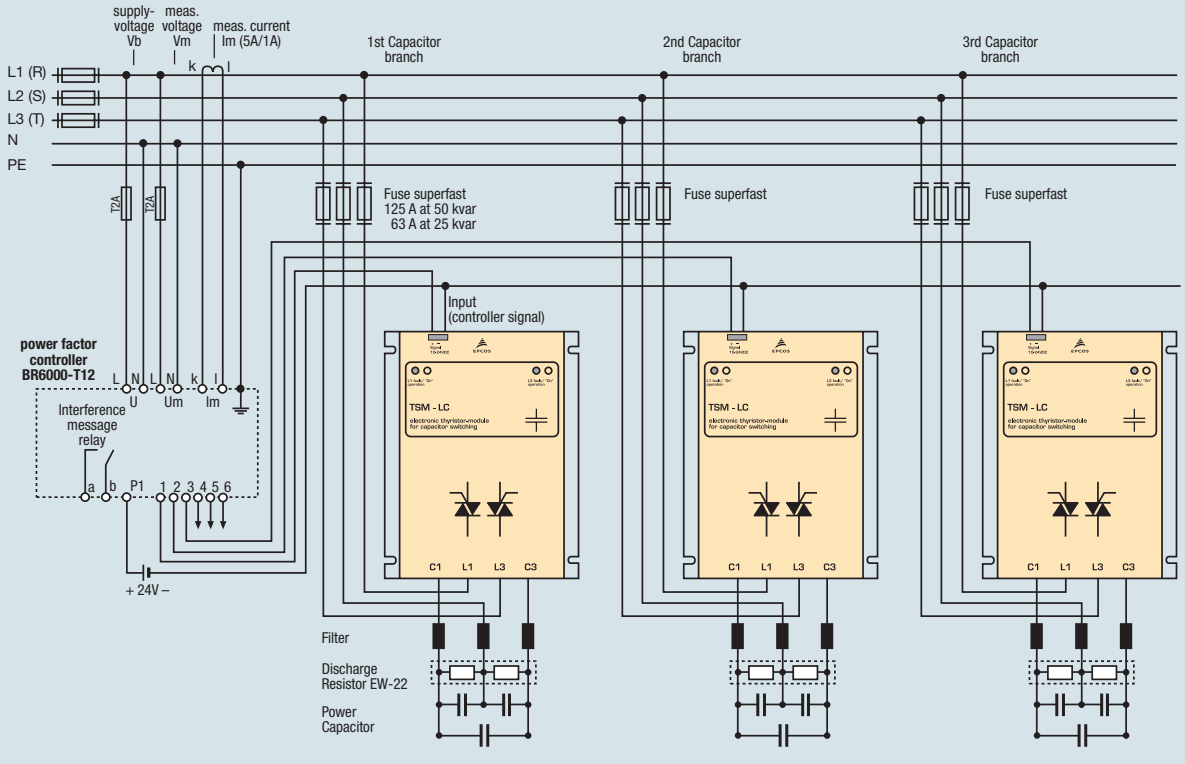
Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

Switching Devices – Thyristor Modules for Dynamic PFC TSM-Series

Dynamic PFC network: one stage



Dynamic PFC network: multiple stages



Switching Devices – Thyristor Modules for Dynamic PFC TSM-Series

TSM-Series

Selection table TSM-series

	TSM-LC10	TSM-LC25	TSM-LC50	TSM-LC100	TSM-LC200
Ordering code	B44066T0010E402	B44066T0025E402	B44066T0050E402	B44066T0100E402	B44066T0200E402
Rated voltage	380 … 400 V	380 … 400 V	380 … 400 V	380 … 400 V	380 … 400 V
Max. grid voltage: – in conventional PFC systems (without reactors)	440 V	440 V	440 V	440 V	440 V
– in detuned PFC system (7% detuning)	440 V (no upwards tolerance)	440 V (no upwards tolerance)	440 V (no upwards tolerance)	440 V (no upwards tolerance)	440 V (no upwards tolerance)
– in detuned PFC system (14% detuning)	400 V	400 V	400 V	400 V	400 V
Frequency	50 / 60 Hz	50 / 60 Hz	50 / 60 Hz	50 / 60 Hz	50 / 60 Hz
Maximum power / at nominal voltage	12.5 kvar	25 kvar	50 kvar	100 kvar	200 kvar
Power circuit	Direct connection 4 pole via terminal clamps (D = 6 mm² resp. 4 mm²)	Direct connection 4 pole via busbar (cable lug 25 mm², D = 8 mm)	Direct connection 4 pole via busbar (cable lug 25 mm², D = 8 mm)	Direct connection 4 pole via busbar (cable lug 70 mm², D = 10 mm)	Direct connection 4 pole via busbar (cable lug 185 mm², D = 12 mm)
Neutral required	no*	no*	no*	no	no*
Aux. supply voltage required	no	no	no	230 V AC (needed for fan) via terminal clamp; automatically controlled cooling, over temperature switch off	230 V AC
Connection	from bottom	from bottom	from bottom	from bottom	from top
Losses (PD in W)	2.0 x I (in A); at 400 V/12.5 kvar approx. 35 W (thermal)	2.0 x I (in A); typical 75 W (thermal)	2.0 x I (in A); typical 150 W (thermal)	2.0 x I (in A); typical 300 W (thermal)	2.0 x I (in A); at 400 V/200 kvar approx. 580 W (thermal)
Recommended fuses "superfast"	3 x NH00 (AC 690 V) 35 A	3 x NH00 (AC 690 V) 63 A	3 x NH00 (AC 690 V) 125 A	3 × NH1 (AC 690 V) 250 A	3 x NH2 (AC 690 V) 125 kvar: 315 A 150 kvar: 350 A 200 kvar: 450 A
Dimensions in mm (w x h x d)	162 x 150 x 75	157 x 200 x 180	157 x 200 x 180	157 x 240 x 195	250 x 480 x 160
Weight	1.75 kg	4.8 kg	4.8 kg	5.5 kg	11.5 kg
LED display per phase	2	2	2	2	2
Cascading	yes	yes	yes	yes	yes
Ambient temperature	–10 °C ... 55 °C	–10 °C ... 55 °C	–10 °C ... 55 °C	–10 °C ... 55 °C	–10 °C ... 55 °C
Discharge resistors EW-22 needed	1	1	1	1–2 in parallel	2–4 in parallel
Current limitation reactor BD-100 needed* **	2	2	2	For standard applications (without detuned filter reactors) a special current limitation reactor is mandatory. Further information upon request.	

* For operation with three-phase capacitor or three single-phase capacitors, ** Only for operation with single-phase capacitors,
*** For PFC systems without detuning reactors mandatory.

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

Switching Devices – Thyristor Modules for Dynamic PFC TSM-Series

	TSM-HV50	TSM-HV200
	B44066T0050E690	B44066T0200E690
	690 V	690 V
	690 V	690 V
	690 V	690 V
	690 V	690 V
	50 / 60 Hz	50 / 60 Hz
	60 kvar	200 kvar
	Direct connection 4 pole via busbar (cable lug 25 mm², D = 8 mm)	Direct connection 4 pole via busbar (cable lug)
	yes**	no*
	230 V AC	no
	from bottom	from bottom
	3.0 x I (in A); at 690 V/50 kvar approx. 125 W (thermal)	2.0 x I (in A); at 690 V/200 kvar typical 350 W (thermal)
	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 200 x 195	410 x 400 x 250
	5 kg	17 kg
	1	6
	yes	yes
	–10 °C ... 55 °C	–10 °C ... 50 °C
	standard-resistor sufficient	standard-resistor sufficient
	not needed	only for systems with detuning-reactors

Accessories for TSM-LC modules

Type / Description	Ordering code
Discharge resistors EW-22 [1] at least 1 piece to be used for all types of TSM-LC if fast re-switching time is required. For higher rated steps please contact your local sales office.	B44066T0022E400
Current limitation reactor BD-100 for PFC systems without detuning reactors to be used for 10 kvar, 25 kvar or 50 kvar step, two units per step required [2]	B44066T0100E400

[1] Consisting of two single resistors of 22 kΩ each
[2] Not suitable for TSM-LC100, TSM-LC200 and TSM-HV200

EW-22


BD-100

Reactors – Antiresonance Harmonic Filter

General

The increasing use of modern power electronic apparatus (drives, uninterruptible power supplies, etc) produces nonlinear current and thus influences and loads the network with harmonics (line pollution).

The power factor correction or capacitance of the power capacitor forms a resonant circuit in conjunction with the feeding transformer. Experience shows that the self-resonant frequency of this circuit is typically between 250 and 500 Hz, i.e. in the region of the 5th and 7th harmonics.

Such a resonance although can lead to the following undesirable effects:

– overloading of capacitors,
– overloading of transformers and transmission equipment,
– interference with metering and control systems, computers and electrical gear,
– resonance elevation, i.e. amplification of harmonics,
– voltage distortion.

These resonance phenomena can be avoided by connecting capacitors in series with filter reactors in the PFC system. These so called "detuned" PFC systems are scaled in a way that the self-resonant frequency is below the lowest line harmonic. The detuned PFC system is purely inductive seen by harmonics above this frequency. For the base line frequency (50 or 60 Hz usually), the detuned system on the other hand acts purely capacitive, thus correcting the reactive power.

Applications

- Avoidance of resonance conditions
- Tuned and detuned harmonic filters
- Reduction of harmonic distortion (network clearing)
- Reduction of power losses

Features

- High harmonic loading capability
- Very low losses
- High linearity to avoid choke tilt
- Low noise
- Convenient mounting
- Long expected life time
- Temperature protection (NC contact)

Technical data and limit values

Filter reactors	
Harmonics*	V_3 = 0.5% V_R (duty cycle = 100%) V_5 = 6.0% V_R (duty cycle = 100%) V_7 = 5.0% V_R (duty cycle = 100%) V_{11} = 3.5% V_R (duty cycle = 100%) V_{13} = 3.0% V_R (duty cycle = 100%)
Effective current	$I_{rms} = \sqrt{(I_1^2+I_3^2 \ldots I_{13}^2)}$
Fundamental current	$I_1 = 1.06 \cdot I_R$ (50 Hz or 60 Hz current of capacitor)
Temperature protection	microswitch (NC)
Dimensional drawings and terminals	see specific datasheets

Three-phase filter reactors to VDE 0532 / EN 60289	
Frequency	50 Hz or 60 Hz
Voltage	400, 440
Output	10 … 100 kvar
Detuning	5.67%, 7%, 14%
Cooling	natural
Ambient temperature	40 °C
Class of protection	I
Enclosure	IP00

* According to DIN ENV VV61000-2-2

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

Reactors – Antiresonance Harmonic Filter

Characteristics

Power	Δ capacitance	Inductance	I_{rms} (I_{eff})	Losses*	Weight	Terminal	Ordering code
kvar	3 · µF	mH	A	W	kg		
Rated voltage V = 400 V, f = 50 Hz, p = 5.67% (f_r = 210 Hz) / Linearity: L ≥ 0.95 · L_R for current up to 2.08 · I1							
10	62	3.06	18.5	64	6.4	10 mm² Kl.	B44066D5010S400
12.5	78	2.45	23.0	89	8.4	10 mm² Kl.	B44066D5012S400
20	125	1.53	36.9	100	13	10 mm² Kl.	B44066D5020S400
25	156	1.23	46.1	130	17	10 mm² Kl.	B44066D5025S400
40	250	0.77	73.7	220	23	M6 Al-flat	B44066D5040S400
50	312	0.61	92.1	290	31	M6 Al-flat	B44066D5050S400
75	496	0.41	138.2	280	35	M8 Al-flat	B44066D5075S400
100	625	0.31	183.8	390	47	M8 Al-flat	B44066D5100S400
Rated voltage V = 400 V, f = 50 Hz, p = 7% (f_r = 189 Hz) / Linearity: L ≥ 0.95 · L_R for current up to 1.73 · I1							
10	61	3.84	16.4	73	5.9	10 mm² Kl.	B44066D7010S400
12.5	77	3.01	20.5	87	8.1	10 mm² Kl.	B44066D7012S400
20	123	1.92	32.7	120	18	Cu bars Ø 9 mm	B44066D7020M400
25	154	1.53	40.9	180	18	Cu bars Ø 9 mm	B44066D7025M400
40	246	0.96	65.4	230	26	Cu bars Ø 9 mm	B44066D7040M400
50	308	0.77	81.8	270	27	Cu bars Ø 9 mm	B44066D7050M400
75	462	0.51	122.7	330	39	Cu bars Ø 9 mm	B44066D7075M400
100	617	0.38	163.3	390	50	Cu bars Ø 11 mm	B44066D7100M400
Rated voltage V = 400 V, f = 50 Hz, p = 14% (f_r = 135 Hz) / Linearity: L ≥ 0.95 · L_R for current up to 1.37 · I1							
10	57	8.29	15.4	87	9.4	10 mm² Kl.	B44066D1410S400
12.5	71	6.64	19.2	100	12	10 mm² Kl.	B44066D1412S400
20	114	4.15	30.8	150	22	Cu bars Ø 9 mm	B44066D1420M400
25	142	3.32	38.5	200	26	Cu bars Ø 9 mm	B44066D1425M400
40	228	2.07	61.6	270	38	Cu bars Ø 9 mm	B44066D1440M400
50	285	1.66	77	290	40	Cu bars Ø 9 mm	B44066D1450M400
75	427	1.11	115.5	380	58	Cu bars Ø 9 mm	B44066D1475M400
100	570	0.83	153.9	470	66	Cu bars Ø 11 mm	B44066D1499M400
Rated voltage V = 440 V, f = 50 Hz, p = 5.67% (f_r = 210 Hz) / Linearity: L ≥ 0.95 · L_R for current up to 2.08 · I1							
10	51	3.71	16.8	74	7	10 mm² Kl.	B44066D5010S440
12.5	64	2.97	21.0	88	9	10 mm² Kl.	B44066D5012S440
25	129	1.48	42.0	130	16.5	M5 Al-flat	B44066D5025S440
50	258	0.74	83.8	230	25	M6 Al-flat	B44066D5050S440
75	387	0.49	125.6	260	36	M8 Al-flat	B44066D5075S440
100	517	0.37	168.0	340	50	M8 Al-flat	B44066D5100S440

* Total max. losses, considering max. specified overvoltage and harmonic currents

Other voltage upon request

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

Reactors – Antiresonance Harmonic Filter

Characteristics

Power	Δ capacitance	Inductance	I_{rms} (I_{eff})	Losses*	Weight	Terminal	Ordering code
kvar	3 · µF	mH	A	W	kg		
Rated voltage V = 440 V, f = 50 Hz, p = 7% (f_r = 189 Hz) / Linearity: L ≥ 0.95 · L_R for current up to 1.73 · I1							
10	50	4.64	14.9	71	6.5	4 mm² Kl.	B44066D7010S440
12.5	63	3.71	18.7	85	8.5	10 mm² Kl.	B44066D7012S440
25	127	1.87	37.2	170	18	Cu bars Ø 9 mm	B44066D7025M440
50	254	0.93	74.3	250	33	Cu bars Ø 9 mm	B44066D7050M440
75	382	0.62	111.4	340	43	Cu bars Ø 9 mm	B44066D7075M440
100	509	0.46	148.7	410	49	Cu bars Ø 9 mm	B44066D7100M440
Rated voltage V = 440 V, f = 50 Hz, p = 14% (f_r = 135 Hz) / Linearity: L ≥ 0.95 · L_R for current up to 1.37 · I1							
10	47	10.04	14.0	87	10	4 mm² Kl.	B44066D1410S440
12.5	58	8.03	17.5	95	13	10 mm² Kl.	B44066D1412S440
25	117	4.02	35.0	160	27	Cu bars Ø 9 mm	B44066D1425M440
50	235	2.01	70.0	300	40	Cu bars Ø 9 mm	B44066D1450M440
75	353	1.34	105.0	440	53	Cu bars Ø 9 mm	B44066D1475M440
100	471	1.00	140.0	490	65	Cu bars Ø 9 mm	B44066D1499M440
Rated voltage V = 440 V, f = 60 Hz, p = 5.67% (f_r = 252 Hz) / Linearity: L ≥ 0.95 · L_R for current up to 2.08 · I1							
25	107	1.24	42.0	125	18	M5 Al-flat	B44066D5025S441
50	215	0.62	83.8	210	25	M6 Al-flat	B44066D5050S441
75	323	0.41	126.0	300	33	M8 Al-flat	B44066D5075S441
100	431	0.31	167.4	400	47	M8 Al-flat	B44066D5100S441
Rated voltage V = 440 V, f = 60 Hz, p = 7% (f_r = 227 Hz) / Linearity: L ≥ 0.95 · L_R for current up to 1.73 · I1							
25	106	1.55	37.2	130	18	Cu bars Ø 9 mm	B44066D7025M441
50	212	0.77	74.4	250	27	Cu bars Ø 9 mm	B44066D7050M441
75	318	0.52	111.4	320	39	Cu bars Ø 9 mm	B44066D7075M441
100	424	0.39	148.6	380	44	Cu bars Ø 9 mm	B44066D7100M441
Rated voltage V = 440 V, f = 60 Hz, p = 14% (f_r = 162 Hz) / Linearity: L ≥ 0.95 · L_R for current up to 1.37 · I1							
25	98	3.35	34.8	180	22	Cu bars Ø 9 mm	B44066D1425M441
50	196	1.67	69.5	290	34	Cu bars Ø 9 mm	B44066D1450M441
75	294	1.12	104.3	380	45	Cu bars Ø 9 mm	B44066D1475M441
100	392	0.84	139.1	480	54	Cu bars Ø 9 mm	B44066D1499M441

* Total max. losses, considering max. specified overvoltage and harmonic currents

Other voltages upon request

Discharge Reactor

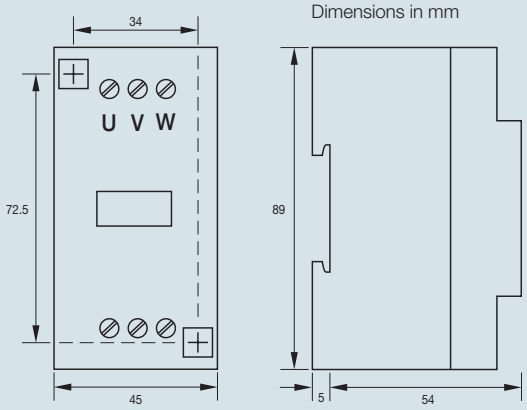
General

The losses of discharge reactors are substantially lower than those of discharging resistors. They satisfy the requirement for permanently connected discharging device and for a discharge time of a few seconds. Fast discharging allows a fast re-switching in automatic PFC equipment. However, max. 5 000 switching operations (according to IEC 60831) should not be exceeded.

Features and dimensional drawings

- Fast discharge for fast reconnection of capacitors
- Reduced losses
- Shockproof case for DIN rail mounting

Dimensions in mm



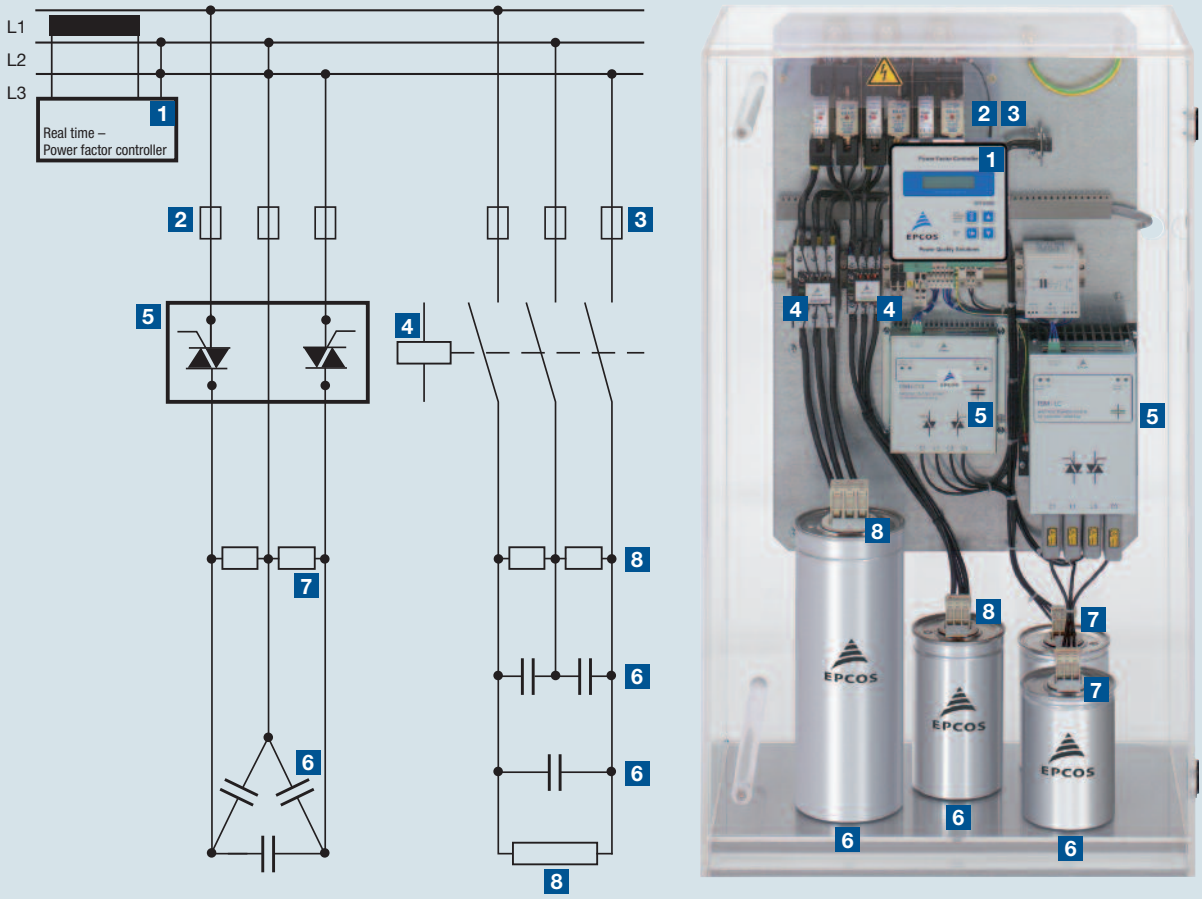
Technical data

Ordering code		**B44066E9900S001**
Voltage	V_R	230 ... 525 V
Frequency	f	50 / 60 Hz
Internal configuration		2 windings in V arrangement
Resistance	R	4 900 Ω
Discharge time	t	230 V up to 25 kvar < 10 s / up to 50 kvar < 20 s / up to 100 kvar < 40 s 400 ... 525 V up to 25 kvar < 5 s / up to 50 kvar < 10 s / up to 100 kvar < 20 s
Power loss	P_{Loss}	< 1.8 W
Free-wheeling current	I	< 4.5 mA
Accepted discharge number		1 x / (minute and 100 kvar)
Insulation class	R_{INS}	T40/B
Cable diameter	ø	0.75 ... 2 x 2.5 mm²
Terminals		fixing torque 0.5 Nm
Installation location		indoor
Ambient temperature		–25 ... 55 °C
Cooling		natural
Dimensions	h x w x d	90 x 45 x 59 mm
Weight		0.5 kg

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

Fundamentals of Power Factor Correction

Application example



1 Power factor controller
2 Semiconductor fuses
3 Fuses
4 Contactor
5 Thyrisor module
6 Capacitor
7 Discharge resistor (EW-22)
8 Discharge resistor (plug in)

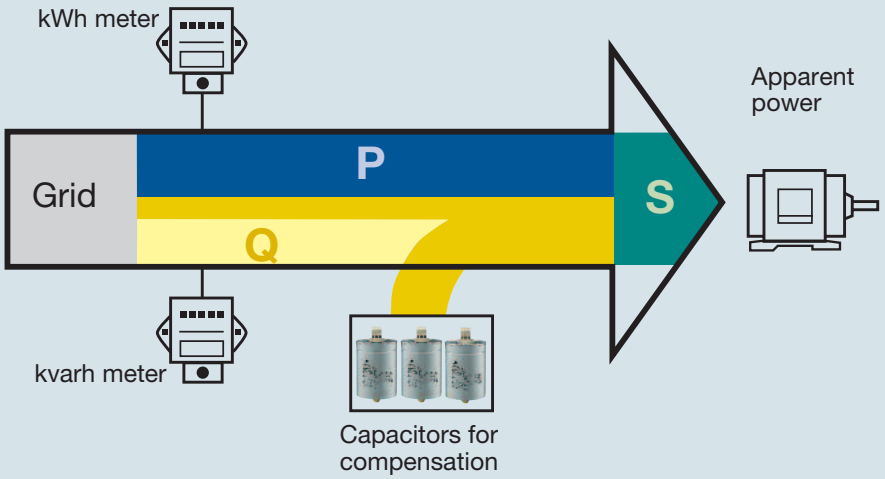
The rational use of electrical energy calls for economical generation, transmission and distribution with little losses. That means restricting all factors in electrical networks that cause losses. One of these factors is lagging reactive power. Loads in industrial and public power grids are primarily of an ohmic-inductive nature. The purpose of systems for power factor correction in networks is to compensate the generated lagging reactive power by leading reactive power at defined nodes. This also serves to avoid impermissibly high voltage drops and additional ohmic losses. The necessary leading power is produced by capacitors parallel to the supply network, as close as possible to the inductive load. Static capacitive compensation devices reduce the lagging reactive power component transmitted over the network. If grid conditions change, the required leading reactive power can be matched in steps by adding or taking out single power capacitors (automatic PFC) to compensate the lagging reactive power.

Benefits of power factor correction

- Fast return on investment through lower power costs
  – Power factor correction reduces the reactive power in a system.
  – Power consumption and thus power costs drop in proportion.
- Effective use of installation
  An improved power factor means that an electrical installation operates more economically (higher effective power for the same apparent power).
- Improved voltage quality
- Reduced voltage drops
- Optimum cable design
  – Cable cross-sections can be reduced with improvement of power factor (less current). In existing installations for instance, extra or higher power can be transmitted.
- Reduced transmission losses
  The transmission and switching devices carry less current, i.e. only the effective power, meaning that the ohmic losses in the leads are reduced.

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

Conventional power factor correction



1. Capacitor

Power factor correction (PFC) capacitors produce the necessary leading reactive power to compensate the lagging reactive power. They should be capable of withstanding high inrush currents caused by switching operations (>100 · I_R). If they are connected in parallel, i.e. as banks, the inrush current will increase (≥150 · I_R) because the charging current comes from the power line as well as from other capacitors connected in parallel.

Design of capacitors

MKK/MKP technology

Metalized plastic compact capacitors with self-healing properties and a polypropylene dielectric. Film metallization with zinc/aluminum alloy results in high performance and a low film thickness allowing significantly more compact dimensions and a lower weight.

A heavy edge and special film-cutting technique (optimized combination of wavy and smooth cuts) produces a maximum effective surface for the metal spraying or contacting process.

Series PhaseCap and PhaseCap HD dry technology – impregnation with an inert gas (nitrogen N2).

Series PhaseCap Compact – semi-dry biodegradable resin.

Series PhiCap – impregnation with semi-dry biodegradable soft resin.

Series MKP-Filter – soft resin.

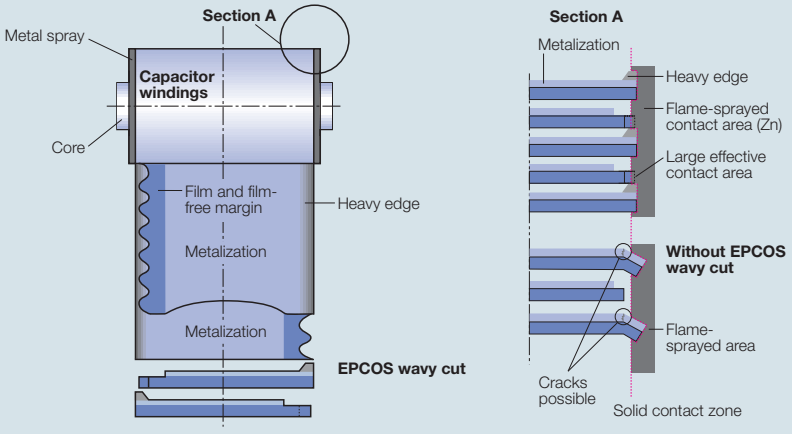
MKV technology

Based on oil-impregnated polypropylene-paper capacitor winding. The winding element consists of double-sided metalized paper as the electrode carrier and an unmetalized polypropylene film as the dielectric. This combination is especially well suited for high power dissipations.

The film-paper arrangement that forms the winding is wound in a slightly staggered alignment: one edge of each double-sided metalized paper projects from the winding.

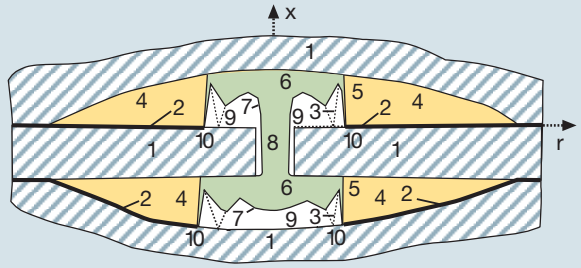
The edges are electrically contacted with vaporized zinc. The Schooping or metal-spray process uses zinc of the highest purity.

Wavy cut design



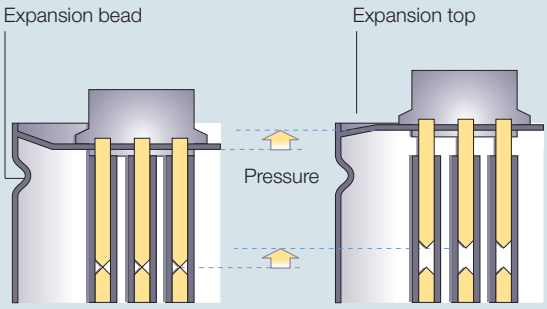
Please read *Important notes* on page 12 and *Cautions* on page 82–85.

Self-healing



1 Dielectric
2 Metalized electrodes
3 Material displacing shock wave
4 Air gap with metal vapor
5, 6 Plasma zone
7 Boundary layer between gas phase dielectric and plasma
8 Breakdown channel
9 Gas phase dielectric
10 Zone of displaced metalization and dielectric (isolating region)

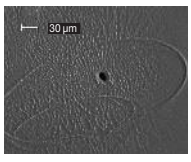
Overpressure disconnector

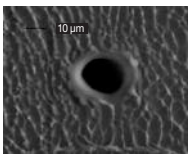


Safety

Self-healing properties

In the event of thermal or electrical overload, an electric breakdown occurs. The dielectric in the breakdown channel is broken down into highly compressed plasma that explodes out of the breakdown channel and pushes the dielectric layers apart. The discharge continues within the spreading plasma via the metal layers so that the metal surrounding the faulty area is completely burnt out. This produces perfect isolation of the faulty area within microseconds. The self-healing process results in negligible capacitance loss – less than 100 pF per event. The capacitor remains fully functional during the entire process.





Overpressure disconnector

At the end of the capacitor's service life or when a high pressure forms inside the can, the overpressure disconnector is activated.

The specially designed cover with an expansion bead moves upwards. Expansion beyond a certain degree will separate the wires and disconnect the capacitor safely from the line. The disconnector is separated at its break point (small notch) and the flow of current to the capacitor windings is interrupted.

⚠ Caution:
To ensure full functionality of an overpressure disconnector, the following is required:

1. The elastic elements must not be hindered, i.e.
   – connecting lines must be flexible leads (cables),
   – there must be sufficient space (at least 20 mm) for expansion above the connections (specified for the different models),
   – folding beads must not be retained by clamps.
2. The maximum permissible fault current of 10 000 A to the UL 810 standard must not be exceeded.
3. Stress parameters of the capacitor must be within the IEC 60831 specification.

Dry technology/ vacuum impregnation

The active winding elements are heated and then dried for a defined period. Impregnation is performed under vacuum. In this way, air and moisture are extracted from the inner capacitor, and oxidation of the electrodes as well as partial discharges are avoided. Afterwards, the capacitor elements are hermetically sealed in cases (e.g. aluminum). This elaborate process ensures excellent capacitance stability and long useful life.

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

Components for Power Factor Correction

2. Power factor controller

Modern PF controllers are microprocessor-based. The microprocessor analyzes the signal from a current transformer and produces switching commands to control the contactors that add or remove capacitor stages.

Intelligent control by microprocessor-based PF controllers ensures even utilization of capacitor stages, a minimized number of switching operations and an optimized life cycle of the capacitor bank.

After the required capacitor output has been determined, the number of steps should be defined. The broad product range of controllers from EPCOS allows customized solutions: the BR604 is suited to small PFC systems with four steps. The BR6000 series is available for conventional, dynamic and mixed compensation with six and twelve steps for medium and large systems respectively.

Rule of thumb: the number of steps depends on the number of loads, i.e. the more small inductive loads, the higher the number of steps should be. The switching time is also of major importance here: the more frequently a capacitor is switched, the more stress is placed on it and its contactors.

3. Multi measuring device

An external meter combining several features in a single device. Combined with the appropriate PF controller, it allows the monitoring, display and storage of various grid parameters. It provides additional protection for the capacitor and the PFC system. As a standalone solution, it acts as a meter, a signal trigger for thyristor modules or as a switch.

4. Switching devices

Two types of switching devices are available from EPCOS: capacitor contactors and thyristor modules. Before choosing a switching device for a PFC system, the user must consider the number of switching operations.

Capacitor contactor

Contactors are electromechanical switching elements used to switch capacitors or reactors and capacitors in standard or detuned PFC systems. The pre-switching auxiliary contacts of EPCOS capacitor contactors close before the main contact and avoid peak current values by pre-loading the capacitor. Note: Even when using capacitor contactors, it is important not to exceed the annual switching capability of the particular capacitor series.

Thryristor modules

Fast-changing loads of any kind require technologies that act in real time. In dynamic PFC systems, thyristor modules replace slow-acting electromechanical switches. This not only allows them to react within a few milliseconds, but also increases the life expectancy of all components without any mechanical wear out of the thyristor module.
Note: A dynamic PF controller is required, e.g. of the BR6000-T series.

5. Reactors (compensation and filtering)

Power distribution networks are increasingly subjected to harmonic pollution from modern power electronics devices, known as non-linear loads, e.g. drives, uninterruptible power supplies and electronic ballasts. Harmonics are dangerous for capacitors connected in the PFC circuit, especially if they operate at a resonant frequency. The series connection of a reactor and capacitor to detune the series resonant frequency (the capacitor's resonant frequency) helps to prevent capacitor damage. The most critical frequencies are the 5th and 7th harmonics (250 and 350 Hz at 50 Hz grid frequency). Detuned capacitor banks also help to reduce the harmonic distortion level and clean the network.

6. Discharge devices

Discharge resistors

- Discharge resistors are required to discharge capacitors and protect human beings against electric shock hazards as well as to switch capacitors in automatic PFC equipment (opposing phase).
- EPCOS discharge resistors are designed to discharge capacitors to 75 V or less within 60 seconds (types marked with 4) in the table of ordering codes: ≤ 75 V in 90 seconds).
- Before switching on again, capacitors must be discharged to 10% or less of their nominal voltage.
- Discharge resistors are included in the scope of delivery, pre-mounted for the PhaseCap Premium, PhaseCap Compact, PhiCap B32344 series and MKV-capacitors.

⚠ Caution:
Discharge and short-circuit the capacitor before handling it!

Discharge reactor

Whenever fast discharge of a capacitor is required, a discharge resistor is not sufficient. Discharge reactors must be used to allow a discharge of within a few seconds. Also, the various steps in a PFC system can then be switched much faster, minimizing losses at the same time.

7. Protection

An HRC fuse or MCCB acts as a safety device for short-circuit protection.

- HRC fuses do not protect a capacitor against overload – they are designed for short-circuit protection only.
- The HRC fuse rating should be 1.6 to 1.8 times the nominal capacitor current.

⚠ Caution:
Do not use HRC fuses for switching (risk of arcing!).

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

Standard Values: Selection Tables for Cables, Cable Cross Sections and Fuses

Selection table

Power kvar	Current A	Section mm²	Fuse A
Rated voltage 230 V, 60 Hz			
2.5	6.3	1.5	10
5.0	12.6	2.5	25
7.5	18.8	6.0	35
10.0	25.1	10.0	50
12.5	31.4	16.0	50
15.0	37.7	16.0	63
20.0	50.2	25.0	80
25.0	62.8	35.0	100
30.0	75.3	50.0	125
40.0	100.4	70.0	160
50.0	125.5	120.0	200
75.0	188.3	185.0	315
100.0	251.0	2 x 120.0	400
Rated voltage 400 V, 50 Hz			
2.5	3.6	1.5	10
5.0	7.2	2.5	16
7.5	10.8	2.5	16
10.0	14.4	4.0	25
12.5	18.0	4.0	35
15.0	21.6	6.0	35
20.0	28.8	10.0	50
25.0	36.0	16.0	63
30.0	43.2	25.0	80
40.0	57.6	35.0	100
50.0	72.0	35.0	125
75.0	108.3	70.0	160
100.0	144.3	120.0	250
125.0	180.3	150.0	300
150.0	216.5	2 x 95.0	350
175.0	252.6	2 x 120.0	400
200.0	288.0	2 x 120.0	500
Rated voltage 440 V, 60 Hz			
2.5	3.3	1.5	10
5.0	6.6	2.5	16
7.5	10.0	2.5	16
10.0	13.2	4.0	25
12.5	16.8	4.0	25
15.0	19.8	6.0	35
20.0	26.4	10.0	50
25.0	33.0	16.0	63
30.0	39.6	25.0	80
40.0	52.8	35.0	100
50.0	66.0	35.0	125
75.0	99.0	70.0	160
100.0	132.0	120.0	200
125.0	165.0	150.0	300
150.0	198.0	2 x 95.0	350
175.0	231.0	2 x 120.0	400
200.0	264.0	2 x 120.0	500

The above mentioned values are guidelines for operation in normal conditions at ambient temperatures up to 35 °C.
Upgrade accordantly if conditions, e.g. temperature or hamonics differ.
The internal wiring of a capacitor bank is sometimes possible with a smaller cross section.
Various parameters such as temperature inside the cabinet, cable quality, maximum cable insulation temperature, single or multi core cable, cable length and laying system have to be considered for a proper selection.
Additionally the regulations and standards in the specific country have to be considered.

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

Standard Values: Selection Tables for Cables, Cable Cross Sections and Fuses

Selection table

Power kvar	Current A	Section mm²	Fuse A
Rated voltage 480 V, 60 Hz			
2.5	3.0	1.5	10
5.0	6.0	2.5	16
7.5	9.0	2.5	16
10.0	12.0	4.0	25
12.5	18.0	6.0	35
15.0	21.0	6.0	35
20.0	24.0	10.0	50
25.0	30.0	16.0	50
30.0	36.0	25.0	63
40.0	48.0	25.0	80
50.0	60.0	35.0	100
75.0	90.0	70.0	160
100.0	120.0	120.0	200
125.0	150.0	120.0	250
150.0	180.0	150.0	300
175.0	210.0	2 x 95.0	350
200.0	240.0	1 x 120.0	400
Rated voltage 525 V, 50 Hz			
2.5	2.7	1.5	10
5.0	5.5	1.5	10
7.5	6.9	2.5	16
10.0	11.0	2.5	16
12.5	13.7	4.0	25
15.0	16.5	4.0	25
20.0	22.0	6.0	35
25.0	27.5	10.0	50
30.0	33.0	16.0	63
40.0	44.0	25.0	80
50.0	55.0	35.0	100
75.0	82.5	70.0	160
100.0	110.0	95.0	200
125.0	137.5	120.0	200
150.0	165.0	150.0	300
175.0	193.0	2 x 95.0	350
200.0	220.0	2 x 120.0	350
Rated voltage 690 V, 50 Hz			
2.5	2.1	1.5	10
5.0	4.2	1.5	10
7.5	6.3	1.5	10
10.0	8.4	2.5	16
12.5	10.5	2.5	16
15.0	12.6	4.0	25
20.0	16.7	4.0	25
25.0	20.9	6.0	35
30.0	25.1	10.0	50
40.0	33.5	16.0	63
50.0	41.8	25.0	80
75.0	62.8	35.0	125
100.0	83.7	70.0	160
125.0	105.0	70.0	160
150.0	126.0	120.0	200
175.0	146.0	120.0	250
200.0	167.0	150.0	300

The above mentioned values are guidelines for operation in normal conditions at ambient temperatures up to 35 °C.
Upgrade accordantly if conditions, e.g. temperature or hamonics differ.
The internal wiring of a capacitor bank is sometimes possible with a smaller cross section.
Various parameters such as temperature inside the cabinet, cable quality, maximum cable insulation temperature, single or multi core cable, cable length and laying system have to be considered for a proper selection.
Additionally the regulations and standards in the specific country have to be considered.

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

Calculation Table for Reactive Power Demand (Qc)

Current (ACTUAL) tan φ	cos φ	Achievable (TARGET) cos φ 0.80	0.82	0.85	0.88	0.90	0.92	0.94	TARGET cos φ = 0.96	0.98	cos φ ≤ 1 1.00
		Faktor F							$Q_c = P_{mot} \cdot F\ (0.96) = \ldots$ [kvar] 100 · 1.01 = 101.0 kvar		
3.18	0.30	2.43	2.48	2.56	2.64	2.70	2.75	2.82	2.89	2.98	3.18
2.96	0.32	2.21	2.26	2.34	2.42	2.48	2.53	2.60	2.67	2.76	2.96
2.77	0.34	2.02	2.07	2.15	2.23	2.28	2.34	2.41	2.48	2.56	2.77
2.59	0.36	1.84	1.89	1.97	2.05	2.10	2.17	2.23	2.30	2.39	2.59
2.43	0.38	1.68	1.73	1.81	1.89	1.95	2.01	2.07	2.14	2.23	2.43
2.29	0.40	1.54	1.59	1.67	1.75	1.81	1.87	1.93	2.00	2.09	2.29
2.16	0.42	1.41	1.46	1.54	1.62	1.68	1.73	1.80	1.87	1.96	2.16
2.04	0.44	1.29	1.34	1.42	1.50	1.56	1.61	1.68	1.75	1.84	2.04
1.93	0.46	1.18	1.23	1.31	1.39	1.45	1.50	1.57	1.64	1.73	1.93
1.83	0.48	1.08	1.13	1.21	1.29	1.34	1.40	1.47	1.54	1.62	1.83
1.73	0.50	0.98	1.03	1.11	1.19	1.25	1.31	1.37	1.45	1.63	1.73
1.64	0.52	0.89	0.94	1.02	1.10	1.16	1.22	1.28	1.35	1.44	1.64
1.56	0.54	0.81	0.86	0.94	1.02	1.07	1.13	1.20	1.27	1.36	1.56
1.48	0.56	0.73	0.78	0.86	0.94	1.00	1.05	1.12	1.19	1.28	1.48
1.40	0.58	0.65	0.70	0.78	0.86	0.92	0.98	1.04	1.11	1.20	1.40
1.33	0.60	0.58	0.63	0.71	0.79	0.85	0.91	0.97	1.04	1.13	1.33
1.30	0.61	0.55	0.60	0.68	0.76	0.81	0.87	0.94	1.01	1.10	1.30
1.27	0.62	0.52	0.57	0.65	0.73	0.78	0.84	0.91	0.99	1.06	1.27
1.23	0.63	0.48	0.53	0.61	0.69	0.75	0.81	0.87	0.94	1.03	1.23
1.20	0.64	0.45	0.50	0.58	0.66	0.72	0.77	0.84	0.91	1.00	1.20
1.17	0.65	0.42	0.47	0.55	0.63	0.68	0.74	0.81	0.88	0.97	1.17
1.14	0.66	0.39	0.44	0.52	0.60	0.65	0.71	0.78	0.85	0.94	1.14
1.11	0.67	0.36	0.41	0.49	0.57	0.63	0.68	0.75	0.82	0.90	1.11
1.08	0.68	0.33	0.38	0.46	0.54	0.59	0.65	0.72	0.79	0.88	1.08
1.05	0.69	0.30	0.35	0.43	0.51	0.56	0.62	0.69	0.76	0.85	1.05
1.02	0.70	0.27	0.32	0.40	0.48	0.54	0.59	0.66	0.73	0.82	1.02
0.99	0.71	0.24	0.29	0.37	0.45	0.51	0.57	0.63	0.70	0.79	0.99
0.96	0.72	0.21	0.26	0.34	0.42	0.48	0.54	0.60	0.67	0.76	0.96
0.94	0.73	0.19	0.24	0.32	0.40	0.45	0.51	0.58	0.65	0.73	0.94
0.91	0.74	0.16	0.21	0.29	0.37	0.42	0.48	0.55	0.62	0.71	0.91
0.88	0.75	0.13	0.18	0.26	0.34	0.40	0.46	0.52	0.59	0.68	0.88
0.86	0.76	0.11	0.16	0.24	0.32	0.37	0.43	0.50	0.57	0.65	0.86
0.83	0.77	0.08	0.13	0.21	0.29	0.34	0.40	0.47	0.54	0.63	0.83
0.80	0.78	0.05	0.10	0.18	0.26	0.32	0.38	0.44	0.51	0.60	0.80
0.78	0.79	0.03	0.08	0.16	0.24	0.29	0.35	0.42	0.49	0.57	0.78
0.75	0.80		0.05	0.13	0.21	0.27	0.32	0.39	0.46	0.55	0.75
0.72	0.81			0.10	0.18	0.24	0.30	0.36	0.43	0.52	0.72
0.70	0.82			0.08	0.16	0.21	0.27	0.34	0.41	0.49	0.70
0.67	0.83			0.05	0.13	0.19	0.25	0.31	0.38	0.47	0.67
0.65	0.84			0.03	0.11	0.16	0.22	0.29	0.36	0.44	0.65
0.62	0.85				0.08	0.14	0.19	0.26	0.33	0.42	0.62
0.59	0.86				0.05	0.11	0.17	0.23	0.30	0.39	0.59
0.57	0.87					0.08	0.14	0.21	0.28	0.36	0.57
0.54	0.88					0.06	0.11	0.18	0.25	0.34	0.54
0.51	0.89					0.03	0.09	0.15	0.22	0.31	0.51
0.48	0.90						0.06	0.12	0.19	0.28	0.48
0.46	0.91						0.03	0.10	0.17	0.25	0.46
0.43	0.92							0.07	0.14	0.22	0.43
0.40	0.93							0.04	0.11	0.19	0.40
0.36	0.94								0.07	0.16	0.36
0.33	0.95									0.13	0.33

$Q_C = P_A \cdot (\tan \varphi 1 - \tan \varphi 2)$
Q_C [kvar] = P_A · F = active power [kW] · factor "F"
$P_A = S \cdot \cos \varphi$ = apparent power · cos φ
tan φ1 + φ2 according to cos φ values ref. table

Example:

Actual motor power	P = 100 kW
ACTUAL cos φ	0.61
TARGET cos φ	0.96
Factor F from table	1.01
Capacitor reactive power Q_C	
$Q_C = 100 \cdot 1.01 = 101.0$ kvar	

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

Individual PFC for Motors

Approximate values (specified by the German Electricity Association VDEW) for fixed PFC of motors

Motor nominal rating kW	Capacitor power rating (1500 r.p.m.*) kvar	Capacitor power rating (1000 r.p.m.*) kvar	Capacitor power rating (750 r.p.m.*) kvar
1 ... 1.9	0.5	0.5	0.6
2 ... 2.9	1	1.1	1.2
3 ... 3.9	1.5	1.6	1.7
4 ... 4.9	2	2.1	2.3
5 ... 5.9	2.5	2.6	2.9
6 ... 7.9	3	3.2	3.5
8 ... 10.9	4	4.2	4.6
11 ... 13.9	5	5.3	5.8
14 ... 17.9	6	6.3	6.9
18 ... 21.9	7.5	8.0	8.6
22 ... 29.9	10	10.5	11.5
30 ... 39.9	approx. 40% of the motor power		
40 and above	approx. 35% of the motor power		

*r.p.m.: revolutions per minute

The capacitor output should be approx. 90% of the apparent power of the motor when idle.

This means a power factor of 0.9% at full load and 0.95 … 0.98 during idling. Important: The capacitor output must not be rated too high for individual compensated machines where the capacitor is directly connected with the motor clamp. This especially applies when the machine has a big oscillating weight and still continues to rotate after switching off. The capacitor placed in parallel may act as generator for the motor which will cause serious overvoltages. The consequence could be heavy damage to the capacitor as well as to the motor.

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

Individual PFC for Transformers

Standard values for transformer power factor correction		
Rated apparent power of transformer **kVA**	**Rated capacitor power for oil immersed transformers** **kvar**	**Rated capacitor power for cast resin transformers** **kvar**
10	1.0	1.5
20	2.0	1.7
50	4.0	2.0
75	5.0	2.5
100	5.0	2.5
160	7.0	4.0
200	7.5	5.0
250	8.0	7.5
315	10.0	8.0
400	12.5	8.5
500	15.0	10.0
630	17.5	12.5
800	20.0	15.0
1000	25.0	16.7
1250	30.0	20.0
1600	35.0	22.0
2000	40.0	25.0
2500	50.0	35.0
3150	60.0	50.0

For an exact calculation of the right capacitor value, following formula can be used:

$$Q_C = I_0\% \cdot \frac{A_N}{100}$$

Q_C = needed capacitor (kvar)
$I_0\%$ = magnetising current of the transformer ($A_S\%$)
A_N = apparent rated power of the transformer in kVA

There are regional differences in the guidelines of power suppliers concerning the admissible size of capacitors directly connected with a transformer. Therefore a consultation with the respective power supplier is recommended before installation of a compensation bank. Modern transformers have laminations which only need low capacity to reverse the magnetism. In case the capacitor output is too high, stress increase may occur during idling.

Please read the *Important notes* on page 12 and *Cautions* on page 82–85.

Detuned PFC in General

When installing capacitors for PFC purpose, the problem of dealing with harmonics has to be faced. They have to be taken into account when designing the PFC system in order to prevent parallel and / or series resonance conditions that would damage the whole electrical system.

When PFC capacitors are connected, the inductance of the transformer together with the capacitors forms a resonant circuit that could be excited by a harmonic current generated by the load. This resonant circuit has a resonance frequency, and if a harmonic current of this frequency (or close to it) exists, it will lead the circuit into a resonance condition where high current will flow through the branches (L: the transformer, and C: the capacitor bank), overloading them and raising the voltage across them and across the whole electrical system that is connected in parallel.

PFC detuned filtering is a technique to correct the power factor avoiding the risk of resonance condition performed by shifting the resonance frequency to lower values where no harmonic currents are present.

This is achieved by modifying the basic LC circuit formed by the transformer and the capacitor bank, introducing a filter reactor in series with the capacitors, making this way a more complex resonant circuit but with the desired feature of having a resonance frequency below the first existing harmonic. This way it's not possible to have a real resonance condition.

Besides this main objective, the reactor connected in series with capacitors form a series resonant circuit with a certain tuning frequency at which the branch will offer a low impedance path. Filtering of harmonic currents and "cleaning" of the grid will be achieved.

Components for PFC detuned filters must be carefully selected according to the desired PFC purpose, to the harmonics present in the system, to some features of the system like short circuit power and impedances, to the desired filtering effect and to the characteristics of the resonant circuit configured.

For example, the voltage across the capacitors will be higher than the nominal grid voltage when they have a reactor connected in series.

The reactors must be selected in line with the inductance value to obtain the desired tuning frequency and current capability high enough for the harmonic current absorption that can be expected. The tuning frequency is usually indirectly referred to as the detuning factor p and expressed as a percentage.

$$p = 100 \cdot \frac{X_L}{X_C} = \left(\frac{f}{f_{RES}}\right)^2 \cdot 100$$

PFC detuned filtering is an engineering speciality that takes experienced know-how to implement it in a satisfying and safe way.

The design-instructions for detuned PFC systems on page 70 have to be followed to ensure an optimum performance of the PFC system.

Note: The recommendations given in the selection tables are meant as a support tool. EPCOS does not take over any responsibility for the design as apart from the theoretical conditions the prevailing circumstances in the application have to be taken into account.

Detuned PFC: Important Facts and Instructions

Important design instructions to be followed for detuned PFC Systems

1 Determine the necessary effective power (kvar) of the capacitor bank in order to obtain the desired PF.

2 Design the capacitor stages in such a way that the sensibility of the bank is around 15–20% of the total available power. It's not useful to have a more sensitive bank that reacts with a 5 or 10% of the total power because this would lead to a high amount of switching operations, wasting the equipment unnecessarily when the real objective is to have a high average PF.

3 Try to design the bank with standard kvar values of effective power steps, preferably multiples of 25 kvar.

4 Measure the presence of harmonic currents in the main feeder cable of the system without capacitors at all possible load conditions. Determine frequency and maximum amplitude for every harmonic that could exist.
Calculate the Total Harmonic Distortion of Current $THD\text{-}I = 100 \cdot SQR\,[(I_3)^2 + (I_5)^2 + \ldots + (I_R)^2]/I_I$
Calculate every existing value for $THD\text{-}I_R = 100 \cdot I_R/I_I$

5 Measure the presence of harmonic voltages that might come from outside your system, if possible measure the HV side.
Calculate the Total Harmonic Distortion of Voltage $THD\text{-}V = 100 \cdot SQR\,[(U_3)^2 + (U_5)^2 + \ldots + (U_N)^2]/U_I$

6 Are there harmonics such as $THD\text{-}I > 10\%$ or $THD\text{-}V > 3\%$ (measured without capacitors)?
If YES → use PFC-DF and go to consideration 7.
If NO → use standard PFC and skip considerations 7, 8 and 9.

7 Is there 3rd harmonic content, $I_3 > 0.2 \cdot I_5$?
If YES → use PFC-DF with p = 14% and skip consideration 8.
If NO → use PFC-DF with p = 7% or 5.67% and go to consideration 8.

8 THD-V is:
3–7% → use PFC-DF with p = 7%
>7% → use PFC-DF with p = 5.67%
>10% → ask for special filter design

9 Select the proper components using EPCOS tables for PFC-DF and standard values for effective power, the voltage and frequency of your grid, and the determined detuned factor p.

10 Always use genuine EPCOS application-specific designed components for PFC-DF. Please observe that reactors are specified for their effective power at grid voltage and frequency. This power will be the real effective power of the whole LC set at fundamental frequency. Capacitors for PFC-DF must be selected for a higher rated voltage than the grid's because of the overvoltage caused by the series connection with the reactor. Contactors for capacitors are designed as application-specific to reduce inrush capacitors currents and to handle capacitive loads in a reliable way.

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

Component Selection Tables for Detuned PFC

Selection table

Detuning factor %	Effective filter output kvar	Capacitor ordering code	Reactor ordering code	Contactor ordering code	Cable* cross-section mm²	Fuse** rating A
Grid voltage: 400 V – 50 Hz detuned filters components selection table						
5.67	10.0	1 x B25667B4177A375	B44066D5010S400	B44066S1810J230	4	25
5.67	12.5	1 x B25667B4237A375	B44066D5012S400	B44066S1810J230	4	25
5.67	20.0	1 x B25667B4417A375	B44066D5020S400	B44066S2410J230	10	50
5.67	25.0	1 x B25667B4467A375	B44066D5025S400	B44066S3210J230	25	63
5.67	40.0	1 x B25667B4337A375 1 x B25667B4417A375	B44066D5040S400	B44066S6210J230	35	100
5.67	50.0	2 x B25667B4467A375	B44066D5050S400	B44066S6210J230	35	125
5.67	75.0	3 x B25667B4467A375	B44066D5075S400	B44066S7410J230	70	160
5.67	100.0	4 x B25667B4467A375	B44066D5100S400	B44066S9910J230	120	250
7	10.0	1 x B25667B4177A375	B44066D7010S400	B44066S1810J230	4	25
7	12.5	1 x B25667B4237A375	B44066D7012S400	B44066S1810J230	4	25
7	20.0	1 x B25667B4417A375	B44066D7020S400	B44066S2410J230	10	50
7	25.0	1 x B25667B4467A375	B44066D7025S400	B44066S3210J230	25	63
7	40.0	1 x B25667B4337A375 1 x B25667B4417A375	B44066D7040S400	B44066S6210J230	35	100
7	50.0	2 x B25667B4467A375	B44066D7050S400	B44066S6210J230	35	125
7	75.0	3 x B25667B4467A375	B44066D7075S400	B44066S7410J230	70	160
7	100.0	4 x B25667B4467A375	B44066D7100S400	B44066S9910J230	120	250
14	10.0	1 x B25667B5177A375	B44066D1410S400	B44066S1810J230	4	25
14	12.5	1 x B25667B4207A375	B44066D1412S400	B44066S1810J230	4	25
14	20.0	1 x B25667B4347A375	B44066D1420S400	B44066S2410J230	10	50
14	25.0	1 x B25667B4417A365	B44066D1425S400	B44066S3210J230	25	63
14	40.0	2 x B25667B5347A375	B44066D1440S400	B44066S6210J230	35	100
14	50.0	2 x B25667B4417A365	B44066D1450S400	B44066S6210J230	35	125
14	75.0	3 x B25667B4417A365	B44066D1475S400	B44066S7410J230	70	160
14	100.0	4 x B25667B4417A365	B44066D1499S400	B44066S9910J230	120	250
Grid voltage: 400 V – 60 Hz detuned filters components selection table						
5.67	25.0	1 x B25667B4307A375 1 x B25667B4826A375	B44066D5025S401	B44066S3210J230	25	63
5.67	50.0	1 x B25667B4417A375 1 x B25667B4247A375 1 x B25667B4127A375	B44066D5050S401	B44066S6210J230	35	125
5.67	75.0	2 x B25667B4417A375 1 x B25667B4337A375	B44066D5075S401	B44066S7410J230	70	160
5.67	100.0	3 x B25667B4417A375 1 x B25667B4337A375	B44066D5100S401	B44066S9910J230	120	250
7	25.0	1 x B25667B4307A375 1 x B25667B4826A375	B44066D7025S401	B44066S3210J230	25	63
7	50.0	1 x B25667B4417A375 1 x B25667B4247A375 1 x B25667B4127A375	B44066D7050S401	B44066S6210J230	35	125
7	75.0	2 x B25667B4417A375 1 x B25667B4337A375	B44066D7075S401	B44066S7410J230	70	160
7	100.0	3 x B25667B4417A375 1 x B25667B4307A375	B44066D7100S401	B44066S9910J230	120	250
14	25.0	1 x B25667B4347A375	B44066D1425S401	B44066S3210J230	25	63
14	50.0	2 x B25667B4347A375	B44066D1450S401	B44066S6210J230	35	125
14	75.0	3 x B25667B4347A375	B44066D1475S401	B44066S7410J230	70	160
14	100.0	4 x B25667B4347A375	B44066D1499S401	B44066S9910J230	120	250

* The above mentioned values are guidelines for operation under normal conditions at ambient temperatures up to 35 °C. Various parameters such as temperature inside the cabinet, cable quality, maximum cable insulation temperature, single or multi core cable, cable length and laying system have to be considered for a proper selection. Upgrade/downgrade accordingly if conditions differ. Additionally do not forget to consider the regulations and standards which are valid for your country.

** Fuse size of HRC fuses for short circuit protection of each individual stage of a capacitor bank.

The warnings, cautions, product specific notes in the particular data sheets and the important notes must be observed!

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

Component Selection Tables for Detuned PFC

Selection table

Detuning factor %	Effective filter output kvar	Capacitor ordering code	Reactor ordering code	Contactor ordering code	Cable* cross-section mm²	Fuse** rating A
Grid voltage: 440 V – 50 Hz detuned filters components selection table						
5.67	10.0	1 x B25667B5177A375	B44066D5010S440	B44066S1810J230	4	25
5.67	12.5	1 x B25667B4207A375	B44066D5012S440	B44066S1810J230	4	25
5.67	20.0	1 x B25667B4347A375	B44066D5020S440	B44066S2410J230	10	50
5.67	25.0	1 x B25667B5177A375 1 x B25667B4207A375	B44066D5025S440	B44066S3210J230	16	63
5.67	40.0	1 x B25667B4277A375 1 x B25667B4347A375	B44066D5040S440	B44066S6210J230	35	100
5.67	50.0	1 x B25667B4347A375 1 x B25667B4417A365	B44066D5050S440	B44066S6210J230	35	125
5.67	75.0	1 x B25667B4347A375 2 x B25667B4417A365	B44066D5075S440	B44066S7410J230	70	160
5.67	100.0	2 x B25667B4347A375 2 x B25667B4417A365	B44066D5100S440	B44066S9910J230	120	200
7	10.0	1 x B25667B5177A375	B44066D7010S440	B44066S1810J230	4	25
7	12.5	1 x B25667B4207A375	B44066D7012S440	B44066S1810J230	4	25
7	20.0	1 x B25667B4347A375	B44066D7020S440	B44066S2410J230	10	50
7	25.0	1 x B25667B5177A375 1 x B25667B4207A375	B44066D7025S440	B44066S3210J230	16	63
7	40.0	1 x B25667B4277A375 1 x B25667B4347A375	B44066D7040S440	B44066S6210J230	35	100
7	50.0	1 x B25667B4417A365 1 x B25667B4347A375	B44066D7050S440	B44066S6210J230	35	125
7	75.0	1 x B25667B4347A375 2 x B25667B4417A365	B44066D7075S440	B44066S7410J230	70	160
7	100.0	2 x B25667B4347A375 2 x B25667B4417A365	B44066D7100S440	B44066S9910J230	120	200
14	10.0	1 x B25667B5147A375	B44066D1410S440	B44066S1810J230	4	25
14	12.5	1 x B25667B5177A375	B44066D1412S440	B44066S1810J230	4	25
14	20.0	1 x B25667B5287A375	B44066D1420S440	B44066S2410J230	10	50
14	25.0	1 x B25667B5347A375	B44066D1425S440	B44066S3210J230	16	63
14	40.0	2 x B25667B5287A375	B44066D1440S440	B44066S6210J230	35	100
14	50.0	2 x B25667B5347A375	B44066D1450S440	B44066S6210J230	35	125
14	75.0	3 x B25667B5347A375	B44066D1475S440	B44066S7410J230	70	160
14	100.0	4 x B25667B5347A375	B44066D1499S440	B44066S9910J230	120	200

* The above mentioned values are guidelines for operation under normal conditions at ambient temperatures up to 35 °C. Various parameters such as temperature inside the cabinet, cable quality, maximum cable insulation temperature, single or multi core cable, cable length and laying system have to be considered for a proper selection. Upgrade/downgrade accordingly if conditions differ. Additionally do not forget to consider the regulations and standards which are valid for your country.

** Fuse size of HRC fuses for short circuit protection of each individual stage of a capacitor bank.

The warnings, cautions, product specific notes in the particular data sheets and the important notes must be observed!

Component Selection Tables for Detuned PFC

Selection table

Detuning factor %	Effective filter output kvar	Capacitor ordering code	Reactor ordering code	Contactor ordering code	Cable* cross-section mm²	Fuse** rating A
Grid voltage: 440 V – 60 Hz detuned filters components selection table						
5.67	25.0	1 x B25667B5147A375 1 x B25667B5177A375	B44066D5025S441	B44066S3210J230	16	63
5.67	50.0	2 x B25667B4347A375	B44066D5050S441	B44066S6210J230	35	125
5.67	75.0	2 x B25667B4347A375 1 x B25667B4277A375	B44066D5075S441	B44066S7410J230	70	160
5.67	100.0	3 x B25667B4347A375 1 x B25667B4277A375	B44066D5100S441	B44066S9910J230	120	200
7	25.0	1 x B25667B5147A375 1 x B25667B5177A375	B44066D7025S441	B44066S3210J230	16	63
7	50.0	2 x B25667B4347A375	B44066D7050S441	B44066S6210J230	35	125
7	75.0	2 x B25667B4347A375 1 x B25667B4277A375	B44066D7075S441	B44066S7410J230	70	160
7	100.0	3 x B25667B4347A375 1 x B25667B5237A375	B44066D7100S441	B44066S9910J230	120	200
14	25.0	1 x B25667B5966A375 1 x B25667B5197A375	B44066D1425S441	B44066S3210J230	16	63
14	50.0	3 x B25667B5197A375	B44066D1450S441	B44066S6210J230	35	125
14	75.0	3 x B25667B5237A375 1 x B25667B5177A375	B44066D1475S441	B44066S7410J230	70	160
14	100.0	5 x B25667B5237A375	B44066D1499S441	B44066S9910J230	120	200
Grid voltage: 480 V – 60 Hz detuned filters components selection table						
5.67	25.0	1 x B25667B5177A375 1 x B25667B5966A375	B44066D5025S481	B44066S3210J230	16	50
5.67	50.0	2 x B25667B5197A375 1 x B25667B5147A375	B44066D5050S481	B44066S6210J230	35	100
5.67	75.0	3 x B25667B5237A375 1 x B25667B5127A375	B44066D5075S481	B44066S7410J230	70	160
5.67	100.0	4 x B25667B5237A375 1 x B25667B5147A375	B44066D5100S481	B44066S9910J230	120	200
7	25.0	1 x B25667B5177A375 1 x B25667B5966A375	B44066D7025S481	B44066S3210J230	16	50
7	50.0	2 x B25667B5197A375 1 x B25667B5147A375	B44066D7050S481	B44066S6210J230	35	100
7	75.0	3 x B25667B5237A375 1 x B25667B5127A375	B44066D7075S481	B44066S7410J230	70	160
7	100.0	4 x B25667B5237A375 1 x B25667B5147A375	B44066D7100S481	B44066S9910J230	120	200
14	25.0	1 x B25668A6107A375 1 x B25668A6137A375	B44066D1425S481	B44066S3210J230	16	50
14	50.0	2 x B25668A6107A375 2 x B25668A6137A375	B44066D1450S481	B44066S6210J230	35	100
14	75.0	3 x B25668A6107A375 3 x B25668A6137A375	B44066D1475S481	B44066S7410J230	70	160
14	100.0	4 x B25668A6107A375 4 x B25668A6137A375	B44066D1499S481	B44066S9910J230	120	200

* The above mentioned values are guidelines for operation under normal conditions at ambient temperatures up to 35 °C. Various parameters such as temperature inside the cabinet, cable quality, maximum cable insulation temperature, single or multi core cable, cable length and laying system have to be considered for a proper selection. Upgrade/downgrade accordingly if conditions differ. Additionally do not forget to consider the regulations and standards which are valid for your country.

** Fuse size of HRC fuses for short circuit protection of each individual stage of a capacitor bank.

The warnings, cautions, product specific notes in the particular data sheets and the important notes must be observed!

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

Component Selection Tables for Detuned PFC

Selection table

Detuning factor %	Effective filter output kvar	Capacitor ordering code	Reactor ordering code	Contactor ordering code	Cable* cross-section mm²	Fuse** rating A
Grid voltage: 690 V – 50 Hz detuned filters components selection table						
5.67	25.0	1 x B25668A7996A375 1 x B25668A7626A375	B44066D5025M690	B44066S2410J230	6	35
5.67	50.0	2 x B25668A7127A375 1 x B25668A7626A375	B44066D5050M690	B44066S5010J230	25	80
5.67	75.0	3 x B25668A7127A375 1 x B25668A7996A375	B44066D5075M690	B44066S6210J230	35	125
5.67	100.0	4 x B25668A7137A375 1 x B25668A7746A375	B44066D5100M690	B44066S7410J230	70	160
7	25.0	1 x B25668A7626A375 1 x B25668A7996A375	B44066D7025M690	B44066S2410J230	6	35
7	50.0	2 x B25668A7127A375 1 x B25668A7626A375	B44066D7050M690	B44066S5010J230	25	80
7	75.0	4 x B25668A7996A375 1 x B25668A7746A375	B44066D7075M690	B44066S6210J230	35	125
7	100.0	5 x B25668A7127A375	B44055D7100M690	B44066S7410J230	70	160
14	25.0	1 x B25668A7137A375	B44066D1425M690	B44066S2410J230	6	35
14	50.0	2 x B25668A7137A375	B44066D1450M690	B44066S5010J230	25	80
14	75.0	3 x B25668A7127A375 1 x B25668A7626A375	B44066D1475M690	B44066S6210J230	35	125
14	100.0	4 x B25668A7127A375 1 x B25668A7746A375	B44066D1499M690	B44066S7410J230	70	160
Grid voltage: 690 V – 60 Hz detuned filters components selection table						
5.67	25.0	1 x B25668A7137A375	B44066D5025M690	B44066S2410J230	6	35
5.67	50.0	1 x B25668A7127A375 1 x B25668A7137A375	B44066D5050M690	B44066S5010J230	25	80
5.67	75.0	1 x B25668A7127A375 2 x B25668A7137A375	B44066D5075M690	B44066S6210J230	35	125
5.67	100.0	1 x B25668A7127A375 3 x B25668A7137A375	B44066D5100M690	B44066S7410J230	70	160
7	25.0	1 x B25668A7127A375	B44066D7025M690	B44066S2410J230	6	35
7	50.0	1 x B25668A7127A375 1 x B25668A7137A375	B44066D7050M690	B44066S5010J230	25	80
7	75.0	1 x B25668A7127A375 2 x B25668A7137A375	B44066D7075M690	B44066S6210J230	35	125
7	100.0	1 x B25668A7996A375 3 x B25668A7137A375	B44055D7100M690	B44066S7410J230	70	160
14	25.0	1 x B25668A7127A375	B44066D1425M690	B44066S2410J230	6	35
14	50.0	2 x B25668A7127A375	B44066D1450M690	B44066S5010J230	25	80
14	75.0	3 x B25668A7996A375 1 x B25668A7626A375	B44066D1475M690	B44066S6210J230	35	125
14	100.0	3 x B25668A7137A375 1 x B25668A7746A375	B44066D1499M690	B44066S7410J230	70	160

* The above mentioned values are guidelines for operation under normal conditions at ambient temperatures up to 35 °C. Various parameters such as temperature inside the cabinet, cable quality, maximum cable insulation temperature, single or multi core cable, cable length and laying system have to be considered for a proper selection. Upgrade/downgrade accordingly if conditions differ. Additionally do not forget to consider the regulations and standards which are valid for your country.

** Fuse size of HRC fuses for short circuit protection of each individual stage of a capacitor bank.

The warnings, cautions, product specific notes in the particular data sheets and the important notes must be observed!

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

Dynamic PFC: Important Facts and Instructions

General

Conventional PFC systems quickly reach their limits when they have to deal with fast changing loads. Applications like rolling mills, steel presses, wind turbines, container cranes and large buildings include a huge amount of electric consumers that require a reactive power adjustment on the ms scale. Production equipment, elevators, chillers, and other electric devices not only require such dynamic reactions of the power factor compensation equipment, they also lead very soon to a total number of switchings that exceeds the specifications of standard electromechanical contactors by far.

In conventional PFC systems, standard capacitor contactors are used to switch capacitor steps on and off. These electromechanical devices offer between 100 000 and 200 000 switching operations in total during their life time which means that in such an application they reach their life expectancy after 1 to 2 years already. It has to be mentioned that capacitors are much stricter limited with regard to the permitted annual number of switching operations (IEC 60831). This typically results in destruction of their inrush current damping capability and may also damage the contacts in the main power circuit. Burnt main contacts may produce oscillation or “unclean” (re-bouncing) switching operations. This massive overload not only shortens the life expectancy of the capacitor, but also increases the risk of premature failure and in the worst case represents a potential safety risk.

But furthermore the capacitor itself is specified for a limited number of switching operations per year. The standard IEC 60831 gives an acceptable value of 5 000 switching operations per year, a value far below switching numbers up to 100 000 that may be required per year in dynamic applications. Such large switching numbers and the respective overvoltages and overcurrents during each switching operation are likely to damage the capacitor and may lead to a very early capacitor failure.

In dynamic PFC systems, the capacitor contactors are replaced by thyristor modules that are suitable for a nearby unlimited number of switching operations as there is no mechanical wear-off. Thyristor modules feature electronic semiconductor switches that are able to react to a changing reactive power demand on the ms scale and that can switch capacitors without additional stress. The EPCOS TSM-thyristor switches keep the capacitors at the peak value of the grid voltage and connect them only when the grid reaches this peak voltage value. Thus the capacitors are switched current free and inrush currents that can reach values of 200 times the nominal current for conventional contactors are avoided. Additionally capacitor discharge times up to 75 s as necessary for conventional PFC are not required here.

In summary dynamic PFC does not only prevent wear-off of the capacitors and the switches and increases thus the lifetime of a PFC system and its safety. It also increases the power quality in the grid essentially as it can almost react in real time to reactive power demands. Fast enough for example, to take care of motor start up effects or spot welding requirements.

EPCOS offers all necessary key components to set up a dynamic PFC systems as the thyristor modules (TSM, see page 52), the required fast transistor output controllers (BR6000-T, page 42), and the EPCOS standard reactor (page 56) and of course capacitor series (page 13). A further help to compose such a system for a large number of situations is given by the dynamic PFC selection tables on page 76 ff.

Note: The recommendations given in the selection tables are meant as a support tool. EPCOS does not take over any responsibility for the design as apart from the theoretical conditions the prevailing circumstances in the application have to be taken into account.

Component Selection Tables for Dynamic PFC

Component selection table for dynamic LV PFC antiresonance filter circuits

De-tuning factor %	Effective filter output kvar	Capacitor[1] quantity and ordering code	Reactor quantity and ordering code	Thyristor module quantity and ordering code	Discharge resistor[2] quantity and ordering code	Cable[3] cross-section mm²	Fuse[3] A
Grid voltage: 400 V – 50 Hz dynamic detuned filters components selection table							
5.67	10	1x B25667B5197A375	1x B44066D5010S400	1x B44066T0010E402	1x B44066T0022E400	10	35
5.67	12.5	1x B25667B5237A375	1x B44066D5012S400	1x B44066T0010E402	1x B44066T0022E400	10	35
5.67	20	2x B25667B5197A375	1x B44066D5020S400	1x B44066T0025E402	1x B44066T0022E400	10	50
5.67	25	2x B25667B5237A375	1x B44066D5025S400	1x B44066T0025E402	1x B44066T0022E400	16	63
5.67	40	1x B25667B5287A375 2x B25667B5237A375	1x B44066D5040S400	1x B44066T0050E402	1x B44066T0022E400	35	100
5.67	50	2x B25667B5347A375 1x B25667B5237A375	1x B44066D5050S400	1x B44066T0050E402	1x B44066T0022E400	35	125
5.67	100	4x B25667B5347A375 2x B25667B5237A375	1x B44066D5100S400	1x B44066T0100E402	2x B44066T0022E400[2]	120	250
7	10	1x B25667B5197A375	1x B44066D7010S400	1x B44066T0010E402	1x B44066T0022E400	10	35
7	12.5	1x B25667B5237A375	1x B44066D7012S400	1x B44066T0010E402	1x B44066T0022E400	10	35
7	20	1x B25667B5177A375 1x B25667B5197A375	1x B44066D7020M400	1x B44066T0025E402	1x B44066T0022E400	10	50
7	25	2x B25667B5237A375	1x B44066D7025M400	1x B44066T0025E402	1x B44066T0022E400	16	63
7	40	1x B25667B5287A375 2x B25667B5237A375	1x B44066D7040M400	1x B44066T0050E402	1x B44066T0022E400	35	100
7	50	2x B25667B5347A375 1x B25667B5237A375	1x B44066D7050M400	1x B44066T0050E402	1x B44066T0022E400	35	125
7	100	4x B25667B5347A375 2x B25667B5237A375	1x B44066D7100M400	1x B44066T0100E402	2x B44066T0022E400[2]	120	250
14	10	1x B25667B5177A375	1x B44066D1410S400	1x B44066T0010E402	1x B44066T0022E400	10	35
14	12.5	1x B25667B5966A375 1x B25667B5127A375	1x B44066D1412S400	1x B44066T0010E402	1x B44066T0022E400	10	35
14	20	1x B25667B5347A375	1x B44066D1420M400	1x B44066T0025E402	1x B44066T0022E400	10	50
14	25	1x B25667B5197A375 1x B25667B5237A375	1x B44066D1425M400	1x B44066T0025E402	1x B44066T0022E400	16	63
14	40	2x B25667B5347A375	1x B44066D1440M400	1x B44066T0050E402	1x B44066T0022E400	35	100
14	50	3x B25667B5287A375	1x B44066D1450M400	1x B44066T0050E402	1x B44066T0022E400	35	125
14	100	5x B25667B5347A375	1x B44066D1499M400	1x B44066T0100E402	2x B44066T0022E400[2]	120	250
Grid voltage: 400 V – 60 Hz dynamic detuned filters components selection table							
5.67	25	2x B25667B5197A375	1x B44066D5025M401	1x B44066T0025E402	1x B44066T0022E400	16	63
5.67	50	4x B25667B5197A375	1x B44066D5050M401	1x B44066T0050E402	1x B44066T0022E400	35	125
5.67	100	1x B25667B5177A375 6x B25667B5237A375	1x B44066D5100M401	1x B44066T0100E402	2x B44066T0022E400[2]	120	250
7	25	2x B25667B5197A375	1x B44066D7025M401	1x B44066T0025E402	1x B44066T0022E400	16	63
7	50	4x B25667B5197A375	1x B44066D7050M401	1x B44066T0050E402	1x B44066T0022E400	35	125
7	100	1x B25667B5177A375 6x B25667B5237A375	1x B44066D7100M401	1x B44066T0100E402	2x B44066T0022E400[2]	120	250
14	25	2x B25667B5177A375	1x B44066D1425M401	1x B44066T0025E402	1x B44066T0022E400	16	63
14	50	3x B25667B5237A375	1x B44066D1450M401	1x B44066T0050E402	1x B44066T0022E400	35	125
14	100	6x B25667B5237A375	1x B44066D1499M401	1x B44066T0100E402	2x B44066T0022E400[2]	120	250

[1] In some cases special interconnection of the single phase capacitors needed, in case you are not familiar please contact EPCOS for further details
[2] In some cases special interconnection of the discharge resistors needed, in case you are not familiar please contact EPCOS for further details.
[3] The above mentioned values are guidelines for operation in normal conditions at ambient temperatures up to 35 °C.
Various parameters such as temperature inside the cabinet, cable quality, maximum cable insulation temperature, single or multi core cable, cable length and laying system have to be considered for a proper selection. Upgrade/downgrage accordingly if conditions differ.
Additionally do not forget to consider the regulations and standards which are valid for your country.
The warnings, cautions, product specific notes in the particular data sheets and the important notes must be observed!

Component Selection Tables for Dynamic PFC

Component selection table for dynamic LV PFC antiresonance filter circuits

De-tuning factor %	Effective filter output kvar	Capacitor[1] quantity and ordering code	Reactor quantity and ordering code	Thyristor module quantity and ordering code	Discharge resistor[2] quantity and ordering code	Cable[3] cross-section mm²	Fuse[3] A
Grid voltage: 440 V – 50 Hz dynamic detuned filters components selection table							
5.67	25	2x B25667B5197A375	1x B44066D5025M440	1x B44066T0025E402	1x B44066T0022E400	16	63
5.67	50	2x B25667B5287A375 1x B25667B5197A375	1x B44066D5050M440	1x B44066T0050E402	1x B44066T0022E400	25	125
5.67	100	3x B25667B5287A375 2x B25667B5347A375	1x B44066D5100M440	1x B44066T0100E402	2x B44066T0022E400[2]	95	250
7	25	2x B25667B5197A376	1x B44066D7025M440	1x B44066T0025E402	1x B44066T0022E400	16	63
7	50	2x B25667B5287A375 1x B25667B5197A375	1x B44066D7050M440	1x B44066T0050E402	1x B44066T0022E400	25	125
7	100	3x B25667B5287A375 2x B25667B5347A375	1x B44066D7100M440	1x B44066T0100E402	2x B44066T0022E400[2]	95	250
14	25	6x B25667B5177A175[1]	1x B44066D1425M440	1x B44066T0050E690[4]	3x B44066T0022E400[2]	16	63
14	50	12x B25667B5177A175[1]	2x B44066D1425M440	2x B44066T0050E690[4]	6x B44066T0022E400[2]	2 x 16	2 x 63
14	100	8x B25668A6167A375 1x B25668A6836A375	1x B44066D1499M440	1x B44066T0200E690[4]	4x B44066T0022E400[2]	95	250
Grid voltage: 440 V – 60 Hz dynamic detuned filters components selection table							
5.67	25	1x B25667B5177A375 1x B25667B5147A375	1x B44066D5025M441	1x B44066T0025E402	1x B44066T0022E400	16	63
5.67	50	1x B25667B5177A375 1x B25667B5237A375	1x B44066D5050M441	1x B44066T0050E402	1x B44066T0022E400	25	125
5.67	100	5x B25667B5237A375 1x B25667B5177A375	1x B44066D5100M441	1x B44066T0100E402	2x B44066T0022E400[2]	95	250
7	25	1x B25667B5177A375 1x B25667B5147A375	1x B44066D7025M441	1x B44066T0025E402	1x B44066T0022E400	16	63
7	50	2x B25667B5237A375 1x B25667B5177A375	1x B44066D7050M441	1x B44066T0050E402	1x B44066T0022E400	25	125
7	100	5x B25667B5237A375 1x B25667B5127A375	1x B44066D7100M441	1x B44066T0100E402	2x B44066T0022E400[2]	95	250
14	25	6x B25667B5147A175[1]	1x B44066D1425M441	1x B44066T0050E690	3x B44066T0022E400[2]	16	63
14	50	12x B25667B5147A175[1]	2x B44066D1425M441	2x B44066T0050E690	6x B44066T0022E400[2]	25	125
14	100	6x B25667B5197A375	1x B44066D1499M441	1x B44066T0200E690	2x B44066T0022E400[2]	95	250

[1] In some cases special interconnection of the single phase capacitors needed, in case you are not familiar please contact EPCOS for further details
[2] In some cases special interconnection of the discharge resistors needed, in case you are not familiar please contact EPCOS for further details.
[3] The above mentioned values are guidelines for operation in normal conditions at ambient temperatures up to 35 °C.
[4] Neutral-line required

Various parameters such as temperature inside the cabinet, cable quality, maximum cable insulation temperature, single or multi core cable, cable length and laying system have to be considered for a proper selection. Upgrade/downgrade accordingly if conditions differ.
Additionally do not forget to consider the regulations and standards which are valid for your country.
The warnings, cautions, product specific notes in the particular data sheets and the important notes must be observed!

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

Component Selection Tables for Dynamic PFC

Component selection table for dynamic LV PFC antiresonance filter circuits

De-tuning factor %	Effective filter output kvar	Capacitor[1] quantity and ordering code	Reactor quantity and ordering code	Thyristor module quantity and ordering code	Discharge resistor[2] quantity and ordering code	Cable[3] cross-section mm²	Fuse[3] A
Grid voltage: 690 V – 50 Hz dynamic detuned filters components selection table							
5.67	25	3x B25667B5177A175[1]	1x B44066D5025M690	1x B44066T0050E690	3x B44066T0022E400[2]	10	63
5.67	50	3x B25667B5147A175[1] 3x B25667B5177A175[1]	1x B44066D5050M690	1x B44066T0050E690	3x B44066T0022E400[2]	16	100
5.67	100	6x B25667B5147A175[1] 6x B25667B5177A175[1]	2x B44066D5050M690	2x B44066T0050E690	6x B44066T0022E400[2]	2 x 16	2 x 100
7	25	3x B25667B5177A175[1]	1x B44066D7025M690	1x B44066T0050E690	3x B44066T0022E400[2]	10	63
7	50	3x B25667B5147A175[1] 3x B25667B5177A175[1]	1x B44066D7050M690	1x B44066T0050E690	3x B44066T0022E400[2]	16	100
7	100	6x B25667B5147A175[1] 6x B25667B5177A175[1]	2x B44066D7050M690	2x B44066T0050E690	6x B44066T0022E400[2]	2 x 16	2 x 100
14	25	3x B25667B5147A175[1]	1x B44066D1425M690	1x B44066T0050E690	3x B44066T0022E400[2]	10	63
14	50	6x B25667B5147A175[1]	1x B44066D1450M690	1x B44066T0050E690	3x B44066T0022E400[2]	16	100
14	100	12x B25667B5147A175[1]	1x B44066D1450M690	2x B44066T0050E690	6x B44066T0022E400[2]	2 x 16	2 x 100
Grid voltage: 690 V – 60 Hz dynamic detuned filters components selection table							
5.67	25	3x B25667B5147A175[1]	1x B44066D5025M691	1x B44066T0050E690	3x B44066T0022E400[2]	10	63
5.67	50	3x B25667B5117A175[1] 3x B25667B5147A175[1]	1x B44066D5050M691	1x B44066T0050E690	3x B44066T0022E400[2]	16	100
5.67	100	6x B25667B5117A175[1] 6x B25667B5147A175[1]	2x B44066D5050M691	2x B44066T0050E690	6x B44066T0022E400[2]	2 x 16	2 x 100
7	25	3x B25667B5147A175[1]	1x B44066D7025M691	1x B44066T0050E690	3x B44066T0022E400[2]	10	63
7	50	3x B25667B5117A175[1] 3x B25667B5147A175[1]	1x B44066D7050M691	1x B44066T0050E690	3x B44066T0022E400[2]	16	100
7	100	6x B25667B5117A175[1] 6x B25667B5147A175[1]	2x B44066D7050M691	2x B44066T0050E690	6x B44066T0022E400[2]	2 x 16	2 x 100
14	25	3x B25667B5117A175[1]	1x B44066D1425M691	1x B44066T0050E690	3x B44066T0022E400[2]	10	63
14	50	6x B25667B5117A175[1]	1x B44066D1450M691	1x B44066T0050E690	3x B44066T0022E400[2]	16	100
14	100	12x B25667B5117A175[1]	2x B44066D1450M691	2x B44066T0050E690	6x B44066T0022E400[2]	2 x 16	2 x 100

[1] In some cases special interconnection of the single phase capacitors needed, in case you are not familiar please contact EPCOS for further details
[2] In some cases special interconnection of the discharge resistors needed, in case you are not familiar please contact EPCOS for further details.
[3] The above mentioned values are guidelines for operation in normal conditions at ambient temperatures up to 35 °C.
Various parameters such as temperature inside the cabinet, cable quality, maximum cable insulation temperature, single or multi core cable, cable length and laying system have to be considered for a proper selection. Upgrade/downgrage accordingly if conditions differ.
Additionally do not forget to consider the regulations and standards which are valid for your country.
The warnings, cautions, product specific notes in the particular data sheets and the important notes must be observed!

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

PFC Basic Formulas

The following electrical formulas may be used to calculate basic PFC values.

Active power

The amount of input power converted to output power is the active power.

$$P = \sqrt{3} \cdot V \cdot I \cdot \cos \varphi \quad [W]$$

Formula 1

Reactive power

The reactive power is the power consumed in an AC circuit due to the expansion and collapse of magnetic (inductive) and electrostatic (capacitive) fields.

$$Q = \sqrt{3} \cdot V \cdot I \cdot \sin \varphi \quad [VAr]$$

Formula 2

Apparent Power

The apparent power is the power delivered to an electric circuit.

$$S = \sqrt{3} \cdot V \cdot I \quad [VA]$$

Formula 3

Power factor

The power factor of an AC electrical power system is defined as the ratio of the real (active) power to the apparent power.

$$\text{Power factor} = \frac{\text{Active power}}{\text{Apparent power}} = \frac{P}{S}$$

Formula 4

Power Factor Correction

When the AC load is partly capacitive or inductive, the current waveform is out of phase with the voltage. This requires additional AC current to be generated that is not consumed by the load, creating I^2R losses in power cables. Capacitors are used to supply reactive energy to inductive loads. Reactive energy must be produced as closely as possible to the loads to prevent unnecessary flow of current in the network. This is known as power factor correction.

$$Q_C = P \cdot (\tan \varphi_1 - \tan \varphi_2) \quad [VAr]$$

Formula 5

Q_C: reactive power needed
P: total reactive power
φ_1: actual angle of cos φ actual
φ_2: target angle of cos φ target

Connection and rating of capacitors

The reactive power of the capacitor is a function of its rated voltage and current.

$$Q_C = V_C \cdot I_C \quad [VAr]$$

Formula 6

$$Q_C = \frac{V_C \cdot V_C}{X_C} = \frac{(V_C)^2}{X_C}$$

Formula 7

$$X_C = \frac{1}{\omega \cdot C} = \frac{1}{2\pi \cdot f \cdot C}$$

Formula 8

f: frequency of network
X_C: impedance of capacitor
C: capacitance value

Formula (7) and (8) together

$$Q_C = (V_C)^2 \cdot \omega \cdot C = (V_C)^2 \cdot 2\pi \cdot f \cdot C$$

Formula 9

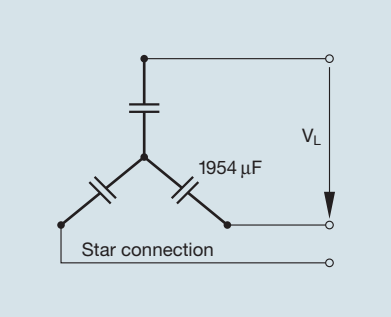
Please read *Important notes* on page 12 and *Cautions* on page 82–85.

PFC Basic Formulas

Capacitor in three-phase PFC application

Three-phase PFC applications have two types of capacitor connections: star and delta.

■ STAR connection



$$Q_{TOT} = 3 \cdot Q_C$$

Formula 10

$$V_C = V_L / \sqrt{3}$$

Formula 11

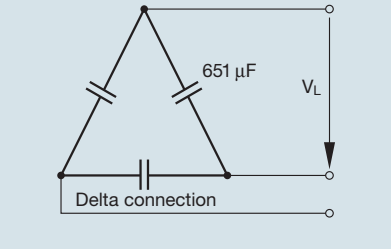
From formulas (9), (10) and (11)

$$Q_{TOT} = 3 \cdot \frac{(V_L)^2}{(\sqrt{3})^2} \cdot \omega \cdot C_{STAR}$$

$$C_{STAR} = \frac{Q_{TOT}}{(V_L)^2 \cdot \omega} = \frac{Q_{TOT}}{(V_L)^2 \cdot 2\pi \cdot f}$$

Formula 12

■ DELTA connection



$$V_C = V_L$$

Formula 13

From formulas (9), (10) and (13)

$$Q_{TOT} = 3 \cdot (V_L)^2 \cdot \omega \cdot C_{DELTA}$$

$$C_{DELTA} = \frac{Q_{TOT}}{3 \cdot (V_L)^2 \cdot \omega} = \frac{Q_{TOT}}{3 \cdot (V_L)^2 \cdot 2\pi \cdot f}$$

Formula 14

As a conclusion formula (12) and (14)

$$C_{DELTA} = \frac{C_{STAR}}{3}$$

Formula 15

Capacitor output kvar:

From the formula (9), if we find the Q_{new} with ratio: C will be constant.

$$Q_{New} = \left(\frac{V_{New}}{V_R}\right)^2 \cdot \frac{f_{New}}{f_R} \cdot Q_C$$

Formula 16

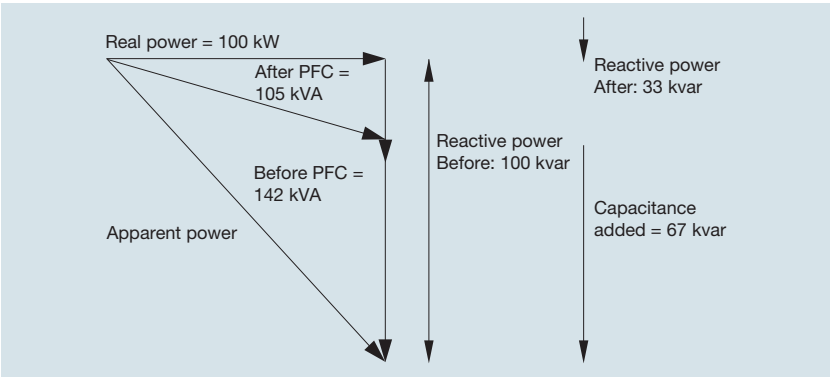
These values are operating conditions:
Q_{new}: new reactive power
V_{new}: new voltage
f_{new}: new frequency

These values are the values capacitor is designed:
Q_C: rated capacitor reactive power
V_C: rated capacitor voltage
f_R: rated frequency

Calculation examples

Example 1:
The relationship between active, reactive and real power and cos φ.

In the diagram below, the power triangle shows an initial power factor of 0.70 for a 100 kW (real power) inductive load. The reactive power required by the load is 100 kvar. By installing a 67-kvar capacitor, the apparent power is reduced from 142 to 105 kvar, resulting in a 26% reduction in current. The power factor is improved to 0.95.



Formulas used (1), (2), (3) and (4).

Power factor calculations:
Before PFC: 100/142 = 0.70 or 70%

After PFC: 100/105 = 0.95 or 95%

Please read *Important notes* on page 12 and *Cautions* on page 82–85.

PFC Basic Formulas

Example 2:
Calculation of capacitor rating for industrial installation

■ Given parameters:

Induction motor	220 kW
Network (line delta)	440 V AC, 3-phase
Frequency	50 Hz
Power factor	
– Current cos φ	0.7
– Target cos φ	0.9

Target to correct the power factor to 0.9:

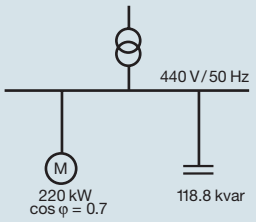
$\cos \varphi 1 = 0.7 \qquad \tan \varphi 1 = 1.02$

$\cos \varphi 2 = 0.9 \qquad \tan \varphi 2 = 0.48$

$Q_C = P (\tan \varphi 1 - \tan \varphi 2)$

$= 220 \cdot 1\,000 (1.02 - 0.48)$

$= 118.8$ kvar



Example 3:
Calculating capacitor ratings for DELTA and STAR connections in example 2

■ STAR connection:

$$V_C = \frac{V_L}{\sqrt{3}} = \frac{440}{\sqrt{3}} = 254 \text{ V}$$

$$C_{STAR} = \frac{Q_{TOT}}{(V_L)^2 \cdot \omega} = \frac{Q_{TOT}}{(V_L)^2 \cdot 2\pi \cdot f}$$

$$C_{STAR} = \frac{118.8 \cdot 1\,000}{(440)^2 \cdot 2\pi \cdot 50} = 1\,954 \text{ µF / Line (phase)}$$

$C_{TOT} = 5\,862$ µF

■ DELTA connection:

$$V_C = V_L = 440 \text{ V}$$

$$C_{DELTA} = \frac{Q_{TOT}}{3 \cdot (V_L)^2 \cdot \omega} = \frac{Q_{TOT}}{3 \cdot (V_L)^2 \cdot 2\pi \cdot f}$$

$$C_{DELTA} = \frac{118.8 \cdot 1\,000}{3 \cdot (440)^2 \cdot 2\pi \cdot 50} = 651 \text{ µF / Line (phase)}$$

$C_{TOT} = 1\,954$ µF

Example 4:
Calculating apparent power reduction (S1–S2) in example 2

$S_1 = P / \cos \varphi 1 = 220 / 0.7 = 314$ kVA

$S_2 = P / \cos \varphi 2 = 220 / 0.9 = 244$ kVA

$S_1 - S_2 = 70$ kVA

Thus, additional power of $70 \cdot (0.9) = 63$ kW can be supplied and transferred via the existing network.

Cable cross-section calculation

Line current drawn by the motor:

I_1 uncompensated load (0.7):

$$I_1 = \frac{220 \cdot 1\,000}{\sqrt{3} \cdot 440 \cdot (0.7)} = 412 \text{ A}$$

I_2 compensated load (0.9):

$$I_2 = \frac{220 \cdot 1\,000}{\sqrt{3} \cdot 440 \cdot (0.9)} = 320 \text{ A}$$

Thus, the cable can carry an additional load of 92 A, or the designer can reduce the cable cross-section.

Cautions

Temperature class of capacitors (according IEC 60831-1)			
Temperature class	**Temperature of capacitor surrounding air**		
	Maximum	**Maximum mean for 24 h**	**Maximum mean for 1 year**
B	45 °C	35 °C	25 °C
C	50 °C	40 °C	30 °C
D	55 °C	45 °C	35 °C

Enclosure of capacitors (IPxx)		
Enclosure	**First digit**	**Second digit**
IP00	No protection against finger touch and ingress of solid foreign bodies	No protection against ingress of water
IP20	Protection against finger touch and solid foreign bodies ≥ 12.5 mm diameter	No protection against ingress of water
IP41	Protection against tool touch and solid foreign bodies ≥ 1 mm diameter	Drip-water protection
IP54	Protection against tool touch and solid foreign bodies ≥ 1 mm diameter, protection against dust deposit	Splash water protection

Maximum admissible overvoltage			
Frequency (50/60 Hz)	**Max. voltage (V_{rms})**	**Max. duration**	**Remarks**
Line frequency	$1.00 \cdot V_R$	Continuous duty	Highest mean during entire operating time of capacitor; exceptions (see below) are admissible for times of < 24 h
Line frequency	$1.10 \cdot V_R$	8 h daily	Line voltage fluctuations
Line frequency	$1.15 \cdot V_R$	30 min daily	Line voltage fluctuations
Line frequency	$1.20 \cdot V_R$	5 min daily	Line voltage fluctuations
Line frequency	$1.30 \cdot V_R$	1 min daily	Line voltage fluctuations
Line frequency with harmonics	Such that current does not exceed maximum admissible figure ($I_{max.} = 1.3 \cdot I_R$)		

Temperature class of capacitors to standard IEC 60831-1

Capacitors are divided into temperature classes. Each class is represented by a number followed by a letter, e.g. –40/D. The number is the lowest ambient temperature at which a capacitor may operate. The upper limit temperature is indicated by the letter (see table above).

The useful life of a capacitor depends very much on temperature. Proper cooling of a capacitor must ensure that the maximum temperature is not exceeded, otherwise useful life is degraded. When configuring a circuit, one should make sure that capacitors are not subjected to heat from adjacent components (reactors, bus bars, etc). Forced cooling is preferable for compact designs. And it is highly inadvisable to arrange capacitors directly above reactors. Exceeding specified temperature limits may set in worst case the safety device out of operation.

Enclosure of capacitors (IPxx)

For different models there are different types of enclosure. The type of enclosure is indicated by a designation consisting of the two letters IP followed by two digits.

Current rating/maximum admissible overcurrent

The rated current (I_R) is the current resulting for rated voltage (V_R) and frequency (in Hz), excluding transients. Maximum permitted rms current for each particular capacitor is specified in the data sheet. Continuously exceeding of the nominal current will lead to increased self-heating of the capacitor and reduce life time. The maximum admissible overcurrent (I_{max}) of $1.3 \cdot I_R$ to IEC 60831 standard is maintained or overachieved by all capacitors in this catalog. The figures for overcurrent allow for the combined effects of harmonics, overvoltage and capacitance tolerance.

Maximum admissible overvoltage

Capacitors from EPCOS are suitable for operation on overvoltages quoted by IEC 60831 (see table). Overvoltages higher than $1.15 \cdot V_R$ reduce life time of the capacitor and must not occur more than 200 times during life time of capacitor. Overvoltages above $1.3 \cdot V_R$ must not occur at all, appropriate overvoltage protection (e.g. against lightning strikes) must be ensured.

Cautions

Mean life expectancy

The mean life expectancy of power capacitors is mainly governed by the following factors:
– duration of overload,
– ambient temperature and the resulting case temperature,
– maximum rms current and the resulting case temperature,
– voltage height and duration.

The calculated life expectancy of the various series is stated for nominal operating conditions. If components are stressed less than the IEC 60831 factors, longer useful life can be expected, and a correspondingly shorter one or increased failure rate if nominal parameters are exceeded.

Fuse protection

Power capacitors have to be protected against short circuits by fuses or thermal magnetic overcurrent relays. Slow-blow, low-voltage high-breaking-capacity fuses (HRC) are preferable. The fuse rating should be 1.6 to 1.8 times the rated current of the capacitor. Magnetic short circuit relays should be set to between 9 and 12 times rated current to prevent them responding to high inrush currents. Maximum allowed fault current of 10000 A in accordance with UL 810 standard must be ensured by the application design.

⚠ HRC fuses must not be used for switching. Resulting electric arcing can cause death! It may also cause capacitor failures, and result, worst case, in capacitor bursting and fire.

Switching of capacitors

When a capacitor is switched to an AC system, the result is a resonant circuit damped to a greater or lesser degree. In addition to the rated current, the capacitor accepts a transient current that is a multiple of (up to 200 times) its rated current. Fast switching, low-bounce contactors should be used, and have the switching capacity for capacitive currents stated by the producer. Special capacitor contactors with leading contacts that feature precharging resistors to damp inrush currents are recommended. As per IEC 60831 standard, a maximum of 5000 switching operations per year is acceptable. Before considering a higher number of switching operations, please contact EPCOS.

Discharging

Capacitors must be discharged to a maximum of 10% of rated voltage before they are switched in again. This prevents an electric impulse discharge in the application, influences the capacitor's useful life in PFC systems, and protects against electric shock. The capacitor must be discharged to 75 V or less within 3 min. There must not be any switch, fuse or any other disconnecting device in the circuit between the power capacitor and the discharging device. EPCOS supplies capacitor discharge resistors to all series, alternatively discharge reactors are available.

⚠ Caution: Discharge and short circuit capacitor before handling!

Capacitors in networks with harmonics

Harmonics are produced in the operation of electric loads with a non-linear voltage / current characteristic (e.g. rectifiers and inverters for drives, welding apparatus and uninterruptible power supplies). Harmonics are sinusoidal voltages and currents with higher frequencies of a multiple of the 50 or 60 Hz line frequency. In low-voltage three-phase systems the 5th and 7th harmonics are especially troublesome. Detuned PFC should be used in systems subject to harmonics. This represents a series resonant circuit of power capacitor and reactor. The circuit is tuned so that the series resonant frequency is below the lowest harmonics appearing in the system. This produces an inductive response to all frequencies above the series resonant frequency, avoiding resonances with system inductances. Depending on the selected series resonant frequency, part of the harmonic current is taken up by the detuned PFC system. The remainder of the harmonic current flows into the superordinate system. The use of detuned PFC thus contributes to reducing voltage distortion through harmonics and lessens the disturbing effect on proper operation of other electric loads.

Most international standards limit THD-V on LV side to 5%. However it has to be noted that in many grids these levels are exceeded and even lower distortion, e.g. 3–4% THD-V can generate extreme overcurrents in case of resonance condition.

Maximum overcurrents as specified under technical data of each series must not be exceeded.

Resonance must be avoided by appropriate panel design. Resonance may cause very high overcurrents which can lead to capacitor failures, and worst case, to explosion and fire.

Cautions

Mechanical damage

In case of dents or any other mechanical damage, capacitors must not be used at all.

Vibration resistance

The resistance to vibration of capacitors corresponds to IEC 68, part 2–6.

Max. test conditions:

Test duration	2 h	
Frequency range	10 ... 55 Hz	corresponding to max. 0.7 g
Displacement amplitude	0.75 mm	

Because the fixing and the terminals may influence the vibration properties, it is necessary to check stability when a capacitor is built in and exposed to vibration. Irrespective of this, you are advised not to locate capacitors where vibration amplitude reaches the maximum in strongly vibrating equipment.

Connection

Make sure connection cables are of flexible type or flexible copper bands are used. This is mandatory to allow the overpressure disconnector work and avoid mechanical stress on the terminals and feedthroughs.

The connection cables to the capacitor should be designed for a current of at least 1.5 times the rated current so that no heat is conducted into the capacitor. If reactors are used in an application, the distance between reactor and capacitor must be great enough so that no heat of the reactors, which are operating at a much higher temperature level, is conducted via connection cable to the capacitors.

Avoid bending cable lugs, cables or other mechanical force on the terminals. Otherwise leakages may set the safety device out of operation.

Ensure firm fixing of terminals, fixing torque to be applied as per individual specification.

Maximum specified terminal current (please refer to technical data of specific series) must not be exceeded at any case.

Grounding

The threaded bottom stud of the capacitor has to be used for grounding. In case grounding is done via metal chassis that the capacitor is mounted to, the layer of varnish beneath the washer and nut should be removed.

Storage and operating conditions

Do not use or store capacitors in corrosive atmosphere, especially where chloride gas, sulfide gas, acid, alkali, salt or the like are present. In dusty environments regular maintenance and cleaning especially of the terminals is required to avoid conductive path between phases and / or phases and ground.

Installation

Specifications like IEC 61921, VDE 0100, VDE 0101, VDE 0560 part 4 and 46, EN 60831 and IEC 60831 apply to the installation and operation of power capacitors. Capacitors should be sited in cool and well ventilated locations away from other heat-radiating elements. Natural heat dissipation is generally sufficient for cooling purposes if enough air is able to flow to and away from them and the capacitors are spaced at least 20 mm apart. Otherwise, in a less well ventilated environment, forced cooling (fans) will be necessary, scaled so that the maximum admissible ambient temperature is not exceeded.

Useful life of capacitors strongly depends on the operating temperature (refer to page 82, temperature classes of capacitors).

Exceeding maximum allowed temperature may set the safety device out of operation.

Please read the *Installation and Maintenance Instructions* on the internet at www.epcos.com/pfc.

Note

Products shown in this catalog reflect typical specifications. You are kindly requested to approve our product specifications or request our approval for your specification before ordering.

Cautions

Reactors – Antiresonance harmonic filter

During operation, all electrically active parts of this equipment such as windings, electronic components, leads, fuses and terminals carry a dangerous voltage which can lead to burns or electric shock.

Covers which protect these electrically active parts from being touched must not be opened or removed during operation.

Before any assembly or maintenance work is started, all installations and equipment must be disconnected from the power source.

Noncompliance with these instructions may lead to death, serious injury or major damage to equipment.

In order to exclude impermissible temperatures and thus overload of the insulation system, the following directions must additionally be observed:

1. Only those protective devices specified on the type plates, such as fuses and motor protection switches, may be used. It is mandatory to observe the set values specified for the motor protection switches. Any temperature-sensitive protective devices such as temperature switches and temperature sensors must be connected in accordance with the installation instructions.
2. High temperatures are permissible for the surfaces under rated operating conditions, and especially in the event of overload. Depending on the temperature class and type of loading, these may attain values of up to 260 °C and may also affect adjacent components which have been packed too densely.
3. The insertion position should be selected so that any cooling ducts present within the winding are arranged vertically and that the current of cooling air is not impeded by adjacent components, connecting leads etc.
4. The maximum voltage of the insulating system specified on the type plate must not be exceeded.

Noncompliance with these instructions may lead to considerable damage to equipment or fire due to impermissibly high temperatures.

Thyristor modules (TSM-series)

- Live parts in the PFC equipment must not be touched!
- Warning signs in the PFC systems are required!
- Wait 10 minutes after the main switch is turned off – until the voltage in the system has dropped to an uncritical value.
- In non-detuned systems (400 V grid) capacitors with a higher voltage rating (e.g. 440 V) are needed.
- In detuned systems (400 V grid) capacitors with a voltage of 525 V are needed.
- For discharging the capacitors, special high-voltage resistors type EW-22 are required. Standard resistors cannot be used!
- In dynamic PFC systems discharge reactors cannot be used (this would be a short circuit of the highvoltage DC)!
- In PFC systems without filter circuit reactors current limiting reactors are required (e.g. BD-100) for the TSM.
- For short circuit protection, superfast electronic fuses for protection of the thyristor are required, standard HRC fuses are not suitable. See selection table on pages 64 and 65.
- Failure to follow cautions may result, worst case, in premature failures or physical injury.

Capacitor contactors

In case auxiliary contacts are used for switching of discharge resistors (not in accordance with IEC 60831 standard), make sure that the current of the discharge resistors is not higher than the rated current of the auxiliary contacts.

Only flame-resistant and self-extinguishing materials may be used in the proximity of capacitor contactors because abnormal temperatures cannot be ruled out in the area near the resistance spirals.

Capacitor contactors N110/N230 may only be used in PFC systems with reactors.

PF controllers (BR604 and BR6000 series)

Controller hunting: When putting the capacitor bank into operation, it is required to avoid needless switching cycles (means permanent switching on and off of steps without significant change of consumer loads). This so called “controller hunting” would increase the number of switching operations of the connected contactors and capacitors and decrease the expected life cycle (wear out) and result, in worst case, in bursting and fire etc. This can be avoided by a proper programming of the BR604 and BR6000 with the actual system parameters (current transformer prim. and sec., first kvar step, control series, switching time).

The “ZVEI General safety recommendations for power capacitors” must be observed in addition to the safety instructions given in this catalogue and in the particular data-sheets. They are available on the EPCOS website in the various product groups. They may also be called up from the ZVEI website.

Get in Contact

AFRICA

Egypt
Siemens Ltd., EPCOS Div.
Cairo
T +202 333 36 69
F +202 333 36 07
sales.egypt@epcos.com

Maghreb: Morocco, Algeria, Lybia, Tunisia, Malta
EPCOS SAS
Saint-Denis la Plaine, France
T +33 1 49 46 67 89
F +33 1 49 46 67 67
sales.france@epcos.com

Republic of South Africa
Electrocomp (PTY) Ltd.
Sandton
T +27 11 458 90 00 32
F +27 11 458 90 34
sales.southernafrica@epcos.com

AMERICAS

NAFTA
EPCOS, Inc.
Iselin, NJ, USA
T +1 732 9 06 43 00
F +1 732 6 32 28 30
sales.usa@epcos.com

South America
EPCOS do Brasil Ltda.
São Paulo
T +55 11 38 17 34 46
F +55 11 38 17 34 43
sales.br@epcos.com

Argentina
ELECOND CAPACITORES S.A.
Buenos Aires
T +54 11 43 03 12 03
info@elecond.com.ar

Bolivia
Electric Mundial S.R.L.
T +59 13 33 32 90 91

Brazil
EPCOS do Brasil Ltda.
São Paulo
T +55 11 38 17 34 46
F +55 11 38 17 34 43
sales.br@epcos.com

IFG ELECTROMEC
Gravataí
T +55 51 34 88 25 65

RIONEPAR
Rio de Janeiro
T +55 21 38 99 35 33

Siemens LTDA
São Paulo
T +55 11 39 08 34 23

WGR Indústria Comércio
Importação e Exportação Ltda.
São Paulo
T +55 11 21 55 55 00
F +55 11 21 55 55 16

Chile
CLAS INGENIERÍA
ELÉCTRICA S.A.
Santiago de Chile
T +562 3 98 81 00
clasmail@clas-sa.com

Colombia
SIEMENS S.A.
Bogotá
T +571 2 94 22 57

ESPECIALIDADES
ELÉCTRICAS S.A.
Cali
T +572 4 39 81 81
ventasee@
especialidadeselectricas.com

Costa Rica
SIEMENS S.A.
San José
T +506 2 87 51 19

Ecuador
SIEMENS S.A.
Guayaquil
T +593 4 2 16 00 50

El Salvador
SIEMENS S.A.
San Salvador
T +503 2 78 33 33

Guatemala
SIEMENS S.A.
Ciudad de Guatemala
T +502 3 32 44 44

Honduras
SIEMENS S.A.
Tegucigalpa
T +504 5 50 66 33

Nicaragua
SIEMENS S.A.
Managua
T +505 2 49 11 11

Paraguay
LUMINOTECNIA
Assunción
T +59 52 12 49 20 00

Peru
SIEMENS S.A.
Lima
T +511 2 15 00 30
comunicaciones@siemens.com

Uruguay
MGI S.A.
Montevideo
T +598 22 00 78 00
mginstal@adinet.com.uy

Venezuela
EMI – EQUIPOS Y SISTEMAS
Caracas
T +582 12 2 43 60 79/
50 72/64 01

ASIA

Bangladesh
S.A. Traders & Co.
Dhaka
T +880 2 955 83 40
F +880 2 956 57 26

China
EPCOS (China) Investment Ltd.
EPCOS (Shanghai) Ltd.
Shanghai Office
T +86 21 33 02 46 20
F +86 21 63 91 68 89
sales.cn@epcos.com

EPCOS (Shanghai) Ltd.
Beijing Office
T +86 10 58 79 38 38
F +86 10 58 79 36 91
sales.cn@epcos.com

EPCOS (Shanghai) Ltd.
Shenzhen Office
T +86 7 55 26 93 57 58
F +86 7 55 26 93 57 57
sales.cn@epcos.com

EPCOS (Xiamen) Co. Ltd.
Xiamen Office
T +86 592 6 10 23 88
F +86 592 6 15 17 00
sales.cn@epcos.com

EPCOS LIMITED
Hong Kong Office
T +85 2 31 01 56 00
F +85 2 31 01 56 46
sales.cn@epcos.com

India
EPCOS India Private Ltd.
Bangalore
T +91 80 40 39 06 09
T +91 80 40 39 06 40
F +91 80 40 39 06 03
sales.in@epcos.com

EPCOS India Private Ltd.
Mumbai, Maharashtra
T +91 22 26 83 26 51/50
F +91 22 26 83 26 45

EPCOS India Private Ltd.
Kolkata
T +91 33 24 42 84 76
F +91 33 24 44 90 10

EPCOS India Private Ltd.
New Delhi
T +91 11 43 54 99 11/12
F +91 11 23 70 41 46

Indonesia
PT Industrindo Niagatama
Jakarta
T +62 21 65 30 26 58
F +62 21 65 06 396

PT Omtraco Arya Samanta
Grha Praba Samanta
Jakarta
T +62 21 619 61 99/
T +62 21 619 69 77
F +62 21 619 34 47/
F +62 21 619 17 63

Iran
Saba Khazen Co.
Tehran
T +98 21 88 88 90 13
F +98 21 88 77 20 67

Israel
Nisko Projects Electronics
& Communications (1999) Ltd.
Tel Aviv
T +972 37 65 73 00
F +972 37 65 73 33

Japan
EPCOS KK
Yokohama
T +81 45 4 78 72 00
F +81 45 4 78 72 25
sales.jp@epcos.com

EPCOS KK
Osaka
T +81 6 62 92 69 11
F +81 6 62 92 69 15
sales.jp@epcos.com

Korea
EPCOS Korea LLC
Seoul
T +82 2 34 50 75 70
F +82 2 34 50 75 98
sales.kr@epcos.com

Malaysia
Alpha Automation
(Selangor) Sdn. Bhd.
Selangor
T +60 3 55 69 36 98
F +60 3 55 69 40 99/
F +60 3 55 69 32 30

EPCOS Sdn. Bhd.
Kuala Lumpur
T +60 3 79 60 81 80
F +60 3 79 60 81 82
sales.asean@epcos.com

Nepal
Machinery & Electric Complex
Kathmandu
T +97 71 423 25 44,
F +97 71 423 05 73

Get in Contact

Pakistan
Siemens Pakistan Eng. Co.Ltd.
Karachi
T +92 21 256 75 72
F +92 21 257 77 93

Singapore
EPCOS PTE LTD
Singapore
T +65 68 41 20 11
F +65 67 44 69 92
sales.asean@epcos.com

Asia Electric Transformers
Pte Ltd
Singapore
T +65 62 98 85 50
F +65 62 99 60 69

Sri Lanka
K.I.K Group Of Companies
Dehiwala
T +94 11 281 87 61
F +94 11 282 71 29

Syria
ZAHABI CO.
Aleppo
T +963 21 21 22 23 5/6
F +963 21 21 22 23 7
zahabi-co@mail.sy

Taiwan
EPCOS Taiwan Co. Ltd.
Taipei
T +886 2 26 55 76 76
F +886 2 55 59 02 88
sales.tw@epcos.com

Thailand
ITM Capacitors Co. Ltd.
Samut Prakam
T +66 2 336 11 16
F +66 2 336 11 14
tm@itm.co.th

United Arab Emirates
Gama Electro-Mechanics
Sharjah UAE
T +971 65 33 54 53
F +971 65 33 81 82

AUSTRALIA

Electric Components
Solutions Pty. Ltd.
Mulgrave
T +61 3 85 61 19 99
F +61 3 95 74 70 55
sales.au@epcos.com

EUROPE

Austria, Bulgaria, Montenegro, Romania, Serbia
EPCOS OHG
Vienna, Austria
T +43 51 70 72 56 30
F +43 51 70 75 56 45
sales.csee@epcos.com

Belgium, Luxembourg, Netherlands
EPCOS SAS
Agency for Benelux
Antwerp, Belgium
T +32 3287 3910
F +32 3239 9644
sales.france@epcos.com

Croatia
ERG d.o.o.
Varazdin
T +385 42 35 17 77
F +385 42 35 17 70
erg@erg.hr

Czech Republic
EPCOS s.r.o.
Prague
T +420 2 33 03 22 81
F +420 2 33 03 22 89
sales.czech@epcos.com

Finland
EPCOS Nordic OY
Espoo
T +358 10 5 11 32 00
F +358 10 5 11 22 85
sales.nordic@epcos.com

France
EPCOS SAS
Saint-Denis la Plaine
T +33 1 49 46 67 89
F +33 1 49 46 67 67
sales.france@epcos.com

Germany, Liechtenstein, Switzerland
EPCOS AG
Customer Service, München
T (D) 0180 500 33 48
(0,12 Euro/Min.)
T (CH) 08 48 37 26 71
F +49 89 63 62 80 10
sales.germany@epcos.com

Greece
Siemens A.E.
Amaroussio/Athens
T +30 210 68 64 148
F +30 210 68 64 562

Hungary
EPCOS Elektronikai Alkatrész Kft.
Értékesítési iroda
Budapest
T +36 1 436 07 20
F +36 1 436 07 21
sales.hungary@epcos.com

Italy
INFINEON
EPCOS Sales
Milan
T +39 02 24 36 42 65
F +39 02 24 36 43 80
sales.italy@epcos.com

Poland, Latvia, Lithuania
EPCOS Poland Sp. z.o.o.
Warsaw, Poland
T +48 22 24 604 13
F +48 22 24 604 00
sales.poland@epcos.com

Portugal
EPCOS 2 Portugal LDA
Évora
T +351 91 75 67 927
F +351 21 49 33 476
sales.portugal@epcos.com

Romania
S.C. Electroglobal S.R.L.
Cluj-Napoca
T +40 264 43 76 17
F +40 264 43 78 43

Russia, Belarus, Kazakhstan, Moldavia, Ukraine
OOO Siemens, EPCOS Div.
Moscow, Russia
T +7 495 7 37 24 17/18
F +7 495 7 37 23 46
sales.cis@epcos.com

Serbia
MK Trade d.o.o.
Belgrade
T +381 11 318 37 80
F +381 11 227 46 35
info@mktrade.co.yu

Montprojekt
Belgrade
T +381 11 312 92 31
F +381 11 312 91 69
info@montprojekt.yu

Slovakia
EPCOS Sales Agency
Dolný Kubín
T +42 1 43 5 82 36 73
F +42 1 43 5 82 37 33
sales.slovakia@epcos.com

Slovenia, Bosnia & Herzegovina
EPCOS Sales Representative
Škofljica, Slovenia
T +386 59 95 63 53
F +386 59 95 63 54
sales.slovenia@epcos.com

Spain
Siemens S.A., EPCOS Div.
Getafe
T +34 91 5 14 80 00
F +34 91 5 14 70 14
sales.iberia@epcos.com

Sweden, Estonia, Iceland, Denmark, Norway
EPCOS Nordic AB
Kista, Sweden
T +46 8 4 77 27 00
F +46 8 4 77 27 01
sales.nordic@epcos.com

Turkey
EPCOS AG
Liaison Office
Istanbul
T +90 216 5 69 81 00
F +90 216 4 64 07 56
sales.turkey@epcos.com

United Kingdom, Ireland
EPCOS UK Ltd.
Bracknell
T +44 13 44 38 15 10
F +44 13 44 38 15 12
sales.uk@epcos.com

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