# Film Capacitors – Power Factor Correction

## Installation and maintenance instructions for PFC capacitors

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| **Series/Type:** | **PhiCap series with fast-on terminals** |
| **Ordering code:** | **B32340/B32343** |
| Date: | November 2009 |
| Version: | 1 |

## Installation and maintenance instructions

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| **Read this first!** | Read the following »Installation and Maintenance Instructions« carefully before installing a capacitor in your application. |
| **About this manual** | The information stated in this manual applies to typical, approved usage. Please refer to our product specifications, or request our approval for your own individual specifications, before installing capacitors. |
| **For your safety!** | Disregarding the guidelines in this manual can result in operational failure, bursting and fire. In case of doubt, contact your local EPCOS sales organization or distributor for assistance. |
| **General safety notes for installation and operation** | ■ Ensure you are using the right capacitor type for your application. Please refer to the EPCOS product catalog and application notes for appropriate selection of capacitors. Please contact EPCOS for any assistance required in selection.<br>■ Maintain good, effective grounding of capacitor enclosures.<br>■ Ensure that any faulty units/banks in the system can be isolated.<br>■ Handle capacitor units carefully, as they may be charged even after disconnection due to faulty discharging devices.<br>■ Follow appropriate engineering practices.<br>■ Do not use HRC fuses to power the capacitor up and down (as this could lead to the risk of electrical arcing!).<br>■ Consider capacitor terminals, connected bus bars and cables, and any other devices connected with them, as being energized. The device is electrically charged! |
| **Storage and operation conditions** | Do not use or store capacitors in a corrosive atmosphere, especially where chloride gas, sulfide gas, acid, alkali, salt or similar substances are present. In a dusty environment, regular maintenance and cleaning, especially of the terminals, is required to avoid a conductive path being set up the phases and/or the phases and ground. |
| **Ambient temperature** | The ambient temperature category for most standard capacitors types is –25/D. This means a maximum temperature of 55 °C, an average temperature over 24 hours of 45 °C, and an average temperature in one year not exceeding 35 °C. The maximum casing temperature of 60 °C must not be exceeded. Temperature is one of the main stress factors for polypropylene type capacitors and has a major influence on their useful life expectancy. For higher temperature requirements, EPCOS offers MKV type capacitors for ambient temperatures of up to 70 °C (with natural cooling). |

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| **Caution!** | Exceeding the maximum allowed temperature may cause the safety device to be in operative.<br>Capacitors should no longer be used if they are dented or have suffered mechanical or any other kind of damage!<br>Check the integrity of discharge resistors before installation. |

# Installation

**Mounting the capacitors**

**Mounting position**

Capacitors installed in a cabinet should be placed on the bottom to minimize the stress temperature.

**Note!**

PhiCap capacitors series may be mounted only in a vertical position.

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| **Warning!** | Do not install capacitors with dents deeper than 0.5 mm! |

**Mounting conditions**

PFC capacitors must be installed in a cool and well ventilated place, and not close to objects that radiate heat such as filter-circuit reactors and furnaces, or in direct sunlight.

**Cooling space for capacitors**

Make sure that sufficient cooling space is available (see Figure 2):

- A minimum distance of 20 mm between the capacitors is necessary to maintain sufficient cooling.
- Keep a gap of at least 20 mm above the capacitor and do not attach any mounting components onto the crimp or on top. This gap will allow longitudinal extension of the can so that the over-pressure disconnector can extend fully.

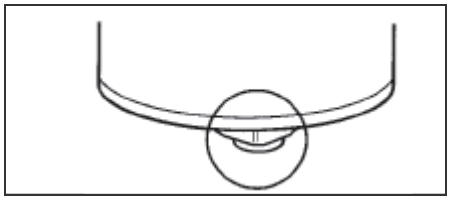

*Figure 2:* Minimum space over and between the capacitors.

**Using reactors: cooling space for cables**

Note that any reactors used in an application operate at a much higher temperature. The distance between the reactor and capacitor must be large enough to stop any reactor heat being conducted via the connecting cable to the capacitor and to prevent the capacitor overheating due to heat radiation from the reactor.

**Fixing threaded bottom stud**

The threaded mounting stud is located at the base of the capacitor:



**Fixing**

The threaded bottom stud must be fastened with the following specified torques:

M12 bottom stud for diameters > 53 mm: torque 10 Nm

M 8 bottom stud for diameters < 53 mm: torque 4 Nm

**Grounding**

The M12/M8 bottom stud is used for grounding. Connect it to ground by cable, or else connect the capacitor to any other conductive item which is connected to ground.

**Note!**

Suitable connectors have to penetrate existing layers of enamel to ensure good, constant conductivity and sufficient current carrying capability.

If the capacitor is grounded via the metal chassis to which it is mounted, the layer of varnish beneath the washer and nut should be removed.

**Connecting**

When connecting, avoid bending cable lugs or cables, or the use of other forms of mechanical force on the terminals. Otherwise, leakage could disable the safety device!

Ensure firm fixing of terminals, and apply the fixing torque as individually specified.

The maximum specified terminal current must never be exceeded. Please refer to the technical data of the relevant series.

Parallel connection of capacitors via the terminal is not recommended.

## Connecting the supply cable

**Cable specification**

The connecting cable must be of flexible type, preferably of copper.

**Note!**

Do not use solid-core cables!

The maximum cable cross section for PhiCap Pl top is 4 mm²

Further information can be found in the appendix.

The connecting cables to the capacitor should be dimensioned for a current at least 1.5 times the rated current so that no heat is conducted into the capacitor.

**Maximum terminal currents**

Do not exceed the maximum permissible current:

- PhiCap: up to 60 A total RMS current

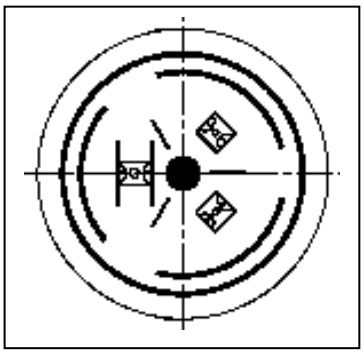
**Attaching the supply cable**

Attach the supply cable:

- B32340: cable crimped with lug & fixed with fast on terminal
- B32343: cable crimped with lug & fixed with fast on terminal

**Supply cable with lug crimped**

Use an appropriate wire as specified for the connection in the appendix and fix it onto the fast-on terminal on top of the capacitor.



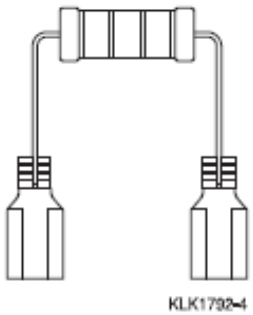
**Using discharge resistors**

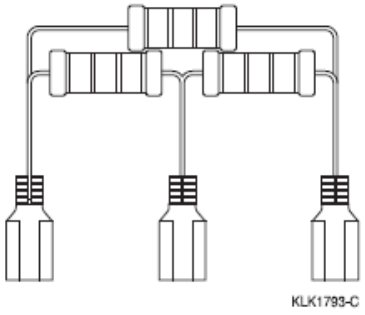
Discharge resistors are included in the delivery package.

Discharge resistors are required for discharging capacitors to protect operating personal (risk of electric shock) and for re-switching capacitors in automatic PFC equipment (phase opposition!).

EPCOS discharge resistors are designed to discharge capacitors down to 75 V or less within 60 seconds. For particular types, the time of discharge down to 75 V or less can be within 90 seconds.

Make sure that the correct resistor (with the same ohmic rating and push-on connector diameter) is used for replacement.




**Discharging the capacitor**

Before re-switching, capacitors must be discharged to 10% of the rated voltage or below.

A discharge resistor can be replaced by removing it from the fast-on terminal.

**Inrush current limitation**

Switching LV PFC capacitors can cause high inrush currents of more than 200 times the rated current, especially when they are connected in parallel to others that are already energized. This may cause additional stress to contactors as well as to capacitors and reduce their life cycle.

Inrush currents have a negative effect on the power quality, e.g. transients, voltage drop. MKK and MKP designs have high impulse handling capability, but require inrush current limitation such as:

- Contactors with pre-charging resistors for pre-loading of capacitors
- Serial air coils (approx. 8 turns in the connecting cables between contactor and capacitor with a diameter of 10 cm)

**IEC 60831 standard and reference**

According to the IEC 60831 standard, a maximum of 5000 switching operations per year is acceptable. Before considering a higher number of switching operations, please contact EPCOS.

**Harmonics**

Harmonics are sinusoidal voltages and currents with frequencies that are multiples of the 50 or 60 Hz power supply frequency.

Harmonics result from the operation of electrical loads with non-linear voltage-current characteristics.

They are mainly caused by loads operated in modern electronic devices, such as converters, electrical drives, welding machines and uninterruptible power supplies (UPS).

Ensure that the current flowing through the capacitor does not exceed the following values: up to $1.3 \cdot I_R$.

This may indicate the heavy presence of harmonics. Check the voltage and current using a true RMS multi-meter.

Ensure that the voltage does not exceed $1.1 \cdot V_R$ and the peak voltage does not exceed $1.6 \cdot V_R$. Use a true RMS and peak voltmeter or oscilloscope to check this.

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| **Caution!** | Only power capacitors with reactors – namely de-tuned capacitor banks – should be used in applications with harmonic distortion. Depending on the chosen series resonance frequency, a part of the harmonic current will be absorbed by the power capacitor. The rest of the harmonic current will flow into the grid. The use of power capacitors with reactors reduces harmonic distortion and minimizes the disturbing effects on the operation of other loads. |

**Avoid resonance conditions**

The most important reason for installing de-tuned capacitor banks is to avoid resonance conditions. These may multiply existing harmonics, create power quality problems and damage distribution equipment.

Occurrences of resonance should ideally be avoided by appropriate application design!

The total RMS capacitor current (incl. fundamental and harmonic currents) specified in the technical data of the relevant series must never be exceeded.

**Overpressure disconnector**

Electrical components do not have an unlimited operating life; this also applies to self-healing capacitors. As polypropylene-type capacitors seldom produce a pronounced short circuit, HRC fuses or circuit breakers alone do not offer sufficient protection.

All capacitors of the PhiCap series are consequently fitted with a disconnector that responds to overpressure. If numerous electric breakdowns occur at the end of its life or as the result of thermal or electric overload (within IEC 60831 specification), the formation of gas causes the pressure inside the capacitor case to rise.

This causes a change in length due to the curvature of the lid or stretching of the expansion bead. Expansion beyond a certain point will separate the internal wires (tear-off fuses) and disconnect the capacitor from the power line.

**Caution!**

To ensure full functionality of an overpressure disconnector, observe the following requirements:

1) The expandable metal top must not be impaired:
   - The connecting lines must be flexible leads (cables).
   - There must be sufficient space for expansion above the connections (stated for the different models).
   - The folding groove 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) The stress parameters of the capacitor must be within the IEC60831 specification.

**Overcurrent / short circuit protection**

HRC fuses or molded case circuit breakers for short circuit protection must be used. Short circuit protection equipment and connecting cables should be dimensioned to permanently handle 1.5 times the rated current of the capacitor.

- HRC fuses do not protect the capacitor against overload. They only offer short-circuit protection!
- HRC fuse rating must be 1.6 ... 1.8 times the nominal capacitor current.
- Do not use HRC fuses for switching capacitors (lightning arc!).
- Use thermal/magnetic overcurrent relays for overload protection.

## Maintenance

**Caution!**

Disregarding the following measures may result in severe operational failure, bursting and fire.

- Check the tightness of the connections/terminals periodically, at the latest two weeks after installation, and then once every month.
- Clean the terminals/bushings periodically to avoid short circuits due to dust or other contamination.
- Check the short-circuit protection fuses.
- Take a current reading twice a year and compare it with the nominal current. Use a harmonic analyzer or true effective RMS meter.
- If the current above rises above its nominal value, check your application for modifications.
- If a significant increase in the amount of non-linear loads is detected, call in a consultant to examine the harmonics.
- In the presence of harmonics, consider the installation of a de-tuned capacitor bank (reactors).
- Check the discharge resistors/reactors and check their function in case of doubt:
  (1) Power the capacitor up and down.
  (2) After 60 seconds, the voltage across the terminals must drop to less than 75 V (after 90 seconds for particular types).
- Check the temperature of energized capacitors. If individual capacitors become excessively hot, it is recommended to replace them, as this could indicate a loss factor increase which is a sign that they are reaching the end of their operating life.

**Note!**

For detailed information about PFC capacitors and cautions, refer to the latest version of the EPCOS PFC Product Profile.

Please note again that these »Installation and Maintenance Instructions« apply to typical specifications. Refer to our product specifications, or request our approval for your specification, before installing a capacitor.

# Appendix

**Connection cable cross section, HRC fuse rating**

The VDE 0100 recommendations for fusing and cable cross sections for three-phase power capacitors are listed below.

**VDE 0100 recommendations**

The cross-section values mentioned below are guideline values valid for operation under normal conditions and at an ambient temperature of 40 °C. Higher values should be selected if conditions differ from the norm, such as higher temperatures or harmonic distortion.

| kvar rating at 400 V kvar | Nominal current A | HRC fuse rating A | Cross section of supply cable $mm^2$ |
|---|---|---|---|
| 1 | 1.4 | 5 | 1 |
| 1.5 | 2.2 | 5 | 1.5 |
| 2 | 2.9 | 10 | 1.5 |
| 2.5 | 3.6 | 10 | 2.5 |
| 5 | 7.2 | 15 | 2.5 |

For other voltage ratings:

230 V table figure • 1.74

440 V table figure • 0.91

480 V table figure • 0.83

525 V table figure • 0.76

A lower cross section is normally sufficient for the internal wiring of a capacitor bank. Various parameters such as the temperature inside the cabinet, the cable quality, the maximum cable isolation temperature, the cable type (single or multicore) and length have to be taken into consideration when selecting the appropriate value.

**Vibration resistance**

The capacitor's resistance to vibration corresponds to IEC 68, part 2-6. The following values apply to the capacitor alone.

**Test conditions**

Max. test conditions:

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

The connections and terminals may influence the vibration properties. It is The stability must be checked when an installed capacitor is exposed to vibration. Irrespective of this, it is not advised to locate capacitors where the vibration amplitudes could reach maximum levels in strongly vibrating appliances.

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.
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