



## Dear Customer,

We would like to thank you for choosing a power factor correction system from FRAKO Kondensatoren- und Anlagenbau GmbH. It is a pleasure to welcome you into the ever-expanding circle of satisfied users of FRAKO products worldwide. We hope that the following information will help you to install and operate the power factor correction system without encountering any problems. If you have any questions or need help, we are always at your disposal.

Best regards from **FRAKO Kondensatoren- und Anlagenbau GmbH**

## General

FRAKO power factor correction systems are prewired and receive a thorough individual inspection to verify the good working order of all components before leaving the factory.

Before commissioning the system it is only necessary to connect the power supply and the cabling to the current transformer. The current transformer itself, however, is not included in the scope of supply for power factor correction systems.

The reactive power control relay must be adjusted according to the separate operating manual supplied with the instrument.

Any questions that may arise concerning the wiring and commissioning of the system are treated in detail in these instructions.

## Safety instructions

**Caution:** Dangerous voltages are exposed inside the cabinet. Every operation that involves opening the door may therefore only be made by a qualified electrician.

The installation of the power factor correction system, the verification of its good working order and any actions taken to rectify faults may only be carried out by appropriately qualified specialists who have received instruction on the electrical hazards involved.

All other actions can be carried out by persons who have familiarized themselves with these instructions and the operating manual for the reactive power control relay and follow them at all times.

- These instructions and the operating manual for the reactive power control relay must be read through carefully before the system is installed, connected up and commissioned.
- The power factor correction system must always be earthed.
- Do not install the system near to any liquids, and do not expose it to an excessively humid atmosphere.
- If the power factor correction system is visibly damaged, it must not be installed, connected up or commissioned.
- Do not cover the ventilation grille.
- Do not expose the system to direct sunlight or install it near to a source of heat.
- If the system is not put into service immediately, it must be stored in a dry location at a temperature between -20 °C and +60 °C.
- Please observe all current statutory regulations governing the recycling of the packaging materials.

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## 1 System location

Standard versions of FRAKO power factor correction systems are constructed with IP 30 ingress protection to EN 60529 (in some cases IP 20 and IP 54 for small Series LSK systems) and are designed for operation in dry rooms. The ambient temperature must not exceed 40 °C. Openings are provided in the enclosures for ventilation, and these must not be covered, as this would inhibit the free circulation of air.

Special versions, such as those constructed for IP 54 ingress protection or for room temperatures over 40 °C, or choked systems, are fitted with fan/filter units. If there is any tendency for hot air to accumulate in the room where the system is installed, it must be ensured that the room is adequately ventilated.

## 2 Fuses and cables

When the installation work is carried out in Germany, the VDE (German Association of Electrical Engineers) regulations VDE 0100 and VDE 0105, the general guidelines of the VDEW (German Electricity Association) and the conditions of supply of the utility company concerned must be complied with. In other countries the relevant local regulations must be observed.

VDE 0560 Part 41 states that capacitor units must be suitable for a continuous r.m.s. current of 1.3 times the current that is drawn at the sinusoidal nominal voltage and nominal frequency. If the capacitance tolerance of  $1.1 \times C_N$  is also taken into account, the maximum allowable current can reach values of up to  $1.38 \times I_N$ . This overload capability together with the high inrush current to the capacitors must be taken into account when dimensioning fuses and cable cross sections.

**Note:** FRAKO power capacitors offer a current load capacity of  $2 \times I_N$  at 400V.

**Table 1:**

Fuses and supply cable cross sections according to VDE 0100 Part 430, installation category C

| Power in kWAr | 230V / 50 Hz |           |                                  | 400V / 50 Hz |           |                                  | 525V / 50 Hz |           |                                  |
|---------------|--------------|-----------|----------------------------------|--------------|-----------|----------------------------------|--------------|-----------|----------------------------------|
|               | Current in A | Fuse in A | Cross section in mm <sup>2</sup> | Current in A | Fuse in A | Cross section in mm <sup>2</sup> | Current in A | Fuse in A | Cross section in mm <sup>2</sup> |
| 2.5           | 6.3          | 10        | 4 x 1.5                          | 3.6          | 10        | 4 x 1.5                          | 2.7          | 10        | 4 x 1.5                          |
| 5             | 12.6         | 20        | 4 x 2.5                          | 7.2          | 10        | 4 x 1.5                          | 5.5          | 10        | 4 x 1.5                          |
| 6.25          | 15.7         | 25        | 4 x 4                            | 9.0          | 16        | 4 x 2.5                          | 6.9          | 10        | 4 x 1.5                          |
| 7.5           | 18.8         | 35        | 4 x 6                            | 10.8         | 16        | 4 x 2.5                          | 8.2          | 16        | 4 x 2.5                          |
| 10            | 25.1         | 35        | 4 x 6                            | 14.4         | 20        | 4 x 2.5                          | 11.0         | 16        | 4 x 2.5                          |
| 12.5          | 31.4         | 50        | 4 x 10                           | 18.0         | 25        | 4 x 4                            | 13.7         | 20        | 4 x 2.5                          |
| 15            | 37.7         | 63        | 4 x 16                           | 21.7         | 35        | 4 x 6                            | 16.5         | 25        | 4 x 4                            |
| 17.5          | 43.9         | 63        | 4 x 16                           | 25.3         | 35        | 4 x 6                            | 19.2         | 35        | 4 x 6                            |
| 20            | 50.2         | 80        | 3 x 25/16                        | 28.9         | 50        | 4 x 10                           | 22.0         | 35        | 4 x 6                            |
| 25            | 62.8         | 100       | 3 x 35/16                        | 36.1         | 50        | 4 x 10                           | 27.5         | 50        | 4 x 10                           |
| 27.5          | 69.0         | 100       | 3 x 35/16                        | 39.7         | 63        | 4 x 16                           | 30.2         | 50        | 4 x 10                           |
| 30            | 75.3         | 125       | 3 x 50/25                        | 43.3         | 63        | 4 x 16                           | 33.0         | 50        | 4 x 10                           |
| 31.25         | 78.4         | 125       | 3 x 50/25                        | 45.1         | 63        | 4 x 16                           | 34.4         | 50        | 4 x 10                           |
| 37.5          | 94.1         | 160       | 3 x 70/35                        | 54.1         | 80        | 3 x 25/16                        | 41.2         | 63        | 4 x 16                           |
| 40            | 100.4        | 160       | 3 x 70/35                        | 57.7         | 80        | 3 x 25/16                        | 44.0         | 63        | 4 x 16                           |
| 43.75         | 109.8        | 160       | 3 x 70/35                        | 63.1         | 100       | 3 x 35/16                        | 48.1         | 80        | 3 x 25/16                        |
| 45            | 113.0        | 160       | 3 x 70/35                        | 65.0         | 100       | 3 x 35/16                        | 49.5         | 80        | 3 x 25/16                        |
| 50            | 125.5        | 200       | 3 x 95/50                        | 72.2         | 100       | 3 x 35/16                        | 55.0         | 80        | 3 x 25/16                        |
| 52.5          | 131.8        | 200       | 3 x 95/50                        | 75.8         | 125       | 3 x 50/25                        | 57.7         | 80        | 3 x 25/16                        |
| 60            | 150.6        | 250       | 3 x 120/70                       | 86.6         | 125       | 3 x 50/25                        | 66.0         | 100       | 3 x 35/16                        |
| 62.5          | 156.9        | 250       | 3 x 120/70                       | 90.2         | 125       | 3 x 50/25                        | 68.7         | 100       | 3 x 35/16                        |
| 67.5          | 169.4        | 250       | 3 x 120/70                       | 97.4         | 160       | 3 x 70/35                        | 74.2         | 125       | 3 x 50/25                        |
| 68.75         | 172.6        | 250       | 3 x 120/70                       | 99.2         | 160       | 3 x 70/35                        | 75.6         | 125       | 3 x 50/25                        |
| 75            | 188.3        | 315       | 3 x 185/95                       | 108.3        | 160       | 3 x 70/35                        | 82.5         | 125       | 3 x 50/25                        |
| 87.5          | 219.6        | 315       | 3 x 185/95                       | 126.3        | 200       | 3 x 95/50                        | 96.2         | 160       | 3 x 70/35                        |
| 93.75         | 235.3        | 400       | 2x 3 x 95/50                     | 135.3        | 200       | 3 x 95/50                        | 103.1        | 160       | 3 x 70/35                        |
| 100           | 251.0        | 400       | 2x 3 x 95/50                     | 144.3        | 200       | 3 x 95/50                        | 110.0        | 160       | 3 x 70/35                        |
| 112.5         | 282.4        | 400       | 2x 3 x 95/50                     | 162.4        | 250       | 3 x 120/70                       | 123.7        | 200       | 3 x 95/50                        |
| 120           | 301.2        | 500       | 2x 3 x 120/70                    | 173.2        | 250       | 3 x 120/70                       | 132.0        | 200       | 3 x 95/50                        |
| 125           | 313.8        | 500       | 2x 3 x 120/70                    | 180.4        | 250       | 3 x 120/70                       | 137.5        | 200       | 3 x 95/50                        |
| 150           | 376.5        | 630       | 2x 3 x 185/95                    | 216.5        | 315       | 3 x 185/95                       | 165.0        | 250       | 3 x 120/70                       |
| 175           | 439.3        | 630       | 2x 3 x 185/95                    | 252.6        | 400       | 2x 3 x 95/50                     | 192.5        | 315       | 3 x 185/95                       |
| 200           | 502.0        | 800       | 2x 3 x 240/120                   | 288.7        | 400       | 2x 3 x 95/50                     | 219.9        | 315       | 3 x 185/95                       |
| 225           | -            | -         | -                                | 324.8        | 500       | 2x 3 x 120/70                    | 247.4        | 400       | 2x 3 x 95/50                     |
| 250           | -            | -         | -                                | 360.8        | 500       | 2x 3 x 120/70                    | 274.9        | 400       | 2x 3 x 95/50                     |
| 275           | -            | -         | -                                | 396.9        | 630       | 2x 3 x 185/95                    | 302.4        | 500       | 2x 3 x 120/70                    |
| 300           | -            | -         | -                                | 433.0        | 630       | 2x 3 x 185/95                    | 329.9        | 500       | 2x 3 x 120/70                    |
| 350           | -            | -         | -                                | 505.2        | 800       | 2x 3 x 240/120                   | 384.9        | 630       | 2x 3 x 185/95                    |
| 375           | -            | -         | -                                | 541.3        | 800       | 2x 3 x 240/120                   | 412.4        | 630       | 2x 3 x 185/95                    |
| 400           | -            | -         | -                                | 577.4        | 800       | 2x 3 x 240/120                   | 439.9        | 630       | 2x 3 x 185/95                    |

## 3 Cable connections

Each cabinet or wall-mounted enclosure must always be provided with its own supply cable, with terminals for the L1, L2, L3, N and PE conductors. If a four-core cable is used, a connection must be made between the PE and N conductors in order to supply power to the reactive power control relay and contactor coils.

With wall-mounted systems, either a PG cable gland or a rubber grommet with a strain relief clip, depending on the power rating concerned, is provided for cable entry. With freestanding cabinets the cables enter through the floor of the enclosure.

In the case of systems with a built-in fan/filter unit, care must be taken that the opening in the floor is closed again after the cables have been connected, in order to achieve an efficient cooling effect within the cabinet.

## 4 Current transformer

A current transformer is necessary to operate power factor correction systems. This is not included in FRAKO's standard scope of supply, but can be supplied with the system if the requirements in the customer's installation have been clarified.

The primary current in the current transformer is dictated by the user's current consumption, the device being selected on the basis of the maximum current load or the load connected to the transformer. The circuit to the reactive power control relay is designed for a .../1 to .../5 A current transformer with a rating of 5 VA, Class 3.

If additional instruments are to be operated from the same current transformer, this must be taken into account when specifying its rating.

If ammeters are installed in series with the control relay, the rating of the current transformer must be increased to suit. The internal power consumption in the control relay circuit amounts to some 1.8 VA for a current transformer with 5 A nominal current.

Losses also occur in the current transformer wiring, and these must also be taken into account if there are long lengths of cable between the current transformer and the reactive power control relay.

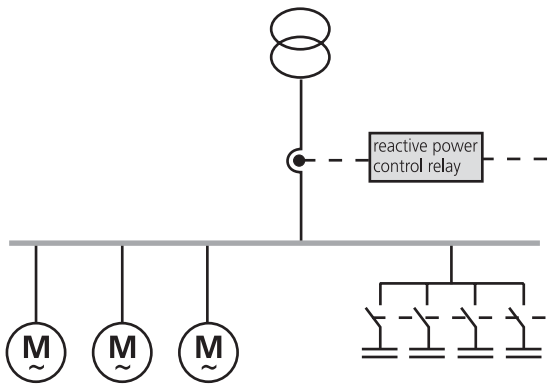
**Table 2:**

Power losses in copper conductors from a current transformer with a secondary current of 5 A:

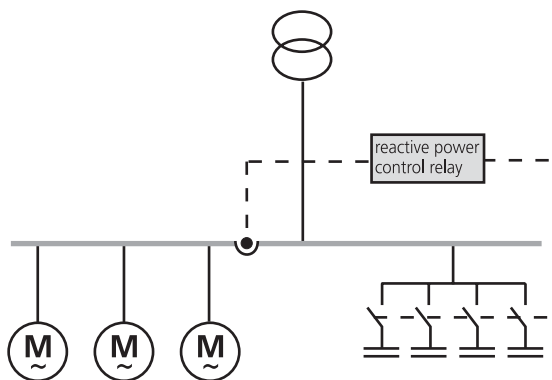
| Cross section in mm <sup>2</sup> | Losses per metre of two-core cable in VA |
|----------------------------------|--|
| 2.5                              | 0.36                                     |
| 4.0                              | 0.22                                     |
| 6.0                              | 0.15                                     |
| 10.0                             | 0.09                                     |

**Note:** The current transformer must be installed in any one of the three phases so that the entire current to the loads requiring power factor correction and the capacitor current flow through it (as shown in Figs. 1 - 3). Terminal P1 (K) is connected to the supply side, terminal P2 (L) to the load side.

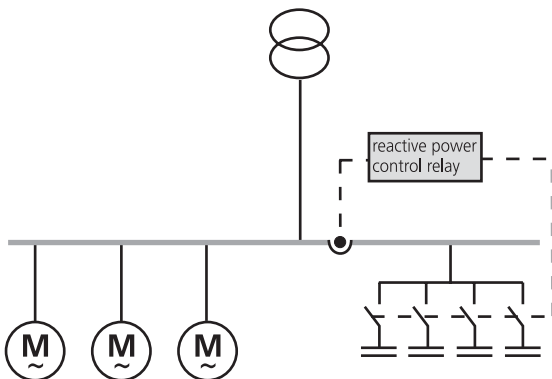
**Caution:** When the circuit is broken, voltage surges occur which could destroy the current transformer. The terminals S1 (k) and S2 (l) must therefore be short-circuited before the current transformer circuit is broken.



**Fig. 1: Correctly** installed current transformer registers load current **and** capacitor current



**Fig. 2: Incorrect!** The current transformer only registers the load current: the capacitor bank is switched in but not out again. Automatic calibration of the reactive power control relay is not possible!



**Fig. 3: Incorrect!** The current transformer only registers the capacitor current: the capacitor bank is not switched in. The reactive power control relay gives the message "I = 0" (no current in transformer circuit)!

When selecting the current transformer, the step-down ratio must be considered as well as the installed load, in order to ensure optimum functioning of the reactive power control relay.

Please look up the smallest and largest capacitor stages that can be switched in as stated in the technical documentation supplied with the power factor correction system. The minimum and maximum possible current transformer step-down ratios can then be obtained from Table 3 below.

**Table 3:**  
Minimum and maximum current transformer step-down ratios

| Smallest stage (in kVAr) | Largest stage (in kVAr) | Min. and max. current transformer ratios | Min. and max. nominal primary currents for .../5 A transformers | Min. and max. nominal primary currents for .../2.5 A transformers | Min. and max. nominal primary currents for .../1 A transformers |
|--------------------------|-------------------------|--|---|---|---|
| 2.5                      | 2.5                     | 1.5 ... 80                               | 10 ... 400  | 5 ... 200   | 5 ... 80  |
| 2.5                      | 5                       | 3 ... 80                                 | 15 ... 400  | 10 ... 200  | 10 ... 80   |
| 2.5                      | 7.5                     | 4.5 ... 80                               | 25 ... 400  | 15 ... 200  | 15 ... 80   |
| 2.5                      | 10                      | 6 ... 80                                 | 30 ... 400  | 20 ... 200  | 20 ... 80   |
| 2.5                      | 15                      | 9 ... 80                                 | 50 ... 400  | 25 ... 200  | 25 ... 80   |
| 2.5                      | 20                      | 12 ... 80                                | 60 ... 400  | 30 ... 200  | 30 ... 80   |
| 5                        | 5                       | 3 ... 160                                | 15 ... 800  | 10 ... 400  | 10 ... 160  |
| 5                        | 10                      | 6 ... 160                                | 30 ... 800  | 20 ... 400  | 20 ... 160  |
| 5                        | 15                      | 9 ... 160                                | 50 ... 800  | 25 ... 400  | 25 ... 160  |
| 5                        | 20                      | 12 ... 160                               | 60 ... 800  | 30 ... 400  | 30 ... 160  |
| 5                        | 30                      | 18 ... 160                               | 100 ... 800   | 50 ... 400  | 50 ... 160  |
| 5                        | 40                      | 24 ... 160                               | 120 ... 800   | 60 ... 400  | 60 ... 160  |
| 6.25                     | 6.25                    | 3.75 ... 160                             | 20 ... 1000   | 10 ... 500  | 10 ... 160  |
| 6.25                     | 12.5                    | 7.5 ... 160                              | 40 ... 1000   | 20 ... 500  | 20 ... 160  |
| 6.25                     | 18.75                   | 11.3 ... 160                             | 60 ... 1000   | 30 ... 500  | 30 ... 160  |
| 6.25                     | 25                      | 15 ... 160                               | 75 ... 1000   | 40 ... 500  | 40 ... 160  |
| 6.25                     | 37.5                    | 22.5 ... 160                             | 120 ... 1000  | 60 ... 500  | 60 ... 160  |
| 6.25                     | 50                      | 30 ... 160                               | 150 ... 1000  | 75 ... 500  | 75 ... 160  |
| 7.5                      | 7.5                     | 4.5 ... 240                              | 25 ... 1200   | 15 ... 600  | 15 ... 240  |
| 7.5                      | 15                      | 9 ... 240                                | 50 ... 1200   | 25 ... 600  | 25 ... 240  |
| 7.5                      | 22.5                    | 13.5 ... 240                             | 75 ... 1200   | 40 ... 600  | 40 ... 240  |
| 7.5                      | 30                      | 18 ... 240                               | 100 ... 1200  | 50 ... 600  | 50 ... 240  |
| 7.5                      | 45                      | 27 ... 240                               | 150 ... 1200  | 75 ... 600  | 75 ... 240  |
| 7.5                      | 60                      | 36 ... 240                               | 200 ... 1200  | 100 ... 600   | 100 ... 240   |
| 10                       | 10                      | 6 ... 320                                | 30 ... 1600   | 20 ... 800  | 20 ... 320  |
| 10                       | 20                      | 12 ... 320                               | 60 ... 1600   | 30 ... 800  | 30 ... 320  |
| 10                       | 30                      | 18 ... 320                               | 100 ... 1600  | 50 ... 800  | 50 ... 320  |
| 10                       | 40                      | 24 ... 320                               | 120 ... 1600  | 60 ... 800  | 60 ... 320  |
| 10                       | 60                      | 36 ... 320                               | 200 ... 1600  | 100 ... 800   | 100 ... 320   |
| 10                       | 80                      | 48 ... 320                               | 250 ... 1600  | 120 ... 800   | 120 ... 320   |
| 12.5                     | 12.5                    | 7.5 ... 400                              | 40 ... 2000   | 20 ... 1000   | 20 ... 400  |
| 12.5                     | 25                      | 15 ... 400                               | 75 ... 2000   | 40 ... 1000   | 40 ... 400  |
| 12.5                     | 37.5                    | 22.5 ... 400                             | 120 ... 2000  | 60 ... 1000   | 60 ... 400  |
| 12.5                     | 50                      | 30 ... 400                               | 150 ... 2000  | 75 ... 1000   | 75 ... 400  |
| 12.5                     | 75                      | 45 ... 400                               | 250 ... 2000  | 120 ... 1000  | 120 ... 400   |
| 12.5                     | 100                     | 60 ... 400                               | 300 ... 2000  | 150 ... 1000  | 150 ... 400   |
| 15                       | 15                      | 9 ... 480                                | 50 ... 2400   | 25 ... 1200   | 25 ... 480  |
| 15                       | 30                      | 18 ... 480                               | 100 ... 2400  | 50 ... 1200   | 50 ... 480  |
| 15                       | 45                      | 27 ... 480                               | 150 ... 2400  | 75 ... 1200   | 75 ... 480  |
| 15                       | 60                      | 36 ... 480                               | 200 ... 2400  | 100 ... 1200  | 100 ... 480   |
| 15                       | 90                      | 54 ... 480                               | 300 ... 2400  | 150 ... 1200  | 150 ... 480   |
| 25                       | 25                      | 15 ... 800                               | 75 ... 4000   | 40 ... 2000   | 40 ... 800  |
| 25                       | 50                      | 30 ... 800                               | 150 ... 4000  | 75 ... 2000   | 75 ... 800  |
| 25                       | 75                      | 45 ... 800                               | 250 ... 4000  | 120 ... 2000  | 120 ... 800   |
| 25                       | 100                     | 60 ... 800                               | 300 ... 4000  | 150 ... 2000  | 150 ... 800   |
| 50                       | 50                      | 30 ... 1600                              | 150 ... 8000  | 75 ... 4000   | 75 ... 1600   |
| 50                       | 100                     | 60 ... 1600                              | 300 ... 8000  | 150 ... 4000  | 150 ... 1600  |

## 5 RM 8406, RM 9606, RM 9612 and EMR 1100 reactive power control relays

To avoid reactive power penalty charges, the reactive power control relay must be set, as a minimum requirement, at the target value of  $\cos \varphi$  required by the local utility company. The basic factory settings represent the most frequently specified  $\cos \varphi$  requirement. A detailed description of the possible control characteristics is given in the operating manual for the reactive power control relay.

### 5.1 Automatic detection of connection, switching sequence and response current.

RM 8406, RM 9606, RM 9612 and EMR 1100 reactive power control relays automatically detect the connection (phase position), the switching sequence and the response current (C/k). These instruments have a factory setting of 0.92 for the target power factor. If it is desired to operate at this power factor, no further setting is necessary when commissioning the reactive power control relay.



When the AC supply voltage is applied to the instrument for the first time, the reactive power control relay carries out the connection and response current detection process, and is then ready to operate.

### Note

As the control relays always adapt to the installed supply system configuration, it can be necessary in individual cases to enter the required parameters manually. This option is not available with the RM 8406 control relay, so that in such situations a type RM 9606, RM 9612 or EMR 1100 control relay must be used.

When the low voltage supply system is fed by several transformers arranged in parallel, the capacitor current is distributed between all the transformers. If this current is not measured via totalizing current transformers, the change in current measurable by the control relay when the capacitor stages are switched in is too small, which would result in too low a response current for automatic C/k detection. In cases of this type, and also in networks with continual load changes (e.g. saw mills, automatic presses, welding lines and drop forges with switching periods < 2 seconds), a type RM 9606, RM 9612 or EMR 1100 reactive power control relay with manual C/k entry must be used.

### 5.2 No-volt release

The reactive power control relays are provided with a no-volt release function. This prevents all the capacitor stages being switched in simultaneously following an outage of the supply voltage when the latter is restored. The contactors are released on power failure, and are then energized again to suit requirements. Standard systems are wired so that the control voltage for the contactors is tapped from the voltage supply to the control relay. It is strongly advised not to use an external control voltage, since with this the no-volt release would no longer function, with the possibility that damage might be caused not only to the power factor correction system but also to other components in the electrical installation.

### 5.3 Overcurrent trip

The RM 9606, RM 9612 and EMR 1100 control relays have the capability of determining the ratio between the r.m.s. current and the fundamental current in the capacitor. If this ratio exceeds a value set at the control relay for at least one minute, on account of system harmonics and the consequent amplification they produce due to resonance, all the capacitor stages are switched out. An alarm signal is also given when this happens.

With unchoked systems we recommend setting this ratio or factor at a value of 1.3 (factory setting), whereas with choked systems it must be set at its maximum value of 3.0 (and therefore not active)!

## 6 Commissioning

Before the AC supply voltage is applied to the system, a visual check should be carried out by a qualified technician to verify that no equipment or connections have worked loose during transport. If this has happened, however, the components and connections concerned must be correctly tightened again. Please verify that the connections to the current transformer are made at terminals S1 and S2 (current transformers are not included in the standard scope of supply).

### 6.1 Powering up

When the AC supply voltage is applied to the control relay, it automatically carries out the connection detection procedure. Horizontal lines appear in the digital display. After switching in all capacitor stages several times, the measured power factor appears in the display. This is preceded by a + sign to indicate inductive conditions (the procedure takes some 5 - 10 minutes).

The capacitor stages required are switched in within a few seconds, and their corresponding LEDs light up on the control relay. When inductive loads are switched off, the control relay within a few seconds switches out a sufficient number of stages until the set power factor has been reached again.

The operating manual supplied with the control relay describe in detail how to reprogram the set power factor or other parameters if required.

If the control relay does not react as described here, please systematically check through the individual points given in Section 8, Troubleshooting.

### 6.2 Switching in capacitor stages manually

Press the **Man/Set** key for about three seconds. The **Manual** LED then begins to flash, indicating that the instrument has been switched over to manual operation. A capacitor stage can then be selected by means of the + or - keys. After a delay of about ten seconds the selected stage is switched in, or if that stage was already switched in, it is switched out.

Defective or unidentified capacitor stages are signalled as follows in manual mode:

#### RM 8406:

A small "o" (half display) appears next to the number of the selected stage.

#### RM 9606, RM 9612 and EMR 1100:

The number of the selected stage flashes.

Please do not forget to press the **Man/Set** key again to revert to automatic control!

### 6.3 Switching off the voltage

If the voltage is to be removed from the power factor correction system, switch the control relay over to manual mode and then switch out all the capacitor stages. This enables the main fuses to be removed or the fuse switch-disconnector to be switched off under no-load conditions.

## 7. Operation and maintenance

Power factor correction systems operate automatically and for a long time without any maintenance. Carrying out a regular inspection at least once a year can, however, prevent reactive power penalty charges suddenly being incurred or the correction system being damaged by an undetected fault.

### 7.1 Alarm signal

All FRAKO reactive power control relays are provided with a built-in alarm contact (terminals a and b), which can be connected to an alarm system. If the set power factor is not achieved, a signal is given and the **Alarm** LED on the instrument itself lights up continuously. The operating manual for the control relay contains more information on the types of alarm and the programming of their set points.

### 7.2 Fuses

Low voltage, high breaking capacity fuses undergo an ageing process when carrying the high switched currents associated with capacitors. They should therefore be inspected at least once per year. We recommend replacing the fuse links after ten years at the latest.

### 7.3 Contactors

Contactors specially designed to switch capacitors in and out are always used in FRAKO systems. Please therefore ensure when replacing contactors that only the capacitor-switching type is fitted.

The contacts of capacitor switching contactors have a particularly demanding duty. They are tested for 80,000 switching cycles and must be completely replaced once this number has been reached. If the power factor correction system has a control relay with a switching cycle counter (such as the RM 9606, RM 9612 or EMR 1100), a separate message is given for each stage after 80,000 switching cycles (factory setting which can, however, be reprogrammed) to inform the operator that contactor replacement is due.

The current counter readings can be accessed via the control relay: when capacitor stages are switched in manually, the number of switching cycles appears briefly in the display (multiply reading by 1000).

**Wear and tear of the switching contacts has an adverse effect on the service life of the capacitors!**

## 7.4 Temperature alarm

Power factor control relays have a built-in temperature switch interlocked with the control system.

If a build-up of heat causes the interior temperature of the enclosure to rise above 70 °C, the system shuts down. After it has cooled down, the system is switched in again in stages.

If the system comprises several cabinets, the temperature interlock is looped through all of them.

## 7.5 Discharge resistors

The discharge resistors are fitted to the capacitor terminals for safety reasons in compliance with VDE (German Association of Electrical Engineers) regulations. In addition to their safety function, they are also indispensable for problem-free operation of the system and must on no account be removed. Attention must be paid to this point particularly when capacitors are replaced!

## 7.6 Choked systems

Choked systems have been specially designed for operation in networks that are highly distorted by harmonics. The filter circuit chokes have a strong self-heating tendency and can reach temperatures in excess of 100 °C. They are, however, designed for these temperatures and have a built-in temperature switch. This switches off the contactor associated with the choke for a long enough time until the latter has cooled down again.

## 7.7 Fan/filter units

Fan/filter units are fitted to systems that are designed for ambient temperatures exceeding 40 °C or have IP 54 ingress protection, or to choked systems. The voltage supply to the fan motor is via the control system fuse. An adjustable thermostat, which should be set at 30 °C, controls the fan. Adequate ventilation can only be ensured if the filter mats are clean. It is therefore necessary to clean these regularly, the frequency depending on the amount of dust present at the location concerned.

## 7.8 Capacitors

The capacitors must be checked visually during the annual inspection for any mechanical changes. Any variation in capacitance or distortion by harmonics can be inferred from the operating currents measured. If any irregularities are detected, please contact your local FRAKO representative or call us directly (Tel. +49 7641/453-0).

## 7.9 General

Please ensure that the system is kept clean at all times, if necessary having it cleaned by skilled personnel. During the annual inspection the system must be given a visual check by an electrician to verify its good working order (sound electrical contacts, no evidence of overheating, etc.).

## 8 Troubleshooting

If the power factor correction system does not operate as expected, please investigate the following points systematically:

### 8.1 No reaction, no display at all on control relay

Cause: No voltage at control relay  
Action: Check voltage at terminals L1, L2, L3 and N, check control circuit fuse.

### 8.2 Contactors do not close even though the capacitor stage display on the control relay indicates switched-in stages.

Cause: No control voltage or N at contactor  
If four-wire supply, no jumper installed between N and PE  
Action: Check control fuses and cabling.

### 8.3 Contactors do not close. Cap is indicated in the display, even though the load is inductive.

Cause: Current transformer installed in spur to capacitors  
Action: Install current transformer in the main supply line, as shown in Section 4, Fig. 1.

### 8.4 The message "U = 0" flashes in the control relay display.

Cause: No voltage or wrong voltage connected to control relay for measurement  
Action: Check whether the voltage being measured at the control relay is at the correct level.

### 8.5 The message "I = 0" flashes in the control relay display.

Cause: No current or too little current in the current transformer circuit  
Action: Check current transformer ( $I_{\min} \geq 0.02 \text{ A}$ ) and cabling.

### 8.6 The message "C = 0" flashes in the control relay display.

Cause: The control relay has not detected any capacitances despite carrying out the calibration procedure. No capacitor current is registered by the current transformer.  
See Section 4, Fig. 2.  
Action: Install current transformer in main supply line as shown in Section 4, Fig.1.

### 8.7 Control relay switches all stages in, but does not switch them out when the load reduces.

Cause: Current transformer registers only the load current without the capacitor current.  
Action: Install current transformer in main supply line as shown in Section 4, Fig.1.

### 8.8 The reactive power control relay does not terminate the automatic calibration procedure.

Cause 1: Fault in control circuit (contactors not closing)  
Action: Check control circuit fuses and cabling.  
Cause 2: Very unstable network (wide  $\cos \varphi$  fluctuations)  
Action: Wait for stable network conditions or enter C/k and type of connection manually (see control relay operating manual).  
Cause 3: No current in current transformer circuit  
Action: Check current transformer and cabling.

### 8.9 Reactive current consumption too high even though all capacitors are switched in

Cause 1: Capacitor power rating inadequate  
Action: Check whether all contactors have closed. Check fuses and capacitor currents. Review the calculation of the required capacitor rating.  
Cause 2: Spur to capacitors is connected **before** the instrument transformer for the utility company's meter.  
Action: Relocate the connection.



# Commissioning and Maintenance of Power Factor Correction Systems

We recommend that you complete the following check list, so that if it ever becomes necessary at a later date to trace faults and possibly consult FRAKO, all the relevant data is available on one sheet. This will greatly speed up the troubleshooting process.

## 9 Check list

Please keep the completed list available in case you need to consult FRAKO because of technical problems.

|   |  |  |
|---|--|--|
| Contact person (department for power factor correction projects):   | Tel.: +49 7641/453-0   | Fax.: +49 7641/453-545                                     |
| Power factor correction system type designation:  |  |  |
| Current transformer step-down ratio:  |  |  |
| Supply line to power factor correction system   | Cross section:   | mm <sup>2</sup>  |
|   | Overcurrent protection:  | A  |
| Length of cable between current transformer and PF correction system:   |  | metres   |
| Core cross section of current transformer cable:  | 2 x  | mm <sup>2</sup>  |
| Is an additional measuring device connected to the current transformer in addition to the power factor correction system? | <input type="checkbox"/> no  | <input type="checkbox"/> yes                               |
|   | (Please state type of instrument)  |  |
| If yes, how is it connected?  | <input type="checkbox"/> in series with the reactive power control relay   |  |
|   | <input type="checkbox"/> in parallel with the reactive power control relay |  |
| Types of load?  | - normal inductive loads   | approx. kW   |
|   | - high-speed switching loads   | approx. kW (load cycles ≤ 5 seconds)                       |
| Is "low-load" operation ever required?  | <input type="checkbox"/> no  | <input type="checkbox"/> yes approx. kW                    |
| Does the facility have its own transformer?   | <input type="checkbox"/> no  | <input type="checkbox"/> yes Rating: kVA, u <sub>k</sub> % |
| Is a fixed PF correction system connected to transformer?   | <input type="checkbox"/> no  | <input type="checkbox"/> yes Rating: kVAr                  |
| Where do the utility company's meters measure consumption?  | <input type="checkbox"/> low voltage side                                  |  |
|   | <input type="checkbox"/> high voltage side (before transformer)            |  |
| Further information or sketch of network  |  |  |



10 EC Declaration of Conformity

**EG-Konformitätserklärung**  
**Declaration of Conformity**



Dokument-Nr.: EG-LSFC-117A / 03.2002

Wir/We **FRAKO Kondensatoren- und Anlagenbau GmbH**  
**Tscheulinstraße 21 a**  
**79331 Teningen**  
**GERMANY**

erklären in alleiniger Verantwortung, daß das Produkt  
*declare under our sole responsibility that the product*

Produktbezeichnung: **Blindleistungs - Regelanlagen, eingebaut in Stahlblechgehäuse**  
*name of product* **Power Factor Control System**

Typenreihe: **LSFC** ab Fert.-Nr. **G01 13001**  
*family* *from Ser. No.*

auf das sich diese Erklärung bezieht, mit der/den folgenden Norm(en) oder normativen Dokument(en)  
übereinstimmt:

*to which this declaration relates is in conformity with the following standard(s) or other normative document(s):*

- |    |             |       |  |
|----|-------------|-------|--|
| 1. | EN 50 081-1 | 01.92 | EMV, Fachgrundnorm Störaussendung Wohnbereich      |
|    | EN 50 081-2 | 07.93 | EMV, Fachgrundnorm Störaussendung Industriebereich |
|    | EN 50 082-1 | 11.97 | EMV, Fachgrundnorm Störfestigkeit Wohnbereich      |
|    | EN 50 082-2 | 03.95 | EMV, Fachgrundnorm Störfestigkeit Industriebereich |

gemäß der Bestimmungen der Richtlinien  
*following the provisions of Directive*

|            |  |
|------------|--|
| 89/336/EWG | Elektromagnetische Verträglichkeit / Electromagnetic Compatibility Directive |
| 92/31/EWG  | Änderung der Richtlinie 89/336/EWG / Modification of 89/336/EEC              |
| 93/68/EWG  | Änderung der Richtlinien 89/336/EWG / Modification of 89/336/EEC             |

- |    |             |      |   |
|----|-------------|------|---|
| 2. | EN 60 439-1 | 1999 | Niederspannung-Schaltgerätekombination  |
|    | EN 60 831-1 | 1997 | Selbsteilende Leistungs-Parallelkondensatoren mit Nennspannung bis 1000V<br>Teil 1 Allgemeines und Sicherheitsanforderungen |
|    | EN 60 831-2 | 1997 | Teil 2 Alterungsprüfung, Selbstheilprüfung und Zerstörungsprüfung   |

gemäß der Bestimmungen der Richtlinien  
*following the provisions of Directive*

|           |  |
|-----------|--|
| 73/23/EWG | Niederspannungsrichtlinie / Low Voltage Directive              |
| 93/68/EWG | Änderung der Richtlinien 73/23/EWG / Modification of 73/23/EEC |

Teningen, den 07.05.2002

  
H.-G. Mall

Diese Erklärung bescheinigt die Übereinstimmung mit den genannten Richtlinien, beinhaltet jedoch keine Zusicherung von Eigenschaften. Die Sicherheitshinweise der mitgelieferten Produktdokumentation sind zu beachten.  
*This declaration certifies the conformity according to the mentioned directives, without any assurance of features. Please note the safety instructions of the attached product documentation.*



11 EC Declaration of Conformity

**EG-Konformitätserklärung**  
*Declaration of Conformity*



Dokument-Nr.: EG-LSK-111A\_97 / 04.2002

Wir/We **FRAKO Kondensatoren- und Anlagenbau GmbH**  
**Tscheulinstraße 21 a**  
**79331 Teningen**  
**GERMANY**

erklären in alleiniger Verantwortung, daß das Produkt  
*declare under our sole responsibility that the product*

Produktbezeichnung: **Blindleistungs - Regelanlagen, eingebaut in Stahlblechgehäuse**  
*name of product Power Factor Control System*

Typenreihe: **LSK** ab Fert.-Nr. **G96 49001**  
*family from Ser. No.*

auf das sich diese Erklärung bezieht, mit der/den folgenden Norm(en) oder normativen Dokument(en)  
übereinstimmt:

*to which this declaration relates is in conformity with the following standard(s) or other normative document(s):*

- |    |             |       |  |
|----|-------------|-------|--|
| 1. | EN 50 081-1 | 01.92 | EMV, Fachgrundnorm Störaussendung Wohnbereich      |
|    | EN 50 081-2 | 07.93 | EMV, Fachgrundnorm Störaussendung Industriebereich |
|    | EN 50 082-1 | 11.97 | EMV, Fachgrundnorm Störfestigkeit Wohnbereich      |
|    | EN 50 082-2 | 03.95 | EMV, Fachgrundnorm Störfestigkeit Industriebereich |

gemäß der Bestimmungen der Richtlinien  
*following the provisions of Directive*

|            |  |
|------------|--|
| 89/336/EWG | Elektromagnetische Verträglichkeit / Electromagnetic Compatibility Directive |
| 92/31/EWG  | Änderung der Richtlinie 89/336/EWG / Modification of 89/336/EEC              |
| 93/68/EWG  | Änderung der Richtlinien 89/336/EWG / Modification of 89/336/EEC             |

- |    |             |      |   |
|----|-------------|------|---|
| 2. | EN 60 439-1 | 1999 | Niederspannung-Schaltgerätekombination  |
|    | EN 60 831-1 | 1997 | Selbsteilende Leistungs-Parallelkondensatoren mit Nennspannung bis 1000V<br>Teil 1 Allgemeines und Sicherheitsanforderungen |
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gemäß der Bestimmungen der Richtlinien  
*following the provisions of Directive*

|           |  |
|-----------|--|
| 73/23/EWG | Niederspannungsrichtlinie / Low Voltage Directive              |
| 93/68/EWG | Änderung der Richtlinien 89/23/EWG / Modification of 89/23/EEC |

Teningen, den 07.05.2002

H.-G. Mall

Diese Erklärung bescheinigt die Übereinstimmung mit den genannten Richtlinien, beinhaltet jedoch keine Zusicherung von  
Eigenschaften. Die Sicherheitshinweise der mitgelieferten Produktdokumentation sind zu beachten.  
*This declaration certifies the conformity according to the mentioned directives, without any assurance of features. Please note the  
safety instructions of the attached product documentation.*