FAMCO
هایپرصنعت

# Reactive Power Control Relay
# EMR 1100 /-S
## Operating Instructions

FRAKO



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## Fig. 1: View of Front Panel

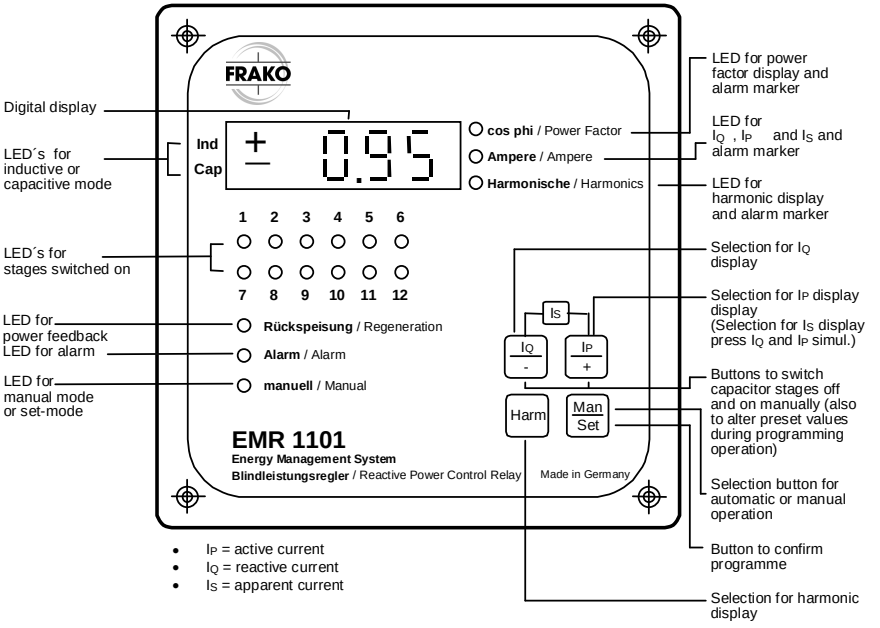


**Figure 1:** View of Front Panal

## Fig. 2: View from below

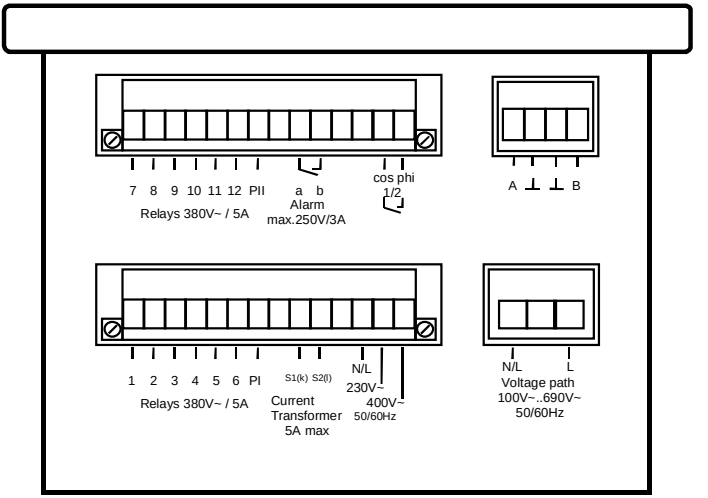


**Figure 2:** View from below



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## Contents



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## Safety and Warning Instructions
## Important, read before commissioning!

- The user must make sure that every person handling this unit must know these operating instructions and handle the unit accordingly.
- These operating instructions must be read thoroughly before the unit is installed and commissioned.
- Proceed only according to these operating instructions.
- Only trained personnel should install and commission this unit. Specific rules and regulations must be observed.
- The unit is under power and must not be opened.
- If the unit is visibly damaged it must not be installed, connected and commissioned.
- Disconnect the unit immediately if it does not operate after commissioning.
- Do observe all laws and regulations concerning this product.

Additionally all safety and commissioning instructions of the Reactive Power Control System are to be observed.



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# EG-Konformitätserklärung

## *Declaration of Conformity*

FRAKO

Dokument-Nr.: EG-EMR-101A / 07.2002

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:<br>*name of product* | Bindleistungsregler EMR 1100 und EMR 1100-S<br>*Power Factor Control System* | |
| Typenreihe:<br>*family* | **EMR** | ab Fert.-Nr. 002000<br>*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 | 08.93 | EMV, Fachgrundnorm Störaussendung Industriebereich |
| | EN 50 082-1 | 03.93 | EMV, Fachgrundnorm Störfestigkeit Wohnbereich |
| | EN 50 082-2 | 01.93 | 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 61 010-1 | 1993 | Sicherheitsbestimmungen für elektrische Meß-, Steuer-, Regel- und Laborgeräte |

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

| | |
|---|---|
| 73/23/EWG | Niederspannungsrichtlinie / Low Voltage Directive |

Teningen, den 26.07.2002

P. Herbst / 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 the mentioned directives, without any assurence of features. Please note the safety instructions of the attached product documentation.*

## 1. Summary of Instructions

On delivery, the control relay is set to pre-programmed standard values.
(see Table 1, pages 18 to 20)
The Reactive Power Control Relay **EMR 1100** is self-regulating (i.e. it detects and adjusts to the voltage phase connection, frequency and the response curent (c/k ratio) automatically).

Before a reactive power control system can be put into operation, the target power factor has to be programmed.

**How to programme the Control Relay:**

a) The control relay should be connected as shown in (see page 12).

b) ) Apply voltage to the control relay: "---" appears on the digital display. The control relay now identifies the location of the current and voltage source. This process takes at least 2 minutes and a maximum of 15 minutes. The power factor is displayed. (If this is not the case, see section 8. page 38).

c) Press the "Set" button for 8 seconds. "-01-" will appear on the digital display and the "manual" LED flashes.

d) By repressing the "Set" button the target power factor is displayed. If necessary, reprogramme to the nearest higher or lower value by pressing either the "+" or "-" button until the required target power factor is displayed.

**If no numbers appear on the display then the control relay must be briefly disconnected from the voltage source and the "Set" button has to be pressed again according to c).**

e) To confirm the value press the "Set" button again. "-02-" will appear on the display.

f) Now press the "-" button twice until "END" appears on the display. Store this value by pressing the "Set" button. The target power factor is now stored permanently.

To display the correct values for power and current, enter the current and voltage transformer ratios
(see sections 5.18 and 5.19).

To prevent unintentional reprogramming, the set mode can only be activated within the first 5 minutes after the operating voltage has been applied. If the set mode has been activated within the first 5 minutes, you have one hour to complete the programming. In order to obtain the set mode again after this period of time the control relay must be briefly disconnected from the voltage source.

On pages 18 - 20 all other preprogrammed standard values and their programme ranges are listed. The function of the pre-programmed standard values is described under section 5.



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## 2. Functions

The reactive power and active power portions of the power source are continuously calculated in the control relay from the measured voltage and the signals of the current transformer. If the reactive power portion exceeds certain threshold values, which the control relay has measured at the time of auto-adaption or are set as per section 5, a switching action will take place at the switching outputs.

In the case of inductive reactive current (inductive reactive power) one or more control contacts of the reactive power control relay are closed after the preprogrammed time delay.

This causes the **EMR 1100** to switch capacitor stages onto the power source supply, as and when required, in order to achieve the programmed target power factor. If the inductive reactive current portion of the load is reduced, the excess of reactive current causes the capacitor stages to be switched off line.

The Control Relay **EMR 1100** allows a variety of possible settings to meet the conditions on site. The relay's cyclic operations prolong the life of all connected devices by averaging the length of time the capacitor stages are switched on. An effective supervision of the reactive power control system (capacitor bank) is secured by the power factor display.

### 2.1 Device version

The Control Relay **EMR 1100** is availaby as a basic version (**-S)** and a full version. During the power up of the Control Relay, the software version and the device version are shown at the display:

i.e.: 2005 == software version V2.00
basic version (**-S)**
200 == software version V2.00
full version

The basic version has the following reductions:

- no bus- or serial connection possible
- only settings for tariff 1 available

The basic version can be enlarged by an update-key for the full version any time. (see accessories, section 7)

### 2.2 Automatic Identification of Voltage and Current Source

When voltage is initially applied to the control relay, it determines the location of the current and voltage sources (automatic phase rotation), i.e. it identifies in which phase and at which phase angle the current path and the voltage path are connected. Should the control relay fail to identify the current and voltage source due to power instabilities, repeat the procedure when the power has stabilized. It is also possible to programme the phasing manually (see sections 5.14 and 5.15).



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**Resetting of the control relay and re-identification of voltage and current sources is initiated by pressing buttons "+" and "Set" simultaneously for at least 8 seconds.**

### 2.3 Automatic Identification of the Connected Capacitor Stages

Having determined the voltage and current source identification, the **EMR 1100** automatically calculates the c/k identification. During the identification process all the control contacts of the relay are individually switched on and off again. The stage currents ascertained are then stored. These values determine the stage sequence. In this way it can also be determined which switching outputs are in use.

The processes of automatic identification of voltage and current source and/or the automatic identification of capacitor stages are only carried out when switching on or pressing the combination of buttons "+", "-" and "Set" for min. 8 seconds.
(see section 2.1)

**Precondition:** The automatic identification mode or the automatic identification of connected capacitor stages mode are switched to "ON".

The **EMR 1100** checks stored stage currents at specific time intervals during normal operation. If it recognises that a capacitor stage has failed, this stage (stage without capacitance) will be ignored in future normal operations.

All failed stages are switched on from time to time in order to re-check their capacitance. If a capacitor stage is added later on, or defective fuses are exchanged, the **EMR 1100** itself identifies this after some time and the stage is then reintegrated into the normal operation. However, we recommend that if capacitor stages are added at a later date, the set-up procedure be repeated (see section 2.1).

**Note:**
In case of low voltage networks being fed by several transformers switched in parallel, the capacitor current is distributed to all the transformers. If measurements are **not** carried out via a summation transformer, the current change, measured by the control relay, is too low when switching on the capacitor stages, which can lead to errors during the automatic stage identification process. In such situations we recommend that the stage identification be switched off and the relevant values be programmed manually.
(see sections 5.9 to 5.12)



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### 2.4 Automatic Setting of Switching Time Delay

In order to keep the wear of the capacitor's contactors down to a minimum the response time of the control relay is lengthened or shortened automatically according to the frequency of the change of the load.

### 2.5 Power Feedback

The **EMR 1100** is equipped with a four quadrant control. This means that even when active power is fed back into the mains, the control relay ensures compensation for the reactive power which has been drawn from the mains. In this case the LED "Regen" lights up.

### 2.6 Tariff Switching *)

The **EMR 1100** offers the possibility to store two different target power factors (Tariffs 1/2). These can be chosen through an external, potential free contact. It is therefore possible to achieve different switching actions (i.e. at high or low demand times or during normal operation and emergency power operations).

### 2.7 Bus Connection *)

The **EMR 1100** is equipped with a 2-wire bus connection. It can therefore be connected to the FRAKO Energy Management System Central Unit EMIS 1500 series (which can be linked to a PC). All system data (voltage, current, harmonics, etc.), controller parameters, and settings for the **EMR 1100** can be edited, changed, and printed via the PC connected to the Central Unit EMIS 1500.
The control relay can be connected to a PC or a PLC system via the Interface Unit EMP 1100 and all data will be available for controlling or editing.
Further information is available from FRAKO or its agents and representatives.

***)** *only possible at full version*

## 3. Installation and Connection

The Reactive Power Control **EMR 1100** automatically determines the location of the current and voltage sources (automatic phase rotation). It may be connected either to two phases (phase / phase) or to one phase and neutral (phase/neutral). The current transformer can be installed in any phase. It has to be passed by both capacitor and consumer current.

**IMPORTANT NOTICE:**
**During installation and service work the control relay must be kept free of voltage.**

### 3.1 Installation

As accessories (protection kit; see section 7) insulated fixing screws are available. These can be used to install the control relay into switchgear cabinets of cubicles of protective class II. Furthermore a sealing ring is part of the protection kit, which must be used when installing the control relay in switchgear cabinets and cubicles of protection class IP 54.

The pre-mounted terminal connections allow a quick and easy installation. The control relay is electrically connected through a multiple connecting terminal supplied with the relay.

### 3.2 Supply Voltage Connection

The control relay should preferably be connected to the three-phase system as shown in (page 12). To keep the function "Zero Voltage Alarm" operational the supply voltage of the control relay should be connected in the same phase as the contactor voltage.

Supply voltage of 230 V should be connected between the terminals "N/L" and "230V". Supply voltage of 400V should be connected at the terminals "N/L" and "400V".

**IMPORTANT NOTICE:**
**The control relay is designed for a mains voltage of 230 VAC or 400 VAC (phase/neutral or phase/phase).**

**For voltages greater or equal to 400 V, a control transformer for the supply of the controller must be used.**

**It is not allowed to use both connecting terminals "230V" and "400V" simultaneously.**

**The connection of the supply voltage must be fused externally with max 4A.**



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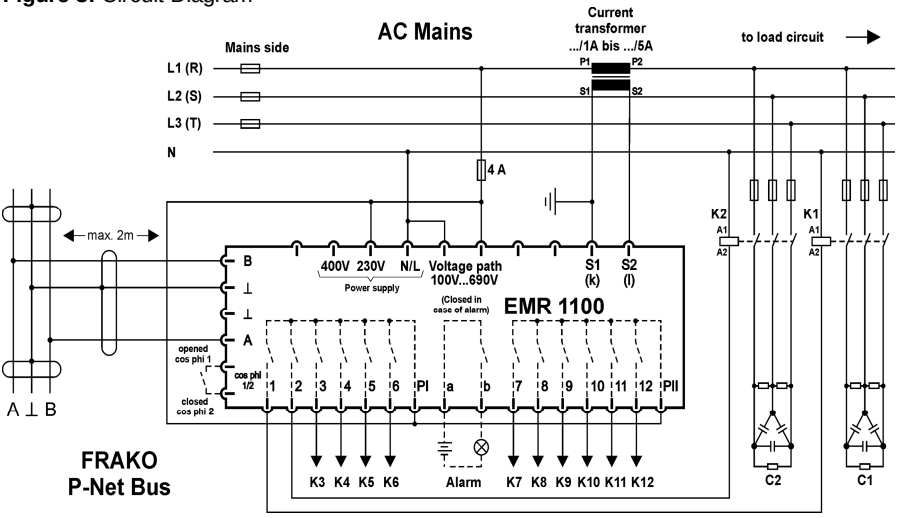
**Figure 3:** Circuit Diagram




### 3.3 Current Transformer Connection

The outputs S1 and S2 of the current transformer are connected to the terminals S1 and S2 of the control relay. In order to keep the load on the current transformer as low as possible the supply lines should have a cross-section area of 2.5 mm².

**ATTENTION:**
**The rated current in the current transformer path should not exceed 5 Amps.**

**Notice:**
After connection the short-circuiting bridge might have to be removed from the current transformer.

### 3.4 Measuring Voltage Connection

The **EMR 1100** is equipped with a separate measuring voltage path. Therefore measuring voltage and supply voltage are separated (i.e. to measure at the medium voltage side).



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**IMPORTANT NOTICE:**
**The control relay terminals of the measuring voltage must be externally protected by fuses.**
**The voltage path (measuring input) is suitable for voltages of 100 to 690 VAC only.**

### 3.5 Alarm Contacts

A potenial-free alarm signal contact is accessible on the terminals "a" and "b". The contact closes when either there is no mains voltage applied to the control relay or when an alarm is signalled.(section 6.3) When there is an alarm signal, the LED "alarm" lights up and the relevant LED begins to flash on the control relay.

**IMPORTANT NOTICE:**
**It must not be possible to touch the applied voltage at the alarm contact. If this cannot be achieved the voltage must be earthed, even if it is only small protective voltage.**
**The maximum load for the alarm contact is 250 VAC and 3 Amps.**

***)** *only possible at full version*

### 3.6 Control Contacts

The control voltage of the contactors should be connected to the terminals "PI" and "PII". These circuits are potential free.

**IMPORTANT NOTICE:**
**In order not to overload the control contacts the sum of the holding currents of all contactor coils connected may not exceed a value of 5 Amps.**
**The max. load of the switching contacts is 380 VAC.**

In order to maintain the function of the undervoltage monitoring it is absolutely necessary to make sure that the control voltage of the contactors is in the same phase as the control relay supply.

### 3.7 Tariff Switching Connection *)

A different switching characteristic can be obtained by closing an external potential free contact.(see Tariff 2, Table 1) Connection is done on terminals marked cos phi 1/2.

**Notice:**
The connection of the tariff switching is connected to the FRAKO Power Bus connection. The external contacts must be potential-free as the 2-wire bus is centrally earthed. (Potential transient currents are possible.)



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### 3.8 FRAKO Power Bus Connection *)

The ***EMR 1100*** is configured for connection to the FRAKO Power Bus®.

It can also be connected to an RS 232 interface with an *"RS232 adapter"* (accessory; see section 7). The PC software *"EMR-SW"* (accessory) can be used as a user interface. (full version only)

The two poles of the 2-wire bus are connected to terminals A and B (note polarity). The shielding is connected to one of the " ⊥" terminals.

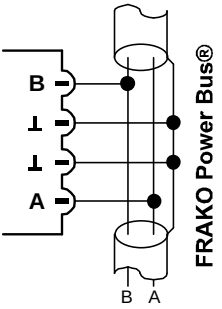


**Figure 4:** FRAKO Power Bus®

Terminal "A" is therefore connected to all terminals "A" of the other devices connected to the bus. Terminal "B" is connected to all other terminals "B". Terminal "⊥" is connected to all other terminals "⊥". ( Do not cross the wires!!)

The bus structure must be linear. All instruments must be looped in the string or connected to it with a wiring. (up to 2 m). Other bus structures can be realised with a repeater (accessory EMB 1101).

The overall length of the bus should not exceed 1200m. A repeater (accessory EMB 1101) must be employed to bridge greater distances.

Terminal resistors must be employed at the beginning and end of a string.

A 120 Ohm resistor must be connected between the terminals "A" and "B".
A 1 kOhm resistor must be connected between "A" and "⊥" in bus systems with less than 4 devices. The resistors must be suitable for 250mW power.

**Note:**
**Never connect the shielding ("⊥") to the earth terminal of EMA 1101.**

**Recommended cables**
Characteristic impedance 100-120Ω;
Ø ≥ 0,3mm²; twisted and shielded;

**Types:**
- IBM Twinax 105 Ω
- Lapp Unitronic® Bus CAN 1x2x0,34
- Helukabel CAN BUS 1x2x0,34

**Note:**
**A mixture of different cable types must always be avoided.**

***)** *only possible at full version*



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### 3.9 Additional Instructions

The installation and connection of the **EMR 1100** is only finished, once it has been installed and wired according to these instructions.

**IMPORTANT NOTICE:**
**Before commissioning of the control relay it has to be ascertained that it is not possible to touch the connecting terminals (e.g. by means of a locked door or covering).**

**The control relay must be kept voltage free during wiring and installation works.**



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# 4. Commissioning

After the control relay has been installed as described in section 3, the relay can be put into operation.

## 4.1 First Commissioning

When the control relay is put into operation for the first time it tries to determine the mode of connection and the size of the stages. The display shows "---" and after a discharge time for the capacitors the stages are switched on and off again one after the other. This process can take up to 15 minutes.

**ATTENTION:**
**If the EMR 1100 does not act as described above, remove voltage source and check installation.**

If the identification process is not concluded within 15 minutes there is probably a fault. (See section 8, page 38)

**Notice:**
**In order for the relay to be able to determine the mode of connection at least one capacitor stage must be operational.**

Possibly the control relay has already been used before and acts as described in section 4.2.

It is also possible to discontinue the identification process by switching off the automatic connection and stage current identifications. This takes place in set mode and at the same time it is necessary to programme the connection and stage parameters manually (see section 5).

After the identification process the actual power factor appears on the display and the control relay begins to function.
If the power factor shown does not coincide with the real power factor, the identification process must be repeated. This can be done by pressing the buttons "+", "-" and "Set" simultaneously for at least 8 seconds.

## 4.2 Renewed Commissioning

After a mains failure the control relay immediately starts the normal control programme again. The data which were determined whilst being put into operation for the first time are stored in a non-volatile memory.

By pressing the buttons "+", "-" and "Set" simultaneously for a least 8 seconds these data are erased from the memory and the control relay again begins to determine the mode of connection and the size of stages.
It is assumed that the automatic connection and stage current identification are switched on (see section 5).



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## 5. Programming (Set)

In order to permit the widest possible use of the control relay, multiple settings are available. To simplify matters, the control relay is set to standard values in our factory before delivery.
(see Table 1, pages 18 to 20)

The user only needs to change the target power factor or a few values to suit his special requirements. As a protection against unintentional reprogramming, the set mode (programming mode) can be invoked only within 5 minutes after operating voltage is applied. After this period the values can only be read (read-only mode). If the set mode has been activated within these 5 minutes, it remains available for one hour. In order to reach the set mode again after this period, it is necessary to disconnect the control relay from its source for a short period of time.

The procedure for checking or reprogramming the set values is as follows:


- Press the "man/set" button for at least eight seconds to switch to the set mode. The display then shows "-01-". This number corresponds to the first variable which is displayed or can be changed in the following sequence (see Table 1).
- The actual value appears on the display when the "man/set" is pressed again.
- By pressing the "+" or "-" button the next higher or lower setting can be attained.
  *The control relay is in the read-only mode if above is not possible. To reach the set mode again, the control relay must be disconnected from its source for a short period of time.*
- Press the "man/set" button repeatedly; the mode numbers appear followed by the programmed value (see Table 1).
- If the "+" is pressed again after mode number "-29-" appears on the display, or if the "-" is pressed again after mode number "-01-" appears on the display, then the display will show "End".
- By confirming the display "End" by pressing the "man/Set" button the control relay assumes normal operation; the preset values are then permanently stored in a non-volatile memory.

**Notice:**
During the "set mode" none of the capacitor stages is changed and there is no switching of the alarm contact.



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**Table 1:** Programming of Values

| Programme Mode No. | Description | Pre-programmed standard Value | Programme Range |
|---|---|---|---|
| *-01-* | Target Power Factor Tariff 1 | Ind. 0.92 | from cap. 0.80 to ind. 0.80 in increments of 0.01 steps |
| *-02-* | Parallel Shift PS (Tariff 1) | -1.0 (Target Power Factor is lower than limit value) | from –2 to +4 in increments of 0.5 steps |
| *-03-* | Limitation L (Tariff 1) | +1.0 (Overcompensation is avoided) | from –2 to +2 in increments of 0.5 steps |
| *-04-* | Switching time delay in sec-onds Tariff 1*) | 45 | 5 to 500 seconds in 1 sec. steps or at a high speed in 5 sec.steps.**) |
| *-05-* | Target Power Factor Tariff 2*) | 1.00 | from cap. 0.80 to ind. 0.80 in increments of 0.01 steps |
| *-06-* | Parallel Shift PS Tariff 2*) | 0.0 | from –2 to +4 in increments of 0.5 steps |
| *-07-* | Limitation L Tariff 2*) | 0.0 | from –2 to +2 in increments of 0.5 steps |
| *-08-* | Switching time delay in sec-onds Tariff 2*) | 45 | 5 to 500 seconds in 1 sec. steps or at a high speed in 5 sec.steps.**) |
| *-09-* | Automatic c/k Identification | ON | ON=automatic mode<br>OFF=manual mode<br>When “ON“, the programme switches directly to programme mode no. -13- |
| *-10-* | Manual c/k Value setting | 2.0 | From 0.02 to 2.0 in 0.01 steps or At high speed in 0.05 steps.**) |

*) settings only at full version possible
**) by pressing the buttons "+" or "-" for some time, the high speed mode will be activated.



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**Table 1** Programming of Values

| Programme Mode No. | Description | Pre-programmed standard Value | Programme Range |
|---|---|---|---|
| *-11-* | Switching sequence | 1:1:1:1:1 | 1:1:1:1:1... 1:1:2:4:4... 1:2:3:4:4...<br>1:1:2:2:2... 1:1:2:4:8... 1:2:3:6:6...<br>1:1:2:2:4... 1:2:2:2:2... 1:2:4:4:4...<br>1:1:2:3:3... 1:2:3:3:3... 1:2:4:8:8... |
| *-12-* | Number of contactors used | 12 | From 1 to 12 |
| *-13-* | Determination of Fixed stages | 0 | 0= no fixed stage<br>1= output fixed<br>2= outputs 1 and 2 fixed<br>3= outputs 1 to 3 fixed |
| *-14-* | Automatic identification of voltage and current source | ON | ON= automatic<br>OFF= manual<br>When “ON“, mode -15- can only be read but not changed. |
| *-15-* | Enter or read mode of connection | Automatic identification | See table 2 |
| *-16-* | Switching-off time | 60 | From 5 to 900 seconds. **) |
| *-17-* | Setting cyclic / non-cyclic switching rotation | ON | ON= cyclic switching<br>OFF= non-cyclic switching |
| *-18-* | Current transformer Ratio | 1 | From 1 to 7000 in steps of 1 or at high speed in steps of 5.**) |
| *-19-* | voltage transformer ratio | 1 | From 1 to 300 in steps of 1 or at high speed in steps of 5.**) |

**) by pressing the buttons "+" or "-" for some time, the high speed mode will be activated.



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**Table 1** Programming of Values

| Programme Mode No. | Description | Pre-programmed standard Value | Programme Range |
|---|---|---|---|
| *-20-* | Bus number | 0 | From 0 to 125 (0 = no Bus function) |
| *-21-* | 5th harmonic threshold in % | 5 | From 1 to 20 % in 0.1 % steps or 0.5 % steps at high speed.**) |
| *-22-* | 7th harmonic threshold in % | 4 | From 1 to 20 % in 0.1 % steps or 0.5 % steps at high speed.**) |
| *-23-* | 11th harmonic threshold in % | 3 | From 1 to 20 % in 0.1 % steps or 0.5 % steps at high speed.**) |
| *-24-* | 13th harmonic threshold in % | 2.1 | From 1 to 20 % in 0.1 % steps or 0.5 % steps at high speed.**) |
| *-25-* | Harmonic over-current | 1.3 | From 1.05 to 3.0 times the nominal value or “H.-AL.” in 0.05 steps or 0.1 increments at high speed |
| *-26-* | Threshold for number of switching alarm | 80 | From OFF to 1000 the value must be entered in x1000 switches |
| *-27-* | Cancelling individual switching counters | 0 | Enter a number of 1-12. When leaving this menu point the counter of the corresponding capacitor stage will be set to 0. Point “ALL“ will reset all counters to 0. |
| *-28-* | Power factor alarm tripping signal | ON | ON or OFF<br>By setting “OFF“ a power factor alarm can be suppressed. |
| *-29-* | Total kvar dis-play | Will only be displayed when in operation | By pressing “set“ button the total power in kvar will be displayed. |

**) by pressing the buttons "+" or "-" for some time, the high speed mode will be activated.



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If the current transformer is installed in correct direction and the connections S1(k) and S2(l) are correctly connected with the control relay, the following kinds of **Connection modes** are valid:

| Connection mode | Connection at the voltage path | | |
|---|---|---|---|
| | L/N – L | L/N – L | L/N – L |
| 0 | L1 – N | L2 – N | L3 – N |
| 1 | L1 – L3 | L2 – L1 | L3 – L2 |
| 2 | N – L3 | N – L1 | N – L2 |
| 3 | L2 – L3 | L3 – L1 | L1 – L2 |
| 4 | L2 – N | L3 – N | L1 – N |
| 5 | L2 – L1 | L3 – L2 | L1 – L3 |
| 6 | N – L1 | N – L2 | N – L3 |
| 7 | L3 – L1 | L1 – L2 | L2 – L3 |
| 8 | L3 – N | L1 – N | L2 – N |
| 9 | L3 – L2 | L1 – L3 | L2 – L1 |
| 10 | N – L2 | N – L3 | N – L1 |
| 11 | L1 – L2 | L2 – L3 | L3 – L1 |
| **CT Location in phase:** | ↑ **L1** | ↑ **L2** | ↑ **L3** |

**Table 2:** Connection mode

**Note:**
If S1(k) and S2(l) are connected the wrong way around or the CT is installed in wrong direction, connection mode number must be added by 6. If the result is higher than 11, 12 must be subtracted. The result corresponds to the connection mode number which have to be entered.



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## 5.1 Setting of Target Power Factor Tariff 1

The desired target power factor can be set from cap. 0.80 to ind. 0.80 in 0.01 steps. The mode of operation of this adjustment can be seen in Figure 5 and Figure 6.

If the control relay operates within the band range shown no switching operations will be activated.
However, if the control relay operates outside the band range, the **EMR 1100** will try to come within the band range with the minimum of switchings.

**Figure 5:** Control response after setting target power factor = 1; L = OFF; PS =0

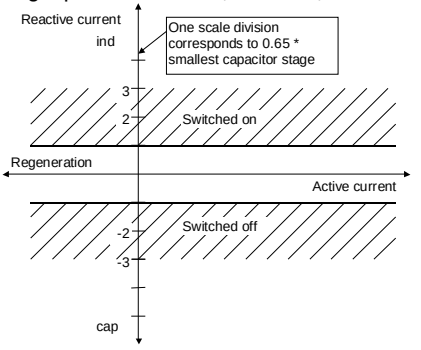
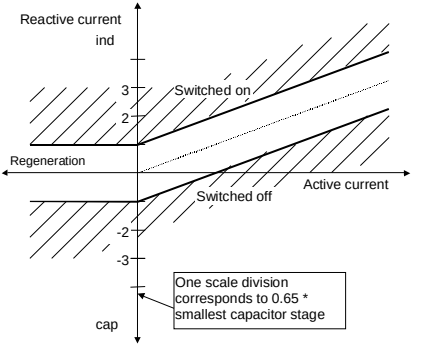



**Figure 6:** Control response after setting target power factor = 0.92 ind; L = OFF; PS = 0




In Figure 6 the behaviour of the control relay during feedback operation can also be seen. The "kink" in the band (characteristic line) is not reflected in the feedback operation but is extended at the point of intersection of the reactive power centre line (axis) with the feed-back operation line.

By shifting the band into the capacitive range (see Figure 8 in section 5.2) the occurrence of an inductive reactive power during the feedback operation can be virtually avoided.

When a capacitive target power factor mode is set, the control band is reflected from the supply side to the feedback side. (see Figure 11).



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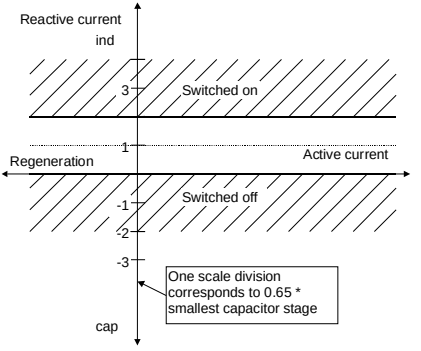
### 5.2 Parallel Shift (PS) Tariff 1

This setting causes a parallel shift of the band range as shown in Figure 5 by the set value.
It will shift to the inductive direction if the plus sign is used and to the capacitive direction if the minus sign is used.

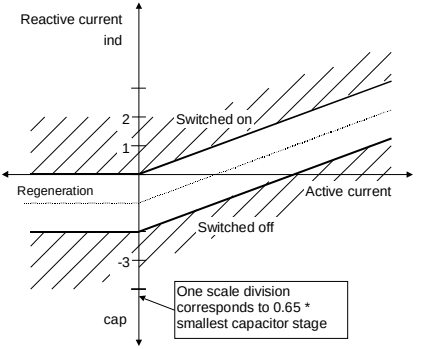
The values -2 to +4 can be set in 0.5 steps. The effects are illustrated by the two examples in Figure 7 and Figure 8.

**Figure 7:** Control response after setting target power factor = 1; L = OFF; PS = +1.0




The set target power factor is therefore the upper limit of the control band.

**Figure 8:** Control response after setting target power factor = 0.92 ind; L = OFF; PS = -1.0




The set target power factor is the lower limit of the control band range.

***(This is the recommended setting when using asynchronic generators in parallel.)***

### 5.3 Limitation (L) Tariff 1

This setting gives new possibilities that could not be attained before due to opposing requirements.

The range of values for L are -2 to +2 in steps of 0.5 and the setting "OFF". Setting the limitation value of 1 and a target power factor of 1.0 has the same effect as the parallel shift. For a target power factor other than 1.0 there is a "kinked" characteristic as shown in Figure 9.



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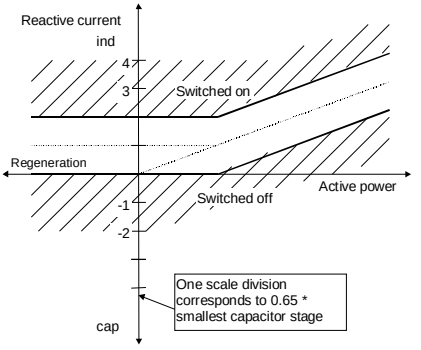
The limitation therefore specifies an absolute reactive power limit, below which the control band does not go.

**Figure 9:** Control response after setting target power factor = 0.92 ind; PS = 0; L = +1.0

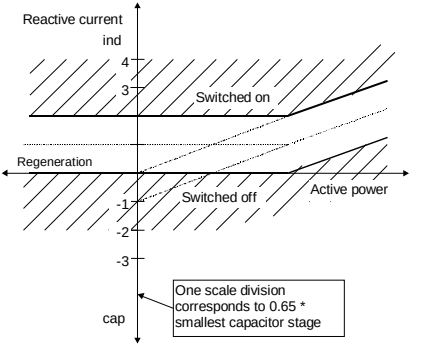



This setting has the following effects:

- The power factor is attained, on the average, in the "upper" power range.
- Over-compensation (capacitive load) is avoided in the low load range.

An appropriate combination of "parallel shift" and "limitation" is illustrated in Figure 10.

**Figure 10:** Control response after setting target power factor = 0.92 ind; PS = -1.0; L = +1.0




This example illustrates:

- In the "upper" power range the set power factor is specified as the lower limit value.
- Over-compensation is avoided in the low load range.

**This setting is the normal setting on delivery from the factory and represents the best possible control characteristic for most applications.**

The following Figure 11 shows the characteristics of the control band when set for a capacitive target power factor. In



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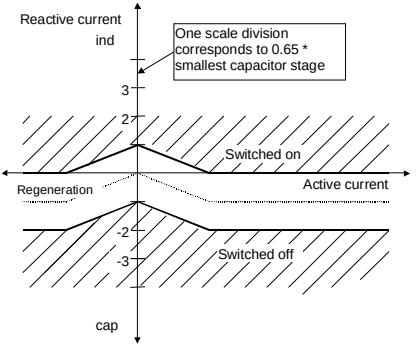
this case the control range is not prolonged at the reactive power axis into the feed back side, but is mirrored from the supply side into the feedback side.

**Figure 11:** Control response after setting target power factor = 0.95 cap; L = 1.0; PS = 0




### 5.4 Switching Time Delay Tariff 1

The switching time delay period can be set between the values of 5 to 500 seconds in 5 second steps. When a capacitor stage is switched on or off the control relay waits for the switching time delay before the switching process takes place. If more stages are required the switching time delay is shortened depending on the number of stages required.

**For example:**
2 stages required = switching time delay /2 (reduced by one-half) or
3 stages required = switching time delay /3 (reduced by two-thirds).

In order to keep the wear on the contacts to a minimum, the switching delay time should be set to less than 45 seconds only in exceptional cases. The discharge period, which ensures that the capacitors are fully discharged before they are switched on again, overrides the switching delay time (see section 5.16).

### 5.5 Target Power Factor Setting Tariff 2*)

The same settings as described in section 5.1 apply for tariff 2.

### 5.6 Parallel Shift (PS) Tariff 2*)

The same settings as described in section 5.2 apply for tariff 2.

### 5.7 Limitation (L) Tariff 2*)

The same settings as described in section 5.3 apply for tariff 2.

### 5.8 Switching Time Delay Tariff 2*)

The same settings as described in section 5.4 apply for tariff 2.

***)** *only possible at full version*



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### 5.9 Automatic Stage Current (c/k) Identification "ON/OFF"

The **EMR 1100** has an automatic c/k identification, i.e. it calculates the appropriate response current the first time the control relay is energized. This procedure is repeated until the amount of capacitive power for each stage is determined and the c/k value has been calculated. The automatic c/k identification feature can be set to "ON" or "OFF".

**When "ON"** the **EMR 1100** operates with the stage currents automatically calculated.
**When "OFF"** the c/k value must be programmed manually (under programme mode 10) according to Table 3 on page 27 or according to the Equation 1. Also programme modes 11 (switching sequence) and 12 (number of contactors used) have to be entered manually.

### 5.10 Response Current (c/k)

The Control Relay **EMR 1100** calculates a control characteristic from the power factor, the parallel shift and the limitation (in Figure 5 to Figure 11 shown as a dotted line) and has a tolerance band of 0.65 times the smallest stage in inductive as well as in capacitive direction (marked with bold line). The control relay consistently achieves this control band by switching on and off systematically. It is assumed that the connected capacitor-stages are sufficiently dimensioned.

The response current corresponds to half the width of the tolerance band, within which the reactive current can change without capacitor stages being switched on or off.
This is essential to ensure that the system does not oscillate. The total width of the tolerance band is selected in such a way that it corresponds to approx. 1.3 times the reactive current of the smallest capacitor stage.

When setting the automatic stage current identification to "OFF" the response current can be set between 0.02 and 2.0 A in steps of 0.01 A. The correct setting for a 400 V voltage system and a current transformer with 5A secondary current can be taken from Table 3.
In the case of other voltages or current transformers for which the primary or secondary current is not given, the response current can be calculated from the general equation:

*Equation 1:*

$$c/k = 0.65 \times \frac{Q}{U \times \sqrt{3} \times k} \approx 0.375 \times \frac{Q}{U \times k}$$

*c/k* = response current (Amps) to be set

*Q* = **capacitor stage rating in var of the smallest stage** (not the complete system)

*U* = mains voltage (V) on the primary side of the current transformer

*k* = transformer ratio
(primary /secondary current)



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**Table 3:** Response Current at 400V mains voltage (c/k value)

| **c/k-adjustment for mains voltage 400 VAC, 50 Hz ~** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current transformer | **Stage rating of the smallest capacitor bank** (not total rating) **in kvar** | | | | | | | | | | | | | |
| **A /A** | **2,5** | **5** | **6,25** | **7,5** | **10** | **12,5** | **15** | **20** | **25** | **30** | **40** | **50** | **60** | **100** |
| **30 /5** | 0,40 | 0,80 | 0,98 | 1,20 | 1,60 | | | | | | | | | |
| **40 /5** | 0,30 | 0,60 | 0,74 | 0,90 | 1,20 | 1,50 | | | | | | | | |
| **50 /5** | 0,24 | 0,48 | 0,59 | 0,72 | 0,96 | 1,20 | 1,44 | | | | | | | |
| **60 /5** | 0,20 | 0,40 | 0,49 | 0,60 | 0,80 | 1,00 | 1,20 | 1,60 | | | | | | |
| **75 /5** | 0,16 | 0,32 | 0,39 | 0,48 | 0,64 | 0,80 | 0,96 | 1,28 | 1,60 | 1,92 | | | | |
| **100 /5** | 0,12 | 0,24 | 0,30 | 0,36 | 0,48 | 0,60 | 0,72 | 0,96 | 1,20 | 1,44 | 1,92 | | | |
| **150 /5** | 0,08 | 0,16 | 0,20 | 0,24 | 0,32 | 0,40 | 0,48 | 0,64 | 0,80 | 0,96 | 1,28 | 1,60 | 1,92 | |
| **200 /5** | 0,06 | 0,12 | 0,15 | 0,18 | 0,24 | 0,30 | 0,36 | 0,48 | 0,60 | 0,72 | 0,96 | 1,20 | 1,44 | |
| **250 /5** | 0,05 | 0,10 | 0,12 | 0,14 | 0,19 | 0,24 | 0,29 | 0,38 | 0,48 | 0,58 | 0,77 | 0,96 | 1,15 | 1,92 |
| **300 /5** | 0,04 | 0,08 | 0,10 | 0,12 | 0,16 | 0,20 | 0,24 | 0,32 | 0,40 | 0,48 | 0,64 | 0,80 | 0,96 | 1,60 |
| **400 /5** | 0,03 | 0,06 | 0,08 | 0,09 | 0,12 | 0,15 | 0,18 | 0,24 | 0,30 | 0,36 | 0,48 | 0,60 | 0,72 | 1,20 |
| **500 /5** | 0,02 | 0,05 | 0,06 | 0,07 | 0,10 | 0,12 | 0,14 | 0,19 | 0,24 | 0,29 | 0,38 | 0,48 | 0,58 | 0,96 |
| **600 /5** | | 0,04 | 0,05 | 0,06 | 0,08 | 0,10 | 0,12 | 0,16 | 0,20 | 0,24 | 0,32 | 0,40 | 0,48 | 0,80 |
| **750 /5** | | 0,03 | 0,04 | 0,05 | 0,06 | 0,08 | 0,10 | 0,13 | 0,16 | 0,19 | 0,26 | 0,32 | 0,38 | 0,64 |
| **1000 /5** | | 0,02 | 0,03 | 0,04 | 0,05 | 0,06 | 0,07 | 0,10 | 0,12 | 0,14 | 0,19 | 0,24 | 0,29 | 0,48 |
| **1500 /5** | | | 0,02 | 0,02 | 0,03 | 0,04 | 0,05 | 0,06 | 0,08 | 0,10 | 0,13 | 0,16 | 0,19 | 0,32 |
| **2000 /5** | | | | | 0,02 | 0,03 | 0,04 | 0,05 | 0,06 | 0,07 | 0,10 | 0,12 | 0,14 | 0,24 |
| **2500 /5** | | | | | | 0,02 | 0,03 | 0,04 | 0,05 | 0,06 | 0,08 | 0,10 | 0,12 | 0,19 |
| **3000 /5** | | | | | | | 0,02 | 0,03 | 0,04 | 0,05 | 0,06 | 0,08 | 0,10 | 0,16 |
| **4000 /5** | | | | | | | | 0,02 | 0,03 | 0,04 | 0,05 | 0,06 | 0,07 | 0,12 |
| **5000 /5** | | | | | | | | | 0,02 | 0,03 | 0,04 | 0,05 | 0,06 | 0,10 |
| **6000 /5** | | | | | | | | | | 0,02 | 0,03 | 0,04 | 0,05 | 0,08 |

If the size of the stage, the current transformer, or the rated current of the control system does not meet the values as given in above table, the equation on page 26 has to be applied in order to determine the c/k value.



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### 5.11 Switching Sequence

When the automatic c/k identification is switched on every optional switching sequence is possible.
Necessary condition: When the optional switching combinations are sorted according to their capacity, the capacity difference between two successive combinations may only be 1.2 times the capacity of the smallest stage.

If the automatic c/k identification is switched off, the switching sequence (switching programme) can be reset to the following combinations of capacitor stages:

| | | |
|---|---|---|
| 1:1:1:1:1... | 1:1:2:4:4... | 1:2:3:4:4... |
| 1:1:2:2:2... | 1:1:2:4:8... | 1:2:3:6:6... |
| 1:1:2:2:4... | 1:2:2:2:2... | 1:2:4:4:4... |
| 1:1:2:3:3... | 1:2:3:3:3... | 1:2:4:8:8... |

The smallest capacitor stage is always "1", the subsequent stages are either the same (1:1:1...) or are larger. In the second line above a more accurate result can be achieved with the same number of switching contactors.

When the automatic c/k identification is switched off, the smallest capacitor stage ("1") must be connected to the first control output of the connecting terminal. All other stages follow according to their capacity. In the case of fixed stages being used, the smallest stage has to be connected following the last fixed stage.

### 5.12 Number of Contactors used

When the automatic c/k identification is switched off, any value between 1 and 12 can be programmed. If, for example, there are five stages in a capacitor bank, these stages are connected to the control outputs "1" to "5" and the number of the control outputs is programmed to "5" in order to prevent the control relay from activating control outputs which have not been connected.

The size of the capacitor stages has no influence on this setting.

### 5.13 Specifying fixed Stages

The Control Relay **EMR 1100** allows the first three control outputs to be treated as fixed stages. Fixed stages are stages which are not included in the normal control cycle but are switched on immediately after the control relay is switched on and always remain switched on. The set discharge period is maintained. The target power factor setting is ignored.

The following settings are possible:

0 = no fixed stages
1 = control output 1 is fixed
2 = control outputs 1 and 2 are fixed
3 = control outputs 1 to 3 are fixed

The switching sequence does not take into account the fixed stages.



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### 5.14 ON/OFF Connection Identification

The control relay has an automatic connection identification feature. (Refer to section 2.1)

**ON:** The connection recognised by the control relay can be read under mode number -15- in accordance with table 2. (not changeable)

**OFF:** The connection must be manually programmed as per table 2.

### 5.15 Connection Mode

Usually, the connection mode should be set to automatic operation. If, however, the control relay failed to determine the connection mode after 15 minutes due to high load changes or phase imbalances, it is possible to enter the connection mode manually as per table 2.

### 5.16 Setting Capacitor Discharge Time

In order to ensure that after switching-off, a capacitor stage is not switched on again before the capacitor has been sufficiently discharged, the switch-off time can be adjusted to the specific needs (discharge mode).
The discharge time can be set between 5 and 900 seconds.

### 5.17 Setting Cyclic/Non-Cyclic Switching Rotation

In certain cases when there are filtered and non-filtered stages within one system, it is necessary to ensure that the control relay does not operate cyclically. For such applications this feature can be disabled. On and off have the following meanings:

**ON:** Small number of switches, cyclic switching is enabled on all levels.

**OFF:** No cyclic switching; the stages within each level are switched on.

### 5.18 Current Transformer (CT) Ratio

In order to display the currents as actual values, the ratio between the primary current and the secondary current of the current transformer used must be entered. If the current transformer ratio is not set the value displayed must be multiplied by the CT ratio. Values between 1 and 7000 can be entered (eg. 1000A/5A → 200).

### 5.19 Voltage Transformer Ratio

If a voltage transformer is used within the measuring circle the voltage transformer ratio must be entered in order to scale the display of missing kvar to reach the target power factor correctly.
The primary/secondary voltage transformer ratio is set between 1 and 300. If no voltage transformer is present, the value "1" must be entered.



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### 5.20 FRAKO Power Bus Address

If the relay is connected to the FRAKO Power Bus it has to be given its own bus address between 1 and 125. This address may only be given once within the bus system.
In case of big systems we advise the use of “System-SW” software to programme the bus address. This software is supplied together with the Bus Central Unit or can be ordered separately.
A bus address can be adjusted also at the basic version (**-S**). An update for a full version is only via the bus system possible (an update-key is needed).

### 5.21 Setting 5th Harmonic Threshold

The Control Relay **EMR 1100** has a harmonic monitoring system for the 5th, 7th, 11th, and 13th voltage harmonics. If the limiting value is exceeded, there is an alarm signal, i.e. the alarm contact closes and the "Alarm" LED illuminates for as long as the limiting value is exceeded. The "Harmonic" LED flashes until the alarm is switched off. The order and the maximum value of the harmonics which have been exceeded, beginning with the maximum deviation, are displayed by multiple pressing of the "Set" button. The "Set" button must be pressed repeatedly until the "Harmonic" LED goes out.

### 5.22 Setting 7th Harmonic Threshold

Setting of the limiting value for the 7th harmonic.

### 5.23 Setting 11th Harmonic Threshold

Setting of the limiting value for the 11th harmonic.

### 5.24 Setting 13th Harmonic Threshold

Setting of the limiting value for the 13th harmonic.

### 5.25 Harmonic Over-Current Alarm Signal

The Control Relay **EMR 1100** is able to determine the ratio between the actually measured RMS current and the nominal current (50 - 60 Hz) of the capacitor.If this ratio is exceeded by the factor set for at least one minute due to harmonics and the resulting resonance phenomenon, the control relay switches off all stages. At the same time an alarm is signalised.

If “H.-AL.” is selected, become with a voltage harmonics alarm (Prog. *-21-* to *-24-*) within 5 seconds all stages switched off.

After the alarm has been acknowledged it takes approx. 4 minutes until the necessary capacitor stages are switched on.

By pressing the "Set" button the peak value is displayed.

**Notice:**
**When exclusively filtered stages are being used, see also section 6.3.3.**

### 5.26 Setting Threshold for Number of Switchings Alarm

In order to support the maintenance of the unit the **EMR 1100** provides an internal counter for each switching output.
During manual operation the present count for each stage can be displayed.
(see section 6.2).

If the maximum of switching actions is chosen the control relay displays the need for maintenance. The stage which has exceeded the limit (e.g. "5h.4" for the 4th stage) flashes on the display (approx. every 10 seconds). At the same time an alarm is signalised. How to put out the alarm is explained in 5.27.

The required number of switches is to be divided by 1000 before being entered. That means that entering 100 evokes an alarm at 100,000 switches of one stage.

The stage alarm signals have no influence on the control behaviour/ performance of the relay.

### 5.27 Reseting Switching Counter

In mode -27- the switching counters can be reset altogether or separately.
When choosing mode *-27-* the display shows "0". With the "+" and "-" buttons a stage number between 1 and 12 or "all" can be chosen. Leaving the programing section by pressing the "man/set" button resets the count of the displayed stage. By setting "all" all counts are reset.

If you do not want to reset any counter "0" has to be set befor pressing the "man/set" button.

### 5.28 Suppressing the Power Factor Alarm

As already described the control relay tries to reach its programmed control band. If this, however, is not possible due to lack of capacitor stages available, an alarm is signalised after several minutes (depending on the size of the difference). In case of a capacitive cos-phi outside the band range the alarm signal functions as well. When setting "OFF" the alarm is suppressed.

### 5.29 Total kvar Display

Provided the current transformer ratio has been entered, the total kvar detected at measured voltage will appear on the display, when "Set" is pressed in Mode *-29-*.



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# 6. Operation

## 6.1 Modes of Display

The power factor display is independent of the control relay operation and can be reprogrammed at any time. To the right of the four and a half character digital display there are three LEDs indicating which display mode is active, either "cos phi", "Ampere", or "Harmonic".

Five modes of display can be selected by pressing the appropriate button:

### 6.1.1 Power Factor

The "Power Factor" display mode is the standard display and can be activated from another mode of display by pressing the buttons "IQ", "IP", or "Harm".
The symbols "+" for ind. and "-" for cap. show whether the power factor is inductive or capacitive.
The LED "Regen" indicates that generative active power is fed back into the mains. Active and reactive currents are measured seprarately. The power factor (cos phi) display value is the result of a mathematical calculation, which ensures accuracy over the entire range down to values close to 0. The minimum apparent current for a correct power factor (cos phi) display is approx. 0.02 A. When the apparent current falls below 0.02 A for three consecutive measurements one capacitor stage is switched off and if there is no change in the measured current, all remaining stages are switched off and *"I=0"* appears on the display.

### 6.1.2 Reactive Current


The display indicates the reactive current portion in the current transformer circuit. The "+" for ind. or "-" for cap. indicate whether the reactive current is inductive or capacitive . The LED "Ampere" lights up. From this mode of display the compensation effect of the capacitor stages e.g. by adding or removing capacitor stages manually, can be monitored. If the current transformer ratio (CT) is programmed via the set mode, the actual reactive current on the primary side of the CT is displayed. Otherwise the current portion is displayed and has to be multiplied by the CT ratio to obtain the actual value.

Pres "IQ", "IP", or "Harm" buttons to exit this mode of display.



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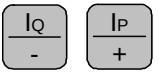
### 6.1.3 Active Current


The display shows the active current on the fundamental oscillation in the current transformer (CT) circuit. The LED "Ampere" lights up.
The current direction is also displayed which is helpful during tests. The LED "Regen" shows that the generative active power is fed back into the mains. If the CT ratio is programmed into the relay, the actual active current is displayed; otherwise the current portion is displayed and must be multiplied by the CT ratio to obtain the actual value.

Press "IQ", "IP", or "Harm" buttons to exit the display.

### 6.1.4 Apparent Current




Pressing the "IQ" and "IP" buttons simultaneously activates the display. The LED "Ampere" lights up. If the CT ratio is programmed into the relay, the actual apparent current on the fundamental oscillation in the current transformer (CT) circuit is displayed; otherwise the current portion is displayed and must be multiplied by the CT ratio to obtain the actual value.

Press "IQ", "IP", or "Harm" buttons to exit the display.

### 6.1.5 Harmonics ($5^{th}$ - $13^{th}$ )


This display shows the $5^{th}$, $7^{th}$, $11^{th}$, and $13^{th}$ harmonics on voltage. The previous harmonic reading appears on the display (in %) and the LED "Harmonic" lights up. By pressing the "+" or "-" buttons several times the portions of the $5^{th}$, $7^{th}$, $11^{th}$, and $13^{th}$ harmonics are subsequently displayed either in ascending or descending order. For example. if *"5. 2.9"* is displayed this means "$5^{th}$ harmonics = 2.9 %".

Press the "Harm" button to exit the display.

### 6.2 Manual Operation


When the "man/Set" button is pressed for more than 3 secs, the control relay switches to manual operation and the LED "manual" begins to flash. The capacitor stages can be switched on or off by pressing the "+" or "-" button.
When the "+" button is pressed once, *"1.ON"* appears on the display until the control relay has switched on the first



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stage after approx. 10 secs provided no further buttons have been pressed. If the first stage was already switched on *"1.OFF"* will appear on the display until the control relay has switched off the first stage after approx. 10 secs. Then the display will change to the last displayed value.
While waiting the switching counter of this stage will be displayed for a short moment. The displayed value is multiplied by 0.001 and is indicated as far as possible as a decimal. That means for example:

*"0.350"* is equivalent to 350 switches.

By pressing the "+" button several times the stages 2-12 will appear in ascending sequence on the display. They can be switched on/off in the same way.
By pressing the "-" button once *"12.ON"* appears on the display until the control relay has switched on the 12th stage after approx. 10 secs. If the 12th stage was already switched on *"12.OFF"* will appear on the display until the control relay has switched off the 12th stage after approx. 10 secs. Then the display will change to the last displayed value. By pressing the "-" button several times the stages 11-1 will appear on the display in a descending sequence. They can be switched on/off in the same way.
In manual mode, the programmed switching off time (discharge time) is taken into consideration, i.e. when switching on a stage which was previously switched off the switching-off time is the same as the discharge time. If a stage was identified as a zero stage (without power) the corresponding numbers would indicate this by flashing.

Press "Man/Set" button to exit manual mode.

### 6.3 Alarms

The potential-free alarm contact (a/b) closes whenever the operating voltage is not applied. In the case of the correct operating voltage, the contact closes if there is an alarm. The conditions for an alarm can be seen in section 6.3.1 to 6.3.6 below. The LED "alarm" lights up for as long as a state of alarm exists. When an alarm is signalised, an alarm marker is put into action (LEDs "Power Factor", "Ampere", or "Harmonic" blink).
The alarm markers remain active after the alarm until they are acknowledged by pressing the "Set" button. After acknowledgement the flashing alarm marker goes out.
The alarm signals have no influence on the control behaviour/performance of the relay.

#### 6.3.1 Power Factor Alarm

If the threshold values set for "switch-on" and "switch-off" are exceeded and no further change can take place in the output



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stages, the alarm signal functions (except for the cos-phi alarm being switched-off; see mode -28-). By pressing the "Set" button the amount of capacitive and reactive power missing to reach the target power factor flashes on the display. Pressing the "Set" button again shows the actual power factor on the display and the alarm marker "Power Factor" no longer flashes.

### 6.3.2 Harmonic Alarm

When the programmed threshold values are exceeded the alarm goes off.
By pressing the "Set" button several times the display shows the order and the maximum values of the exceeded harmonics starting with the maximum deviation.
The button "Set" must be pressed repeatedly until the "Harmonic" alarm no longer flashes.

### 6.3.3 Over-current alarm

If the ratio between the actually measured RMS current and the nominal current of the capacitor has exceeded the programmed value for one minute, the alarm goes off and all stages are switched off.

After the alarm has been acknowledged it takes approx. 4 minutes until the necessary capacitor stages are switched on again.

By pressing the "Set" button the display shows the maximum value of the factor by which the RMS current has exceeded the nominal current.
By pressing the "Set" button again the display shows the actual power factor and the alarm marker "Ampere" no longer flashes. (See also section 5.25, page 30)

**Notice:**
**The over-current ratio is a mathematically determined value and therefore cannot be applied to filtered systems.**

**If "H.-AL." is selected (Prog. *-25* -) only the voltage harmonics are supervised. The over-current ratio is not considered.**

### 6.3.4 "U=0" Alarm

If there is an interruption in the measurement voltage path, the control relay switches off all stages after about 1 sec. and displays "U=0".

At the same time, the alarm contact closes and the "Alarm" LED lights up for as long as there is no voltage applied to the measurement input terminals of the control relay.



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### 6.3.5 “C=0“-Alarm

If the relay does not identify a capacitor stage during the process of automatic terminal and stage current identification an alarm is signalised and the display shows *"C=0"*.
The identification process is carried on despite the alarm.

### 6.3.6 "I=0" Alarm

If there is an interruption in the current path for at least 3 secs., the control relay immediately switches off a capacitor stage.

If there is no change in the current as a result, the stages which are still on are switched off.
There is no alarm.

## 7. Technical Data

**Mode of Connection:**
Phase/Phase connection or
Phase/Neutral connection
Current via current transformer in optional phase (Figure 3, page 12).

**Fusing:**
External, max. 4A

**Operating Voltage:**

| Supply voltage | Mains terminal voltage | Absolute permissible/ threshold values |
|---|---|---|
| 230V~ | 220V~ to 240V~ | 198V~ ... 264 V~ |
| 400V~ | 380V~ to 420V~ | 342V~ ... 462 V~ |

**Voltage Path:**
Voltage input 100V~ ... 690V~

**Frequency:**
50 Hz / 60 Hz (48 to 62 Hz)

**Consumption:**
approx. 13VA

**Current Path:**
For current transformer .../1A~ to ... /5A~

**Consumption in Current Path:**
max. 1.8 VA at 5 A~ rated current of the CT

**Control Contacts:**
12 potential-free relay contacts

**Loading Capacity of the Control Contacts:**
Switching voltage:
380 VAC (acc. to VDE 0110 part B)
250 VAC (acc. to VDE 0110 part C)
Switching current up to 2 x 5 A max.
Switching load up to 1800 VA max.

**Fault Signal Contacts:**
Loading capacity 250V~, 3A

**Temperature Range:**
-20 ºC to +60 ºC

**Enclosure:**
Terminals IP 20
Casing IP 50
When using the sealing ring IP 54
(see accessories)



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**No-Voltage Trip (Undervoltage Monitoring):**
For a voltage loss of longer than 15 ms all capacitor stages connected are switched off. After voltage is restored the control relay switches the required stages on.

**Zero Current Trip:**
For a current loss of longer than 3 secs capacitor stages connected are switched off. After current is restored the control relay switches the required stages on.

**Interfaces (operation mode optional):**
*FRAKO Power Bus®:*
For connection to the FRAKO Energy Management System according to EN 50170 (P-NET) Feldbus standard RS 485, 76,8 kbit/s

*RS-232-interface:*
Via RS232-Adapter (accessory) for direct connection to PC (for using PC software *"EMR-SW"*) 19200 Baud

**Terminals:**
Plug-in connector blocks
(supplied with the control relay)

**Enclosure Material:**
Black synthetic plastic, flame resistant to UL-94, Class V0

**Weight:**
ca. 1.2 kgs

**Mounting Position:**
as desired

**Front Panel Dimensions:**
144 x 144 mm (to DIN 43 700)

**Panel Cut Out:**
138 x 138 mm (to DIN 43 700)

**Mounting Depth:**
105 mm

**Fastening:**
Through the front panel by means of a screwdriver

**Operating Elements:**
Foil keyboard with 4 buttons

**LED Indicators:**
18 LEDs
4 ½ character digital display

**Design:**
according to:
- EN 50 081-1
- EN 50 082-2
- EN 61 010
  (VDE 0411 part 1) Protection Class II
  (if insulated fixing screws are used)

**Accessories:**
protection kit for protection class II / IP 54
.....*item no. 20-50014*
Software “EMR-SW”....*item no. 20-10312*
update full verion.....*item no. 20-50013*
RS232-Adapter (PC)....*item no. 20-10310*
RS232-Adapter (Modem)
.....*item no. 20-10309*



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## 8. Trouble-Shooting

| Pos. | Faults | Possible Causes | Necessary Action |
|---|---|---|---|
| 1 | Control relay does not function, digital display remains blank. | There is either no voltage or the wrong voltage has been applied to the control relay. | Check whether the correct operating voltage is applied to the control relay. |
| 2 | *"U=0"* flashes on the display. | The voltage applied to the voltage path of the control relay is too small. | Check whether the correct voltage has been applied to the voltage path of the control relay. |
| 3 | Relay does not respond to manual operation although it has voltage and digital display is operational. | End of delay time of approx. 10 secs. has not been observed. | For example , if *"1. ON"* appears on the display wait until the control relay has switched on the first stage. |
| | | Relay was not in manual mode. | "Man" button must be pressed leading to flashing of the LED "manual". |
| 4 | Stage display (LED 1-12) lights up but capacitor contactors are not activated | Control circuit is not connected properly or there is no control voltage | Check the control circuit according to the circuit diagram and check fuses. |
| | | There is no neutral on the contactors. | |
| 5 | Control relay does not complete the automatic identification procedure | Unstable power supply (power factor fluctuation). | Wait for power supply to stabilize or manually set c/k factor and mode of connection. |
| 6 | During automatic adjustment process *"C=0"* flashes on the display. | Fault in control circuit (contactors do not switch) | Check control circuit according to the circuit diagram; check fuses. |
| | | Fuses of the capacitor stages are defective or missing. | Check if capacitors are energized after switching. |
| | | Current transformer is in the wrong place. | Check if the position of current transformer corresponds to the circuit diagram. |
| 7 | *"I=0"* flashes on the display. | Current transformer circuit interrupted or there is no current flowing on the secondary side. | Use ammeter to check current on secondary side of CT.<br>(I min >= 0.02A). |
| | | The current flowing on the secondary side of the CT is too small. | (I min >= 0.02A)<br>Install smaller current transformer. |
| | | Current transformer is defective. | Check the current transformer. |



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| Pos. | Faults | Possible Causes | Necessary Action |
|---|---|---|---|
| 8 | Despite inductive load no stages are switched on when relay is in automatic mode. | When programming the control relay, the c/k factor, switching time delay, or discharge time have been set too high. | Check programming of the control relay and change if necessary. |
| | | In automatic operation the c/k factor was not correctly detected. | Check the control circuit according to the circuit diagram and repeat the automatic test procedure. |
| | | A different current measuring meter (e.g. ammeter) has been connected in parallel with the control relay to the secondary side of the current transformer. | All measuring instruments in current path must be connected in series |
| | | The capacitor stages are too wide. | Finer adjustment of the capacitor stages is required. |
| 9 | In automatic mode one stage is continually switched on or off (hunting). | The c/k factor was set too low. | Set c/k value correctly according to Table 3. |
| | | High load change; The delay time was set too low. | Set higher delay time. |
| 10 | The "power factor (cos phi)" display is less than the target power factor although the control relay has switched on all stages | Mode of connection incorrectly programmed. | Reset mode of connection. |
| | | Fault in control circuit. | Check whether the capacitor contactors have been activated. |
| | | Fault in capacitor circuit. | Check the fuses and contacts of the capacitor contactors and perhaps current absorbtion. Measure the current of each capacitor stage with a clamp-on current meter. |
| | | System undersized. | Press "Set" button and read the shortage of power from the display. |
| | | Failure in automatic adjustment. | Repeat identification process. |
| 11 | Control relay does not switch off all stages during times of low load or facility shut-down. | c/k factor is set too high. | Set c/k factor according to Table 3. |
| | | Control relay is in manual mode. | Press "Man/Set" button. |

**Version V1.52a ab SW 2.06**



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# Reactive Power Control Relay
# EMR 1100 /-S

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# Reactive Power Control Relay

RM 2106 / 2112

Operating Instructions

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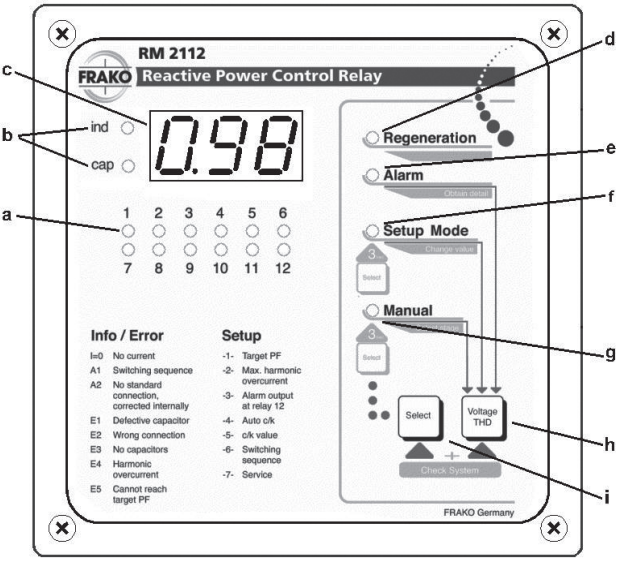


**Figure 1** Front view

**a** Display for active capacitor stages
**b** Display for inductive or capacitive operating status
**c** Digital displays
**d** LED indicates regenerative power
**e** Display for current or historical alarms
**f** LED lights up in setup mode
**g** LED lights up in manual mode
**h** Multifunctional button (see operating instructions)
**i** Selection key for manual mode, setup mode or automatic mode

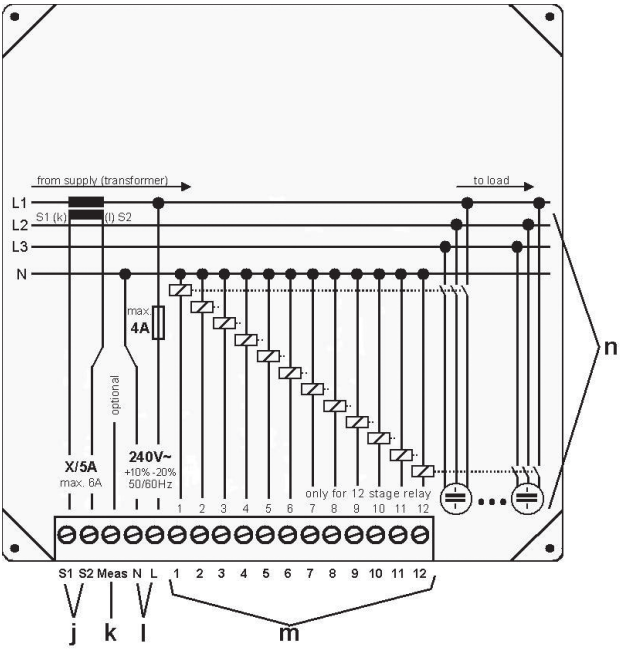


**Figure 2** Rear view

**j** Connection for the current transformer
**k** Optional connector for improved measurement of harmonic wave
**l** Connector for power supply to the control relay
**m** Connectors for the control contacts that switch the contactors. The shared pole is connected to terminal ´**L**´.
**n** Typical connection



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**Safety and Warning Notices.**
**Important !**
**Read this before commissioning !**

- The operating instructions should be read carefully before the device is assembled, installed and put into operation.
- Installation and commissioning should only be carried out by appropriate specialists in accordance with existing regulations and provisions
- The operator must ensure that all operatives are familiar with these operating instructions and proceed accordingly
- The device conducts mains voltage and should not be opened
- If the device is obviously damaged, it should not be installed, connected or commissioned
- If the device does not work after commissioning, it should be disconnected from the mains again
- Any other laws, standards, guidelines, etc. regarding this product must be observed

The commissioning and safety information for the power factor correction system should also be observed.



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# EG-Konformitätserklärung
## *Declaration of Conformity*

Dokument-Nr. EG-RM 2106_RM 2112-3004A / 11.2009
Document-No. CE-RM 2106_RM 2112-3004A / 11.2009

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:<br>*name of product* | Blindleistungsregler<br>*Reactive Power Relay* | | |
| Typenreihe:<br>*family* | **RM 2106 / RM 2112** | ab Fert.-Nr.<br>*from Ser. No.* | SN 000001 |

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 61000-6-3 | 2007-09 | EMV, Fachgrundnorm Störaussendung - Wohnbereich, Geschäfts- und Gewerbebereiche<br>EMC, Emission standard for residential, commercial and light-industrial environments |
| | EN 61000-6-4 | 2007-09 | EMV, Fachgrundnorm Störungsaussendung Industriebereich<br>EMC, Emission standard for industrial environments |
| | EN 61000-6-1 | 2007-10 | EMV, Fachgrundnorm Störfestigkeit - Wohnbereich, Geschäfts- und Gewerbebereiche<br>EMC, Immunity for residential, commercial and light-industrial environments |
| | EN 61000-6-2 | 2006-03 | EMV, Fachgrundnorm Störfestigkeit Industriebereich<br>EMC, Immunity for industrial environments |
| | gemäß den Bestimmungen der Richtlinien / *following the provisions of Directive* | | |
| | 2004/108/EG | | Elektromagnetische Verträglichkeit / *Electromagnetic Compatibility Directive* |
| 2. | EN 61010-1 | 2004-01 | Sicherheitsbestimmungen für elektrische Meß-, Steuer-, Regel- und Laborgeräte – Teil 1: Allgemeine Anforderungen<br>*Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements* |
| | gemäß den Bestimmungen der Richtlinien / *following the provisions of Directive* | | |
| | 2006/95/EG | | Niederspannungsrichtlinie / *Low Voltage Directive* |

Teningen, 16. November 2009

Peter Herbst

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 conformity with the above-mentioned Directives, but does not contain any assurance of properties. Please observe the safety instructions of the attached product documentation.*

# 1 Introduction

The reactive power control relay RM 2112 and RM 2106 respectively is capable of measuring the reactive power and active power of the connected mains network. Working in conjunction with a power factor correction system, the device controls the programmed target power factor by activating or deactivating capacitors.

## 1.1 How to use these operating instructions

| | |
|---|---|
|  | **Important:** |
| It is essential that you read section 2 “Installation and connection” and section 3 „Start-up“ before installing the control relay. | |

The functions of the control relay are also described in brief in **section 1.2 „Scope of functions“**.

The setting options for the control relay are described in **section 4 „Control relay setup”**.

**Section 5 „Functioning and operation“** explains how the control relay works and how to operate it.

**Section 6 „Alarms and troubleshooting“** describes alarms and error messages of the control relay. Troubleshooting information is also provided there.

## 1.2 Scope of functions

Below is a brief overview of the various functions of the device:

- 12 switching contacts at RM 2112 and 6 switching contacts at RM 2106
- Power factor display
- Total harmonic distortion factor display (voltage thd)
- Semi-automatic connection detection
- Automatic detection of the capacitor stages
- Comprehensive connection analysis
- Patented characteristic avoiding over-compensation for low active power
- Four-quadrant regulation
- Cyclic switching of all capacitor stages of the same capacity
- Reactive power requirement-dependent switching delay time
- Optional monitoring of the harmonic overcurrent in the capacitor
- Deactivation at zero voltage or zero current
- Alarm signals for:
  - failure to reach the target power factor
  - overcurrent in the capacitor
  - defects at capacitor stages

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## 2 Installation and connection

The reactive power control relay RM 2112 and RM 2106 respectively can be connected in a number of different ways. The main connection methods are described below.

| | |
|---|---|
|  | **Important information:** |
| The control relay should be disconnected from the mains during installation. | |

### 2.1 Installation

The reactive power control relay is installed from the front in a control panel space measuring 138 x 138 mm and is fixed in place using the mounting screws of the front panel.

As accessories (protection kit; see section 8) insulated fixing screws are available. These can be used to install the control relay into switchgear cabinets and cubicles of protective class II. Also a sealing ring is part of the protection kit, which must be used when installing the control relay in switchgear cabinets and cubicles of protection class IP 54.

The pre-assembled fixing clamps ensure speedy and secure assembly. The electrical connection is created by means of plug-in connectors which are also included in the delivery.

### 2.2 Voltage connection

Reactive power control relay obtains its voltage supply via terminals "**L**" and "**N**" (see figure 2, item '**I**').

A phase conductor is to be connected to terminal "**L**" and neutral conductor to terminal "**N**". For advanced connection variations see sections 2.7 to 2.10.

| | |
|---|---|
|  | **Important information:** |
| The reactive power control relay is designed for voltage supplies of up to 240 V AC.<br><br>The connections for the supply voltage are to be fused externally with 4 A max. | |

In the case of mains networks that do not facilitate voltage tapping in the 220 V AC to 240 V AC range (either phase/phase or phase/neutral), a voltage transformer must be used for the power supply for the control relay. (See section 2.9 )



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### 2.3 Current transformer connection

Outputs S1 and S2 of the current transformer are connected to terminals S1 and S2 (Figure 2, item '**j**') of the control relay. To keep the load of the current transformer as low as possible, the feed lines should have a adequate cross section.

It is permissible for connector S1 or S2 of the current transformer to be grounded.

| | |
|---|---|
|  | **Caution:** |
| The nominal current in the current transformer path may not exceed 5 A. | |

**Note:**
**After connection it is necessary to remove the short-circuit jumper on the current transformer, if present.**

### 2.4 "Meas" measuring voltage connection

This connection can be used to switch the control relay to a different measuring procedure for monitoring overcurrent (see section 2.8 ).

This terminal **"Meas"** (Figure 2, item '**k**') is not used in the standard connection.

| | |
|---|---|
|  | **Important information:** |
| The nominal voltage between the "Meas" and "N" connectors may not exceed 240 V AC. The voltage between the "Meas" and "L" connectors may not exceed 420 V AC.<br><br>If "Meas" is connected directly to a phase conductor, then this is to be secured externally with a maximum of 4 A. | |

### 2.5 Switching contacts

The shared pole of all switching contacts (Figure 2, item '**m**') is connected to terminal "**L**" of the voltage supply.

| | |
|---|---|
|  | **Important information:** |
| The outputs of the switching contacts do not have floating potential. | |

When the switching contacts are switched, the same voltage is applied as is used to supply voltage to the control relay (connection "**L**").

The contactor relays of the capacitor stages are operated (supplied) via the switching contacts of the control relay.

### 2.6 Alarm contact

Switching contact 12 at RM 2112 (switching contact 6 at RM 2106) can be used either as a control output for a capacitor stage or as an alarm contact. The relevant selection is made in setup mode under -3-.

In the event of an alarm, switching contact 6 is closed.

It should be noted that, even when operating as an alarm contact, this switching contact continues to have potential binding to the supply voltage of the control relay. If a floating potential contact is required, use an additional contactor relay.



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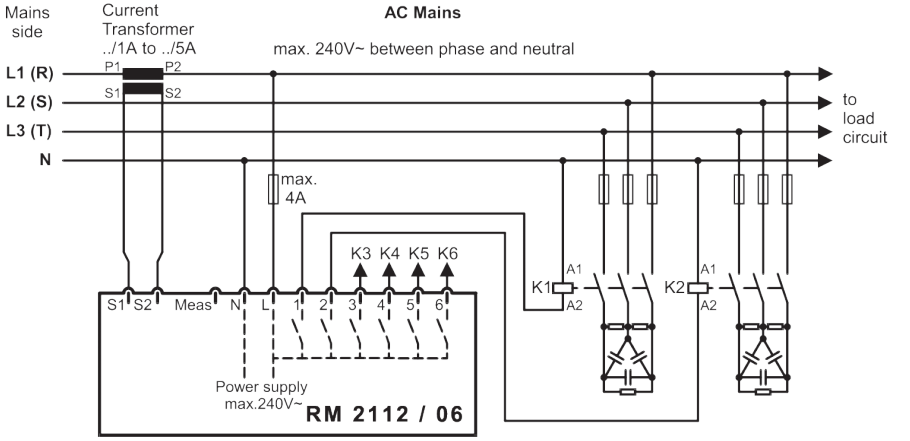


**Figure 3** Single phase connection

### 2.7 Single phase connection

The connection diagram above shows the same connection as the one printed on the back of the control relay.

The voltage signal for power factor measurement is received in parallel with the voltage supply. The terminal **"Meas"** is not in use.

In this connection variant, only the 5th, 7th, 11th and 13th harmonics of the voltage are used to calculate the harmonic overcurrent in the capacitor.

This connection variant can be chosen if the above-mentioned harmonics are sufficient for monitoring overcurrent or if overcurrent monitoring has been completely switched off (setup code -2-).(see section 4.2)

Current transformer and terminal "**L**" should be attached to the same phase conductor: Either L1, L2 or L3.

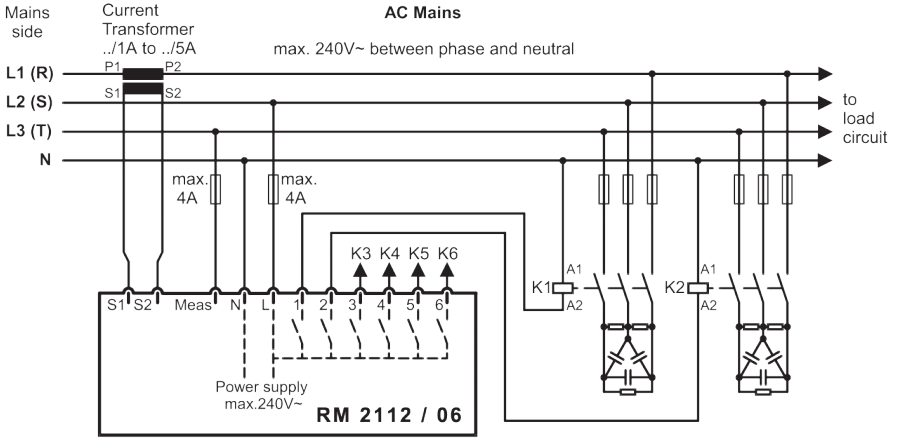


**Figure 4** Extended connection

## 2.8 Extended connection

This type of connection offers a more precise measuring procedure for the overcurrent in the capacitor.

In this case, the terminal **"Meas"** is attached to another phase conductor of the AC mains network. The voltage signal for the internal measurements is tapped between terminal "L" and terminal **"Meas"**.

Because the voltage signal is recorded between two phase conductors to which the capacitors are also connected, the dU/dt measuring procedure can be used for calculating the overcurrent.

This means that all frequencies up to the 31st harmonic are taken into account calculating harmonic overcurrent in the capacitor (see also section 4.2).

The total harmonic distortion factor of the voltage (thd) is also measured between the phase conductors in this type of connection.

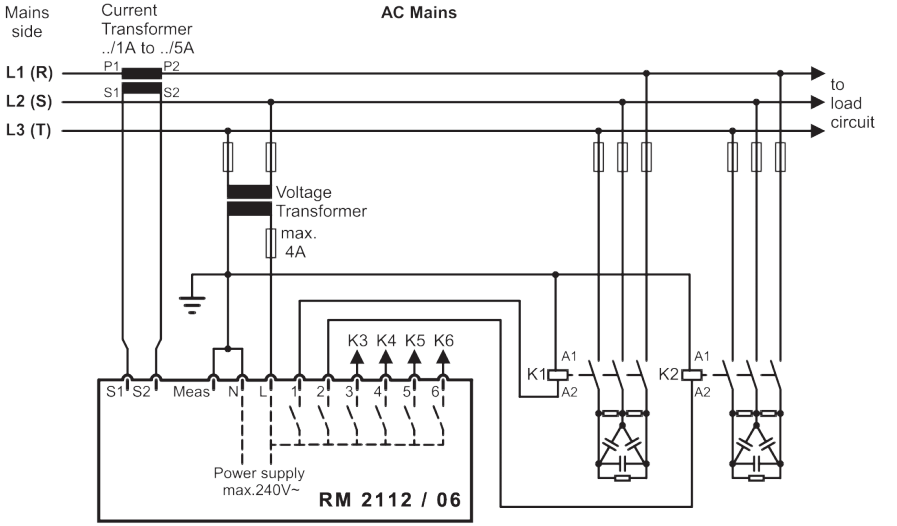


**Figure 5** Connection with voltage transformer

### 2.9 Connection with voltage transformer

The connection diagram above shows how the control relay is connected together with a control transformer.

| | |
|---|---|
| | **Important information:** |
| The control voltage of the transformer may not exceed 240 V AC. | |

If the voltage signal is tapped by the control transformer between two phase conductors,

connection must be as shown in the diagram. The measuring procedure then is similar to that for the extended connection (see section 2.8).

If the control transformer taps the voltage signal between a phase conductor and neutral, the terminal **"Meas"** must remain unused.

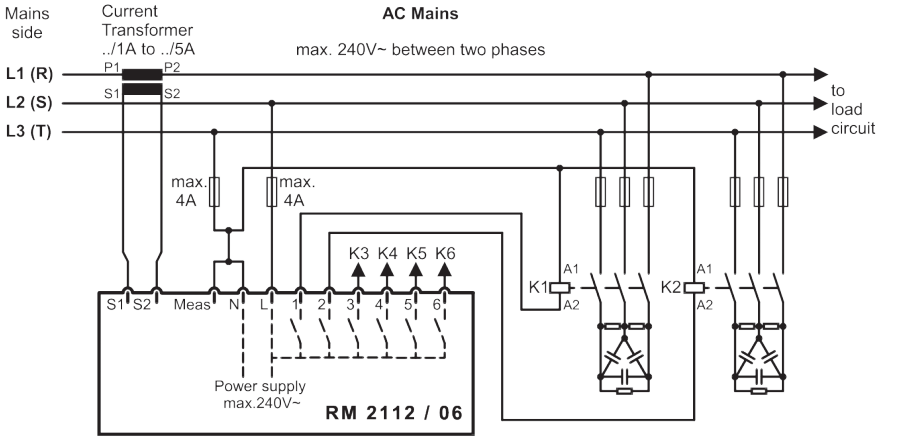


**Figure 6** Connection in special cases

## 2.10 Connection in special cases

The type of connection shown above should be used if the voltage between the phase conductors does not exceed 240 V AC.

**The following general principles apply:**
If the terminal **"Meas"** remains unused, the voltage for terminals **"L"** and **"N"** must be connected to a phase conductor and to the neutral conductor.

If the terminal **"Meas"** is used, the voltage for terminals **"Meas"** and **"L"** must be connected each to a phase conductor.

For all types of connections (figure 3 to 6) it is also possible to connect the current transformer in phase conductors L2 or L3. In this case, the voltage connections to the phase conductors should be exchanged accordingly.

If the control relay operates with automatic response current recognition, connection errors would be reported.

If response current recognition is deactivated, then an error in the connection will lead to functional errors during subsequent operation.



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# 3 Start-up

After installation has been carried out as described in section 2, the control relay can be started.

|  | **Important information:** |
|---|---|
| Make sure that the connector terminals of the control relay are no longer accessible (e.g. by means of a locked door or a cover hood). | |

## 3.1 Initial start-up

During initial start-up the control relay attempts to determine the type of connection and the size of the stages. After about 5 seconds, "---" appears on the display (figure 1, item '**c**'). The stages are switched on and off in succession. This can take up to 15 minutes.

|  | **Important:** |
|---|---|
| If the control relay does not behave as described above, the device should be switched off and the installation should be checked. | |

It may be that the device has already been used and behaves as described in section 3.2.

If the measuring process is not complete after 15 minutes, then an error has probably occurred.

|  | **Important information:** |
|---|---|
| The device should always be switched off before carrying out wiring or installation activities. | |

(For help in troubleshooting see section 6).

**Note:**
**The control relay needs to be connected to at least one capacitor stage to switch in order to determine the type of connection.**

**Make sure that both the control circuit and at least one capacitor stage are fully functional.**

It is also possible to abort the measuring procedure by switching off the automatic connection and responce current identification. This takes place in setup mode -4- and simultaneously requires the manual programming of the stage parameters (see section 4.4).

After measurement the control relay indicates the results it has determined on the display (**c**).

Flashing messages that begin with **E** (e.g. **E2**), indicate an error. Message **"I=0"** also indicates an error after initial start-up.

In such cases the entire control system is to be switched off and the error must be eliminated. (For troubleshooting see section 6.)

In some circumstances the control relay displays the message "**A2**" after identification of the connection type. This means that there are deviations from the types of connection shown that do not restrict the control process.

This message is acknowledged automatically after about 30 seconds or can be acknowledged by pressing any key.

The control relay always displays **"A1"** after identification of the connection type. A stage indicator (**a**) also flashes. The value displayed alternately with **"A1"** in the display is the determined value for the indicated stage (switching contact).

This message is acknowledged automatically for each stage after about 15 seconds or can be acknowledged earlier by pressing any key.

When all messages have been acknowledged, the control relay begins the automatic regulating process. The current power factor appears on the display.

If the power factor displayed does not correspond to the actual power factor, the identification of the connection must be repeated. This is activated by pressing the **"Select"** and **"Voltage THD"** keys simultaneously for at least 3 seconds (check system).

### 3.2 Subsequent start-up

The control relay begins with its normal regulatory program immediately after a power failure.

If the **"Select"** and **"Voltage THD"** keys are pressed simultaneously for at least 3 seconds (check system), then the control relay carries out connection identification again. It then behaves in the same way as in the initial start-up (see section 3.1).

This requires that automatic connection identification should be activated. ( setup mode -4-; see section 4.4)

The programmed control parameters are stored in a non-volatile memory and can be altered as necessary. (see chapter 4)

### 3.3 Maintenance

With maintenance of the power factor correction system, also the function of the control relay should be checked.

The control relay may be cleaned only with a dry cloth.

|  | **Important information:** |
|---|---|
| The control relay should be disconnected from the mains while cleaning the back of the control relay. | |



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## 4 Control relay setup

A wide range of setting options are provided to enable the reactive power control relay to be used in the widest possible way. To simplify matters the control relay is set to standard values in the factory (see table 1 below).

This means that the user mostly only needs to change the target power factor.

The setup mode can be reached from any of the control relay's operating modes.

| Setup code | Significance | Standard values | Setting range |
|---|---|---|---|
| *-1-* | Target power factor | ind 1.00 | From inductive o.85 to o.99 and from inductive 0.85 to 1.00 in steps of 0.01 |
| -2- | Maximum harmonic over-current until the alarm is acti-vated | 1.30 | From 1.05 times to 1.95 times the fundamental wave current or OFF in steps of 0.05 |
| -3- | -Alarm output on contact 6 and contact 12 respectively -switch on or off alarm **E5** | OFF no alarm **E5** | OFF or On with or without alarm **E5** (see section 4.3) |
| *-4-* | Automatic determination of response current | On | OFF or On |

**Table 1** Programmable values

| Setup code | Significance | Standard values | Setting range |
|---|---|---|---|
| -5- | Manual setting of response current | 2.00 | from 0.02 to 2 in steps of 0.01 |
| -6- | Relative value of the stage | 1.0 for each switch output | Optional for each switch output the value 0 to 16 in steps of 1.0 |
| -7- | Service | --- | Measuring (only the fundamental frequency components):<br>- Active current<br>- Reactive current<br>- Apparent current |

**Table 1** Programmable values

The procedure for checking or reprogramming the setting values is as follows:


- Press the **"Select"**(**i**) key to switch to setup mode (approx. 6 seconds) until the **"Setup Mode"** LED (f) lights up. "-1-" then appears on the display. This number (setup code) shows which variable is displayed and/or changed (see Table 1).
- The current setting alternates with the setup code on the display.
- By pressing **"Voltage THD"** key (**h**) it is possible to switch to the next highest setting value. The highest setting value is followed by the lowest setting value again.
- Pressing the **"Select"** key briefly switches to the next setup code (see Table 1). The setting value displayed can also be changed as described above.
- The control relay returns to automatic regulatory mode if the **"Select"** key is held down (approx. 3 seconds).



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**Note:**
**During "setup mode", no controlling activities are carried out by the control relay.**

If no key is pressed for about 15 minutes, setup mode is quit automatically.

### 4.1 Target power factor setting -1-

The required target power factor can be set between 1.00 and ind. 0.85 in steps of 0.01.

This for example results in the following control characteristic for a target power factor of 1.00:

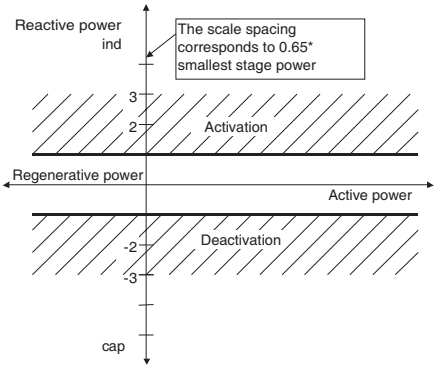


**Figure 7** Target power factor 1.00

In this setting the control relay attempts to minimize reactive power irrespective of active power.

The control relay creates a tolerance band (or control band) around its target (in this case the target is to permit no reactive power). If the operating point is within the control band, then the control relay will not carry out any further switching.

For a target power factor of 1.00 this means that the permitted reactive power may not exceed 0.65 times the lowest capacitor stage.

If, on the other hand, the work point is outside of the control band, the control relay will attempt to reach the control band with the smallest possible number of switchings by means of specific activation and deactivation procedures.

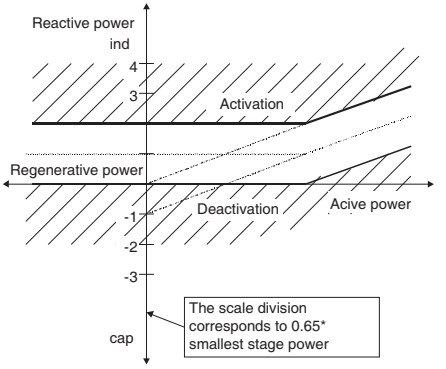


**Figure 8** Target power factor **0**.92

In addition to the target power factor setting 1.00, the control relay can also be set to a target power factor between 0.85 and 0.99. A distinction is made here between two different control bands. The control bands are distinguished by a large or small zero preceding the decimal point in the target power factor input.

The type of control band shown in figure 8 can be achieved by means of a large zero preceding the decimal point of the target power factor setting.

The target power factor forms the upper limit of the control band. The control relay always attempts to obtain a better power factor.

However, the control band levels off at low values of active power in order to avoid overcompensation.

For regenerative power (active power supplied to the mains) the control band stays leveled off for regenerative power.

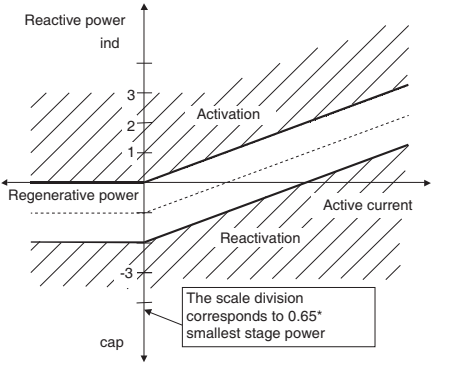


**Figure 9** Target power factor **o**.92

If generators are active in mains parallel mode, even small amounts of inductive reactive powers are unwanted in the mode of regenerative power.

In such cases the target power factor should be set with a small zero preceding the decimal point (see Figure 9).

The target power factor always forms the upper limit of the control band. However, a capacitive power factor in this case is prefered to even small amounts of inductive reactive power. So the control band is completely within the capacitive range for the mode of regenerative power.

### 4.2 Overcurrent switch off -2-

The control relay is capable of calculating the ratio between the rms current and the fundamental wave current (50 - 60 Hz) in the capacitor. This is achieved using the curve of the voltage signal.

If the set value of this ratio is exceeded for at least one minute due to harmonic oscillations and resulting resonance-related amplifications, then the control relay switches off all activated stages. An alarm signal is emitted at the same time.

After the overcurrent falls below the limiting value, the control relay begins to activate the stages again after waiting about 5 minutes.

**Note:**
**This function should be set to OFF when choked capacitor stages are used.**

### 4.3 Switching contact as alarm contact -3-

Contact 6 of the RM 2106 device or contact 12 of the RM 2112 device can be used to issue alarm signals.

If this menu item is set to **On**, then every alarm displayed by the alarm LED will also cause contact 6 or 12 to close.

|  | **Important information:** |
|---|---|
| All contact outputs don't have floating potential.<br>If a floating potential contact is required, use an additional contactor relay. | |

Historical alarms (alarms that are not pending at present) are not reported at the alarm contact.

In addition, at setup code -3- the alarm *„Target power factor not reached“* **E5** can be permitted or suppressed. If the **ind** LED lights up the alarm is permitted. Otherwise the alarm is suppressed.



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### 4.4 Automatic response current identification -4-

If set to **On** the control relay operates with the response current determined at initial start-up and the values determined for the switch outputs. These values can be read under points -5- and -6- .

If set to **Off** the response current (setup code **-5-**) and the value of the switch outputs (**-6-**) must be programmed manually.

This setting is to be selected if the low voltage network is fed by several transformers switched in parallel.

|  | **Important:** |
|---|---|
| If "OFF" is set, connection must be as shown in connection diagrams 3, 4, 5 or 6. Deviations are not signalled and are not corrected automatically. | |

### 4.5 Response current -5-

The response current describes the width of the control band (see figures 7 to 9). The greater the value, the broader the control band.

When automatic response current identification is switched on (**-4-**), the response current is adapted to the connected power factor correction system to optimum effect. The response current determined can be read under setup code -5- but cannot be altered.

When automatic response current identification is switched off (**-4-**), the response current can be set between 0.02 and 2 A in steps of 0.01 A.

The correct setting for 400 V AC mains voltage and current transformer with 5 A AC secondary voltage can be found in Table 2.

For other mains currents or current transformers with unlisted primary or secondary current, the response current can be calculated according to the following formula:

$$I_A = 0.65 \cdot \frac{Q \cdot 400V \cdot k_u}{U^2 \cdot \sqrt{3} \cdot k_i} \approx 150V \cdot \frac{Q \cdot k_u}{U^2 \cdot k_i}$$

$I_A$ = Response current to be set in A
Q = Capacitor **stage rating of the lowest stage** in var (not the overall power of the system)
U = Mains voltage in V (phase to phase)
$k_i$ = Current transformer ratio (primary/secondary current)
$k_u$ = Voltage transformer ratio (primary/secondary voltage) (if any)



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| Response current setting 400 V AC mains voltage | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current transformer | **Step size** (= Rating of smallest stage kvar) | | | | | | | | | | | | | |
| **A/A** | **2.5** | **5** | **6.25** | **7.5** | **10** | **12.5** | **15** | **20** | **25** | **30** | **40** | **50** | **60** | **100** |
| 30/5 | 0.40 | 0.80 | 0.98 | 1.20 | 1.60 | | | | | | | | | |
| 40/5 | 0.30 | 0.60 | 0.74 | 0.90 | 1.20 | 1.50 | | | | | | | | |
| 50/5 | 0.24 | 0.48 | 0.59 | 0.72 | 0.96 | 1.20 | 1.44 | | | | | | | |
| 60/5 | 0.20 | 0.40 | 0.49 | 0.60 | 0.80 | 1.00 | 1.20 | 1.60 | | | | | | |
| 75/5 | 0.16 | 0.32 | 0.39 | 0.48 | 0.64 | 0.80 | 0.96 | 1.28 | 1.60 | 1.92 | | | | |
| 100/5 | 0.12 | 0.24 | 0.30 | 0.36 | 0.48 | 0.60 | 0.72 | 0.96 | 1.20 | 1.44 | 1.92 | | | |
| 150/5 | 0.08 | 0.16 | 0.20 | 0.24 | 0.32 | 0.40 | 0.48 | 0.64 | 0.80 | 0.96 | 1.28 | 1.60 | 1.92 | |
| 200/5 | 0.06 | 0.12 | 0.15 | 0.18 | 0.24 | 0.30 | 0.36 | 0.48 | 0.60 | 0.72 | 0.96 | 1.20 | 1.44 | |
| 250/5 | 0.05 | 0.10 | 0.12 | 0.14 | 0.19 | 0.24 | 0.29 | 0.38 | 0.48 | 0.58 | 0.77 | 0.96 | 1.15 | 1.92 |
| 300/5 | 0.04 | 0.08 | 0.10 | 0.12 | 0.16 | 0.20 | 0.24 | 0.32 | 0.40 | 0.48 | 0.64 | 0.80 | 0.96 | 1.60 |
| 400/5 | 0.03 | 0.06 | 0.08 | 0.09 | 0.12 | 0.15 | 0.18 | 0.24 | 0.30 | 0.36 | 0.48 | 0.60 | 0.72 | 1.20 |
| 500/5 | 0.02 | 0.05 | 0.06 | 0.07 | 0.10 | 0.12 | 0.14 | 0.19 | 0.24 | 0.29 | 0.38 | 0.48 | 0.58 | 0.96 |
| 600/5 | | 0.04 | 0.05 | 0.06 | 0.08 | 0.10 | 0.12 | 0.16 | 0.20 | 0.24 | 0.32 | 0.40 | 0.48 | 0.80 |
| 750/5 | | 0.03 | 0.04 | 0.05 | 0.06 | 0.08 | 0.10 | 0.13 | 0.16 | 0.19 | 0.26 | 0.32 | 0.38 | 0.64 |
| 1000/5 | | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.10 | 0.12 | 0.14 | 0.19 | 0.24 | 0.29 | 0.48 |
| 1500/5 | | | 0.02 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.08 | 0.10 | 0.13 | 0.16 | 0.19 | 0.32 |
| 2000/5 | | | | | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.10 | 0.12 | 0.14 | 0.24 |
| 2500/5 | | | | | | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.08 | 0.10 | 0.12 | 0.19 |
| 3000/5 | | | | | | | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.08 | 0.10 | 0.16 |
| 4000/5 | | | | | | | | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.12 |
| 5000/5 | | | | | | | | | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.10 |
| 6000/5 | | | | | | | | | | 0.02 | 0.03 | 0.04 | 0.05 | 0.08 |

**Table 2** Response current setting with 400 V AC mains voltage



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If the step size, current transformer or nominal voltage of the power factor correction system do not match the values in the table, then the formula 1 on page 28 must be used to calculate the response current.

### 4.6 Relative value of the switch outputs -6-

These values refer to the relative stage ratings.

**Example:**

A system has the following stages:

| Stage rating | => | Relative value |
|---|---|---|
| 6.2 kvar | => | 1.0 |
| 6.2 kvar | => | 1.0 |
| 12.5 kvar | => | 2.0 |
| 25 kvar | => | 4.0 |
| 25 kvar | => | 4.0 |
| 0 kvar | => | 0.0 |

**Note:**
**To assure correct operation of the reactive VA control system the following conditions must be taken into account when choosing stage ratings:**
**If all possible switching combinations are sorted according to reactive power (capacity), then the power difference between two consecutive combinations may not be more than 1.2 times the smallest stage power.**

When automatic response current identification is switched on (**-4-**), the relative value is automatically determined by the control relay. This can be read under setup code -6- but not altered.

When automatic response current identification is switched off (**-4-**), the relative value of the switch outputs must be programmed manually.

The flashing LED in the stage display (**a**) indicate the switch output to which the relative value refers. Pressing the **"Select"** key (**i**) briefly allows you to skip to the next relative value.

The switch outputs with the lowest capacity are assigned relative value 1.0. The relative values for the bigger stages are calculated as follows:

Formula 2:

$$Relative\ value = \frac{Stage\ power}{Smallest\ stage\ power}$$

Free switch outputs are assigned relative value 0.0. Only whole numbers can be entered as factors.

### 4.7 Service -7-

The fundamental wave currents presently flowing in the current path (**j**) of the control relay and be displayed under this point.

The display for inductive or capacitive operating status (**b**) can be used to determine which current is displayed.

**ind.** and **cap.** off => active current
**ind.** or **cap.** off => reactive current
**ind.** and **cap.** on => apparent current



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# 5 Functioning and operation

The control relay runs completely automatically after it has been connected and started. The current power factor appears in the digital display (**c**). The ind and cap LEDs (**b**) show whether the network is loaded with capacitive or inductive reactive power.

At the same time, the stage indicator (**a**) shows the switched capacitor stages.

## 5.1 Automatic control mode

In automatic control mode the control relay constantly measures the current power factor in the network and compares this with the target power factor. If deviations are identified that are in excess of the tolerance range (control band), the required target power factor is restored by activating or deactivating specific capacitor stages within the control relay delay time and in accordance with the capacitor discharge time.

The control relay delay time is adapted to the size of the deviation. The greater the deviation, the shorter the reaction time. In contrast, the capacitor discharge time is fixed at one minute.

In addition, the control relay monitors the overcurrent in the capacitors and checks whether the connected capacitor power is sufficient for compensation. If automatic response current identification is activated, the control relay also checks the power of the capacitors connected.

The control relay issues an alarm in the event of an error. (see section 6)

## 5.2 Displaying the total harmonic distortion factor

If the control relay is in automatic control relay mode and if no historical or current alarm is pending, then pressing the **"Voltage THD"** key (**h**) will display the current total harmonic distortion factor (thd) of the voltage in %.

## 5.3 Check System

Simultaneously pressing **"Voltage THD"** (**h**) and **"Select"** (**i**) displays the current relative value of stage 1. The value displayed alternately with **"A1"** in the display (see section 6.2.2). It is acknowledged automatically for each stage after about 15 seconds or can be acknowledged earlier by pressing any key.

Simultaneously pressing **"Voltage THD"** (**h**) and **"Select"** (**i**) for about 3 seconds brings the control relay into check system mode.

If automatic response current identification (setup code -4-) is activated, then the control relay behaves as described in section 3.1 **„Initial start-up"**.



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**Note:**
**The check system mode defines the present stage ratings as reference values for subsequent stage rating checking.**
(see section 3)

### 5.4 Manual mode

Pressing **"Select"** (**i**) for more than 3 seconds switches the control relay to manual mode. The **"Manual Mode"** LED (**g**) lights up.

The **"Voltage THD"** key (**h**) can now be used to select a switching output. The flashing LED in the stage indicator (**a**) shows which switching output is presently selected.

After a waiting period of about 10 seconds the switching status of the selected switch output is inverted. After switching the control relay remains in manual mode.

To quit manual mode, press the **"Select"** key (**i**) for over 6 seconds until neither the **"Manual Mode"** LED (**g**) nor the **"Setup Mode"** LED (**f**) lights up.

**Note:**
**No automatic switching activities are carried out in manual mode. Manual mode does not terminate automatically.**

Alarm signals E4 and E5 are also generated in manual mode, but do not lead to any switching activities.

An exception to this is the alarm contact when alarm output is activated on contact 6 of the RM 2106 device or contact 12 of the RM 2112 device (setup code -3-).

# 6 Alarms and troubleshooting

The control relay has a number of ways of identifying connection errors and functional errors.

## 6.1 Connection errors

If automatic response current identification has been activated on the control relay (setup code -4-), the control relay can identify the following errors after ”initial start-up” or ”check system” procedure.

In all cases the connection of the power factor correction system and the wiring of the control relay are to be checked (see connection diagrams 3 to 6).

### 6.1.1 E3 - No capacitors

This error message appears when the control relay was able to measure a current, but was unable to detect a change in current when switching the capacitor stages.

This can have the following causes:
- control contacts (contactors) are not connected or are not working correctly
- the fuses of the capacitor stages have not been installed
- the current transformer is not located between power supply and loads (including PFC) (see connection diagrams 3 to 6).

In this case the reactive power control system must be set out of operation and the error has to be eliminated.

The faulty power control system may not be operated under any circumstances in this condition.

### 6.1.2 E1 - Defect capacitor stages

Possible causes:
- individual capacitor stages only have 2-phase connections to the mains
- the defect capacitor stages do not draw a symmetrical current from the 3 phases

### 6.1.3 E2 - Incorrect connection

Possible causes:
- the entire power factor correction system or all capacitors have only been connected in 2-phase connections
- the **”Meas”** terminal is unused and 2 phase conductors are connected between terminal **”N”** and **”L”**
- the **”Meas”** terminal is connected to the neutral conductor
- the **”L”** terminal is connected to the neutral conductor

### 6.1.4 I = 0 - No current in current path

It was not possible to measure a current of more than 20 mA in the current path when capacitor stages were either activated or deactivated.

Possible causes:
- fault in the current transformer connection
- the current transformer is located in the wrong place
- the current transformer ratio is too high

## 6.2 Connection messages

In addition to the error messages, the control relay also displays the results of its automatic connection recognition. Messages A1 and A2 can be acknowledged by pressing any key or are automatically acknowledged after a waiting period of about 30 seconds.

### 6.2.1 A2 - Incorrect connection that can be corrected internally

The connection has not been made in accordance with connection diagrams 3 to 6. However, the problem has been recognised as a simple confusion in the phase conductors or in the connection of the current transformer. The control relay can continue to operate with this connection.

### 6.2.2 A1 - Relative value of the switch output

The value for the relevant switch output is displayed while message A1 appears on the display. Switch outputs at which little or no capacitor rating has been recognised are assigned switching sequence factor 0.0. The user should check whether the values displayed correspond to the connected capacitor stage. The connection must be checked if deviations are extreme. The switching sequence determined is also stored in the setup mode (-6-).

## 6.3 Alarms in automatic control operation

The **"Alarm"** LED (**e**) lights up for as long as an alarm is active. If alarm output was activated on contact 6 of the RM 2106 device or contact 12 of the RM 2112 device (setup code -3-), this contact also closes. If the alarm status has ended, the **"Alarm"** LED turns off and the alarm contact opens again if in use. The message continues to flash on the display. Pressing the **"Voltage THD"** key (**h**) enables the *cause of the alarm* to be read out and the alarm to be acknowledged during or after the alarm .

### 6.3.1 E4 - Harmonic overcurrent in the capacitor

The control relay issues this alarm if the programmed limiting value for the ”harmonic overcurrent” (setup code -2-) is exceeded for more than 1 minute. All activated capacitor stages are deactivated.

After the overcurrent falls below the limiting value, the control relay begins to activate the stages again after waiting about 5 minutes. The maximum overcurrent factor ($I_{eff}/I_{50/60Hz}$) is recorded as the *cause of the alarm*.

### 6.3.2 E5 - Target power factor not reached

If the operating point of the control relay is above the control band (see section 4.1) and if all available capacitor stages have already been activated, the control relay issues error message E5 after a delay. The lowest measured power factor during the alarm is recorded as the *cause of the alarm*.

This alarm can be suppressed at setup code -3-. ( see section 4.3 )

### 6.3.3 E1 - Defect capacitor stages

After initial start-up or ”check system” procedure, the determined stage ratings are stored in a non-volatile memory (only when automatic response current identification is active; setup code -4-).

If the control relay detects a drop in stage rating during operation of more than 20% or there is an extremely asymmetrical current in the three phases of a capacitor stage, it registers these stages as defect. The defect stages can be read out as the *cause of the alarm*.

**Note:**
**This function only works if automatic response current identification is active.**

### 6.3.4 U = 0 - No measuring voltage

This message indicates that the control relay with connected **”Meas”** terminal has been put into operation, however no voltage can be measured at this input at present.

It is not possible to read the *cause of the alarm*. Likewise this message can only be acknowledged by eliminating the error.

### 6.4 I = 0 - No measuring current

If the current in the current measurement path drops below 20 mA, the message ”I=0” appears on the display.



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The control relay deactivates a capacitor stage after about 3 seconds. If this does not result in a change in current, then the stages still active are also deactivated.

This signal does not activate an alarm.

### 6.5 Other errors

Situations may arise due to the connection or special operating conditions that cannot be identified by the control relay.

Table 3 below lists further sources of errors.



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## 7 Trouble-Shooting

| Pos. | Fault | Possible causes | Necessary action |
|---|---|---|---|
| 1 | Control relay not working; no displays on the front of the control relay | No or the wrong voltage has been applied to the control relay | Check that operating voltage applied to the control relay is at the right level |
| 2 | The control relay does not react to manual switching despite availability of power and functioning indicators | Delay time of about 10 seconds is not up | If the required stage flashes in the stage display (**a**) then wait until the stage switches |
| | | Manual mode is not activated | Hold down „Select“ key until **„Manual Mode“** LED (**g**) lights up |
| 3 | Stage indicator (**a**) lights up, however capacitor contactors are not switched on | Control circuit not connected correctly or no control voltage | Check the control circuit in accordance with the connection diagram; check fuse |
| | | No zero conductor at contactors | |
| 4 | Control relay does not terminate the automatic measuring procedure | Unstable mains supply (strong power factor variation) | Wait for more stable mains conditions or enter the response current and switching sequence manually |
| 5 | One stage is continuously activated and deactivated in automatic control relay mode | Response current set too low | Set the response current correctly in accordance with Table 1 or Formula 1 |
| | | Strong load variation | |

**Table 3** Notes on troubleshooting

| Pos. | Fault | Possible causes | Necessary action |
|---|---|---|---|
| 6 | No stage activation in automatic control relay mode despite inductive load | The response current has been programmed incorrectly | Set the response current correctly in accordance with Table 1 or Formula 1 |
| | | Response current not correctly identified despite automatic response current identification being set | Check the control circuit according to the connection diagram and repeat the check system procedure |
| | | Another measuring device switched in parallel with the control relay current path | Current paths for different measuring devices should always be switched in series |
| | | Step size of capacitor is too large | Introduce capacitors with smaller step size |
| 7 | *„I=0“* flashes on the display | Current transformer line interrupted or short-circuited | Check current in current path using ammeter ($I_{min}$ ≥ 0.02 A) |
| 8 | Displayed power factor is less than target power factor, even though the control relay has activated all stages | Error in the control circuit | Check for the contactors to be energized |
| | | Error in the capacitor current circuit | Check fuses and contacts of capacitor contactors as well as the power consumption of the various capacitor stages if necessary |
| | | System too small | Add capacitors |
| 9 | Control relay does not switch off all stages at light load or standstill | Response current is set too high | Set the response current correctly according to Table 1 or Formula 1 |
| | | Control relay in manual mode | Press the **„Select“** key (**i**) |

**Table 3** Notes on troubleshooting

# 8 Technical Data

**Mode of Connection:**
As shown in connection diagrams 3 to 6

**Operating Voltage:**

| Supply voltage | Absolute permissible threshold values |
|---|---|
| 220 - 240 V AC | 195 ... 264 V AC |

**Frequency:**
50 Hz / 60 Hz (48 to 62 Hz)

**Consumption of supply voltage:**
Approx. 4 VA

**Current path:**
For current transformer: ... / 1 A AC to ... / 5 A AC
Permissible maximum current: 6 A~

**Consumption in current path:**
max. 0.5 VA at 5 A AC

**Measuring voltage at terminal "Meas":**
Maximum 264 V AC at terminal **"N"**

**Control Contacts:**
RM 2106: 6 switching contacts
RM 2112: 12 switching contacts
with potential binding to supply voltage (terminal **„L"**)

**Loading Capacity of the control contacts:**

| | |
|---|---|
| per contact (max.) | 2 A |
| (only ohmic or inductive load) | |
| total contact current (max.) | 4 A |
| total contact load (max.) | 950 VA |

**No-voltage Trip**
**(Undervoltage monitoring):**
With voltage drops under 170 V for more than 10 ms all capacitor stages connected are switched off. After voltage is restored the control relay switches the required stages on.

**Zero current trip:**
For a current loss of longer than 3 seconds all capacitor stages connected are switched off. After current is restored the control relay switches the required stages on.

**Discharge time for the capacitors:**
min. 1 min.

**Controls:**
Keypad with 2 keys

**Indicator elements:**
RM 2106: 12 LEDs
RM 2112: 18 LEDs
3 character digital display

**Operating temperature range:**
-25 ºC to +60 ºC



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**Housing:**
Plastic, black
flame-retardant as per UL-94 V0

**Mounting:**
From the front panel using a screwdriver

**Front panel dimensions:**
144 x 144 mm (DIN 43 700)

**Panel hole size:**
138 x 138 mm (to DIN 43 700)

**Installation depth:**
40 mm

**Weight:**
approx. 0.8 kg

**Installation position:**
as required

**Connections:**
Terminal block
cable cross section max. 1.5 $mm^2$

**Protection class:**

| | |
|---|---|
| Terminal block | IP 20 |
| Housing | IP 54 |

(when the sealing ring is used)

**Design as per:**
DIN EN 61010-1 (IEC 1010-1)
Protection Class II (when insulated mounting screws are used)

**EMC:**

| | |
|---|---|
| EMC Immunity | DIN 61000-6-2 |
| EMC Emmission | DIN 61000-6-3 |

**Fuse:**
External, max. 4 A specified

**Accessories:**
protection kit for protection class II/IP54
*Art.No. 20-50014*



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# Reactive Power Control Relay RM 9606

## Operating Instructions


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## Fig. 1: View of Front Panel

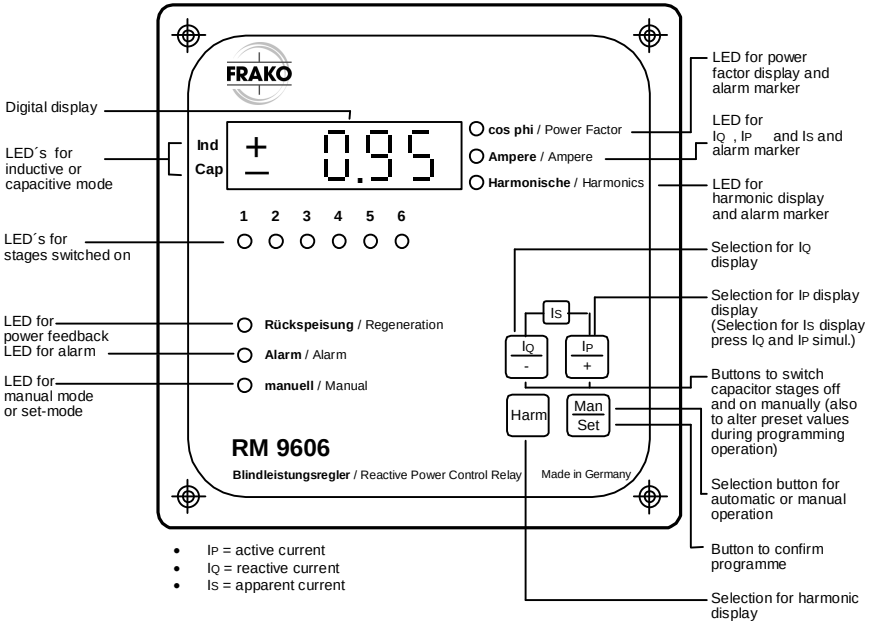


**Figure 1:** View of Front Panal



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## View from below

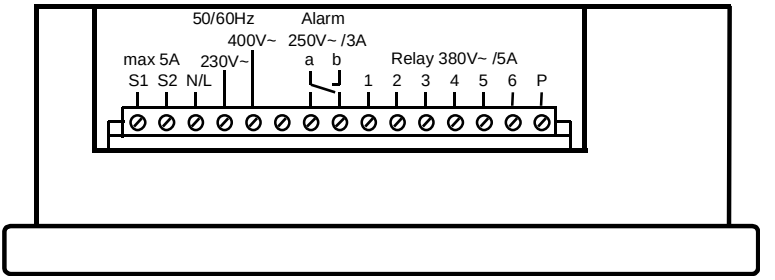


**Figure 2:** View from below



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## Contents





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## Safety and Warning Instructions!!

## !!! Important, read before commissioning !!!

- **The user must make sure that every person handling this unit must know these operating instructions and handle the unit accordingly.**
- **These operating instructions must be read thoroughly before the unit is installed and commissioned.**
- **Proceed only according to these operating instructions.**
- **Only trained personnel should install and commission this unit. Specific rules and regulations must be observed.**
- **The unit is under power and must not be opened.**
- **If the unit is visibly damaged it must not be installed, connected and commissioned.**
- **Disconnect the unit immediately if it does not operate after commissioning.**
- **Do observe all laws and regulations concerning this product.**

**Additionally all safety and commissioning instructions of the Reactive Power Control System are to be observed.**



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# EG-Konformitätserklärung
## *Declaration of Conformity*

FRAKO

Dokument-Nr.: EG-RM9606-101A / 02.2003

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: Bindleistungsregler RM 9606
*name of product* *Power Factor Control Relay RM 9606*

Typenreihe: **RM 9606** ab Fert.-Nr. 002000
*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 | 08.93 | EMV, Fachgrundnorm Störaussendung Industriebereich |
| | EN 50 082-1 | 03.93 | EMV, Fachgrundnorm Störfestigkeit Wohnbereich |
| | EN 50 082-2 | 01.93 | 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 61 010-1 | 1993 | Sicherheitsbestimmungen für elektrische Meß-, Steuer-, Regel- und Laborgeräte |

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

| | |
|---|---|
| 73/23/EWG | Niederspannungsrichtlinie / Low Voltage Directive |

Teningen, den 05.02.2003

P. Herbst / 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 certifiy the conformity according the mentioned directives, without any assurance of features. Please note the safety instructions of the attached product documentation.*

## 1. Summary of Instructions

On delivery, the control relay is set to pre-programmed standard values.
(see Table 1, pages 15 to 17)
The Reactive Power Control Relay RM 9606 is self-regulating (i.e. it detects and adjusts to the voltage phase connection, frequency and the response curent (c/k ratio) automatically).

Before a reactive power control system can be put into operation, the target power factor has to be programmed.

**How to programme the Control Relay:**

a) The control relay should be connected as shown in (see page 11).

b) ) Apply voltage to the control relay: "---" appears on the digital display. The control relay now identifies the location of the current and voltage source. This process takes at least 2 minutes and a maximum of 15 minutes. The power factor is displayed. (If this is not the case, see section 8. page 35).

c) Press the "Set" button for 8 seconds. "-01-" will appear on the digital display and the "manual" LED flashes.

d) By repressing the "Set" button the target power factor is displayed. If necessary, reprogramme to the nearest higher or lower value by pressing either the "+" or "-" button until the required target power factor is displayed.

**If no numbers appear on the display then the control relay must be briefly disconnected from the voltage source and the "Set" button has to be pressed again according to c).**

e) To confirm the value press the "Set" button again. "-02-" will appear on the display.

f) Now press the "-" button twice until "END" appears on the display. Store this value by pressing the "Set" button. The target power factor is now stored permanently.

To display the correct values for power and current, enter the current and voltage transformer ratios
(see sections 5.16 and 5.17).

To prevent unintentional reprogramming, the set mode can only be activated within the first 5 minutes after the operating voltage has been applied. If the set mode has been activated within the first 5 minutes, you have one hour to complete the programming. In order to obtain the set mode again after this period of time the control relay must be briefly disconnected from the voltage source.

On pages 15 - 17 all other preprogrammed standard values and their programme ranges are listed. The function of the pre-programmed standard values is described under section 5.



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## 2. Functions

The reactive power and active power portions of the power source are continuously calculated in the control relay from the measured voltage and the signals of the current transformer. If the reactive power portion exceeds certain threshold values, which the control relay has measured at the time of auto-adaption or are set as per section 5, a switching action will take place at the switching outputs.

In the case of inductive reactive current (inductive reactive power) one or more control contacts of the reactive power control relay are closed after the preprogrammed time delay.

This causes the RM 9606 to switch capacitor stages onto the power source supply, as and when required, in order to achieve the programmed target power factor. If the inductive reactive current portion of the load is reduced, the excess of reactive current causes the capacitor stages to be switched off line.

The Control Relay RM 9606 allows a variety of possible settings to meet the conditions on site. The relay's cyclic operations prolong the life of all connected devices by averaging the length of time the capacitor stages are switched on. An effective supervision of the reactive power control system (capacitor bank) is secured by the power factor display.

### 2.1 Automatic Identification of Voltage and Current Source

When voltage is initially applied to the control relay, it determines the location of the current and voltage sources (automatic phase rotation), i.e. it identifies in which phase and at which phase angle the current path and the voltage path are connected. Should the control relay fail to identify the current and voltage source due to power instabilities, repeat the procedure when the power has stabilized. It is also possible to programme the phasing manually (see sections 5.10 and 5.11).

**Resetting of the control relay and re-identification of voltage and current sources is initiated by pressing buttons "+" and "Set" simultaneously for at least 8 seconds.**

### 2.2 Automatic Identification of the Connected Capacitor Stages

Having determined the voltage and current source identification, the RM 9606 automatically calculates the c/k identification.
During the identification process all the control contacts of the relay are individually switched on and off again. The stage currents ascertained are then stored. These values determine the stage sequence. In this way it can also be determined which switching outputs are in use.



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The processes of automatic identification of voltage and current source and/or the automatic identification of capacitor stages are only carried out when switching on or pressing the combination of buttons "+", "-" and "Set" for min. 8 seconds.
(see section 2.1)

**Precondition:** The automatic identification mode or the automatic identification of connected capacitor stages mode are switched to "ON".

The RM 9606 checks stored stage currents at specific time intervals during normal operation. If it recognises that a capacitor stage has failed, this stage (stage without capacitance) will be ignored in future normal operations.

All failed stages are switched on from time to time in order to re-check their capacitance. If a capacitor stage is added later on, or defective fuses are exchanged, the RM 9606 itself identifies this after some time and the stage is then reintegrated into the normal operation. However, we recommend that if capacitor stages are added at a later date, the set-up procedure be repeated (see section 2.1).

**Note:**
In case of low voltage networks being fed by several transformers switched in parallel, the capacitor current is distributed to all the transformers. If measurements are **not** carried out via a summation transformer, the current change, measured by the control relay, is too low when switching on the capacitor stages, which can lead to errors during the automatic stage identification process. In such situations we recommend that the stage identification be switched off and the relevant values be programmed manually. (see sections 5.5 to 5.8)

### 2.3 Automatic Setting of Switching Time Delay

In order to keep the wear of the capacitor's contactors down to a minimum the response time of the control relay is lengthened or shortened automatically according to the frequency of the change of the load.

### 2.4 Power Feedback

The RM 9606 is equipped with a four quadrant control. This means that even when active power is fed back into the mains, the control relay ensures compensation for the reactive power which has been drawn from the mains. In this case the LED "Regeneration" lights up.



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## 3. Installation and Connection

The Reactive Power Control RM 9606 automatically determines the location of the current and voltage sources (automatic phase rotation). It may be connected either to two phases (phase / phase) or to one phase and neutral (phase/neutral). The current transformer can be installed in any phase. It has to be passed by both capacitor and consumer current.

**IMPORTANT NOTICE:**

**During installation and service work the control relay must be kept free of voltage.**

### 3.1 Installation

Individually supplied control relays are provided with insulated fixing screws. These can be used to install the control relay into switchgear cabinets of cubicles of protective class II. Furthermore a sealing ring is supplied, which must be used when installing the control relay in switchgear cabinets and cubicles of protection class IP 54.

The pre-mounted terminal connections allow a quick and easy installation. The control relay is electrically connected through a multiple connecting terminal supplied with the relay.

### 3.2 Voltage Connection

The control relay should preferably be connected to the three-phase system as shown in (page 11). To keep the function "Zero Voltage Alarm" operational the supply voltage of the control relay should be connected in the same phase as the contactor voltage.

Supply voltage of 230 V should be connected between the terminals "N/L" and "230V". Supply voltage of 400V should be connected at the terminals "N/L" and "400V".

**IMPORTANT NOTICE:**

**The control relay is designed for a mains voltage of 230 VAC or 400 VAC (phase/neutral or phase/phase).**

**For voltages greater or equal to 400 V, a control transformer for the supply of the controller must be used.**

**It is not allowed to use both connecting terminals "230V" and "400V" simultaneously.**

**The connection of the supply voltage must be fused externally with max 4A.**



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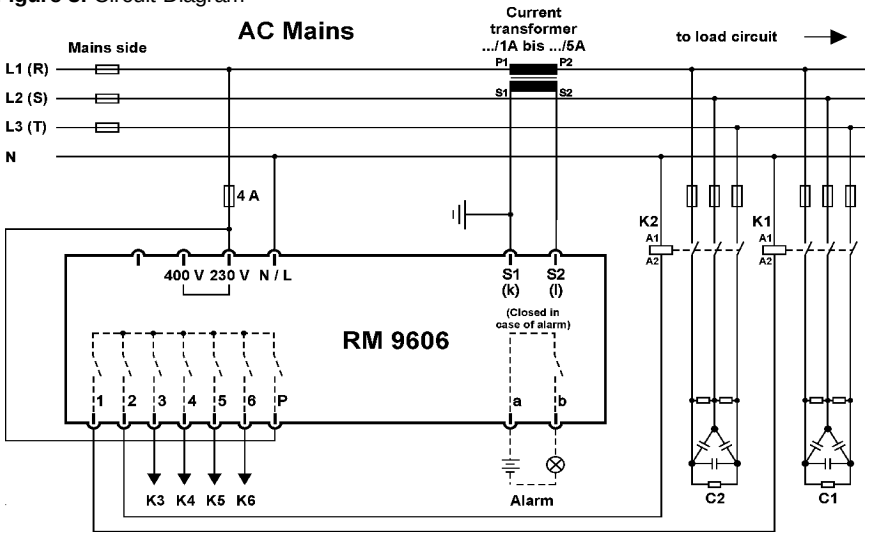
**Figure 3:** Circuit Diagram




### 3.3 Current Transformer Connection

The outputs S1 and S2 of the current transformer are connected to the terminals S1 and S2 of the control relay. In order to keep the load on the current transformer as low as possible the supply lines should have a cross-section area of 2.5 mm².

**ATTENTION:**
**The rated current in the current transformer path should not exceed 5 Amps.**

**Notice:**
After connection the short-circuiting bridge might have to be removed from the current transformer.

### 3.4 Alarm Contacts

A potenial-free alarm signal contact is accessible on the terminals "a" and "b". The contact closes when either there is no mains voltage applied to the control relay or when an alarm is signalled.(section 6.3)



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When there is an alarm signal, the LED "alarm" lights up and the relevant LED begins to flash on the control relay.

**IMPORTANT NOTICE:**

**It must not be possible to touch the applied voltage at the alarm contact. If this cannot be achieved the voltage must be earthed, even if it is only small protective voltage.**
**The maximum load for the alarm contact is 250 VAC and 3 Amps.**

### 3.5 Control Contacts

The control voltage of the contactors should be connected to the terminals "PI" and "PII". These circuits are potential free.

**IMPORTANT NOTICE:**

**In order not to overload the control contacts the sum of the holding currents of all contactor coils connected may not exceed a value of 5 Amps.**
**The max. load of the switching contacts is 380 VAC.**

In order to maintain the function of the undervoltage monitoring it is absolutely necessary to make sure that the control voltage of the contactors is in the same phase as the control relay supply.

### 3.6 Additional Instructions

The installation and connection of the RM 9606 is only finished, once it has been installed and wired according to these instructions.

**IMPORTANT NOTICE:**

**Before commissioning of the control relay it has to be ascertained that it is not possible to touch the connecting terminals (e.g. by means of a locked door or covering).**

**The control relay must be kept voltage free during wiring and installation works.**



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## 4. Commissioning

After the control relay has been installed as described in section 3, the relay can be put into operation.

### 4.1 First Commissioning

When the control relay is put into operation for the first time it tries to determine the mode of connection and the size of the stages. The display shows "---" and after a discharge time for the capacitors the stages are switched on and off again one after the other. This process can take up to 15 minutes.

**ATTENTION:**

**If the RM 9606 does not act as described above, remove voltage source and check installation.**

If the identification process is not concluded within 15 minutes there is probably a fault. (See section 8, page 35)

**Notice:**

**In order for the relay to be able to determine the mode of connection at least one capacitor stage must be operational.**

Possibly the control relay has already been used before and acts as described in section 4.2.

It is also possible to discontinue the identification process by switching off the automatic connection and stage current identifications. This takes place in set mode and at the same time it is necessary to programme the connection and stage parameters manually (see section 5).

After the identification process the actual power factor appears on the display and the control relay begins to function.
If the power factor shown does not coincide with the real power factor, the identification process must be repeated.
This can be done by pressing the buttons "+", "-" and "Set" simultaneously for at least 8 seconds.

### 4.2 Renewed Commissioning

After a mains failure the control relay immediately starts the normal control programme again. The data which were determined whilst being put into operation for the first time are stored in a non-volatile memory.

By pressing the buttons "+", "-" and "Set" simultaneously for a least 8 seconds these data are erased from the memory and the control relay again begins to determine the mode of connection and the size of stages.
It is assumed that the automatic connection and stage current identification are switched on (see section 5).



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## 5. Programming (Set)

In order to permit the widest possible use of the control relay, multiple settings are available. To simplify matters, the control relay is set to standard values in our factory before delivery.
(see Table 1, pages 15 to 17)

The user only needs to change the target power factor or a few values to suit his special requirements. As a protection against unintentional reprogramming, the set mode (programming mode) can be invoked only within 5 minutes after operating voltage is applied. After this period the values can only be read (read-only mode). If the set mode has been activated within these 5 minutes, it remains available for one hour. In order to reach the set mode again after this period, it is necessary to disconnect the control relay from its source for a short period of time.

The procedure for checking or reprogramming the set values is as follows:


- Press the "man/set" button for at least eight seconds to switch to the set mode. The display then shows "-01-". This number corresponds to the first variable which is displayed or can be changed in the following sequence (see Table 1).
- The actual value appears on the display when the "man/set" is pressed again.
- By pressing the "+" or "-" button the next higher or lower setting can be attained. *The control relay is in the read-only mode if above is not possible. To reach the set mode again, the control relay must be disconnected from its source for a short period of time.*
- Press the "man/set" button repeatedly; the mode numbers appear followed by the programmed value (see Table 1).
- If the "+" is pressed again after mode number "-24-" appears on the display, or if the "-" is pressed again after mode number "-01-" appears on the display, then the display will show "End".
- By confirming the display "End" by pressing the "man/Set" button the control relay assumes normal operation; the preset values are then permanently stored in a non-volatile memory.

**Notice:**
During the "set mode" none of the capacitor stages is changed and there is no switching of the alarm contact.



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**Table 1:** Programming of Values

| Programme Mode No. | Description | Pre-programmed standard Value | Programme Range |
|---|---|---|---|
| -01- | Target Power Factor | Ind. 0.92 | from cap. 0.90 to ind. 0.8 in increments of 0.01 steps |
| -02- | Parallel Shift PS | -1.0 (Target Power Factor is lower than limit value) | from –2 to +4 in increments of 0.5 steps |
| -03- | Limitation L | +1.0 (Overcompensation is avoided) | from –2 to +2 in increments of 0.5 steps |
| -04- | Switching time delay in seconds | 45 | 5 to 500 seconds in 1 sec. steps or at a high speed in 5 sec.steps.*) |
| -05- | Automatic c/k Identification | ON | ON=automatic mode<br>OFF=manual mode<br>When “ON“, the programme switches directly to programme mode no. -09- |
| -06- | Manual c/k Value setting | 2.0 | From 0.02 to 2.0 in 0.01 steps or At high speed in 0.05 steps.*) |
| -07- | Switching sequence | 1:1:1:1:1 | 1:1:1:1:1:1 / 1:1:2:2:2:2 / 1:1:2:2:4:4 / 1:1:2:3:3:3 / 1:1:2:4:4:4 / 1:1:2:4:8:8 / 1:2:2:2:2:2 / 1:2:3:3:3:3 / 1:2:3:4:4:4 / 1:2:3:6:6:6 / 1:2:4:4:4:4 / 1:2:4:8:8:8 |
| -08- | Number of contactors used | 6 | From 1 to 6 |
| -09- | Determination of Fixed stages | 0 | 0= no fixed stage<br>1= output fixed<br>2= outputs 1 and 2 fixed<br>3= outputs 1 to 3 fixed |

*) by pressing the buttons "+" or "-" for some time, the high speed mode will be activated.



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**Table 1** Programming of Values

| Programme Mode No. | Description | Pre-programmed standard Value | Programme Range |
|---|---|---|---|
| -10- | Automatic identification of voltage and current source | ON | ON= automatic<br>OFF= manual<br>When “ON“, mode -11- can only be read but not changed. |
| -11- | Enter or read mode of connection | Automatic identification | See Table 2 |
| -12- | Switching-off time | 60 | From 5 to 900 seconds. *) |
| -13- | Setting cyclic / non-cyclic switching rotation | ON | ON= cyclic switching<br>OFF= non-cyclic switching |
| -14- | Threshold for number of switching alarm | OFF | From OFF to 1000 the value must be entered in x1000 switches |
| -15- | Cancelling individual switching counters | 0 | Enter a number of 1-6. When leaving this menu point the counter of the corresponding capacitor stage will be set to 0. Point “ALL“ will reset all counters to 0. |
| -16- | Current trans-former Ratio | 1 | From 1 to 7000 in steps of 1 or at high speed in steps of 5.*) |
| -17- | voltage trans-former ratio | 1 | From 1 to 300 in steps of 1 or at high speed in steps of 5.*) |

*) by pressing the buttons "+" or "-" for some time, the high speed mode will be activated.



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**Table 1** Programming of Values

| Programme Mode No. | Description | Pre-programmed standard Value | Programme Range |
|---|---|---|---|
| -18- | 5th harmonic threshold in % | 5 | From 1 to 20 % in 0.1 % steps or 0.5 % steps at high speed.*) |
| -19- | 7th harmonic threshold in % | 4 | From 1 to 20 % in 0.1 % steps or 0.5 % steps at high speed.*) |
| -20- | 11th harmonic threshold in % | 3 | From 1 to 20 % in 0.1 % steps or 0.5 % steps at high speed.*) |
| -21- | 13th harmonic threshold in % | 2.1 | From 1 to 20 % in 0.1 % steps or 0.5 % steps at high speed.*) |
| -22- | Harmonic over-current | 1.3 | From 1.05 to 3.0 times the nominal value in 0.05 steps or 0.1 increments at high speed |
| -23- | Power factor alarm tripping signal | ON | ON or OFF<br>By setting “OFF“ a power factor alarm can be suppressed. |
| -24- | Total kvar dis-play | Will only be displayed when in operation | By pressing “set“ button the total power in kvar will be displayed. |

*) by pressing the buttons "+" or "-" for some time, the high speed mode will be activated.



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If the current transformer is installed in correct direction and the connections S1(k) and S2(l) are correctly connected with the control relay, the following kinds of **Connection modes** are valid:

| Connection mode | Connection at the voltage path | | |
|---|---|---|---|
| | L/N – L | L/N – L | L/N – L |
| 0 | L1 – N | L2 – N | L3 – N |
| 1 | L1 – L3 | L2 – L1 | L3 – L2 |
| 2 | N – L3 | N – L1 | N – L2 |
| 3 | L2 – L3 | L3 – L1 | L1 – L2 |
| 4 | L2 – N | L3 – N | L1 – N |
| 5 | L2 – L1 | L3 – L2 | L1 – L3 |
| 6 | N – L1 | N – L2 | N – L3 |
| 7 | L3 – L1 | L1 – L2 | L2 – L3 |
| 8 | L3 – N | L1 – N | L2 – N |
| 9 | L3 – L2 | L1 – L3 | L2 – L1 |
| 10 | N – L2 | N – L3 | N – L1 |
| 11 | L1 – L2 | L2 – L3 | L3 – L1 |
| **CT Location in phase:** | ↑ **L1** | ↑ **L2** | ↑ **L3** |

Table 2: **Connection mode**

**Note:**
If S1(k) and S2(l) are connected the wrong way around or the CT is installed in wrong direction, connection mode number must be added by 6. If the result is higher than 11, 12 must be subtracted. The result corresponds to the connection mode number which have to be entered.



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### 5.1 Setting of Target Power Factor

The desired target power factor can be set from cap. 0.9 to ind. 0.8 in 0.01 steps.
The mode of operation of this adjustment can be seen in Figure 4 and Figure 5.

If the control relay operates within the band range shown no switching operations will be activated.
However, if the control relay operates outside the band range, the RM 9606 will try to come within the band range with the minimum of switchings.

**Figure 4:** Control response after setting target power factor = 1; L = OFF; PS =0

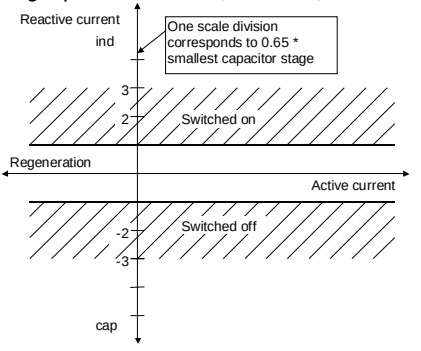
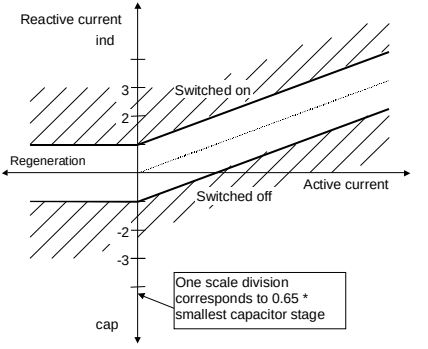



**Figure 5:** Control response after setting target power factor = 0.92 ind; L = OFF; PS = 0




In Figure 5 the behaviour of the control relay during feedback operation can also be seen. The "kink" in the band (characteristic line) is not reflected in the feedback operation but is extended at the point of intersection of the reactive power centre line (axis) with the feed-back operation line.

By shifting the band into the capacitive range (see Figure 7 in section 5.2) the occurrence of an inductive reactive power during the feedback operation can be virtually avoided.

When a capacitive target power factor mode is set, the control band is reflected from the supply side to the feedback side. (see Figure 10).



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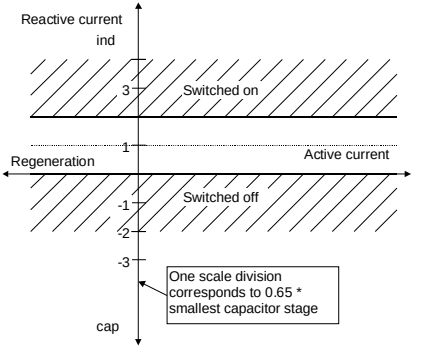
### 5.2 Parallel Shift (PS)

This setting causes a parallel shift of the band range as shown in Figure 4 by the set value.
It will shift to the inductive direction if the plus sign is used and to the capacitive direction if the minus sign is used.

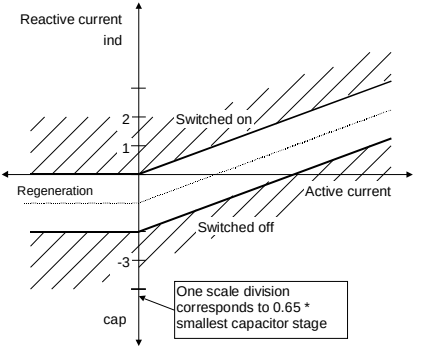
The values -2 to +4 can be set in 0.5 steps. The effects are illustrated by the two examples in Figure 6 and Figure 7.

**Figure 6:** Control response after setting target power factor = 1; L = OFF; PS = +1.0




The set target power factor is therefore the upper limit of the control band.

**Figure 7:** Control response after setting target power factor = 0.92 ind; L = OFF; PS = -1.0




The set target power factor is the lower limit of the control band range.

***(This is the recommended setting when using asynchronic generators in parallel.)***

### 5.3 Limitation (L)

This setting gives new possibilities that could not be attained before due to opposing requirements.

The range of values for L are -2 to +2 in steps of 0.5 and the setting "OFF". Setting the limitation value of 1 and a target power factor of 1.0 has the same effect as the parallel shift. For a target power factor other than 1.0 there is a "kinked" characteristic as shown in Figure 8.



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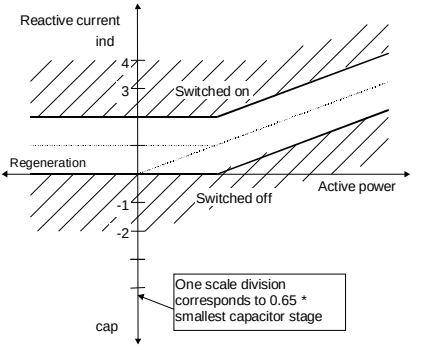
The limitation therefore specifies an absolute reactive power limit, below which the control band does not go.

**Figure 8:** Control response after setting target power factor = 0.92 ind; PS = 0; L = +1.0

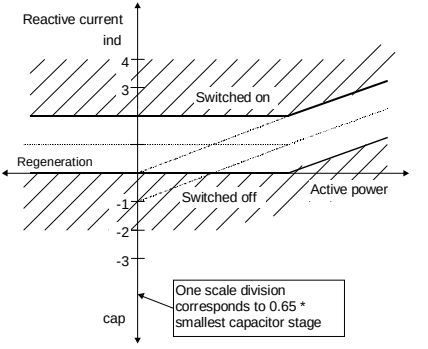



This setting has the following effects:

- The power factor is attained, on the average, in the "upper" power range.
- Over-compensation (capacitive load) is avoided in the low load range.

An appropriate combination of "parallel shift" and "limitation" is illustrated in Figure 9.

**Figure 9:** Control response after setting target power factor = 0.92 ind; PS = -1.0; L = +1.0




This example illustrates:

- In the "upper" power range the set power factor is specified as the lower limit value.
- Over-compensation is avoided in the low load range.

**This setting is the normal setting on delivery from the factory and represents the best possible control characteristic for most applications.**

The following Figure 10 shows the characteristics of the control band when set for a capacitive target power factor. In



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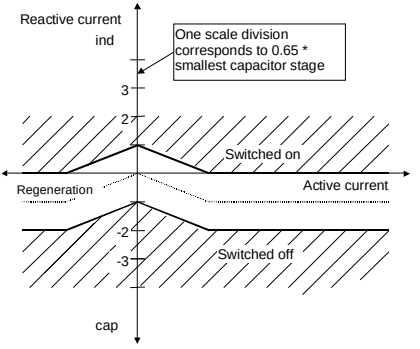
this case the control range is not prolonged at the reactive power axis into the feed back side, but is mirrored from the supply side into the feedback side.

**Figure 10:** Control response after setting target power factor = 0.95 cap; L = 1.0; PS = 0




## 5.4 Switching Time Delay

The switching time delay period can be set between the values of 5 to 500 seconds in 5 second steps. When a capacitor stage is switched on or off the control relay waits for the switching time delay before the switching process takes place. If more stages are required the switching time delay is shortened depending on the number of stages required.

**For example:**
2 stages required = switching time delay /2 (reduced by one-half) or
3 stages required = switching time delay /3 (reduced by two-thirds).

In order to keep the wear on the contacts to a minimum, the switching delay time should be set to less than 45 seconds only in exceptional cases. The discharge period, which ensures that the capacitors are fully discharged before they are switched on again, overrides the switching delay time (see section 5.12).

## 5.5 Automatic Stage Current (c/k) Identification "ON/OFF"

The RM 9606 has an automatic c/k identification, i.e. it calculates the appropriate response current the first time the control relay is energized. This procedure is repeated until the amount of capacitive power for each stage is determined and the c/k value has been calculated. The automatic c/k identification feature can be set to "ON" or "OFF".

**When "ON"** the RM 9606 operates with the stage currents automatically calculated.
**When "OFF"** the c/k value must be programmed manually (under programme mode 6) according to Table 3 on page 24 or according to the Equation 1. Also programme modes 7 (switching sequence) and 8 (number of contactors used) have to be entered manually.



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### 5.6 Response Current (c/k)

The Control Relay RM 9606 calculates a control characteristic from the power factor, the parallel shift and the limitation (in Figure 4 to Figure 10 shown as a dotted line) and has a tolerance band of 0.65 times the smallest stage in inductive as well as in capacitive direction (marked with bold line). The control relay consistently achieves this control band by switching on and off systematically. It is assumed that the connected capacitor-stages are sufficiently dimensioned.
The response current corresponds to half the width of the tolerance band, within which the reactive current can change without capacitor stages being switched on or off.
This is essential to ensure that the system does not oscillate. The total width of the tolerance band is selected in such a way that it corresponds to approx. 1.3 times the reactive current of the smallest capacitor stage.

When setting the automatic stage current identification to "OFF" the response current can be set between 0.02 and 2.0 A in steps of 0.01 A. The correct setting for a 400 V voltage system and a current transformer with 5A secondary current can be taken from Table 3.
In the case of other voltages or current transformers for which the primary or secondary current is not given, the response current can be calculated from the general equation:

*Equation 1:*

$$c/k = 0.65 \times \frac{Q}{U \times \sqrt{3} \times k} \approx 0.375 \times \frac{Q}{U \times k}$$

*c/k* = response current (Amps) to be set

*Q* = **capacitor stage rating in var of the smallest stage** (not the complete system)

*U* = mains voltage (V) on the primary side of the current transformer

*k* = transformer ratio (primary /secondary current)



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**Table 3:** Response Current at 400V mains voltage (c/k value)

| **c/k-adjustment for mains voltage 400 VAC, 50 Hz ~** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current transformer | **Stage rating of the smallest capacitor bank** (not total rating) **in kvar** | | | | | | | | | | | | | |
| **A /A** | **2,5** | **5** | **6,25** | **7,5** | **10** | **12,5** | **15** | **20** | **25** | **30** | **40** | **50** | **60** | **100** |
| **30 /5** | 0,40 | 0,80 | 0,98 | 1,20 | 1,60 | | | | | | | | | |
| **40 /5** | 0,30 | 0,60 | 0,74 | 0,90 | 1,20 | 1,50 | | | | | | | | |
| **50 /5** | 0,24 | 0,48 | 0,59 | 0,72 | 0,96 | 1,20 | 1,44 | | | | | | | |
| **60 /5** | 0,20 | 0,40 | 0,49 | 0,60 | 0,80 | 1,00 | 1,20 | 1,60 | | | | | | |
| **75 /5** | 0,16 | 0,32 | 0,39 | 0,48 | 0,64 | 0,80 | 0,96 | 1,28 | 1,60 | 1,92 | | | | |
| **100 /5** | 0,12 | 0,24 | 0,30 | 0,36 | 0,48 | 0,60 | 0,72 | 0,96 | 1,20 | 1,44 | 1,92 | | | |
| **150 /5** | 0,08 | 0,16 | 0,20 | 0,24 | 0,32 | 0,40 | 0,48 | 0,64 | 0,80 | 0,96 | 1,28 | 1,60 | 1,92 | |
| **200 /5** | 0,06 | 0,12 | 0,15 | 0,18 | 0,24 | 0,30 | 0,36 | 0,48 | 0,60 | 0,72 | 0,96 | 1,20 | 1,44 | |
| **250 /5** | 0,05 | 0,10 | 0,12 | 0,14 | 0,19 | 0,24 | 0,29 | 0,38 | 0,48 | 0,58 | 0,77 | 0,96 | 1,15 | 1,92 |
| **300 /5** | 0,04 | 0,08 | 0,10 | 0,12 | 0,16 | 0,20 | 0,24 | 0,32 | 0,40 | 0,48 | 0,64 | 0,80 | 0,96 | 1,60 |
| **400 /5** | 0,03 | 0,06 | 0,08 | 0,09 | 0,12 | 0,15 | 0,18 | 0,24 | 0,30 | 0,36 | 0,48 | 0,60 | 0,72 | 1,20 |
| **500 /5** | 0,02 | 0,05 | 0,06 | 0,07 | 0,10 | 0,12 | 0,14 | 0,19 | 0,24 | 0,29 | 0,38 | 0,48 | 0,58 | 0,96 |
| **600 /5** | | 0,04 | 0,05 | 0,06 | 0,08 | 0,10 | 0,12 | 0,16 | 0,20 | 0,24 | 0,32 | 0,40 | 0,48 | 0,80 |
| **750 /5** | | 0,03 | 0,04 | 0,05 | 0,06 | 0,08 | 0,10 | 0,13 | 0,16 | 0,19 | 0,26 | 0,32 | 0,38 | 0,64 |
| **1000 /5** | | 0,02 | 0,03 | 0,04 | 0,05 | 0,06 | 0,07 | 0,10 | 0,12 | 0,14 | 0,19 | 0,24 | 0,29 | 0,48 |
| **1500 /5** | | | 0,02 | 0,02 | 0,03 | 0,04 | 0,05 | 0,06 | 0,08 | 0,10 | 0,13 | 0,16 | 0,19 | 0,32 |
| **2000 /5** | | | | | 0,02 | 0,03 | 0,04 | 0,05 | 0,06 | 0,07 | 0,10 | 0,12 | 0,14 | 0,24 |
| **2500 /5** | | | | | | 0,02 | 0,03 | 0,04 | 0,05 | 0,06 | 0,08 | 0,10 | 0,12 | 0,19 |
| **3000 /5** | | | | | | | 0,02 | 0,03 | 0,04 | 0,05 | 0,06 | 0,08 | 0,10 | 0,16 |
| **4000 /5** | | | | | | | | 0,02 | 0,03 | 0,04 | 0,05 | 0,06 | 0,07 | 0,12 |
| **5000 /5** | | | | | | | | | 0,02 | 0,03 | 0,04 | 0,05 | 0,06 | 0,10 |
| **6000 /5** | | | | | | | | | | 0,02 | 0,03 | 0,04 | 0,05 | 0,08 |

If the size of the stage, the current transformer, or the rated current of the control system does not meet the values as given in above table, the equation on page 23 has to be applied in order to determine the c/k value.



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### 5.7 Switching Sequence

When the automatic c/k identification is switched on every optional switching sequence is possible.
Necessary condition: When the optional switching combinations are sorted according to their capacity, the capacity difference between two successive combinations may only be 1.2 times the capacity of the smallest stage.

If the automatic c/k identification is switched off, the switching sequence (switching programme) can be reset to the following combinations of capacitor stages:

| | | |
|---|---|---|
| 1:1:1:1:1:1 | 1:1:2:4:4:4 | 1:2:3:4:4:4 |
| 1:1:2:2:2:2 | 1:1:2:4:8:8 | 1:2:3:6:6:6 |
| 1:1:2:2:4:4 | 1:2:2:2:2:2 | 1:2:4:4:4:4 |
| 1:1:2:3:3:3 | 1:2:3:3:3:3 | 1:2:4:8:8:8 |

The smallest capacitor stage is always "1", the subsequent stages are either the same (1:1:1...) or are larger. In the second line above a more accurate result can be achieved with the same number of switching contactors.

When the automatic c/k identification is switched off, the smallest capacitor stage ("1") must be connected to the first control output of the connecting terminal. All other stages follow according to their capacity. In the case of fixed stages being used, the smallest stage has to be connected following the last fixed stage.

### 5.8 Number of Contactors used

When the automatic c/k identification is switched off, any value between 1 and 6 can be programmed. If, for example, there are five stages in a capacitor bank, these stages are connected to the control outputs "1" to "5" and the number of the control outputs is programmed to "5" in order to prevent the control relay from activating control outputs which have not been connected.

The size of the capacitor stages has no influence on this setting.

### 5.9 Specifying fixed Stages

The Control Relay RM 9606 allows the first three control outputs to be treated as fixed stages. Fixed stages are stages which are not included in the normal control cycle but are switched on immediately after the control relay is switched on and always remain switched on. The set discharge period is maintained. The target power factor setting is ignored.

The following settings are possible:

0 = no fixed stages
1 = control output 1 is fixed
2 = control outputs 1 and 2 are fixed
3 = control outputs 1 to 3 are fixed

The switching sequence does not take into account the fixed stages.



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### 5.10 ON/OFF Connection Identification

The control relay has an automatic connection identification feature.
(Refer to section 2.1)

**ON:** The connection recognised by the control relay can be read under mode number -15- in accordance with Table 2. (not changeable)

**OFF:** The connection must be manually programmed as per Table 2.

### 5.11 Connection Mode

Usually, the connection mode should be set to automatic operation. If, however, the control relay failed to determine the connection mode after 15 minutes due to high load changes or phase imbalances, it is possible to enter the connection mode manually as per Table 2.

### 5.12 Setting Capacitor Discharge Time

In order to ensure that after switching-off, a capacitor stage is not switched on again before the capacitor has been sufficiently discharged, the switch-off time can be adjusted to the specific needs (discharge mode).
The discharge time can be set between 5 and 900 seconds.

### 5.13 Setting Cyclic/Non-Cyclic Switching Rotation

In certain cases when there are filtered and non-filtered stages within one system, it is necessary to ensure that the control relay does not operate cyclically. For such applications this feature can be disabled. On and off have the following meanings:

**ON:** Small number of switches, cyclic switching is enabled on all levels.

**OFF:** No cyclic switching; the stages within each level are switched on.

### 5.14 Setting Threshold for Number of Switchings Alarm

In order to support the maintenance of the unit the RM 9606 provides an internal counter for each switching output.
During manual operation the present count for each stage can be displayed.
(see section 6.2).

If the maximum of switching actions is chosen the control relay displays the need for maintenance. The stage which has exceeded the limit (e.g. "S4.4" for the 4th stage) flashes on the display (approx. every 10 seconds). At the same time an alarm is signalised. How to put out the alarm is explained in section 5.15.



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The required number of switches is to be divided by 1000 before being entered. That means that entering 100 evokes an alarm at 100,000 switches of one stage.

The stage alarm signals have no influence on the control behaviour/ performance of the relay.

### 5.15 Reseting Switching Counter

In mode -15- the switching counters can be reset altogether or separately.
When choosing mode -15- the display shows "0". With the "+" and "-" buttons a stage number between 1 and 6 or "all" can be chosen. Leaving the programing section by pressing the "man/set" button resets the count of the displayed stage. By setting "all" all counts are reset.

If you do not want to reset any counter "0" has to be set befor pressing the "man/set" button.

### 5.16 Current Transformer (CT) Ratio

In order to display the active current (IP), reactive current (IQ), and apparent current (IS) as actual values, the ratio between the primary current and the secondary current of the current transformer used must be entered. If the current transformer ratio is not set the value displayed must be multiplied by the CT ratio.Values between 1 and 7000 can be entered
(eg. 1000A/5A→200).

### 5.17 Voltage Transformer Ratio

If a voltage transformer is used within the measuring circle the voltage transformer ratio must be entered in order to scale the display of missing kvar to reach the target power factor correctly.
The primary/secondary voltage transformer ratio is set between 1 and 300. If no voltage transformer is present, the value "1" must be entered.

### 5.18 Setting $5^{th}$ Harmonic Threshold

The Control Relay RM 9606 has a harmonic monitoring system for the $5^{th}$, $7^{th}$, $11^{th}$, and $13^{th}$ harmonics. If the limiting value is exceeded, there is an alarm signal, i.e. the alarm contact closes and the "Alarm" LED illuminates for as long as the limiting value is exceeded. The "Harmonic" LED flashes until the alarm is switched off. The order and the maximum value of the harmonics which have been exceeded, beginning with the maximum deviation, are displayed by multiple pressing of the "Set" button. The "Set" button must be pressed repeatedly until the "Harmonic" LED goes out.

### 5.19 Setting $7^{th}$ Harmonic Threshold

Setting of the limiting value for the $7^{th}$ harmonic.



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### 5.20 Setting 11th Harmonic Threshold

Setting of the limiting value for the 11th harmonic.

### 5.21 Setting 13th Harmonic Threshold

Setting of the limiting value for the 13th harmonic.

### 5.22 Harmonic Over-Current Alarm Signal

The Control Relay RM 9606 is able to determine the ratio between the actually measured RMS current and the nominal current (50 - 60 Hz) of the capacitor.If this ratio is exceeded by the factor set for at least one minute due to harmonics and the resulting resonance phenomenon, the control relay switches off all stages which have been switched on. At the same time an alarm is signalised. After approximately four minutes the required capacitor stages are switched on again. By pressing the "Set" button the peak value is displayed.

**Notice:**
**When exclusively filtered stages are being used, set this threshold to the highest possible value (in order to inactivate it).**

### 5.23 Suppressing the Power Factor Alarm

As already described the control relay tries to reach its programmed control band. If this, however, is not possible due to lack of capacitor stages available, an alarm is signalised after several minutes (depending on the size of the difference). In case of a capacitive cos-phi outside the band range the alarm signal functions as well.
When setting "OFF" the alarm is suppressed.

### 5.24 Total kvar Display

Provided the current transformer ratio has been entered, the total kvar detected at measured voltage will appear on the display, when "Set" is pressed in Mode -24-.



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# 6. Operation

## 6.1 Modes of Display

The power factor display is independent of the control relay operation and can be reprogrammed at any time. To the right of the four and a half character digital display there are three LEDs indicating which display mode is active, either "cos phi", "Ampere", or "Harmonic".

Five modes of display can be selected by pressing the appropriate button:

### 6.1.1 Power Factor

The "Power Factor" display mode is the standard display and can be activated from another mode of display by pressing the buttons "IQ", "IP", or "Harm".
The symbols "+" for ind. and "-" for cap. show whether the power factor is inductive or capacitive.
The LED "Regen" indicates that generative active power is fed back into the mains.
Active and reactive currents are measured seprarately. The power factor (cos phi) display value is the result of a mathematical calculation, which ensures accuracy over the entire range down to values close to 0. The minimum apparent current for a correct power factor (cos phi) display is approx. 0.02 A. When the apparent current falls below 0.02 A for three consecutive measurements one capacitor stage is switched off and if there is no change in the measured current, all remaining stages are switched off and "I=0" appears on the display.

### 6.1.2 Reactive Current


The display indicates the reactive current portion in the current transformer circuit. The "+" for ind. or "-" for cap. indicate whether the reactive current is inductive or capacitive . The LED "Ampere" lights up. From this mode of display the compensation effect of the capacitor stages e.g. by adding or removing capacitor stages manually, can be monitored. If the current transformer ratio (CT) is programmed via the set mode, the actual reactive current on the primary side of the CT is displayed. Otherwise the current portion is displayed and has to be multiplied by the CT ratio to obtain the actual value.

Pres "IQ", "IP", or "Harm" buttons to exit this mode of display.



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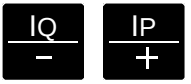
### 6.1.3 Active Current


The display shows the active current on the fundamental oscillation in the current transformer (CT) circuit. The LED "Ampere" lights up.
The current direction is also displayed which is helpful during tests. The LED "Regen" shows that the generative active power is fed back into the mains. If the CT ratio is programmed into the relay, the actual active current is displayed; otherwise the current portion is displayed and must be multiplied by the CT ratio to obtain the actual value.

Press "IQ", "IP", or "Harm" buttons to exit the display.

### 6.1.4 Apparent Current




Pressing the "IQ" and "IP" buttons simultaneously activates the display. The LED "Ampere" lights up. If the CT ratio is programmed into the relay, the actual apparent current on the fundamental oscillation in the current transformer (CT) circuit is displayed; otherwise the current portion is displayed and must be multiplied by the CT ratio to obtain the actual value.

Press "IQ", "IP", or "Harm" buttons to exit the display.

### 6.1.5 Harmonics ($5^{th}$ - $13^{th}$ )


This display shows the $5^{th}$, $7^{th}$, $11^{th}$, and $13^{th}$ harmonics on voltage. The previous harmonic reading appears on the display (in %) and the LED "Harmonic" lights up. By pressing the "+" or "-" buttons several times the portions of the $5^{th}$, $7^{th}$, $11^{th}$, and $13^{th}$ harmonics are subsequently displayed either in ascending or descending order.
For example. if "5. 2.9" is displayed this means "$5^{th}$ harmonics = 2.9 %".

Press the "Harm" button to exit the display.

### 6.2 Manual Operation


When the "man/Set" button is pressed for more than 3 secs, the control relay switches to manual operation and the LED "manual" begins to flash. The capacitor stages can be switched on or off by pressing the "+" or "-" button.



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When the "+" button is pressed once, "1.ON" appears on the display until the control relay has switched on the first stage after approx. 10 secs provided no further buttons have been pressed. If the first stage was already switched on "1.OFF" will appear on the display until the control relay has switched off the first stage after approx. 10 secs. Then the display will change to the last displayed value.
While waiting the switching counter of this stage will be displayed for a short moment. The displayed value is multiplied by 0.001 and is indicated as far as possible as a decimal. That means for example:

"0.350" is equivalent to 350 switches.

By pressing the "+" button several times the stages 2 - 6 will appear in ascending sequence on the display. They can be switched on/off in the same way.
By pressing the "-" button once "6.ON" appears on the display until the control relay has switched on the 6th stage after approx. 10 secs. If the 6th stage was already switched on "6.OFF" will appear on the display until the control relay has switched off the 6th stage after approx. 10 secs. Then the display will change to the last displayed value. By pressing the "-" button several times the stages 5 - 1 will appear on the display in a descending sequence. They can be switched on/off in the same way.

In manual mode, the programmed switching off time (discharge time) is taken into consideration, i.e. when switching on a stage which was previously switched off the switching-off time is the same as the discharge time. If a stage was identified as a zero stage (without power) the corresponding numbers would indicate this by flashing.

Press "Man/Set" button to exit manual mode.

### 6.3 Alarms

The potential-free alarm contact (a/b) closes whenever the operating voltage is not applied. In the case of the correct operating voltage, the contact closes if there is an alarm. The conditions for an alarm can be seen in section 6.3.1 to 6.3.7 below. The LED "alarm" lights up for as long as a state of alarm exists. When an alarm is signalised, an alarm marker is put into action (LEDs "Power Factor", "Ampere", or "Harmonic" blink).
The alarm markers remain active after the alarm until they are acknowledged by pressing the "Set" button. After acknowledgement the flashing alarm marker goes out.
The alarm signals have no influence on the control behaviour/performance of the relay.



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### 6.3.1 Power Factor Alarm

If the threshold values set for "switch-on" and "switch-off" are exceeded and no further change can take place in the output stages, the alarm signal functions (except for the cos-phi alarm being switched-off; see mode -23-). By pressing the "Set" button the amount of capacitive and reactive power missing to reach the target power factor flashes on the display. Pressing the "Set" button again shows the actual power factor on the display and the alarm marker "Power Factor" no longer flashes.

### 6.3.2 Harmonic Alarm

When the programmed threshold values are exceeded the alarm goes off.
By pressing the "Set" button several times the display shows the order and the maximum values of the exceeded harmonics starting with the maximum deviation.
The button "Set" must be pressed repeatedly until the "Harmonic" alarm no longer flashes.

### 6.3.3 Over-current alarm

If the ratio between the actually measured RMS current and the nominal current of the capacitor has exceeded the programmed value for one minute, the alarm goes off and all stages are switched off.

After the alarm has been acknowledged it takes approx. 4 minutes until the necessary capacitor stages are switched on again.

By pressing the "Set" button the display shows the maximum value of the factor by which the RMS current has exceeded the nominal current.
By pressing the "Set" button again the display shows the actual power factor and the alarm marker "Ampere" no longer flashes. (See also section 5.23, page 28)

**Notice:**
**The over-current ratio is a mathematically determined value and therefore cannot be applied to filtered systems.**

### 6.3.4 Operating-Cycles Alarm

If a stage exceeds the set limit for number of operating cycles, the number of the stage that has exceeded the limit blinks in the display about every 10 seconds (e.g. "Sh. 6" for the sixth stage). An alarm signal is also sent. Section 5.15 describes how this alarm signal is cancelled.

### 6.3.5 "U=0" Alarm

If there is an interruption in the measurement voltage path, the control relay switches off all stages after about 1 sec. and displays "U=0".



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At the same time, the alarm contact closes and the "Alarm" LED lights up for as long as there is no voltage applied to the measurement input terminals of the control relay.

### 6.3.6 “C=0“-Alarm

If the relay does not identify a capacitor stage during the process of automatic terminal and stage current identification an alarm is signalised and the display shows "C=0".
The identification process is carried on despite the alarm.

### 6.3.7 "I=0" Alarm

If there is an interruption in the current path for at least 3 secs., the control relay immediately switches off a capacitor stage.

If there is no change in the current as a result, the stages which are still on are switched off.
There is no alarm.

## 7. Technical Data

**Mode of Connection:**
Phase/Phase connection or
Phase/Neutral connection
Current via current transformer in optional phase (Figure 3, page 11).

**Operating Voltage:**

| Supply voltage | Mains terminal voltage | Absolute permissible/ threshold values |
|---|---|---|
| 230V~/ 400V~ | 220V~ to 400V~ | 198V~ ... 440 V~ |

**Attention:** The terminals for 230V and 400V are internally bridged.

**Frequency:**
50 Hz / 60 Hz (48 to 62 Hz)

**Consumption:**
approx. 9-11VA at 0 to 6 switched-on control contacts

**Current Path:**
For current transformer .../1A~ to ... /5A~

**Consumption in Current Path:**
max. 1.8 VA at 5 A~ rated current of the CT

**Control Contacts:**
6 potential-free relay contacts



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**Loading Capacity of the Control Contacts:**
Switching voltage:
380 VAC (acc. to VDE 0110 part B)
250 VAC (acc. to VDE 0110 part C)
Switching current up to 5 A max.
Switching load up to 1800 VA max.

**Fault Signal Contacts:**
Loading capacity 250V~, 3A

**No-Voltage Trip (Undervoltage Monitoring):**
For a voltage loss of longer than 15 ms all capacitor stages connected are switched off. After voltage is restored the control relay switches the required stages on.

**Zero Current Trip:**
For a current loss of longer than 3 secs capacitor stages connected are switched off. After current is restored the control relay switches the required stages on.

**Operating Elements:**
Foil keyboard with 4 buttons

**LED Indicators:**
12 LEDs
4 ½ character digital display

**Temperature Range:**
-20 ºC to +60 ºC

**Enclosure Material:**
Black synthetic plastic, flame resistant to UL-94, Class V0

**Fastening:**
Through the front panel by means of a screwdriver

**Front Panel Dimensions:**
144 x 144 mm (to DIN 43 700)

**Panel Cut Out:**
138 x 138 mm (to DIN 43 700)

**Mounting Depth:**
40 mm

**Weight:**
ca. 0.9 kgs

**Mounting Position:**
as desired

**Terminals:**
Plug-in connector blocks
(supplied with the control relay)

**Enclosure:**
Terminals IP 20
Casing IP 54
(when using the sealing ring)

**Design:**
according to:
- EN 50 081-1
- EN 50 082-2
- EN 61 010
  (VDE 0411 part 1) Protection Class II
  (if insulated fixing screws are used)

**Fusing:**
External, max. 4A



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## 8. Trouble-Shooting

| Pos. | Faults | Possible Causes | Necessary Action |
|---|---|---|---|
| 1 | Control relay does not function, digital display remains blank. | There is either no voltage or the wrong voltage has been applied to the control relay. | Check whether the correct operating voltage is applied to the control relay. |
| 2 | U=0 flashes on the display. | The voltage applied to the voltage path of the control relay is too small. | Check the operating voltage. If the voltage is correct press the buttons "+", "-" and "Set" to recognise this voltage as rated voltage. |
| 3 | Relay does not respond to manual operation although it has voltage and digital display is operational. | End of delay time of approx. 10 secs. has not been observed. | For example , if "1. ON" appears on the display wait until the control relay has switched on the first stage. |
| | | Relay was not in manual mode. | "Man" button must be pressed leading to flashing of the LED "manual". |
| 4 | Stage display (LED 1-6) lights up but capacitor contactors are not activated | Control circuit is not connected properly or there is no control voltage | Check the control circuit according to the circuit diagram and check fuses. |
| | | There is no neutral on the contactors. | |
| 5 | Control relay does not complete the automatic identification procedure | Unstable power supply (power factor fluctuation). | Wait for power supply to stabilize or manually set c/k factor and mode of connection. |
| 6 | During automatic adjustment process "C=0" flashes on the display. | Fault in control circuit (contactors do not switch) | Check control circuit according to the circuit diagram; check fuses. |
| | | Fuses of the capacitor stages are defective or missing. | Check if capacitors are energized after switching. |
| | | Current transformer is in the wrong place. | Check if the position of current transformer corresponds to the circuit diagram. |
| 7 | "I=0" flashes on the display. | Current transformer circuit interrupted or there is no current flowing on the secondary side. | Use ammeter to check current on secondary side of CT. (I min >= 0.02A). |
| | | The current flowing on the secondary side of the CT is too small. | (I min >= 0.02A) Install smaller current transformer. |
| | | Current transformer is defective. | Check the current transformer. |



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| Pos. | Faults | Possible Causes | Necessary Action |
|---|---|---|---|
| 8 | Despite inductive load no stages are switched on when relay is in automatic mode. | When programming the control relay, the c/k factor, switching time delay, or discharge time have been set too high. | Check programming of the control relay and change if necessary. |
| | | In automatic operation the c/k factor was not correctly detected. | Check the control circuit according to the circuit diagram and repeat the automatic test procedure. |
| | | A different current measuring meter (e.g. ammeter) has been connected in parallel with the control relay to the secondary side of the current transformer. | All measuring instruments in current path must be connected in series |
| | | The capacitor stages are too wide. | Finer adjustment of the capacitor stages is required. |
| 9 | In automatic mode one stage is continually switched on or off (hunting). | The c/k factor was set too low. | Set c/k value correctly according to Table 3. |
| | | High load change; The delay time was set too low. | Set higher delay time. |
| 10 | The "power factor (cos phi)" display is less than the target power factor although the control relay has switched on all stages | Mode of connection incorrectly programmed. | Reset mode of connection. |
| | | Fault in control circuit. | Check whether the capacitor contactors have been activated. |
| | | Fault in capacitor circuit. | Check the fuses and contacts of the capacitor contactors and perhaps current absorbtion. Measure the current of each capacitor stage with a clamp-on current meter. |
| | | System undersized. | Press "Set" button and read the shortage of power from the display. |
| | | Failure in automatic adjustment. | Repeat identification process. |
| 11 | Control relay does not switch off all stages during times of low load or facility shut-down. | c/k factor is set too high. | Set c/k factor according to Table 3. |
| | | Control relay is in manual mode. | Press "Man" button. |

**Version V2.10 ab SW 1.21**



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FAMCO
هایپرصنعت

# Reactive Power Control Relay RM 9606

## Sales Programme

FRAKO

Power capacitors for low voltage
Power factor correction systems
Power factor correction systems with reactors
Modules for power factor correction systems
Active filters
Dynamic compensation of harmonics
Reactive power control relays
Maximum demand control systems
Mains monitoring instruments
Cost allocation
Energy management systems

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Subject to technical alteration

**Reliable energy solutions.**

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