

Operating and Commissioning Instruction for Power Factor Control Relay Type CX & CXM

Common Point and Volt free Switching

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CXM
With Multi - Meter



LED Indication
Calling for Capacitor
steps out

Scroll Buttons

LED Indication
Calling for Capacitor
steps in

CX



Fan Control
DIP switch
(see p6)

Function Switch

LED Indication
Calling for Capacitor
steps out

LED Indication
Calling for Capacitor
steps in



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Installation

As with all electrical equipment, the appropriate specifications governing electrical installation must be followed when power factor correction equipment is installed. When removing the front nameplate to adjust the function switch and DIP switches, always ensure that your body is not carrying any electrostatic charge. This can be accomplished by simply touching an earthed object, such as the switchboard metal casing to dissipate any electrical charge before removing the cover plate.

- 1 Check that the measurement and control voltage, supply frequency and current transformer rating comply with the ratings given on the back of the relay.
- 2 Mount the relay in the switch panel (cut out size 138 x 138mm) and retain the relay in position using the ratchet plastic clips included with the relay.
- 3 Connect in accordance with the wiring diagram. **Pay special attention to the cross section size of the CT connections. We recommend 2.5 sq.mm copper conductor for runs up to 10 mtrs.** The CX relay will constantly monitor the supply voltage and if this falls below 70% of nominal all capacitor contactors will be automatically switched out. Note that the control voltage to the supply voltage to the contactor coils must be taken from one of the phases used for the supply voltage to the relay (L2-L3). The spring terminal can be pushed open by hand – or with a 2.5mm blade screwdriver. The steel rear cover of the relay must be earthed, at the earth tag.
- 4 CT outputs of 1A or 5A Class 1 are fed into the two orange terminals marked K-L. When using the CXM multi-meter version the max. CT ratio is 20000/5 or 4000/1. Note that the CX and CXM relays are sensitive down to a current of 0.010 A (10 mA) reactive. The CT input ratio of 1A or 5A is self selecting according to the max CT current measured. The CX relay is therefore sensitive enough to switch a 25 kvar capacitor step at 415V utilising a 10,000/5 CT, or 5 kvar step using a 10000/1 CT ratio, provided the max total current from the CT does not exceed 1 amp.

Function Switch Control Positions

The function control switch (H3) is located behind the removable front plastic nameplate. For the CX relay there are two push buttons (+ & -) located either side of the function switch. For the CXM (multi-meter version) the + & - keys are on the front of the relay. They also allow you to roll through the different measured values of U-I-P-Q-S-F-COSPHI.

If option "L" (fan control) is fitted there will be 2 additional DIP switches (S1/S2) located behind the name plate to select the 4 temperature alarm levels of 30-35-40-45 deg.C.
Factory setting of the function switch is 0 off - see below.

Multifunction Switch (H3) Rotate the switch to the position required with a small screwdriver

- 0 All steps switched off. If the relay is energised, when the function switch is turned to this position, the steps will be switched off after a time delay of 20 secs. If the + - keys are used in this position, you can select the threshold level at which you want the relay to show a capacitor step is defective. You can set this value between 10.....60% of the first recorded kvar value of each step. The factory setting is 50%, so the display will alternate between "50" and "0".
- 1 **p.f. target set**, selectable in the range of 0.70 lag ...1...0.90 lead; Lag is prefixed i Lead = c in display.
Factory setting = 1.0
- 2 **Switching time delay in secs**, selectable from 5 ... 1200 secs. Pushing button + or – for longer than 2 sec. enables rapid selection.
Factory setting: 60 secs.
- 3 **Fully automatic control of power factor correction bank.** LED Display will indicate the system power factor with either I for inductive or C for capacitive load (updated each 3 sec.) A flashing dot in display above the signs either + or – indicates, that the regulator is selecting a suitable capacitor, if available, to meet the reactive load demand. This adjustment is made every 3 secs.

The CXM relay will indicate COS ϕ - Power factor, U-volts, I –Amps, P-kW, S – kVA , Q – kvar, F - Hz

- 4 **Manual operation**

"H" will show in the display to indicate the relay is in "hand" control. Steps are switched in/out using the +/- buttons. The selected time delay per step (pos. 2) will be followed. This is useful when commissioning a bank where there is low or little load. Using the manual control steps can be switched in so as to create a leading power factor. Then put the function switch back to pos.3, for auto control and the relay should adjust automatically to the target pf. selected in Pos 1.

5 Selection of Step Limitation

This position limits the number of steps in circuit. e.g. if you have a CX12, twelve step controller, but only have nine steps connected, adjust this setting to 9. **Do not set to more than the number of steps on the relay as the defective step alarm will be triggered.**

6 Automatic display of failed Capacitors

Indication of either failed capacitor steps or unengaged outputs. Indication "Cd 05" (**Capacitor Defect No.5**) alternating with "**Cd 09**" indicates, that steps 5 and 9 are failing. "Alarm" (AL_ _) will be shown in the display. Once the fault on the failed steps has been rectified, the alarm signal is cleared by pressing buttons + and - for longer than 20 sec. "**Cd 0**" will show in the display to indicate the alarm is cancelled and there are no defective capacitors. (see also (Pos. 9 below)

7 Counter for the number of times each capacitor step contactor has switched.

The number of switching operations for each contactor are shown in the display, e.g. "OC_ 4" for capacitor step No.4 for 2 sec., then "248". This indicates, that contactor no. 4 has completed 248 switching operations. Other contactors can be selected by using the +/- buttons. The micro-processor stores the data for every 10 contactor switching operations. The stored data of all steps can be cancelled by depressing the +/- buttons together for more than 20 sec. Automatic control is active all the time!

8 Indication of Step kvar

This is a very useful way of keeping a check on capacitor step kvar outputs over a period of time. The value indicated on display is **a unit of value proportional** to the step size, but is not the actual kvar. This display will show for example, "**CC 10**" for the 10th step, followed by 2 numbers e.g. "**L 74**" and "**F 84**". "F" stands for the first sensed capacitor size during commissioning and "L" for the last measured value after, let's say several months or years. In this way a check can be kept on the change in kvar output of each step, if any. If the selected defective threshold level in pos. 0, is exceeded due to a failed capacitor or blown fuses, the CX or CXM eliminates this step from the control procedure and alarm "**AL**", appears in the display. The "L" and "F" values for each step can be scrolled through with + or - button, and this is a good check to do on regular capacitor bank maintenance. The stored values can be re-set by pushing buttons + and - together for longer than 20 sec. The regulator will store each step from the moment of re-set. Automatic mode remains active whilst these checks are made. The CXM regulators fitted with multi-meter option "**M**" (Indication of energy data) displays the measured capacitor sizes in real kvar provided the correct CT ratio factor has been inserted (see page 5)

9 Selecting and cancelling the alarm you require

Four alarm types are available and these are selected by scrolling through using the + - buttons, when the function switch is in position 9.

"**A_0**" All alarm indications cancelled. No alarm will appear in the display.

"**A_1**" Alarms will be shown, but will cancel themselves once the position has rectified itself.

"**A_2**" Any alarm recorded will remain in the display until the fault is rectified and the alarm is manually cancelled by pressing + - together for at least 20 secs.

"**A_3**" The alarm stored on the display is cancelled by pressing the + - buttons together for at least 5 secs.

This will re-set alarms for :

Low PF for at least 75 times step switching time, – display indication "AL_ "

Over Temperature if "L" option is fitted – display indication "HA" (Heating Alarm)

If both alarms are operating – i.e. Low PF and High Temp, the display will show "AH"

Once the alarm is cancelled the display will show "ArES"(alarm reset)

NB: if the Defective capacitor Step alarm has operated - with "AL_ " in the display, this can only be cancelled by going to Pos.6 on the function switch and pressing + - together for at least 20 secs.,

A Selection of a 2nd Power Factor Target, or an alarm

Some tariffs allow a lower power factor at certain times. For example at night in order to compensate for a leading pf on the system caused by the Capacitance of buried cable networks in cities. This position of the function switch allows you to select a second target PF, and this second target PF will be triggered by applying voltage between 150-240V 50/60Hz on NT1/NT2 – see wiring diagram. If option "L" is fitted, the lower PF will automatically come into operation if the ambient temperature rises above 57° C.

- B Selection of asymmetrical Switching Time Delay.**
Rapidly changing reactive loads can cause excessive wear on contactors (eg Arc Welders, Crushers or Strip Mills). In this case it is useful to use asymmetrical switching of FAST IN/SLOW OUT. The ratio is set using the + - buttons. If we have "1" (Factory setting) we have equal times for switch in and switch out , as selected in pos. 2. By selecting any number between 1.....99 we can vary the switch out time up to 99 times the switch in time. i.e. if we set to "10" (display Y_10) and have selected a switch time of 5 secs., in Pos 2, we switch in after 5 secs of lagging kvar demand, but only switch out after the leading kvar has exceeded the threshold for 5 x 20 secs + Lock out time (see Pos C). If it is required that the switch out time is quicker than the switch in time (reversal of the above situation) this can be achieved but must be ordered when the relay is built.
- C Selection of Lock Out Time at each Change of Switching Direction**
This position allows adjustment of the lock out time on load reversal and on initial energising. If we set to **L_30** we have 30 secs lock out time, in addition to the time selected in Pos. 2. This will operate each time we have load reversal, thus helping to reduce contactor wear. The lock out time is adjustable from 1...254 sec.;
Factory setting = 30 secs ("L_30")
- D Selection of C.T.Ratio .** This is only applicable for CXM relays. Please see the section of these instructions "**CXM Multi-Meter version**" On the CX relay the display will be non-operative in this position and will show "_not"
- E Selection of V.T. Ratio** This is only applicable on CXM relays. Please see the section of these instructions "**CXM Multi-Meter version**" On the CX relay the display will be non-operative and will show "_not"
- F Selection of Switching Program.**
The switching programs are selected using the + - buttons:
- "Auto" - Fully automatic self selection of capacitor steps in order to achieve the required power factor with no pre-determined switching sequence. Relay voltage measurement L2-L3
- "1 1 1 1": Sequential switching in/out with fully automatic recognition of each capacitor size.
This program could be selected for **tuned filter banks** where it is essential that each tuned step is switched sequentially.
- "Eaut": identical to "Auto", but for **single phase operation, with relay measurement voltage taken from L1-N**
- "E111": identical to "1111", but for **single phase operation with relay measurement voltage taken L1-**
Factory Setting "Auto"

Commissioning

- Apply the supply, measurement and control voltages. Connect the current transformer, and remove any short circuit link. Make sure the Current Transformer is positioned so as to measure the total current of the system including the capacitor bank current. On a 3 phase system the measured voltage L2-L3 must always be taken from the two phases on which the CT is not mounted, i.e. if the CT is on L1, voltage supply must be from L2-L3. If a change must be made on site it is preferable to change the voltage connections rather than the CT so as to avoid the risk of an open circuit CT.
If the supply is single phase, the appropriate setting must be selected on "F" of the function switch with measured voltage connections (L2-L3) changed to single phase.
Indication "I—O" : No current or less than 10mA is flowing in the CT circuit.
If capacitor steps are energised, they will be automatically disconnected after 5 minutes. If the relay is in manual mode, (Pos.4) the steps will stay in circuit.
Indication "U—0" measuring voltage is below 50 V or not connected.
The relay will start to control if the measured voltage (L2-L3) is at 50 volts or above, and the reactive component of the measured current is 10mA or above.
If the measured voltage falls below 50V, energized steps will be switched off after a 2 sec time delay in both automatic and manual mode.
- Factory Settings of Function Switch**

Power factor target = 1	C.T. Ratio = 100
Step switch time = 60 secs	V.T. Ratio = 1
Step limit switch = Max of controller	Switch Mode = Auto

Changes can be made using the function switch, but remember any changes **will only be stored in the memory when the function switch is put in pos. 3** after the change has been made.

3 Ensure that multifunction switch (H3) is set to pos. 3 (Automatic mode)

- 4 The relay has a no-volt release lock out time of 90 secs when first energised. No switching will commence until this time has expired.
- 5 Check preset power factor target in pos. 1 and adjust to required value if necessary.
- 6 Check preset switching time delay pos. 2 and adjust to required value if necessary.
- 7 Check preset step limitation and adjust if necessary to the number of steps in circuit. If any one step is not functioning for any reason, the CX or CXM will try to switch three times to ensure that there is no detectable Output, and it will then lock out this step for a period of 24 hours at least. This lockout will last until there is a cancellation of the Cd alarm (see pos 6) or a loss of supply. The relay will try to switch each defect step again three times and will then permanently disconnect them, with the alarm indication "Cd" in the display.
- 8 Check preset alarm mode and select in pos. 9, if requested.

9 Set the function switch back to pos. 3 – Auto operation

- 10 Display indicates the current power factor cos phi e.g. "i 0.87" for inductive or "c 0.94" for capacitive load.
- 11 If wired correctly after the no volt release lock out time of 90 secs, if there is an inductive load, a "+" dot in the display will start to flash. This indicates the relay is calling for capacitor steps, and switching will commence in accordance with the selected switching time delay to achieve the target power factor. As each step switches, so the system power factor in the display must change. When the target PF has been reached the "+" LED will extinguish. When there is an excess of capacitive kvar the "-" LED will come on and capacitor steps will be switched out so as to achieve the target power factor.
- 12 With the CX or CXM relay it is not necessary to preset any C/k-value (threshold level when to start to switch a step in/out). The relay selects the most suitable capacitor size to meet the target power factor. Consequently capacitor kvar sizes may be mixed. Each time they are switched the reactive output unit of value for each step will be recorded in the CX or CXM relay memory and re-called as required. If all capacitor steps are of equal kvar value, the CX or CXM will switch in rotation so as to provide equal wear on the contactors. For special applications where sequential switching is required (1:1:1:1: etc) this is possible using Pos.F.
- 13 It may happen, that either + or – dots are flashing steadily and the regulator will not switch on/off any step. This is because it is not able to find a suitable step size to meet the target PF. No dot flashes once the target PF is achieved.
- 14 If there is no load on the system at the time of commissioning, put the function switch in pos. 4 "manual control" and bring the steps in by pressing the + button, so as to create a leading power factor. Make sure that the supply voltage to the relay is at least 110V (normally for the UK it will be 415V). Now change the function switch to Pos. 3 (Automatic switching). The CX or CXM relay must now sense a leading power factor and switch the steps out until the target p.f. is achieved. If the relay does not switch the steps out check that the C.T is on the correct phase in relation to the measured voltage L2-L3. i.e. the phase on which L2-L3 are *not* connected), and check that the relay is not reversed – i.e. reading lag when it should be reading lead. If this is the case, de-energise the relay and swap over L2-L3.

Once the required settings or alterations have been made, set function switch (H3) to position 3 "automatic" and replace the front cover plate, so as to inhibit unauthorized interference with relay settings.

Alarm Functions

- 1 Power Factor Alarm** (Display shows: "AL_")
If the predetermined power factor is not obtained in case of insufficient capacitance, the alarm signal is triggered after elapse of 75 x the selected step switching time, valid for both directions lead and lag. If the set target p.f. is exceeded due to overcompensation (welded contacts) after elapse of 75 x the selected step switching time, (**Pos 2**) this alarm will be triggered and "AL_" will be displayed, alternating each 5 secs with any other display selected. To reset the alarm put function switch in **Pos 9** and select A_3 (see **Pos 9** in **control** section)
- 2 Failed Capacitor Step Alarm** (Display shows "AL_")
This symbol will appear at 5 secs. Intervals with any other display. This alarm can only be cancelled as detailed in **Pos 6**
- 3** If the supply voltage to the relay and hence the capacitor bank fails, there is no indication in the display, but contacts M-MO will close and M-MS will open. Provided an external power source is connected to these terminals rated at 3A 250V 50/60Hz, a signal can be given to a BMS system for example.

Data Transmission

Software "WINBSTO" (WIN95/98/ME/NT/2000XP) data logs the date and time for each change in events :
power factor – steps in circuit – steps switched in/out - any triggered alarms.

Each switching operation of the regulator activates 2 telegrams via TTL-interface (14-pole plug on the rear of casing), one before and one after switching procedure. This provides analysis of the compensation effect as each step operates. To store the data on a PC, a data cable with integrated converter TTL/RS232 is required. (data Cable No.8 length 200mm). As an alternative to having PC on site, the data output from the CX relay can be fed into our Data Logger available as follows:

DS 21 – 0,256 MB (Approx 2500 events recorded)
DS 22 – 0.512 MB (Approx 5000 events recorded)
DS 23 – 1.024 MB (Approx 10000 events recorded)

The Data Logger can then be taken to the PC for downloading using a WORD programme.

Optional Features

Option "L" This option has 2 functions:

- 1 Fan Control**
It is very important to monitor the ambient air temperature inside a capacitor cubicle, especially if harmonic blocking reactors are fitted. This is achieved with option "L" If this option is fitted there will be two DIP switches behind the name plate which trigger a volt free alarm contact LF/LF1 rated at 5A 250V 50/60Hz. The contact will close at the temperatures listed below:

Temperature	30°	35°	40°	45°
DIP S1	OFF	ON	OFF	ON
DIP S2	OFF	OFF	ON	ON

The ambient temp must be held for a period of 48 secs before the contacts operate. This starts an 8 minute time window. If the temp remains above the target for 48 secs, even though the fan is running, then another time window of 8 mins. will be activated. If the temp is below the target for at least 48secs., then the contacts will open for a period of 8 mins at least until that time window has expired. To cancel the alarm see **Pos 9 A_3**

- 2 2nd Power Factor Target (High/Low Tariff)**
As described in pos "A" of the multifunction switch (H3), a second target power factor may be applied at times when this lower power factor is permitted by the Power Utility without penalisation. This will extend the life of capacitors, contactors and also reduce energy absorbed due to watt losses in the equipment. The second target PF can be set in the range 0.70 lag...1.0... 0.90 lead. When a voltage of 150...240V 45/65 Hz, is applied across NT/NT1 the relay will switch to the second target PF. When no voltage is applied, the first target PF is applied.

Option "LT":

This option activates the lower PF target automatically when the ambient temperature rises above 57°C, thus reducing the kvar in circuit and hence the heat generated by the installation. If option "L" is fitted the temp alarm contacts will also be operating. Note it is not possible to have "LT" and "NT" – you have to select only one of these options.

Option "M" – Relay Types CXM

Regulators with this option are fitted with a modified fascia with two keys + and - which replace the push buttons behind the name plate on the CX type. This option necessitates the setting of a CT and VT ratio in order to provide the correct indication in the LED display. On large loads an automatic change of scale from kW to MW is provided. For example when the display reads 9999 kW the next increase will show 10.0 MW. Readings are up-dated every three secs.

The CT/VT ratios are set in **Pos D and E** of the function switch.

D = c.t.-ratio:

using key + or – in the range of 1....4000 (e.g. 800A/5A =160)

Factory setting = 100. Holding the + - for longer than 2 secs enables rapid roll through.

E = v.t.-ratio:

using key + or – in the range of 1.0....350.0 (e.g. 20 kV/0.1kV =200)

Factory setting = 1.0. Holding the + - for longer than 2 secs enables rapid roll through

Relay type CXM indicates following energy data selectable by using key + or -:

C	Power Factor
U	Measuring voltage
I	Current in selected phase
P	Total 3 phase active Power*
S	Total 3 phase apparent Power*
q	Total 3 phase reactive Power*
F	Frequency

* Assumes balanced load.

Option "k"

Combi Filter Switching Program

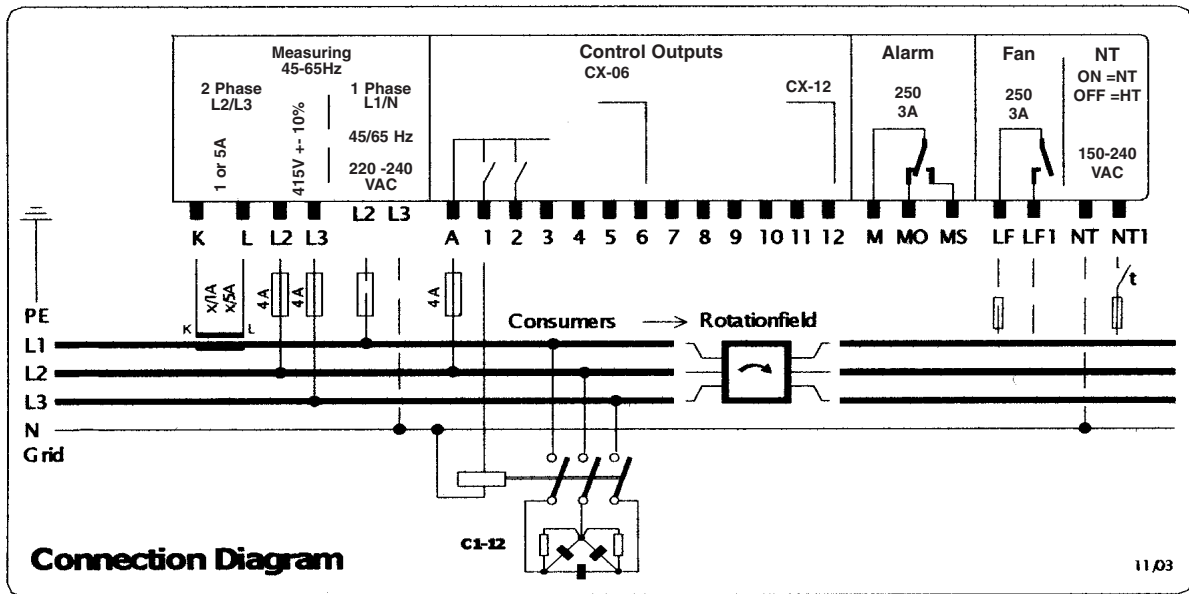
A Combi Filter is employed when two separate frequencies must be blocked :

- The harmonic frequency from the mains supply and
- The Impulse Frequency sometimes used by Utility Companies to give switching commands, for example for switching street lighting according to required times. These impulse switchings are usually made in the range of 160-190Hz.

Option "k" will ensure that the more heavily choked capacitors will switch first (odd step numbers) and the less heavily choked capacitors will be switched second (even step numbers).

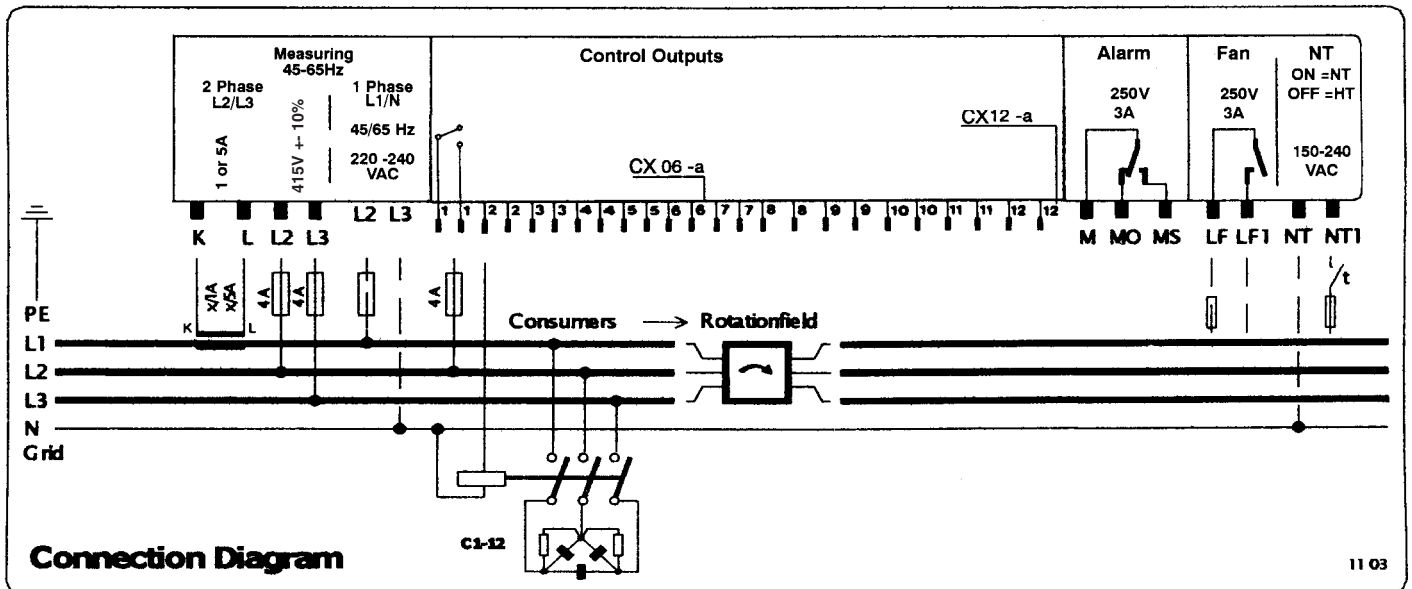
Option "k" must be ordered when the relay is built.

Connecting Diagram - Common Point Switching



Normal Voltage Connection is L2 - L3 415V +- 10% unless othrehwise specified on the order.
 L1 - N connection ONLY used when relay is specified for single phase supply in which case the connections
 L2 - L3 are not made

Connecting Diagram - Volt Free Switching Type CX-A



Normal Voltage Connection is L2 - L3 415V +- 10% unless othrehwise specified on the order.
 L1 - N connection ONLY used when relay is specified for single phase supply in which case the connections
 L2 - L3 are not made

Control Equipment

