STATIC CAPACITOR BANKS
FOR FAST POWER FACTOR COMPENSATION
TYPE EMK

(CIRCUTOR Patent Nr. 542258)

INSTRUCTION MANUAL
M 981 187/ 98A

INDEX

1.- INTRODUCTION

The **EMK** static capacitor banks are provided for the power factor compensation in installations where the load imposes large and fast current fluctuations. The static capacitor banks use **thyristors** to switch the capacitors ON and OFF , instead of the classical switch gears used in the conventional equipment for PF compensation. They give the advantages of fast operation and absence of disturbances during the ON-OFF switching.

2.- DELIVERY SPOT CHECK.

Before installing or manipulating the static bank, please verify the following points:

- Check that the equipment corresponds to your order specifications.
- Check that no damage was done in the shipment process.
- The capacitor bank requires a current transformer (CT) to operate. Check if the mentioned CT is already installed or otherwise if it has been included in the order and delivered.
- Check that the supply voltage of the equipment corresponds to your needs.
- Follow the instructions of paragraph 5 concerning installation and setup.
- If you observe any problem in the delivered equipment, please contact CIRCUTOR sales service , Tel 34-3- 7861900

3.- TECHNICAL CHARACTERISTICS.

3.1.- Electrical characteristics.

Supply voltage*	230 ó 400 Vac , +10 / -15%
Frequency*	50 ó 60 Hz , ± 1%
Maximum ambient temperature	-10 / 45ºC
Fast PF regulator	COMPUTER 6f , up to 6 steps
Step programs	1:1:1,1:2:2 commutable , 1:2:4 , special
Outputs	Static , MOS type
Step commutation speed	Adjustable , 80 a 800 ms
PF adjustment	0,85 Ind. to 0,95 Cap.
Current measuring	External CT (current transformer) In/5A
CONSTRUCTIVE STANDARDS	UNE-EN 60831, EN 60439, UNE 21 136 , UNE-EN 50178

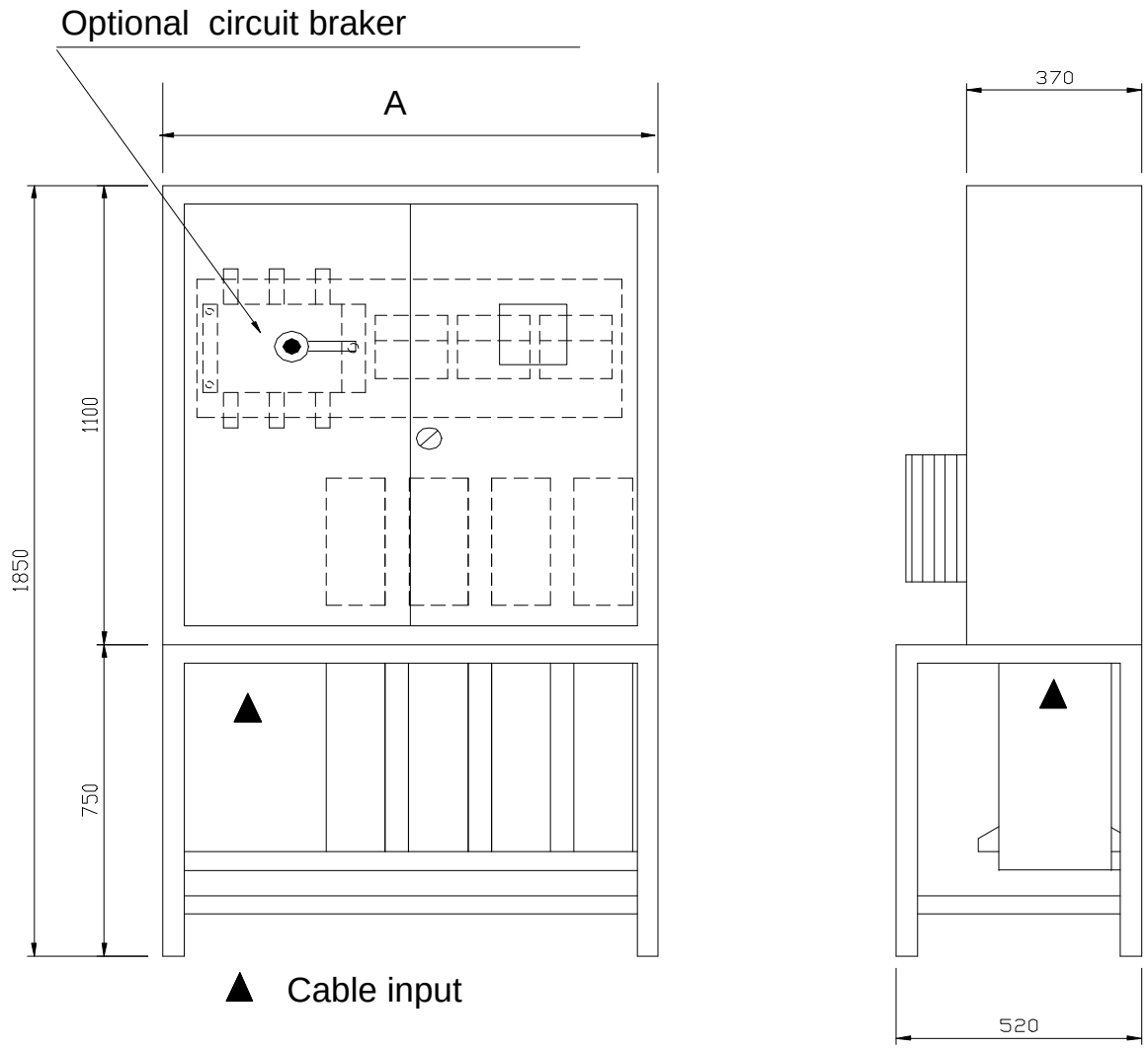
* Other values of V and/or f , under request.

3.2.-Standard types: Power, steps configuration and dimensions.

400 V , 50 Hz Supply					
Type	**Code**	**Steps config.**	**Program**	**kvar**	**Dimensions (mm)**
EMK-4-105-400	4 45 471	15 + 30 + 60	1:2:4	105	1050 x 520 x 1850
EMK-4-140-400	4 45 472	20 +40 + 80	1:2:4	140	1050 x 520 x 1850
EMK-4-165-400	4 45 473	15 + 30 + (2x60)	1:2:4	165	1050 x 520 x 1850
EMK-4-200-400	4 45 474	40 + (2x80)	1:2:2	200	1050 x 520 x 1850
EMK-4-220-400	4 45 475	20 + 40 + (2x80)	1:2:4	220	1050 x 520 x 1850
EMK-4-280-400	4 45 476	40 + (3x80)	1:2:2	280	1050 x 520 x 1850
EMK-6-330-400	4 45 477	30 + (5x60)	1:2:2	330	1500 x 520 x 1850
EMK-6-360-400	4 45 478	40 + (4x80)	1:2:2	360	1500 x 520 x 1850
EMK-6-440-400	4 45 479	40 + (5x80)	1:2:2	440	1500 x 520 x 1850
EMK-6-480-400	4 45 480	6 x 80	1:1:1	480	1500 x 520 x 1850

230 V , 50 Hz Supply					
Type	**Code**	**Steps config.**	**Program**	**kvar**	**Dimensions (mm)**
EMK-4-70-230	4 45 451	10 + 20 + 40	1:2:4	70	1050 x 520 x 1850
EMK-4-82.5-230	4 45 452	7.5 + 15 + (2x30)	1:2:4	82,5	1050 x 520 x 1850
EMK-4-100-230	4 45 453	20 + (2x40)	1:2:2	100	1050 x 520 x 1850
EMK-4-110-230	4 45 454	10 + 20 + (2x40)	1:2:4	110	1050 x 520 x 1850
EMK-4-140-230	4 45 455	20 + (3x40)	1:2:2	140	1050 x 520 x 1850
EMK-6-165-230	4 45 456	15 + (5x30)	1:2:2	165	1500 x 520 x 1850
EMK-6-180-230	4 45 457	20 + (4x40)	1:2:2	180	1500 x 520 x 1850
EMK-6-220-230	4 45 458	20 + (5x40)	1:2:2	220	1500 x 520 x 1850
EMK-6-240-230	4 45 459	6 x 40	1:1:1	240	1500 x 520 x 1850

3.3.- Mechanical characteristics.



TYPE	A (mm)
EMK4-xxx-xxx	1050
EMK6-xxx-xxx	1500

Figure 1.- Dimensions

Cabinet	metal sheet 1,5mm , epoxi painted
Protection degree	IP 21
Dimensions	See fig. 1
Weight	According to types table
Circuit breaker module	Optional

3.4.- Accessories

Accessory	Type
Current transformer (CT)	Compulsory (Type according to rated I of the installation)
Cabinet cooling set (Fan + Thermostat)	Option
Circuit breaker (sizes from 400 to 1000 A)	Option

4.- INTERNAL WIRE DIAGRAM .

A simplified wire diagram showing only the first step of the EMK is represented in fig. 2. The power circuit for successive steps is analogous, i.e. , each thyristor and capacitor set, forming a step, is connected in parallel to L1, L2, L3 through the respective fuse. Each thyristor block (3 modules) is driven by a CPC card which receives the command signal through two wires coming from COMPUTER 6f output (potential free MOS contact). One of the wires is the common , C , connected to COM in the CPC, and the other comes from one of the outputs (C2 , C3 ... C6) corresponding to the driven step.

5.- SYSTEM BLOCKS

From the electrical point of view , the **EMK** is formed by the following blocks (see electrical wire diagram in fig. 2).

Power steps : Each EMK consists of 4 or 6 power steps. Each step is formed by a three phase capacitor, three thyristor modules (two antiparallel thyristors each) controlled by a unique **CPC** card and the protection devices (fuses , di/dt limiting inductance and heat sink for cooling.

Fast PF regulator, COMPUTER 6f: A PF regulator controls up to six power steps. The regulator measures the voltage across two phases and current from the third (by means of an **external current transformer** with a ratio In/5A) , and it controls the connection and disconnection of capacitor steps through the static switches.

Zero crossing control module (CPC): There is a CPC card for each of the power steps. The CPC card takes care of the ON and OFF switching , connecting at zero voltage and disconnecting at zero current.

A more detailed description of the PF regulator and the CPC controller card follows.

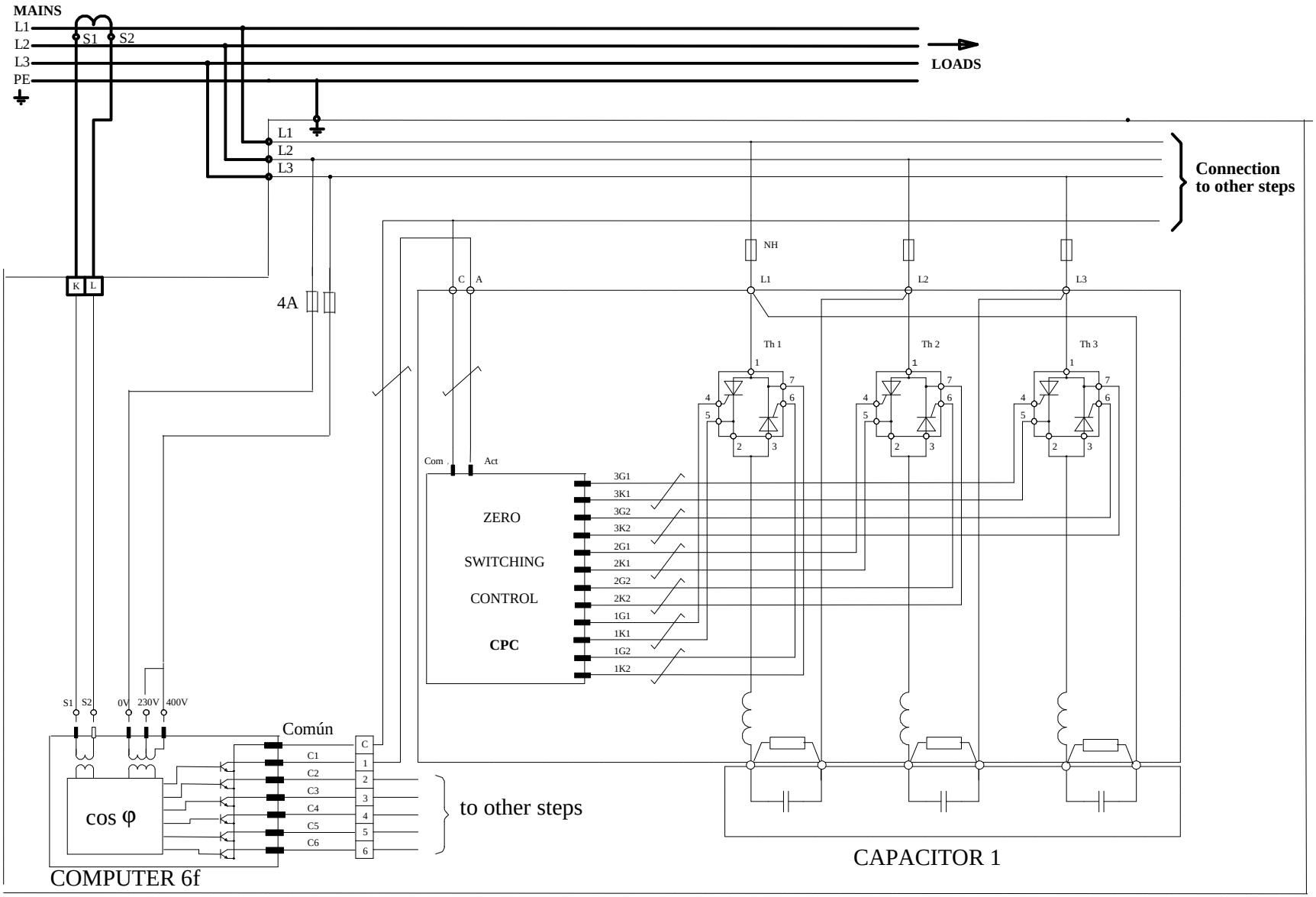


Figure 2.- Wire diagram showing the regulator and the first power step.

6.- FAST PF REGULATOR , COMPUTER 6f.

The COMPUTER 6f is a fast response PF regulator designed for the control of thyristor driven capacitor banks. It's based on a microprocessor and microelectronic devices which perform the measuring and control functions , and is provided with isolated MOS outputs. It gives a standard response time of 160 ms/step , but it may be adjusted to other values

Figure 3 shows the external controls and display signs placed on the frontal and the rear part of the regulator.

A-B Numerical display: During normal operation shows the cos φ . The sign -- indicates that the current measured through the CT is below the sensitivity limit (no capacitors connected in this situation). The sign **ti** means that the CT is not properly connected (wrong phase or S1-S2 reversed. **Note:** This sign appears only when automatic adjustment of C/K is performed , see paragraph 8.4)

C Push button: When pushed , the display shows the number of connected steps

D , E LEDs: Light ON when the measured cos φ is inductive (D) or capacitive (E).

F LED: Lights ON when C is pushed. In this case the display AB shows the number of connected steps.

G , I Push buttons: Allow the manual connection (G) or disconnection (I) of capacitor steps. The operation is delayed approximately 5 seconds.

J C/K factor adjustment: See paragraph 8.4.

K PF adjustment potentiometer: Usually set to 1.

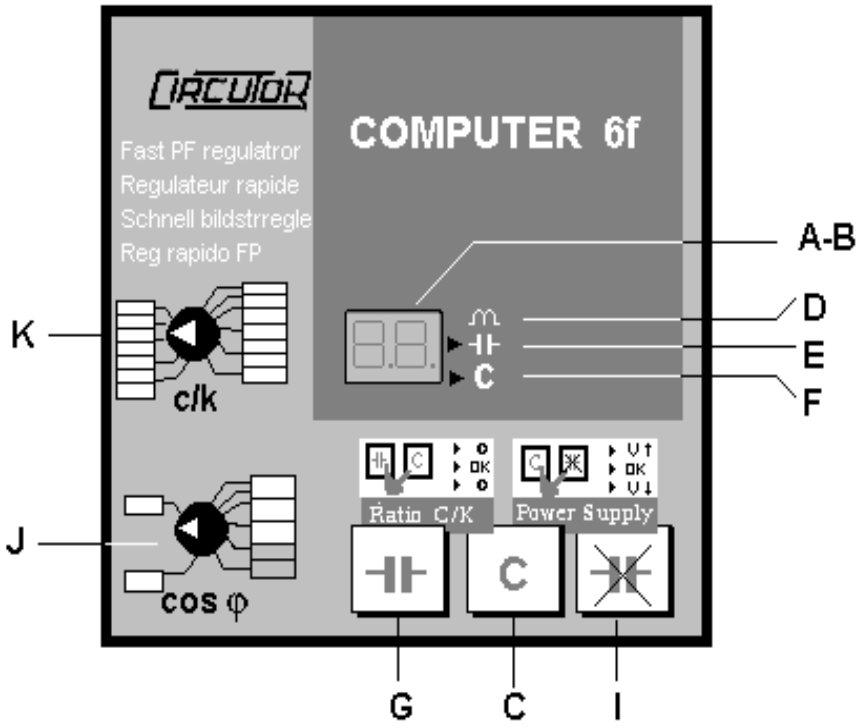
C+I Supply test buttons: Pushing simultaneously these two buttons the LEDs D, E and F show whether the voltage is high, low or OK.

C+G Automatic C/K adjustment: May be used only if all the loads are disconnected. When pushing the buttons C and G, the 1st step will connect and the knob J must be adjusted until the LED E lights.

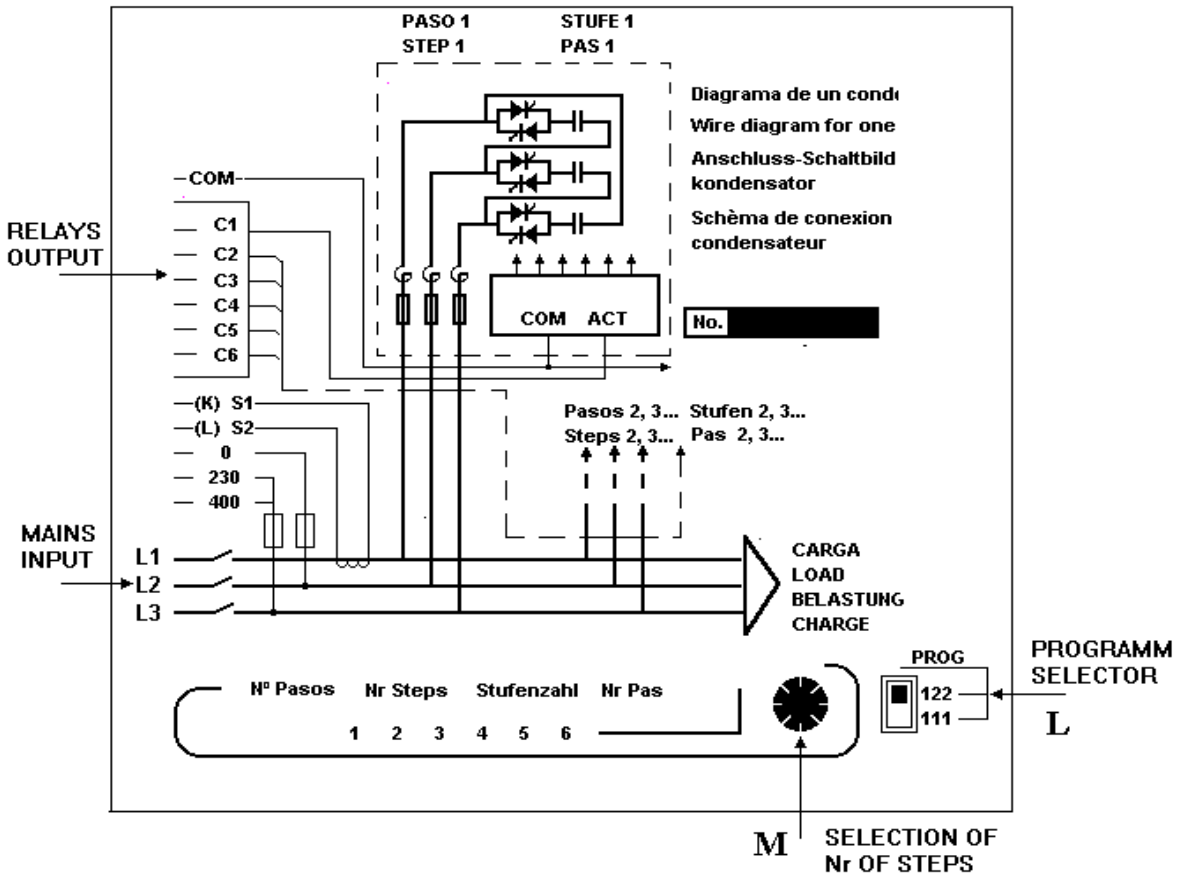
L Program selector: Selects program 1:1:1 or 1:2:2 (1:2:4 with special regulator). This selection has to be according to the power rating of the different capacitor steps.

M Selector of Nr. of steps: Selects the Nr. of available steps up to 6.

NOTE: Except **J** and **K** potentiometers , all the other adjustment controls are set at the factory.



a) Front view



b) Rear view

Figure 3.- COMPUTER 6f : Control and adjustment elements.

7.- ZERO SWITCHING CONTROL MODULES (CPC).

The standard CPC cards are the CPC-400I , provided for 400 V phase to phase or the CPC230I , provided for 230 V. These cards take the supply voltage from the thyristor blocks. For special supply voltages, the CPC-230E, with separate supply is usually employed. The supply voltage is always fed through an isolating transformer , protected at the primary side by a fuse of 0,1 A.

Each CPC card is connected to the thyristor blocks through a 12 terminals connector. The voltage at each end of the thyristor blocks is used to synchronize the firing at zero voltage. The ON-OFF enable signal from the COMPUTER 6f is connected to a set of 2 separate terminals named COM and ACT (see figure 4).

All the signals between the CPC card and the thyristor blocks (synchronism, firing pulses and supply) are connected through optocouplers or the supply transformer, so that the electronic circuits are galvanically isolated from the power circuit.

The CPC card has three red LEDs showing the ON-OFF state of each phase. There is also a connection , usually cabled to a remote LED card placed at the cabinet door. The LED at the door indicates whether the step is ON or OFF.

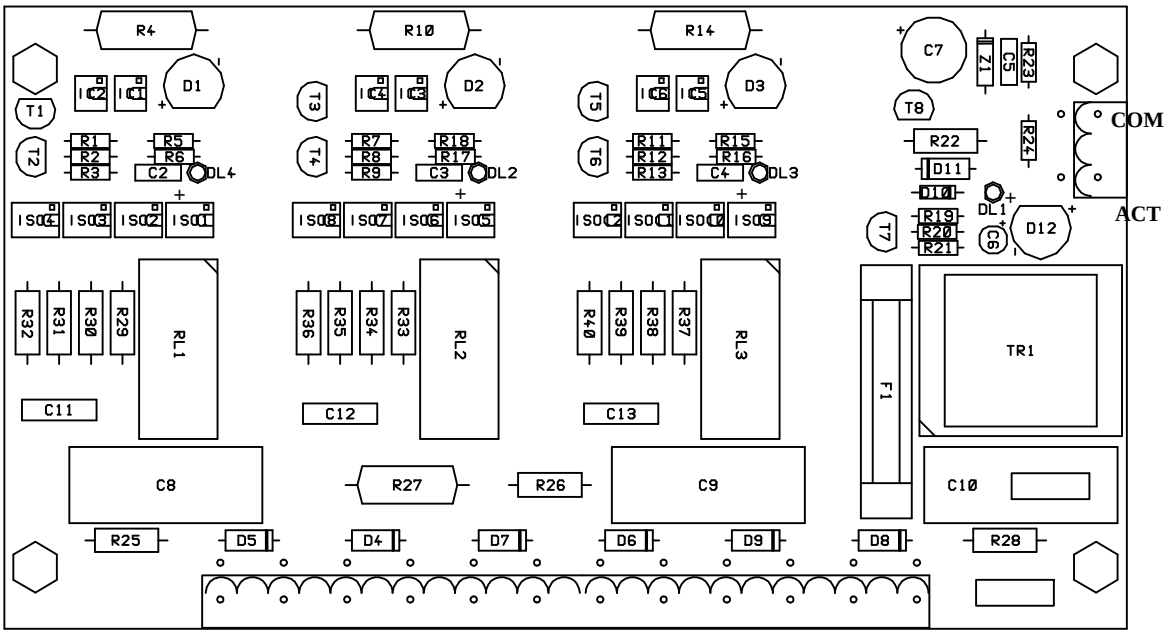


FIGURE 4.- Layout of CPC control card

8.- INSTALLATION AND START UP.

To install and start up the first time an **EMK** capacitor bank , follow the steps below:

8.1.- Initial checking (Before the connection to supply)

- Check that the rated voltage for the equipment , shown in the characteristics plate , matches with the phase to phase voltage at the supply where the bank has to be connected.

- Check that the rated power shown in the plate of the bank corresponds to the needs.

8.2.- External wiring (Check before the application of the supply voltage)

- All the external cables have to be connected to the I/O terminals of the **EMK** cabinet.

- The external wiring of a static capacitor bank is similar to a conventional capacitor bank using switchgears. The figure 2 shows a diagram including external wiring and internal connections to a single step (other steps will follow the same pattern).

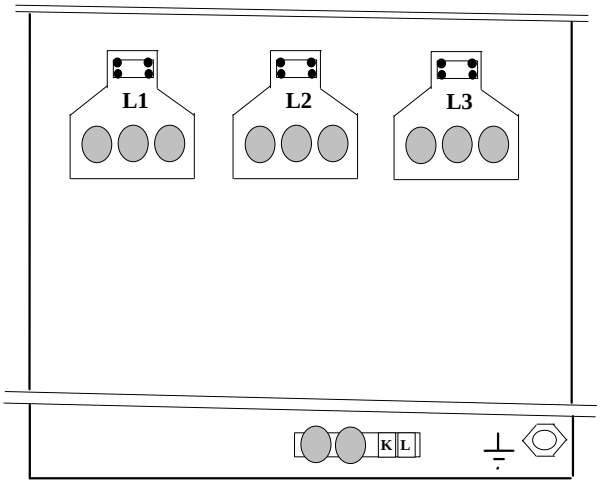


Figure 5.- External wiring terminals

Power wiring: Connect the power cables to terminals **L1 , L2** and **L3** . The bank does not need a neutral connection. The power cables must be sized according to the power of the capacitor bank.

Earthing: Connect the PE cable to the terminal marked as earth.

Connect the CT (current transformer) secondary cables to **K, L**.

The current transformer must be always placed at phase L1 , measuring the total current of load + capacitors. (See figure 6).

- The PF regulator connections may be seen in figure 2. Notice that the voltage inputs must always be taken from phases L2 and L3 , choosing the suitable input of 230 or 400 V , depending on the phase to phase voltage at the line to be compensated.

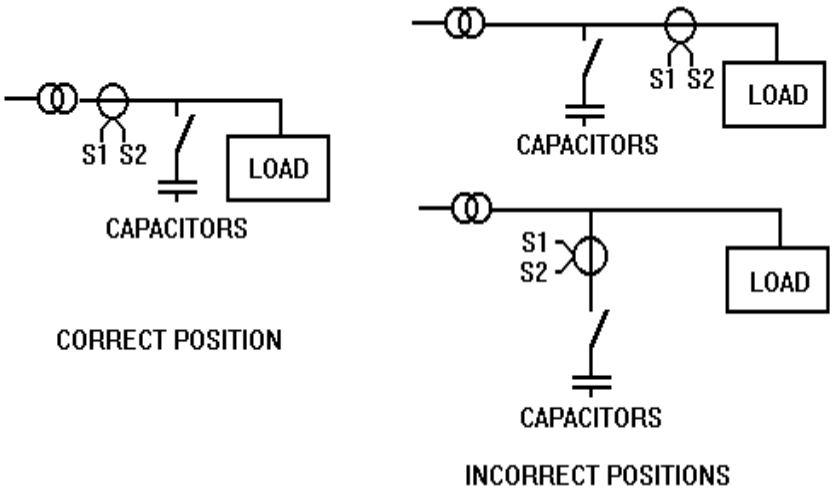


Figure 6.- Position of the current transformer

¡ATTENTION! Let enough free space at the area next to the heat sink to guarantee the correct cooling. The ambient temperature should no be higher of 40º C. In case of higher temperatures a forced cooling must be provided.

If the ECK has to be connected close to a powerful transformer or if it is provided that overvoltages may exist , it is advisable to protect the equipment with some type of overvoltage protection (se types STAE and ST440R from CIRCUTOR S.A.)

8.3.- COMPUTER 6f adjustments.

- The cos φ potentiometer must usually be set to 1.

- The **C/K** factor must be adjusted according to the kvar of the lower step and depending on the primary/secondary ratio of the current transformer. The right value for adjustment is:

$$C/K = \frac{1000 \ . \ Q\ (kvar)}{1{,}73 \ . \ Uc \ . \ Ip/Is}$$

where Q(kvar) = kvar of the smaller capacitor step , Uc = phase to phase voltage
Ip/Is = current transformer ratio (example: for a 1000/5 CT , Ip/Is = 200)

-The **C/K** value may also be obtained from tables 1 or 2 , which gives this value for different supply voltages, CT ratios and kvar values of the smaller capacitor step.

- Check at the rear switch of the COMPUTER 6f the selection of program 1:1:1 (all capacitors equal) or 1:2:2 (1st step half the power of the others). Program 1:2:4 is also available with a special regulator identified by a label 1:2:4 beside the switch.

TABLE 1.- C/K values for lines at 400V (phase to phase)

Current	POWER OF THE LOWER CAPACITOR STEP (kvar)						
Trans.	10	20	30	40	50	60	80
150/5	0,48	0,96					
200/5	0,36	0,72					
250/5	0,29	0,58	0,87				
300/5	0,24	0,48	0,72	0,96			
400/5	0,18	0,36	0,58	0,72	0,87		
500/5	0,14	0,29	0,45	0,54	0,72	0,87	
600/5	0,12	0,24	0,36	0,48	0,60	0,72	0,96
800/5	0,09	0,18	0,27	0,36	0,45	0,54	0,72
1000/5	0,07	0,14	0,22	0,29	0,36	0,43	0,57
1500/5	0,05	0,10	0,14	0,19	0,24	0,29	0,38
2000/5		0,07	0,11	0,14	0,18	0,22	0,28
2500/5		0,06	0,09	0,12	0,14	0,17	0,23
3000/5		0,05	0,07	0,10	0,12	0,14	0,19
4000/5			0,05	0,07	0,09	0,11	0,14

C/K values for lines at 230V (phase to phase)

Current	POWER OF THE LOWER CAPACITOR STEP (kvar)						
Trans.	5	10	15	20	30	40	60
150/5	0,42	0,84					
200/5	0,31	0,63	0,94				
250/5	0,25	0,50	0,75	1,00			
300/5	0,21	0,42	0,63	0,84			
400/5	0,16	0,31	0,47	0,63	0,94		
500/5	0,13	0,25	0,38	0,50	0,75	1,00	
600/5	0,10	0,21	0,31	0,42	0,63	0,84	
800/5	0,08	0,16	0,24	0,31	0,47	0,63	0,94
1000/5	0,06	0,13	0,19	0,25	0,38	0,50	0,75
1500/5		0,08	0,13	0,17	0,25	0,33	0,50
2000/5		0,06	0,09	0,13	0,19	0,25	0,38
2500/5		0,05	0,08	0,10	0,15	0,20	0,30
3000/5			0,06	0,08	0,13	0,17	0,26
4000/5				0,06	0,09	0,13	0,20

8.4.- System start up.

- Connect the supply voltage to the **ECK** equipment and check if it is performing correctly by observing the PF regulator display and controls.

- The fast connection and disconnection of steps has to be considered a normal operation for a static capacitor bank in case of highly fluctuating loads. If the load is steady and the capacitors are continuously switched ON and OFF , check the COMPUTER 6f adjustments. (see paragraphs 6 and 8.3)

¡ ATTENTION! For service purposes switch OFF the equipment. After that, a safety time of 3 minutes must elapse before any manipulation inside the equipment to allow the discharge of the capacitors.

9.- TROUBLE SHOOTING.

The capacitor bank should operate only if there is a minimum load. If the equipment does not work properly check the following points:

9.1.- If the display of the COMPUTER 6f does not light or gives a very slight bright , check the supply voltage and the fuses (power and control fuses)

9.2.- If the display shows the sign -- means that the COMPUTER 6f sees a current below the minimum threshold. Check the CT connections and the C/K adjustment.

9.3.- If the display shows a numerical value and the bottom LED pointing to the letter C is lighting , means that the COMPUTER 6f is measuring a capacitive load. If the expected is an inductive load then check the CT connections (Try to reverse the wires connected to terminals K and L)

9.4.- During the normal operation , check the number of connected steps by pushing the key **C** in the COMPUTER 6f. Notice that in case of programs 1:2:2 or 1:2:4 , the capacitors having a power of 2.P1 or 4.P1 (P1= Power of the 1st step) are counted as 2 or 4 steps.

9.5.- Check that the number of connected steps coincides with the Nr. of steps shown by the COMPUTER 6f . To see whether a step is or not connected , see the red LEDs at the CPC card. The three LEDs must light simultaneously , otherwise indicates that there is one of the phases which does not work properly or the discharge R is open.

9.6.- If one of the steps is never connected, try to force its connection by jumping the terminals COM and ACT in the CPC card. If the step connects in the forced mode, then the fault may be in the COMPUTER or in the wiring.

9.7.- If there are some inactive steps and the COMPUTER shows a lack of compensation , check the settings of such COMPUTER.

9.8.- Once the normal operation is achieved , check if the current consumption of each step is correct, according to its rated power (Current shown in characteristics label). An excess of consumption may be due to an excess of supply voltage or to the presence of harmonics.

9.9.- In case of a faulty operation which may not be solved with the above indications , contact the CIRCUTOR S.A. technical service.

¡IMPORTANT! After one hour in normal operation , check the temperature of the heat sinks. With an ambient temperature below 40ºC the heat sink must be below 80 ºC. In case of higher temperature check the cooling conditions.

10.- MAINTENANCE.

10.1.- Yearly inspection.

- Inspect the equipment visually and check the temperature of the capacitors and the thyristor heat sinks.

- Check that all the steps operate when necessary. Otherwise check the fuses.

- Check that the supply voltage is within the limits.

- Check that the current of each step is in accordance with its labeled value. A higher current may be due to the presence of harmonics. A low current may indicate a faulty capacitor.

- Check that there are not loose connections at the terminals.

11.- TECHNICAL SERVICE AND WARRANTY

All CIRCUTOR products are covered by a warranty of 1 year in case of any manufacturing default . The warranty does not cover the protection elements like fuses or other neither the elements subject to aging in normal service.

This warranty will not be applicable in case of wrong manipulation or in case that the rules of installation have not been respected.

CIRCUTOR offers to all its customers the assistance of its TECHNICAL AND ENGINEERING departments.