POWER FACTOR CORRECTION FILTERS WITH STATIC SWITCHING

FRE SERIES

(CIRCUTOR Patent Nr. 542258)

INSTRUCTIONS MANUAL

M 981 212 / 00A

1.- GENERAL DESCRIPTION

The **FRE** are static capacitor banks which are also equipped with harmonic filters (usually 7% rejection filters). The static capacitor banks use **thyristors** to switch the capacitors ON and OFF , instead of the contactors used in the conventional equipment for PF compensation. The static switches allow the connection and disconnection of capacitors without any transients and thus the FRE equipment is specially suitable for the power factor compensation in installations having high harmonic contents and where the load imposes large and fast current fluctuations. The maintenance for such equipment is minimal since the stress imposed on all the components is very low and perturbations generated by other conventional equipment and which may disturb electronic and computer equipment are completely avoided. **FRE** equipment is controlled by a fast power factor controller **COMPUTER (*)** which is able to perform up to 14 operations/sec if such a fast response is required.

In this manual we assume three phase PF compensation equipment. On request , equipment using single phase static switches may be supplied , giving response to some specific applications. (The most typical are welding and soldering machines)

(*) The PF controller must be a fast type. For details on installation and set up see the manuals of COMPUTER 6f or COMPUTER 8f

2.- TYPES

Types for 230 V / 50 Hz supply

CODE	TYPE	POWER kvar	GROUPS	STEPS	COMPOSITION
6 67 515	FRE6-105-230	105	4	7	$15 + 3 \times 30$
6 67 516	FRE6-120-230	120	4	4	4×30
6 67 517	FRE6-140-230	140	4	7	$20 + 3 \times 40$
6 67 518	FRE6-160-230	160	4	4	4×40
6 67 520	FRE6-180-230	180	5	9	$20 + 4 \times 40$
6 67 522	FRE6-200-230	200	5	5	5×40
6 67 523	FRE6-220-230	220	6	11	$20 + 5 \times 40$
6 67 525	FRE6-240-230	240	6	6	6×40
6 67 530	FRE12-260-230	260	7	13	$20 + 6 \times 40$
6 67 531	FRE12-280-230	280	7	7	7×40
6 67 532	FRE12-300-230	300	8	15	$20 + 7 \times 40$
6 67 533	FRE12-320-230	320	8	8	8×40
6 67 535	FRE12-340-230	340	9	17	$20 + 8 \times 40$
6 67 537	FRE12-360-230	360	9	9	9×40
6 67 539	FRE12-380-230	380	10	19	$20 + 9 \times 40$
6 67 540	FRE12-400-230	400	10	10	10×40
6 67 542	FRE12-420-230	420	11	21	$20 + 10 \times 40$
6 67 544	FRE12-440-230	440	11	11	11×40
6 67 546	FRE12-460-230	460	12	23	$20 + 11 \times 40$
6 67 548	FRE12-480-230	480	12	12	12×40

Types for 400 V / 50 Hz supply

CODE	TYPE	POWER kvar	GROUPS	STEPS	COMPOSITION
6 67 601	FRE6-210-400	210	4	7	$30 + 3 \times 60$
6 67 602	FRE6-240-400	240	4	4	4×60
6 67 603	FRE6-280-400	280	4	7	$40 + 3 \times 80$
6 67 604	FRE6-320-400	320	4	4	4×80
6 67 605	FRE6-360-400	360	5	9	$40 + 4 \times 80$
6 67 606	FRE6-400-400	400	5	5	5×80
6 67 607	FRE6-440-400	440	6	11	$40 + 5 \times 80$
6 67 608	FRE6-480-400	480	6	6	6×80
6 67 609	FRE6-520-400	520	7	13	$40 + 6 \times 80$
6 67 610	FRE6-560-400	560	7	7	7×80
6 67 611	FRE6-600-400	600	8	15	$40 + 7 \times 80$
6 67 612	FRE6-640-400	640	8	8	8×80
6 67 613	FRE6-680-400	680	9	17	$40 + 8 \times 80$
6 67 614	FRE6-720-400	720	9	9	9×80
6 67 615	FRE6-760-400	760	10	19	$40 + 9 \times 80$
6 67 616	FRE6-800-400	800	10	10	10×80
6 67 617	FRE6-840-400	840	11	21	$40 + 10 \times 80$
6 67 618	FRE6-880-400	880	11	11	11×80
6 67 619	FRE6-920-400	920	12	23	$40 + 11 \times 80$
6 67 620	FRE6-960-400	960	12	12	12×80

3.- MECHANICAL BLOCKS

From the mechanical point of view, the FRE equipment is formed by two blocks , which are mounted in separate cabinet compartments

- **Control block** (IP 42). Contains the PF regulator , COMPUTER 6f , the fuses , the static switches and other control elements , if necessary. A main manually operated switch or a circuit breaker may also be provided if so requested.

- **Filters block** (IP 21) : Contains the filter reactors and capacitors.

The following paragraphs give a general description of the equipment , with special emphasis on the description of the static switches

4.- TECHNICAL CHARACTERISTICS.

4.1.- General characteristics

Maximum working voltages (phase-phase)	400 V , delta connection 690V , star connection of C + neutral
Maximum step current:	150A at $T_{ambient}$ <40ºC
Maximum number of steps:	6
Available step control programs:	1:1:1 ; 1:2:2 and 1:2:4
Maximum number of regulation steps:	19 (5,26%) with prog. 1:2:4

Standards: EN 60.439 (IEC 439 , UNE 20 098) , IEC 146 , CSA 22.2 Nº14

4.2.- Static switches characteristics

CPC board supply (Two options)	a) From synchronism terminals b) External supply (Terminals A1-A2)
Standard supply voltage	230 Vac / 400 Vac (other values up to 690Vac , on request)
Frequency	either 50 / 60 Hz
Overload capacity	1,5 I_{rated} for 1 minute.
Protection	NH fuses of suitable size (see values in table 1)
dV/dt	RC protection at 1000 V/µms
Thermostat protection	90 ºC
di/dt	100 A/ms
Maximum allowable ambient temperature.	40 ºC
Maximum temperature of heat sink	85ºC
Control of static switch: CPC or CPCM board	By means of isolated contact between terminals ACT and COM (see table 2)

***Note: CPC control boards for equipment operating above** 440 V_{AC} are specially sized for the required voltage and must be supplied externally at 220V, AC, through an isolation transformer.*

Table 1.- Fuses size and losses of different sizes of three phase static switches

VOLTAGE	POWER (kvar)	LOSSES (W)	FUSES	TYPE
380-400V	40	115	80 A	gl
380-400V	60	175	125 A	gl
380-400V	80	230	160 A	gl
220-240 V	25	125	80 A	gl
220-240 V	37,5	190	125 A	gl
220-240 V	45	225	160 A	gl

Table 2.- Control of the static switches

Terminals COM - ACT	Green LED	Switch status
OPEN CIRCUIT	OFF	DISCONNECTED
SHORT-CIRCUITED	ON	CONNECTED

4.3.- Technical characteristics of LC filters.

Resonance frequency	189 Hz (7%) (others on request)

Reactance

Isolation voltage	2kV
L value tolerance	<3%
Saturation ΔL=5%	1,6 I_{rated}
Maximum allowable ambient temperature	45ºC
Internal temperature at I_{rated}	<110ºC
Protection thermostat	90 ºC
Max. overload (including harmonics $\Sigma(n.In)^2$	
Permanent	1,17 I_{rated}
Transient (1 min.)	2 I_{rated}

Capacitor

Dielectric	Polypropylene 10μm thick
Rated working voltage	460 V
Transient overload (10s)	1000 V
Isolation voltage to earth	3 kV
Maximum allowable ambient temperature	40ºC
Losses	0,5W/kvar

Figure 1 shows the dimensions of a cabinet suitable for a maximum of 6 groups of max. 80 kvar size. Equipment requiring more groups should be mounted in two or more cabinets

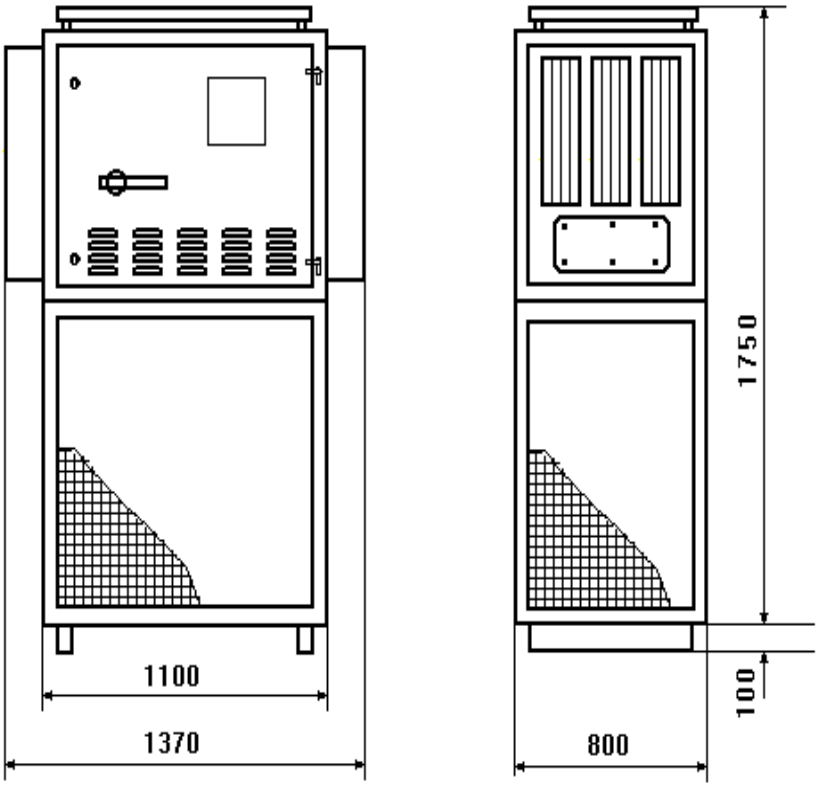

Figure 1.- Cabinet suitable for 6 groups of maximum 80 kvar.

5.- INSTALLATION INSTRUCTIONS FOR FRE EQUIPMENT

To get optimal working conditions of equipment using static switches, the following installation rules must be followed:

- Take care of the **cooling** conditions of the equipment. To ensure the proper cooling , certain minimum clearances (100 mm) must be left free between the FRE and surrounding walls
- Avoid mounting the FRE equipment close to hot components or devices emitting heat. The maximum ambient temperature should be kept below 40 ºC.
- Place the equipment in the upright position and keep the heatsink channels free for air circulation. (No cables or other elements covering the heat sinks)

6.- ELECTRICAL BLOCKS OF FRE EQUIPMENT.

From the electrical point of view , a FRE equipment is identical to a conventional PF correction equipment , with two particular parts:

- The static switches.
- The filter reactors

The drawings 945116/1C and 945116/2C in the central sheets of this manual , show the electric diagram of a generic equipment up to the second LC group. For more groups , up to 6 , the wiring diagrams would be analogous 945116/2C , each being controlled by a different output of the COMPUTER regulator.

It is also possible to control several static switches from a single COMPUTER output , so that they are switched simultaneously. To do that connect in parallel the terminals COM and ACT of all the CPC or CPCM boards of the parallel switches and supply them from a single COMPUTER output. (See also the blocks description in the following paragraphs)

7.- BLOCK DESCRIPTION OF THE STATIC SWITCHES.

Each one of the static switches consists of two parts : (See figure 2)

- Static power block , BPE
- Zero switching control board CPC or CPCM.

7.1.- Static Power Block (BPE)

This block consists basically of two thyristors for each phase mounted on a heatsink. The size of the power components depends on the kvar of the capacitor to be switched

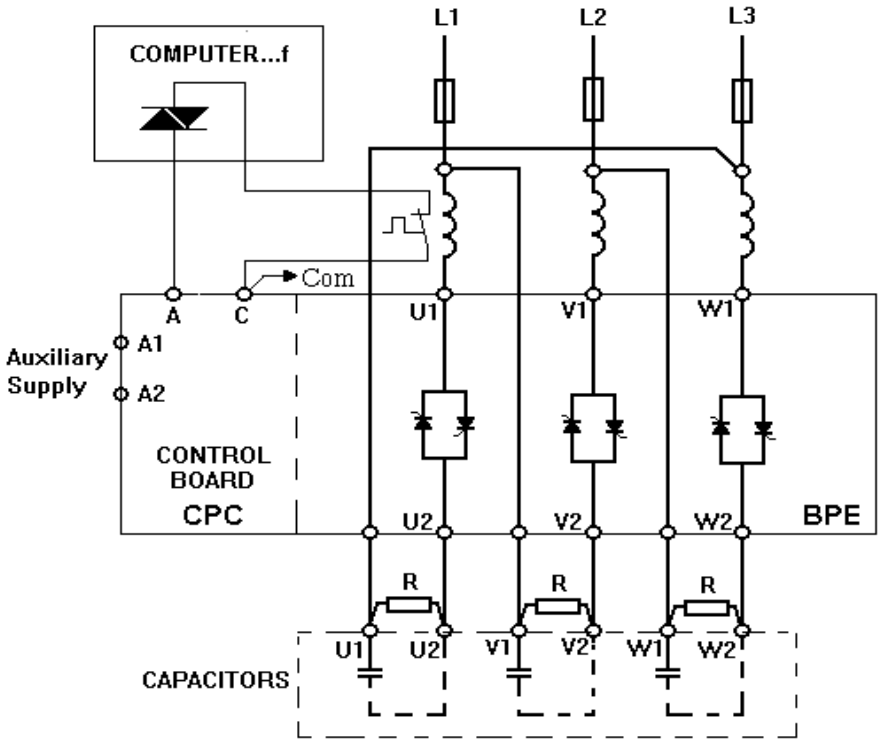

Figure 2.- Block diagram of a three phase group operated by a static switch

7.2.- Zero Switching Control Board (CPC or CPCM).

Every static switch has its own CPC or CPCM board , which controls the ON/OFF switching of an L+C group at zero voltage/zero current. The CPC may be supplied through the called synchronism terminals , namely from terminals 2K2 and 3K2 , or through the input terminals A1 and A2. CPCM must be always supplied through terminals A1 and A2. The supply mode may be chosen depending on the working voltage , but in any case the supply is coupled through an isolation transformer , protected at the primary side by a 0,1A fuse.

The CPC or the CPCM board receives the enable signal for ON-OFF operation of the static switch. This enable signal comes from the PF regulator (usually a COMPUTER) and is connected to terminals ACT and COM. The static switch operation according to this signal, is shown in table 2 in the technical characteristics.

The CPC and the CPCM have a green LED , showing the status of the enable signal and three red LEDs , one for each phase , showing whether the phases are ON or OFF. The cards have also a set of 12 terminals connected to the thyristors for synchronism. The ON switching of each phase occurs at the instant of zero voltage across the corresponding static switch.

Notice that all the synchronism and the firing signals between the CPC or the CPCM cards and the thyristor blocks are coupled through opto isolating devices or through pulse transformers , therefore , the electronic circuits and the power block are galvanically isolated.

7.3.- Single phase PF compensation equipment.

Some single phase loads , such as soldering , welding machines and others need a fast PF compensation. For such cases single phase power groups may be used , taking note of the following points:

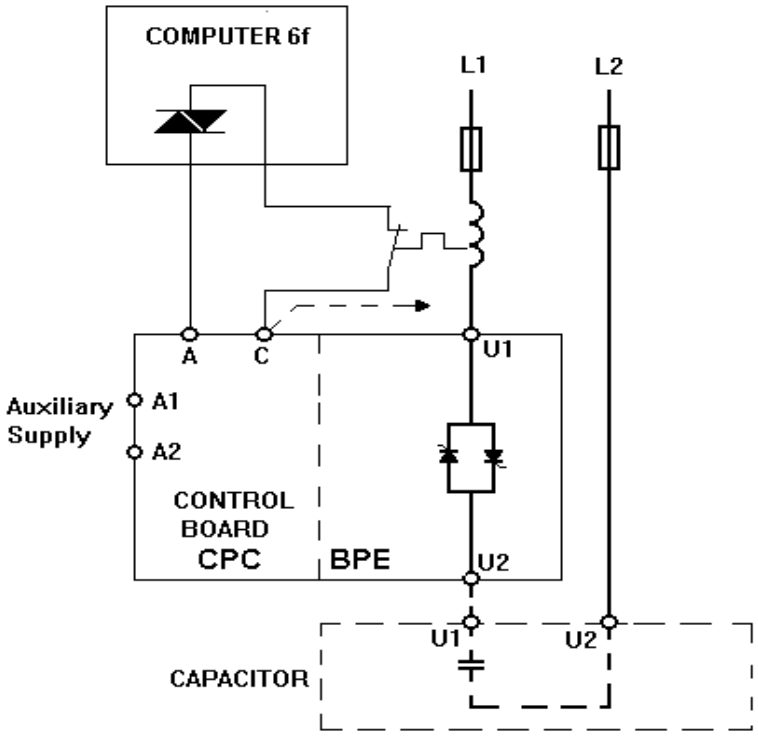

Figure 3.- Basic block diagram of a single phase group operated by a static switch.

- Single phase applications require a special type of PF regulator. Sometimes a simple current relay or even a potential free contact coming from the load controller can be used to drive the COM-ACT command inputs (See paragraph 5.2).
- Single phase steps are similar to three phase ones. The main difference is that they have a unique power pack with two anti parallel thyristors (see fig. 3)

8.- START UP OF PF CORRECTION EQUIPMENT BASED ON STATIC SWITCHES.

To start up PF correction equipment with L+C rejection filters, based on static switches , follow the steps below.

8.1.- Initial checking (before connecting to supply)

- Check that the rated voltage for the **FRE** equipment , shown in the label of characteristics, conforms with the rated voltage available at the site where the equipment has to be installed
- Check the external connections between the PF regulator , COMPUTER , and the current transformer (CT). For details concerning the regulator adjustment see the instructions manual of COMPUTER . See also the figure 4 showing the correct location of CT in the installation.

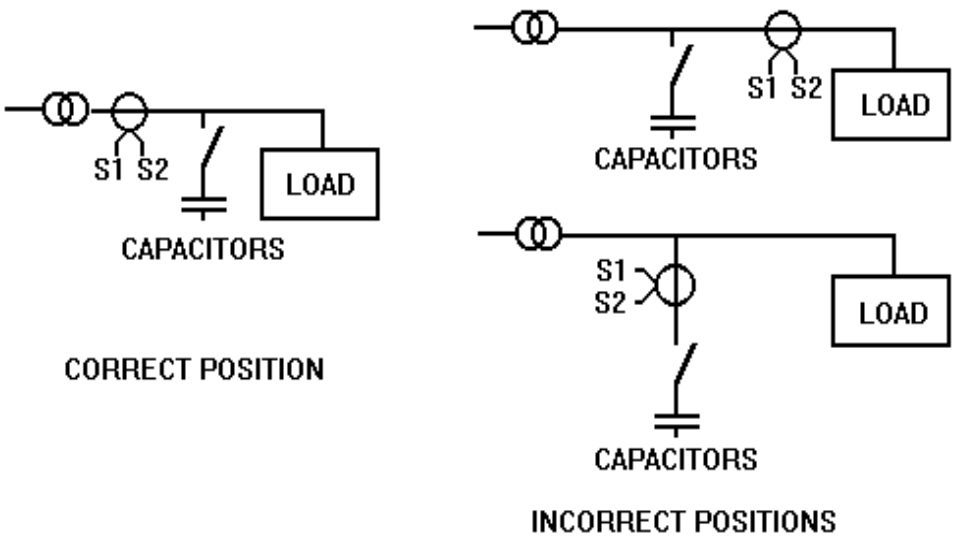

Figure 4.- Location of the current transformer (CT)

8.2.- To be checked immediately after the supply connection

¡ ATTENTION! Before any work is done on the PF correction equipment , remove the supply voltage and wait 5 minutes for capacitors discharge.

In static capacitor banks where the load has great fluctuations, it must be considered normal that the switches operate very often. Nevertheless if the PF regulator operates the capacitor steps very quickly when the load remains constant, check the COMPUTER adjustments.

9.- TROUBLE SHOOTING

Notice that the capacitor bank should not operate unless there is a minimum load. If the equipment does not work properly check the following points:

- If the display of the COMPUTER does not light or gives a very slight glow , check the supply voltage and the fuses (power and control fuses)
- If the display shows some alarm sign other than the PF reading, or the PF reading does not correspond to a expected value , check the COMPUTER settings (see COMPUTER instructions manual).
- During 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. Check that the number of connected steps conforms with the Nr. of steps shown by the COMPUTER display.

- To see whether a step is connected or not, see the green LED at the CPC card. The green LED and the three red LEDs must light simultaneously , otherwise there is one of the phases which does not work properly.
- If one of the steps is never connected, try to force its connection by shorting the terminals COM and ACT in the corresponding static module. If the step connects in the forced mode (check the current in each phase with a current clamp) , then the fault is probably located in the COMPUTER or in the wiring.
- If there are some inactive steps and the COMPUTER shows a lack of compensation , check the settings of such COMPUTER .
- Once the normal operation is achieved , check if the current consumption of each step is correct, according to its rated power (Current shown on characteristics label of each capacitor). Notice that an excess of consumption may be due to an excess of supply voltage or to the presence of harmonics.
- 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. It must be below 85 ºC. In case of higher temperature check the cooling conditions.

10.- MAINTENANCE.

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 labelled 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.

9.- 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 ageing in normal service.
This warranty will not be applicable in case of incorrect operation 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.