EnviroVAr™ Three Phase Power Factor Correction Installation & Commissioning Guide

Version 2 January 2008

50kVA to 400kVA

EnviroVAr™ Three Phase Power Factor Correction Systems

IMPORTANT WARNING

Failure to read and comply with this manual may result in damage to the EnviroVAr Unit and driven equipment and may render the warranty invalid.

1. **Only a competent electrician should carry out the electrical installation.**
2. **EnviroVAr must be earthed with an earthing conductor connected to the earthing terminal.**
3. **Before installation check the application rating plate to ensure that the EnviroVAr is correctly rated for the application.**
4. **Internal components and areas of the control circuit boards, (except the isolated I/O terminals), can be at mains potential when the EnviroVAr is connected to a three-phase supply. The voltage is extremely dangerous and may cause death or severe injury if you come into contact with it.**
5. **When the EnviroVAr is connected to the mains, the load connections should be treated as being live even if the load is not running.**
6. **The control I/O terminals are isolated from mains potential but the relay outputs may have dangerous voltages present even if the mains are not connected.**
7. **Do not make any connections when the EnviroVAr is connected to live mains.**
8. **Do not make voltage withstand tests on any part of the EnviroVAr without isolating the unit.**
9. **Do not touch IC-circuits on the PCB. Certain items are static-sensitive and static voltage discharge may destroy the components.**
10. **Make sure the cover is closed before applying mains voltage to the EnviroVAr.**
11. **Updated and current Installation and Commissioning Guides are maintained on the EMS (European) web site at http://www.EnviroStart.com; always check the web site for latest issue documents before commencing installation.**

CONTENTS

1 INTRODUCTION

Thank you for choosing the EnviroVAr Power Factor Correction Unit. The system has been designed with ease of use and set up in mind. The majority of applications will operate effectively without the need to make any changes to the default settings set prior to the shipping of the unit, however should such changes be necessary please do read through this Installation and Commissioning Guide so as to better understand the effects of the changes you are making.

Components used in the manufacture of this system have been selected with reliability in mind and have generally been over-rated for the power of the unit manufactured. Using the standard IQA, (Institute of Quality Assurance), methodologies the expected lifetime of EnviroVAr is rated at 100,000 hours continuous use, (eleven years), maintenance is however required and periodic checks, (two yearly), of the capacitive elements are essential to ensure continued effective “correction” of power factor

In the unlikely event that you do need further support please contact your local EMS (European) Distributor or failing that contact us directly either by e-mail or fax. All details of how to contact us are available on our web site at http://www.EnviroVAr.com, please remember that we are constantly updating documentation and information about EnviroVAr, all such information is posted and publicly available on the web site.

1.1 FEATURES

The **EnviroVAr** is a high specification reactive power correction system, (power factor correction) and is available in standard units from 25kVAr to 400kVAr sizes. (Specials are available to request).

- EASE OF INSTALLATION THROUGH PRE-DELIVERY CONFIGURATION
- HIGH ELEMENT SWITCHING FREQUENCY OPTION AVAILABLE USING ENVIROSWITCH SOLID STATE SWITCHES
- CONTACTOR PROTECTION MODE AVAILABLE WHEN ENVIROSWITCH NOT USED
- FULL ALARM AND STATUS NOTIFICATION OF SYSTEM CONDITION
- CONFIGURABLE SECOND POWER FACTOR LEVEL SELECTION AVAILABLE
- VERSATILE CABLE ENTRY POINTS INTO CABINETS
- FULL CONTROL OF CAPACITIVE LOAD SWITCHING TIMES, (TIME IN AND TIME OUT)
- FAULT TOLERANT, (STAGE LOSS DOES NOT SHUT DOWN TOTAL SYSTEM)
- OVER TEMPERATURE AND PRESSURE SENSORS ON ALL CAPACITIVE ELEMENTS
- USE OF ELEKTRONICON CAPACITORS
- USE OF BELUK REACTIVE POWER CONTROL RELAY
- TROPICALISED DESIGN SYSTEMS
- RUGGED HOUSING, IP54, NEMA 1

1.2 CE DECLARATION OF CONFORMITY

CE

MANUFACTURERS DECLARATION OF CONFORMITY

This declaration covers all **EnviroVAr Power Factor Correction** units.

This product fulfils the following European Community Directives when applied as follows:

Low Voltage Directive

The above products fulfil the Low Voltage Directive 73/23/EEC, 89/336/EEC and 93/68/EEC amendment for industrial equipment; however, they must be installed to general good electrical engineering practices and regulations by a suitably qualified person with strict reference to the instructions in the product's Technical Manual.

Harmonised Standards Applicable

BSEN 60439; BSEN 60831 (Parts 1 and 2); 72/73/EEC; BSEN 61921:2003

Electrical Requirements Specification G5/4 (2002)

Dated: May 2007

2 GENERAL SYSTEM INSTALLATION

The EnviroVAr system supplied should be tailor made to fit the requirements you defined at the time of your order. The system is pre-configured within our manufacturing facilities to ensure that you have as little commissioning and setting up to do as possible when the unit is received at site.

WARNING

To ensure personal safety and ultimately correct operation of the equipment please ensure that the following recommendations and instructions are followed with regard to the installation and commissioning of EnviroVAr systems.

Please be aware of the fact that potentially lethal voltages and currents exist within the EnviroVAr cabinets and no work should be undertaken without ensuring that all circuits are isolated from the supply and that no residual potentials exist as a result of damaged bleed resistors or faulty connections

IF IN DOUBT CHECK USING A RELIABLE METER

IF UNCERTAIN THEN PLEASE CONTACT EMS (EUROPEAN) FOR ADVICE

2.1 EQUIPMENT DESCRIPTION

The equipment is designed and manufactured to the following requirements

BSEN60439	Low Voltage assemblies
BSEN60831 parts 1 & 2	Capacitors
72/23/EEC	EU Low Voltage directive
89/336/EEC	EU EMC directive
BSEN61921:2003	Power Capacitors

The control and switching of the capacitors, in Master Cubicles, is achieved via an integral reactive power control relay. (Full details of this Beluk control follow this section).

For Slave Cubicles, the automatic control will be affected via a remote switching facility.

2.2 INSTALLATION

Check that the data on the equipment rating plate (i.e. voltage, current, number of phases, frequency) is compatible with the system to which the equipment is to be connected and is specifically as ordered. If there is any discrepancy then contact EMS (European) immediately.

2.3 ERECTION AND PHYSICAL LOCATION

The equipment should be securely fixed to the floor and/or wall as appropriate. It is important that the equipment is stable and rigid. The cabinets provide a high degree of security from the environment however wherever possible it is preferable to site the EnviroVAr units in a dry well ventilated area.

Ideally the EnviroVAr systems should be located adjacent to the incoming supply switchgear and metering or adjacent to existing, remaining power factor correction equipment.

2.4 CONNECTION

The equipment should be connected to the supply system via cable rated in accordance with the current edition of the IEE Wiring Regulations (BS 7671). The cables should be adequately rated to accommodate the possibility of excess current drawn by the capacitor caused by high voltage and/or harmonic distortion. To comply with BSEN 60831 cables must be rated at 1.5 times the nominal capacitor current, that is, for a 50kVAr unit the nominal current is 67A at 400V; cables must be rated at 100A in this case. The cables must also be sized so that the correct protection is provided by the feeder device.

When making the mains connections, care must be taken to ensure that the correct phase rotation is maintained i.e.

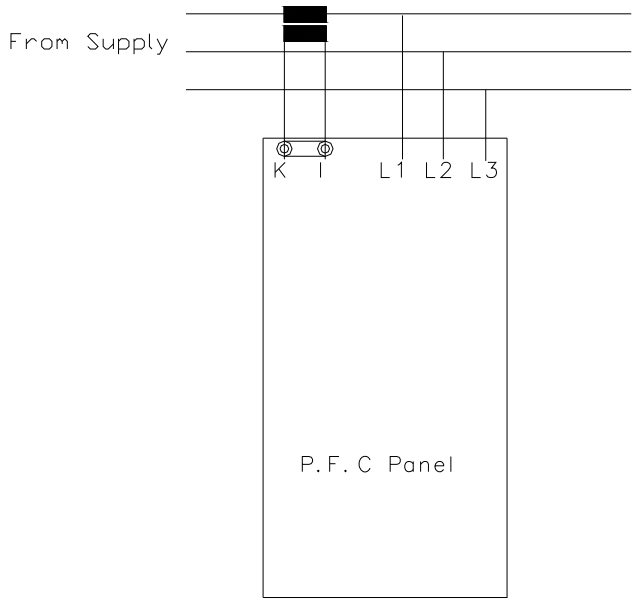
L1 = Red (or Brown) Phase,

L2 = Yellow (or Black) Phase

L3 = Blue (or Grey) Phase.

The established phase colours of RED/YELLOW/BLUE will be replaced by BROWN/BLACK/GREY in the future in accordance with BSI document HD308 S2

It is important that all EnviroVAr systems are effectively and correctly earthed either back through the earth connections on the main switchboard or via a separate earth point.



To LOAD

NOTES :-

ALL CUBICLES

1. Installation must be carried out in accordance with BS7671 (16th Edition of IEE regs)

2. Mains cable MUST be rated to carry 1.3 x Nominal Capacitor Current and to the rating of the feeder device

3. Connections to Main Isolator

L1 = BROWN Phase (previously Red)
L2 = BLACK Phase (previoulsy Yellow)
L3 = GREY Phase (previously Blue)

MASTER CUBICLES ONLY

4. Reactive Power Relay to be set as detailed in leaflets in panel.

5. Care must be taken to avoid connecting the Current Transformer unless CT terminals are shorted

6. Remove C/T link before carrying out commissioning of relay (normally by Power Capacitors Engineer).

IMPORTANT NOTE :- Link MUST be in place whenever the C/T connections are adjusted.

Note that all EnviroVAr units are shipped with CT's and non-ferrous gland plates

2.5 SIGNAL CT FOR MASTER CUBICLES

A current signal to the Beluk reactive power relay is used to calculate the reactive power on the system, and hence the system power factor. This signal is provided by a current transformer on the red (brown) phase of the main distribution board. This current transformer must be located at such a point so that it reads the current of the total load including the capacitor bank.

The secondary of the current transformer should be connected to terminals S1 & S2 on the control strip in the capacitor equipment. The CT shorting link across these terminals should **not** be removed until the equipment is commissioned.

2.6 COMMISSIONING

Detailed setting up of the Beluk Reactive Power Control Relay can be found in Section 3 of this guide You should find that there is no need for any on site commissioning, beyond fine tuning and establishing that the systems are fully operational, as all EnviroVAr units are shipped pre-configured and fully tested at the time of despatch.

2.7 HARMONIC DISTORTION

Care must be exercised when installing capacitors onto systems that may be subject to harmonic distortion. Under these conditions it is possible to

1. Overload the capacitors and/or
2. Cause system disturbance and amplification of the harmonic distortion.

If it is suspected that there may be harmonic distortion an appropriate harmonic analysis should be carried out to determine the level of distortion and the possible solutions.

At the time of system definition it should have been established what level of harmonics existed within the supply and appropriate account taken for this. If the level of harmonics is higher than 20% but less than 50% of the total load current then a detuned EnviroVAr system will reduce those harmonics. A detuned EnviroVAr contains not only necessary capacitance to correct the reactive power element of the supply but also inductive reactance in the form of chokes so as to limit specific harmonic frequencies on the supply. (See Appendix 2 for details of the harmonic reactors).

In cases where the harmonic levels exceed 50% then it will be necessary to consider providing specialised filtering systems in addition to the EnviroVAr power factor correction. In this case please contact EMS (European) for specialist direction and guidance.

2.8 VENTILATION

Care must be taken to ensure that the ventilation provided in the cabinets is not obstructed. Where filters are fitted, these **MUST** be cleaned regularly to maintain the effective cooling of the equipment.

The Elektronicon capacitors used throughout the EnviroVAr systems are designed to withstand the following temperatures within the cubicle; hence it is important that the temperature of the air around the cubicle will allow the ventilation system to cool the capacitors.

Maximum ambient	50^0C
Highest Mean over 24 Hours	40^0C
Highest Mean over 1 Year	30^0C

2.9 MAINTENANCE

Power Factor Correction Equipment should be regularly inspected (at least annually) to verify its effective operation. These checks should include:

1. Check on the operation of the isolator
2. Check on all fuses
3. Check on the operation of the contactors or EnviroSwitch solid state contactors if fitted
4. Check on the integrity of the case earthing
5. Check on the operation of the ventilation system
6. Check the running current of each capacitor section
7. Check the integrity and operation of the capacitor bleed resistors

3 BELUK REACTIVE POWER RELAY

3.1 INSTALLATION

WARNING

As with all electrical control 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 relating to the Beluk Reactive Power Relay always ensure that your body is not carrying any electrostatic charge as the relay contains static sensitive components. 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.

IF IN DOUBT CHECK USING A RELIABLE METER

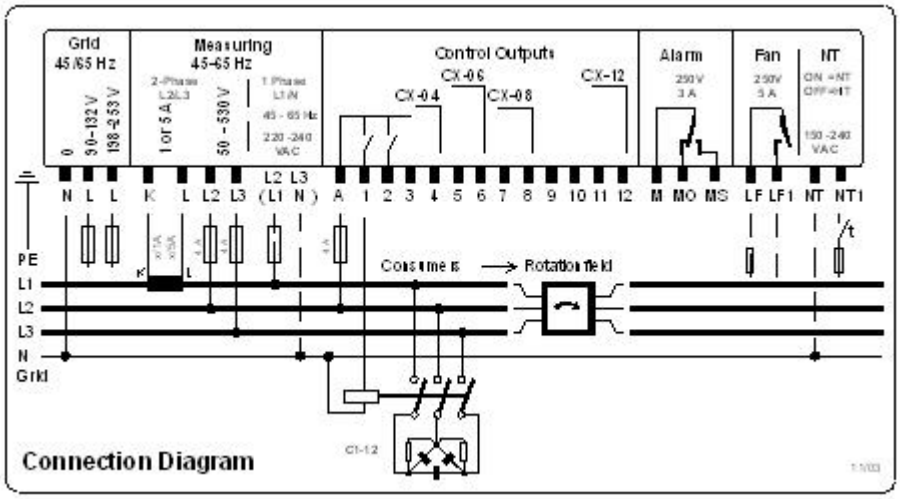
IF UNCERTAIN THEN PLEASE CONTACT EMS (EUROPEAN) FOR ADVICE

NOTE:

Much of the detail that follows in this section deals with a new installation or replacement of a Beluk reactive power relay. It is unlikely that you will need to go through any of the following steps if you have are installing a complete EnviroVAr system as all the functional testing and commissioning of the RPR, (reactive power relay), has been done at the time of the system build.

3.1.1 PRE INSTALLATION CHECKS

1. Check that the measurement and control voltage, supply frequency and current transformer rating comply with the ratings given on the back of the reactive power relay.
2. Mount the reactive power 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 shown below. Pay special attention to the cross section size of the CT connections. We recommend 2.5 sq/mm copper conductors for runs of up to 10 meters. The CX relay constantly monitors the supply voltage, if this falls below 70% of nominal then all capacitor contactors will be automatically switched out. Note that the control supply to the contactor coils, (typically 220V, (L – Neutral), must be taken from one of the phases used for the supply to the Beluk reactive power relay itself, (L2 - L3). The steel rear cover of the Beluk relay must be earthed, at the earth tag.

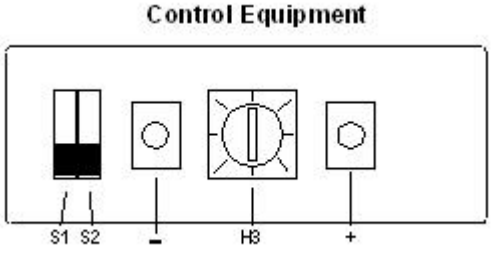


4. CT output of 1A, or 5A, is fed into the two orange terminals marked K and L. When using the CXM multi-meter version the maximum CT ratio is 20000/5 or 4000/1. Note that the CX and CXM relays are sensitive down to a current of 0.010A (10 mA) reactive. The CT input ratio of 1A or 5A is self selecting according to the max CT current measured. The CX relay is therefore sensitive enough to switch a 25kVAr capacitor step at 415V utilising a 10000/5 CT or a 5kVAr step using a 10000/1 CT ratio, provided the maximum total current from the CT does not exceed 1A.

3.2 CONTROL

3.2.1 MAIN CONTROL FUNCTIONS

The function control switch (H3) is located behind the removable front plastic nameplate on the reactive power relay. For the CX relay there are two push buttons (+ and -) located either side of the function switch. For the CXM (multi-meter version) the + and - 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-CosΦ.



3.2.2 FAN CONTROL FUNCTION

If option **"L"** (fan control) is fitted there will be two additional DIP switches (S1/S2) located behind the name plate to select the four temperature alarm levels of 30, 35, 40, or 45°C. The factory setting of the function switch is "3" see Section 3.2.3 below.

3.2.3 H3 - MAIN CONTROL FUNCTION

H3 is a multifunction switch (1 – 9 & A – F). Use a small screwdriver to rotate it to the position required

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 seconds. 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% and 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 Power Factor Target Set is selectable in the range of 0.70 lag to 0.90 lead; lag is prefixed l, lead is prefixed c on the display. The factory setting is 1.0

2 Switching Time Delay in Seconds selectable from 5 to1200 seconds. Pushing button +/– for longer than 2 seconds enables rapid selection. The factory setting is 40 seconds.

3 Fully Automatic Control of the power factor correction switchable elements. The LED display will indicate the system power factor with either I for inductive or C for capacitive load (updated each 3 seconds). A flashing dot in the display above the signs either +/ – indicates, that the regulator is selecting a suitable capacitor, if available, to meet the reactive load demand. This adjustment is made every 3 seconds. The CXM relay will indicate Cosφ - Power Factor; U – Voltage; I – Amperage; P – kW; S – kVA; ., Q – kVAr; F – Hz.

4 Manual Operation an "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 (Position 2) will be followed. This setting is useful when commissioning a capacitor 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 Position 3, for auto control and the relay should adjust automatically to the target power factor selected in Position 1.

5 Selection of Step Limitation. This position limits the number of steps in the circuit, for example if you have a CX12, that is a 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. This provides an Indication of either failed capacitor steps or unengaged outputs. For example an indication "Cd 05" (Capacitor Defect Bank 5) alternating with "Cd 09" (Capacitor Defect Bank 9) indicates, that steps 5 and 9 are failing. "Alarm" (AL_ _) will be shown on the display. Once the fault associated with the failed banks has been rectified, the alarm signal is cleared by pressing buttons +/ – for longer than 20 seconds "Cd 0" will show in the display to indicate the alarm is cancelled and there are no defective capacitors. (See Position 9).

7 Capacitor Contactor Switch Counter. This shows the number of switching operations for each contactor; for example "OC_ 4" for capacitor step No.4, this shows for 2 seconds then switches to the count of the switching operation, say "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 ten contactor switching operations. The stored data of all steps can be cancelled by depressing the +/- buttons together for more than 20 seconds; automatic control is active all the time.

8 Indication of Step kVAr This function 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, for example "L 74" and "F 84". "F" stands for the first sensed capacitor size during commissioning and "L" for the last measured value after commissioning; 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 Position 0, is exceeded due to a failed capacitor or blown fuses, the CX or CXM RPR eliminates this step from control procedure and an alarm "AL" indication appears in the display. The "L" and "F" values for each step can be scrolled through with the +/– button; this is a good check to do during regular capacitor bank maintenance.

The stored values can be re-set by pushing buttons +/– together for longer than 20 seconds; the regulator will store each step from the moment of the re-set. Automatic mode remains active whilst these checks are made.

The CXM regulators fitted with multi-meter option "M" (Indication of energy data) display the measured capacitor sizes in real kVAr provided the correct CT ratio factor has been programmed.

9 Selecting and Cancelling an Alarm Indicator. Four alarm types are available, each of which is selectable by scrolling using the +/- buttons:

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

2 "A_1" Alarms will be shown, but will cancel themselves once the cause of the alarm has been resolved.

3 "A_2" Any alarm recorded will remain on the display until the fault is rectified and the alarm is manually cancelled by pressing +/- together for at least 20 seconds.

4 "A_3" The alarm stored on the display is cancelled by pressing the +/- buttons together for at least 5 seconds. This will re-set alarms for:

4.1 Low PF for at least 75 times step switching time having given display indication "AL_"

4.2 Over Temperature, (if "L" option is fitted), giving display indication "HA" (Heating Alarm)

4.3 Both Alarms Operating, (Low PF and High Temp), the display will show "AH"

Once the alarm is cancelled the display will show "ArES" (Alarm Reset**)**

If the Defective Capacitor Step alarm has operated with an "AL_" in the display, this can only be cancelled by going to Position 6 on the H3 function switch and pressing +/- together for at least 20 seconds.

A Selection of a 2nd Power Factor Target. Some tariffs allow a lower power factor at certain times, for example, at night when the power supply companies try to compensate for a leading power factor on the system caused by the capacitance of buried cable networks. This position of the function switch allows selection of a second target power factor; this second target power factor will be triggered by applying a voltage of between 150V and 240V across NT1/NT2. If option "L" is fitted, the lower power factor will automatically come into operation if the ambient temperature rises above 57º C. (This to reduce the generated heat within the cabinet).

B Selection of Asymmetrical Switching Time Delay. Rapidly changing reactive loads can cause excessive wear on contactors due to their frequent switching. This would be found in environments such where arc welders, crushers or strip mills are being used, places where loads are changing significantly during short time periods. (This would also be an environment where EnviroSwitch solid state switching elements should be used to replace the standard contactor systems, (see separate Installation and Commissioning Guide).

When standard contactors are fitted and where loads are changing fast and by a large amount it is useful to use asymmetrical switching of the contactors providing Fast-In/Slow-Out. The ratio of "In" to "Out" time is set using the +/- buttons. If we have "1" (Default), we have equal times for "switch-in" and "switch-out"; by selecting any number between 1 and 99 we can vary the switch out time up to 99 times the "switch-in" time. For example if we set the ratio to "10" (display shows "Y_10") and have selected a switch time of 5 seconds in Position 2, we switch-in after 5 seconds of lagging kVAr demand, but only switch out after the leading kVAr has exceeded the threshold for 5 x 10 seconds + Lock-out time, (see Pos C detail below). (If for some reason it is required that the switch-out time is quicker than the switch in time, that is, the reverse of the norm this can be achieved but must be specified at the time that the original EnviroVAr is ordered.

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 of the EnviroVAr. If we set "L_30" we have a 30 second lock-out time; this time period is in addition to the time selected in Position 2. This will operate each time there is a load reversal, thus helping to reduce contactor wear. The lock-out time is adjustable from 1 to 254 seconds; the factory setting is 30 seconds ("L_30").

D Selection of CT Ratio. This is only applicable for CXM relays. On the CX reactive power 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. On the CX reactive power relay the display will be non-operative and will show **"_not"**

F Selection of Switching Program. The switching programs are selected using the +/- buttons:

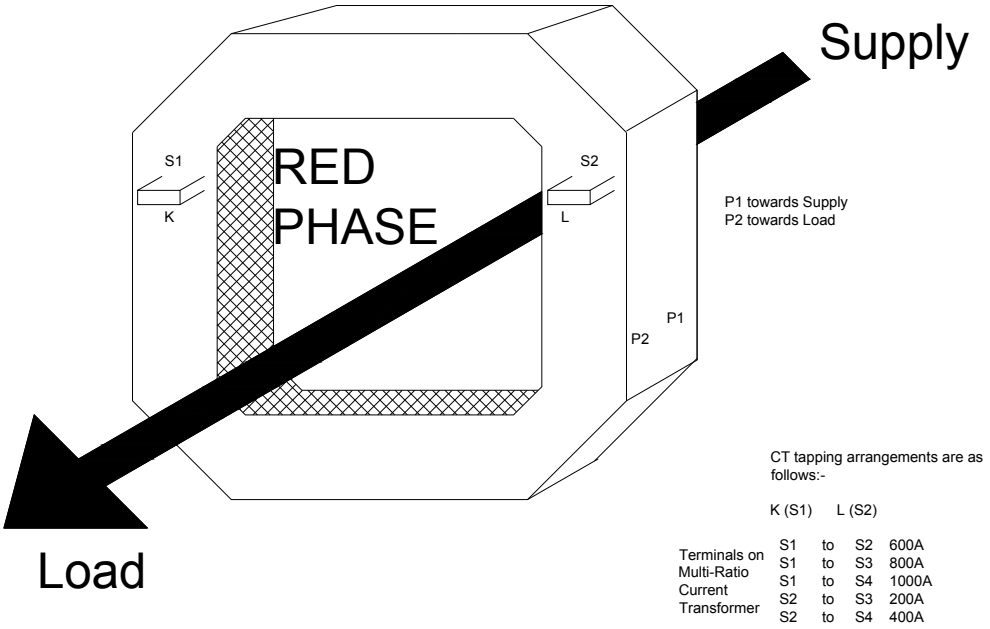
1 "Auto" gives fully automatic self selection of capacitor steps in order to achieve the required power factor with no pre-determined switching sequence. Relay voltage measurement L2 - L3.
2 "1.1.1.1" gives sequential switching in/out with fully automatic recognition of each capacitor size. This program could be selected for tuned filter banks where it is essential that each tuned step is switched sequentially.
3 "Eaut" this is identical to **"Auto"** but for single phase operation, with relay measurement voltage taken from L1 – N.
4 "E111": identical to **"1.1.1.1"**, ., but for single phase operation with relay measurement voltage taken L1 – Earth.

The factory setting for this function is **"Auto"**

3.3 COMMISSIONING THE RELAY

1 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, that is, if the CT is on L1, the voltage must be taken 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 Position "F" of Function Switch H3 with measured voltage connections (L2 - L3) changed to single phase.



A display indication of **"I—O"** shows that there is no current or that there is less than 10mA flowing in the CT circuit.

If capacitor steps are energised, they will be automatically disconnected after five minutes. If the relay is in manual mode, (Position 4) the steps will stay in circuit.

Indication **"U—0"** measured voltage is below 50V or not connected.

The relay will start to control only if the measured voltage, (L2 - L3) is above 50V and the reactive component of the measured current is 10mA or above.

If the measured voltage falls below 50V the energized steps will be switched off after a two second time delay, this happens in both automatic and manual modes

2 Factory Settings of Function Switch

Power factor target = 1
Step switch time = 40 seconds
Step limit switch = Maximum

CT Ratio = 100
VT Ratio = 1
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 Position 3 (Automatic Mode).

4 The reactive power relay has a no-volt release lock out time of 90 seconds when first energised. No switching will commence until this time has expired.

5 Check preset power factor target in Position 1 and adjust to required value if the default of 1 is not suitable.

6 Check preset switching time delay Position 2 and adjust to required value if necessary.

5 Check preset step limitation and adjust if necessary to the number of steps in circuit. If any one steps 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 minimum period of twenty four hours or until there is a cancellation of the CD alarm, (see details relating to Position 6), or there is a loss of supply. The relay will try to switch each defective capacitive element at least three times after which it will permanently disconnect that capacitor bank and show the alarm indication “Cd”.

6 Check preset alarm mode and select change using Position 9 if required.

7 Set the function switch back to Position 3 – Auto operation.

8 Display indicates the current power factor CosΦ, for example “i0.87” for inductive or “c0.94” for capacitive load.

9 If wired correctly after the no volt release lock out time of 90 seconds, if there is an inductive load, a “+” indicator in the display will start to flash. This indicates the relay is calling for capacitive correction banks, 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 will change. When the target power factor has been reached the “+” indication on the display will extinguish. When there is an excess of capacitive kVAr the “-“indicator will show on the display and capacitor banks will be switched out so as to achieve the target power factor.

10 With either the CX or CXM reactive power relay it is not necessary to preset any C/k value (threshold level when to start to switch a step in or out), as the relay selects the most suitable capacitor size to meet the target power factor according to the size of capacitance kVAr available; 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 for example), this is possible using Position F.

11 It may happen, that either +/– indicator is flashing steadily and the regulator will not switch on or off any step. This is because it is not able to find a suitable step size to meet the target power factor. (This may be the case if there is a faulty capacitor bank within the system stopping the relay achieving the target power factor). No dot flashes once the target power factor is achieved.

12 If there is no load on the system at the time of commissioning, put the function switch in Position 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 it will be 415V). Now change the function switch to Position 3 (Automatic switching). The CX or CXM relay should now sense a leading power factor and switch the steps out until the target power factor is achieved. If the relay does not switch the steps out check that the CT is on the correct phase, (normally L1), in relation to the measured voltage taken from L2 – L3 and check that the relay voltage connection is not reversed, that is, 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

3.4 RELAY ALARM FUNCTIONS

Power Factor Alarm, the display shows **"AL_"** if the predetermined power factor is not obtained due to insufficient capacitance. The alarm signal is triggered after a period of 75x the selected step switching time, valid for both lead and lag. If the set target power factor is exceeded due to overcompensation, possibly because of one or more banks contactors becoming short circuit holding those banks in permanently then, after 75x the selected step switching time set by Position 2 the alarm will be triggered and "AL_" will be displayed, alternating each 5 seconds with any other display function that has been selected. To reset the alarm put function switch H3 in Position 9 and select A_3.

Failed Capacitor Step Alarm, the display shows **"AL_ _"** This indication will appear at 5 second intervals alternating with any other with any other display function set. This alarm can only be cancelled using H3 Position 6.

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 could be sent to an external indicator such as a BMS or system PLC.

3.5 DATA TRANSMISSION

The software suite "WINBSTO", (suitable for WIN95/98/ME/NT/2000XP), data logs the date and time for each change in events occurring within the overall system, logging: power factor; steps in circuit; steps switched in/out and any triggered alarms. Each switching operation of the regulator activates two communications via a TTL-interface (14-pole plug on the rear of casing), one communication before and one after the switching procedure, this provides an effective ability to analyse the compensation effect as each step operates. To store the data on a PC, a data cable with integrated converter TTL/RS232 is required. As an alternative to having a PC on site, the data output from the CX or CXM relay can be fed into our optional Data Logger and then downloaded into either Microsoft Excel or Word.

DS 21 - 256kb (Approx 2,500 events recorded)
DS 22 - 512kb (Approx 5,000 events recorded)
DS 23 - 1Mb (Approx 10,000 events recorded)

3.6 OPTIONAL FEATURES

There are four optional features available on the CX and CXM reactive power relays, these are generally not capable of being fitted after the relay has been integrated into a power factor control system and as such they need to be specified at time of order. Options “L” and “LT” will almost always be integrated into EnviroVAr systems as they provide substantial system protection.

3.6.1 OPTION L

Option L has two major functional aspects:

3.6.1.1 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. (5A 250V 50/60Hz).The contact will close at the temperatures listed below according to the DIP switch settings shown.

Temperature	20°	25°	30°	35°
DIP S1	OFF	ON	OFF	ON
DIP S2	OFF	OFF	ON	ON

The ambient temperature must be held for a period of 48 seconds before the contacts operate. This change of state lasts for eight minutes, (running the fans), if the temperature remains above the target for 48 seconds, even though the fans are running, then another time window of eight minutes will be activated. If the temp is below the target for at least 48 seconds then the contacts will open for a period of 8 minutes or at least until that time window has expired. To cancel this alarm, see the detail shown for **H3 Position 9**, **A_3.**

3.6.1.2 SECOND POWER FACTOR CORRECTION TARGET

As described in Position “A” of the multifunction switch H3, a second target power factor may be applied at times when a lower power factor is permitted by the Power Utility supplier. This is generally at night times when the loading on the overall supply lines is lower. Using this feature will extend the life of capacitors, contactors and also reduce energy absorbed due to watt losses in the equipment. The second target power factor can be set in the range 0.70 lag to 0.90 lead. When a voltage of between 150V - 240V 45/65Hz is applied across NT - NT1 the reactive power relay will switch to the second target power factor. When no voltage is applied, the first target power factor is applied.

3.6.2 OPTION LT

This option activates the lower power factor target automatically when the ambient temperature rises above 57ºC, reducing the kVAr in circuit at any given time and hence the heat generated by the installation. If option “L” is fitted the temperature alarm contacts will also operate.

3.6.3 OPTION “M” RELAY TYPES

Reactive power relays with this option are fitted with a modified fascia with two keys +/- 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 on the display. On large loads an automatic change of scale from kW to MW is provided. For example when the display reads 9999kW the next increment will show 10.0MW. (Readings are up-dated every three seconds).

The CT and VT ratios are set in Position D and E of the function switch H3.

D = CT ratio: using key +/– in the range of 1 - 4000 (for example 800A/5A = 160).
Factory setting = 100. Holding the +/- for longer than 2 seconds enables rapid roll through.

E = VT ratio: using key +/– in the range of 1 – 350 (for example 20 kV/0,1kV = 200).
Factory setting = 1. Holding the +/- for longer than 2 seconds enables rapid roll through.

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

C Power factor
U Measured Voltage
I Current in selected phase
P Total three phase active Power*
S Total three phase apparent Power*
q Total three phase reactive Power*
F Frequency

* Assumes a balanced load at all times

3.6.4 OPTION “k” COMB FILTER SWITCHING

A Comb Filter is employed when two separate frequencies need to be blocked to ensure effective operation of the overall system. The general reasons for selecting this option will be that there is interference from one or both of the following sources:

a) The harmonic frequency from the mains supply and

b)The Impulse Frequency sometimes used by Utility Companies to give switching commands , for example for switching items such as street lighting according to required times. These impulse switch signals are usually made in the range of 160 -190Hz.

Specifying “Option k” will ensure that the more heavily choked capacitors will switch first (odd bank numbers) and the less heavily choked capacitors will be switched second (even bank numbers). Option “k” must be specified at the time of order placement.

Appendix 1

General Handling and Safety Practices Associated with Power Factor Correction Capacitors

The purpose of this appendix is to provide users with instructions on the proper conditions for using capacitor banks and equipments for power-factor correction.

The regulations for safe use of the capacitors and capacitor banks meet the following standards:

- CEI 33-5 static capacitors for power-factor correction of the self-healing type for alternating current power systems having a rated voltage up to and including 660V.
- CEI 33-1 static capacitors for power factor correction in AC systems.
- IEC 831-1shunt power capacitors of the self-healing type for AC systems having a rated voltage up to and including 660V.
- IEC 831-2 shunt power capacitors of the self healing type for AC systems having a rated voltage up to and including 660V
- IEC 871-1 shunt capacitors for AC power systems having a rated voltage above 660V.
- IEC 871-2 Shunt capacitors for AC power systems having a rated voltage above 660V.

(Note 1: The CEI 33-1 standard will shortly be replaced by a new standard based on IEC 871-1)

In the context of this Installation and Commissioning Guide capacitors and capacitor banks shall not be used for other purposes than power-factor correction in AC systems.

The purpose of the methods, parameters and test specifications set forth in the CEI standards for capacitors is to verify the design and construction from the standpoint of safety and quality. They shall not be construed as an indication that a capacitor or capacitor bank is suitable for service under conditions that are equivalent to the test conditions.

General Requirements

The user of any capacitive system shall make sure that the CEI label is affixed to the nameplate of HV capacitors and the IMQ label on that of LV capacitors.

The user shall make sure that the capacitors nameplate voltage and frequency rating is suitable for the network in which it is installed.

The user shall make sure that the capacitor is installed as specified by the manufacturer, e.g. for outdoor or indoor installation, vertical or horizontal arrangement.

The user shall not operate capacitors that show oil or any other form of material leakage.

Capacitors shall not be exposed to chemical attack or to attack by flora and/or fauna.

Capacitors shall be adequately protected against mechanical damage under normal operation or during installation. Any capacitor that should be electrically or mechanically damaged for any reason in transit, storage or erection, shall not be used, and those damaged in operation shall be immediately removed.

Protection of Persons and the Environment

Capacitors are usually made of flammable materials. Even when a fire does not start in the capacitors, they may spread it, depending on their mass and position. Under these circumstances, the capacitor's materials might release toxic or corrosive fumes and gases, therefore, installation shall be carried out in such a way, that the fire and fumes cannot spread externally to any associated plant.

When hazardous explosive or flammable atmospheres are or might be present, refer the CEI 64-2.

When capacitors and banks are installed, any live part shall be suitably protected against accidental contact as specified in the CEI standards.

Prior to start up, check the terminal clamps for tightness.

Capacitors and capacitor banks shall always be protected against possible short-circuits, fuses, under voltage and over current protections and imbalance protection is especially effective.

The presence of fuses within the capacitor shall not be deemed to be a substitute for external protective fuses or switches, which are always needed. It should however be kept in mind that an internal failure in a self-healing capacitor might occur therefore the external fuses or switches are not generally sufficient to prevent the capacitor from bursting. In this case, capacitors with anti-bursting devices should be used.

Limiting Fuses for HV Capacitors

These shall be used to protect individual capacitors or capacitor banks when, in case of short circuit, the energy surge into the capacitor is such as to cause the casing to burst.

Expulsion Fuses for HV Capacitors

These are mounted to protect individual capacitors. Their intervention may harm persons or objects in the immediate neighbourhood, and the user shall take proper precautions by additionally installing suitable mechanical protections.

Imbalance Protection for HV Capacitor Banks

A capacitor bank may be equipped with imbalance protection, the cut-in threshold will be set by the manufacturer and no attempt to modify it should be made.

Voltage

The rated voltage of a capacitor is the reference voltage for which the capacitor was designed and on which the test voltage values are based.

Safe operation of a capacitor requires the operating voltage not to exceed rated voltage. However under special conditions, not envisaged at the time of installation, over voltages within the limits set forth in the Table 1, below, are admitted. In any case, it shall be kept in mind that operation under overload conditions shortens the capacitor's life expectance.

Rated Voltage Selection

The capacitor rated voltage shall be selected taking the following considerations into account:

A) In some networks, the difference between operating voltage and rated voltage may be significant.
B) Shunt-connected capacitors for power-factor correction may cause voltage to increase where they are installed.
C) Further voltage increase may be needed in the presence of harmonics.
D) Voltage at capacitor terminals is likely to be especially high under low-load conditions (e.g. at night).
E) Voltage at capacitor terminals increases when an inductor is series-connected to the capacitor in order to limit the effect of harmonics.
F) When a capacitor is permanently connected to a motor, over voltage may occur after the motor has been disconnected. The motor revolves by inertia and may operate as a self-excited generator, originating voltages that are significantly higher than the systems voltage.
G) The residual voltage due to self-excitation after the machine was disconnected is especially harmful to induction generators and motors equipped with a no-voltage safety brake (e.g., motors of lifting gear).
H) When a capacitor is connected to a Star Delta configured motor, it shall be arranged in such a way that no over voltage occurs when the starter device operates.
I) Capacitors that are exposed to over voltage due to atmospheric discharges shall be adequately protected. When over voltage arresters are used, they shall be located as close to the capacitors as possible.

Current

A capacitor's rated current is the reference current for which the capacitor was designed.

The current in the capacitor may be greater than the rated current because of the presence of harmonics. In no case shall the RMS current in the capacitor be greater than 1.3 times the current absorbed under rated voltage and frequency, transients excluded.

The peak value of the over current due to insertion operations shall be limited to a maximum of one hundred times the rated RMS current. This limitation may be obtained by supplying the capacitor or banks via resistors or inductors.

The following shall be taken into account when evaluating the possible over currents in capacitors:

a) The main source of harmonics in an electric system is electronic power equipment (converters), arc furnaces and the saturated cores of transformers.
b) At the load, the increase in line voltage is heightened by the presence of capacitors. In this case, the saturation of the transformer cores may be such as to generate voltage and current harmonics that will damage the transformers and cables; for this reason, the capacitors shall not be left on when power-factor correction is not needed.
c) When harmonics are present, one of them may be amplified by resonance between the capacitors and the supply lines producing over currents the values which can be harmful for the capacitors and for the entire system. In this case, suitable inductors shall be series-connected to prevent or filter the resonance.

The cross section of the cables connecting the capacitors and bank shall be dimensioned for at least 1.5 times the rated current, taking the capacitor tolerance into account. In no case shall the heat generated by the cable significantly overheat the capacitor terminals.

Operating Temperature

The ambient operating temperature is a major parameter for the safe operation of power-factor correcting capacitors. Capacitors shall be installed in such a way as to have adequate convective and radiating dissipation of the loss-generated heat, and the site shall be ventilated in such a way that the ambient air temperature limit around the capacitors is never exceeded.

Capacitors are classified by categories according to the ambient temperature in which they can operate. This category always appears on the nameplate. To check the capacitor's thermal operating conditions, the cooling air temperature shall be measured at steady state at the hottest spot between two capacitors. When one capacitor only is installed, the cooling air temperature shall be measured at 2/3 of its height above the base and 0.1m distance towards outside.

Depending on the category to which the capacitor belongs, the cooling air temperature shall never exceed the limits shown in Table 2, below, by more than 5^{o}C.

Mechanical Stress

The user shall not submit the capacitor to excessive mechanical stresses.

During installation, the capacitor shall be handled by its lugs and not by the isolators.

When wiring the capacitor in, the terminals shall not be tightened to a greater torque than specified by the manufacturer.

Care is required in the electrical and geometric dimensioning of the connections to prevent mechanical stresses due to temperature changes.

Discharge Devices

Each capacitor or capacitor bank shall be fitted with a device that can discharge that capacitor or capacitor bank in less than or equal to three minutes, for capacitors rated <660V, or in less than or equal to five minutes for higher rated capacitors. Discharge time is calculated from the initial voltage peak multiplied by √ 2V to drop to less than or equal to 75V. No switch, fuse or other breaker shall be inserted between the capacitor and the discharge device. The discharge device does not release the user from the obligation to short-circuit and earth the terminals prior to handling the capacitor.

The discharge circuits shall be capable of withstanding the discharge current required to discharge the capacitor from the 1.3V over voltage peak.

Residual Voltage

When the capacitor is energized, the residual voltage shall not exceed 10% of rated voltage. To comply with this requirement, discharge resistors having a lower resistance value or additional discharge devices are generally necessary when the capacitors are automatically switched on and off.

Casing Earth Connections

To maintain the casing, when of metal, at fixed potential and to permit conducting any fault current in case of discharge towards the casing, the casing shall be equipped with an earthing terminal capable of withstanding the fault current. The terminal shall be connected via a conductor capable of withstanding the fault current as set forth in the CEI 17-13 standard.

Altitude

In general capacitors shall not be used above 2000m altitude without effective derating being applied to their use.

Special Environmental Conditions

Capacitors are not suitable for installation in environments where the following conditions occur:

a. High relative humidity, (continuously >95% RH)
b. Rapid mould growth
c. Corrosive or saline atmosphere
d. High concentration of dust, (unless effective filtering is applied within the cabinet)
e. Presence of explosive or highly flammable materials
f. High vibration

Maintenance

Before gaining access to the terminals of a capacitor or bank of capaitors, wait at least five minutes and short-circuit and earth the terminals. Periodical checks and inspections are required to ensure reliable operation; in general this should include the following:

Once a Month:

- Clean insulation grommets on the capacitors and insulators on the battery with cloth and alcohol; use special care for those between tiers.
- Check all fixtures for tightness
- Check that there are no visible indications of overheating.

Once a Year (In addition to the monthly checks detailed above)

- Check surface conditions of the cabinets and or storage racks, paint or treat as needed.
- Check terminal clamps for tightness. This operation is always required before start up.

A more thorough maintenance schedule should be established according to the specific operating conditions in which the capacitor or capacitor bank is fitted; for instance, installation in a polluted or saline environment may make more frequent cleaning necessary.

Additional Considerations for Power Factor Correction Systems with Operating Voltages up to 660V

Power-factor correction equipment means a set of capacitors composed of:

- One or more capacitor sets, which can be switched in automatically or manually via suitable controls (contractors, switches, breakers etc)
- Controls
- Protection, measurement and control devices
- Wiring

Mounting can be sight-exposed or enclosed in a board.

While all that was stated above on capacitors and banks still stands, power-factor correcting equipment only is considered hereafter.

General Requirements

Users must comply with manufacturer's instructions as contained in this documentation and observe safety distances, erection and wiring criteria, operating criteria and inspection and maintenance instructions.

Unless allowed by the degree of protection, the apparatus shall not be exposed to rain and solar radiation and shall not be placed in environments where humidity might pose condensation hazards.

If the equipment is fitted with forced-draft ventilation, check its effectiveness once a month and clean the filters if any.

Suitable precautions should be taken to prevent dangerous interference with adjacent equipment.

Automatic Installations

Capacitors mounted in an automatic-control bank are submitted to frequent severe voltage and current surges at insertion. These transients wear out the controls and damage the capacitors.

Frequently inspect the contactor switches, as using contactors with worn switches is hazardous.

Table 1

Maximum Permissible Voltage

Type	Voltage Factor x U^n (RMS)	Maximum duration	Observation
Power frequency	1.00	Continuous	Highest average value during any period of capacitor energisation. For periods of less than 24h exceptions apply.
Power frequency	1.10	8h in every 24h	System voltage regulation and fluctuation
Power frequency	1.15	30 mins in every 24h	System voltage regulation and fluctuation
Power frequency	1.20	5 mins	Voltage rise at light load
Power frequency	1.30	I min	

It is assumed that the over voltages given in the table and having a value higher than 1.15 U^n occur 200 times in the life of the capacitor.

Table 2

Cooling Air Temperature Limits

Symbol		Ambient air temperature (ºC)	
	Max	Highest average in period of	
		24 h	1 year
A	40	30	20
B	45	35	25
C	50	40	30
D	55	45	35

Note: The temperature values according to this table can be found in the meteorological temperature tables covering the installation site.

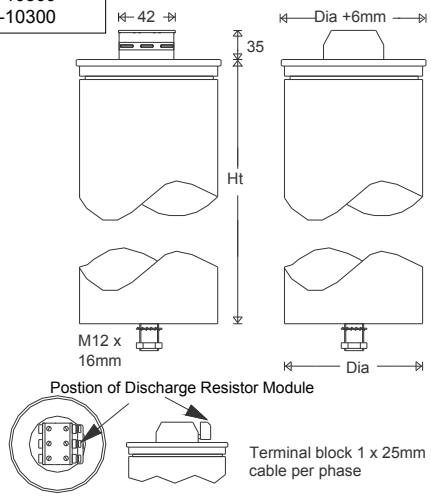
Appendix 2

Elektronicon Three Phase MKP Dry Wound Polypropylene Gas Impregnated PFC Capacitors with Terminal and Resistor Modules

kVAr 415V	Capacitance tolerance -5% / +15%	Current Amps	Dia mm	Ht mm	**PART NUMBER**	Discharge Module Part Number
25.0	3 x 154uF	3 x 34.8	116	245	275.188-615400	275.100 -10120
20.0	3 x 123uF	3 x 27.8	116	230	275.186-612300	275.100 -10180
15.0	3 x 92.4uF	3 x 20.9	85	230	275.156-509200	275.100 -10180
12.5	3 x 77uF	3 x 17.4	85	230	275.156-507700	275.100 -10300
10.0	3 x 61.6uF	3 x 13.9	75	230	275.546-506200	275.100 -10300
7.5	3 x 46.2uF	3 x 10.4	85	164	275.155-504600	275.100 -10300
5.4	3 x 33uF	3 x 7.0	75	176	275.147-603300	275.100 -10300

NOTE.
Capacitors may be mounted in any position - except upsidedown.

275.5**-****** - discharge module integral to terminals



Suitable for operation on system volatges up to and including 450Vrms subject to BS EN 60831 temperature category C.

Temp Cat	Absoute Max	Max avge (24hrs)	Max avge (365days)	Anticipated Life(hrs)
C	**50°C**	**40°C**	**30°C**	**130,000**
D	**55°C**	**45°C**	**35°C**	**100,000**

Losses <0.2 W/kVAr - dielectric
0.3 W/kVAr - typical

Limit Loss Factor 0.0005

Permissible Overvoltages 110% Vn 8 hours/day
115% Vn 30 mins/day
120% Vn 5 min 200 times
130% Vn 1 min 200 times

Transient Overvoltage 300% Vn Peak value

Permissible Overcurrents 130% In Continuous
200% In Peak

Relevant Specifications VDE 10140
CSA 22.2 No 190-M 1985
UL No. 810
BS EN 60831 - 1 BS EN 60831 - 2

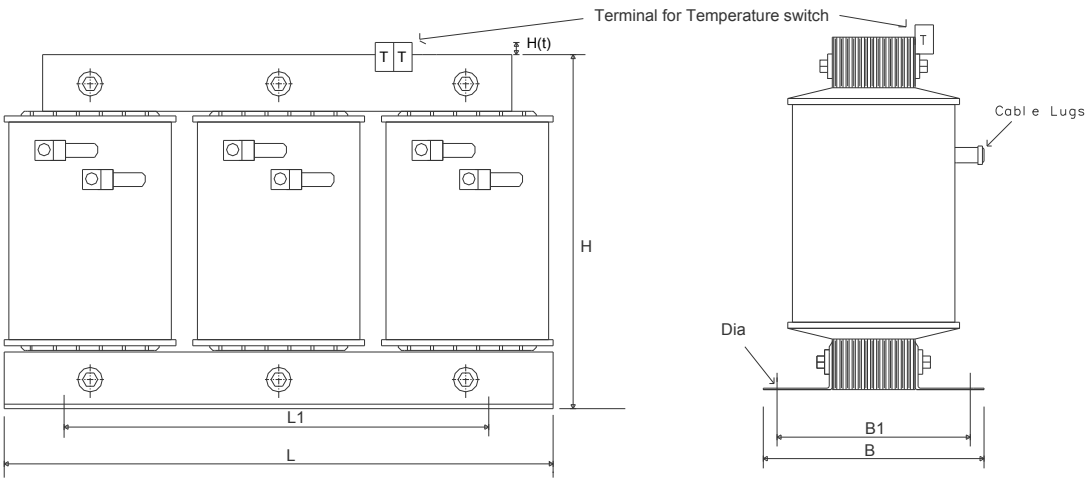
A Typical Capacitor Bank showing the wiring and also the bleed resistor packs

WARNING

It is imperative that the bleed resistors be operational so as to dissipate the charge on the capacitors when the unit is turned off. When the system is switched off you should see the voltage across the resistors drop from the operational voltage, (normally 415V), to 0V in less than 40 seconds. If this does not happen then it is essential that the resistor pack be changed.

Appendix 3

Standard Reactive Elements for 400V 50Hz Systems



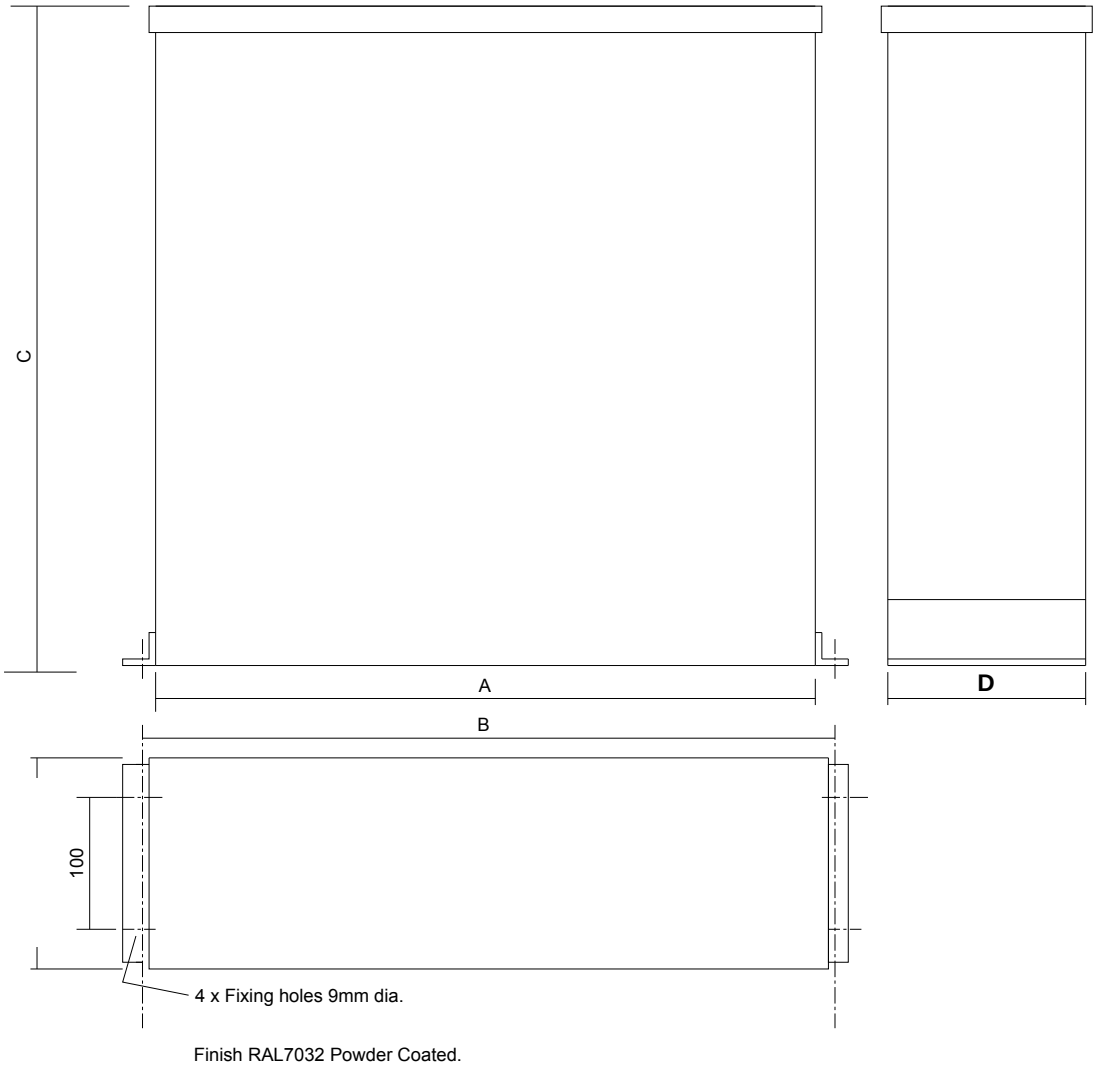
GENERAL DATA
Standards : VDE0570 PT2/IEC96/104/CD
Design : three phase, iron core, double air gap
Protection IP00
Insulation Class : T40/B
Insulation Voltage : 3kV
Temp Monitoring : 120C
Harmonic Loading (1.06 x Capacitor fundamental)
3rd Harmonic Loading : 0.5% of Fundamental Voltage
5th Harmonic Loading : 5% of Fundamental Voltage
7th Harmonic Loading : 5% of Fundamental Volatge

Part Number	L	L1	H	H(t)	B	B1	Dia	Losses	kg
10/415/50/5.67/D	190	170	165	0	102	78	8	35	8.5
12.5/415/50/5.67/D	190	170	165	0	102	78	8	40	10
20/415/50/5.67/D	210	175	185	10	115	95	8	55	17
25/415/50/5.67/D	240	200	215	5	141	115	9	65	19
50/415/50/5.67/D	300	240	265	2	177	145	11	95	40

A Typical Inductive Reactor Used for Harmonic Filtering in a Detuned EnviroVAr Cabinet

Appendix 4

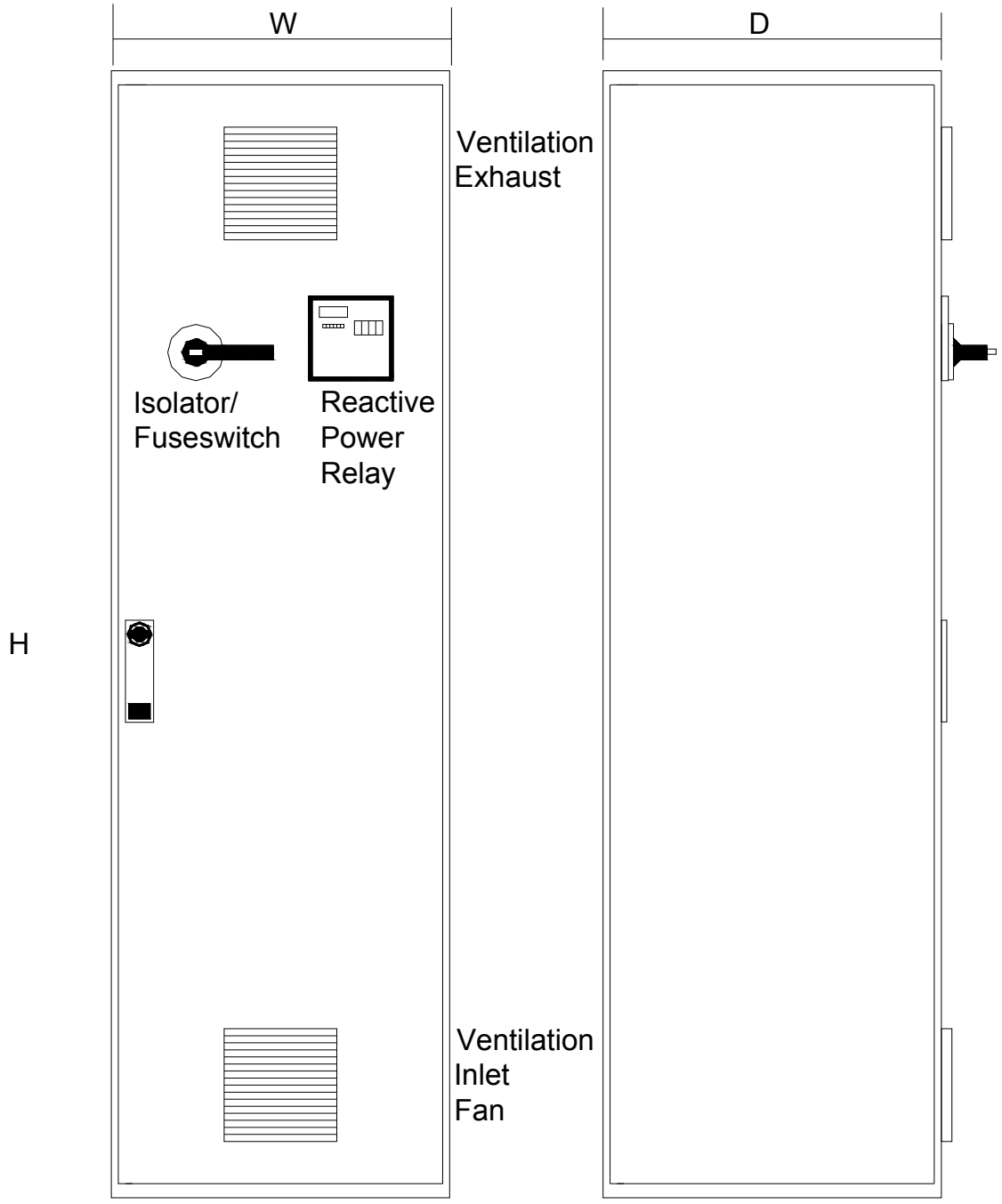
Cabinet Dimensions 50kVAr Units (Standard and Detuned)



Finish RAL7032 Powder Coated.

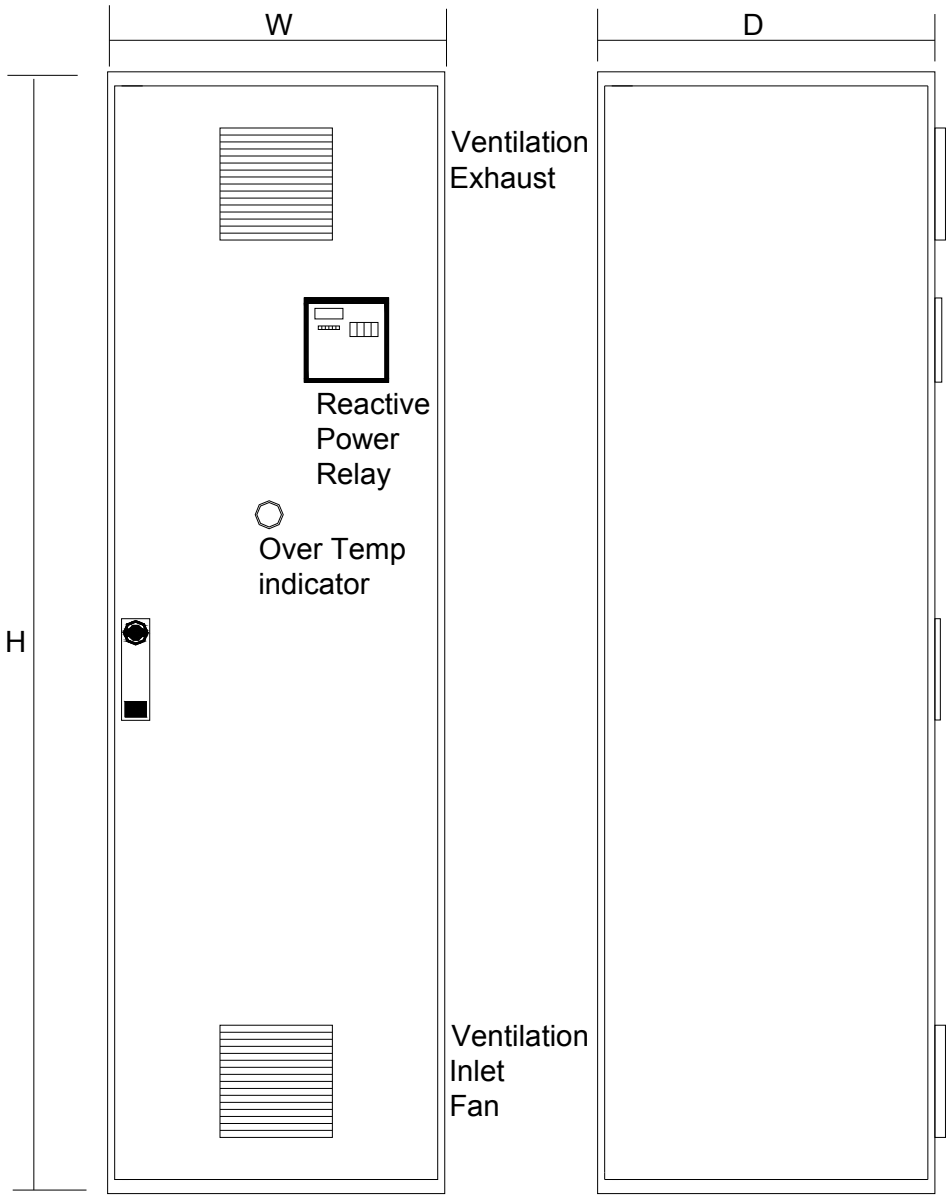
Height “C”	Width “A” & “C”	Depth “D”
700mm	500mm	250mm

100 – 400kVAr Standard Cabinets with Isolator (Standard and Detuned)



Unit	Height "H"	Width "W"	Depth "D"
100kVAr	1000mm	600mm	300mm
150 – 200kVAr	1200mm	600mm	300mm
250 – 400kVAr	2000mm	600mm	300mm

100 – 400kVAr Standard Cabinets without Isolator (Standard and Detuned)



Unit	Height "H"	Width "W"	Depth "D"
100kVAr	1000mm	600mm	300mm
150 – 200kVAr	1200mm	600mm	300mm
250 – 400kVAr	2000mm	600mm	300mm

Appendix 5

Cabinet Weights 50kVAr through 450kVAr Units (Standard and Detuned)

EnviroVAr Size in kVAr	Standard Unit Weight (kg)	Detuned Unit Weight (kg)
50	69	145
75	71	151
100	78	158
125	114	214
150	117	237
175	132	272
200	135	295
225	224	404
250	237	437
275	251	471
300	264	504
325	301	561
350	315	595
375	319	619
400	322	642
425	327	667
450	330	690

The above detail assumes standard fittings; weights will be increased on average by 12kg if a split 25/12.5/12.5kVAr multi-stage is substituted for a single 50kVAr stage. There is only a nominal increase in weight if Auto/Manual switching is included.

Caution should be exercised with shipping and handling if there are weight limitations at any stage of the delivery to installed site as the above weights do not include the weight of packing. If in any doubt in this matter please contact EMS (European) to establish the precise shipped weight.