LV POWER FACTOR CORRECTION

PARTS AND TRAYS

GENERAL SALES CONDITIONS
downloadable from our website

ABOUT ORTEA

Founded in 1969, ORTEA SpA is a leading company in manufacturing and engineering Power Quality solutions.

Fifty years in the business and ongoing technical research have made of ORTEA SpA a competitive and technologically advanced company.
Close co-operation between design, production and marketing enables to meet the requirements of a constantly growing number of customers.
Beside standard production, ORTEA SpA can be extremely flexible in developing and manufacturing special equipment according to User's specification. All this thanks to the experience gained over many years of applied technological development. Such development includes IT tools that enable the technical staff to elaborate electrical and mechanical designs for each "custom product" on a quick and cost-effective basis.

The ORTEA SpA products are installed and working in a large number of countries, and, thanks to strategically positioned offices and distributors, guarantee rapid and competent support.

QUALITY CERTIFIED

CERTIFIED
ISO 9001 · ISO 14001
OHSAS 18001

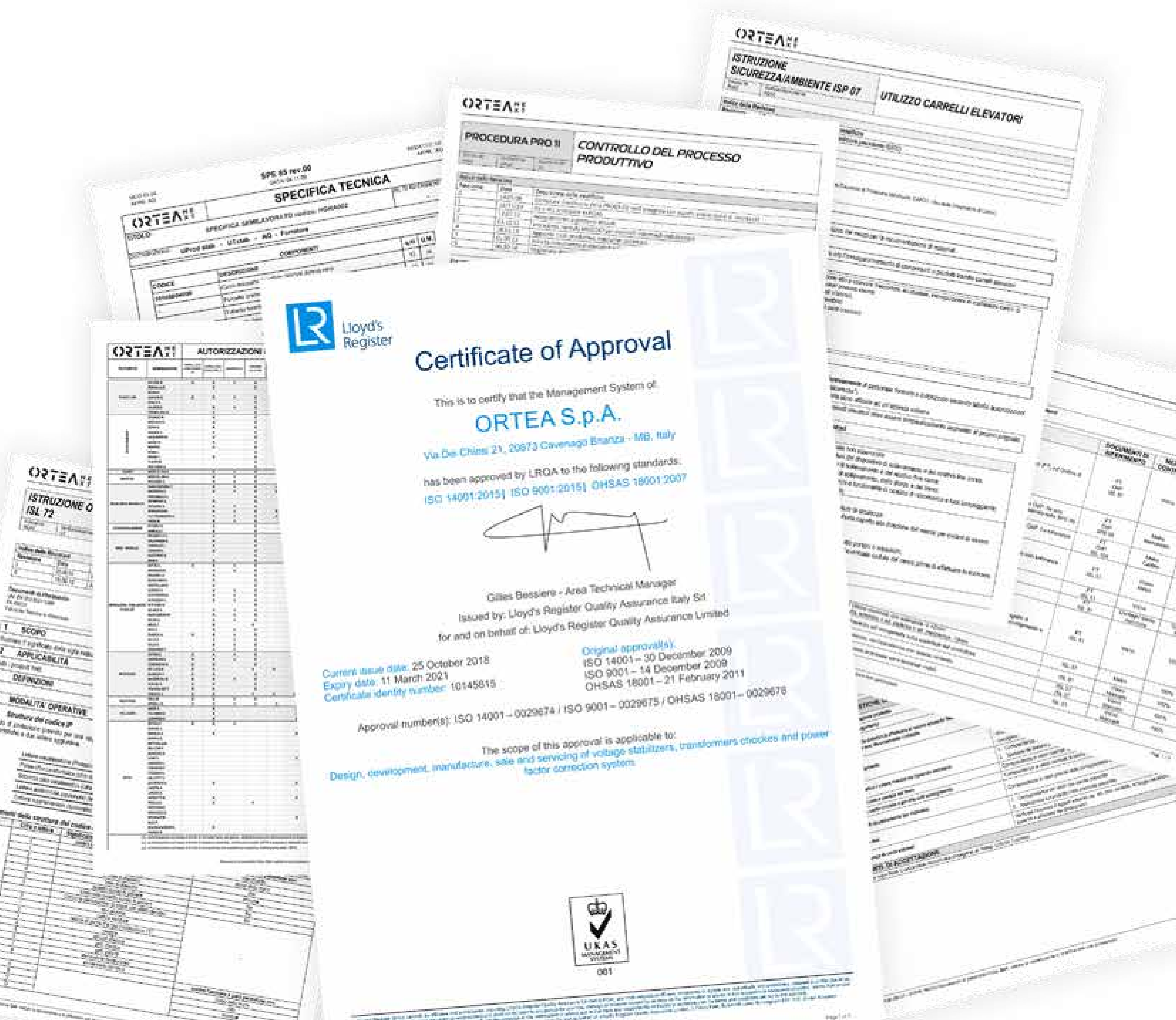
The belief that product quality and Customer satisfaction are the core of a modern organisation, led to the implementation of a certified Company Managing System.

A modern Company that wants to accept the challenge of today's business scenario cannot do so without conforming to standardized organizational criteria.
Customer satisfaction, product quality and responsible occupational practices are the basis on which the Company's activities can be consolidated. ORTEA SpA understood this a long time ago: the first ISO 9001 approval dates back to 1996.

Today ORTEA SpA Integrated Managing System is approved by Lloyd's Register according to the main Standards:

- ISO9001 (Quality management systems).
- ISO14001 (Environmental management systems).
- OHSAS18001 (Occupational health & safety management systems).

This means that ORTEA SpA can ensure that its performance is optimized in terms of internal process management, commitment towards environmental issues and attention to health & safety at work within the frame of a single Managing System.



ORTEA POWER QUALITY SOLUTIONS

Companies are more and more sensitive to Power Quality issues because they can cause troubles and damages to equipments and processes, up to interrupting the production cycle.

ORTEA SpA, with his brands ORTEA, ICAR and ENERSOLVE, offers a unique range of products and services for Power Quality and Energy Efficiency of low voltage electrical networks: voltage stabilisers, sag compensator, power factor correction systems, transformers and active harmonic filters.

VOLTAGE VARIATION	VOLTAGE STABILISERS	ORTEA
SAGs/DIPs	SAG COMPENSATOR	ORTEA
EXCESSIVE REACTIVE POWER	POWER FACTOR CORRECTION SYSTEMS	ICAR
UNPROTECTED LOADS	LV TRANSFORMERS	ORTEA
HARMONIC POLLUTION	ACTIVE HARMONIC FILTERS	ICAR
WASTE OF ENERGY	ENERGY EFFICIENCY SMART DEVICES	ENERSOLVE

THE 4 REASONS TO HAVE POWER FACTOR CORRECTIONS

Electricity Authorities.

The Electricity Authorities, force companies distributing electricity to apply financial penalties to utilities that have a substantial contractual power and low energy cos phi (generally 0,9). The correct power factor of the electric plant allows you to avoid those penalties, which often are not reflected in the bill, and then are paid by the final user without even realizing it.

Economic convenience.

Economical benefits due to penalties elimination and current reduction, with consequent optimized dimensioning of the components and increased life expectancy.

Energy efficiency.

The power factor correction reduces the “useless” inductive currents required by the loads and that impacts the entire electric network, both in the generation, transmission and distribution stages.
Power factor correction is therefore an important contribution to the energy efficiency of both the user’s electrical system and the electricity grid.

Power Quality.

In many industrial electric plants supplied by MT there is a tension considerably distorted, due often to excessive load of MV/LV transformer.
The correct Power Factor Correction with a consequent load reduction by the transformer allow to bring it back to the operating conditions within the linearity limits, substantially reducing the voltage distorsion.
Furthermore the proper Power Factor reduces the presence of harmonic currents.

SERVICES

It is particularly convenient to install an effective power factor correction system, correctly sized
It is essential to monitor the proper functioning because if you do not keep them in perfect working order, they “lose power”, and you are likely to pay penalties.
With proper maintenance you can avoid wasting money and unnecessary power dissipation in the electric plant cables and transformers that undergoes premature aging.

It is also important a proper maintenance and use of original spare parts since capacitors, when worn or of poor quality, are likely to burst causing damage to electrical equipment, plant shutdowns due to protection tripping, or even real fire.

We offer a wide range of services to help you in all situations that must be addressed from the choice of the correct power factor correction system, to commissioning, to management, to replacement.
The measurements can be made with an instrument compliant with IEC 61000-4-30 class A, able to check the energy quality according to the indications of the IEC 50160 standard.

Commissioning.

Design and production according to User’s specification.

Design and production for complex plants.

Technical training.

Check-up of existing systems.

Make your own measurement and let us know.

Local support.

Energy Quality Analysis.

Revamping solutions, original spare parts.

GLOSSARY

Cos phi

Simplifying, in an electrical system is appointed with phi (φ), the phase shift between the voltage and the electric current at the fundamental frequency of the system (50Hz). The cos phi is therefore a dimensionless number between 0 and 1, and varies from moment to moment.
Typically, an industrial electrical system has an inductive cos phi, which value depends on the characteristics of the user plant.

Power factor

In an electrical system means, with power factor, the ratio between the active power and the apparent power. Also the power factor is a dimensionless quantity between 0 and 1, which varies from moment to moment. However, the cos phi and the power factor coincide only in systems devoid of sinusoidal harmonic currents. In a system with harmonic, the power factor is always less than the cos phi.

Monthly average power factor

Electricity bills often show the monthly average power factor, obtained from the ratio between the active power consumed by the user and the apparent power transited the point of delivery. Typically, the average monthly power factor is calculated separately on different time slots.

Isolation level

For a capacitor that complies with IEC 60831-1, the isolation level is indicative of the voltage pulse that can withstand.

Insulation voltage

For a power factor correction system that complies with the IEC 61439-1/2, the isolation voltage is indicative of the maximum voltage that can withstand the entire system.

Nominal voltage of the capacitor U_N

It is the rated voltage of the capacitor, at which its output rated power is calculated.

Maximum operating voltage U_{MAX}

It is the maximum voltage that the capacitor can withstand, for the time indicated by the IEC 60831-1/2.
The following relation applies U_{MAX} = 1,1 U_N

Rated operational voltage Ue

It is the rated voltage of the power factor correction system, which guarantees proper use. A capacitor with a rated voltage can have on board capacitors with voltage U_N > Ue.
It may never happen otherwise.

Short-circuit current Icc

As indicated in the IEC 61439-1, is the prospective short-circuit current that the cabinet can endure for a specified time. It's a value stated by the manufacturer of the cabinet on the basis of laboratory tests. The short-circuit current of the cabinet can be increased, in case of need, by installing fuses. In this case the declared data must be accompanied by the words "fuse conditioning short-circuit current".

Resonance

In a LV plant, resonance is the amplification phenomenon of harmonic currents generated by one or more non-linear Loads. The LC circuit is responsible for the amplification, consisting of the MV/LV Power Transformer, that feeds that portion of installation, and by the PF improving capacitor bank. To avoid this phenomenon, wherever there is the risk it might happen, the capacitor bank must be equipped with Harmonic Blocking Reactors.

Steps

They are the physical units of power factor bank, each controlled by a dedicated switching device (static switch or contactor). A rack may be constituted by a single step (as typically occurs in detuned bank) or more steps. For example, the MULTIrack HP10 from 150kvar/400V consists of 6 steps: 2 from 15kvar and 4 from 30kvar. It 'is easily verified by counting the number of contactors present on the front of the drawer. More step can be merged to achieve larger power steps: in these cases they are controlled by the same controller contact of the reactive power regulator.

Electrical steps

It is the internal configurations number which proposes a particular automatic power factor corrector, as a function of the steps (number and power) that has on board. For example, a power factor corrector of 280kvar with steps 40-80-160kvar offers 7 combinations: 40-80-120-160-200-240-280kvar. The greater the number of possible combinations, the better "accuracy" and the flexibility to use the power factor correction bank.

THD (Total Harmonic Distorsion)

For a periodic non-sinusoidal wave, the THD is the ratio between the rms of all harmonic components value and the rms value of the fundamental at 50Hz/60Hz.

$THDI_C$

It is the maximum THD that a capacitor can withstand, with regard to the current passing through it. It is a characteristic value of each capacitor, indicative of its robustness: much higher is the $THDI_C$ more robust is the capacitor.
The $THDI_C$ is the most significant value to compare different capacitors, together with the maximum temperature of use.

$THDI_R$

It is the maximum THD bearable by the capacitor relatively to the current that circulates in the plant to be corrected. It is an empirical fact, which is based on the used construction technology and experience of the manufacturer. There is no theoretical link between $THDI_R$ and $THDI_C$ valid for all plants. The $THDI_R$ can also be very different for capacitors with the same $THDI_C$ as made by different manufacturers.

$THDV_R$

It is the maximum voltage THD on the net and also represents the maximum value bearable by a power factor correction bank with harmonic blocking reactors.

f_D

It is the detuning frequency between inductance and capacitance of a detuned capacitor bank, that is a capacitor bank equipped with harmonic blocking reactors.
The detuning frequency is the most objective parameter for detuned capacitor bank comparison; the lower the detuning frequency is the sounder the capacitor bank is. In particular an 180Hz detuned capacitor bank is sounder and more reliable than another with 189Hz detuning frequancy f_D.
As of Ferranti effect, detuned capacitor bank capacitors are exposed to a voltage that is higher than the rated system voltage; for this reason these capacitors are rated for higher voltage compared to the mains voltage.
The according frequency can also be expressed, indirectly, by indicating the detuning factor p%.

POWER FACTOR CORRECTION: QUALITY AND SAFETY

We define safety the absence of dangers for people and things while the good is in use or stored in a warehouse. This means to identify stresses, risks and potential damages and the relevant elimination and to keep them under control so that to reduce the risk to a reasonable level.

Power capacitors and capacitor banks shall NOT be used:
- For uses other than Power Factor Correction and for AC or DC plants.
- As tuned or detuned filters unless specifically approved in written by ORTEA SpA.

General requirement

The capacitors are constructed in accordance with IEC - CEI EN methods, parameters and tests. The low voltage capacitors are assembled with the required protection devices and assembled into banks to give a quality product which will operate safely.
They are not considered as the indication that the capacitors and the power factor correction equipments are suitable for a use in the same conditions of the tests. The user has to verify that the capacitor and power factor correction equipment are of the correct voltage and frequency suitable for values of the network on which they are installed. The user has to verify that the installation of the capacitors and/or the power factor correction equipment is in accordance with the catalogue and the instructions of use. Capacitors and power factor correction equipment must not be exposed to damaging action of chemical substance or to attacks of flora and/or fauna.
Capacitors and power factor correction equipments must be protected against risks of mechanical damaging to which could be exposed during normal working conditions or during the installation.
Capacitors and power factor correction equipments that were mechanically or electrically damaged for any reason during the transport, the storage or the installation must not be used and these that breakdown during use must be immediately removed.

Additional instructions about power factor correction equipments

Definition

Power factor correction equipment means:
- One or more groups of capacitors that can be connected and disconnected on the network automatically or manually using suitable operating devices (contactors, circuit breakers, load-break switch...).
- Operating devices.
- Control, protection and measure systems.
- Connections.

The equipment could be open or closed inside a metal enclosure.

General requirement

Follow ORTEA instructions in the documentation attached to equipments considering the safe distance, the connection standard criteria, working standards and the instructions for the controls and the maintenance.

Compatibility

It must be paid attention to the electromagnetic interferences with the near by equipments.

Contactors

It is advisable to adopt capacitor duty contactors (category AC6-b) because they are equipped with pre charge resistors that substantially reduce the inrush currents while capacitors are switched on.
The early switching on of these resistors in respect to the closing or the contactor contacts, allows:
- To avoid main contacts melting.
- To avoid capacitor damage.

Recommendations for installation

Fixing and connection

To fix the power factor correction equipments it is advised to use these types of screws:
- SUPERRiphaso with M10 screw.
- MICROmatic and MICROfix wall-mounted with Fischer 8.
- MINImatic wall-mounted and floor-mounted with M8 screw.
- MULTImatic and MINImatic floor-mounted with M12 screw.

The installation of the power factor correction equipment is for indoor application; for different use call ORTEA technical department.

Protection devices

Operating devices (load-break switch) or operation and protection (circuit-breakers if the cables are longer than 3m) must be dimensioned to withstand capacitive currents (about 1.43 times nominal current), the inrush currents, the number of operations and they must be re-strike free.
The capacitors are made of polypropylene that is a flammable material. Even if a fire doesn’t begin from capacitors or inside the panel, they could however spread it creating dangerous gasses. If a danger exists from the presence of an explosive or flammable atmosphere, the IEC standard; ”Electric equipment with explosion and fire danger”, shall be strictly followed.
The protection device must never be opened when the panel is in operation with one or more racks inserted.

Danger for people

When we install power factor correction equipment we must pay attention that the parts which could be exposed to voltage are correctly protected from accidental contacts in accordance with IEC standards.
Before the commissioning verify the tightening of the terminal and of all the bolts is correct.

Protections

Overpressure devices
All the capacitors have an overpressure device which when operated, as in the case of breakdown, disconnects the element from use. This device is not a substitution for the fuses or external circuit-breakers that are specified in our power factor correction equipment.

Limit conditions

The influence of each factor below has not to be considered individually, but in combination and with the influence of other factors.

Voltage
Capacitor and capacitor bank nominal voltage is intended as the design and testing voltage.
The safe and proper use of power factor correction capacitors and capacitor banks, implies that the working voltage is not higher than the nominal voltage.
In special conditions, excluding the installation phases, higher over voltage are allowed as per below table (ref. IEC 60831).

Overvoltage factor (x U_N eff)	Max duration	Observation
1	Continuous	Highest average value during any period of capacitor energization. For period less than 24h, exceptions apply as indicated below
1,10	8h every 24h	System voltage regulation and fluctuation
1,15	30 min every 24h	System voltage regulation and fluctuation
1,20	5 min	Voltage rise due to light loads
1,30	1 min	

Note: for voltage without harmonics.

The life expectancy of capacitors and power factor correction equipment is greatly reduced when operating in overload conditions.
The choice of the nominal voltage is determined by the following considerations:
- On some networks working voltage could be very different from nominal voltage.
- Power factor correction equipment in parallel could cause an increase of the voltage at the connection point.
- The voltage increases with the presence of harmonics on the network and/or cosφ of in advance.
- The voltage at the capacitor terminals increases when capacitors are in series with reactors for harmonic blocking.
- If the power factor correction equipment is connected to a motor and not sized correctly, when we disconnect it from the network we may have a phenomena caused by the inertia that makes the motor to work as a self-excited generator consequently increasing of the voltage level at the terminals of the equipment.
- The remaining voltage caused by the self-excited after that the equipment has been disconnected from the network is dangerous for the generators.
- If the power factor correction equipment is connected to a motor with a star-delta starting device we have to pay attention to not cause the overvoltage when this device is working.
- All the power factor correction equipments exposed to overvoltage caused by atmospheric lightning must be protected in correct way.

If surge arresters are used they should be placed as close as possible to the equipment.

Working temperature
Working temperature of power factor correction equipment is a fundamental parameter for safe operation. As a consequence it is very important that heat generated is dissipated correctly and that the ventilation is such that the heat losses in the capacitors do not exceed the ambient temperature limits.
The highest workings temperature in normal service conditions between two capacitors is measured at a point 2/3 of the capacitors height and at a distance of 1cm from them. The capacitor temperature must not exceed the temperature limits showed in the following table.

	Ambient temperatures [°C]		
		Highest mean over any period of:	
Symbol	Maximum	24h	1 year
A	40	30	20
B	45	35	25
C	50	40	30
D	55	45	35

Mechanical Limits
The user has not to expose the equipment to exaggerated mechanical limits of operation. The user has to pay attention to the electrical and geometrical dimensioning of the connections to avoid exceeding the mechanical limits which may be reached by temperature variation.

Other considerations for working safety

Discharge device
Every capacitor must have a discharge device that can discharge it within 3 minutes.
The discharge time is calculated from the starting peak of voltage equal to rad(2)V_N until 75V.
Between the capacitor and the discharge system there shall not be a circuit-breaker, fuses or other sectioning devices.
This doesn't relief to short-circuit the capacitor terminals and earth every time it is required to handle the capacitor.

Residual voltage
When the capacitor is placed under tension its residual voltage must not exceed 10% of the rated voltage. This condition is generally satisfied when the power factor correction equipment is calibrated properly, the reactive power controller, reconnection time shall be appropriate to the discharge time.

Enclosure connection
To keep capacitors enclosure at fix voltage and to discharge fault current toward the case itself, they are grounded by connecting to earth the capacitors supporting frame.

Altitude
Power factor correction equipment must not be used above an altitude of 2000m. On the contrary please contact technical assistance.

Particular ambient conditions
Power factor correction equipment are not suitable for the applications in places where there are conditions as follows:

- Fast generation of mould.
- Caustic and saline atmosphere.
- Presence of explosive materials or very flammable.
- Vibrations

For environments with these characteristics: high relative humidity, high concentration of dust and atmospheric pollution, please contact technical assistance.

Maintenance

After the disconnection of the bank, prior to accessing the terminals of the capacitors wait 5 minutes and then shortcircuit the terminals and earth.
Periodically make these procedures:

Once every 6 months:

- Cleanliness by blast of air of the internal part of the power factor correction equipment and of the air filter anytime there is a cooling system.
- Visual control.
- Control of the ambient temperature.

Once a year:

- Control of the surfaces condition: painting or other treatments.
- Control of the correct tightening of the screw (this operation must be done before the commissioning).
- Checking the contactors status.
- Checking the capacitors and chokes (if present) status.

If there are concerns about any environmental conditions an appropriate maintenance program must be established (for example in a dusty environment could be necessary to clean using blasts of air more frequently).

Storage and handling

The power factor correction equipment handling must be made carefully avoiding the mechanical stresses and shocks. The equipment in highest cabinet may be hard to handle, because the center of gravity may be very high and decentralized.
Upon receipt of new equipment, make sure that the packaging is not damaged, although mild.
Always make sure that the equipment has not been damaged by transportation: take away the packaging and make a visual inspection with open door. If you discover some damage, write it on the delivery note (carrier copy) the reason for refusal or reserve.
The capacitors and power factor correction awaiting installation storage must be done leaving them in their original packaging, in a covered and dry place.

ORTEA NEXT

IMPROVE YOUR POWER QUALITY

EXPERIENCE

Founded in 1969, ORTEA SpA has gained experience and know-how that enabled continuous growth and evolution. This never-ending process has allowed the Company to assume a leading role worldwide in designing and manufacturing Power Quality solutions.

RELIABILITY

Thanks also to its long-established Quality System, ORTEA SpA can ensure the production of reliable and long lasting products, each one of them accurately tested.

FLEXIBILITY

In addition to the standard production, the extremely flexible organization of ORTEA SpA is able to develop and manufacture cost-effective special equipment based on the Customer's specification.

QUALITY

Aiming at providing for the best quality, the manufacturing process includes checks during production and detail test sessions for each equipment.
The certified Integrated Managing System ensures the control of every manufacturing phase, starting from checking the components at reception and ending with the best package in relation to the transport type.

RESEARCH & DEVELOPMENT

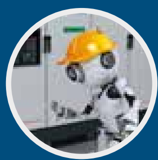
ORTEA SpA constantly collaborates with Universities and Business Partners in the research and development of new products and new technologies.

SYNERGY

By working together, marketing, design, production and after-sales service allow the Company to meet the necessities set forth by an increasingly globalised and competitive market.

EXPERTISE

ORTEA SpA pre- and after-sales organization is able to intervene quickly, analyzing the problems and providing the correct solution.



CUSTOMER SERVICE

The continuous monitoring and analysis of requests and claims carried out by the after-sales service enables the improvement the quality of both products and service to the Customer.

INDEX

SIZING AND SELECTION CRITERIA

To correctly correct power factor of a LV electrical system we must start from the target we want to achieve.

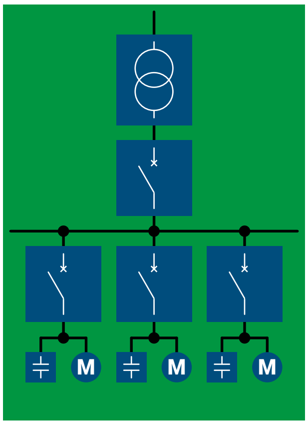
Meaning:

- A higher power factor as measured "at the energy counter" compared to that imposed by the energy authority for excess of reactive energy consumption, so to avoid penalties and / or risk detachment from the network.
- The reduction of currents (and therefore of joules losses and voltage drops) in longer and intensively loaded plant sections.

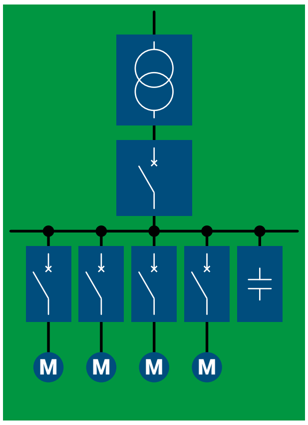
Depending on the electrical loads features present in the system (working cycle, power, power factor), topology (radial, ring, etc) and the extension of the plant itself, once calculated the power factor correction requirement, it will be clear how to size the capacitor bank.

LV PFC methods

The most common methods are distributed power factor correction (each of the utilities is equipped with its own unit for power factor correction, typically fixed) and centralized power factor correction (a single automatic PFC system is installed and dedicated to the whole plant).
It is also possible to create "mixed" solutions according to the peculiarity of the plant.



Distributed power factor correction



Centralized power factor correction

PF improvement of an asynchronous motor

Typical application of distributed power factor correction is that for a three-phase asynchronous motor. The PFC unit is chosen from tables, remembering to pay attention to the self-excitation risk.

Motor power		Required reactive power [kvar]				
HP	KW	3000 rpm	1500 rpm	1000 rpm	750 rpm	500 rpm
0,4	0,55	–	–	0,5	0,5	–
1	0,73	0,5	0,5	0,6	0,6	–
2	1,47	0,8	0,8	1	1	–
3	2,21	1	1	1,2	1,6	–
5	3,68	1,6	1,6	2	2,5	–
7	5,15	2	2	2,5	3	–
10	7,36	3	3	4	4	5
15	11	4	5	5	6	6
30	22,1	10	10	10	12	15
50	36,8	15	20	20	25	25
100	73,6	25	30	30	30	40
150	110	30	40	40	50	60
200	147	40	50	50	60	70
250	184	50	60	60	70	80

PF improvement of a Power Transformer

In MV electrical systems it is useful to compensate for the reactive power of the MV/LV transformer that supplies the LV part of the system. The required power is worked out starting from the percentage of no-load current (I0%). In the absence of this data, the following table can be used.

Power transformer [kVA]	Standard		Low losses	
	Oil [kvar]	Resin [kvar]	Oil [kvar]	Resin [kvar]
10	1	1,5	–	–
20	2	1,7	–	–
50	4	2	–	–
75	5	2,5	–	–
100	5	2,5	1	2
160	7	4	1,5	2,5
200	7,5	5	2	2,5
250	8	7,5	2	3
315	10	7,5	2,5	3,5
400	12,5	8	2,5	4
500	15	10	3	5
630	17,5	12,5	3	6
800	20	15	3,5	6,5
1000	25	17,5	3,5	7
1250	30	20	4	7,5
1600	35	22	4	8
2000	40	25	4,5	8,5
2500	50	35	5	9
3150	60	50	6	10

Selection criteria depending on the type of plant

The choice of power factor correction equipment must be made by evaluating the design data of the system or, better yet, your electricity bills.
The choice of the power factor correction type must be carried out according to the following table, which shows on the ordinate the rate of harmonic distortion of the plant current ($THDI_R$%) and in abscissa the ratio between the reactive power Q_C (kvar) of the PFC bank and LV/MV transformer apparent power A_T (kVA).
In light of these data, it identifies the box with proposed families, starting from the family that ensures the proper functioning with the best quality/price ratio.
So you choose the automatic power factor corrector series.
The fixed power factor correction must have the same electrical characteristics of the automatic.

The table was made starting from the following assumptions:

- Network voltage 400V.
- Initial power factor of the plant 0.7 inductive.
- Power factor target 0.95 inductive.
- Non linear load with 5°-7°-11°-13° harmonics current. High frequency harmonics are not allowed.

The hypotheses used are general and valid in the most of cases. In particular situations (harmonics coming from other branch of network, presence of rank equal to or a multiple of 3 harmonics) previous considerations may be invalid. In these cases, the guarantee of a correct choice of the equipment occurs only as a result of a measurement campaign of harmonic analysis of the network and/or the appropriate calculations.
ORTEA SpA disclaims any responsibility for incorrect choice of the product.

PFC systems selection guidelines

	$Q_C / A_T \leq 0,05$	$0,05 < Q_C / A_T \leq 0,1$	$0,1 < Q_C / A_T \leq 0,15$	$0,15 < Q_C / A_T \leq 0,2$	$0,2 < Q_C / A_T \leq 0,25$	$Q_C / A_T > 0,25$
$THDI_R\% > 27$	HP10 HP20	FH20 FH30	FH20 FH30	FH20 FH30	FH20 FH30	FH20 FH30
$20 < THDI_R\% \leq 27$	HP10 HP20	FH20 FH30	FH20 FH30	HP20 HP30	HP30 FH20	FH20 FH30
$12 < THDI_R\% \leq 20$	HP10 HP20	FH20 FH30	FH20 FH30	HP20 HP30	HP20 HP30	FH20 FH30
$THDI_R\% \leq 12$	HP10 HP20	HP20 HP30	HP30 FH20	HP10 HP20	HP20 HP30	FH20 FH30

Application example

For example, consider a MV connected system through a MV/LV 1000kVA transformer, and with a $THDI_R$% equal to 25%.
Assuming that the power factor correction system to be installed has a reactive power of 220kvar, the ratio Q_C/A_T is equal to 0.22.
The recommended power factor correction is therefore that in the box identified from the abscissa $0.2 < Q_C/A_T \leq 0.25$ and the ordinate $20 < THDI_R \% \leq 27\%$.
You can choose an HP30 family device, or go to the FH20 family.

The choice of the power factor correction unit needed for the installation must be made by evaluating the design data of the installation or, even better, the electricity bills.

Selection of the CT, its position and how to connect it to the APFC bank

The electronic regulator installed on the capacitor bank calculates the power factor of the plant that has to be corrected by measuring a phase to phase voltage and the related 90° lagging current.
The wiring which is necessary to obtain the signal is realized inside the APFC bank, therefore for a correct operation it is necessary to properly choose, position and wire the CT, which is not included in the capacitor bank.
The CT has to be chosen according to the characteristics of the load that has to be compensated and to the distance between its point of installation and the regulator:

- The primary of the CT has to be chosen according to the current absorbed by the loads that have to be compensated; it does not depend on the power of the APFC bank. The primary has to be approximately the same (or slightly higher) of the maximum current which can be absorbed by the load. However it is better not to choose a CT with an excessive primary: if this happens, when the load will absorb a limited current the CT will supply to the secondary a current which will be too weak to be calculated by the regulator.
  For example, if the load that has to be compensated has a maximum absorption of 90A, it is advisable to choose a CT with a 100A primary.

- The secondary of the CT must be 5A. If you want to use a CT with 1A secondary you will have to parameterize the regulator.

- The performance of the CT (apparent power) must be chosen taking into consideration the dissipation of the cable which connects the CT to the APFC bank. The table below shows how many VA are dissipated for each linear meter of a cable with different sections: to correctly calculate the wiring dissipation you need to consider the total route of the cable (way there and way back).

Cable section [mm^2]	VA for each meter of cable at 20°C[1]
2,5	0,410
4	0,254
6	0,169
10	0,0975
16	0,0620

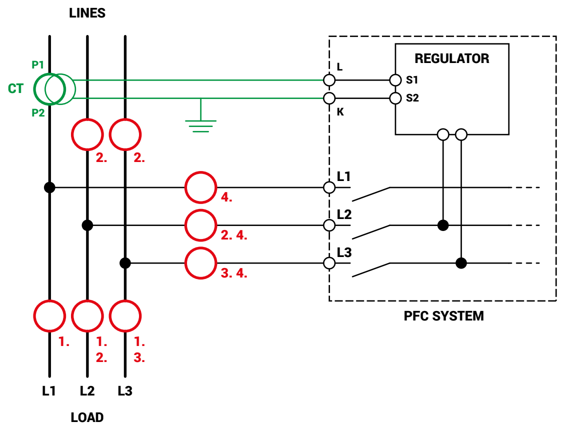
1. For each 10°C of temperature variation, the VA absorbed by the cables increase by 4%, the above values are extracted from the typical resistance of flexible class 5 cables.

- The precision of the CT is very important to avoid problems of bad functioning of the APFC bank. Choose class 1 CT or, even better, class 0,5.

The wiring has to be carried out with an appropriate section, to not excessively weaken the signal coming from the secondary of the CT: choose a 2,5mm^2 cable section only if the wiring between the CT and regulator is 1 m max. Use cable section at least 4mm² for wirings up to 10m, 6mm^2 up to 20m and 10 mm^2 for more than 20m wirings (however not recommended).
Connect to earth one of the two clamps of the CT.
It is strongly recommended to use a dedicated CT for the APFC bank, to avoid to put in series more than one device (ammeter, multimeter) on the same CT.

Position of the CT

As before mentioned, the electronic regulator installed on the APFC bank accurately calculates the cosφ of the plant if it can measure a phase to phase voltage and the related 90° lagging current.
Since the wiring is already internally carried out on the APFC bank on L2 and L3 phases downstream the load break switch (clamps 9 and 10, see the scheme), the CT must be positioned on phase L1 of the power cable upstream the APFC bank (below image, in green). The side of the CT with P1 (or K) mark has to be oriented to the line (upstream). The wiring of the secondary of the CT (clamps S1 and S2) to the APFC bank (clamps L and K) is made by the customer, according to the instructions in the previous points.



Please note that possible positions here below indicated in red are wrong because:

1. the CT is downstream the APFC bank
2. the CT is on the wrong phase (L2)
3. the CT is on the wrong phase (L3)
4. the CT is installed on the cable goes to the APFC bank.

For further information read the regulator's manual.

Selection of APFC bank protection device

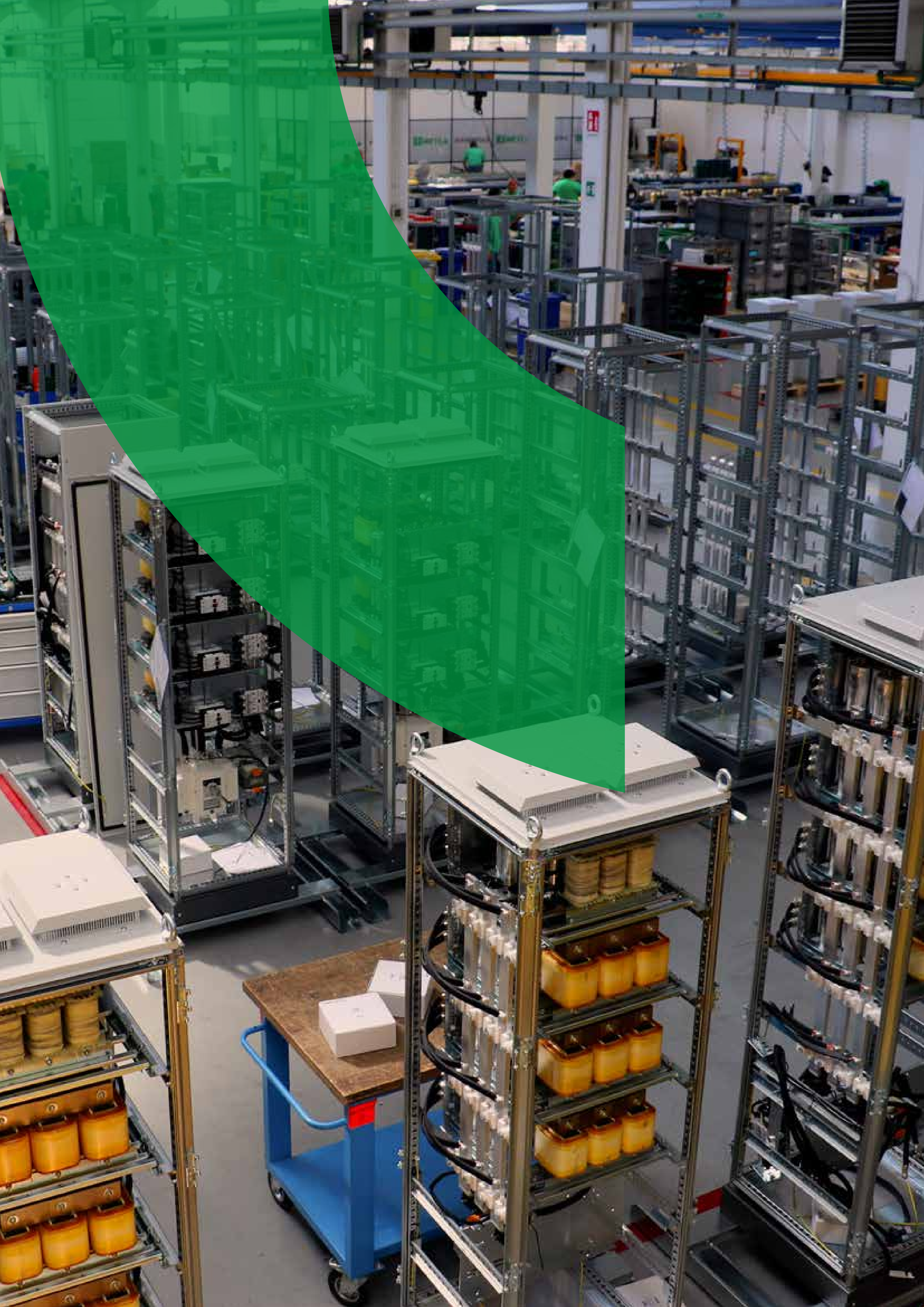
The low Voltage APFC bank equipped with self-healing capacitors are compliant with IEC EN 60831-1/2 (capacitors) and IEC EN 61439-1/2, IEC EN 61921 (complete devices) regulations.
According the above-mentioned regulations, the capacitor bank must be able to work in continuous supporting an rms value of 1.3 times the nominal current (this regulation takes into consideration that, when harmonics are present in the system, capacitors are overloaded).

Known this, and considering that APFC banks can have a tolerance on the nominal reactive power up to 10% more than nominal one, it is possible to indicate the calculation necessary for the choice and setup of the protection device to be installed upstream the APFC bank (Circuit Breaker or Fused Load Break Switch).

Calculation of the current
Maximum absorbed current:

$$In_{max} = 1{,}3 \times 1{,}1 \times \frac{Qn}{\sqrt{3} \times Vn} = 1{,}43In$$

Where In is the nominal current of the device calculated with the data present on the label, that is to say Vn (nominal voltage of the network) and Qn (nominal reactive power of the APFC bank at the nominal voltage of the network).
It is therefore necessary to choose and install a protection device (Circuit Breaker or Fused Load Break Switch) with current ≥ In_{max}, value according to which it has to be dimensioned the cable (or bars) which supply the APFC bank.



CRT POWER CAPACITORS

The film used in the CRT power capacitors comes directly from the ORTEA experience in the high performance capacitors, in particular it is defined as "High density metallized polypropylene film".

The main difference in comparison to standard polypropylene capacitors is the way in which the dielectric film is metalized. In standard polypropylene capacitors the thickness of the metal layer deposited on the film surface is constant; in 1995, instead, it has developed a manufacturing process that enables obtaining a metal layer with properly modulated thickness and achieving extraordinary results in the capacitors field for direct current and energy accumulation applications.
Subsequently this technology has been extended to capacitors for alternating current applications, with same remarkable results in power factor correction of industrial facilities.
The modulation of the metallization thickness, considerably betters capacitors performances (and therefore those of the power factor corrector systems of which they are the basic component) in terms of:

- Increased specific power (kvar/dm^3) with resulting reduction of power factor corrector systems dimension.
- Improvement of the strengthens to continuous and temporaries overvoltage for a better reliability even in plants with voltage peaks due to the network or manoeuvres on the plant; CRT capacitors are in fact tested at three times the rated voltage (type test).
- Better reaction to the internal short circuit thanks to the special metallization with variable thickness.

General description

The main features are:

- Three phase windings delta connected in a cylindrical aluminum case.
- Rated power from 2,5kvar up to 50kvar.
- Rated voltage from 230V up to 800V.
- Rated frequency 50 / 60 Hz.
- IP20 terminal board.
- Reduced mounting cost thanks terminal lid connections.
- Up to 130.000 hours service life design.
- Dry, environment friendly construction.
- Suitable for any mounting position (vertical preferable for better cooling).
- Indoor installation.

Applications

- Individual fixed Power Factor Correction for motors, low voltage transformers, etc.
- Low voltage automatic Power Factor Correction Capacitor Banks.
- Low voltage detuned/tuned Capacitor Banks.

Damping of Inrush Current

Capacitors used for power factor correction have to withstand a lot of switching operations.
The switching of a capacitor in parallel with energized capacitor banks, produces extremely high inrush currents and voltage transients. The connection of a low voltage power factor correction capacitor without damping to an AC power supply, could lead to a reduced lifetime.
For this reason, capacitors should be protected during the switching operation by means of suitable contactors equipped with damping resistors (AC6b).

Harmonics

Harmonics are sinusoidal voltages and currents with multiple frequencies of the 50 or 60 Hz line frequency. In presence of harmonics the resonance phenomena can be avoided by connecting capacitors in series with reactors (detuned filters). Components for detuned filter must be carefully selected (see next chapter). Particular care has to be taken for capacitors because the voltage across them will be higher than the nominal voltage when they have a reactor in series.

Discharging

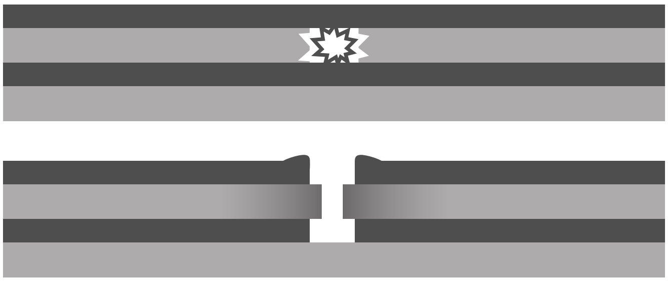
Capacitors must be discharged in 3 minutes to 75V or less. There shall be no switch, fuse or any other isolating device between the capacitor unit and the discharging device. ORTEA supplies capacitor discharge resistors to all series.

Safety features

CRT capacitors are equipped with the most modern and reliable safety features to keep capacitor working in proper conditions and to prevent heavy breakdowns.

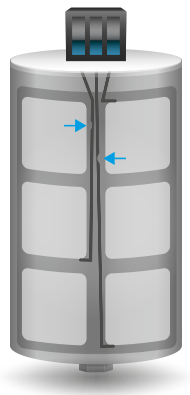
Self-healing metallized polypropylene

This metallized polypropylene feature is widely used in Power Capacitors as a mean to keep capacitors working even when voltage breakdown between the metal layers occurs.
In case of arc, the metallized surface around is evaporated but the breakdown is kept in limited area and it does not enlarge its effects.

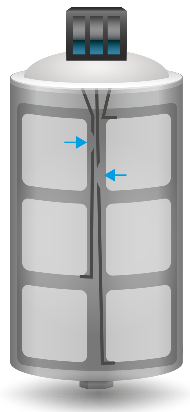


Over pressure safety device

In the case or fault, due to over voltage, overload or normal ageing, the self-healing process may accelerate and so to create a increasing pressure within the case.
In order to prevent the case from bursting, capacitor is fitted with an over pressure device that set out of service the capacitor from the supply; two of the supply leads have reduced section, and while the pressure increases leads are strained by the top lid till breaking of cables.



CAPACITOR IN WORKING CONDITIONS



CAPACITOR WITH OPERATED MECHANISM

Dry technology

As CRT capacitor is filled with resin, there is no risk of leaking oil or gas.

Touch proof terminals

CRT is equipped with terminal board of IP20 protection degree (see product tables for specific feature application).

Inside layout

Metallized Polypropylene

The CRT capacitor has a peculiar metallization process that enables obtaining a metal layer with properly modulated thickness and achieving extraordinary performances in terms of voltage withstand and overall reliability. The film is then cut and wound on high precision and fully automated winding machines, sprayed with abundant metal contact layer to reduce the contact resistance.

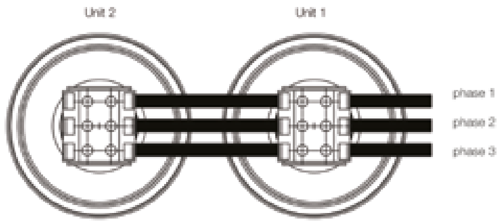
Wave cut film

CRT capacitors are also fitted with wave cut film to reduce the stress between the polypropylene film layers and the contact layer. This enable capacitors to withstand higher inrush currents during the switching operations.

Environmentally friendly filler

Capacitors need filler around capacitive elements in order to protect metal layers from oxidation and to help heat dissipation. Without this feature capacitors would cope with accelerated self healing and so a shorter service life.
The filler are all PCB free.

Limits for parallel of CRT capacitors



The maximum number of parallel connected units should not have a total output higher than 40kvar.
The cross section of cables in the Unit 1 (phase 1, 2, 3) have to be selected considering the total amount of the Unit 1 and Unit 2 output. Leave enough space to allow longitudinal expansion of the can for proper operation of the internal over pressure safety device (25 mm). A minimum space of 20 mm between capacitors is necessary to ensure proper cooling.

Installation and maintenance

Handling and Storage
Capacitors shall have to be handled and stored with care in order to avoid any mechanical damage during transportation. Protection against environmental influences shall also be taken.

Installation
Capacitors are suitable for indoor installation and vertical mounting position is preferable for better coolig.
Capacitors must be installed in such a way that the specified limit temperature is not overcome.
Not being in compliance with the above instructions will result as a reduction of the expected service life.
Installation of capacitors shall have to be performed in such a way that any dangerous resonance phenomena due to harmonics is avoided.

Automatic power factor correction banks
The switching of a capacitor bank in parallel with energized capacitor(s), produces extremely high inrush currents and voltage transients. For this reason, it is extremely important to wait for the unit discharge befor e a new switching.

Assembly
Capacitors shall have to be assembled by means of the threaded M12 bottom stud. The maximum applicable tightening torque is 10Nm.
The catalogue specifies the recommended cross section of the supplying cables.
In order to ensure a proper operation of the internal overpressure safety device, an extra minimum 25mm clearance distance between the upper part of capacitors and assembly enclosures shall have to be provided.
Capacitors shall be placed in such a way that there is an adequate dissipation by convection and radiation of the heat produced by the capacitor losses.
The ventilation of the operating room and the arrangement of the capacitor units shall provide good air circulation around each unit. A minimum 20mm distance between the units has to be maintained.

Maintenance
Periodical checks and inspections are required to ensure reliable operation of capacitors.
Monitoring and recording of the electrical service parameters are also recommended to become acquainted with progressive capacitors stress conditions.

Protections
Capacitors shall have to be protected against inrush peak currents during switching operations of automatic banks by means of suitable contactors equipped with pre-making resistors.

Safety Instructions

DO NOT MISAPPLY CAPACITORS FOR POWER FACTOR CORRECTION APPLICATIONS
Capacitors according to the Standards, are equipped with a suitable discharge device such as discharge resistors, permanently connected. They are able to reduce the residual voltage so that any dangerous resonance phenomena due to harmonics is avoided.

Automatic power factor correction banks
DO NOT TOUCH ANY CAPACITOR TERMINAL IF NOT SHORT CIRCUITED AND EARTHED IN ADVANCE to prevent damage to people and goods due to improper usage and/or application of capacitors, the “RECOMMENDATION FOR THE SAFE USE OF STATIC CAPACITORS, BANKS AND EQUIPMENT FOR POWERFACTOR CORRECTION” shall have to be strictly respected.
ORTEA SpA is not responsible for any kind of possible damages occurred to people or things, derived from the improper installation and application of Power Factor Correction capacitors.

Most common misapplication forms
- Current, voltage, harmonics and frequency above specification.
- Working or storage temperature beyond the specified limits.
- Unusual service conditions as mechanical shock and vibrations, corrosive or abrasive conductive parts in cooling air, oil or water vapour or corrosive substances, explosive gas or dust, radioactivity, excessive and fast variations of ambient conditions, service areas higher than 2000 m above sea level...

In case of doubt in choice or in performances of the capacitors ORTEA SpA technical service MUST be contacted.

Personal Safety
Electrical or mechanical misapplications of CRT capacitors may become hazardous. Personal injury or property damage may result from disruption of the capacitor and consequent expulsion of melted material.
Before using the capacitors in any application, please read carefully the technical information contained in “Installation and operating manual”.
The energy stored in a capacitor may become lethal.
The capacitor should be short circuited and earthed before handling to prevent any chance of shock.
Special attention must be taken to make sure the capacitors are correctly used for each application and that warnings and instructions are strictly followed.
Capacitors are made with polypropylene that is a flammable material.
The risk of fire cannot be totally eliminated; therefore suitable precautions shall be taken. Reliability data have a statistical value (i.e. based on a large number of components), it is not possible to transfer automatically data from a limited quantity or even to a batch of capacitors.
This applies in particular to consequential damage caused by component failure.

CRT POWER CAPACITORS

Common technical characteristics

Dielectric	polypropylene metallized film
Winding connection	delta
Safety device	internal overpressure disconnector
Capacitance tolerance	-5%, +10%
Over voltages	according to IEC Un +10% (up to 8 hours daily) Un +15% (up to 30 minutes daily) Un +20% (up to 5 minutes daily) Un +30% (up to 1 minute daily)
Maximum inrush current	200 In
Insulation level	3 / 12 kV
Voltage test between terminals (routine test)	2.15 Un, 50Hz, 10 seconds
Voltage test between terminals (type test)	3.00 Un, 50Hz, 60 seconds
Voltage test terminals/case	3000V, 50Hz, 10 seconds
Dielectric losses	< 0.2 W/kvar

Temperature class	-25/D
Cooling	natural air of forced ventilation
Permissible humidity	95%
Service life (hot spot 50°C)	130.000 operating hours
Service life (hot spot 55°C)	100.000 operating hours
Altitude above sea level	2000 m
Impregnation	resin filled, PCB free
Terminals	terminal board
Fixing and Ground	threaded M12 stud on case bottom
Mounting position	vertical preferable for better cooling
Protection degree	IP20
Installation	indoor
Discharge resistors	included
Discharge time	< 3 minutes to 75V or less
Applicable standards	IEC 60831-1/2

Un = 400V(415V)-50Hz

Part number	Model	Q Power [kvar]	C Capacity [μF]	In Current [A]	D Diameter [mm]	H Height [mm]	Pcs/box	Box dimensions [mm]	Discharge resistor
6DCRTX0500F50	**CRT-X-75201-5-400**	5	3 x 33.2	3 x 7.2	75	201	12	285x370x360	External
6DCRTX0750F50	**CRT-X-75201-7.5-400**	7.5	3 x 49.7	3 x 10.8	75	201	12	285x370x360	External
6DCRTX1000F50	**CRT-X-85201-10-400**	10	3 x 66.3	3 x 14.4	85	201	12	285x370x360	External
6DCRTX1250F50	**CRT-X-85201-12.5-400**	12.5	3 x 82.9	3 x 18	85	201	12	285x370x360	External
6DCRTX1500F50	**CRT-X-100201-15-400**	15	3 x 99.5	3 x 21.7	100	201	15	560x340x345	External
6DCRTX2000F50	**CRT-X-100201-20-400**	20	3 x 132.6	3 x 28.9	100	201	15	560x340x345	External
6DCRTX2500F50	**CRT-X-120201-25-400**	25	3 x 165.8	3 x 36.1	120	201	6	445x305x370	External
6DCRTX3000F50	**CRT-X-120201-30-400**	30	3 x 198.9	3 x 43.3	120	201	6	445x305x370	External
6DCRTX4000F50	**CRT-X-120276-40-400**	40	3 x 265.4	3 x 57.7	120	276	6	445x305x370	External
6DCRTX5000F50	**CRT-X-120276-50-400**	50	3 x 332	3 x 72.2	120	276	6	445x305x370	External

Un = 450V-50Hz

Part number	Model	Q Power [kvar]	C Capacity [μF]	In Current [A]	D Diameter [mm]	H Height [mm]	Pcs/box	Box dimensions [mm]	Discharge resistor
6DCRTX0500G50	**CRT-X-75201-5-450**	5	3 x 26.2	3 x 6.4	75	201	12	285x370x360	External
6DCRTX0750G50	**CRT-X-75201-7.5-450**	7.5	3 x 39.3	3 x 9.6	75	201	12	285x370x360	External
6DCRTX1000G50	**CRT-X-85201-10-450**	10	3 x 52.4	3 x 12.8	85	201	12	285x370x360	External
6DCRTX1250G50	**CRT-X-85201-12.5-450**	12.5	3 x 65.5	3 x 16	85	201	12	285x370x360	External
6DCRTX1500G50	**CRT-X-100201-15-450**	15	3 x 78.6	3 x 19.2	100	201	15	560x340x345	External
6DCRTX2000G50	**CRT-X-100201-20-450**	20	3 x 104.8	3 x 25.7	100	201	15	560x340x345	External
6DCRTX2500G50	**CRT-X-120201-25-450**	25	3 x 131	3 x 32.1	120	201	6	445x305x370	External
6DCRTX3000G50	**CRT-X-120201-30-450**	30	3 x 157.2	3 x 38.5	120	201	6	445x305x370	External
6DCRTX4000G50	**CRT-X-120276-40-450**	40	3 x 209.7	3 x 51.3	120	276	6	445x305x370	External
6DCRTX5000G50	**CRT-X-120276-50-450**	50	3 x 262.1	3 x 64.2	120	276	6	445x305x370	External

Un = 525V-50Hz

Part number	Model	Q Power	C Capacity	In Current	D Diameter	H Height	Pcs/box	Box dimensions	Discharge resistor
		[kvar]	[µF]	[A]	[mm]	[mm]		[mm]	
6DCRTX0500H50	**CRT-X-75201-5-525**	5	3 x 19.2	3 x 5.5	75	201	12	285x370x360	External
6DCRTX0750H50	**CRT-X-75201-7.5-525**	7.5	3 x 28.9	3 x 8.2	75	201	12	285x370x360	External
6DCRTX1000H50	**CRT-X-75238-10-525**	10	3 x 38.5	3 x 11	75	238	12	285x370x360	External
6DCRTX1250H50	**CRT-X-75201-12.5-525**	12.5	3 x 48.1	3 x 13.7	85	201	12	285x370x360	External
6DCRTX1500H50	**CRT-X-85238-15-525**	15	3 x 57.7	3 x 16.5	85	238	12	285x370x360	External
6DCRTX2000H50	**CRT-X-100201-20-525**	20	3 x 77	3 x 22	100	201	15	560x340x345	External
6DCRTX2500H50	**CRT-X-120201-25-525**	25	3 x 96.2	3 x 27.5	120	201	6	445x305x370	External
6DCRTX3000H50	**CRT-X-120201-30-525**	30	3 x 115.5	3 x 33	120	201	6	445x305x370	External
6DCRTX4000H50	**CRT-X-120276-40-525**	40	3 x 154	3 x 44	120	276	6	445x305x370	External
6DCRTX5000H50	**CRT-X-120276-50-525**	50	3 x 193	3 x 55	120	276	6	445x305x370	External

Un = 690V-50Hz

Part number	Model	Q Power	C Capacity*	In Current	D Diameter	H Height	Pcs/box	Box dimensions	Discharge resistor
		[kvar]	[µF]	[A]	[mm]	[mm]		[mm]	
6DCRTX0500L50	**CRT-X-75238-5-690**	5	3 x 33.3	3 x 4.2	75	238	12	285x370x360	External
6DCRTX0750L50	**CRT-X-75238-7.5-690**	7.5	3 x 50.1	3 x 6.3	75	238	12	285x370x360	External
6DCRTX1000L50	**CRT-X-75238-10-690**	10	3 x 66.9	3 x 8.4	75	238	12	285x370x360	External
6DCRTX1250L50	**CRT-X-75238-12.5-690**	12.5	3 x 83.7	3 x 10.5	75	238	12	285x370x360	External
6DCRTX1500L50	**CRT-X-85238-15-690**	15	3 x 100.2	3 x 12.5	85	238	12	285x370x360	External
6DCRTX2000L50	**CRT-X-100238-20-525**	20	3 x 133.8	3 x 16.7	100	238	15	560x340x345	External
6DCRTX2500L50	**CRT-X-100238-25-690**	25	3 x 167.1	3 x 20.9	100	238	15	560x340x345	External
6DCRTX3000L50	**CRT-X-100238-30-690**	30	3 x 200.7	3 x 25.1	100	238	15	560x340x345	External
6DCRTX4000L50	**CRT-X-100285-40-690**	40	3 x 267.6	3 x 33.5	100	285	15	560x340x345	External

** Star connection.*

Un = 400V-60Hz

Part number	Model	Q Power	C Capacity	In Current	D Diameter	H Height	Pcs/box	Box dimensions	Discharge resistor
		[kvar]	[µF]	[A]	[mm]	[mm]		[mm]	
6DCRTX0500D60	**CRT-X-75201-5-400-60**	5	3 x 27.6	3 x 7.2	75	201	12	285x370x360	External
6DCRTX1000D60	**CRT-X-75201-10-400-60**	10	3 x 55.3	3 x 14.4	75	201	12	285x370x360	External
6DCRTX1250D60	**CRT-X-85201-12.5-400-60**	12.5	3 x 69.1	3 x 18	85	201	12	285x370x360	External
6DCRTX1500D60	**CRT-X-85201-15-400-60**	15	3 x 82.9	3 x 21.7	85	201	12	285x370x360	External
6DCRTX2500D60	**CRT-X-100238-25-400-60**	25	3 x 138.2	3 x 36.1	100	238	15	560x340x345	External
6DCRTX3000D60	**CRT-X-120201-30-400-60**	30	3 x 165.9	3 x 43.3	120	201	6	445x305x370	External

Un = 480V-60Hz

Part number	Model	Q Power	C Capacity	In Current	D Diameter	H Height	Pcs/box	Box dimensions	Discharge resistor
		[kvar]	[µF]	[A]	[mm]	[mm]		[mm]	
6DCRTX0500K60	**CRT-X-750201-5-480-60**	5	3 x 19.2	3 x 6	75	201	12	285x370x360	External
6DCRTX0750K60	**CRT-X-75201-7.5-480-60**	7.5	3 x 28.9	3 x 9	75	201	12	285x370x360	External
6DCRTX1000K60	**CRT-X-75201-10-480-60**	10	3 x 38.5	3 x 12	75	201	12	285x370x360	External
6DCRTX1250K60	**CRT-X-85201-12.5-480-60**	12.5	3 x 48.1	3 x 15	85	201	12	285x370x360	External
6DCRTX1500K60	**CRT-X-85201-15-480-60**	15	3 x 57.7	3 x 18	85	201	12	285x370x360	External
6DCRTX2000K60	**CRT-X-100201-20-480-60**	20	3 x 77	3 x 24.1	100	201	15	560x340x345	External
6DCRTX2500K60	**CRT-X-100238-25-480-60**	25	3 x 96.2	3 x 30.1	100	238	15	560x340x345	External
6DCRTX3000K60	**CRT-X-100201-30-480-60**	30	3 x 115.5	3 x 36.1	100	201	15	560x340x345	External
6DCRTX4000K60	**CRT-X-120230-40-480-60**	40	3 x 154	3 x 48.1	120	238	6	445x305x370	External
6DCRTX5000K60	**CRT-X-120201-50-480-60**	50	3 x 192	3 x 60.1	120	201	6	445x305x370	External

HARMONIC BLOCKING REACTORS

The growing use of power electronic devices is causing an increasing level of harmonic distortion in the electrical systems, which frequently leads to problems with capacitor installations. This is the reason why energy suppliers and actual conditions require the usage of harmonic blocking reactors.

A detuned capacitor system works out the function of power factor correction whilst preventing any amplification of harmonic currents and voltages caused by resonance between capacitor and inductance impedances of the electrical system. By adding an appropriately rated series reactor to the power capacitor, both elements form a low-pass resonant circuit (usually below the 5th) which prevents higher order harmonics to flow into capacitors.
ORTEA harmonic blocking reactors are made of high-class transformer sheets and aluminiun or copper coils. They are fully manufactured at our premises, dried and impregnated in a vacuum with environmentally-friendly, low-styrole resin which ensures high voltage withstand, low noise levels, and enjoys a long operating life.

Parameters and selection

Coupling of Capacitors and Reactors

Combination of capacitors and reactors is a delicate procedure which has to be properly done. The ORTEA scheme is proposing in following pages comes from its experience in the Automatic Power Factor Correction systems design and manufacturing and it considers all of the aspects involved, such as:

- Voltage increase across capacitor terminals.
- Allowable harmonic overload of reactors and capacitors.
- Actual reactive power output.

It is then warmly recommended to respect the proposed coupling of capacitance and reactance, as well as capacitor rated voltage.

Detuning frequency [f_D]

Harmonic blocking reactor choice is based on the actual harmonic current spectrum; the most relevant and lowest harmonic current determines the harmonic blocking frequency, hence the reactor selection. In detail:

- 12.7% will be used if the 5^{TH} harmonic current is higher than 25%.
- 5.4% or 7% will be used if the 5^{TH} harmonic current is lower than 25%.

Rated inductance [L]

Inductance rating of reactor, measured at rated current In, epressed in mH (Milli-Henry) is the main component feature.

Capacitance [C]

It comes from the delta connection of three single phase capacitive elements. Stated value is the multiple by three of each element and it is expressed in µF (micro Farad).

Capacitor Rated voltage [V]

The series connection of capacitor and reactor causes a voltage rise at the capacitor terminals as described by the following formula which must be considered when selecting a capacitor for the case.

$$U_C = \frac{U_N}{[1 - \frac{p}{100\%}]}$$

where

$$p = 100\% \cdot \frac{X_L}{X_C}$$

Examples:

Detuning factor p	Detuning frequency f_D	
	f = 50Hz	f = 60Hz
5.4%	NA	258Hz
7%	189Hz	227Hz
12.7%	140Hz	NA

Rated capacitor power [Q]

The rated capacitor output is defined as the power the capacitor can generate if supplied at rated voltage; it is important to follow the manufacturer recommendation in terms of voltage selection. This parameter also makes easier the selection of proper CRT capacitor in series to reactor.

Real output [Qc]

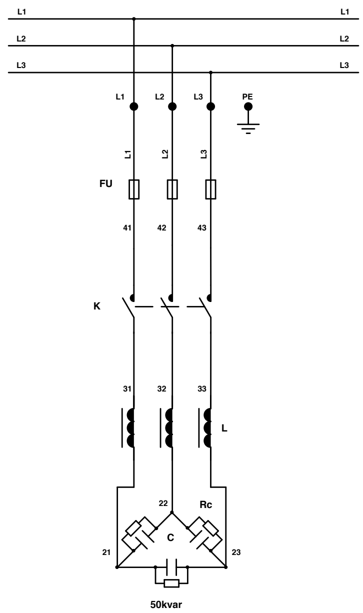
Actual capacitor output is increased respect to the rated value by the higher voltage at capacitor terminals. However this effect is already incorporated in the table Qc Reactive Power.

RSS current [Irms]

Actual load flowing on the reactor in permanent operation, it is composed by the fundamental wave plus harmonic currents. Component selections described in this catalogue are made in respect to the maximum reactor and capacitor allowed manufacturer limits.

Recommended connecting scheme

Reactors shown in this catalogue are designed for the following scheme of wiring.



Installation and maintenance

Handling and Storage

Reactors shall have to be handled and stored with care in order to avoid any mechanical damage during transportation. Protection against environmental influences shall also be taken.

Installation

Reactors are suitable for indoor installation and for vertical position. Reactors must be installed in such a way that the specified limit temperature is not overcome.
Not being in compliance with the above instructions will result as a reduction of the expected service life.

Assembly

Total losses are sum of all iron, winding, and stray field losses at max. specified over voltage and harmonic content.
Depending on the detuning factor, actual dissipation power of our reactors is between 4 and 6W/kvar.
While using capacitors and reactors within a capacitor bank, suitable means for heat dissipation and cooling of components shall be taken.
A minimum 20mm distance between the units has to be maintained.

Maintenance

Periodical checks and inspections are required to ensure reliable operation of reactors.
Monitoring and recording of the electrical service parameters are also recommended to become acquainted with progressive reactors stress conditions.

Protections

All reactors are provided with a separate screw terminal for the temperature switch (opening switch) which is located inside everyl coil. These leads shall be wired in series to contactor coils to switch off in case of over load.

Safety instructions

DO NOT MISAPPLY REACTORS FOR POWER FACTOR CORRECTION APPLICATIONS.
To prevent damage to people and goods due to improper usage and/or application of reactors, the “RECOMMENDATION FOR THE SAFE USE OF STATIC CAPACITORS, BANKS AND EQUIPMENT FOR POWERFACTOR CORRECTION”. Published by ANIE shall have to be strictly respected. ORTEA SpA is not responsible for any kind of possible damages occurred to people or things, derived from the improper installation and application of Power Factor Correction capacitors and reactors.

Most common misapplication forms

Current, voltage, harmonics and frequency above specification:

- Working or storage temperature beyond the specifi ed limits.
- Unusual service conditions as mechanical shock and vibrations, corrosive or abrasive conductive parts in cooling air, oil or water vapour or corrosive substances, explosive gas or dust, radioactivity, excessive and fast variations of ambient conditions, service areas higher than 2000 m above sea level...

In case of doubt in choice or in performances of the capacitors and reactors ORTEA SpA technical service MUST be contacted.

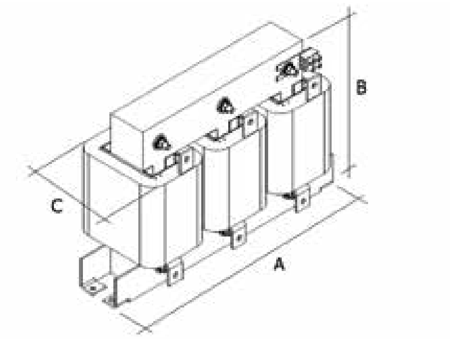
Personal Safety

Electrical or mechanical misapplications of Harmonic Blocking Reactors capacitors may become hazardous.
Special attention must be taken to make sure the reactors are correctly used for each application and that warnings and instructions are strictly followed.
Reactors are made not only but also with iron, aluminium, paper and resin that are partially flammable materials. The risk of fire cannot be totally eliminated; therefore suitable precautions shall be taken.
Reliability data quoted by ORTEA SpA should be considered as statistical i.e. based on a number of components, and does not guarantee properties or performance in the legal sense.
ORTEA SpA liability is limited to the replacement of defective components. This applies in particular to consequential damage caused by component failure.

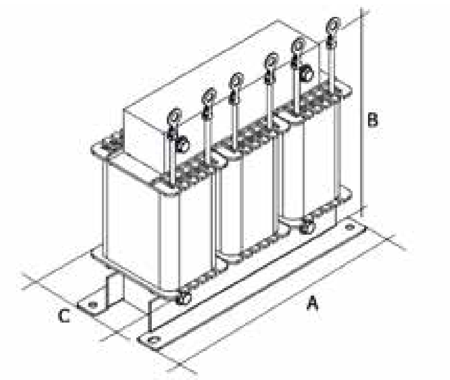
HARMONIC BLOCKING REACTORS

Common technical characteristics

Applicable standards	IEC 60076-6
Rated voltages	230V...1.1kV
Inductance tolerance	±5% (average value in the three phases)
Linearity	I lin = 1.6...1.8 In
Insulation (winding-core)	3 kV
Temperature class	F (155°C)
Maximum Ambient Temperature	40°C
Protection class	IP00 indoor mounting
Humidity	95%
Cooling	natural air
Design	Three phase, iron core with double air gap
Winding material	Aluminium foil/copper wires
Impregnation	Polyester resin, class H
Terminals	Aluminim bar with hole, or cable lugs.
Temperature Switch	Reactors with a current higher than 33A are provided with a separate screw terminal for the temperature switch (opening switch) which is located inside each coil
Switching temperature	140°C
Voltage	250Vac (<5A)
Tolerance	±5K



ALUMINIUM



COPPER

Ue	f	f_D	I_{250Hz}%*
400V	50Hz	189Hz	**≤25%**

** Percentage of the 5th harmonic.*

Part number	Qc at 400V	L	Irms	Material	Dimensions (AxBxC)	Weight	Capacitor Part number	Qc at rated voltage	Capacitor rated voltage	Capacitance
	[kvar]	[mH]	[A]		[mm]	[kg]		[kvar]	[V]	[μF]
RHF5300H001	5	8.3	8	copper	205x170x65	6	6DCRTX0750H50	7.5	525	87
RHG0012H001	10	4.2	17	copper	205x181x79	7.7	6DCRTX1250G50	12.5	450	196
RHG0015H001	12.5	3.465	21	copper	240x142x100	13	6DCRTX1500G50	15	450	236
PRG0032DAB57528	20	2.2	37	aluminium	340x215x120	18	6DCRTX2500G50	25	450	393
PRG0028DAB57538	25	1.73	40	aluminium	340x215x110	17	6DCRTX3000G50	30	450	471
PRG0064DAB57527	40	1.1	75	aluminium	340x215x145	27	6DCRTX2500G50 + 6DCRTX3000H50	25+30	450+525	738
PRG0050DAB57567	50	0.786	79	aluminium	340x215x140	28	2 x 6DCRTX3000G50	60	450	942

Ue	f	f_D	I_{250Hz}%*
400V	50Hz	140Hz	**>25%**

** Percentage of the 5th harmonic.*

Part number	Qc at 400V	L	Irms	Material	Dimensions (AxBxC)	Weight	Capacitor Part number	Qc at rated voltage	Capacitor rated voltage	Capacitance
	[kvar]	[mH]	[A]		[mm]	[kg]		[kvar]	[V]	[μF]
RHG001BH001	5	14.8	9	copper	205x170x78	7.4	6DCRTX0750H50	7.5	525	87
RHG0022H001	10	7.4	18	copper	205x180x113	12.8	6DCRTX1500H50	15	525	173
RHG0023H002	12.5	6.3	19	copper	205x170x113	13.5	6DCRTX2000H50	20	525	231
RHG0043H002	20	3.7	35	copper	270x215x90	21	6DCRTX3000H50	30	525	345
PRG0056DAB57235	25	2.595	43	aluminium	340x215x135	27	6DCRTX4000H50	40	525	462
PRG0076DAB57664	40	2.12	61	aluminium	340x215x135	35	2 x 6DCRTX3000H50	60	525	692
PRG0093DAB57418	50	1.57	77	aluminium	380x215x165	37	6DCRTX2500H50 + 6DCRTX5000H50	75	525	867

Ue	f	f_D	I_{300Hz}%*
400V	60Hz	227Hz	**≤25%**

** Percentage of the 5th harmonic.*

Part number	Qc at 400V [kvar]	L [mH]	Irms [A]	Material	Dimensions (AxBxC) [mm]	Weight [kg]	Capacitor Part number	Qc at rated voltage [kvar]	Capacitor rated voltage [V]	Capacitance [μF]
RR46015810	5	5.8	8	copper	205x167x68	5.5	6DCRTX0750K60	7.5	480	87
RR46012910	10	2.9	16	copper	205x184x68	8.6	6DCRTX1500K60	15	480	173
RHG0023H001	12.5	2.1	33	copper	205x160x113	13	6DCRTX2000K60	20	480	231
RR46011451	20	1.45	32	copper	205x184x88	9.5	6DCRTX3000K60	30	480	346
PRG0019DAB57872	25	1.22	40	aluminium	340x215x110	18	6DCRTX3000K60 + 6DCRTX0750K60	37.5	480	433
PRG0030DAB57579	40	0.73	65	aluminium	340x215x110	18	2 x 6DCRTX3000K60	60	480	692
PRG0037DAB57692	50	0.6	78	aluminium	340x215x120	21	6DCRTX5000K60 + 6DCRTX2500K60	75	480	864

Ue	f	f_D	I_{300Hz}%*
400V	60Hz	258Hz	**≤25%**

** Percentage of the 5th harmonic.*

Part number	Qc at 400V [kvar]	L [mH]	Irms [A]	Material	Dimensions (AxBxC) [mm]	Weight [kg]	Capacitor Part number	Qc at rated voltage [kvar]	Capacitor rated voltage [V]	Capacitance [μF]
RHG0012H001	5	4.2	17	copper	205x181x79	8	6DCRTX0750K60	7.5	480	87
RR46012401	10	2.4	18	copper	205x184x68	6	6DCRTX1500K60	15	480	173
RHG0023H001	12.5	2.1	33	copper	205x160x113	14	6DCRTX1000K60 + 6DCRTX0750K60	17.5	480	202
PRG0019DAB57872	20	1.22	40	aluminium	340x215x110	18	6DCRTX1500K60 + 6DCRTX1250K60	27.5	480	317
PRG004GDAB57571	25	1.045	66	aluminium	340x215x120	22	6DCRTX2000K60 + 6DCRTX1500K60	35	480	404
PRG0030DAB57579	40	0.6	78	aluminium	340x215x120	21	6DCRTX3000K60 + 6DCRTX2500K60	55	480	634
PRG0093DAB57626	50	0.523	133	aluminium	380x215x170	38	6DCRTX5000K60 + 6DCRTX2000K60	70	480	807

Ue	f	f_D	I_{300Hz}%*
230V	60Hz	227Hz	**≤25%**

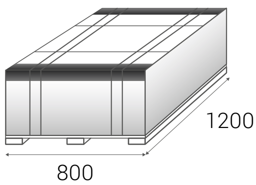
** Percentage of the 5th harmonic.*

Part number	Qc at 400V [kvar]	L [mH]	Irms [A]	Material	Dimensions (AxBxC) [mm]	Weight [kg]	Capacitor Part number	Qc at rated voltage [kvar]	Capacitor rated voltage [V]	Capacitance [μF]
RR46012401	5	2.4	19	copper	205x185x90	6	6DCRTX1500D60	15	400	249
PRG0019DAB57872	10	1.22	40	aluminium	340x215x110	18	6DCRTX3000D60	30	400	497
PRG0039DAB57871	20	0.6	78	aluminium	340x215x120	21	2 x 6DCRTX3000D60	60	400	996
PRG0035DAB57693	25	0.45	88	aluminium	320x220x130	19	3 x 6DCRTX2500D60	75	400	1242
PRG0033DAB57694	40	0.273	109	aluminium	320x220x120	18.5	3 x 6DCRTX3000D60 + 6DCRTX2500D60	115	400	1908
PRG0043DAB57695	50	0.2	146	aluminium	320x220x135	21.5	4 x 6DCRTX3000D60 + 6DCRTX2500D60	145	400	2406

Packing details:

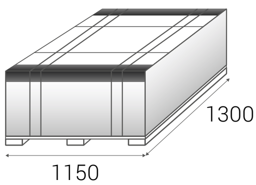
Pallet

Reactor type	Reactors per package
Copper winding	20
Aluminium winding	16



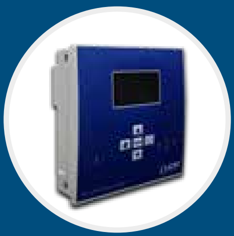
Wooden box

Reactor type	Reactors per package
Copper winding	90
Aluminium winding	72



REACTIVE POWER REGULATOR

RPC 5LGA



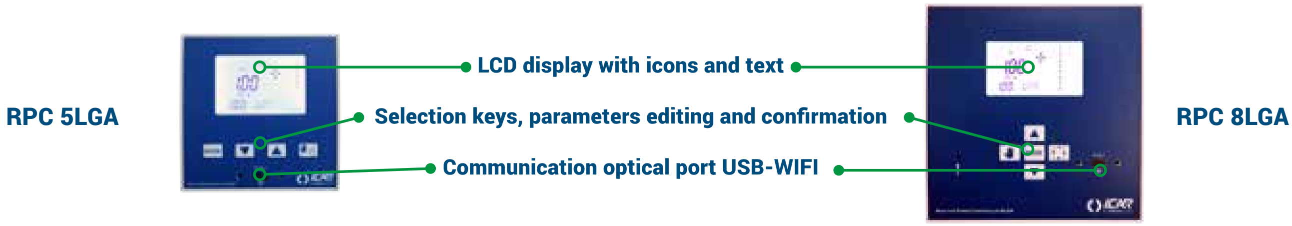
RPC 8LGA

RPC 8BGA

The reactive power regulator is, together with the capacitors and reactors (in detuned filter cabinets), the key component of the automatic power factor correction system.
It is in fact the “intelligent” element, responsible for the verification of the power factor of the load, in function of which controls the switching on and off of the capacitors batteries in order to maintain the power factor of the system beyond the target.

The reactive power regulators RPC used in our automatic power factor correction systems are designed to provide the desired power factor while minimizing the wearing on the banks of capacitors, accurate and reliable in measuring and control functions are simple and intuitive in installation and consultation.
By purchasing an automatic power factor correction system you receive it ready for commissioning.
In fact he controller is already set, you just need to connect it to the line CT and set the value of the primary current. The controller automatically recognizes the current direction of the CT secondary, to correct any wiring errors.
The flexibility of regulators allows you to modify all the parameters to customize its operation to fit the actual characteristics of the system to be corrected (threshold power factor, sensitivity of step switching, reconnecting time of the steps, presence of photovoltaics, etc.).
As described below, the regulators offer important features as for the maintenance and management of the power factor correction bank, aimed at identifying and solving problems, which could lead to its damage with consequent life expectancy reduction.

Reactive power regulators RPC 5LGA and RPC 8LGA



The reactive power regulator RPC 5LGA equips MICROmatic and MINImatic automatic power factor correction systems, while the new regulator RPC 8LGA equips MIDImatic.
Both are managed by a microprocessor and offer many features maintaining a simple user interface locally or from a PC.
They are characterized by a large LCD display with text messages (in 6 languages: ITA, ENG, FRA, SPA, POR, GER) and icons for quick and intuitive navigation.
The regulators are very flexible: they are in fact able to adjust the power factor between 0.5 inductive and 0.5 capacitive, to operating with power from 100 to 440 VAC, to run on the 4 quadrants for cogeneration installations, to accept in Input CT secondary 5A or 1A.
The regulators have standard temperature control and the ability to configure one of the available relays for activating visual alarms sound at a distance; also control the distortion of current and voltage.
Regulators RPC 5LGA-8LGA can operate in automatic or manual mode: in the first case in complete autonomy by switching batteries available up to the desired power factor; in the second case it will be the operator to force the insertion and disconnection of the battery: the regulator still oversee operations to prevent potential damage to the capacitors (for example by assessing compliance of discharge times before a subsequent insertion).

Measurement functions

Regulators RPC 5LGA and 8LGA provide many standard measurements in order to check and monitor the correct electrical and temperature conditions of the power factor correction system.
Display shows the following values: power factor, voltage, current, delta kvar (reactive power missing to reach the target power factor), average weekly power factor, total harmonic distortion of the current system ($THDI_R$%) with detailed harmonic for harmonic from 2nd to 15th, total harmonic distortion of the voltage ($THDV_R$%) with detail for harmonic harmonic from 2nd to 15th, total harmonic distortion in the current % ($THDI_C$%) capacitor, temperature.
The controller stores and makes available for consultation the maximum value of each of these variables, to evaluate the most severe stress suffered by the automatic power factor correction since the last reset: the temperature, the voltage and the total harmonic distortion have a strong impact on the capacitors as if they hold more than the nominal values can drastically reduce the service life.

Alarms

The RPC regulators offer many different alarms as standard, which help in the correct operation of the system.
The alarms are set to the following values:

- Under-compensation: the alarm is activated if, with all the steps of power factor correction switched on, the power factor is lower than the desired value.
- Over-compensation: the alarm is activated if, with all the steps of power factor correction switched off, the power factor is greater than the desired value.
- Minimum and maximum current: to assess the condition of the system load.
- Minimum and maximum voltage: to evaluate the stresses due to the variations of the supply voltage.
- Maximum THD%: to assess the pollution of network as regards to harmonic current.
- Maximum temperature in the enclosure: to monitor the capacitor climatic conditions.
- Short voltage interruptions.

Alarms are programmable (enable, threshold, time of activation / deactivation).

Display Indications

The LCD display icons and text provides the following information for quick identification of the state of the system:

- Operating mode automatic/manual.
- Status of each battery (on / off).
- Recognition power factor inductive / capacitive.
- Type of value displayed.
- Active alarm code, and explanatory text (in a language of choice among the 6 available: ITA, ENG, FRA, SPA, POR, GER).

Safety

The RPC 5LGA and 8LGA controllers have passwords to prevent not authorized access.
A backup copy of the factory settings is always available in memory.

Contacts

The regulators RPC 5LGA and 8LGA have power contacts for controlling the steps, to control the eventual cooling fan and for the activation of alarms to distance; contacts are NO and have a range of 5A at 250Vac or 1.5A at 440Vac.
A contact is in exchange for alarm functions (NO or NC).

Additional module

The regulator RPC 5LGA has the ability to accommodate, in the back slot, an additional module.
The regulator RPC 8LGA has two rear slots to accommodate up to two additional modules.
Once installed an additional module, the controller recognizes and activates the menu for its programming.
Additional modules can be installed even in the bank already in service. Slots for additional module may be already used to implement necessary functions to the context in which the controller is mounted. If you decide to add a module to an already operating, ensure that there is an available slot.

- **OUT2NO** two digital outputs module for additional step control (two 5A 250Vac relays)
- **COM232** isolated RS232 interface
- **COM485** isolated RS485 interface
- **WEBETH** Ethernet interface (only for RPC 8LGA)

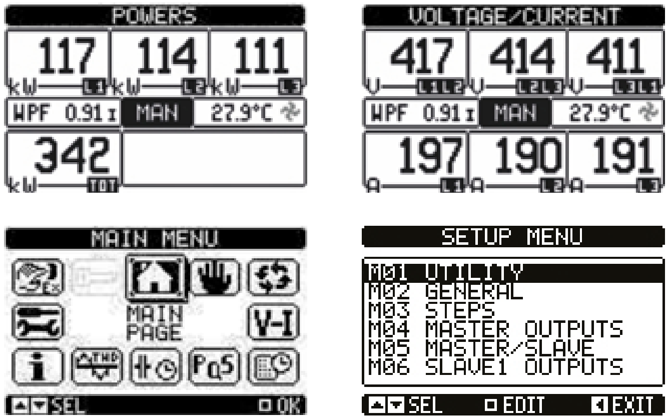
Data sheet	RPC 5LGA	RPC 8LGA
Control	microprocessor	
Auxiliary supply voltage	100÷440Vac	
Frequency	50Hz/60Hz	
Voltage measuring input	100÷600V	
Current measuring input	5A (1A programmable)	
Current reading range	from 25mA to 6A (from 25mA to 1.2A)	
Automatic current way sensing	yes	
Operation in systems with cogeneration	yes	
Power consumption	9.5VA	
Output relay	5A - 250Vac	
Cosφ adjustment	from 0.5 ind. to 0.5 cap.	
Step switching time	1s ÷ 1000s	
Alarm relay	yes	
Degree of protection	IP54 on front, IP20 at terminals	
Operating temperature	from -20°C to +60°C	
Storage temperature	from -30°C to + 80°C	
Front optical port	for communication USB or WIFI with dedicated accessories	
Compliance with the standards	IEC 61010-1; IEC 61000-6-2; IEC 61000-6-4; UL508; CSA C22-2 nr.14	
Output relay number	5 (expandable up to 7)	8 (expandable up to 12)
Dimensions	96x96mm	144x144mm
Weight	0.35kg	0.65kg
Part number	6CF46411050	6CF025

Reactive power regulators RPC 8BGA

The RPC 8BGA reactive power regulator equips MULTImatic automatic power factor correction systems. It is a very innovative controller, with exclusive features:

- High electrical performance
- Extended Capabilities
- Graphic display
- Advanced communication
- Upgradability, even after installation
- Powerful supervision software
- Choice language (10 languages available on board).

More details below, referring to the following page tables and manuals for further information.



High electrical performance

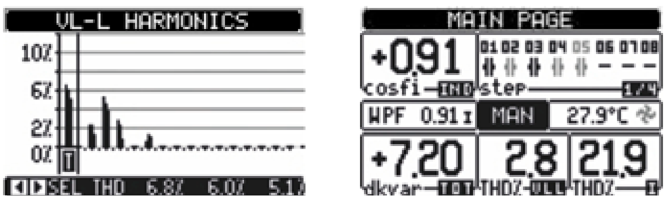
The 8BGA controller is equipped with powerful hardware, which allows a considerable electrical performances: it can be connected to the CT secondary 5A or 1A, it can work on networks with voltages from 100 to 600Vac with a measuring range from 75Vac to 760Vac, it can be connected to a single CT (typical configuration of the power factor corr ection) or three-CTs (for a more accurate measurement of the power factor, and this fact makes the 8BGA controller to refocus and to be a multimeter as well).

Extended Capabilities

The 8BGA reactive power regulator is controlled by a powerful microprocessor that allows a set of new functions to solve problems even in complex plant.
8BGA can work master-slave functions, handles up to 10 languages simultaneously, can be used in MV systems managing the transformation ratio of the VT, it can support multiple inputs and outputs via optional modules, it can handle target cos phi from 0.5 inductive to 0.5 capacitive.
8BGA can build a network of 4 wired units (one master three slaves) to be able to handle up to 32 steps of power factor correction in a consistent and uniform way.

Graphical display with high readability

Forget the regulators with small displays and difficult to read: 8BGA will amaze you with its display matrix graphic LCD 128x80 pixels.
The detail and sharpness allow intuitive navigation between the different menus, represented with text and icons.



Advanced communication

8BGA born to be a regulator able to communicate in a manner in line with the latest technology: Ethernet, RS485, USB, WIFI.
Now you can see the information of the company cos phi, without having to go in front of the regulator. Now you can consult it by a PC.
The information about the cos phi is important, because it impacts heavily on the company's income statement.

Evolutivity

The "basic" 8BGA regulator can be enhanched with up to four additional modules "plug and play" which greatly expands its performance.
It is possible to add additional control relays (up to a total of 16), even for a static control (thyristors), digital and analog inputs, analog outputs, communication modules.
Your controller can become a small PLC, and the PFC system can become a point of data aggregation, for remote communication.

Measurement functions and help to maintain

8BGA is a real evolved multimeter, thanks also to the graphic display of excellent readability and to the powerful microprocessor.
The measured parameters are the basic ones (cosφ, PF, V, I, P, Q, A, Ea, Er) with the addition of the distortion of the voltage and current (THD, histogram of the value of each harmonic, waveform graphic visualization).
If 8BGA is connected to three CT, the harmonic analysis is detailed for each phase, in order to identify any anomalies of single phase loads. 8BGA measure and count values that can help in ruling the PFC (temperature, number of switching of each step). 8BGA also suggests the maintenance to be carried out by means of simple messages on the display.
Keep efficient capacitor becomes much easier.
8BGA stores the maximum values of current, voltage, temperature, each associated with the date and time of the event for a better analysis of what happened.

Alarms
The set of alarms (maximum and minimum voltage, maximum and minimum current, over and undercompensation, overload of the capacitors, maximum temperature, microinterruption) associated with the readability of the messages on the display allows a better understanding of what happened.
Even alarm programming (enable / disable, delay, relapse etc.) is easier and faster.

Data sheet	RPC 8BGA
Controllo	a microprocessore
Auxiliary supply voltage	100÷440Vac
Frequency	50Hz/60Hz
Voltage measuring input	100÷600V (-15% / +10%)
Current measuring input	5A (1A programmable)
Current reading range	from 25mA to 6A (from 10mA to 1.2A)
Automatic current way sensing	yes
Operation in systems with cogeneration	yes
Power consumption	12VA (10.5W)
Output relay	5A - 250Vac
Cosφ adjustment	from 0.5 ind. to 0.5 cap. (tan φ da -1.732 a +1.732)
Step switching time	1s ÷ 1000s (20ms with STR4NO module)
Alarm relay	yes
Degree of protection	IP55 on front, IP20 at terminals
Operating temperature	from -30°C to +70°C
Storage temperature	from -30°C to + 80°C
Front optical port	for communication USB or WIFI with dedicated accessories
Temperature control	from -30°C to +85°C
Compliance with the standards	IEC 61010-1; IEC 61000-6-2; IEC 61000-6-3; UL508; CSA C22-2 nr.14
Output relay number	8 (expandable up to 16)
Dimensions	144x144mm
Weight	0.98kg
Part number	6CF46411000

Additional modules

The RPC 8BGA controller accommodates up to 4 additional modules “plug & play”. Once you have added an additional module, the controller recognizes and activates the menu for its programming. Additional modules can also be installed retrospectively (consult us).

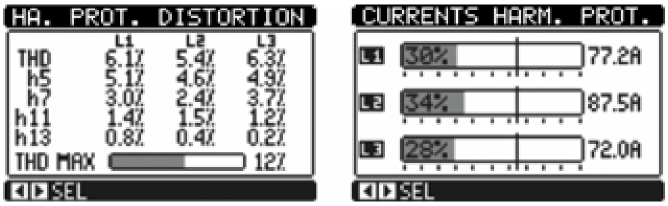
Digital inputs and outputs
These modules allow you to increase the contacts funding for control of the steps contactors (OUT2NO module) or thyristors (STR4NO module) switched banks, or to add inputs and / or digital / analog acquisition of parameters and implementing simple logic.

- **OUT2NO** module 2 digital outputs to control additional steps (two relays 5A 250 Vac)
- **STR4NO** module 4 static outputs for thyristor control steps (range SPEED)
- **INP4OC** module 4 digital inputs

Protection functions
The control and protection module MCP5 allows a more detailed inspection of the electrical parameter and temperature that can damage the capacitors.
Thanks to algorithms particularly suitable for automatic equipment consisting of capacitors and reactors.

- **MCP5** module for protection and control for additional safety of capacitors, especially suitable in the detuned banks

MULTImatic detuned systems are equipped with RPC 8BGA controller with MCP5 module.
This module has very important function: it directly monitors, through two CTs installed inside, the current in the capacitors analyzing the harmonic content.
In case of harmonic content increases (for example, due to the aging of the capacitors) exceeding a certain limit value, the PFC system is taken out of service, excluding the risk of bursting or overcharging of the capacitors.
The MCP5 module allows the harmonic currents affecting the capacitors to be monitored directly on the RPC 8BGA controller screens, as can be seen in the two pictures shown below.
The individual harmonics are kept under control, with the possibility of setting an alarm level and an intervention level on each. The MCP5 module also allows to monitor two additional temperatures in order to avoid excessive overheating even inside the panel.
Without this functionality, the regulator would carry out the evaluation of the harmonic content with greater difficulty and less precision.



Analysis of the harmonic current absorbed by the capacitors, in percentage, detailed harmonic by harmonic, and absolute.

Communication functions
RPC 8BGA regulator is very powerful in terms of communication. The modules dedicated to these functions allow multiple solutions to remotely control the power factor system and all other variables measured, calculated or obtained from the instrument.

- **COM232** isolated RS232 interface
- **COM485** isolated RS485 interface
- **WEBETH** Ethernet interface
- **COMPRO** isolated Profibus-DP interface
- **CX01** cable connection from the RPC 8BGA optical port to the USB port of the computer for programming, downloading / uploading data, diagnostics etc
- **CX02** device to connect the optical port in the RPC 8BGA via WIFI: for programming, downloading / uploading data, diagnostics etc

ELECTRONIC FAST SWITCHES

Electronic Fast Switches is the best and sometimes the sole choice when it is necessary to compensate loads over short periods of time.

Examples are steel companies, lifting apparatus (cranes, quay cranes, etc), cable makers (extruders, etc), welding machines, robots, compressors, skiing lift stations, LV industrial networks (chemical plants, paper mills, automotive suppliers).
Thyristor switched capacitor bank are also an ergonomic solution where noise can be problematic, like hotels, banks, offices, service infrastructures (telecommunications board, informatics boards, hospitals, malls).

Limits of the traditional contactor switched banks

- High inrush current and over voltages.
- Risk of over voltages due to the arc breaking.
- Longer reconnecting time: more than 30 sec.
- More demanding maintenance compared with static switches.

General advantages of Power Factor Correction

- Reduced losses on mains and power transformers.
- Increase of plant available power.
- Less voltage drop in the plant.

Electronic Fast Switches benefits include

- Minimises network disturbances such as Voltage Drop and Flicker.
- No moving parts therefore reduced maintenance (i.e. no Electro-magnetic contactors).
- Enhanced capacitor life expectancy.

In general there is a comprehensive plant efficiency, because power factor correction is fast, the power transformer and line design can be done considering only the actual load. Therefore longer working life and reliability of plant. Static switches allow unlimited operations. Steps switching is also done limiting transient phenomena that inside normal plants stresses the capacitors reducing their working life.

General characteristics

Electronic fast switches features are described below:

- Switching speed: 20ms ON - 20ms OFF.
- Electronic components: SCR.
- Connectable power: up to 100kvar-400/415V.
- Possibility to switch capacitors without reactor.
- Fan dedicated to the cooling radiator.
- Protection circuit with signalling LED.

Further advantages

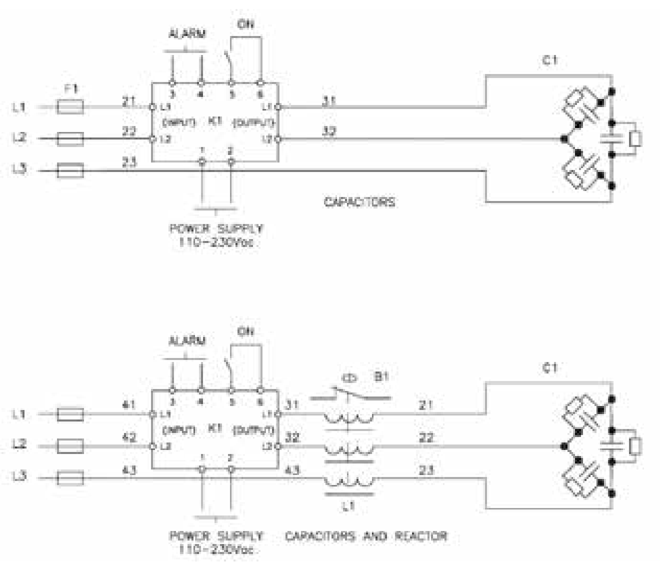
- The control technology adopted doesn't allow switching that could generate self damage.
- Very small dimensions.
- High temperature protection.
- Protection from high speed switching.
- Electronic Fast Switch doesn't need any external supply.

Technical characteristics

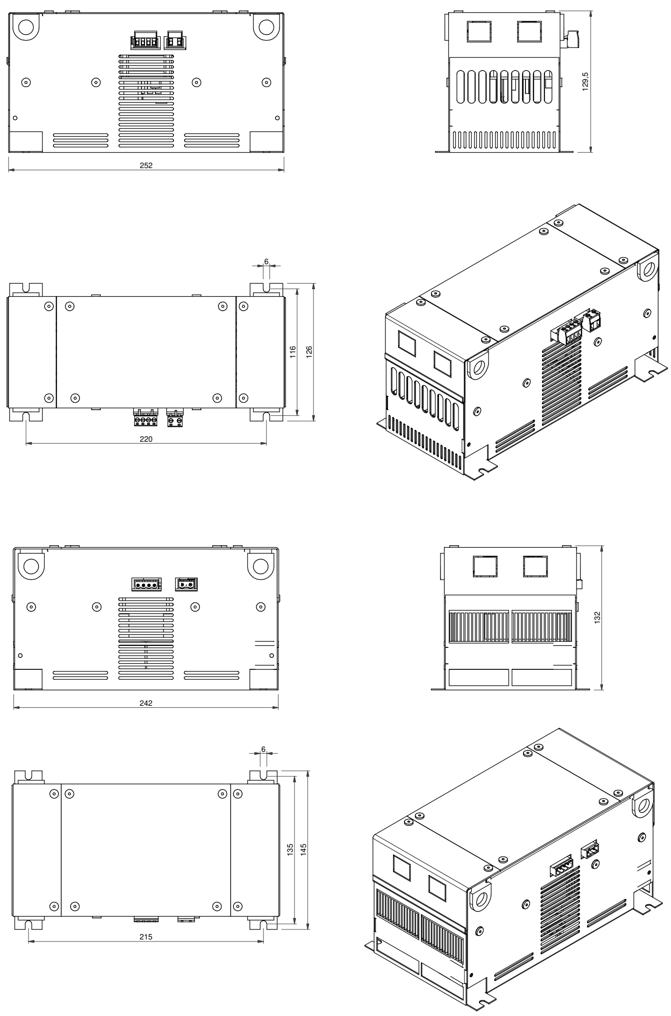
Voltage	230V...415V
Frequency	50Hz / 60Hz
Activation	Using external contact voltage free (type SSR Bi-directional opto-mos recommended); no need for 24Vdc
Duty cycle max speed	20ms ON – 20ms OFF
Operating ambient temperature	-5/+45°C

Part number	Max Power	Dimensions (WxDxH)	Weight
	[KVAR]	[mm]	[kg]
IS050K0IE050K	50	252x126x129.5	3
IS100K0IE100K	100	242x145x132	3.5

Connecting diagram



Drawings



EURORACK TRAYS

Design features

Every tray is complete of:
- Capacitor Contactors (230Vac coil).
- Self-extinguish cable harness according to EN 50525 - EN 50575 - EN 50575/A1 standards.
- Power fuses NH00-gG.
- Three phase self-healing polypropylene capacitors with 525V rated voltage (HP30-FH20-FH30- 50Hz only).
- Three-phase tinned copper bus bar system.
- Discharge resistors.
- Three phase detuning chokes (FH only) with dedicated frequency detuning; each coil winding temperature sensor and NC switch.

Standard accessories

(supplied along with each tray)
- Connecting tinned copper bars and bolts.
- IP20 plexiglass protection.

Option

Adaptation bracket, for fitting of 600 mm width trays in 800 mm width cabinets, and 800 mm width trays in 1000 mm width cabinets.

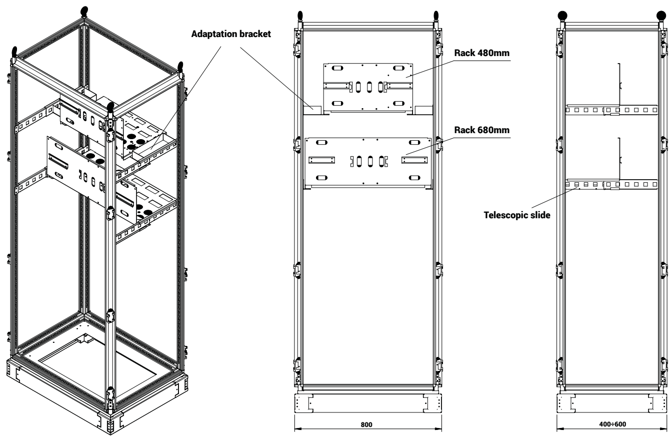
General characteristics

EUROrack system is ideal solution for OEM and switchgears manufacturers, they are indeed suitable to the most common switchgears sizes, in addition:
- EUROrack is compact and with high power density.
- EUROrack is available detuned and not detuned.
- Powers from 12.5 kvar to 150kvar in a single tray.
- Bus bars suitable to bear up to 400kvar detuned or not detuned.
- Easy to assembly as power bus bars and NH fuses are incorporated in the tray support.

EUROracks are suitable for plants where the current Total Harmonic Distortion is as much as 100% (detuned FH20/ FH30).
EUROracks are equipped with high energy density metallized polypropylene capacitors which assure elevated performances with low losses and small dimensions.

Cabinet fitting

EUROracks trays are easy to fit inside any standard cabinet thanks to sliding and adjustable side supports.
Furthermore thanks to extensible brackets, 480 mm width racks could be also fitted in 800 mm width cabinet (see drawing below), allowing a very flexible combination of steps and total reactive power.
The maximum reactive power the bus bar system can bear is 400kvar 415V 50Hz, both detuned and not detuned.
Extesions of additional trays is possible at any time.
Every rack auxiliary and control component is supplied already wired to the terminal board, which is available on a DIN rail of any tray support.



HP10

EUROrack trays 400-415V 50Hz

Ue	U_N	U_{MAX}*	f	$THDI_R$%	$THDI_C$%**
400-415V	415V	455V	50Hz	≤12%	≤50%

** Maximum admissible value according to IEC 60831-1.*
*** Attention: in this conditions of load network harmonic amplification phenomena is possible.*

Technical characteristics

Rated operational voltage	Ue=400-415V
Rated frequency	50Hz
Max current overload In (tray)	1.3 In
Max overload Vn (tray)	1.1xUe
Insulation voltage (tray)	690V
Capacitors insulation level	3/12kV
Temperature range	-5/+40°C
Discharge resistors	on each capacitor
Installation	indoor
Service	continuous
Internal connection	delta
Operation devices	capacitors contactors (AC6b)
Total tray losses	~ 2W/kvar
Inner surface finish	zinc passivation
Standards (tray)	IEC 61439-1/2 IEC 61921
Standards (capacitors)	IEC 60831-1/2

Main characteristics

Power factor correction banks indicated for the plants where the current harmonic distortion, without capacitors installed, has values lower than 12%.
Use of high energy density metallised polypropylene capacitors assures elevated performances, high resistance to strong voltage overload and low losses.

Generalities

- Special contactors with damping resistors to limit capacitors inrush current (AC6b).
- FS17 450/750V self-extinguish cable according to EN 50525 - EN 50575 - EN 50575/A1.
- Power fuses NH00-gG.
- Three-phase self-healing metallized polypropylene capacitor with U_N=415V rated voltage.
- Discharge devices.
- Degree of protection: IP20.

Part number	Power [kvar]			Steps Ue=400V	Dim. number	Fix dist. number
	U_N 415V	Ue 415V	Ue 400V			
IY0AKK225050359	25	25	25	25	97	91
IY0AKK250050359	50	50	50	2x25	97	91
IY0AKK275050359	75	75	75	3x25	97	91
IY0AKK310050359	100	100	100	4x25	97	91
Contact us	100	100	100	2x12.5-25-50	97	91
IY0AKK312550359	125	125	125	5x25	98	92
IY0AKK315050359	150	150	150	6x25	98	92
Contact us	150	150	150	2x12.5-25-2x50	98	92

HP20

EUROrack trays 400-415V 50Hz

Ue	U_N	U_{MAX}*	f	$THDI_R$%	$THDI_C$%**
400-415V	450V	495V	50Hz	≤20%	≤70%

** Maximum admissible value according to IEC 60831-1.*
*** Attention: in this conditions of load network harmonic amplification phenomena is possible.*

Technical characteristics

Rated operational voltage	Ue=400-415V
Rated frequency	50Hz
Max current overload In (tray)	1.3 In
Max overload Vn (tray)	1.1xUe
Insulation voltage (tray)	690V
Capacitors insulation level	3/12kV
Temperature range	-5/+40°C
Discharge resistors	on each capacitor
Installation	indoor
Service	continuous
Internal connection	delta
Operation devices	capacitors contactors (AC6b)
Total tray losses	~ 2W/kvar
Inner surface finish	zinc passivation
Standards (tray)	IEC 61439-1/2 IEC 61921
Standards (capacitors)	IEC 60831-1/2

Main characteristics

Power factor correction banks indicated for the plants where the current harmonic distortion, without capacitors installed, has values lower than 20%.
Use of high energy density metallised polypropylene capacitors assures elevated performances, high resistance to strong voltage overload and low losses.

Generalities

- Special contactors with damping resistors to limit capacitors inrush current (AC6b).
- FS17 450/750V self-extinguish cable according to EN 50525 - EN 50575 - EN 50575/A1.
- Power fuses NH00-gG.
- Three-phase self-healing metallized polypropylene capacitor with U_N=450V rated voltage.
- Discharge devices.
- Degree of protection: IP20.

Part number	Power [kvar]			Steps Ue=400V	Dim. number	Fix dist. number
	U_N 450V	Ue 415V	Ue 400V			
IY0JHK230050359	30	26	25	25	97	91
IY0JHK260050359	60	52	50	2x25	97	91
IY0JHK290050359	90	78	75	3x25	97	91
IY0JHK312050359	120	104	100	4x25	97	91
Contact us	120	104	100	2x12.5-25-50	97	91
IY0JHK315050359	150	134	125	5x25	98	92
IY0JHK318050359	180	160	150	6x25	98	92
Contact us	180	160	150	2x12.5-25-2x50	98	92

HP30

EUROrack trays 415V 50Hz

Ue	U_N	U_{MAX}*	f	$THDI_R$%	$THDI_C$%**
415V	525V	580V	50Hz	≤27%	≤85%

** Maximum admissible value according to IEC 60831-1.*
*** Attention: in this conditions of load network harmonic amplification phenomena is possible.*

Technical characteristics

Rated operational voltage	Ue=415V
Rated frequency	50Hz
Max current overload In (tray)	1.3 In
Max overload Vn (tray)	1.1xUe
Insulation voltage (tray)	690V
Capacitors insulation level	3/12kV
Temperature range	-5/+40°C
Discharge resistors	on each capacitor
Installation	indoor
Service	continuous
Internal connection	delta
Operation devices	capacitors contactors (AC6b)
Total tray losses	~ 2W/kvar
Inner surface finish	zinc passivation
Standards (tray)	IEC 61439-1/2 IEC 61921
Standards (capacitors)	IEC 60831-1/2

Main characteristics

Power factor correction banks indicated for the plants where the current harmonic distortion, without capacitors installed, has values lower than 27%.
Use of high energy density metallised polypropylene capacitors assures elevated performances, high resistance to strong voltage overload and low losses.

Generalities

- Special contactors with damping resistors to limit capacitors inrush current (AC6b).
- FS17 450/750V self-extinguish cable according to EN 50525 - EN 50575 - EN 50575/A1.
- Power fuses NH00-gG.
- Three-phase self-healing metallized polypropylene capacitor with U_N=525V rated voltage.
- Discharge devices.
- Degree of protection: IP20.

Part number	Power [kvar]		Steps Ue=415V	Dim. number	Fix dist. number
	U_N 525V	Ue 415V			
IY0SQK240050359	40	25	25	97	93
IY0SQK280050359	80	50	2x25	97	93
IY0SQK312050805	120	75	3x25	97	93
IY0SQK316050359	160	100	4x25	97	93
IY0SQK316050803	160	100	2x12.5-25-50	97	93
IY0SQK320050359	200	125	5x25	98	94
IY0SQK324050359	240	150	6x25	98	94
IY0SQK324050804	240	150	2x12.5-25-2x50	98	94

FH20

EUROrack detuned trays 400-415V 50Hz

Ue	U_N	U_{MAX}*	f	$THDI_R$%	I_{250Hz}%**	$THDV_R$%	f_D
400-415V	525V	580V	50Hz	100%	≤25%	≤6%	180Hz

** Maximum admissible value according to IEC 60831-1.*
*** Percent current of 5TH harmonic.*

Technical characteristics

Rated operational voltage	Ue=400-415V
Rated frequency	50Hz
Max current overload In (tray)	1.3 In
Max overload Vn (tray)	1.1xUe
Insulation voltage (tray)	690V
Capacitors insulation level	3/12kV
Temperature range	-5/+40°C
Discharge resistors	on each capacitor
Installation	indoor
Service	continuous
Internal connection	delta
Operation devices	capacitors contactors
Total tray losses	~ 6W/kvar
Inner surface finish	zinc passivation
Standards (tray)	IEC 61439-1/2 IEC 61921 IEC 61642
Standards (capacitors)	IEC 60831-1/2

Main characteristics

Power factor correction banks indicated for the plants where the current harmonic distortion, without capacitors installed, has values up to 100%.
Use of high energy density metallised polypropylene capacitors assures elevated performances, high resistance to strong voltage overload and low losses.

Generalities

- Contactors for capacitive loads.
- FS17 450/750V self-extinguish cable according to EN 50525 - EN 50575 - EN 50575/A1.
- Power fuses NH00-gG.
- Three-phase self-healing metallized polypropylene capacitor with U_N=525V rated voltage.
- Discharge devices.
- Degree of protection: IP20.
- Three phase detuning choke with tuning frequency f_D=180Hz (N=3.6-p%=7.7%).

Part number	Power [kvar]		Steps Ue=400V	Dim. number	Fix dist. number
	Ue 415V	Ue 400V			
IY7TFK212550360	13.5	12.5	12.5	97	93
IY7TFK218850360	20	18.75	6.25-12.5	97	93
IY7TFK225050362	27	25	2x12.5	97	93
IY7TFK225050360	27	25	25	97	93
IY7TFK250050422	54	50	2x25	97	93
IY7TFK250050360	54	50	50	97	93
IY7TFK275050360	80	75	25-50	98	94
IY7TFK310050360	107	100	50-50	98	94

FH30

EURОrack detuned trays 400-415V 50Hz

Ue	U_N	U_{MAX}*	f	$THDI_R$%	I_{250Hz}%**	$THDV_R$%	f_D
400-415V	525V	580V	50Hz	100%	>25%	≤6%	135Hz

** Maximum admissible value according to IEC 60831-1.*
*** Percent current of 5TH harmonic.*

Technical characteristics

Rated operational voltage	Ue=400-415V
Rated frequency	50Hz
Max current overload In (tray)	1.3 In
Max overload Vn (tray)	1.1xUe
Insulation voltage (tray)	690V
Capacitors insulation level	3/12kV
Temperature range	-5/+40°C
Discharge resistors	on each capacitor
Installation	indoor
Service	continuous
Internal connection	delta
Operation devices	capacitors contactors
Total tray losses	~ 6W/kvar
Inner surface finish	zinc passivation
Standards (tray)	IEC 61439-1/2 IEC 61921 IEC 61642
Standards (capacitors)	IEC 60831-1/2

Main characteristics

Power factor correction banks indicated for the plants where the current harmonic distortion, without capacitors installed, has values up to 100%.
Use of high energy density metallised polypropylene capacitors assures elevated performances, high resistance to strong voltage overload and low losses.

Generalities

- Contactors for capacitive loads.
- FS17 450/750V self-extinguish cable according to EN 50525 - EN 50575 - EN 50575/A1.
- Power fuses NH00-gG.
- Three-phase self-healing metallized polypropylene capacitor with U_N=525V rated voltage.
- Discharge devices.
- Degree of protection: IP20
- Three phase detuning choke with tuning frequency f_D=135Hz (N=2.7-p%=13.7%).

Part number	Power [kvar]		Steps Ue=400V	Dim. number	Fix dist. number
	Ue 415V	Ue 400V			
IY7NFK212550426	13.5	12.5	12.5	97	91
IY7NFK218850426	20	18.75	6.25-12.5	97	91
IY7NFK225050427	27	25	2x12.5	97	91
IY7NFK225050426	27	25	25	97	93
IY7NFK250050426	54	50	50	97	91
IY7NFK275050426	80	75	25-50	98	94

HP10

EURОrack trays 400V 60Hz

Ue	U_N	U_{MAX}*	f	$THDI_R$%	$THDI_C$%**
400V	400V	440V	60Hz	≤12%	≤50%

** Maximum admissible value according to IEC 60831-1.*
*** Attention: in this conditions of load network harmonic amplification phenomena is possible.*

Technical characteristics

Rated operational voltage	Ue=400V
Rated frequency	60Hz
Max current overload In (tray)	1.3 In
Max overload Vn (tray)	1.1xUe
Insulation voltage (tray)	690V
Capacitors insulation level	3/12kV
Temperature range	-5/+40°C
Discharge resistors	on each capacitor
Installation	indoor
Service	continuous
Internal connection	delta
Operation devices	capacitors contactors (AC6b)
Total tray losses	~ 2W/kvar
Inner surface finish	zinc passivation
Standards (tray)	IEC 61439-1/2 IEC 61921
Standards (capacitors)	IEC 60831-1/2

Main characteristics

Power factor correction banks indicated for the plants where the current harmonic distortion, without capacitors installed, has values lower than 12%.
Use of high energy density metallised polypropylene capacitors assures elevated performances, high resistance to strong voltage overload and low losses.

Generalities

- Special contactors with damping resistors to limit capacitors inrush current (AC6b).
- FS17 450/750V self-extinguish cable according to EN 50525 - EN 50575 - EN 50575/A1.
- Power fuses NH00-gG.
- Three-phase self-healing metallized polypropylene capacitor with U_N=400V rated voltage.
- Discharge devices.
- Degree of protection: IP20.

Part number	Power [kvar]	Steps Ue=400V	Dim. number	Fix dist. number
	Ue 400V			
IY0AFF225060359	25	25	95	91
IY0AFF250060359	50	2x25	95	91
IY0AFF275060359	75	3x25	95	91
IY0AFF310060359	100	4x25	95	91

HP30

EUROrack trays 480V 60Hz

Ue	U_N	U_{MAX}*	f	$THDI_R$%	$THDI_C$%**
480V	480V	530V	60Hz	≤12%	≤50%

** Maximum admissible value according to IEC 60831-1.*
*** Attention: in this conditions of load network harmonic amplification phenomena is possible.*

Technical characteristics

Rated operational voltage	Ue=480V
Rated frequency	60Hz
Max current overload In (tray)	1.3 In
Max overload Vn (tray)	1.1xUe
Insulation voltage (tray)	690V
Capacitors insulation level	3/12kV
Temperature range	-5/+40°C
Discharge resistors	on each capacitor
Installation	indoor
Service	continuous
Internal connection	delta
Operation devices	capacitors contactors (AC6b)
Total tray losses	~ 2W/kvar
Inner surface finish	zinc passivation
Standards (tray)	IEC 61439-1/2 IEC 61921
Standards (capacitors)	IEC 60831-1/2

Main characteristics

Power factor correction banks indicated for the plants where the current harmonic distortion, without capacitors installed, has values lower than 12%.
Use of high energy density metallised polypropylene capacitors assures elevated performances, high resistance to strong voltage overload and low losses.

Generalities

- Special contactors with damping resistors to limit capacitors inrush current (AC6b).
- FS17 450/750V self-extinguish cable according to EN 50525 - EN 50575 - EN 50575/A1.
- Power fuses NH00-gG.
- Three-phase self-healing metallized polypropylene capacitor with U_N=480V rated voltage.
- Discharge devices.
- Degree of protection: IP20.

Part number	Power [kvar]		Steps Ue=480V	Dim. number	Fix dist. number
	U_N 480V	Ue 480V			
Contact us	25	25	25	95	91
Contact us	50	50	2x25	95	91
Contact us	75	75	3x25	95	91
Contact us	100	100	4x25	95	91

FH20

EUROrack detuned trays 400V 60Hz

Ue	U_N	U_{MAX}*	f	$THDI_R$%	I_{300Hz}%**	$THDV_R$%	f_D
400V	480V	530V	60Hz	100%	≤25%	≤6%	216Hz

** Maximum admissible value according to IEC 60831-1.*
*** Percent current of 5TH harmonic.*

Technical characteristics

Rated operational voltage	Ue=400V
Rated frequency	60Hz
Max current overload In (tray)	1.3 In
Max overload Vn (tray)	1.1xUe
Insulation voltage (tray)	690V
Capacitors insulation level	3/12kV
Temperature range	-5/+40°C
Discharge resistors	on each capacitor
Installation	indoor
Service	continuous
Internal connection	delta
Operation devices	capacitors contactors
Total tray losses	~ 6W/kvar
Inner surface finish	zinc passivation
Standards (tray)	IEC 61439-1/2 IEC 61921 IEC 61642
Standards (capacitors)	IEC 60831-1/2

Main characteristics

Power factor correction banks indicated for the plants where the current harmonic distortion, without capacitors installed, has values up to 100%.
Use of high energy density metallised polypropylene capacitors assures elevated performances, high resistance to strong voltage overload and low losses.

Generalities

- Contactors for capacitive loads.
- FS17 450/750V self-extinguish cable according to EN 50525 - EN 50575 - EN 50575/A1.
- Power fuses NH00-gG.
- Three-phase self-healing metallized polypropylene capacitor with U_N=480V rated voltage.
- Discharge devices.
- Degree of protection: IP20.
- Three phase detuning choke with tuning frequency f_D=216Hz (N=3.6-p%=7.7%).

Part number	Power [kvar] Ue 400V	Steps Ue=400V	Dim. number	Fix dist. number
IY7TFF225060360	25	25	97	91
IY7TFF225060360	50	50	97	91

FH20

EUROrack detuned trays 480V 60Hz

Ue	U_N	U_{MAX}*	f	$THDI_R$ %	I_{250Hz} %**	$THDV_R$ %	f_D
480V	575V	760V	60Hz	100%	≤25%	≤6%	216Hz

** Maximum admissible value according to IEC 60831-1.*
*** Percent current of 5TH harmonic.*

Technical characteristics

Rated operational voltage	Ue=480V
Rated frequency	60Hz
Max current overload In (tray)	1.3 In
Max overload Vn (tray)	1.1xUe
Insulation voltage (tray)	690V
Capacitors insulation level	3/12kV
Temperature range	-5/+40°C
Discharge resistors	on each capacitor
Installation	indoor
Service	continuous
Internal connection	delta
Operation devices	capacitors contactors
Total tray losses	~ 6W/kvar
Inner surface finish	zinc passivation
Standards (tray)	IEC 61439-1/2 IEC 61921 IEC 61642
Standards (capacitors)	IEC 60831-1/2

Main characteristics

Power factor correction banks indicated for the plants where the current harmonic distortion, without capacitors installed, has values up to 100%.
Use of high energy density metallised polypropylene capacitors assures elevated performances, high resistance to strong voltage overload and low losses.

Generalities

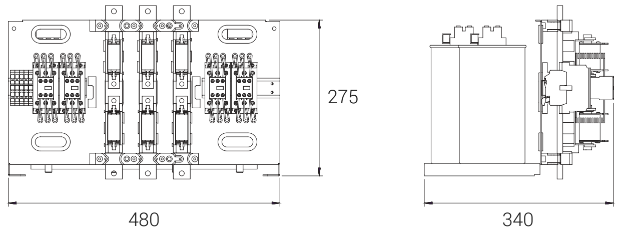
- Contactors for capacitive loads.
- FS17 450/750V self-extinguish cable according to EN 50525 - EN 50575 - EN 50575/A1.
- Power fuses NH00-gG.
- Three-phase self-healing metallized polypropylene capacitor with U_N=575V rated voltage.
- Discharge devices.
- Degree of protection: IP20.
- Three phase detuning choke with tuning frequency f_D=216Hz (N=3.6-p%=7.7%).

Part number	Power [kvar] Ue 480V	Steps Ue=480V	Dim. number	Fix dist. number
IY7TGG225060360	25	25	97	93
IY7TGG250060360	50	50	97	93

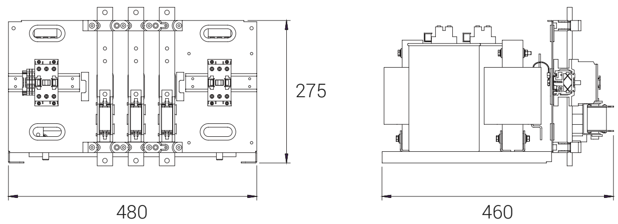
DRAWINGS

Dimensional number	Dimensions [mm] W	D	H	Fixing distance number	For cabinets: W	D
95	480	340	275	**91**	600	400÷600
97	480	460	275	**91/93**	600	500÷600
98	680	460	275	**92/94**	800	500÷600

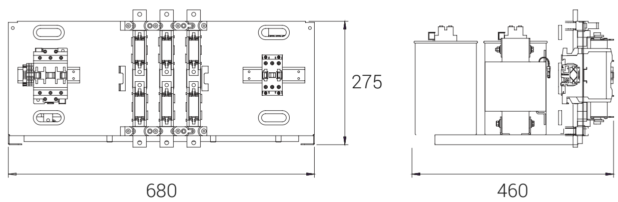
95



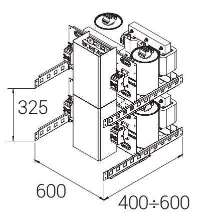
97



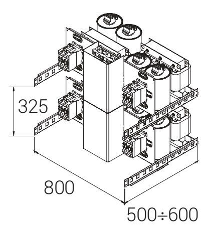
98



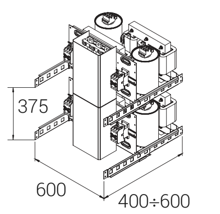
91



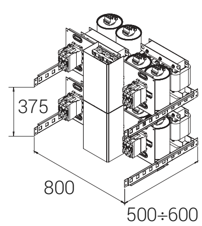
92



93



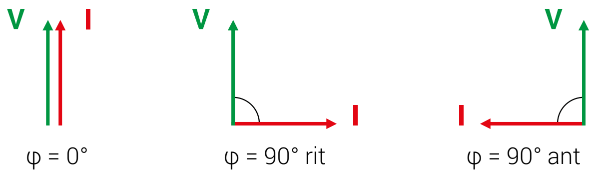
94



TECHNICAL NOTES

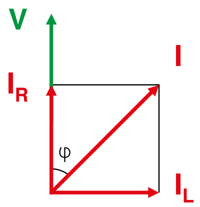
Power factor correction: why?

In electrical circuits the current is in phase with the voltage whenever are in presence of resistors, whereas the current is lagging if the load is inductive (motors, transformers with no load conditions), and leading if the load is capacitive (capacitors).



The total absorbed current, for example, by a motor is determined by vector addition of:

- **I_R** resistive current;
- **I_L** inductive reactive current;

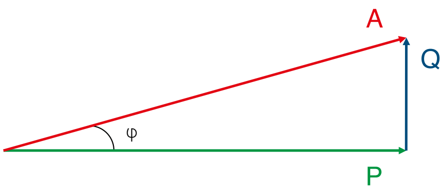


$$\cos\varphi = \frac{I_R}{I}$$

These currents are related to the following powers:

- **Active power** linked to I_R;
- **Reactive power** linked to I_L;

The reactive power doesn't produce mechanical work and it is an additional load for the energy supplier.
The parameter that defines the consumption of reactive power is the power factor.
We define power factor the ratio between active power and apparent power:



$$FP = \frac{P}{A}$$

$$A = \sqrt{P^2 + Q^2}$$

As far as there are not harmonic currents power factor coincides to cosφ of the angle between current and voltage vectors.
Cosφ decreases as the reactive absorbed power increases.

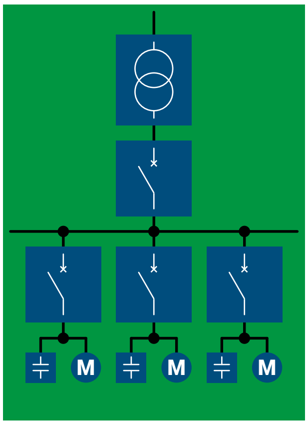
Low cosφ, has the following disadvantages:

- High power losses in the electrical lines.
- High voltage drop in the electrical lines.
- Over sizing of generators, electric lines and transformers.

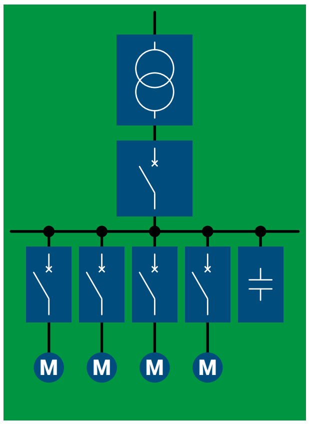
From this we understand the importance to improve (increase) the power factor.
Capacitors need to obtain this result.

Power factor correction: how?

By installing a capacitor bank it is possible to reduce the reactive power absorbed by the inductive loads in the system and consequently to improve power factor. It is suitable to have cosφ a little in excess of 0.95 to avoid paying the penalties provided for by the law.
The choice of the correct power factor correction equipment depends on the type of loads present and by their way of working.
The choice is between **individual compensation** and **central compensation**.
Nel caso di rifasamento distribuito, le unità rifasanti sono disposte nelle immediate vicinanze di ogni singolo carico che si vuole rifasare.
Individual compensation: power factor correction is wired at each single load (i.e. motor terminals).
Central compensation: there is only one bank of capacitors on the main power distribution switch board or substation.



Individual compensation



Central compensation

The individual compensation is a simple technical solution: the capacitor and the user equipment follow the same sorts during the daily work, so the regulation of the cosφ becomes systematic and closely linked to the load. Another great advantage of this type of power factor correction is the simple installation with low costs.
The daily trend of the loads has a fundamental importance for the choice of most suitable power factor correction. In many systems, not all the loads work in the same time and some of them work only a few hours per day. It is clear that the solution of the individual compensation becomes too expensive for the high number of capacitors that have to be installed. Most of these capacitors will not be used for long period of time.
The individual compensation is more effective if the majority of the reactive power is concentrated on a few substatios loads that work long period of time.
Central compensation is best suited for systems where the load fluctuates throughout the day. If the absorption of reactive power is very variable, it is advisable the use of automatic regulation in preference to fixed capacitors.

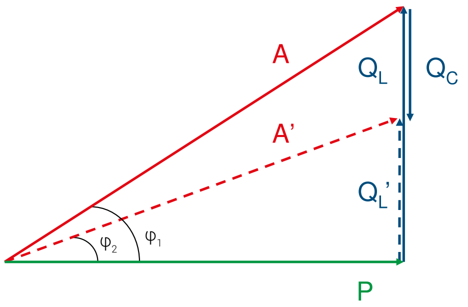
Power factor correction: How many?

The choice of capacitor bank to install in a system is closely depended from:

- $\cos\varphi_2$ value that we would obtain;
- $\cos\varphi_1$ starting value;
- installed active power.

By the following equation:

$Q_C = P \cdot (\tan\varphi_1 - \tan\varphi_2)$



Can be also written $Q_C = k \cdot P$

where the parameter k is easily calculated using Table 1 (in APPENDIX).
As example if we have installed a load that absorbs an active power of 300 kW having a power factor 0.7 and we want to increase it until 0.97.
From the table 1 we find: k = 0,770.
and therefore:

Q_C = 0,770 · 300 = 231 kvar

where:
Q_C = required capacitors reactive output (kvar);
P = active power (kW);
Q_L, Q_L' = inductive reactive output before and after the installation of the capacitor bank;
A, A'= apparent power before and after the power factor correction (kVA).

A typical example of power factor correction, sometimes not much considered but surely important, concerns the power factor correction of transformers for the distribution of energy.
It is essentially a fixed power factor correction that must compensate for the reactive power absorbed by the transformer in its no load condition (this happens often during the night). The calculation of the needed reactive output is very easy and it bases itself on this equation:

$$Q_C = I_0\% \cdot \frac{A_N}{100}$$

where
I_0% = magnetising current of the transformer
A_N = apparent rated power in kVA of the transformer

If we don't have these parameters, it is convenient to use the following table.

Power transformer [kVA]	Standard		Low losses	
	Oil [kvar]	Resin [kvar]	Oil [kvar]	Resin [kvar]
10	1	1,5	–	–
20	2	1,7	–	–
50	4	2	–	–
75	5	2,5	–	–
100	5	2,5	1	2
160	7	4	1,5	2,5
200	7,5	5	2	2,5
250	8	7,5	2	3
315	10	7,5	2,5	3,5
400	12,5	8	2,5	4
500	15	10	3	5
630	17,5	12,5	3	6
800	20	15	3,5	6,5
1000	25	17,5	3,5	7
1250	30	20	4	7,5
1600	35	22	4	8
2000	40	25	4,5	8,5
2500	50	35	5	9
3150	60	50	6	10

Another very important example of power factor correction concerns asynchronous three-phase motors that are individually corrected.
The reactive power likely needed is reported on following table:

Motor power		Required reactive power [kvar]				
HP	KW	3000 rpm	1500 rpm	1000 rpm	750 rpm	500 rpm
0,4	0,55	–	–	0,5	0,5	–
1	0,73	0,5	0,5	0,6	0,6	–
2	1,47	0,8	0,8	1	1	–
3	2,21	1	1	1,2	1,6	–
5	3,68	1,6	1,6	2	2,5	–
7	5,15	2	2	2,5	3	–
10	7,36	3	3	4	4	5
15	11	4	5	5	6	6
30	22,1	10	10	10	12	15
50	36,8	15	20	20	25	25
100	73,6	25	30	30	30	40
150	110	30	40	40	50	60
200	147	40	50	50	60	70
250	184	50	60	60	70	80

Be careful: the capacitor output must not be dimensioned too high for individual compensated machines where the capacitor is directly connected with the motor terminals. The capacitor placed in parallel may act as a generator for the motor which will cause serious overvoltages (self-excitation phenomena). In case of wound rotor motor the reactive power of the capacitor bank must be increased by 5%.

Power factor correction: technical reasons

Recent energy market deregulation, along with new potential energy supplier rising, had lead to many and different type of invoicing which are not very clear in showing Power Factor up. However as energy final price is steady growing, to correct power factor is becoming more and more convenient. In most of the cases power factor improvement device prime cost is paid back in few months.
Technical-economical advantages of the installation of a capacitor bank are the following:

- Decrease of the losses in the network and on the transformers caused by the lower absorbed current.
- Decrease of voltage drops on lines.
- Optimisation of the system sizing.

The current I, that flows in the system, is calculated by:

$$I = \frac{P}{\sqrt{3} \cdot V \cdot \cos\varphi}$$

where
P = Active power.
V = Nominal voltage.

While cosφ increases, with the same absorbed power we can obtain a reduction in the value of the current and as a consequence the losses in the network and on the transformers are reduced.
Therefore we have an important saving on the size of electrical equipment used on a system. The best system sizing has some consequence on the line voltage drop. We can easily see that looking at the following formula:

$$\Delta V = R \cdot \frac{P}{V} + X \cdot \frac{Q}{V}$$

where
P = Active power on the network (kW).
Q = Reactive power on the network (kvar)
while R is the cable resistance and X its reactance (R<<X).

The capacitor bank installation reduces Q so we have a lower voltage drop. If, for a wrong calculation of the installed capacitor bank value, the reactive part of the above equation becomes negative, instead of a reduction of the voltage drop we have an increasing of the voltage at the end of the line (Ferranti Effect) with dangerous consequence for the installed loads.

Some examples clarify the concepts set out above:

cosφ	Power loss[1] [kW]	Supplied active power[2] [kW]
0,5	3,2	50
0,6	2,3	60
0,7	1,6	70
0,8	1,3	80
0,9	1	90
1	0	100

1. In function of cosφ, from a copper cable 3 x 25mm² 100m long carrying 40kW at 400Vac
2. By a 100kVA transformer, in function of cosφ

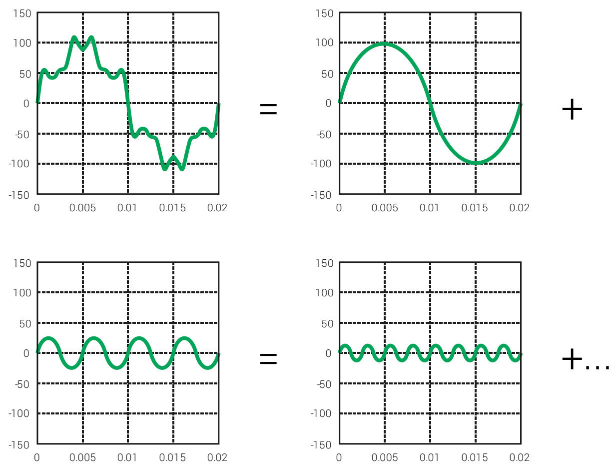
As we can see as the power factor increases we have fewer losses in the network and more active power from the same KVA. This allows us to optimise on the system sizing.

Power factor correction: Harmonics in the network

The distortions of the voltage and current waveforms are generated by non-linear loads (inverter, saturated transformers, rectifier, etc.) and produce the following problems:

- On the AC motors we find mechanical vibration that can reduce expected life. The increase of the losses creates overheating with consequent damaging of the insulating materials.
- In transformers they increase the copper and iron losses with possible damaging of the windings. The presence of direct voltage or current could cause the saturation of the cores with consequent increasing of the magnetising current.
- The capacitors suffer from the overheating and the increasing of the voltage that reduce their life.

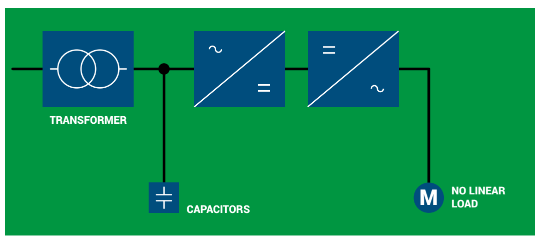
The waveform of the current (or voltage) generated by a nonlinear load being periodical, could be represented by the sum of many sinusoidal waves (a 50Hz component called fundamental and other components with multiple frequency of the fundamental component so called **harmonics**).

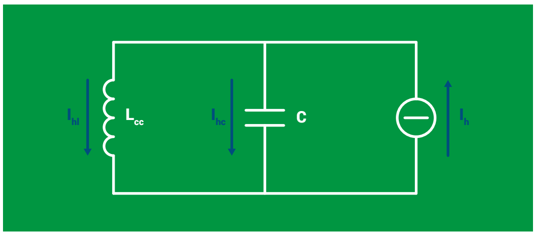


$$I = I_1 + I_2 + I_3 + \ldots + I_n$$

It is not advisable to install the power factor correction without considering the harmonic content of a system. This is because, even if we could manufacture capacitors that can withstand high overloads, capacitors produce an increase of harmonic content, with the negative effects just seen.
We speak about resonance phenomena when an inductive reactance is equal to the capacitive one:

$$2\pi f\, L = \frac{1}{2\pi f\, C}$$





Ideal current generator represents motor as harmonic current components generator I_h, these are independent from circuit inductance, while L_{CC} is obtainable by capacitor upstream short circuit power (in general it is equal to transformer short-circuit inductance).

The resonance frequency is obtained as follows:

$$N = \sqrt{\frac{S_{CC}}{Q}} \cong \sqrt{\frac{A \cdot 100}{Q \cdot V_{CC}\%}}$$

where
S_{cc} = short-circuit power of the network (MVA)
Q = output of power factor correction bank (kvar)
A = rated power transformer (kVA)
V_{cc}% = transformer short-circuit voltage
N = resonance harmonic order

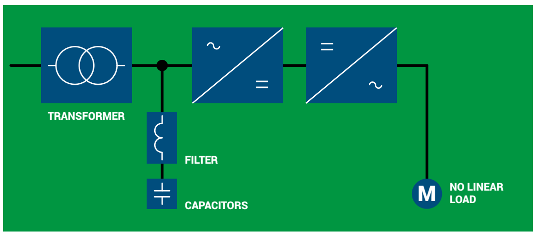
In parallel resonance conditions the current and the voltage of the circuit L_{CC} - C are heavily amplified as well as the nearby harmonic currents.

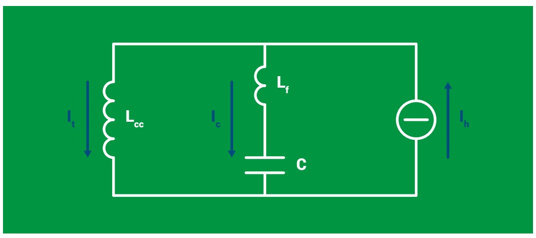
Hereinafter an example:
A = 630kVA (rated power transformer)
V_{CC}% = 6 (transformer short-circuit voltage %)
Q = 300kvar (output of power factor correction bank)

$$N = \sqrt{\frac{A \cdot 100}{Q \cdot V_{CC}\%}} = \sqrt{\frac{630 \cdot 100}{300 \cdot 6}} \cong 6$$

The result shows that in these conditions the system transformer-capacitor bank has the parallel resonance frequency of 300Hz (6x50Hz). This means likely amplification of 5th and 7th harmonic current.

The most convenient solution to avoid this is the detuned filter, formed introducing a filter reactor in series with the capacitors, making this a more complex resonant circuit but with the desired feature of having a resonance frequency below the first existing harmonic.





With this type of solution, the parallel resonance frequency is modified from

$$f_{rp} = \frac{1}{2 \cdot \pi \cdot \sqrt{L_{cc} \times C}}$$

to

$$f_{rp} = \frac{1}{2 \cdot \pi \cdot \sqrt{(L_{cc} + L_f) \times C}}$$

Normally the resonance frequency between the capacitor and the series reactance is shifted lower than 250Hz and it is generally between 135Hz and 210Hz. The lower frequencies correspond to higher harmonic loads.
The installation of a reactance in series with the capacitor bank produces a series resonance frequency:

$$f_{rs} = \frac{1}{2 \cdot \pi \cdot \sqrt{L_f \times C}}$$

If a harmonic current I_h with the same frequency of the resonance in series exists, this one will be totally absorbed by the system capacitors - reactors without any effect on the network. The realisation of a tuned passive filter is based on this simple principle.
This application is required when we want the reduction of the total distortion in current (THD) on the system:

$$THD = \frac{\sqrt{I_3^2 + I_5^2 + I_7^2 + ... + I_n^2}}{I_1}$$

where
I_1 = component at the fundamental frequency (50Hz) of the total harmonic current
I_3 - I_5 - ... = harmonic components at the multiple frequency of the fundamental (150Hz, 250Hz, 350Hz, ...)

The dimensioning of tuned/passive filters is linked to the circuit parameter:

- Impedance of the network (attenuation effect less as the short-circuit power on the network increases: in some cases could be useful to add in series with the network a reactance to increase the filtering effect).
- Presence of further loads that generate harmonics linked to other nodes on the network.
- Capacitor types.

On this last point we have to make some considerations.
It is known that the capacitors tend to decrease capacity over time: varying the capacity inevitably varies the resonance series frequency

$$f_{rs} = \frac{1}{2 \cdot \pi \cdot \sqrt{L_f \times C}}$$

and this drawback can be very dangerous because the system could lead in parallel resonance conditions. In this case, the filter does not absorb more harmonics but even amplifies them.
In order to have a constant capacity guarantee over time we need to use another type of capacitors made in bimetallized paper and oil impregnated polypropylene.
In addition to the passive absorption filter realized with capacitors and inductances is possible to eliminate the network harmonics, with another type of absorption filter: the Active Filter. The operation principle is based on the in-line injection of the same current harmonics produced by non-linear loads, but out of phase.

Power factor correction in the presence of a photovoltaic system in spot trading

If on electrical plant of an industrial user is added a photovoltaic system, the active power drawn from the supply is reduced because of the power supplied by the photovoltaic system and consumed by the plant (consumption).
Therefore, it changes the relationship between reactive power and active energy drawn from the network and, consequently, the power factor is lower than the same system without photovoltaic.
We must therefore pay particular attention to the power factor correction not to have any penalties for low cosφ that could seriously erode the economic benefits of the photovoltaic system.
The power factor correction will be reviewed both for installed capacity, both for construction type. In fact, increasing the power factor corrector power, you will modify the resonance conditions with the MV/LV transformer which supply the system.
When the photovoltaic system has more power than the users one, or if it is possible that power is introduced to the network, the power factor corrector must also be able to run on the four quadrants. The two "standard" quadrants are related to the plant operation as a user that absorbs from the network both active and inductive reactive power, while the two quadrants related on the plant functioning as a generator, it provides the network active power, but it absorbs the inductive reactive power (quadrants of generation.

All range of cosφ electronic controllers are able to operate in four quadrants, running two different cosφ targets to optimize the system economic performance.
To manage the cogeneration quadrants you can alter some parameters settings. It is advisable to enter a value equal to 1, to optimize the yield of the PFC Bank. Refer to the manuals of the controllers for more details.
To get the maximum benefit in the time allowed by the PFC Bank, we recommend to use metallized polypropylene capacitor with increased thickness.

APPENDIX

Table 1

K factor for turning active power into reactive power to achieve target power factor.

Starting power factor	Target power factor										
	0,90	**0,91**	**0,92**	**0,93**	**0,94**	**0,95**	**0,96**	**0,97**	**0,98**	**0,99**	**1,00**
0,30	2,695	2,724	2,754	2,785	2,817	2,851	2,888	2,929	2,977	3,037	3,180
0,31	2,583	2,611	2,641	2,672	2,704	2,738	2,775	2,816	2,864	2,924	3,067
0,32	2,476	2,505	2,535	2,565	2,598	2,632	2,669	2,710	2,758	2,818	2,961
0,33	2,376	2,405	2,435	2,465	2,498	2,532	2,569	2,610	2,657	2,718	2,861
0,34	2,282	2,310	2,340	2,371	2,403	2,437	2,474	2,515	2,563	2,623	2,766
0,35	2,192	2,221	2,250	2,281	2,313	2,348	2,385	2,426	2,473	2,534	2,676
0,36	2,107	2,136	2,166	2,196	2,229	2,263	2,300	2,341	2,388	2,449	2,592
0,37	2,027	2,055	2,085	2,116	2,148	2,182	2,219	2,260	2,308	2,368	2,511
0,38	1,950	1,979	2,008	2,039	2,071	2,105	2,143	2,184	2,231	2,292	2,434
0,39	1,877	1,905	1,935	1,966	1,998	2,032	2,069	2,110	2,158	2,219	2,361
0,40	1,807	1,836	1,865	1,896	1,928	1,963	2,000	2,041	2,088	2,149	2,291
0,41	1,740	1,769	1,799	1,829	1,862	1,896	1,933	1,974	2,022	2,082	2,225
0,42	1,676	1,705	1,735	1,766	1,798	1,832	1,869	1,910	1,958	2,018	2,161
0,43	1,615	1,644	1,674	1,704	1,737	1,771	1,808	1,849	1,897	1,957	2,100
0,44	1,557	1,585	1,615	1,646	1,678	1,712	1,749	1,790	1,838	1,898	2,041
0,45	1,500	1,529	1,559	1,589	1,622	1,656	1,693	1,734	1,781	1,842	1,985
0,46	1,446	1,475	1,504	1,535	1,567	1,602	1,639	1,680	1,727	1,788	1,930
0,47	1,394	1,422	1,452	1,483	1,515	1,549	1,586	1,627	1,675	1,736	1,878
0,48	1,343	1,372	1,402	1,432	1,465	1,499	1,536	1,577	1,625	1,685	1,828
0,49	1,295	1,323	1,353	1,384	1,416	1,450	1,487	1,528	1,576	1,637	1,779
0,50	1,248	1,276	1,306	1,337	1,369	1,403	1,440	1,481	1,529	1,590	1,732
0,51	1,202	1,231	1,261	1,291	1,324	1,358	1,395	1,436	1,484	1,544	1,687
0,52	1,158	1,187	1,217	1,247	1,280	1,314	1,351	1,392	1,440	1,500	1,643
0,53	1,116	1,144	1,174	1,205	1,237	1,271	1,308	1,349	1,397	1,458	1,600
0,54	1,074	1,103	1,133	1,163	1,196	1,230	1,267	1,308	1,356	1,416	1,559
0,55	1,034	1,063	1,092	1,123	1,156	1,190	1,227	1,268	1,315	1,376	1,518
0,56	0,995	1,024	1,053	1,084	1,116	1,151	1,188	1,229	1,276	1,337	1,479
0,57	0,957	0,986	1,015	1,046	1,079	1,113	1,150	1,191	1,238	1,299	1,441
0,58	0,920	0,949	0,979	1,009	1,042	1,076	1,113	1,154	1,201	1,262	1,405
0,59	0,884	0,913	0,942	0,973	1,006	1,040	1,077	1,118	1,165	1,226	1,368
0,60	0,849	0,878	0,907	0,938	0,970	1,005	1,042	1,083	1,130	1,191	1,333
0,61	0,815	0,843	0,873	0,904	0,936	0,970	1,007	1,048	1,096	1,157	1,299
0,62	0,781	0,810	0,839	0,870	0,903	0,937	0,974	1,015	1,062	1,123	1,265
0,63	0,748	0,777	0,807	0,837	0,870	0,904	0,941	0,982	1,030	1,090	1,233
0,64	0,716	0,745	0,775	0,805	0,838	0,872	0,909	0,950	0,998	1,058	1,201
0,65	0,685	0,714	0,743	0,774	0,806	0,840	0,877	0,919	0,966	1,027	1,169
0,66	0,654	0,683	0,712	0,743	0,775	0,810	0,847	0,888	0,935	0,996	1,138
0,67	0,624	0,652	0,682	0,713	0,745	0,779	0,816	0,857	0,905	0,966	1,108
0,68	0,594	0,623	0,652	0,683	0,715	0,750	0,787	0,828	0,875	0,936	1,078
0,69	0,565	0,593	0,623	0,654	0,686	0,720	0,757	0,798	0,846	0,907	1,049
0,70	0,536	0,565	0,594	0,625	0,657	0,692	0,729	0,770	0,817	0,878	1,020
0,71	0,508	0,536	0,566	0,597	0,629	0,663	0,700	0,741	0,789	0,849	0,992
0,72	0,480	0,508	0,538	0,569	0,601	0,635	0,672	0,713	0,761	0,821	0,964
0,73	0,452	0,481	0,510	0,541	0,573	0,608	0,645	0,686	0,733	0,794	0,936
0,74	0,425	0,453	0,483	0,514	0,546	0,580	0,617	0,658	0,706	0,766	0,909
0,75	0,398	0,426	0,456	0,487	0,519	0,553	0,590	0,631	0,679	0,739	0,882
0,76	0,371	0,400	0,429	0,460	0,492	0,526	0,563	0,605	0,652	0,713	0,855
0,77	0,344	0,373	0,403	0,433	0,466	0,500	0,537	0,578	0,626	0,686	0,829
0,78	0,318	0,347	0,376	0,407	0,439	0,474	0,511	0,552	0,599	0,660	0,802
0,79	0,292	0,320	0,350	0,381	0,413	0,447	0,484	0,525	0,573	0,634	0,776
0,80	0,266	0,294	0,324	0,355	0,387	0,421	0,458	0,499	0,547	0,608	0,750
0,81	0,240	0,268	0,298	0,329	0,361	0,395	0,432	0,473	0,521	0,581	0,724
0,82	0,214	0,242	0,272	0,303	0,335	0,369	0,406	0,447	0,495	0,556	0,698
0,83	0,188	0,216	0,246	0,277	0,309	0,343	0,380	0,421	0,469	0,530	0,672
0,84	0,162	0,190	0,220	0,251	0,283	0,317	0,354	0,395	0,443	0,503	0,646
0,85	0,135	0,164	0,194	0,225	0,257	0,291	0,328	0,369	0,417	0,477	0,620
0,86	0,109	0,138	0,167	0,198	0,230	0,265	0,302	0,343	0,390	0,451	0,593
0,87	0,082	0,111	0,141	0,172	0,204	0,238	0,275	0,316	0,364	0,424	0,567
0,88	0,055	0,084	0,114	0,145	0,177	0,211	0,248	0,289	0,337	0,397	0,540
0,89	0,028	0,057	0,086	0,117	0,149	0,184	0,221	0,262	0,309	0,370	0,512
0,90	-	0,029	0,058	0,089	0,121	0,156	0,193	0,234	0,281	0,342	0,484
0,91	-	-	0,030	0,060	0,093	0,127	0,164	0,205	0,253	0,313	0,456
0,92	-	-	-	0,031	0,063	0,097	0,134	0,175	0,223	0,284	0,426
0,93	-	-	-	-	0,032	0,067	0,104	0,145	0,192	0,253	0,395
0,94	-	-	-	-	-	0,034	0,071	0,112	0,160	0,220	0,363
0,95	-	-	-	-	-	-	0,037	0,078	0,126	0,186	0,329

CT-ORTEA PFCp&t-2021.00.00

IMPROVE YOUR POWER QUALITY

Companies are more and more sensitive to Power Quality issues because they can cause troubles and damages to equipments.

Our Power Quality solutions:

VOLTAGE STABILISERS
SAG COMPENSATOR
LV TRANSFORMERS
PFC SYSTEMS
ACTIVE HARMONIC FILTERS
ENERGY EFFICIENCY SMART DEVICES

CERTIFIED
ISO 9001 · ISO 14001
OHSAS 18001

ORTEA SpA
Via dei Chiosi, 21
20873 Cavenago di Brianza MB | ITALY
tel. +39 02 95 917 800

www.next.ortea.com
sales@ortea.com