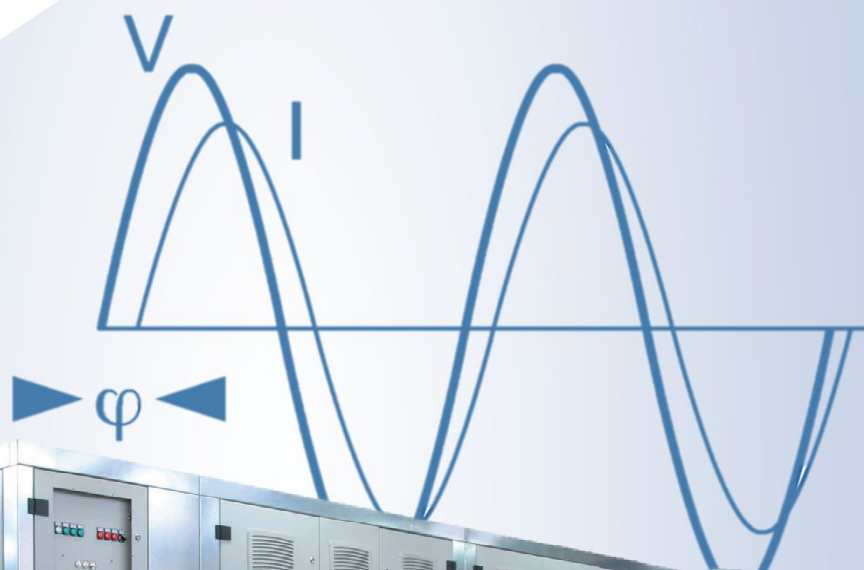


POWER FACTOR CORRECTION MEDIUM VOLTAGE



Save Your **Energy.**

Solutions and components for
Power Factor Correction.

Introduction

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Introduction

Since 1968 we provide standard products, as well as tailor-made solutions, depending on the needs of the Customer. We are leaders in the production of single-phase and three-phase **capacitors**, **power factor correction** equipment including those with blocking / de-tuning inductances, and **filters** for harmonic reduction.

Installers, design companies and end users find answers to their needs regarding both the correction of the power factor and the reduction of harmonics in electrical networks.

Strengthened by the value that **Made in Italy** represents, we sell in over 90 countries worldwide, thanks to a sales network that guarantees the availability of COMAR solutions for power factor correction on every continent.

Vision

We firmly believe that the increased electricity demand of the developed and emerging countries must be faced first of all with the reduction of waste.

Power Factor Correction plays a fundamental role in the "intelligent" exploitation of the energy currently produced, in fact it postpones and limits the creation of new power plants, and it contributes to the **environment protection**, by reducing atmospheric emissions and non-renewable fuel consumption..

Mission

Provide state-of-the-art engineering solutions that, in addition to compliance with quality and safety standards, are also appreciated by Customers for their flexibility, respect of delivery times, ease of installation and maintenance,



Quality & Certifications

The excellence of COMAR Condensatori products is possible thanks to Italian supply chain, fully under control in our factory located near Bologna. The path to ensure the quality of the methods of design, procurement, production, testing and delivery sees the achievement of the **ISO 9001**, **ISO 14001** and **OHSAS 18001** certifications.

The quality of the company system permeates the products, which comply with the requirements of the main international regulations in the sector.

All COMAR solutions, contained in this catalog, comply with the European directives for low voltage, concerning the minimum safety requirements and the emission / immunity of electrical devices.

Materials & Environment

Thanks to constant work with suppliers, we guarantee the compliance of our products with the **RoHS** and **REACH** directives. Particular attention is given to the substances published in the SVHC list.

We recommend that the out-of-service capacitors are disposed according to the local laws and regulations in force in each country. For EU countries the European Directives 91/156 / EEC, 91/689 / EEC apply and the capacitors disposal shall be in compliance with the European Waste Identification Code (CER 2002).



Internal Fuses

COMAR capacitors can be provided with internal fuses, where each capacitive element is provided with a fuse set in series with the element (see figure A); if the capacitive element breaks the fuse trips; disconnecting the broken element from the unit that is not involved in the short circuit, thereby making it possible for the capacitor to work.

The fuse tripping then produces a reduction in capacitance; if a number of fuses trip, the variation must be such as to anyhow keep the resulting total capacitance within the limits of tolerance prescribed by the reference standards.

This system offers the obvious advantage of being able to operate also with units in which there are broken elements (respecting the above criteria); however there are construction limits due to the need to have a fair number of capacitive elements connected in parallel for each series branch, so that disconnecting the broken element has no effect on the remaining elements in terms of overvoltage and overcurrent.

In general it is necessary for the rated voltage of the capacitor to be ≤ 7200 V and rated power ≥ 300 kvar.

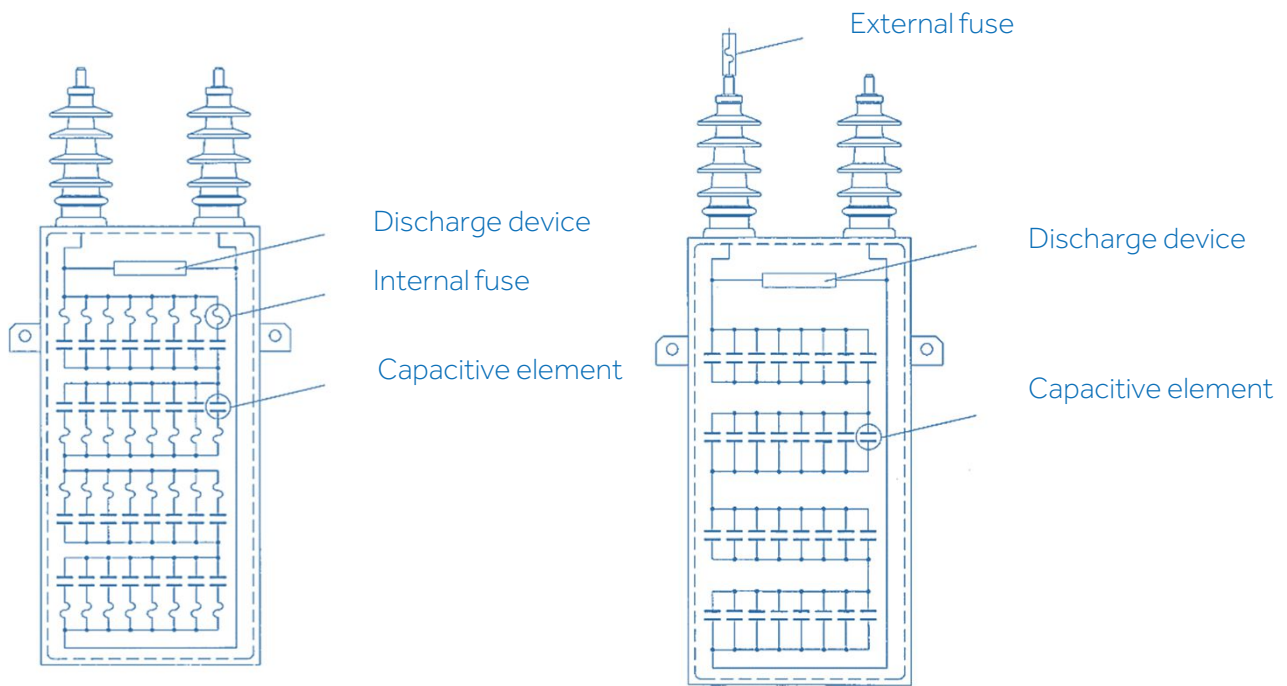


fig. A
View of capacitor with internal fuses.

fig. B
View of capacitor with external fuses.

The medium voltage capacitors and banks can be provided with external fuses (see figure B) to protect against faults caused by short-circuiting. The main rules and parameters determining the choice and sizing of the fuse are the following:

- The rated voltage of the fuses must be equal to (or greater than) the phase voltage of the system.
- The choice must take account of the current transients and whether there are any inrush reactors.
- The fuse must be able to withstand all the inrush overcurrent due to the operations during the life of the capacitor. The peak value of the inrush current must not exceed 100 times the effective value of the rated current.
- The permanent current of the fuse must be equal to at least 2-3 times the rated current to consider all the possible overloads.
- The fuses must be designed to be able to withstand, permanently, a current of $1.3 I_n$. As a result of the actual value of the capacitance that can at most be equal to 1.15 times the value corresponding to its rating, this current can have a maximum value of $1.3 * 1.15 = 1.5$ times the rated current for the single units and lower values for the banks. As an indication, the rated current of the fuse must be equal to 2 times the rated current of the unit.
- In a balanced three-phase system disconnecting a unit on a phase causes an increase in voltage on the bank of capacitors; in medium and high power banks where there is a real need that if one or more units breaks down the system will keep on working, this increase must be contained within 10%.
- The fuse or fuses connected to a good unit or to a number of good units must be able to withstand the discharge currents due to perforation of another unit or other units and the currents due to short-circuiting outside the unit or units, especially in medium and high power three-phase banks.
- When choosing fuses you need to try and minimize the likelihood of the container breaking if the unit breaks down.
- For medium and high power banks where unbalance protection is necessary, the choice of the rated current of the fuse must be coordinated with these systems.

The external fuses used by COMAR are divided into:

- "H.R.C. FUSES"
- "EXPULSION FUSES"

HRC Fuses

H.R.C. fuses are normally used to protect small banks and/or three-phase capacitors, designed in accordance with DIN and IEC standards for protection against thermal and dynamic effects, caused by current exceeding the tolerated value in magnitude and duration. The main characteristics of H.R.C. fuses are:

- low minimum trip current;
- low dissipated power;
- low voltage of the electric arc;
- high breaking capacity;
- high current limiting;
- easy maintenance;
- small dimensions.

H.R.C. fuses are the best solution in situations where using other protection systems would require an excessive cost compared to that of the whole system. To obtain the maximum current limitation, and therefore the best protection, the rated current of the chosen fuse must be selected at the lowest possible level compared to the value of the current equal to about 2 times I_n .

The fuse cartridge striker, besides performing the function of signalling tripping, can be associated with the device for turning off the operating-disconnecting switch and/or with the external indicator device. Besides H.R.C. fuses, accessories can be supplied such as the specific fuse holder bases and the trip signalling devices.



Unbalance Protection

The only protection against overcurrent does not ensure sufficient protection against internal unit breakdown; additional protection is therefore necessary, especially when many units are involved. The optimal and efficient solution to guarantee the effectiveness and correct monitoring of the banks of capacitors is unbalance protection.

There are several types of unbalance protection, the one most widely used involves measuring the current unbalance between the two star centers; the operation of this protection is based on checking the symmetry of the two star centers of the bank.

In a balanced three-phase system the current between the two star centers is practically zero, whereas if elements or units break down they shift with circulation of the residual current; by inserting a current transformer between two star centers (see figure W) it is possible to measure this residual current and, with a special relay it is possible to promptly perform operations such as releasing the main switch, opening circuits or signaling a problem without causing damage to the good units.

This very sensitive system is also able to detect failure of a single element and this prevents the remaining installed components from getting damaged; in addition, the protection and operating devices work on breaks in loads at nominal levels and not at short circuit levels.

Unbalance protection therefore comprises a current transformer and a monopolar residual current relay; the following points show you the main characteristics of these components.



Current transformer for unbalance protection

The function of the current transformer is to measure the currents deriving from the unbalance of the two stars of the bank of capacitors and to insulate neutral at the same level as the mains voltage.

Figures D and E show the current transformers for inside and outside installation used by COMAR in the standard versions; we should point out that on request other types of transformers can be installed with different ratios, insulating voltage, performance, etc...

The main data of the current transformer for **inside** installation are:

- Insulation level: 24 kV
- Transformation ratio: 100-50/5 A (double primary ratio)
- Power: 10 VA
- Class and safety factor: 5P10 (for measurement)
- 10P10 (for protection)
- Thermal current (I_{th}): 100 I_n
- Dynamic current: 2.5 I_{th}
- Frequency: 50-60 Hz
- Weight: 16kg

The main data of the current transformer for **outside** installation are:

- Insulation level: 24 kV
- Transformation ratio: 30/1 A
- Power: 15 VA
- Class and safety factor: 10P10
- Thermal current (I_{th}): 100 I_n
- Dynamic current: 2.5 I_{th}
- Frequency: 50-60 Hz
- Weight: 60 kg

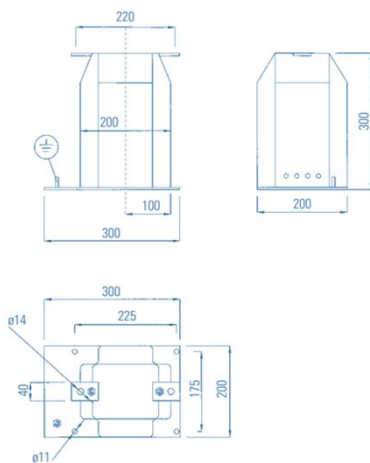


fig. D

Current transformer for unbalance protection for indoor installations.

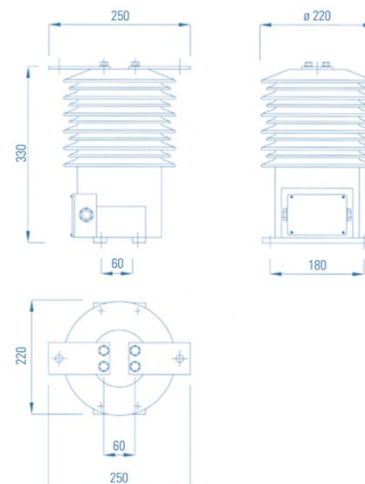


fig. E

Current transformer for unbalance protection for outdoor installations.

Relay for unbalance protection

The unbalance protection relay is a monopolar residual current relay that is insensitive to harmonics with independent time.

The types of relay used by COMAR are given here.

Convention relay

This is a relay made with a conventional system that due to its characteristics of high reliability, easy settings and inexpensiveness is the one most widely used.

The relay is equipped with a trip threshold that is associated with a relay with double output contacts in the standard version; for the protection of banks with high powers or where required, it is recommended to use two relays to create two thresholds (alarm and trip). The main data of this relay are:

- Auxiliary voltage:
 - 24 ÷ 125 V AC
 - 24 ÷ 220 V DC
 - 24 ÷ 230 V AC (via auxiliary transformer)
- Working frequency: 44 ÷ 66 Hz
- Amperometric signal from CT (I_{ON}): 1 or 5 A
- Permanent overload: 4 I_{ON}
- Max current output contacts: 5 A
- Field of adjustment of current threshold:
 - 1 ÷ 10% I_{ON} (resolution 0.1%)
 - 5 ÷ 50% I_{ON} (resolution 0.5%)
- Field of adjustment of time threshold:
 - 0.04 ÷ 1 s (resolution 0.01 s)
 - 0.4 ÷ 10 s (resolution 0.1 s)
- Working ambient air temperature: -10 ÷ +55°C
- Max working ambient air temperature: -25 ÷ +70°C
- Working ambient humidity: 10 ÷ 95%
- Fitting: protruding or
- Degree of protection: up to IP52 (for flush-mounting only)
- Weight: 1.6 kg

Microprocessor digital relay

COMAR also has different types of relay for unbalance protection made with microprocessor technology; these are multifunction relays and they offer greater adjustment possibilities compared to conventional relays. In addition, they have more trip and/or alarm thresholds. Other functions can be incorporated such as:

- overload protection $I >$,
- overcurrent protection $I >>$,
- minimum and maximum voltage protection,
- possibility of communication via RS232/R5485 port.

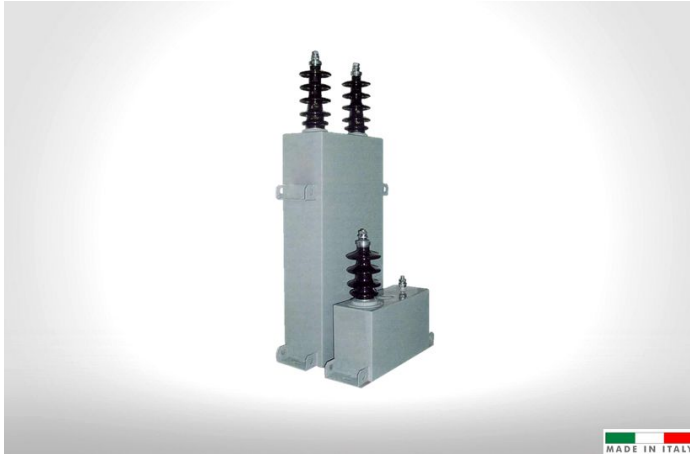
We recommend you contact COMAR engineering department that will be glad to advise you on the optimal type of relay for your needs and to provide you with the appropriate technical information.



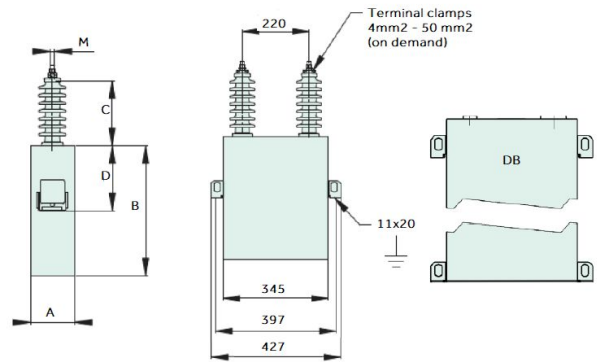
CMMT • CMTM • MVCB • ILMT & FMT

Medium Voltage PFC Capacitors & Reactors





DRAWINGS



CMMT single phase capacitors are the result of continual innovation and technological development of materials and production cycles, featuring extra low losses, high reliability and they are applicable to various needs.

They are chiefly used in making:

- three phase banks for power factor correction;
- filters for harmonics;
- protection against overvoltages;
- loss reduction.



QUALITY AND TESTING

Regulations

IEC/EN 60871/1 - 4

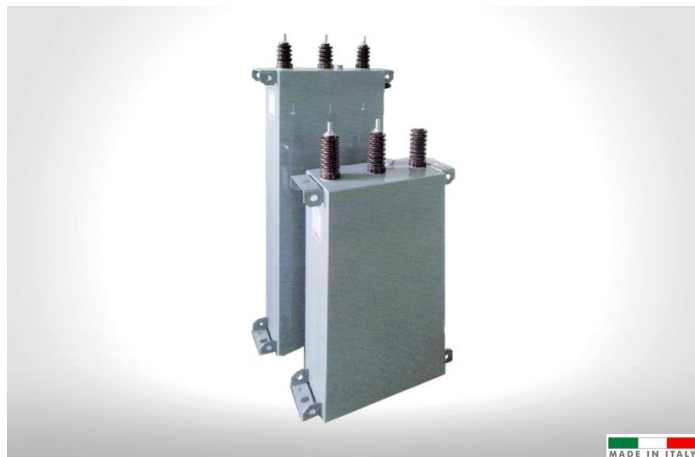
The capacitors can be made with all the terminals insulated or with a terminal connected to the container.

Qn kvar	A mm	B mm	C mm	Up = 75 / 95									Up = 125		
				Um = 3,6 Un = 2,08			Um = 7,2 Un = 4,16			Um = 12 Un = 6,93			Um = 24 Un = 13,86		
				D mm	kg	kg	D mm	kg	kg	D mm	kg	kg	D mm	kg	kg
100	135	310	120	240	26	28	240	26	28	240	26	28	315	26	28
150	135	400	200	240	32	34	240	32	34	240	32	34	315	32	34
200	135	520	200	240	39	42	240	39	42	240	39	42	315	39	42
250	135	640	200	240	47	50	240	47	50	240	47	50	315	47	50
300	135	740	200	240			240	53	56	240	53	56	315	53	56
350	135	840	200	240			240	60	65	240	60	65	315	60	65
400	135	940	200	240			240	66	70	240	66	70	315	66	70
450	145	1000DB	100	240			240			240	75	78	315	75	78
500	175	920DB	100	240			240			240	82	89	315	82	89
550	190	960DB	100	240			240			240	93	98	315	93	98
600	190	960	100	240			240			240	93	98	315	93	98

- Un Nominal voltage, RMS value (kV)
- Um Insulation level – Highest voltage, RMS value (kV)
- Up Insulation level – Lighting impulse, Basic Insulation Level (BIL), Peak value (kV)
- Qn Rated output power (kvarh)
- DB Double brackets on each side

Please note that, besides the capacitors indicated in the following tables, COMAR makes types with insulation levels, dimensions, bushings, rated frequency at 60 Hz and other characteristics when specifically requested by the Customer.

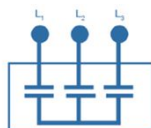
The above dimensions are not to be considered binding in relation to the continual development, product research and production of capacitors with or without internal fuses. Other characteristics and sizes on request.



CTMT three-phase capacitors are the result of continual innovation and technological development of materials and production cycles, featuring extra low losses, high reliability and they are applicable to various needs.

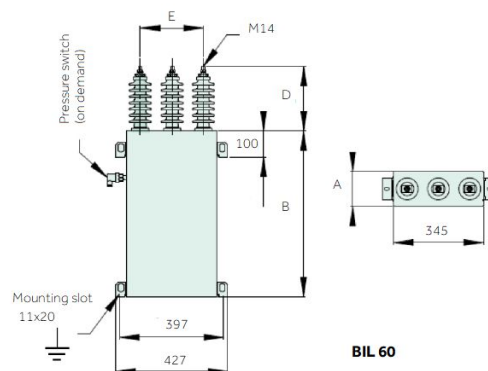
They are chiefly used in making:

- power factor correction of engines;
- transformer power factor correction;
- loss reduction.

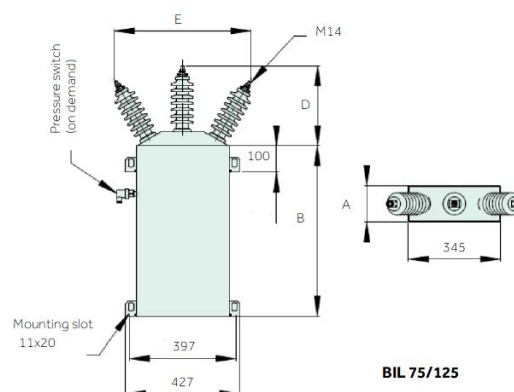


The capacitors can be made with all the terminals insulated or with a terminal connected to the container.

DRAWINGS



BIL 60



BIL 75/125

QUALITY AND TESTING

Regulations

IEC/EN 60871/1 -4

Qn kvar	Up = 60							Up = 75					
	Um = 3,6 Un = 3,3 & Um = 7,2 Un = 4,16							Um = 12 Un = 11					
	A	D	E	Without Internal Fuses		With Internal Fuses		D	E	Without Internal Fuses		With Internal Fuses	
mm	mm	mm	B	kg	B	kg	mm	mm	B	kg	B	kg	
100	135	250	240	275	23	290	23	300	510	275	28	290	28
150	135	250	240	370	30	400	30	300	510	370	35	400	35
200	135	250	240	470	37	520	37	300	510	470	42	520	42
250	135	250	240	570	44	620	44	300	510	570	49	620	49
300	135	250	240	670	51	720	51	300	510	670	55	720	55
350	135	250	240	770	60	825	60	300	510	770	63	825	63
400	135	250	240	870	66	940	66	300	510	870	69	940	69
450	145	250	240	970	73	1050	73	300	510	970	76	1050	76

Un Nominal voltage, RMS value (kV)

Um Insulation level – Highest voltage, RMS value (kV)

Up Insulation level – Lighting impulse, Basic Insulation Level (BIL), Peak value (kV)

Qn Rated output power (kvarh)

DB Double brackets on each side

Please note that, besides the capacitors indicated in the following tables, COMAR makes types with insulation levels, dimensions, bushings, rated frequency at 60 Hz and other characteristics when specifically requested by the Customer.

The above dimensions are not to be considered binding in relation to the continual development, product research and production of capacitors with or without internal fuses. Other characteristics and sizes on request.



The range of **BMT** capacitor banks type capacitor banks offers various solutions for industrial power factor correction thanks to the many combinations that can be made:

- small and high powers;
- working voltages greater than 24 kV obtained with overlapping frame structures (see the following paragraphs);
- indoor and outdoor installations;
- constructions on fully open structures (IP rating 00) or in special boxes (for powers up to 14.4 Mvar-24 kV also with degree of protection IP 54);
- different levels of insulation;
- operation under harsh working and environmental conditions;
- making filters for harmonics;
- special user requirements.

In addition, these capacitors banks offer several advantages:

- easy installation operations thanks to the complete line of accessories offered;
- optimization of the installation thanks to the systems fitted for connections to the various systems;
- simplification of the transport and handling operations thanks to the construction in compact and versatile structures;
- easy maintenance operations;
- different possibilities of making the frames, including hot galvanized steel or stainless steel frames (for corrosive environments).

These banks are composed of a number of single-phase capacitors that are assembled and interconnected in order to obtain greater power the connection is normally DELTA with insulated neutral. In addition to the capacitors and frame, the supply normally includes:

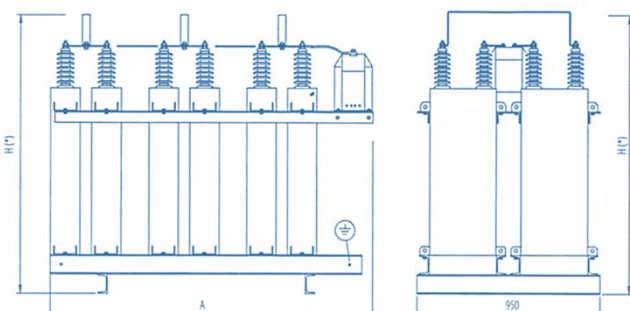
- post insulators;
- connection bars;
- protection via transformer and unbalance relay;
- damping reactors.

It is moreover possible to install other accessories and components such as:

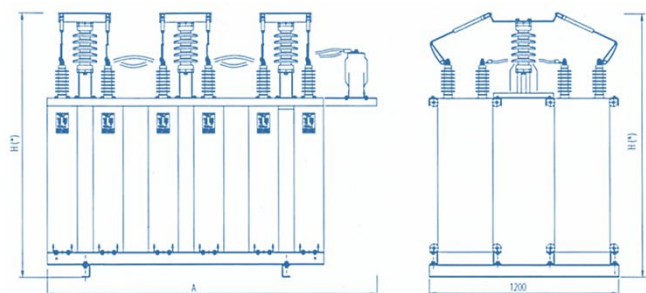
- fast discharge devices;
- harmonic block or filter reactors;
- earthing and/or line disconnector switches;
- HRC fuses (for indoors) or expulsion fuses (for outdoors);
- current and voltage transformers and relays for protection against overloading, short-circuiting, etc..
- electromechanical interlock systems for correct bank operation
- systems protecting against contact for the working personnel;
- exchangers and ventilation systems (for banks in boxes);
- space heater elements (for banks in boxes);
- other accessories on request.

Below we share an overview of the capacitor banks in the most widely used standard versions; besides these, we make types of banks defined on specific Customer requirements.

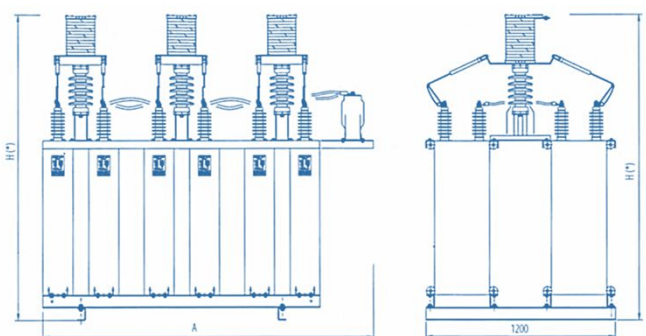
CONFIGURATION



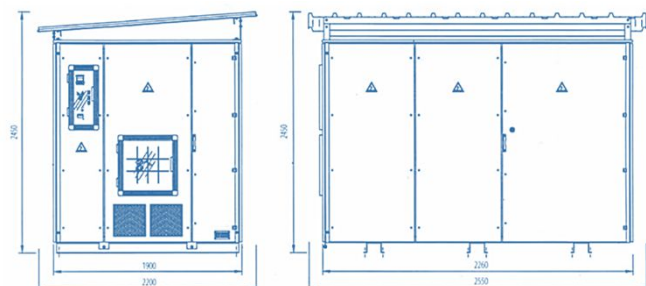
Standard Version IP00 with damping Reactors and C.T. for unbalance protection.



Standard Version IP00 with expulsion fuses and C.T. for unbalance protection.



Standard Version IP00 with expulsion fuses, damping reactors and C.T. for unbalance protection.



Standard Version in Box with degree of protection up to IP54.

Max. Power <i>kvar</i>	Number of capacitors	L max <i>mm</i>	H max <i>mm</i>	P max
3600	6	2020	2100	1450
7200	12	2960		
10800	18	3900	2350	
14400	24	4840		

N.B. The outfit may comprise: fuses, damping reactors, fast discharge devices, C.T. for unbalance protection, line disconnector switch, earthing switch, system with space heater element, voltage on/off indicator with kilovolt meter (if applicable), electromechanical interlock with control panel, ventilation system.

QUALITY AND TESTING

Regulations

IEC/EN 60871/1 -4

ILMT reactors are used to limit the inrush peak current to less than 100 times the rated current of the bank of capacitors.

The inrush current peak is due to the transitory phenomena of high amplitude and high frequency that are generated when the bank of capacitors cuts in on the supply network; this peak is considerably accentuated when a bank of capacitors is inserted in parallel with other banks that are already energized. The reactors are single phase with an air core and copper winding.

They are set in series with the bank of capacitors. They can be made for either indoor installation (see figure 1) or outdoor installation (see figure 2). The reactors must be installed on stand-off insulators with an insulation class equal to or greater than that of the bank of capacitors.

The reactors must be chosen considering the following main factors:

- the sizing voltage must be equal to or greater than the network voltage;
- the sizing current must take account of the rated current of the bank and the current peaks;
- the reactor must be sized appropriately to withstand the dynamic and thermal stresses caused by the current peaks at inrush;
- the influence of other banks of capacitors on the same network;
- the type of network in which to operate;
- the environmental conditions in which to operate.



fig. 1
Reactor for indoor installation.



fig. 2
Reactor for outdoor installation.

FMT reactors are filters for harmonics, used to prevent resonances occurring, which are extremely dangerous situations for the electric system because of the ensuing overcurrent and overvoltage. The “block” reactors are used with the sole purpose of correcting the power factor of the loads generating harmonics; the filter is therefore tuned only to a single frequency below the lowest one present.

The most commonly used tuning frequencies are:

- 210 Hz corresponding $X_L = 6\% X_C$
- 190 Hz corresponding $X_L = 7\% X_C$
- 133 Hz corresponding $X_L = 14\% X_C$

Normally, reactors to block harmonics are single-phase with an air core, but three-phase reactors can be used with an iron core for limited powers (see figure 3); the main difference is that reactors with an air core do not saturate but they are bulky, while reactors with an iron core saturate but they are smaller. In both cases the reactors are set in series with the bank of three-phase capacitors and types can be made for either indoor or outdoor installation.

The “filter” reactors are used with the aim of reducing the factor of distortion; the filter is therefore tuned to a frequency close to that of the harmonics present. If there are several harmonics to filter; then different filters will need to be made associated with separate banks of capacitors. The reactors are typically single-phase with an air core (see figure 4).

The filter reactors are set in series with the bank of three-phase capacitors and can be made for either indoor or outdoor installation. When used for indoor installations, it is fundamental to verify whether the power dissipated by the reactors affects the temperature of the installation environment; in such cases it is necessary to use air exchangers and/or air conditioning systems.

If reactors with an air core are used, they can be arranged side by side in a line, triangle or overlapping (to reduce the overall dimensions), but in all cases the minimum distances between them must be respected, as towards metal bodies, magnetic bodies, current and/or voltage transformers and components made by winding closed coils.



fig. 3
Reactor with iron core for indoor installation.



fig. 4
Reactor with air core for outdoor installation.



MVCELL

Medium Voltage Automatic PFC





PERFORMANCE DATA

- ▣ **Rated voltage** Up to 24 kV (single stage)
- ▣ **Rated power** Up to 4 Mvar (single stage)

The **MVCELL** are high technology equipment usable to compensate the reactive power of grids. They are essential to improve the performance, saving energy. The single stage is typically used to compensate a single load, such as a motor.

Higher powers (> 4 Mvar) can be achieved by paralleling stages. The multi stage is typically used to compensate an electric system, with many loads.

DESCRIPTION OF THE EQUIPMENT

- The first stage can be composed of:
- Cable entry
 - Switch isolator
 - Switch isolator with earthing blades
 - Mechanical safety interlock
 - Measuring transformers
 - Surge protection devices (spd)
 - Control board

- Each additional compensation stage is composed of:
- Protection with HRC fuse
 - switching device (contactor or circuit breaker)
 - Series inductance (damping or de-tuning)
 - Capacitor bank
 - Other accessories available on request
 - The rated voltage of each stage can be up to 24 kV, the rated power up to 4 MVA.

- The equipment are customizable in terms of:
- Rated power and voltage
 - Protection degree from IP00 till IP55
 - Lightning withstand (BIL – Basic Insulation Level)
 - Short circuit withstand: up to $I_{cw} = 50 \text{ KA} @ 3s$
 - Safety levels for the operator
 - Harmonic levels on the electric grid

Diagnostic levels:

- Low →
 - Undervoltage and overvoltage ansi 27/59
 - Over temperature in the cabinet
 - Under compensation
 - Harmonic level thdi too high
- Medium →
 - Capacitor Bank Unbalance With A Voltage Sensor On The Neutral (Neutral Voltage Sensor, Nvs) In A Single Star (Y) Configuration – Ansi 59n
 - Capacitor Bank Unbalance With A Current Sensor Between The Neutral Point In A Double Star (YY) Configuration (Neutral Current Sensor, Ncs) – Ansi 46n
 - Fuse Failure Indication
- High →
 - Overload ANSI 49RMS
 - Overcurrents ANSI 50/51
 - Capacitor bank unbalance with a voltage sensor between the neutral point in a double star (YY)
 - overpressure drives capacitive
 - fire detector protection
 - Indoor or outdoor installation
 - Altitude up to 4500 m above sea level

CONFIGURATION

The range of MVCELL medium voltage cells is designed for MV power factor correction applications composed of three-phase capacitors or capacitor banks for medium power factor correction of loads such as transformers, motors, etc...

They are particularly suited in cases where the user needs power factor correction that is easy to install and fast and practical to combine with existing boards, also thanks to their structural conformation being compact and complete boards.

The standard one is composed of a MV cell made with a board with an IP30 degree of protection (it is possible to make the metalwork with an IP55 degree of protection), which incorporates the safety fuses, inrush peak current limiting reactors, capacitors or battery, and the key interlock system. The power supply is normally through cables from the bottom of the cell, but it is also possible to make them on request.

The main accessories available to complete the standard version are:

- CT to relieve unbalances;
- fast discharge devices;
- harmonic block reactors (in this case the ventilation unit is included too);
- device signaling fuses tripping;
- capacitive insulators and relative voltage on/off signaling;
- inspection window;
- space heater element with humidity gauge;
- inside light;
- other accessories on request.

Besides the standard versions, we also make cells defined on specifications and metalwork requested by the Customer.



Example of MVCELL power factor correction cells at 15KV-1+2+3 Mvar-50 Hz.

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