

High Voltage Reactive Power Compensation and Harmonic Filtering Products

Our high voltage products enhance power quality of installations and improve electrical network efficiency, both resulting in considerable economical savings for end users.



High voltage reactive power compensation and harmonic filtering products help to improve performance of end user's installations through energy savings and better power quality. With Alstom Grid products and solutions, end users save money and reduce the environmental impact of their operations.



Reactive Power Compensation and Filtering components

- High voltage capacitor units
- High voltage reactors
- Electronic products for high voltage applications

Reactive Power Compensation and Filtering equipment

- High voltage shunt capacitor banks

Alstom Grid reactive power compensation and Harmonic Filtering Products – a wide range of components and one-off solutions at high voltage levels. We analyze your needs and engineer the right solutions offering optimal efficiency and economy.

Customer Benefits

- Energy savings
- Improved power quality
- Pay-back period 0.5-2 years
- Reduction of losses in the electrical network
- Improved transmission capacity

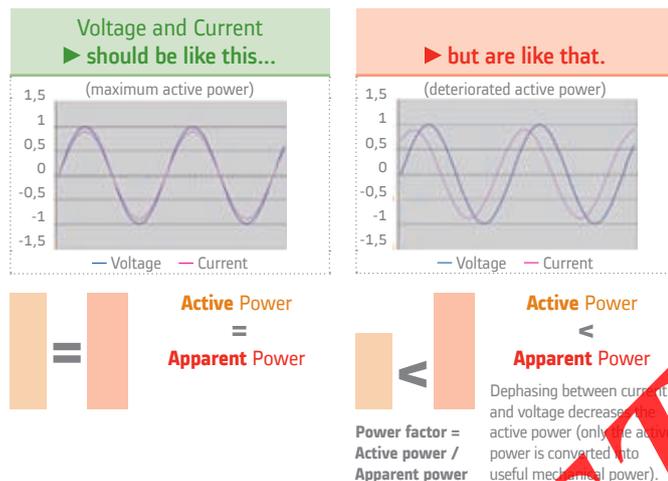
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Why do we need Reactive Power Compensation and Harmonic Filtering?

Reactive power compensation

Connected equipment (transformers, motors, air-conditioning, refrigerators, etc.) cause a phase angle between current and voltage. When the current is phase-shifted, it takes more current to deliver the same amount of active power.



Impact of reactive power

- Transmission equipment has to be sized for the apparent power, yet only active power is useful
- Increased losses in the network
- You pay for apparent power but use active power (higher electricity bill)
- Penalty fees to customers with a low power factor installation (example < 0.95)

WHO

- Power consumers, network operators, electric utilities, power industry, hospitals, offices, public and commercial buildings, factories

SOLUTION

- The power factor of a facility can be improved by installing capacitor banks.

Harmonic filtering

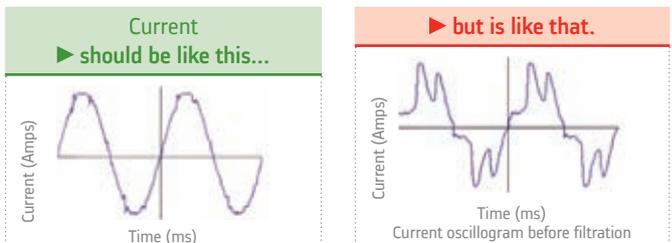
Variable speed drives (process industries, lifts, air conditioning pumps, etc.), uninterruptible power supplies for computers, electronic equipment, etc. distort the current (introduce harmonics).

Impact of harmonics on transmission / distribution equipment

- Additional losses (paid for by the end user)
- Heating in power cables
- Audible noise (transformers)
- Metering errors

Impact of harmonics on equipment connected

- Decreased machinery efficiency and lifetime
- Costly process shutdowns
- Disturbed electronic equipment (computers, telephones)



WHO

- Power consumers, network operators, electric utilities, power industry, public and commercial buildings

SOLUTION

- Harmonics can be filtered through a combination of reactors and capacitors (passive filtering) or by injecting the exact opposite of the harmonics detected (active filter) into the network.

Reactive power compensation and harmonic filtering bring

ECONOMIC BENEFITS

- Saving the costs of reactive power
- Additional savings through reduced active power losses
- Reduction in investment cost
 - increase of machinery lifetime
 - decrease of maintenance requirements and downtime of equipment

➔ Return on investment is generally below 18 months.

ENVIRONMENTAL BENEFITS

- **Reduced CO₂ emissions**
Customers see environmental benefits through energy savings and more efficient power systems.

➔ By saving millions of tons of CO₂, reactive power compensation makes an active contribution to protecting the environment.

High voltage capacitor units

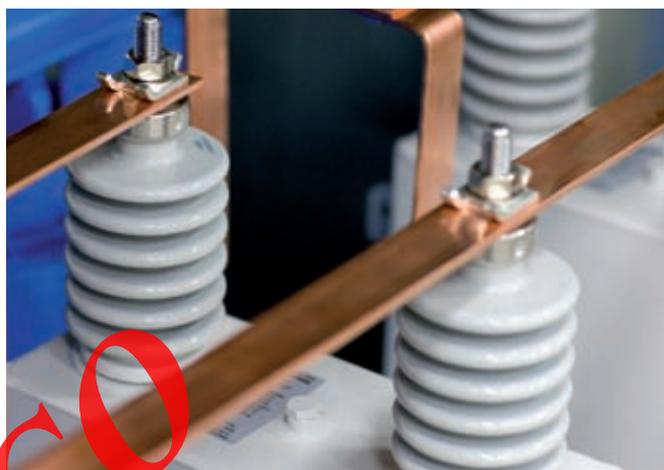
Alstom Grid high voltage capacitor unit offering is divided in:

HV power capacitor units

- HV 3-phase power capacitor units
- HV 1-phase power capacitor units

HV special capacitor units

- HV 1-phase surge protection capacitor units
- HV 1-phase induction heating installation capacitor units



HV power capacitor units

Their purpose is to compensate inductive loading from devices like electric motors and transmission lines to make the load appear to be mostly resistive.

Alstom Grid's capacitor units are a simple, economical and reliable source of reactive power on electrical power systems to improve their performance, quality and efficiency.

Advantages

- Improving power factor
- Reducing installation's losses
- Decreasing voltage drop

Applications

- Shunt capacitor banks
 - Open rack capacitor banks
 - Enclosed capacitor banks
 - Pole mounted capacitor banks
- Series capacitor banks
- SVCs

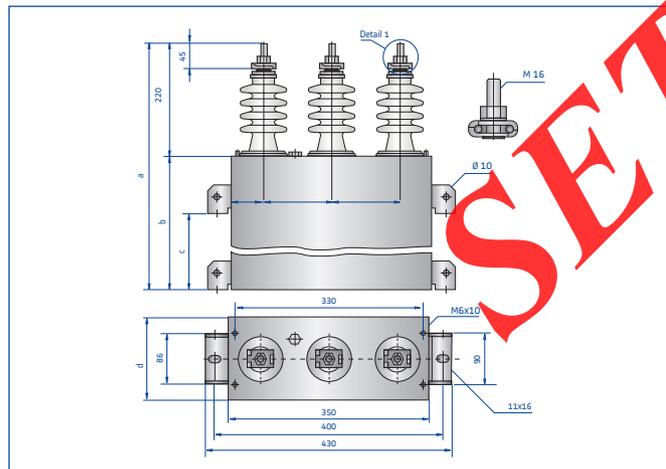


HV 3-phase power capacitor units

Product features

Alstom Grid high voltage power capacitor units are designed and manufactured using the most advanced technology and high quality materials. They are all-film dielectric capacitor units impregnated with a biodegradable dielectric liquid. Each capacitor unit element has the possibility of having separate internal fuse. In addition, each capacitor unit is provided with an internal discharge resistor.

All high voltage power capacitor units are light-weight and have low losses. They comply with most national and international capacitor unit standards.



Technical data

Type	impregnated all-film dielectric
Rated voltage	up to 8 kV
Rated frequency	50 Hz or 60 Hz
Rated power	up to 850 kvar
Average losses	< 0.15 W/kvar
Dielectric liquid	non-pcb
All-film dielectric	polypropylene
Temperature category	-50° C to + 55° C (D)
Standards	IEC 60871-1 ANSI/IEEE, CSA
Standard colour	Light grey (RAL 7035)



The dielectric liquid is specially made for capacitor units and has been chosen by Alstom Grid for its excellent electrical properties and heat stability at both low and high temperatures. It is non-pcb, non-chlorine and biodegradable.

- The capacitor units are equipped with weld-type porcelain bushings.
- Capacitor unit containers are made of stainless steel.
- Capacitor units for specific purposes can be designed and manufactured to meet customer requirements.
- Fuseless/External fuse designs on request.

Standard types (internally fused)

Type	Power kvar		Voltage V	Dimensions mm				Weight kg
	50 Hz	60 Hz		a	b	c	d	
QYLP	50	60	3300/6600	500	280	180	145	28
QYLP	75	90	3300/6600	520	300	200	145	29
QYLP	100	120	3300/6600	520	300	200	145	29
QYLP	150	180	3300/6600	620	400	300	145	35
QYLP	200	240	3300/6600	720	500	400	145	42
QYLP	250	300	3300/6600	820	600	500	145	48
QYLP	300	360	3300/6600	920	700	600	145	55
QYLP	350	420	3300/6600	1000	780	680	145	60
QYLP	400	480	3300/6600	1100	880	780	145	67
HYLP	450	540	3300/6600	920	700	600	200	74
HYLP	500	600	3300/6600	980	760	660	200	79
HYLP	550	660	3300/6600	1060	840	740	200	85
HYLP	600	720	3300/6600	1140	920	820	200	92
HYLP	650	780	3300/6600	1180	960	860	200	95

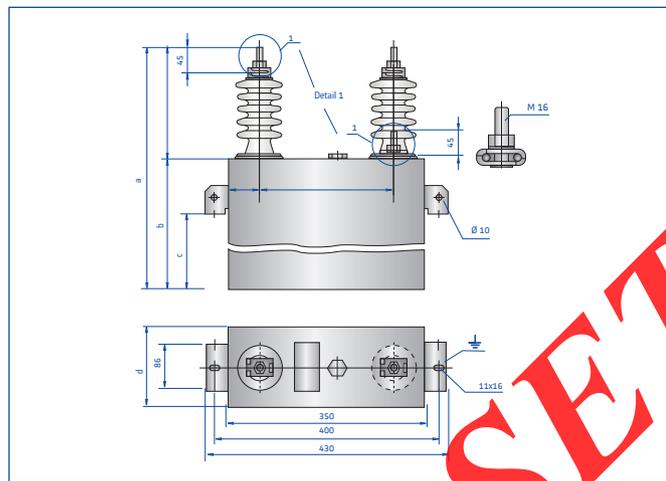
In line with our policy of on-going product development, we reserve the right to alter specifications.



HV 1-phase power capacitor units

Product features

Alstom Grid high voltage power capacitor units are designed and manufactured using the most advanced technology and high quality materials. They are all-film dielectric capacitor units impregnated with a biodegradable dielectric liquid.



Each capacitor element has the possibility of having a separate internal fuse. In addition, each capacitor unit is provided with an internal discharge resistor.

All high voltage power capacitor units are light-weight and have low losses. They comply with most national and international capacitor unit standards.

The dielectric liquid is specially made for capacitor units and has been chosen by Alstom Grid for its excellent electrical properties and heat stability at both low and high temperatures. It is non-pcb, non-chlorine and biodegradable.

- The capacitor units are equipped with weld-type porcelain bushings.
- Capacitor unit containers are made of stainless steel.
- Capacitor units for specific purposes can be designed and manufactured to meet customer requirements.
- Fuseless/External fuse designs on request.

Technical data

Type	impregnated all-film dielectric
Rated voltage	1000...13800 V (with internal fuses) above 13800 V (without internal fuses)
Rated frequency	50 Hz or 60 Hz
Rated power	Up to 1000 kvar
Average losses	< 0.15 W/kvar
Dielectric liquid	non-pcb
All-film dielectric	polypropylene
Temperature category	-50° C to + 55° C (D)
Standards	BS IEC 60871-1 ANSI/IEEE, CSA
Standard colour	Light grey (RAL 7035)
Standard bushings	125 kV BIL Creep 380 mm 150 kV BIL Creep 620 mm 200 kV BIL Creep 820 mm

Dimensions (8000 V) (internally fused)

Type	Power kvar		Dimensions mm				Weight kg
	50 Hz	60 Hz	a	b	c	d	
PSLP/PILP	100	120	620	400	300	145	31
PSLP/PILP	200	240	760	540	440	145	40
PSLP/PILP	300	360	860	640	540	145	47
PSLP/PILP	400	480	940	740	640	145	53
TSLP/TILP	500	600	840	620	520	200	63
TSLP/TILP	600	720	940	720	620	200	71
TSLP/TILP	700	840	1060	840	740	200	81
TSLP/TILP	800	960	1160	940	840	200	89

In line with our policy of on-going product development, we reserve the right to alter specifications.

High voltage special capacitor units

High voltage surge protection capacitor units

Medium voltage rotating machines and transformers can be exposed to abnormal voltages (transient overvoltages or surges) due to internal or external reasons. The causes are:

- Capacitor bank switching on the connected power systems
- Operation of vacuum circuit breakers
- System faults
- Lightning

These surges can cause damage to the turn-to-turn insulation of rotating machines and transformers. Connecting surge capacitor units from line to ground prevents this damage by bringing down the steepness or slope of over voltage transients.

The surge capacitor units must be designed to withstand and absorb damped or oscillatory line disturbances without affecting the mains frequency performance at the point of common coupling.

Applications

- Large motors and generators
- MV switchgear and motor control centers
- Large transformers
- Shunt reactors

HV 1-phase surge protection capacitor units

- Electrical features:
 - Rated voltage: up to 21 kV
 - Rated frequency: 50 Hz or 60 Hz
 - Capacitance: 0.1 μ F - 0.5 μ F
 - Element fuses: fuseless design
 - Internal discharge resistors as standard
 - 1 or 2 bushings design
 - Insulation level: up to 70/170 kV
 - Standard capacitance tolerance: -5%...+10%
 - Total losses: under 0.14 W/kvar
 - Manufacturing standard: IEC 60871



High voltage induction heating installation capacitor units

These capacitor units are designed for the oscillatory circuits of induction heating equipment. They tune the circuits to obtain a resonant frequency close to the power supply frequency.

Advantages

- Improving the low power factor of these installations
- Improving the electrical circuit properties

Applications

- Heat treatment furnaces
- Billet heating furnaces
- Forging and casting furnaces
- Melting furnaces

HV 1-phase induction heating installation capacitor units

- Electrical features:
 - Rated voltage: up to 3 kV
 - Rated frequency: 50 Hz or 60 Hz
 - Rated power:
 - > 50 Hz: up to 600 kvar
 - > 60 Hz: up to 600 Kvar
 - Element fuses: internal fuse or fuseless designs
 - Internal discharge resistors as standard
 - 2 bushings design
 - Insulation level: up to 10/40 kV
 - Standard capacitance tolerance: -5%...+10%
 - Total losses: under 0.2 W/kvar
 - Manufacturing standard: IEC 60110

High voltage reactors

Alstom Grid high voltage reactors offering is divided in:

HV encapsulated reactors

- HV encapsulated damping reactors

HV iron-core reactors

- HV iron-core harmonic filter reactors
 - HV iron-core detuned filter reactors
 - HV iron-core tuned filter reactors

HV air-core reactors

- HV air-core shunt reactors
- HV air-core current-limiting reactors
- HV air-core neutral-earthing reactors
- HV air-core power flow control reactors
- HV air-core motor starting reactors
- HV air-core arc-furnace series reactors
- HV air-core damping reactors
- HV air-core harmonic filter reactors
 - HV air-core detuned filter reactors
 - HV air-core tuned filter reactors
- HV air-core discharge reactors
- HV air-core smoothing reactors
- HV air-core reactors for special applications
 - HV air-core SVC reactors (TSR and TCR)
 - HV air-core test lab reactors



HV encapsulated damping reactors

When capacitor banks are switched on, this connection causes voltage transients and very high inrush currents. Damping reactors installed in capacitor banks limit the current transients to acceptable values for the capacitor units and reduce surge currents to acceptable values for the corresponding switching devices.

Advantages

- Increase of switching equipment's life
- Increase of capacitor units' life

Applications

- Capacitor banks formed by several steps
- Several capacitor banks connected in the same busbar
- Installations with very high network short-circuit power in relation to the power of the capacitor bank to be connected

HV iron-core harmonic filter reactors

These reactors are connected in series with the capacitor units to form a series resonant circuit with a very low impedance.

Advantages

- Reactive power compensation (power factor correction) in networks with harmonics
- Reduction of inrush currents that flow from step to step of the capacitor banks when switched
- Avoiding the risk of resonance as the LC circuit is having a resonance frequency below the first existing harmonic
- Decrease the level of harmonic distortion as the circuit is also having a certain tuning frequency at which the branch will offer a low impedance path for harmonic currents

Applications

- Capacitor banks formed by several steps
- Several capacitor banks connected in the same busbar
- Capacitor bank installations with risk of resonance or with presence of harmonics



HV air-core reactors

Air-core dry-type reactors provide a linear response of impedance versus current that is essential to numerous applications. They are mainly employed in electric power transmission and distribution systems as well as in electric power systems of electrical plants. They are installed to protect these systems and to increase their efficiency. These reactors are also used in electrical test laboratories and research institutions.

Advantages

- No ferromagnetic saturation
- Good linearity degree
- Minimum maintenance
- Safe operation
- Fire and explosion proof
- Environmentally friendly

Applications

- Power generation
- T&D networks
- Industrial sites
- Electrical test laboratories



Electronic products for high voltage applications

Alstom Grid electronic products offering is divided in:

Power factor controllers

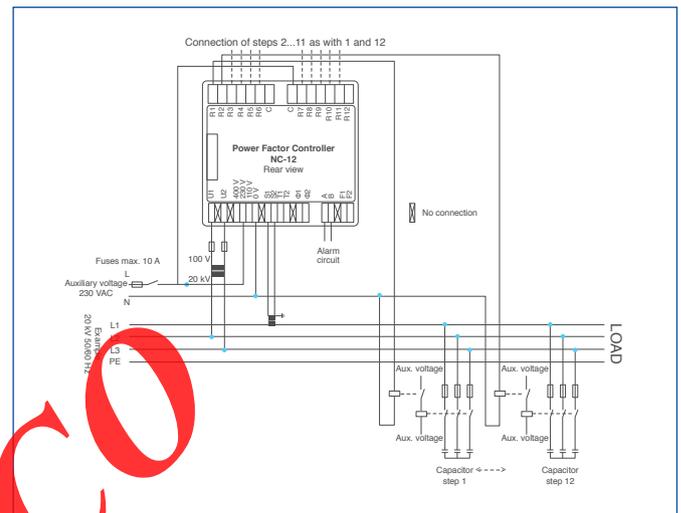
- NC-12 power factor controllers
 - Modbus communication systems
 - External temperature probes

Capacitor bank protection relays

- Complete protection relays
 - NPR-series protection relays
- Unbalance protection relays
 - NUR-series unbalance protection relays

Digital capacitance meters

- NCM-20 digital capacitance meters



Power factor controllers

NC-12 power factor controllers

Product features

Alstom Grid power factor controllers provide your network with efficient reactive power compensation, measurement and supervision.

Improved user-friendliness and condition monitoring

Improved user-friendliness due to multilingual user interface, clear text and symbol messages, graphics, alarm log and communication interface. Alstom Grid's power factor controller offers advanced condition monitoring for your network as well as for the capacitor bank.

The supervision and condition monitoring functions add to the simplified programming with intelligent self set-up to ensure optimal use of the reactive power compensation system.

Applications

- Control and supervision of capacitor banks

Typical customers

- Electrical panel builders
- HV switchgear manufacturers



Advantages

- Optimized user interface for easy operation
- Intelligent stepping algorithm for optimum step utilization and fast response
- All traditional stepping sequences also available
- Quick and simple mounting and wiring
- Monitoring and protection
- User-friendly
- Several language versions
- Robust constructions

Available accessories

- Modbus communication systems
- External temperature probes

NC-12

Control up to 12 capacitor steps
 Microprocessor-based technology
 C/K auto search
 Measures / Alarms of THD(U)
 Separate C/K setting for inductive and capacitive side
 Accuracy class 1.5%
 Ambient temperature 0 to + 60° C
 Protection class IP41 at panel and IP20 DIN-rail installation
 Measurements: cos ϕ , P, Q, S, THD(U), I_p, I_q, I_{rms}/I₁, harmonics and temperature
 Communication RS485/modbus via optional auxiliary modules

Capacitor bank protections relays**NPR-series****Types**

- NPR-C
 - Overcurrent protection
 - Overvoltage/undervoltage protection
 - Current unbalance protection
- NPR-V
 - Overvoltage/undervoltage protection
 - Voltage unbalance protection

Product features

- Measuring and supervision of electrical values
- Wide range of power supply voltages
- Wide graphical LCD screen with backlight
- Simple installation and commissioning
- Reliability in operation
- Calculated values are true RMS values
- Up to 32 configurable alarms
- Includes over-temperature protection

**Available accessories**

- Data communication by RS-485 modbus
- Data recorder

NUR-series unbalance protection relays

Our protection relay NUR-36 is a single phase, sensitive, over-current relay. It features two stages of over-current protection, both having their own parameters and output relays. The NUR-36 is designed for unbalance current protection of double star (Y-Y) or H-connected capacitor banks in high voltage applications. It has solid state construction and is suitable for panel installation (DIN 43700). The relay has filters for harmonic currents and operate at fundamental frequency only. Protection is tested according to IEC 255-5c, 255-22-2 class III, 801-4 class III and the product fulfils the CE requirements. Information about measurements and relay functions is given by digital display and LEDs.

Product features

- Memory storage for measured currents
 - Values can be used for calibration purposes
- Current inputs: 1 A and 5 A
- Power supply: 40...265 V AC/DC (50/60 Hz)
- Power consumption: 3 W
- Ambient operating temperature: -10° C to +55° C
- User-friendly set-up and operation
- Simple installation and commissioning
- Separate settings for alarm and trip



1. Push-buttons for the menu selections and parameter scrolling
2. SET push-button for parameter settings
3. ENTER push-button for confirming new setting
4. Display
5. POWER indicator, indicates that all the supply voltages of the system are in order
6. FAULT indicator, indicates that an internal fault has been detected in the unit
7. Mode indicators
8. Trip and Alarm indicators
9. Start current and operate time of trip stage
10. Start current and operate time of alarm stage
11. Indicates routed Signal to Relay 3



Digital capacitance meters

NCM-20 digital capacitance meters

Product features

- Designed to quickly and accurately measure the capacitance of
 - Loose capacitor units
 - Capacitor units mounted in a capacitor bank (without the need of removing any connecting wire between the capacitor units)
- The measurement is used to find
 - Capacitor units with low capacitance (with blown internal fuses)
 - Capacitor units with high capacitance (with short-circuit over a series connection)
- Measurement range:
 - 0 μF to 2000 μF with 0.05% resolution

Advantages

- No need for power supply
 - The display unit and the generator unit have rechargeable batteries
 - The meter can be used in areas without readily available power supply
- Built-in calibration system
 - Calibration capacitor located inside the generator unit
 - Display unit and current clamp can be calibrated easily and fast by putting the clamp around the handle of the generator unit
 - Calibration is recommended before and after each measurement
- Small size and weight (approx. 9.5 kg)
- Rigid aluminum case
- Digital display

Typical customers

- Electric utilities
- Companies providing maintenance
- Companies providing measurements
- Consultant firms

Accessories supplied with every capacitance meter

- Clamp-on current transformer (100 mm opening)
- Voltage clips with 1 m cable and connector
- 1 pc carrying strap for display unit
- 1 pc suspension strap for generator unit
- Instruction manual
- Battery charger 230VAC/18VDC 50/60 Hz



Specifications

Ranges	2000 μF 200 μF 20 μF	Range Display	0...1999 μF 0...199.9 μF 0...19.99 μF
Loading capacitance			2000 μF max.
Measuring frequency			111.86 Hz
Measuring voltage			1.41 Vrms
Error			$\pm 1\%$ of reading ± 2 digits
Resolution			0.05 % between 1 and 2000 μF
Temperature range			-10...+ 50° C
Dimensions			450 x 350 x 250 mm
Weight			approx. 9.5 kg

High voltage shunt capacitor banks

Alstom Grid high voltage shunt capacitor bank offering is divided in:

By bank construction

- HV open rack capacitor banks
- HV enclosed capacitor banks

By bank design

- HV capacitor banks without reactors
- HV capacitor banks with damping reactors
- HV harmonic filter capacitor banks
 - HV detuned filter capacitor banks
 - HV tuned filter capacitor banks
 - HV double-tuned filter capacitor banks
 - HV triple-tuned filter capacitor banks
 - HV C-type filter capacitor banks
 - HV high-pass filter capacitor banks



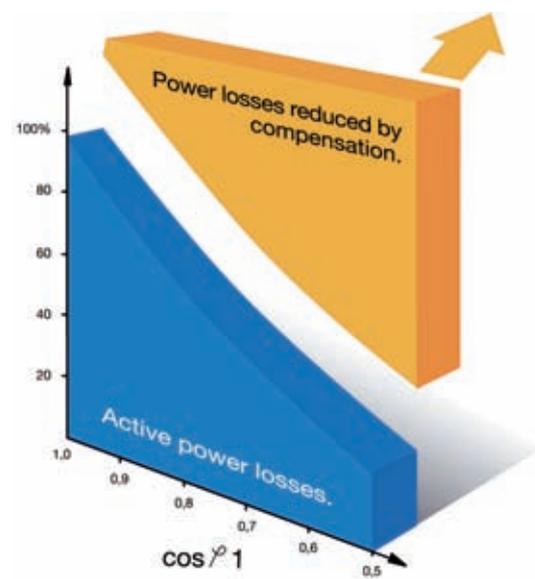
High voltage shunt capacitor banks

In power systems, the predominantly inductive nature of loads and distribution feeders as well as transformers and lines accounts for significant power losses due to lagging currents. Shunt capacitor banks are used to improve the quality of the electrical supply and the efficient operation of the power systems.

They are inexpensive solutions and can be easily and quickly installed anywhere on the network. Capacitor banks are formed by several capacitor units connected in series and in parallel to obtain a certain power rate at a given voltage.

When it comes to high voltage shunt capacitors, Alstom Grid is the name to remember. Whatever your exact needs are, Alstom Grid can supply the right product. Our product range is both flexible and comprehensive, with a large number of options available.

We build the capacitor banks to match your precise requirements, and we can also produce special designs for use in places where space is restricted or climatic conditions are difficult.



Reactive Power Compensation reduces transmission and distribution losses

From the arctic to the tropics

Alstom Grid's capacitor banks are already giving excellent service in all parts of the world. Our know-how covers the design of capacitor banks for use in extreme climatic conditions, ranging from the freezing arctic of northern Canada and Scandinavia to the tropical heat of Africa and the Far East.

Alstom Grid's shunt capacitor banks are built up from high voltage, all-film dielectric capacitor units. The impregnation liquid is both non-PCB and non-chlorine, and the individual units are fully sealed in welded weather resistant stainless steel cases (AISI 409).

The cases are given a protective coating of paint selected according to conditions at the installation site.

Installation work minimized

Alstom Grid's capacitor banks are designed for maximum possible ease of installation, and allowance is also made for the special requirements imposed by transportation. The capacitor units are mounted in the frames or enclosures and ready wired up before dispatch from the factory. At the installation site it is only necessary to fix the frames or enclosure in position and complete the connections.

High quality standards

Alstom Grid put itself well ahead of its competitors when it was the first manufacturer to connect a 735 kV capacitor bank to the network. This pioneering installation has proved itself over the years, and has subsequently helped to bring Alstom Grid a number of commissions for other major projects. With a wealth of know-how and expertise that is second to none, our Research and Development team continues to produce innovative applications to improve the quality of electrical supplies. Alstom Grid's capacitor factory in Tampere is one of the most modern in Europe and provides all the facilities required for the development and production of reliable, high technology equipment.

Installation

Installation of shunt capacitor banks can be made to any point of the network. When measurements are done and harmonic distortion is known, the selection of the compensation method can be made (figure 1):

- Individual compensation: bank connected directly to the terminals of the consumer
- Group compensation: bank connected to a distribution system that feeds a number of individual loads
- Central compensation: bank connected to the main busbar in large installations where many individual loads operate

Data required for design

- Schematic diagram of the system to be compensated
- Rated voltage and frequency
- Reactive power needed
- Data of harmonic loads if any
- Permitted level of harmonic currents and voltages
- Insulation level
- Short circuit level of the system
- Installation and environmental requirements
- Protection systems needed
- Extra accessories needed

Advantages

- Reduced power system losses
- Reactive energy billing charges reduction
- Capital investments postponement
- Improved voltage profile of the system
- Released power system capacity
- Harmonic distortion removal

Applications

- Windfarms
- Electric utilities
- Heavy manufacturing plants
- Large commercial institutions
- Mines
- Petrochemical industries
- Pulp and paper factories
- Steel processing plants

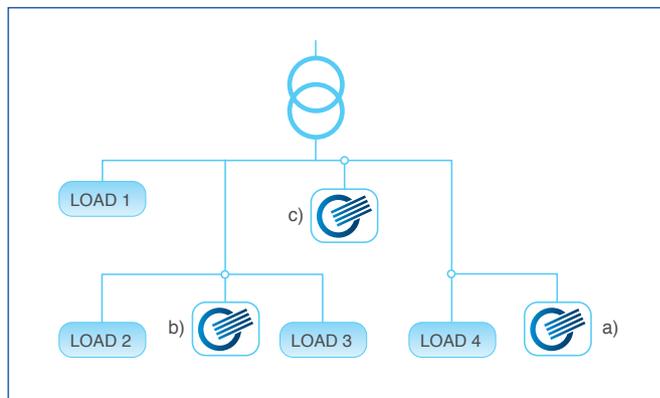


Figure 1: Installation of shunt capacitor banks

High voltage enclosed capacitor banks

Power factor correction systems, especially automatic ones, have increased their presence in the electric utilities, large industrial and commercial consumer environments during the last years. The main reason behind this increase is the need to maintain voltage at acceptable levels and to compensate reactive power to reduce losses in medium voltage distribution systems.

Enclosed capacitor banks designed by Alstom Grid are used for power factor correction, voltage support, harmonic suppression and to maximize network capacity in industrial applications and distribution systems. They supply individual, group or central reactive power compensation of fluctuating loads in three-phase networks up to 36 kV.

Product features

- Modular, compact and robust design optimised for easy future expansion of the system, facilitating transport, storage and installation.
- Galvanised steel enclosures available for indoor and outdoor installations, with different ventilation systems. Protection class ranges from IP30 to IP44.
- Design and testing complies with the requirements of the latest edition of relevant standards and the specific technical requirements set by the customers.
- Use of simplified design and proven components ensures high reliability and low maintenance costs.
- Several communication protocols and the possibility of using arc sensors available in protection relays.
- Optimised to give a low environmental load by using recyclable materials.
- The banks are supplied as fully assembled units, factory tested and ready for connection.

Types of banks

Fixed banks

Formed by capacitor units and reactors mounted in a common enclosure with no stepping capability. The bank is connected on continuous mode directly to the loads and provides a fixed quantity of reactive power at all times. This method of correction is suitable for example for large machines operating at steady loads.

These banks can be permanently connected to the loads or they can be switched by means of devices located in customer's switchgear.



Fixed banks with switching device

The construction of these banks is basically the same as the fixed banks, but they are fitted with a switching device (contactor or circuit breaker), that allows them to be connected and disconnected from the network at any time.

Automatic banks

Formed by different steps, each one composed of capacitor units, reactors and switching devices, mounted in a common enclosure.

They can improve the power factor by providing the required amount of reactive power under varying load conditions.

The operation, control and monitoring of the different steps is carried out by a microprocessor based controller according to the need for reactive power. The controller also provides network data and alarm conditions.

Configuration of banks

A bank is usually formed by an incoming cubicle where the main circuit breaker or disconnect, earthing switch and control and protection relays are placed. Next to it there are one or more step cubicles where capacitor units, reactors, fuses and the switching devices are located. Banks can be manufactured with various options and configurations to meet virtually all customer needs.

Protection devices

Typical system protection might include:

- Capacitor units equipped with internal fuses and discharging resistors
- Unbalance current protection
- Overcurrent and earth-fault protection
- Over and undervoltage protection
- Monitoring of internal enclosure temperature
- HV-HRC fuses with failure indication
- Earthing switches
- Quick discharge transformers

Switching components

Switching devices with tested capacitive switching capability are used like vacuum or SF₆ contactors and circuit breakers.

Reactors

Depending on the harmonic level of the network to which the bank is connected, and the number of steps needed, the banks can be fitted with air-cored or iron cored damping reactors or harmonic filter reactors.

Capacitor units

Depending on the capacitor unit's connection configuration, the banks are divided into two groups:

- Banks with one-phase capacitor units connected in star or double-star, up to 36 kV.
- Banks with three-phase capacitor units connected in star, up to 8 kV.

Additional components

Voltage indicators, ventilation fans, cooling units, anticondensation heaters, earthing terminals, arc containment relief vents, enclosure illumination, key locks, electrical locks, key interlocking systems, bottom or side wall cable entries, door contact switches.



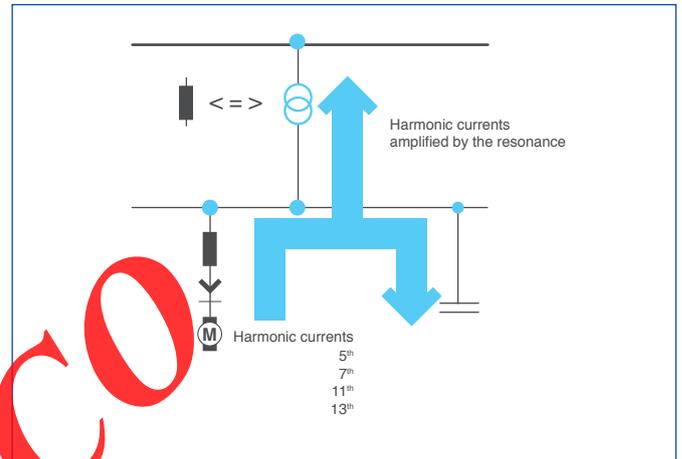
High voltage harmonic filter capacitor banks



Power transmission and distribution systems are designed for operation with sinusoidal voltage and current waveforms at a constant frequency.

However, when non-linear loads - such as thyristor drives, converters and arc furnaces - are connected to the system, excessive harmonic currents are generated, and this causes both current and

voltage distortion. Harmonic filtering is the best way to eliminate this distortion from the power system.



The capacitor bank and network may form a parallel resonant circuit.

Harmonic filtering makes electrical power work more efficiently

Harmonic distortion - an increasingly common problem

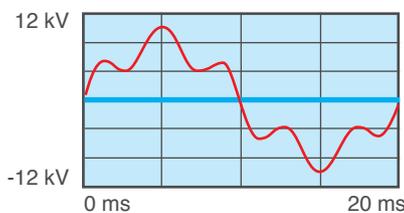
Harmonic distortion problems are becoming increasingly common and, ironically, the cause can be traced back to the “electronic revolution”. Modern electronic power control devices provide many advantages over conventional control methods, and are widely used in industrial processes. Their major disadvantage, however, is that they also generate harmonics.

Problems are most often caused by the 3rd, 5th, 7th, 11th and 13th order harmonics.

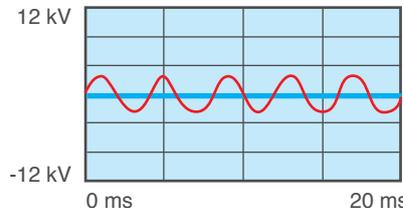
High frequency harmonic currents often give rise to unexpected problems. Excessive heat loss occurs in transformers, cables and other components. Control, protection and metering systems fail to function as required. Telecommunications and data networks are subject to interference and disturbance.

Particular problems are experienced when the network contains power factor correction capacitor banks. The capacitor bank and the inductance of the network may form a parallel resonant circuit at the harmonic frequency, with the result that harmonics are amplified to such an extent that the voltage becomes unsuitable for most applications.

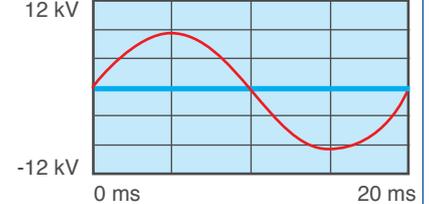
1. Voltage waveform distorted by 5th harmonic.



2. 5th harmonic (250 Hz).



3. Pure 50 Hz sine wave.



With increasing reactive power charges, adequate reactive power compensation has become an economic necessity. Power factor correction systems pay for themselves in only 12-36 months through reduced costs. In many countries regulations concerning the quality of electricity supplies also sets limits on the amount of harmonic distortion permitted.

Harmonic filters keep the voltage and current distortion within allowed limits

Harmonic filters represent the optimum solution to distortion problems. Consisting of capacitor units, reactors and resistors, filter circuits provide a low impedance for harmonics. Distortion is reduced to the required levels. Single-tuned, double-tuned and high-pass filters are all available. At the fundamental frequency (50 or 60 Hz) the filter acts as capacitor and produces reactive power, functioning in the same way as a conventional capacitor bank.

For the best results, the capacitor units and reactors must be properly matched. Alstom Grid is the only filter manufacturer in the world with its own capacitor and air core reactor production. Alstom Grid filters contain perfectly matched components for trouble-free operation.

For effective harmonic filtering, call the professionals

The effective solution of distortion problems demands a high level of power transmission and distribution know-how. For many years Alstom Grid's professional team has successfully been designing filters to eliminate harmonic distortion problems for customers in countries all over the world. Alstom Grid's expertise has been further enhanced by cooperation with major industrial companies and electrical utilities. Alstom Grid uses the latest computer software for system simulation and design purposes. With accurate modelling techniques, the optimum solution can be quickly and reliably found.

Each filter is custom designed; the input data for the design process is obtained from on-site measurements or from a computer model.



Harmonic filtering in practice

Alstom Grid’s harmonic filter capacitor banks are most commonly used in cases where reactive power is required, but capacitor banks without reactors or with damping reactors would tend to amplify existing distortion to excessive levels.

In a typical application (figure 3), Alstom Grid’s custom designed filters represented the best solution to reactive power and distortion problems at a paper mill. In the system, a number of 6-pulse rectifiers (total rating 10.5 MW) were connected to an 11 kV bus supplied by a 31.5 MVA transformer.

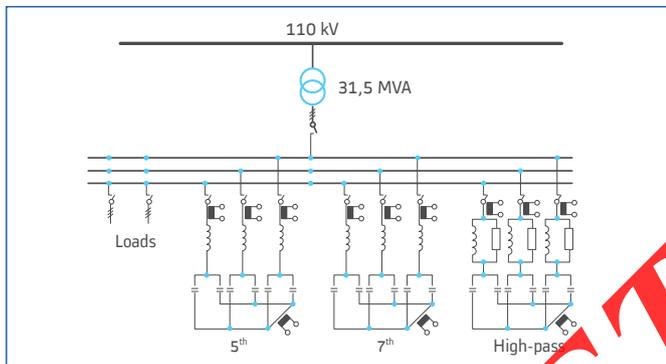
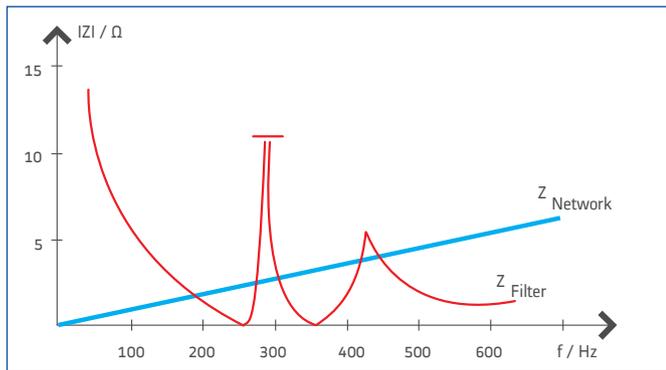


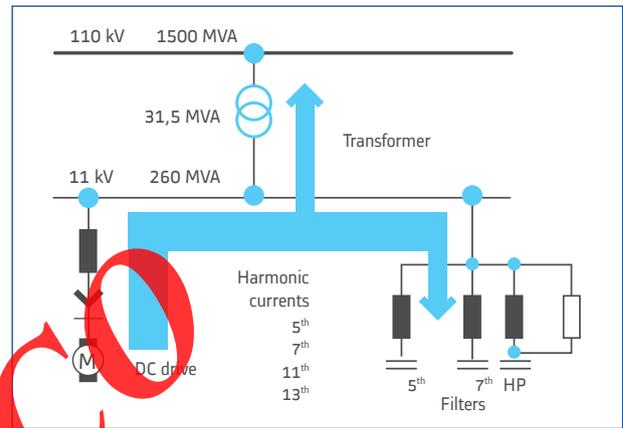
Figure 3: 5th, 7th and high-pass filter

A total of three filters - two single tuned filters for 5th and 7th harmonics plus a high-pass filter for higher order harmonics - were connected to the busbar. Together the filters produced a total reactive power output of 13 Mvar, while the harmonics entering the system were reduced by 70%.

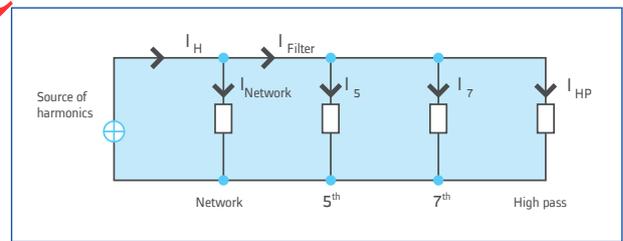


Impedance curves for network and filter

This problem could not have been solved by the use of capacitor banks without reactors or with damping reactors, because the resulting parallel resonance would have amplified the harmonics and exacerbated the distortion problem.



Online diagram



Equivalent circuit

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GRID



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