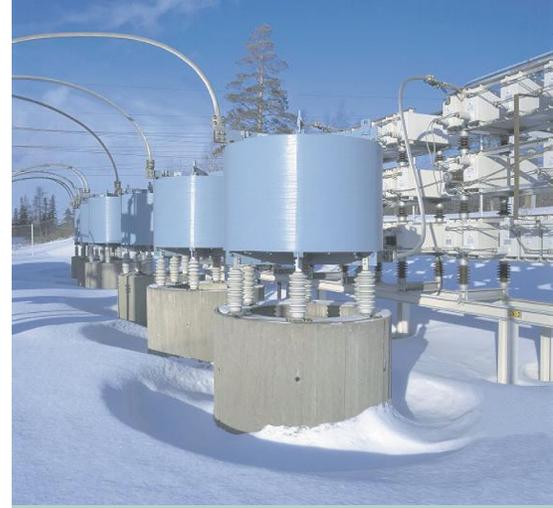


# HV COMPENSATION & FILTERING PRODUCTS

## Providing Power Quality and Energy Efficiency

High Voltage (HV) reactive power compensation and harmonic filtering solutions help customers improve the performance of installations through energy savings and better power quality, enabling end users to save money and reduce the environmental impact of their operations.

APPLICATION	PRODUCTS	CUSTOMER TYPES
Reactive power compensation and harmonic filtering in distorted networks	Turned harmonics filter capacitor banks (automatic or fixed)	<ul style="list-style-type: none"> <li>• Electric utilities for generation, T&amp;D</li> <li>• Heavy industries like steel or aluminum</li> <li>• MV/HV system integrators</li> <li>• Electrical contractors</li> </ul>
Reactive power compensation and harmonic filtering in distorted networks	Detuned harmonic filter capacitor banks (automated or fixed)	<ul style="list-style-type: none"> <li>• Electric utilities for generation, T&amp;D</li> <li>• Heavy industries like steel or aluminum</li> <li>• MV/HV system integrators</li> <li>• Electrical contractors</li> </ul>
Reactive power compensation and harmonic filtering in distorted networks	Capacitor banks without reactors or with damping reactors (automatic or fixed)	<ul style="list-style-type: none"> <li>• Electric utilities for generation, T&amp;D</li> <li>• Light industries of all kinds</li> <li>• MV/HV system integrators</li> <li>• Electrical contractors</li> </ul>
Reactive power compensation in networks without harmonics	Capacitor banks without reactors or with damping reactors (automatic or fixed)	<ul style="list-style-type: none"> <li>• MV panel builders</li> <li>• Electric utilities</li> <li>• MV/HV system integrators</li> <li>• Maintenance companies</li> </ul>



### Key Benefits

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

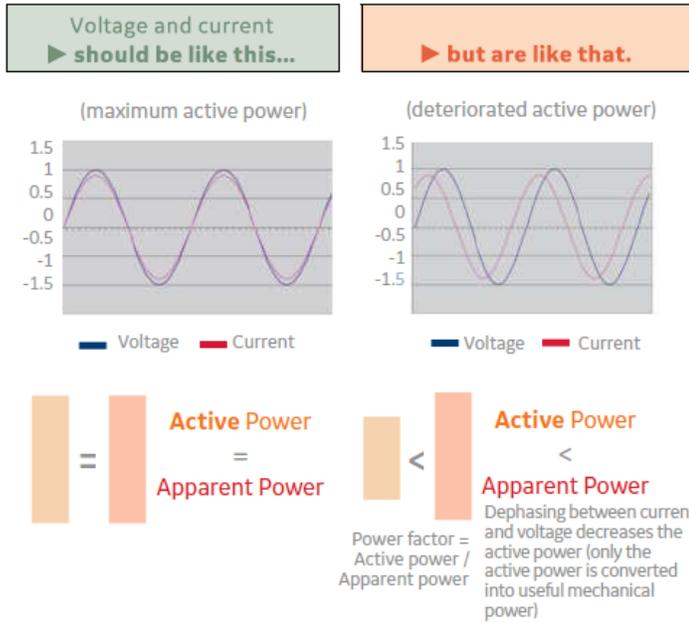
### Safety – Our Priority

- HV capacitor units
- HV reactors
- Electronic products for HV applications
- HV shunt capacitor banks
- HV filter capacitor banks

# 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.

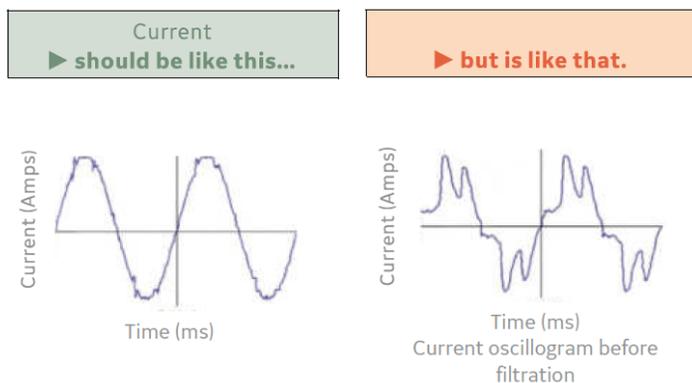


IMPACT OF REACTIVE POWER
<ul style="list-style-type: none"> <li>Transmission equipment has to be sized for the apparent power, yet only active power is useful</li> <li>Increased losses in the network</li> <li>You pay for apparent power but use active power (higher electricity bill)</li> <li>Reactive power energy fees to customers with a low power factor installation (example &lt; 0.95)</li> </ul>
WHO
<ul style="list-style-type: none"> <li>Power consumers, network operators, electric utilities, power industry, hospitals, offices, public and commercial buildings, factories</li> </ul>
SOLUTION
<ul style="list-style-type: none"> <li>The power factor of a facility can be improved by installing capacitor banks</li> </ul>

# Why do we need reactive power compensation and harmonic filtering?

## 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).



<b>WHO</b>
<ul style="list-style-type: none"> <li>• Power consumers, network operators, electric utilities, power industry, public and commercial buildings</li> </ul>
<b>SOLUTION</b>
<ul style="list-style-type: none"> <li>• 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</li> </ul>

<b>IMPACT OF HARMONICS ON TRANSMISSION / DISTRIBUTION EQUIPMENT</b>
<ul style="list-style-type: none"> <li>• Additional losses (paid for by the end user)</li> <li>• Heating in power cables</li> <li>• Audible noise (transformers)</li> <li>• Metering errors</li> </ul>
<b>IMPACT OF HARMONICS ON EQUIPMENT CONNECTED</b>
<ul style="list-style-type: none"> <li>• Decreased machinery efficiency</li> <li>• Costly process shutdowns</li> <li>• Disturbed electronic equipment (computers, telephones)</li> </ul>

## Reactive Power Compensation and Harmonic Filtering Bring:

<b>ECONOMIC BENEFITS</b>
<ul style="list-style-type: none"> <li>• Saving the costs of reactive power</li> <li>• Additional savings through reduced active power losses</li> <li>• Reduction in investment cost             <ul style="list-style-type: none"> <li>- increase of machinery lifetime</li> <li>- decrease of maintenance requirements and downtime of equipment</li> </ul> </li> </ul> <p>Return on investment is generally under 18 months.</p>

<b>ENVIRONMENTAL BENEFITS</b>
<ul style="list-style-type: none"> <li>• Reduced CO<sub>2</sub> emissions</li> </ul> <p>Customers see environmental benefits through energy savings and more efficient power systems.</p> <p>By saving millions of tons of CO<sub>2</sub>, power compensation makes an active contribution to protecting the environment.</p>

## HV Capacitor Units

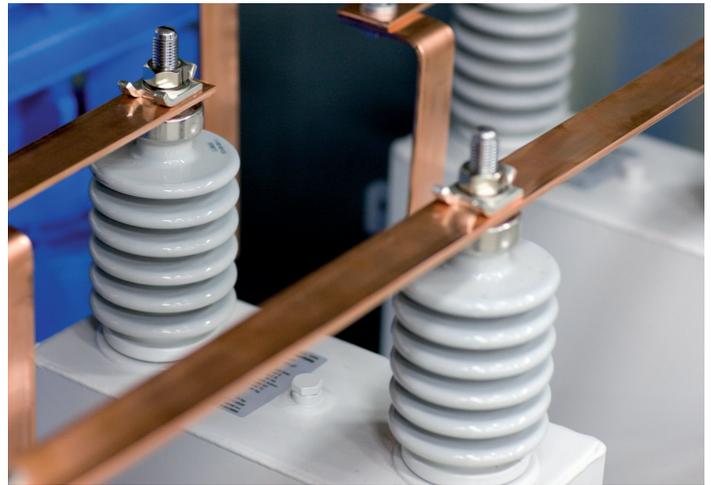
Grid Solutions at GE Vernova's HV capacitor units are available as:

### HV Power Capacitor Units

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

### HV Special Capacitor Units

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



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## HV Special Capacitor Units

HV power capacitors are designed to compensate inductive loading from devices like electric motors and transmission lines to make the load appear to be mostly resistive.

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

### Advantages

- Improve power factor
- Reduce installation losses
- Decrease voltage drop

### Applications

- Shunt capacitor banks
  - Open rack capacitor banks
  - Enclosed capacitor banks
  - Pole-mounted capacitor banks
- Series capacitor banks
- Static Var Compensation (SVC) Systems
- High Voltage Direct Current (HVDC) Solutions
- Static Synchronous Compensator (STATCOM) Solutions

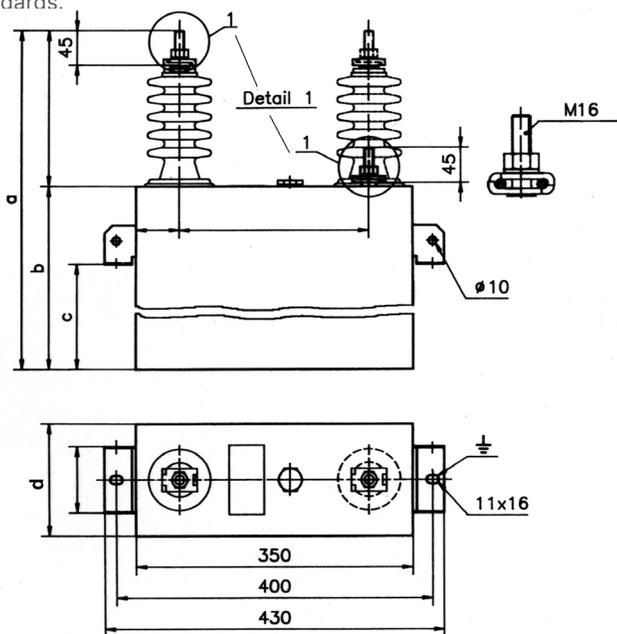


# HV 1-Phase Power Capacitor Units

## Product Features

Grid Solutions' HV 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 HV 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 GE Vernova's Grid Solutions business 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.

## Typical at 8,000 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/ PILP	500	600	840	620	520	200	63
TSLP/ PILP	600	720	940	720	620	200	71
TSLP/ PILP	700	840	1060	840	740	200	81
TSLP/ PILP	800	960	1160	940	840	200	89

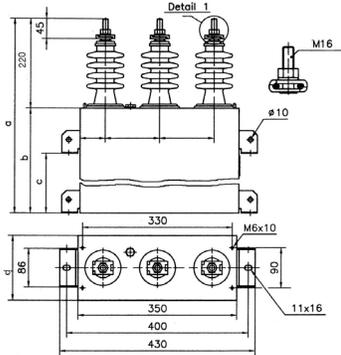
In line with our policy of on-going product development, we reserve the right to alter specifications.

TYPE	IMPREGNATED ALL-FILM DIELECTRIC
Rated voltage	up to 8kV
Rated frequency	1000...13,800 V (with internal fuses) up to 24,000 V (without internal fuses)
Rated power	50 Hz or 60 Hz
Average losses	< 0.15 W/kVAr
Dielectric liquid	non-PCB
All-film dielectric	polypropylene
Temperature category	-50° C to + 55 C (D)
Electrical safety	IEC 60871-1 ANSI/IEE, CSA BS, GOST
Standard color	Light grey (RAL 7035)
Standard bushings	125 kV BIL, Creepage 380 mm 150 Kv BIL, Creepage 620 mm 200 kV BIL, Creepage 820 mm

# HV 3-Phase Power Capacitor Units

## Product Features

Grid Solutions' HV 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.



## Technical Data

TYPE	IMPREGNATED ALL-FILM DIELECTRIC
Rated voltage	up to 8kV
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)
Electrical safety	IEC 60871-1 ANSI/IEE, CSA BS, GOST
Standard color	Light grey (RAL 7035)

The dielectric liquid is specially made for capacitor units and has been chosen by Grid Solutions 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	3,300/6,600	500	280	180	145	28
QYLP	75	90	3,300/6,600	520	300	200	145	29
QYLP	100	120	3,300/6,600	520	300	200	145	29
QYLP	150	180	3,300/6,600	620	400	300	145	35
QYLP	200	240	3,300/6,600	720	500	400	145	42
QYLP	250	300	3,300/6,600	820	600	500	145	48
QYLP	300	360	3,300/6,600	920	700	600	145	55
QYLP	350	420	3,300/6,600	1000	780	680	145	60
HYLP	400	480	3,300/6,600	1100	880	780	200	67
HYLP	450	540	3,300/6,600	920	700	600	200	74
HYLP	500	600	3,300/6,600	980	760	660	200	79
HYLP	550	660	3,300/6,600	1060	840	740	200	85
HYLP	600	720	3,300/6,600	1140	920	820	200	92
HYLP	650	780	3,300/6,600	1180	960	860	200	95

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

## HV Special Capacitor Units

### HV 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
- Medium voltage 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 F - 0.5 F
  - Element fuses: fuseless design
  - Internal discharge resistors as standard
  - 1 or 2 bushing(s) design
  - Insulation level: up to 70/170 kV
  - Standard capacitance tolerance: -5% to +10%
  - Total losses: under 0.14 W/kVAR
  - Standard: IEC 60871, IEC 60871-1



### HV 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 Induction Heating Installation

- 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
  - Standard: IEC 60110, IEC 60871-1

## HV Reactors

Grid Solutions' HV reactors offering is divided in:

### HV Air-Core Reactors

- HV air-core shunt reactors
- HV air-core current-limiting reactors
- HV air-core neutral-earthling 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 (TS R and TCR)
  - HV air-core test lab reactors

### HV Iron-Core Reactors

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

### HV Encapsulated Reactors

- HV encapsulated damping 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

- Increased switching equipment life
- Increased 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 Reactors

The filter 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
- Environmentally friendly
- Dry-type construction

### Applications

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



# Electronic Devices for HV Applications

## Product Features

Grid Solutions' electronic products offering is divided in:

### Power Factor Controllers

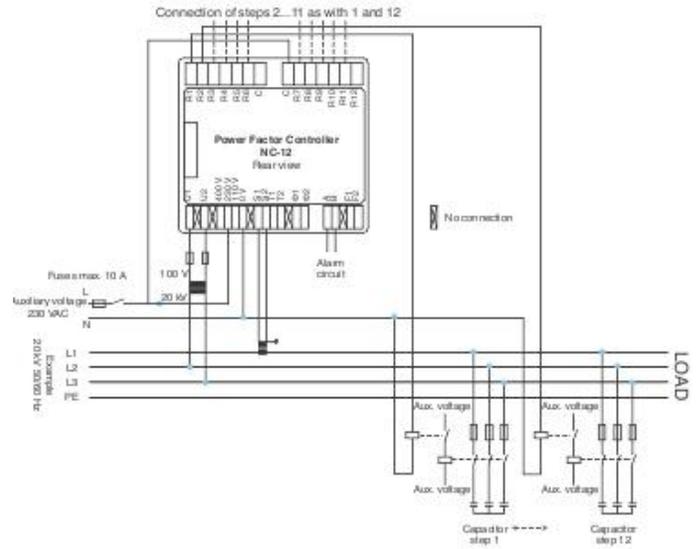
- NC-12 power factor controllers
  - Modbus communication systems
  - External temperature probes

### Capacitor Bank Protection Relays

- NPR-series protection relays
- NUR-36 series unbalance protection relays

### Digital Capacitance Meters

- NCM-20 digital capacitance meters



# Electronic Devices for HV Applications

## NC-12 Power Factor Controllers

### Product Features

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

### User-friendly with Improved Condition Monitoring

Improved user-friendliness due to multilingual user interface, clear text and symbol messages, graphics, alarm log and communication interface. Grid Solutions' 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**

- Enhanced user interface for easy operation
- Intelligent stepping algorithm for improved 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 construction

**Available accessories**

- Modbus communication systems
- External temperature probes

**NC-12**

Control up to 12 capacitor steps

Microprocessor-based technology

C/K auto search

Separate C/K setting for inductive and capacitive side

Accuracy class 2%

Ambient temperature 0°C to + 60°C

Protection class IP41 at panel and IP20 DIN-rail installation

Measurements:  $\cos\phi$ , P, Q, S, THD(U),  $I_p$ ,  $I_q$ ,  $I_{rms}/I_1$ , U,  $I_s$ , harmonics and temperature

Communication RS485/modbus via optional auxiliary modules

## Capacitor Bank Protection 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

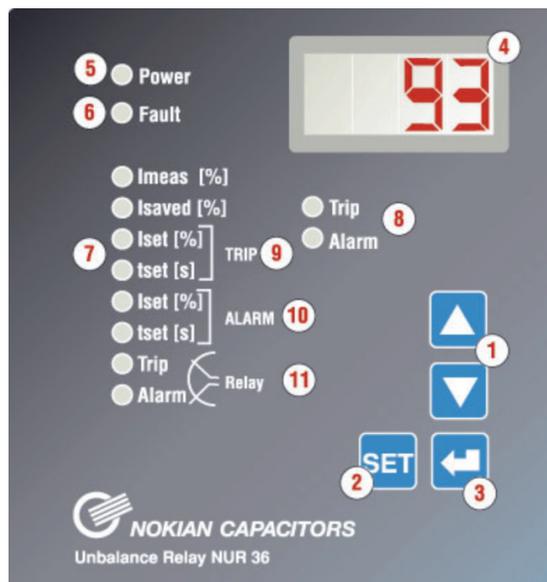
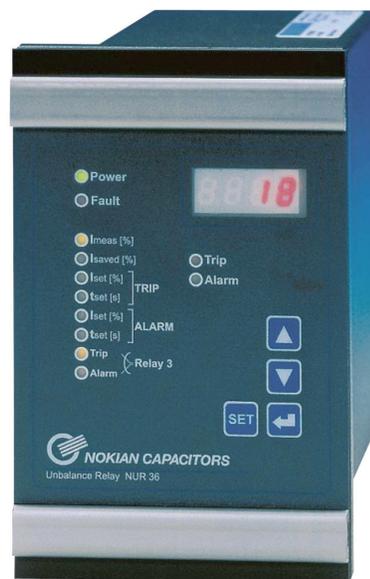
NUR-36 is a single-phase, sensitive, over-current relay. It features two stages of over-current protection, both having their own parameters and output relays. The NUR-36 is designed for unbalance current protection of double star (Y-Y) or H-connected capacitor banks in HV applications. It has solid state construction and is suitable for panel installation (DIN 43700).

The relay has filters for harmonic currents and operate at fundamental frequency only. 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 Vac/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 settings
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

## NC-12 Power Factor Controllers

### 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 shortcircuit over a series connection)
- Measurement range: 0 $\mu$ F to 2,000  $\mu$ F 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 230 VAC/18 VDC 50/60 Hz



### Specifications

Ranges	2000 $\mu$ F 200 $\mu$ F 20 $\mu$ F	Range Display	0,1,999 $\mu$ F 0,1,99.0 $\mu$ F 0,1,9.99 $\mu$ F
Loading capacitance			2,000 $\mu$ F max.
Measuring frequency			111.86 Hz
Measuring voltage			1.41 Vrms
Error			$\pm$ 1% of reading $\pm$ digits
Resolution			0.05% between 1 and 2,000 $\mu$ F
Protection class IP41 at panel and IP20 DIN-rail installation			-10°C to + 50°C
Dimensions			450 × 350 × 250mm
Weight			approx. 9.5 kg

## HV Capacitor Banks

Grid Solutions' HV capacitor bank solutions can be categorized in the following way:

### 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



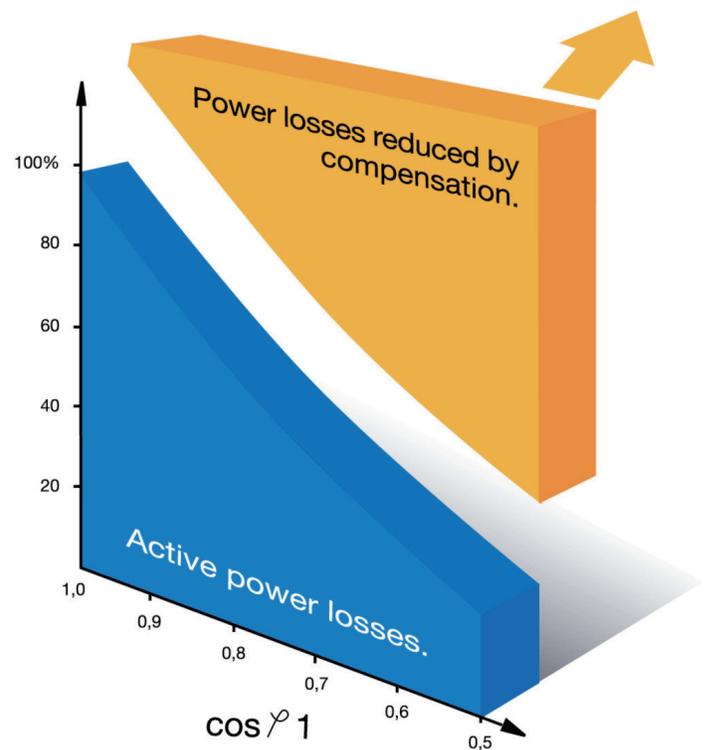
## HV Shunt Capacitor Banks

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 HV shunt capacitors, Grid Solutions is the name to remember. Whatever your exact needs are, we 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

Grid Solutions' capacitor banks are in operation globally. 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. Grid Solutions' 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

Grid Solutions' 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 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

Grid Solutions 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 Grid Solutions a number of commissions for other major projects. With a wealth of know-how and expertise that is second to none, our R&D team continues to produce innovative applications to improve the quality of electrical supplies. Grid Solutions' 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-quality equipment.

### Installation

Installation of 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 operated

### 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
- Reduced reactive energy costs
- 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

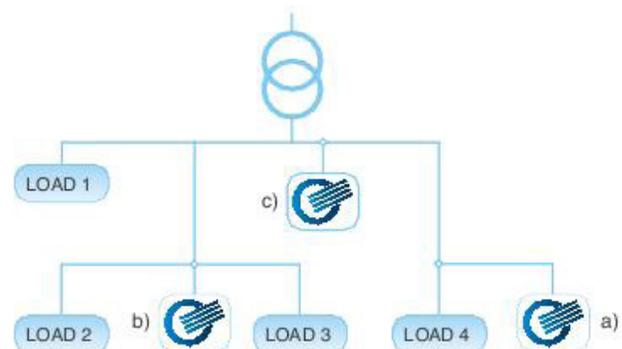


Figure 1: Installation of shunt capacitor banks

## HV 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 few 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 Grid Solutions 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 for easy future expansion of the system, facilitating transport, storage and installation
- Galvanized steel enclosures available for indoor and outdoor installations, with different ventilation systems
- Degree of protection 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
- Improved 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 the customer's switchgear.



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 disconnector, 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 like vacuum 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. Depending on the capacitor unit connection configuration, the banks are divided into two groups:

## Capacitor Units

Depending on the capacitor unit 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



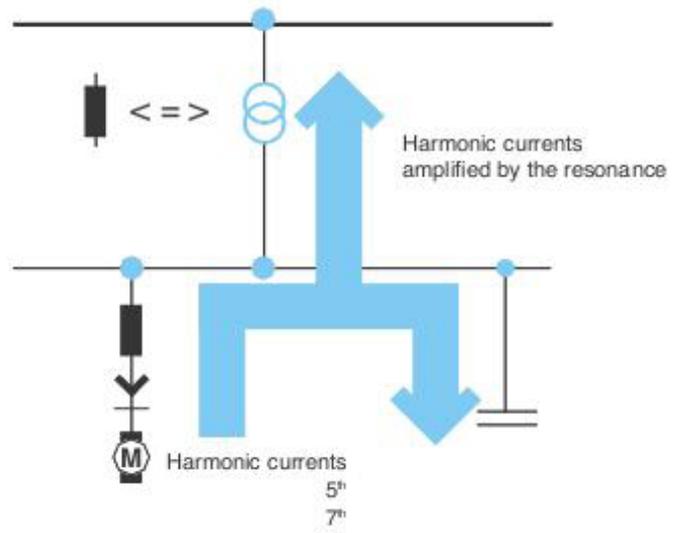
# HV Harmonic Filter Capacitor Banks



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

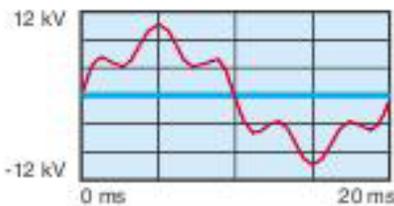
### Harmonic Distortion - An Increasingly Common Problem

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.

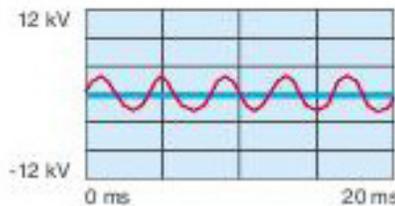
Problems are most often caused by the 3rd, 5th, 7th, 11th and 13th order harmonics.

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.

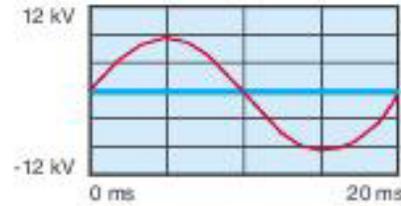
Particular problems are experienced when the network contains power factor correction capacitor banks. The capacitor bank and the inductance of the network may form a parallel resonant circuit at the harmonic frequency, with the result that harmonics are amplified to such an extent that the voltage becomes 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 Distorsion 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. Grid Solutions is one of the few manufacturers in the world with its own capacitor and air-core reactor production. Grid Solutions filters contain perfectly matched components for trouble-free operation.

## Effective Harmonic Filtering

The effective solution of distortion problems demands a high level of power transmission and distribution know-how. For many years Grid Solutions' professional team has successfully been designing filters to eliminate harmonic distortion problems for customers in countries all over the world. Grid Solutions's expertise has been further enhanced by cooperation with major industrial companies and electrical utilities. Grid Solution's uses the latest tools 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 simulation.



# Harmonic Filtering in Practice

Grid Solutions' 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 2), Grid Solutions' 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.

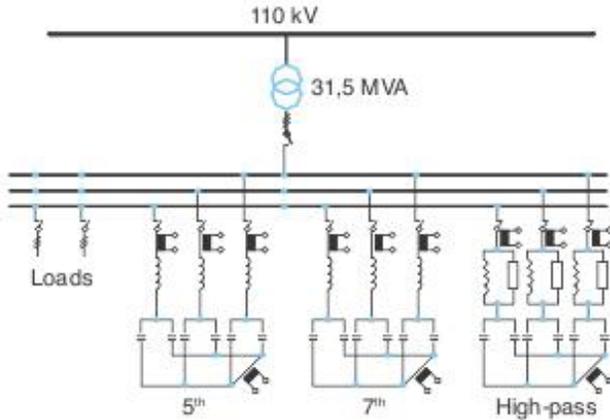
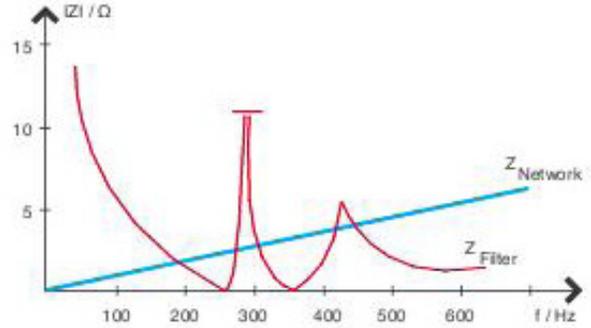
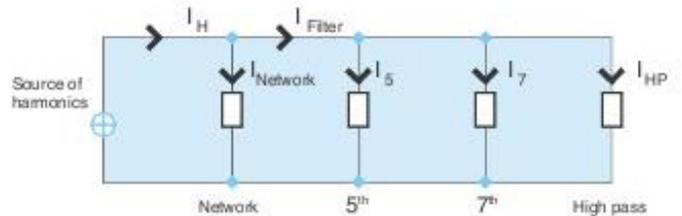
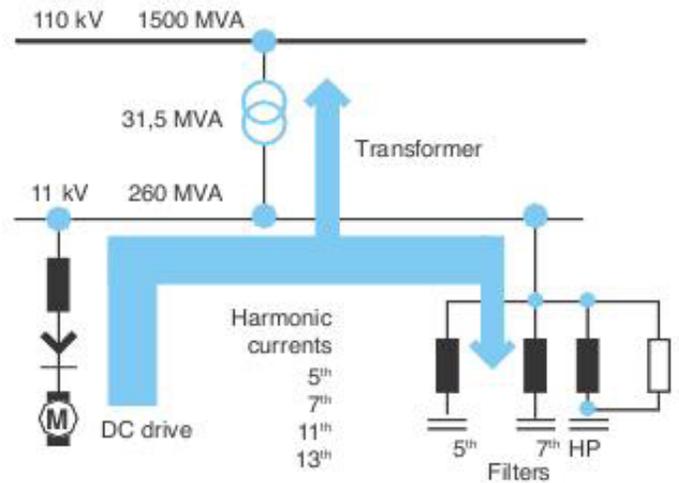


Figure 2: 5th, 7th and high-pass filter

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%.



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.



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