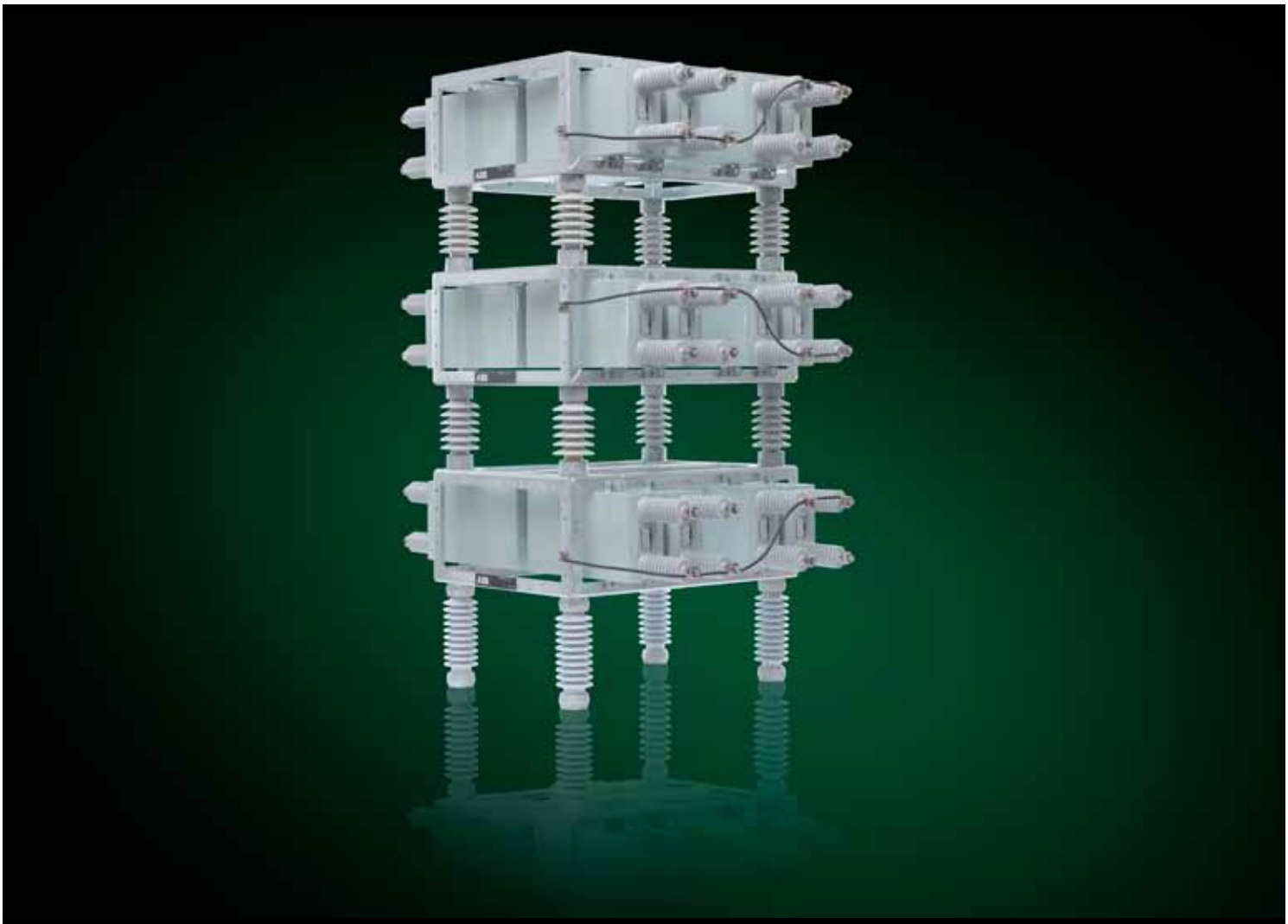

Power Capacitors and Harmonic Filters Buyer's Guide

Power and productivity
for a better world™

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145 kV filter installation in Oman

Give your grid a power injection with power capacitors from ABB

A complete program with complete support

ABB's capacitors and capacitor banks are used both in transmission and distribution grids, as well as in industrial and commercial applications. There are filter installations, shunt and series compensating installations, and HVDC transmission systems all over the world, both at power companies and in industries.

As a customer, you gain access to an all-embracing line of capacitors and complete support in the form of analyses, calculations and suggestions on custom solutions for the generation of reactive power and harmonic filtering. Solutions that make it possible to increase active power and reduce disturbances through a smoother sinus form.

Our comprehensive product line, which apart from capacitors also includes all other apparatus for transmission and distribution grids up to 800 kV, makes us a comprehensive supplier of both individual apparatuses and complete turnkey installations.

ABB's capacitors are used all over the world

Our capacitors have demonstrated their robustness and reliability at power installations all over the world. The capacitors are designed for reliable operation in all climates, from the arctic cold to the tropical heat.

ABB delivers the full value chain in low, medium and high voltage technologies with a focus on efficient and environmentally-friendly power transport to resources connected to the electrical grid. ABB has been driving development in the field of power quality for over 80 years and has been responsible for several important development stages in capacitor and filtering technologies. Some of these developments include:

- The introduction of low voltage dry capacitor technology using metallized plastic film. This technique had the advantage over rival technologies at the time by providing capacitors that were more environmentally friendly, reliable, compact and more energy efficient. As a demonstration of our success and leadership in this field, ABB offers this technology today also for the DC capacitors of HVDC links.
- The introduction of intelligent power factor controllers and fast switching technology allowing precise power factor control under even the most severe conditions and for both slow and fast loads.
- The introduction in the low voltage market of active filter technology for industrial and commercial low voltage applications.
- The implementation of innovative sound attenuation techniques in our medium and high voltage capacitor range, positioning them at the top of what is best available, for the benefit of the environment.

300 Mvar/420 kV/50 Hz capacitor installaion in Norway

ABB — the world's leading manufacturer of power capacitors

ABB can offer superior capacitor technology thanks to our extensive research and development.
With the development of high performance materials and state-of-the-art manufacturing processes, our products achieve the highest ratings in the industry.

Over the years, our integrated self-protecting technology has been further developed. We are now the world-leader in this field. Our capacitor program focuses both on individual capacitor units as well as complete systems. We design and manufacture our products for a service life of at least 30 years.

Description of installation	System voltage	Power range	Product family
Power factor improvement for indoor/outdoor applications			
Metal-enclosed type installation with or without damping reactors	1 - 24 kV	1 - 15 Mvar	SIKAP *)
Open-rack type installation with damping reactors	1 - 800 kV	from 1 Mvar	QPLUS
Open-rack type installation without damping reactors	1 - 800 kV	from 1 Mvar	QBANK
Harmonic filtering for indoor/outdoor applications			
Band-pass filters	1 - 500 kV	from 3 Mvar	CHARM-BP
Band-pass filters with detuned reactors	1 - 500 kV	from 3 Mvar	CHARM-BP/D
High-pass filters	1 - 500 kV	from 3 Mvar	CHARM-HP
C-filter	1 - 500 kV	from 3 Mvar	CHARM-C

*) Other MECB products with different characteristics are also available. More information is given in the 'Product Information'-section of this buyer's guide.

Please note

This buyer's guide covers medium and high voltage capacitor units and capacitor banks for standard shunt compensation and harmonic filtering. While this is a global brochure, the products shown are intended for the European, Middle Eastern and African market. In other regions, product specifications may differ. For applications such as LV capacitor and filter products, capacitors for HVDC and FACTs applications, traction applications, test laboratories, motor starting applications etc. please contact your ABB sales representative.

Descriptions - Definitions

Reactive power fundamentals

var
The unit of measurement for reactive power.

Active power (P)
Active power is the useful power that does the actual work. Active power is measured in W, kW, MW.

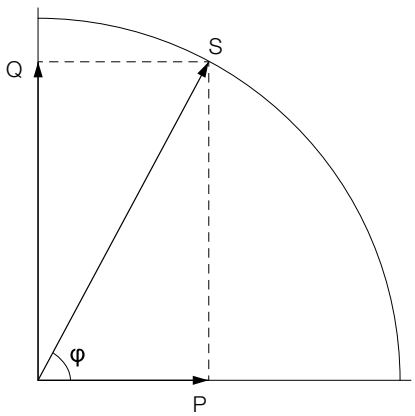
Reactive power (Q)
Reactive power is a product of an AC system. Reactive power is used to produce magnetic fields. Reactive power is measured in var, kvar, Mvar.

Apparent power (S)
Apparent power or total power is a combination of active power and reactive power. Apparent power is measured in VA, kVA, MVA.

Ratio of the active power to the apparent power
Power factor or cos φ, is a measurement of the efficiency in the system. Power factor describes the relationship between active and apparent power.

Generated reactive power
Generated reactive power of the bank/system is the power generated at the operational voltage, expressed in Mvar.

Rated output
Rated output is the theoretical power of the bank/system generated at the rated voltage, expressed in Mvar. It is also referred as installed power.



Uncompensated load

General information

Rated insulation level
The combination of voltage values that characterizes the insulation of the equipment with regard to its capability to withstand dielectric stresses. These values are selected based on the rated voltage of the bank/system.
Standard insulation values are given for altitudes ≤1000 m above sea level. For higher altitudes, a correction factor must be used.

Lightning impulse test
The lightning impulse test is performed with a standardized wave shape (1.2/50 µs) for simulation of lightning overvoltage. The value is expressed in kV peak.

Rated Power Frequency Withstand Voltage
This test is to show that the apparatus can withstand the power frequency over-voltages that can occur.

The Rated Power Frequency Withstand voltage indicates the required withstand voltage. The value is expressed in kV rms.

Rated SIWL
For voltages ≥300 kV, the power-frequency voltage test is partly replaced by the switching impulse test. The wave shape 250/2500 µs simulates switching overvoltage.

The rated Switching Impulse Withstand Level (SIWL) indicates the required withstand level phase-to-earth (phase-to-ground), between phases and across open contacts.
The value is expressed in kV as a peak value.

Degree of protection
The extent of protection provided by an enclosure against access to hazardous parts, against entry of solid foreign objects and/or against entry of water and is verified by standardized test methods. (IEC 60529)

IP code
A coding system to indicate the degrees of protection provided by an enclosure against access to hazardous parts, entry of solid foreign objects, entry of water and to give additional information in connection with such protection. (IEC 60529)

IEV
International Electrotechnical Vocabulary

Capacitors

Capacitor element
Device consisting essentially of two electrodes separated by a dielectric (IEV 436-01-03).

Capacitor unit
Assembly of one or more capacitor elements in the same container with external terminals (IEV 436-01-04).

Capacitor bank
Multiple capacitor units connected so as to act together (IEV 436-01-06).

Capacitor
The word “capacitor” is used when it is not necessary to put particular stress on the different meanings of the terms capacitor unit or capacitor bank.

Discharge device of a capacitor
Device that may be incorporated in a capacitor, capable of reducing the voltage between the terminals practically to zero within a given time after the capacitor has been disconnected from a network (IEV 436-03-15, modified).

Internal capacitor fuse
Fuse connected inside a capacitor unit, in series with an element or a group of elements (IEV 436-03-16).

Line terminal
Terminal intended for connection to a line conductor of a network (IEV 436-03-01).

Rated capacitance of a capacitor C_N
Capacitance value derived from the values of rated output, voltage and frequency of the capacitor (IEV 436-01-12).

Rated output of a capacitor Q_N
Reactive power for which the capacitor has been designed (IEV 436-01-16).

Rated voltage of a capacitor U_N
RMS value of the alternating voltage for which the capacitor has been designed (IEV 436-01-15).

Rated frequency of a capacitor f_N
Frequency for which the capacitor has been designed (IEV 436-01-14).

Rated current of a capacitor I_N
RMS value of the alternating current for which the capacitor has been designed (IEV 436-01-13).

Capacitor losses
Active power dissipated in the capacitor (IEV 436-04-10).

Maximum permissible AC voltage of a capacitor
Maximum rms alternating voltage which the capacitor can sustain for a given time under specified conditions (IEV 436-04-07).

Maximum permissible AC current of a capacitor
Maximum rms alternating current that the capacitor can sustain for a given time under specified conditions (IEV 436-04-09)

Ambient air temperature
Temperature of the air at the proposed location of the capacitor.

Steady-state condition
Thermal equilibrium attained by the capacitor at constant output and at constant ambient air temperature.

Residual voltage
Voltage remaining on the terminals of a capacitor at a certain point in time following disconnection.

Creepage distance
The shortest distance, or the sum of the shortest distances, along the insulating parts of an insulator between parts that normally have the operating across them.
(IEV 471-01-04, modified)

Unified specific creepage distance (USCD)
Creepage distance of an insulator divided by the rms value of the highest operating voltage across the insulator. This is normally expressed in mm/kV and as a minimum.

Descriptions – Definitions

Harmonics and filters

Fundamental (component)
The component of order 1 of the Fourier series of a periodic quantity. (IEV 161-02-17)

Harmonic
The component of the Fourier-series decomposition of a voltage or current periodic wave. (IEV 161-02-18 modified)

Harmonic order (h)
The ratio of the frequency of a harmonic (f_h) to the fundamental (rated) network frequency (f_1). (IEV 161-02-19 modified)

Odd harmonics
Harmonics with odd harmonic order.

Even harmonics
Harmonics with even harmonic order.

Characteristic harmonics
Those harmonics produced by static converters during theoretically ideal operation. The characteristic harmonic order of static AC/DC converters is given by $h = m_p \pm 1$, where p is the pulse number of the converter and m is any integer.

For example, the six-pulse converter circuit has characteristic harmonics with order numbers h = 5, 7, 11, 13,1 7, 19... . (IEC 61642)

Non-characteristic harmonics
Those harmonics that are produced as a result of imbalance in the AC power system or asymmetrical delay of the firing angle of the converter. They are also produced by other non-linear, time-varying devices, for example frequency converters, fluorescent lamps, arc furnaces, electric welding machines, etc. (IEC 61642)

Filter
A device generally constituted by reactors, capacitors and resistors if required, tuned to present a known impedance over a given frequency range. (IEC 61642)

Tuning frequency
The frequency at which the filter impedance, calculated from the rated values, has a minimum or maximum value.
(IEC 61642)

Tuned filter
A filter with a tuning frequency that differs by no more than 10% from the frequency that is to be filtered. (IEC 61642)

Detuned filter
A filter with a tuning frequency more than 10% below the lowest harmonic frequency with considerable current/voltage amplitude. (IEC 61642)

Damped filter
A filter with low, predominantly resistive, impedance over a wide band of frequencies. (IEC 61642)

Band-pass filter
A reactor (inductance) connected in series with a capacitor (capacitance).

High-pass filter
A damped band-pass filter. A resistor is connected in parallel with the reactor in a band-pass filter, which creates damping on the parallel resonance.

C-type filter
High-pass filter modified with an extra capacitor to short-circuit the resistor for the fundamental frequency. Alternative when a damped filter is needed for a low-tuned filter (normally $n < 5$).

Double-tuned filter
Filter configuration with two tuning frequencies, mainly used in HVDC filter systems.

Displacement factor
The ratio of the active power of the fundamental wave to the apparent power of the fundamental wave.
(IEV 131-03-21 modified)

Distortion factor
The ratio of the rms value of the harmonic content to the rms value of the fundamental quantity, expressed as a percentage of the fundamental frequency. (IEV 131-03-04 modified)

DF = (sum of the squares of rms values of the harmonics)$^{1/2}$ / rms value of the fundamental frequency x 100%

Total Harmonic Distortion, THD

The square root of the sum of squares of all individual harmonic distortions (voltages or currents) is called the Total Harmonic Distortion (THD).

$$THD(U) = \sqrt{\sum_{2}^{50} \left(\frac{U_n}{U_1}\right)^2}$$

and

$$THD(I) = \sqrt{\sum_{2}^{50} \left(\frac{I_n}{I_1}\right)^2}$$

U_n = harmonic voltage

U_1 = fundamental voltage and

I_n = harmonic voltage

I_1 = fundamental voltage

Point of common coupling (PCC)

The point of the public supply network, electrically nearest to a particular consumer's installation, and at which other consumer installations are or may be connected. (IEV 161-07-15)

Capacitor inrush current

It is the transient charging current that flows in a capacitor when a capacitor bank is initially connected to a voltage source.

Capacitor outrush current

The high frequency, high magnitude current discharge of one or more capacitors into a short circuit, such as into a failed capacitor unit connected in parallel with discharging units, or through a circuit breaker closing into a fault.

Parallel resonance

When an electric circuit consisting of inductive and capacitive impedance in parallel has maximum impedance.

Series resonance

When an electric circuit consisting of inductive and capacitive impedance in series has minimum impedance.

Quality factor

Method to indicate the efficiency of a filter. Based on the relation of reactor reactive power consumption and filter active losses at the tuning frequency.

$q = Q_{reactor}/P_{loss}$

Service conditions

Temperature

According to the IEC 60871-1 standard, capacitors are classified in various temperature categories, with each category being specified by a number followed by a letter. The number represents the lowest ambient air temperature at which the capacitor may operate. The letters represent upper limits of temperature variation ranges, having maximum values as specified in Table 1

Ambient temperature			
Symbol	Maximum temp (°C)	Highest mean temp, 24 hours (°C)	Highest mean temp, 1 year (°C)
A	40	30	20
B	45	35	25
C	50	40	30
D	55	45	35

Table 1: Temperature ranges according to IEC 60871-1

Any combination of minimum and maximum values can be chosen for the standard temperature category of a capacitor, for example –40/A or –5/C.

The upper temperatures may have an impact on the overall service life performance of the capacitor. They also define certain conditions for the thermal stability test. The lower temperature limit is important for partial discharge phenomena and it has a direct impact on test procedures for verification of transient overvoltage capabilities (TOV tests). The endurance test according to IEC 60871-2 includes such verifications.

As per latest IEEE std. 18, capacitors shall be designed for continuous operation at a maximum average ambient temperature of 46 °C over a 24-hour period, irrespective of mounting arrangement, and capacitors shall be capable of continuous operation at a minimum ambient temperature of -40 °C. For colder climates, a minimum ambient temperature of -50 °C can be specified.

If the capacitors are exposed to strong sunlight it may be necessary to consider some type of sun protection when designing the bank.

A non-standard temperature class can be quoted on request.

Installation altitude

Always specify the installation altitude and normal rated insulation levels on the inquiry form. Normal service conditions are considered as altitudes of ≤ 1000.

When electrical equipment is installed at higher altitudes, special consideration must be taken to the air having a lower withstand capability. The common practice is to introduce a correction when installations are at altitudes higher than 1000 m above sea level. The basic high voltage switchgear standard, IEC 62271-1, provides recommendations that should be applied.

The following correction factor is multiplied for voltage requirements defining external insulation performance, such as the AC wet test voltage and BIL test voltage. This ensures that the insulation withstand at high altitude is achieved even when the equipment is tested at lower altitudes.

Correction factor

$$k = e^{\frac{H-1000}{8150}}$$

H is the altitude in meters above sea level (m.a.s.l.)

As an example, assume an installation at 3,000 m.a.s.l. and a bus voltage of 22 kV. 22 kV entails insulation requirements for AC/BIL of 50/125 kV, which should be valid at the location for the installation. The correction factor becomes 1.28 and thus the AC test voltage at sea level should be raised to 64 kV and the BIL test should be 144 kV. For internal insulation, such as primary insulation between internal elements and the container, the requirement 50/125 kV remains unchanged.

According to IEEE std. 18 the stipulated insulation requirements shall be fulfilled up to 1800 m above sea level. For elevations higher than 1800 m, and for locations with severe contamination, a general statement about the need to consider increased insulation withstands and/or creepage distances is made.

Pollution levels

Environmental conditions with respect to pollution are sometimes categorized in pollution levels. Five pollution levels are described in IEC 60815-1. There is a relationship between each pollution level and a corresponding minimum nominal specific creepage distance. Always specify the required pollution level on the inquiry form.

Seismic withstand capability

There are many regions in the world where earthquakes may occur, and where the equipment should be designed to withstand the corresponding stresses. To demonstrate earthquake withstands capabilities, ABB conducts tests and calculations for the various units and applications. Always specify the seismic withstand capability on the inquiry form.

Pollution level	Examples of environmental conditions (per IEC 60071-2)	[1] Specific creepage demand (SCD) mm/kV	[2] Unified specific creepage demand (USCD = √3 x SCD) mm/kV
a - Very light		12.7	22.0
b – Light	- No or low density of industries or buildings. - Agriculture or mountain areas - Locations at least 10 to 20 km from the sea	16	27.8
c – Medium	- Industries not producing particularly polluting emissions - High density of buildings and/or industries but subjected to frequent winds and/or rainfall - Wind from the sea but not too close to the coast	20	34.7
d – Heavy	- High density of industries and suburbs of large cities producing pollution. - Areas close to the sea	25	43.3
e - Very heavy	- Industrial emissions producing conductive deposits - Areas very close to the sea and exposed to sea spray (salt) - Desert areas.	31	53.7

[1] Specific creepage distance is defined as the leakage distance measured between phase and ground over the rms phases to phase voltage of the highest voltage for the equipment. (Definition according to previous versions of IEC standard 60815)

[2] Unified specific creepage distance is a simplification of definition 1. It may be applied to any insulation path, phase-ground or phase-phase voltage. The leakage distance across the insulator component is based on the actual voltage present.

Non-standard creepage requirements can be quoted on request

Wind load

There are many regions in the world where the wind load is high, and where the equipment should be designed to withstand the corresponding stresses. To demonstrate the wind load withstands capabilities, ABB conducts tests and calculations for the various units and applications.
Always specify the wind load on the inquiry form.

Noise restrictions

High voltage equipment is being installed increasingly closer to residential areas where the sound generated by the equipment is often perceived as annoying. We can design capacitor units for compliance with specific noise restrictions.

Premium quality worldwide

ABB capacitors are produced in highly automated workshops, but it is the commitment of our employees that is the determining factor in attaining final results. A finely tuned quality system with constant checks during all phases of production guarantees high and consistent quality of the capacitor. No matter where in the world it is produced.

ABB has a solid reputation as a supplier of high quality products. Our capacitor plants, with their skilled and dedicated staff, is one of the most important reasons for this. Proper technical design, strict material requirements and highly automated production are important cornerstones of our operations.

Production controlled by well-established quality routines

Production is entirely customer-driven and each capacitor is individually monitored through the process using a computerized production follow-up system that enables full traceability. So as to be able to identify any deviations from the specified values at an early stage, verification measurements are made after several of the process steps. Each capacitor undergoes final testing to ensure quality.

Environmental matters play a central role in our operations

ABB capacitor plants are committed to ABB's general environmental policy with respect to sustainable development and low environmental impact. For all new and further development, substantial emphasis is placed on recyclability, production with low environmental impact and minimizing environmental impact during the active period of use.

Among the ways of reducing environmental impact are minimizing capacitor losses, increasing the output per volume unit and optimizing installations with as few and as large units as possible.

Certification

Production is quality certified according to ISO 9001, environmentally certified according to ISO 14001 and occupational health and safety certified according to OHSAS 18001.

Testing resources close by

ABB has close contact with independent laboratories and testing resources equipped for most type and routine tests, such as high voltage AC or DC voltage tests, tests in high/low ambient temperatures and discharge tests.

Test can be conducted in the laboratories in compliance with the requirements stipulated in the international standards IEEE and IEC. Special tests in accordance with our customer's specifications can also be conducted.

ABB also has facilities for carrying out development tests. With these testing resources, we are at the forefront in developing safe and reliable new-generation products.

Type test reports are available for tests performed on capacitor units similar to those stipulated in customer specifications.

The routine tests are part of the process of producing capacitor units and are always performed with the same test procedures, irrespective of whether or not the tests are witnessed by the client's representative. All aspects of tests for each capacitor unit are documented in routine test reports, generated by the computerized testing system. After verification by the ABB certified test supervisor, this report is provided to the customer as part of the order documentation.

Goal-oriented research and developments are behind ABB's successes in the field of capacitors. Our goal is to further develop the technological solutions so that they create even better prospects for good operating economy in customers' electrical grids.

Power capacitor standards

Capacitor manufacturing standards

The most common manufacturing standards for high voltage power capacitors are IEC 60871 and ANSI/IEEE standard 18. Applicable routine tests and type tests according to these two standards are listed below.

Special notes for type tests and special tests

Type tests are carried to ascertain that the capacitors comply with the characteristics and operational requirements specified in the standard as regards to design, size, materials and manufacturing. The type tests are conducted on capacitors of a design identical to that of the capacitor to be supplied or on capacitors of a design that does not differ from it in any way that might influence properties. Per the IEC or IEEE/ANSI standard, it is not essential that all type tests be carried out on the same capacitor unit; they may also be carried out on different units having the same characteristics.

All capacitor units are manufactured in accordance with previously type-tested designs. Test reports for type tests performed on capacitor units similar to customer specifications can be provided upon request. This is in full compliance with the recommended procedures in the IEC or IEEE/ANSI standard. If the type tests must be repeated for any project, this will delay delivery and will involve extra costs.

Classification of tests as per IEC 60871-1

Routine tests

- Capacitance measurement (see Section 7).
- Measurement of the tangent of the loss angle (tan δ) of the capacitor (see Section 8).
- Voltage test between terminals (see Section 9).
- AC voltage test between terminals and container (see Section 10).
- Test of internal discharge device (see Section 11).
- Sealing test (see Section 12).
- Discharge test on internal fuses (see 5.1.1 of IEC 60871-4).

Type tests

- Thermal stability test (see Section 13).
- Measurement of the tangent of the loss angle (tan δ) of the capacitor at elevated temperature (see Section 14).
- AC voltage test between terminals and container (see Section 15).
- Lightning impulse voltage test between terminals and container (see Section 16).
- Short-circuit discharge test (see Section 17).
- Test of an external fuse in combination with a capacitor (see Annex C).
- Disconnecting test on internal fuses (see Section 5.3 of IEC 60871-4).

Acceptance tests

All or parts of the routine and/or type tests may be repeated subject to special agreement with the purchaser. The number of samples and the acceptance criteria must be mutually agreed upon.

As a standard acceptance test procedure, ABB welcomes customers to witness routine tests on capacitor units per the applicable standard.

Special tests

Endurance tests, as per IEC 60871-2, may be repeated subject to special agreement with the purchaser. The number of samples and the acceptance criteria must be mutually agreed upon.

Classification of tests as per ANSI/IEEE standard 18

Design tests

- Impulse withstand test (see Section 7.1.1)
- AC voltage tests (see Section 7.1.2)
- Thermal stability test (see Section 7.1.3)
- Radio influence voltage test (see Section 7.1.4)
- Short circuit discharge test (see Section 7.1.5)
- Performance test (see Section 7.1.6)
- Fuse disconnect test for internally fused capacitors (see Section 7.1.7)

Production tests

- Short-time overvoltage test (see Section 7.2.1)
- Capacitance test (see Section 7.2.2)
- Leak test (see Section 7.2.3)
- Discharge resistor test (see Section 7.2.4)
- Loss determination test (see Section 7.2.5)
- Fuse capability test for internally fused capacitors (see Section 7.2.6).

Acceptance tests

This part is not specifically addressed in the IEEE standard. However, all or parts of the routine and/or type tests may be repeated subject to special agreement with the purchaser. The number of samples and the acceptance criteria must be mutually agreed upon.

As a standard acceptance tests procedure, ABB welcome customers to witness routine tests on capacitor units per the applicable standard.

Power capacitor standards

Description of routine tests

- **Capacitance measurement**
  The measurement must be made at high voltage with high precision equipment.

- **Measurement of the tangent of the loss angle (loss factor)**
  This measurement is usually made simultaneously with capacitance measurement. With the low loss dielectrics normally used today, high accuracy performance is required and thorough calibration of the test equipment is necessary.

- **Voltage test between terminals**
  This test is intended to check the electrical strength of the dielectric and to detect possible weak elements. A choice between a 10-second test with AC or with DC is provided by the standards. For capacitors with high kvar ratings, the DC method may require less sophisticated test voltage sources.

- **AC voltage test between terminals and container**
  This test objective is to verify that the primary insulation between terminals and case is properly manufactured. It is not applicable to capacitors with only one bushing (other terminal connected to case).

- **Test of internal discharge device.**
  A check of the resistance value is usually sufficient.

- **Sealing test**
  According to IEC the manufacturer can decide the test procedure If the customer has not specified any details.

- **Discharge test on internal fuses (IEC 60871-4)**
  The routine discharge test is only required for internal fuses. The objective to verify that the fuse components and their associated contact joints are properly manufactured.

Comparison of routine tests between IEC 60871-1 and ANSI/IEEE standard 18

Tests	IEC 60871-1	ANSI/IEEE standard 18
1. Capacitance measurement	0.9 – 1.1 x U_n	Measurement at U_n
2. Loss measurement	0.9 – 1.1 x U_n	Measurement at U_n
3. Voltage test between terminals	AC: 2.0 x U_n, 10 sec. OR DC: 4.0 x U_n, 10 sec.	AC: 2.0 x U_n, 10 sec. OR DC: 4.3 x U_n, 10 sec.
4. AC test between terminals and container	According to AC/BIL or 2.5 x $U_{bushing}$ 10 sec., dry test	According to AC/BIL-table 10 sec., dry test
5. Test of internal discharge device	By R-measurement	By R-measurement (a suitable test)
6. Sealing test	By suitable method of manufacturers choice	By suitable method of manufacturers choice
7. Discharge test on internal fuses	Discharge level (DC): 1.7 x U_n (1 discharge)	Discharge level (DC): 1.7 x U_n (1 discharge)

Description of type tests

A type test is intended to verify the soundness of the design. Tests on capacitors "that do not differ from it in any way that might influence the properties to be checked by the type test" are allowed according to IEC. To compile type test reports on similar capacitors, a summary report that gives the justification for the selection is common industrial practice. Type testing cannot be seen as a tool for verification of manufacturing quality at a particular production facility. The sampling would be too limited. Good manufacturing is assured through other quality assurance activities.

- **Thermal stability test**
  The purpose of this test is to ensure thermal stability of the capacitor under overload conditions. It is also a means for conditioning the capacitor to enable a reproducible loss measurement to be made. An important procedural step is to arrange the tested unit in such a way that the influence of adjacent units in service is simulated.

- **Measurement of the tangent of the loss angle (tan δ) at elevated temperature**
  The measurement is usually made directly in connection with the thermal stability test.

- **AC voltage test between terminals and container.**
  This test shall verify that the primary insulation between terminals and case is properly designed. It is not applicable to capacitors with only one bushing. If the capacitor is designed for outdoor use, the test shall be made with artificial rain.

- **Lightning impulse voltage test between terminals and container**
  This test also verifies the design of the primary insulation and that the specified insulation class is fulfilled. It is not applicable to capacitors with only one bushing.

- **Short-circuit discharge test**
  The short-circuit test is to ensure that internal fuses, as well as other internal connection leads, can withstand external flash between the terminals. The flashover is simulated at a certain overvoltage level.

- **Disconnection test on internal fuses (IEC 60871-4)**
  An element breakdown is intentionally simulated at the extremes of the working voltage range specified for the internal fuses. The fuse shall pass without damaging other vital insulation or components adjacent to the fuse. The withstand of the residual voltage across an operated fuse is also checked.

Comparison of type tests between IEC 60871-1 & ANSI/IEEE standard 18

Tests	IEC 60871-1	ANSI/IEEE standard 18
1. Thermal stability test	1.44 x Q_n (= 1.2 x U_n) Max $T_{ambient}$, 48 hrs	1.44 x Q_n x (= 1.2 x U_n) 46 °C, >24 hrs
2. Losses at elevated temperature	Check at end of the stability test Same voltage as in stability test	
3. AC test between terminals and container	According to AC/BIL or 2.5 x $U_{bushing}$ 1 min., wet if outdoor	No AC test (Spec. bushing test applies)
4. Impulse test between terminals and container	According to AC/BIL class 15+15 pulses, only 2 bushings	Acc to AC/BIL-class 3 pos. pulses, only 2 bushings
5. Short-circuit discharge test	Discharge level (DC): 2.5 x U_n 5 discharges, undamped	Discharge level (DC): 2.5 x U_n 5 discharges, undamped
6. Disconnection test on internal fuses	Disconnection (puncture) test at 0.9 - 2.2 x U_n	Disconnection (puncture) test at 0.9 - 2.5 x U_n
7. RIV test		1.15 x U_n <250 mV, 1 MHz
8. Performance test	TOV test in IEC 60871-2	300 TOVs/2 days at 2.25 x U_n 96 hrs at 1.4 x U_n

Power capacitor standards

Description of endurance test IEC 60871-2

The endurance test consists of two parts, one for transient overvoltage cycling test (TOV test) and one for aging test. The test is intended to verify the design of the elements (their dielectric design and composition) and the processing of these elements when assembled in a capacitor unit. The endurance test, which is time-consuming to perform, may cover a range of capacitor designs.

The TOV test is carried out to ascertain that repeated overvoltage cycles do not cause a dielectric breakdown at the lowest ambient temperatures. Partial discharge phenomena (PD) is likely to be the critical factor during TOVs and it is most pronounced at low temperatures. The test stresses the dielectric at a high level for a short period of time followed by a reduction of the voltage to a level with a certain margin above the rated. After some minutes at the lower voltage level, the sequence is repeated. The sequence is repeated several times and the total testing time is several days.

The aging test is carried out to ascertain that the progression of deterioration resulting from increased voltage stress at elevated temperature does not cause untimely failure of the dielectric. The standard stipulates a testing time of 1000 hours or more.

IEC allows tests on “model” capacitors, provided that certain conditions regarding design details are fulfilled.

Endurance test parameters according to IEC 60871-2

TOV-test	850 TOV’s
	TOV-pulse, 10-15 cycles at 2.25 x U_n
	Min ambient temperature
Ageing test	1000 hrs at 1.4 x U_n or 3000 hrs at 1.25 x U_n
	Diel. temp > 60 °C

Other standards

Beside these international standards there are also several national standards, for example:

- VDE 0560 Part 410 (Germany),
- NEMA CP1-2000 (USA)
- SN-18.1d (Hydro Quebec, Canada)
- NBR & GOST

ABB capacitor units can also be designed and tested as per these national standards.

Fusing technologies

Impregnated capacitor unit — CHD

The CHD type is a single-phase power capacitor of the all-film type, with low dielectric losses and long service life. The capacitors are impregnated with Faradol, a bio-degradable product with high insulation strength. The edges of the electrode foils are folded, enabling higher electrical stress. The ABB capacitor units have an extremely low failure rate and high reliability.

The CHD capacitor unit is made up of a number of elements, each consisting of very thin layers of dielectric materials and thin foils of aluminum as electrodes. The elements are stacked inside the capacitor container and connected in series and parallel to accommodate the voltage and capacitance ratings specified for the entire capacitor unit. The dielectric is undoubtedly the most influential factor for the reliability of the entire capacitor or capacitor bank. However, this is very dependent on the fuse technology and the unbalance protection arrangements.

Different fuse technologies

ABB capacitor units are available with all types of fuse technologies – internal fuses, external fuses or fuseless.

ABB can offer all those technologies. To limit failures related to electrical failures inside the capacitor unit, the capacitor can be equipped with fuses. The earliest type was the externally fused capacitor, with the fuse (of expulsion type) installed on the line, between the line and the capacitor. ABB later developed the internally fused technology CHDB, with each element inside the capacitor equipped with a fuse. Beside this, there is an option of using fuseless capacitors type CHDF and the original externally fused, CHDE.

Internally fused concept, type CHDB

When it comes to internally fused capacitors, we are recognized as the world leader with over 50 years of experience. The internal fuses are current-limiting fuses. One fuse is connected in series with each element within the capacitor unit. They are designed and coordinated to isolate internal faults at the element level and allow continued operation of the remaining elements of that capacitor unit. This results in a very small part of the capacitor being disconnected, with the capacitor unit and the bank remaining in service. The fundamental concept is that by dividing a large system into small, individually protected elements, overall reliability is greatly enhanced. Advantages include higher reliability, less space, lower installation and maintenance costs and fewer live parts.

Externally fused concept, type CHDE

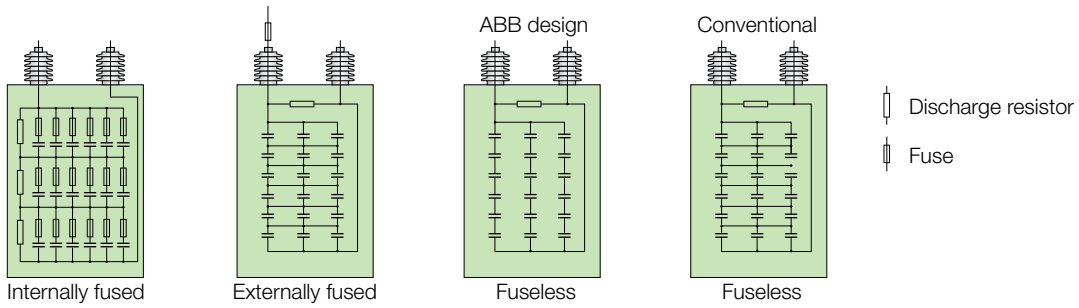
Each unit has its own fuse for disconnecting a failed capacitor unit from the bank. Once a capacitor unit is removed, an overvoltage on the remaining parallel capacitors results. This overvoltage must either be limited to a maximum value of 110% voltage or the bank must be tripped offline. The bank consists of many capacitor units connected in parallel. Concerns with excessive parallel energy and fuse limitations require the capacitors to be relatively small (average of 200 kvar). Although the external fuses provide a visual indication of a failure, banks tend to occupy more substation space, are more expensive, have many live parts subject to possible damage by animals and have higher installation and maintenance costs.

Fuseless concept – conventional CHDF

This concept was developed by ABB in the 1980s and is a result of the high reliability of today's all-film dielectric with capacitor case ruptures being a rare event. The internal design of fuseless capacitors (many elements in series) combined with the method by which the banks are connected (many "strings" of capacitor units in series), account for this design's excellent performance. A bank containing failed elements will operate continuously and withstand switching transients without rupturing the capacitor case. This is possible due to heavy duty welding of the two foil electrodes within the failed element, consequently diminishing the possibility of continued arcing.

Fuseless concept – internal strings, type CHDF

As an alternative to the conventional fuseless concept ABB, has developed a fuseless design based on a different internal connection of the element matrix. The elements are connected in parallel strings, which has the benefits of less capacitance deviation upon element failure, limitation of parallel energy inside the unit and that normal bank connection can be used. This technology does not restrict the capacitor unit size.



High quality surface treatment for CHD capacitors

ABB manufactures capacitor units for outdoor applications with the best surface treatment system available. The quality of the surface treatment is verified both by laboratory and field tests.

High quality surface treatment of capacitor units

Capacitors are installed in widely varying and often severe environmental conditions, and normally operate for long periods without inspection. Thorough surface treatment of the capacitors is therefore necessary to counter the environmental conditions. The surface treatment system used is part of the company's overall approach to quality and satisfies very stringent requirements.

Surface treatment on a continuous conveyor

The capacitor containers are made of ferritic Ti-stabilized chromium steel plate and are fully welded at robot production stations. The surface treatment operations are performed in a specially designed conveyor installation. Each capacitor is suspended in a cart on the conveyor and the surface treatment program is entered into the central computer via a bar code reader.

The computer keeps track of the location of each cart, thus ensuring that every capacitor unit is subjected to its particular surface treatment program.

Step 1: Washing

The capacitor units are automatically washed and rinsed in water in a closed system.

Step 2: Blasting

After successful completion of routine tests according to the applicable standards, the capacitor units are blasted with mineral blasting material. The blasting process cleans the metal and roughens the surface, creating excellent conditions for good paint adhesion. Good adhesion ensures good resistance to damage caused by handling and by humid environmental conditions. It also improves protection against the effects of chemical or corrosive environmental conditions.

Step 3: Painting

The capacitors move on to the painting station, where they are electrostatically painted by a robot. Electrostatic painting allows the amount of paint applied to be accurately controlled, providing a uniform coating and preventing paint waste.
A two-component paint is used. It is mixed in a controlled continuous process at the painting station. Paint and hardener are subjected to continuous laboratory tests. As a result of extensive development work, the paint has excellent resistance to mechanical and chemical attack

Step 4:

The paint on the capacitor units is hardened in an IR oven, making it quickly ready for further handling.

Quality control

The results of surface treatment are checked by frequent inspections. Among the factors inspected are the degree of blasting and the thickness and appearance of the paint coat.

Properties of the paint

The paint is an oxirane-ester based on ethoxilated vegetable oil. It contains pigments for both rust protection and color. The chart below shows the properties of the paint coating after application to chromium steel sheet that has been blasted to Sa 2 112 according to ISO 8501-1:1988.

Mechanical data

Coating thickness	ISO 2808, min. 80 µm
Gloss	Semi-mat
Color	Grey, Munsell 5BG 7/1
Hardness	ISO 1522, 130 s
Adhesion	ISO 2409, Degree 0
Elasticity	ISO 1520, 1 mm

Applications for capacitors
General information

Capacitors play an important role

Capacitors are very beneficial in power grids. By producing reactive power, they compensate for the reactive power consumption of electrical motors, transformers, etc.
The results can be seen in the form of more stable power grids with increased transmission capacity and reduced losses thanks to higher power factors.

Capacitors also constitute a key component in the various filter solutions that reduce harmonic content. A non-distorted sinusoidal voltage without harmonics reduces the risk of problems in the form of disturbances in production equipment, metering errors and malfunctions in relay protection. It also extends the service life of connected equipment.

Consumers expect high quality of supply in order to operate their plants efficiently and generate return on capital. A financial calculation most often shows that a capacitor installation quickly pays for itself.

Capacitors play an important role in improving the power quality and our portfolio reflects a wide range of capacitor and electronic solutions spanning all voltage levels for power utility and industrial applications.

The benefits of good power quality include:

Utilities
- Enhanced asset utilization
- Lower network losses and CO_2 emissions
- Expansion of network capacity
- Voltage stability

Industry
- Reduction of electricity expenses
- Lower network losses and CO_2 emissions
- Grid compliance
- Increase in plant capacity
- Higher productivity (i.e. fewer outages, lower operating costs)

Applications for capacitors
Reactive power compensation

Most of the apparatus and loads connected to the electrical power system consume both active and reactive (inductive) power. Some examples of such components are transformers, transmission and distribution lines, induction motors, rectifiers, induction furnaces, etc. The most economical method of reducing reactive power consumption in electrical power systems is by installing capacitor banks. This method is called reactive power compensation.

The capacitor injects reactive power into the system, thus reducing the load in the entire transmission and distribution system. The advantage of reactive power compensation was realized early and today, most power utilities as well as large consumers of electrical power are installing capacitor banks in their systems.

If harmonics are present in the network, harmonic filtering solutions are recommended.

420 kV capacitor bank installation in Norway.

The main reasons for installing power capacitors are:

1. Tariffs for reactive power consumption

Most of the power utilities supply reactive power free of charge up to a certain limit. Reactive power consumption exceeding this limit however, is subject to a tariff based on the power supplier's cost for the production and distribution of reactive power. The customers can thus reduce their electricity bills by installing power capacitors.

2. Loss reduction

Reactive power compensation leads to reduction of active losses in transformers, cables and transmission and distribution lines. The higher the power factor, the lower the losses in the grid.

3. Better utilization of existing transmission and distribution systems

Reactive power compensation results in reductions of apparent power drawn from the network, which can provide the following benefits:

- Additional loads can be connected to previously fully loaded transformers.
- Investments in new transformers, cables and lines can be postponed.

4. Optimal design of new plants.

By including capacitors at the planning stage of new plants, optimal design of transmission and distribution systems can be obtained.

5. Voltage control

The greatest part of the voltage drop along a transmission and distribution system is due to the reactive power consumption of the system itself and at the load-end of the system. Capacitor banks can be used to compensate the voltage drop and thus stabilize the voltage.

6. Starting of large motors

The starting current for induction motors is almost purely inductive and causes a significant voltage drop, consequently disturbing other loads connected to the same bus bar and sometimes making it impossible to start the motors. To eliminate the problem, specially designed capacitors are switched in during startup.

Solution selection

Depending on the requirements, a suitable reactive power compensation solution can be selected following the product selection guide. For detailed information on each product family, please see the appropriate sections in this buyer's guide.

Applications for capacitors
Harmonic filtering

In a perfect world, the voltage and current in an electrical AC power system have a sinusoidal waveform, with specific amplitude, frequency and phase angle. In the real world however, this is seldom the case. If the voltage is measured with an oscilloscope, the sinusoidal curve is always more or less distorted by sinusoidal waves different from the fundamental frequency. These disturbances called harmonics are generated by non-linear loads in the system. The degree of distortion is dependent on the magnitude of the individual harmonics and can be expressed as Total Harmonic Distortion, THD.

145 kV filter installation in Norway.

Voltage THD is used as a contractual basis at the point of common coupling (PCC) between utilities and consumers. The THD levels vary depending on the voltage level, with requirements for lower THD the higher the voltage. For the same voltage level there can also be different limits for THD depending on the type of load.

Modern electrical equipment requires power quality

Modern electrical equipment imposes stringent demands on voltage stability and power quality. The power network must have sufficient low harmonics and other electrical disturbances. By installing harmonic filters, several benefits are obtained:

- Higher power factor, improved voltage stability and lower network losses
- Filtering of harmonics in the system
- Avoidance of resonance problems and amplification of electrical disturbances

A “clean” network also puts much less strain on equipment and lengthens its service life. This means lower maintenance costs and lower costs for replacing worn-out equipment.

What problems can harmonics cause?

- Increased losses, e.g. machines will operate at higher temperatures and can overheat
- Triggering of resonance between the inductive and capacitive parts of the power network
- Malfunctioning of control systems since electronic meters, relays, etc. are matched to the fundamental frequency
- Overloading of capacitors, leading to malfunctioning and premature aging
- Interference with telecommunications and computers
- Disturbances in ripple control systems
- High currents in neutral conductors

Where do harmonics come from?

Most types of equipment common in electrical systems today generate harmonics:

- Equipment containing electronics that control other apparatuses, e.g. variable speed drives, soft starters, static compensators, rectifiers, etc.
- Arc furnaces
- Common electrical appliances such as home electronic appliances, low energy lamps, etc.
- In certain cases, transformers, reactors and rotating machines

Harmonics are therefore present on all voltage levels in the power grid, not just in industrial networks. Harmonics are generally produced on the lower voltage levels and transmitted up to the higher levels in proportion to the strength of the network, and they cause problems for other power users.

Recommendations and international standards regarding power network distortion

The maximum acceptable voltage distortion and total harmonic distortion (THD) have been specified in various national and international standards and recommendations. ABB designs and manufactures filters according to various specifications. We discuss the choice of suitable requirements with our customers and provide recommendations. (Differing national requirements and technical considerations may determine the optimum choice.)

The most common international standards for harmonic levels are IEC 61000-2-2 /-4, EN50160 and ANSI/IEEE std. 519-1992. The standards stipulate the limits regarding individual harmonic currents or voltages, as well as THD.

IEC 61000-2-4

Total harmonic voltage distortion:

Class I (Light) 5%

Class II (Medium) 8%

Class III (Heavy) 10%

IEC 61000-2-4 also includes>

Individual odd/even harmonics

Interharmonics

Voltage changes, voltage dips, short-time interruptions, voltage unbalance, power frequency deviations

IEEE Std 519

Total Harmonic Voltage Distortion:

kV	Individual	THDV %
- 69	3.0	5
69 - 161	1.5	2.5
161 -	1.0	1.5

IEEE 519 also includes requirements in harmonic current distortion, depending on: Voltage level, load current vs. short-circuit power ratio and frequency.

Beside these international standards, there are also several national standards, such as the UK standard G5/4. The national standards might specify slightly different limit values for harmonic distortion but are generally quite similar.

Each plant needs its own solution

Thorough know-how and experience are required to properly design harmonic filters. Each plant is unique and requires its own special technical solution. Both system and component know-how are essential for finding the optimal solution in each individual case. An important component in a filter is the capacitor. Since it handles all harmonic content, it must be designed with the greatest care.

Filter design philosophy

In a network where harmonic distortion is very high, typically industrial networks, it's seldom that only one harmonic occurs at a time . More often it's a matter of several harmonics appearing simultaneously. A filter system thus has to be designed in a such way that each harmonic is dealt with separately. A filter system can then consist of several branches. An example could be a system with four branches. Three consisting of band-pass filters, which filter 3rd, 5th and 7th harmonics. The 4th branch filters the 11th harmonic and is constructed as a high-pass filter.

From analysis to commissioning

ABB has the expertise to support filter projects from beginning to end. During the entire course of a project, we concentrate on collaboration and dialog with our customer so that the best possible solution is selected and achieved.

Analysis

We analyze the plant using single-line diagrams, types and sizes of loads and mode of operation as input. The analysis culminates in a measurement plan.

Measurement

We carry out measurements in the plant under differing operating conditions. The type of activity determines the scope of the measurements. Complex processes can take several days to measure, whereas static processes do not normally involve much time. We utilize sophisticated harmonic analysis equipment and store information for subsequent processing.

Calculation

The resulting measurements are mathematically evaluated using analyzing tools. Various filter configurations and operational modes are simulated. The calculations result in a report with a recommendation as to how the filter installation should be designed to achieve the best results and where it should be located. We also calculate the distortion level anticipated after the proposed installation.

Design

ABB calculates and designs the filter. Our own production plant manufactures the capacitor units and we enjoy close cooperation with selected producers of other components such as reactors and resistors. We can also supply the relay protection for the filter, so that the correct protective level is attained.

Commissioning

We supervise installation and commissioning. Our undertaking can also include verification measurements to confirm that the performance the equipment was designed for has been achieved.

Applications for capacitors
Harmonic filtering

Benefits of installing harmonic filters

1. Reduction of overvoltage problems

The harmonic voltage is superimposed on top of the fundamental voltage, which increases the stress on insulation in electrical equipment such as transformers, cables, motors, etc. The overvoltage could also lead to shortened service life e.g. for light bulbs and fluorescent tubes in households, which besides being annoying, means more money spent on new bulbs and tubes.

2. Reduction of losses in the network

Harmonics also produce higher losses, which means higher temperatures for the equipment and system. This could lead to hot-spot failures and higher stress on insulation. All in all, the service life of the equipment is reduced and equipment operation is more expensive.

3. Improvement of wave shape quality

Electronic devices may malfunction due to harmonics. This is especially significant for devices that rely on counting the voltage zero-crossing for timing. These could be logic programmable controls, sampling devices for measuring, etc. The device will count extra voltage zero-crossings and the frequency will no longer be 50 Hz.

4. Reduction of cable overload

In low voltage systems, buildings, etc. the 3rd harmonic could cause a particular problem. The 3rd harmonic is a zero-sequence harmonic and is not detectable between phases in a balanced three-phase system. But the 3rd harmonic current from each of the three phases accumulates in the neutral conductor. This could lead to overheating of cables and strong magnetic fields along the cables.

5. Reduction of capacitor overload

The first sign of problems with harmonics however is the failure of capacitor banks installed for reactive power compensation. The capacitance reactance is lower for higher frequencies and will attract the harmonic currents. This will lead to an excess overvoltage across the capacitor and it will eventually fail.

High power quality pays

A tough competitive climate means stringent availability demands being imposed on all industrial installations. Profits are dependent on the avoidance of downtime and limiting breakdowns as much as possible. A reliable and consistent power supply is an important condition in this respect. The expression “high power quality” is of vital concern to utilities and industrial plants.

A harmonic filter represents a dependable method of achieving high power quality in the form of stable voltage and low distortion. This ensures reliable power supply and a high degree of availability.

We have unique experience

ABB Capacitors has been manufacturing power capacitors since the early 1930s. We have considerable experience in the design of harmonic filters for both different plant types and different industrial sectors. Further, we have comprehensive know-how from all other types of capacitor applications, e.g. HVDC, SVC, shunt and series compensation, etc.

Our capacitors are of the very highest quality. They are usually equipped with internal fuses, i.e. each capacitor element has an individual fuse. In this way, a stable tuning frequency, high availability and long service life are achieved.

Product selection guide

Depending on the unique requirements of each plant, a suitable harmonic filter solution can be chosen by following the product selection guide. For detailed information on each product family, please see the individual sections in this buyer’s guide.

Other applications

ABB provides a range of capacitors for special applications. Our long experience as a supplier of capacitors ensures products that meet the stringent requirements that apply for this type of equipment.

Traction

Loads from railroad applications are rapidly becoming a major factor in electrical supply grids. ABB offers a wide range of solutions to keep voltage fluctuations and harmonics within the stipulated limits. ABB's extensive experience in traction applications means both technical and economical advantages for our customers.

ABB's solutions for power factor correction and harmonic filtering are important components in our assortment for traction applications. The CHARM–BP (band-pass) and CHARM-HP (high-pass) harmonic filters are the most commonly used harmonic filter solutions in traction applications. These harmonic filters are installed in converter stations and connected between two phases. An example is a 1-phase bank with a frequency of 16 2/3 Hz. We can also conduct harmonic measurements and analyses to map sources of distortion and identify the measures needed.

Test room and laboratory applications

ABB capacitors are widely used in test room and laboratory applications. These applications are mainly classified under: (a) reactive compensation in test rooms; and (b) capacitors for generating energy in laboratories.

In reactive compensation (or shunt compensation), the tested object is compensated for its consumption of reactive power. In the absence of compensation, reactive power is needed from the network, which is normally not feasible. The application is generally not that critical from the stress point of view, but the design must fully comply with the safety requirements. Among these requirements, one is control of the parallel energy on the test bank. Test banks are designed to operate at different frequencies, such as 50 Hz, 60 Hz and 240 Hz. Test banks can be used both in 1- or 3-phase testing applications. Test banks consist of modules designed to meet customer requirements. These modules are used to achieve varying amounts of reactive power.

Application	Reactive compensation (or shunt compensation)		
Voltage range	10 - 300 kV	Power range	5 - 300 Mvar
Frequency	50/60/240 Hz	Test mode	1-phase/3-phase
AC/DC	AC	Connection	Grounded

In laboratories, capacitor banks are used to generate energy to test the capability of test objects to withstand or break high currents such as discharge or short-circuit currents. A test object could be a transformer, shunt reactor, circuit breaker, etc.
The reason for testing is to confirm the capability to withstand any current or voltage that may occur during service. The results are documented in the form of type test reports or certificates. A test laboratory that performs type tests and issues certification must be able to carry out a large number of tests to meet the requirements of the international standards. One example of these tests is the short-circuit test, which tests the capability to withstand high short-circuit currents. The synthetic test circuit that provides the necessary short-circuit current must be equipped with DC capacitors that provide the necessary energy.

ABB has a proven design for DC capacitors. For the toughest applications the capacitor elements are equipped with taps, which increases the withstand capability of the electrical joints inside the elements. This makes our capacitors the perfect choice.

Capacitor bank for test room

Other applications

Surge capacitors

A surge capacitor provides high transient voltage withstand, a design for long service life, low loss dielectrics and rugged construction.

Steep-fronted waves (lightning or switching surges) can cause damage to the turn-to-turn insulation of rotary machines and transformers. These capacitors provide premium surge protection for high voltage motors and generators. They can also be used in combination with surge arresters for added protective capability. Connecting surge capacitors line-to-ground at the motor terminals prevents damage. For a more comprehensive protection solution, surge capacitors may be used in conjunction with surge arresters. This surge pack modifies both wave shape and magnitude. Surge capacitors are designed for use in very demanding conditions.
Surge capacitors can be installed indoors or outdoors and vertically or horizontally.

Suitable for ambient temperatures not exceeding 50 °C, they are virtually maintenance-free, requiring only occasional cleaning of bushings and paint surfaces, and checks that the connections are correctly tightened.

	Single- and three-phase	Single-phase
Standard	ANSI/IEEE	IEC
	USA	Europe
Voltage	1002.4 - 24 kV	1007.2 - 36 kV
Capacitance/pole	0.13 - 0.75 µF	0.13 - 0.65 µF
Application	Surge protection	Surge protection

Motor surge protection

The combination of surge arresters and surge capacitors serve to limit the turn-to-turn insulation stress imposed on the device being protected.

The motor surge protector (MSP) includes a surge arrester and a surge capacitor in a compact modular enclosure. The system can be adapted to customer needs by adding fuses and other protective devices.

This device provides premium surge protection of high voltage motors and generators with a surge capacitor and station surge arrester combination package. The unit is factory assembled in an NEMA 3R outdoor enclosure.

The MSP is suitable for voltage ranges between 1 kV and 24 kV.

Split-phase capacitor

The economical way to combine two capacitors in one housing

The ABB split-phase capacitor unit combines two capacitors in a single housing. The split-phase capacitor units provide an economical double-star (Y-Y) unbalance detection configuration using only three units, compared with conventional designs using six units. This is particularly advantageous in low power capacitor banks in fixed, enclosed and pole-mount capacitor bank applications. The capacitor unit has three bushings consisting of one common terminal and two capacitor output terminals.

Split-phase capacitors are characterized by negligible losses and high reliability. The capacitors consist of a thin dielectric polypropylene film wound together with electrodes of aluminum foils. Discharge resistors are built in.

A biodegradable hydrocarbon compound with excellent electrical properties is used as the impregnation fluid. The container is made of surface-treated high-quality steel and the bushings and terminals are of the highest quality and reliability.

Ratings	
Max power	800 kvar (400 + 400)
Rated voltage	Up to 17.5 kV line-to-line
	Up to 10.5 kV line-to-common
Frequency	50, 60 Hz
Max current	180 A
Internal connection	Two capacitors in parallel

Other applications

Three-phase capacitor

Three-phase capacitors are characterized by negligible losses and high reliability. A capacitor consists of thin dielectric polypropylene film, wound together with electrodes of aluminum foil. Discharge resistors are built in.

A biodegradable hydrocarbon compound with excellent electrical properties is used as the impregnation fluid. The container is made of surface-treated high quality steel and the bushings and terminals are of the highest quality and reliability.

Rating	CHDTR standard	CHDTR non-standard
Max power	300 kvar	500 kvar
Voltage	2.4 kV 4.16 kV 4.8 kV	4.8 - 13.8 kV
Frequency	50, 60 Hz	50, 60 Hz
Max current	75 A	75 A
Internal connection		
Application	Power factor correction for motors and load centers	Power factor correction for motors and load centers

Product selection guide

Selection guide for bank solutions

	SHUNT COMPENSATION				HARMONIC FILTERING			
	SIKAP *)		QBANK	QPLUS	CHARM-BP	CHARM-BP/D	CHARM-HP	CHARM-C
Application								
Compensation	X	X	X	X	X	X	X	X
Inrush-limiting	-	X	-	X	X	X	X	X
Anti-resonance	-	-	-	-	-	X	-	-
Harmonic filtering	-	-	-	-	X	-	X	X
Installation								
Metal-enclosed	X	X	-	-	-	-	-	-
Enclosure IP class	IP 44	IP 44	-	-	-	-	-	-
Open-rack type	-	-	X	X	X	X	X	X
Ratings								
Voltage range, kV	1 - 24	1 - 24	1 - 800	1 - 800	1 - 500	1 - 500	1 - 500	1 - 500
Power range, Mvar	1 – 15	1 – 15	≥ 1	≥ 1	≥ 3	≥ 3	≥ 3	≥ 3
Bank connection								
Single-star, Y	X	X	X	X	-	-	-	-
Double-star, Y-Y	X	X	X	X	X	X	X	X
Bridge connection, H	-	-	X	X	X	X	X	X
Capacitor unit								
Internally fused, CHDB	X	X	X	X	X	X	X	X
Externally fused, CHDE	X	X	X	X	X	X	X	X
Fuseless, CHDF	-	-	≥ 36	≥ 36	≥ 36	≥ 36	≥ 36	≥ 36
Bird caps	-	-	Optional	Optional	Optional	Optional	Optional	Optional
Component data								
Unbalance protection CT								
Single-star, Y	-	-	-	-	-	-	-	-
Double-star, Y-Y	Standard	Standard	Standard	Standard	Standard	Standard	Standard	Standard
Bridge connection, H	-	-	Standard	Standard	Standard	Standard	Standard	Standard
Reactor	-	Standard	-	Standard	Standard	Standard	Standard	Standard
Mounting:								
Side-by-side	-	Standard	-	Standard	Standard	Standard	Standard	Standard
Stacked	-	-	-	-	Optional	Optional	-	-
Resistor	-	-	-	-	-	-	Standard	Standard
Interconnecting material	Standard	Standard	Standard	Standard	Standard	Standard	Standard	Standard
Relays								
SPAJ 160C	Optional	Optional	Optional	Optional	Optional	Optional	Optional	Optional
SPAJ 141C	Optional	Optional	Optional	Optional	Optional	Optional	Optional	Optional
Portable capacitance meter, CB-2000	Optional	Optional	Optional	Optional	Optional	Optional	Optional	Optional
Lifting device	-	-	Optional	Optional	Optional	Optional	Optional	Optional

*) Other MECB products with different characteristics are also available. More information is given in the 'Product Information'-section of this buyer's guide.

Product information

A complete program with complete support

ABB's MV/HV capacitors and capacitor banks are used in both transmission and distribution grids from 1 kV to 800 kV. There are filter installations, shunt and series compensating installations, and HVDC transmission systems all over the world, both at power utility companies and in industries.

As a customer, you gain access to an all-embracing line of capacitors and complete support in the form of analyses, calculations and suggestions on custom solutions for the generation of reactive power and harmonic filtering. Solutions that make it possible to increase active power and reduce disturbances through a smoother sinus form.

Our comprehensive product line, which apart from capacitors also includes all other equipment for transmission and distribution grids from 1 kV to 800 kV, makes us a comprehensive supplier of both individual apparatuses and complete turn-key installations.

ABB's capacitors are used all over the world

Capacitors from ABB have demonstrated their robustness and reliability at power installations around the world. Our capacitors are designed for reliable operation in all climates, from arctic cold to tropical heat.

145 kV filter installation in Oman

Product information
Capacitor unit

The ABB capacitor unit is designed for heavy duty operation in shunt, harmonic filter, series capacitor, SVC and HVDC applications in all climatic conditions.

Design features

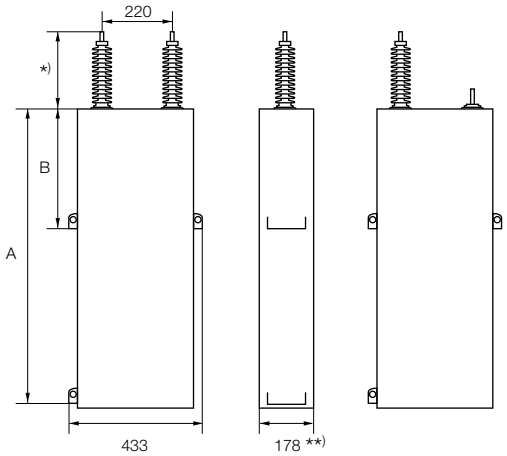
- The single-phase power capacitor is a all-film type, with low dielectric losses and long service life. The capacitors are impregnated with a hydrocarbon fluid with high insulation strength.
- The edges of the electrode foils are folded, enabling higher electrical stress.
- The capacitor units have an extremely low failure rate and high reliability.
- The capacitor units are available with internal or external fuses or fuseless designs.
- The capacitor unit is made up of a number of elements, each consisting of very thin layers of dielectric materials and thin foils of aluminum as electrodes. The elements are stacked inside the capacitor container and connected in series and parallel to accommodate the voltage and capacitance ratings specified for the entire capacitor unit. The dielectric is certainly the most influential factor for the reliability of the entire capacitor or capacitor bank. However, this is very dependent on the fuse technology and the unbalance protection arrangements.

Dimensions and maximum power ratings

Size	A	B	Weight	Power	
				50 Hz	60 Hz
	mm	mm	kg	kvar	kvar
220	240	140	23	155	185
330	295	140	28	220	260
440	345	140	32	270	325
550	405	190	39	310	370
660	460	190	44	360	430
770	525	350	49	410	490
880	635	350	59	540	645
990	685	350	63	595	715
130	750	350	67	660	790
140	820	370	73	725	870
160	920	320	82	800	960
180	1030	430	90	900	1080
200	1140	535	100	1000	1200

**) The units can also be delivered in a 138 mm configuration (slim unit)

All dimensions in mm
*) 235 or 290 mm depending on bushings type BIL 75-95 or 125 kV



Technical data

Unit type	CHDB	CHDE	CHDF
Fusing type	Internally fused	Fuseless unit with all elements connected directly in parallel (often referred to as externally fused units)	Fuseless unit with separate parallel element strings
Power range [1]	300 - 1200 kvar	100 - 500 kvar	300 – 1200 kvar
Voltage range	1 – 14.4 kV	2.4 - 25 kV	12 – 25 kV
Frequency	50 or 60 Hz	50 or 60 Hz	50 or 60 Hz
Temperature range [2]	-50 to +55 °C	-50 to +55 °C	-50 to +55 °C
Dielectric material	Polypropylene film	Polypropylene film	Polypropylene film
Impregnant	Synthetic impregnation fluid, Faradol	Synthetic impregnation fluid, Faradol	Synthetic impregnation fluid, Faradol
Discharge resistor	Built-in type	Built-in type	Built-in type
Location	Indoor/outdoor	Indoor/outdoor	Indoor/outdoor
Capacitor container			
Material	Ferritic stainless steel	Ferritic stainless steel	Ferritic stainless steel
Thickness	1.5 mm	1.5 mm	1.5 mm
Surface treatment	Mineral-blasted surface Two layers of two-component paint	Mineral-blasted surface Two layers of two-component paint	Mineral-blasted surface Two layers of two-component paint
Color	Grey, Munsell 5BG 7/1	Grey, Munsell 5BG 7/1	Grey, Munsell 5BG 7/1
Fixing brackets	One or two per side	One or two per side	One or two per side
Terminations			
Bushings	Porcelain, one or two (standard grey color)	Porcelain, one or two (standard grey color)	Porcelain, one or two (standard grey color)
Terminals	M16 x 2.0	M16 x 2.0	M16 x 2.0
Clamps	Nickel-coated brass, max. 2 x 70 mm^2	Nickel-coated brass, max. 2 x 70 mm^2	Nickel-coated brass, max. 2 x 70 mm^2
Type designation			
Unit with single bushing	CHDB XX1: Internally fused	CHDE XX1: Externally fused	CHDF XX1: Fuseless
Unit with double bushing	CHDB XX2: Internally fused	CHDE XX2: Externally fused	CHDF XX2: Fuseless

1) Values applicable for 50 Hz
2) Non-standard temperature range can be quoted on request. Test report for temperatures -55 °C is available according to GOST standard.

Product information
QBANK

QBANK is a flexible concept for open-rack shunt banks and enables very compact solutions that save space at installations based on ABB capacitor units with high reactive output. Configuration and power can be varied within a wide range.

A long-term goal has been to reduce capacitor losses and to increase the output per volume unit. CHD capacitors are a result of this development. With CHD capacitors, we tailor cost-effective and environmentally friendly capacitor banks for reactive power compensation in all types of power grids.

Design features

QBANK is built with single-phase capacitor units mounted in hot-dip galvanized steel racks. The capacitor units may be mounted vertically, but are normally horizontally mounted to fully benefit from their compact design. The units are connected in series and parallel to achieve the desired voltage and power rating. The banks are built either by placing the racks on top of each other, with any necessary insulators in between, or with the racks placed side-by-side, depending on the space available at the installation site.

An unbalance current transformer is supplied as standard when the capacitor bank is Y-Y or H connected. QBANK is supplied with internally fused, externally fused or fuseless configurations depending on the bank's voltage and power level.

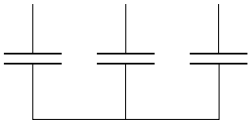
QBANK is certified according to EMC directive 89/336/EEC.

As a safety feature, the bank can be equipped with insulated wires and bird caps. See the Accessories section.

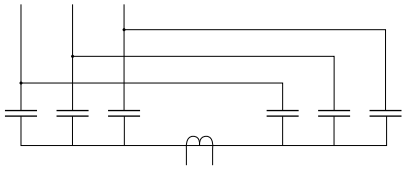
Type designation

QBANK-A	Open-rack capacitor bank with capacitor unit mounted horizontally on either side of the rack
QBANK-B	Open-rack capacitor bank with capacitor unit mounted horizontally at only one side of the rack
QBANK-C	Open-rack capacitor bank with capacitor unit mounted vertically in one rack

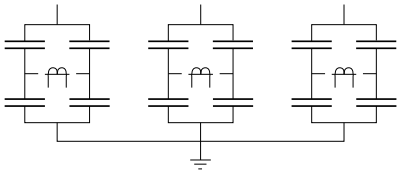
Connection diagram



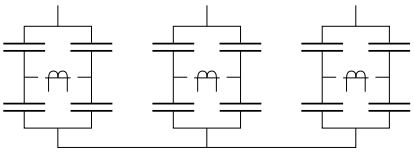
Single-Y (Y) connection



Double-Y (Y-Y) connection



Bridge connection for grounded system, Y-0-H



Bridge connection for ungrounded system, Y-H

Technical data

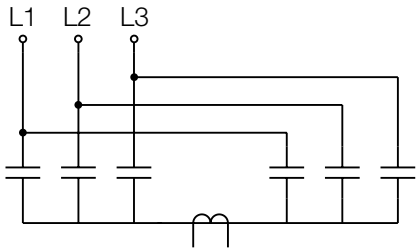
Power rating	From 1 Mvar
Voltage rating	1 to 800 kV
Frequency	50 or 60 Hz (other frequencies on request)
Bank connection types	Single-Y (Y) connection Double-Y (Y-Y) connection Bridge connection for grounded system, Y-0-H Bridge connection for ungrounded system, Y-H, etc.
Bank protection	Unbalance CT for Y-Y & H connection
Fuse technology	Internally fused, CHDB Externally fused (conventional fuseless type), CHDE Fuseless type, CHDF
Temperature range [1]	-50 to +55 °C
Installation	Indoor or outdoor
Scope of supply	– Single-phase capacitor units mounted in hot-dip galvanized steel racks complete with necessary support insulators and internal connections. – CT for capacitor bank unbalance protection when bank is in double-star (Y-Y) or bridge (H) configuration. – Standard interconnecting material between capacitor bank and unbalance CT.

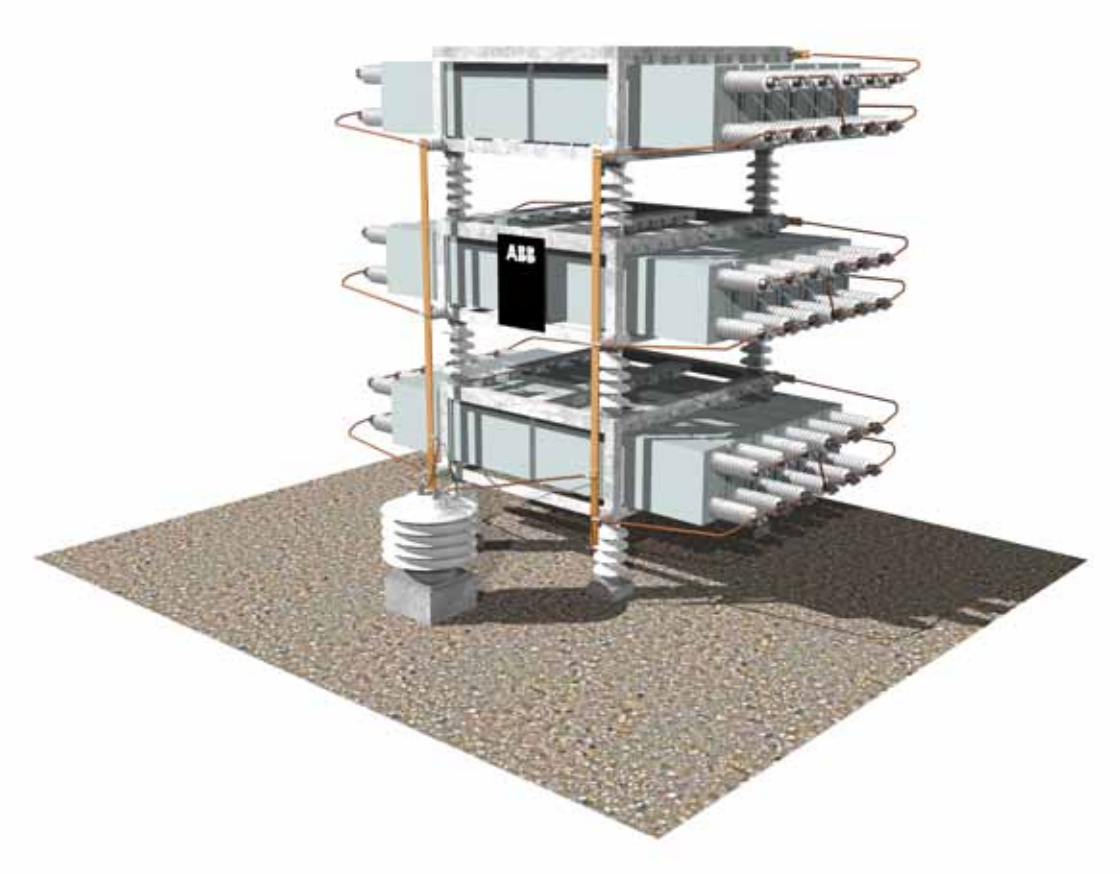
[1] Non-standard temperature range can be quoted on request.

Product information
QBANK-A – Examples

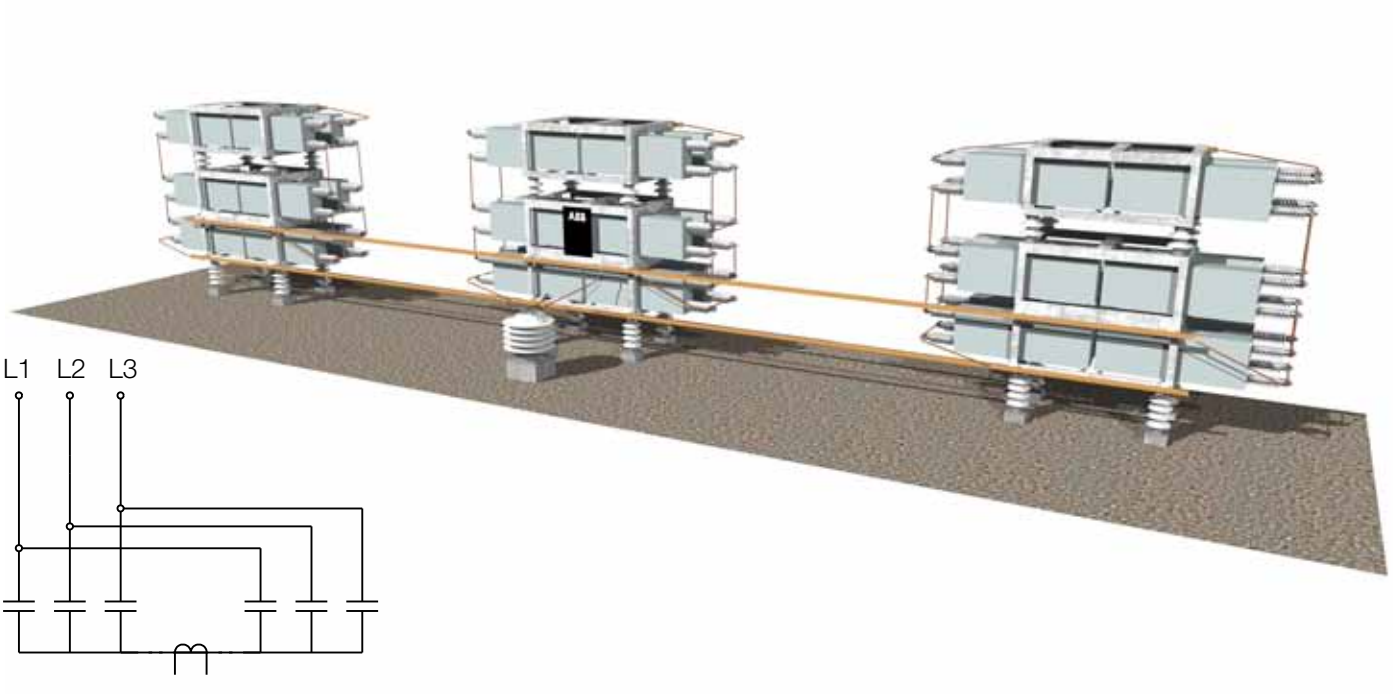
Large banks (12 units and more)

Three racks, one per phase, mounted on top of each other with insulators in between, is a common arrangement for bank voltages up to 52 kV. The maximum number of units is sixty. For higher voltages or more capacitor units, the phases of the bank are placed side-by-side. The racks are then placed on top of each other, with insulators in between, for each phase. In principle, there is no limit for voltage, power or number of capacitor units for the QBANK-A type of capacitor bank.

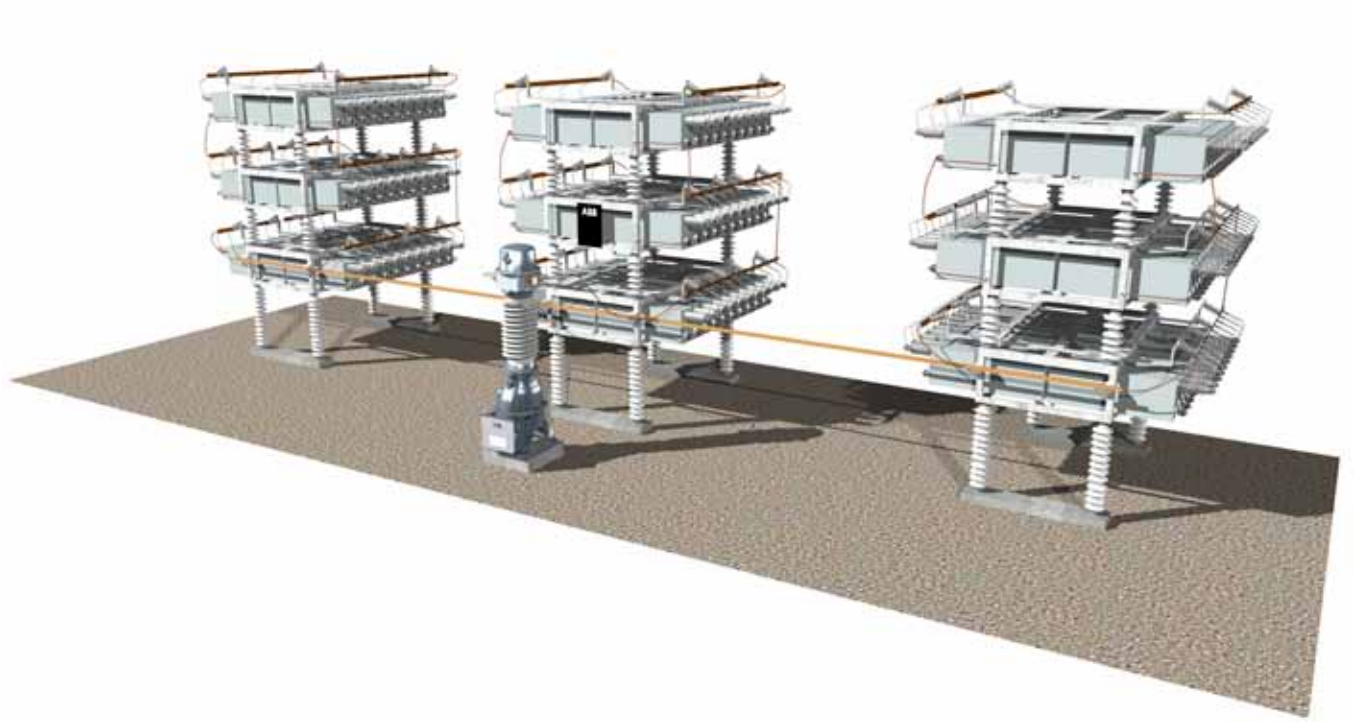




Three-phase stacked capacitor bank (internally fused units)



Single-phase stacked capacitor bank (internally fused units)

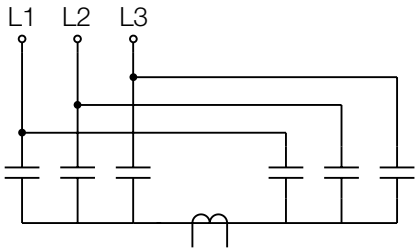


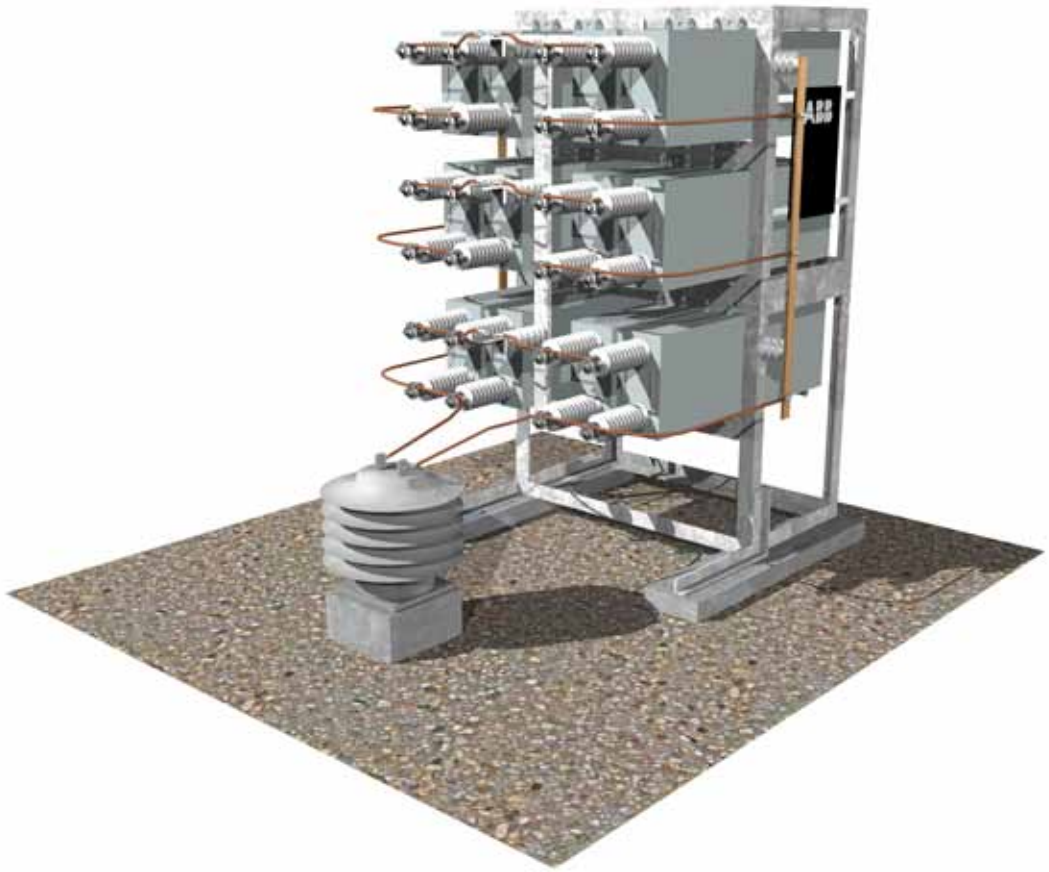
Single-phase stacked capacitor bank (externally fused units)

Product information
QBANK-B – Example

Medium banks (9–30 units)

This type of capacitor bank can only be built with internally fused capacitors units. Horizontally mounted units are installed at one side of the rack only. The highest rated voltage for QBANK-B is 24 kV and the maximum number of capacitor units is thirty.



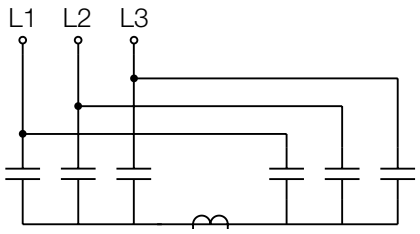


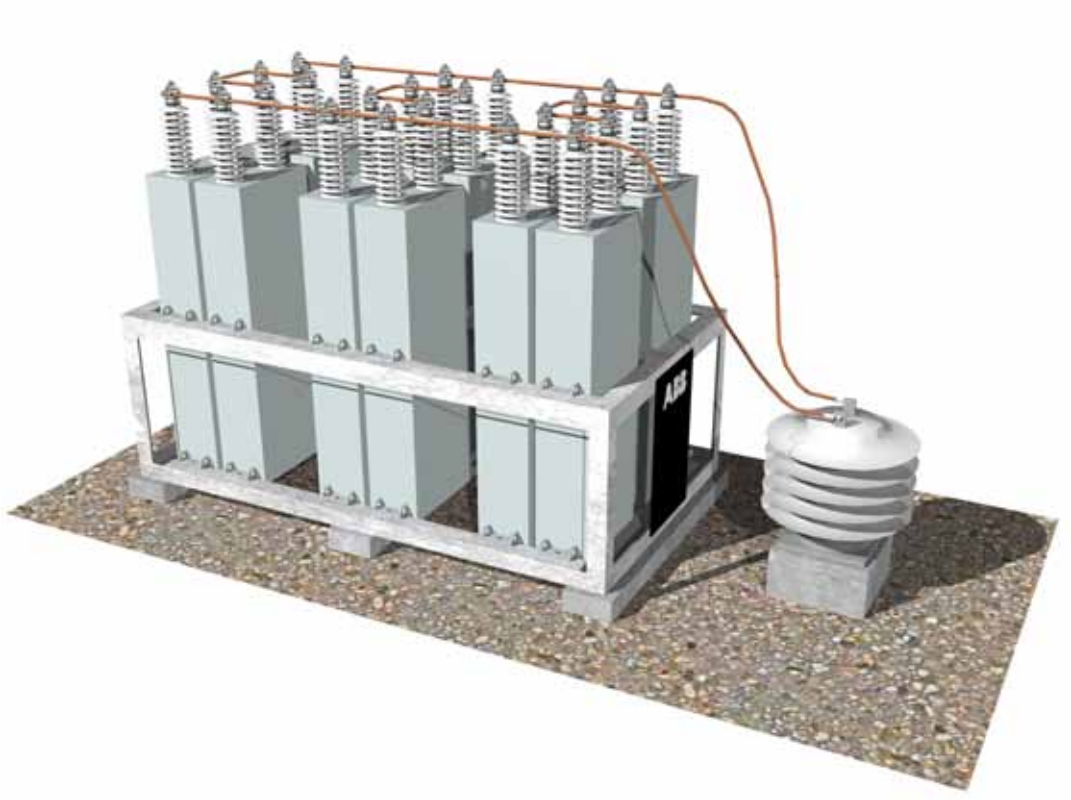
Three-phase stacked capacitor bank (internally fused units)
(A current transformer can also be mounted on top of the bank.)

Product information
QBANK-C – Example

Small banks (3–18 units)

In small capacitors banks, the units are normally mounted vertically in one rack. The highest rated voltage for QBANK-C is 24 kV and the maximum number of capacitor units is eighteen. Banks of three or six units are normally mounted in one rack and with no unbalance protection provided.





Three-phase stacked capacitor bank (internally fused units)

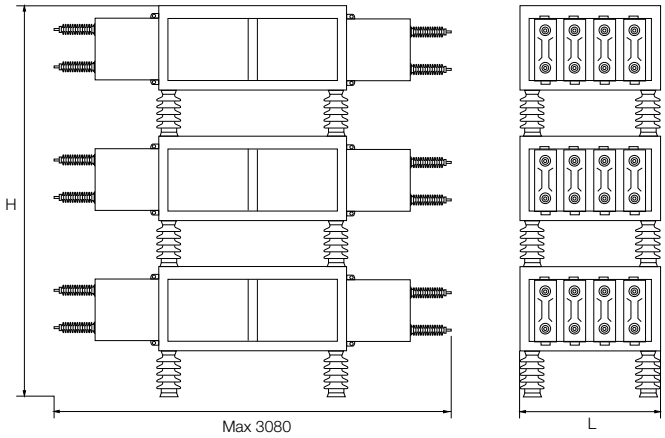
Product information
QBANK — Standard layout drawings

QBANK-A: Large banks (12 units and more)

QBANK-A. Internal fuses. Dimensions and weights

No. of units	L (mm) 12 kV	L (mm) 24 kV	L (mm) 36 kV	L (mm) 52 kV	Weight (kg)
12	840	840	840	-	2150
18	840	1050	840	-	2800
24	1050	1050	-	1050	3450
30	1050	1470	-	-	4100
36	1470	1470	1470	1890	4750
42	1680	1890	-	-	5450
48	1890	1890	-	1890	6100
54	2100	2310	2310	-	6750
60	2310	2310	-	-	7400

	12 kV	24 kV	36 kV	52 kV
H (mm)	2205	2495	2890	3300

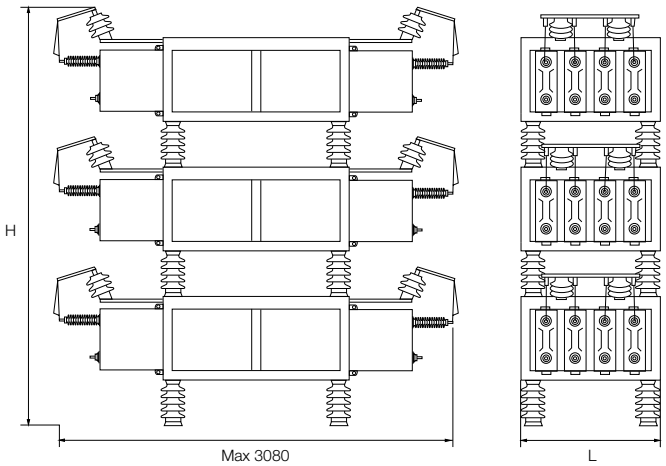


Connection Y-Y

QBANK-A. External fuses. Dimensions and weights

No. of units	L (mm) 12 kV	L (mm) 24 kV	L (mm) 36 kV	L (mm) 52 kV	Weight (kg)
12	840	840	840	-	2250
18	840	1050	840	-	2900
24	1050	1050	-	1050	3550
30	1050	1470	-	-	4250
36	1470	1470	1470	1890	4900
42	1680	1890	-	-	5650
48	1890	1890	-	1890	6350
54	2100	2310	2310	-	7050
60	2310	2310	-	-	7700

	12 kV	24 kV	36 kV	52 kV
H (mm)	2355	2645	3040	3450

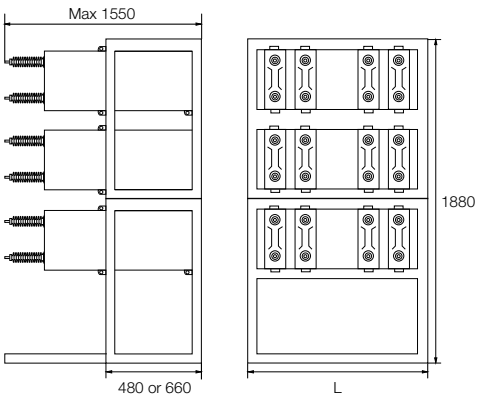


Connection Y-Y

QBANK-B: Medium banks (9–27 units)

QBANK-B. Internal fuses. Dimensions and weights

No. of units	L (mm) 12 kV	L (mm) 24 kV	Weight (kg)
6	840	840	850
9	1050		1150
12	1260	1260	1450
15	1470		1850
18	1680	1680	2150
21	1890		2500
24	2100	2100	2800
27	2310		3150



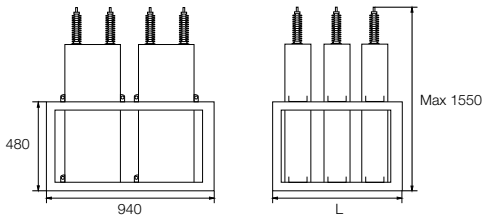
Connection Y-Y

QBANK-C: Small banks (3–18 units)

QBANK-C. Internal fuses. Dimensions and weights

No. of units	L (mm) 12 kV	L (mm) 24 kV	Weight (kg)
6	840	1260 *)	700
9	1470		1050
12	1470	1890	1350
15	2100		1690
18	2100		1990

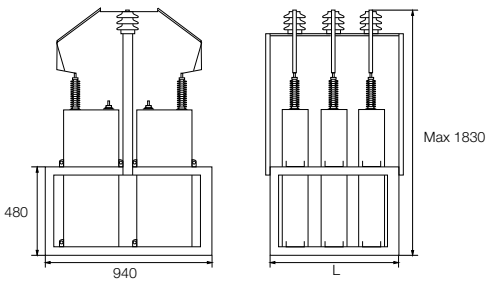
*) Connection: Y



Connection Y-Y

QBANK-C. External fuses. Dimensions and weights

No. of units	L (mm) 12 kV	L (mm) 24 kV	Weight (kg)
6		1260	720
9		1890	1080
12		1890	1380
15		2100	1720
18		2100	2020



Connection Y-Y

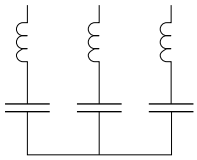
Product information
QPLUS

QPLUS is a flexible concept for open-rack capacitor banks (QBANK) used in combination with damping reactors designed to limit switching inrush currents.
When a capacitor is switched into a supply, there is a powerful current surge because initially the capacitor appears to be a short circuit. This current surge will be particularly large if the capacitor is connected in parallel with one or more capacitors that are already charged.

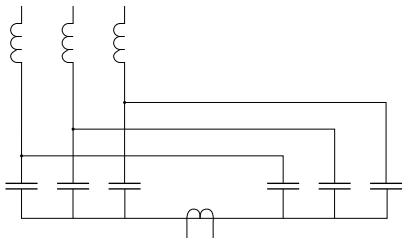
If the damping inductance between the capacitor banks is too low, it may be necessary to connect series reactors between such capacitor banks due to the possible stresses on the circuit breakers and even on the capacitor themselves.

These reactors are often referred to as inrush current limiting reactors or damping reactors. Damping reactors also provide protection for capacitor banks from outrush currents.

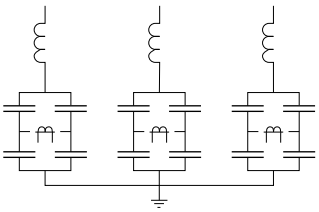
Connection diagram



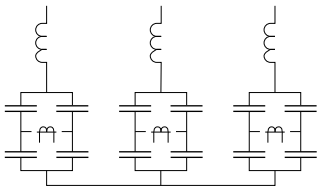
Single-Y (Y) connection



Double-Y (Y-Y) connection



Bridge connection for grounded system, Y-0-H



Bridge connection for ungrounded system, Y-H

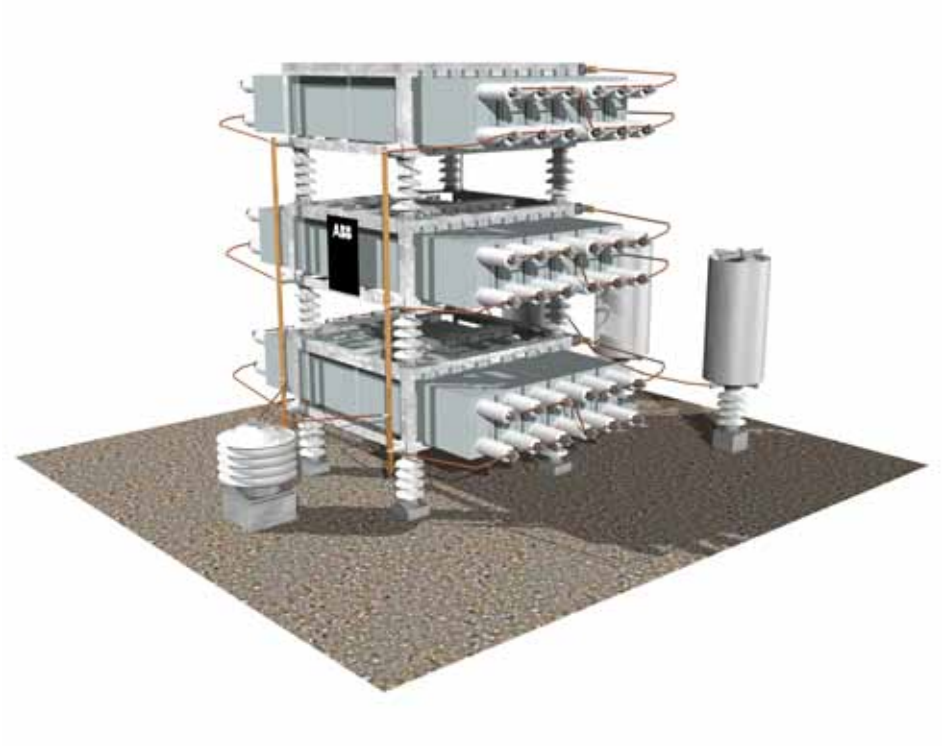
Technical data

Power rating	From 1 Mvar
Voltage rating	1 to 800 kV
Frequency	50 or 60 Hz (other frequencies on request)
Bank connection types	Single-Y (Y) connection Double-Y (Y-Y) connection Bridge connection for grounded system, Y-0-H Bridge connection for ungrounded system, Y-H, etc.
Bank protection	Unbalance CT for Y-Y & H connection
Fuse technology	Internally fused, CHDB Externally fused (conventional fuseless type), CHDE Fuseless type, CHDF
Temperature range [1]	-50 to +55 °C
Installation	Indoor or outdoor
Scope of supply	– Single-phase capacitor units mounted in hot-dip galvanized steel racks complete with necessary support insulators and internal connections. – CT for capacitor bank unbalance protection when bank is in double-star (Y-Y) or bridge (H) configuration. – Damping or inrush current limiting reactor – Standard interconnecting material between capacitor bank, unbalance CT and reactor.

[1] Non-standard temperature range can be quoted on request.

Product information
QPLUS – Example

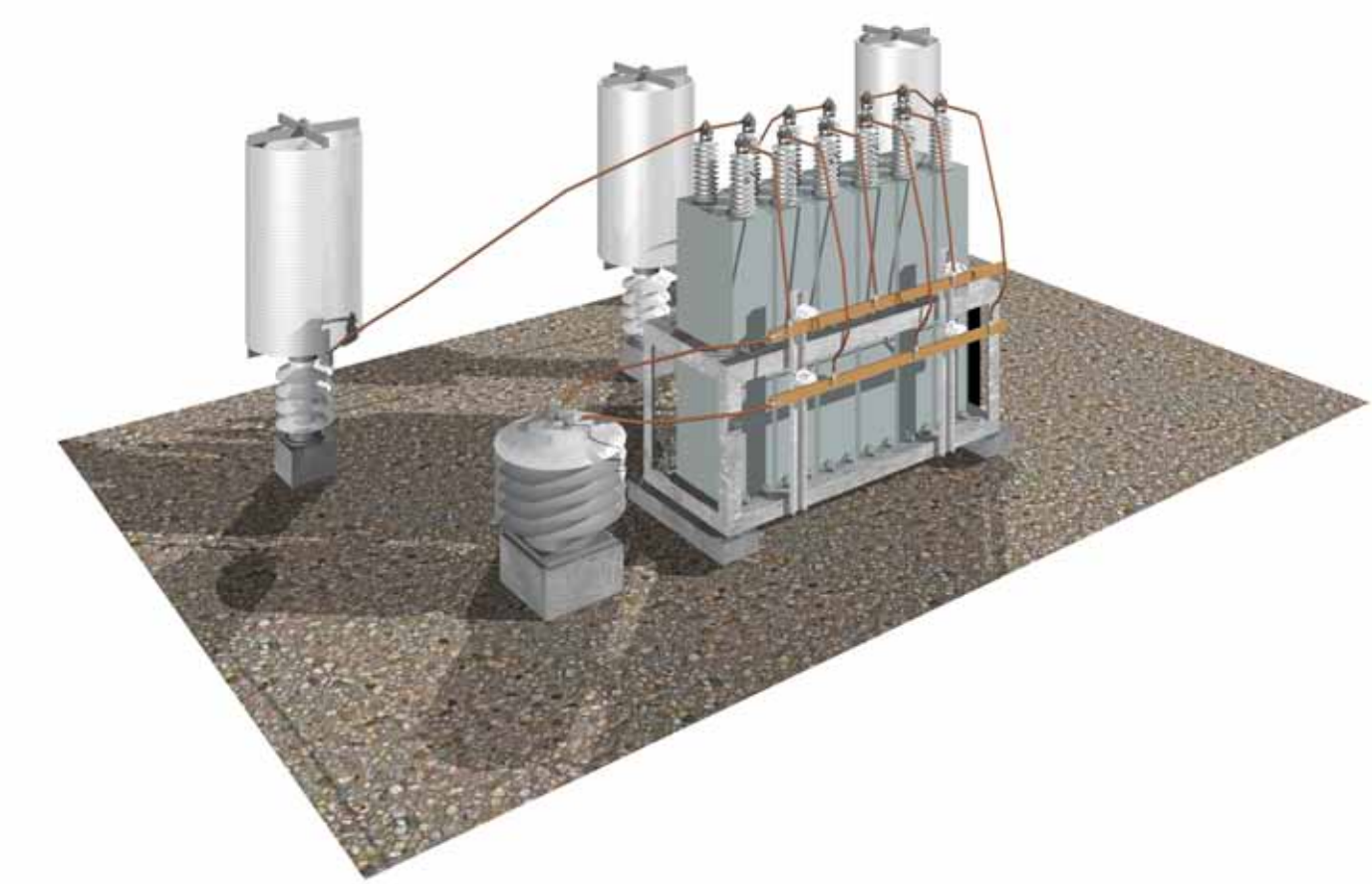
Three-phase stacked capacitor bank, QBANK-A, with damping reactor



Three-phase stacked capacitor bank, QBANK-B, with damping reactor

Product information
QPLUS – Example

Three-phase stacked capacitor bank, QBANK-C, with damping reactor

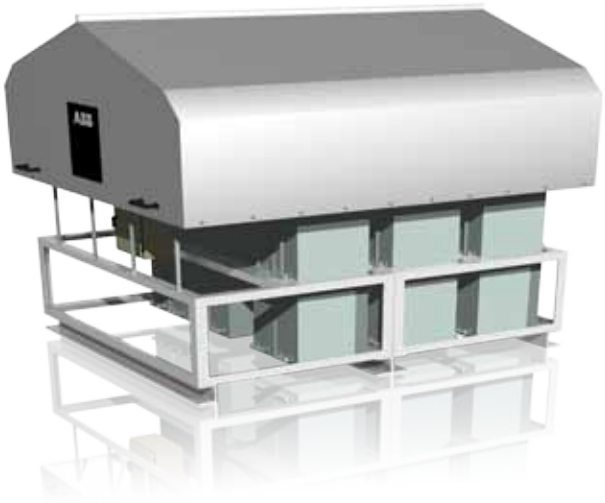


Product information
SIKAP

SIKAP is an economical form of enclosed capacitor bank with protection from exposure to live parts being of the highest priority.

Design features

- Increases personal safety by avoiding direct contact with live parts
- Provides protection against short-circuits caused by animals
- An aluminum enclosure designed to cover live parts that eliminates need for any extra protective fencing
- Compact design
- ABB impregnated capacitors with long service life time and low losses
- Internal electrical wiring between all units
- Can be equipped with damping reactor if needed



Enclosed capacitor bank SIKAP 18

Type designation

SIKAP 3	Capacitor bank consisting of 3 capacitor units
SIKAP 6	Capacitor bank consisting of 6 capacitor units
SIKAP 9	Capacitor bank consisting of 9 capacitor units
SIKAP 12	Capacitor bank consisting of 12 capacitor units
SIKAP 15	Capacitor bank consisting of 15 capacitor units
SIKAP 18	Capacitor bank consisting of 18 capacitor units

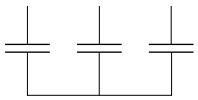
Technical data

Power rating	1 - 15 Mvar
Voltage rating	1 - 24 kV
Frequency	50 or 60 Hz
Bank connection types	Single-star, (Y) Double-star, (Y-Y)
Bank protection	Unbalance CT for Y-Y connection
Fuse technology	Internally fused, CHDB
Temperature range [1]	-40 to +40 °C
Installation	Indoor or outdoor
Enclosure protection class	IP 44
Incoming cable terminals	3 x 100 mm^2, maximum
Scope of supply	– Single-phase capacitor units mounted in hot-dip galvanized steel racks complete with internal connections and housed inside IP 44 metal enclosure designed to cover live parts. – CT for capacitor bank unbalance protection when bank is in double-star (Y-Y) configuration. – Damping or inrush current limiting reactor (optional) – Standard interconnecting material between capacitor bank, unbalance CT and reactor.

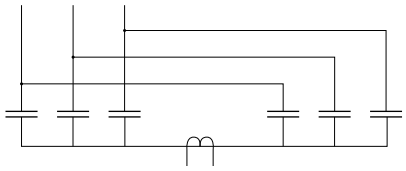
[1] Non-standard temperature range can be quoted on request.

Product information
SIKAP — Examples

Connection diagram — SIKAP without damping reactors



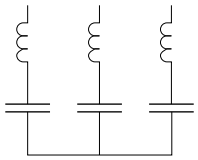
Single-Y (Y) connection



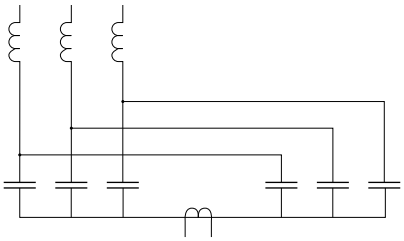
Double-Y (Y-Y) connection

SIKAP 12

Connection diagram — SIKAP with damping reactors

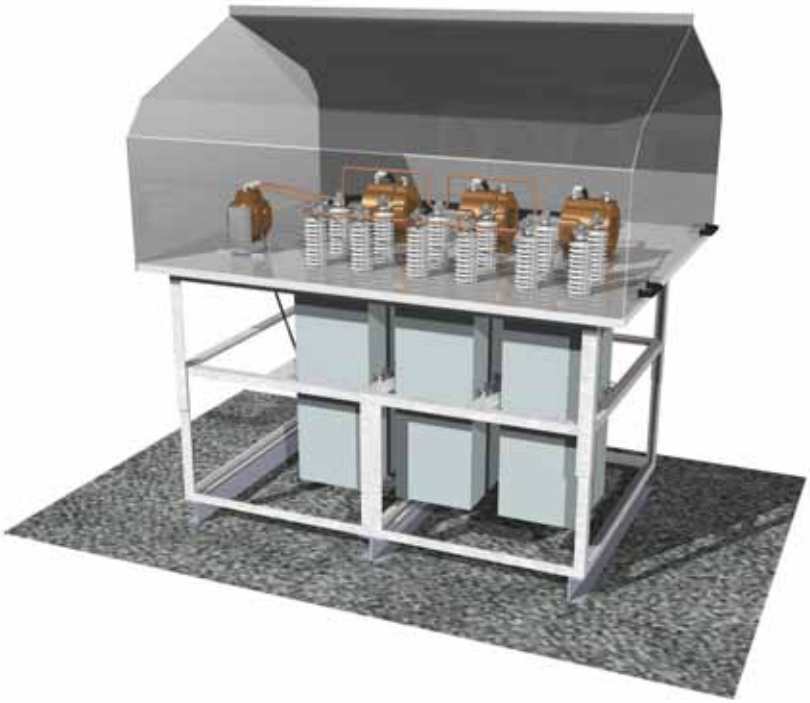


Single-Y (Y) connection



Double-Y (Y-Y) connection

SIKAP 6



Product information
ABBACUS

The ABBACUS Metal-enclosed Capacitor Bank (MECB) is a fully integrated ABB solution for reactive compensation in medium voltage networks. The design of the ABBACUS provides compensation for both electrical distribution utilities and large industrial power users including mining, pulp and paper, chemical, petrochemical, wind farms, plastics and heavy industries. The ABBACUS can also be designed to provide passive harmonic filtering solutions.

Design features
- Consists of ABB's premium range of components
- Factory tested
- Integrated design of primary and secondary equipment
- Range of enclosure types to suit a variety of applications
- Proven ABB design reducing life cycle costs
- Fully enclosed design protecting live parts
- Type tested bus bar system
- Modular in design and easily expandable
- Relocatable asset, can be moved as plant demands change
- Flexibility in the range of options available to suit differing applications

Technical data

Voltage	1-36 kV
Maximum output	> 20 Mvar
Frequency	50 or 60 Hz
Location	Indoor or outdoor
Ambient temperature	-40/+55 °C
Altitude	< 1000 m above sea level
Humidity	Maximum 90% RH non-condensing
Insulation level	≤ 12 kV 28/75 kV BIL
	≤ 12 kV - 17.5 kV 38/95 kV BIL
	≤ 17.5 kV - 24 kV 50/125 kV BIL
	≤ 24 kV - 36 kV 70/170 kV BIL
Short-circuit current	Up to 50 kA for 1 second
Bank configuration	Fixed, switched, single or multistep
Standards	IEC or equivalent

Product information
EMPAC

EMPAC MV fixed metal-enclosed capacitor banks in double star configuration are used for distribution substations and wind farms. EMPAC is designed for indoor/outdoor substations where space is an issue. They are available with or without a SF_6 circuit breaker depending on customer needs.

Design features

- Compact design resulting in a small footprint and height.
- Fully enclosed design protecting live parts. Interlocking scheme between circuit breaker and grounding switch is always fitted for human protection. Live line indicators as well as integral interlocking scheme are also available on request.
- Same footprint and volume in case of Mvar expansion
- Very easy handling and lifting. No additional assembly required on site.
- SF_6 breaker mechanically staggered for synchronized switching where switching transients are critical (optional)
- Very easy replacement of components in the event of failure or malfunction.

Technical data

Rated voltage	From 1 kV to 36 kV
Maximum output	10.6 Mvar at 24 kV / 16 Mvar at 36 kV
Capacitor configuration	Double star / Single star (on request)
IP rating	IP 23 - IP 44
Frequency	50 or 60 Hz
Standard	IEC or equivalent
Location	Indoor or outdoor
Temperature	-25 ºC up to +55 °C
Short-circuit current	40 kA for 1s
Circuit breaker	SF_6, 3-pole
Inrush reactors	Epoxi resin cast
Current transformers	Epoxi resin cast, X/5 A
Earth switch	Air insulated
Optional	Fast discharge reactors
	Live line indication
	Protection relay

Product information
Harmonic filter, CHARM-BP

Band-pass filters are generally used for lower harmonics (normally up to 7th harmonic) and when there is no risk for resonance.

Design information
Band-pass filter circuit consisting of a reactor connected in series with a capacitor. Band-pass filters will have the following impact on the network:

- Low impedance at the resonant frequency of the circuit
- Capacitive behavior below the resonant frequency
- Inductive behavior above the resonant frequency

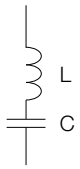
Type designation
The type designation itself provides detailed information about the product and its use. See the figure below:

CHARM-BP

Product family name: Harmonic filtering application

Type of harmonic filter characteristics: Band-pass

Schematic

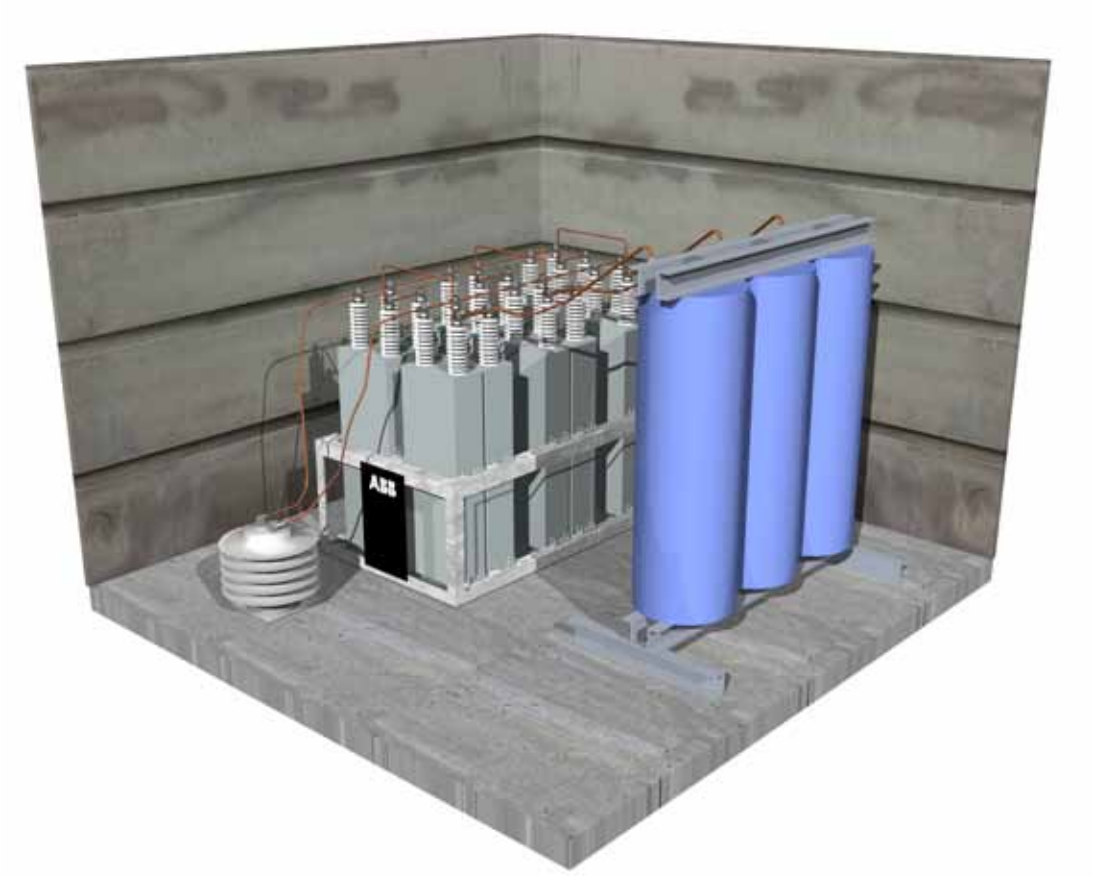


Band-pass filter

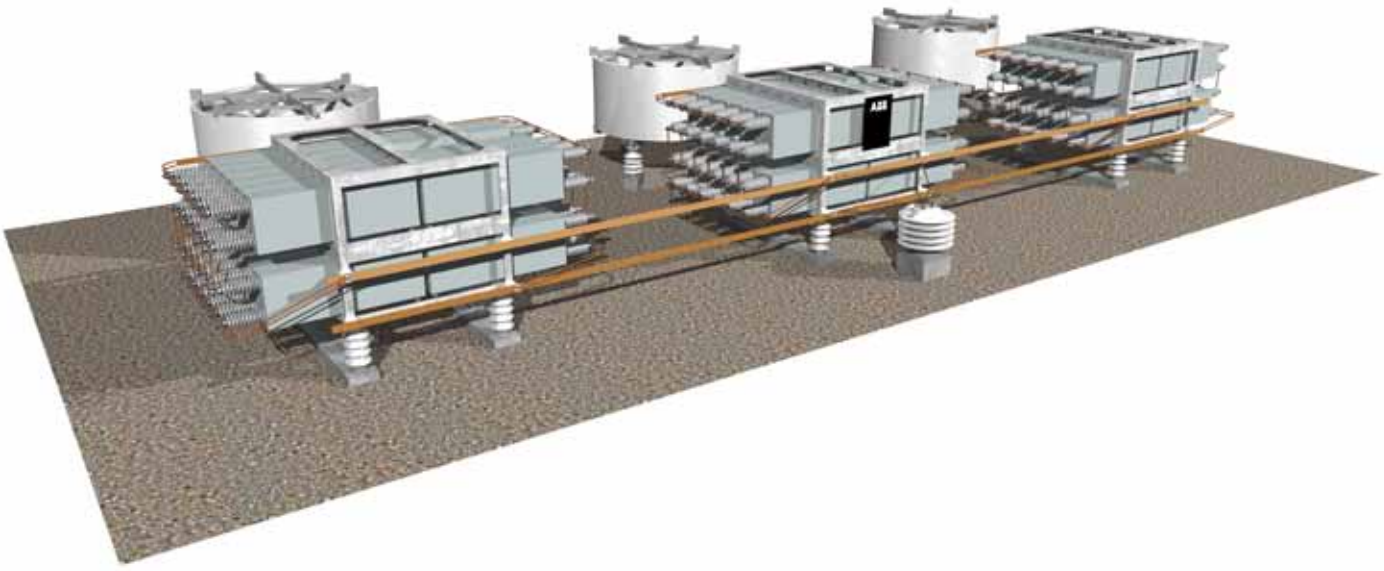
Technical data

Power rating	From 3 Mvar
Voltage rating	1 to 500 kV
Frequency	50 or 60 Hz
Bank connection types	Single-Y (Y) connection Double-Y (Y-Y) connection Bridge connection for grounded system, Y-0-H Bridge connection for ungrounded system, Y-H, etc.
Bank protection	Unbalance CT for Y-Y & H connection
Fuse technology	Internally fused, CHDB Externally fused (conventional fuseless type), CHDE Fuseless type, CHDF
Temperature range [1]	-50 to +55 °C
Installation	Indoor or outdoor
Scope of supply	– Single-phase capacitor units mounted in hot-dip galvanized steel racks complete with necessary support insulators and internal connections. – CT for capacitor bank unbalance protection when bank is in double-star (Y-Y) or bridge (H) configuration. – Filter reactor – Standard interconnecting material between capacitor bank, unbalance CT and reactor.

[1] Non-standard temperature range can be quoted on request.



Band-pass filter for indoor installation with iron core reactor



Band-pass filter for outdoor installation with air core reactor

Product information
Harmonic filter, CHARM-BP/D

A special application of band-pass filters is the anti-resonance filter, also known as a de-tuned filter.

Detuned filter banks are used when total harmonic distortion or individual harmonic current is not above the acceptable limits. In detuned filter banks, tuning frequency is chosen to not be close to a harmonic, which means that it is detuned rather than fine-tuned to the harmonic. A detuned filter can often be regarded as a standard component designed to generate reactive power without magnifying the harmonics present in the network. A detuned band-pass filter will have the following impact on the network:

- Low impedance at the resonant frequency of the circuit
- Capacitive behavior below the resonant frequency
- Inductive behavior above the resonant frequency

Type designation

The type designation itself gives detailed information about the product and its use. See the figure below:

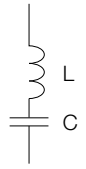
Special application anti resonance detuned filter

CHARM-BP/D

Product family name: Harmonic filtering application

Type of harmonic filter characteristics: Band-pass

Schematic

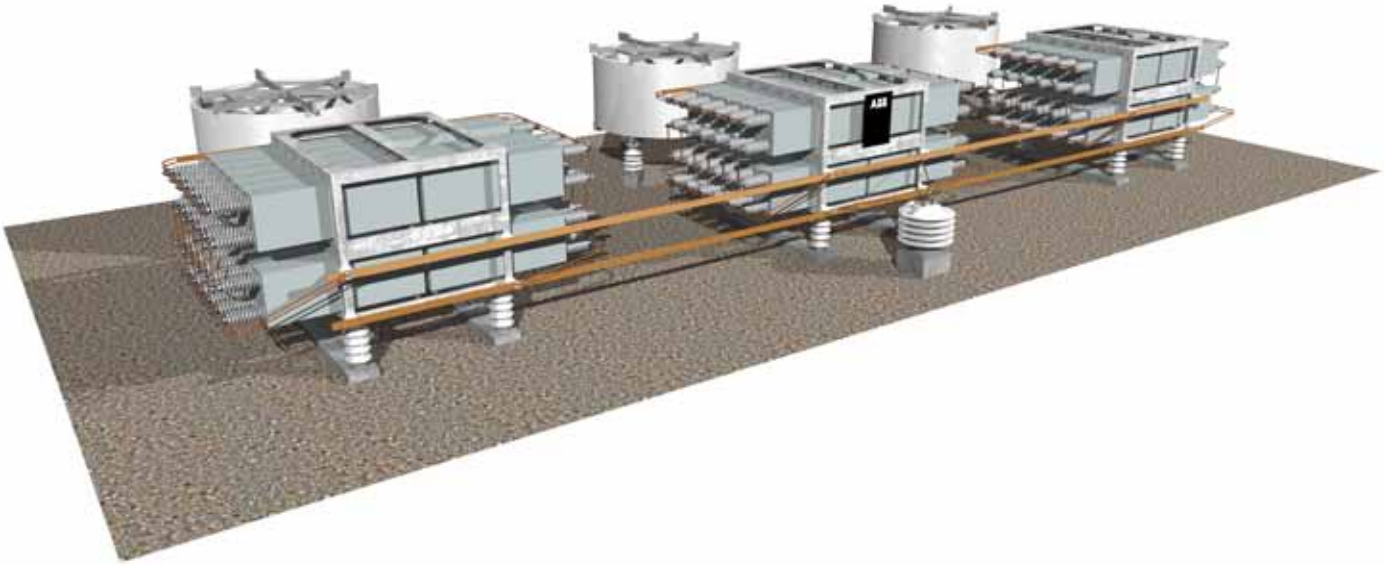


Band-pass filter

Technical data

Power rating	From 3 Mvar
Voltage rating	1 to 500 kV
Frequency	50 or 60 Hz
Bank connection types	Single-Y (Y) connection Double-Y (Y-Y) connection Bridge connection for grounded system, Y-0-H Bridge connection for ungrounded system, Y-H, etc.
Bank protection	Unbalance CT for Y-Y & H connection
Fuse technology	Internally fused, CHDB Externally fused (conventional fuseless type), CHDE Fuseless type, CHDF
Temperature range [1]	-50 to +55 °C
Installation	Indoor or outdoor
Scope of supply	– Single-phase capacitor units mounted in hot-dip galvanized steel racks complete with necessary support insulators and internal connections. – CT for capacitor bank unbalance protection when bank is in double-star (Y-Y) or bridge (H) configuration. – Detuned reactor – Standard interconnecting material between capacitor bank, unbalance CT and reactor.

[1] Non-standard temperature range can be quoted on request.



Detuned type band-pass filter with one-phase stacked capacitor bank

Product information
Harmonic filter, CHARM-HP

In heavy industrial networks, harmonic distortion and network conditions may vary during different duty cycles. For this reason it may be difficult to avoid parallel resonance and increased harmonic distortion. The parallel resonance can be dampened by using a high-pass filter. High-pass filters are commonly used for filtering higher order harmonics.

Design information

By adding a resistor in parallel with the reactor in the band-pass filter, the filter will become a high-pass filter and the behavior of the filter will change. The introduction of the resistor will imply

- Better filtering characteristics for higher frequencies
- Higher impedance (less filtering effect) at tuning frequency
- Reduced amplification at parallel resonance frequency
- Higher filter losses at the fundamental frequency

High-pass filters are often used in combination with band-pass filters in cases when the harmonic load is heavy and the requirement for harmonic distortion is high. The damping resistor in the high-pass filter helps reduce magnification of the parallel resonance and helps create a more rigid filter system.

Type designation

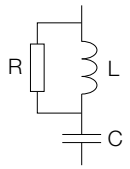
The type designation itself gives detailed information about the product and its use. See the figure below:

CHARM-HP

Product family name: Harmonic filtering application

Type of harmonic filter characteristics: High-pass

Schematic

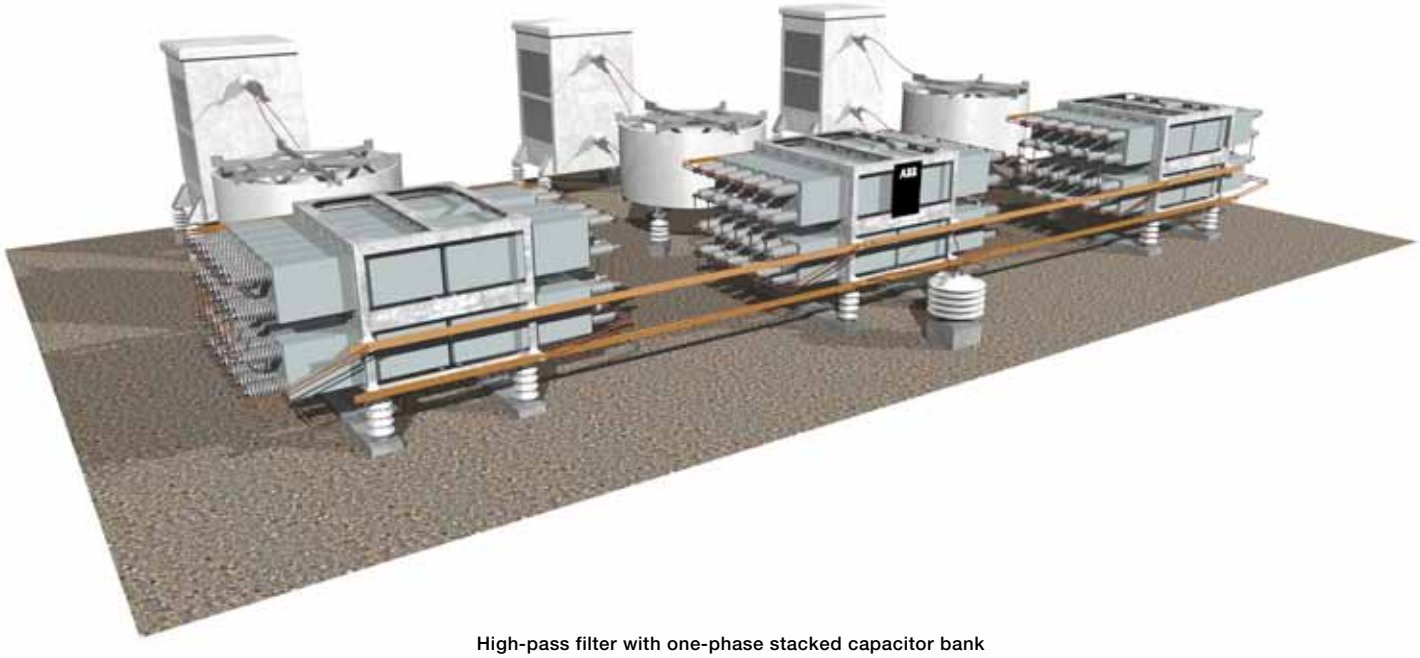


High-pass filter

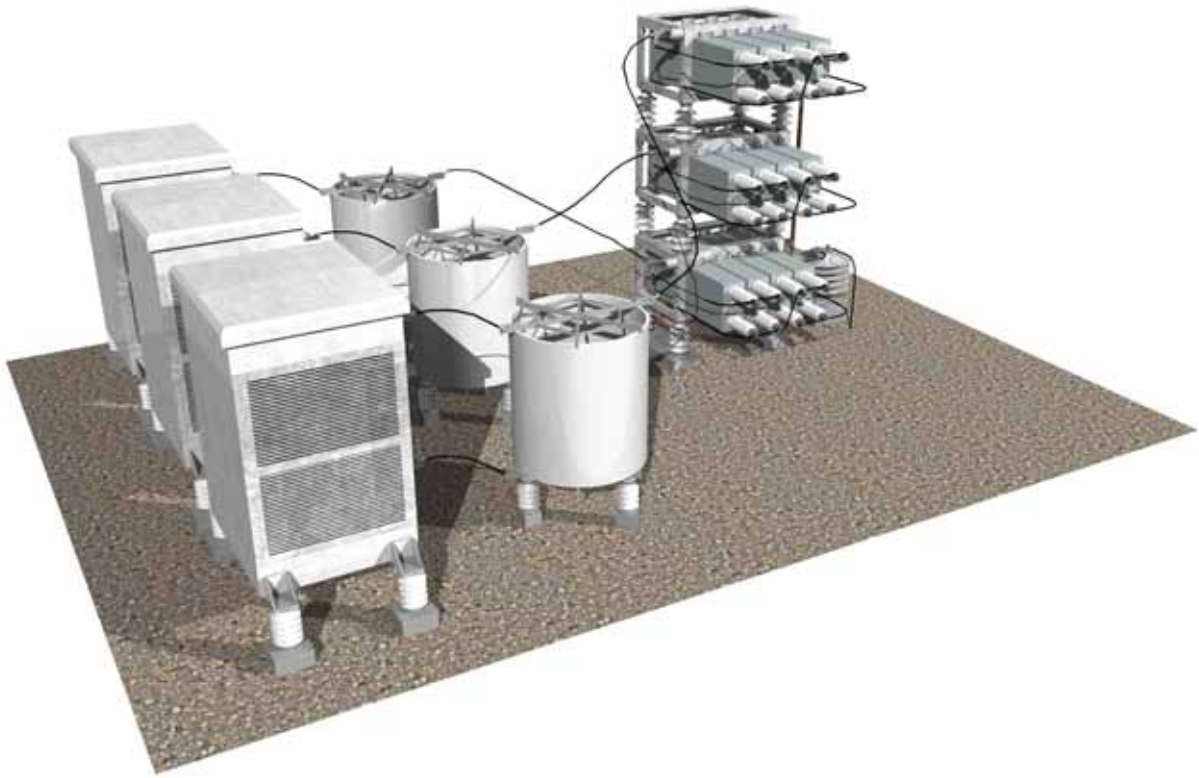
Technical data

Power rating	From 3 Mvar
Voltage rating	1 to 500 kV
Frequency	50 or 60 Hz
Bank connection types	Single-Y (Y) connection Double-Y (Y-Y) connection Bridge connection for grounded system, Y-0-H Bridge connection for ungrounded system, Y-H, etc.
Bank protection	Unbalance CT for Y-Y & H connection
Fuse technology	Internally fused, CHDB Externally fused (conventional fuseless type), CHDE Fuseless type, CHDF
Temperature range [1]	-50 to +55 °C
Installation	Indoor or outdoor
Scope of supply	– Single-phase capacitor units mounted in hot-dip galvanized steel racks complete with necessary support insulators and internal connections. – CT for capacitor bank unbalance protection when bank is in double-star (Y-Y) or bridge (H) configuration. – Filter reactor – Filter resistor – Standard interconnecting material between capacitor bank, unbalance CT, reactor and resistor

[1] Non-standard temperature range can be quoted on request.

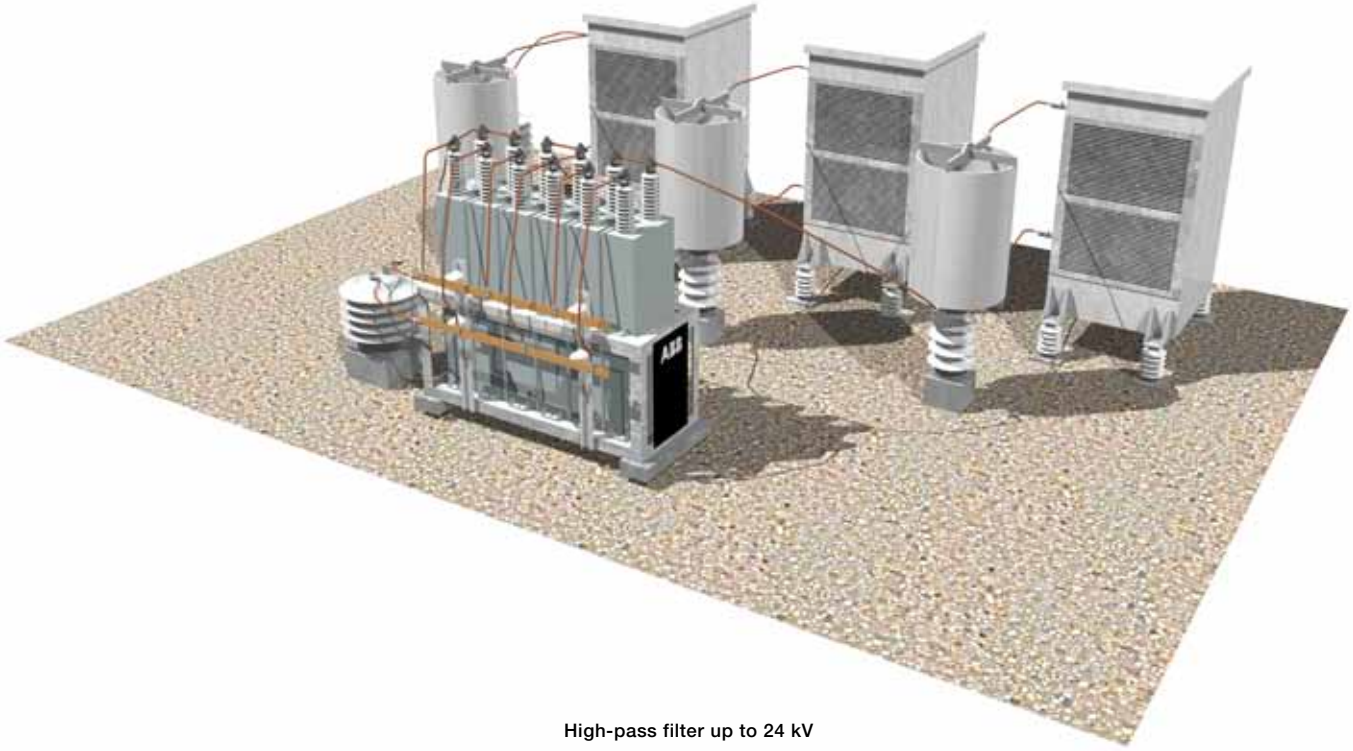


High-pass filter with one-phase stacked capacitor bank



High-pass filter with three-phase stacked capacitor bank

Product information
Harmonic filter, CHARM-HP



High-pass filter up to 24 kV

Product information
Harmonic filter, CHARM-C

C-type filters are commonly used in heavy industrial networks, such as steel mills with electric arc furnaces, rolling mills with cyclo-converters, etc. C-type filters are often used as one or more of the filter branches in static var compensators. It has also become increasingly common to install C-type filters in high voltage transmission and distribution systems, often as 3rd harmonic filters. The heavy damping in the filter makes it a perfect choice for situations when the harmonic pollution is unknown or when the future harmonic distortion is difficult to predict. C-type filters will provide reactive power and voltage stability and also reduce any harmonic pollution.

Design information

The C-type filter is a modified high-pass filter for low tuning and heavy damping, and reducing losses. In this filter, the resistor is short-circuited for the fundamental frequency by means of an extra capacitor connected in series with the reactor; see figure the below. By doing this, the fundamental losses in the resistor can be nearly eliminated.

A C-type filter is a heavily damped high-pass filter. The filter reactor and capacitor C_2 create a circuit tuned to the fundamental frequency. This means that there is no fundamental voltage drop across the circuit and thereby no added voltage across the main capacitor C_1, and the reactive power generated by C_1 is fed to the network via the tuned circuit L + C_2. C_1 and C_2 together with L create another tuned circuit for the network and that acts as a harmonic filter.

CHARM-C filter is often referred as MSCDN, mechanically switched capacitor with damping network.

Type designation

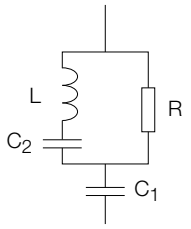
The type designation itself gives detailed information about the product and its use. See the figure below:

CHARM-C

Product family name: Harmonic filtering application

Type of harmonic filter characteristics: C-type filter

Schematic



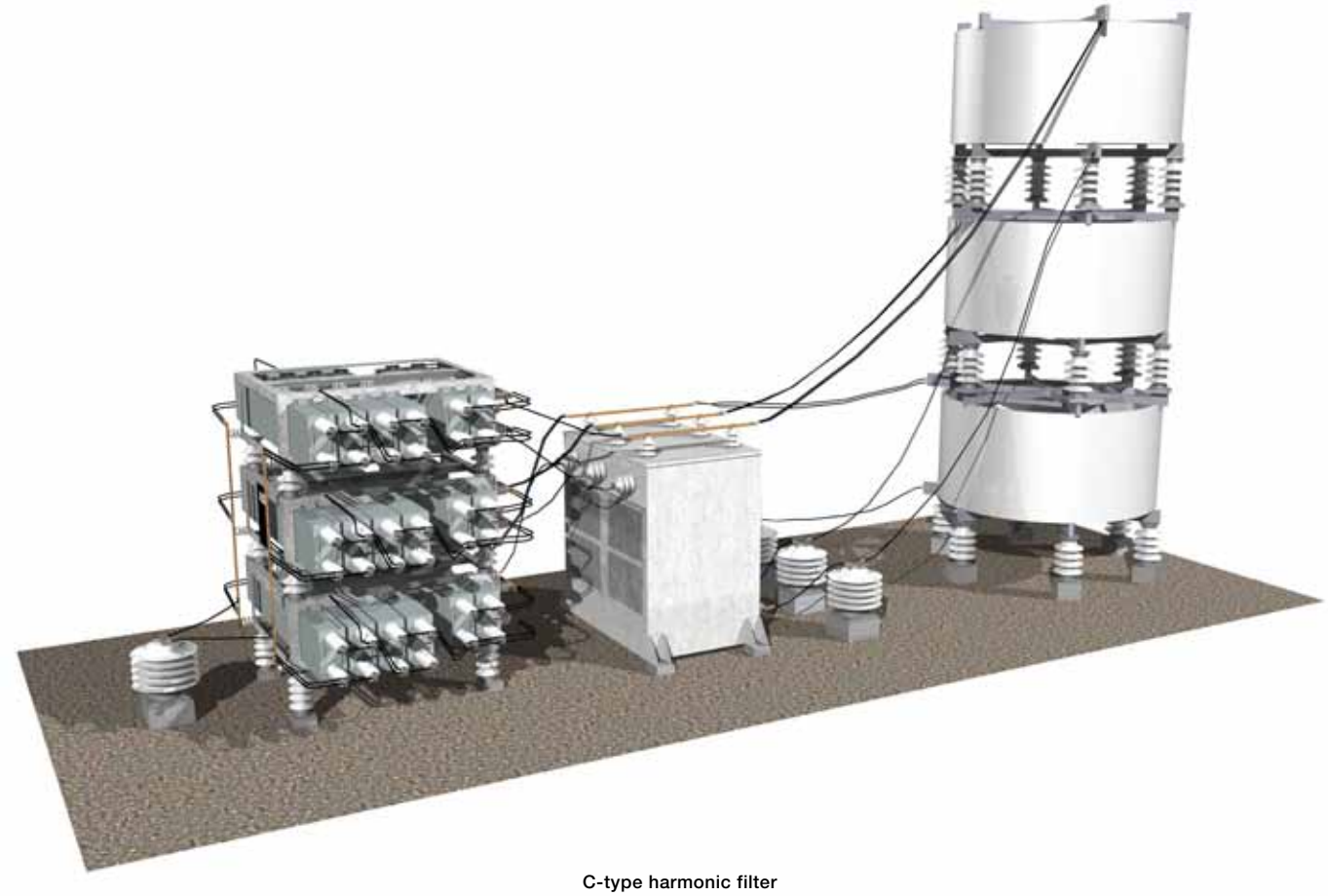
C-type filter

Technical data

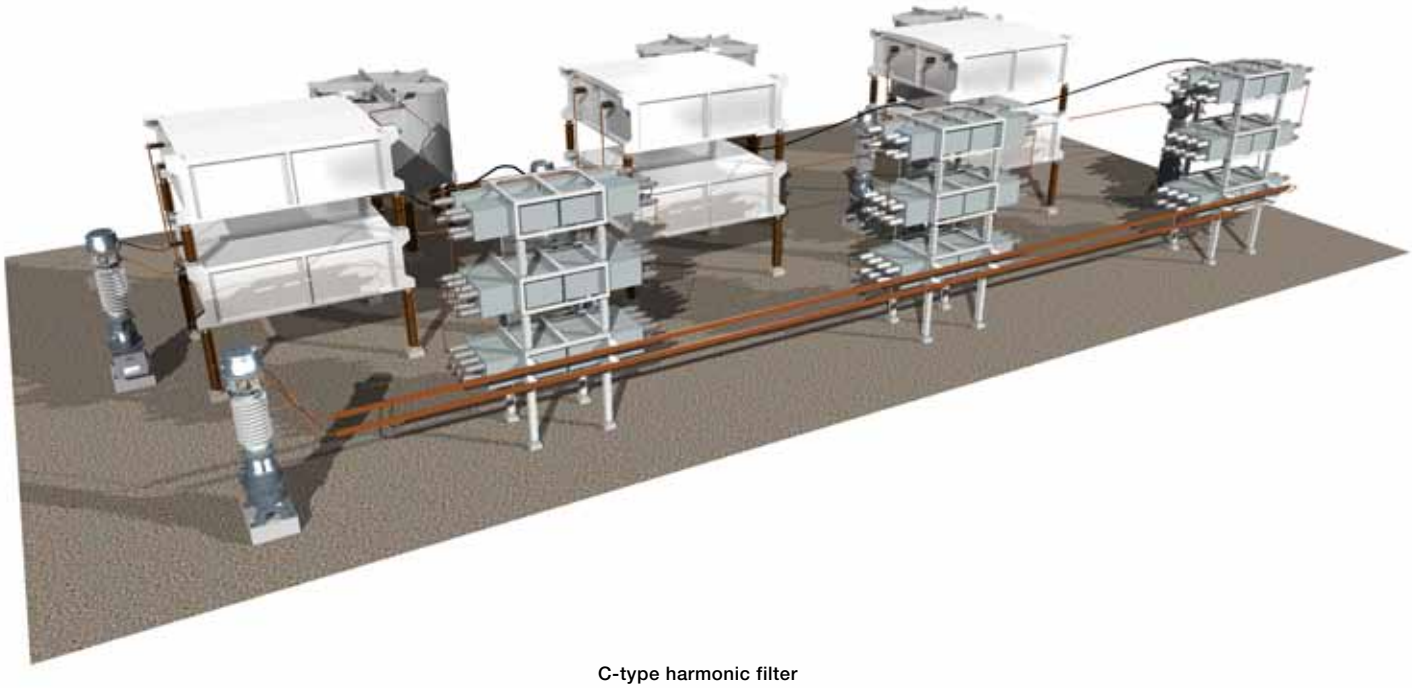
Power rating	From 3 Mvar
Voltage rating	1 to 500 kV
Frequency	50 or 60 Hz
Bank connection types	Single-Y (Y) connection Double-Y (Y-Y) connection Bridge connection for grounded system, Y-0-H Bridge connection for ungrounded system, Y-H, etc.
Bank protection	Unbalance CT for Y-Y & H connection
Fuse technology	Internally fused, CHDB Externally fused (conventional fuseless type), CHDE Fuseless type, CHDF
Temperature range [1]	-50 to +55 °C
Installation	Indoor or outdoor
Scope of supply	– Single-phase capacitor units mounted in hot-dip galvanized steel racks complete with necessary support insulators and internal connections. – CT for capacitor bank unbalance protection when bank is in double-star (Y-Y) or bridge (H) configuration. – Filter reactor – Filter resistor – Standard interconnecting material between capacitor bank, unbalance CT, reactor and resistor

[1] Non-standard temperature range can be quoted on request.

Product information
Harmonic filter, CHARM-C



C-type harmonic filter



C-type harmonic filter

Accessories
Bird caps

Wildlife protection

ABB's bird cap is the solution to problems caused by accidental contact in HV capacitor banks. The bird cap used together with insulated wiring between capacitor units will increase the insulation sufficiently to avoid the risk for flashover or short-circuiting in the bank.

Capacitor bank outings and failures are often caused by accidental contact by animals. Vermin, rodents, cats, birds, etc. use the capacitor banks as a resting place or a landing site. When the animal touches the live HV parts, this can result in a flashover that might cause unnecessary interruptions or consequential damages to the entire bank unless the bank is sufficiently equipped with protection relays.

Our bird cap is a low-cost safety-enhancing feature for high voltage capacitor banks. The risk for mechanical problems due to exposure to animals or the atmosphere is extremely low.

The bird cap is designed to fit all ABB standard S-type bushings used for both internally fused and fuseless capacitor units. It is easily mounted on bushings after the connecting wire has been secured. The bird cap is suitable for most climatic conditions, pollution levels and temperatures. The polypropylene plastic material ensures long service life without risk for deterioration of the insulation, and good capability to endure high temperatures.

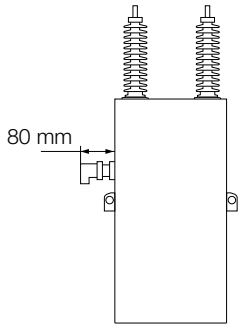
The benefits of bird caps in areas rich in wildlife or with heavy pollution are achieved by using internally fused capacitor units. The increased insulation also benefits the compact and cost-efficient design with high power, internally fused capacitor units.

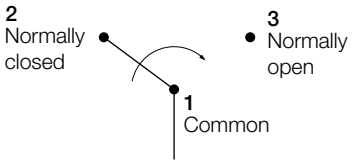
Accessories
Pressure switches

ABB power capacitors are normally protected internally by individual element fuses and externally by protective relays. A major insulation breakdown in a capacitor unit requires fast disconnection of the entire capacitor bank. For small capacitor banks or capacitors for special applications, it may be difficult or expensive to arrange reliable relay protection. The protection of capacitors in such cases can be improved by providing each capacitor unit with a pressure switch. The pressure switch will signal a trip of the capacitor bank in case of a severe internal capacitor unit failure, such as simultaneous breakdown of a large number of capacitor elements or a main insulation failure.

Properties

The pressure switch incorporates a diaphragm pressure element with exceptional compatibility and long service life. A temperature range from -20 to +80 °C enables operation in widely ranging environmental conditions and increases application flexibility. The switch can withstand overpressures of up to 300 bar without damage or loss of calibration.





Change-over contact details

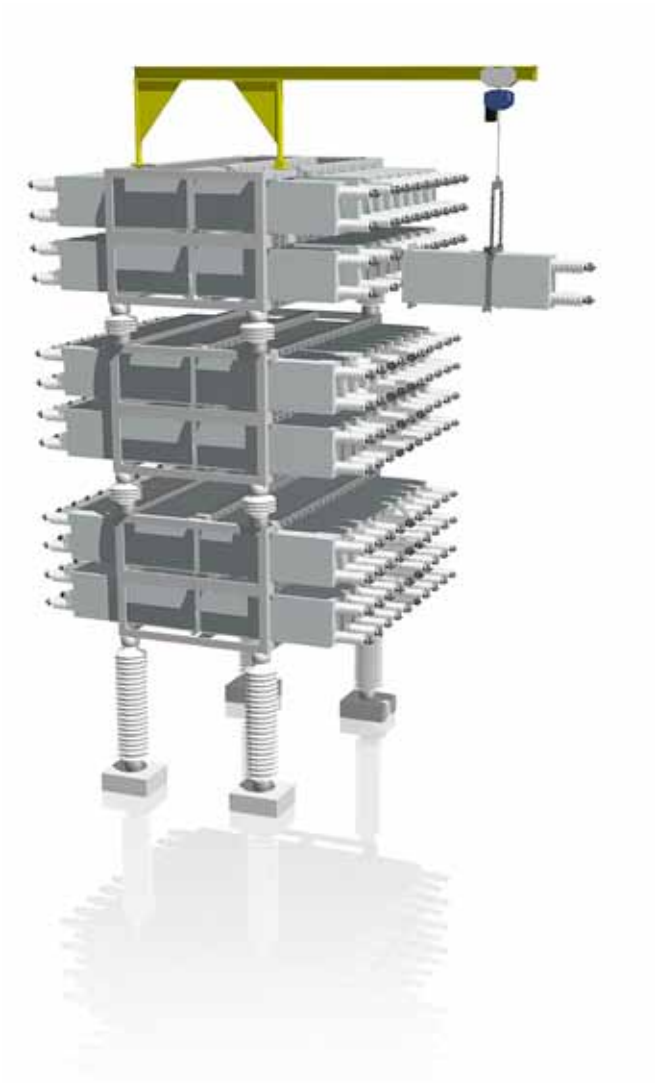
Technical data

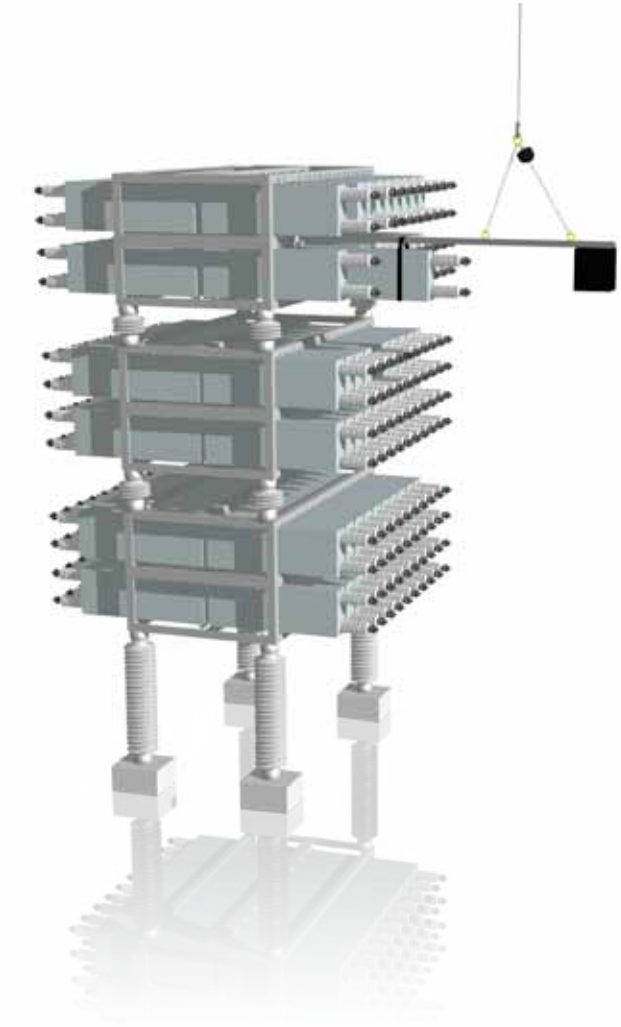
Switch type	Diaphragm type with micro-switch
Chamber material	Galvanized steel
Maximum pressure	300 bar
Adjustment range	0.5 – 5 bar
Ambient temperature range	-20 to +80 °C
Internal temperature range	-30 to +100 °C
Maximum operation frequency	200 times/min
Mechanical service life	10^6 operations
Electrical connections	AMP sprint 6.3 x 0.8 mm
Electrical ratings	250 VAC, 4 A
Protection class	IP 65
CE-marking	LVD directive EN 60 947-5-1

Accessories
Lifting device

The capacitor lifting device tool is easy to operate and facilitates safe handling during the removal and installation of large and heavy capacitor units in an open-stack substation bank.

The device weighs less than 25 kg and operates with ABB bank designs only. It is typically used with fuseless and internally fused capacitor banks with capacitors weighing up to 100 kg, which the device is rated to easily handle. It includes a rail assembly, retaining support, gurney and winch. One person can operate the device safely and efficiently.





Testing equipment
Portable capacitance meter, CB-2000

The CB-2000 is an advanced measurement instrument characterized by its compact design and low weight, which makes it easy to carry when conducting measurements. No disconnections in the capacitor bank or mains connection are required. The collected measurement values can be easily transferred to a PC for storage and analysis. The stored values from the PC can just as easily be transferred to the meter so that they are available when new measurements are made.

Measuring capacitance is an important part of the regular maintenance of capacitor banks. With the CB-2000, even large capacitor banks can be measured quickly and easily because no internal disconnections are necessary within the capacitor bank. The CB-2000 is simple to use and easy to carry using the supplied shoulder strap. The measured values are clearly presented on the LCD display, which can be read both in daylight and in dark environments.

Measurement principle
The test signal is generated from the installed rechargeable battery pack or power adapter and connected to the measurement object with two voltage clips. The test voltage is 1.1–1.4 V. The test current is measured using a clip-on transformer that is easily positioned around the capacitor's bushing. For each measurement, the capacitance value, time and temperature are registered. The meter can handle data from five measurements per measurement object.

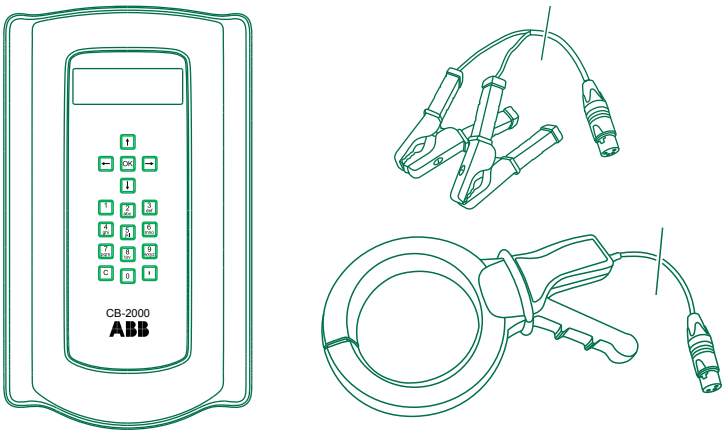
Analysis on PC
The CB-2000 is supplied with a program that enables the transfer of data to and from a PC via a USB cable. Prior to measurement, the CB-2000 can be prepared by uploading data from previously conducted measurements. After the measurements are made, the measurement values can be stored and analyzed on a PC. Measurement data is saved as tab-delimited text, which can be opened in Excel or similar spreadsheet program.

Support and downloads
Please visit www.abb.com/powercapacitors for more information and support. Here you can find can the user's guide in different languages and also download the latest software.

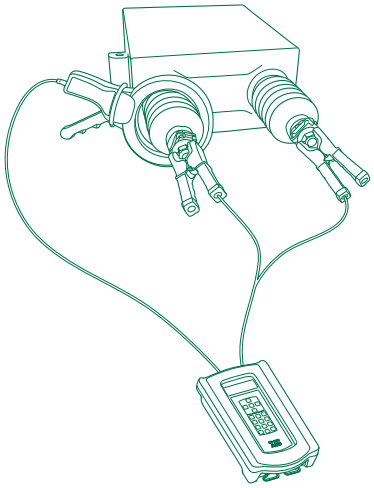
Technical data

Measuring range	0 - 1000 µF
Measurement accuracy	± 1.0 %
Maximum load	2000 µF
Test voltage	1.1 - 1.4 VAC pk - pk, 40 - 160 Hz
Weight (CB-2000)	2.4 kg
Operating time	More than 8 hours

Measuring of capacitance in capacitor bank, Norway



The capacitance meter is delivered complete with clip-on transformer, voltage clips, rechargeable NiMH battery pack, power adapter, extra battery holder, USB stick with software, case and manual.



Measuring principle

Accessories
Relays

Capacitor protection relay SPAJ 160 C

The numerical capacitor relay SPAJ 160 C is an integrated current-measuring multi-function relay designed for the protection of capacitor banks.

The capacitor banks are usually protected against overloads caused by harmonic currents and overvoltages caused by internal faults in the bank. Protection against unintentional reconnection of a charged capacitor to an energized network is also included. All these functions are incorporated in the capacitor protection relay.

A complete protection system for capacitor banks should also include overcurrent, short-circuit and ground-fault protection. The capacitor protection relay SPAJ 160 C is easily supplemented with adequate overcurrent and ground-ground-fault relays from the SPACOM product range.

The SPAJ 160 C relay can be included in delivery as an optional item.

Features of SPAJ 160 C relay:

- Three-phase overload stage with definite time characteristic
- One-, two- and three-phase overload stage with inverse (ANSI) time characteristics
- Phase unbalance protection stage with definite time characteristics
- Phase unbalance protection stage with inverse time characteristics
- Undercurrent protection for detection of capacitor disconnection
- Reconnection time with wide settings range

Combined overcurrent and ground-fault relay SPAJ 141 C

The combined overcurrent and ground-fault relay SPAJ 141 C is intended for selective short-circuit and ground-fault protection of radial feeders in solidly grounded, resistance grounded or impedance grounded power systems. The integrated protection relay includes an overcurrent unit and ground-fault unit with flexible tripping and signaling capabilities. The overcurrent and ground-fault relays can also be used for other applications requiring single-, two-, or three-phase overcurrent protection and ground-fault protection. The combined overcurrent and ground-fault relay includes a circuit-breaker failure protection unit.

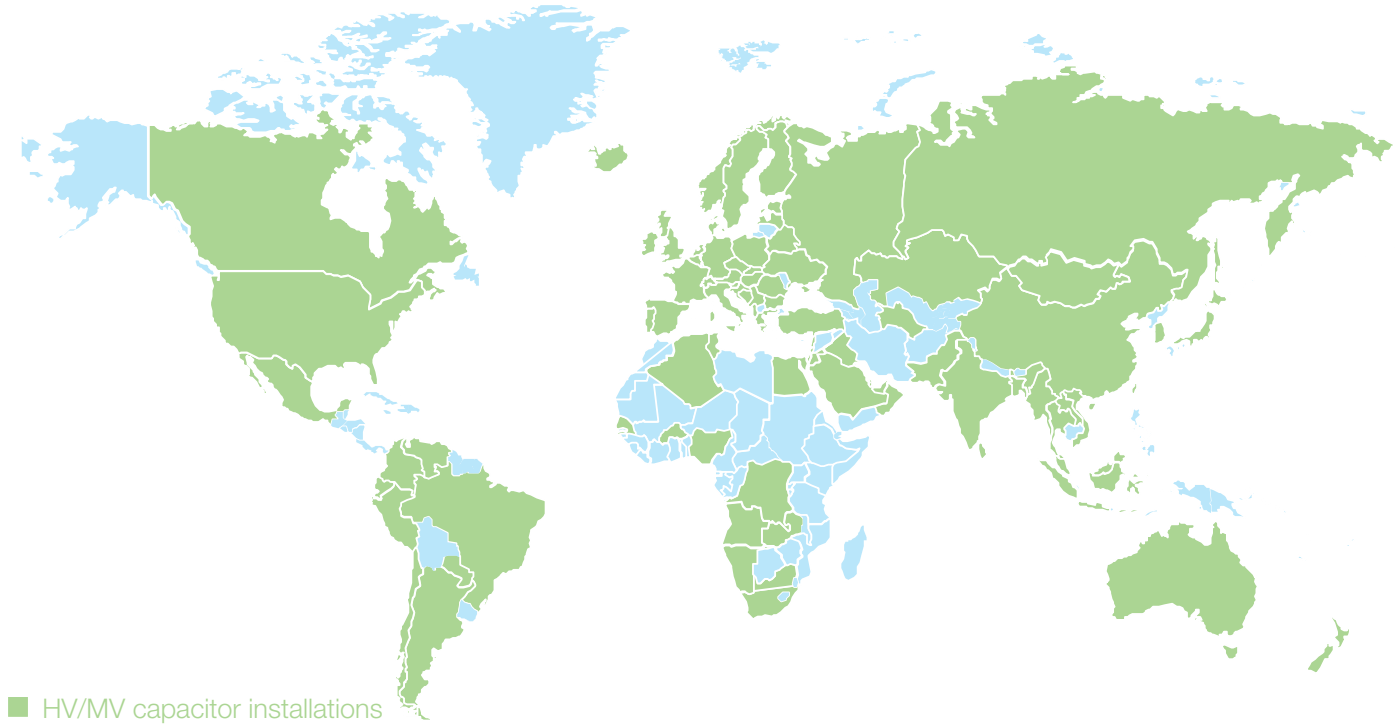
The SPAJ 141 C relay can be included in delivery as an optional item.

Features of SPAJ 160 C relay

- Three-phase, low-set phase overcurrent unit with definite time or inverse definite minimum time (IDMT) characteristics
- Three-phase, high-set phase overcurrent unit with instantaneous or definite time operation

References

ABB capacitors are in service around the globe



Examples of customers

North America
USA, PG&E

South America
Argentina, Transener
Brazil, Furnas
Colombia, ISA/Restrictiones

Europe
Belgium, Electrabel, Tessenderlo
Denmark, NESA
Finland, Tapal
France, RTE
Germany, Amprion
Greece, PPC 3
Iceland, Icelandic Alloys
Italy, Terna
Norway, Statnett
Poland, Polish Power Grid
Portugal, REN
Russia, FSK
Sweden, Vattenfall, SvK
Switzerland, Haefely Test Laboratory

Africa
Algeria, CEEG
South Africa, ESKOM

Middle East
Iraq, MOE
Jordan, NEPCO
Oman, PDO, Sohar Aluminium
Saudi Arabia, SEC
United Arab Emirates, DEWA

Asia
China, CPG, SGCC
India, PGCIL
Indonesia, PLN
Malaysia, TNB
South Korea, KEPCO
Sri Lanka, CEB
Thailand, EGAT
Vietnam, EVN

A complete program with comprehensive support
ABB has more than 80 years of experience in developing and manufacturing power capacitors.

The capacitors and their applications are used both in transmission and distribution grids.

We have delivered filter components, shunt- and series-compensating gear and HVDC and FACTS transmission systems to power companies and industries all over the world.

There is potential for efficiency gains in most grids and our capacitors and filters are key components in achieving them.

References

Polish Power Grid Company
Stabilizing the power grid for 110 kV

Customer need

The Polish Power Grid Company, PSE experienced disturbances in power distribution during the particularly hot summer of 2007. High consumption, partly related to air conditioning use, led to shortages in the northern part of the country.
To strengthen the grid, the decision was made to install filters at the 110 kV level. This project was the first filter installation for PSE at 110 kV. The goal of the installation was to relieve the load on the distribution line, raise the voltage and minimize losses in the network.

ABB solution

ABB quoted and installed three band-pass filters in the Wloclawek, Torun and Narew substations. The filters were tuned to the 5th harmonic so as to reduce the harmonic to this level. Each filter produces 50 Mvar at 110 kV.

The main task of the ABB filter solution is to provide reactive power. This stabilizes the grid and also fulfills the requirement for allowed distortion levels at 110 kV.

The PSE contract stipulated that measurements at each connection point of the grid were to be made before finalization of the solution. These measurements were made by ABB.

In-depth analyses of the measurements made by ABB showed that there could be a problem in connecting a filter with a true BP configuration at one of the substations. This substation is situated at the end of a transmission line, and resonance could occur between the grid and the filter at this point. The final solution was due to the analyses modified from the first suggestion by ABB, and a resistive element was added into the filter circuit. A dampened filter was used, which minimized the risk for resonance with the net.

This was a turnkey delivery and included other ABB equipment, such as circuit breakers, Switchsync™ controllers, VTs/CTs and surge arresters from our plants in Sweden and Poland.

The three filters are in operation, doing the job they were intended for – strengthening the Polish power grid.

110 kV/50 Mvar filter installation at PSE substation in Poland

Customer benefits

- A high-end solution in compliance with the Polish national power grid code regarding permitted harmonics at 110 kV
- A solution that took consideration to the actual situation in the grid and eliminated grid resonance
- Optimized filter components for a small installation footprint.
- Execution of a complete, tailor-made, turnkey project
- Short design and delivery times

110 kV/50 Mvar filter installation at PSE substation in Poland

Facts

Country	Poland
Customer	Polish Power Grid Company (PSE Operator S.A.)
PSE net	750/400/220/110 kV
Location of project	Wloclawek, Torun and Narew
Scope of delivery	3 units, band-pass filters
Year of delivery	2009
Engineering and construction of installation	ABB Sp. z o.o.

The filters installed and energized during 2009.

References

Reactive compensation for testing shunt reactors and large power transformers

Customer need

ABB Power Transformers manufactures ≤ 800 kV HVDC and ≤ 800 kV AC power transformers and ≤ 800 kV AC shunt reactors, with fixed or variable reactive power consumption for stabilizing line voltages. In a comprehensive, major contract with a customer in the Middle East, testing was requested at 300 Mvar rated power, 400 kV rated voltage and with 3-phase energizing. To accomplish this, ABB Power Transformers determined that a test hall upgrade was necessary.

Specifications for the bank called for extremely low PD levels and reconnection capabilities at various Mvar ratings. To house this new equipment, the test hall was expanded.

ABB solution

Expertise is readily available at ABB Capacitors, which operates on adjoining premises in Ludvika. Each delivery from Transformers is unique and thus requires the capacity to run many different test cases at various voltages and outputs. This was a technological challenge on a major scale.

The solution developed in collaboration between ABB Power Transformers and ABB Capacitors is a flexible solution, consisting of a capacitor bank made up of modules (a total of 24). Each module has unbalanced measurement using optical measurement transformers. The flexibility permits testing in various combinations – ≤ 146 kV 300 Mvar, one- or three-phase with 50 Hz, 60 Hz or 240 Hz.

To achieve a low bank height, each phase is constructed as two capacitor stacks for a total of six for the three phases. This configuration enables the placement of switch gear/busbar runs in ceilings and on walls. With its advanced control system, ABB Power Transformers can utilize automation to connect the various test cases. The high PD demands are met by equipping each floor with corona rings.

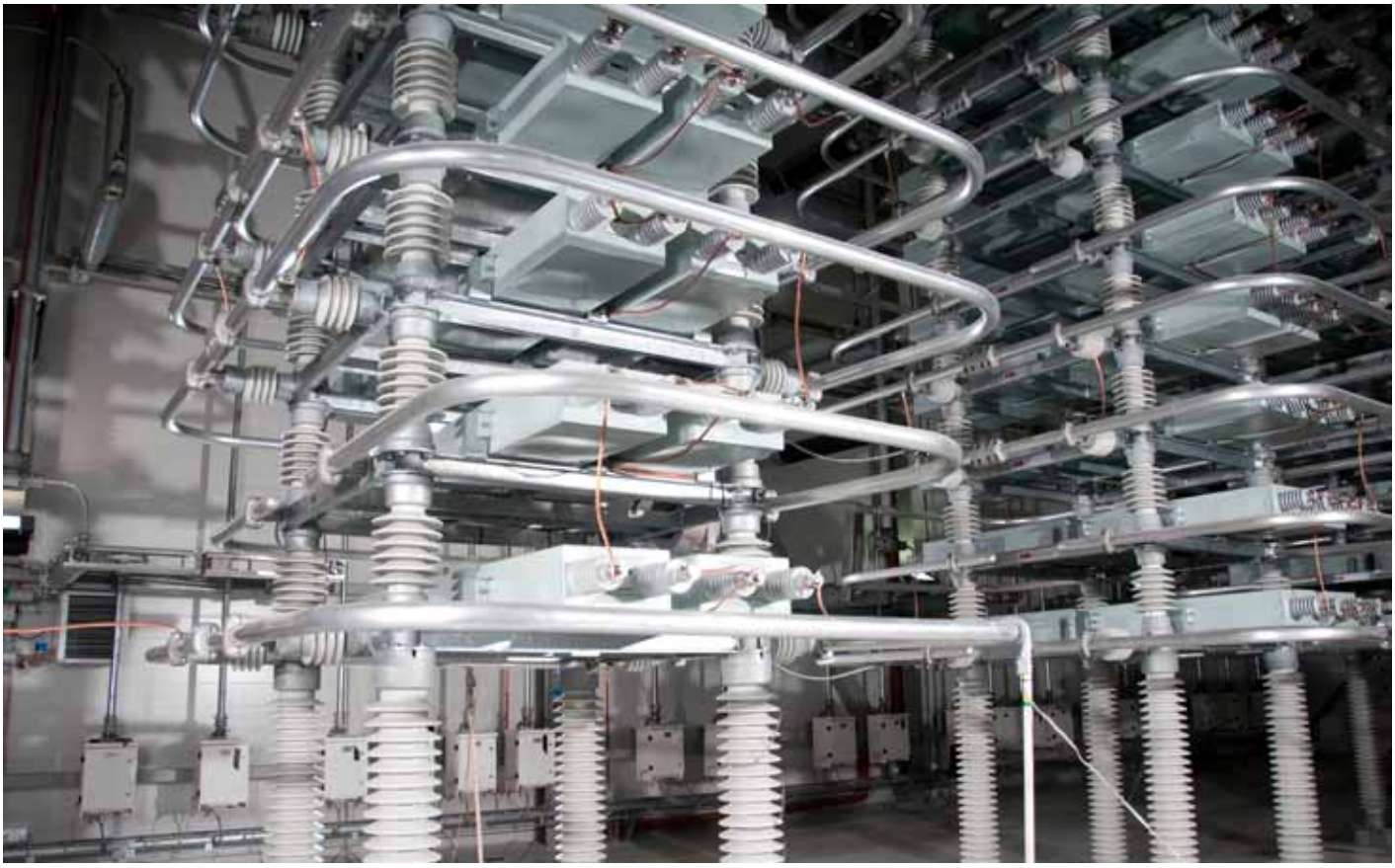
ABB Capacitors:

- Designed and built the technically complex bank according to stringent specifications.
- Met the extremely high PD requirement.
- Delivered quickly. The bank for testing of shunt reactors was put in operation well ahead of schedule.

The test hall capacitor bank is in regular operation, doing its job of generating reactive power for testing of larger shunt reactors and power transformers.

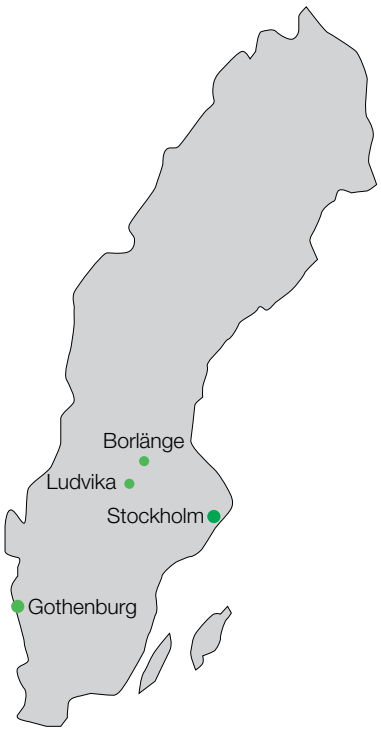
Customer benefits

- A secure and flexible solution which fulfilled the criteria for testing
- A solution that considered the actual situation on site
- A complex solution that could in a short time be designed, produced and installed.
- A very satisfied customer



Facts

Country	Sweden
Customer	ABB Power Transformers
Location of project	Ludvika
Scope of supply	Reconnectable test room capacitor bank
Year of delivery	2008
Engineering and construction of installation	Cooperation between ABB Capacitors and ABB Power Transformers, Ludvika



References

ABBACUS metal enclosed capacitor bank
Modular solution for reactive power compensation

As part of an overall project to minimize their cost structure, an Australian Tyre manufacturer initiated an analysis of their power consumption and associated demand charges levied by the Distribution Utility on their manufacturing plant.

ABB solution

With a relatively low power factor of 0.75, a significant saving in energy costs could be achieved by the installation of reactive compensation on the 11kV reticulation system.

With a target power factor of 0.99 decided upon by the plant-management, a typical load profile for the site was analyzed to determine the required reactive compensation to achieve the target and the step size to follow the load profile.

As is typical in most brown field sites where reactive compensation banks are to be installed, real estate is at a premium and the advantages of an ABBACUS Metal Enclosed Capacitor Bank solution soon become obvious.

Customer benefits: one-stop shop

The ABBACUS typically includes primary components and secondary associated control and protection elements. Integration into one assembly eliminates what could be a potentially complicated co-ordination effort between suppliers to ensure that all the components are rated appropriately for capacitor applications.

Customer benefits: compact foot print

A MECB system that takes up minimal space is a key benefit as the majority of installations are into existing industrial or “brown fields” sites where available ground space is limited.

The compact footprint is further enhanced by the ABBACUS with all the energised components assembled inside a metal enclosure which no longer requires the capacitor site to be fenced.

Customer benefits: operation and operator safety

An inherent danger with capacitors is the residual voltage present in the capacitor immediately after disconnection from the circuit. Each capacitor is conventionally fitted with internal discharge resistors that will reduce this residual voltage down to a safe level over a period of time (typically 75V in 10min or 50V in 5 min). However, during this discharge time capacitor units are potentially dangerous and should be given the time to discharge before handling. The installation of a timer combined with the interlocking system in an ABBACUS will prevent doors being opened before the capacitor units have been allowed sufficient time to discharge.

Operator safety is further enhanced by the provision of ceiling vents in the ABBACUS system. These vents direct hot gases away from operators in the event of a fault occurring in the cubicle.

Customer benefits: modular solution

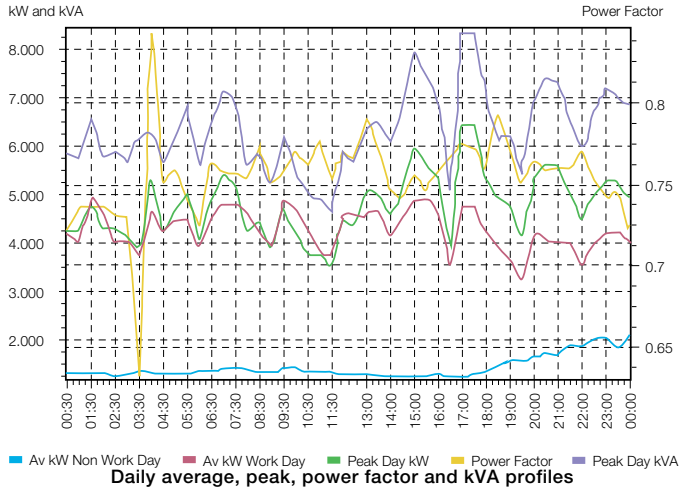
As more electrical load is installed on an industrial site, there may be a requirement for further reactive compensation. With the modular concept of the ABBACUS, it is possible to expand the ABBACUS system with extra capacitor stages to meet the new demands negating the requirement for a new capacitor installation.

Customer benefits: factory tested solutions

Having a fully tested solution ensures a quick installation time onsite. The installation consists of connecting modules together, connecting HV cable, control cables and commissioning of pre programmed control and protection systems. A reduction in installation time ensures that crucial plant and equipment downtime will be reduced minimising lost time in production.

ABB technology

The MECB is available in a range of assembly configurations making the ABBACUS suitable for a wide array of applications. The modular, expandable and compact design of the ABBACUS is able to satisfy current customer needs, whilst maintaining the flexibility to meet increased future demands if required.



Daily average, peak, power factor and kVA profiles

Key features of ABBACUS MECB

- small foot-print (less space required)
- flexibility in specifications to meet client's various requirements
- modular design (incoming module and power modules)
- expandability for modules (should the client wish to add more steps or kvar later on)
- integration of secondary and primary systems. (beneficial for when the client wishes to re-locate the ABBACUS to other sites. All the components can be moved as a single unit.)
- type tested busbar system
- proven IP rating for wide range of site conditions
- fault gas vents on roof for safety of operators
- wide options of interlocking configurations
- maximize factory assembly & testing, minimize time for testing and installation at site
- ease of installation (all the work has been done at the factory, less risk of problems at site.)
- use of ABB components (assurance of ABB quality throughout the component chain)

Facts

Country	Australia
Customer	A tyre manufacturer
Location of project	Lilydale, Australia
Scope of supply	Minimize costs
Year of delivery	2013

Inquiry specification sheet
CHD units

Name of project		
Position	#1	
Quantity		Nos.

General information

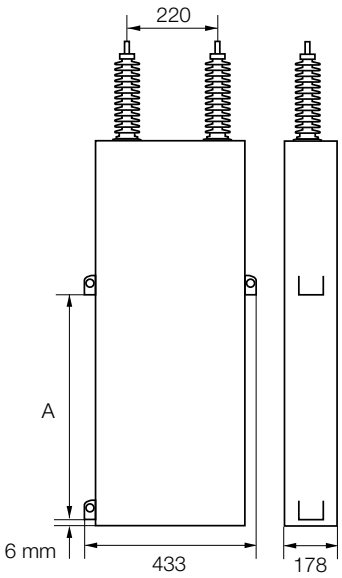
System voltage		kV
System frequency		Hz
Bank connection	Y, Y-Y, etc.	
Units in series/phase		Nos.
Units in parallel		Nos.

Other information

Language		
Documents	☐ English (default)	☐
Rating plate	☐ English (default)	☐
Accessories		
bird caps	☐ Yes	☐ No

For spares/replacement requirement

ABB order no.	
Unit serial no.	
Photo of the rating plate is required	



Technical information

Standard	☐ IEC 60871-1: 2005			
	☐ IEC 60871-2: 1999			
	☐ IEEE Std. 18: 2012			
Other standard	☐			
Temperature class				
Min temperature				°C
Max temperature				°C
Fusing type	☐ Internal			
	☐ External			
	☐ Fuseless			
Rated voltage				kV
Rated output				kvar
Rated capacitance				µF
Rated current				Amps
Discharge time/voltage				sec/V
Insulation level	☐ 75	☐ 95	☐ 125	kV
Bushing type [1]				
No. of bushings	☐ 1	☐ 2		Nos.
Color	☐ Grey (default)	☐ Brown		
Mounting brackets				
No. of brackets	☐ 2	☐ 3	☐ 4	Nos.
Upper bracket position [2]				mm
Pollution level (SCD) according to IEC 60815-1				
Light	☐ 16 mm/kV			
Medium	☐ 20 mm/kV			
Heavy	☐ 25 mm/kV			
Very heavy	☐ 31 mm/kV			

Special requirement

[1] ABB standard S-type bushings
[2] Distance from the base of can (capacitor unit container)

Inquiry specification sheet
QBANK

Name of project	
Quantity	Nos.
Reactive power generation in	Mvar, system voltage and nominal frequency

General information

System voltage			kV
Max. operating voltage			kV
System frequency			Hz
Frequency variation			%.
Voltage variation			%
Short-circuit current			kA/sec
Design short-circuit power (true)			MVA
System earthing	☐ Grounded	☐ Ungrounded	
Location	☐ Indoor	☐ Outdoor	
Altitude	☐ < 1000	☐	m.a.s.l
Temperature class			
Min temperature			°C
Max temperature			°C
Insulation level, BIL			kV
Color of			
insulators	☐ Grey (default)	☐ Brown	
unit bushings	☐ Grey (default)	☐ Brown	
Space limitation			
length x width			mm
height			mm
Seismic demand/horizontal accelaration value			g
Wind speed	☐ 40 (default)	☐	m/sec
Solar radiation			kW/m²

Other information

Language		
Documents	☐ English (deafult)	☐
Rating plate	☐ English (deafult)	☐

Accessories for capacitor units

Bird caps	☐ Yes	
Relays	☐ SPAJ 160 C	
	☐ SPAJ 141 C	
Spare units	☐ 2% (default)	☐
CB-2000	☐ Yes	
Lifting device	☐ Yes	

Capacitor bank — 3-phase data

Type	☐ QBANK-A	
	☐ QBANK-B (max 24 kV)	
	☐ QBANK-C (max 24 kV)	
Bank connection	Y, Y-Y, Y-O-H, etc.	
Standard	☐ IEC 60871-1: 2005	
	☐ IEC 60871-2: 1999	
	☐ IEEE Std. 18: 2012	
Rated voltage		kV
Rated output		kvar
Rated current		Amps

Capacitor unit data

Fusing type	☐ Internal, CHDB	
	☐ External, CHDE	
	☐ Fuseless, CHDF	
Discharge requirement	☐ 50 V/300 sec	
for unit	☐ 75 V/600 sec	

Component data — unbalance CT

Type		
Standard	☐ IEC	☐ IEEE/ANSI
Rated voltage		kV
Ratio		A/A
Burden		VA
Accuracy class	1.0, FS 10 (default)	

Information about existing capacitor bank

No. of parallel banks		Nos.
Total Mvar		Mvar
Pollution level (SCD) according to IEC 60815-1		
Light	☐ 16 mm/kV	
Medium	☐ 20 mm/kV	
Heavy	☐ 25 mm/kV	
Very heavy	☐ 31 mm/kV	

Special requirement

Inquiry specification sheet
QPLUS

Name of project	
Quantity	Nos.
Reactive power generation in	Mvar, system voltage and nominal frequency

General information

System voltage			kV
Max. operating voltage			kV
System frequency			Hz
Frequency variation			%
Voltage variation			%
Short-circuit current			kA/sec
Design short-circuit power (true)			MVA
System grounding	☐ Grounded	☐ Ungrounded	
Location	☐ Indoor	☐ Outdoor	
Altitude	☐ < 1000	☐	m.a.s.l
Temperature class			
Min temperature			°C
Max temperature			°C
Insulation level, BIL			kV
Color of			
insulators	☐ Grey (default)	☐ Brown	
unit bushings	☐ Grey (default)	☐ Brown	
Space limitation			
Length x width			mm
Height			mm
Seismic demand/horizontal accelaration value			g
Wind speed	☐ 40 (default)	☐	m/sec
Solar radiation			kW/m²

Other information

Language		
Documents	☐ English (default)	☐
Rating plate	☐ English (default)	☐

Accessories for capacitor units

Bird caps	☐ Yes	
Relays	☐ SPAJ 160 C	
	☐ SPAJ 141 C	
Spare units	☐ 2% (default)	☐
CB-2000	☐ Yes	
Lifting device	☐ Yes	

Capacitor bank — 3-phase data

Type	☐ QBANK-A	
	☐ QBANK-B (max 24 kV)	
	☐ QBANK-C (max 24 kV)	
Bank connection	Y, Y-Y, Y-O-H, etc.	
Standard	☐ IEC 60871-1: 2005	
	☐ IEC 60871-2: 1999	
	☐ IEEE Std. 18: 2012	
Rated voltage		kV
Rated output		kvar
Rated current		Amps

Capacitor unit data

Fusing type	☐ Internal, CHDB
	☐ External, CHDE
	☐ Fuseless, CHDF
Discharge requirement	☐ 50 V/300 sec
for unit	☐ 75 V/600 sec

Component data — unbalance CT

Type		
Standard	☐ IEC	☐ IEEE/ANSI
Rated voltage		kV
Ratio		A/A
Burden		VA
Accuracy class	1.0, FS 10 (default)	

Component data — reactor

Type	☐ Air core	☐ Iron core
Application	☐ Damping	
Standard	☐ IEC	☐ IEEE/ANSI
Mounting	☐ Side by side (default)	
Rated inductance		mH
Rated current		Amps

Pollution level (SCD) according to IEC 60815-1

Light	☐ 16 mm/kV
Medium	☐ 20 mm/kV
Heavy	☐ 25 mm/kV
Very heavy	☐ 31 mm/kV

Special requirement

Inquiry specification sheet
CHARM-HP/CHARM-C

Name of project

Position	#1	Product type	QBANK/CHARM-BP/D/HP/C	Quantity	
Capacitor bank solution delivering		Mvar at nominal system voltage at nominal frequency			

General information

System voltage		kV
Max. operating voltage		kV
System frequency		Hz
Frequency variation		%
Voltage variation		%
Fault level at rated voltage		kA/sec
Design short-circuit power (true)		MVA
System grounding	☐ Grounded ☐ Ungrounded	
Location	☐ Indoor ☐ Outdoor	
Altitude	☐ < 1000 ☐	m.a.s.l
Temperature class		
Min temperature		°C
Max temperature		°C
Insulation level, BIL		kV
Color of insulators	☐ Grey (default) ☐ Brown	
unit bushings	☐ Grey (default) ☐ Brown	
Space limitation		
length x width		mm
height		mm
Seismic demand/horizontal acceleration value		g
Wind speed	☐ 40 (default) ☐	m/sec
Solar radiation		kW/m²

Other information

Language	
Documents	☐ English (default) ☐
Rating plate	☐ English (default) ☐

Accessories for capacitor units

Bird caps	☐ Yes
Relays	☐ SPAJ 160 C ☐ SPAJ 141 C
Spare units	☐ 2% (default) ☐
CB-2000	☐ Yes
Lifting device	☐ Yes

Capacitor bank — 3-phase data

Type	☐ QBANK-A ☐ QBANK-B (Max 24 kV) ☐ QBANK-C (Max 24 kV)	
Bank connection	Y, Y-Y, Y-O-H etc.	
Standard	☐ IEC 60871-1: 2005 ☐ IEC 60871-2: 1999 ☐ IEEE Std. 18: 2012	
Rated voltage		kV
Rated output		kvar
Rated capacitance		µF
Rated current		Amps

Capacitor unit data

Fusing type	☐ Internal, CHDB ☐ External, CHDE ☐ Fuseless, CHDF
Discharge requirement for unit	☐ 50V/300 sec ☐ 75V/600 sec

Component data — unbalance CT

Type		
Standard	☐ IEC	☐ IEEE/ANSI
Rated voltage		kV
Ratio		A/A
Burden		VA
Accuracy class	1.0, FS 10 (default)	

Component data — reactor

Type	☐ Air core	☐ Iron core
Application		
Standard	☐ IEC	☐ IEEE/ANSI
Mounting	☐ Side by side (deafult)	
Rated inductance		mH
Rated current		
Fundamental		Amps
RMS		Amps

Component data — resistor

Type		
Application	Harmonic filtering	
Standard	☐ IEC	☐ IEEE/ANSI
Mounting		
Rated power		kW
Rated current		Amps

Harmonic voltage/current data

Fundamental	%Volts/%Amps
2nd harmonic	%Volts/%Amps
3rd harmonic	%Volts/%Amps
4th harmonic	%Volts/%Amps
5th harmonic	%Volts/%Amps
7th harmonic	%Volts/%Amps
11th harmonic	%Volts/%Amps
13th harmonic	%Volts/%Amps
17th harmonic	%Volts/%Amps
19th harmonic	%Volts/%Amps
Or attach separate measurement data with RFQ	

Pollution level (SCD) according to IEC 60815-1

Light	☐ 16 mm/kV
Medium	☐ 20 mm/kV
Heavy	☐ 25 mm/kV
Very heavy	☐ 31 mm/kV

Special requirement

Sound demand	☐ Yes ☐ No
Loss evaluation	☐ Yes ☐ No
Other	

Inquiry specification sheet
CHARM-BP/CHARM-BP/D

Name of project			
Position	#1	Quantity	
Capacitor bank solution delivery		Mvar at nominal system voltage at nominal frequency	

General information

System voltage		kV
Max. operating voltage		kV
System frequency		Hz
Frequency variation		%
Voltage variation		%
Fault level at rated voltage		kA/sec
System grounding	☐ Grounded ☐ Ungrounded	
Location	☐ Indoor ☐ Outdoor	
Altitude	☐ < 1000 ☐	m.a.s.l
Temperature class		
Min temperature		°C
Max temperature		°C
Insulation level, BIL		kV
Color of insulators	☐ Grey (default) ☐ Brown	
unit bushings	☐ Grey (default) ☐ Brown	
Space limitation		
Length x width		mm
Height		mm
Seismic demand/horizontal accelaration value		g
Wind speed	☐ 40 (default) ☐	m/sec
Solar radiation		kW/m²

Other information

Language		
Documents	☐ English (default)	☐
Rating plate	☐ English (default)	☐

Accessories for capacitor units

Bird caps	☐ Yes	
Relays	☐ SPAJ 160 C ☐ SPAJ 141 C	
Spare units	☐ 2% (default)	☐
CB-2000	☐ Yes	
Lifting device	☐ Yes	

Capacitor bank — 3-phase data

Type	☐ QBANK-A ☐ QBANK-B (Max 24 kV) ☐ QBANK-C (Max 24 kV)	
Bank connection	Y, Y-Y, Y-O-H, etc.	
Standard	☐ IEC 60871-1: 2005 ☐ IEC 60871-2: 1999 ☐ IEEE Std. 18: 2012	
Rated voltage		kV
Rated output		kvar
Rated capacitance		µF
Rated current		Amps

Capacitor unit data

Fusing type	☐ Internal, CHDB ☐ External, CHDE ☐ Fuseless, CHDF	
Discharge requirement for unit	☐ 50V/300 sec ☐ 75V/600 sec	

Component data — unbalance CT

Type		
Standard	☐ IEC	☐ IEEE/ANSI
Rated voltage		kV
Ratio		A/A
Burden		VA
Accuracy class	1.0, FS 10 (default)	

Component data — reactor

Type	☐ Air core	☐ Iron core
Application	☐ Detuned reactors ☐ Harmonic filtering	
Standard	☐ IEC	☐ IEEE/ANSI
Mounting	☐ Side by side ☐ Stacked	
Rated inductance		mH
Rated current		
Fundamental		Amps
RMS		Amps

Harmonic voltage/current data

Fundamental	%Volts/%Amps
2nd harmonic	%Volts/%Amps
3rd harmonic	%Volts/%Amps
4th harmonic	%Volts/%Amps
5th harmonic	%Volts/%Amps
7th harmonic	%Volts/%Amps
11th harmonic	%Volts/%Amps
13th harmonic	%Volts/%Amps
17th harmonic	%Volts/%Amps
19th harmonic	%Volts/%Amps
Or attach separate measurement data with RFQ	

Pollution level (SCD) according to IEC 60815-1

Light	☐ 16 mm/kV
Medium	☐ 20 mm/kV
Heavy	☐ 25 mm/kV
Very heavy	☐ 31 mm/kV

Special requirement

Sound demand	☐ Yes ☐ No
Loss evaluation	☐ Yes ☐ No
Other	

Notes

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