Reactive Power Compensation
Reactive Power Compensation

Main Topics

Topics

- Introduction
  - The need for capacitors
  - Reactive power
  - Effects of reactive power
  - Reactive power compensation
  - Implementing compensation in network
  - Benefits of reactive power compensation
  - Compensation solutions

- Capacitors: Main components & Building blocks
- ABB Capacitors: History & background
- ABB Capacitors: Solutions & Portfolio
Reactive Power Compensation
Introduction
Power factor
Displacement factor (cos φ)

Benefits
- Improves system power factor
- Reduces network losses
- Avoid penalty charges from utilities for excessive consumption of reactive power
- Reduces cost and generates higher revenue for the customer
- Increases system capacity and saves cost on new installations
- Improves voltage regulation in the network
- Increases power availability

Reactive power compensation implies compensating the reactive power consumed by electrical motors, transformers etc.
Power factor
Harmonic distortion

Benefits

- Reduces harmonic content in the network which further reduces disturbances in telecommunication network, misbehavior in control equipments and relay protections, measuring errors in metering system
- Reduces network losses
- Reduces equipment overloading & stress on insulation
- Reduces cost and generates higher revenue for the customer
- Reduces unplanned outages and increases power availability

Harmonic filtering implies mitigating harmonic currents generated by the non-linear loads like rectifiers, drives, furnaces, welding machines, converters, HF lamps, electronic equipments etc in the network.
The need for capacitors
We operate on all voltages in the network
Active power (P)
It is the useful power that is doing the actual work. It is measured in W, kW, MW & calculated as, \( P = S \times \cos \phi \)

Reactive power (Q)
It is a consequence of an AC system. Reactive power are used to build up magnetic fields. It is measured in var, kvar, Mvar & calculated as, \( Q = S \times \sin \phi \) or \( P \times \tan \phi \)

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

Power factor (\( \cos \phi \))
It is a measurement of the efficiency in a system. Power factor describes the relationship between active (P) and apparent Power (S)
Reactive power Compensation

\[ \cos \varphi \quad \text{– power factor before compensation} \]

\[ \cos \varphi' \quad \text{– power factor after compensation} \]

Reactive power compensation (supplied by capacitors)

Reduced reactive power need/demand (supplied by network)
Reactive power
Implementing the compensation in the network

Shunt compensation of reactive power can be employed either at load level, substation level or at transmission level.

Compensation should be provided as close as possible to the consumption point to avoid having to distribute this power in the other part of network.

Location is primarily determined by the reason for compensation.

- *A : Direct Compensation
- *B : Group Compensation
- *C : Central Compensation at LV side
- *D : Central Compensation at HV side
Example of power factor correction
Relief in transformer loading

- **Connected load**: 1000 kW
  - **Cos \( \phi \) = 0.7
  - 1425 kVA (95% loading factor)
  - 1020 kvar

- **Power triangle** of an installation running at low cos \( \phi \) and for which the transformer is close to full load

- **1500kVA Transformer**
  - Recovered Capacity = 0 kVA (0%)
  - ~1100 kVA (74% loading factor)

- **Power triangle of the same installation where power factor correction has been applied** reduces load on the transformer / releases capacity for additional loads

- **Cos \( \phi \) = 0.9
  - 1425 kVA
  - 470 kvar
  - 1020 kvar
  - 22% available

- **1500kVA Transformer**
  - Recovered Capacity = 325 kVA (22%)
Reactive Power Compensation
Added value: optimizing power availability

\[
\begin{align*}
\cos \phi_1 &= 0.85 \\
\cos \phi_2 &= 0.97 \\
\end{align*}
\]

\[
P = 60 \text{ MW}
\]

\[
Q_{\text{free}} = \% \times P \\
\text{according to tariff}
\]

Example
\[
0.15 \times 60 \text{ MW} = 9 \text{ Mvar}
\]
Reactive Power Compensation
Advantages: Summary/Conclusion

\[
Q_{\text{free}} = X \% \times P \text{ according to tariff/utility regulation}
\]

Max. \( Q_{\text{free}} \text{ allowed from utility} = 0,15 \times 60 = 9 \text{ Mvar} \)

\[
P = 60 \text{ MW}
\]

Before

- Consumption exceeding limits (28.1 Mvar)
- 9 Mvar (free)

\[
\Delta Q = 22.1 \text{ Mvar (cap. Bank power)}
\]

\[
\begin{array}{|c|c|}
\hline
\text{Before} & \text{After} \\
\hline
\text{Cos} \phi_1 = 0,85 & \text{Cos} \phi_2 = 0,97 \\
\hline
P = 60 \text{ MW} & \\
\hline
S_1 = 70,59 \text{ MVA} & S_2 = 61,86 \text{ MVA} \\
\hline
Q_1 = 37,19 \text{ Mvar} & Q_2 = 15,04 \text{ Mvar} \\
\hline
\Delta Q = 22,1 \text{ Mvar (cap. Bank power)} & \\
\hline
\end{array}
\]

After

- Compensation supplied by capacitor (22.1 Mvar)
- Reduced consumption exceeding limits (6 Mvar)
- 9 Mvar (free)

\[
\begin{array}{|c|c|c|}
\hline
\text{Before} & \text{After} \\
\hline
28,14 \text{ Mvar (76\%)} & 22,14 \text{ Mvar (60\%)} \\
\hline
9 \text{ Mvar (24\%)} & 9 \text{ Mvar (24\%)} \\
\hline
6 \text{ Mvar (16\%)} & \\
\hline
\end{array}
\]

- Supplied from Utility (Free)
- Supplied from Utility (Charged)
- Supplied from capacitor bank
Reactive Power Compensation

Purpose

Solution depends on aim:

- Reactive Power need and no harmonics: Capacitor Banks
- Reactive Power need and no distortion even if Harmonics are present: Detuned Filters
- Reactive Power need and distortion problems: Tuned Filters
- Reactive Power need and strong distortion problems such as fast voltage fluctuations and/or phase asymmetry: Dynamic / SVC’s
Reactive power
Apparent, Active & Reactive Power

It is the Active Power that contributes to the energy consumed, or transmitted. Reactive Power does not contribute to the energy. It is an inherent part of the “total power” which is often referred as “Useless Power”.

APPARENT POWER
Beer: Full glass
Electricity - Available from utility

REAL POWER
Beer: Drinkable
Electricity = Able to do work

REACTIVE POWER
Beer: Foam
Electricity - Unable to do work
ABB Capacitors
Main components & Building Blocks
Main components and building blocks
Basic definitions: Capacitor & Capacitance

**Capacitor**
Two conductor layers separated by a insulating layer (dielectric)

**Capacitance**

\[ C = \varepsilon \cdot \frac{A}{h} \]

- Area of the plates = \( w \times d \)
- Distance between the plates (thickness of the dielectric)
- Permittivity of the insulating material (dielectric) or Dielectric constant

**Reactive Power**

\[ Q = 2\pi f \times U^2 \times C \]

- Capacitance
- Voltage
- Frequency
ABB’s unique features
Reliable and well utilized capacitor elements

Optimal electric field strength, well utilized insulation:

- Several film layers (normally three)
- High electrical withstand
- Folded foils at electrode edges
- Low electric stress amplification
- Minimized PD generation
Reliability

ABB Capacitors: well proven experience

We know that world-class products, requires top of the line personnel, careful selection of materials and most modern machinery.

Our workshop has the most modern machinery and processes. These are often tailor made in order to satisfy the high demands of our customers.
### Reliability

**ABB Capacitors: Failure rates examples**

<table>
<thead>
<tr>
<th>Project (Installed)</th>
<th>Application</th>
<th>No. of units</th>
<th>Failure (%/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Itaipu (1985-93)</td>
<td>HVDC</td>
<td>15224</td>
<td>0.03</td>
</tr>
<tr>
<td>IPP (1986-91)</td>
<td>HVDC</td>
<td>13786</td>
<td>0.05</td>
</tr>
<tr>
<td>Pacific (1987-94)</td>
<td>Filter</td>
<td>1008</td>
<td>0.15</td>
</tr>
<tr>
<td>Itaipu (1990-94)</td>
<td>SC</td>
<td>5040</td>
<td>0.04</td>
</tr>
<tr>
<td>Rihand-Delhi</td>
<td>HVDC</td>
<td>6103</td>
<td>0.004</td>
</tr>
</tbody>
</table>
Power Factor Compensation & Filter Solutions
Basic definitions: Capacitor unit components

- Bushing
- Elements
- Internal fuse
- Discharge resistor
- Internal insulation
- Can (stainless steel)
ABB’s unique features
HiQ units available in all type of fusing technologies

- Internally fused
- Externally fused
- ABB Design
- Conventional

Fused versus Fuseless

- Fuse
- Discharge Resistor
ABB’s unique features
Expertise in all type of fusing technologies

ABB is the only manufacturer supplying all types of fusing technologies
ABB’s unique features
Large units - gives lower cost for the customer

- Same dielectric stress
- Same number of elements
- Same active material
- Less passive material (bushings, insulation etc.)
- Less ground area implies
- Less foundation
- Less fence

2 X 500 kvar

1 X 1000 kvar
Power Factor Compensation & Filter Solutions
Capacitor Banks: Core components

Bank design means transforming the requested reactive power into a physical structure with all environmental aspects and customer requirements taken into account.
Capacitors
C [μF]

Reactors
L [mH]

Resistance
R [Ω]

For filter performance these values are the important

Design voltages and currents come out of these, based on the system calculations.
Power Factor Compensation
ABB Capacitors
History and background
Number of HV/MV factories: 4
Number of LV factories: 2
Local assembly units: 5
Sales Office in 100 countries
ABB in Ludvika
A world center of high voltage

Surge Arresters
Instrument Transformers
Capacitor Banks
Live Tank Circuit Breakers
Disconnecting Circuit Breakers

One-Stop source for air-insulated HV equipment
ABB in Ludvika
“The High Voltage Valley”
Capacitors in ABB
Technical Lead Center in Ludvika

- Technical lead center for ABB medium and high voltage capacitors
- One of the worlds largest factories for capacitors.
- Most modern factory in the world
- Export: >95%
- Employees: app. 150
- Volume: 30 000 Mvar/year
Capacitors in ABB
High quality production facility

One of the most modern production lines with:
- Continuous optimization and improvement programs
- Certified personnel

Traceability through Electronic control cards
- Order no., part no., batch no., operator’s name etc. stored at each workstation through barcode system

Extremely low failure rate for capacitor units

Quality ensured by most modern optimized production process
Power Factor Compensation
ABB MV & HV Product Portfolio
We can meet all customer needs
### Capacitor unit types

<table>
<thead>
<tr>
<th></th>
<th>Internally fused units</th>
<th>Externally fused units</th>
<th>ABB fuseless units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit voltage range:</strong></td>
<td>1-15 kV</td>
<td>2.4 – 25 kV</td>
<td>12 – 25 kV</td>
</tr>
<tr>
<td><strong>Reactive power range:</strong></td>
<td>300-1200 kvar (50 Hz)</td>
<td>100 – 500 kvar (50 Hz)</td>
<td>300 – 1200 kvar (50 Hz)</td>
</tr>
</tbody>
</table>
ABB MV & HV Capacitors Portfolio
Medium voltage enclosed capacitor banks

ABBACUS  EMPAC  SIKAP

1-36 kV  1-36 kV  1-24 kV

Control Equipment & Switchgear

Complete with switchgear or only capacitor bank
### ABB MV & HV Capacitors Portfolio

**MV enclosed capacitor bank type ABBACUS**

<table>
<thead>
<tr>
<th>Type:</th>
<th>ABBACUS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enclosed mult-step switched cap. bank</strong></td>
<td></td>
</tr>
<tr>
<td><strong>One enclosure = Several steps</strong></td>
<td></td>
</tr>
<tr>
<td>Voltage Range:</td>
<td>Max. 36 kV</td>
</tr>
<tr>
<td>Power Range:</td>
<td>Up to 20 Mvar</td>
</tr>
<tr>
<td>Switching:</td>
<td>Yes</td>
</tr>
<tr>
<td>Protection degree:</td>
<td>IP65</td>
</tr>
<tr>
<td>Capacitor units:</td>
<td>Capacitors units equipped with internal fuse and discharging resistor.</td>
</tr>
<tr>
<td>Connection</td>
<td>Single or Double Star</td>
</tr>
<tr>
<td>Installation:</td>
<td>Indoor/Outdoor</td>
</tr>
<tr>
<td>Temperature range:</td>
<td>-50 to +55 °C (up to 24 kV)</td>
</tr>
<tr>
<td></td>
<td>-10 to +55 °C (36 kV)</td>
</tr>
<tr>
<td>Delivered with all internal electrical wiring between capacitors; CT and reactors (if included) pre connected / factory assembled</td>
<td></td>
</tr>
</tbody>
</table>
### ABB MV & HV Capacitors Portfolio

**MV enclosed capacitor bank type EMPAC**

<table>
<thead>
<tr>
<th>Type:</th>
<th>EMPAC Enclosed switched MV Capacitor Bank</th>
</tr>
</thead>
<tbody>
<tr>
<td>One enclosure = One step</td>
<td></td>
</tr>
<tr>
<td>Voltage range:</td>
<td>Max. 36 kV</td>
</tr>
<tr>
<td>Power &amp; Voltage range in one single step:</td>
<td></td>
</tr>
<tr>
<td>▪ Up-to 24 kV – 1 level: 7.2 Mvar</td>
<td></td>
</tr>
<tr>
<td>▪ Up-to 24 kV – 2 levels: 10.8 Mvar</td>
<td></td>
</tr>
<tr>
<td>▪ 24 to 36 kV – 2 levels: 14.4 Mvar</td>
<td></td>
</tr>
<tr>
<td>Switching:</td>
<td>Yes (Optional)</td>
</tr>
<tr>
<td>Protection degree</td>
<td>IP 44</td>
</tr>
<tr>
<td>Capacitor units:</td>
<td>Capacitors units equipped with internal fuse and discharging resistor.</td>
</tr>
<tr>
<td>Connection:</td>
<td>Double star</td>
</tr>
<tr>
<td>Installation</td>
<td>Indoor or Outdoor</td>
</tr>
<tr>
<td>Temperature range:</td>
<td>-25 to +40°C</td>
</tr>
<tr>
<td>Delivered with all internal electrical wiring between capacitors; CT and reactors (if included) are pre-connected/factory assembled</td>
<td></td>
</tr>
</tbody>
</table>
### ABB MV & HV Capacitors Portfolio

**MV enclosed capacitor bank type SIKAP**

<table>
<thead>
<tr>
<th>Type</th>
<th>SIKAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enclosed MV non-switched capacitor bank</td>
<td></td>
</tr>
</tbody>
</table>

- **One enclosure = One step**
- **Voltage Range:** 4.5 - 24 kV
- **Power Range:** Up to 18 Mvar
- **Switching:** No
- **Protection degree:** IP44
- **Capacitor units:** Capacitors units equipped with internal fuse and discharging resistor.
- **Connection:** Single or Double Star
- **Installation:** Indoor/Outdoor
- **Temperature range:** -40 to +40 °C
- **Origin:** Sweden

Delivered with all internal electrical wiring between capacitors, CT and reactors (if included) pre-connected/factory assembled.
### ABB MV & HV Capacitors Portfolio
### MV & HV Product Range: Main ratings

<table>
<thead>
<tr>
<th></th>
<th>ABBACUS</th>
<th>EMPAC</th>
<th>SIKAP</th>
<th>Q-POLE</th>
<th>Q-BANK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MV Metal enclosed capacitor banks</strong></td>
<td>MV Metal enclosed capacitor banks</td>
<td>MV Metal enclosed capacitor banks</td>
<td>MV Metal enclosed capacitor banks</td>
<td>MV Metal enclosed capacitor banks</td>
<td>MV Metal enclosed capacitor banks</td>
</tr>
<tr>
<td><strong>Control equipment and switchgear</strong></td>
<td>Yes</td>
<td>Yes (1)</td>
<td>Yes</td>
<td>Yes (2)</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Application:</strong></td>
<td><strong>var compensation</strong></td>
<td>Indoor &amp; outdoor</td>
<td>Indoor &amp; outdoor</td>
<td>Indoor &amp; outdoor</td>
<td>Indoor &amp; outdoor</td>
</tr>
<tr>
<td><strong>Harmonic filtering</strong></td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes (2)</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Installation</strong></td>
<td>Indoor &amp; outdoor</td>
<td>Indoor &amp; outdoor</td>
<td>Indoor &amp; outdoor</td>
<td>Indoor &amp; outdoor</td>
<td>Indoor &amp; outdoor</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>50 and 60 Hz</td>
<td>50 and 60 Hz</td>
<td>50 and 60 Hz</td>
<td>50 and 60 Hz</td>
<td>50 and 60 Hz</td>
</tr>
<tr>
<td><strong>Voltage</strong></td>
<td>Up to 36 kV</td>
<td>Up to 36 kV</td>
<td>Up to 24 kV</td>
<td>Up to 36 kV</td>
<td>Up to 800 kV</td>
</tr>
<tr>
<td><strong>Max. total reactive power @ 50 Hz</strong></td>
<td>20 Mvar</td>
<td>14.4 Mvar</td>
<td>18 Mvar</td>
<td>3.6 Mvar</td>
<td>Undefined (limited by design)</td>
</tr>
<tr>
<td><strong>Multi-step</strong></td>
<td>Yes (Up to 8)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Max. power per step</strong></td>
<td>Up to 5 Mvar</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>IP</strong></td>
<td>65</td>
<td>44</td>
<td>44</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td><strong>Temperature range</strong></td>
<td>-50 to +55°C</td>
<td>-25 to +40°C</td>
<td>-40 to +40°C</td>
<td>-50 to +55°C</td>
<td>-50 to +55°C</td>
</tr>
<tr>
<td><strong>Applicable standards</strong></td>
<td>IEC 60871-1, IEC 60871-4, IEEE 18, Others on request</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Mostly for detuned filtering, in order to prevent resonance issues. Small tuned filters can also be used, mostly with filter building blocks (reactors and resistors) installed separated and not in the enclosure.

2) Can be used for tuned filters with filter building blocks (reactors and resistors) installed separated and not in the enclosure.
## ABB MV & HV Capacitors Portfolio
### MV & HV Product Range: Main features & accessories

<table>
<thead>
<tr>
<th>Feature</th>
<th>ABBACUS</th>
<th>EMPAC</th>
<th>SIKAP</th>
<th>Q-POLE</th>
<th>Q-BANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>MV Metal enclosed capacitor banks</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control equipment and switchgear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pole-mounted MV bank</td>
<td></td>
<td></td>
<td>(1)</td>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>MV &amp; HV open-rack capacitor banks</td>
<td></td>
<td></td>
<td>(1)</td>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>Switched multi-step bank</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relays</td>
<td>●</td>
<td>●</td>
<td></td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Protection</td>
<td>●</td>
<td></td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Unbalance</td>
<td>●</td>
<td>●</td>
<td></td>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td>Switching</td>
<td>● (1 per step)</td>
<td>● (1 per bank)</td>
<td>● (1 per bank)</td>
<td>For HV only</td>
<td></td>
</tr>
<tr>
<td>Contactors &amp; switches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circuit breaker &amp; accessories</td>
<td>● (1 per step)</td>
<td>● (1 per bank)</td>
<td>● (1 per bank)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MV fuse-link protection</td>
<td>●</td>
<td></td>
<td></td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Earthing switch</td>
<td>●</td>
<td>●</td>
<td></td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Reactors</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Inrush</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detuned</td>
<td>●</td>
<td></td>
<td></td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Filter</td>
<td>● (1)</td>
<td>● (1)</td>
<td>● (1)</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Instrument Transformers</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Unbalanceance CT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protection CTs</td>
<td>●</td>
<td></td>
<td></td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Protection VTs</td>
<td>●</td>
<td></td>
<td></td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Rapid-discharge VT’s</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

(1) Supplied loose and installed separately
# ABB MV & HV Capacitors Portfolio

## Pole-mounted MV capacitor bank

<table>
<thead>
<tr>
<th>Type:</th>
<th>Q-POLE Pole mounted capacitor bank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Range:</td>
<td>Up to 36 kV</td>
</tr>
<tr>
<td>Power Range:</td>
<td>Up to 3.6 Mvar</td>
</tr>
<tr>
<td>Switching:</td>
<td>Yes</td>
</tr>
<tr>
<td>Protection degree:</td>
<td>IP00</td>
</tr>
<tr>
<td>Capacitor units:</td>
<td>Capacitors units equipped with discharging resistor.</td>
</tr>
<tr>
<td>Connection:</td>
<td>Designed from voltage and system grounding</td>
</tr>
<tr>
<td>Installation:</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Temperature range:</td>
<td>-50 to +55°C</td>
</tr>
</tbody>
</table>

Delivered with all electrical wiring between capacitors; Controller, CS, PT and reactors (if included) are pre-connected/factory assembled
**ABB MV & HV Capacitors Portfolio**  
**MV & HV open-rack capacitor bank type QBANK**

<table>
<thead>
<tr>
<th>Type</th>
<th>QBANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open-rack capacitor bank</td>
<td></td>
</tr>
<tr>
<td>Voltage Range:</td>
<td>1 - 800 kV</td>
</tr>
<tr>
<td>Power Range:</td>
<td>0.5 - 300 Mvar</td>
</tr>
<tr>
<td>Structures</td>
<td>Hot-dip galvanized steel, copper bars and wires, porcelain support insulators</td>
</tr>
<tr>
<td>Mechanics</td>
<td>Designed for wind, snow, seismic requirements, etc.</td>
</tr>
<tr>
<td>Connection:</td>
<td>Designed from voltage and system grounding</td>
</tr>
<tr>
<td>Temperature range:</td>
<td>-50 to +55 °C</td>
</tr>
<tr>
<td>Installation:</td>
<td>Indoor or outdoor, side-by-side or stacked</td>
</tr>
<tr>
<td></td>
<td>Delivered mounted and connected as far as possible in the factory (excluding support insulators)</td>
</tr>
</tbody>
</table>

![QBANK-A](image1.png)  
![QBANK-B](image2.png)  
![QBANK-C](image3.png)
ABB MV & HV Capacitors Portfolio
MV & HV open-rack capacitor bank type QBANK
# ABB MV & HV Capacitors Portfolio

## Harmonic filters type CHARM

### Type: CHARM

**Tuned or detuned design:**
- **Tuned filters:** Suitable when source of harmonics, and harmonic content is well defined
- **De-tuned filters:** Suitable when harmonics originate from many sources, and many harmonic frequencies are present

**Band-pass, High-pass or C-type filters**

**Voltage Range:** 1 - 800 kV

**Power Range:** Defined by needs

**Temperature range:** -50 to + 55 °C

---

![Band-pass](C) L + C

![High-pass](C) L // R + C

![C-type](C) (L+C2) // R + C1

(filter with extra low fundamental losses)
ABB MV & HV Capacitors Portfolio
Dynamic compensation: SVC

With dynamic compensation following additional features will be achieved:
- Fast voltage fluctuation (Flicker)
- Phase asymmetric loads
- Continuous power factor control

Typical application is fast changing loads

These applications need SVC

Power Range: Defined by needs
Surge Capacitors & MSP

Protection against power surges, switching transients, faults, and lightning strikes mainly for critical industrial loads:
- Large Motors and generators;
- Large transformers;
- MV switchgear and motor control centers

The primary function of the Type MSP motor surge protector is to guard the winding insulation of the device being protected.

Voltage Range: 2.4 - 24 kV

Availability: Standard units kept in stock

Motor Surge Protector (MSP)
Includes surge capacitor and surge arrester
ABB MV & HV Capacitors Portfolio
Switching: Capacitor switch PS range

- PS15 (15 kV) → PS36 (36 kV)
  - Up to 400 A
  - ABB vacuum interrupter technology
  - Magnetic actuator
  - Mechanical or electrical latching
  - NO oil, gas or foam
  - Maintenance free
  - Hydrophobic ‘cycloaliphatic’ epoxy (HCEP) resin insulator
**ABB MV & HV Capacitors Portfolio**

**Capacitor Switch: CQ900 range**

<table>
<thead>
<tr>
<th>CQ900 Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>User friendly interface</td>
</tr>
<tr>
<td>Extensive range of control modes</td>
</tr>
<tr>
<td>Measurement &amp; monitoring</td>
</tr>
<tr>
<td>Data logging</td>
</tr>
<tr>
<td>Protection</td>
</tr>
<tr>
<td>Communication: DNP3, IEC 61850</td>
</tr>
<tr>
<td>Easy programming &amp; commissioning</td>
</tr>
<tr>
<td>Durable IP54 power coated stainless steel enclosure</td>
</tr>
</tbody>
</table>
ABB MV & HV Capacitors Portfolio

Synchronized switching: Switchsync™ relays

Voltage transients when energizing one phase of a 72 kV capacitor bank

A: Energizing close to the power frequency voltage peak. A high voltage transient is generated

B: With Switchsync™ relay. Energizing close to voltage zero. The transient is considerably reduced

Energizing of capacitor banks and harmonic filters may cause severe inrush currents and voltage oscillations
ABB MV & HV Capacitors Portfolio
Metering & Maintenance: CB2000

<table>
<thead>
<tr>
<th>Capacitance Bridge Type CB2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed for capacitor measurements in HV capacitor banks</td>
</tr>
<tr>
<td>Easy to use and handle</td>
</tr>
<tr>
<td>Data collection &amp; storage</td>
</tr>
<tr>
<td>No disconnections in the bank</td>
</tr>
<tr>
<td>Shorter service operations</td>
</tr>
<tr>
<td>No disconnections required in the capacitor bank during measurement</td>
</tr>
</tbody>
</table>
High Voltage Capacitors
Documentation
Documentation
Catalogues

Capacitors and Filters
Improving power quality for efficiency and reliability

ABB Capacitor Plant
Ludvika, Sweden

Portable Capacitance Meter
CB-2000

Download from abb.com/highvoltage