ABB Power Quality Products

Improved energy efficiency through harmonic mitigation and PF correction
Agenda

1. What is Power Quality?
2. Power Factor
3. Harmonics
4. Solutions
5. Quick Selection Guide
Power Quality

Reactive power
Harmonics
Load imbalance

Flicker, Spikes,
HF Voltage sags & surges
Notches
Energy saving calculation
Regulations

Utility → penalty if PF < 0.93
Locating capacitors on your system

Various locations on your electrical system

1. on the plant feeder (MV)
2. on the main LV bus
3. on the auxiliary/remote bus
4. at the individual load point

<table>
<thead>
<tr>
<th>Capacitor location</th>
<th>1</th>
<th>2 &amp; 3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical approach</td>
<td></td>
<td></td>
<td>Best</td>
</tr>
<tr>
<td>Flexibility</td>
<td></td>
<td></td>
<td>Best</td>
</tr>
<tr>
<td>Cost per kvar</td>
<td></td>
<td></td>
<td>Best</td>
</tr>
</tbody>
</table>
When to use a reactor?
“Quick” selection guide

\[ Q_{\text{comp}} = P \times (\tan \phi_1 - \tan \phi_2) \]

- **Providing there is no resonance**
- **Reactor value must not interfere with existing telecommunication frequency.**
- **Requires harmonic analysis. Please contact ABB’s specialist.**

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**Non linear loads total power (kVA)**

- **< 15%**
  - **Standard range**
- **15 to 25%**
  - **Reinforced range**
- **> 25%**
  - **De-tuned range**
- **> 60%**
  - **De-tuned range + Harmonic filtering solution**

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1. Providing there is no resonance
2. Reactor value must not interfere with existing telecommunication frequency.
3. Requires harmonic analysis. Please contact ABB’s specialist.
Harmonics coming from the net or Non linear Load

![Diagram showing resonance]

RESONANCE
Danger of electrical resonance
Bank in Luxembourg

- A building with
  - 6 transformers equipped with capacitor banks
  - Plain capacitors with no anti-resonance reactors
- Resonant circuitry when excited by harmonic frequencies
- Overcurrent and overvoltages in the installation
- Overheating of capacitors
- Premature ageing and shorter lifetime
THDI and THDV
## Lighting technologies

<table>
<thead>
<tr>
<th>Tested lamp</th>
<th>Dimming angle [°]</th>
<th>Harmonic [%]</th>
<th>Fund</th>
<th>3rd</th>
<th>5th</th>
<th>7th</th>
<th>THDI</th>
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<tr>
<td>Osram 20W LED dim</td>
<td>0°</td>
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<td>100</td>
<td>49.5</td>
<td>26.5</td>
<td>8.2</td>
<td>62.4</td>
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<tr>
<td></td>
<td>45°</td>
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<td>17.9</td>
<td>9.4</td>
<td>73.9</td>
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<tr>
<td></td>
<td>90°</td>
<td></td>
<td>100</td>
<td>86.6</td>
<td>71.2</td>
<td>60.0</td>
<td>209.0</td>
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<tr>
<td></td>
<td>135°</td>
<td></td>
<td>100</td>
<td>99.9</td>
<td>98.0</td>
<td>98.0</td>
<td>360.4</td>
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<td>82.1</td>
<td>49.3</td>
<td>13.1</td>
<td>104.1</td>
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<tr>
<td></td>
<td>45°</td>
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<td>79.4</td>
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<tr>
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<td>94.5</td>
<td>95.9</td>
<td>92.8</td>
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<tr>
<td></td>
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<td></td>
<td>100</td>
<td>98.2</td>
<td>95.3</td>
<td>94.1</td>
<td>309.6</td>
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</tbody>
</table>
QCap – ABB cylindrical capacitor series
The ABB cylindrical capacitors.
ABB quality and reliability for mainstream PFC applications.

CLMD03 – power module pro
Easy to build into power modules for most common ratings.
Only high-runner ratings from the market are available.
Same technology as CLMD.

CLMD – all-around star
The ultimate solution for LV PFC applications thanks to its flexible ratings and wide voltage range up to 1000V; including heavy-duty, customized design and other demanding loads.
Reliability and safety first
Result of strict components specification

“First class components”:
- QCap: exceptional reliability & safety
- ABB specific reactor: electrical robustness
- RVC & RVT controllers: proven and easy interface
- ABB shelves
- ABB contactor & breaker (optional)
- ABB enclosure
APCQ-M LV Capacitor Banks Design
Main parts of an automatic capacitor banks

- Cabinet
- Ventilation (fan)
- Power factor controller (regulator)
- Capacitor sections
- Base plinth
APCQ-L LV Capacitor Banks Design Guideline
Main parts of an automatic capacitor banks

- Ventilation (fan)
- Power factor controller (regulator)
- Capacitors
Modular Racks with Qcap

Exemple of 50 kvar capacitor step module with reactor

- Reactor
- Capacitors
- Mounting plate
- Fuses holder
- Contactor
Power Quality
Harmonics- Key Standards

- **IEC 61000-series** (depends on the current and type of Industry). (THDv < 8%)

- **Series 6.4**: Electromagnetic Compatibility (EMC) Emission standard for industrial environments

- **Series 6.3**: Electromagnetic Compatibility (EMC) Emission standard for residential, commercial and light-industrial environments.

- **Series 3.6**: Assessment of emission limits for distorting loads in MV and HV power systems – Basic EMC publication

- **IEEE 519 (1992)**: Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems (THDv < 5%)

- **Engineering Recommendation G5/4-1**: Planning Levels For Harmonic Voltage Distortion And The Connection of Non-Linear Equipment To Transmission Systems And Distribution Networks In The United Kingdom - October 2005 (Individual Harmonic current limit)
How ABB can support customer?

**Save Energy**
- Improve the power factor (reduce kvar)
- Eliminate the harmonic current from your network (reduce $I_R^2$)

**Solve technical problems (power quality issues)**
- Identify root cause of electrical equipment failure with power quality analyser and customer installation study

**Improve overall efficiency**
- Reduce maintenance costs and down time
- Improve equipment reliability.

**Compliance with local/international regulations (IEEE, IEC, G5/4, etc…)**
- Make sure that you comply with regulations and standard (THDv < 5%) while connection to the grid
Way forward
Tell us more…

- Single Line Diagram
  - Min. data to collect in order to size our solution

- Type of load & load conditions

- Power Quality Measurement
  - Best solution

- Electricity Bill
  - Useful for Energy saving calculation
Requested data for harmonic analysis

Project ref.: 

Date:

**HV Network**
- Short-circuit power: MVA
- Voltage: V
- Frequency: Hz
- Remote control frequency (if any): Hz

**Transformer**
- Nominal power: kVA
- Short-circuit impedance:
- Secondary Voltage: V

**UPS**
- Power: kVA
- Full time / Back up
- Static/Dynamic

**Transformer-busbar cable**
- Length: m
- Cross section / phase: mm²
- Nr parallel connections:

**Single phase loads:**
- Dimmers: pieces
- kW (total)
- PC / Printers: pieces
- Lights (ballast): pieces
- kW (total)

**Drives**

**Linear Load**
- Active power: kW
- cos φ:

**Existing capacitors**
- Fix & Automatic banks: kvar
- Reactor banks: kvar
- Tuning: Hz
- Filters: kvar
- Tuning: Hz

**Targets to reach**
- cos φ:
- THD at Poc
- THD at LV bus

**Problem to solve:**
- Reduce voltage drop
- Harmonic regulation (specify)
- Other: (specify)

**Inform us if notches are present on the network as dedicated output filter may be required (it is recommended to send us oscillogram of network voltage waveform)**

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LV Filtro activo de armónicos: rango PQF
Principio de funcionamiento
LV active harmonic filters: PQF range

- Answer to Power Quality problems
- Active filtering of harmonics
- Inductive and capacitive stepless reactive power compensation
- Balancing of unbalanced loads
- Includes redundancy option

Your Benefits
- Trouble-free operation of your system and less down-time
- Compliance with regulations
- Possible reduction of running costs and CO₂ emissions
- PQFM available in IP00 versions for OEM customers
- PQFS (compact model) can be integrated in OEM enclosures
PQF: Where are they installed?

Segment

- Buildings & Infrastructure: 29%
- Water Industry / Utility: 18%
- Transportation: 14%
- Manufacturing: 11%
- Cement, Minerals & Mining: 5%
- Food & Beverage: 4%
- Pharmaceutical / Chemicals: 3%
- Oil & Gas: 6%
- Wholesale and Retail Trade: 3%
- Textiles: 1%
- Pulp & Paper: 3%
Mining industry: Hellas Gold in Greece
PQFI active filter

- Problems:
  - Significant level of harmonic currents
  - Bad voltage waveform

- Customer benefits
  - Efficient filtering of harmonics → reduced electrical pollution
  - Improved performance of electrical loads → downtime reduction
Cement Industry_Turkey
PQF for AC drives

- A cement plant with
  - Large number of variable speed drives
  - High degree of harmonics
  - Damage of sensitive loads, failure of electronic cards, increased losses
  - Bad power quality

- **Solution**: 3 PQFI at each transformer feeding the plant loads
  - 1 PQFI 180A for the 690V bus
  - 2 PQFI 450A for the 400V buses

<table>
<thead>
<tr>
<th>Transformers</th>
<th>690V</th>
<th>400V</th>
<th>400V</th>
</tr>
</thead>
<tbody>
<tr>
<td>THD(U)</td>
<td>6.7%</td>
<td>5.4%</td>
<td>4.0%</td>
</tr>
<tr>
<td>THD(I)</td>
<td>33.0%</td>
<td>39.9%</td>
<td>24.7%</td>
</tr>
<tr>
<td>THD(U)</td>
<td>2.6%</td>
<td>1.8%</td>
<td>1.5%</td>
</tr>
<tr>
<td>THD(I)</td>
<td>8.1%</td>
<td>6.6%</td>
<td>4.3%</td>
</tr>
</tbody>
</table>
Paper industry: Kimberley Clark in El Salvador

PQFI and PQFM active filters

- Problems:
  - Harmonic pollution due to non linear loads
  - Reactive power compensation needed due to many motors

- Customer benefits
  - Reduction of harmonics distortion
  - Power factor correction according to regulations
  - Reduction of capacitor damages and power electronics failures
Solar Plant: Italian Utility
PQFI Active Filters

Line currents (waveforms) **without** the PQFI active filter at 20kV
THDv : 1.5% / THDi : 20%

Line currents (waveforms) **with** the PQFI active filter at 20kV
THDv : 0.6 % / THDi : 1.5%
WindMill Application
PQF Active Filters

- Measurements 66kV
  - 66kV/22kV
- Measurements PQS 22kV

- 6 x 1.5MW
- 7 x 1.5MW

- Statcom 20xPC S100
- PQFI 3x450A

Spectrum in supply transfo current

- Current @ 66kV (Arms)
  - Harmonic order

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ABB PQC-STATCON range

Answer to key power quality problems
- Instantaneous, stepless inductive and capacitive dynamic reactive power compensation
- Balancing of unbalanced loads

Your Benefits
- Trouble-free operation of electrical system and less down-time
- Compliance with regulations
- Possible reduction of running costs and CO2 emissions

For inductive and capacitive loads
For highly fluctuating loads e.g. welding loads, rolling mills etc.
For industrial loads fed by weak networks, e.g. captive generators
For three phase and single phase applications, e.g. railways
Suitable for LV networks, and MV networks with step-up transformer

Response time: 8.062ms (Rise)
How do we improve PF for welding Loads?

- Source PF of 2.5 MVA transformer (PQC Off)

- Source PF of 2.5 MVA transformer (PQC STATCON on)

- Figure: PQC Performance in M/s FIAT India Automobiles.
Our references

Customers

Kimberly-Clark  SANDVIK  BECHTEL  SAMSUNG

Kraft  IBM  CocaCola  Nestle  Unilever

BMW  Volkswagen  BASF  Chrysler  H&D

Conoco  Dow  ROC  James Walker  Meyer

gsk  ThyssenKrupp  vitopal  manroland  ExtruDex

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