Power Quality Compensator - Reactive (PQCR)
Enhancing power quality and energy efficiency of your electrical network
ABB is a pioneering technology leader in power grids, electrification products, industrial automation and robotics and motion, serving customers in utilities, industry and transport & infrastructure globally. Continuing a history of innovation spanning more than 130 years, ABB today is writing the future of industrial digitalization with two clear value propositions: bringing electricity from any power plant to any plug and automating industries from natural resources to finished products. As title partner in ABB Formula E, the fully electric International FIA motorsport class, ABB is pushing the boundaries of e-mobility to contribute to a sustainable future. ABB operates in more than 100 countries with about 147,000 employees.

ABB offers a wide range of products from 208 V up to 1200 kV that help enhance the reliability, efficiency and quality of power in transmission and distribution grids, power plants and industries while minimizing environmental impact. The wide product range is complemented by a comprehensive service offering.

Power quality is a major concern for transmission and distribution utilities, industries, and transport and infrastructure sectors. Poor power quality affects grid reliability, productivity, leads to higher operating costs and penalties for non-compliance with grid codes. ABB is a technology leader with a wide range of products, systems and services that improve power quality including capacitors and filters, power electronics-based compensators and software solutions, across the power value chain for low, medium and high-voltage applications, helping to shape a stronger, smarter and greener grid.

Power Quality Compensator - Reactive (PQCR) is a solid state reactive power and harmonic compensator for dynamic and highly fluctuating loads. A single module is rated up to 375 kvar at 415 V (or 440 V) and is designed with a small footprint. An overall reactive power compensation rating up to 12000 kvar can be reached by paralleling modules in a hybrid topology.

PQCR technology works on the principle of Voltage Source Converters (VSC) using high power IGBTs and low loss capacitors.

Single unit ratings of PQCR are available from 150 kvar to 375 kvar.

PQCR can be used for applications requiring instantaneous and stepless dynamic compensation and harmonic mitigation for dynamic and unbalanced loads with response time of less than 1 cycle like:

- Inductive and capacitive loads
- Highly fluctuating loads
- Industrial loads fed by weak networks
- Three phase and single phase applications
- LV networks and MV networks with step-up transformer

Applications Include:

- Automotive manufacturing plants
- Steel plants
- Rolling mills
- Traction loads
- Wind and solar farms
- Pulp and paper industries
- Crane operation facilities
- Cable capacitance compensation

Enhancing power quality and energy efficiency
Applications in several areas of the power value chain
**Stepless power compensator PQCR**

**Unique features and benefits**

- **Improved power quality**
  PQCR can compensate for dynamic reactive power and unbalanced loads in a fast and transient-free manner. It can compensate both inductive and capacitive behaviour of the loads, thereby enhancing power quality in a truly superior way.

  PQCR in combination with equal rated fixed filter banks doubles the dynamic range of the capacitive reactive power compensation capacity and reduces the Total Harmonic Distortion (THD).

- **Robust construction of components**
  PQCR consists of robust components like:
  - Latest generation IGBTs with high thermal capacity
  - Better ripple current handling capacity of DC film capacitors increases the operating life
  - Compact and robust IGBT stack with higher unbalancing capacity and reduced footprint

- **Compliance with utility regulations**
  PQCR enables compliance with stringent power quality regulations on power factor and THD. This helps customers avoid penalties imposed by utilities and/or refusal to connect installations to the grid. Rapid reactive power compensation also helps to maintain the voltage in the network.

- **Enhanced energy efficiency by reducing system losses**
  High power requirement at a very low power factor results in a high load current. High current results in additional losses (I^2R losses) in supply cables and transformers which leads to inefficient operation of the plant.

  The customer faces an increased energy bill due to higher losses in the system. Moreover the energy losses because of reactive power and harmonics present in the system may lead to excessive heating of various components which reduces the life expectancy of the electrical equipment.

  PQCR enhances energy efficiency by improving the power factor dynamically and thereby reduces these energy losses.

- **Easy installation, commissioning and operation**
  PQCR is provided with a 7 inch touchscreen display which provides a versatile interactive interface to users. The simple organization of menus and sub-menus ensures ease in navigation. Minimal configuration set-up of the system parameters eases the commissioning process. The PQCR-Manager follows the TCP/IP communication protocol and can communicate externally over Ethernet/LAN port. All parameters, settings and measurements are accessible remotely.

- **Improved system usage**
  In thermally limited equipment, such as transformers or cables, PQCR enhances capacity and thus allows a greater payload/usage of the same system. By furnishing the necessary magnetizing current through PQCR to induction motors and transformers, the current drawn from the power supply is reduced. Less current means less load on transformers and feeder circuits. If a system has an existing overload, because of reactive power, PQCR can eliminate it.

  PQCR brings cost savings as no additional investment is needed for infrastructure equipment like transformers, switchgear and cable, which may otherwise be required to serve additional loads.

- **Reduced maintenance needs and enhanced life of electrical installations**
  Poor power quality leads to inefficient running of installations, system down time and reduced equipment life and consequently high installation running costs. With PQCR the power quality of electrical installations is maintained and the installation lifetime can be optimized.
Technology based on Voltage Source Converters
Enabling enhanced power quality of your electrical network

PQCR is based on Voltage Source Converter (VSC) technology. VSC technology consists of Insulated Gate Bipolar Transistors (IGBT) as fully controlled power semiconductor devices.

Major components like VSC converter, switchgear and controllers are designed in-house, meeting relevant international standards as well as ensuring consistency in quality.

The VSC produces single or three phase AC voltages from a DC source voltage. The VSC generated voltage is coupled to the supply voltage through a Pulse Width Modulation (PWM) reactor. By varying the magnitude of the AC terminal voltage of the VSC, reactive power exchange takes place between the VSC and the AC source. Further, PQCR generates appropriate magnitude of voltage at the AC terminal of the VSC to compensate for negative sequence current due to unbalanced loads.

Hence, the source is totally relieved from reactive current and negative sequence current (due to unbalanced loads). This results in a flow of balanced real current in all three phases in the source. In addition, the dominant harmonics can also be reduced.

PQCR provides excellent steady state performance, instantaneous response (<1 power cycle) and has superior control characteristics, thanks to high speed Digital Signal Processor (DSP) technology.

Let’s take an example of a typical welding load in an automobile factory. Arc welders draw high levels of inrush current during their operating cycle, which is often only several seconds in duration. These high cycle-to-cycle currents cause high reactive power to be drawn from the supply resulting in a drop of the voltage at the transformer secondary and leading to failure or loss of productivity.

When PQCR is connected to the load, it compensates reactive power to support the arc welder and reduces reactive power demand upon the upstream electrical system. The system transformer does not see the massive demand for reactive current and does not experience significant voltage drops, and therefore the voltage remains stable.

The response time of PQCR is less than one power cycle of fundamental kvar compensation, ensuring accuracy and quality of the welding operation.

PQCR – Dynamic response

![Diagram of PQCR current, Source voltage, Step response](image)

ABB’s PQCR enhances productivity and energy efficiency at Toyota Indus Motor company, Karachi, Pakistan
**Technical specifications**

**PQCR**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>3 phase</th>
<th>1 phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal voltage</td>
<td>V</td>
<td>380 - 440</td>
<td>380 - 440</td>
</tr>
<tr>
<td>Maximum kvar unit</td>
<td>kvar</td>
<td>375</td>
<td>275</td>
</tr>
<tr>
<td>Maximum capacity per unit</td>
<td>A(RMS)</td>
<td>520</td>
<td>665</td>
</tr>
<tr>
<td>Maximum kvar support @ Voltage</td>
<td>V</td>
<td>415/440</td>
<td>415/440</td>
</tr>
<tr>
<td>Network frequency</td>
<td>Hz</td>
<td>50/60</td>
<td>50/60</td>
</tr>
<tr>
<td>Response time</td>
<td>ms</td>
<td>&lt;20</td>
<td>&lt;20</td>
</tr>
<tr>
<td>Number of parallel units</td>
<td>Nos</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>Communication features</td>
<td></td>
<td>Ethernet/LAN port</td>
<td>Ethernet/LAN port</td>
</tr>
<tr>
<td>Target cos φ</td>
<td></td>
<td>Inductive/ Capacitive</td>
<td>Programmable from 0.6 (inductive) to 0.6 (capacitive)</td>
</tr>
<tr>
<td>Acoustic noise level</td>
<td>dB</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Enclosure dimensions</td>
<td>mm</td>
<td>900 (W) X 960 (D) X 2225 (H)</td>
<td>900 (W) X 960 (D) X 2225 (H)</td>
</tr>
<tr>
<td>Mode of operation</td>
<td></td>
<td>var compensation</td>
<td>var compensation</td>
</tr>
<tr>
<td>Load unbalance compensation</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Unbalance compensation range</td>
<td>%</td>
<td>50 to 100</td>
<td>NA</td>
</tr>
<tr>
<td>Environmental conditions</td>
<td></td>
<td>Ambient temperature</td>
<td>-5 to 40°C</td>
</tr>
<tr>
<td>Enclosure protection</td>
<td></td>
<td>IP 30</td>
<td>IP 30</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>%</td>
<td>0-95%</td>
<td>0-95%</td>
</tr>
</tbody>
</table>

PQCR has external communication feature. Customer shall establish and maintain appropriate measures (such as but not limited to the installation of firewalls, application of authentication measures, encryption of data, installation of intrusion prevention etc.) to protect PQCR network system and its interfaces against any kind of security breaches, unauthorized access, intrusion, leakage and/or theft of data or information. ABB is not liable for damage and/or losses related to such security breaches, any unauthorized access, intrusion leakage and/or theft of data or information.

Tests performed as per IEC61439: heat run test/ dielectric test/ strength of material/ ingress protection/ protective circuit/ clearance and creepage and mechanical operation.
Application example: Automobile industry
Enhancing power quality and energy efficiency for Toyota Motors

The Toyota Indus Motor company, located at Port Bin Qasim Industrial Zone near Karachi, is the only manufacturing site in the world where both Toyota and Daihatsu brands are manufactured under the same roof. Along with state-of-the-art production technology, the facility has also implemented the world renowned Toyota Production System, that eliminates waste or ‘muda’ to enhance efficiency and productivity.

PQCR compensates reactive power instantaneously and helps lower operating costs.

Customer problem statement
To create the body of the car, a spot welding process is deployed. This requires high levels of current repetitively for several milliseconds during the operating cycle. The welders also operate in an asymmetrical manner across phases. All this leads to highly fluctuating reactive power and an unbalanced load current, causing large and uneven drops in transformer voltages.

Additionally, the facility at times faces intermittent supply and frequent power outages. During such instances, the Toyota Motors facility is supported by standby power from 1500 rpm diesel generators. “During a utility power outage, when operating on one 2250 kVA generator, the number of operating welders had to be reduced from 95 to 40 due to disruption caused by the high amount of reactive power and unbalanced currents drawn by the spot welding process. To operate at full capacity, two additional 725 kVA or one 1600 kVA generator had to be installed,” says Fahad Iftikhar, Manager, Toyota Indus Motor Company.

ABB solution
After a detailed study of the various electrical parameters, ABB’s stepless reactive power compensator, PQCR, was proposed as a solution.

The PQCR technology is used to provide reactive power support for grid-based supply networks as well as for dynamic loads fed from standby generators. By installing a PQCR at Toyota Indus Motor Company, the power factor of the network increased from 0.85 to 0.95, thus enhancing power quality at the facility.

Fahad Iftikhar, Manager of IMC’s Projects Department says, “There have been notable benefits by installing ABB’s PQCR in our welding shop. We now operate only one 2250 kVA generator in the event of utility outages, leading to cost and environmental benefits. Resultant savings are up to US$300 per hour. There are also considerable improvements in welding quality owing to reduced voltage drops during power outage.”

He also added that “Being the first of its kind in Pakistan, this project had many stringent prerequisites. It was successfully completed due to the strong commitment and dedication of the teams of ABB in India and Pakistan.”
Application example: Railways

ABBY power quality solutions help Bulgarian Railways ensure grid compliance

The Bulgarian State Railways, founded in 1888, are among the oldest rail networks in Europe. Providing passenger and freight services, they cover more than 4,200 kilometers and connect diverse geographies – from the snow-capped Balkan mountains to the sunny Black Sea coast, from the bustling state capital Sofia to culture hub Plovdiv, and from Balkan Serbia to Mediterranean Greece.

Reactive power compensators from ABB, installed in five traction substations across Bulgaria have improved power quality across the rail network, bringing further benefits such as increased availability of the supply network, higher reliability and improved energy efficiency.

The National Railway Infrastructure Company (NIRC), responsible for the smooth operation and maintenance of this railway infrastructure and the electrical power that supports it, was facing power quality challenges across the network.

Customer problem statement

Large varying non-linear loads are an inherent feature of electrical rail-way traction systems. Since the load changes dynamically and constantly, the traction power supply system draws a high amount of reactive power resulting in low power factor affecting power quality. Poor power quality is not only harmful to the traction system itself, but also prone to spreading through the supply grid and can cause disturbances to other users on the same grid. It also results in non-compliance to grid codes, leading to financial impact in the form of penalties.

An efficient and cost-effective solution from ABB NIRC approached ABB for a solution to its power quality challenge. After a detailed study of the various electrical parameters, ABB’s stepless reactive power compensators PQCR were installed in the traction substations.

The PQCR technology is used to provide reactive power support for grid-based supply networks. By installing this technology at various nodes across its electrical system, NIRC will experience improved power quality and better compliance to grid codes. Further benefits are accurate and precise compensation without the need for manual intervention, voltage stability and avoidance of penalties by the grid.

Deyan Andonov, Project Manager, ABB in Bulgaria says, “PQCR and power quality monitoring equipment is now installed at five NIRC substations across Bulgaria and will help NIRC maintain the right power quality across its network and avoid significant financial penalties. It will also give them added benefits like reliability and availability of the supply network, energy efficiency and lower maintenance costs.”

Quality assurance

At ABB, we are committed to providing the best products and services. Our products comply with or exceed the latest international standards. In addition to type tests in independent laboratories, our certified design and manufacturing processes guarantee the highest quality. We are certified according to the latest relevant ISO quality standards.

Sustainability

For ABB, sustainability is about balancing economic success, environmental stewardship and social progress to benefit all our stakeholders. Sustainability considerations cover how we design and manufacture products, what we offer customers, how we engage suppliers, how we assess risks and opportunities, and how we behave in communities where we operate and towards one another, while striving to ensure the health, security and safety of our employees, contractors and others affected by our activities. We are certified according to the latest relevant ISO quality standards.
ABB is a technology leader with a wide range of products, systems and services that improve power quality including capacitors and filters, power electronics-based compensators and software solutions, across the power value chain for low, medium and high-voltage applications, helping to shape a stronger, smarter and greener grid.