POWER QUALITY SOLUTIONS

Enabling a stronger, smarter and greener grid
Many of us have experienced the consequences of poor power quality. These might be as simple as a washing machine or dishwasher malfunction, or a flicker on the computer screen in the office. Or they may cause a deeper impact like equipment breakdown at an industrial plant, potentially resulting in considerable losses, damages and penalties.

Power interruptions are often seen as a consequence of random events in the network or inherent faults in equipment, but they may also be the result of poor power quality. Billions of dollars in revenue are lost each year as a result of power quality issues that cause hours of downtime, lost productivity, and possibly, the need to repair or replace equipment prematurely. Power quality issues can lead to higher energy bills, and some utilities also impose penalties for non-compliance to grid regulations. Poor power quality also has a negative impact on carbon emissions and energy efficiency.

Poor power quality is not a new problem. Momentary outages have occurred for years, but they were not so easily perceived because electrical equipment – usually based on electro-

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**Consequence of poor power quality**

1. **Wind power generation**
   - Not able to connect to the grid in case of over voltage or under voltage or if harmonic pollution emitted is too high.

2. **Marine**
   - Non-compliance, not allowed to connect to grid, increase in running costs, frequent outages and downtime.

3. **Conventional power generation**
   - Higher stress on generators leading to premature failure/eratic behavior, higher running costs.

4. **Industry**
   - Non-compliance to grid codes, not allowed to connect to grid, penalties, lower productivity, potentially higher CO₂ emissions.

5. **Power distribution**
   - Not able to connect to the grid in case of over voltage or under voltage or if harmonic pollution emitted is too high.

6. **Railway**
   - Non-compliance, penalties, frequent outages and downtime, reduced operational efficiency.

7. **Solar power generation**
   - Not able to connect to the grid in case of over voltage or under voltage or if harmonic pollution emitted is too high.

8. **Infrastructure**
   - Penalties, frequent outages and downtime, reduced equipment life, potentially higher CO₂ emissions.

9. **Residential and small commercial**
   - Poor power factor and harmonics resulting in inefficiency and high energy bills.

10. **Microgrid**
    - Power quality is an issue for any generation installation.
Benefits of good power quality

Power quality is a major concern for anyone involved in the generation, transmission and distribution of power, as well as for many industrial and commercial consumers.

Good power quality is a measure of the availability, quality and efficiency of the electricity being supplied and utilized on a consistent basis. It leads to higher reliability and availability of the supply network, improved energy-efficiency, industrial productivity and eco-efficiency with lower environment impact.

With the right analysis and solutions, both utilities and consumers can tackle power quality issues so that the broad benefits of advanced power electronics, renewable energy and electric transportation can be fully realized.
ABB and power quality
Addressing power quality challenges across the grid

ABB is a leader in improving power quality. We offer a wide range of products and solutions that address all forms of power quality issues, enabling both utilities and industrial users to improve the reliability and availability of their power networks and thus enabling a stronger, smarter and greener grid.

Power quality phenomena

Steady state
- Voltage fluctuation
- Reactive power
- Harmonics and high frequency noise
- Load imbalance
- Voltage drops, sags and swells.

Transient
- Voltage sags and swells
- Transient caused by Lightning and/or switching
- Frequency support
- Interruptions or outages.

Utilities

Impact of poor power quality
- Generators not able to connect to the grid
- Higher stress on generators leading to premature failure or erratic behavior
- Higher cost of electricity due to losses in the grid and higher running costs of generators
- Reduced efficiency due to transmission and distribution losses.

ABB solutions that address power quality issues
- Consulting
- Plant surveys and assessments
- FACTS
- Capacitor banks
- Shunt reactors
- Harmonic filters
- Surge arresters
- Volt-Var management software
- Protection relays
- Line voltage regulator (MV/LV)
- Energy storage
- Plant surveys and assessments
- Automation.

Numerous benefits of improved power quality
- Lower running costs
- Compliance with grid codes
- Postponement of grid upgrades
- Grid stabilization
- Ease of integration of distributed renewables and electric vehicles
- New revenue from ancillary services.
For utilities, ABB offers everything from FACTS solutions to conventional reactive power compensation for voltage support in transmission systems. We help enhance power factor in substations using compact, metal enclosed solutions for urban environments or modular mobile solutions. We also offer solutions for distribution line compensation to reduce copper cable losses.

For industrial and infrastructure providers, ABB offers solutions to increase plant Mvar capacity or solve intermittent outages caused by voltage variations and harmonics. We have solutions for instantaneous power factor correction for fast acting loads like welders, cranes and lifts, up to more complex solutions for removing harmonics, voltage flicker and voltage imbalance, as well as energy storage solutions. ABB also offers solutions that better utilize power from the grid and reduce harmonics which, in some applications, have directly reduced copper cable losses by 10–15 percent.

ABB is uniquely placed to help solve power quality challenges. Not only do we have extensive power industry expertise, we also have the capability to develop and deliver the right power quality solution for virtually any application. Most importantly, we can help demonstrate that rather than being an added cost burden, attention to power quality paves the way for more energy-efficient and reliable networks that deliver a significant return on investment.

### INDUSTRY
- Penalties due to non-compliance to grid codes
- Lower productivity
- Increased in running cost
- Frequent outages and downtime
- Potentially higher CO₂ emissions.

### TRANSPORTATION AND INFRASTRUCTURE
- Penalties due to non-compliance with grid codes
- Frequent outages and downtime
- Reduced operational efficiency
- Reduced equipment life
- Potentially higher CO₂ emissions.

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Power generation
Delivering reliable power efficiently and consistently

Producers and suppliers of electricity can create value only through the consistent generation and delivery of power. This means not only managing reactive power and implementing frequency stabilization solutions, but also keeping power oscillations, voltage fluctuation and harmonic pollution below required levels.

Burbo Bank offshore windfarm, UK – optimizing renewable energy use while enhancing grid stability and power quality

ABB delivered an order from Ørsted, the global leader in offshore wind, for a two megawatt (MW) Battery Energy Storage System (BESS) to support the National Grid with frequency response at Burbo Bank offshore windfarm near Liverpool, UK. The 90 MW Burbo Bank offshore wind farm has been in operation since 2007 and is capable of supplying electricity for up to 80,000 UK homes. This will be the first time an offshore wind farm integrates such a storage system to stabilize the frequency of the grid in the UK.

The UK’s National Grid operates at a frequency level of 50 Hertz (Hz) to ensure grid stability and quality of power supplies. Grid frequency is dependent on the balance between power supply and load demand. Integration of large amounts of variable wind energy increases complexity from a supply perspective and can result in frequency variations that can affect grid supply and impact consumers. ABB and Ørsted’s BESS solution will work with the windfarm to help stabilize grid frequency ensuring offshore wind plays an important role supporting the grid in addition to supplying renewable energy.
Rampion windfarm, UK – enabling green power generation and grid compliance

E.ON’s new 400 MW Rampion offshore wind farm, on the UK’s south coast, includes 116 turbines, with the nearest located 13 kilometers from shore.

ABB delivered a turnkey onshore substation equipped with four STATCOM units, to ensure grid code compliance and reliable, green power production from the wind farm. The STATCOM provides reactive power compensation by detecting and instantaneously compensating for voltage fluctuations associated with the intermittent nature of wind energy.

NTPC Solar Power Plant, Dadri, India – boosting revenues by minimizing losses in power generation

A new 5 MW solar power plant in India was able to deliver only 50% of its peak output into the local generation bus. ABB carried out detailed harmonic measurement, analysis and system resonance studies to investigate the problem. We found that there was network resonance with a predominant harmonic at the 18th order frequency.

ABB’s solution was to install a 100 kvar, 18th order, single tuned LC passive filter at each 1.1 kV bus. The result is that the customer is now able to feed all its output into the grid. Not only is this boosting revenues, it is also helping to enhance the life of the equipment by reducing network over-voltages.
Transmission and distribution utilities
Maintaining efficiency and reliability with low operational costs

For power utilities, poor power quality can cause very expensive damage to network components – such as transformers, breakers, capacitor banks – as a result of excessive heating and overloads, as well as reduced energy efficiency, undesirable fault tripping and early aging (for example, in cables).

Poor power quality also leads to complaints from customers, who may suffer interruptions in production and possibly damage to equipment and property – with a potentially severe financial impact.

With good control over the quality of power, utilities can deliver a clean, green and trouble-free supply to their customers. They are also able to provide more power, more efficiently, with fewer interruptions, with a lower environmental impact and with lower capital and operational costs.

Réseau de transport d’électricité (RTE) – enabling grid stability by reducing harmonics

Réseau de transport d’électricité (RTE), manages the largest transmission system in Europe, supplying electricity to consumers via 105,000 km of lines. In Brittany, in the northwest of France, RTE had identified a potential risk of severe voltage drop in the event of a cold winter and line tripping.

ABB proposed and provided a solution to stabilize the network in Brittany to make it more resilient to stress, using its Flexible Alternating Current Transmission Systems (FACTS) technology.

The solution included ABB’s Static Var Compensator (SVC) technology – part of its FACTS portfolio – which helps to stabilize power grids.

The solution reduces Total Harmonic Distortion (THD) and improves the efficiency of the transmission system – leading to increased grid reliability, improved voltage stability and lower risk of blackouts.
**Power Grid Company of Bangladesh – boosting efficiency in the power grid**

Capacitor banks installed at eight substations owned by Power Grid Company of Bangladesh (PGCB) have improved the performance of its 132 kV transmission grid, parts of which were suffering losses because of voltage drops and poor power quality. The reactive power compensation solution from ABB has brought the equivalent of 34 MW of extra power into the grid, without the need to build any additional generation capacity. The ability to deliver this much additional power has significantly improved PGCB’s revenues.

The cost of the solution is a fraction – less than 15% – of the capital that would have been required to build a conventional fossil fuel power plant to produce this much power. The payback period for PGCB’s investment is estimated to be 18 months.

Additionally, because the ABB system recovers lost energy rather than generating new, there are no continuous operating costs and no greenhouse gas emissions.

**Radius Elnet, Denmark – efficient utilization of renewable energy and grid load reduction**

ABB has commissioned Denmark’s first urban battery energy storage system (BESS) which is integrated with the local electricity grid in the harbor district of Nordhavn, Copenhagen. The system has been commissioned for Radius Elnet, Orsted’s electrical grid division.

The BESS is part of the ‘EnergyLab Nordhavn’ project implemented in the Nordhavn district of Copenhagen. The project aims to develop and demonstrate energy solutions of the future. This includes providing valuable knowledge to help realize a more flexible and sustainable electricity grid with large amounts of renewable energy. These solutions are crucial for reaching the Danish government’s ambitious goal of turning Copenhagen into the world’s first carbon-neutral capital in 2025.

Radius’ BESS will play a significant role in the energy system, in which solar and wind energy will provide the majority of the electricity production. Since renewable energy production is less predictable, the storage system will be a key element of energy supply. It is a flexible and modular system which can be used for different functionalities, such as peak load shaving and frequency response.

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Below: ABB has commissioned Denmark’s first urban battery energy storage system (BESS) in Copenhagen.
Power consumers
Boosting productivity, efficiency and grid compliance

The need for consumers to manage power quality is growing as small-scale renewable generation is now more commonplace and a growing range of power electronic equipment is installed in plants and commercial premises.

Industrial and commercial consumers have always faced power quality challenges due to the non-linear loads present in their facilities. Improving power quality contributes directly to their revenues, as consistent high-quality power reduces downtime and wear and tear on equipment, boosting productivity and saving on maintenance costs. There is also the added advantage of avoiding penalties such as those associated with low power factor.

Accenture, India – reduced equipment downtime

Accenture, the global management consulting, technology services and outsourcing company, commissioned an external agency to conduct a power quality audit due to a three-fold increase of issues at uninterrupted power supply (UPS) equipment at large server clusters in Chennai and Hyderabad. The 24x7 availability of the servers is critical to Accenture’s business. The major findings of the study were disturbances in the power supply due to high levels of neutral ground voltage, voltage harmonic distortion, current harmonics, neutral current, and other issues.

ABB installed its PQF Active Filters – 7 nos. at Accenture Chennai Centre and 4 nos. at its Hyderabad Center to protect sensitive equipment from heavy harmonics and tripping. This led to a boost in power quality, improved energy-efficiency and reduced equipment downtime.

Fonterra, New Zealand – minimizing production downtime

When the leading multinational dairy manufacturer Fonterra needed a power protection solution for its processing and packaging lines at its facility in Takanini, Auckland, ABB was able to provide a solution that would eliminate voltage sags and cut out over four power quality events annually, saving an estimated cost of USD200,000 per year.

The facility draws between 30 to 40 MW of power, mainly consumed by large AC drives and motors. Most of its power quality problems are short-term voltage sags caused by faults and events in the external electricity utilities network. This can
mean that the milk is not sterilized for consumer use and has to be disposed or reprocessed.

Installing ABB’s PCS100 Active Voltage Conditioner (AVC) has mitigated voltage disturbances in Fonterra’s facility, minimizing unwanted downtime and wasted product. In the first four months after it was installed, Fonterra suffered five power quality events. The PCS100 AVC enabled the UHT area of the plant to maintain operations, while other areas that were not protected were shut down.

**Bulgarian National Railway Infrastructure Company, Bulgaria – savings on penalties, lower maintenance costs and increased energy-efficiency**

The Bulgarian State Railway is one of the oldest in Europe, and today provides passenger and freight services across more than 4,200 kilometers of track. This makes it a major power user.

The electrical railway traction system, operated by Bulgaria’s National Railway Infrastructure Company, comprises large and varying loads, which generates large amounts of dynamic reactive power. This often led to low power factor and voltage fluctuations and disturbances.

This was not only harmful to the traction system itself, its effects could also potentially spread to the local grid, cause disruption to other users and incur financial penalties.

To minimize these effects on the utility grid, ABB designed and supplied a PQCR-based reactive power compensation solution (previously known as PQC-STATCON), which dynamically varies reactive power at various key nodes across the rail network. This provides an instantaneous and step-less compensator for dynamically varying reactive power and unbalanced loads connected to the grid – improving power factor and reducing voltage variations.

The Bulgarian railways now benefit from precise compensation without the need for manual intervention, with a stable voltage and power factor compliant with utility standards – so avoiding penalties. The railway also benefits from increased reliability and availability of supply, energy-efficiency and lower maintenance costs.

**PepsiCo, India – enabling energy-efficiency and savings at bottling plant**

ABB has delivered a power quality solution to PepsiCo in India, reducing electricity bills at one of its bottling plants by 5 to 10% annually, delivering a return on investment of less than two years. The innovative technology behind the energy efficient solution is ABB’s PQCR dynamic and step-less reactive power compensation equipment.

ABB conducted a study for PepsiCo India to identify an optimal solution to enhance the power factor at its bottling plant, based on the nature and behavior of its loads. As a result of ABB’s power quality solution, the power factor has improved to close to unity from its previous level of 0.94, resulting in significant energy-efficiency gains and yielding savings of 5 to 10% in annual electricity charges, benefiting from the local billing scheme of the utility. Based on the savings rate, the expected ROI on the solution is less than two years.
Improving power quality across the board

ABB’s in-depth knowledge of power quality technology – combined with our comprehensive experience in addressing power quality challenges and practices – means we can offer a wide portfolio of products, systems, solutions, services and consulting capabilities to serve almost every customer need.
Our power quality expertise spans the entire value chain, from initial assessment, systems studies and measurement, through advice and solution design, to engineering and deployment of the solution, as well as lifecycle services.

ABB’s expertise and broad portfolio in power conversion solutions means we can provide the world’s most advanced FACTS solutions like STATCOM, SVC and series compensators.

Our capacitor, reactor and filter solutions can be found in all utility and industry sectors, across the world, covering the power value chain for low, medium and high-voltage applications. We add value for producers, system operators and consumers by helping them implement the right power quality solutions and products for their applications. Both passive and active solutions are available.

Our active voltage conditioning (AVC) and uninterrupted power supply (UPS) solutions ensure power resiliency of critical infrastructures such as hospitals, datacenters and industrial facilities such as production lines, food and beverage plants, oil & gas rigs, and mines.

The increasing integration of new distributed energy resources (DERs), including renewables and CHP (combined heat and power) together with new load types, such as electric vehicle (EV) charging or active building solutions is a growing challenge for power quality, security and reliability. ABB is tackling these challenges with technologies such as Line Voltage Regulation (LVR), Battery Energy Storage Systems (BESS), intelligent PV inverters and EV charging stations.

At the network level ABB’s Advanced Distribution Management System (ADMS) offers an integrated solution for distribution management, with real-time monitoring and control, network analysis, network optimization and outage management capabilities in an integrated software platform.

With the addition of a new Distributed Energy Resource Management System (DERMS), ABB optimizes control of the grid and DERs, including capabilities such as Volt-var optimization (VVO), power quality management and the coordination of DER dispatch to support operational needs. Together, ADMS and DERMS enable utilities, energy service companies and grid operators to efficiently manage the entire lifecycle of resources like solar, batteries and wind, while ensuring the safe, secure and efficient operation of the electricity distribution network.
ABB has one of the broadest portfolios of power quality technologies, solutions and products for all voltage levels and segments. We are able to provide exactly what our customers need, whatever the application, whether in power generation, power grids, industry, transport, infrastructure, commercial and residential.

Our engineers have the experience and expertise to help customers at every stage from measurement and analysis, through designing and building tailored solutions, to providing ongoing lifecycle services and training.

Enhancing power quality on the ‘roof of the world’

Tibet is often referred to as the “Roof of the World” and not without reason. Standing more than three miles above sea level, it is surrounded by imposing mountain ranges that harbor some of the world’s highest summits, with several of them making the top ten list. Extreme cold, permafrost and high ultraviolet levels only add to the challenges of the location.

The Qinghai-Tibet HVDC (high-voltage direct current) project is built by the State Grid Corporation of China. The ±400 kV (kilovolt) portion of the line starts from Geermu, Qinghai Province, and ends in Lhasa, Tibet, with a total length of 1038 kilometers. What makes this portion of the project especially noteworthy is that it is among the world’s highest overhead transmission lines and also the longest HVDC line ever built at such altitudes. For example, it traverses terrain that averages 4,500 meters (nearly 15,000 ft) with the highest point reached at the dramatic 5300-meter mountain pass at Tanggula. It is therefore critical that the high-voltage equipment, in particular its external insulation, meets the demands imposed by such altitudes and climatic conditions. ABB has supplied more than 900 high-voltage capacitor units for the converter station in Lhasa, Tibet at an altitude of above 4,000 meters. The modular design of the units has helped reduce installation time, and cuts maintenance costs.

In a HVDC transmission link a number of components such as the HVDC converters and transformers draw reactive power from the network leading to poor power quality. ABB supplied filter capacitor banks and shunt capacitor banks at a voltage a level of 220 kV for the Lhasa converter station. The capacitors installed close to the converters and transformers generate reactive power locally and as less reactive power is drawn from the grid power quality improves. This leads to higher supply network reliability and availability as well as energy efficiency.
Shaping the future of sustainable energy with pioneering technologies as the partner of choice for a stronger, smarter and greener grid

**Consulting**
- Asset consultancy
- System studies and consultancy
- Solution optimization and filtering design
- Training services

**Capacitors and filters**
- LV, MV capacitor units
- LV, MV, HV capacitor banks
- LV, MV, HV filter solutions
- Dry DC capacitors
- Power quality controllers
- Capacitor switches

**Surge arresters and surge capacitors**
- HV surge arresters
- MV surge arresters
- MV surge capacitors
- Voltage-limiting devices

**Monitoring, protection and controls**
- Protection relays with power quality monitoring
- Automation and communication solutions

**Shunt reactors**
- Shunt reactors
- Variable shunt reactors
- Series reactors
- Earthing transformers
- Dry and water-cooled reactors

**FACTS**
- TCSC (Thyristor controlled series compensation)
- Static Var Compensation
- STATCOM

**Active filtering solutions**
- Inverter-based power factor correction
- Inverter-based harmonic compensation
- Inverter-based unbalance compensation

**Volt-var management**
- Volt-var management across the distribution network
- Capacitor banks control system
- Line voltage regulator
- Synchronous condenser

**Voltage conditioning and regulation**
- Active voltage conditioners
- Uninterruptible power supplies
- Line voltage regulator

**Energy storage**
- Energy storage inverters
- Energy storage systems
- Scalable, modular and turnkey solutions

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**Your benefits**
- Optimized revenue – lower running costs
- Enhanced grid reliability and stability
- Compliance with grid codes
- Deferral of grid upgrades
- Ease of integration or realization of integration
- New revenue from ancillary grid services
- Reduced penalties from harmonic pollution and demand peaks
- Improved productivity and saving on maintenance costs
- Increased self-consumption of renewables