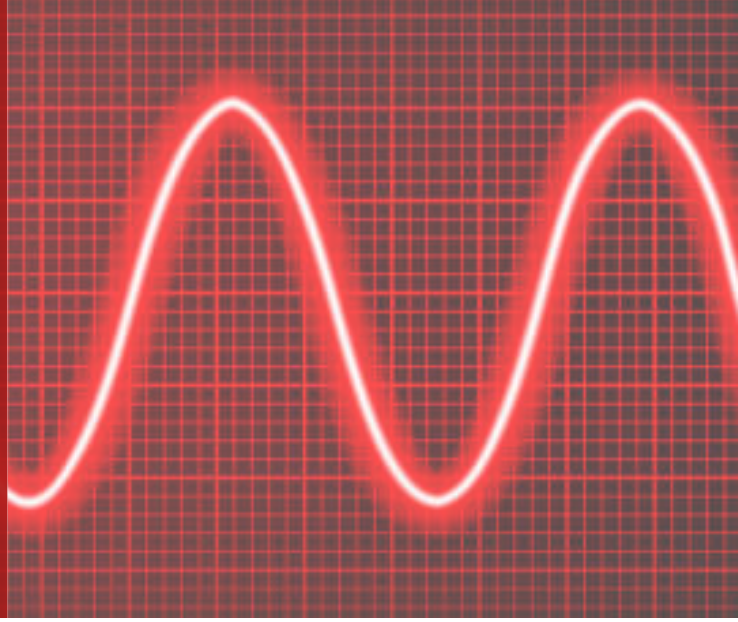
MITSUBISHI ELECTRIC POWER PRODUCTS, INC.

THE COST OF POOR POWER QUALITY



Modern industrial plants along with commercial sites depend on reliable, high-quality power to maintain assets at peak performance, stick to production schedules, and delivering fair profit to owners/operators and value to customers. Poor power quality can cause problems that cascade through a business, increasing costs and disrupting throughput. In this paper, we'll discuss the real costs of poor power quality. We'll also describe proven methods for detecting and resolving common power quality issues.

The Cost of Poor Power Quality

Several factors adversely impact power quality. The most common being voltage sags and surges, harmonics, spikes, and voltage flicker.

When not corrected in time, power quality issues can cause outages that take down the whole plant. The costs of downtime can be devastating in terms of lost productivity, wasted resources, and extensive repairs. But even when power issues don't lead to a shutdown, they can result in expensive problems. Here are just a few examples:

Voltage Sags

- Increased wear and tear on equipment - ratchets up costs in both the short and long term, causing higher maintenance costs, more frequent needs for part replacements, breakdowns, and eventually, a shorter asset lifespan.
- Increased energy consumption - driving up energy costs for the plant.

Harmonics, Spikes, and other Electrical Disturbances

- Create problems with production line - even if power quality problems do not bring the plant offline, they can cause defects in products. As time goes on, this can create problems in quality, downtime, scrap, and late deliveries, jeopardizing the company's reputation and customer relations.

Voltage Fluctuations

- Causes equipment to malfunction, decrease efficiency, or fail prematurely

Voltage Flicker

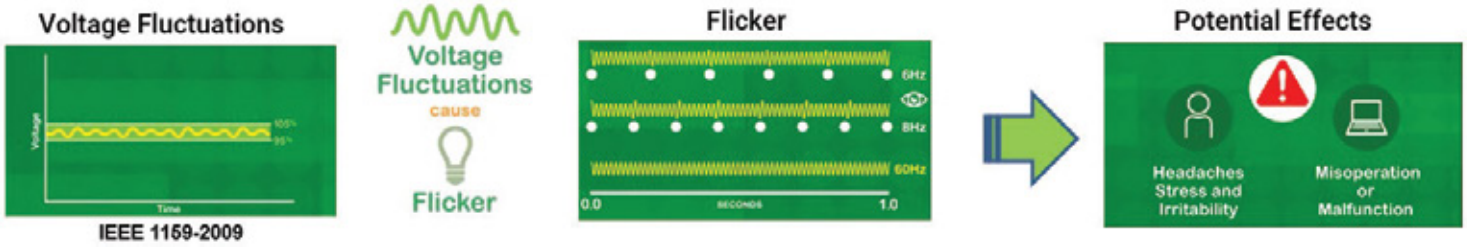
- Causes visual discomfort, reduce productivity, and interfere with electronic equipment.

Voltage fluctuations and flicker are both related to electrical power systems, but they are not the same thing. Voltage Fluctuations are rapid changes in the magnitude of voltage in a power system caused by load changes, switching events, or other disturbances. Flicker is a type of voltage fluctuation that causes the brightness of lights to rapidly changed visibly, often due to rapid load changes, arc furnaces, or renewable power intermittency.

A Deeper Dive Into Flicker

Voltage fluctuations is an electromagnetic phenomenon typically created by electrical loads that have significant recurring variations whereas flicker is the objectionable consequence of that phenomenon. Voltage flicker refers to the rapid and repeated fluctuations in the voltage level of a power supply, which can cause noticeable changes in the intensity of lighting and can affect the performance of other electrical equipment. These fluctuations can be annoying and may lead to operational issues with sensitive equipment.

Flicker is characterized by voltage variation typically within the range of ±10% around the nominal value. The variations can happen at irregular intervals and may differ in duration and intensity. The frequency of the variation, often measured in cycles per second or hertz (Hz), determines the rapidity of the flickering effect. A higher frequency of voltage fluctuations can lead to more pronounced flicker, which can be particularly noticeable in lighting systems where rapid changes in brightness can be visually disturbing.



Causes of Voltage Flicker

Rapidly Varying Loads:

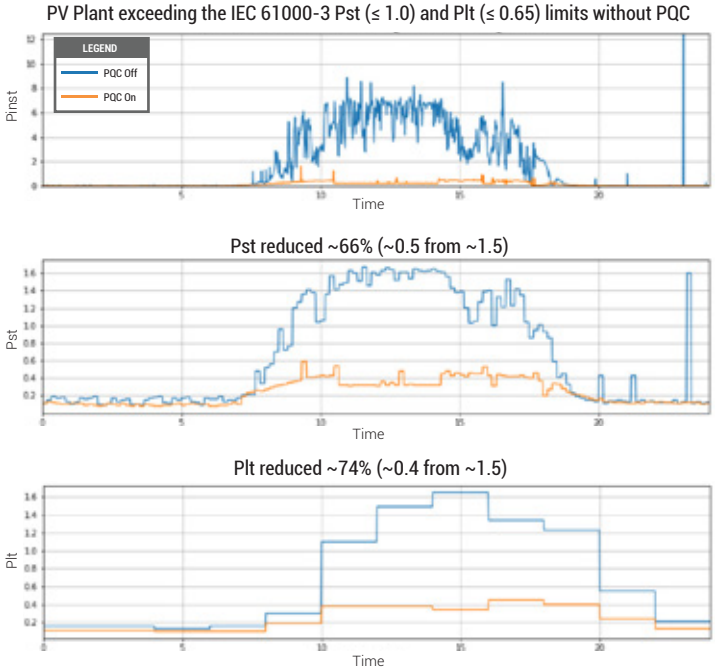
- Electric Arc Furnaces (EAF): These are common in steel manufacturing and cause significant flicker due to their highly variable load.
- Welding Machines: Welding operations often involve rapidly changing current demands, causing voltage flicker.
- Large Motors: The starting and stopping of large motors can create substantial changes in load, leading to voltage fluctuations.

Intermittent Renewable Energy Sources:

- Wind Turbines: The power output from wind turbines can vary quickly with changing wind speeds, leading to flicker.
- Solar Panels: Rapid changes in solar irradiance, such as passing clouds, can cause fluctuations in power output.

PQC Installed at PCC of Multi-MW PV Plant

Flicker 24Hr Trend - PQC Off vs. PQC On



Faults and Switching Operations:

- Short Circuits and Faults: Faults in the network can cause sudden drops or rises in voltage.
- Switching Operations: Switching operations in the power network can lead to transient voltage variations.
- Effects of Voltage Flicker

Lighting Fluctuations:

- Visible Flicker: Changes in light intensity can be perceived by the human eye, which can be particularly annoying in environments with sensitive lighting, such as offices and homes.
- Health Issues: Prolonged exposure to flickering lights can cause discomfort, headaches, and visual fatigue.

Equipment Performance:

- Sensitive Equipment: Electronic devices, computers, and other sensitive equipment may malfunction or suffer from reduced performance due to voltage flicker.
- Process Interruption: Industrial processes relying on stable power can be disrupted, leading to production losses.

Increased Wear and Tear:

- Electrical Components: Frequent voltage fluctuations can lead to increased wear and tear on electrical components, reducing their lifespan and increasing maintenance costs.
- Measuring Voltage Flicker

Pst (Short-Term Flicker Severity):

- Pst is a measure of the perceptibility of flicker to the human eye over a 10-minute period. A Pst value of 1 indicates the threshold at which flicker becomes annoying to the average person.

Plt (Long-Term Flicker Severity):

- Plt is the average value of Pst over a 2-hour period, providing a measure of the long-term impact of flicker.

Diagnosing and Correcting Power Quality Issues

Around 80% of power quality issues are caused by voltage sags. If you suspect this, you can use a multimeter to quickly check supply voltages at panels and sub-panels. Sometimes, voltage dips are just a matter of loose wiring, which is an easy fix.

For events that happen periodically, a power quality analyzer would provide constant capture for each phase, providing detailed information like date, timestamp, phase, amplitude, and duration. Power quality analyzers can be permanently or temporarily put in place for longer recording periods.

You can also use a power analyzer to identify harmonics, transients, and other electrical disturbances. Together with analytical software, your power quality analyzer can monitor and compare voltage and harmonic data to accurately predict distortions before they impact machine health.

A good power quality analyzer, coupled with the right software, can be an important tool for troubleshooting existing or potential power quality issues. Power quality tools help provide event data collection as well as data about energy cost and plant efficiency. In some cases, the right tools can keep you a few steps ahead of problems by helping you predict and correct issues before they become serious.

It's best practice to perform routine power quality tests, even when your plant isn't experiencing any obvious electrical problems. Staying ahead of voltage sags and swells, as well as other disturbances will keep your plant a few steps away from serious issues.

Poor power quality can cause devastating and expensive problems for any organization. Taking steps to improve your power quality can reduce maintenance costs, improve operational efficiency, and increase productivity.

How the Power Quality Compensator (PQC) Mitigates Voltage Flicker

The solution to this common power quality issue can be to install a Power Quality Compensator (PQC) system. The PQC can effectively realize voltage flicker reduction and improve power quality by injecting capacitive or consuming inductive reactive power as needed in sync with the subharmonic voltage fluctuation. The frequency band is programmable and can be customized for the application. Available in both a skidded or mobile solution, the PQC can run multiple operation modes simultaneously and priority can be set to ensure the most value can be realized by owner/operator.

Dynamic Reactive Power Compensation:

- Rapid Response: PQCs provide fast and dynamic reactive power compensation. By quickly adjusting the amount of reactive power injected or absorbed, PQCs can smooth out voltage fluctuations.
- Instantaneous Control: The voltage source converter (VSC) in a PQC can respond within milliseconds, which is essential for mitigating rapid voltage changes that cause flicker.

Voltage Stabilization:

- Voltage Support: PQCs stabilize the voltage at the point of common coupling (PCC) by maintaining the voltage within specified limits. This helps in reducing the amplitude of voltage fluctuations.
- Steady Voltage Levels: By providing continuous voltage support, PQCs ensure that the voltage remains steady even when there are rapid changes in load.

Harmonic Filtering:

- Reduction of Harmonics: Although primarily designed for reactive power compensation, PQCs can also help in reducing harmonic distortions that might accompany voltage flicker.
- Cleaner Waveform: By reducing harmonics, PQCs contribute to a cleaner voltage waveform, which can help mitigate flicker caused by distorted waveforms.

Load Balancing:

- Phase Balancing: PQCs can help in balancing the load across different phases in a three-phase system, which can reduce voltage imbalances that contribute to flicker.
- Even Distribution: Ensuring an even distribution of loads helps in maintaining a stable voltage profile, thereby reducing flicker.

PQC Applications

Industrial Plants:

- Electric Arc Furnaces (EAF): In steel plants, EAFs are significant sources of voltage flicker. PQCs are commonly used to stabilize voltage and reduce flicker during the melting process.
- Welding Operations: Welding machines can cause rapid voltage changes. PQCs provide the necessary reactive power support to mitigate flicker in welding operations.
- Saw Mills: Entry and exit of the workpiece into/from the saw cause sudden and huge variations in the electric power demand, resulting in rapid voltage changes. PQCs can exchange reactive power with the electric distribution system to mitigate these voltage changes and consequently the associated flicker.
- Steel Rolling Mills: The “Metal in Stand” occurs when the work piece enters the rolling stand, causing a sudden and large increase in the power electric demand of the plant. Conversely, when the workpiece disengages the rolling stand, the sudden drop in power demand generated a surge in the voltage. Flicker may be associated with these events. PQCs can significantly mitigate them.

Renewable Energy Integration:

- Wind Farms: The intermittent nature of wind energy can cause voltage fluctuations. PQCs help in smoothing these fluctuations and maintaining voltage stability.
- Solar Farms: Rapid changes in solar irradiance can lead to voltage flicker. PQCs assist in stabilizing the voltage output of solar farms.

Urban and Residential Areas:

- Grid Stability: In areas with a high density of sensitive electronic equipment, PQCs ensure stable voltage levels, reducing flicker and protecting equipment.
- Benefits of Using PQC for Flicker Mitigation
- Improved Power Quality: By reducing voltage flicker, PQCs enhance overall power quality, which is crucial for the reliable operation of sensitive equipment.
- Increased Equipment Lifespan: Reducing voltage fluctuations decreases the stress on electrical equipment, leading to longer operational life and reduced maintenance costs.
- Enhanced Comfort: In residential and commercial areas, mitigating voltage flicker improves the comfort and satisfaction of occupants by providing stable lighting and power supply.

Reactive power is a critical component of power system reliability that helps electricity travel around the grid safely, economically, and efficiently. The solution to these common power quality issues can be to install a Mitsubishi Electric Power Products, Inc. (MEPPI) PQC system, which will sense the voltage changes automatically and will inject or absorb reactive power to correct the voltage violation and restore balance. Our flagship product, the Power Quality Compensator (PQC) , is a ±1 to 4 MVar, 3 phase dynamic power conversion system that can operate in a 2 or 4 quadrant power control mode.

With its flexibility, advanced features, and ability to run multiple operational modes simultaneously, the PQC is the perfect solution for improving power quality, stability, resiliency, and overall power grid reliability.

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