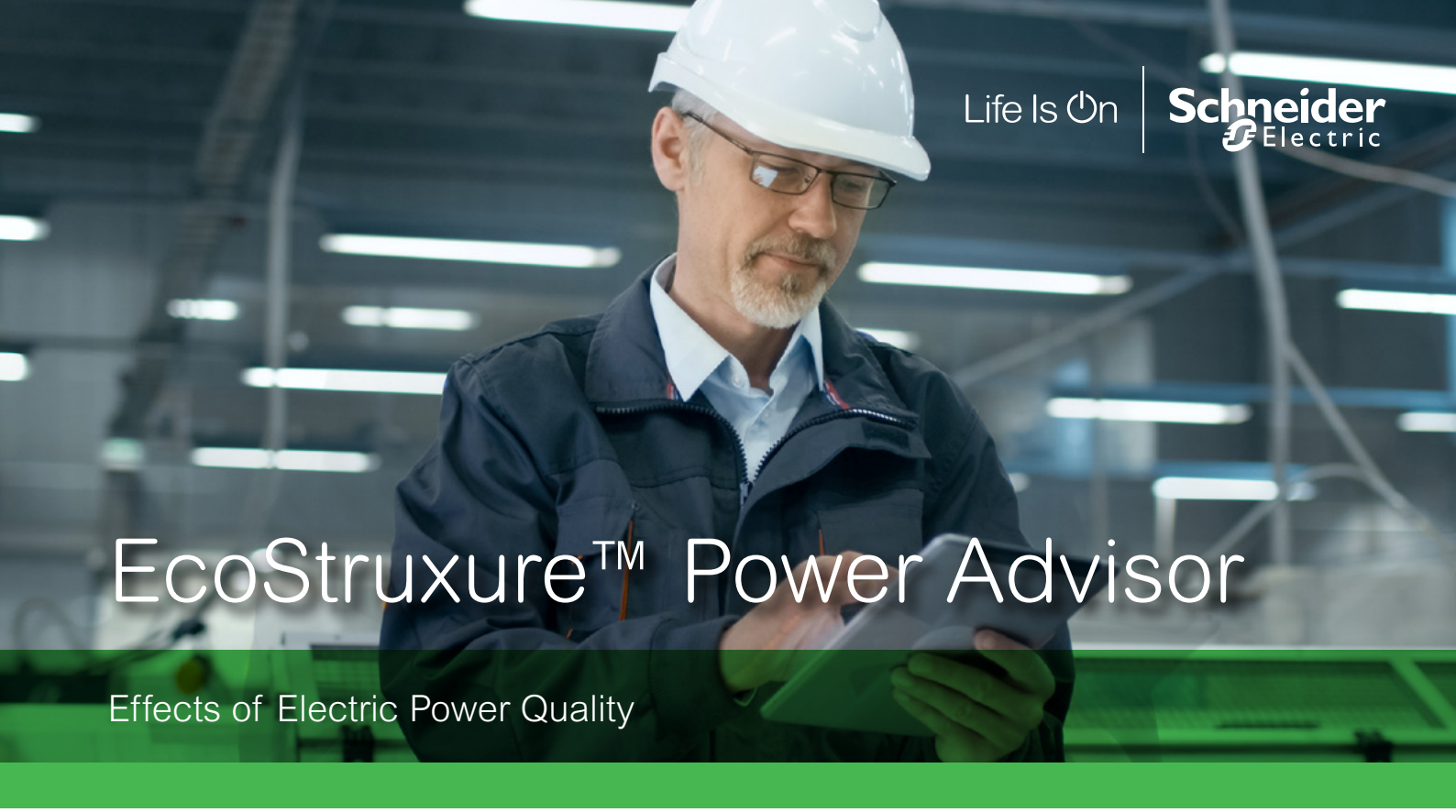


# EcoStruxure™ Power Advisor

Effects of Electric Power Quality

## Power Quality

Just as automobiles require a minimum quality of fuel and oil to operate properly and efficiently, electric loads such as motors, lighting, and data servers also require a minimum quality energy source. The term power quality, or PQ, conveys the extent to which an electrical system's sources approximate an ideal source.

High quality power is critical to ensuring productive operations. With an increasing amount of electro-sensitive equipment attached to the electrical distribution system, knowing what is flowing into the network is important. Maintaining a high level of power quality can:

- Improve equipment efficiency
- Decrease capital, operational, and maintenance expenses
- Increase equipment life expectancy
- Reduce environmental impact

## EcoStruxure™ Power Advisor

EcoStruxure Power Advisor, an advanced analytics solution provided as part of an EcoStruxure Power Advisor Digital Service Plan, is designed to monitor the health of metering systems and electrical networks. Power quality is one of the elements that EcoStruxure Power Advisor analyzes to deliver actionable insights. For more information about running EcoStruxure Power Advisor on your system, please contact your Schneider Electric Technical Support Engineer, or visit schneider-electric.us/ecostruxure-power-advisor.

schneider-electric.us/ecostruxure-power-advisor

## Harmonic Distortion

Distorted voltage signals can produce an array of problems in electrical systems and equipment. Harmonic distortion is described as a steady-state condition where the fundamental power frequency sinusoidal signal contains other non-fundamental frequencies. More specifically, harmonic distortion, or "harmonics," is voltage or current frequencies that are integer multiples of the fundamental frequency. For example, the third harmonic component of a 60 Hertz signal is 180 Hertz (3 x 60 Hertz).

Harmonic distortion is created by loads that consume energy in a non-linear fashion (e.g. computer equipment, variable speed drives and fluorescent light ballasts). This means that the voltage and current signals are not proportional to each other as shown on graph.

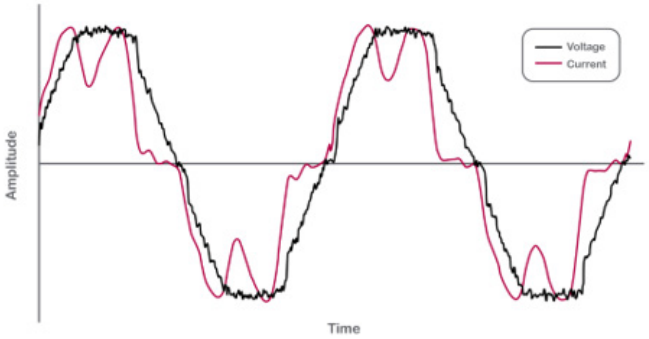



Figure 1. Single-Phase Voltage and Current Waveforms for a Non-Linear Three Phase Load.

## Potential Effects

Harmonic distortion can produce a number of harmful effects on both your equipment and business, including:

- Malfunctions of microprocessor-based equipment
- Overheating of motors and transformers
- Power factor correction capacitor failure and/or fuses blowing
- Intermittent breaker and/or relay operation
- Decreased operational efficiency
- Shorter equipment life
- Fire hazards due to overloaded neutral conductors

Did you know that while harmonic distortion is usually present to some degree in all electrical systems, there are different factors involved to determine whether or not it leads to a problem? System impedance, the magnitude of current distortion, and the particular harmonic frequencies present all play an important role in how detrimental harmonics can be within a facility.

## How EcoStruxure Power Advisor Can Help

EcoStruxure Power Advisor analyzes the system and detects harmonic distortion. Support engineers can provide practical solutions to solve the issue in the most efficient way. EcoStruxure Power Advisor can analyze the voltage total harmonic distortion (THD) and coincident current measurements within your electrical system hierarchy, helping you identify the source of the harmonics, leading to a quicker resolution of the problem.

## Overloaded Transformers

Transformers are critical components in the electrical infrastructures of most industrial and commercial operations. Some uses of transformers include providing the appropriate utilization voltage, improving voltage regulation, isolating essential and non-essential electrical system segments from each other, creating local neutral-ground bonds, and filtering of noise and some harmonic components. Most facilities have a substantial investment in the transformers scattered throughout their facility.

As important as they are to a facility's operation, transformers are often taken for granted. As loads are added or otherwise augmented, it's easy to lose track of, or simply forget about the increased demand on the system transformers. Overloading accounts for 5–10% of all transformer failures, all of which are easily preventable.

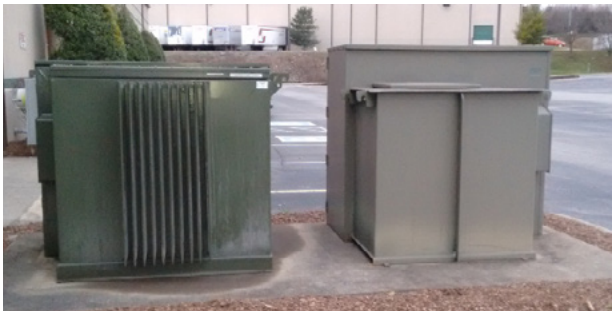
## Potential Effects

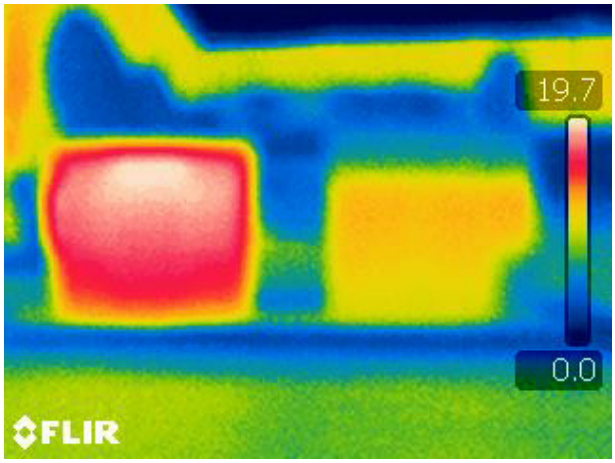
The unexpected failure of a transformer not only impacts capital expenses, but can also affect productivity, revenue, safety, and more. Exceeding a transformer's rated capacity can lead to the following issues within electrical systems:

- Excessive stressing, heating and damage to transformer windings
- Waveform distortion due to saturated core
- Reduced life expectancy or transformer failure
- Increased operational expenses and carbon footprint due to additional system losses
- Increased personnel and site risk from transformer explosions due to overloading

## How EcoStruxure Power Advisor Can Help

By monitoring transformer loads, EcoStruxure Power Advisor can help you keep track of key operating metrics that provide insight into how the equipment is being used versus what it was designed for, helping to avoid overload situations.






Overloaded transformer (exterior and thermal camera view)

Did you know it's a common oversight to neglect the harmonic currents of loads when sizing a transformer? Harmonic currents produce additional heat in a transformer, which can shorten their operational life.

## Overvoltage

It is a common misbelief that if low voltage is bad, then high voltage must be good. In fact, high voltage (i.e., overvoltage) is just as damaging as low voltage (i.e., undervoltage).

Overvoltage is a sub-category of long-duration RMS variations – a category of power quality issues. There are different definitions of overvoltage, based on different industry standards. IEEE defines overvoltage as a condition lasting longer than one minute and exceeding the system nominal voltage by 10%. In a 120-volt system, an overvoltage would be at least 132 volts. ANSI C84.1 defines an overvoltage condition as being only 5% (126 volts in 120 volt system) above the system nominal voltage volts at the service entrance during normal conditions.

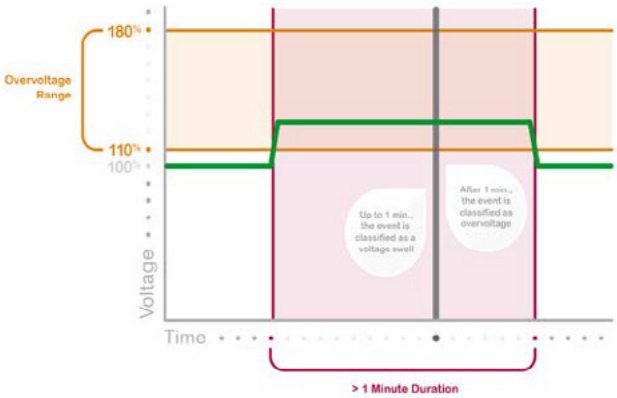
## Potential Effects

Overvoltage can have several causes, both internal and external. Internally, it can occur when significant loads are removed from the system. Externally, it is caused primarily by lightning strikes. Overvoltage can produce a number of harmful effects in electrical equipment including:

- Excessive heating and stressing of components and equipment
- Reduced life expectancy or equipment failures
- Saturated core of power transformers
- Damage to integrated circuits
- Increased operational expenses and carbon footprint due to additional system losses

## How EcoStruxure Power Advisor Can Help

By monitoring voltage levels in your system, and contrasting against relevant industry standards, EcoStruxure Power Advisor can help you monitor your system for overvoltage instances, so you can ensure that your electrical system and assets are not at risk.




Overvoltage RMS

Did you know that voltage motors are typically rated below the nominal system voltage (e.g., 460V vs 480V) because it is assumed that the voltage will drop due to the impedance between the source and the motor's terminals? It is important to ensure the voltage level at a motor's terminals is within an acceptable range.

## Undervoltage

Many modern pieces of equipment, especially those with electro-sensitive integrated circuits, are designed to operate at a steady state voltage. When these assets are supplied with a below-optimal voltage level, a number of problems can arise.

Undervoltage occurs when the RMS voltage of a power system falls below nominal levels. Similar to overvoltage, undervoltage is a sub-category of long-duration RMS variations, which is a category of power quality issues. IEEE defines an undervoltage condition as lasting longer than one minute and being at least 10% below the system nominal voltage. So for a 120-volt system, an undervoltage would be 108 volts or less.

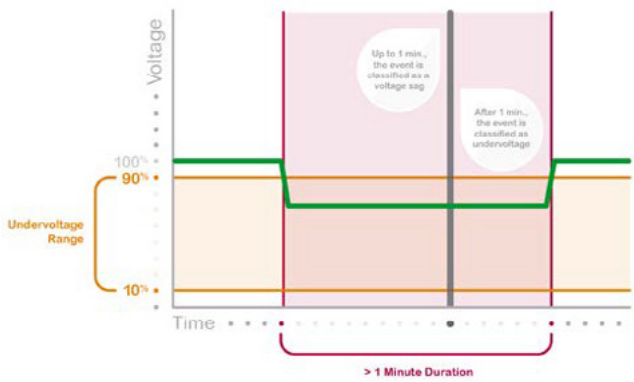
## Potential Effects

Undervoltage can be caused when loads on transformers exceed their capacity, when large loads are switched on, or when capacitor banks are shut off. As with any abnormal voltage condition, undervoltage can produce a number of harmful effects in electrical equipment including:

- Erratic equipment or system performance
- Reduced life expectancy or equipment failures
- Unexpected equipment trips and motor contactor dropouts leading to unplanned operational interruptions
- Decreased light output on some fixture/lighting types
- Increased capital, operational and maintenance expenses from equipment failures
- Reduced effectiveness of power factor correction capacitors

## How EcoStruxure Power Advisor Can Help

Similar to overvoltage, EcoStruxure Power Advisor can provide you with an assessment of actual voltage levels relative to nominal thresholds, alerting you to situations where your system may be at risk of some of the negative consequences of undervoltage.




Undervoltage RMS

Did you know that severe undervoltage conditions decrease a motor's torque, which can prevent it from starting? It is important to operate motors near their rated voltage.

## Voltage Imbalance

Three phase power is pervasive in modern electrical systems. Whether being used to distribute energy from generation sources to end users, or powering the countless motors in commercial and industrial settings, three phase systems are everywhere. However, these systems can suffer from problems of voltage imbalance, which can have negative effects on assets and operations.

Voltage imbalance is a condition where either the voltages in the phases are not balanced, or where the angle between phases differs. A balanced three-phased electrical system will exhibit phase voltages that are equal in magnitude and offset by 120°. As shown in illustration (a), balanced systems are symmetrical about neutral n. Unbalanced three-phase systems exhibit some combination of differing phase voltage magnitudes and/or phase offsets greater or less than 120°. The illustration (b) demonstrates the inherent non-symmetry in an imbalanced electrical system.

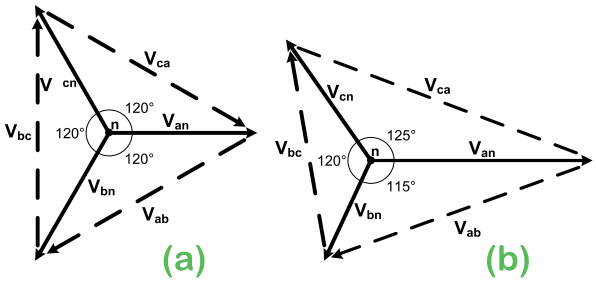



Figure 1. Single-Phase Voltage and Current Waveforms for a Non-Linear Three Phase Load.
(a) Balanced three-phase system and
(b) Imbalanced three-phase system

Did you know that voltage imbalance is estimated to be the source of approximately 5% of all power quality issues in North America? Long-term voltage imbalance produces irreversible damage to the insulation on motor windings.

## Potential Effects

Voltage imbalance can adversely affect three-phase equipment, specifically induction motors and transformers. Three-phase induction motors of all sizes are very common in many industrial and some commercial facilities. When the three-phase source voltage for polyphase induction motors is not balanced, the line currents will typically experience imbalances between 6-10 times the voltage imbalance. These unbalanced currents produce additional heating in an induction motor, shortening the motor's life. Some other adverse conditions produced by voltage imbalance include:

- Increased capital and maintenance expenses due to asset malfunctions, degradations and failures
- Increased potential for unexpected downtime
- Difficulty or inability to synchronize to alternative sources (e.g., closed transition switching back to utility)

## How EcoStruxure Power Advisor Can Help

EcoStruxure Power Advisor can monitor for excessive voltage imbalances in your system, identifying situations where measured values exceed a set threshold. By drawing attention to these instances, you can proactively address the issue, and potentially avoid unnecessary downtime or asset failures.

## Power Factor

With businesses striving for increasing levels of operational efficiency, one area that may be overlooked is the electric power system.The power factor of an electrical system is a means of representing the ratio of power drawn to power actually consumed.In essence, this is a measure of how efficiently your equipment and power distribution system use energy.

A good analogy to help explain the concept is to think of a heavy load sitting on a cart that can only move along a straight line.If a rope were attached to the cart and pulled at an angle to the direction of movement, it would require more work to be done to move the cart a certain distance than if it were pulled directly in line with the cart's path.

Relating this example to the power triangle as shown in the figure, the power required to move the cart the specified distance is the 'real power', and the total work actually performed is 'apparent power'. 'Reactive power' is energy that is consumed, but not used in a productive way (non-working power).

## Potential Effects

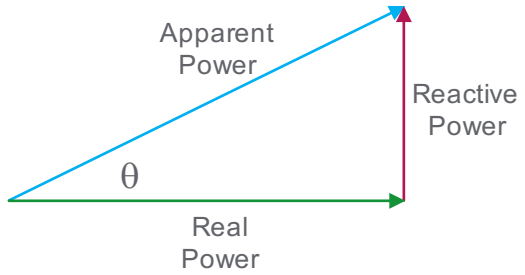
Power factors can be lagging or leading, depending on the type of loads connected to the system. Lagging power factors, those caused by inductive loads such as motors, transformers, and ballasts, can be costly, both in terms of capex and opex. Some potential effects could be:

- Equipment with a low power factor draws more internal current than equipment with a high power factor, which can cause excess heating, and potentially shorten the equipment's lifespan
- Electric utilities typically charge industrial customers a penalty if their overall system power factor falls below a certain threshold, typically 0.9 to 0.95, raising the total energy cost

## How EcoStruxure Power Advisor Can Help

EcoStruxure Power Advisor monitors each meter in your network, identifying potential issues with the average lagging power factor at peak demand, which is typically the most common basis for utility reactive power penalties. With this information, you can avoid additional utility charges, as well as help to maximize your assets' life expectancy.

$$Power\ Factor = \cos\theta = \frac{Real\ Power}{Apparent\ Power}$$




Power Triangle: relation of components used to determine power factor

Did you know that Schneider Electric produces a range of products that can help you manage your operation's power factor? We can help you optimize your power consumption, and avoid potential penalties from your energy supplier.

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