The Impact of Poor Power Quality

Poor power quality can result in equipment damage, production scrap loss, and even costlier downtime. A Single interruption power outage interruption in the process can result in substantial costs, ranging from ten thousand to millions USD per occurrence. Costs to certain industries such as data centers, banks, customer service centers and the like can be even higher. In fact momentary voltage sags lasting less than 100ms impacting these facilities can have just as great of a cost impact as a total outage lasting minutes.

Electrical downtime in a plant can cause electrical device and mechanical failures, loss of production time, increased production scrap, increased unscheduled maintenance costs, to name a few.   The cost of power quality disturbance can be typically seen and calculated in: product-related costs including lost capacity, disposal charges, and increased inventory; labor costs including idle labor, overtime and cleanup; other costs such as damaged equipment, opportunity costs and penalties to name a few. These costs vary widely depending on severity of the disturbance, industry, product produced, scarcity, labor costs, and other basic economic drivers.

IEEE Standard 1346 provides a standard framework to calculate factors to be considered in determining the cost of power quality disturbances.

Analysis - Causes and Signs of Poor Power Quality

One might suspect poor power quality when seeing evidence such as equipment alarms, control system faults, and electrical component failures. Sags and swells in power are also a sign of poor power quality. A voltage sag is defined as a momentary reduction in the supply voltage of between 90% to 10% rms retained voltage for a duration of between 0.5 to 30 cycles. An interruption is defined as a voltage sag with a less than 10% retained voltage in the rms supply voltage. Short circuit faults on the power system or large motor starting events can cause voltage sags. Although these sags might not directly impact the equipment they can cause equipment to mis-operate or fault out.

Sag severity is directly related to the magnitude and duration of the sag. So equipment with ride through capabilities not designed for sags falling outside of specified values will trip, or become inoperable, resulting in potential greater cost due to downtime.

Voltage sags are one of the most costly occurrences, often resulting in large economic impact. Equipment such as under-voltage relays, process controls, drive controls and a variety of automated machines (equipment sensitive to only the voltage during an rms voltage variation) that are sensitive to sags and swells can likely cause equipment to mis-operate. Also, equipment sensitive to both the magnitude and duration of the rms variation (consisting of almost all equipment using electronic power supplies) as well as equipment sensitive to phenomenon other than the magnitude and duration can be the cause. The devices affected by other rms variations are more subtle and difficult to identify.

IEEE Standard 1159 (Recommended Practice for Monitoring Electric Power Quality) defines sag duration lasting between 0.5 cycles and 30 cycles (instantaneous), lasting between 30 cycles and 3 seconds (momentary), and those lasting between 3 seconds and 1 minute (temporary). It is important to record and document sag magnitude and duration for each leg of a 3 phase power system as this data can impact the identification of equipment sensitivity and root cause analysis of specific equipment malfunctions.

Measurement Metrics

To understand the root causes of degradation in power quality, real time measurement and monitoring over, ideally, a full Machine Cycle is needed for machine derived power issues or an extended period of days or months to identify power supplier issues. Factors for machine derived issues such as motor starting, power frequency, voltage magnitude variations, electrical noise, harmonics, phase unbalance, common mode voltage/noise, notching, grounding and bonding issues to name a few should be measured. Long-term power supplier issues such as like sags, surges, sustained interruptions, phase shifts, and high frequency switching transients, should be monitored along with other variables.

Determining the Solution: Economic Calculations

In order to define what equipment is needed to improve power quality and then decide if that investment is to be made, it is imperative to characterize the system power quality performance first. This is typically done by assessing and monitoring the environment for power quality, estimating the costs of variations, and economically comparing alternative options. A "do-nothing" base case is typically compared against several alternative scenarios, using a total lifecycle cost or calculated ROI approach. Calculations can also be combined with energy monitoring costs.

The cost of mitigating equipment to address voltage sags is one way to both improve downtime as well as reduce ongoing wear on equipment. Typically the higher the cost of interruption, the more reason to purchase mitigating equipment, as proven by cost-benefit analysis calculations.