Total Power Quality Solution Approach for Industrial Electrical Reliability

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As industrial automation continues to evolve with the introduction of computer based control systems, the importance of AC power quality has never been higher. The inclusion of more sensitive electronic equipment in industrial processes demands the delivery of clean and stable power. Even the smallest service or process interruption can have a devastating effect on a company's production and profitability.

Industrial computer applications have increased efficiency and productivity gains while decreasing manufacturing and operation costs. Examples of these applications include distributed control systems, CNC machine tools, robotics, assembly lines and many other automation and control oriented processes. As the number of system components has increased, so have the number of devices drawing power from the utility grid. This expanded demand has led to greater dependency on the power quality level within industrial facilities.

The performance of electronic devices is directly linked to the power quality level in a facility. When subjected to power disturbances, these devices can malfunction. Disturbances are often the result of electrical wiring and grounding errors, heavy machinery and other equipment within the user premises.

To attain an acceptable level of electrical performance in an industrial environment, the following steps should be taken to protect against disturbances:

1. Ensure the integrity of the AC distribution system within the facility by inspecting the wiring, grounding and bonding system.

2. Monitor the power for a reasonable amount of time. The amount of time required will depend on the process. Note any interruptions in the process and try to correlate with the data collected. Apply power conditioning to correct for any disturbances which resulted in an interruption in the process. Proper grounding, accurate wiring and the addition of adequate power conditioning products will provide a reliable and consistent electrical system.

Choosing the Correct Method to Improve Power Quality

Grounding & Bonding Integrity

Computer based industrial system performance is directly related to the quality of the equipment grounding and bonding. If the grounding and bonding is incorrectly configured, poor system performance is the result. Grounding is one of the most important and misunderstood aspects of the electrical system.

It is essential to differentiate the functions of the grounded conductor (neutral) from the equipment grounding system (safety ground). The safety ground protects the electrical system and equipment from super-imposed voltages caused by lightning or accidental contact with higher voltage systems. It also prevents static-charges build-up. The safety ground establishes a "zero-voltage" reference point for the system. The safety ground must be a low impedance path from the equipment to the bonding point to the grounding electrode at the service entrance. This allows fault currents high enough to clear the circuit interrupters in the system preventing unsafe conditions.

The grounded conductor (neutral) is a current carrying conductor which is bonded to the grounding system at one point. Grounding this conductor limits the voltage potential inside the equipment in reference to grounded parts (see Figure 1). Neutral and ground should only be bonded together at the service entrance or after a separately derived source. One of the most common errors in a system is bonding the neutral to ground in multiple locations. Whether intentional or unintentional, these ‘extra’ bonding points should be identified and eliminated.

Proper grounding and bonding minimizes costly disturbances. An acceptable degree of reliability can be established by following Article-250 of the National Electrical Code (NEC) requirements.

Proper Wiring

An overall equipment inspection is crucial to ensure proper wiring within a facility. The entire electrical system should be checked for loose, missing or improper connections at panels, receptacles and equipment. Article 300 of the National Electrical Code cover wiring methods and should be followed to ensure safe and reliable operation.

There are many types of commonly available circuit testers that can be used to check for improper conditions such as reversed polarity, open neutral or floating grounds. Make certain to isolate panels feeding sensitive electronic loads from heavy inductive loads, or other electrically noisy equipment such as air compressors or refrigeration equipment. Also check neutral and ground conductors to make sure they are not shared between branch circuits.

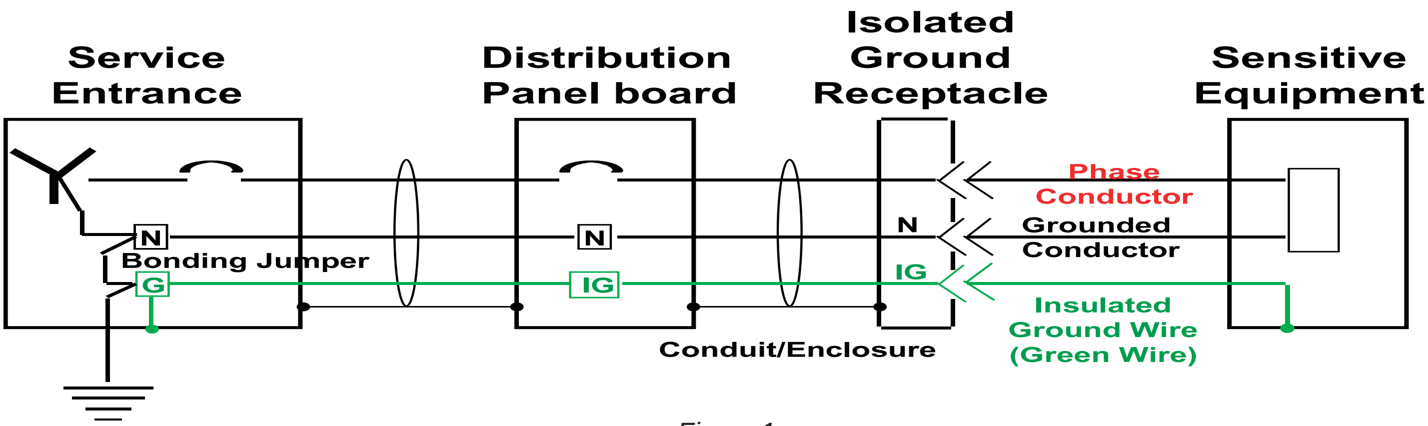

Figure 1

Power Disturbances

Voltage fluctuations and noise are common power disturbances present in any electrical environment that directly affect electronic equipment. These disturbances exist in numerous forms including transients, sags, swells, over voltages, under voltages, harmonics, outages, frequency variations and high frequency noise.

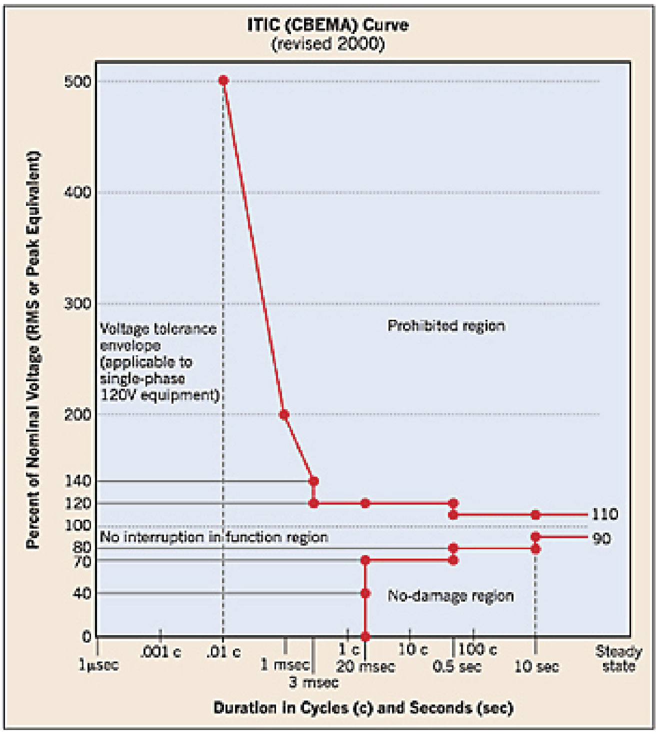

Figure 2

Harmonic distortion has emerged as significant problem due to the increased use of electronic equipment. This electronic equipment draws current that is not linear to the voltage waveform. This non-linear current can cause high neutral current, overheated neutral conductors, overheated transformers, voltage distortion and breaker tripping. Loads such as solid-state controls for adjustable speed motors, computers and switched mode power supplies are sources of non-linear currents.

The Information Technology Industry Council (ITIC) has revised the CBEMA curve in 2000 (see Figure 2). This curve is used to define the voltage operating envelope within which electronic equipment should operate reliably. Equipment should be able to tolerate voltage disturbances in the “no interruption” region of the chart. When the voltage disturbance is in the “no-damage” region, the equipment may not operate properly, but should recover when voltage returns to normal. If voltages reach the “prohibited region,” connected equipment may be permanently damaged. Expensive equipment should be protected from voltages in the prohibited region. Processes which require high reliability should be protected from both the prohibited and no-damage regions.

Power Conditioning Equipment

Several types of power enhancement devices have been developed over the years to protect equipment from power disturbances. The following devices play a crucial role in developing an effective power quality strategy.

Transient Voltage Surge Suppressors (TVSS) - provide the simplest and least expensive way to condition power. These units clamp transient impulses (spikes) to a level that is safe for the electronic load. Employing an entire facility protection strategy will safeguard the electrical system against most transients. Multi-stage protection entails using TVSS at the service entrance, sub-panel and at the point of use. This co-ordination of devices provides the lowest possible let through voltage to the equipment.

TVSS
STV 100K & STV25K

STF Series
Active Tracking Filters

Filters - provide protection against low-voltage high-frequency noises. Filters are designed to pass the fundamental frequency (typically 50 or 60Hz) and reject higher frequency noise such as conducted electromagnetic interference (EMI) and radio frequency interference (RFI). Harmonic current filters prevent the harmonic content of non-linear loads from being fed back into the power source.

Isolation Transformers - provide a degree of isolation and filtering. These devices effectively reduce conducted electrical noise by physical separation of the primary and secondary through magnetic isolation. Isolation transformers reduce normal and common mode noises, however, they do not compensate for voltage fluctuations and power outages.

Voltage Regulators – correct voltage sags, swells, and brownouts.
Voltage regulators maintain output voltage at nominal voltage under all but the most severe input voltage variations. Voltage regulators are normally installed where the input voltage fluctuates, but total loss of power is uncommon. There are three basic types of regulators:

Isolation Transformers

Tap Changers: Designed to adjust for varying input voltages by automatically transferring taps on a power transformer. The main advantage of tap changes over other voltage regulation technology is high efficiency. Other advantages are wide input range, high overload current capability and good noise isolation. Disadvantages are noise created when changing taps and no waveform correction.

Buck Boost: Utilize similar technology to the tap changers except the transformer is not isolated. Advantages are the units withstand high in-rush currents and have high efficiency. Disadvantages are noise created when changing taps, poor noise isolation and no waveform correction.

Constant Voltage Transformer (CVT): Also known as ferroresonant transformers. The CVT is a completely static regulator that maintains a nearly constant output voltage during large variations in input voltage. Advantages are superior noise isolation, very precise output voltage and current limiting for overload protection. The lack of moving parts mean the transformer requires little or no maintenance. Disadvantages are large size, audible noise and low efficiency.

Constant Voltage Transformers

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Uninterruptible Power Supply(UPS): UPS systems provide protection in the case of a complete power interruption (blackout). They should be applied where “down time” resulting from any loss of power is unacceptable. UPS are designed to provide continuous power to the load in the event of momentary interruptions. They also provide varying degrees of protection from surges, sags, noise or brownouts depending on the technology used. There are three major UPS topologies each providing different levels of protection:

Off-Line UPS (also called Standby): Low cost solution for small, less critical, stand-alone applications such as programmable logic controllers, personal computers and peripherals. Off-line UPS systems supply the load directly from the electrical utility with a limited conditioning. The unit provides power to the load from the battery during sags, swells and power interruptions. They offer some noise suppression through a filter/surge suppressor module. Advantages of off-line UPS are high efficiency, low cost and high reliability. The main disadvantage is that protection from high and low voltages is limited by the battery capacity. Other disadvantages are poor output voltage regulation and noticeable transfer time. To keep unit cost low, most off-line units utilize step-sine wave outputs when on battery power.

Line-Interactive UPS: Provides highly effective power conditioning plus battery back-up. These units are ideal in areas where voltage fluctuations are frequent. The defining characteristic of line-interactive models is they can regulate output voltage without depleting the battery. Advantages are good voltage regulation and high efficiency. Disadvantages are noticeable transfer time and difficulty in comparing competing units. The output waveform can be either a sine wave or step-sine wave depending on the manufacturer and model.

True On-Line UPS: Provides the highest level of power protection, conditioning and power availability. True on-line technology, also called double conversion is unique in that the power is converted from AC utility to DC for battery charging and to power the inverter. The DC is then converted back to AC to power the critical load. Advantages of the on-line UPS include the elimination of any transfer time and superior protection from voltage fluctuations. Voltage regulation is achieved by continuously regenerating a clean sine wave. Disadvantages are lower efficiency and higher audible noise.

Motor-Generators Set – Consists of an electric motor driving a generator with coupling through a mechanical shaft. This solution provides complete decoupling from incoming disturbances such as voltage transients, surges and sags. Motor-Generators ride through short periods of power loss, but will not protect against sustained outages without the addition of an additional motor powered by an alternate fuel source (such as diesel or propane).

In conclusion, reliable electronic system performance in the industrial environment requires an initial inspection of the wiring and grounding system. Without stable and dependable system wiring, reoccurring electrical problems are inevitable. Once the integrity of the wiring is established, power conditioning products can be effectively applied to protect critical equipment and processes. This effective power quality strategy will result in the best return on power quality investment.

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